Public Service Company of Oklahoma
2022 Energy Efficiency & Demand Response Programs: Annual Report

Prepared for:

Oklahoma Corporation Commission

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

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1 Executive Summary

This report presents an evaluation of the performance of the energy efficiency and demand response programs, also known as the Demand Portfolio, offered by the Public Service Company of Oklahoma (PSO) in 2022. 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 first program year (PY2022) of the implementation cycle, spanning from January 1, 2022, to December 31, 2022. [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 filed in 2021.[2]
- **Reported Impacts** refer to annual energy savings (kWh) and peak demand (kW) reduction estimates based on actual customer participation in PY2022 before program evaluation activities.
- **Verified Impacts** refer to energy savings (kWh) and peak demand (kW) reduction estimates for PY2022 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 calculated as the verified impact divided by the reported impact. Therefore, a RR greater than 100% represents verified impacts greater than reported impacts.

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,

[1] All the programs represent program participation from January 1, 2022 – December 31, 2022, except the Energy Saving Products Program. The reported savings for LED retail discounts span the period of December 1, 2021 – November 30, 2022. This offset allows for reconciliation of retail sales data and manufacturer/retailer invoices.
[2] Approved by the OCC in Cause No. PUD 2021000041.
[3] A description of ADM and their commitment to safety is included in 5.3Appendix H:.

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 1.4, Appendix B:, and 5.3Appendix 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, and verified annual energy savings and peak demand reduction during 2022 are summarized in the following sections.

1.1 2022 Program Offerings

In 2022, 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 subprogram: Custom and Prescriptive (including Oil & Gas, Agriculture, and Strategic Energy Management), Small Business Energy Solutions, and Commercial Midstream.

PSO also offered customers two demand response programs, one residential (Power Hours) and one commercial/industrial (Peak Performers). Additionally, PSO performed energy efficiency in 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.

Table 1-1: Program Start Dates

Program	Sector	Start Date
Energy-Efficiency Programs		
Business Rebates	Commercial & Industrial, Small Business	January 1st, 2022
Residential Energy Services	Residential	January 1st, 2022
Home Weatherization	Low-Income Residential	January 1st, 2022
Conservation Voltage Reduction	Multiple Classes	January 1st, 2022
Demand Response Programs		
Power Hours	Residential	January 1st, 2022
Peak Performers	Commercial & Industrial	January 1st, 2022

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 5.3Appendix 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 5.3Appendix 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	2.20	1.58	0.52	1.78	3.31
Residential Energy Services	1.74	1.68	0.38	2.30	5.37
Home Weatherization	1.61	2.67	0.62	3.19	4.19
Conservation Voltage Reduction	4.30	4.75	0.61	5.95	-
Total - EE Programs	**2.21**	**2.03**	**0.49**	**2.52**	**4.98**
Demand Response Programs					
Power Hours	1.25	1.80	1.25	1.80	-
Peak Performers	2.45	7.65	2.40	7.65	4.09
Total - DR Programs	**2.03**	**4.51**	**2.00**	**4.51**	**4.82**
Research and Development Programs					
Research and Development	0.00	0.00	0.00	0.00	0.00
Total - R&D Programs	**0.00**	**0.00**	**0.00**	**0.00**	**0.00**
Portfolio Total	**2.19**	**2.18**	**0.58**	**2.63**	**4.97**

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)

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

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

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%)	
2022 Residential[7]	$14,759,106	382,975,071	$0.039	328,264,094	$0.045
2022 Commercial[8]	$10,865,860	395,334,864	$0.027	347,829,901	$0.031
2022 CVR	$3,480,691	237,754,892	$0.015	191,048,211	$0.018
2022 EE Programs	**$29,105,656**	**1,016,064,827**	**$0.029**	**867,142,205**	**$0.034**

Demand response programs are designed to encourage customers to change their normal consumption patterns during periods when prices are high, or system reliability is potentially constrained. These programs encourage load reduction during a short period of time, usually a limited number of days during the summer. As such, demand response program performance was assessed on a peak demand reduction (kW) per dollar basis. 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
2022	$4,958,543	76,260	$65.02

1.3 Summary of Energy Impacts

[5] Calculated as described in 5.3Appendix 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.

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. 2022 program year results of annual energy savings are shown in Table 1-5.

Table 1-5: Summary of Gross Energy Impacts – PY2022[9]

Program	Gross Annual Energy Savings (MWh)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Annual Energy Savings (MWh)
Energy-Efficiency Programs						
Business Rebates	39,487	42,243	45,285	107%	93%	41,998
Residential Energy Services	41,303	52,372	55,211	105%	94%	52,094
Home Weatherization	2,527	3,968	3,967	100%	100%	3,967
Conservation Voltage Reduction	15,411	18,546	15,935	86%	100%	15,935
Total – EE Programs	**98,728**	**117,129**	**120,398**	**103%**	**95%**	**113,994**
Demand Response Programs						
Power Hours	0	0	123	-	100%	123
Peak Performers	60	0	758	-	100%	758
Total - DR Programs	**60**	**0**	**882**	**-**	**100%**	**882**
Research and Development Programs						
Research and Development	**153**	**0**	**0**	**-**	**-**	**0**
Total – R&D Programs	**153**	**0**	**0**	**-**	**-**	**0**
Portfolio Totals	**98,941**	**117,129**	**121,280**	**104%**	**95%**	**114,875**

1.4 Summary of Peak Demand Impacts

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

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

impacts of PSO's energy efficiency and demand response programs during the program year.

Table 1-6: Summary of Demand Impacts – PY2022[10]

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	8.02	7.84	8.91	114%	95%	8.45
Residential Energy Services	7.41	11.74	12.2	104%	90%	10.97
Home Weatherization	0.91	2.23	2.23	100%	100%	2.23
Conservation Voltage Reduction	3.99	4.92	3.58	73%	100%	3.58
Total – EE Programs	**20.33**	**26.73**	**26.92**	**101%**	**94%**	**25.23**
Demand Response Programs						
Power Hours	16.12	14.50	15.11	104%	100%	15.11
Peak Performers	60.00	89.68	55.19	62%	100%	55.19
Total - DR Programs	**76.12**	**104.18**	**70.30**	**67%**	**100%**	**70.30**
Research and Development Programs						
Research and Development	**0.17**	**0.00**	**0.00**	**-**	**-**	**0.00**
Total – R&D Programs	**0.17**	**0.00**	**0.00**	**-**	**-**	**0.00**
Portfolio Total	**96.62**	**130.91**	**97.22**	**74%**	**98%**	**95.54**

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 – PY2022

Program	Projected Net		Verified Net		Percent of Verified/Projections	
	MWh	MW	MWh	MW	MWh	MW
Energy-Efficiency Programs						
Business Rebates	36,789	7.45	41,998	8.45	114%	113%
Residential Energy Services	38,094	6.63	52,093	10.97	137%	165%
Home Weatherization	2,527	0.91	3,967	2.23	157%	245%
Conservation Voltage Reduction	15,411	3.99	15,935	3.58	103%	90%
Total – EE Programs	**92,820**	**18.99**	**113,994**	**25.23**	**123%**	**133%**
Demand Response Programs						
Power Hours	0	16.12	123	15.11	-	94%
Peak Performers	60	60.0	758	55.19	1264%	92%
Total - DR Programs	**60**	**76.12**	**882**	**70.30**	**1469%**	**92%**
Research and Development Programs						
Research and Development	**146**	**0.17**	**0**	**0.00**	**-**	**-**
Total – R&D Programs	**146**	**0.17**	**0**	**0.00**	**-**	**-**
Portfolio Total	**93,026**	**95.28**	**114,875**	**95.54**	**123%**	**100%**

1.5 Summary of Overall Program Satisfaction

Participants from each program were surveyed about their satisfaction with their overall experience with the program. In general, participant satisfaction for the program year is estimated at 84%.[11] Participant satisfaction results by subprogram are summarized in Table 1-8. Process evaluation findings by program are presented in Chapters 3 and 0 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	91%
Business Rebates – SBES	96%
Multifamily & Manufactured Homes[12]	80%
Home Weatherization	87%
Energy Saving Products	82%
Homes Rebates - Single Upgrades	85%
Homes Rebates - Multiple Upgrades	95%
Homes Rebates – New Homes[13]	63%[14]
Education[15]	97%
Behavioral[16]	73%
Power Hours	74%
Peak Performers	82%

[12] Percent of owners/managers that reported being somewhat satisfied or very satisfied with the overall PSO Multifamily program.

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

[14] Score represents the percentage of respondent's reporting a score of 4 or 5 out of 5. Interviews were conducted with 8 builders in the program and the average overall satisfaction score was 78%.

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

[16] Percent of program participants that reported being somewhat satisfied or very satisfied with the combined aspects of the Home Energy Report.

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 2022. 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 PY2022. 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	36.07%	739	27
Residential Energy Services	44.71%	267,390	52
Home Weatherization	3.39%	1,901	9
Conservation Voltage Reduction	15.83%	22,062	1
Cumulative EE Totals	**100.00%**	**292,092**	**89**
Power Hours	0.00%	11,029	2
Peak Performers	0.00%	1,827	1
Cumulative DR Totals	**0.00%**	**12,856**	**3**
Cumulative R&D Totals	**0.00%**	**0**	**0**
Cumulative Portfolio Totals	**100%**	**304,948**	**92**

*Participants represents 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 2022 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)	1,584.59	116	17

Using the eGRID emission rates and lifetime energy savings for measures installed through the PSO Demand Portfolio in 2022 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)
1,460,495	1,049,738	77	11

Reductions in water consumption at participant homes/facilities resulting from PSO's 2022 portfolio of programs were only tracked for the Home Weatherization Program. The result was an annual water savings of 27,109 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, dishwashers, etc.) were limited in the portfolio design because of the high prevalence of natural gas water heating in the PSO service territory. The Business Rebates Program does offer incentives for measures that have water saving potential for C&I customers (e.g., variable frequency drives on pump motors). The effects on water consumption for these measures were not quantified for PY2022.

There are also water savings associated with reduced energy generation attributable to PSO's energy efficiency and demand response programs. PSO's generation fuel mix in

2022 was made up of coal (~8%), natural gas (~21%), purchased power non-wind (~50%) and wind (~22%).

All non-wind generation fuel sources are used in thermoelectric power plants which boil water to create steam, which in turn drives turbines. After the steam passes through a turbine, it is cooled so that it condenses, and the water can be reused. The process of cooling the steam accounts for almost all water use in most thermoelectric power plants, as the steam itself circulates in a closed system. A portion of the water used for this cooling process is lost to evaporation. The specifics regarding how much water is consumed in the process depend largely on the technologies used in each power plant (once-through water cooling, recirculating water cooling, dry-cooling).

A 2003 report by the National Renewable Energy Laboratory (NREL) 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 2022 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)
1,460,495	78%	510	580,984,712

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.

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

The ESP expanded their offerings through the years to include rebates for Level 2 electric vehicle chargers, limited time offerings of energy efficiency measures at discounts on PSO website and point of sale discounts on an assortment of home maintenance measures (door sweeps, door seals, air filters, and spray foam). The addition of these measures is an example of how PSO continues to transform the market by affecting customer purchasing decisions.

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. During 2022, the program offered some no cost HERS ratings to builders to entice participation in a home energy rating program.

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

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

2.3 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 but limited to 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 to not get 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	Residential (Existing Homes)	Multifamily	New Construction	Residential (Existing Homes)
Technology	ASHP	ASHP	ASHP	HPWH
Approved Qty of fuel switching conversions to HP technology	70	50	NA	10
Qty Converted from natural gas	1	0	NA	8
Qty converted from propane	2	0	NA	1
Qty with natural gas backup replaced with same source	9	0	NA	0
Qty with electric backup replaced with same source	154	161	NA	4
Incentivized Total	**166**	**161**	**75**	**13**

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 2020 – 2022

Year	Net Sales (GWh)	Sales Growth	Energy at Generator (GWh)	Energy Growth	Peak Demand (MW)	Demand Growth
2020	17,668	-5.33%	18,782	-5.02%	3,884	-5.37%
2021	18,294	3.55%	19,280	2.65%	4,042	4.09%
2022	19,033	4.04%	20,321	5.40%	4,281	5.90%
Compound Growth Rate	**3.79%**		**4.02%**		**4.99%**	

Table 2-7 and Table 2-8 show weather-normalized annual growth rates and 2020 - 2022 compound growth rates (CPGR) for utility energy sales by customer class.

Table 2-7: 2020 – 2022 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
2020	6,336	3.27%	4,712	-4.5%	5,711	-7.2%	1,202	-3.1%	17,961	-2.7%	8	-0.3%
2021	6,325	-0.2%	4,931	4.67%	5,834	2.16%	1,224	1.79%	18,314	1.97%	8	-1.0%
2022	6,269	-0.9%	5,035	2.10%	6,069	4.01%	1,269	3.69%	18,641	1.79%	9	2.08%
CPGR	-0.5%		3.37%		3.08%		2.74%		1.88%		0.53%	

Table 2-8: 2020 – 2022 Total System Weather Normalized Retail Meter Sales

	Total System	
Year	**GWh**	**%Change**
2020	17,961	-2.72%
2021	18,314	1.97%
2022	18,641	1.79%
Compound Growth Rate	**1.88%**	

Table 2-9 shows 2022 Demand Portfolio funding as a percent of total annual electricity revenue.

Table 2-9: 2022 Demand Portfolio Funding

Funding	Value
2022 Demand Portfolio Program Cost ($M)	$31.373
2022 Operating Revenues ($M)	$1,892.058
Program Cost as % of Utility Operating Revenue	1.65%

Table 2-10 shows 2022 Demand Portfolio net energy savings as a percent of total annual energy sales.

Table 2-10: 2022 Demand Portfolio Energy Savings

Metric	Value
2022 Demand Portfolio Net Energy Savings (GWh)	115
2022 Metered Energy Sales (GWh)	19,033
Savings as % of Utility Sales	0.60%

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	2022	
	Opt-Out Eligible	Chose to Opt-Out -EE
Number of accounts	7,817	3,652
2022 Electric Sales (GWh)	7,031	6,517
Aggregate load as a percentage of total sales	36.9%	35.6%

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	2022	
	Opt-Out Eligible	Chose to Opt-Out -DR
Number of accounts	7,817	3,492
2022 Electric Sales (GWh)	7,031	5,982
Aggregate load as a percentage of total sales	36.9%	31.2%

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 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 much of 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, formerly known as Belo and Cubic Creative. 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:

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

2.8 Summary of Process Evaluation Findings

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

2.8.1 Business Rebates

The business rebates program includes Prescriptive and Custom, Small Business Energy Solutions, and Commercial Midstream.

- Survey findings indicate most participants were satisfied with the application and participation process. Consistent with ADM's past surveys, most respondents to both the Business Rebates and SBES surveys reported satisfaction with the program participation process and required steps.
- A portion of customers' survey responses suggest an opportunity for PSO/ICF to provide additional support for navigating the application process. Seventeen percent of Business Rebates respondents suggested that the program improve the program application process/paperwork process. A portion of customer write-in comments from both the Business Rebates and SBES surveys also suggested some customers may initially struggle to navigate the application process and to find information on available lighting and HVAC rebates.
- The program faces several challenges including supply chain issues, economic conditions, as well as state and federal code and regulation changes. Findings from staff-facilitated discussions and trade ally surveys suggest staff awareness and efforts to understand and overcome several challenges to meeting program goals.
- The Strategic Energy Management (SEM for mid-sized businesses) subcomponent of the Business Rebates program is in its first year and presents an opportunity for growth. ICF's business operations manager said they had partnered with GridPoint and began offering this part of the program in 2022. She noted they had spent more time recruiting participants to the program in 2022 compared to "sitting down and working on holistic management" and in upcoming years there will be an opportunity to grow this program.
- Trade allies generally perceive the primary barrier to participation to be budgetary concerns or finances. About half of the Business Rebates trade allies surveyed observed budgetary concerns or finances as the primary reasons businesses may decide not to participate in the program or make energy efficiency improvements. Similarly, three of the four SBES trade allies indicated budget constraints and equipment costs were the primary barriers to program participation.
- The schedule of projects is perceived as a challenge for the Custom program. PSO's energy efficiency coordinator stated that the "end of the year hook" is a weakness or challenge. He noted that there can be a reliance on larger projects and suggested "filling in the gaps" with more medium or smaller projects. ICF's lead technical consultant and senior program manager observed that this is a program challenge and suggested staff were currently considering various options

to address the issue (for example structuring the program around construction schedules).

- There may be an opportunity to improve the program website or trade ally understanding of the application tools. Two Prescriptive and Custom trade allies made suggestions related to the program's website. One mentioned that some equipment types were not listed on the website. The other trade ally said that the website was "a bit hard to navigate" and indicated it did not have all the information needed to participate in the program such as deadlines for applying and required rebate application forms.
- The SBES staff facilitated discussion and trade ally survey results suggest the addition of smart thermostats and on-bill financing could strengthen the program and add value for customers. The SBES refrigeration trade ally stated that on-bill financing could potentially mitigate customer aversion to working with a contractor and participating in the program. Findings from the staff discussion and review of PY2021 recommendations indicate smart thermostats were under consideration to be added as a program measure.
- Business Rebates and SBES trade ally surveys indicated that program staff continues to provide sufficient program support for successful program implementation. Eight of the nine Business Rebates trade allies were satisfied with ICF staff's knowledge about energy efficiency and energy-efficient products and their response time to answer questions. All the SBES trade ally respondents interacted with ICF in 2022 and were satisfied with their level of professionalism and courteousness, knowledge about energy efficiency and energy-efficient products, response time to answer questions, and ability to explain program rules and customer eligibility. The SBES and Business Rebates trade allies that had interactions with PSO rated their interactions with them highly.
- Survey and interview findings suggest the Midstream program plays an important role in end-use lighting customers' decision-making process. Both lighting distributors perceive the PSO Midstream discounts as an important factor in customers' decision-making and most lighting end-use survey respondents indicated that the program influenced their decision-making process to some extent.
- The Midstream HVAC program was impacted by supply chain issues. All three HVAC service providers noted that their ability to participate in the program was limited by equipment availability. The two distributor contacts observed that supply chain issues had impacted their sales of program-qualified units. More particularly, one said that supply chain issues made determining the impacts of the program challenging and the other said their sale of program-qualified units had decreased

due to a lack of available units. Despite these issues, a portion of end-use customers noted that the program had influenced their decision-making process.

- Distributor interviews suggest an opportunity to improve program communication. One lighting and one HVAC distributor indicated dissatisfaction with the amount of support and communication provided from program staff. The lighting distributor mentioned interest in re-enrolling in the program and being unable to reach program staff, while the HVAC distributor communicated interest in program updates and periodic contact from staff.
- More engaged distributors tended to be more satisfied with program participation. The majority of program sales were made through one lighting distributor and an HVAC rebate processing consultant. The contacts that represented these two organizations were satisfied with the program overall, as well as various aspects of program participation.
- The Midstream facilitated discussion with program staff and HVAC Service Provider interviews suggest an opportunity to increase service provider engagement through better understanding of program requirements. One service provider interview suggested an opportunity to improve understanding of program participation requirements. The service provider said the rebate process was “cumbersome” and stated that they do not file for reimbursement in some instances because of the administrative requirements to participate. Further, this contact said they “shouldn’t have to jump through hoops to get the rebate” and alluded to onsite picture and paperwork requirements. ADM’s facilitated discussion with PSO and ICF staff confirmed that service providers may be hesitant to participant because of misperceptions regarding its requirements. ICF’s account manager said they are not required to complete onsite photo verification and participation requires minimal paperwork.
- Midstream HVAC service providers observed long rebate processing times. All three service providers said that they had experienced long rebate processing times. ICF’s account manager noted that distributor’s internal systems may cause these delays.
- There were improvements to the online intake tool, enabling expanded QA/QC and bulk project uploading. The program’s online intake tool was improved to allow for easier bulk uploading of invoices. The more active lighting distributor noted that there had been a two-month period in the summer of 2022 during which he could not submit program documentation; ICF’s account manager confirmed that the system had experienced an issue, but the problem had been remedied.

2.8.2 Multifamily & Manufactured Homes

- Multifamily & Manufactured Homes program changed in 2022 to add manufactured homes. With manufactured home communities having 1) common areas and 2) owner-renter barriers that resemble apartment complexes, adding manufactured homes has proven a success.
- Survey and interview results verify that the Multifamily & Manufactured Homes program incentive played an important role in the decision-making process. All five decisionmaker survey respondents indicated the program incentive was important in their decision-making process. Interview findings from PSO staff, ICF staff, as well as the two primary service providers also suggested that program funds are a crucial factor in participating properties' decision-making.
- The program is not currently accepting new construction projects. ICF staff noted that the program was no longer accepting new construction project applications. The contacts noted that there is sufficient demand for retrofit projects and alluded to past net-to-gross results as reasons for the update.
- The program pipeline from 2021 drove participation in 2022, with a minimal number of additional applicants accepted because of budget limitations. During the facilitated discussion, the program staff noted that free ridership pre-screening had not been necessary in PY2022 as participation was driven by the pipeline of projects established in the prior program year.
- Service providers are instrumental for the program's implementation. The decisionmaker survey results showed that the service providers are driving program awareness and participation. Further, the facilitated discussion with program staff supported this finding as they mentioned the program's two primary service providers as both a strength and potential threat.
- Providing service providers additional information could ease and improve program participation. First Star Energy's owner observed that the process of verifying home heating fuel type is time-intensive; if the program provided customer account information it would ease participation. The owner also suggested that receiving summary reports on their company's number of projects completed, with savings information and program details could help them gauge their impact and understand their performance within the program.
- Decisionmaker satisfaction remains high. The decisionmaker survey results show high overall satisfaction with the program, though findings indicate opportunities to improve communication regarding the improvements performed, scheduling of improvements, and the quality of installation work.
- A limited number of participating properties received direct installation measures; these measures are no longer being offered through the program. ICF's technical specialist and participating service providers confirmed installation of direct install

measures through the program in 2022, however the technical specialist noted that no additional low flow showerheads, high efficiency faucet aerators, LED light bulbs, and low flow showerheads were being purchased and only existing inventory was being provided through the program.

2.8.3 Home Weatherization

- 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 6 percent said they had participated in another program offered by PSO since participating in the program.
- The program offers an easy, straightforward enrollment and participation process for low-income customers in PSO's territory. Overall, customers were satisfied with the sign up and scheduling process. Survey findings also show that the majority of customers are satisfied with the quality of the weatherization improvements and their experience with the program implementation contractor.
- Some customer skepticism persists; it is generally overcome through the participation process or communication with PSO and Titan staff. Survey results indicate a portion of customers had reservations about signing up for the program, but through the sign up and participation process these concerns were assuaged.
- Participant satisfaction is high. The vast majority of survey respondents were satisfied with the program overall, the measures they received, as well as with PSO as their electric utility. A very small portion of respondents voiced dissatisfaction with some aspect of their experience.
- The staff facilitated discussion suggested a high level of understanding of the customer journey through the program. The discussion with ADM provided an opportunity to reflect on opportunities for deeper understanding of the customer participation process; Titan ES and PSO staff are well-informed of customer thoughts and key touch points throughout the participation process.
- High bill complaints draw customers to the program, though participation may not lead to customers noticing lower bills. PSO staff noted that the program is not typically marketed as a way to lower bills, though it can be a motivating factor for customers that sign up for the program. Survey findings indicate not all customers notice lower bills following program participation. If customers follow-up after program participation, PSO customer call center and Titan ES staff explain that customers may not notice lower bills because of seasonal temperature variations, usage changes, and electricity rate adjustments.
- Consistent with past evaluation results, there remains an opportunity to bolster customer understanding of program improvements and the benefits of energy efficiency. About one-quarter of survey respondents said that they either had not

received or did not recall receiving one or more improvement that the tracking data indicated they received. Furthermore, less than half of survey respondents said the program contractor had spoken with them about ways to use less energy in their home.

2.8.4 Energy Saving Products

- Program staff relies on the inputs from various stakeholders and data resources to implement and continuously improve upon the program. Program staff indicated they adapt and update their offers throughout the program year by changing the rebate amount, channels of delivery, and check for purchasing/sales trends. These aspects make the nature of the program very fluid and susceptible to the state of the current market (e.g., inflation, supply chain issues).
- The success of the program is centered around catering to the interest of the PSO customers in purchasing more energy efficient products at rebated or discounted prices. PSO will continue to increase awareness of energy efficiency and increase the amount of energy efficient measures that are installed within the service territory. During the beginning of PY2023, program staff plans to launch LTOs for lighting measures and will try to obtain energy savings from LED lighting measures before the EISA backstop is implemented.
- Program staff described the LTO launch as an overall success. Although the team experienced minor logistical challenges, the program staff stated they met their goals. Customers have learned about the limited time offers through email blasts and social media posts on Facebook and Instagram. Program staff indicated they will explore selling different measures through their LTO campaigns.
- LED lighting was the most common measure purchased through the LTO. The 15-watt reflector LED light bulbs were the most common measure purchased through the LTO, followed by 5-watt globe bulbs, and 5-watt candelabra bulbs. Other measures rebated through the LTO included advanced power strips, room air purifiers, and Wi-Fi smart thermostats. Most customers stated they decided to purchase the measure after viewing the promotion on the LTO and that the instant discount or price of the product led them to finalize the purchase.
- Most survey respondents were satisfied with the LTO. Overall, 85% were satisfied with their purchase experience. Most survey respondents were satisfied with the measure they purchased. Additionally, many respondents indicated that their experience with the LTO offering was important when making the decision to take additional energy savings actions. This suggests that customers’ experience with PSO’s LTO was important in their decision to take energy saving actions.

- The overall net promoter score was lower for lighting measures compared to non-lighting measures offered through the LTO. The overall net promoter score of the LTO among survey respondents was 47%. Most survey respondents (63%) were considered promoters, 21% were passive, and 16% were detractors. When analyzed by measure the score was highest among people who purchased a room air purifier and lowest among those who purchased a globe LED light bulb. Detractors were displeased with the packaging of the LEDs. Other reasons included the bulbs did not fit their fixtures or they did not like the color or brightness of the bulbs. This finding could suggest that the NPS was influenced by the large share of survey respondents who received broken bulbs.
- Wi-Fi thermostats accounted for almost half of the rebated measures through the downstream channel in 2022. Forty-six percent of the appliances rebated through the downstream program were Wi-Fi thermostats, followed by clothes washers (31%), clothes dryers (19%), EV chargers (4%), and heat pump water heaters (1%). Among the 714 customers who requested rebate for program-eligible measures, 65% received a rebate for a single measure, while 35% received rebates for more than one measure. July, August, September, and October were the months with the largest number of measures being rebated.
- Most downstream participants first learned about the PSO rebate before they made the purchase and through the PSO website. Many participants learned about the available rebates from PSO's website, followed by the retailer's website or an internet search. Most purchases were made with the intention of saving energy and money in their homes or to replace an existing appliance. Most participants received their rebates in four weeks or less.
- Downstream participants were generally 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. The overall net promoter score of the downstream channel was very good at 61%. When analyzed by measure, the NPS was highest among people who purchased ENERGY STAR® washers or dryers (65% each) and lowest among those who purchased a heat pump water heater (50%).
- Most participants indicated they were satisfied with the EV charger rebate and the program had a high net promoter score. In addition to the overall program, participants also indicated their satisfaction with various components of the level 2 EV charger rebate program. In general, most were satisfied with the charger they purchased, the rebate amount, the rebate turnaround time, and the application process. The net promoter score of the LTO among survey respondents was

exceptional at 92%. Most survey respondents were considered promoters of the EV charger rebate program.

- Most survey respondents purchased the ENERGY STAR® level 2 charger to charge their new electric vehicle and to charge it faster. Eighty-three percent learned about the rebate through the PSO website, and one customer learned about the rebate through an electric vehicle salesperson, and another survey respondent was aware of other utilities promoting EV chargers and called PSO to ask if they were also offering a rebate. The ability to charge their car quicker was the top reason for respondents to purchase a level 2 charger. Additionally, many stated the rebate PSO offered was very important as well as protecting the environment or combating climate change was also important in their decision to buy the charger.
- Tulsa, Jenks, Coweta, Bartlesville, and Broken Arrow were the cities where EV level 2 chargers were most often rebated. Almost half (46%) of rebated EV chargers were ChargePoint, followed by 17% which were Enel X Way (JuiceBox), and 11% which were Emporia.
- Customers are most likely to charge their EVs a few times or once per week. Survey participants stated that they either used the level 2 charger once a day (25%), a few times a week (42%), once a week (25%), or could not recall (8%). Most customers are using an app to set charging times for their EV and the frequency of use tended to correlate with the frequency of charging. Charging duration varied, with half indicating they typically charge their EV between 3 and 5 hours. Forty-two percent of respondents reported charging their vehicles between 12 and 7 am.

2.8.5 Home Rebates

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

1.1.1.1 New Homes

- Additional program requirements were implemented due to program budget constraints. Due to the increase in volume of the number of homes being built to PSO efficiency standards in PY2021, ICF instated a new requirement into the program in PY2022 to help alleviate issues with the budget in order to pay out rebates to all homes built to PSO efficiency standards. For a home to qualify for a program rebate in PY2022, it had to be permitted in 2021 and built in 2022. This changed eligibility requirements and allowed for all homes built to PSO efficiency standards to be rebated in PY2022.

- Attrition rate among builders and the number of rebated homes as part of the New Homes Program decreased PY2022. There was a decrease in new builder attrition in PY2022 compared to PY2021 due to saturation level with program budget and the existing predominate builders already participating in the program. PSO was able to reach the saturation threshold for acquiring builders into the program. There was also a decrease in the overall number of homes that were rebated through the program in PY2022. This is due to external factors, including the increased number of homes that were built in 2021, supply chain issues for building materials, and an increase in federal interest rates. Also, the change in program requirements implemented in PY2022 decreased the number of homes rebated through the program.

1.1.1.2 Single and Multiple Upgrades

- Incentives increased for duct replacement and duct sealing upgrades offered through the program in PY2022. The rebate amounts increased for duct replacement from up to $1,600 to up to $3,000 and increased for duct sealing from up to $800 to up to $1,500. The final rebate amount is still based on HVAC tonnage and covers up to 30% of the duct replacement/sealing cost.
- Participant satisfaction remains high for the multiple upgrades program. Most survey respondents were satisfied with the upgrades that were installed as part of the program, their contractor and quality of work done on their home, the TPV, the program overall, and PSO as their electric utility.
- Participant satisfaction is high for the single upgrades program, though some customers noted issues. Most survey respondents were satisfied with the program overall, the measures they received, as well as with PSO as their service provider. A small portion of respondents voiced dissatisfaction with some aspects of their experience. This includes not receiving their rebate or difficulties with receiving their rebate and challenges in communication with the contractor. These issues could indicate an opportunity to improve customer understanding of the participation process.
- There is less trade ally participation for the Single Upgrade Program than desired. PSO is looking to improve program outreach to increase regional diversity. Additional outreach material is needed (specifically for the rural areas outside of Tulsa) to expand the awareness of the program to potential trade allies, which helps increase customers participation.
- Incentives decreased for HVAC tune-ups offered through the program and new incentivized measures were added to the program in PY2022. The rebate amount for HVAC tune-ups decreased from up to $150 to up to $75 for qualifying

customers. Rebates for ENERGY STAR® Programmable Wi-Fi thermostats were added to the Single Upgrade Program to accommodate current market need.

2.8.6 Education

- The program operated successfully in PY2022. Student and teacher survey data indicate satisfaction with the program with 87% of student respondents rating the program as “excellent” or “good” and nearly all teachers stating they would participate in the program again.
- The program design was mostly consistent with past years, though there were some updates. Kits were delivered in soft backpacks rather than cardboard boxes and the program curriculum was updated to include new and relevant content tailored to Oklahoma Education Standards.
- Findings from the teacher focus groups and teacher surveys suggest the curriculum is viewed as a valuable resource for 5th-grade teachers in Oklahoma. Teacher feedback indicates the program materials stimulate student interest. A significant portion of teachers observed that some or all of the curriculum would not otherwise be taught if the program was not offered.
- ADM’s analysis of student survey results indicates opportunities to update question-wording to improve the program’s ability to gauge its impact on students and their families.
- Two teacher focus groups were held in January 2023; results and materials generated from the focus groups will be used to help inform future evaluations. Updates to the 2023 evaluation may include revisions or additions to ADM’s teacher survey as well as follow-up questions during ADM’s in-depth interviews with program staff to gauge any program changes that were made or had been considered as a result of the focus groups.

2.8.7 Behavioral Modification

- Program design is reflected in current implementation and there were no changes to the underlying theory of the program. 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. 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.
- Reports are delivered according to the planned schedule and frequency to enrolled participants. PSO indicated that they ensure timely delivery of emailed and mailed HERs. They reported an improved PSO’s J.D. Power score and an increased overall awareness of energy efficiency among customers.

- Attrition is a larger challenge to the Behavioral Program than opt-out rates. Staff have identified that attrition is largely related to customers closing their accounts when they move from their current residence. To achieve the program's energy savings goals, Opower staff are constantly addressing customer attrition by creating an ongoing rolling enrollment of customers with new accounts and with their control group counterparts. Program staff did not report high opt-out rates among participants and did not believe it to be an issue.
- Survey respondents were satisfied with the HERs and the information presented in the reports. Most respondents were somewhat or very satisfied with the method and frequency of receiving the reports, the information provided in them, and the number of other PSO emails they receive about their home's energy use. Many survey respondents indicated receiving a HER has greatly or somewhat improved their opinion of PSO. Those respondents who were not satisfied with the HERs indicate that they would like to see additional components or changes to the reports, don't find the reports to be accurate, or would prefer emails to paper.
- Most survey respondents recalled receiving both emailed and mailed HERs and reading most or all the reports. More than half of all participant respondents reported they received both the mailed and emailed versions of the HER, while 21% recalled receiving only the mailed version, and 21% said they got only the emailed version. Most respondents reported that they read most or all the HERs they received and on received an average of six reports in 2022. Less than a quarter of survey respondents reported that someone else in their household had read the HERs.
- Participants described the HERs as easy to understand, accurate, and found the report components valuable. Most survey respondents rated the information on home energy use as very or somewhat accurate. Additionally, most respondents rated the comparison to similar homes, comparison to previous year's usage, energy use benchmark, and the energy saving tips as very or somewhat valuable.
- Participants reported learning something about energy efficiency from the HERs. Most respondents reported they had learned something about energy efficiency from the HERs, with 29% reporting learning a lot and an average score of 3.6 on a 5-point scale. Wave 5 HERs participants were the highest proportion of those who reported having learned a lot about energy efficiency but also the highest proportion reporting they did not learn anything.
- The information contained in the HERs was important to most participants in their decision to adopt new energy saving behaviors and/or install an energy efficient item in 2022. Many participants reported adopting new energy saving behaviors in their homes in 2022. Among those who adopted new behaviors, 80% indicated they did so because of the information they had learned from their HERs.

Participants who indicated they learned a lot were more likely to report adopting a new behavior compared to those who had learned nothing. Furnace filters, ENERGY STAR® certified appliances, door seals/sweeps, and advanced power strips were the most common energy efficient items installed among participants in 2022. Respondents said that the information provided in the HERs was important in their decision to take new steps to save energy and/or install energy efficiency appliances or equipment.

- Low utilization of the Energy Management Tool. Few respondents reported logging onto the Energy Management Tool web portal, with many not aware of it. Very few survey respondents indicated they had logged onto the Energy Management Tool web portal. Among those who accessed the portal, a large proportion stated they viewed information about their home's energy use. Most respondents who had not logged on to the Energy Management Tool indicated they were not aware of the portal or were getting all the information they needed from the HERs.
- Participant and non-participant respondents reported positive beliefs and attitudes about energy efficiency. Both groups agreed that energy efficiency saves money, know the steps to take to reduce household energy use, and it does not mean sacrificing comfort. Participants agreed at slightly higher levels than non-participants that they try to be energy efficient for the benefit of the greater good and for their own benefit.
- A small percentage of participants and non-participants believe their community or state are taking steps to become more energy efficient. Compared to participants, non-participants less frequently agreed that their communities and state were taking steps toward energy efficiency and more frequently said they were unaware of any initiatives.
- Participants and non-participants both reported taking energy saving actions. Using a scale from 1 (never considered doing this) to 5 (doing this all the time), non-participants had higher average scores for most actions compared to participants, except for five actions where there were no differences in average scores. Turning off lights, waiting to start the dishwasher, setting temperatures on thermostats in the summer and winter, and replacing furnace filters were the most common actions that respondents reporting doing all or most of the time. This finding could be a result of social desirability bias which may have influenced how respondents answered questions.
- Purchasing LED lighting and installing energy efficient items was common among participants and non-participants. Both groups indicated they purchased LED light bulbs from PSO's Limited Time Offer online marketplace and reported purchasing a similar number of bulbs. The most common items installed by participants and non-participants were furnace filters, ENERGY STAR® appliances or equipment,

and door seals/sweeps. Of the respondents who purchased ENERGY STAR® appliances, refrigerators, clothes washers, and clothes dryers were among the top purchases made among participants and non-participants.

2.8.8 Power Hours

- Power Hours program design changed in 2022 to a direct load control program only. The TOD and VPP components were dropped, and the direct load control event bill credits were replaced with an end of season gift card. Also, thermostats are now rebated through Residential Energy Services program and are no longer offered through Power Hours.
- Tulsa area accounted for most of Power Hours participation in 2022. Honeywell thermostats accounted for 68% of the thermostats participating in the Power Hours program, followed by Nest and Ecobee thermostats.
- More than one-third of respondents had past experience with Power Hours.. Additionally, 27% learned of the program through the PSO website, followed by 13% who learned of Power Hours from bill inserts. New participants largely learned of the program from the PSO website.
- Many respondents indicated they enrolled in the program through PSO's website and were motivated to save energy and receive the incentive. New participants reported enrolling through their thermostats or a mobile app at a higher rate compared to existing participants. Very few survey respondents enrolled in the program through the telephone. Most survey respondents found the enrollment process somewhat or very easy. About a quarter of respondents had concerns (e.g., home comfort, PSO controlling their thermostat, or privacy concerns) prior to participation. The most influential factors for customers to enroll in Power Hours were saving money on energy bills, receiving an enrollment incentive, or lowering their electricity usage.
- Most participants became aware of peak events through a notice on their thermostat or mobile app. Thirty-two percent of survey respondents first became aware of a peak event by seeing the notice on their thermostat and 23% through a notice on their app. Forty-four percent of survey respondents reported that they were somewhat less comfortable during an event, 34% were at least as comfortable compared to other times, 18% reported that they were much less comfortable, and 3% were unsure. Customers often ran fans other than their cooling system to remain comfortable during events.
- Most participants do not override temperature adjustments during peak events and felt the number of events was about right. Thirty-three percent of survey participants stated they or someone in their household overrode the temperature

adjustment during a peak event. The most common reason for overriding the event was that the home felt too uncomfortable. Forty-nine percent of survey respondents indicated the number of peak events that occurred over the summer was about what was expected, followed by 19% who indicated it was fewer than expected and 9% who believed it was more than expected.

- Power Hours participants were mostly satisfied with the program. The net promoter score for Power Hours was 17, with 45% of survey respondents being promoters. Seventy-four percent of survey respondents were very or somewhat satisfied with the program overall. Most who were dissatisfied with Power Hours indicated they had not received the gift certificate or were not able to redeem an electronic gift card. Others were dissatisfied with the lack of energy savings, and some were dissatisfied with the program requirements.

2.8.9 Peak Performers

- Most of the 2023 program participants were located in Tulsa. The Peak Performers program had an average estimated reduction of 89,681 kW, with Tulsa accounting for largest share of reduction among participants.
- Education and outreach are important components of Peak Performers. Program staff indicated they plan to better support the participating business accounts by understanding how reducing energy load affects their business model and how their participation in the program supports energy saving goals. Program staff continues to identify and mitigate the challenges to enrollment and maximizing curtailment during peak events. Staff indicated they will explore opportunities to expand to various market segments that do not enroll as much compared to other business types. In general, program staff identified small businesses as a potential target group.
- Most survey respondents communicated to others in their organization about the Peak Performers program. Survey respondents indicated they communicated about when a peak event was happening, managed energy usage during the event, signed up for the program, and were the primary point of contact. Twenty percent of survey respondents indicated they communicated with PSO staff or Peak Performer representatives once they started participating in the program and most were very satisfied with those interactions.
- Many survey respondents indicated they did not opt out of any events. Thirty percent of survey respondents indicated five to seven events per year would be their preferred number of events per year and another 30% indicated as many events as needed. Approximately 30% of Peak Performer participants participated in all six peak events in 2022.

- Satisfaction with the Peak Performers program is high. Peak Performers received a net-promoter score of 47, with 65% of respondents being promoters and 18% were detractors. Most stated it was likely that their organization would participate in Peak Performers in 2023. Additionally, many respondents indicated they were satisfied with the event notification process, incentive amount, and the energy usage data available to them while participating in the program.

3 Energy-Efficiency Programs

This chapter reports on evaluation findings of the 2022 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	39,487	42,243	45,285	554,104	107%	93%	41,998
Multifamily	1,726	3,645	3,639	58,900	100%	100%	3,639
Home Weatherization	2,527	3,968	3,967	67,705	100%	100%	3,967
Energy Saving Products	8,599	19,152	19,447	293,681	102%	85%	16,621
Home Rebates	5,419	6,083	6,051	111,542	99%	95%	5,759
Education	2,723	3,221	3,889	39,557	121%	100%	3,889
Behavioral	22,838	20,271	22,186	22,186	109%	100%	22,186
Conservation Voltage Reduction	15,411	18,546	15,935	398,387	86%	100%	15,935
Energy-Efficiency Totals	**98,728**	**117,129**	**120,398**	**1,546,062**	**103%**	**95%**	**113,994**

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	8.02	7.84	8.91	114%	95%	8.45
Multi-Family	0.40	0.91	0.93	102%	100%	0.93
Home Weatherization	0.91	2.23	2.23	100%	100%	2.23
Energy Saving Products	1.39	4.20	3.88	92%	71%	2.77
Home Rebates	1.68	2.81	2.52	90%	95%	2.40
Education	0.41	0.65	0.55	86%	100%	0.55
Behavioral	3.51	3.19	4.32	135%	100%	4.32
Conservation Voltage Reduction	3.99	4.92	3.58	73%	100%	3.58
Energy Efficiency Totals	**20.33**	**26.73**	**26.92**	**101%**	**94%**	**25.23**

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

3.1 Residential Energy Services programs

This section presents findings from the impact and process evaluation of the 2022 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	PY2022
Number of Participants	267,390
Budgeted Expenditures	8,543,338
Actual Expenditures	8,203,841
Energy Impacts (kWh)	
Projected Energy Savings	41,302,806
Reported Energy Savings	52,371,499
Gross Verified Energy Savings	55,210,937
Net Verified Energy Savings	52,093,193
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	7,403
Reported Peak Demand Savings	11,747
Gross Verified Peak Demand Savings	12,200
Net Verified Peak Demand Savings	10,974
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.68
Utility Cost Test Ratio	1.74

3.1.1 Home Rebates

This chapter presents findings from the impact and process evaluation of the 2022 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. Builders received $800 for construction that met 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 – SEER 15 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

Additionally, bonus rebates were offered for:

- $200 for installing SEER 16 Air Conditioner
- $600 for installing SEER 18+ Air Conditioner
- $800 for installing SEER 20+ Air Conditioner
- $800 + $350/ton Ground Source Heat Pump
- $1000 for installing Ductless Minisplit
    - $50 for installing minimum 32-amp devoted circuit attached to a NEMA 14-50 plug

HERs raters received a $50 rebate per rated home. 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.

The Multiple Upgrades component of the program focused on energy efficiency upgrades to existing residential homes. To qualify for the program in 2022, customers needed to install two or more eligible equipment upgrades. Eligible measures are shown in Table 3-4.

Table 3-4: Multiple Upgrades Rebates Offered

Upgrades	Multiple Upgrades Rebates
Attic/Ceiling Insulation (R-22 or less existing)	$600
Knee Wall Insulation	$525
Wall Insulation (R-0 existing)	$450
Floor/Crawlspace Insulation (R-0 existing)	$450
Exterior Wall Insulation	$450
Air Infiltration	10% of air sealing cost covered up to $1,000
Duct Replacement	30% of duct replacement cost covered up to $3,000
Duct Sealing	30% of duct sealing cost covered up to $1,500
Air Conditioner/Heat Pump Replacement*	-
ENERGY STAR® SEER 16-16.99	$300
ENERGY STAR® SEER 17-17.99	$900
ENERGY STAR® SEER 18-19.99	$1,200
ENERGY STAR® SEER 20+	$1,500
Ductless Minisplit, 20 SEER Minimum*	$1,500
Geothermal/Ground Source Heat Pump	$1,200 + $525 per ton

** HVAC replacement in the Multiple Upgrades Program was combined with Duct Replacement or Duct Sealing.*

The Multiple Upgrades Program included a walk-through assessment from a PSO approved contractor to help identify energy-efficiency measures that could improve customers' comfort level while reducing energy costs. After the initial audit was complete, a PSO/ICF contracted employee, also referred to as PSO Third Party Verifier (TPV), performed a diagnostic test on the home after the upgrades were installed. This process measured and documented the efficiency gains from infiltration reduction and duct sealing measures along with HVAC equipment.

The Single Upgrade component of the program focused on energy-efficiency upgrades to existing residential homes. To qualify for this component of the program, customers needed to install one or two eligible equipment upgrades. Eligible measures are shown in Table 3-5.

Table 3-5: Single Upgrade Rebates Offered[17]

Upgrades	Single Upgrade Rebates
Attic/Ceiling Insulation (R-22 or less existing)	$400
Air Conditioner/Heat Pump Replacement	-
ENERGY STAR® SEER 16-16.99	$200
ENERGY STAR ® SEER 17-17.99	$200
ENERGY STAR ® SEER 18-19.99	$600
ENERGY STAR ® SEER 20	$800
Ductless Minisplit, 20 SEER Minimum	$1,000
Geothermal/Ground Source Heat Pump	$800 + $350 per ton
HVAC Tune-Up (based on existing HAVC unit)	$75 + $25 per pound of refrigerant*
ENERGY STAR® Swimming Pool Pump	$400
ENERGY STAR® Programmable Wi-Fi Thermostat	$75

**Up to 2 pounds of refrigerant per project*

Home Rebates 2022 performance metrics are summarized in Table 3-6.

[17] Drop-Off Energy Kits were included in the Single Upgrade Program in 2021 at no additional cost to program participants.

Table 3-6: Performance Metrics – Home Rebates Program

Metric	PY2022
Number of Participants	3,384
Budgeted Expenditures	$3,592,056
Actual Expenditures	$4,107,313
Energy Impacts (kWh)	
Projected Energy Savings	5,418,507
Reported Energy Savings	6,082,679
Gross Verified Energy Savings	6,050,660
Net Verified Energy Savings	5,758,724
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	1,684.68
Reported Peak Demand Savings	2,805.40
Gross Verified Peak Demand Savings	2,515.37
Net Verified Peak Demand Savings	2,396.54
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.36
Utility Cost Test Ratio	0.89

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 methodologies used for evaluation of the 2022 New Homes portion of the Home Rebates Program.

3.1.1.2.1 EM&V Methodology

This section provides an overview of the gross and net impact evaluation and process evaluation of the New Homes component of the Home Rebates Program. Findings from the process evaluation for all program components are provided in Section 3.1.1.6.

3.1.1.2.2 Impact Evaluation Activities

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

- 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 HERS rater documentation, building drawings, and builder provided documentation)
- Gross Impact analysis. Engineering analysis of site-level and program level impacts
    - Net Impact analysis. ADM used survey results from online builder surveys to determine the level of free ridership in the program. In addition, ADM determined spillover through program documentation.

3.1.1.2.3 Process Evaluation Activities

ADM performed a process evaluation assessing the 2022 Home Rebates 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 staff at PSO and an implementation contractor. Table 3-7 summarizes the data collection activities.

Table 3-7: 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
On-Site Verifications	Observe the program data collection process and document simulation model inputs

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?

3.1.1.2.4 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.

In developing the sample plan, ADM reviewed program tracking data to explore potential designs and ensure there were no duplicate entries or other inconsistencies. In this review ADM found that four HERS raters accounted for 99% of program savings. It was determined that the sample design would stratify the program population by each of these HERS raters, with the remaining HERS raters allocated to a fifth strata denoted as 'other' (as they collectively only accounted for 1% of program impacts). While this stratification proved an efficient sample design, it also enabled the evaluation to explore whether there were statistically significant differences between the HERS raters and provide program feedback.

3.1.1.2.5 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. In some instances, such as survey designs, a census of participants is necessary to maximize the sample; which may not always meet the precision target. Table 3-8 summarizes the sample size for each primary data collection activity.

Table 3-8: New Homes - Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Builder Surveys Completed	9
Home Buyer Surveys Completed	82
Facilitated Discussion with Program Staff	3
On-Site Verifications	10
Impact Evaluation Analysis Sample	26

The sample for the engineering review of building simulation models was designed to achieve ±10% relative precision or better at the 90% confidence interval. 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 an verified precision. Sample design precision at the 90% confidence interval was ±8.95% for estimated annual energy savings. Table 3-9 below summarizes the sample framework exceeding the targeted 10% precision.

Table 3-9: New Homes - Sample Design

Strata	Measure	Reported Energy Savings (kWh)	Population Size	CV*	Sample Size	Relative Precision
Stratum 1	Rater 1	720,219	324	0.20	7	12%
Stratum 2	Rater 2	429,313	255	0.20	5	15%
Stratum 3	Rater 3	341,029	180	0.48	7	29%
Stratum 4	Rater 4	175,556	72	0.27	5	19%
Stratum 5	Other	20,958	10	0.51	2	53%
Total	**-**	**1,687,074**	**841**		**26**	**8.95%**

** The CV of the verified energy savings (and realization rates) were set at a minimum value of 0.30 by strata for calculation of precision. This ensures that the number of sample points extrapolated by strata properly represents the strata compared to the population.*

3.1.1.2.6 Data Collection

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

Builder Survey

For the New Homes Program, all builders were pulled from the tracking data and included in the survey sample list. The builder contact information was requested from PSO and any builder who participated in the program in 2022 was sent the online survey in January 2023. A total of 17 homebuilders were sent the online survey.

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 sent the online survey in January 2023. A total of 523 participants were sent the home buyer survey letter.

Program Staff Facilitated Discussion

ADM conducted a facilitated discussion of the Home Rebates – New Homes Program with program and implementation staff in January 2023. The facilitated discussion involved a group discussion with key personnel responsible for discussing past program year recommendations and brainstorming implementation strategies. The discussion focused on 1) following up on main points from the program strengths, weaknesses, opportunities, and threats (SWOT) analysis discussion from PY2021, 2) following up on program recommendations from PY2021, 3) identifying data collection issues and program analysis needs for PY2022, and 4) answering any outstanding questions for PY2022.

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 helped provide simulation model inputs during the implementation reviews.

3.1.1.2.7 Gross Impact Methodology

Energy impacts are calculated through energy simulation using Ekotrope.[18] 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. A detailed description of this methodology can be found in Appendix G.

3.1.1.2.8 Net-to-Gross (NTG) Estimation Methodology

The evaluation team at ADM estimated the net impacts of the New Homes Program 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 described in Appendix G were used to calculate a free ridership score for each builder.

3.1.1.2.9 Verified Gross Savings Results

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

Program Activity

Participation and reported savings estimates per builder are shown in Table 3-10. The top six participating builders accounted for 86% of New Homes estimated annual energy savings.

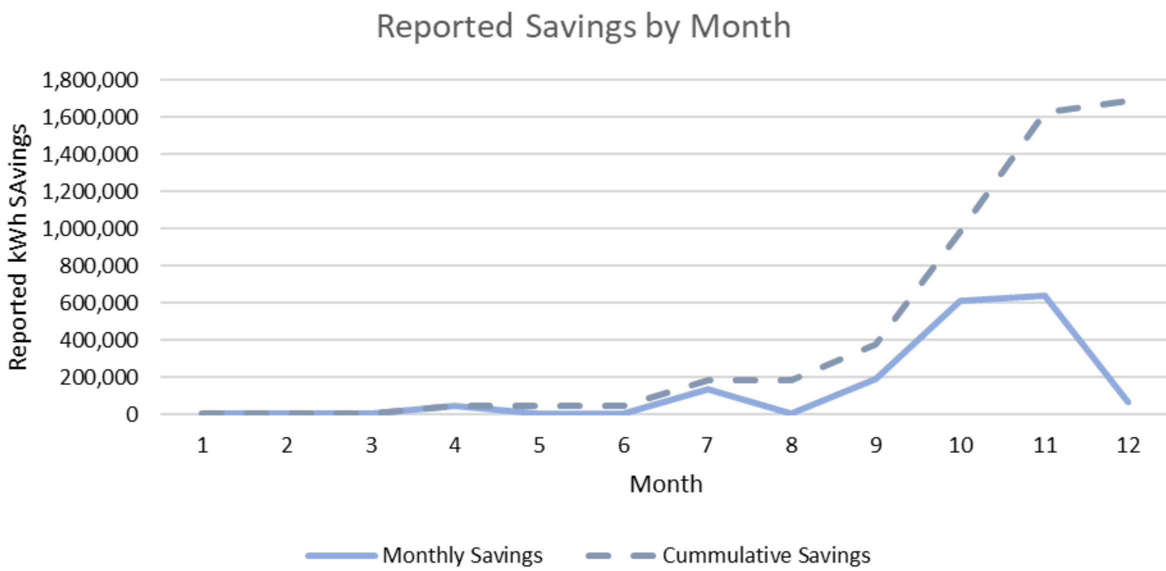
[18] https://www.ekotrope.com/

Table 3-10: New Homes - Participation and Savings per Builder

Builder	Number of Homes	Reported Energy (kWh)	Reported Demand (kW)	Percent of Program Energy Savings
Executive Homes	191	463,200	177.81	27.5%
Simmons Homes LLC	160	286,975	107.29	17.0%
Shaw Homes	116	212,536	76.59	12.6%
Rausch Coleman Homes	125	183,995	69.38	10.9%
Sunview Construction, LLC	72	175,556	26.90	10.4%
Capital Homes Residential Grp., LLC	72	129,989	47.73	7.7%
Homes By Classic Properties LLC	19	35,133	12.97	2.1%
TRADITION HOMES	17	30,587	11.74	1.8%
Concept Builders	12	26,682	10.04	1.6%
Home Creations	11	17,760	6.64	1.1%
Cobblestone Homes, Inc.	5	16,083	6.20	1.0%
SPECTACULAR HOMES	7	13,703	5.07	0.8%
Hensley Custom Homes, LLC	6	12,451	4.56	0.7%
Homeowner	1	11,030	1.17	0.7%
True North Homes LLC	3	10,940	4.10	0.6%
TCGH LLC	6	9,611	3.56	0.6%
J. Madden Homes LLC	1	9,033	0.99	0.5%
DMP Custom Homes Inc.	3	7,320	2.90	0.4%
Mike Fretz, Inc.	3	6,075	2.32	0.4%
Ketchum Properties, LLC	2	4,953	1.65	0.3%
Abbey Homes LLC	2	4,749	1.64	0.3%
Central Oklahoma Habitat for Humanity	1	4,235	0.64	0.3%
Homeowner	1	3,780	0.20	0.2%
Capron Construction, Inc.	1	3,160	1.13	0.2%
Homeowner	1	3,021	1.06	0.2%
Beacon Homes IV LLC	1	2,499	0.98	0.1%
Bgreen Homes, LLC	1	2,020	0.78	0.1%
Total	**840**	**1,687,074**	**586.02**	**100%**

Participation in the New Homes program throughout the program year is shown in Figure 3-1.

Figure 3-1: New Homes - Cumulative Reported kWh during the Program Year



Program Documentation Review

No issues were found with the provided program tracking data. Ekotrope models were received directly from Ekotrope.

Verified Gross Savings

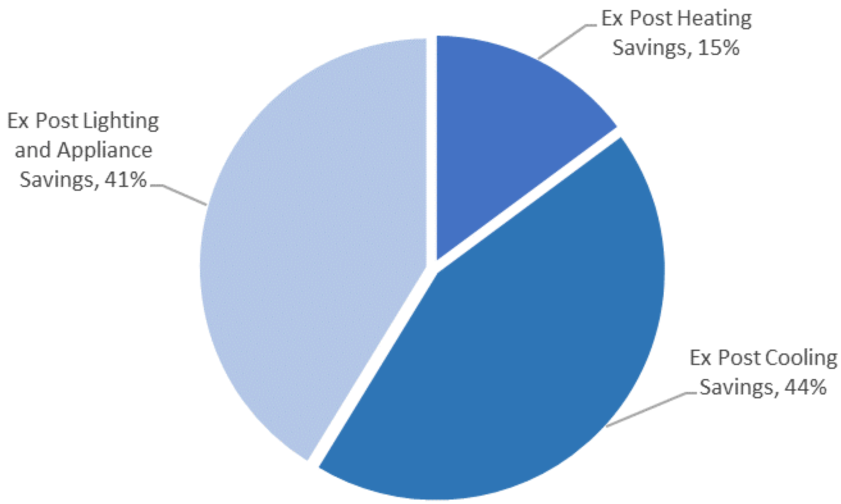
ADM was able to perform on-site and virtual data collection for ten sampled projects. Findings from these data collection activities were used to update simulation models as appropriate. Various updates to model inputs such as furnace EAE and AFUE %, air conditioner SEER, value, HVAC heating and cooling output capacities, water heater energy factor, and window u-value and SHGC were determine through analyzing provided photographs and documentation.

Differences Between Reported and Verified Simulation Inputs

Using Ekotrope, the baseline conditions 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, though there were some areas where bedroom count differed from site visit.

The figure below (Figure 3-2) 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 heating systems, followed by upgrades to lighting and appliances.

Figure 3-2: New Homes - Energy Savings of Aggregated Sample by End Use



Verified adjustments to the models resulted in minor impacts to the program savings. The impact, while approximately 0.32% of the program, was found in energy savings due to electric heating and cooling end-uses. Results by strata and sample precision with verified annual energy savings is shown in Table 3-11.

Table 3-11: Sample Results

Strata	Measure	Sample Reported Energy Savings (kWh)	Sample Evaluated Energy Savings (kWh)	Population Size	Sample Size	Relative Precision
Stratum 1	Rater 1	15,428	15,389	324	7	12%
Stratum 2	Rater 2	7,261	7,145	255	5	15%
Stratum 3	Rater 3	13,234	13,198	180	7	30%
Stratum 4	Rater 4	12,700	12,999	72	5	20%
Stratum 5	Other	3,748	3,748	10	2	40%
Total		**52,372**	**52,480**	**841**	**26**	**9.08%**

Due to the minor changes in the verified models, the program achieved a 100% realization rate for the program year 2022. Reported and verified energy impacts are presented in Table 3-12.

Table 3-12: 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	720,219	273.34	718,391	273.19	14,367,828	100%	100%
Rater 2	429,313	158.17	422,457	144.38	8,449,148	98%	91%
Rater 3	341,029	120.84	340,107	120.74	6,802,130	100%	100%
Rater 4	175,556	26.90	179,696	26.73	3,593,919	102%	99%
Other	20,958	6.77	20,957	6.79	419,145	100%	100%
Total	**1,687,074**	**586.02**	**1,681,609**	**571.83**	**33,632,170**	**100%**	**98%**

The difference in the reported and gross annual energy savings results were due to model assumptions and physical home characteristics verified on-site (e.g., differences in key model inputs). Program level reported and gross annual energy savings are summarized in Table 3-13. 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 3-13: 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
1,687,074	586.02	1,681,609	571.83	33,632,170	100%	98%

3.1.1.2.10 Net-to-Gross (NTG) Estimation Results

Eight builders contributing 32% of the program’s annual energy savings participated in online surveys for 2022. 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 2022, 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 3-14).

The New Homes portion of the Home Rebates Program was over-subscribed in 2022. This did not stop builders from filling out applications and continuing to build homes to program requirements. The implementation staff worked with builders to alleviate concerns and ensure homes were built with the energy efficiency expectations of the homeowners without incentive. ADM accounted for the energy savings of the homes tracked by the implementation team that went through the application process but were not able to receive an incentive. A total of 439 homes were built to program specifications and not incentivized. The energy savings for these homes is considered spillover for the program. The magnitude of energy impacts due to free ridership and spillover are presented in Table 3-14.

Table 3-14: 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)
345,987	21%	90.35	16%	708,041	257.55

Based on impact evaluation results, the total verified net energy and demand savings are presented in Table 3-15 below.

Table 3-15: 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)
1,681,609	571.83	121%	126%	2,043,662	739.04	40,873,246

3.1.1.3 Multiple Upgrades

This section presents the methodologies used for evaluation of the 2022 Multiple Upgrades portion of the Home Rebates Program.

3.1.1.3.1 EM&V Methodology

This section provides an overview of the gross and net impact evaluation and process evaluation of the Multiple Upgrades component of the Home Rebates Program. Findings from the process evaluation for all program components are provided in Section 3.1.1.6.

3.1.1.3.2 Impact Evaluation Activities

Data collection included online participant and trade ally surveys, a facilitated discussion with program and implementation staff, and on-site verifications. Additional sources of data to inform the impact evaluation were a census of program tracking data from the program implementor's tracking and reporting system, along with project documentation 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
- 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

3.1.1.3.3 Process Evaluation Activities

ADM performed a process evaluation assessing the 2022 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, a facilitated discussion with program and implementation staff, and on-site verification visits. Table 3-16 summarizes the data collection activities.

Table 3-16: 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.
On-Site Verifications	Observe the program data collection process and document measure inputs

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?

3.1.1.3.4 Sampling Plan

Table 3-17 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 3-17: Multiple Upgrades - Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Participant Surveys Completed	80
Trade Ally Surveys Completed	21
Facilitated Discussion with Program Staff	2
On-Site Verification Visits	15

Online Participant Surveys

For the calculation of sample size for survey completes for the online participant survey, a coefficient of variation of 0.5 was assumed.[19] With this assumption, a minimum sample size of 68 participants was needed, as shown in the following formula. This minimum sample size of 63 was exceeded with 80 surveys completed.

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

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

19 The coefficient of variation, cv(y), is a measure of variation for the variable to be estimated. Its value depends on the mean and standard deviation of the distribution of values for the variable (i.e., cv(y) = sd(y)/mean(y)).

Where:

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

3.1.1.3.5 Data Collection

Data collection activities supporting the evaluation included participant surveys, trade ally surveys, a facilitated discussion with program and implementation staff, on-site verification visits, and collection of all program documentation to complete a census engineering analysis.

Participant Survey

For the Multiple Upgrades Program, ADM conducted a participant survey of PSO customers who participated in the Multiple Upgrades Program in 2022. All Multiple Upgrades participants (as of November 2023) were pulled from the tracking data and included in the survey sample list. Any participant with a valid email address was sent the online participation survey. Participants were contacted via email in November and December 2022 to complete the survey 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 636 participants, which resulted in 80 survey completes.

Trade Ally Survey

For the Multiple Upgrades Program, ADM conducted a survey of all trade allies who participated in the Single & Multiple Upgrades Program in 2022. 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 contacted via email in December 2022 to complete a survey using an online survey platform (Qualtrics). A total of 93 Trade Allies were contacted, which resulted in 21 survey completes.

Program Staff Facilitated Discussion

ADM conducted a facilitated discussion of the Home Rebates - Single Upgrade and Multiple Upgrades Program with program and implementation staff in October 2022. The facilitated discussion involved a group discussion with key personnel responsible for discussing past program year recommendations and brainstorming possible implementation strategies. The discussion focused on 1) following up on main points from the program strengths, weaknesses, opportunities, and threats (SWOT) analysis discussion from 2021, 2) following up on program recommendations from PY2021, 3) identifying data collection issues and program analysis needs for PY2022, and 4) answering any outstanding questions for PY2022.

On-Site Verification Visits

ADM performed 15 in-person verifications in 2022. During the on-site visits, ADM observed the program data collection process, as well as completed a field data collection form. These forms were completed to verify insulation thickness and type, duct replacement (insulation) square footage, and HVAC unit efficiency/capacity. Additionally, photographs were taken to confirm the collected data. This information helped provide simulation model inputs during the implementation reviews.

3.1.1.3.6 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 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 as 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 Appendix G.

3.1.1.3.7 Net-to-Gross (NTG) Estimation Methodology

Net impacts of the program were determined through the calculation of free ridership and spillover as described in Appendix G. The algorithms are based on self-claimed information gathered during participant survey efforts.

3.1.1.3.8 Verified Gross Savings Results

This section details findings from Multiple Upgrades program activity for 2022, the reported and verified gross savings that resulted from that activity, and the NTG estimates applied to the gross savings to produce the net savings reported in Section 3.1.1.5.

Program Activity

The Multiple Upgrades part of Home Rebates in 2022 had 873 total applications as part of the program. Final energy savings were based on a total of 1,981 energy-saving measures. See Table 3-18 below for a breakdown of total quantities for each energy-saving measure in the program.

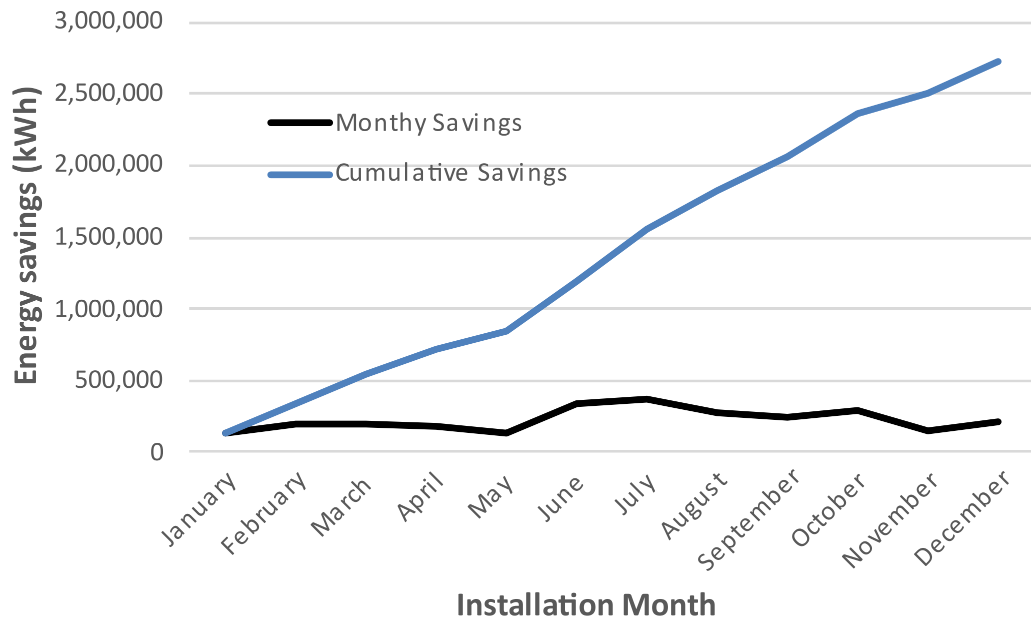
Table 3-18: Multiple Upgrades - Per Measure Equipment Quantities

Measure	Quantity in Program
Air Sealing Package	5
Duct Replacement	224
Duct Sealing	706
Central AC	818
Heat Pump[20]	30
Attic Insulation	163
Floor Insulation	5
Knee Wall Insulation	28
Wall Insulation	2
Total	**1,981**

The monthly energy savings, along with the cumulative annual savings for the 2022 Multiple Upgrades Program are detailed in Figure 3-3 below.

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

Figure 3-3: Multiple Upgrades - Cumulative Reported kWh Savings During PY2022



Reported and Verified Gross Savings

The Multiple Rebates program's gross verified savings estimates resulted in an energy savings realization rate of 99% and demand reduction realization rate of 84%. The following presents the gross verified savings by measure, lifetime energy savings (kWh), and realization rates by measure.

Table 3-19: 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	1,571	1,571	1.17	1.17	17,278	100%	100%
Duct Replacement	470,061	485,155	295.68	272.39	9,703,110	103%	92%
Duct Sealing	1,215,292	1,252,003	783.19	734.17	22,536,054	103%	94%
Central AC	798,559	764,237	435.53	264.30	14,520,508	96%	61%
Heat Pump	94,652	49,450	32.00	12.77	791,196	52%	40%
Attic Insulation	119,716	119,646	91.78	92.32	2,392,923	100%	101%
Floor Insulation	2,613	2,613	0.67	0.67	52,260	100%	100%
Knee Wall Insulation	16,772	18,588	12.34	13.38	371,764	111%	108%
Wall Insulation	3,516	3,516	1.62	1.62	70,320	100%	100%
Total	**2,722,752**	**2,696,780**	**1,653.98**	**1,392.79**	**50,455,413**	**99%**	**84%**

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. ISRs for each measure type were developed based on the findings from the online participant survey data and on-site verification visits, and then extrapolated to the population. Findings from the participant survey and verification visits determined a 100% ISR for all sampled measures in Multiple Upgrades for 2022. 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 five air sealing projects in the Multiple Upgrades Program in 2022. The realization rates for air sealing were 100% for energy savings and 100% for the demand savings.

Duct Replacement (Insulation): This measure consists of 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 103% for energy savings and 92% for the demand savings. Although the realization rates were close to 100%, the difference between the reported and verified savings was due to the verified savings calculations capping the pre-flow capacity at 40% of the post-flow capacity as per the AR TRM. The reported savings calculations are set up to accommodate non-tested scenarios and, in those cases, 5% is the default within the formula.

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 103% for energy savings and 94% for the demand savings. Although the realization rates were close to 100%, the difference between the reported and verified savings was due to the verified savings calculations capping the pre-flow capacity at 40% of the post-flow capacity as per the AR TRM.

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 61% for demand savings. The difference in energy savings is a result of the baseline capacity exceeding the efficient capacity for a total of 46 central air conditioner projects in the program. For those projects, the verified energy saving calculations used the baseline condition; ADM assumed that the contractor right sized the unit in the baseline condition as any additional oversized baseline would have a different EFLH. Also, one project reported a baseline SEER of 12.44 for the reported savings calculations instead of the 2016 federal minimum SEER of 14, which is utilized by the verified savings calculations for all projects The difference in demand savings is a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using the old federal minimum baseline EER value of 10.8 for 543 projects out of the 819 total central air conditioner projects.

Heat Pumps:[21] 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 52% for energy savings and 40% 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. These differences in baseline and efficient capacities resulted in the realization rate for energy savings to be less than 100%. The difference in demand savings is a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using the old federal minimum baseline EER values of 10.8 for half (50%) of all heat pump projects in the program.

Ground Source Heat Pumps: 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. There were no ground source heat pump projects in the Multiple Upgrades Program in 2022.

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 100% 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.

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

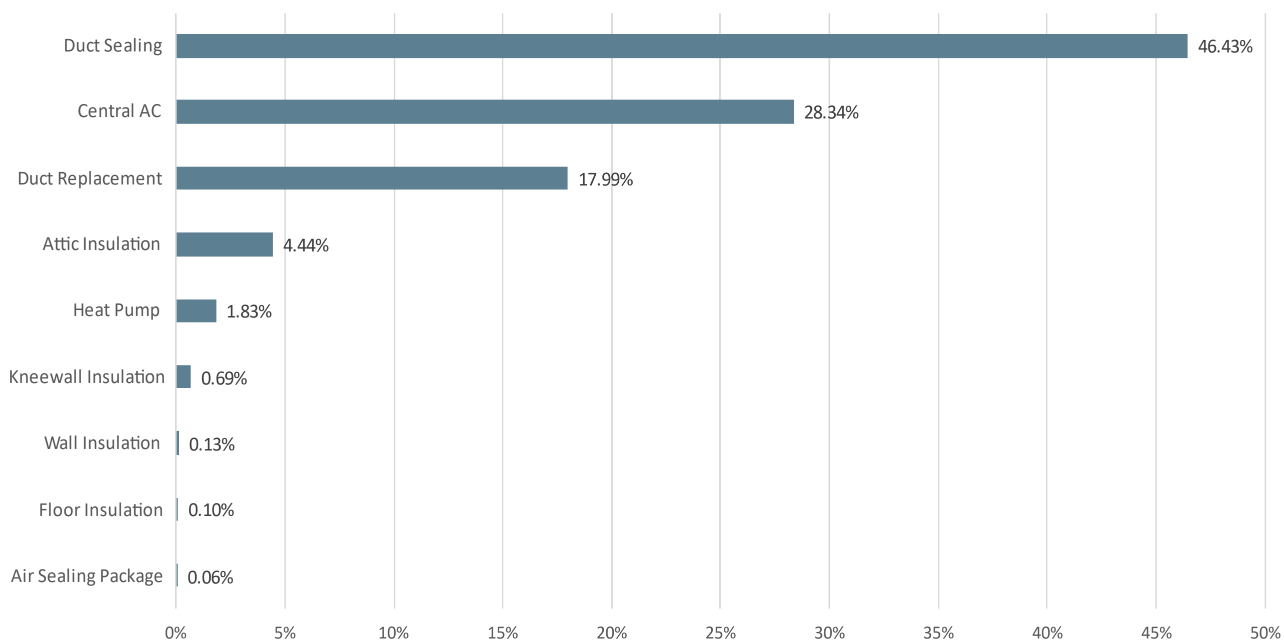
Floor Insulation: This measure presents two eligible scenarios for retrofitting a crawlspace underneath an uninsulated floor, one which includes insulating the underside of the floor (above the vented crawlspace), where the floor previously had no insulation, and the other includes "encapsulating" the 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 were five floor insulation projects in the Multiple Upgrades Program in 2022. 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 111% for energy savings and 108% for demand savings. The verified saving calculations are based on zero existing insulation due to the assumptions in the AR TRM 8.1 of the baseline being an uninsulated knee wall. However, 10 out of 28 knee wall insulation projects in the reported savings calculations had a baseline insulation depth reported.

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 2022. The realization rates for wall insulation were 100% for energy savings and 100% for demand savings.

The percent of gross verified energy savings reported by measure for the 2022 Multiple Upgrades Program are detailed in Figure 3-4 below.

Figure 3-4: Multiple Upgrades – Percent of Gross Verified Energy Savings per Measure



3.1.1.3.9 Net-to-Gross (NTG) Estimation Results

Survey data from a total of 80 Multiple Upgrades participants were used to determine the NTG ratio for this program. Survey respondents were asked a series of questions aimed at determining the program influence on the purchase and installation decisions for each installed measure 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. Although 10 survey respondents provided specific details of additional equipment/products they purchased in 2022, the savings were not considered spillover as the participants did not rate the influence of the program high enough to claim added savings in the NTG estimation. Therefore, there was 0% spillover for the Multiple Upgrades Program in 2022.

The average free ridership score was 14%. 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 86% for energy and demand savings. Based on the impact evaluation results, the total verified net energy savings for the Multiple Upgrades Program are 2,316,671 kWh, and the total verified net peak demand savings are 1,192.80 kW. A summary of Multiple Upgrades net impact findings is shown in Table 3-20.

Table 3-20: 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
2,696,780	1,392.79	2,316,671	1,196.06	86%

3.1.1.4 Single Upgrade

This section presents the methodologies used for evaluation of the 2022 Single Upgrade portion of the Home Rebates Program.

3.1.1.4.1 EM&V Methodology

This section provides an overview of the gross and net impact evaluation and process evaluation of the Single Upgrade component of the Home Rebates Program. Findings from the process evaluation for all program components are provided in Section 3.1.1.6.

3.1.1.4.2 Impact Evaluation Activities

The primary data collection activities for Single Upgrade consisted of online participant and trade ally surveys, a facilitated discussion with program and implementation staff, and on-site verifications. Additional sources of data to inform the impact evaluation were a census of program tracking data from the program implementor's tracking and reporting system, along with project documentation 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

3.1.1.4.3 Process Evaluation Activities

ADM performed a process evaluation assessing the 2022 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, a facilitated discussion with program and implementation staff, and on-site verification visits. Table 3-21 summarizes the data collection activities.

Table 3-21: 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.
On-Site Verifications	Observe the program data collection process and document measure inputs

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?

3.1.1.4.4 Sampling Plan

Table 3-22 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 3-22: Single Upgrade - Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
Participant Survey	148
Trade Ally Surveys Completed	21
Facilitated Discussion with Program Staff	2
On-Site Verifications	2

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, as shown in Equation 3-1. This minimum sample size of 68 was exceeded with 126 surveys completed.

3.1.1.4.5 Data Collection

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

Participant Survey

For the Single Upgrade Program, ADM conducted a participant survey of PSO customers who participated in the Multiple Upgrades Program in 2022. All Multiple Upgrades participants (as of November 2023) were pulled from the tracking data and included in the survey sample list. Any participant with a valid email address was sent the online participation survey. Participants were contacted via email in November and December 2022 to complete the survey 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 974 participants, which resulted in 148 survey completes.

Trade Ally Survey

For the Single Upgrade Program, ADM conducted a survey of all trade allies who participated in the Single & Multiple Upgrades Program in 2022. 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 contacted via email in December 2022 to complete a survey using an online survey platform (Qualtrics). A total of 93 Trade Allies were contacted, which resulted in 21 survey completes.

Program Staff Facilitated Discussion

ADM conducted a facilitated discussion of the Home Rebates - Single Upgrade and Multiple Upgrades Program with program and implementation staff in October 2022. The facilitated discussion involved a group discussion with key personnel responsible for discussing past program year recommendations and brainstorming possible implementation strategies. The discussion focused on 1) following up on main points from the program strengths, weaknesses, opportunities, and threats (SWOT) analysis discussion from 2021, 2) following up on program recommendations from PY2021, 3) identifying data collection issues and program analysis needs for PY2022, and 4) answering any outstanding questions for PY2022.

On-Site Verification Visits

ADM performed two in-person verifications in 2022. During the on-site visits, ADM observed the program data collection process, as well as completed a field data collection form. These forms were completed to verify attic insulation thickness and type, pool pump type and horsepower, Wi-Fi thermostat type, and HVAC unit efficiency/capacity. Additionally, photographs were taken to confirm the collected data. This information helped provide simulation model inputs during the implementation reviews.

3.1.1.4.6 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 as 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 Appendix G.

Lifetime kWh 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 3-23 shows the EUL and source for each measure type.

Table 3-23: 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[22]
Wi-Fi Thermostat	11

3.1.1.4.7 Net-to-Gross (NTG) Estimation Methodology

This section provides a summary of the method used to score survey responses for free ridership and spillover. The online survey sample of program participants were asked a series of questions aimed at estimating program attribution and identifying spillover measures. The attribution scoring system had three components: measure-level free ridership score, project-level free ridership score, and the spillover score. Detailed information is found in Appendix G.

3.1.1.4.8 Verified Gross Savings Results

This section details the level of the Single Upgrade program activity for 2022, the reported and verified gross savings that resulted from that activity, and the NTG estimates that were applied to the gross savings.

Program Activity

In 2022, the Single Upgrade portion of Home Rebates had 1,670 total applications as part of the program. Final energy savings were based on a total of 1,904 energy-savings measures. See Table 3-24 below for a breakdown of total quantities for each energy-saving measure in the program.

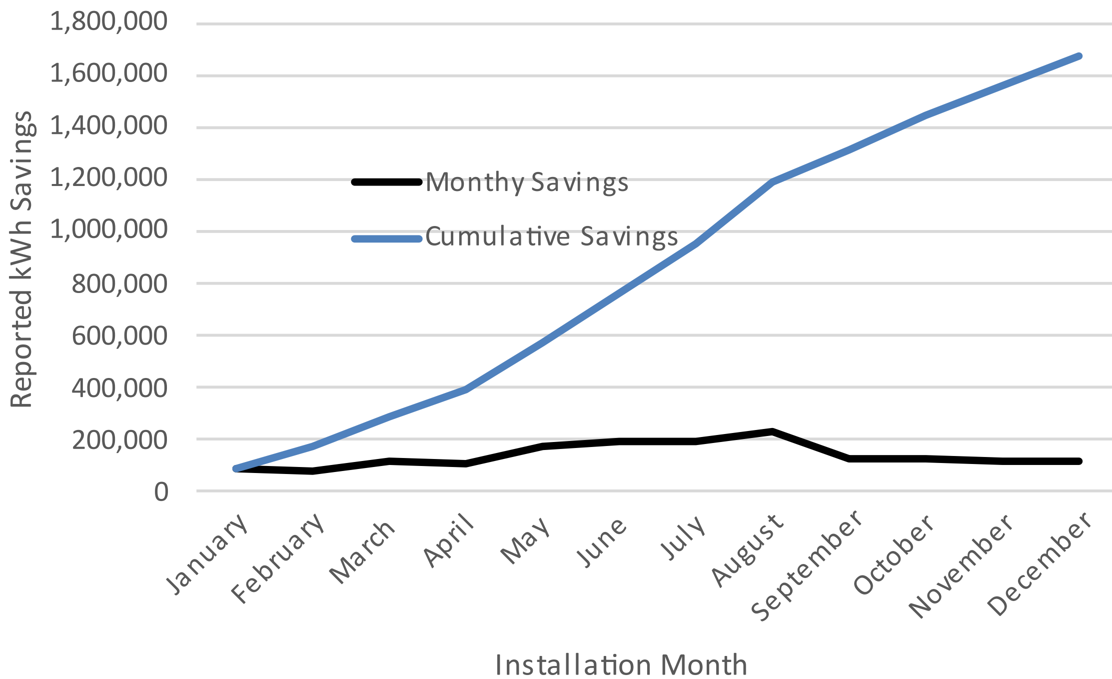
[22] Used default EUL of 10 years (refrigerant added) from AR TRM 8.1.

Table 3-24: Single Upgrade – Per Measure Equipment Quantities

Measure	Quantity in Program
Central AC	1,031
Heat Pump[23]	126
Ground Source Heat Pump	10
Attic Insulation	321
Pool Pump	253
HVAC Tune-Up	42
Wi-Fi Thermostat	121
Total	**1,904**

The monthly energy savings, along with the cumulative annual savings for the 2022 Single Upgrade Program are detailed in Figure 3-5 below.

Figure 3-5: Single Upgrades – Cumulative Reported kWh Savings During PY2022



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

Single Upgrade Reported and Verified Gross Savings

The verified gross and reported savings by measure are shown in the following table. The savings estimates result in a gross annual energy realization rate of 100% and a peak demand reduction realization rate of 97%. Table 3-25 presents the gross verified savings, lifetime energy savings (kWh), and realization rates by measure.

Table 3-25: 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	678,873	679,308	274.59	270.93	12,898,595	100%	99%
Heat Pump[24]	224,782	225,766	40.78	27.91	3,208,185	100%	68%
Ground Source Heat Pump	62,772	58,243	13.60	11.75	1,456,084	93%	86%
Attic Insulation	230,471	234,237	130.45	131.96	4,684,734	102%	101%
Pool Pump	400,546	400,566	92.28	92.28	4,005,657	100%	100%
HVAC Tune-Up	28,458	27,202	13.69	15.93	272,016	96%	116%
Wi-Fi Thermostat	46,950	46,950	0.00	0.00	516,453	100%	100%
Total	**1,672,852**	**1,672,272**	**565.40**	**550.75**	**27,041,724**	**100%**	**97%**

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 on-site verification visits, 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 2022. 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 100% for energy savings and 99% for demand savings. The difference in demand savings is a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using the old federal minimum

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

baseline EER value of 10.8 for 13 projects out of the 1,031 total central air conditioner projects.

Heat Pumps:[25] 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 100% for energy savings and 68% 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 demand savings is a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using the old federal minimum baseline EER value of 10.8 for 5 projects out of the 126 total heat pump projects.

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 93% for energy savings and 86% for demand savings. The difference in energy and demand savings is a result of the verified savings calculations using the 2016 federal minimum EER of 11.8 for all units in the program, while the reported savings calculations are using a baseline EER values of 11.2. The difference in energy and demand savings also resulted from the verified savings calculations using a COP of 2.403, which is based on the 2016 federal minimum HSPF of 8.2, while the reported savings calculations are using a COP of 2.26, which is based on an HSPF of 7.7 (old federal minimum). ADM noted that one project reported having no existing heating/cooling baseline equipment.

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 extra inches of insulation that provide an R value beyond the R-49 table were not included, as the heat transfer rate diminished with each extra R value past R-49. The realization rates are slightly over 100% due to extra savings 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.

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

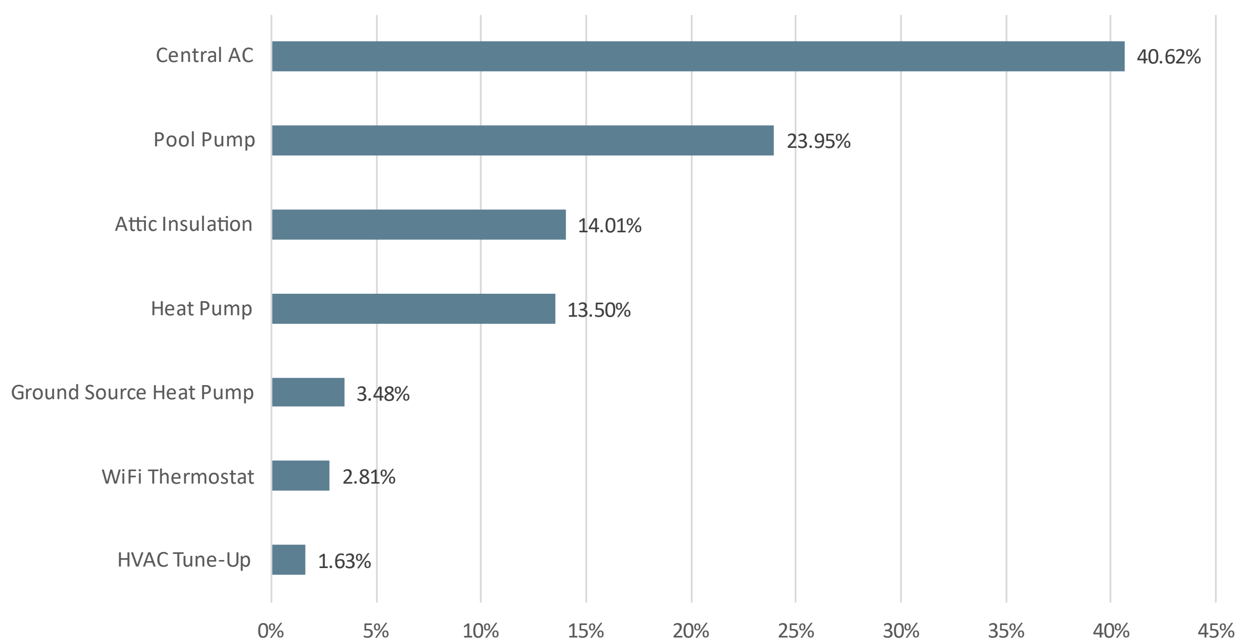
Variable Speed Drive Pool Pumps (Summer Only and Year-Round): This measure involves replacing a single-speed pool pump with a variable speed drive (VSD) pool pump in a residential pool. The realization rates for pool pumps were 100% for energy savings and 100% for demand savings.

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 96% for energy savings and 116% 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. Also, the average improvement of the EER (pre) to EER (post) is 112% even without having refrigerant added to each HVAC system in the program.

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 2022 Single Upgrade Program are detailed in Figure 3-6 below.

Figure 3-6: Single Upgrades – Percent of Gross Verified Energy Savings per Measure



3.1.1.4.9 Net-to-Gross (NTG) Estimation Results

Survey data from a total of 148 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. Although 19 survey respondents provided specific details of additional equipment/products they purchased in 2022, the savings were not considered spillover as their program influence score was not high enough to claim added savings in the NTG estimation. Therefore, there was 0% spillover for the Single Upgrade Program in 2022.

The average free ridership score was 16%. 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 86% for energy savings and demand savings. Based on the impact evaluation results, the total verified net energy savings for the Single Upgrade Program are 1,398,391 kWh, and the total verified net peak demand savings are 461.44 kW. A summary of Single Upgrade impact findings is shown in Table 3-26.

Table 3-26: 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
1,672,272	550.75	1,398,391	461.44	84%

3.1.1.5 Home Rebates Impact Evaluation Findings

The component programs of the Home Rebates are listed below with the verified gross energy and demand savings in Table 3-27.

Table 3-27: 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	1,687,074	586.02	1,681,609	571.83	33,632,170
Multiple Upgrades	2,722,752	1,653.98	2,696,780	1,388.99	50,455,413
Single Upgrade	1,672,852	565.40	1,672,272	550.75	27,041,724
Total	**6,082,678**	**2,805.40**	**6,050,661**	**2,511.57**	**111,129,307**

Table 3-28 and Table 3-29 summarize the verified net impacts of the complete Home Rebates Program.

Table 3-28: Verified Gross and Net Energy Savings

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Energy (kWh)	Net Verified Energy (kWh)
New Homes	21%	42%	121%	1,681,609	2,043,662
Multiple Upgrades	14%	0%	86%	2,696,780	2,316,671
Single Upgrade	16%	0%	84%	1,672,272	1,398,391
Total				**6,050,661**	**5,758,724**

Table 3-29: Verified Gross and Net Peak Demand Reduction

Program	Free Ridership	Participant Spillover	NTG Ratio	Gross Verified Demand (kW)	Net Verified Demand (kW)
New Homes	16%	45%	126%	571.83	739.04
Multiple Upgrades	14%	0%	86%	1,392.79	1,196.06
Single Upgrade	16%	0%	84%	550.75	461.44
Total				**2,515.37**	**2,396.54**

3.1.1.6 Process Evaluation Findings

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

3.1.1.6.1 New Homes

ADM conducted a facilitated discussion of the Home Rebates – New Homes Program with program and implementation staff in January 2022. The facilitated discussion involved a group discussion with key personnel responsible for discussing past program year recommendations and brainstorming implementation strategies. The discussion focused on 1) following up on main points from the program strengths, weaknesses, opportunities, and threats (SWOT) analysis discussion from PY2021, 2) following up on program recommendations from PY2021, 3) identifying data collection issues and program analysis needs for PY2022, and 4) answering any outstanding questions for PY2022.

The following summarizes key findings of the facilitated discussion of the Home Rebates – New Homes Program

- Program staff noted the decrease in builder attrition in PY2022. There was a decrease in new builder attrition in PY2022 compared to PY2021 due to saturation level with program budget and the existing predominate builders already participating in the program. In PY2021, the program was able to acquire the last large builder companies in the Oklahoma market, which was accomplished through the HERs raters.
- An aspect of the program that poses limitations to efficiency and participation is budget constraints. Program staff offered insight into budget issues that may limit program efficiency and participation. Due to the increase in volume of the number of homes being built to PSO efficiency standards in PY2021, the implementation team instated a new requirement into the program in PY2022 to help alleviate issues with the budget to pay out rebates to all homes built to PSO efficiency standards. For a home to qualify for a program rebate in PY2022, it had to be permitted in 2021 and built in 2022. This changed eligibility requirements and allowed for all homes built to PSO efficiency standards to be rebated in PY2022.
- External threats to the New Homes Program include national and statewide code changes and competition with gas rebates. According to program staff, current and future building code changes increase difficulty of meeting energy efficiency goals of the program. Oklahoma state home building codes do not require builders to utilize energy-efficient materials in their construction. Typically, the incentives do not cover the full cost for upgrading to energy efficient materials and items. However, more education about the importance of energy-efficiency could benefit the program and strengthen partnerships with the homebuilders who seem to struggle with their commitment to building energy-efficient homes year after year. Also, PSO has established connections with code officials to foresee what is happening with state building codes, which has allowed them to stay proactive with any changes. One code change that will affect the program is raising energy-

efficiency standards for lightbulbs starting in 2023. All inefficient lighting will be phased out so that LED lightbulbs will be the new baseline lighting equipment type. Another external threat to the program is competition with gas rebates from energy competitors which challenges the expansion of all-electric homes.

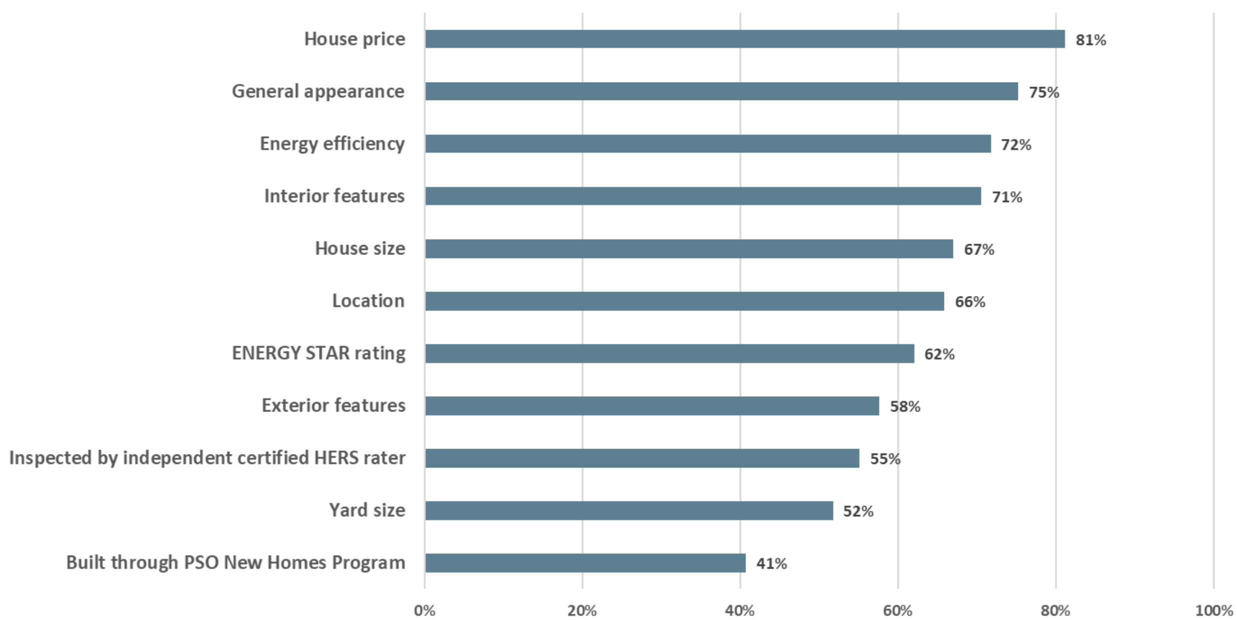
- PSO program staff provided details of customer engagement for the New Homes Program in PY2022. Even though customer engagement for the New Homes Program mainly focuses on builders, residential customers were targeted as part of the customer engagement campaign in PY2022. PSO noted that they included a flier marketing the New Homes Program in the Parade of Homes.

ADM conducted a home buyer survey of PSO customers who purchased an energy efficient home as part of the New Home Program in 2022. Home buyers were emailed to complete an online survey during December 2022 and offered a monetary incentive if they completed the questionnaire. ADM sent the online survey to a total of 523 home buyers, which resulted in 82 survey completes.

The majority of survey participants (88%) did not know about the PSO New Homes Program prior to being invited to take the survey. Those that did know about the program (n = 9) learned of it from the homebuilder (56%), PSO's website (11%), an email from PSO (11%), through an internet search (20%), or through some other method (11%).

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 that were rated as a "9" or "10", ranging from the most important factor to the least important factor as reported by survey respondents are shown in Figure 3-7.

Figure 3-7: Importance of Features for Purchasing a Home (n=85)

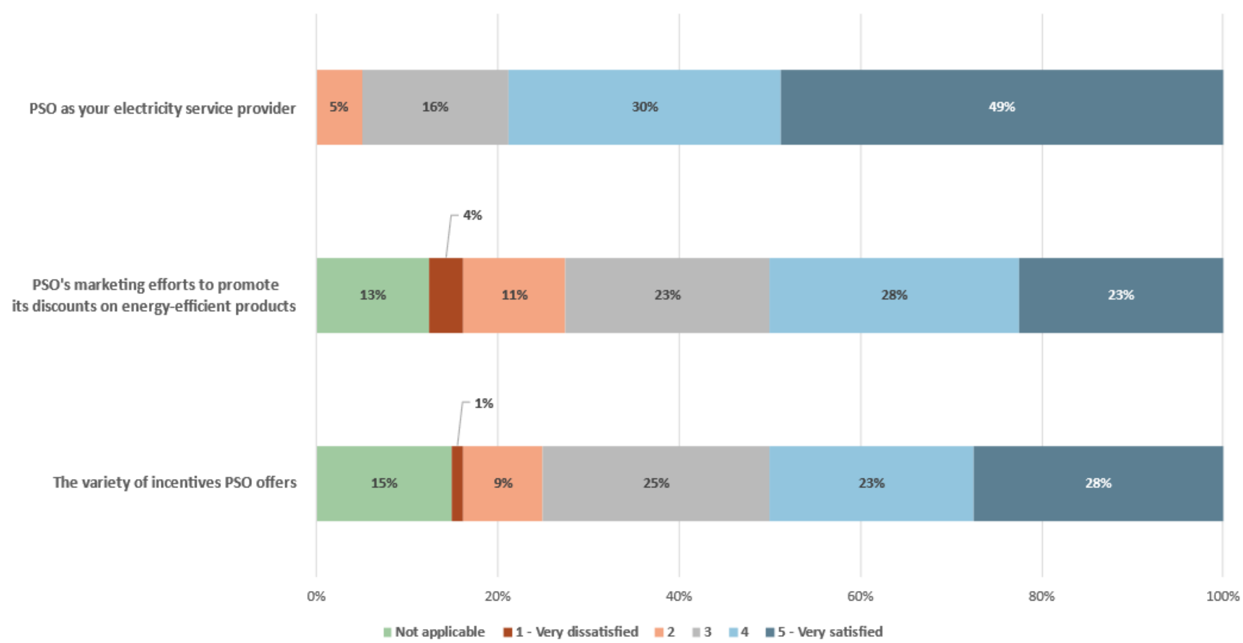


Survey participants provided feedback on how well informed they are about energy efficiency practices and energy-efficient options for their household. On a scale of 1 to 5, with 1 being "Not at all informed" and 5 being "Extremely informed", almost half of respondents (44%) reported they were informed, providing a rating of 4 or higher.

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. The majority of respondents reported being satisfied with aspects of PSO, rating the following statements as a 4 or higher:

- The variety of incentives PSO offers (50%)
- PSO's customer engagement efforts to promote its discounts on energy efficient products (50%)
- PSO overall as an electricity trade ally (79%)

Figure 3-8: Home Buyer PSO Satisfaction (n = 80)



ADM evaluators surveyed builders that participated in PSO's 2022 New Homes Program to gain insight into their experience with the program. Builders were emailed to complete an online survey during January 2023. Of the 17 builders ADM contacted, a total of 9 completed the survey.

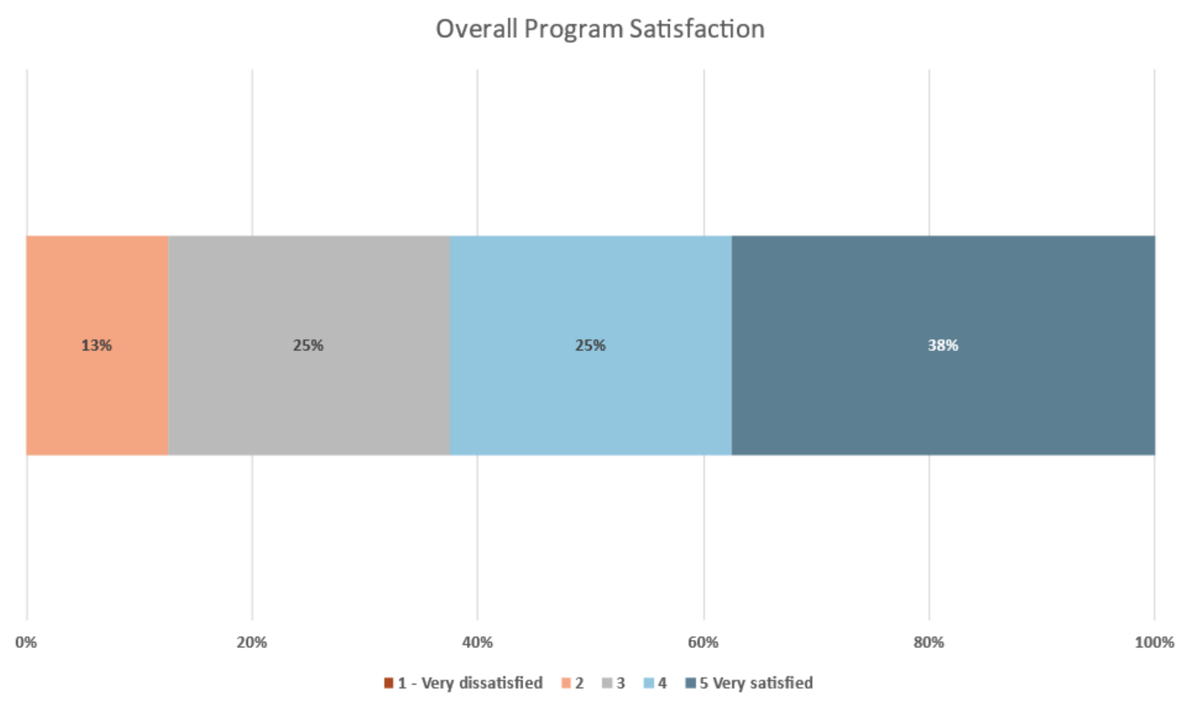
Builders were surveyed about program outreach in 2022. The main communication channel that PSO and ICF used to keep builder informed about the program is through email (63%). All the builders reported that PSO is a trustworthy source of information regarding energy-efficient building techniques/practices, rating it as 4 or higher on a scale of 1 to 5, where 1 means “Not at all trustworthy” and 5 means “Extremely trustworthy”. The majority of builders (63%) reported that the program outreach to builders has been effective, rating it as 4 or higher on a scale of 1 to 5, where 1 means “Not at all effective” and 5 means “Very effective”. For the 25% of builders who gave a rating of 3 did not provide feedback on what could be done to make program outreach to builders more effective.

Of program-incented homes, 38% of builders reported either some or all their customers already knew they wanted a home built to the PSO program standards prior to purchasing one. Nearly half of the builders (38%) indicated they actively encourage home buyers who were not looking for energy-efficient homes to buy a home built to PSO’s energy efficiency standards. Builders encourage home buyers to purchase homes built to PSO efficiency standards by explaining the energy-efficient features of the home, as well as the money they can save on their utility bills. Builders reported being able to convince all of their customers (100%) to build to PSO program standards. Builders also noted that printed materials, such as pamphlets and newsletters (33%) seem to work best when engaging with customers. The biggest challenge for customer engagement of energy-efficient homes as reported by builders is the price of the homes (88%). One builder noted that customer engagement materials can be improved by making educational materials to educate buyers more available.

Builders reported that the most important aspects home buyers consider when purchasing a home are a home’s price and the home being above code performance, general appearance, interior features, and house size. Home buyers also find utility bills/cost of maintaining the home, general appearance, interior features, and house size important when purchasing a home.

Builders that completed the survey were satisfied with the program. Overall program satisfaction was positive, with the majority of builders (63%) giving a rating of 4 or higher on a scale of 1 to 5 where 1 is “Very dissatisfied” and 5 is “Very satisfied”. Builder satisfaction with the program overall is shown in Figure 3-9.

Figure 3-9: Builder Overall Satisfaction with the New Homes Program (n = 8)



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

- Additional program requirements were implemented due to program budget constraints. Due to the increase in volume of the number of homes being built to PSO efficiency standards in PY2021, the implemented instated a new requirement into the program in PY2022 to help alleviate issues with the budget in order to pay out rebates to all homes built to PSO efficiency standards. For a home to qualify for a program rebate in PY2022, it had to be permitted in 2021[26] and built in 2022. This changed edibility requirements and allowed for all homes built to PSO efficiency standards to be rebated in PY2022.
- Attrition rate among builders and the number of rebated homes as part of the New Homes Program decreased PY2022. There was a decrease in new builder attrition in PY2022 compared to PY2021 due to saturation level with program budget and the existing predominate builders already participating in the program. PSO was able to reach the saturation threshold for acquiring builders into the program. There was also a decrease in the overall number of homes that were rebated through the program in PY2022. This is due to external factors, including the increased number of homes that were built in 2021, supply chain issues for building materials, and

[26] All permits must have been received by end of December 2021, but ICF staff noted they received so many applications that the permit date ended up being cut off in October 2021.

an increase in federal interest rates. Also, the change in program requirements implemented in PY2022 decreased the number of homes rebated through the program.

3.1.1.6.2 Single and Multiple Upgrades

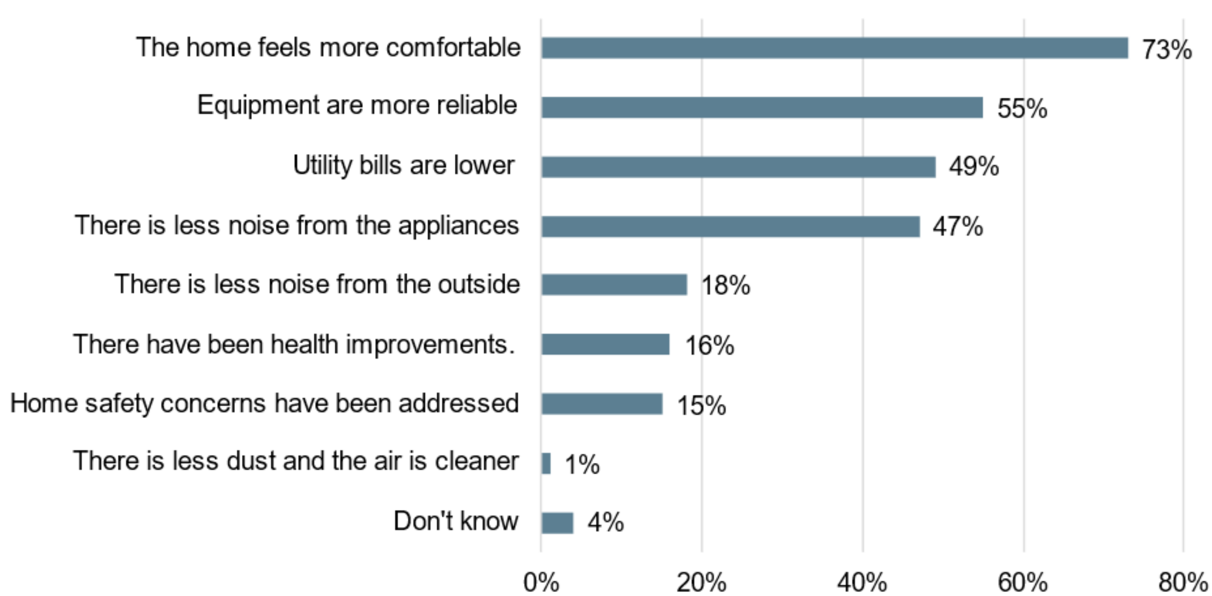
Multiple Upgrades

ADM conducted a participant survey of PSO customers who participated in the Multiple Upgrades Program in 2022. Participants were contacted via email in November and December 2022 to complete a survey 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 636 participants, which resulted in 73 survey completes. The survey assessed program awareness, experience with the program, satisfaction with PSO and the program, home characteristics, and demographics.

Multiple Upgrades participants provided feedback about how they first learned about the rebates that PSO offers for energy-saving upgrades to their home. Most participants (75%) learned about the rebates from a contractor. Other sources of awareness included PSO's website (14%), bill inserts (3%) and PSO's monthly newsletter (3%).

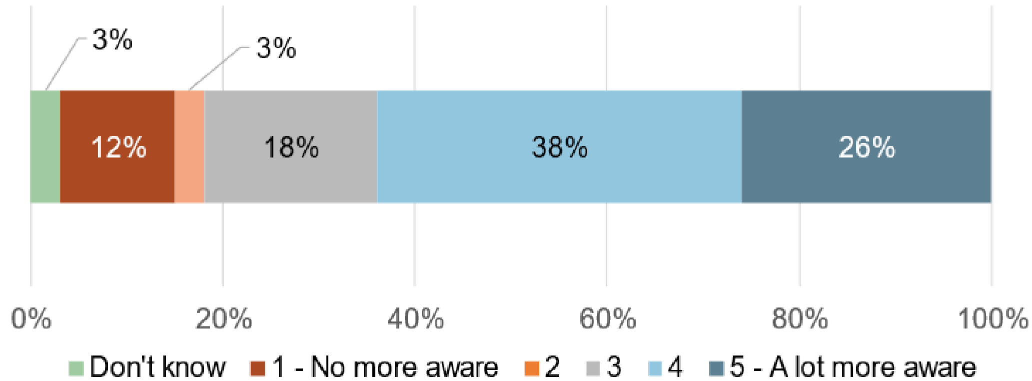
Participants provided feedback about their experience with the program and the efficiency improvements they made. Respondents reported improved home comfort (73%), higher reliability of heating and cooling appliances (61%), lower utility bills (55%) and reduced noise from appliances (47%) as the most perceived benefits from their energy saving upgrades. For all other responses, refer to Figure 3-10.

Figure 3-10: Benefits of Energy Saving Upgrade Improvements (n = 73)



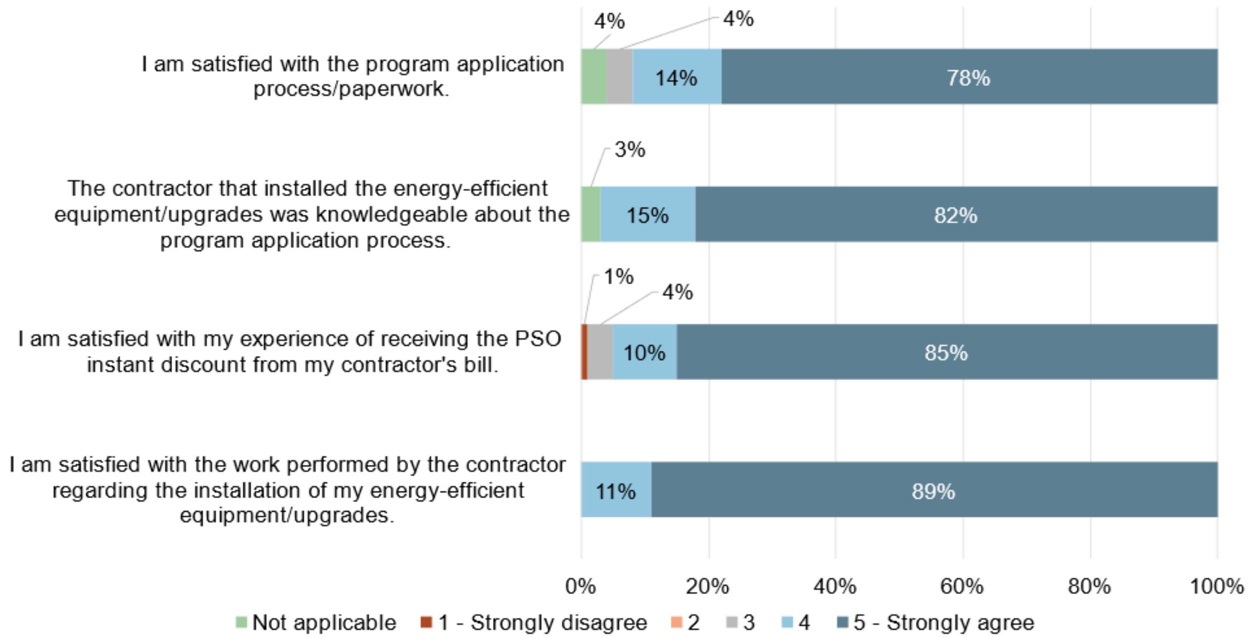
Respondents were asked if having the improvements made them more aware of the advantages of energy efficiency and most respondents reported increased awareness. Most respondents said they were more aware of the advantages of energy efficiency (see Figure 3-11.

Figure 3-11: Awareness of Energy Efficiency After Upgrade (n = 73)



Ninety-five percent of respondents indicated they were satisfied with their experience with the program overall. Moreover, the majority of respondents agreed that they were satisfied with the application process and the quality of their contractor's work. None of the survey respondents reported dissatisfaction with the energy saving upgrades made to their homes through the program. Figure 3-12 displays respondents' level of agreement with various statements about their program experience. Respondents that rated any aspect of their experience as less than satisfactory (3 or less on a 5-point scale) were given an opportunity to write in comments or provide an explanation of their ratings. One percent of respondents indicated they had not yet received their rebate.

Figure 3-12: Multiple Upgrades Program Satisfaction (n = 73)



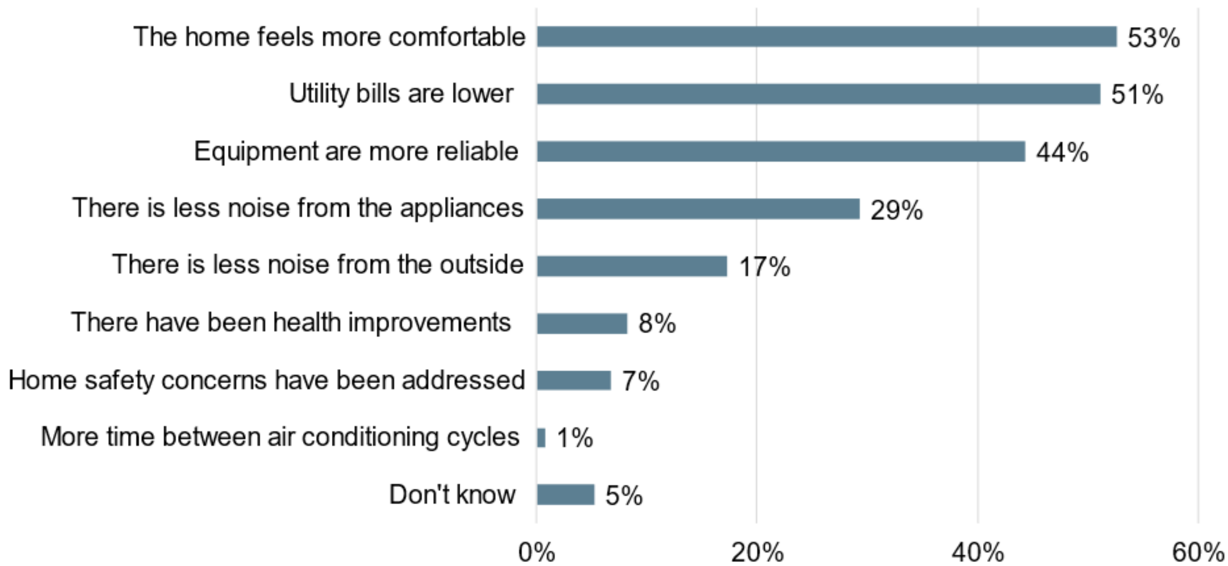
Single Upgrades

ADM conducted a participant survey of PSO customers who participated in the Single Upgrade Program in 2022. Participants were contacted via email in November and December 2022 to complete a survey 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 974 participants, which resulted in 133 survey completes. The survey assessed program awareness, experience with the program, satisfaction with PSO and the program, home characteristics, and demographics.

Single Upgrade participants provided feedback about how they first learned about the rebates that PSO offers for energy-saving upgrades to their home. Most respondents (71%) learned about the rebates from a contractor. Other sources of awareness included PSO's website (13%), bill inserts (3%) and word of mouth (2%).

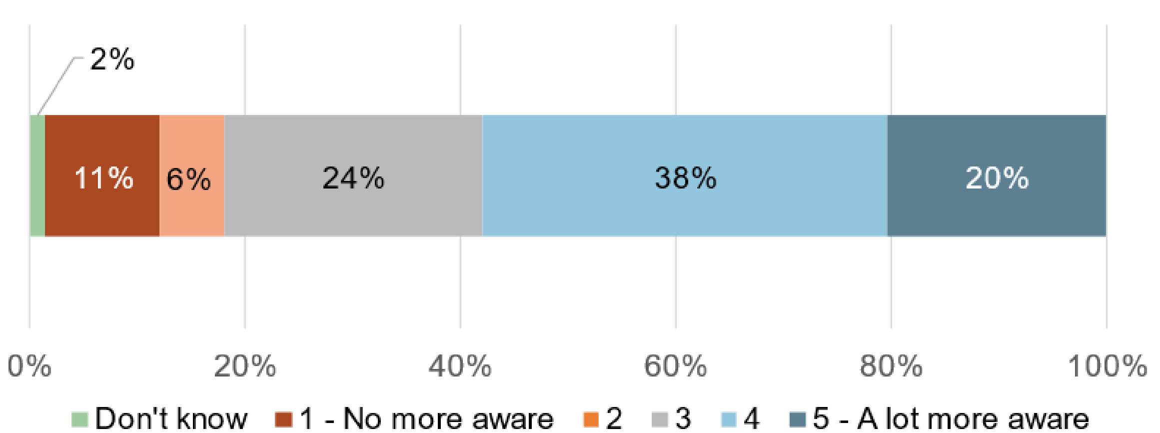
Participants provided feedback about their experience with the program and the efficiency improvements they made. Respondents reported improved home comfort (53%), lower utility bills (51%), and higher reliability of heating and cooling appliances (44%) as the most perceived benefits from their energy saving upgrades. For all other responses, refer to Figure 3-13.

Figure 3-13: Benefits of Energy Saving Upgrade Improvements (n = 133)



ADM asked respondents if having the improvements made them more aware of the advantages of energy efficiency and most respondents reported increased awareness. Most respondents said they were more aware of the advantages of energy efficiency. (Figure 3-14).

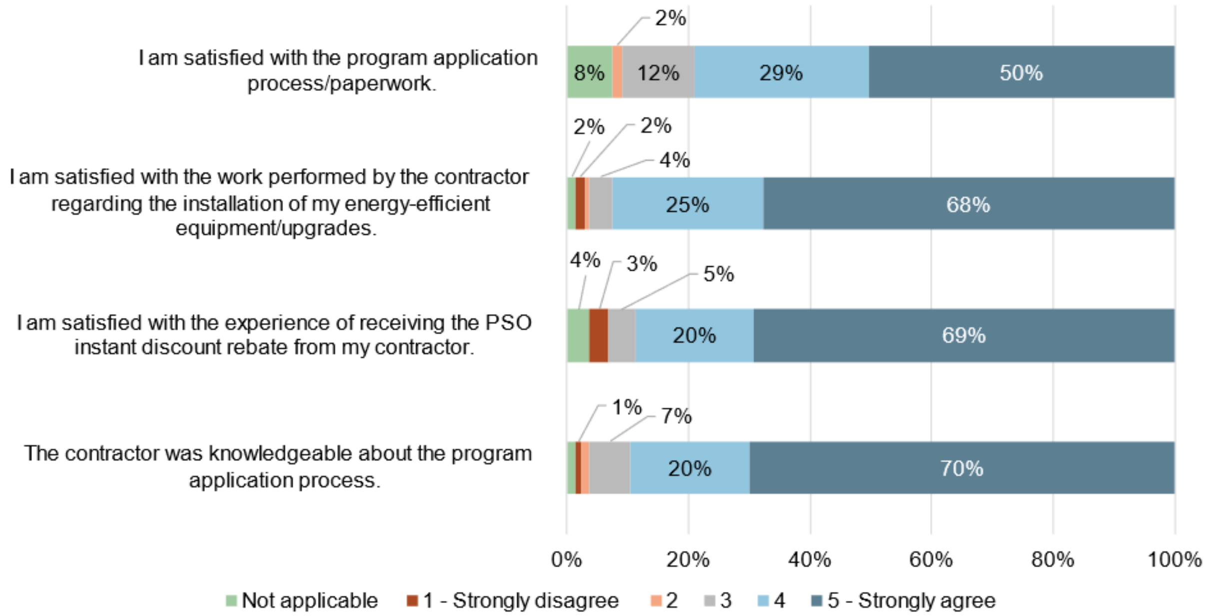
Figure 3-14: Awareness of Energy Efficiency After Upgrade (n = 133)



Participants provided feedback about their satisfaction with program staff, the contractor who installed the upgrades, and their satisfaction with the Single Upgrade Program overall. Ten percent of respondents reported interacting with program staff as part of receiving the rebate through the program. All these respondents (n = 13) reported being somewhat or very satisfied with their interactions with program staff. Eighty-five percent of respondents indicated they were satisfied with their experience with the program overall. Moreover, the majority of respondents agreed that they were satisfied with the application process and the quality of their contractor's work.

Figure 3-15 shows respondents' level of agreement with various statements about their program experience.

Figure 3-15: Single Upgrade Program Satisfaction (n = 133)



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

- Participant satisfaction remains high for the Multiple Upgrades Program. Most survey respondents were satisfied with the upgrades that were installed as part of the program, their contractor and quality of work done on their home, the TPV, the program overall, and PSO as their electric utility.
- Program focusing on educating customers and service providers about the benefits of heat pumps. PSO plans on performing extensive education to customers and trade allies about the benefits of heat pumps (air source and ground source). This includes expanding the level of customer engagement for heat pumps to residential customers. A webinar was conducted for trade allies in PY2022, which provided educational information regarding heat pumps offered through the program.

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

- Participant satisfaction is high, though some customers noted issues. Most survey respondents were satisfied with the program overall, the measures they received, as well as with PSO as their service provider. A small portion of respondents voiced dissatisfaction with some aspects of their experience. This includes not receiving their rebate or difficulties with receiving their rebate and challenges in communication with the contractor. These issues could indicate an opportunity to improve customer understanding of the participation process through communication with the contractor.

- There is less trade ally participation for the Single Upgrade Program than desired. PSO is looking to improve program customer engagement to increase regional diversity. Additional customer engagement material is needed (specifically for the rural areas outside of Tulsa) to expand the awareness of the program to potential trade allies, which helps increase customers participation.
- Incentives decreased for HVAC tune-ups offered through the program and new incentivized measures were added to the program in PY2022. The rebate amount for HVAC tune-ups decreased from up to $150 to up to $75 for qualifying customers. Rebates for ENERGY STAR® Programmable Wi-Fi thermostats were added to the Single Upgrade Program to accommodate current market need.

3.1.1.7 Conclusions and Recommendations

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

- Continue improving relationships with larger building companies. Program staff outline one of the main goals of the program is to continue to build relationships with large building companies. In 2021, PSO was able to work with a building company that completes a large number of homes in the Oklahoma area. Program staff noted that they continue to build a relationship with this builder by offering them free HERs raters in PY2022. PSO will subsidize HERs raters across builders to ensure customers are not left out of the program.
- Consider developing a campaign to educate the public on homes built to PSO's energy-efficiency standards and the benefits of owning one of these homes. PSO could consider ways to better market the benefits of a home built to PSO's energy-efficiency standards to both residential customers and builders. The New Homes Program is marketed towards builders, who then market the homes they build to potential home buyers. As reported by the home buyers and builders survey respondents, most residential customers did not know about the program prior to purchasing their home. If residential customers had more information about homes built to PSO's energy-efficiency standards, they may be more inclined to purchase one of these homes. Program staff could work with staff for other programs (e.g., Power Hours, Single Upgrade, etc.) to further explain how energy-efficient homes can help save money on monthly utility bills and provide long term return on investment. PSO should consider exploring how to better incorporate non-energy benefits (e.g., carbon efficiency, environmental benefits, comfort) into

customer engagement of the program to promote them to both builders and home buyers.

- Consider recent federal changes to baseline conditions that will impact the program. Efficiency requirements for lighting and HVAC systems will have an impact on the energy savings generated by the program. These changes should be considered in program delivery.

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

- Consider surveying customers that do not complete a test-out assessment in order to qualify for a rebate as part of the Multiple Upgrades Program. In order to help better understand a customer’s decision to not have a test-out assessment performed as part of the process of having energy-efficient equipment installed though a program service provider, an online survey may provide PSO with additional information. With this additional information, PSO can implement different processes in order to help overcome customer hesitancy in the test-out process. If more test-out assessments can be completed, then this will increase the overall participation in the Multiple Upgrades Program, as well as allow service providers to receive rebates for those customers.

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

- Consider program staff having additional communication with program participants. Many customers expressed a lack of understanding about the rebate process. Communication with program staff was rated highly by customers, so having program staff reach out to a select number of customers periodically may increase customers’ knowledge and understanding of the program process, including the rebate process. It will also reassure customers that their needs are being met. Additional hand-out material for trade allies to provide to customers may also be beneficial.
- Continue expanding customer engagement for the program with additional focus on underserved areas. Most customers learn of the program through their trade allies as opposed to knowing about the program before they make an appointment to upgrade their equipment. Additional customer engagement can persuade customers to consciously make appointments to upgrade their equipment. Customer engagement material can also be used by the trade allies to better explain the benefits of the qualifying higher-efficiency measures that they may be recommending to customers. This includes additional customer engagement and educational materials about the benefits of energy-efficient heat pumps to both trade allies and residential customers.

3.1.2 Energy Saving Products Program

This chapter presents the findings from the impact and process evaluation of the 2022 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 financial incentives for purchasing products that meet high efficiency standards.

For PY2022, 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, water dispensers, 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 light bulbs, room air purifiers, and smart thermostats. In addition, the program included the distribution of free LEDs in partnership with food banks and local food pantries within the PSO service territory. Free and discounted LEDs distributed through local food pantries, and the LTO program made up approximately 30% of the reported energy savings for the PY2022 ESP program.

In PY2022 the ESP 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 4% of the non-lighting 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 40,960 packages of LEDs and 253,824 individual bulbs were distributed through the LTO program or in partnership with local food pantries. The total number of all other verified upstream measures purchased through the ESP program was 89,220, while the total number of verified measures rebated through the downstream portion of the program was 1,387. Overall, the ESP program supported the purchase of over 340,000 energy efficient measures during PY2022.

Table 3-30 provides a summary of program metrics for the 2022 program year.

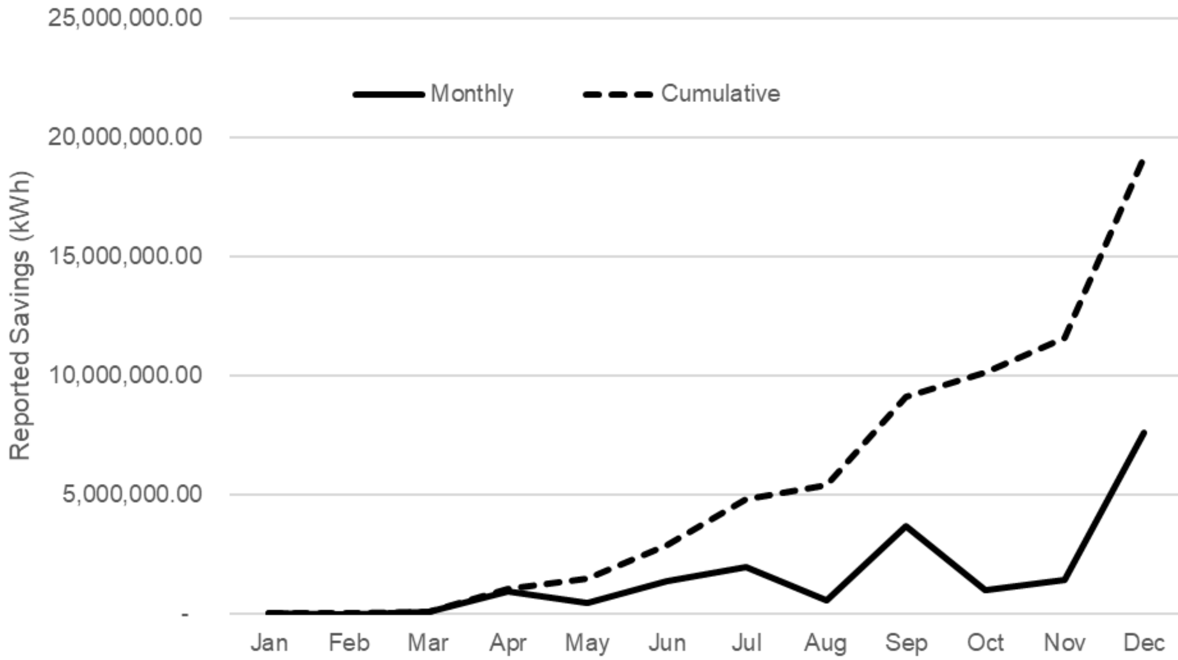
Table 3-30: Performance Metrics – Energy Saving Products Program

Metric	PY2022
Number of Known Participants[27]	1,352
Budgeted Expenditures	$1,778,453
Actual Expenditures	$1,339,375
Energy Impacts (kWh)	
Projected Energy Savings	8,598,502
Reported Energy Savings	19,151,711
Gross Verified Energy Savings	19,446,612
Net Verified Energy Savings	16,620,804
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	1,394.81
Reported Peak Demand Savings	4,197.81
Gross Verified Peak Demand Savings	3,878.61
Net Verified Peak Demand Savings	2,771.25
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.46
Utility Cost Test Ratio	5.03

Participation in the ESP program was mostly consistent throughout the 2022 program period. Figure 3-16 shows the reported daily kWh savings and the cumulative reported kWh savings throughout the 2022 program year.

[27] 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.

Figure 3-16: ESP Accumulation of Reported Savings During the 2022 Program Year



3.1.2.2 Impact Evaluation Methodologies

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

3.1.2.2.1 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
- 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, one survey of upstream rebate participants, and interviews with program staff members. The Limited Time Offer survey was administered in two waves, one in the summer of 2022 (July) and a second during the fall of 2022 (October). The final sample size for each primary data collection activity is presented in Table 3-31 below.

Table 3-31: ESP Data Collection Activities

Data Collection Activities		N
General Population Survey		178
Downstream Rebate Participant Survey	Appliance Survey	164
	Electric Vehicle Level 2 Charger Survey	12

Three surveys were conducted as part of the evaluation: an LTO survey and two downstream rebate participant surveys. All three survey efforts were conducted online through emailed invitations. 315 LTO participants qualified for the survey and completed it fully. For a disaggregation of qualifying survey responses by measure, see Table 3-32. The survey collected data on program awareness and insights into energy-saving product purchases for lighting and non-lighting measures in addition to data regarding measure satisfaction and household demographics.

Table 3-32: ESP Measures Bought During 2022

Measure	Number of Eligible Respondents
LED Light Bulbs	552
Energy Saving Advanced Power Strips	127
ENERGY STAR® Room Air Purifiers	50
ENERGY STAR® Wi-Fi Thermostats	68

Note: the number of eligible responses column does not sum to 315 (the number of surveys completed) since surveyed customers could have purchased more than 1 discounted measure.

Customers that had received rebates for heat pump water heaters, clothes dryers, clothes washers, Wi-Fi Thermostats, and electric vehicle chargers through the PSO ESP program were invited to participate in online surveys. Screening questions were asked to assess customer program awareness. Table 3-33 breaks down what types of appliances the survey respondents purchased.

Table 3-33: ESP Rebated Measure Participants Contacted vs. Survey Responses

Rebated Equipment	Percent of Survey Respondents (n = 152)
ENERGY STAR® Clothes Washer	21%
ENERGY STAR® Clothes Dryer	6%
ENERGY STAR® Wi-Fi Thermostat	55%
ENERGY STAR® Heat Pump Water Heater	2%
ENERGY STAR® Clothes Washer and Dryer	12%
ENERGY STAR® clothes washer and Wi-Fi thermostat	1%
ENERGY STAR® clothes washer, dryer, and Wi-Fi thermostat	3%

Note: Percentage may exceed 100% due to rounding

To inform the process evaluation, ADM also conducted an in-depth interview with program staff at PSO and the implementation contractor. This interview provided insight into various aspects of the program and its organization, but also focused on changes to the program that occurred during 2022. Interviewees also discussed aspects of the program operations that they considered to be successful as well as the challenges faced over the course of the program year. These results, along with program feedback collected via the participant surveys, have been consolidated in a separate memo, the “2022 Process Evaluation Memo”.

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, and the Oklahoma Deemed Savings Document (OKDSD). Inputs to savings algorithms as well as in-service rates were determined through self-claimed survey responses. Further details on each measures energy savings methodology can be found in Appendix G.

3.1.2.2.3 Net-to-Gross (NTG) Estimation Methodology

Free ridership and spillover were determined for each program delivery mechanism. Participant survey responses were used to determine free ridership and spillover for downstream measures and LTO offerings. The 2021 General Population survey was used to determine NTG for measures with retail discounts. A NTG of 100% was applied to measures distributed through Foodbanks. Detailed explanations of the NTG methodologies can be found in Appendix G.

3.1.2.3 Process Evaluation Methodology

ADM evaluators completed a process evaluation to assess the Energy Saving Products (ESP) Program. The evaluators assessed program design, operations, and delivery through a logic model 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? Are there data tracking and/or communication efficiencies that can be gained?
- 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 do the incentive levels or discount amounts for Level 2 electric vehicle chargers, weatherization measures, bathroom ventilation fans, water dispensers, air filters, and room air conditioners compare to those offered by other utilities and the measure costs?
- How satisfied are customers with the variety of incentives? Are customers satisfied with the quality of measures available through the ESP program (both downstream and upstream)?
- 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?

Table 3-34:ESP 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.
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.

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 compiled by the implementor and provided through AEG for the ESP program lighting component identified a total of 11,248 packages of LEDs were discounted through the LTO program. An additional 29,712 packages of LEDs were distributed free-of-charge through local food banks Table 3-35 shows the reported quantities and impacts of measures discounted or distributed free-of-charge through the ESP program during PY2022.

Table 3-35: ESP Reported Measure Quantities and Impacts – Lighting Only

Distribution Type	Measure Type	Package Quantity	Bulb Quantity	Reported kWh	Reported kW
LTO	Candelabra LED - 5W	1,372	16,464	429,735	69.87
	Globe LED – 5W	2,446	29,352	764,368	124.28
	Reflector LED – 15W	7,430	89,160	2,541,604	413.23
Food Bank	A19 LED - 8.5W or 9W	16,704	66,816	538,148	87.50
	Candelabra LED - 4W	13,008	52,032	1,377,515	223.97
Totals		**40,960**	**253,824**	**5,651,371**	**918.84**

Verification

ADM reviewed the program tracking database to determine if energy and demand impacts were correctly calculated according to the Oklahoma Deemed Savings Document algorithms for each LED type. For PY2022, ADM calculated verified energy and demand impacts based on OKDSD but used 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. Each program eligible bulb was checked to determine the correct bulb wattage and ensure the correct lumen output and baseline wattage was applied. The discrepancies identified through the database review required adjustment for the actual wattages and/or baseline wattages used in the calculation of energy and demand impacts for some bulbs.

Table 3-36 provides the estimated impact each of these adjustments had over reported annual energy savings (kWh). ADM identified 6 LED models in the program tracking data that significantly differed[28] from the calculated savings. Many of these differences are due to parameters such as wattage, baseline wattage, or lumens being reported differently from the verified values in the ENERGY STAR® database. There are also many instances of omnidirectional bulbs that use Tier 2 baseline wattages for the savings calculations instead of Tier 1.

Table 3-36: ESP Gross kWh Savings Adjustments – Lighting Only

Model Number	Lamp Category	Watts		Lumens		Baseline Watts	
		Reported	Verified	Reported	Verified	Reported	Verified
2365763	omnidirectional	9.2	9	800	800	20	43
2284584	specialty	5	5	300	350	40	40
2363177	specialty	8	8	650	670	40	40
2284584	specialty	5.5	5	350	350	40	40
2311173	specialty	9.5	10	750	750	60	60
2363177	specialty	10	8	650	670	40	40

In-Service Rate Adjustments

Service rates were calculated by bulb type for the LTO delivery based on survey responses. ISR's ranged from 67% to 71%. ISR for the foodbank offering was set at 100% due to the difficulties in collecting participant information. For the LTO offering, these ISR's were applied to the first year annual energy savings. For the remaining lifetime savings an ISR of 97% will be applied, as it was assumed that 97% of the bulbs are installed within three years based on the stipulations in the deemed savings document.

Final Verified Gross Savings Estimates

The realization rate factors impacting lighting measures included baseline and efficient bulb wattage differences, annual hours of use, and the application of ISR's. The application of higher hours of use outweighed the reduction in savings due to the application of ISR's. Table 3-37 compares reported and verified impact estimates for this program component following verification.

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

Table 3-37: ESP Program Impact Findings – Initial Gross Verified Lighting Savings Only

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
LTO	Candelabra LED - 5W	16,464	429,735	355,440	69.87	48.18
	Globe LED – 5W	29,352	764,368	673,633	124.28	91.31
	Reflector LED – 15W	89,160	2,541,604	2,129,600	413.23	288.66
Food bank	A19 LED - 8.5W or 9W	66,816	2,094,970	2,094,970	87.50	283.97
	Candelabra LED - 4W	52,032	1,703,402	1,703,402	223.97	230.89
Total		**253,824**	**5,651,371**	**6,957,044**	**918.84**	**943.01**

Air Filter Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 16,242 qualifying air filters were sold at participating retail stores during the 2022 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 452 air filters were assigned incorrect efficient full load cooling hours (EFLHc) which resulted in differences between reported and verified kWh savings. ADM assigned EFLHc based on reported zip codes. These differences can be found in Table 3-38.

Table 3-38: ESP Air Filter EFLHc Discrepancies

Zip Code	Reported EFLHc	Verified EFLHc	Verified Weather Zone
74133	1305	1486	8b
74132	1681	1486	8b
74019	1681	1305	9
74055	1681	1486	8b

Final Verified Gross Savings Estimates

Verified gross savings included the application of an ISR. An ISR was sourced from ADM's 2021 general population survey (82%). Table 3-39 compares reported and verified impact estimates for air filters rebated through the program in 2022.

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	16,242	838,058	685,481	2,948.29	2,412.24

Advanced Power Strip Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 4,323 qualifying advanced power strips (APS) were sold at participating retail stores during the 2022 program year. An additional 1,217 were provided through the LTO program.

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 Advanced Power strips were assigned the correct kWh and kW savings in the program tracking data.

Final Verified Gross Savings Estimates

Table 3-40 compares reported and verified impact estimates for APS discounted through the program in 2022. ADM found no discrepancies between the reported and verified savings calculations. Results from the LTO survey indicated an ISR of 95%. This is ISR was applied to both the LTO offering and the upstream offering.

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	4,323	361,835	342,218	41.07	38.84
LTO	APS	1,217	101,863	96,340	11.56	10.93
Total		**5,540**	**463,698**	**438,558**	**52.63**	**49.78**

Bathroom Ventilating Fan Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 563 qualifying bathroom ventilation fans (BVF) were sold at participating retail stores during the 2022 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 that one BVF model was assigned incorrect cubic feet per minute (CFM) value in the tracking data (shown in Table 3-41).

Table 3-41: ESP Bathroom Ventilating Fans CFM Discrepancies

Model Number	Number in Program	Reported CFM	Verified CFM	Reported kWh	Verified kWh
FV-0811RF1	22	150	110	33.7	24.7

Final Verified Gross Savings Estimates

Table 3-42 compares reported and verified impact estimates for BVF rebated through the program in 2022. An ISR of 100% was applied to the measure as survey data was insufficient.

Table 3-42: ESP Program Impact Findings – Bathroom Ventilating Fans

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	BVF	563	15,739	15,541	1.95	1.93

Clothes Dryer Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 243 clothes dryers (CD) were rebated during the 2022 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 10 clothes dryers in the program tracking data using the ENERGYSTAR® ID's. Two of the clothes dryer ENERGYSTAR® ID's were identified as clothes washers, four ID's were identified as refrigerators, one ID did not produce any results, and three ID's were missing from the program tracking data. Therefore 10 clothes dryers discounted through the program were not eligible to receive energy efficiency savings; as a result, no verified kWh savings and kW reduction were attributed to these measures.

All the verified models in the reported tracking data were standard electric vented clothes dryers, resulting in a CEF baseline of 3.11 following the guidance of the AR TRM. The reported CEF baseline was 2.73, which resulted in higher kWh and kW savings (shown in Table 3-43).

Table 3-43: ESP Clothes Dryers Savings Discrepancies

Reported CEF baseline	Verified CEF baseline	Reported kWh	Verified kWh
2.73	3.11	246.6497	160.4368

Final Verified Gross Savings Estimates

Table 3-44 compares reported and verified impact estimates for clothes dryers rebated through the program in 2022.

Table 3-44: ESP Program Impact Findings – Clothes Dryers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CD	233	57,973	37,300	5.95	3.82

Clothes Washer Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 395 clothes washers (CWs) were rebated during the 2022 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 66 clothes washers discounted through the program were not eligible to receive energy efficiency savings[29]; as a result, no verified kWh savings and no kW reduction were attributed to these models.

Final Verified Gross Savings Estimates

Table 3-45 compares reported and verified impact estimates for clothes washers rebated through the program in 2022.

Table 3-45: ESP Program Impact Findings – Clothes Washers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	CWs	329	37,617	37,141	8.92	8.81

Electric Vehicle Charger Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 43 qualifying electric vehicle chargers (EVC) were rebated through the program during the program year. Of these, 1 EVC were installed to support the charging of 2 electric vehicles.

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 but one EV Chargers were assigned the correct

[29] 63 CW's reported having existing front load type to top load efficiency, one CW was not ENERGYSTAR® certified, one CW didn't have model or ENERGYSTAR® ID, and one CW ENERGYSTAR® ID resulted in a refrigerator.

kWh and kW savings. One EV Charger in the reported tracking data did not have an ENERGYSTAR® ID, as a result, no savings were attributed to this measure.

A review of available electric vehicles in 2021 and 2022 indicated an increase is average efficiency from 32 MPGe (kWh/100 miles) to 36 MPGe. Using 36 MPGe resulted in an increase in energy savings.

Final Verified Gross Savings Estimates

Table 3-46 compares reported and verified impact estimates for EV Chargers rebated through the program in 202 2022. Combined survey results from 2020 – 2022 were used to determine an ISR of 83%

Table 3-46: ESP Program Impact Findings – Electric Vehicle Chargers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	EVC	42	11,213	10,168	N/A	N/A

Heat Pump Water Heater Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 13 heat pump water heaters (HPWHs) were rebated during the 2022 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 1 HPWH discounted through the program was not eligible to receive energy efficiency savings[30]; as a result, no verified kWh savings and no kW reduction were attributed to this model. In addition, reported parameters did not match the verified parameters, including tank storage volume, efficient uniform energy factor (UEF), and ambient temperature. As a result, reported and verified kWh and kW savings do not match.

Final Verified Gross Savings Estimates

Table 3-47 compares reported and verified impact estimates for HPWHs rebated through the program in 2022.

[30] One HPWH did not have an ENERGYSTAR® ID.

Table 3-47: ESP Program Impact Findings – Heat Pump Water Heaters

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	HPWH	12	36,539	43,577	3.20	3.82

Room Air Conditioner Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 2,063 qualifying room air conditioners (RAC) were sold at participating retail stores during the 2022 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 EFLHc and energy efficiency ratio (EER) did not match the verified parameters. ADM followed guidance from the AR TRM v8.1 to estimate kWh and kW savings.

Final Verified Gross Savings Estimates

The 2021 general population survey indicated an ISR of 100%. Table 3-48 compares reported and verified impact estimates for Room Air Conditioners rebated through the program in 2022.

Table 3-48: ESP Program Impact Findings – Room Air Conditioners

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RAC	2,063	51,767	72,841	61.26	128.04

Room Air Purifier Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 1,953 room air purifiers (RAP) were sold at participating retail stores and provided through the LTO program during the 2022 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 and provided through the LTO program. This review found that all air purifiers were assigned the correct kWh and kW savings in the program tracking data.

Final Verified Gross Savings Estimates

Table 3-49 compares reported and verified impact estimates for RAP rebated through the program in 2022.

Table 3-49: ESP Program Impact Findings – Room Air Purifiers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	RAP	516	275,402	275,399	31.60	31.60
LTO	RAP	1,437	788,927	788,927	90.51	90.51
Total		**1,953**	**1,064,328**	**1,064,325**	**122.11**	**122.11**

Smart Thermostats Gross Energy Savings and Peak Demand Impact

ADM's review of program tracking data identified that a total of 4,171 Wi-Fi Thermostats were sold at participating retail stores and provided through the LTO program during the 2022 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 retailers and provided through the LTO program. ADM followed the AR TRM v8.1 to estimate kWh savings.

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 90% and through the downstream rebate offering was 97%.

Final Verified Gross Savings Estimates

Table 3-50 compares the total reported and verified impact estimates for this program component.

Table 3-50: ESP Program Impact Findings – Smart Thermostats

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Downstream Rebates	Wi-Fi Thermostat	693	397,740	444,825	N/A	N/A
LTO	Wi-Fi Thermostat	3,478	2,542,307	2,280,005	N/A	N/A
Total		**4,171**	**2,940,047**	**2,724,830**	**N/A**	**N/A**

Water Dispenser Gross Energy Savings and Peak Demand Impacts

ADM's review of program tracking data identified that a total of 45 qualifying water dispensers (WD) were sold at participating retail stores during the 2022 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 WD sold through the program. This review found that all WD were assigned the correct kWh and kW savings.

Final Verified Gross Savings Estimates

Table 3-51 compares reported and verified impact estimates for WD rebated through the program in 2022.

Table 3-51: ESP Program Impact Findings – Water Dispensers

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	WD	45	33,014	33,014	3.69	3.69

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 9,163 door seals and sweeps, and 50,173 cans of spray foam were sold at participating retail stores during the 2022 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 kWh and kW savings. Results from the 2021 general population survey indicated that door seals and sweep as well as spray foam combined resulted in an ISR of 92%.

Final Verified Gross Savings Estimates

Table 3-52 compares reported and verified impact estimates for WMs rebated through the program in 2022.

Table 3-52: ESP Program Impact Findings – Weatherization Measures

Distribution	Measure	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW
Retail Discounts	Door Seals and Sweeps	9,163	353,811	326,061	3.16	2.91
Retail Discounts	Spray Foam	50,173	7,596,536	7,000,729	67.81	62.49
Total		**59,336**	**7,950,347**	**7,326,790**	**70.97**	**65.40**

Summary of Impact Evaluation Findings

Gross savings are determined through an engineering review of the measure level savings calculations with an In-Service Rate (ISR) applied. Results are shown in Table 3-53. Table 3-54 provides a detailed summary of ADM's impact evaluation findings for all measures included in the ESP program in 2022.

Table 3-53: 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	361,835	41.07	0.946	342,218	38.84
	Air Filter	837,811	2,948.29	0.818	685,481	2,412.24
	Bathroom Ventilation Fans	15,541	1.93	1.000	15,541	1.93
	Door Seals and Sweeps	353,811	3.16	0.922	326,061	2.91
	Room AC	72,841	128.04	1.000	72,841	128.04
	Room Air Purifier	275,399	31.60	1.000	275,399	31.60
	Spray Foam	7,596,536	67.81	0.922	7,000,729	62.49
	Water Dispenser	33,014	3.69	1.000	33,014	3.69
Retail Discount Subtotals		**9,546,788**	**3,225.58**	**N/A**	**8,751,285**	**2,681.73**
Downstream Rebates	Clothes Dryer	37,300	3.82	1.000	37,300	3.82
	Clothes Washer	37,141	8.81	1.000	37,141	8.81
	EV Charger	12,251	N/A	0.830	10,168	N/A
	HPWH	43,577	3.82	1.000	43,577	3.82
	Wi-Fi Thermostat	458,583	N/A	0.970	444,825	N/A
Downstream Rebate Subtotals		**588,851**	**16.45**	**N/A**	**573,011**	**16.45**
LTO Program	APS	101,863	11.56	0.946	96,340	10.93
	Candelabra LED	531,400	72.03	0.669	355,440	48.18
	Globe LED	947,380	128.42	0.711	673,633	91.31
	Reflector LED	3,132,672	424.63	0.680	2,129,600	288.66
	Room Air Purifier	788,927	90.51	1.000	788,927	90.51
	Wi-Fi Thermostat	2,542,307	N/A	0.897	2,280,005	N/A
LTO Program Subtotals		**8,044,548**	**727.14**	**N/A**	**6,323,944**	**529.60**
Foodbank	A19 LED - 8.5W or 9W	2,094,970	283.97	1.000	2,094,970	283.97
	Candelabra LED - 4W	1,703,402	230.89	1.000	1,703,402	230.89
Foodbank Subtotals		**3,798,372**	**514.86**	**N/A**	**3,798,372**	**514.86**
Program Totals		**21,978,559**	**4,484.04**	**0.885**	**19,446,612**	**3,742.64**

Table 3-54: 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	4,323	361,835	342,218	41.07	38.84	95%	95%

Distribution Type	Measure Type	Verified Quantity	Reported kWh	Verified kWh	Reported kW	Verified kW	RR kWh	RR kW
	Air Filter	16,242	838,058	685,481	2,948.29	2,412.24	82%	82%
	Bathroom Ventilation Fans	563	15,739	15,541	1.95	1.93	99%	99%
	Door Seals and Sweeps	9,163	353,811	326,061	3.16	2.91	92%	92%
	Room AC	2,063	51,767	72,841	61.26	128.04	141%	209%
	Room Air Purifier	516	275,402	275,399	31.60	31.60	100%	100%
	Spray Foam	50,173	7,596,536	7,000,729	67.81	62.49	92%	92%
	Water Dispenser	45	33,014	33,014	3.69	3.69	100%	100%
Retail Discount Subtotals		**83,088**	**9,526,161**	**8,751,285**	**3,158.83**	**2,681.73**	**92%**	**85%**
Downstream Rebates	Clothes Dryer	233	57,973	37,300	5.95	3.82	64%	64%
	Clothes Washer	329	37,617	37,141	8.92	8.81	99%	99%
	EV Charger	42	11,213	10,168	N/A	N/A	91%	NA
	HPWH	12	36,539	43,577	3.20	3.82	119%	119%
	Wi-Fi Thermostat	693	397,740	444,825	N/A	N/A	112%	NA
Downstream Rebate Subtotals		**1,309**	**541,082**	**573,011**	**18.08**	**16.45**	**106%**	**91%**
LTO Program	APS	1,217	101,863	96,340	11.56	10.93	95%	95%
	Candelabra LED	16,464	429,735	355,440	69.87	48.18	83%	69%
	Globe LED	29,352	764,368	673,633	124.28	91.31	88%	73%
	Reflector LED	89,160	2,541,604	2,129,600	413.23	288.66	84%	70%
	Room Air Purifier	1,437	788,927	788,927	90.51	90.51	100%	100%
	Wi-Fi Thermostat	3,478	2,542,307	2,280,005	N/A	N/A	90%	NA!
LTO Program Subtotals		**141,108**	**7,168,804**	**6,323,944**	**709.45**	**529.60**	**88%**	**75%**
Foodbank	A19 LED	66,816	538,148	2,094,970	87.50	283.97	389%	325%
	Candelabra LED	52,032	1,377,515	1,703,402	223.97	230.89	124%	103%
Foodbank Subtotals		**118,848**	**1,915,663**	**3,798,372**	**311.46**	**514.86**	**198%**	**165%**
Program Totals		**344,353**	**19,151,711**	**19,446,612**	**4,197.81**	**3,742.64**	**102%**	**89%**

3.1.2.5 Net-to-Gross Estimation Results

The NTG analysis for the ESP program was conducted using the methodologies outlined in the process evaluation methodology section. NTG ratios for the LTO offering were based on participant survey results, as shown in Table 3-55.

Table 3-55: Survey Responses and Free-Ridership Score: ESP LTO

Measure	PY2022 Survey Responses	Free Ridership Score for PY2022	Net-to-Gross Score for PY2022
Advanced Power Strip	127	0.02	0.98
Room Air Purifier	50	0.02	0.98
Wi-Fi Thermostat	68	0.01	0.99
Candelabra LED 5W	88	0.00	1.00
Globe LED – 5W	157	0.00	1.00
Reflector LED – 15W	307	0.00	1.00

NTG ratios for in-store markdowns (upstream) were sources from PSO's portfolio planning. Ratios are shown in Table 3-56.

Table 3-56: ESP In-Store Markdown NTG

Measure	Net-to-Gross Score
Advanced Power Strip	0.640
Air Filter	0.580
Bathroom Ventilation Fans	0.720
Door Seals and Sweeps	0.720
Room AC	0.690
Room Air Purifier	0.690
Spray Foam	0.720
Water Dispenser	0.710

NTG ratios for downstream rebates were determined through participant survey responses. Survey results from 2020 – 2022 were used to represent NTG ratios for clothes dryers, clothes washers, and EV chargers. Wi-Fi thermostats were new to the program so only results from 2022 were used. Participation for heat pump water heaters was limited in 2022, resulting in only 2 responses. These responses were used for NTG ratio as it was felt they represented the limited measures in the program. Results are shown in Table 3-57.

Table 3-57: Survey Responses and Free Ridership Scores: ESP Downstream Measures

Measure	Survey Responses				Evaluation Cycle Average Free Ridership	Net-to-Gross Score for PY2022
	2020	2021	2022	Total		
Clothes Dryers	58	67	26	151	0.55	0.45
Clothes Washers	110	106	46	262	0..54	0.46
Heat Pump Water Heater	-	-	2	2	N/A	1.00
Electric Vehicle Chargers	1	8	12	21	0.26	0.74
Wi-Fi Thermostat	-	-	78	78	0.31	0.69

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.[31] 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 3-58. Program level net verified savings results in an overall realization rate of 86% for annual energy savings.

Table 3-58: 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	342,218	38.84	0.640	219,019	24.86
	Air Filter	685,481	2,412.24	0.580	397,579	1,399.10
	Bathroom Ventilation Fans	15,541	1.93	0.720	11,190	1.39
	Door Seals and Sweeps	326,061	2.91	0.720	234,764	2.10
	Room AC	72,841	128.04	0.690	50,261	88.35
	Room Air Purifier	275,399	31.60	0.690	190,025	21.80
	Spray Foam	7,000,729	62.49	0.720	5,040,525	44.99
	Water Dispenser	33,014	3.69	0.710	23,440	2.62

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

Distribution Type	Measure Type	ISR Gross Verified kWh	ISR Gross Verified kW	NTG	Net kWh	Net kW
Retail Discount Subtotals		**8,751,285**	**2,681.73**	**0.705**	**6,166,803**	**1,585.20**
Downstream Rebates	Clothes Dryer	37,300	3.82	0.450	16,785	1.72
	Clothes Washer	37,141	8.81	0.460	17,085	4.05
	Electric Vehicle Charger Level 2	10,168	N/A	0.740	7,525	N/A
	Heat Pump Water Heater	43,577	3.82	1.000	43,577	3.82
	Wi-Fi Thermostat	444,825	N/A	0.687	305,461	N/A
Downstream Rebate Subtotals		**573,011**	**16.45**	**0.681**	**390,432**	**9.59**
LTO Program	Advanced Power Strip	96,340	10.93	0.978	94,237	10.70
	Candelabra LED - 5W	355,440	48.18	0.996	353,959	47.98
	Globe LED - 5W	673,633	91.31	0.998	672,539	91.16
	Reflector LED - 15W	2,129,600	424.63	0.996	2,121,563	423.02
	Room Air Purifier	788,927	90.51	0.980	773,430	88.73
	Wi-Fi Thermostat	2,280,005	N/A	0.987	2,249,469	N/A
LTO Program Subtotals		**6,323,944**	**665.56**	**0.991**	**6,265,197**	**661.59**
Foodbank	A19 LED	2,094,970	283.97	1.000	2,094,970	283.97
	Candelabra LED	1,703,402	230.89	1.000	1,703,402	230.89
Foodbank Subtotals		**3,798,372**	**514.86**	**N/A**	**3,798,372**	**514.86**
Program Totals		**19,446,612**	**3,878.61**	**0.797**	**16,620,804**	**2,771.25**

3.1.2.6 Lifetime Savings

Lighting measures in the ESP program will have delivery mechanism derived ISR's shown in Table 3-58 above applied to the first year of lifetime savings, the remaining years of lifetime savings,19 years, will have a TRM deemed ISR of 0.97 applied as shown in Table 3-59.

Table 3-59: ESP LTO LED Lifetime kWh Savings

Measure Name	First Year Annual kWh savings (Survey derived ISR)	Remaining Lifetime (19 years) Annual kWh savings (0.97 ISR)	Total Lifetime kWh Savings
Candelabra LED	353,959	513,310	10,106,858
Globe LED	672,539	917,467	18,104,403
Reflector LED	2,121,563	3,027,225	59,638,837

Lifetime energy savings for all measures in the ESP program are shown in Table 3-60.

Table 3-60: Total Lifetime Energy Savings – ESP Program

Measure Type	Net Total Lifetime Savings (kWh)
Candelabra LED	44,174,902
Globe LED	18,104,403
Reflector LED	59,638,837
A19 LED	14,972,871
Air Filters	38,456
Advanced Power Strips	3,692,313
Bathroom Ventilation Fans	89,517
Clothes Dryers	204,262
Clothes Washers	179,094
Door Seals and Sweeps	2,335,150
Electric Vehicle Chargers	65,596
Heat Pump Water Heaters	435,766
Room Air Conditioners	367,121
Room Air Purifiers	8,150,593
Smart Thermostats	28,104,239
Spray Foam	50,137,139
Water Dispensers	158,468
Total	**230,848,727**

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, and participant surveys. The evaluators assessed program design, operations, and delivery through a logic model facilitated discussion and participant surveys. A detailed process evaluation memo was delivered to PSO in December of 2022.

3.1.2.7.1 Program Operations Findings

ADM conducted a facilitated discussion of the logic model developed for the ESP program in 2022. The logic model provides an illustrative overview of the short, intermediate, and long-term goals the program proposes to achieve through a series of inputs, activities, and outputs (Figure 3-17). The logic model was updated per discussions with program staff to reflect the discussions around program design, delivery, and implementation.

According to program staff, the overarching goal of the ESP program is to support PSO's efforts in reaching a diverse range of customers by offering a variety of energy efficient measures that do not require a large upfront monetary investment. The logic model created for the ESP program includes all the different channels (i.e., Upstream, Downstream, EV Chargers, and LTO).

Figure 3-17: ESP Logic Model

<table>
<tr><th>Inputs</th><th>Activities</th><th>Outputs</th><th>Short-term Outcomes</th><th>Intermediate Outcomes</th><th>Long-term Outcomes</th></tr>
<tr><td>Resources to implement activities and produce outputs</td><td>Activities implemented to produce outputs</td><td>Products and services delivered</td><td>Immediate results achieved following delivery of output</td><td>Results expected to lead to the end outcome</td><td>Ultimate desired change because of program</td></tr>
<tr><td rowspan="6">PSO Staff
Implementation Staff
Retailers/ Car Dealerships
PSO Customers
Budget
Utility Stakeholders and other Partners
Data systems
Social media accounts
Website
ADM Associates
Participant survey data</td><td>Identify a mix of measures to incent/rebate and continuously evaluate incentives</td><td>Downstream and upstream measure mix</td><td>Increased energy efficient product purchased within the PSO service territory – (reaching more customers outside of Tulsa and Lawton)</td><td rowspan="3">Increased awareness the importance of energy efficiency

Change in energy efficiency knowledge among customers</td><td rowspan="3">Improved opinion of energy efficiency among PSO customers</td></tr>
<tr><td>Design and implement an application system and verification process</td><td>Streamlined application system and codified verification process</td><td>Increased satisfaction with the rebate process and PSO among customers who purchase energy efficient products</td></tr>
<tr><td>Identify retailers / car dealership to partner with for instant rebates and in-store signage</td><td>Participating retailers / car dealerships and in-store signage developed/placed</td><td>Provide retailers training and support to educate customers about energy efficiency</td></tr>
<tr><td>Identify ways to reduce any burdens for adoption and installation of measures by customers</td><td>Barriers for adoption and installation identified and considered</td><td>Decrease the number of barriers for adoption and installation of energy efficient measures</td><td rowspan="3">Impact market transformation to increase customers' purchases of energy efficient products

Increase the number of energy efficiency measures that are installed within the service territory</td><td rowspan="3">Increased kWh savings for ESP program</td></tr>
<tr><td>Monitor program metrics for managing program activities and outcomes</td><td>Program data and metrics available to program administrators, implementers, and evaluators</td><td>Implement Continuous Quality Improvement (CQI) strategies to ensure ongoing improvements to program offerings</td></tr>
<tr><td>Explore opportunities to offer an online marketplace and limited time offers (LTOs)</td><td>Online marketplace and LTOs operationalized</td><td>Increase access to energy efficient products</td></tr>
<tr><td colspan="3">Assumptions, Factors, and Barriers impacting Product/Service Delivery</td><td colspan="3">Assumptions, Factors, and Barriers impact achievement of outcomes</td></tr>
</table>

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

- Program staff relies on the inputs from various stakeholders and data resources to implement and continuously improve upon the program. Program staff indicated they adapt and update their offers throughout the program year by changing the rebate amount, channels of delivery, and check for purchasing/sales trends. These aspects make the nature of the program very fluid and susceptible to the state of the current market (e.g., inflation, supply chain issues).
- The success of the program is centered around catering to the interest of the PSO customers in purchasing more energy efficient products at rebated or discounted prices. PSO will continue to increase awareness of energy efficiency and increase the amount of energy efficient measures that are installed within the service territory. During the beginning of PY2023, program staff plans to launch LTOs for lighting measures and will try to obtain energy savings from LED lighting measures before the EISA backstop is implemented.
- Program staff described the LTO launch as an overall success. Although the team experienced minor logistical challenges, the program staff stated they met their goals. Customers have learned about the limited time offers through email blasts and social media posts on Facebook and Instagram. Program staff indicated they will explore selling different measures through their LTO campaigns.

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 951 responses were collected. The following highlights findings affecting all the LTO measures component of the program.

- LED lighting was the most common measure purchased through the LTO. The 15-watt reflector LED light bulbs were the most common measure purchased through the LTO, followed by 5-watt globe bulbs, and 5-watt candelabra bulbs. Other measures rebated through the LTO included advanced power strips, room air purifiers, and Wi-Fi smart thermostats. Most customers stated they decided to purchase the measure after viewing the promotion on the LTO and that the instant discount or price of the product led them to finalize the purchase.
- Most survey respondents were satisfied with the LTO. Overall, 85% were satisfied with their purchase experience. Most survey respondents were satisfied with the measure they purchased. Additionally, many respondents indicated that their experience with the LTO offering was important when making the decision to take additional energy savings actions. This suggests that customers' experience with PSO's LTO was important in their decision to take energy saving actions.

- The overall net promoter score was lower for lighting measures compared to non-lighting measures offered through the LTO. The overall net promoter score of the LTO among survey respondents was 47%. Most survey respondents (63%) were considered promoters, 21% were passive, and 16% were detractors. When analyzed by measure the score was highest among people who purchased a room air purifier and lowest among those who purchased a globe LED light bulb. Detractors were displeased with the packaging of the LEDs. Other reasons included the bulbs did not fit their fixtures or they did not like the color or brightness of the bulbs. This finding could suggest that the NPS was influenced by the large share of survey respondents who received broken bulbs.

3.1.2.7.3 Downstream Offerings Findings

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

- Smart thermostats accounted for almost half of the rebated measures through the downstream channel in 2022. Forty-six percent of the appliances rebated through the downstream program were Smart thermostats, followed by clothes washers (31%), clothes dryers (19%), EV chargers (4%), and heat pump water heaters (1%). Among the 714 customers who requested rebate for program-eligible measures, 65% received a rebate for a single measure, while 35% received rebates for more than one measure. July, August, September, and October were the months with the largest number of measures being rebated.
- Most downstream participants first learned about the PSO rebate before they made the purchase and through the PSO website. Many participants learned about the available rebates from PSO’s website, followed by the retailer’s website or an internet search. Most purchases were made with the intention of saving energy and money in their homes or to replace an existing appliance. Most participants received their rebates in four weeks or less.
- Downstream participants were generally 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. The overall net promoter score of the downstream channel was very good at 61%. When analyzed by measure, the NPS was highest among people who purchased ENERGY STAR® washers or dryers (65% each) and lowest among those who purchased a heat pump water heater (50%)

3.1.2.7.4 Level II EV Charger Offering Findings

The following highlights findings affecting all the EV Level 2 Chargers component of the program.

- Most participants indicated they were satisfied with the EV charger rebate and the program had a high net promoter score. In addition to the overall program, participants also indicated their satisfaction with various components of the level 2 EV charger rebate program. In general, most were satisfied with the charger they purchased, the rebate amount, the rebate turnaround time, and the application process. The net promoter score of the LTO among survey respondents was exceptional at 92%. Most survey respondents were considered promoters of the EV charger rebate program.
- Most survey respondents purchased the ENERGY STAR® level 2 charger to charge their new electric vehicle and to charge it faster. Eighty-three percent learned about the rebate through the PSO website, and one customer learned about the rebate through an electric vehicle salesperson, and another survey respondent was aware of other utilities promoting EV chargers and called PSO to ask if they were also offering a rebate. The ability to charge their car quicker was the top reason for respondents to purchase a level 2 charger. Additionally, many stated the rebate PSO offered was very important as well as protecting the environment or combating climate change was also important in their decision to buy the charger.
- Tulsa, Jenks, Coweta, Bartlesville, and Broken Arrow were the cities where EV level 2 chargers were most often rebated. Almost half (46%) of rebated EV chargers were ChargePoint, followed by 17% which were Enel X Way (JuiceBox), and 11% which were Emporia.
- Customers are most likely to charge their EVs a few times or once per week. Survey participants stated that they either used the level 2 charger once a day (25%), a few times a week (42%), once a week (25%), or could not recall (8%). Most customers are using an app to set charging times for their EV and the frequency of use tended to correlate with the frequency of charging. Charging duration varied, with half indicating they typically charge their EV between 3 and 5 hours. Forty-two percent of respondents reported charging their vehicles between 12 and 7 am.

3.1.2.8 Conclusions and Recommendations

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

- Consider making the specifications of each measure more accessible or visible on the LTO website. Program staff could explore ways for customers to understand the characteristics and quality of the bulbs being offered. Additionally, providing more information to customers about the products would benefit the program offering (e.g., noticeable hyperlinks, videos of the actual bulbs, information about the benefits of replacing older inefficient equipment, etc.).
- Continue to improve the information and messaging regarding the downstream component of ESP. Although satisfaction rates were high, people continued to express some frustration with clarity on eligibility rules and rebate application process. Program staff could explore opportunities to add additional information or resources online or through the retailers for customers to better understand the program. They could also look for additional avenues to promote the availability of heat pump water heaters to increase the number rebated.
- Continue to improve the information and messaging about the availability of the EV level 2 charger component of ESP. There were some customers who expressed some issues with not being able to easily find the information about the rebate. With EV car sales expecting to accelerate in coming years, it will be advantageous for customers to be aware of the rebate and be able to easily find information about it. Program staff could consider exploring additional customer engagement efforts and increase educational resources that could be made available to retailers or car dealerships.

3.1.3 Education Program

This chapter presents findings from the impact and process evaluation of the 2022 PSO Education 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 3-61 summarizes the overall performance of the program in Program Year 2022.

Table 3-61: Performance Metrics – Education Program

Metric	PY2022
Number of Customers	15,926
Budgeted Expenditures	$967,020
Actual Expenditures	$885,474
Energy Impacts (kWh)	
Projected Energy Savings	2,722,718
Reported Energy Savings	3,221,445
Gross Verified Energy-savings	3,888,623
Net Verified Energy-savings	3,888,623
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	411.56
Reported Peak Demand Savings	645.17
Gross Verified Peak Demand Savings	554.21
Net Verified Peak Demand Savings	554.21
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.86
Utility Cost Test Ratio	1.91

The Education program consists of three components. (1) Education materials provided to teachers, (2) kits with energy saving measures for students to install at home, and (3) the PSO Education Program webpage.[32]

Educational materials were developed by the implementer to form a five-day curriculum 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.

Students are engaged through compelling stories and illustrated characters such as C.A.D.E. (the Champion And Defender of Energy). C.A.D.E. goes on energy-saving adventures and teaches students about energy-saving habits and ways to be more energy-efficient at home.

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. Students are given instructions on how to install the measures in the kit and instructed to install them in their homes. The measures provide energy savings to participating families and reinforce concepts taught through the curriculum.

The final component of the program, 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.

3.1.3.2 EM&V Methodologies

This section provides an overview of the data collection activities, gross impact calculation methodologies, net-to-gross estimation, and process evaluation activities employed in evaluating the PSO Education Program.

3.1.3.2.1 Data Collection

Data sources for the evaluation of the program include:

- Program Tracking Data
- Implementation Invoices

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

- 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.

Collaboration with the program implementers was done to develop two quizzes and two surveys to be conducted through the program. The quizzes assess the student's knowledge about electricity and energy use before and after participation in the program. The surveys collect information about the home, such as heating fuel and air conditioning system type, and information about program-related activities, 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.

Finally, a facilitated discussion was conducted with program staff to gain insight into the program execution. Interviews were completed in August 2022 with key personnel responsible for the program and discussed past program year recommendations and brainstormed possible implementation strategies for future changes. Table 3-62 summarizes the data collection activities and purpose.

Table 3-62: Education Data Collection and Sample Size Effort by Survey

Data Collection Activity	Data Use	Achieved Sample Size
Program Tracking Data	Impact/Process	15,926
PSO Student Survey	Impact/Process	2,939
ADM Teacher Survey	Process	122
Implementation Staff Interviews	Process	2

3.1.3.2.2 Reported Savings Calculations Review

Reported savings sources and calculations were reviewed for all measures to explain any savings discrepancies. Measure level In-Service Rates (ISR) were calculated from student surveys. The student surveys are provided with the kits and collected by the implementation team.

3.1.3.2.3 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) and Arkansas Technical Reference Manual v8.2 (AR TRM).
- Determined measure installation for gross savings adjustments: the ISR for ENERGY STAR® LEDs, FilterTone® alarms, LED night lights, and the advanced power strip 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 Appendix G. Prescriptive algorithms were used from Arkansas TRM v8. In-service rates were determined through student survey responses. The survey questions and the evaluation inputs for which they were used, are shown in Table 3-63.

Table 3-63: Student Survey Questions and Uses

Survey Question	Question Use
There were four 9-watt LED light bulbs included in your kit. How many of the LED Light Bulbs did your family install on the inside of your home? AND How many of the four LED Light Bulbs did your family install on the outside of your home?	LED Bulbs ISR, Interactive Effects, and Coincidence Factor
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

3.1.3.2.4 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. It is therefore not reasonable to assume that a parent or student was a free rider when they received the kit.

3.1.3.2.5 Lifetime Savings

Lifetime annual energy savings were calculated by multiplying the gross annual energy savings by the Effective Useful Life (EUL) for each measure type. EUL values for each measure were based on the assumptions in the AR TRM and PA TRM. Table 3-64 shows the EUL and source for each measure type.

Table 3-64: Education Per-Measure Estimated Useful Life (EUL)

Kit Contents	EUL	Source
ENERGY STAR® 9W LED	19[33]	AR TRM
Advanced Power Strip	10	AR TRM
FilterTone® Alarm	14	PA TRM
LED Night Light	8	PA TRM

3.1.3.2.6 Process Evaluation

ADM evaluators completed a process evaluation to assess the PSO Education Program. The program provides educational materials and energy-efficient products to 5th-grade

[33] ADM followed the AR TRM algorithms for LED bulbs and used EISA Tier 1 baselines for the first year of the measure life (2021-2022), and EISA Tier 2 baselines thereafter.

students through teacher-led learning modules and an energy kit the students get to take home. ADM facilitated a logic model discussion with PSO and implementation staff during PY2022. The evaluators assessed program design, operations, and delivery through a discussion with the staff as well as through student and teacher surveys. Recommendations for refining and improving the program for the next program 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:

- 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 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?
- Were there any notable successes, challenges, or other program developments?
- What types of quality control processes are established to ensure kit delivery?
- Is the program on track to meet its kit distribution goals? If not, what are the barriers to meeting the distribution goals?
- 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 do teachers think about the program, the educational materials, and the kits? To what degree do the teachers incorporate the educational materials into their curriculum, and what would they teach if they did not receive those materials?
- Are there ways to improve the design or implementation process?

Table 3-65 below summarizes the data collection activities and corresponding process evaluation research objectives used to complete the process evaluation.

Table 3-65: Education Process Evaluation Data Collection Activities Summary

Data Type	Process Evaluation Research Objectives
Program Materials Review	Provide information on program design, implementation, and delivery. Provide school and teacher participation data to help interpret data from student surveys. Provide information to develop a sample of teachers to survey.
Student Survey	Assess pre-post differences in energy quiz. Assess whether quiz performance is related to household or school characteristics. Determine whether assessed energy-saving activities, including installation of kit measures, are related to household characteristics, school characteristics, or quiz performance.
Teacher Survey	Assess teacher perceptions of the program, materials, and kits; use of materials in curriculum development; and level of teacher involvement in kit distribution.
Logic Model Development and Discussion and/or Review	Develop program logic models or review already-developed logic models by program staff.

3.1.3.3 Impact Evaluation Findings

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. The implementation team addressed questions about the final data.

3.1.3.3.2 Energy Impact Adjustments

Gross energy impacts were evaluated using the engineering algorithms described in the methodology section of this chapter. Gross energy impacts were adjusted for ISR to determine verified energy impacts. In-Service Rates, as calculated based on the methodology section, are the result of student surveys. In total, 2,939 student surveys were completed. Table 3-66 displays the in-service rates by measure. The change in ISR for the Advanced Power Strip and FilterTone Alarm could be attributed to the difference in the wording of the survey question. The ISR for the LED Night Light and 9-watt LED decreased compared to previous years.

Table 3-66: Education School Kit In-Service Rates

Measure	Number of Measures	ISR
7-Plug Advanced Power Strip	15,926	61%
LED Night Light	15,926	68%
FilterTone® Furnace Filter Alarm	15,926	34%
9-watt LED	63,704	43%[34]

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. These values were used to create weighted average savings and demand reduction for advanced power strips. Based on the student survey responses, a greater overall ISR of 61% was determined for advanced power strips, compared to the assumed ISR of 54%. The change in ISR could be attributed to the difference in the wording of the survey question. Installation locations were found to be roughly similar to the installation locations reported in 2021.

The verified average energy savings and demand reductions were found to be 113 kWh and 0.01 kW per power strip, resulting in a realization rate for advanced power strips of 108% for both energy and demand due to differences in installation from reported (reported) assumptions and a verified in-service rate that was lower than assumed.

3.1.3.3.4 LED Night Light

Verified energy savings differ from reported due to the differences between the assumed in-service rate (71%) and verified in-service rate (68%). There is no demand reduction for LED night lights.

3.1.3.3.5 FilterTone® Alarm

Verified energy savings differ from reported due to the differences between the assumed in-service rate of 30%, and the verified in-service rate of 34% calculated from the student survey.

3.1.3.3.6 ENERGY STAR® LED

The program tracking data and student survey was used to determine LED in-service rates, interactive effects, and coincidence factors. The differences in savings and demand

[34] Average in-service rate across all 4 bulbs. Per bulb in-service rates varied from 60% for the first bulb to 29% for the fourth bulb, like the rates from the previous year, which varied from 61% to 28%. The 2022 average in-service rates decreased from the 2021 in-service rate of 45%.

reductions between ADM and the implementer were due to differences between the verified and assumed values for these inputs, as shown in Table 3-67.

Table 3-67: Differences Between Assumed and Verified Inputs for LED Light Bulb Calculations – Education Program

Calculation Input	Assumed Value	Verified Value
In-Service Rate	45%	43%
Interactive Effect (Energy)	0.94	0.92
Interactive Effect (Demand)	1.23	1.23
Coincidence Factor (CF)	0.075	0.072

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 3-68 details the education kit contents and savings impacts per measure.

Table 3-68: Summary of Kit Contents and Verified Energy Savings and Demand Reduction by Measure – Education Program

Kit Contents	Quantity	Verified kWh Savings Per Measure	Verified kW Reduction Per Measure	Verified kWh Savings Per Kit	Verified kW Reduction Per Kit
9-watt LED Light bulb	4	13.06	0.0013	52.24	0.0052
7-Plug Advanced Power Strip	1	113.15	0.0130	113.15	0.0130
FilterTone® Alarm	1	60.93	0.0165	60.93	0.0165
LED Night Light	1	17.86	0.0000	17.86	0.0000
Digital Thermometer	1	0.00	0.0000	0.00	0.0000
Total				**244.17**	**0.0348**

Table 3-69 and Table 3-70 show a comparison of the verified gross annual energy-savings (kWh) and peak demand reduction (kW) of the 2022 Education Program, by measure to the reported savings estimates.

Table 3-69: Gross Energy-Savings (kWh) Summary by Measure for PY2022

Measure	Reported Energy (kWh) Savings	Verified Energy (kWh) Savings	Realization Rate (kWh)	Verified Lifetime Energy Savings (kWh)
7-Plug Advanced Power Strip	1,316,127	1,801,952	136.9%	18,019,518
LED Night Light	295,652	284,359	96.2%	2,274,873
FilterTone® Furnace Filter Alarm	740,827	970,392	131.0%	13,585,493
9-watt LED	868,838	831,920	95.8%	5,676,631
Total	**3,221,445**	**3,888,623**	**121%**	**39,556,515**

Table 3-70: Gross Demand Reductions (kW) Summary by Measure for PY2022

Measure	Reported Demand (kW) Reduction	Verified Demand (kW) Reduction	Realization Rate (kW)
7-Plug Advanced Power Strip	151.57	207.23	136.7%
LED Night Light	0.00	0.00	-
FilterTone® Furnace Filter Alarm	402.84	263.43	65.4%
9-watt LED	90.76	83.55	92.1%
Total	**645.17**	**554.21**	**85.9%**

Evaluation findings represent a kit level realization rate for energy-savings and demand reduction of 105% and 107%, respectively. Reported savings are based on the verified program savings from PY2021, meaning differences between the reported and verified program savings are due to differences in installation locations (indoor vs. outdoor for LEDs and system type for the advanced power strip) from 2021 results (used for reported estimates), and a verified in-service rate that was higher than assumed.

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, including the development of a logic model. ADM provided a detailed process evaluation memo to PSO after the completion of the 2022 program year.

3.1.3.4.1 Program Activity

A total of 15,926 kits were sent to 455 different fifth-grade teachers within the PSO territory for PY2022. According to the data, Franklin Energy sent 761 kits during the spring semester and 15,165 in the fall. Figure 3-18: Distribution of Education Program School Kits

displays the geographic distribution of school kit distribution by zip code.

Figure 3-18: Distribution of Education Program School Kits

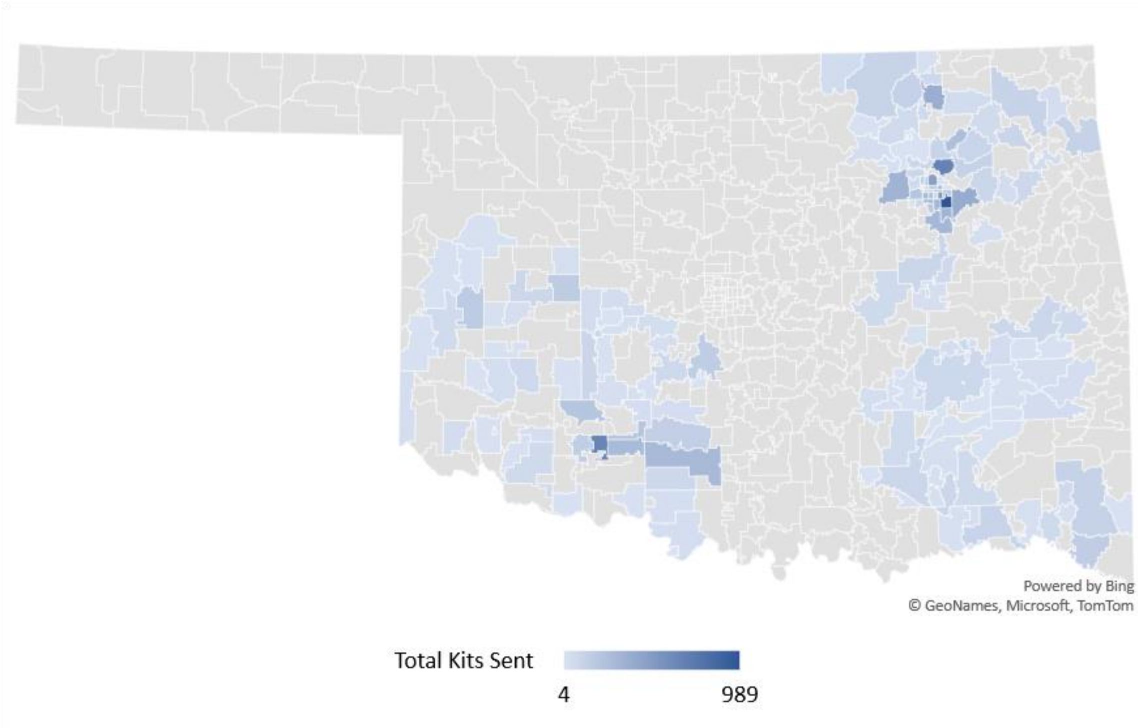


Table 3-11 provides an overview of the kit distribution among the top ten cities. The largest proportion of distributed kits went to the cities of Tulsa (28%), Broken Arrow (11%), and Lawton (7%).

Table 3-11: School Kit Distribution Among Cities

City	Number of Schools[35]	Number of Kits	Percentage of Kits
Tulsa	110	4393	28%
Broken Arrow	47	1701	11%
Lawton	36	1154	7%
Owasso	25	671	4%
Bartlesville	17	496	3%
Sand Springs	8	333	2%
Bixby	3	305	2%
Duncan	6	286	2%
Oologah	7	259	2%
Elk City	3	168	1%
All Others[36]	193	6160	38%

The program also served smaller schools in rural or underserved communities. There were 827 kits delivered to schools in cities and towns with fewer than 500 inhabitants. 1,666 kits were delivered to cities and towns with fewer than 1,000 inhabitants.

3.1.3.4.2 Facilitated Discussion

A program-specific logic model was created, which provides an illustrative overview of the short, intermediate, and long-term goals. Throughout the discussion, the logic model was updated to better reflect program design, delivery, and implementation. According to program staff, the overarching goal of the Education program is to support PSO's efforts to meet the annual energy savings (kWh) goals and promote the practice of energy efficiency and conservation through a comprehensive curriculum geared towards fifth graders in the service territory. The Energy Saver Kit curriculum includes topics such as how energy systems work and affect different aspects of society, the distribution of energy resources, the importance of demand response initiatives, and how the grid works. The logic model is shown Figure 3-19.

[35] Many schools had multiple teachers participating.
[36] All Others represent cities that represent less than 1% of kits.

Figure 3-19: Education Program Logic Model

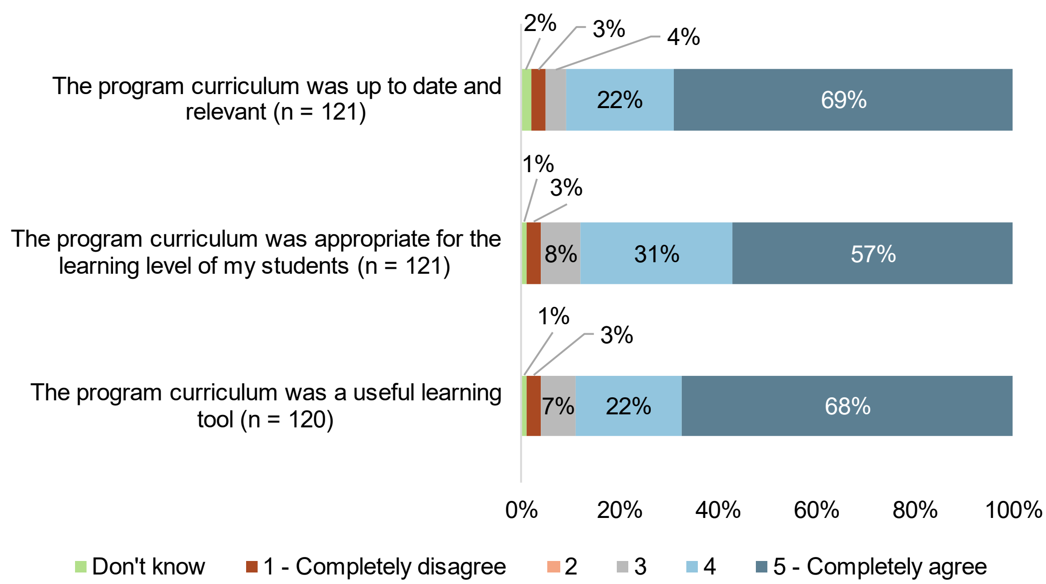
Inputs	Activities	Outputs	Short-term Outcomes	Intermediate Outcomes	Long-term Outcomes
Resources to implement activities and produce outputs	Activities implemented to produce outputs	Products and services delivered	Immediate results achieved following delivery of output	Results expected to lead to the end outcome	Ultimate desired change because of program
PSO Staff **AM Conservation Staff** **Teachers/Schools/Students** **Educational Curriculum** **PSO Customers** **Budget** **Utility Stakeholders and other Partners (subcontractors)** **Data systems** **Social media accounts** **Website (PSO and AM Conservation)** **ADM Associates** **Teacher & Student survey data**	Identify and recruit eligible schools to participate in program	Enrolled 5th grade classrooms within the service territory	Increased interest in participating in PSO's Education program	Increased engagement among students and families with energy efficiency	
	Design and implement high-quality and relevant energy efficiency curriculum and materials	High-quality and up-to-date energy efficiency curriculum and activities	Increased teacher engagement with curriculum and materials	Improved energy efficiency knowledge and awareness of energy consumption among students	
	Design, build, and send energy efficiency kits to participating schools	Energy efficiency kits delivered to enrolled schools	Ensure timely delivery of energy efficiency kits to schools and classrooms	Increased teacher and student satisfaction with kits	Improved opinion of PSO among customers and future ratepayers
	Work with schools and teachers to improve energy efficiency curriculum and identify ways to reduce any burdens for installation of kit measures by students	Barriers for teachers and students identified Mitigation strategy	Decrease the number of barriers for teachers to implement curriculum and materials and installation of kit measures	Increase the number of energy efficiency kit measures that are installed among participating student	Increased kWh savings for Education program
	Monitor program metrics	Program data and metrics available to program administrators, implementers, and evaluators	Implement Continuous Quality Improvement (CQI) strategies to improve the program	Enhanced Education program administered and implemented	
	Explore opportunities to offer activities online and increase accessibility for teachers and parents	Online and accessible activities	Increase opportunities for teachers, students, and families to access educational materials online	Increase teacher and parent energy efficiency knowledge and awareness of energy saving behaviors	
Assumptions, Factors, and Barriers impacting Product/Service Delivery			Assumptions, Factors, and Barriers impact achievement of outcomes		

3.1.3.4.3 Teacher Survey

An electronic survey was administered to participating teachers. The purpose of the teacher survey was to assess the instructor's experience with the curriculum, how they implemented it in their classroom, and their overall satisfaction. Participants received a monetary incentive after completing the survey. The following summarizes the data collected.

Most teachers agreed that the program curriculum was up-to-date and relevant, appropriate for the learning level of their students, and a useful learning tool (Figure 3-20)

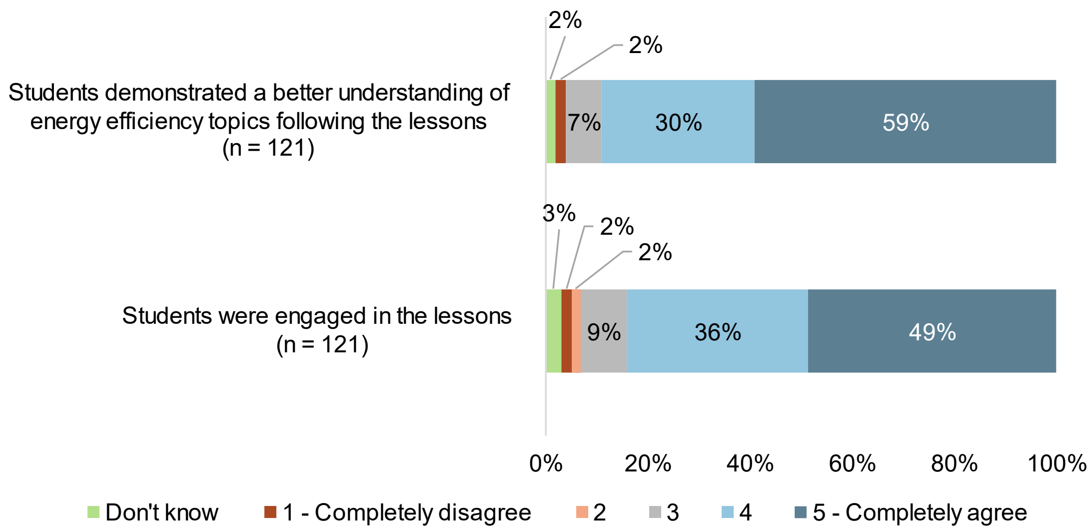
Figure 3-20: Teacher Perceptions of the Program Curriculum



Of the 121 teachers who responded to the survey, most (75%) reported teaching concepts that they normally teach in their regular curriculum. Many teachers indicated their lessons and curriculum would not have been as interactive, and they would not have taught energy efficiency as thoroughly as the program provides.

Most teachers (89%) agreed that the material was appropriate for their students' learning level and 85% agreed their students demonstrated a better comprehension of energy efficiency from the lessons (Figure 3-21).

Figure 3-21: Perception of Student Experience



Nearly all teachers (97%) indicated they would participate in the program again.

3.1.3.4.4 Student Results

During the program, students completed short quizzes about their knowledge of energy efficiency before and after completing the curriculum. The instructors' perception of the high level of engagement and comprehension of energy efficiency is well supported by the improvement of scores from Pre and Post Quiz results. The average test score improved by 22 percentage points (see Table 3-71). The greatest improvements were identified in questions four and five, which also had the lowest pre-survey scores.

Table 3-71: Analysis of Test Scores – Education Program

Measurements	Pre-Survey (n = 2,908)	Post-Survey (n = 2,819)	P-value
Mean of test scores	58%	80%	<0.0001

3.1.3.5 Conclusions and Recommendations

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

- The program operated successfully in PY2022. Student and teacher survey data indicate satisfaction with the program with 87% of student respondents rating the program as "excellent" or "good" and all teachers stating they would participate in the program again.
- The program design was mostly consistent with past years, though there were some updates. Kits were delivered in soft backpacks rather than cardboard boxes, and changes were made to the program curriculum.

- Findings from the teacher focus groups and teacher surveys suggest the curriculum is viewed as a valuable resource for 5th-grade teachers in Oklahoma. Teacher feedback indicates the program materials stimulate student interest. A significant portion of teachers observed that some or all of the curriculum would not otherwise be taught if the program was not offered.
- ADM's analysis of student survey results indicates opportunities to update question-wording to improve the program's ability to gauge its impact on students and their families.
- Two teacher focus groups were held in January 2023; results and materials generated from the focus groups will be used to help inform future evaluations. Updates to the 2023 evaluation may include revisions or additions to ADM's teacher survey as well as follow-up questions during ADM's in-depth interviews with program staff to gauge any program changes that were made or had been considered as a result of the focus groups.

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

- Continue to update and improve curriculum and materials. ADM noted that attendees of the teacher focus groups voiced interest in translated materials, age-appropriate material, and more interactive curriculum options**.** Kahn Research's executive summary highlighted teacher interest in more digital resources and interactive materials.
- Revise student survey. Some of the questions in the student survey regarding knowledge of energy efficiency before the curriculum and after the curriculum could be modified to improve clarity.

3.1.4 Multifamily and Manufactured Homes Program

An impact and process evaluation of PSO's Multifamily Program has been completed. 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 fourth year in the Public Service Company of Oklahoma (PSO) portfolio during program year 2022 (PY2022). PY2022 is the first year in the 2022-2024 evaluation cycle for PSO. The PY2022 reported Program savings continued to exceed project goals, reaching 184% of the Total Annual Energy Savings (kWh), while remaining under budget. This makes two consecutive years of exceeding savings goals without exceeding budget, as was the case in the program's first two years (PY2019 & PY2020). The number of projects paid increased to 287 in PY2022 compared to 129 in PY2021. Table 3-72 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 included direct installation measures (LED screw-in light bulb, low-flow showerheads, and faucet aerators) as well as duct sealing and air sealing.

Table 3-72: Performance Metrics - Multifamily Program

Metric	PY2022
Number of Customers	256
Budgeted Expenditures	$989,559.00
Actual Expenditures	$929,655.38
Energy Impacts (kWh)	
Projected Energy Savings	1,725,578
Reported Energy Savings	3,644,673
Gross Verified Energy Savings	3,638,574
Net Verified Energy Savings	3,638,574
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	398.73
Reported Peak Demand Savings	907.33
Gross Verified Peak Demand Savings	928.29
Net Verified Peak Demand Savings	928.29
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	3.13
Utility Cost Test Ratio	2.86

The Program provides comprehensive energy efficient measures for qualifying Multifamily properties and Manufactured Homes in the PSO service territory. The Program offers direct install measures (ENERGY STAR® LEDs, faucet aerators, and low-flow showerheads) at no cost to the participating property. Tenant dwellings that receive direct install measures are eligible for an energy survey. The energy survey is turned into a report that compares the energy use of the property to similar properties in the neighborhood, recommends ways to be more energy efficient, and shows potential savings of energy upgrades. The \ 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, water heaters, ENERGY STAR® windows, ENERGY STAR® pool pumps, ENERGY STAR® washing machines, ENERGY STAR® dryers, 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 Multifamily customers. The Program has the following goals:

- Increase owner/operator awareness and knowledge of applicable energy-saving measures and their benefits.

- Increase the market share of Commercial-grade high-efficiency technologies sold through market channels.
- Increase the installation rate of high-efficiency technologies in Multifamily facilities by businesses that would not have done so absent the Program.

The 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 on a per kWh and kW impact basis. Table 3-73 summarizes Program activity by the percentage of reported savings by measure type.

Table 3-73: Percentage of Reported Savings by Measure Type – Multifamily and Manufactured Homes Program

Measure Type	Percent of Program
HVAC	69.58%
Building Envelope	18.16%
Lighting	8.23%
Appliances	2.69%
Water Heating	1.33%

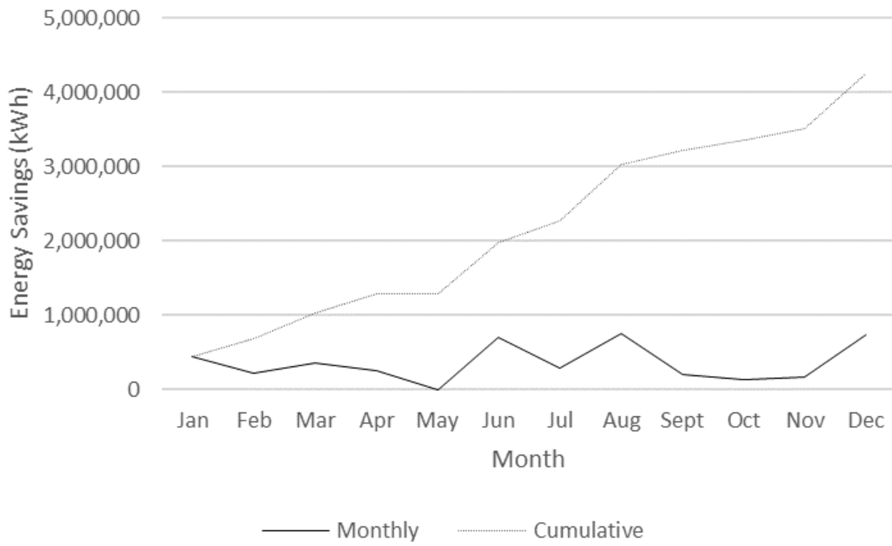
Air sealing, duct sealing, faucet aerators, LEDs, and low-flow showerheads were all offered for manufactured homes. A breakout of measure implemented for manufactured homes and multifamily homes is shown in Table 3-74.

Table 3-74: Installed Measures for Multifamily and Manufactured Homes

Measure	Manu. Home Measure Count	Multifamily Measure Count	Manu. Home Reported kWh	Multifamily Reported kWh
Duct Sealing	178	514	1,039,221	1,355,977
Air Sealing	86	461	115,390	306,508
LED Screw-In	49	145	9,521	184,601
Attic Insulation	NA	55	NA	186,546
Heat Pump	NA	161	NA	140,214
Low-Flow Showerhead	40	3	17,391	68,243
Lighting	NA	50	NA	63,146
Window	NA	17	NA	53,403
ENERGY STAR Clothes Washer	NA	3	NA	29,835
Space-By-Space (NC Lighting)	NA	1	NA	20,159
ENERGY STAR Clothes Dryer	NA	2	NA	13,400
Whole Building Approach (NC Lighting)	NA	1	NA	11,914
Occupancy Sensor	NA	32	NA	10,745
Faucet Aerator	34	3	2,717	9,711
ENERGY STAR Refrigerator	NA	4	NA	5,394
Air Conditioner	NA	2	NA	637
Total	**387**	**1,454**	**1,184,240**	**2,460,432**

Participation in the Program was consistent throughout the year, with the number of projects per month ramping up towards the end of the year. December had the largest savings and incentive projects, followed by July and November. Figure 3-22 illustrates program activity throughout the year, including monthly and cumulative project savings.

Figure 3-22:Accrual of Reported Annual Energy Savings During the Program Year – Multifamily and Manufactured Homes Program



3.1.4.2 EM&V Methodology

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

Data Collection

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

Program information and documentation was obtained for the census of projects within the program. Documentation included energy savings algorithms and inputs, project invoices, equipment specification sheets, and any available implementation documents such as inspection reports. 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). PSO uses Sightline in conjunction with an SQL Server Reporting Services (SSRS) system as its central tracking and reporting system. Review and collection of this documentation is the desk review portion of the impact evaluation.

Multiple on-site inspections were performed to confirm measure installation and gather information to better inform the program analysis. Data collection activities included property owner/manager surveys, service provider interviews, and a program staff facilitated discussion. 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 3-75 shows the achieved sample sizes for the different types of data collection activities utilized for this study.

Table 3-75: Multifamily and Manufactured Homes Sample Sizes for Data Collection Efforts

Evaluation Activity	Achieved Sample Size
On-Site Visit	5
Property Owner/Manager Survey	7
Facilitated Discussion with Program Staff	1
In-depth Interviews with Service Providers	2
Engineering Desk Review	Census

3.1.4.2.1 Gross 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 to determine the scope of the Program and to ensure there were no data issues such as duplicate entries or missing data.
- Periodic review of the program data was completed throughout the year, to reduce the risk of evaluation uncertainty through performing desk reviews of initial project data and providing commentary to PSO regarding the utilized methodologies of savings calculations.
- 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 3-76 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 3-76: Multifamily References for Energy Savings Calculations

Measure	Methodology References
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
Faucet Aerators	Arkansas TRM v.8.1, Section 2.3.4
Heat Pumps	2013 OKDSD, Section 12
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
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 install or non-direct install. A discussion of the two free ridership methodologies can be found in Appendix G..

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 did PSO market this program? Which marketing methods were most effective?
- What motivates owners/property managers to participate in the program? What barriers prevent participation?
- How well did PSO staff, service providers, implementation contractors, and property managers/owners work together? 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?
- Did property managers/owners find the energy survey of their property to be beneficial? If not, how could the survey be improved?
- What are PSO staff and implementation staff perspectives on the program? What are reactions to program design choices that have been implemented?
- What are key indicators of program success? Is the program achieving success? Do various stakeholders perceive the program to be successful?
- What types of multifamily properties participated in the program? Could certain facility types be targeted more effectively?
- Were there any significant obstacles during the 2022 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 decisionmakers and interviews with service providers and program staff (facilitated discussion) to gain insight into program design and implementation. Table 3-77 details the data collection activities performed for this program's evaluation.

Table 3-77: Multifamily Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
Program Staff Facilitated Discussion	Discuss decisionmaker journey to create a common understanding of participation experience and identify key touchpoints to create a journey map.
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.
Property Owner/Manager Survey	Gather data on participant knowledge and awareness of the program, business practices, satisfaction, reasons for participating, decision-making process, as well as general attitudes and behaviors regarding energy efficiency, PSO's Multifamily program, and PSO as their utility.
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 Data Review and On-Site Findings

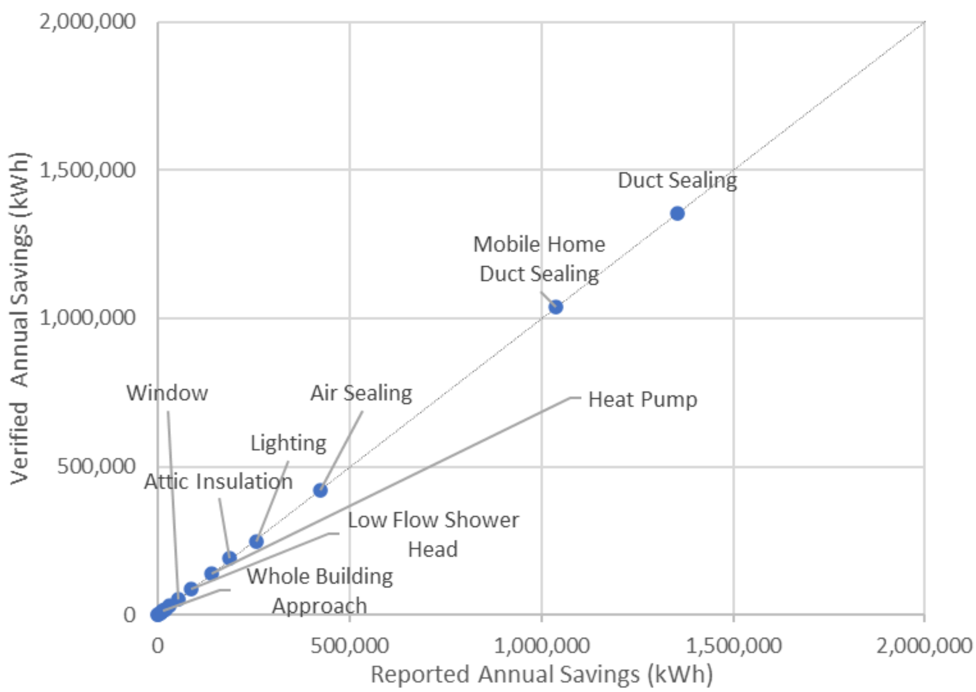
Review of program tracking data did not result in any significant findings that had any influence on the program savings calculations. There were some issues with the way that tracking data was presented for lighting projects. For instance, quantities were not correctly displayed for the baseline and efficient quantities, and some lines for baseline wattage was left empty. Any issue with the data was validated using the project documentation. Ultimately, these issues did not have an adverse effect on realization rates, but have been noted for posterity. Field work was performed to verify baseline and efficient equipment installation, quantities, and efficiencies. The test-in/test-out values for blower door testing was confirmed during the ride-alongs. Additionally, the use of incandescent bulbs as the baseline for the "LED Screw-In Bulb" measure was confirmed during the site-visits.

3.1.4.4 Impact Evaluation Findings

Impact evaluation findings determine net annual energy savings (kWh) and net coincident 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.

The program in 2022 consisted of 16 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. Verified savings and realization rates are shown in Figure 3-23. The solid line in the figure indicates a theoretical 100% realization rate. As shown in the figure, duct sealing, mobile home duct sealing, and air sealing are the measures with the largest impact on the program, all with realization rates of 100% for both energy savings and demand reduction. Duct sealing can be attributed to 37% of program savings. The top contributing measures are labeled while measures with minimal impact are not labeled. Those not labeled include, air conditioners, ENERGY STAR® washing machines, dryers, refrigerators, faucet aerators, new construction lighting (Space-by-Space), and lighting controls.

Figure 3-23: Multifamily and Manufactured Homes Reported vs. Verified Measure Level Energy Savings



The program level realization rate for gross annual energy savings is 100% with measure level variation from 92% to 151%. Figure 3-24 below illustrates the factors causing savings discrepancy and the frequency in which they occurred, while Figure 3-25 illustrates the change in savings affected due to these different factors.

Figure 3-24 Multifamily and Manufactured Homes Factors Affecting Realization Rates, Measures Affected

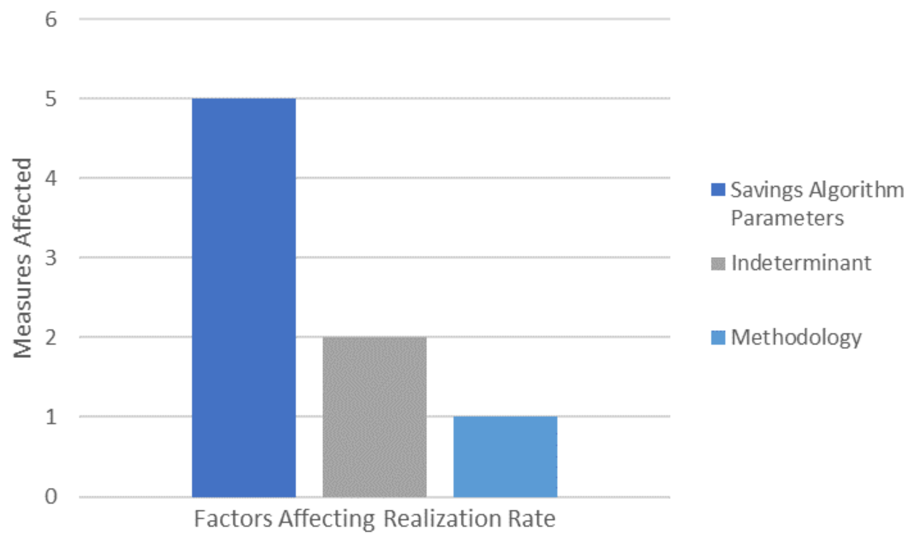
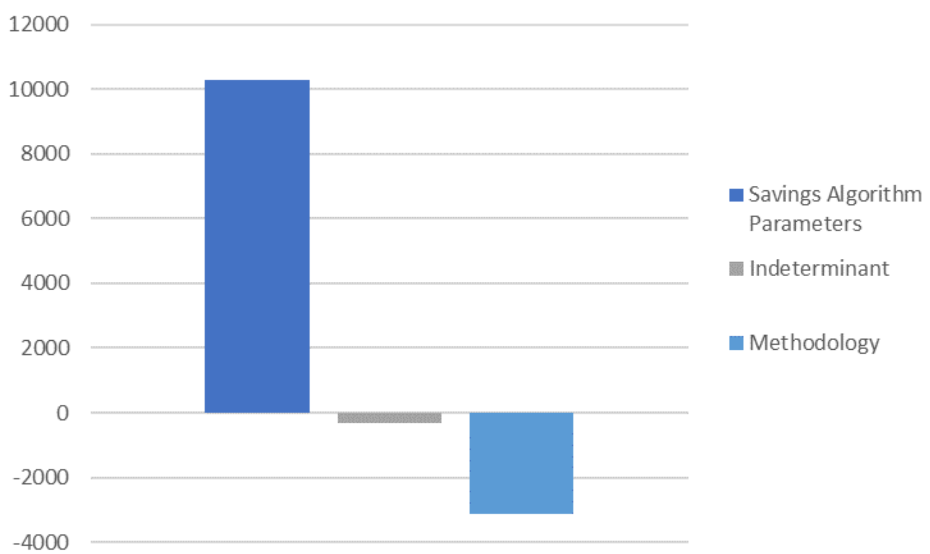


Figure 3-25 Multifamily and Manufactured Homes Factors Affecting Realization Rates, Savings



There was no discrepancy found in energy savings methodology 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. For these measures, the input difference could be anything from interactive effects, hours of use, or from spec sheets reflecting different efficiencies than what was reported. The measure where “Input” affected realization rates were faucet aerators, occupancy sensors, air conditioners, ENERGY STAR® Refrigerators, and retrofit lighting.

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 measures where this was chosen were whole building approach and space by space, both new construction lighting measures. Savings for both measures were determined using provided values and TRM inputs. The claimed savings could not be recreated to explain the reason for the discrepancy.

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. There was only one instance where this is applicable, which is for faucet aerators. Both the reported and verified savings calculations utilized the AR TRM for determining savings, however, the verified savings were determined using an optional, more precise method.

More detailed explanation for the savings discrepancies of the installed measures are included in the following section.

Table 3-78 details gross annual energy savings for each measure present in the program. Findings for measure types that deviated from reported estimates are explained below.

Table 3-78: Verified Gross Annual Energy Savings by Measure – Multifamily and Manufactured Homes Program

Equipment	Reported kWh	Verified kWh	kWh RR
Duct Sealing	1,355,977	1,356,245	100%
Mobile Home Duct Sealing	1,039,221	1,039,707	100%
Air Sealing	421,898	421,898	100%
Lighting	257,268	247,135	96%
Attic Insulation	186,547	189,676	102%
Heat Pump	140,214	140,214	100%
Low Flow Shower Head	85,634	85,630	100%
Window	53,403	53,403	100%
ENERGY STAR® Clothes Washer	29,835	29,835	100%
Space by Space	20,159	20,367	101%
ENERGY STAR® Clothes Dryer	13,400	13,399	100%
Faucet Aerator	12,427	12,526	101%
Whole Building Approach	11,914	12,037	101%
Occupancy Sensor (Lighting)	10,745	10,531	98%
ENERGY STAR® Refrigerator	5,394	5,021	93%
Air Conditioner	637	950	149%
Total	**3,644,673**	**3,638,574**	**100%**

Approximately two-thirds of program savings were attributed to multifamily facilities and one-third to manufactured homes. Reported and verified savings by building type is shown in Table 3-80.

Table 3-79: Multifamily and Manufactured Homes Reported and Verified Gross Savings by Building Type

Building Type	Reported kWh	Reported kW	Verified kWh	Verified kW
Manufactured Home	1,184,240	211.62	1,183,426	211.53
Multifamily Building	2,460,433	695.72	2,455,149	716.76
Program Total	3,644,673	907.34	3,638,575	928.29

3.1.4.4.1 Measure Level Gross Annual Energy Savings (kWh)

There was no discrepancy found in energy savings methodology for most of the energy efficiency measures in the program. Measures with a savings discrepancy are detailed below.

Faucet Aerator

The annual energy savings realization rate for faucet aerators is 101%. Line items for this measure can be sorted into two group, those in the Zone 7 weather zone and those in Zone 8. For the faucet aerators installed in Zone 7, the realization rate is 100%. For the faucet aerators installed in Zone 8, the verified energy savings realization rate is 101%. The only information from the tracking data utilized to determine savings are the quantities installed, all other inputs are taken from the AR TRM.

Occupancy Sensor (Lighting)

The annual energy savings realization rate for occupancy sensors measures is 98%. The only inputs for calculating savings provided are the hours of use, and the quantity and wattage of lights installed. It appears that the claimed savings are being calculated using a control power adjustment factor (PAF) of 0.65, which correspond to “occupancy sensor with daylighting control – ON/OFF” and a savings interactive effect of 1.0. The verified savings calculations also utilized the same PAF of 0.65, however, the savings interactive effect of 0.98 (Unknown Fuel Type) was used, as the fuel type for these projects was not included.

Retrofit Lighting

The annual energy savings realization rate for retrofit lighting measures is 96%. The realization is being affected by a large line item (40.9% of measure-level savings) that has an 87% realization rate. The project is using an energy savings interactive effect of 1.00 for the reported energy savings calculations, whereas the verified savings calculations utilize a value of 0.87 for electric resistance heating (AR TRM), based on the heating type for the facility reported in Sightline.

Attic Insulation

The annual energy savings realization rate for attic insulation is 102%. 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.

Whole Building Approach

The program tracking data included one project under Whole Building Approach. The project was a New Construction Lighting project so a lighting power density (LPD) savings approach was considered. The baseline condition was determined to be based on ASHRAE 90.1-2007; consistent with the AR TRM v8.1. The efficient condition was determined based on provided project documentation. Algorithm inputs used in this calculation were based on the provided project documentation and assumptions from the AR TRM v8.1.

Space by Space

The annual energy savings realization rate for this measure is 101% with a realization rate of 431% for demand reduction. This measure consists of a single New Construction Lighting project. Review of the project documents reveals that there were multiple space types within the project that should have been represented as their own line items, however only two of those line items were considered in reported calculations. The LPD methodology was used to determine verified energy savings, with ASHRAE 90.1 2007 representing the baseline condition. The efficient condition was determined from provided project documentation (hours of use, square footage, and installed wattage). Other assumptions were borrowed from the AR TRM v8.1, such as interactive effects.

ENERGY STAR® Refrigerator

The annual energy savings realization rate for this measure is 93%. Project documents were reviewed to determine the type of refrigerator that was installed and confirm the savings inputs provided in the project documentation matches the TRM. The inputs were taken from the TRM based on the equipment type installed, it was confirmed that the values match with what was presented in project documents, however the adjusted volume of the refrigerators do not match what is presented in the project documents. Even when utilizing the same adjusted volume as is presented in the project documents the analysis does not have a 100% realization rate, there appears to be an issue with the application of the TRM methodology for the reported savings calculation.

Central Air Conditioner

The annual energy savings realization rate for this measure is 149% with two line-items contributing to less than 1% of program savings. Verified savings impacts are based on efficiency ratings and capacities from the AHRI directory, based on the installed equipment, whereas the claimed savings impacts utilize the spec sheet ratings of the installed equipment.

3.1.4.4.2 Coincident Peak Demand Reduction (kW)

The overall realization rates for the peak demand reduction are 102%. The main difference in calculated peak demand reduction values is in the calculation for both space by space and whole building approach new construction lighting. Other discrepancies were found in air conditioners and EnergyStar® dryers. Discrepancies in the calculation of air conditioner kW is due to a difference in equipment efficiencies as determined by the AHRI certificates of installed air conditioners from the ratings listed in the tracking data.

The discrepancies for the new construction lighting measure are both covered under the discrepancy explanations in the section above.

The peak demand reduction realization rate for ENERGY STAR® Dryers is 10%. The reason for the discrepancy in peak demand reduction was determined to be a magnitude error in the coincidence factor used in the reported calculations. There were also realization rates of 46% and 70% for air conditioners and water heaters, respectively. The explanation for these discrepancies is the same as stated in the section above. Demand reduction by measure is shown in Table 3-80.

Table 3-80: Verified Gross Peak Demand Reduction by Measure – Multifamily and Manufactured Homes Program

Equipment	Total Reported kW	Total Verified kW	kW RR
Duct Sealing	364.10	364.11	100%
Mobile Home Duct Sealing	198.23	198.55	100%
Lighting	137.05	149.28	108%
Heat Pump	55.83	55.83	100%
Air Sealing	55.34	55.34	100%
Attic Insulation	40.29	40.82	101%
Window	18.37	18.37	100%
ENERGY STAR® Clothes Dryer	13.40	1.34	10%
Low Flow Shower Head	8.91	8.91	100%
ENERGY STAR® Clothes Washer	7.06	7.06	100%
Whole Building Approach	3.20	13.63	426%
Space by Space	2.91	12.53	388%
Faucet Aerator	1.29	1.30	101%
ENERGY STAR® Refrigerator	0.75	0.73	97%
Air Conditioner	0.60	0.49	82%
Total	**907.33**	**928.29**	**102%**

3.1.4.4.3 Net-To-Gross Estimation Findings

Survey data was collected to assign free ridership scores from property owners/manager. Free ridership has been determined based on seven self-claimed survey results of the property owners/managers.

There was no free ridership found in relation to any of the surveyed property owners/managers, as six of the surveyed answered no to having the financial ability to perform the projects themselves. The final survey participant had the financial ability to perform the project but had no plans to install energy efficient equipment prior to their exposure to the Multifamily program. The combined overall free ridership score for this program year for is 0% for both energy savings and peak demand reduction.

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

The NTG ratios are calculated as 1-free-ridership plus spillover. This results in a program level annual energy savings NTG of 100.0%. Results are shown in Table 3-81 for annual energy savings and Table 3-82 for peak demand reduction.

Table 3-81: 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	3,644,673	3,638,574	0	3,638,574	100.0%
Total	**3,644,673**	**3,638,574**	**0**	**3,638,574**	**100.0%**

Table 3-82: 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	907.33	928.29	0	928.29	100.0%
Total	**907.33**	**928.29**	**0**	**928.29**	**100.0%**

3.1.4.4.4 Lifetime Energy Savings

Lifetime energy savings were calculated by multiplying the annual energy savings by the effective useful life (EUL) from the corresponding AR TRM section. Lifetime energy savings and average EUL by measure type are shown in Table 3-83.

Table 3-83: Multifamily and Manufactured Homes Measure EUL's and Lifetime Energy Savings

Equipment	EUL	Gross Lifetime Savings (kWh)	Net Lifetime Savings (kWh)
Duct Sealing	18	24,412,409	24,412,409
Mobile home duct sealing	18	18,714,734	18,714,734
Air Sealing	11	4,695,561	4,695,561
Lighting	19	4,543,411	4,543,411
Attic Insulation	20	3,793,524	3,793,524
Heat Pump	16	2,243,422	2,243,422
Windows	20	1,068,064	1,068,064
Low Flow Shower Head	10	856,301	856,301
ENERGY STAR® Washing Machine	14	417,690	417,690
Space by Space (NC Lighting)	11	224,032	224,032
ENERGY STAR® Dryer	14	160,786	160,786
Whole Building Approach (NC Lighting)	11	132,407	132,407
Faucet Aerator	10	125,258	125,258
Occupancy Sensor (Lighting)	8	115,836	115,836
ENERGY STAR® Refrigerator	17	85,365	85,365
Air Conditioner	19	18,051	18,051
Total		**61,618,957**	**61,918,957**

3.1.4.5 Process Evaluation Findings

Process evaluation activities included a survey for property owners/managers, service provider interviews, and a facilitated discussion with program staff used to develop a customer journey map. A detailed process evaluation memo was provided to PSO after the completion of the 2022 program year.

3.1.4.5.1 Service Provider Perspectives

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

3.1.4.5.2 Owner/Manager Survey

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

3.1.4.5.3 Customer Journey Map

A facilitated discussion with program staff to support the development of a customer journey map for the program was performed. A customer journey map is a graphic representation of how a customer or participant interacts with a program or product. Key customer touchpoints were categorized into five phases: awareness, planning, installation, quality assurance and post-installation, and feedback.

The customer journey map includes customer thoughts as obtained during surveying efforts. These can be thought of as Key Moments of Truth (KMOT) for the customer or decisionmaker. More detail on each phase of the customer experience for a retrofit project is presented in Figure 3-26.

Figure 3-26: Multifamily Retrofit Decisionmaker Journey Map

Customer Group: Retrofit multifamily decisionmakers (property managers, owners)

Objective: Create a common understanding of the participation experience, identify key touchpoints & opportunities for program improvement

PSO MULTIFAMILY PROGRAM	AWARENESS	PLANNING	INSTALLATION	QUALITY ASSURANCE & POST INSTALLATION	FEEDBACK
TOUCHPOINT	*Service Providers, ICF/PSO Staff, Word-of-Mouth, or Internet Search*	*ICF Program Staff or Service Provider*	*Service Providers or participating company staff*	*ICF Program Staff; third-party-verifier (TPV), participating customer staff*	*ICF Program Staff, participating company staff, ADM*
CUSTOMER ACTION	1. Receive outreach from PSO/ICF Staff or Service Providers *OR* 1. Research available rebates and no-cost measure improvements available through Program on internet *OR* 1. Learn about program from friend, colleague, family	1. Work with Program staff, service provider, and TPV (as required) to determine appropriate measures to implement. 2. Assist service provider with required program paperwork/intake form (as needed) *OR* 2. Complete program paperwork/intake form with Program staff guidance or assistance	1. Coordinate with service provider to complete Program installations/improvements *OR* 1. Have internal staff or service provider complete rebated/no-cost measure installations	1. Coordinate with TPV, contractor or ICF staff to complete any post-installation requirements a) Test-in/out for air and duct sealing and HVAC installs b) Visual verification for lighting measures 2. Receive payment (if applicable)	1. Complete decision-maker survey and site visits with ADM Associates

CUSTOMER THOUGHTS	• **My property needs improvements. (KMOT)**
	  • Tenants are interested in improvements.
	  • The property would be more attractive to potential tenants with improvements.
	  • Improvements must meet company efficiency requirements.
	• Are there ways for me to get no cost or incentivized improvements for my property?
	• Is my property eligible for this program?
	• **Do I have the authority and ability to enroll my property? (KMOT)**
		• **What is the out-of-pocket, upfront cost for each improvement type? (KMOT)**
		• Is financing available?
		• What are the participation requirements for each improvement type?
		• **How can making improvements reduce property bill costs? (KMOT)**
			• How will I notify all tenants of the improvements?
			• How long will installation of program measures take?
			• Will it be a challenge to coordinate measure installation with the service provider?
				• **Did the equipment that we installed qualify for the Program incentive as expected? (KMOT)**
				• Coordination with the contractor and ICF/PSO staff was well executed.
					• I do not have time for a survey.
					• I am satisfied with improvements made through program, contractor, and overall program experience.
					• Can other properties we own or manage participate?
					• Can we complete additional upgrades at the participating property?

3.1.4.6 Conclusions and Recommendations

Evaluation of the Program consisted of a process and impact evaluation to determine verified net energy savings estimates as well as assess achievement of the program's objectives. A summary of program level impacts is shown in Table 3-84 and Table 3-85.

Table 3-84: Summary of Multifamily and Manufactured Homes Program Level Annual Energy Savings Impacts (kWh)

Program	Reported Gross kWh Savings	Verified Gross kWh Savings	Realization Rate	Net-to-Gross Ratio	Verified Net kWh Savings
Multifamily	3,644,673	3,638,574	100%	100.0%	3,638,574

Table 3-85: Summary of Multifamily and Manufactured Homes Program Level Coincident Peak Demand Impacts (kW)

Program	Reported Gross kW Savings	Verified Gross kW Savings	Realization Rate	Net-to-Gross Ratio	Verified Net kW Savings
Multifamily	907.33	928.29	102%	100.0%	928.29

The following conclusions were developed from the evaluation findings.

- The program pipeline from 2021 drove participation in 2022, with a minimal number of additional applicants accepted because of budget limitations.
- Decisionmaker satisfaction remains high. The decisionmaker survey results show high overall satisfaction with the program, though findings indicate opportunities to improve communication regarding the improvements performed, scheduling of improvements, and the quality of installation work.
- Service providers are instrumental for the program's implementation. The decisionmaker survey results showed that the service providers are driving program awareness and participation. Further, the facilitated discussion with program staff supported this finding as they mentioned the program's two primary service providers as both a strength and
- A limited number of participating properties received direct installation measures; these measures are no longer being offered through the program. ICF's technical specialist and participating service providers confirmed installation of direct install measures through the program in 2022, however the technical specialist noted that no additional low flow showerheads, high efficiency faucet aerators, LED light bulbs, and low flow showerheads were being purchased and only existing inventory was being provided through the program.
- Providing service providers additional information could ease and improve program participation. First Star Energy's owner observed that the process of

verifying home heating fuel type is time-intensive; if the program provided customer account information it would ease participation. The owner also suggested that receiving summary reports on their company's number of projects completed, with savings information and program details could help them gauge their impact and understand their performance within the program.

- The program is driven by HVAC and Building Envelope measures, which make up 87.74% of program savings. With increased minimum efficiency standards rolling out in 2023, it can be expected that program savings will decrease, but the measure mix should not be affected by the changes, unless there is a drastic change in program offerings
- Duct sealing was the largest contributor with program savings (37% of program portfolio), followed by mobile home duct sealing (29%), and air sealing (12%). A similar ratio should be similar in the future as multiple DI measures are no longer being purchased, with current projects being completed with existing inventory.

The following recommendations were developed for the Multifamily Program.

- Seek to engage with additional service providers and potentially expand network. Findings from the facilitated discussion indicated a threat to the program was its reliance on a limited number of service providers. Recruiting and working with additional service providers may better ensure program stability and mitigate this threat.
- Allocate additional program funding to meet demand for projects. Program staff and service provider interview findings suggest a surfeit of properties in PSO territory that would benefit from program participation. The program's multifamily-focused service provider indicated their company paused program operations in Spring due to program funding restrictions.

Ensure there is sufficient communication with participating decisionmakers regarding improvements made through the program. Service provider interviews and decisionmaker survey findings indicate there may be an opportunity to increase decisionmakers' awareness of the improvements completed and the impact of the program. Offering decisionmakers a summary report, coupled with a brief service provider discussion to review its details, could act to ensure awareness of the improvements made through the program. With greater decisionmaker understanding of participation details, they may more readily be able to understand and address potential tenant concerns and recommend the program to other decisionmakers. Further, understanding the benefits of program participation and energy efficiency more broadly will aid in market transformation as more multifamily decisionmakers are informed of weatherizing and upgrading building equipment.

3.1.5 Behavioral Modification

This chapter presents findings from the impact and process evaluation of the 2022 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 on 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. PY2022 was the first year that the current implementor, Opower, executed the program. In PY2019-PY2021, the Program had a different implementor.

As of 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 3-86 shows the performance metrics achieved by the program.

Table 3-86: Performance Metrics – Behavioral Modification Program

Metric	PY2022
Number of Customers	246,472
Budgeted Expenditures	$1,216,250
Actual Expenditures	$942,024
Energy Impacts (kWh)	
Projected Energy Savings	22,837,500
Reported Energy Savings	20,270,991
Gross Verified Energy Savings	22,186,468
Net Verified Energy Savings	22,186,468
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	3,513.46
Reported Peak Demand Savings	3,191.21
Gross Verified Peak Demand Savings	4,323.30
Net Verified Peak Demand Savings	4,323.30
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.25
Utility Cost Test Ratio	1.22

PSO's Behavioral program serviced 246,472 households during the 2022 program year. Table 3-87 shows the annual energy savings (kWh) per wave for PY2022.

Table 3-87: 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	58,771	0.3182	116.1	6,823,313	6,823,313
2	24,744	0.5553	202.7	5,015,609	5,015,609
3	33,059	0.2527	92.2	3,048,040	3,048,040
4	29,867	0.2649	96.7	2,888,139	2,888,139
5	100,031	0.1208	44.1	4,411,367	4,411,367
Total	**246,472**	**0.2466***	**90.0****	**22,186,468**	**22,186,468**

**Daily kWh savings per customer values are depicted in Table 3-87 with enough precision to represent the average annual kWh savings per customer accurately. In subsequent tables, they will be rounded to two decimal places.*

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

3.1.5.2 EM&V Methodologies

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 for cross-program participation.
- Treatment and control surveys to determine differences in LED purchasing patterns, potential impacts of the coronavirus pandemic, and customer satisfaction.
- In-depth interviews with program staff to support the process evaluation.

3.1.5.2.2 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. For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[37] With this assumption, a minimum sample size of 68 participants per wave was required, as shown in Equation 3-2.

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

Equation 3-2: Minimum Sample Size Formula for 90 Percent Confidence Level

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

Where:

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

3.1.5.2.3 Survey Objective

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

The survey was administered online using an emailed link to a randomly selected group of participants and controls. Reminder emails were sent as needed to increase the number of responses. The number of customers contacted, and number of surveys completed, by wave, is shown in Table 3-88.

Table 3-88: Behavioral Summary of Customers Contacted and Response Rates

Wave	Control Group		Treatment Group	
	Number of Customers Contacted	Number of Completed Surveys	Number of Customers Contacted	Number of Completed Surveys
1	919	40	951	31
2	1086	43	1087	45
3	940	43	965	36
4	311	32	317	38
5	110	43	110	27
Total	**3,366**	**201**	**3,430**	**177**

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 that participants were sent energy reports during 2022.
- 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 length 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.

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. Customers that were contacted for the Key Performance Indicators program were also included in the evaluation. Although one of 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 Appendix G to determine daily average electricity savings for treatment group members.

3.1.5.2.7 Calculation of Annual Energy Savings

The average daily annual energy savings for the post period treatment group is defined as coefficient β_4 in the regression model. 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 2022 and had not opted out of the program.

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 used to determine estimates for the Behavioral Modification Program during portfolio planning. An average value across the peak demand window was drawn from the energy savings curve. The peak demand window is defined as consumption non-holiday weekdays between 2 PM and 6 PM in the months of June through September.

3.1.5.2.9 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 group. The NTG ratio is assumed to be 1, because the RCT design minimizes selection bias and the only assumed difference between the treatment and control groups is the receipt of energy reports.

3.1.5.2.10 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

ADM evaluators completed a process evaluation of the PSO Behavioral Program. The Behavioral program provides energy usage reports to residential customers, known as Home Energy Reports (HERs). The program was designed to generate greater awareness of energy use and suggests ways to reduce energy use through behavioral changes. The evaluators conducted participant and non-participant surveys to assess program design, operations, and delivery.

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 the response rate?
- Were the reports delivered according to the planned schedule and frequency, enrolled participants, and by program design?
- Do program utility and implementation contractor staff effectively coordinate to deliver the program? Were there any changes related to the new implementation contractor, Opower?
- What is the customer opt-out rate? Do staff track reasons for opting out and, if so, what reasons are given?
- What is the utilization rate of the additional engagement tools (e.g., customer portals)? Are there any additional engagement tools that the program employs?
- 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?
- To what extent is social desirability bias influencing the responses to questions related to energy saving actions and purchases? Can rephrasing these questions reduce social desirability bias?

Table 3-89 below summarizes the data collection activities and corresponding process evaluation research objectives used to complete the process evaluation.

Table 3-89: 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.
Participant Online Survey	Assess experience with and perceptions of the reports and other information on home energy use, actions taken to reduce energy use, satisfaction, and efficient equipment purchases (including LEDs).
Non-participant Online Survey	Assess actions taken to reduce energy and efficient equipment purchases (including LEDs).
Program Staff Facilitated Discussion	Assess program staff perspectives regarding program operations, strengths, or barriers to success.

3.1.5.3 Impact Evaluation Findings

The following section reports the findings for PY2022 annual energy savings and coincident 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 3-90.

Table 3-90: 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	13,305	42.41	58,287	42.34	0.33
2	10,380	48.61	24,636	48.64	0.77*
3	16,555	35.05	33,047	35.07	0.57
4	8,609	39.92	29,798	40.01	0.32
5	24,316	34.55	99,228	34.47	0.18

* *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 that there was a statistically significant difference in the rate at which Wave 2 and Wave 4 treatment and control group customers participated in the Energy Savings Products Program (ESP). Members of the treatment and control groups for Waves 2 and 4 who participated in the program 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 3-91 shows the results of the t-tests for each program and wave. The p-value showing evidence of a statistically significant difference is bolded.

Table 3-91: Behavioral Cross Participation with other PSO Residential Programs

ESP program					
Behavioral Program Wave	**Control Group**		**Treatment Group**		**t-test**
	n	**%**	**n**	**%**	**p-value**
1	48	0.36%	204	0.35%	0.930
2	21	0.20%	79	0.32%	**0.071**
3	27	0.16%	70	0.21%	0.300
4	8	0.09%	59	0.20%	**0.056**
5	35	0.14%	161	0.16%	0.581
Home Weatherization					
Behavioral Program Wave	**Control Group**		**Treatment Group**		**t-test**
	n	**%**	**n**	**%**	**p-value**
1	79	0.59%	306	0.52%	0.375
2	35	0.34%	106	0.43%	0.234
3	68	0.41%	162	0.49%	0.256
4	36	0.42%	132	0.44%	0.832
5	73	0.30%	331	0.33%	0.452
Home Rebates, Multiple Upgrades					
Behavioral Program Wave	**Control Group**		**Treatment Group**		**t-test**
	n	**%**	**n**	**%**	**p-value**
1	44	0.33%	194	0.33%	1.000
2	29	0.28%	51	0.21%	0.250
3	41	0.25%	70	0.21%	0.476

4	21	0.24%	74	0.25%	1.000
5	38	0.16%	136	0.14%	0.534
Home Rebates, Single Upgrade					
Behavioral Program Wave	**Control Group**		**Treatment Group**		**t-test**
	n	**%**	**n**	**%**	**p-value**
1	51	0.38%	250	0.43%	0.497
2	42	0.40%	104	0.42%	0.866
3	47	0.28%	103	0.31%	0.671
4	31	0.36%	119	0.40%	0.679
5	48	0.20%	186	0.19%	0.811
Key Performance Indicators					
Behavioral Program Wave	**Control Group**		**Treatment Group**		**t-test**
	n	**%**	**n**	**%**	**p-value**
1	6	0.05%	14	0.02%	0.308
2	0	-	1	0.00%	1.000
3	0	-	4	0.01%	0.377
4	2	0.02%	3	0.01%	0.684
5	0	-	9	0.01%	0.287
Multifamily					
Behavioral Program Wave	**Control Group**		**Treatment Group**		**t-test**
	n	**%**	**n**	**%**	**p-value**
5	10	0.04%	66	0.07%	0.199
Power Hours					
Behavioral Program Wave	**Control Group**		**Treatment Group**		**t-test**
	n	**%**	**n**	**%**	**p-value**
1	25	0.19%	126	0.22%	0.582
2	21	0.20%	41	0.17%	0.567
3	10	0.06%	37	0.11%	0.111
4	20	0.23%	71	0.24%	1.000
5	52	0.21%	253	0.25%	0.279

Since the participants of the ESP upstream lighting program are unknown, ADM surveyed Behavioral Program treatment and control participants to understand their lighting purchases. To determine if there was program uplift on upstream LED purchases due to the Behavioral Modification program, ADM performed a two-sample t-test on the treatment and control survey data results regarding lighting purchases. The results are provided in Table 3-92. The t-test shows that there was no significant program uplift in LED purchases due to the Behavioral Modification program.

Table 3-92: Behavioral Cross Participation with ESP's Upstream Lighting Program

Control Group		Treatment Group		t-test p-value
Mean Number of LEDs Purchased	n	Mean Number of LEDs Purchased	n	
15.6	22	14.6	21	0.79

3.1.5.3.3 Data Cleaning

Table 3-93 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, the participant had opted out of the program, billing records were abnormal or outliers, or participants had insufficient data to include in the panel regression analysis. A description of the data cleaning steps is provided in Section 3.1.5.2.4.

Table 3-93: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	29,724	121,334
Participants not listed in billing data	14,395	62,895	11,295	26,658	17,818	35,757	9,547	33,024	29,484	120,366
Participants not active PSO customers in the program year	13,427	58,789	10,417	24,746	16,565	33,063	8,621	29,877	24,477	100,046
Participants who opted out of email and mailed reports	13,427	58,771	10,417	24,744	16,565	33,059	8,621	29,867	24,477	100,031
Filter to participants with actual billing readings	13,427	58,771	10,417	24,744	16,565	33,059	8,621	29,867	24,477	100,031
Removed outliers	13,418	58,748	10,405	24,720	16,558	33,050	8,618	29,857	24,442	99,873
Accounts with insufficient data	13,418	58,748	10,405	24,720	16,558	33,050	8,618	29,857	24,388	99,623
Accounts before Control Matching and Cross Participant Removal	13,305	58,287	10,401	24,713	16,555	33,047	8,617	29,855	24,316	99,228
Number of accounts in final model:	13,305	58,287	10,380	24,636	16,555	33,047	8,609	29,798	24,316	99,228

* *"Treatment Group"*

3.1.5.3.4 Calculated Energy Savings (kWh)

Table 3-94 provides the results of the mixed-effects panel regression model. A negative coefficient indicates daily savings attributable to the program.

Table 3-94: Behavioral Results of Mixed Effect Panel Regression Modeling

Wave	Post × Treat Coefficient	Standard Error	T-Statistic	P-Value	R-Squared
1	-0.32	0.06	-5.53	<0.001	0.70
2	-0.56	0.08	-6.58	<0.001	0.73
3	-0.25	0.05	-5.54	<0.001	0.61
4	-0.26	0.08	-3.39	<0.001	0.69
5	-0.12	0.04	-2.71	0.007	0.73

3.1.5.3.5 Total Annual Energy Savings (kWh)

Annual energy savings per customer were determined by multiplying the daily kWh 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 3-95.

Table 3-95 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	58,771	0.32	116.1	6,823,313	6,823,313
2	24,744	0.56	202.7	5,015,609	5,015,609
3	33,059	0.25	92.2	3,048,040	3,048,040
4	29,867	0.26	96.7	2,888,139	2,888,139
5	100,031	0.12	44.1	4,411,367	4,411,367
Total	**246,472**	**0.25***	**90***	**22,186,468**	**22,186,468**

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

The average daily savings in 2022 are comparable to the average savings from 2021. The average daily savings for each wave from 2019 through 2022 are shown in Table 3-96.

Table 3-96 Behavioral Program Average Daily Savings, by Wave, from 2019-2022

Wave	Daily kWh Savings per Customer, PY2019	Daily kWh Savings per Customer, PY2020	Daily kWh Savings per Customer, PY2021	Daily kWh Savings per Customer, PY2022	2021 to 2022 Change
1	0.10	0.29	0.31	0.32	+0.01
2	0.20	0.47	0.42	0.56	+0.14
3	0.16	0.24	0.20	0.25	+0.05
4	-	0.24	0.23	0.26	+0.03
5	-	-	-	0.12	-
Weighted Average	**0.14**	**0.30**	**0.29**	**0.25**	**-0.04**

3.1.5.3.6 Coincident Peak Demand Reduction (kW)

The peak demand reduction results by wave are reported in Table 3-97.

Table 3-97: Behavioral Program Coincident Peak Demand Reduction, by Wave

Wave	Number of Treatment Customers	Verified Net kW Peak Reduction
1	58,771	1,329.60
2	24,744	977.35
3	33,059	593.95
4	29,867	562.79
5	100,031	859.61
Total	**246,472**	**4,323.30**

3.1.5.3.7 Verified Gross Impacts

Verified and reported annual energy savings (kWh) as well as peak demand reduction (kW) are shown in Table 3-98.

Table 3-98: 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
20,270,991	3,191.21	22,186,468	4,323.30	109%	135%

3.1.5.3.8 Net and Lifetime Evaluation Impacts

As described in the methodology section, net impacts are equivalent to gross impacts for the Behavioral Modification Program. The effective useful life of the Behavioral

Modification Program is 1 year, making the lifetime energy savings equivalent to the annual energy savings.

3.1.5.4 Process Evaluation Findings

A facilitated discussion of the logic model was developed with program staff during PY2022. The logic model developed by ADM provided an illustrative overview of the short, intermediate, and long-term goals of the program through a series of inputs, activities, and outputs. Based on the results of the discussion, the logic model was updated to reflect program design, delivery, and implementation.

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. Ultimately, the more customers adopt energy efficiency practices, the more they impact market transformation within the PSO service territory.

As the Behavioral program continues to educate PSO customers and improve, program staff hope to see more adoption of energy efficiency measures by PSO customers, increased customer engagement with the portal, increased energy savings, and further changes to the current market. To see a summary of the logic model, see Figure 3-27 for more details.

Figure 3-27 Behavioral Program Logic Model

<table>
<tr><th>Inputs</th><th>Activities</th><th>Outputs</th><th>Short-term Outcomes</th><th>Intermediate Outcomes</th><th>Long-term Outcomes</th></tr>
<tr><td>Resources to implement activities and produce outputs</td><td>Activities implemented to produce outputs</td><td>Products and services delivered</td><td>Immediate results achieved following delivery of output</td><td>Results expected to lead to the end outcome</td><td>Ultimate desired change because of program</td></tr>
<tr><td rowspan="6">PSO Staff
Portfolio plan
Opower Staff
PSO Customers
Budget
Utility Stakeholders and other Partners
Data systems
Website
Customer portal
ADM Associates
Participant survey data</td><td>Develop an eligible cohort of customers to receive home energy reports, along with the control</td><td>Participant and control waves</td><td>Increase interest in energy efficiency among participants</td><td>Increased energy saving among the treatment group compared to the control group</td><td rowspan="2">Improved HERs content and engagement with energy efficiency behaviors</td></tr>
<tr><td>Design report template and content for HERs; Modify HERs as needed to address customers' concerns or feedback</td><td>HER template and content for mail and email; updated as needed</td><td>Increase participant engagement with HERs and other energy efficiency programs</td><td>Change in energy efficiency knowledge and program awareness</td></tr>
<tr><td>Design a schedule for mailed and emailed HERs</td><td>HERs delivery schedule (monthly emailed HERs and every other month mailed HERs)</td><td>Ensure timely delivery of emailed and mailed HERs</td><td>Increase participant satisfaction (e.g., JD Power Scores) with HERs</td><td rowspan="2">Increased kWh savings for Behavioral program</td></tr>
<tr><td>Identify and tailor energy saving tips for customers</td><td>Tailored and useful energy saving tips</td><td>Monitor customer engagement with energy saving tips</td><td>Increase the adoption of energy saving tips and implementation of energy efficient behaviors</td></tr>
<tr><td>Monitor opt-out rates and other program metrics (customer attrition)</td><td>Monthly, quarterly reports with program-specific metrics</td><td>Monitor and track customer attrition to add new participants</td><td>Continuously adding new customers to meet goals</td><td rowspan="2">Increased engagement among customers with portal</td></tr>
<tr><td>Maintain customer portal</td><td>Current and up-to-date customer portal</td><td>Implement Continuous Quality Improvement (CQI) strategies</td><td>Increase customer visits to portal</td></tr>
<tr><td colspan="3">Assumptions, Factors, and Barriers impacting Product/Service Delivery</td><td colspan="3">Assumptions, Factors, and Barriers impact achievement of outcomes</td></tr>
</table>

Process evaluation activities included 378 participant survey responses, an interview with the PSO Program manager, and an interview with the implementer. ADM provided a process evaluation memo to PSO in December of 2022 with detailed findings. The following summarizes the key findings from the process evaluation of the Behavioral Modification Program. The PSO Behavioral Program remained consistent with previous years.

Participant satisfaction was reported for several program characteristics and has remained consistently high from 2019 to 2022. Ratings on the information provided in the energy reports as well as the frequency and method of receiving the reports were high with over 70% of respondents reporting being satisfied or very satisfied. Results are shown in Table 3-99.

Table 3-99: Behavioral Program Year Comparison of Satisfaction with HERs Aspects

Satisfaction	2019	2020	2021	2022
Information Provided on Home's Energy Use				
1 – Very dissatisfied	2%	1%	3%	5%
2	3%	1%	3%	6%
3	11%	14%	13%	13%
4	31%	22%	28%	24%
5 – Very satisfied	51%	60%	52%	50%
Don't know	2%	2%	1%	2%
Number of Emails Received on Home's Energy Use				
1 – Very dissatisfied	1%	1%	1%	3%
2	3%	4%	3%	5%
3	14%	19%	17%	14%
4	30%	23%	26%	22%
5 – Very satisfied	45%	48%	47%	48%
Don't know	8%	5%	7%	8%
Frequency of Receiving HER				
1 – Very dissatisfied	1%	1%	1%	3%
2	2%	4%	5%	5%
3	13%	9%	14%	14%
4	28%	26%	22%	18%
5 – Very satisfied	50%	56%	56%	53%
Don't know	6%	4%	2%	6%
Method of Receiving HER				
1 – Very dissatisfied	1%	1%	2%	3%
2	1%	2%	2%	2%
3	9%	8%	11%	15%
4	23%	26%	24%	15%
5 – Very satisfied	64%	63%	59%	60%
Don't know	2%	0%	2%	4%
Note: percentages may exceed or be less than 100% due to rounding errors.				

The amount of participant interactions with available online tools can be used as an indicator of interest in performing energy efficiency actions. Eleven percent of survey respondents recalled logging onto the Energy Management Tool web portal—the same percentage as in PY2021. Among those who accessed the portal, a large majority (90%) stated they viewed information about their home's energy use.

Most respondents who said they had not logged on to Energy Management Tool indicated they were not aware of the portal (41%) or were getting all the information they needed from the HERs (20%), (see Table 3-100).

Table 3-100: Primary Reason why Customers had not logged onto the Energy Management Tool – Behavioral Program

Reason	Percent of Respondents (n = 205)
Was not aware of the Energy Management Tool	41%
Was getting all the information needed from the Home Energy Reports	20%
Not interested	15%
Do not have the time	11%
Unable to log onto My Energy Advisor (technical difficulties)	2%
Other	4%
Don't know	5%

The likelihood of logging onto the Energy Management Tool was positively related to having received both the email and paper HER, with 20% reporting that they logged onto the web portal, compared to none of those who recalled receiving only the mailed version and 6% who recalled only receiving emailed HERs.

3.1.5.5 Discussion of Findings

Sixty-three percent of Behavioral Program survey respondents in the treatment group reported that they adopted energy saving behaviors in 2022 compared to 43% of the control group respondents. This 20% difference between the treatment and control group was statistically significant (Pearson's Chi-squared test, $p < 0.1$).

There were several key differences—in reported energy savings, survey responses, and demographics—between waves. Wave 2 in PY2022 had an increase of average daily energy savings per customer of 0.14 kWh compared to last year. This wave also had the highest average daily energy savings per customer in PY2020 and PY2021 (0.47 and 0.42 kWh respectively).

Survey respondents for the Wave 2 treatment group were just as likely to report that they adopted energy saving behaviors in 2022 as the other legacy waves (Pearson's Chi-squared test, $p = 0.4728$). Compared to the other legacy waves, Wave 2 treatment group survey respondents were just as likely to have positive energy saving attitudes. One exception was the question: “It is possible to be energy efficient without sacrificing comfort”—significantly more Wave 2 participants agreed with that statement compared to other legacy waves (Pearson’s Chi-squared test, $p < 0.1$).

Where Wave 2 differed from the other waves was homeownership. Wave 2 respondents were more likely to be homeowners compared to respondents for the other legacy waves (Pearson’s Chi-squared test, $p < 0.1$). Research has found that, renters are just as[38] if not more likely[39] to have positive energy saving attitudes compared to homeowners. However, homes occupied by renters tend to be less energy-efficient[40,41,42] because they have less control over when energy efficiency upgrades are made to their homes[41,42]. In the Behavioral Program survey, renters in all waves were less likely to indicate that they took energy saving actions compared to homeowners, exemplifying this phenomenon.

In 2019-2021, the previous implementor excluded multifamily homes as part of their data cleaning process[43]. Because Opower did not implement a similar data cleaning step, Wave 5 was the only wave to have multifamily cross-participants (Table 3-91) and had a higher proportion of both multifamily residents and renters compared to the other waves (Pearson’s Chi-squared test, $p < 0.1$). Wave 5 also had the lowest average daily energy savings per customer of all waves. If a portion of the difference in energy savings between Wave 5 and the legacy waves is due to the higher proportion of renters in this wave, then it is expected energy savings will continue to be lower for this wave—and future waves with a greater proportion of multifamily premises—compared to Waves 1-4. Nevertheless, it is still beneficial to encourage energy savings behaviors among renters and multifamily households. Wave 5 was the only wave where significantly more treatment participants agreed with the statement “My community is taking steps to become more energy efficient” compared to the control (Pearson's Chi-squared test, $p < 0.1$). This difference suggests that the Behavioral Program is both encouraging participants to save more energy as individuals, and to believe that other members of their community are doing the same.

[38] Buck, Linda E.. “Comparison of Oregon renters' and non-renters' home energy conservation behavior, belief about the U.S. energy problem, belief about their home energy efficiency, and belief about four energy policy directions.” (1981). https://ir.library.oregonstate.edu/downloads/ff365809g

[39] https://www.naahq.org/maximize-resident-engagement-energy-efficiency. Last Accessed: March 1, 2023.

[40] https://www.jchs.harvard.edu/blog/are-renters-less-energy-efficient-than-homeowners. Last Accessed: March 1, 2023.

[41] M.N.M. Souza, “Why are rented dwellings less energy-efficient? Evidence from a representative sample of the U.S. housing stock”, Energy Policy, Volume 118, 2018, Pages 149-159, ISSN 0301-4215, https://doi.org/10.1016/j.enpol.2018.03.013.

[42] Krishnamurthy, Chandra Kiran B and Kriström, Bengt, How Large is the Owner-Renter Divide? Evidence from an OECD Cross-Section (October 30, 2013). CERE Working Paper, 2013:8, Available at SSRN: https://ssrn.com/abstract=2378890 or http://dx.doi.org/10.2139/ssrn.2378890

[43] “Public Service Company of Oklahoma 2021 Energy Efficiency & Demand Response Programs: Annual Report,” ADM Associates, Inc., 2021.

3.1.5.6 Conclusions and Recommendations

This section presents conclusions and recommendations based on evaluation of the program for the 2022 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 for PY2022. The verified net annual energy savings totaled 22,186,468 kWh and the verified net peak demand reduction totaled 4,323.30 kW—which translated to realization rates of 109% and 135% respectively.
- Significantly more treatment group participants reported adopting energy saving behaviors in 2022 compared to the control group.
- Wave 2 had both the highest average daily energy savings per customer (0.56 kWh) and a significantly higher percentage of homeowners among survey respondents compared to the other waves. Wave 5 had the lowest average daily energy savings per customer (0.12 kWh) While first-year waves are more likely to have low savings compared to historical waves, it is also important to note that Wave 5 had a significantly lower percentage of homeowners among survey respondents compared to the other waves, which could impact savings in future years. Overall, renters were less likely to indicate they took energy saving actions compared to homeowners.
- Over 70% of respondents are satisfied with the information presented in the HERs and about 70% of respondents are satisfied with the number of emails sent.
- Only 11% of respondents are using the Energy Management tool with a plurality of those who had not logging 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.

- Develop customer engagement campaigns to increase customer awareness of the Energy Management Tool. Program staff indicated the online program portal continues to be an important aspect of the program. However, just 11% of survey respondents recalled logging onto the Energy Management Tool web portal. This finding suggests that few customers are aware of the additional tool to monitor energy usage in their home. The program might benefit from additional campaigns to increase awareness and usage of the web portal.

- Encourage more HERs participants to complete home profiles to increase customer confidence in their energy usage. Some survey respondents indicate there are unique attributes about their homes and do not feel like they are considered in their report. To increase participant confidence in their home energy reports, program staff could encourage customers to complete their home profile.
- Consider accounting for participants who are renters and tailor energy saving tips for this group. Renters were less likely to indicate they took energy saving actions compared to homeowners. While some of this could be related to fewer opportunities for renters compared to homeowners, if renters had more tailored tips, they may adopt energy saving actions at similar rates to homeowners.
- Continue to treat Waves 1 and 2. These waves continue to have average daily energy savings that are greater than the other waves, and treating these waves can increase our understanding of how behavioral program waves respond to increased longevity as the program matures overall.
- Continue to include multifamily residents in future waves. Including multifamily residents in Wave 5 has allowed for a more holistic view of how the Behavioral Program is affecting a more diverse population. Wave 5 survey respondents in the treatment group also reported that their community was taking more steps to conserve energy compared to the control.
- 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 2022 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, and Custom and Prescriptive (C&P). The program offers incentives for many commercial and industrial measures including lighting, plug load & controls, insulation, Appliance & Equipment, HVAC, 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 program is designed to influence distributor stocking practices, as well as promote the sale of higher efficiency equipment, such as light bulbs, air conditioners, and heat pumps. This subprogram allows customers to receive instant rebates on qualifying equipment through distribution channels. The program is focused on lighting and HVAC distributors.

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[44], 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). PSO has partnered with GridPoint to provide commercial customers with an innovative technology platform that helps with automating energy and facility management. Using artificial intelligence, the platform will learn your building's energy patterns and communicate via installed controls to help it be more efficient.

3.2.2 Evaluation Summary

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

The Business Rebates Program exceeded annual energy savings goals within budget for the 2022 program year. Table 3-101 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 3-101: Performance Metrics – Business Rebates Program

Metric	PY2022
Number of Projects	976
Budgeted Expenditures	$11,757,461
Actual Expenditures	$10,865,860
Energy Impacts (kWh)	
Projected Energy Savings	39,487,056
Reported Energy Savings	42,243,078
Gross Verified Energy Savings	45,285,221
Net Verified Energy Savings	41,998,395
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	8,021
Reported Peak Demand Savings	7,837.06
Gross Verified Peak Demand Savings	8,913.70
Net Verified Peak Demand Savings	8,455.62
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.58
Utility Cost Test Ratio	2.20

The evaluation included a process evaluation as well as an impact evaluation. Evaluation activities included surveying, in-depth interviews, program tracking data review, field verification visits, gross energy savings analysis, and net energy savings analysis. Table 3-102 summarizes the achieved sample sizes for the various data collection activities for the Business Rebates Program evaluation.

Table 3-102: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size		
	Custom/Prescriptive	SBES	Midstream
On-Site M&V Visits & Engineering Analysis	41	21	-
Engineering Desk Reviews Only (including billing regression analysis and provided system trend data)	1		Census (2)
Customer Decision Maker Survey	47	40	27
Program Staff Facilitated Discussions	2	1	1
Trade Ally or Distributor (Midstream) Survey	9	4	5

The evaluation determined overall gross annual energy savings were higher than estimated. Differences at the project level can be attributed to the estimate of annual operating hours, baseline condition variables, efficient equipment quantities, and algorithm discrepancies. When accounting for the effects of free-ridership and spillover, the net program savings are approximately 1% below reported annual energy savings. Free ridership was determined through interviews and survey results with participants. Free ridership scores are based on participant responses to questions regarding the influence of the Business Rebates program on their decision to install energy efficient equipment.

3.2.3 Custom and Prescriptive

PSO's Business Rebates Program seeks to generate energy savings for custom and prescriptive projects by promoting high-efficiency electric end-use products. The program allows PSO's customers to participate by either self-sponsoring or by working through a third-party service provider to leverage technical expertise. The program seeks to combine the distribution of financial incentives with access to technical expertise to maximize program penetration across the range of potential commercial and industrial customers. Additionally, the program aims to accomplish the following:

- Increase customer awareness and knowledge of applicable energy-saving measures and their benefits,
- Increase the market share of commercial-grade high-efficiency technologies sold through market channels,

And increase the installation rate of high-efficiency technologies in C&I facilities by businesses that would not have done so in absence of the program.

For custom and prescriptive projects, a 110% realization rate for gross energy savings and a 123% realization rate for gross peak demand reduction was found. A net-to-gross ratio of 92% for energy savings and 94% for peak demand reduction was found.

3.2.3.1 Impact Evaluation Overview

PSO's prescriptive and custom projects provided rebates for a total of 440 projects. Lighting system retrofit projects continued to be the main source of program savings with approximately 46% of reported annual energy savings (kWh). Agriculture projects represented 30% of reported savings and had the largest increase when compared to last year (4% in 2021). Custom projects accounted for approximately 8% of reported savings (down from 18% in 2021), and projects with multiple measures account for approximately 3%. Individual measures within this category differed across 9 different projects, roughly two-thirds included a lighting component. A breakdown of measure type (aggregated by category based on provided measures type) by the percentage of program savings is shown in Table 3-103.

Table 3-103: Measure Type as Percentage of Reported Annual Energy Savings

Aggregated Measure List	Percent of Program
Retrofit Lighting	46%
Agriculture	30%
Custom	8%
Oil & Gas	7%
New Construction Lighting	4%
Multiple	3%
Refrigeration & Kitchen Equipment	<1%
SEM MiD	<1%
HVAC VFD	<1%
Business Appliances	<1%
Total	**100%**

Overall, the number of rebated projects decreased from 456 in 2021 to 440 in 2022, however, the magnitude of reported annual energy savings increased by approximately 2%. Compared to 2021, Agriculture saw a substantial increase (+26%) in reported savings while sites with multiple measures (including lighting and non-lighting measures in the same project) had the largest decrease (-26%) in reported savings. Table 3-104 provides a summary of Custom and Prescriptive project savings in the program.

Table 3-104: Performance Metrics – Custom & Prescriptive

Metric	PY2022
Number of Projects	440
Energy Impacts (kWh)	
Reported Energy Savings	31,588,374
Gross Verified Energy Savings	34,751,340
Net Verified Energy Savings	32,018,506
Peak Demand Impacts (kW)	
Reported Peak Demand Savings	5,363.46
Gross Verified Peak Demand Savings	6,578.54
Net Verified Peak Demand Savings	6,197.03
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.54
Utility Cost Test Ratio	2.80

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 application process or energy consultant, and program satisfaction. A total of 47 customer decision makers responded to the participant survey. A detailed process evaluation memo was provided to PSO in December 2022.

Participation in the program accelerated toward the end of the year. Figure 3-28: Accrual of Reported kWh Savings During the Program Year

displays the accrual of reported energy savings as well as the monthly savings into the program.

Figure 3-28: Accrual of Reported kWh Savings During the Program Year

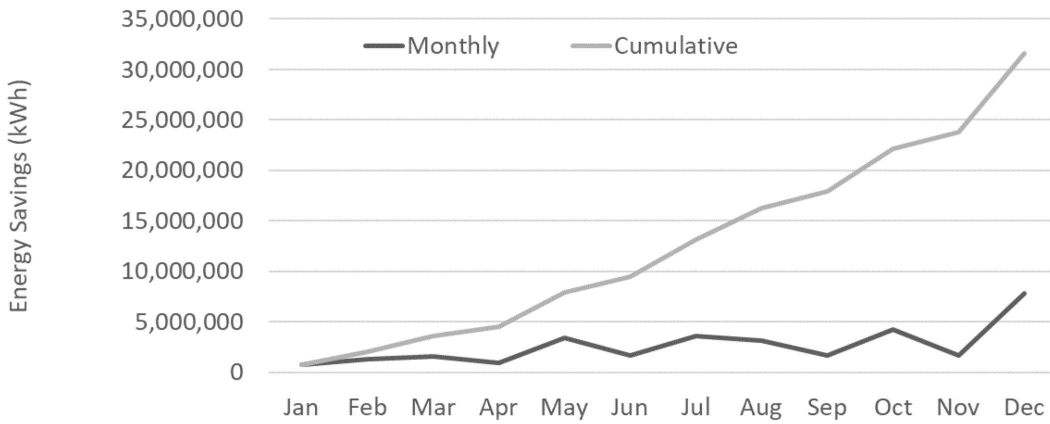


Table 3-105 summarizes the share of reported savings by district. As with past program years, a large amount of savings comes from the Tulsa region; however, compared to the previous program year, the Eastern District saw a significant increase (+19%) in annual energy savings.

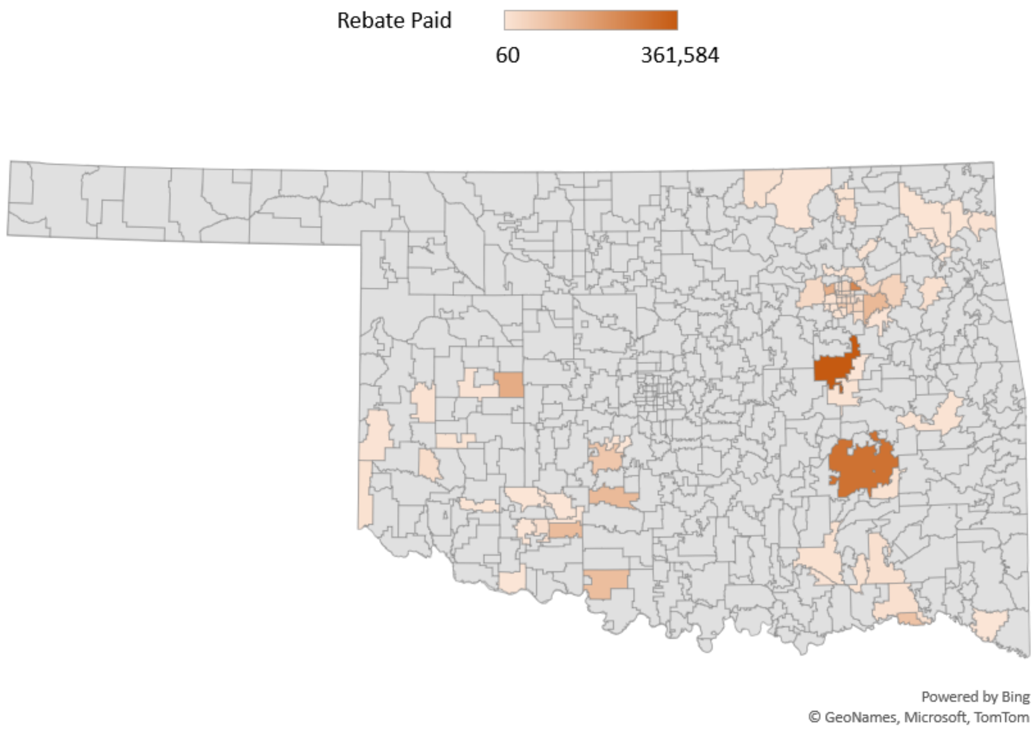
Table 3-105: District Share of Reported kWh Savings

Region	Sum of Reported Energy Savings (kWh)	Percentage of Program kWh	Reported Rebate Dollars Paid	Percent of Reported Rebate Dollars Paid
Eastern District	9,047,468	29%	$900,658	32%
Tulsa District	15,189,007	48%	$1,205,160	42%
Tulsa Northern District	945,474	3%	$111,642	4%
Western District	6,406,425	20%	$637,098	22%
Total	**31,588,374**	**100%**	**$2,854,558**	**100%**

A detailed depiction of geographic incentive allocation is shown in Figure 3-29: Distribution of Custom and Prescriptive Projects

This heat map shows the concentration of incentive dollars throughout the PSO Territory based on zip code.

Figure 3-29: Distribution of Custom and Prescriptive Projects



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

3.2.3.3 Evaluation Methodology

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 Appendix G:.

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), 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 verification visits are performed for projects selected in the random sample. For 2022, verification visits were achieved physically on-site. 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, compressed air, and cooling tower equipment) were 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. In the situation where observations and information is not available during on-site verification, these 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 nine program contractors. ADM researchers facilitated a discussion with program staff in October 2022. Table 3-106 shows the achieved sample sizes for the different types of data collection utilized for this evaluation.

Table 3-106: Sample Sizes for Data Collection Efforts

Data Collection Activity	Achieved Sample Size
On-site M&V Visits	41
Sample Desk Review	1
Customer Decision Maker Surveys	47
Trade Ally Surveys	9
Program Staff Facilitated Discussion	1

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.

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

The sample size was designed to meet reported annual energy savings at ±10% precision at the 90% confidence level for the program. Separate samples were drawn for custom and prescriptive projects, SBES projects, and Midstream projects. Table 3-107 shows the sample design that was used for custom and prescriptive projects. Stratum classifications were based on verified measure installations. The 42 projects that were sampled for evaluation verification account for approximately 40% of reported program annual kWh savings.

Table 3-107: Sample Design for Prescriptive and Custom

Stratum Name	Reported kWh Savings	Strata Boundaries (kWh)	Population of Projects	Design Sample Size
Custom & Other 1	188,837	229 – 22,992	23	2
Custom & Other 2	2,008,647	28,109 – 160,613	28	3
Custom & Other 3	3,417,845	182,078 – 575,643	11	4
Custom & Other 4	10,106,296	657,165 – 1,892,573	8	6
NC Lighting 1	623,200	11,298 – 95,657	12	2
NC Lighting 2	695,415	153,683 – 369,529	3	2
Prescriptive 1	65,270	61 – 9,825	27	4
Retrofit Lighting 1	2,238,338	88 – 29,552	211	7
Retrofit Lighting 2	4,618,309	30,218 – 117,543	74	6
Retrofit Lighting 3	3,343,026	124,266 – 279,104	19	2
Retrofit Lighting 4	4,283,191	292,602 – 705,539	9	4
Total	**31,588,374**		**440**	**42**

Impact Evaluation 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.

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 were spillover effects associated with non-rebated purchases by program participants.[45] The Custom and Prescriptive and SBES Programs utilized the same NTG methodology. The methodology is described in detail in Appendix G.

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. If a measure is not listed in the

45 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.

AR TRM, then a different industry standard reference, such as another technical reference manual is considered. For custom equipment, the EUL is determined based on the lifespan of the equipment or if that cannot be determined then the industry standard of 20 years is applied. Energy savings for any behavioral measures in the program is only granted one year of EUL.

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

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

Process Evaluation Methodology

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

- How did PSO market this program?
- How effective were marketing efforts for the program?
- Which marketing methods were most effective?
- How well do PSO staff, service providers, and distributors work together? Are there rebate processing, data tracking, and/or communication efficiencies that can be gained?
- Did the program implementation reflect its design? Are there underlying assumptions about program implementation and design that are being made about how the program will unfold? Are there ways to improve the design or implementation process?
- Were participants, service providers, 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?
- How is the program working to meet its regional and measure diversity goals? Are new measures or pilot programs being explored?
- What are PSO staff and implementation staff perspectives on the program? What are reactions to program design choices that have been implemented?

- What types of buildings/facilities participated in the program? Could certain facility types be targeted more effectively?
- What customer barriers to participation do distributors see? How can these be mitigated?
- 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?
- Were there any significant obstacles during each program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?
- What changes, if any, were made to the program design or implementation procedures?

To address these questions, the process evaluation activities included surveys to program participants as well as in-depth interviews with program staff and trade allies. Table 3-108 provides a summary of data collection activities for the process evaluation.

Table 3-108: Custom and Prescriptive Research Questions

Data Collection Activity	Process Evaluation Research Objectives
Program Staff Facilitated Discussions	Assess program staff perspectives regarding program operations, strengths, or barriers to success. Discuss customer journey to create a common understanding of participation experience and identify key touchpoints to create a journey map.
Participant Surveys	Source of program awareness, factors that influenced project decision making, experience with the application process, energy consultant, and program satisfaction.
Trade Ally Surveys	Assess program changes, barriers to participation, satisfaction with program procedures and how it compares to other programs in the region, assessment of program customer engagement materials, training, and communications with program staff

3.2.3.4 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.

Gross Annual Energy Savings

The verified gross annual energy savings for Prescriptive and Custom projects are summarized, by sampling stratum, in Table 3-109.

Table 3-109: Reported and Verified Gross kWh Savings by Sampling Stratum – Prescriptive and Custom

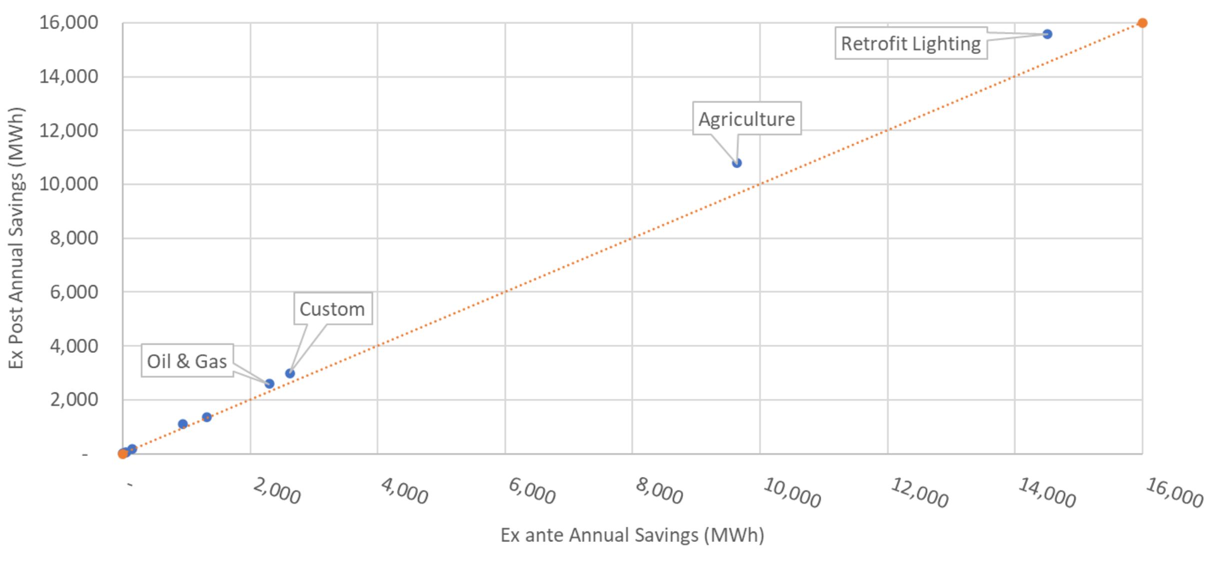
Stratum	Reported kWh Savings	Verified Gross kWh Savings	Gross kWh Realization Rate
Custom & Other 1	188,837	233,887	124%
Custom & Other 2	2,008,647	2,674,978	133%
Custom & Other 3	3,417,845	3,316,560	97%
Custom & Other 4	10,106,296	11,553,885	114%
NC Lighting 1	623,200	656,923	105%
NC Lighting 2	695,415	688,378	99%
Prescriptive 1	65,270	68,906	106%
Retrofit Lighting 1	2,238,338	2,069,040	92%
Retrofit Lighting 2	4,618,309	5,854,402	127%
Retrofit Lighting 3	3,343,026	3,372,884	101%
Retrofit Lighting 4	4,283,191	4,261,497	99%
Total	**31,588,374**	**34,751,340**	**110%**

The achieved sample design results in reported gross annual energy savings estimates with ±8.8% relative precision at the 90% confidence interval, and ±8.4% in verified gross annual energy savings.[46] Overall annual energy savings were found to be greater than expected. Large variability was found within individual projects, with realization rates ranging from 56% to 220%. Figure 3-30: Custom and Prescriptive Realization Rate Impact

demonstrates the impact of measure type realization rates for the program. The dotted line represents a theoretical realization rate of 100%. As can be seen, retrofit lighting has the largest impact based on the magnitude and is at a 107% realization rate. Agriculture represented the second largest impact based on magnitude. Agriculture measures commonly included horticultural lighting and humidifiers.

[46] That is, we are 90% confident that the true verified gross savings are between 31,821,453 and 37,681,228 kWh based on the uncertainty introduced by sampling.

Figure 3-30: 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 categories; 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 67% to 156%.

Retrofit Lighting Projects

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 used lighting schedules from detailed interviews with facility staff as well as deemed hours of use when applicable. Lighting settings from Energy Management Systems (EMS), timers, and photocells were used, where appropriate, based on On-site interview findings. When an accurate HOU was not available, or the HOU varied, deemed values from the Arkansas TRM v8 were used.

The driver of evaluation risk for retrofit lighting projects was HOU and interactive effects. On-site verifications indicated that generally as found HOU were greater than or less than the HOU the reported utilized. Only two sampled retrofit lighting sites had a 100% realization rate. While high project by project variance in HOU, the overall sample evened out compared to the HOU used by implementation. Additionally, there were some sites where the reported did not apply interactive effects (IEFe) for conditioned spaces while the Evaluator found these projects to have conditioned spaces, these sites with the IEFe oversite drove the realization rate over 100%. The overall realization rate was 107%.

Table 3-110 below shows the frequency of realization rate factors for retrofit lighting sampled projects.

Table 3-110: Frequency of Realization Rate Factors, Retrofit Lighting

Sample Size	Differing HOU	Differing IEFe	Differing Baseline Wattage
19	14	9	1

New Construction Lighting Projects

Energy savings analyses for new construction lighting projects require a lighting power density (LPD) approach to determine the proper baseline condition. The LPD baseline condition is based on allowable building codes and are stipulated by space type. Project realization rates ranged from 90% to 110%. The variation in realization rates was due to some variation in the hours of use and interactive effects. The overall realization rate was 102%.%. Table 3-111 below shows the frequency of realization rate factors for new construction lighting sampled projects.

Table 3-111: Frequency of Realization Rate Factors, NC Lighting

Sample Size	Differing HOU	Differing IEFe	Differing Baseline Wattage
4	3	2	0

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 oil & gas, chillers, cooling towers, compressed air, indoor grow lighting, and whole facility new construction. These measure types were grouped in the sample due to the nature of the measure, the number of projects, and the annual energy savings (kWh). Some larger projects underwent pre-reviews to help mitigate evaluation risk. Additionally, monitoring was conducted on three custom projects, an indoor grow lighting site, a compressed air site, and a cooling tower site.

All sampled projects fell within a realization rate of 56% to 220%. Projects representing a higher level of risk included:

- An indoor agricultural facility grow lighting projects where intensity lighting loggers were installed and collected ~2.5 months of monitored data. The loggers were installed to verify hours of use and dimming schedules. This site had an energy savings kWh realization rate of 89%. The discrepancy in energy savings is mostly attributed to a difference in hours of use found on the site. The reported calculations rely on interviews with the staff on-site and their description of the dimming cycles for each room. This resulted in the hours of use being 3,615 for the bloom/flower room's efficient hours of use, and 5,677 for the clone/vegetative room's efficient hours of use. The verified hours of use relied on installed lighting loggers which logged lumens over two months. These lumen outputs were analyzed using verified tools and the resulting hours of use were found to be 3,272 for the bloom/flower room's efficient hours of use, and 6,549 for the clone/vegetative room's efficient hours of use. 3,272 hours is around 80% of the reported hours of use, resulting in lower realization rates. The remainder of grow lighting projects relied on schedules confirmed with site contacts during field verification which differed from what the reported utilized.

- Energy monitoring equipment was installed at a compressed air project, gathering a month of post-installation data. The loggers were installed to verify compressor operation and hours of use. The energy savings and demand reduction realization rate for the custom air compressor component of the project were 77% and 27%, respectively. The primary reason for the discrepancy is a difference in the analytical approach used to determine savings. The reported savings were determined using deemed methodologies, whereas the verified calculations were determined using a custom analysis for the compressors.
- Power monitoring equipment was installed on the cooling tower fans and chilled water pumps driving a process load for an industrial facility. The monitoring equipment was left in place for 27 days. Savings were calculated using engineered algorithms and average monitored pump/fan power. The kWh savings realization rate was 128%. The realization rate driver was the difference in analytical approach, the reported used a Trane model while the verified used post-install monitored data.

Overall, custom & agriculture projects represented a realization rate of 113%.

Strategic Energy Management (SEM)

GridPoint's Strategic Energy Manager (SEM) platform learns a building's energy patterns and communicates via installed controls to help be more efficient. This is achieved via smart thermostats, HVAC controllers, zone temperature sensors, duct probe temperature sensors, optimizing setpoints/schedules, and lighting controls in some cases. This was the first year of SEM projects and the first project did not go online until June of 2022. SEM project savings made up less than 1% of program savings. Do to the variety of measure available through SEM and the interactive effects between the measures, ADM treated them as Custom and were included in the custom strata. One SEM project was in our evaluation sample. A review of this project indicates energy savings based on IPMVP Option C, a whole facility billing regression analysis.[47]

ADM adhered to ASHRAE Guide 14 and IPMVP guidelines in performing billing regression analyses. This resulted in the use of additional efficient data in the regression as well as the application of normalizing the baseline and efficient condition regressions to typical year (TMY3) weather. The regression analysis is normalized to a typical year because of the measure life exceeds one year. 24 months of pre-implementation data and 8 months of post-implementation data were used in the regression, which had a resulting R^2 of 0.96.

The daily pre/post implementation regression mathematically describes the impact of implemented measures on facility energy consumption (kWh), using influential variables, including NOAA weather data for Tulsa International Airport. ADM first cleaned the available meter data to remove outliers as well as any data periods in which anomalies could not be properly accounted for in the regression. The regression analysis was run with monthly energy consumption values. Regression parameters explored for the analysis include Cooling Degree Days (CDD), Heating Degree Days (HDD), day type (weekday vs. weekend), pre/post condition (binary defining pre-installation and post installation), as well as any additional post-installation interactive impacts on the mechanical system. In addition, ADM reviewed each project for impacts of non-routine events.

The savings realization rate was driven by a difference in analytical approach. The reported calculates savings by utilizing 24 months of pre-implementation billing data and regression analysis (R^2 0.81) to model/predict the facility usage without the SEM implementation. The savings result from the predicted kWh minus the actual observed post-SEM implementation kWh usage. The SEM was implemented in June of 2022. This meant that the reported savings needed to wait for the post SEM implementation billing data to accrue. As a result, the reported savings for June 2022 to November 2022. The verified took a more traditional billing regression approach as outlined above and had the benefit of access to more verified billing data. Lastly, the verified savings are TMY3 normalized for an entire typical year from January to December.

Measure-Level Results

The realization rate by measure type for the program is presented in Table 3-112.

47 https://www.nrel.gov/docs/fy02osti/31505.pdf

Table 3-112: Realization Rate by Project Type

Project Type	Realization Rate	Percent of Custom and Prescriptive
Retrofit Lighting	107%	46%
Agriculture	112%	30%
Custom	114%	8%
Oil & Gas	113%	7%
New Construction Lighting	102%	4%
Multiple (Retrofit Lighting, HVAC, Kitchen Equipment, etc.)	117%	3%
Refrigeration & Kitchen Equipment	106%	<1%
HVAC	133%	<1%
Business Appliance	100%	<1%
SEM MiD	129%	<1%

Gross Coincident Peak Demand Reduction (kW)

The verified gross coincident peak demand reduction (kW) is summarized by the sampling stratum in Table 3-113. The peak demand reduction realization rate for prescriptive and custom projects is 123%.

Table 3-113: 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
Custom & Other 1	29.47	37.06	126%
Custom & Other 2	402.69	269.28	67%
Custom & Other 3	528.78	1414.44	267%
Custom & Other 4	1677.64	1847.82	110%
NC Lighting 1	114.64	129.93	113%
NC Lighting 2	127.46	141.73	111%
Prescriptive 1	10.27	10.63	104%
Retrofit Lighting 1	485.16	415.31	86%
Retrofit Lighting 2	865.02	827.53	96%
Retrofit Lighting 3	531.55	660.40	124%
Retrofit Lighting 4	590.78	824.42	140%
Total	**5,363.46**	**6,578.54**	**123%**

The achieved sample design resulted in reported gross peak demand reduction estimates with ±16.8% relative precision at the 90% confidence interval and 23.8% 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.
- 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.

Net-to-Gross Estimation

The data used to assign free ridership scores were collected through a survey of customer decision makers for projects rebated through the Business Rebates Program during the 2022 evaluation. Completed survey responses represent 47 custom and prescriptive projects. The calculation of NTG was determined based on the ridership criteria (four areas of questions) and spillover.

Table 3-114 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. 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.

[48] That is, we are 90% confident that the ex-post gross peak demand reduction is between 5,010 and 8,147 kW based on the uncertainty introduced by sampling.

Table 3-114: 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	3%	100%
Y	Y	N	Y	0%	100%
Y	Y	Y	N	1%	67%
N	Y	N	Y	1%	67%
N	Y	N	N	16%	33%
N	Y	Y	N	0%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	0%	33%
N	N	N	N	51%	0%
N	N	Y	N	30%	0%
N	N	Y	Y	0%	0%
Required program to implement measures				0%	0%
The project would have been deferred by one year or more in the absence of a program				0%	0%
Total				**100%**	**8%**

Overall, the estimated percentage of program free ridership is 8%. Project specific free ridership was determined on a measure level basis. Moderate levels of free ridership were found in several projects that consisted of lighting and custom cooling projects.

Customer decision maker survey responses were also analyzed to estimate participant spillover effects. No respondents reported installing efficient equipment that met the attribution criterion; thus, no spillover was determined.

The NTG for the program is calculated as 1 – free-ridership + participant spillover. This results in an NTG of 92% for annual energy savings and 94% for peak demand reductions. Table 3-115 shows the amount of savings and peak demand reduction impacted by free ridership and spillover.

Table 3-115: 2022 Free-Ridership and Spillover for Custom and Prescriptive

Savings	Free Ridership	Spillover
Annual Energy Savings (kWh)	834,668	-
Peak Reduction (kW)	94.13	-

The gross and net verified annual energy savings and peak demand reduction for Custom and Prescriptive projects are summarized in Table 3-116.

Table 3-116: 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	34,751,340	32,018,506	92% - kWh 94% - kW	6,578.54	6,197.03

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 an effective useful life (EUL) to be extrapolated to the population by strata. Sample level EUL's by strata as well as total population lifetime energy savings are shown in Table 3-117.

Table 3-117: C&P EUL's and Lifetime Energy Savings

Stratum	EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Custom & Other 1	5.26	1,231,180	1,134,360
Custom & Other 2	8.54	22,850,616	21,053,650
Custom & Other 3	16.22	53,807,856	49,576,423
Custom & Other 4	11.29	130,470,727	120,210,550
NC Lighting 1	9.90	6,501,802	5,990,502
NC Lighting 2	13.53	9,310,779	8,578,582
Prescriptive 1	15.75	1,085,353	1,000,001
Retrofit Lighting 1	14.70	30,414,971	28,023,148
Retrofit Lighting 2	10.30	60,322,718	55,578,958
Retrofit Lighting 3	12.71	42,871,860	39,500,431
Retrofit Lighting 4	11.36	48,390,705	44,585,275
Total	**11.72**	**407,258,567**	**375,231,881**

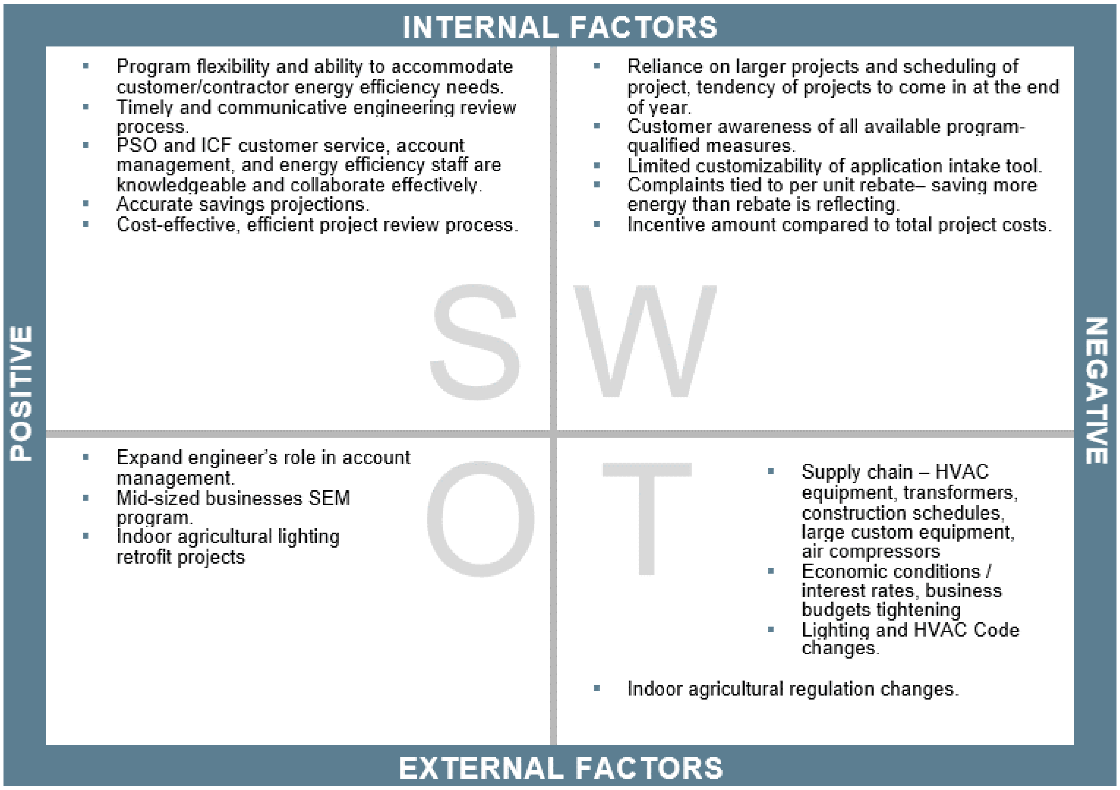
3.2.3.5 Process Evaluation Findings

The process evaluation consisted of a participant survey, a trade ally survey, and a program staff facilitated discussion. ADM provided a detailed process evaluation memo to PSO after the completion of the 2022 program year.

Program Staff Facilitated Discussions

ADM researchers facilitated a discussion with program staff in October 2022. The purpose of the discussion was to investigate the status of the recommendations ADM provided to PSO the previous year as well as the Business Rebates Program's internal strengths, weaknesses, external opportunities, and program threats (SWOT). A SWOT analysis encourages a focused discussion on external and internal factors that impact the program, thus bringing to light areas in which the program is excelling as well as areas in which the program could be improved. Attendees included four implementation staff (a senior program manager, a business operations manager, an energy engineer, and a lead technical consultant) and two PSO staff (an energy efficiency coordinator and a senior engineer). A SWOT matrix was developed to synthesize the ideas shared during the facilitated discussion (see Figure 3-31).

Figure 3-31: Business Rebates Custom and Prescriptive Program SWOT Analysis

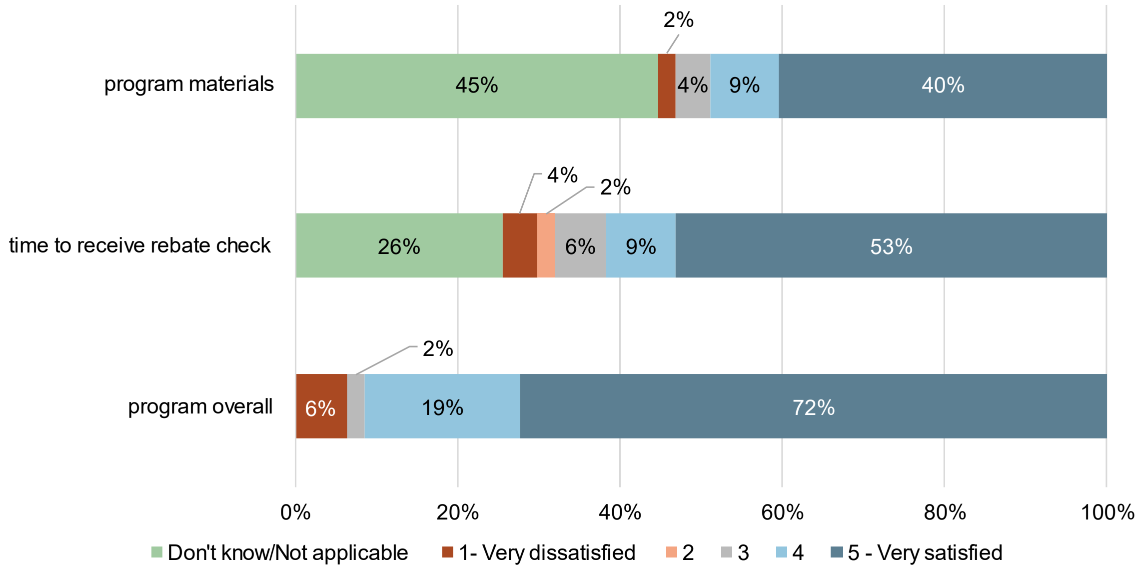


Prescriptive and Custom Customer Survey

A mixed-mode survey (email/phone) of Prescriptive and Custom participants was administered in October and November 2022. Twelve customers completed the survey through an email invitation link and 35 completed the survey over the phone. A total of 47 program 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 3-32).

Figure 3-32: Custom and Prescriptive Overall Respondent Satisfaction with Aspects of Program Participation



Fifty-nine percent of survey respondents said that they had recommended the program to someone else. Of those who had not yet recommended the program, 83% said they would be likely to recommend it to a friend or colleague.[49] Eighty-eight percent of respondents also noted being satisfied with PSO as their electric utility.[50]

Prescriptive and Custom Trade Ally Survey

In October 2022, ADM collected survey responses from nine Prescriptive and Custom rebate trade allies, including energy consultants, electrical, HVAC, mechanical contractors, and lighting/electrical distributors. All trade allies indicated they were satisfied with the program overall. The following is a summary of findings.

- Trade allies identified ways to improve program awareness. Trade allies shared recommendations to help build awareness for the program such as increased customer engagement of the program with mailers, bill inserts, emails, and/or social media posts.
- Trade allies noted financial and non-financial barriers to participation. Some trade allies observed budgetary concerns or finances as the primary reasons businesses may decide not to participate in the program or make energy efficiency improvements. Four trade allies noted various non-financial barriers or reasons for nonparticipation:

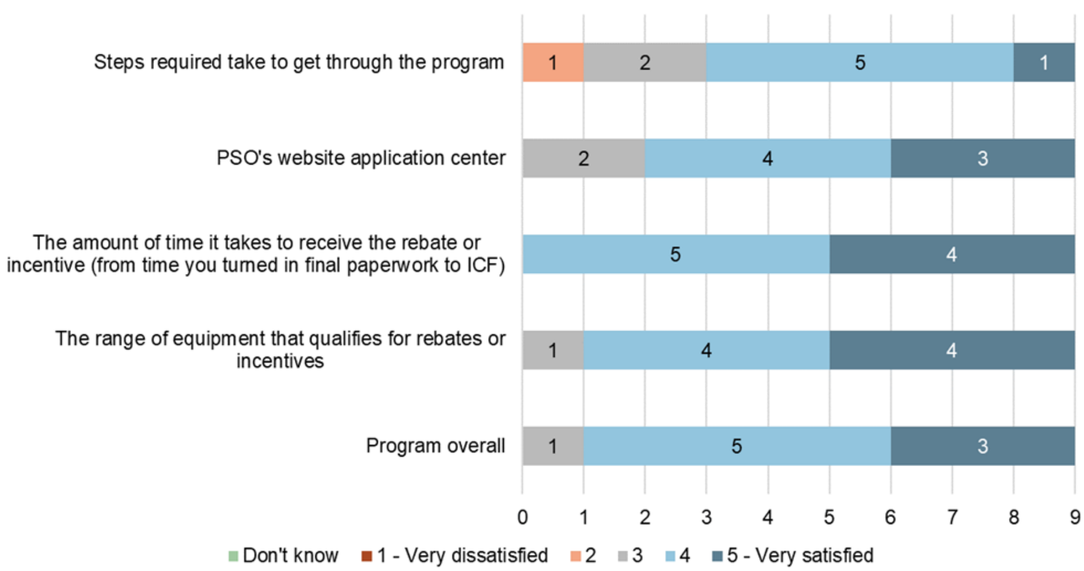
[49] Rated their likelihood of recommending the program a 7 or higher on a scale from 0 (not at all likely) to 10 (extremely likely).

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

- Program-qualified equipment is not available or has long lead times.
- The customer does not complete the required paperwork.
- Project timing or deadline challenges.
- Skepticism regarding the legitimacy of the program, and lack of understanding.

- Most of the trade allies believe the current incentive levels are effective at motivating customers to buy high-efficiency equipment instead of standard-efficiency equipment.[51]
- Implementation and PSO staff continue to provide strong program communications and sufficient trade ally support. All the respondents had some sort of interaction with ICF staff in 2022, and they all were satisfied with the staff's professionalism, courteousness, and ability to explain program rules and customer eligibility.[52]
- All trade allies indicated they were satisfied with the program overall. Figure 3-33 displays trade ally satisfaction with the Business Rebates program.53

Figure 3-33: Custom and Prescriptive Trade Ally Satisfaction



[51] Five respondents gave a rating of 4 or 5 on a scale from 1 (not at all effective) to 5 (very effective) for the incentives at motivating customers. Two rated the effectiveness a 3 out of 5, and one rated them a 2 out of 5. One did not provide a rating.
[52] Rated their level of satisfaction a 4 or 5 on a scale from 1 (completely disagree) to 5 (completely agree).
[53] A rating of 4 or 5 on a scale from 1 (very dissatisfied) to 5 (very satisfied).

3.2.3.6 Custom and Prescriptive Conclusions and Recommendations

This section presents conclusions and recommendations for the Custom and Prescriptive subprogram based on the 2022 evaluation.

Conclusions

- The program was able to sustain a high level of program savings given some of the challenges (supply chain issues) implementation faced in 2021 an continued into 2022. Verified gross energy impacts were higher than estimated. Net annual energy savings for the program year are 32,018,506 kWh for an overall net realization rate of 101%.
- Evaluation risk was found for several measures. Custom measure projects represent the largest project level realization rate risk. Custom measures include HVAC VFDs, compressed air, grow lighting, and chiller plant upgrades. Grow lighting had a large increase in program participation in 2022, although there is uncertainty as to what the outlook for 2023 will be. Customers have expressed concerns with indoor grow market saturation and black-market penetration.
- Lighting measures continue to contribute most to program level energy savings, but the wide range of measure offerings presents many opportunities for customers.
- Survey findings indicate most participants were satisfied with the application and participation process. Consistent with ADM's past surveys, most respondents to both the Business Rebates and SBES surveys reported satisfaction with the program participation process and required steps.
- A portion of customers' survey responses suggest an opportunity for additional support to navigate the application process. Seventeen percent of Business Rebates respondents suggested that the program improve the program application process/paperwork process. A portion of customer write-in comments from both the Business Rebates and SBES surveys also suggested some customers may initially struggle to navigate the application process and to find information on available lighting and HVAC rebates.
- The program faces several challenges including supply chain issues, economic conditions, as well as state and federal code and regulation changes. Findings from staff-facilitated discussions and trade ally surveys suggest staff awareness and efforts to understand and overcome several challenges to meeting program goals.
- The Strategic Energy Management (SEM for mid-sized businesses) subcomponent of the Business Rebates program is in its first year and presents an opportunity for growth. ICF's business operations manager said they had

partnered with GridPoint and began offering this part of the program in 2022. She noted they had spent more time recruiting participants to the program in 2022 compared to "sitting down and working on holistic management" and in upcoming years there will be an opportunity to grow this program.

- Trade allies generally perceive the primary barrier to participation to be budgetary concerns or finances. About half of the Business Rebates trade allies surveyed observed budgetary concerns or finances as the primary reasons businesses may decide not to participate in the program or make energy efficiency improvements. Similarly, three of the four SBES trade allies indicated budget constraints and equipment costs were the primary barriers to program participation.

Recommendations

- Lighting measures continue to contribute most to program level energy savings, but lighting controls are still underrepresented. There is potential to increase energy savings with the inclusion of lighting control especially as LED lighting retrofit opportunities diminish.
- Grow lighting participation increased from last year. Grow lighting resulted in a high realization rate risk in 2022. ADM performed pre-reviews of grow sites when requested but verified evaluation found that hours/schedules or quantities had changed from when ADM performed the pre-review. Only 2 of the 5 grow sites that ADM pre-reviewed had an verified realization rate of 100%. We recommend continuing to request pre-review by ADM for grow lighting projects.
- Ensure there is continued focus on custom projects' timelines and the schedule of projects. ICF's senior program manager indicated that ICF and PSO had recently met to discuss strategies to mitigate the impacts of the custom projects on the program, as they are more vulnerable to supply chain and equipment issues. Continued coordination and focus on these projects can mitigate risks and avoid unanticipated year-end savings shortfalls.
- Continue to develop the SEM for mid-sized businesses subcomponent of the Business Rebates program. During ADM's facilitated discussion with program staff, it was noted that there was an opportunity to grow this program. Additional information regarding the program design and participation process will bolster ADM's ability to provide recommendations for this program subcomponent in the future.

3.2.4 Small Business Energy Solutions (SBES)

This section reports findings from the Small Business Energy Solutions (SBES) evaluation. ADM performed an impact and process evaluation. The verified annual energy savings estimates for SBES resulted in a 99% realization rate for net energy savings and a 98% realization rate for net peak demand reduction.

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

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

Direct install rebates are available to customers that qualify for the SBES portion of the program. To qualify for the program, businesses must use 320,000 kWh or less annually and use a PSO approved service provider. Customers may request an exemption of these requirements. Exemptions are granted on a case-by-case basis, determined by how a customer fits within the program goals.

3.2.4.1 Impact Evaluation Overview

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

PSO provided rebates for a total of 272 SBES projects. The number of rebated projects decreased from 383 in PY2021 to 272 in PY2022. The reported energy savings decreased from 8,156 MWh (PY2021) to 7,665 MWh (PY2022). As with previous years, program energy savings were driven by lighting projects.

The estimated annual energy savings NTG ratio changed from 99.5% in 2021, to 100.0% in 2022. The estimated peak demand NTG ratio changed from 99.7% in PY2021 to 100.0% for PY2022. Table 3-118 provides projected and verified energy and demand impacts, as well as other program performance metrics for SBES projects.

Table 3-118: Performance Metrics – Small Business Energy Solutions

Metric	PY2022
Number of Projects	272
Energy Impacts (kWh)	
Reported Energy Savings	7,664,560
Gross Verified Energy Savings	7,597,610
Net Verified Energy Savings	7,597,610
Peak Demand Impacts (kW)	
Reported Peak Demand Savings	1,877.97
Gross Verified Peak Demand Savings	1,835.27
Net Verified Peak Demand Savings	1,835.27
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.75
Utility Cost Test Ratio	1.46

3.2.4.2 Process Evaluation Overview

The process evaluation included participant surveys, trade ally surveys, and a facilitated discussion with program staff to investigate the status of the recommendations ADM provided to PSO in its 2021 Final Report and Process Memo as well as to explore customers' journey through the SBES Program. The objectives of the participant survey were to assess the source of program awareness, factors that influenced project decision making, experience with the application process or energy consultant, and program satisfaction. A total of 40 customer decision makers responded to the participant survey. A detailed process evaluation memo was delivered to PSO in November of 2022.

Participation in SBES increased steadily as the year progressed, with a notable increase at the end of the year. (Figure 3-34)

Figure 3-34: SBES Reported Energy Savings

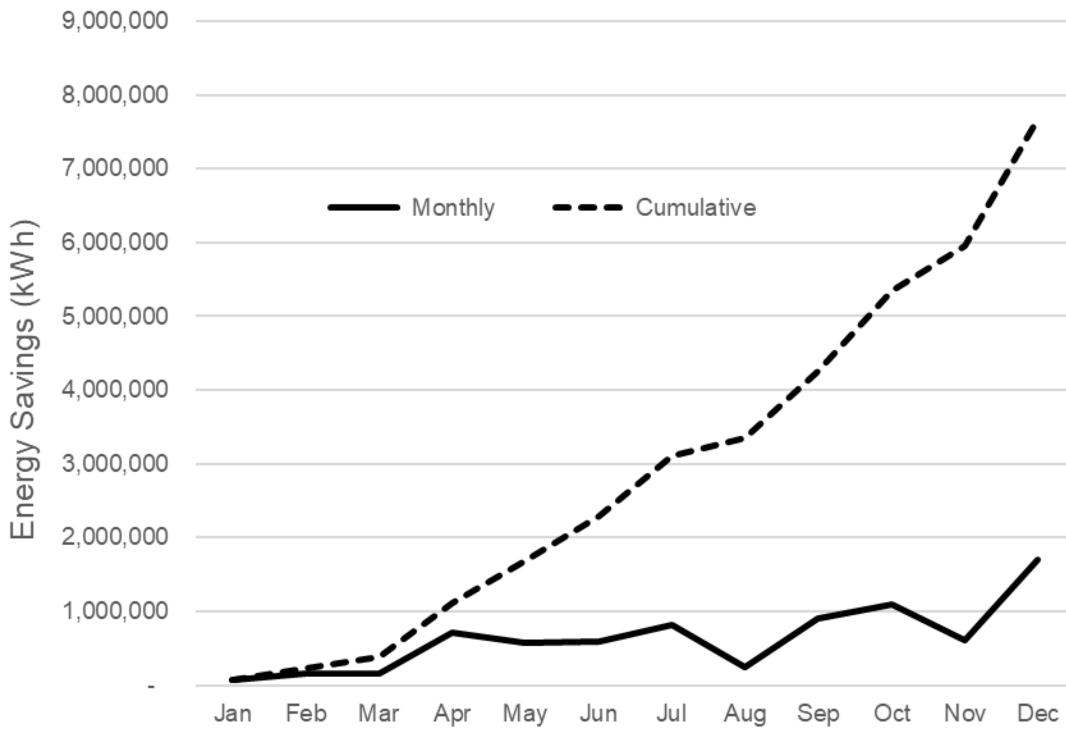


Table 3-119 summarizes program activity by service provider. Four lighting service providers represented most of the energy savings. National Resource Management (NRM) represented 2% of energy savings with refrigeration equipment, a decrease from PY 2021.

Table 3-119:SBES Summary by Service Provider

Service Provider	Sum of Reported Energy Savings (kWh)	Percentage of Projects kWh
Bridgepoint Electric	1,899,879	25%
Entegrity Partners	1,975,242	26%
First Light Systems	2,776,134	36%
Luminous of OK	866,342	11%
National Resource Management	146,964	2%

Project Activity by Location

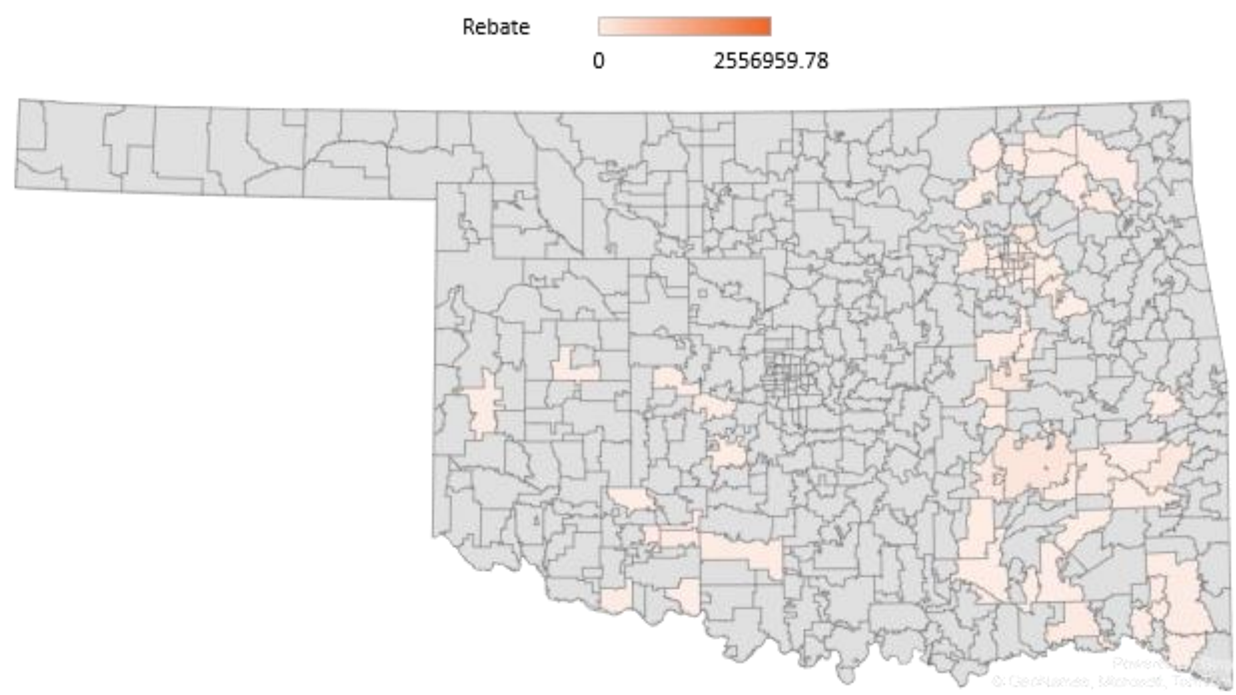
Table 3-120 displays the share of SBES savings by district. The distribution of savings is consistent with program goals. As expected, savings are associated with regions that have a higher density of businesses.

Table 3-120: SBES District Share of Reported kWh Savings

Region	Sum of Reported Total Energy Savings (kWh)	Percentage of Projects kWh
Eastern District	2,112,711	28%
Tulsa District	4,035,918	53%
Tulsa Northern District	576,214	8%
Western District	939,718	12%
Total	**7,664,560**	**100%**

Figure 3-35 shows a heat map of the location of SBES projects across the service territory based on zip code. The density of projects increases as the color darkens; based on the number of projects. Zip codes represented in grey indicate that no incentives were achieved.

Figure 3-35: Distribution of Small Business Energy Solutions Projects



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

Two projects consisting of reported annual energy savings over 320,000 kWh represented 10.56% of SBES projects annual energy savings. The two projects were manufacturing facilities located in the Tulsa District.

3.2.4.3 Evaluation Methodology

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

Data Collection

Data for the analysis were 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 program 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, on-site and virtual verification visits. 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 and virtual visits were used to collect data for gross impact calculations, to verify measure installation, and to determine measure operating parameters. Facility staff members were interviewed to determine the operating hours of the installed systems and provide any additional operational characteristics relevant to calculating energy savings.

In addition to the 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 (fall 2022). A total of 40 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 3-121 shows the achieved sample sizes for the different types of data collection employed for this study.

Table 3-121: 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	40
Program Staff Facilitated Discussions (SWOT)	1
Trade Ally interviews	4

Impact Evaluation Sampling Plan

As with Custom and Prescriptive projects, ADM created a stratified sample based on the amount of estimated annual energy savings and type of measure installed in each project. Sample sizes were designed to meet ±10% precision at the 90% confidence level at the program level. Table 3-122 below shows the sample design that was used for SBES projects. Stratum classifications were based on verified measure installations. The 21 projects sampled for measurement and verification account for approximately 30% of reported program annual energy savings.

Table 3-122: 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	729,507	0-12,000	125	3
Lighting 2	1,413,489	12,000-26,000	77	3
Lighting 3	761,932	26,000-42,000	24	1
Lighting 4	741,665	42,000-65,000	14	1
Lighting 5	1,613,400	65,000-150,000	18	3
Lighting 6	2,257,602	150,000+	9	7
Refrigeration	146,964	0-35,000	5	3
Total	**7,664,560**		**272**	**21**

Impact Evaluation Methodology

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

- The program tracking database was reviewed to determine the scope of the program, check for data completeness, data entry errors, outlier values, and to ensure there were no duplicate project entries. The tracking database was used to define a discrete set of rebated projects that made up the program population. A sample of projects was then drawn from the population established in the tracking system review.
- A detailed desk review was conducted for each project sampled for in person 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 and virtual fieldwork by identifying potential uncertainties and missing data. Additionally, the review process involved

assessing the reasonableness of deemed savings values and calculation input assumptions.

- After reviewing the project materials, on-site verification visits for data collection were scheduled for sampled projects. The on-site and virtual visits were used to collect data for savings calculations, to verify measure installation, and to determine measure operating parameters.
- The data collected during the on-site verification visits was used to revise savings calculations, as necessary. For example, if the reported savings calculations relied on certain measure operating hours that were determined inaccurate based on the facilities actual schedule, changes were made to reflect actual operating conditions more accurately.
- 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 kWh reductions.

Net-to-Gross Estimation (NTG)

The purpose of net savings analysis is to determine what portion of gross savings achieved by PSO customers is the direct result of program influence. This methodology includes both free ridership and participant spillover. The methodology for SBES is the same as Custom and Prescriptive and described in the Custom and Prescriptive Evaluation Methodology section in Appendix G.

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. For custom equipment, the EUL is determined based on the lifespan of the equipment or if that cannot be determined then the industry standard of 20 years is applied. Energy savings for any behavioral measures in the program is only granted one year of EUL.

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

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

Process Evaluation Methodology

The 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.

3.2.4.4 Impact Evaluation Findings

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

Gross Annual Energy Savings

The verified gross annual energy savings for SBES projects are summarized by sampling stratum in Table 3-123. Projects saw an overall realization rate of 99%. Ninety-eight percent of verified annual energy savings for the SBES Program resulted from lighting projects.

Table 3-123: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	729,507	716,478	98%
Lighting 2	1,413,489	1,446,646	102%
Lighting 3	761,932	873,973	115%
Lighting 4	741,665	493,390	67%
Lighting 5	1,613,400	1,600,901	99%
Lighting 6	2,257,602	2,327,458	103%
Refrigeration	146,964	138,764	94%
Total	**7,664,560**	**7,597,610**	**99%**

The achieved sample design resulted in reported gross annual energy savings estimates with ±8.89% relative precision at the 90% confidence interval and verified at ±8.95% for kWh.[54] Realization rates varied from project to project and stratum to stratum.

Differences from reported to verified energy savings stem from annual hours of operation and baseline wattage assumptions. In cases where baseline wattage was not able to be determined during on site and virtual verification visits, ADM used default baseline wattages as presented in the Arkansas TRM v8 (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 from reported fixtures and verified fixtures.

Project level realization rates ranged from 67% to 120%. The project with the lowest realization rate was incentivized for LED lights in a small office. The projected calculations for these measures used differing baseline wattage and hours whereas ADM incorporated the AR TRM v8.0 baseline wattages and actual hours of use. In this specific project the hours found on site verse reported hours accounted for 27% reduction of kWh while the baseline wattage difference from TRM and reported accounts for 6% reduction of kWh.

For Small Business lighting projects, linear tubes are the highest percentage of equipment type retrofitted through the program as can be seen from Table 3-124 at around 72% of the lighting program.

54That is, we are 90% confident that the true verified gross savings are between 6,917,870 and 8,277,349 kWh based on the uncertainty introduced by sampling.

Table 3-124:SBES Percentage of Lighting by Type

Lighting Type	Percent of Program Lighting kWh
LED Linear Tubes	71.76%
LED Fixture	11.30%
LED Screw-ins	7.11%
LED Exterior Lights	6.47%
LED Exit Sign	1.70%
Occupancy Sensor	0.86%
Abandoned Fluorescent	0.46%
LED Case Lights	0.22%
Abandoned CFL	0.09%
Abandoned HID	0.02%
Total	**100%**

For the 5 Small Business non-lighting projects, cooler door heaters accounted for the highest percentage of reported annual energy savings (kWh). Equipment type retrofitted through the program can be seen in Table 3-125.

Table 3-125:SBES Percentage of Non-Lighting by Measure Type

Measure Type	Percent of Program Non-Lighting kWh
Cooler Door Heater Controls	44%
Evaporative/Compressor Controls	42%
EC Motors	8%
Novelty Setback Controls	5%
Total kWh for Non Lighting	**100%**

Gross Coincident Peak Demand Reduction (kW)

The verified gross peak demand reduction is summarized by sampling stratum in Table 3-126. Overall, the verified gross peak demand reduction is equal to 98% of the reported reduction for SBES projects.

Table 3-126: 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	259.03	258.66	100%
Lighting 2	497.41	439.81	88%
Lighting 3	232.93	258.03	111%
Lighting 4	176.89	190.62	108%
Lighting 5	367.41	301.69	82%
Lighting 6	331.18	373.03	113%
Refrigeration	13.12	13.43	102%
Total	**1,877.97**	**1,835.27**	**98%**

The achieved sample design resulted in reported gross peak demand reduction estimates with ±20.60% relative precision at the 90% confidence interval and verified at ±20.36%.[55] Much of the difference between reported and verified demand reduction, as in past program years, is explained by either 1) variation of annual operating hours, or 2) use of stipulated coincidence factors (CF) that did not align well with actual equipment schedules. For lighting projects, the ADM verified lighting calculators generate an hourly curve (8760 hours) to determine the average peak demand reduction value across the peak demand period for each lighting schedule within a project.

Net-to-Gross Estimation

The data used to assign free ridership scores were collected through a survey of SBES customer decision makers for projects rebated. Free ridership was estimated using the methodology described in the Evaluation Methodology section for Custom and Prescriptive. Results are based on 40 respondents representing 40 unique projects. A percentage of free ridership was determined for each of the 40 projects based on the four avenues of questions. The percentage of free ridership was then applied to each project's verified annual energy savings. The overall results were then extrapolated to the remaining projects in the program.

Table 3-127 shows percentages of total gross verified savings associated with different combinations of free ridership indicator variable values for the SBES incentive component.

55 That is, we are 90% confident that the verified gross peak demand reduction is between 1,462 and 2,209 kW based on the uncertainty introduced by sampling.

Table 3-127: 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	0%	100%
Y	Y	N	Y	0%	100%
Y	Y	Y	N	0%	67%
N	Y	N	Y	0%	67%
N	Y	N	N	0%	33%
N	Y	Y	N	0%	0%
N	Y	Y	Y	0%	33%
N	N	N	Y	0%	33%
N	N	N	N	15%	0%
N	N	Y	N	70%	0%
N	N	Y	Y	15%	0%
Required program to implement measures				0%	0%
Project would have been deferred by one year or more in the absence of the program				0%	0%
Total				**100%**	**0.00%**

No free ridership was determined through survey efforts. Customer decision maker survey responses were also analyzed to estimate participant spillover effects. None of the survey respondents reported meeting the attribution criterion for any energy savings to be estimated, as shown in Table 3-128. Therefore, no spillover was found in the program during this program year.

Table 3-128: Free-Ridership and Spillover for SBES Projects

Savings	Free Ridership	Spillover
Annual Energy Savings (kWh)	0	0
Peak Reduction (kW)	0.00	0

The final net-to-gross ratio for SBES projects is calculated as 1 – free-ridership + participant spillover. This results in an NTGR of 100.0% for annual energy savings and

100.0% for peak demand reductions. The SBES gross and net verified energy savings and peak demand reduction are summarized in Table 3-129.

Table 3-129: 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	7,597,610	7,597,610	100.0% - kWh 100.0% - kW	1,835.27	1,835.27

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 3-130.

Table 3-130:SBES EUL's and Lifetime Energy Savings

Stratum	EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Lighting 1	12.88	9,227,477	9,227,477
Lighting 2	14.71	21,277,531	21,277,531
Lighting 3	13.01	11,373,804	11,373,804
Lighting 4	13.39	6,605,640	6,605,640
Lighting 5	14.95	23,932,575	23,932,575
Lighting 6	14.07	32,744,051	32,744,051
Refrigeration	11.47	1,591,485	1,591,485
Total	**13.50**	**106,752,563**	**106,752,563**

3.2.4.5 Process Evaluation Findings

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

Program Staff Facilitated Discussion

ADM researchers facilitated a discussion with two ICF and two PSO staff in October 2022. The purpose of the discussion was to investigate the status of the recommendations ADM provided to PSO in its 2021 Final Report and Process Memo as well as to explore customers' journey through the SBES Program. Attendees included two ICF staff (a lead technical consultant and a senior program manager) and two PSO staff (an energy efficiency coordinator and a senior energy efficiency principal). During the call, ADM staff shared their computer screen via video call and took notes to ensure attendees' thoughts were accurately captured.

PY2022 Recommendation Review

As part of the review of the PSO SBES program design and operations in PY2021, ADM recommended that the SBES program design be reviewed to expand its impact and made three specific sub-recommendations for program improvement based on its evaluation. ICF and PSO staff noted that none of the recommendations had been implemented. ADM's recommendations are organized and outlined below, with notes taken from the facilitated discussion with ICF and PSO staff.

Not implemented or no change made

- Consider expanding the range of eligible measures or increase promotion of other programs; this could help businesses address energy efficiency at their facility more holistically. Trade allies suggested adding thermostats and HVAC tune-ups to the program and increasing incentives to promote lighting controls.

  ICF's senior program manager said that the eligible measures and program cross-promotion stayed the same in 2022. He noted that the customer intake tool requires service providers to cross-promote the Power Hours and Peak Performers programs and participating SBES service providers also work with PSO's Business Rebates program so they are able to engage customers with that program as well.

  ICF and PSO contacts noted that there had been recent discussions regarding adding thermostats as a program measure. ICF's senior program manager said that there was potential to consider HVAC tune-ups as a program measure and it had been success in other markets but noted there was a significant amount of lighting "still out there to be done", so they had not sought to add this as a program measure.

- Provide an on-bill financing option for projects. This design feature would enable more businesses to participate by eliminating out-of-pocket costs and deferring upfront costs.

  PSO's energy efficiency coordinator said that on-bill financing is discussed periodically, but there was "nothing moving in this direction."

Customer Journey Map

A customer journey map is a graphic representation of how a customer or participant interacts with a program or product. It may display touchpoints, satisfaction, actions, key moments of truth (KMOT), pain points, or emotions. Before the call with ICF and PSO staff, ADM sought to create a map that could be viewed as a "living document" that could assist program staff, service providers, and evaluators in understanding small business customers' participation process. We used program documents, customer survey results, as well as past service provider surveys and staff to drat the initial journey map and the discussion with staff to update the map. ADM sought to clarify and enhance the contents of the initial customer journey map by guiding staff in a facilitated discussion of the various customer experience phases. The final draft journey map is displayed as Figure 3-36.

Figure 3-36: PSO SBES Customer Journey Map

SMALL BUSINESS ENERGY SOLUTIONS PROGRAM

Customer Group: Small business customers with 320,000 kWh per meter or 2,000,000 kWh aggregate usage

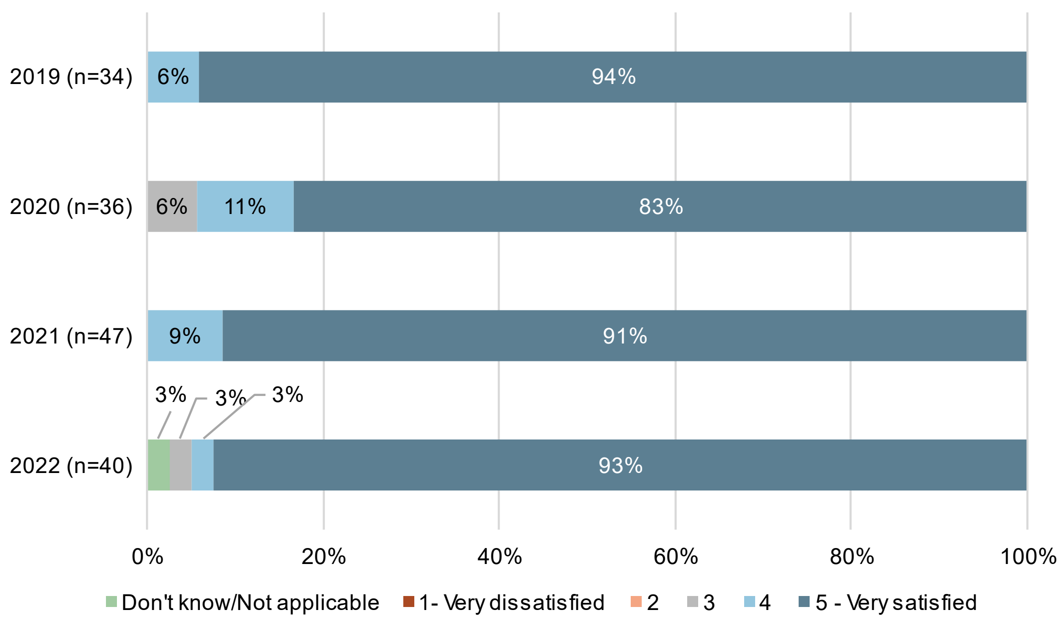
Objective: Create a common understanding of the participation experience, identify key touchpoints & opportunities for program improvement

	AWARENESS	ENROLLMENT	INSTALLATION	POST INSTALLATION & QUALITY ASSURANCE	FEEDBACK
TOUCHPOINT	*Bridgepoint Electric, Entegrity Partners, First Light Systems, Luminous of OK, National Resource Management, ICF/PSO, Word-of-Mouth, Internet Search*	*Bridgepoint Electric, Entegrity Partners, First Light Systems, Luminous of OK, National Resource Management*	*Bridgepoint Electric, Entegrity Partners, First Light Systems, Luminous of OK, National Resource Management*	*ICF internal inspector*	*Bridgepoint Electric, Entegrity Partners, First Light Systems, Luminous of OK, National Resource Management, Program Staff, ADM*
CUSTOMER ACTION	1. Receive outreach from Service Provider (phone calls, in person visits) *OR* 1. Research available rebates and no-cost measure improvements available through Program on internet *OR* 1. Learn about program from friend, colleague, family *OR* 1. Learn about program from PSO/ICF marketing (email, radio, video streaming)	1. Receive contact and sign up directly through service provider 2. Set appointment for audit or receive an audit at the time of signing up 3. Sign a participation agreement that reflects scope of project	1. Coordinate with service provider to complete program installations/improvements 2. Walk through facility and verify improvements, if desired 3. Sign a certificate of completion 4. Receive invoice 5. Pay contractor	1. Coordinate with ICF and ADM staff to complete any post-installation requirements	1. Complete survey with ADM Associates 2. Contact contractor, ICF, or PSO if there are any issues with project
CUSTOMER THOUGHTS	• **What is the out-of-pocket to my business to participate? (KMOT)** • What is the timeline for program participation? • **How can I reduce my electric bill? (KMOT)** • Are there ways for me to get no cost or incentivized improvements for my property? • Is this too good to be true?	• The service provider was knowledgeable, professional, and made the program easy for them to understand. • What does the participation process require? • When are services and measures are available? • Which rebates or incentives is my business eligible for? • Will it be a challenge to coordinate measure installation with the service provider?	• The contractor was efficient and professional. • The contractor was communicative regarding the installation date and time. • **The wait time met or exceeded my expectations. (KMOT)**	• I understand an inspection was part of the process. • ICF staff was amenable to my schedule and worked to make QA/QC easy. • I appreciate PSO's dedication to quality and verification of my program participation.	• **I am satisfied with improvements made through program, contractor, and overall program experience. (KMOT)** • I would not recommend any changes to the program. • PSO could improve marketing of its programs and available incentives. • I recommend this program to friends and colleagues. • What other ways are there that I can save money on my electric bill? • I do not have time for a survey.

SBES Participant Survey

ADM conducted a mixed mode (phone/email) survey of SBES participants, in October and November 2022. ADM contacted customers with up to three phone calls. Fourteen customers completed the survey through an email invitation link and 26 completed the survey over the phone. Overall satisfaction was high and consistent with past program years (see Figure 3-37 for SBES customer satisfaction from 2019-2022).

Figure 3-37: Overall SBES Respondent Satisfaction 2019-2022



Sixty-three percent of survey respondents said that they had 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-three percent of respondents said they were satisfied with PSO as their electric utility.

Two customers provided feedback regarding aspects of the program they were dissatisfied with and one requested a follow-up from program staff regarding the status of their rebate payment. One noted that finding information about program participation was challenging. They stated that they did not receive sufficient information when they called PSO and that “there was not a clear path on the website” to reach an SBES service provider. The other respondent that elaborated on their dissatisfaction indicated they were interested in HVAC improvements for their business, but when they inquired with program representatives, they referred them to refrigeration rebates. They also mentioned that installation of the program-sponsored lighting components had not been completed at the time of the survey, occupancy sensors were not functioning, and they “did not get adequate instruction on the use of lighting app.”

SBES Trade Ally Survey

Four trade allies were interviewed via phone as part of the process evaluation. A summary of findings includes the following.

- Consistent with ADM's past SBES trade ally survey results, the trade allies perceive there to be a lack of awareness about the program among small businesses. Three of the trade allies estimated that between 20-29% of the small business customers that received discounted equipment through the program in 2022 were aware of the program equipment discounts before they mentioned it to them. The other trade allies estimated that 50-59% of small business customers knew about the program, though these results still indicate a significant opportunity to increase awareness. All four trade allies said they always mention the program when they are working with small business customers who do not already know about equipment discounts.
- SBES trade allies noted various methods to recruit participants. All four trade allies said that they promoted the program in person or on the phone during their sales visits/calls. Two trade allies each noted sending emails, sending materials in the US mail, and posting to social media to promote the program. One trade ally also mentioned several other ways that they promote the program. They said that they attended in-person events (e.g., Chamber of Commerce, parades), and had a dedicated phone line, a landing page on their website, and a referral program to promote the SBES program.
- The three lighting-focused SBES trade allies said that the current incentive levels were effective at motivating small business customers to buy high-efficiency equipment. However, two of these trade allies noted budget constraints and equipment costs were the primary barriers to program participation. Further, one trade ally observed that customers may be implementing improvements in a piecemeal, rather than in a holistic or facility-wide manner. He noted that it had been a challenging year "on the back of COVID" and that about one-quarter of small businesses have budget constraints that prohibit them from retrofitting their facilities' lighting. The remaining trade ally suggested that the primary reason customers choose not to participate is that they do not own the building their business operates in and are not interested in spending money to upgrade someone else's building.
- The refrigeration contractor indicated the incentive levels were somewhat effective.[56] He stated that the primary reason customers choose not to participate in the program is that the incentives are not high enough to offset the cost of high-efficiency equipment. The refrigeration trade ally also noted that small business

[56] Rated the effectiveness of the rebates a 3 on a scale from 1 (not at all effective) to 5 (

customers may not perceive the energy savings from equipment replacements to be worth the trouble of replacing it and working with a contractor. He noted that on-bill financing could potentially mitigate customer aversion to working with a contractor and participating in the program.

- Trade allies are satisfied with the program overall. All four of the trade allies said they were satisfied with the steps required to get through the program, the range of equipment that qualifies for the program, the amount of time it takes to receive the rebate, and the program overall.[57] Three of the trade allies indicated they were satisfied with the PSO website application center.[58]
- Program staff are professional and courteous and provide sufficient program support for successful program implementation. All the SBES trade ally respondents interacted with ICF in 2022 and were satisfied with the ICF program staff's level of professionalism and courteousness, knowledge about energy efficiency and energy-efficient products, response time to answer questions, and ability to explain program rules and customer eligibility.[59] The three trade allies that interacted with PSO in 2022 all agreed PSO staff were knowledgeable about the programs, timely in their responses, and professional and courteous.[60]
- The SBES program acts as a resource for PSO small business customers. The three lighting SBES trade allies observed that small business customers are interested in LED technology. However, two observed that though customers are interested and comfortable with LED technology, they tend to follow trade ally recommendations and "the program helps guide them." The other trade ally said that customers are interested in color-tunable fixtures and appreciate that these enable them to illuminate different areas with warmer or brighter tones.
- Smart thermostats were suggested to be added to the program. One trade ally suggested adding smart thermostats and mentioned that many small business customers run their HVAC systems even when their facilities are not occupied. He suggested smart thermostats could help small business customers to heat and cool their spaces on more appropriate schedules.
- Two trade allies offered suggestions to increase customer awareness. One simply suggested utilizing available social media platforms to promote the program. The other suggested "co-branded marketing material" that contractors could use to promote the program.

[57] Rated their satisfaction a 4 or 5 on a scale from 1 (extremely satisfied) to 5 (extremely satisfied).
[58] One trade ally indicated they were not familiar with PSO's website application center and unable to provide a rating.
[59] Rated their level of satisfaction a 4 or 5 on a scale from 1 (extremely dissatisfied) to 5 (extremely satisfied).
[60] Rated their level of agreement a 4 or 5 on a scale from (completely disagree) to 5 (completely agree).

3.2.4.6 SBES Conclusions and Recommendations

This section presents conclusions and recommendations for the SBES Program based on the 2022 process and impact evaluation findings.

Conclusions

- The SBES Program continues to be driven by lighting energy efficiency measures with a small contribution from refrigeration measures.
- Implementation practices resulted in program level estimated energy savings aligned with verified energy savings. Overall realization rates for annual energy savings and coincident peak demand reduction were high.
- Evaluation activities identified there was no free-ridership or spillover related to participation in the program.
- The SBES staff facilitated discussion and trade ally survey results suggest the addition of smart thermostats and on-bill financing could strengthen the program and add value for customers. The SBES refrigeration trade ally stated that on-bill financing could potentially mitigate customer aversion to working with a contractor and participating in the program. Findings from the staff discussion and review of PY2021 recommendations indicate smart thermostats were under consideration to be added as a program measure.
- The SBES trade ally surveys indicated that program staff continues to provide sufficient program support for successful program implementation. All the SBES trade ally respondents interacted with ICF in 2022 and were satisfied with their level of professionalism and courteousness, knowledge about energy efficiency and energy-efficient products, response time to answer questions, and ability to explain program rules and customer eligibility. The SBES trade allies that had interactions with PSO rated their interactions with them highly.

Recommendations

- Create targeted customer engagement or focus efforts to promote the SBES program’s non-lighting measures. Consistent with past program years, program tracking data indicates refrigeration projects made up a small portion of total program savings in 2022. Moreover, survey results suggest there is interest in additional communication from PSO regarding available PSO incentives/programs. PSO and ICF could work with the program’s refrigeration contractor to create co-branded materials and highlight the SBES program’s non-lighting incentives.

3.2.5 Commercial Midstream

This section reports findings from the Commercial Midstream lighting and HVAC program. The commercial midstream program aims to influence stocking practices to promote energy efficient equipment for various commercial lighting and HVAC equipment. An impact and process evaluation specific to this subprogram was performed. The gross verified annual energy savings estimates for midstream projects resulted in a 98% realization rate for gross energy savings and an 84% realization rate for gross peak demand reduction. Net energy impacts were determined through survey efforts of program participants. Separate net-to-gross ratio's (NTG) for both annual energy savings and peak demand reduction were determined for lighting and HVAC. The lighting NTG is 74.80% for annual energy savings and 78.16% for peak demand reduction. The HVAC NTG is 91.49% for annual energy savings and 100.00% for peak demand reduction.

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

3.2.5.1 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 264 projects. 237 projects consisted of lighting measures and 37 projects consisted of HVAC equipment. Table 3-131 provides projected, reported, and verified energy and demand impacts, as well as other program performance metrics for midstream projects.

1) Table 3-131: Performance Metrics – Midstream Lighting and HVAC

Metric	PY2022
Number of Projects	264
Energy Impacts (kWh)	
Reported Energy Savings	2,990,143
Gross Verified Energy Savings	2,936,271
Net Verified Energy Savings	2,382,279
Peak Demand Impacts (kW)	
Reported Peak Demand Savings	595.63
Gross Verified Peak Demand Savings	499.89
Net Verified Peak Demand Savings	423.32
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.56
Utility Cost Test Ratio	1.22

3.2.5.2 Process Evaluation Overview

The process evaluation consisted of facilitated discussions with program staff, interviewing distributors, and surveying 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 Methodology

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.

Data Collection

Data for the analysis was collected through provided program and project documentation, program staff facilitated discussion, distributor interviews, and end-use customer surveys. Program materials and documentation were gathered through the Sightline data management system. These materials were supplemented with information from manufacturers as well as the Air Conditioning, Heating and Refrigeration Institute (AHRI).

Impact Evaluation Methodology

The overall objective of the impact evaluation is to develop statistically valid estimates of gross and net annual energy savings (kWh), lifetime energy savings (kWh), and peak demand reductions (kW). 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, we employed an engineering analysis 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 analyses the methodologies from the Arkansas TRM v.8 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 sold fixtures/lamps were installed. The facilities will be categorized according to the definitions provided in the AR TRM v8. 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.

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 Program's lighting net-to-gross ratio (NTGR) was investigated through a survey of end-use customers. The data from each avenue reviewed prior to completing the analysis and determined sufficient information was reported from the end-user survey such that free ridership was calculated using only data collected through that survey.

Self-reported responses were used from end-use customers who purchased efficient lighting from the Midstream program during the current program year to estimate lighting discount free ridership.

The survey aimed to elicit information from which to estimate the number of bulbs that the customer would have purchased in the counterfactual scenario where the efficient light bulbs were not discounted. All customers included in the program tracking data through September 2022 were sent one email invitation and one reminder message. Subsequently, follow-up phone calls were made.

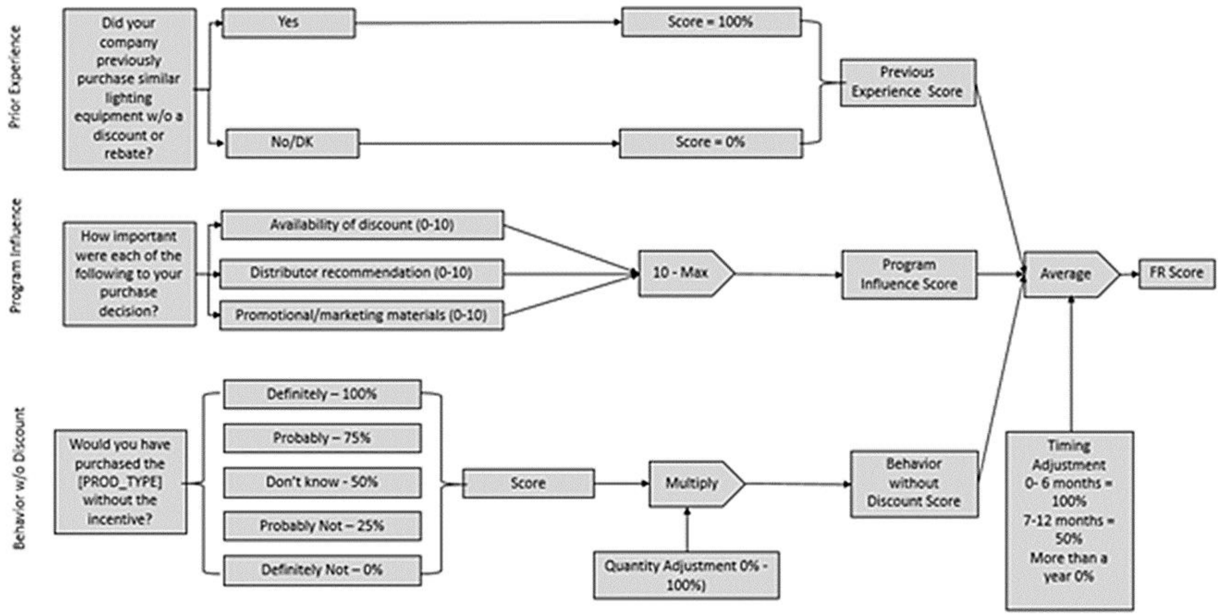
Survey respondents were asked a series of questions to elicit feedback regarding influences on their light bulb purchasing decisions. Each respondent was assigned a free ridership score based on a consistent free ridership scoring algorithm. The scoring algorithm used is based on the methodology described in the AR TRM v8.1.

Spillover was not assessed for the Midstream Lighting program. The final respondent net-to-gross score was calculated as follows:

$$NTG = 1 - \text{Free ridership}$$

The eight main questions were asked to determine each respondent's free ridership score. The free ridership scoring algorithm for light bulb purchases from the surveys is shown in Figure 3-38: Commercial Midstream Free Ridership Scoring Algorithm

Figure 3-38: Commercial Midstream Free Ridership Scoring Algorithm



The flow diagram has three paths or branches.

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

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

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

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

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

- Would you have purchased [PROD_TYPE] without the discount?
- Without the discounts from PSO, do you think you would have purchased the same amount, fewer, or more lamps?
- What percent of the lamps would you still have purchased if the discounts from PSO were not available?

- Did you purchase the [PROD_TYPE] earlier than you otherwise would have if the discount from PSO were not available? [DO NOT ASK TO NEW CONSTRUCTION PROJECT CUSTOMERS]
- When would you have purchased [PROD_TYPE] if the discounts from PSO were not available?

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

Midstream Non-Lighting NTG

The PSO Midstream HVAC Program's net-to-gross ratio (NTGR) was investigated through surveys of end-use customers, service provider interviews, as well as from a survey of participating HVAC distributors.

The data from each avenue was reviewed prior to completing the analysis and determined sufficient information was reported from the end-user survey such that free ridership was calculated using only data collected through that survey. Free ridership 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 the Custom and Prescriptive Evaluation Methodology section.

Lifetime Energy Savings

Lifetime energy savings (kWh) is the product of annual energy savings (kWh) multiplied by the Effective Useful Life (EUL). The EUL considers the technical lifespan of the equipment as well as the change in energy savings over time. The EUL is determined by measure for each measure within each project of the evaluation sample. The EUL for prescriptive measures is sourced from the AR TRM 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.

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?
- Were distributors satisfied with their experience? What was the level of satisfaction with the rebate amount, the application process, the rebated measures, and other aspects of program participation?
- What are PSO staff and implementation staff perspectives on the program? What are the reactions to program design choices that have been implemented?
- What do distributors like about the program? Why? What would they like to change about the program? Why?
- What share of projects are associated with specific distributors? How are savings distributed across them? Are there any differences in opinion between active and less active distributors?
- What types of buildings/facilities participated in the program? Could certain facility types be targeted more effectively?
- What customer barriers to participation do distributors see? How can these be mitigated?
- Were there any significant obstacles during the 2022 program year?
- Looking forward, what are the key barriers and drivers to program success within PSO's market?

To address these questions, the PY2022 process evaluation activities included a review of program materials, program staff interviews, distributor interviews, and end-use customer surveys. Table 3-132 provides a summary of data collection activities for the process evaluation.

Table 3-132: Commercial Midstream Process Evaluation Data Collection Activities Summary

Data Collection Activity	Process Evaluation Research Objectives
Review Program Materials	Review customer engagement materials, program procedure manuals, program websites, and other program documentation as it becomes available.
Program Staff Facilitated Discussion	Assess staff perspectives regarding the strengths, weaknesses, opportunities, and threats to program success.
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 basis) to determine program level net energy impacts.

Midstream Lighting Gross Impacts

The Midstream lighting program included 22,584 items sold with reported energy savings of 1,806,006 kWh and verified savings of 1,821,922 kWh, resulting in a gross realization rate of 101%. The program channel also claimed a peak summer demand savings of 408.50 kW, with a calculated verified summer peak demand savings of 350.62, resulting in a realization rate of 86%. A summary of the program level savings is shown in Table 3-133.

Table 3-133: 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
1,806,006	1,821,922	101%	408.50	350.62	86%

Data Collection

A review of the provided program database and associated project documentation was conducted to ensure there were no input errors or repeat entries. As the program is tracked at the distribution level, the data provided was used to determine lamp type, end-use customer, quantities, and wattages of each lamp type sold. No issues were found with the provided program database.

A summary of savings by facility type can be seen in Figure 3-39. The facility type that contributed the most program savings was “Office”. The second largest contributing facility type was “Warehouse: Non-refrigerated”. The “Office” space type contributed savings of 559,985 kWh, 31% of overall savings; while the “Warehouse: Non-refrigerated” space type contributed savings of 299,861 kWh, 16.6% of overall savings.

Figure 3-39: Commercial Midstream Reported kWh Savings by Facility Type

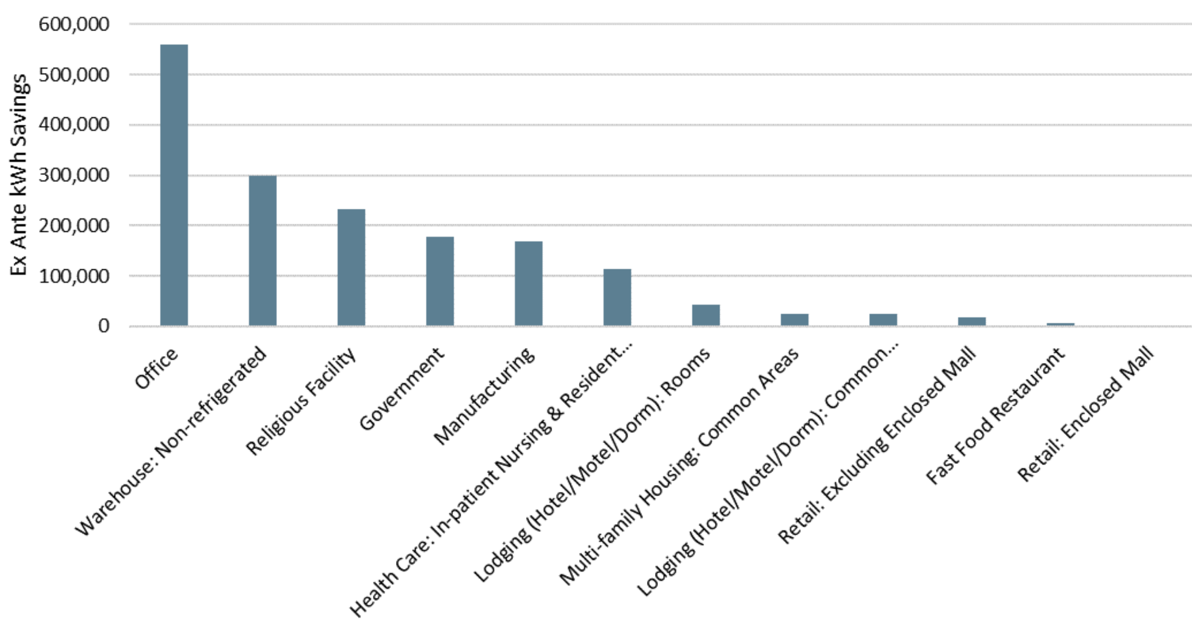
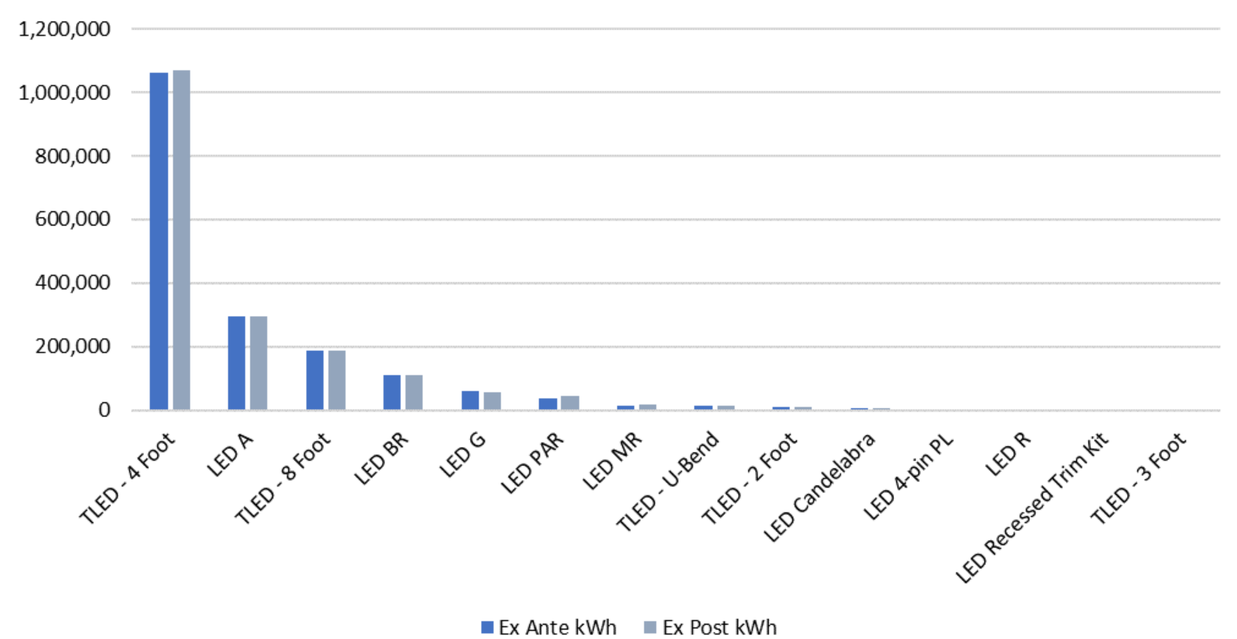


Figure 3-40 illustrates the relationship between reported and verified savings for lighting measures.

Figure 3-40: Commercial Midstream kWh Savings per Lamp Type



Discrepancies in the reported and verified program energy savings can mostly be attributed to a difference in the baseline and efficient wattages between the two calculations. The verified efficient wattages were determined by reviewing the spec sheets of the installed equipment. 23% of line items had a difference in the efficient wattage when comparing the reported and verified data, the range of difference goes from -2.5W to 3W. 11% of line items had a difference in the baseline wattage when comparing the reported and verified data, with a range of -20W to 15W.

Another discrepancy affecting the demand reduction savings was due to a difference in the coincidence factor (CF) utilized for the "Government" facility type. The reported savings calculation utilized a CF value of 0.7 sourced from the Mid-Atlantic TRM for an "Office" facility type, whereas the verified savings calculations utilized a CF value of 0.54 from the AR TRM for an "Office" building type. The "Government" facility type is not an official facility type in the TRM's, so "Office" is used as a general approximation. This difference in coincidence factor is the primary factor affecting the demand reduction realization rate.

Midstream Lighting NTG

Based on customer survey and distributor interview results, the distributor interviews were not considered for the calculation of free ridership. Only two distributors were able to be interviewed.

A phone survey was administered to customers that purchased lighting through the PSO Midstream Lighting program. 55 customers were invited to take the survey and 21 replied (response rate of 38%). All customers included in the program tracking data through

September 2022 were sent an email invitation and one reminder message. Subsequently, the survey team made up to two follow-up phone calls to 51 customers. Four survey responses were collected via email invitation, and 17 were collected via follow-up phone call. About 13% of the email survey invitations bounced. The 21 customers that were surveyed represent 67% of Midstream Lighting Program annual energy savings.

Customers that responded to the survey confirmed purchasing LED linear lamps, A-Line lamps, BR lamps, MR lamps, Globe, and/or PAR lamps. All the survey respondents confirmed that they purchased the program-discounted LEDs for the business or organization they worked for, owned, or managed to retrofit or replace existing lighting.

Self-reported responses from customers who had purchased efficient lamps and fixtures were used to estimate free ridership at 74.80% for annual energy savings and 78.16% for peak demand reduction.

- Twelve respondents had free ridership scores of 33% or greater (representing 63% of the sample kWh savings). Free ridership is based on three categories, prior experience, program influence, and behavioral without a discount.
  - Prior Experience: Three of these twelve respondents were assigned 100% "Prior Experience" scores because they reported having similar experience purchasing energy efficient lighting without a discount or rebate from PSO.
  - Program Influence: Five were assigned "Program Influence" free ridership scores that indicated the availability of the discount, recommendation from the distributor, and any marketing material they viewed were not important factors in their decision-making process.[61]
  - Behavior: Ten respondents stated they would have purchased this energy efficient lighting without the discount.
- One respondent represented 56% of the sampled kWh. They were scored as a partial free rider as they indicated they had purchased similar energy efficient lighting without a discount or rebate from PSO.
- Five respondents indicated that the program had affected the timing of their project. Two respondents said that their projects would have been completed more than one year later if the program were not available and were assigned free ridership scores of 0. Two said their project would have been completed between 7 months and 12 months later; their scores were reduced by 50%. The remaining respondent's score was not adjusted as they said they still would have purchased the lighting within 6 months.

[61] Did not rate any program element as important (7 or higher) in their decision-making process. ADM offered respondents a scale from 0 (not at all important) to 10 (very important).

See Table 3-134 and Table 3-135 for a summary of net savings impacts for the Midstream lighting program.

Table 3-134: Summary of Net kWh Savings - Midstream Lighting

Program Year	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
PY2022	1,806,006	1,821,922	101%	20,426,241	74.80%	1,362,798	15,278,828

Table 3-135: Summary of Net kW Savings – Midstream Lighting

Program Year	Reported kW Savings	Gross Verified Savings kW	Gross Realization Rate	kW NTG Ratio	Net Verified Savings kW
PY2022	408.50	350.62	86%	78.16%	274.04

Midstream Non-Lighting Gross Impacts

The Midstream Non-Lighting program involved the installation of 289 measures over 78 projects consisting of unitary and split system air conditioners, air source heat pumps, and variable refrigerant flow heat pumps. The gross verified energy savings and demand reduction was 1,029,962 kWh and 147.65 kW, resulting in realization rates of 94% and 80%, respectively. A summary of the program level savings is shown in Table 3-136.

Table 3-136: Summary of Midstream Non-Lighting Savings

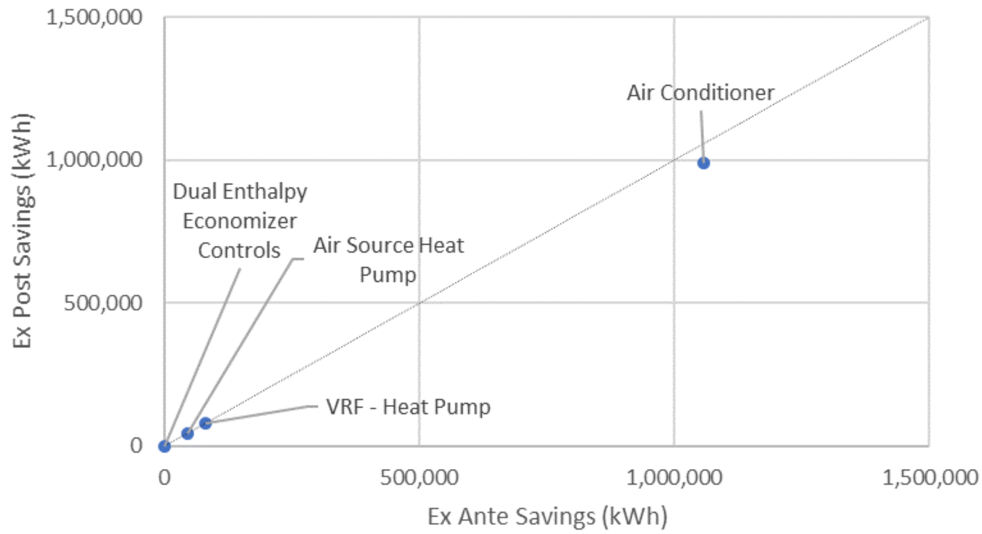
Reported kWh Savings	Verified kWh Savings	Gross kWh Realization Rate	Reported kW Savings	Verified kW Savings	Gross kW Realization Rate
1,184,138	1,114,349	94%	187.13	149.27	80%

Data Collection

Verified savings were determined for the Midstream Non-Lighting Program using the program tracking data provided by the implementation contractor. The data was reviewed to identify and remove any input errors or duplicates prior to final analysis. Provided AHRI identification numbers were used to determine capacities and efficiency ratings of the installed equipment. Other algorithm inputs were determined from the Arkansas v8 Technical Reference Manual (TRM) and MidAtlantic v8 TRM. No issues were found with the provided data.

A summary of savings by equipment type is shown in Figure 3-41. 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 with reported annual energy savings of 1,056,740 kWh, 89% of the program savings.

Figure 3-41: Commercial Midstream Non-Lighting Reported Savings vs Gross Verified Savings (kWh) by Equipment Type



The savings discrepancies in the Midstream Non-Lighting analysis were generally due to a difference in AHRI-rated efficiencies of the installed equipment, as opposed to the nameplate efficiencies utilized in the reported calculations. In some cases, this difference in efficiency rating warranted a shift in the baseline efficiencies based on values taken from the AR TRM, which affected the savings realization rates.

Midstream Non-Lighting NTG

A phone survey was administered in October 2022 to customers that purchased HVAC equipment through the PSO Midstream Program. 6 customers were surveyed after contacting all ten end use customers up to five times (three phone calls, two emails). Five respondents provided sufficient information to determine free ridership. The customers surveyed had purchased eligible air conditioners, controls, and a heat pump.

These self-reported responses from customers who had purchased eligible equipment were used to estimate net-to-gross ratios at 91.49% for verified annual energy savings and 100% for verified peak demand reduction, compared to 90.9% and 96.8% in 2021. Free ridership is applied as a percentage of each project’s annual energy savings and peak demand reduction. Free ridership may be applied at 33%, 66% or 100% of the project’s annual energy savings.

One respondent was scored as a full free rider. This respondent indicated they had the financial ability to make the purchase as well as plans to make the purchase. The other four respondents were determined not to be free riders as they indicated that they either did not have plans to purchase efficient equipment or did not have the financial ability to purchase the efficient equipment without the discount. Table 3-137 and Table 3-138 for details the summary of net savings impacts for the Midstream Non-Lighting Program.

Table 3-137: 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
PY2022	1,184,138	1,114,349	94%	16,092,084	91.49%	1,019,481	14,722,112

Table 3-138: 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
PY2022	187.13	149.27	80%	100.00%	149.27

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 3-139. Average EUL by measure classification is provided for reference.

Table 3-139: Midstream EUL's and Lifetime Energy Savings

Measure Classification	Average EUL	Gross Program Lifetime Energy Savings (kWh)	Net Program Lifetime Energy Savings (kWh)
Lighting	10	20,426,241	15,278,828
Non-Lighting	14	16,092,084	14,722,112
Total	**N/A**	**36,518,325**	**30,000,940**

3.2.5.5 Process Evaluation Findings

The process evaluation consisted of a participant survey, distributor interviews, and program staff interviews. A detailed process evaluation memo was provided to PSO after the completion of the 2022 program year.

Lighting End User Survey

A survey was administered via email in September and October 2022 to customers that purchased lighting through the PSO Midstream Program. The survey gathered information regarding program awareness, decision-making, satisfaction, and the participation process.

Fifty-five customers were invited to take the survey and 21 replied (response rate of 38%). All customers included in the program tracking data through September 2022 were sent one email invitation and one reminder message. Subsequently, the survey team made up to two follow-up phone calls to 51 customers. Four survey responses were collected via email invitation, and 17 were collected via follow-up phone call. About 13% of the email survey invitations bounced.

Customers that responded to the survey confirmed purchasing LED linear lamps, A-Line lamps, BR lamps, MR lamps, Globe, and/or PAR lamps. All the survey respondents confirmed that they purchased the program-discounted LEDs for the business or organization they worked for, owned, or managed to retrofit or replace existing lighting.

Midstream lighting end-use customers represent a variety of business types and typically rely on their organization's staff to install the lighting. Eighty-six percent of respondents noted that their organization had installed the discounted lighting, while the remaining 14% said that they had hired another company to install them. Table 3-140 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.

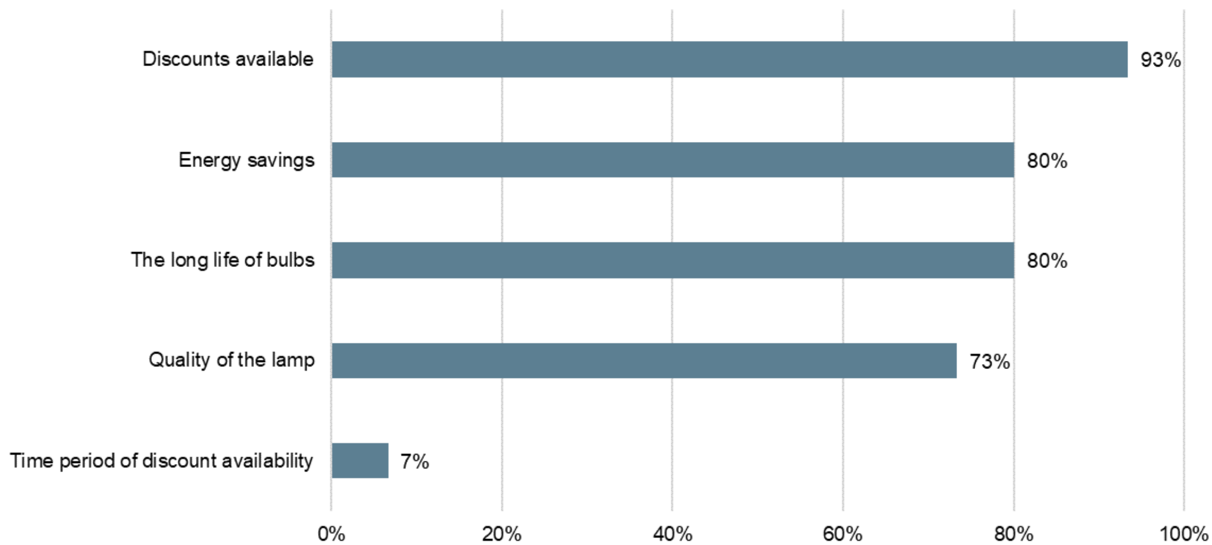
Table 3-140: Commercial Midstream Lighting Space Type where the lights were installed?

Type of Work	Number of Respondents	Percent of Respondents
Office	38%	8
Retail	19%	4
Religious	14%	3
Auto Repair	10%	2
Warehouse or distribution center	5%	1
College/university	5%	1
Restaurant	5%	1

Survey findings indicate customers are aware of the PSO Midstream program discount. Ninety percent of respondents said that they knew that all the energy-efficient lighting they purchased through the PSO Midstream Program had been discounted. All these respondents said they knew that the discount was sponsored by PSO.

Lighting distributor staff play a significant role in program awareness and customer understanding of lighting products. Eighty-six percent of respondents said that they learned about the discounted lighting from a distributor employee (81%) or customer engagement materials at the store (5%). Other respondents mentioned contacting PSO to ask about available discounts, receiving an email from PSO, or word-of-mouth information from a friend, relative, contractor, or colleague. Seventy-one percent of respondents recalled a sales representative at the lighting distributor discussing the benefits of the discounted lighting with them. Figure 3-42 displays the benefits respondents recalled salespeople discussing with them during their visit to purchase PSO-sponsored lighting products.

Figure 3-42: What benefits of the discounted lighting did the salesperson mention?[62]



Survey findings indicate that the Midstream Lighting program was an important factor for some customers, though a significant portion of respondents had purchased energy-efficient lighting in the past without a discount.

- Forty-three percent of respondents said that the availability of discounts was important in their decision to purchase energy-efficient lighting.[63]
- Seventy-one percent of respondents said they had purchased similar energy-efficient lighting in the past and 40% of those respondents reported having purchased it without a discount.
- Sixty-two percent of respondents said that a lighting distributor recommendation had been an important factor in their decision to purchase energy-efficient lighting.[64]

The three respondents with the greatest savings indicated the program was an important factor in their decision-making process. Three respondents that represented 87% of the kWh surveyed indicated the discount was important and without the discount they probably would not have purchased the lighting.

[62] n=15. Percentages exceed 100% because respondents may have selected more than one benefit that a salesperson mentioned.
[63] n=22.
[64] n=21. Rated the importance of the discounts a 7 or higher on a scale from 0 (not at all important) to 10 (very important)

Most of the survey respondents said that all the discounted lamps they purchased through the program had been installed, though some respondents mentioned they had not had an opportunity to install all the lamps yet. Table 3-141 displays the percent of the program discounted lamps respondents reported having installed currently.

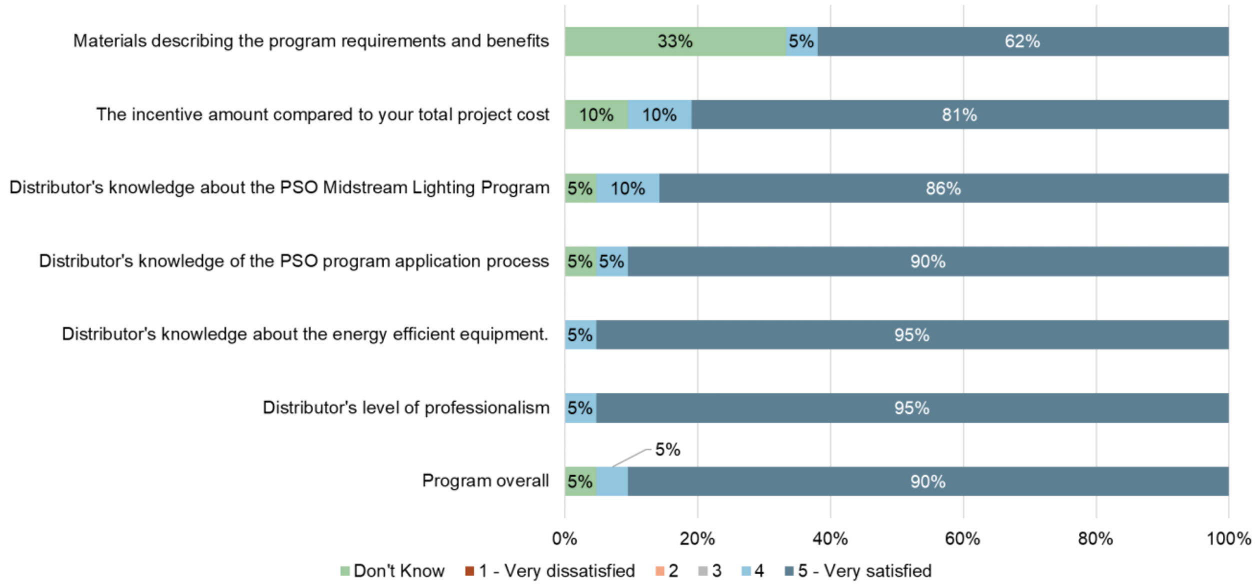
Table 3-141: Commercial Midstream Lighting in-service rates for discounted LED lamps

Product Type	Percent of Lamps Installed	Sample Size (n)
LED Linear Lamp(s)	94%	17
PAR Lamp(s)	100%	4
BR Type Lamp(s)	100%	2
Globe Lamp(s)	100%	2
A-Line Lamp(s)	67%	2
MR Type Lamp(s)	100%	1

Survey respondents were asked about their satisfaction with the PSO Midstream program and provided customers an opportunity to share recommendations to improve the Program. Most respondents were very satisfied with their lighting distributor, materials describing the program, the incentive amount compared to the total project cost, as well as the program overall (see Figure 3-43). Further, 57% of respondents said they had recommended this program to someone else. Fifty-six percent of customers who had not recommended the program said they would recommend it.[65] Ninety-five percent of respondents said they were satisfied with PSO as their electric utility.[66]

[65] n=9.
[66] n=21. The remaining respondent did not know how to rate their satisfaction with PSO as their utility.

Figure 3-43: Midstream Lighting Customer Satisfaction



Lighting Distributor Interviews

In October 2022 PSO Midstream program's two participating lighting distributors were interviewed. These interviews addressed Program awareness and distributors' reasons for participating, the Program training they received, the types of customers they serve and how they reach them, and aspects of their Program experience. The following summarizes the findings.

- The lighting distributors provided mixed satisfaction feedback. Both indicated they were satisfied with the program overall and the sales tracking process. One distributor was satisfied with the enrollment process, incentive processing aspect of the program, sales generated from program participation, and the program managers. The other distributor indicated that they were dissatisfied with the enrollment process and incentive processing aspects of the program and not satisfied with the program managers.[67] The primary reason for their dissatisfaction related to enrollment and not receiving a response from program staff after multiple inquiries regarding re-enrollment and updating their participation agreement.
- Training and support were sufficient for the actively engaged distributor; the other distributor indicated a desire for additional support. One distributor indicated that they had received training in 2022. This distributor said they were satisfied with the training and amount of support received from the program. The other distributor noted that they had not received training and indicated they would like to be contacted by ICF for support, specifically to assist with re-enrolling in the program.

[67] The distributor rated their satisfaction with enrollment and the incentive processing aspects of the program a 1 or 2 and the program staff a 3, using a scale from 1 (very dissatisfied) to 5 (very satisfied).

- Lighting distributors perceive the PSO Midstream discounts as an important factor in customers' decision-making. The distributors indicated that without the program they would have sold only 30% of the LED linear lamps and A-line lamps.
- The distributors observed that the Midstream program discounts motivate hotels and religious facilities to upgrade lighting. Both distributors mentioned that the program discount was a strong motivator for hotels to upgrade their lighting; one also mentioned religious facilities. The more active service provider observed that participating in the program had "gotten more people in the door to take advantage of the discounts, especially with the hotels and lodging."
- Both distributors suggested expanding the program to include additional efficient lighting types, specifically LED fixtures. Consistent with findings from interviews with lighting distributors in past program years, there is interest in expanding the range of eligible measures.

Program Staff Facilitated Discussion

A facilitated discussion with PSO's energy efficiency coordinator and ICF's account manager for the Midstream Program was performed in October 2022. The purpose of the discussion was to investigate the status of the recommendations provided to PSO in the 2021 Final Report and Process Memo as well as the program's progress towards energy-savings goals, changes to program design, strengths and challenges, and planned changes for the future.

The facilitated discussion resulted in the following findings.

- The Midstream Program will update its lighting and HVAC offerings. Program measures were changing for HVAC and lighting next year and that there would be a revised program guide. Code changes will eliminate general service lamps as an eligible measure. HVAC measures will be influenced by new federal standards and additional measures will be considered such as VFD's.
- There were improvements to the online intake tool, enabling expanded QA/QC and bulk project uploading. The program's online intake tool was improved to allow for easier bulk uploading of invoices. The feature is available for both lighting and HVAC projects.
- There are efforts to maintain relationships with participating distributors as well as to engage with non-participating distributors that are active in PSO territory; as distribution channels and distributor offerings change it presents opportunities to work with new distributors.
- HVAC service providers typically complete rebate paperwork and submit the required application and invoices to participating distributors; they are not required to complete any onsite verification data and there is currently no QA/QC photo

requirement for service providers to fulfill. The implementers account manager observed that service providers that have yet to participate “often balk” at the program because they perceive the process as difficult. However, once they participate, they recognize it as a simple process.

- Upcoming regulatory changes amplified existing supply chain challenges and made qualifying equipment expensive and difficult to obtain. In 2022, replace-on-burnout out projects “dried up” because purchasing program-qualified equipment in a timely fashion was not possible. Distributors have sought to sell off their existing inventory of equipment that will no longer be able to be sold in 2023 and that distributors stopped taking orders for certain equipment types.

HVAC End User Survey

A phone survey was administered in October 2022 to customers that purchased HVAC equipment through the PSO Midstream Program. 6 customers were surveyed after contacting all ten end use customers up to five times (three phone calls, two emails). Unless otherwise stated, the calculations, graphs, and tables in this process evaluation use the complete sample of respondents (n = 6).

Most HVAC customers were aware of the Midstream program discount. Five of the respondents knew that the equipment they bought had been discounted and all these respondents knew that the discount had been sponsored by PSO.

The program is utilized by customers completing new construction, replace-on-burnout, and retrofit projects. Three of the respondents said that the energy-efficient HVAC equipment their organization purchased was for a new construction project. Two respondents said they bought PSO-discounted equipment because of equipment failure; these respondents also cited reducing energy use/costs. The third respondent that replaced equipment said they purchased the PSO-discounted equipment to replace old or outdated equipment/ get latest technology. Table 3-142 displays customers’ reasons for purchasing the PSO-discounted HVAC equipment.

Table 3-142: Commercial Midstream HVAC Why did your organization buy the PSO-discounted equipment?

Replacement Type	Number of Respondents (n=3)
Old equipment had failed	2
To reduce energy costs/use	2
To replace old or outdated equipment/ get latest technology	1
Scheduled change out related to company budget	1

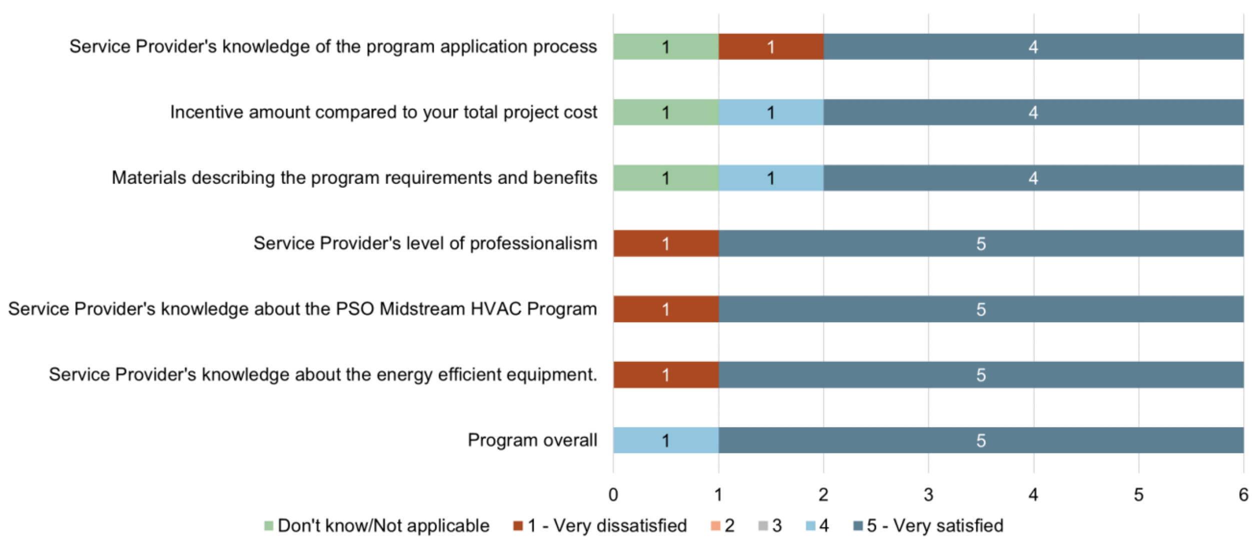
The five respondents who were aware that PSO sponsored a discount on the HVAC equipment they purchased answered questions regarding their decision-making process.

Three respondents said they purchased more efficient HVAC equipment because of the discount. And two said they would not have purchased the same energy-efficient HVAC equipment without the PSO-discount.

Three respondents said they had previous experience with PSO energy efficiency programs and all these respondents said that it was important in their decision to complete the energy efficient HVAC equipment project through PSO's Midstream Program.[68]

All HVAC end user survey respondents said they were satisfied with the program overall and five indicated they were satisfied with their experience with their HVAC service provider (see Figure 3-44). Three customers said they had recommended the program, and the three who had not yet recommended it said they would be likely to recommend it.[69] All respondents said they were satisfied with PSO as their electric utility.[70]

Figure 3-44: Midstream HVAC Customer Satisfaction



HVAC Distributor Interviews

In October 2022, three HVAC distributor contacts that participated in the PSO Midstream Program were interviewed. We contacted all five distributors that participated in the program in 2022, up to five times (three phone calls, two emails). These interviews addressed Program awareness, training, reasons for participating, stocking and sales of Program-qualified equipment, and other aspects of their experience in PY2022.

Two of the contacts worked directly for HVAC distributors ("distributor representatives") and one stated that they were a consultant, and their company facilitated PSO Midstream HVAC projects by working with a distributor and end-use customers.

[68] Rated the importance of their experience as very important.

[69] Rated their likelihood of recommending the program a 7 or higher on a scale from 0 (not at all likely) to 10 (extremely likely).

[70] Rated their satisfaction with PSO a 4 or 5 on a scale from1 (very dissatisfied) to 5 (very satisfied).

The two distributors said that they sell most or all their equipment to service providers. The consultant stated they work directly with end-use customers and act as a designer/engineer and intermediary between the HVAC distributor and the customer. Their primary customers are school districts.

The two distributors cited service provider requests as the primary reason for participating in the program. The consultant stated that they charge a fee that comes out of the rebate check, and they began participating in the program to assist a school district with program participation.

All three HVAC distributor contacts were satisfied with the program overall, though one distributor representatives communicated opportunities for improvement. The consultant and one distributor indicated they were satisfied with the program overall as well as individual aspects of their participation and did not offer suggestions for improvement. One distributor representative noted that they were not satisfied with program sales tracking, incentive processing aspects of the program, or program managers and other staff involved in the program.

All three contacts noted that their company used at least one strategy to sell program-qualified units. Table 3-143 displays the strategies that contacts noted using to sell qualified units, as well as the number of contacts that said the Program had influenced them to use each strategy.[71]

Table 3-143: Commercial Midstream HVAC Strategies used to promote qualified equipment

Promotion Strategy	Number of contacts that use strategy	Number of contacts influenced by Program to use strategy
Discuss the benefits of Program-qualified units with design professionals	2	2
Customer engagement of Program-qualified units	2	2
Upsell contractors	2	1
Develop customer engagement or informational materials for service providers	1	1
Conduct training workshops for contractors	0	N/A

The two distributor representatives observed that supply chain issues had impacted their sales of program-qualified units. More particularly, one said that supply chain issues made determining the impacts of the program challenging and the other said their sale of program-qualified units had decreased due to a lack of available units. One distributor representative said stocking of program-qualified units had decreased since enrolling in

[71] Rated the Program's level of influence on their decision to use a promotion strategy a 7 or higher on a scale from 0 (not at all influential) to 10 (greatly influential)

the program, while the other said their stocking had remained the same. All three interviewees noted that supply chain issues had impacted their ability to participate in the program because program-qualified units had long lead times and reduced availability in 2022.

HVAC Service Provider Interviews

In October 2022, three HVAC service provider contacts that participated in the PSO Midstream Program were interviewed. We contacted all eight service providers that had participated in the program at the time, up to five times (three phone calls, two emails). These interviews addressed program awareness, training, reasons for participating, sales practices, satisfaction, and other aspects of their experience in PY2022. The interviewees all noted having participated in PSO's commercial energy efficiency programs for several years.

The financial benefit to customers and competitive advantage against other service providers were cited as the primary motivators for HVAC Service Providers to participate. All three interviewees said that they were motivated to participate because the program provided customers with a financial incentive; two mentioned that they participated because it gave their company a competitive advantage.

The interviewees said that they told most or all the customers they were working with about the program. Two of the interviewees noted that the availability of eligible equipment affected whether they told customers about the program. All three said they told customers about the program during in-person sales visits and provided estimates or proposals with the program discount specified on it.

The interviewees all noted that their ability to participate in the program was limited by equipment availability. Beyond equipment availability, the service providers cited several reasons for limited program participation. Some reasons related to program design, some related to implementation. All three service providers said that they had experienced long rebate processing times. Two service providers specifically voiced frustration with the Midstream program's design and shared a preference for direct payments to service providers rather than to distributors. One service provider indicated that the rebate process was "cumbersome" and stated that they do not file for reimbursement in some instances because of the administrative requirements to participate. Further, this contact said they "shouldn't have to jump through hoops to get the rebate" and alluded to onsite picture and paperwork requirements.

One service provider said the program was important in influencing their level of customer engagement and selling the program qualified equipment to PSO customers in 2022.[72] They noted that they quoted customers for higher efficiency equipment because of the

[72] One service provider rated the importance of the program an 8 on a scale from 0 (not at all important) to 10 (very important).

program. One service provider indicated that the program had not influenced their sales practices. The remaining service provider observed that though the influence of the program had lessened as equipment prices had risen, it still “makes a difference” in some cases in which a customer may not be able to afford the equipment without the rebate.

Two respondents were satisfied with the program overall, and all three were satisfied with the program staff.[73] None were satisfied with the rebate amounts or the range of equipment that qualified for rebates.[74] Two noted that the rebate levels were not sufficient; one observed that “mini-splits have the only worthwhile incentive” and that the program previously influenced sales, but now it does not. Two service providers were also dissatisfied with the amount of time it took for rebate payments

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.

- Survey and interview findings suggest the Midstream program plays an important role in end-use lighting customers’ decision-making process. Both lighting distributors perceive the PSO Midstream discounts as an important factor in customers’ decision-making and most lighting end-use survey respondents indicated that the program influenced their decision-making process to some extent.
- The Midstream HVAC program was impacted by supply chain issues. All three HVAC service providers noted that their ability to participate in the program was limited by equipment availability.
- Distributor interviews suggest an opportunity to improve program communication. One lighting and one HVAC distributor indicated dissatisfaction with the amount of support and communication provided from program staff. The lighting distributor mentioned interest in re-enrolling in the program and being unable to reach program staff, while the HVAC distributor communicated interest in program updates and periodic contact from staff.
- More engaged distributors tended to be more satisfied with program participation. Most program sales were made through one lighting distributor and an HVAC rebate processing consultant. The contacts that represented these two organizations were satisfied with the program overall, as well as various aspects of program participation.
- The facilitated discussion with program staff and HVAC Service Provider interviews suggest an opportunity to increase service provider engagement

[73] Rated their satisfaction a 4 or 5 on a scale from 1 (very dissatisfied) to 5 (very satisfied).
[74] Rated their satisfaction a 3 or lower on a scale from 1 (very dissatisfied) to 5 (very satisfied).

through better understanding of program requirements. One service provider interview suggested an opportunity to improve understanding of program participation requirements.

- HVAC service providers observed long rebate processing times. All three service providers said that they had experienced long rebate processing times.
- There were improvements to the online intake tool, enabling expanded QA/QC and bulk project uploading. The program's online intake tool was improved to allow for easier bulk uploading of invoices.

Recommendations

- Continue to conduct outreach to service providers and distributors to ensure understanding of program requirements and participation process. Outreach and education for distributors and service providers is important as there are upcoming regulatory changes, program updates, and a general lack of familiarity with Midstream program participation requirements from inexperienced distributors and service providers.
- Seek to reduce HVAC distributor rebate processing times and timely payment of service providers. Working with distributors to establish payment systems that quickly process credits before projects are submitted could help lessen potential frustration with program participation for service providers.
- Ensure there is sufficient communication with all distributors that are interested in engaging with the program. One lighting and one HVAC distributor indicated dissatisfaction with the amount of support and communication provided from program staff. There may be potential to expand program participation with increased communication with interested distributors.
- Consider additional measures to the Midstream program. As previously recommended, incentivizing food service equipment will reduce reliance on lighting and HVAC measures and potentially increase the range of business types that engage with the program.

3.3 Home Weatherization Program

This chapter presents evaluation findings from the impact and process evaluation of the Home Weatherization's 2022 program year.

3.3.1 Program Overview

PSO's Home Weatherization Program objective is to generate energy savings and peak demand reduction for limited-income residential customers through the direct installation of weatherization measures in eligible dwellings. The weatherization program provides no-cost energy efficiency improvements to PSO customers living in homes that are less than 2,200 square feet, built before 2010, with household incomes of $55,000 or less. PY2022 performance metrics are summarized in Table 3-144.

Table 3-144: Performance Metrics – Weatherization

Metric	PY2022
Number of Customers	1,901
Budgeted Expenditures	$3,415,715
Actual Expenditures	$3,361,071
Energy Impacts (kWh)	
Projected Energy Savings	2,526,832
Reported Energy Savings	3,968,049
Gross Verified Energy Savings	3,966,545
Net Verified Energy Savings	3,966,545
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	908.65
Reported Peak Demand Savings	2,229
Gross Verified Peak Demand Savings	2,228
Net Verified Peak Demand Savings	2,228
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	2.67
Utility Cost Test Ratio	1.61

In 2022, 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 3-145 shows measures installed through the program in 2022. Duct sealing made up the largest share of reported kWh savings and was the second most common measure type installed. In conjunction with attic insulation and air sealing, this makes up approximately 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 2022, the program continued to provide these measures (excluding advanced power strips). These measures made up less than one percent of program savings.

Table 3-145: Summary of Weatherization Measures Implemented

Measure	Number of Projects	% Share of Reported kWh Savings
Duct Sealing	1,556	52%
Attic Insulation	1,297	27%
Air Infiltration	1,560	20%
Air Infiltration (Mobile home)	25	0.4%
Water Heater Pipe Insulation	724	0.2%
Water Heater Jacket	65	0.1%
LED (Mobile home)	22	0.1%
Faucet Aerators (Mobile home)	23	<0.1%
Low Flow Showerheads (Mobile home)	3	<0.1%

PSO’s Home Weatherization Program serviced 1,901 households during the 2022 program year. Participants saved an average of 2,158 kWh. This compares to an average of 2,111 kWh in 2018, 1,828 kWh in 2019, 1,959 kWh in 2020, and 1,911 kWh in 2021. Titan ES was responsible for the installation of these energy efficiency measures at most of these homes (see Table 3-146).

Table 3-146: Weatherization Homes by Agency

Agency	Number of Homes
Titan ES	1,862
RTT	39
Total	**1,901**

Participation in the Home Weatherization Program remained consistent throughout the year. Figure 3-45 displays the accrual of reported energy savings throughout 2022. This is a positive indication of a steady flow of energy efficiency projects throughout the implementation period.

Figure 3-45: Weatherization Accrual of Reported kWh Savings During the Program Year

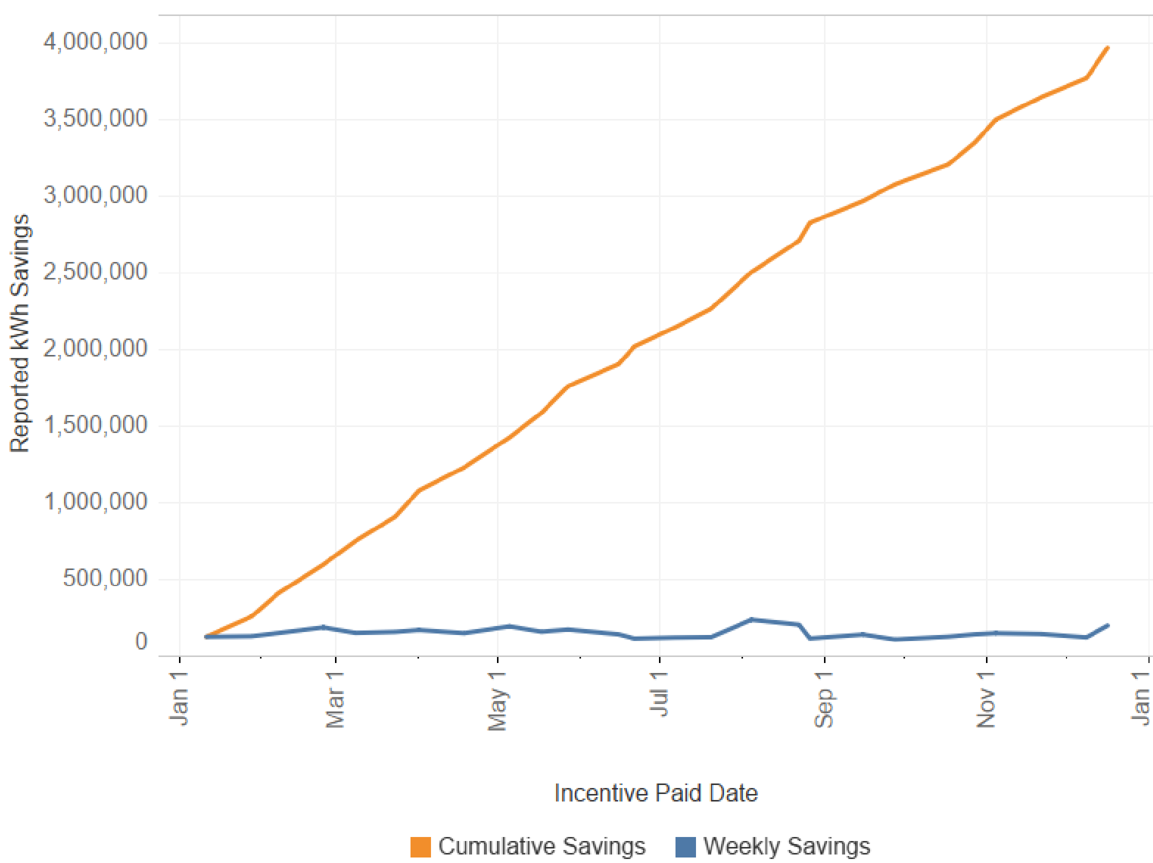
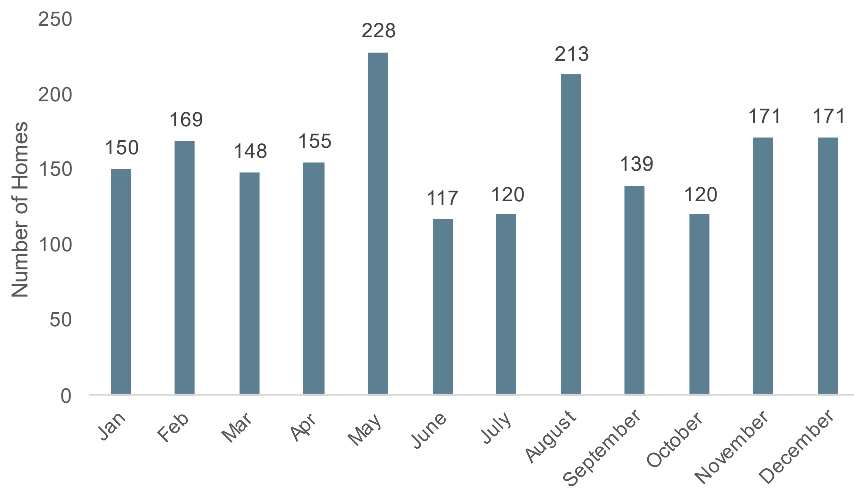


Figure 3-46 displays the number of homes invoiced each month. May had the highest number of homes invoiced. June and July had the fewest number of homes.

Figure 3-46: Weatherization Number of Projects by Month



3.3.2 EM&V Methodologies

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. Process evaluation activities included a participant survey, ride-alongs with the program's contractor and third-party verifier, and a facilitated discussion with staff to investigate the implementation of ADM's past recommendations and to develop a customer journey map.

3.3.2.1 Data Collection

Several primary and secondary data sources were used for the evaluation. Tracking data and supporting documentation for the program was obtained from SQL Server Reporting Services (SSRS). This tracking data was used as the basis for quantifying participation and assessing program impacts. Additional data was collected through phone surveys, photographic verification with participating customers, virtual verifications with the primary program contractor, and staff interviews. Table 3-147 summarizes the data collection activities and evaluation purposes.

Table 3-147: Weatherization Data Collection Efforts

Data Collection Activity	Achieved Size	Evaluation Purpose
Ride-Alongs with Installation Contractor	3	Measure and installation process verification
Ride-Alongs with Third-Party Verification Contractor	3	Observation of verification process, verification of and measure installation
Photo verification from participating customers	5	Measure and installation verification
Customer Surveys	105	Measure verification, In-Service Rate, customer satisfaction
In-Depth Interviews with Program Staff	2	Assess relevance of past years' evaluation recommendations. Discuss customer journey to create a common understanding of participation experience and identify key touchpoints and create a journey map.

Participant Telephone Survey Sampling Plan

To provide program feedback, ADM conducted a mixed mode (phone/email) survey of PY2022 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 percent confidence level (90/10).

For the calculation of sample size for survey completes, a coefficient of variation of 0.5 was assumed.[75] With this assumption, a minimum sample size of 68 participants was required, as shown in the following formula:

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

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

Where:

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

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

Both respondent types (phone/email) were offered a $10 incentive (either digital or physical gift card) for completing the survey. Additional survey completes will be 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.

Participant Telephone 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.

Additionally, program participants that receive direct install measures including LED light bulbs, 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. Section 0 provides details regarding the findings of ADM's survey efforts.

3.3.2.2 Gross Impact 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 its participant telephone 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 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 Appendix G. Table 3-148 displays the references or sources for savings methodologies for the measures offered through the home weatherization program in PY2022.

Table 3-148: 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

3.3.2.3 Net-to-Gross Estimation

The Home Weatherization Program specifically targets customers with limited income, providing all services at no cost to the customer. It is likely that participating customers would not have funded the installed energy efficiency measures on their own. As a result, an assumed NTG ratio of 100% was applied to all measures.

3.3.2.4 Ride-Alongs with Contractor

ADM staff shadowed the program's implementation and Third-Party Verification (TPV) contractors during home weatherization and post-weatherization verification visits. During the installation contractor ride-along visits ADM verified contractor procedures and visually verified the installation of major program measures (attic insulation, duct sealing, and air sealing). ADM attended TPV visits to observe verification procedures and to visually corroborate program tracking records.

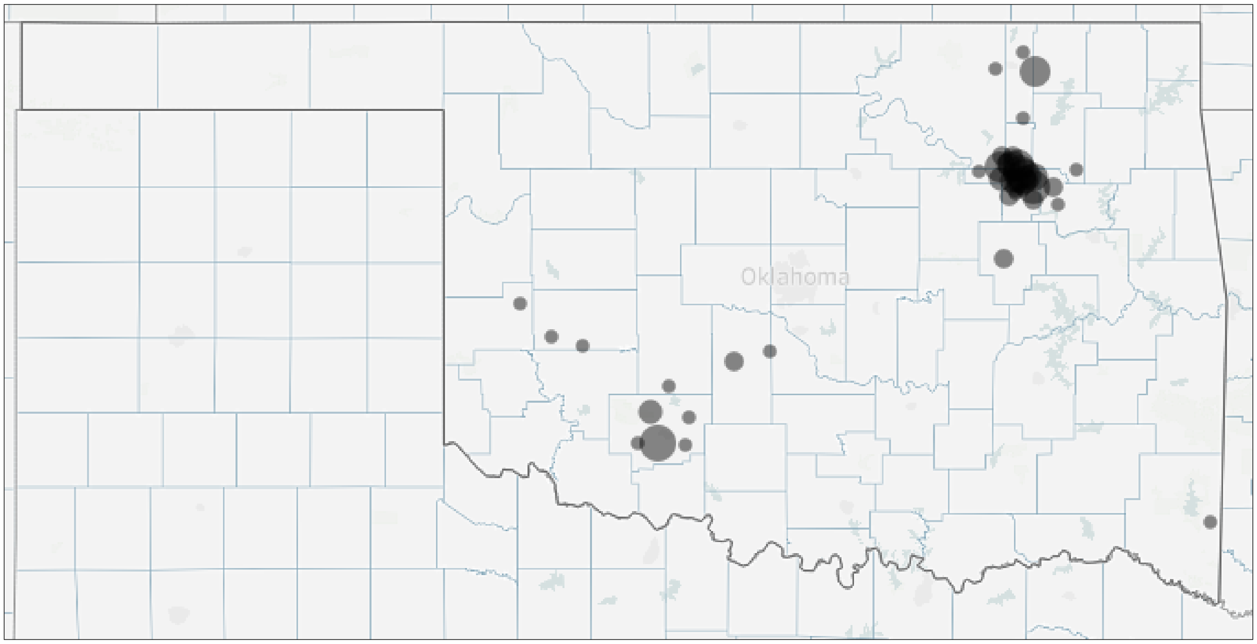
3.3.3 Impact Evaluation Findings

This section provides information on the impact evaluation findings for PY2022.

3.3.3.1 Participant Telephone Survey Findings

ADM completed surveys with program participants across the service territory. ADM's in-house survey team called 278 participants and completed 50 phone surveys (18% response rate) and 56 email surveys (17% response rate) for a total of 105 survey responses. Survey responses represented 13 counties and 44 zip codes. Survey participants by zip code is shown in Figure 3-47. Each point represents a unique zip code. Larger points indicate more survey responses, with the sizes representing from 1 to 7 projects.

Figure 3-47: Number of Survey Participants by Zip Code[76]



3.3.3.2 Email Verification Findings

Survey respondents were asked if they were willing to send photographic evidence to further verify participation. Six survey respondents that received water heater jacket or pipe insulation installations provided visual evidence of measure installation by sending an email with a photo attachment.

3.3.3.3 Ride-Along Findings

Thirteen on-site ride-along visits were conducted; six visits with Titan ES and seven with the program's TPV. The visits were in May and June 2022. The primary goal of the installation contractor ride-along visits was to verify contractor procedures and to visually verify the installation of major program measures (attic insulation, duct sealing, and air sealing). The third-party verification contractor ride-along visits were conducted to verify TPV contractor procedures and to visually verify the installation of major program measures (attic insulation, duct sealing, and air sealing).

Upon arrival at each of the six customer homes selected for ride-alongs with Titan ES, the Titan ES supervisor and crew showed ADM's field technician the areas that they intended to conduct air sealing or duct sealing, the pre-condition of the ride-along homes' attics, as well as initial blower door test and duct leakage test results.

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

ADM's field technician observed Titan ES staff perform work needed to improve the home's energy efficiency. Once work was completed Titan ES staff performed final blower door and duct sealing tests.

Upon arrival at each of the seven customer homes selected for ride-alongs with the TPV contractor, the contractor showed ADM's field technician the areas they observed as having signs of the claimed work done by Titan ES. Once all claimed work was observed and annotated as verified, the contractor performed blower door and duct leakage tests, if applicable. The contractor compared his results with Titan ES' results.

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

- Air Sealing: ADM observed homes with gaps around doors, under sinks, and around pipes and windows before Titan ES performed improvements. After Titan ES staff completed their work, ADM observed weatherstripping around doors, foam sealant under sinks around pipes, and caulking around windows and doors.
- Duct Sealing- ADM noted gaps around registers and plenum holes before Titan ES conducted weatherization improvements. We noted signs of mastic and tape on ducts, plenums, registers, and returns after weatherization was complete.
- Attic Insulation- ADM observed that the six homes had unevenly spread insulation at depths ranging from 3-6 inches. After Titan ES staff completed weatherization, ADM's field technician verified insulation was evenly spread at depths from 14-16 inches.

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

For each of the ride-alongs with the program's TPV, ADM noted the following post-conditions for each program measure:

- Air Sealing: ADM observed weatherstripping around doors, foam sealant under sinks around pipes, and caulking around windows and doors.
- Duct Sealing: ADM noted signs of mastic and tape on ducts, plenums, registers, and returns.
- Attic Insulation: ADM verified insulation evenly spread at depths from 14-16 inches for six of the seven homes visited with the TPV. During one of ADM's ride-alongs with TPV, the TPV contractor and ADM technician observed 9-10 inches of post insulation. The TPV contractor informed the ADM technician he failed verification of this measure for the home and would contact the installation contractor for review.

The program's tracking system indicates this home was flagged for review by the TPV in June 2022. Because of the findings during the TPV ride-along ADM did not assign verified savings for this project, though the program's reported data attributed savings to this project.

During the TPV ride-alongs the ADM technician observed test-out values for both blower door and duct blaster tests and took post-pictures of the measures performed the results were as expected with six of the seven homes ADM visited with the TPV.

3.3.3.4 Air Infiltration

A total of 87 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. Visually identifying caulking and/or sealing is not always apparent and as these respondents could not determine, their responses were considered inconclusive. 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 (CFM_{50} 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.

3.3.3.5 Attic Insulation

A total of 73 survey respondents were asked to confirm whether they had attic insulation installed. Two respondents did not recall receiving this measure, so their responses were considered inconclusive and were removed from ADM's ISR calculation. An ISR of 100% was applied for attic insulation. ADM assigned no savings to one project because of findings from one of its ride-along visits during which the TPV flagged the site for review. This finding did not materially affect the overall measure level realization rate.

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.

3.3.3.6 Duct Sealing

A total of 86 customers were asked to confirm duct sealing improvements made through the program. Twelve 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. The third respondent was unable to be reached; ADM verified program tracking data for this customer and based on these findings, 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. Additional details can be found in Appendix G regarding the methodology. ADM calculated the prescriptive savings values for each home and determined the program-level realization rates for duct sealing were 100%.

3.3.3.7 LED Light Bulbs

Because of limited participation with this measure, ADM did not survey participants that received LED light bulbs through the program in 2022. Responses were used from the 2020 and 2021 evaluations to calculate an ISR for this measure. In 2020, thirteen respondents confirmed that 61 LEDs they received through the program were still installed. In 2021, five respondents confirmed all the LEDs were still installed. One respondent stated that none of the 6 LEDs they had received were currently still installed. An ISR of 94% was applied to the verified (verified) energy-saving calculation (ISR=93/99).

LED bulb gross savings calculations resulted in realization rates of 94% kWh and 94% for peak demand reduction based on the above ISR. The reported savings calculations were otherwise consistent. LED savings made up a small portion of total program savings (0.1%).

3.3.3.8 Water Heater Jackets and Pipe Insulation

ADM completed 44 verification surveys with customers that had water heater insulation or jackets installed in their homes through the program. Thirty-one respondents were able to confirm installation of water heater jackets or pipe insulation. Seven stated they did not receive this measure. Titan ES staff followed up with these customers and were able to verify installation of pipe insulation or water heater jackets at each of the homes. Six respondents did not recall receiving this measure, so their responses were considered inconclusive. Based on these findings, an ISR of 100% was applied.

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 100%.

3.3.3.9 Faucet Aerator(s)

Due to the limited installation of this measure through the program in 2022, 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 73% for peak demand reduction and 75% for kWh 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.

3.3.3.10 Low Flow Showerhead(s)

Due to the limited installation of this measure through the program in 2022, 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).

ADM used the AR TRM to determine savings for this measure and found savings methodologies were consistent with the reported estimates.

We found a realization rate of 74% for peak demand reduction and kWh savings for this measure. The main driver of the less than 100% realization rate for low flow showerhead(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.

3.3.3.11 Impact Evaluation 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 largely consistent with past evaluation years with minor changes for faucet aerator and low flow showerheads, which had minor impacts on realization rates. Realization rate risk was apparent for direct install measures in the application of in-service rates to gross savings. Table 3-149 displays the results.

Table 3-149: Home Weatherization In-Service Rates

Measure	Verified/Claimed	Number of Measures	ISR	Other Realization Rate Factors
Attic Insulation	Verified	71	100%	N/A
	Claimed	71		
Duct Sealing	Verified	74	100%	N/A
	Claimed	74		
Infiltration	Verified	86	100%	N/A
	Claimed	86		
WH Pipe Wrap/Insulation	Verified	38	100%	N/A
	Claimed	38		
LED Bulbs	Verified	93	94%	N/A
	Claimed	99		
Faucet Aerators	Verified	12	80%	Savings Algorithm
	Claimed	15		
Low Flow Showerheads	Verified	11	73%	Savings Algorithm
	Claimed	15		

Verified and reported annual energy savings and peak demand reduction by measure are shown in Table 3-150. 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 2021.

Table 3-150: Home Weatherization Reported and Verified Energy Savings (kWh and Peak kW)

Measure	Reported Energy Savings (kWh)	Reported Peak Demand Savings (kW)	Verified Gross Energy Savings (kWh)	Verified Gross Peak Demand Savings (kW)	kWh Realization Rate	kW Realization Rate
Duct Sealing	2,064,003	933.22	2,064,003	933.22	100%	100%
Attic Insulation	1,071,788	1,004.07	1,071,232	1,003.32	100%	100%
Air Infiltration	799,954	283.30	799,626	283.30	100%	100%
Air Infiltration (Mobile home)	16,095	5.42	16,095	5.42	100%	100%
Water Heater Pipe Insulation	6,820	2.17	6,820	2.17	100%	100%
Water Heater Jacket	4,420	0.33	4,420	0.33	100%	100%
LED (Mobile home)	2,424	0.35	2,277	0.33	94%	94%
Faucet Aerators (Mobile home)	1,625	0.18	1,391	0.14	86%	83%
Low Flow Showerheads (Mobile home)	920	0.10	681	0.07	74%	74%
Total	**3,968,049**	**2,229.13**	**3,966,545**	**2,228.30**	**100%**	**100%**

3.3.4 Process Evaluation Findings

ADM's process evaluation activities included a participant survey and a facilitated discussion with program staff. The process evaluation memo ADM provided to PSO in November of 2022 contained more detailed information on the facilitated discussion and participant survey.

3.3.4.1 Program Staff Facilitated Discussion

ADM facilitated a discussion with program staff to support the development of a customer journey map for the program and the status of the recommendations provided to PSO in its 2021 Final Report and Process Memo.

3.3.4.2 PY2021 Recommendation Review

As part of the review of the PSO Home Weatherization program design and operations in PY2021, ADM provided ten recommendations for program improvement. ADM noted the status of each of the recommendations as completed, ongoing, no longer applicable, or not implemented/no change made. ADM's recommendations are organized by status below, with italicized notes taken from the facilitated discussion with PSO and implementation staff.

<u>*Completed recommendations*</u>

- Continue to consider ways to increase the pipeline of projects such as revisiting past participant homes and adjusting program qualifications. Program staff noted that there may be an opportunity to reassess and make weatherization improvements at past participants' homes. They also suggested revisiting the income level, age of home, and square footage eligibility requirements.

  In addition, consider review of program qualifications and the possibility of revisiting past participant homes. Qualifications that PSO could revisit include income level, age of home, and home square footage. Though the pool of eligible homes is not a current threat, this recommendation could help ensure a continuous, strong pipeline of projects.

  Program Adjustment: The income and home size eligibility requirements were increased. Prior participants are now able to participate if their home was weatherized more than 10 years ago.

- Continue to advertise the program to eligible PSO customers, focusing on highlighting program measures and improvement limitations. PSO Home Weatherization customer engagement and outreach can continue to promote educational material, ensuring customers understand the program's offerings and eligibility requirements.

  Program Adjustment: PSO's program coordinator observed that customer engagement was consistent in 2022 with past years and did not note any updates to messaging or platforms used.

- Verify customer awareness of home improvements and utilize platform to promote energy efficiency actions and behaviors. Implementation contractor staff can ensure all participants are aware of the measures being installed in their homes and the benefits of weatherization and energy efficiency.

  Program Adjustment: PSO and Titan ES contacts stated that weatherization staff leave a report with information on the improvements made, and the president of Titan ES said crew leaders speak with each customer following home weatherization project completion. PSO's program coordinator stated that they also leave a brochure that outlines PSO programs.

Ongoing recommendation implementation

- Consider additional measures and expand the installation of direct install measures to capture additional energy savings. In 2020 and 2021 the faucet aerator, low flow showerhead, LEDs, and advanced power strip measures had limited participation. Additional measures such as dusk to dawn LED light bulbs could help the program achieve additional savings.

ADM noted that in 2022 limited engagement with direct install measures continued, though PSO's program coordinator said that the program provides direct install measures when a customer is interested and allows installation.

Not implemented or no change made

- Ensure focus remains on a holistic approach to home weatherization with the addition of emerging technologies or other improvements. Program staff noted that they had discussed adding additional improvement types to the program such as dusk to dawn LED light bulbs. They also noted possibly increasing participation for direct install measures.

  No additional measures were added or implemented in PY2022; direct installation participation did not increase.

- Continue to align program tracking data reported savings and peak demand reduction methodologies. ADM utilizes measure-level reports and a summary report. To reconcile monthly and measure level savings these reports should align.

  ADM shared information on TRM version updates with PSO and AEG; because of the small impact no adjustments were made. This recommendation will be revisited, if necessary.

3.3.4.3 Customer Journey Map

A customer journey map is a graphic representation of how a customer or participant interacts with a program or product. It may display touchpoints, satisfaction, actions, key moments, pain points, or emotions. ADM sought to create a map for the Home Weatherization program that could be viewed as a "living document" that could assist staff, service providers, and evaluators in understanding customers' participation process. We used program documents, customer survey results, as well as past service provider and staff interviews to draft the initial map.

The initial customer journey map for the Home Weatherization program categorized the customer touchpoints into five phases. These five phases were awareness, enrollment, assessment and installation, quality assurance and post-installation, and feedback. ADM sought to clarify and enhance the contents of the initial customer journey map by guiding the staff in a facilitated discussion of the various customer experience phases.

Based on the discussion, we updated the initial draft and created the map presented as Figure 3-48. Four key moments of truth (KMOT) are indicated in bold to show key touchpoints identified by the staff or ADM as important moments during the customer journey. These moments indicate times during the journey that dictate or guide customers’ participation path (i.e., ability or decision to participate, level of satisfaction, interest in promoting the program).

Figure 3-48: Home Weatherization Customer Journey Map

HOME WEATHERIZATION PROGRAM

Customer Group: Low-Income Residential customers
(Titan ES: Homeowners and renters, with an annual household income of $55,000 or less, living in a home less than 2,200 square feet and built prior to 2010
RTT: Homeowners within Tulsa city limits that meet income threshold.)

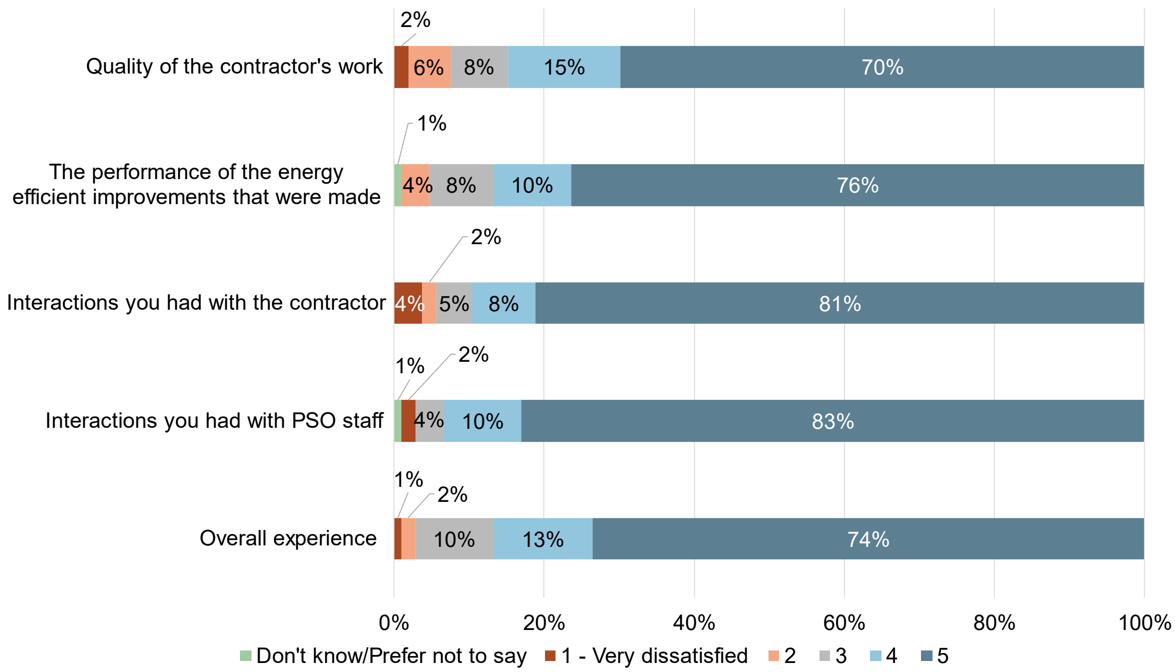
Objective: Create a common understanding of the participation experience, identify key touchpoints & opportunities for program improvement

	AWARENESS	ENROLLMENT	ASSESSMENT & INSTALLATION	QUALITY ASSURANCE & POST INSTALLATION	FEEDBACK
TOUCHPOINT	*Titan ES, RTT, ICF/PSO, Word-of-Mouth, Internet Search*	*Titan ES, PSO website, RTT*	*Titan ES, RTT*	*Third-party-verifier (TPV)*	*Program Staff, ADM*
CUSTOMER ACTION	1. Receive outreach from Service Provider, PSO (email campaign, bill insert/mail message, direct outreach) *OR* 1. Research available rebates and no-cost measure improvements available through Program on internet *OR* 1. Learn about program from friend, colleague, family	1. Call customer service center *OR* 1. Visit PSO website and submit online form *OR* 1. Receive contact and sign up directly through Titan ES	1. Schedule home assessment. 2. Have assessment of home. 3. (If applicable) Verify permission from property owner to do work. 4. Schedule service provider weatherization visit. 5. Have installation of weatherization measures.	1. (If necessary) Schedule TPV staff visit to verify weatherization. a) Test-in/out for air and duct sealing b) Visual verification for attic insulation, pipe wrap, water heater jackets and direct install measures	1. Complete survey with ADM Associates
CUSTOMER THOUGHTS	• **My bill has gone up, what can I do to reduce my bill? (KMOT)** • Does PSO have a program to help improve home comfort? • Are there ways for me to get no cost or incentivized improvements for my property?	• **Do I meet the eligibility requirements? (KMOT)** • Which improvements is my home eligible for? • Is this too good to be true/is this legitimate? • When are services available? • What does the participation process require? • I am excited I qualify for program and am willing to wait for services. • I do not want to participate because a measure is not offered (e.g., windows).	• The wait time met or exceeded my expectations. • The contractor was efficient and professional. • What improvements were made at my home? • What else can I do to save energy?	• I appreciate PSO's dedication to quality and verification of my program participation. • I feel over-burdened by the number of visits to my home. • I don't have time for another visit. • Who is this calling me, I do not recognize this number?	• **I am satisfied with improvements made through program, contractor, and overall program experience. (KMOT)** • What else can I do to improve my home's energy use? • I feel appreciative for this service. • I do not have time for a survey. • Are there any additional services available through this or other programs? • I wish more people knew about this program. • **Why is my bill the same? (KMOT)**

3.3.4.4 Participant Survey Results

Consistent with 2021, most survey respondents stated they were satisfied with the performance of the improvements, the quality of the contractor's work, interactions with the contractor, and PSO staff (see Figure 3-49). Furthermore, nearly all survey respondents indicated satisfaction with their overall experience.[77]

Figure 3-49: Home Weatherization Customer Satisfaction



Eighty-seven percent of survey respondents were satisfied with their experience overall. Further, 81% of respondents said they had recommended the program to someone else. And of those who had not recommended the program, 44% said they would be likely to recommend it (n=18).[78] However, 30% provided written feedback regarding one or more aspect of their experience they were not satisfied with or recommendations to improve the program or PSO services. [79]

- Fourteen percent mentioned dissatisfaction with the quality or cleanliness of the contractor's work.
- Eight percent said they were interested in additional weatherization or efficiency-related improvements.

[77] Eighty-seven percent of respondents rated their overall satisfaction with the home weatherization service a 4 (13%) or 5 (74%).
[78] Rated their likelihood of recommending the program a 7 or higher on a scale from 0 (not at all likely) to 10 (extremely likely).
[79] The bulleted breakout of issues and recommendations sums to more than 30% because customers may have written in about multiple issues or concerns.

- Six percent noted an opportunity to improve communications from the contractor regarding the improvements completed and the participation process (e.g., providing a report, additional details, or information on work completed).
- Four percent were interested in learning about additional PSO services or program offerings such as AC tune-ups.
- Four percent provided written comments related to improving the leave-behind report provided through the program. These participants said they were interested in more detailed information on improvements completed (e.g., pre/post blower door test values), reasons for the selected improvements were implemented, as well as potential for additional improvements. One indicated they were interested in an emailed report.
- Three percent said they had challenges with eligibility requirements or signing up for the program.

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

3.3.5 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the 2022 Home Weatherization Program.

- 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 6 percent said they had participated in another program offered by PSO since participating in the program.
- The program offers an easy, straightforward enrollment and participation process for low-income customers in PSO's territory. Overall, customers were satisfied with the signup and scheduling process. Survey findings also show that the majority of customers are satisfied with the quality of the weatherization improvements and their experience with the program implementation contractor.
- Participant satisfaction is high. The vast majority of survey respondents were satisfied with the program overall, the measures they received, as well as with PSO as their electric utility. A very small portion of respondents voiced dissatisfaction with some aspect of their experience.
- The staff-facilitated discussion suggested a high level of understanding of the customer journey through the program. The discussion with ADM provided an opportunity to reflect on opportunities for deeper understanding of the customer participation process; Titan ES and PSO staff are well-informed of customer thoughts and key touch points throughout the participation process.

- High bill complaints draw customers to the program, though participation may not lead to customers noticing lower bills. PSO staff noted that the program is not typically marketed as a way to lower bills, though it can be a motivating factor for customers that signup for the program. Survey findings indicate not all customers notice lower bills following program participation. If customers follow up after program participation, the PSO customer call center and Titan ES staff explain that customers may not notice lower bills because of seasonal temperature variations, usage changes, and electricity rate adjustments.
- Consistent with past evaluation results, there remains an opportunity to bolster customer understanding of program improvements and the benefits of energy efficiency. About one-quarter of survey respondents said that they either had not received or did not recall receiving one or more improvements that the tracking data indicated they received. Furthermore, less than half of survey respondents said the program contractor had spoken with them about ways to use less energy in their homes.
- No additional measures were added or implemented in PY2022; direct installation participation did not increase. In 2021 ADM suggested the program ensure the focus remains on a holistic approach to home weatherization with the addition of emerging technologies and expanding the installation of direct installation measures, as warranted.

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

- Utilize home weatherization assessment and/or installation visit to promote energy efficiency actions and behaviors. Survey findings suggest the program could be leveraged to a greater extent to promote additional engagement with PSO and additional energy-saving actions.
- Verify customer awareness of home improvements completed through the program. Ensuring customers are aware of the improvements made through the program adds value in multiple ways. ADM's survey findings indicate that some customers do not notice savings or enhanced home comfort. Thus, understanding the measures provided through the program is important as it provides customers justification for any perceived burden of participating (i.e., scheduling, contractor visits, modifications to home). If customers understand the improvements made, they are better able to communicate program benefits to friends, family, and other potential participants. More generally, as an understanding of energy efficiency permeates PSO's service area and in the market more broadly, there is potential for interest to naturally arise and lead to customers taking action to make improvements that are not incented, and thus transform the market.

- Consider expanding email and social media customer engagement for the program. Customers who pay bills online may be more inclined to interact with PSO when prompted by digital communication rather than through physical mail outreach. The high response rate to ADM's email survey, conducted for the first time in 2022, indicates email and other forms of digital communication may be effective ways to recruit customers to the program. Though PSO already markets the program using social media and emails, it may be beneficial to increase the frequency or revisit the strategies used.
- Investigate participant background and demographic characteristics. To deepen understanding of the types of customers served by the program, consider adding a battery of questions to ADM's annual satisfaction and verification survey. This information could provide insights into appropriate channels for targeted customer engagement and potentially identify underserved groups.
- Increase the provision of direct installation measures through the program and/or consider expanding offerings to include other improvements. There may be opportunities to achieve additional savings at each participating home through increased provision of direct install measures or other offerings. Examples of cost-effective direct install measures include advanced power strips and faucet aerators. Faucet aerators are currently a program offering, however only a small portion of program participants receive this measure. To increase uptake, the program could consider encouraging weatherization contractor staff to ensure they thoroughly explain the benefits of the measure and offer it at each participating home.

3.4 Conservation Voltage Reduction (CVR) Program

This chapter presents findings from the impact evaluation of the 2022 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.[80] Voltage levels were controlled independently for each of the three phases for all evaluated circuits. Detailed information on how they system operates is explained in Appendix G.

The 2022 CVR program evaluation consisted of 4 substations and 23 circuits (See Table 3-151). PSO's CVR deployment included upgrades inside the substation, as well as on the distribution system. Inside the substation included installing a new RTU, as well as new relaying or metering equipment to provide all the necessary information for the CVR system to function properly. The distribution system required the installment of voltage regulators, capacitor banks, end of line monitors, and repeaters. Once the construction was complete, all devices underwent a commissioning period of field testing. After field testing was completed and Yukon was programmed, CVR was put into service.

Table 3-151: CVR Deployment Timeline

Substation	Construction Start Date	Construction Complete Date	In Service Date
15th & Fulton	1/1/2021	5/18/2022	5/20/2022
Broken Arrow North	1/1/2021	5/18/2022	5/20/2022
Catoosa	1/1/2021	1/10/2022	1/12/2022
Clinton Junction	1/1/2021	1/10/2022	1/12/2022

Circuits associated with the four 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 3-152.

[80] 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

Table 3-152: CVR Circuit Customer Count

Substation	Customer Count	Residential	Commercial	Industrial	Other/Unknown	Municipal
15th & Fulton	7,301	84%	10%	1%	4%	1%
Broken Arrow North	8,467	82%	12%	1%	4%	1%
Catoosa	4,039	82%	11%	2%	4%	1%
Clinton Junction	2,255	76%	12%	1%	9%	3%

Gross annual energy savings at the substation were projected to be 16,286,445 kWh for the circuits claimed in 2022. ADM’s verified savings estimates for CVR at the substation are 15,935,475 kWh, resulting in an 86% realization rate for gross annual energy savings. Table 3-153 provides reported and verified program performance metrics.

Table 3-153: Performance Metrics - CVR

Metric	PY2022
Number of Customers	22,062
Budgeted Expenditures	$857,004
Actual Expenditures	$357,203
Energy Impacts (kWh)	
Projected Gross Energy Savings	15,411,094
Reported Energy Savings	18,546,429
Gross Verified Energy Savings	15,935,475
Net Verified Energy Savings	15,935,475
Peak Demand Impacts (kW)	
Projected Gross Peak Demand Savings	3,992.00
Gross Verified Peak Demand Savings	3,578.39
Net Verified Peak Demand Savings	3,578.39
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	4.75
Utility Cost Test Ratio	4.30

3.4.2 EM&V Methodologies

For the PY2022 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. 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. **Regression Analysis**

The on/off regression analysis for CVR is the accepted industry standard for evaluation of voltage control technologies.[81] The regression model configuration used for this analysis is described in Equation 3-4.

Equation 3-4: 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

$DayType_t$ = the hourly interval the model is predicting usage for

$Hour_t$ = 1 if CVR is on during time t; 0 otherwise

The coefficient β_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.

[81] 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

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. Equation 3-5 shows how this value is calculated.

Equation 3-5: CVR Factor Calculation

$$CVR\ Factor = \frac{\%\Delta\ Energy\ Consumption}{\%\Delta\ Voltage}$$

Where:

$\%\Delta\ Energy\ Consumption$ = the % reduction in energy consumption when CVR is operational vs. not operational, as estimated in the regression analysis

$\%\Delta\ Voltage$ = the average % reduction in voltage when CVR is operational vs. not operational

Exceptions to the use of this framework are detailed in Appendix G.

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 Appendix G.

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 3-6 shows how average daily percent usage reductions are calculated using the CVR factors estimated in previous steps.

Equation 3-6: Daily Percent Savings Calculation

$$DailySavingsPercent = CVRFactor * \%\Delta\ Voltage$$

Where:

$CVRFactor$ = The CVR factor

$\%\Delta\ Voltage$ = the average % 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 3-7 shows this calculation.

Equation 3-7: Season Savings Calculation

$$SeasonSavings = (DailySavingsPercent * DailyBaselineEnergyUsage) * sdays$$

Where:

$DailySavingsPercent$ = Average daily % reduction in energy consumption

$DailyBaselineEnergyUsage$ = 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.

3.4.2.1 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 PY2022, the system peak consumption time was 4 PM to 5PM on July 26, 2022.

3.4.3 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.

3.4.4 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 described in Section 3.4.2). As additional improvements were made to each electrical circuit, baseline voltage condition was derived from the full year before CVR installation. Net impacts are equivalent to gross impacts for the CVR program due to the nature of implementation at the distribution level with no incentives provided.

3.4.4.1 Verified Annual Energy Savings (kWh)

The gross verified annual energy savings (kWh) represents an overall annual percent energy savings of 2.27% relative to the evaluated circuit demand. Table 3-154 and Table

3-155 below show the summary of a typical year's gross verified annual energy savings separated by season (Cooling versus Heating) due to operation of CVR on each circuit.

Table 3-154: CVR Cooling Season Verified Energy Savings (kWh)

Substation	Circuit	% Savings	Cooling Season Savings (kWh)	Cooling Season Annual Baseline Consumption (kWh)
Clinton Junction	CJ11	2.29%	255,281	10,016,224
	CJ15	2.16%	363,304	11,710,955
	CJ17	2.27%	0	11,307,156
Broken Arrow North	L1	2.74%	88,427	8,307,561
	L2	1.72%	327,834	23,090,497
	L3	1.58%	209,473	17,514,146
	L4	1.64%	566,392	18,134,502
	L5	1.56%	280,403	22,608,171
	L6	2.73%	221,475	14,061,147
	L7	2.25%	273,413	10,942,126
	L8	2.08%	360,602	14,107,543
Catoosa	O1	1.55%	433,692	17,806,947
	O2	1.66%	727,001	21,389,802
	O3	2.47%	367,955	18,693,118
	O4	3.00%	483,314	13,206,108
15th and Fulton	V1	1.83%	446,029	18,406,724
	V2	3.29%	384,598	24,039,640
	V3	1.80%	596,606	24,647,876
	V4	2.71%	247,238	12,536,060
	V5	1.45%	342,678	14,162,377
	V6	2.29%	82,925	7,806,726
	V7	2.58%	381,451	15,765,479
	V8	2.78%	190,997	15,951,562
Total		**2.08%**	**7,631,090**	**366,212,444**

Table 3-155: CVR Heating Season Verified Energy Savings (kWh)

Substation	Circuit	% Savings	Heating Season Savings (kWh)	Heating Season Annual Baseline Consumption (kWh)
Clinton Junction	CJ11	1.60%	128,459	8,034,985
	CJ15	2.13%	217,899	10,220,595

	CJ17	1.58%	232,813	14,717,926
Broken Arrow North	L1	0.00%	0	7,320,845
	L2	1.71%	393,671	22,991,954
	L3	0.00%	0	17,094,253
	L4	1.70%	461,263	27,133,060
	L5	0.00%	0	15,852,138
	L6	1.59%	236,103	14,854,828
	L7	0.00%	0	9,241,903
	L8	1.56%	190,183	12,186,231
Catoosa	O1	4.94%	1,040,228	21,052,580
	O2	0.00%	0	22,043,981
	O3	8.14%	2,007,745	24,680,262
	O4	1.73%	220,020	12,731,903
15th and Fulton	V1	4.82%	678,499	14,064,851
	V2	2.43%	431,006	17,751,862
	V3	4.50%	680,908	15,143,108
	V4	1.77%	180,847	10,212,771
	V5	5.26%	410,934	7,816,111
	V6	1.13%	61,792	5,484,661
	V7	3.74%	457,317	12,240,962
	V8	1.96%	274,700	13,983,692
Total		**2.47%**	**8,304,385**	**336,855,462**

3.4.4.2 Verified Coincident Peak Demand Reduction (kW)

The gross verified coincident peak demand reduction (kW) results per circuit are shown in Table 3-156.

Table 3-156: Verified Peak Demand Reduction

Substation	Circuit	Peak Demand Reduction (kW)
Clinton Junction	CJ11	115.81
	CJ15	154.91
	CJ17	0.00
Broken Arrow North	L1	40.19
	L2	162.53
	L3	97.92
	L4	293.26
	L5	135.06
	L6	100.47

Substation	Circuit	Peak Demand Reduction (kW)
	L7	118.32
	L8	180.13
Catoosa	O1	256.04
	O2	298.34
	O3	231.58
	O4	210.89
15th and Fulton	V1	156.52
	V2	198.32
	V3	250.61
	V4	125.48
	V5	153.67
	V6	45.76
	V7	158.53
	V8	94.04
Total		**3,578.39**

3.4.5 Conclusions and Recommendations

The following summarizes the key findings of the evaluation of the CVR Program.

- Program annual energy savings were verified to be less than estimated, with an 86% realization rate. The less than expected energy savings may be due to no CVR being conducted for the Broken Arrow North circuits on Bus X1 (L1, L3, L5, and L7) during the heating season as well as zero savings being found for CJ17 in the cooling season and O2 in the heating season.
- The overall average reduction in distributed energy due to CVR across the evaluated circuits is 2.27%. Table 3-157 shows a comparison of how overall percent reduction compared to previous years' evaluations.

Table 3-157: CVR On/Off Overall Percent Reduction; Year-to-Year Comparison

Season	PY2019	PY2020	PY2021	PY2022
Cooling	2.69%	3.16%	2.13%	2.08%
Heating	2.66%	2.54%	3.29%	2.47%

- The average CVR factor is 0.69 (0.63 during the cooling season, and 0.76 during the heating season). Table 3-158 shows a comparison of how the average CVR factors from this year 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 3-158: On/Off CVR Factors; Year-to-Year Comparison

Season	PY2019	PY2020	PY2021	PY2022
Cooling	0.63	0.73	0.71	0.63
Heating	0.62	0.54	0.92	0.76

Recommendations

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

- Collect more downline voltage readings. The CVR factors improved for Catoosa when downline voltage was applied.
- Regression model fit improves when sufficient data is collected; ideally, evaluation testing should be performed for all circuits and all seasons.

3.4.6 Detailed Circuit Level On/Off Results

Table 3-159: Clinton Junction Substation Savings by Phase – Cooling Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Avg. Consumption	% Savings	CVR Factor	CVR Factor Notes
CJ11	A	123.18	120.43	411.09	20,620	1.99%	0.89	
	B	123.92	121.16	578.67	24,642	2.35%	1.06	
	C	123.93	121.04	689.72	20,635	3.34%	1.44	
Total / Average		**123.67**	**120.88**	**1,679.48**	**65,896**	**2.56%**	**1.13**	
CJ15	A	123.18	120.43	781.90	33,707	2.32%	1.04	
	B	123.94	121.18	981.70	20,527	4.78%	2.15	
	C	123.93	121.04	626.55	22,812	2.75%	1.18	
Total / Average		**123.68**	**120.89**	**2,390.16**	**77,046**	**3.28%**	**1.46**	
CJ17	A	123.20	120.41	0.00	22,542	0.00%	0.00	Assume zero savings
	B	123.94	121.11	0.00	27,735	0.00%	0.00	Assume zero savings
	C	123.97	120.93	0.00	24,113	0.00%	0.00	Assume zero savings
Total / Average		**123.70**	**120.82**	**0.00**	**74,389**	**0.00%**	**0.00**	

Table 3-160: Clinton Junction Substation Savings by Phase – Heating Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Avg. Consumption	% Savings	CVR Factor	CVR Factor Notes
CJ11	A	122.98	120.05	199.68	12,432	1.61%	0.68	Avg. of other two phases
	B	123.77	120.85	205.18	13,608	1.51%	0.64	
	C	123.43	120.48	198.23	11,683	1.70%	0.71	
Total / Average		**123.39**	**120.46**	**603.09**	**37,723**	**1.60%**	**0.68**	
CJ15	A	122.97	120.07	385.36	19,838	1.94%	0.82	
	B	123.79	120.88	418.84	13,228	3.17%	1.35	
	C	123.43	120.48	218.80	14,919	1.47%	0.61	
Total / Average		**123.40**	**120.48**	**1023.00**	**47,984**	**2.19%**	**0.93**	
CJ17	A	122.97	120.04	301.96	21,530	1.40%	0.59	
	B	123.78	120.87	423.25	25,570	1.66%	0.70	
	C	123.43	120.50	367.81	21,998	1.67%	0.71	
Total / Average		**123.39**	**120.47**	**1093.02**	**69,098**	**1.58%**	**0.67**	

Table 3-161: Broken Arrow North Substation Savings by Phase – Cooling Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Avg. Consumption	% Savings	CVR Factor	CVR Factor Notes
L1	A	124.76	119.90	254.55	23,982	1.06%	0.27	
	B	125.13	120.28	136.15	15,171	0.90%	0.23	
	C	125.40	120.47	191.06	15,501	1.23%	0.31	
Total / Average		**125.09**	**120.22**	**581.76**	**54,655**	**1.06%**	**0.27**	
L2	A	124.79	120.56	645.61	47,645	1.36%	0.40	
	B	124.77	120.72	848.24	54,161	1.57%	0.48	
	C	124.44	120.49	662.95	50,105	1.32%	0.42	
Total / Average		**124.67**	**120.59**	**2,156.80**	**151,911**	**1.41%**	**0.43**	
L3	A	124.75	119.89	393.56	32,977	1.19%	0.31	Avg. of other two phases
	B	125.12	120.27	495.25	41,723	1.19%	0.31	
	C	125.42	120.49	489.30	40,525	1.21%	0.31	
Total / Average		**125.10**	**120.22**	**1,378.11**	**115,225**	**1.20%**	**0.31**	
L4	A	124.74	120.53	1,118.84	35,238	3.18%	0.94	
	B	124.75	120.70	1,355.69	42,286	3.21%	0.99	
	C	124.43	120.50	1,251.74	41,782	3.00%	0.95	
Total / Average		**124.64**	**120.58**	**3,726.26**	**119,306**	**3.13%**	**0.96**	
L5	A	124.74	119.89	513.77	43,146	1.19%	0.31	
	B	125.12	120.27	792.55	64,150	1.24%	0.32	Avg. of other two phases
	C	125.40	120.48	538.44	41,441	1.30%	0.33	
Total / Average		**125.09**	**120.21**	**1,844.76**	**148,738**	**1.24%**	**0.32**	
L6	A	124.78	120.62	588.07	33,062	1.78%	0.53	
	B	124.75	120.77	548.29	32,954	1.66%	0.52	
	C	124.45	120.56	320.71	26,492	1.21%	0.39	
Total / Average		**124.66**	**120.65**	**1,457.07**	**92,508**	**1.55%**	**0.48**	
L7	A	124.78	119.92	611.60	30,289	2.02%	0.52	
	B	125.19	120.30	455.81	17,101	2.67%	0.68	
	C	125.45	120.50	731.36	24,597	2.97%	0.75	
Total / Average		**125.14**	**120.24**	**1,798.77**	**71,988**	**2.55%**	**0.65**	
L8	A	124.74	120.56	816.12	30,306	2.69%	0.80	
	B	124.77	120.72	826.49	30,982	2.67%	0.82	
	C	124.43	120.51	729.77	31,524	2.31%	0.73	
Total / Average		**124.65**	**120.60**	**2,372.38**	**92,813**	**2.56%**	**0.79**	

Table 3-162: Broken Arrow North Substation Savings by Phase – Heating Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Avg. Consumption	% Savings	CVR Factor	CVR Factor Notes
L1	A	124.54	-	0.00	13,586	0.00%	0.00	No CVR for PY2022
	B	124.76	-	0.00	10,460	0.00%	0.00	No CVR for PY2022
	C	125.04	-	0.00	10,324	0.00%	0.00	No CVR for PY2022
Total / Average		**124.78**	**-**	**0.00**	**34,370**	**0.00%**	**0.00**	
L2	A	124.42	121.05	619.44	35,676	1.74%	0.64	Avg. of L6 and L8
	B	124.71	121.26	644.48	36,361	1.77%	0.64	Avg. of L6 and L8
	C	124.50	121.34	584.30	35,906	1.63%	0.64	Avg. of L6 and L8
Total / Average		**124.67**	**121.22**	**1,848.22**	**107,943**	**1.71%**	**0.64**	
L3	A	124.53	-	0.00	21,510	0.00%	0.00	No CVR for PY2022
	B	124.75	-	0.00	30,692	0.00%	0.00	No CVR for PY2022
	C	125.05	-	0.00	28,052	0.00%	0.00	No CVR for PY2022
Total / Average		**124.78**	**-**	**0.00**	**80,255**	**0.00%**	**0.00**	
L4	A	124.38	121.05	687.87	40,059	1.72%	0.64	Avg. of L6 and L8
	B	124.66	121.31	767.20	44,456	1.73%	0.64	Avg. of L6 and L8
	C	124.57	121.35	710.49	42,871	1.66%	0.64	Avg. of L6 and L8
Total / Average		**124.54**	**121.23**	**2,165.55**	**127,385**	**1.70%**	**0.64**	
L5	A	124.53	-	0.00	21,397	0.00%	0.00	No CVR for PY2022
	B	124.75	-	0.00	31,020	0.00%	0.00	No CVR for PY2022
	C	125.05	-	0.00	22,006	0.00%	0.00	No CVR for PY2022
Total / Average		**124.78**	**-**	**0.00**	**74,423**	**0.00%**	**0.00**	
L6	A	124.40	121.03	389.03	24,922	1.56%	0.58	Avg. of other two phases
	B	124.69	121.24	565.14	23,553	2.40%	0.87	
	C	124.49	121.31	154.29	21,266	0.73%	0.28	
Total / Average		**124.53**	**121.19**	**1108.46**	**69,741**	**1.56%**	**0.58**	
L7	A	124.56	-	0.00	16,432	0.00%	0.00	No CVR for PY2022
	B	124.80	-	0.00	12,584	0.00%	0.00	No CVR for PY2022
	C	125.09	-	0.00	14,373	0.00%	0.00	No CVR for PY2022
Total / Average		**124.81**	**-**	**0.00**	**43,389**	**0.00%**	**0.00**	
L8	A	123.87	121.06	259.17	18,547	1.40%	0.62	
	B	124.11	121.46	309.28	20,530	1.51%	0.71	Avg. of other two phases
	C	124.24	121.45	324.43	18,135	1.79%	0.80	
Total / Average		**124.08**	**121.33**	**892.88**	**57,212**	**1.56%**	**0.71**	

Table 3-163: Catoosa Substation Savings by Phase – Cooling Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	% Savings	CVR Factor	CVR Factor Notes
O1	A	124.11	120.28	969.43	34,417	2.82%	0.91	Avg. of other two phases
	B	122.91	119.78	1,007.06	42,811	2.35%	0.92	
	C	123.35	120.34	876.75	39,923	2.20%	0.90	
Total / Average		**123.46**	**120.13**	**2,853.24**	**117,151**	**2.46%**	**0.91**	
O2	A	123.27	118.16	1,100.09	48,723	2.26%	0.54	
	B	123.12	118.05	954.01	46,398	2.06%	0.50	
	C	122.22	118.05	2,728.80	45,601	5.98%	1.76	
Total / Average		**122.87**	**118.09**	**4,782.90**	**140,722**	**3.43%**	**0.93**	
O3	A	123.58	118.36	718.22	32,501	2.21%	0.52	
	B	122.89	118.60	769.73	42,188	1.82%	0.52	Use Phase A
	C	122.60	118.07	932.80	48,292	1.93%	0.52	Use Phase A
Total / Average		**123.03**	**118.34**	**2,420.76**	**122,981**	**1.99%**	**0.52**	
O4	A	123.47	119.10	1,189.27	28,853	4.12%	1.16	
	B	123.33	119.08	1,004.21	26,985	3.72%	1.08	Avg. of other two phases
	C	123.07	119.14	986.22	31,044	3.18%	1.00	
Total / Average		**123.29**	**119.11**	**3179.69**	**86,882**	**0.04**	**1.08**	

Table 3-164: Catoosa Substation Savings by Phase – Heating Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Average Consumption	% Savings	CVR Factor	CVR Factor Notes
O1	A	123.42	120.22	1,353.10	28,108	4.81%	1.86	
	B	122.61	119.75	2,054.86	39,422	5.21%	2.24	
	C	123.63	120.65	1,475.75	31,309	4.71%	1.95	
Total / Average		**123.22**	**120.21**	**4,883.70**	**98,838**	**4.91%**	**2.01**	
O2	A	124.10	118.53	0.00	35,738	0.00%	0.00	Assume zero savings
	B	124.00	118.50	0.00	34,527	0.00%	0.00	Assume zero savings
	C	123.94	118.57	0.00	33,228	0.00%	0.00	Assume zero savings
Total / Average		**124.01**	**118.54**	**0.00**	**103,493**	**0.00%**	**0.00**	
O3	A	124.09	118.63	2,929.85	32,481	9.02%	2.05	
	B	123.70	118.82	3,156.46	41,541	7.60%	1.93	
	C	123.64	118.69	3,339.72	41,848	7.98%	1.99	
Total / Average		**123.81**	**118.71**	**9,426.04**	**115,870**	**8.20%**	**1.99**	
O4	A	124.18	118.57	344.98	19,378	1.78%	0.39	Use Phase C
	B	123.89	118.55	329.49	19,400	1.70%	0.39	Use Phase C
	C	124.01	118.64	358.49	20,996	1.71%	0.39	
Total / Average		**124.03**	**118.58**	**1,032.96**	**59,774**	**1.73%**	**0.39**	

Table 3-165: 15th and Fulton Substation Savings by Phase – Cooling Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Avg. Consumption	% Savings	CVR Factor	CVR Factor Notes
V1	A	124.73	120.42	932.93	39,463	2.36%	0.68	Use V3 Phase B
	B	125.11	120.63	1,081.39	44,253	2.44%	0.68	Use V3 Phase B
	C	125.26	120.75	920.09	37,381	2.46%	0.68	Use V3 Phase B
Total / Average		**125.03**	**120.60**	**2,934.40**	**121,097**	**2.42%**	**0.68**	
V2	A	124.31	119.26	727.94	54,308	1.34%	0.33	
	B	124.56	119.41	859.89	52,927	1.62%	0.39	Avg. of other two phases
	C	124.48	119.43	942.43	50,920	1.85%	0.46	
Total / Average		**124.45**	**119.37**	**2,530.25**	**158,156**	**1.61%**	**0.39**	
V3	A	124.72	120.41	1,315.54	55,662	2.36%	0.68	Use V3 Phase B
	B	125.11	120.64	1,251.69	51,209	2.44%	0.68	
	C	125.25	120.75	1,357.81	55,286	2.46%	0.68	Use V3 Phase B
Total / Average		**125.03**	**120.60**	**3,925.04**	**162,157**	**2.42%**	**0.68**	
V4	A	124.29	119.23	639.78	30,558	2.09%	0.51	
	B	124.52	119.38	417.28	24,352	1.71%	0.41	
	C	124.48	119.43	569.50	27,564	2.07%	0.51	
Total / Average		**124.43**	**119.35**	**1,626.57**	**82,474**	**1.96%**	**0.48**	
V5	A	124.73	120.42	780.77	33,038	2.36%	0.68	Use V3 Phase B
	B	125.11	120.64	747.78	30,588	2.44%	0.68	Use V3 Phase B
	C	125.27	120.77	725.91	29,548	2.46%	0.68	Use V3 Phase B
Total / Average		**125.04**	**120.61**	**2,254.46**	**93,174**	**2.42%**	**0.68**	
V6	A	124.30	119.24	152.72	17,187	0.89%	0.22	
	B	124.54	119.40	149.19	13,997	1.07%	0.26	Avg. of other two phases
	C	124.49	119.44	243.65	20,176	1.21%	0.30	
Total / Average		**124.45**	**119.36**	**545.56**	**51,360**	**1.05%**	**0.26**	
V7	A	124.76	120.44	910.47	38,497	2.37%	0.68	Use V3 Phase B
	B	125.11	120.64	806.01	32,955	2.45%	0.68	Use V3 Phase B
	C	125.28	120.78	793.07	32,268	2.46%	0.68	Use V3 Phase B
Total / Average		**125.05**	**120.62**	**2,509.55**	**103,720**	**2.42%**	**0.68**	
V8	A	124.28	119.22	305.00	31,262	0.98%	0.24	
	B	124.55	119.41	522.24	36,909	1.41%	0.34	
	C	124.49	119.50	429.32	36,773	1.17%	0.29	Avg. of other two phases
Total / Average		**124.44**	**119.38**	**1,256.56**	**104,944**	**1.19%**	**0.29**	

Table 3-166: 15th and Fulton Substation Savings by Phase – Heating Season

Circuit	Phase	Baseline OFF Voltage	ON Voltage	Daily Avg kWh Savings	Daily Avg. Consum-ption	% Savings	CVR Factor	CVR Factor Notes
V1	A	124.21	120.61	991.71	21,663	4.58%	1.58	
	B	124.47	120.93	1,223.45	23,976	5.10%	1.79	
	C	124.06	120.61	970.28	20,393	4.76%	1.71	
Total / Average		**124.25**	**120.72**	**3,185.44**	**66,032**	**4.81%**	**1.69**	
V2	A	123.80	118.75	546.13	29,181	1.87%	0.46	
	B	124.06	118.94	761.58	26,706	2.85%	0.69	
	C	124.06	119.02	715.79	27,455	2.61%	0.64	
Total / Average		**123.97**	**118.90**	**2,023.50**	**83,342**	**2.44%**	**0.60**	
V3	A	124.19	120.55	1,092.45	25,237	4.33%	1.48	
	B	124.47	120.89	861.69	21,664	3.98%	1.38	
	C	124.03	120.52	1,242.62	24,193	5.14%	1.82	
Total / Average		**124.23**	**120.66**	**3,196.75**	**71,094**	**4.48%**	**1.56**	
V4	A	123.78	118.73	347.73	16,815	2.07%	0.51	
	B	124.04	118.91	255.24	14,474	1.76%	0.43	
	C	124.05	119.01	246.07	16,658	1.48%	0.36	
Total / Average		**123.96**	**118.88**	**849.05**	**47,947**	**1.77%**	**0.43**	
V5	A	124.19	120.56	490.08	12,803	3.83%	1.31	
	B	124.47	120.90	640.27	12,100	5.29%	1.84	Avg. of other two phases
	C	124.04	120.50	798.92	11,793	6.77%	2.37	
Total / Average		**124.24**	**120.65**	**1,929.27**	**36,695**	**5.30%**	**1.84**	
V6	A	123.80	118.75	97.47	8,659	1.13%	0.28	
	B	124.05	118.92	82.24	7,221	1.14%	0.28	Use Phase A
	C	124.06	119.02	110.38	9,869	1.12%	0.28	Use Phase A
Total / Average		**123.97**	**118.90**	**290.10**	**25,750**	**1.13%**	**0.28**	
V7	A	124.21	120.59	740.73	20,480	3.62%	1.24	
	B	124.47	120.89	835.30	19,021	4.39%	1.53	
	C	124.07	120.60	571.00	17,968	3.18%	1.13	
Total / Average		**124.25**	**120.69**	**2,147.03**	**57,469**	**3.73%**	**1.30**	
V8	A	123.59	118.53	381.06	19,380	1.97%	0.48	Avg. of other circuits on Bus X2
	B	124.15	119.02	471.04	23,725	1.99%	0.48	Avg. of other circuits on Bus X2
	C	124.19	119.17	437.57	22,546	1.94%	0.48	Avg. of other circuits on Bus X2
Total / Average		**123.98**	**118.91**	**1,289.67**	**65,651**	**1.96%**	**0.48**	

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 (MWh)					Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	Verified Lifetime Savings	NTG Ratio	Net Annual Energy Savings (MWh)
Power Hours	0	0	123	-	123	100%	123
Peak Performers	60	0	758	-	0	100%	758
Demand Response Totals	**60**	**0**	**882**	**-**	**123**	**100%**	**882**

Program-level peak demand reduction is summarized in Table 4-2.

Table 4-2: Peak Demand Reduction – Demand Response Programs

Program	Gross Peak Demand Reduction (MW)				Net Impacts	
	Projected	Reported	Verified	Gross Realization Rate	NTG Ratio	Net Peak Demand Reduction (MW)
Power Hours	16.12	14.50	15.11	1.04	1.00	15.11
Peak Performers	60.00	89.68	55.19	0.62	1.00	55.19
Demand Response Totals	**76.12**	**104.18**	**70.30**	**0.67**	**1.00**	**70.30**

4.1 Power Hours Program

This chapter presents findings from the 2022 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. Over two hundred megawatt-hour (MWh) of energy was saved by this program in 2022 because of the DLC events. A peak demand reduction of over fifteen megawatts (MW) was realized.

Table 4-3: Performance Metrics – Power Hours Program

Metric	PY2022
Number of Customers	11,029
Number of Devices	13,497
Budgeted Expenditures	$2,137,400
Actual Expenditures	$1,723,832
Energy Impacts (kWh)	
Projected Energy Savings	0
Reported Energy Savings	0
Gross Verified Energy Savings	123,313
Net Verified Energy Savings	123,313
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	16,122
Reported Peak Demand Savings	14,500
Gross Verified Peak Demand Savings	15,109
Net Verified Peak Demand Savings	15,109
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	1.80
Utility Cost Test Ratio	1.25

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 have at least one program-eligible Wi-Fi enabled thermostat installed. PY2022 was the seventh year PSO administered the program. At the end of PY2022 there were 13,497 active devices, with 5,265 new devices joining the program in 2022.

The thermostats allow participants to receive a load curtailment signal allowing for 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. Once the event period is over, the thermostats setpoints are returned to the setpoint before the event occurred.

Eight DLC events occurred in PY2022. All events used a temperature offset curtailment strategy, with an offset of three degrees.

Participants can override the DLC curtailment if they do not wish to participate in an event. Participants can override (or opt-out of) the curtailment either by using 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 the peak reduction (kW) and annual energy savings (kWh) during DLC events. 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 is done for a better match with weather data and to improve statistical model effectiveness.

Local temperature data was retrieved from the National Oceanic and Atmospheric Administration (NOAA). Temperature values were converted to cooling degree days (CDD). This was done because CDD values can quantify how power consumption relates to the weather more effectively than temperature values. Equation 4-1 shows how temperature is converted to CDD.

Equation 4-1: Temperature to CDD Conversion

$$CDD_t = \begin{cases} 0 & if\ temp_t < cddbase \\ (temp_t - cddbase)\ /\ 48 & if\ temp_t \geq cddbase \end{cases}$$

Where:

$temp_t$ = temperature at time t

$cddbase$ = determined CDD base temperature

To calculate the most accurate CDD values, the optimal CDD base temperature for the evaluated population was determined. For a detailed description of how optimal CDD base temperatures are determined, see Appendix G.

Once the necessary data is processed, the devices that participate in the DLC events are identified. Because customers can manually override the DLC curtailment signal or various technical failures may occur, not every available device participates in the events. Thus, devices that are non-responsive to the called events need to be identified so that the calculation of energy savings included only devices that participate in the event.

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-min interval during the DLC events except Google Nest thermostats, which does 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. See Appendix G for a more detailed description of each of these tests and how they are applied.

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 PY2022, 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 4-2).

Equation 4-2: Baseline Energy Usage Curve Regression Model

$$kW_t = CDD_t + CDD_{t-2} + t$$

Where:

t = the 30-minute interval for which kW usage is being predicted

CDD_t = cooling degree days at time t

CDD_{t-2} = cooling degree days one hour before t

To ensure the baseline curves are as accurate as possible, a normalizing factor is calculated and applied to the baseline curve of each event day (Equation 4-3).

Equation 4-3: Normalization Factor Calculation

$$nf = kW_{actual.hour=es-2} \,/\, kW_{baseline.hour=es-2}$$

Where:

$kW_{actual.hour=es-2}$ = kW measured two hours before the event

$kW_{baseline.hour=es-2}$ = kW predicted by the baseline two hours before the event

With the baseline curve determined, demand reduction can be calculated. Demand reduction represents the average decrease in energy usage that occurs for the average event participant during a given time interval. Demand reduction is calculated for the event period and the snapback period. The event period is the time from when the event starts to when the event ends. The snapback period is the time from when the event ends to two hours after the event ends. The snapback period represents the time when all devices are resuming normal function and, as a result, typically have a small spike in energy usage before returning to normal. Equation 4-4 shows the formula for calculating demand reduction.

Equation 4-4: 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. The equation is shown in Equation 4-5.

Equation 4-5: DLC Event Energy Savings (kWh) Calculation

$$kWh_{saved} = \sum_{t \in EventPeriod} \left(\frac{kW_t^{reduction}}{2}\right)$$

Where:

t = the 30-minute interval for which energy savings is being calculated
$EventPeriod$ = all time intervals from event start to two hours after the event end
$kW_t^{reduction}$ = demand reduction calculated at time t

Peak reduction is calculated for each event, representing the maximum drop in energy usage that occurred for the average event participant. The equation is shown in Equation 4-6.

Equation 4-6: Verified Peak Reduction (kW) Calculation

$$kW_{reduced} = max_{\, t \in EventPeriod} \, (kW_t^{reduction})$$

Where:

t = the 30-minute interval for which energy savings is being calculated
$EventPeriod$ = all time intervals from event start hour to the event end hour
$kW_t^{reduction}$ = demand reduction calculated at time t

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

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: Power Hours 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.
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 impacts on customer energy use for the Power Hours program. The goal of the impact evaluation is to determine verified annual energy savings (kWh) and peak demand reduction (kW). Findings are presented and discussed in this section.

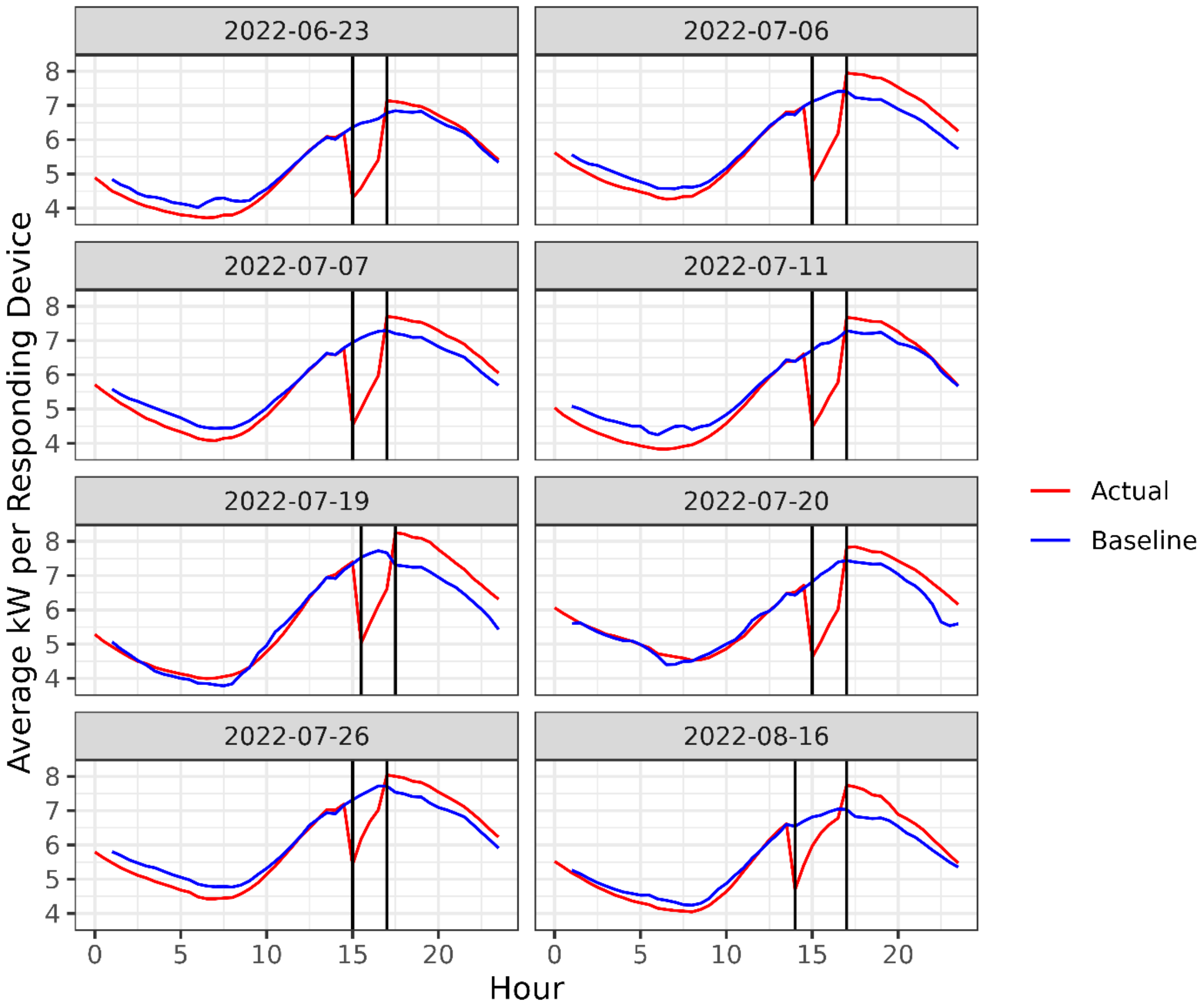
In 2022, eight Direct Load Control (DLC) event were called. The schedule of these events is summarized in Table 4-5.

Table 4-5: Power Hours Summary of Events

Date	Event Start Hour	Event End Hour	Duration (Hours)	Curtailment Strategy
6/23/2022	15	17	2	Temperature Offset
7/6/2022	15	17	2	Temperature Offset
7/7/2022	15	17	2	Temperature Offset
7/11/2022	15	17	2	Temperature Offset
7/19/2022	15.5	17.5	2	Temperature Offset
7/20/2022	15	17	2	Temperature Offset
7/26/2022	15	17	2	Temperature Offset
8/16/2022	14	17	3	Temperature Offset

Using the methodology described previously in this chapter, a baseline consumption curve was developed for each event day to represent a typical residences 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: Power Hours 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 4-6 shows the response rates for each event.

Table 4-6: Power Hours Active and Responsive Device Counts per Event

Date	Available Devices	Responsive Devices	Response Rate
6/23/2022	9,215	6,927	75.17%
7/6/2022	9,182	7,041	76.68%
7/7/2022	9,184	7,044	76.70%
7/11/2022	9,186	6,909	75.21%
7/19/2022	9,192	6,768	73.63%

Date	Available Devices	Responsive Devices	Response Rate
7/20/2022	9,207	6,750	73.31%
7/26/2022	9,193	6,718	73.08%
8/16/2022	9,205	7,002	76.07%

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 event period and the snapback period. The event period is the time from when the event starts to when the event ends. The snapback period is the time from when the event ends to two hours after the event ends.

Demand reduction was calculated in 30-minute increments as shown in Table 4-7. Each column represents the average kW reduction per responding device during the specified time interval. Time intervals during the snapback period are identified with grey cells.

Table 4-7: Power Hours Demand Reduction (kW) per 30-Minute Interval

Date	14	14.5	15	15.5	16	16.5	17	17.5	18	18.5	19
6/23/2022	--	--	2.07	1.89	1.51	1.20	-0.35	-0.27	-0.26	-0.21	--
7/6/2022	--	--	2.35	1.99	1.61	1.23	-0.53	-0.69	-0.69	-0.65	--
7/7/2022	--	--	2.42	2.07	1.67	1.29	-0.41	-0.47	-0.46	-0.47	--
7/11/2022	--	--	2.25	2.02	1.56	1.30	-0.39	-0.41	-0.40	-0.35	--
7/19/2022	--	--	--	2.50	2.06	1.61	1.06	-0.94	-0.94	-0.87	-0.84
7/20/2022	--	--	2.20	1.97	1.60	1.38	-0.39	-0.45	-0.41	-0.36	--
7/26/2022	--	--	1.89	1.29	0.91	0.70	-0.32	-0.47	-0.47	-0.45	--
8/16/2022	1.85	1.29	0.84	0.52	0.37	0.27	-0.71	-0.87	-0.82	-0.69	--

Average annual 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 4-8 shows average annual energy savings per device and total savings for the duration of each event. The curtailment event duration varied from 2-3 hours.

Table 4-8: Power Hours Energy Savings (kWh) per Event

Date	Responsive Devices	Savings During Event Hours, per Device (kWh)	Savings During Snapback Hours, per Device (kWh)	Energy Savings per Device (kWh)	Total Energy Savings (kWh)
6/23/2022	6,927	3.34	-0.54	2.79	19,357
7/6/2022	7,041	3.59	-1.28	2.31	16,239
7/7/2022	7,044	3.73	-0.91	2.82	19,866
7/11/2022	6,909	3.56	-0.77	2.79	19,294
7/19/2022	6,768	3.61	-1.8	1.81	12,270
7/20/2022	6,750	3.57	-0.8	2.77	18,704
7/26/2022	6,718	2.4	-0.85	1.54	10,376
8/16/2022	7,002	2.57	-1.54	1.03	7,207
Total					**123,313**

Peak reduction per device was calculated by finding the largest difference between the baseline curve and the actual usage curve that occurred during event hours (see Equation 4-6). 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 4-9: Power Hours Program-Level Peak Reduction (kW) per Event

Date	Responsive Devices	Peak Reduction per Device (kW)	Peak Reduction per Event (kW)
6/23/2022	6,927	2.07	14,335.47
7/6/2022	7,041	2.35	16,534.75
7/7/2022	7,044	2.42	17,052.32
7/11/2022	6,909	2.25	15,513.64
7/19/2022	6,768	2.5	16,948.40
7/20/2022	6,750	2.2	14,827.06
7/26/2022	6,718	1.89	12,727.38
8/16/2022	7,002	1.85	12,935.56
Average			**15,109.32**

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 per event. These results are shown in Table 4-10.

Table 4-10: Power Hours Total Peak Reduction

Verified Peak Reduction (kW)	Max Peak Reduction (kW)
15,109.32	17,052.32

Total net energy savings were calculated by adding up the total energy savings of each DLC event. The results are shown in Table 4-11.

Table 4-11: Power Hours Total Net Energy Savings

Source	Total Energy Savings (kWh)
DLC Events	123,313

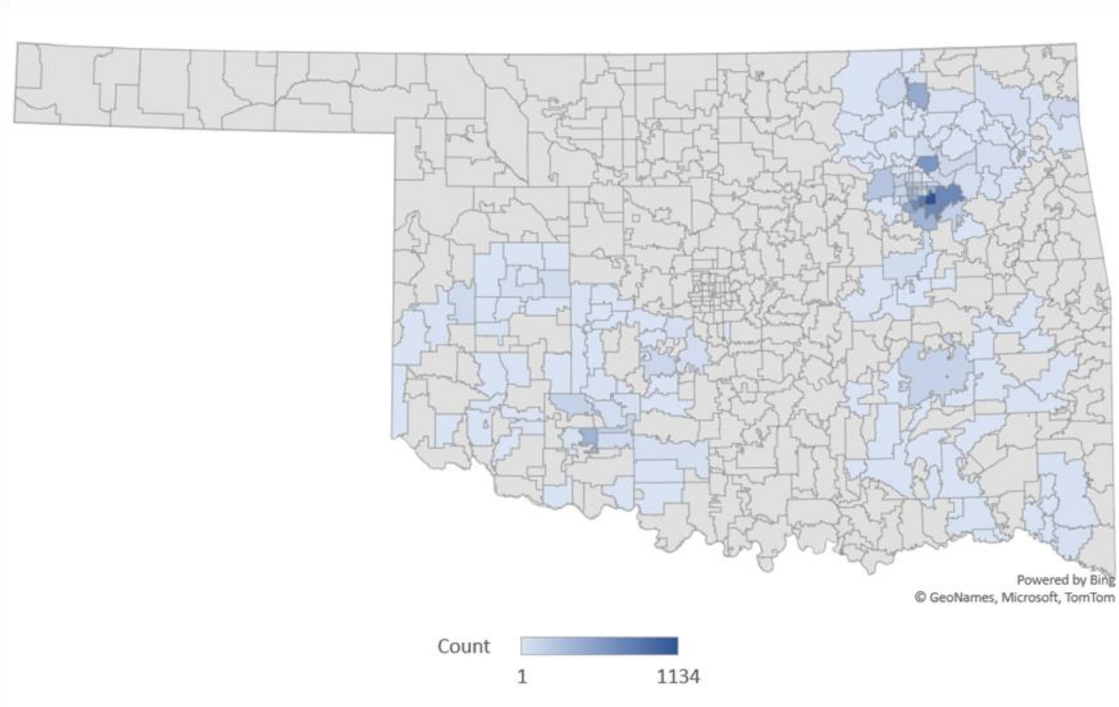
4.1.4 Process Evaluation Findings

ADM's process evaluation activities included a review of program materials, a participant survey, and development of a program logic model. A process evaluation memo was delivered to PSO after the completion of the 2022 program year which includes details of the methodologies and findings. This section summarizes findings from the process evaluation.

4.1.4.1 Program Activity

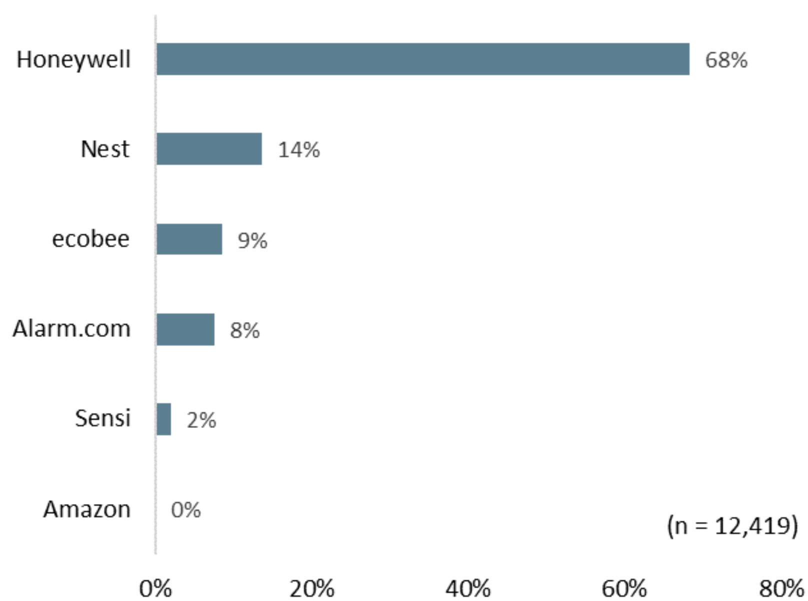
The Power Hours Program had 11,029 active participants in 2022. ADM reviewed the distribution of participants using a heat map. Heat maps provide data visualization on the density of participants with increased shading representing an increase in participants. While there is participation throughout all of PSO's service territory, most program participants (82%) reside in the following cities: Tulsa, Broken Arrow, Lawton, Owasso, Jenks, Bartlesville, and Bixby (see Figure 4-2)

Figure 4-2: Distribution of Power Hours Program Participants Within Service Territory



ADM reviewed the distribution of thermostats by participants. Honeywell thermostats accounted for 68% of the thermostats participating in the Power Hours program, followed by Nest and ecobee thermostats (see Figure 4-3).

Figure 4-3: Power Hours Thermostats Participating in Power Hours



4.1.4.2 Logic Model

ADM conducted a logic model discussion with program staff during PY2022. The logic model provides an illustrative overview of the short, intermediate, and long-term goals the program proposes to achieve through a series of inputs, activities, and outputs. According to program staff, the overarching goal of the Power Hours program is to reduce power consumption during seasonal peak demand days.

The following is a summary of inputs, activities, and outputs of the logic model:

- To implement and constantly improve upon the program, program staff relies on the inputs of PSO staff, implementation staff, utility stakeholders and partners, the Evaluator, PSO residential customers, and program budget. They also use information gathered from their data systems, PSO's website, and participant survey data.
- Over the years, program staff recruited participants through outreach, program promotional campaigns, or through the PSO website. Thermostat manufacturers now push alerts to customers about the availability of Power Hours. PSO staff discussed social media campaigns to increase enrollment. Participants can enroll online or through their thermostat.
- Program staff continues to identify and mitigate the challenges to enrollment and opting out of program as well as monitoring program metrics. Staff indicated they will explore opportunities to expand to various market segments who typically enroll at lower rates compared to other segments.

The success of the program continues to improve customers' opinion of PSO and of the demand response programs, and it also increases the kW savings of the program long-term. Short-term outcomes of the Power Hours program include ensuring that most or all smart thermostats are eligible to participate in demand response events, ensuring PSO customers can easily enroll in the program, increasing interest in implementing smart thermostats and participating, decreasing the number of barriers for customers to enroll, identifying reasons why participants opt out of the program and/or events, and increasing interest in demand response programs in identified market segments. Intermediate-term outcomes of the Power Hours program include increasing engagement among PSO customers with demand response programs, increasing customer satisfaction with the program, changing customers' knowledge and attitudes towards demand response, increasing the number of customers enrolled, and decreasing opt-out rates. The developed logic model is shown in Figure 4-4.

Figure 4-4: Power Hours Program Logic Model

Inputs	Activities	Outputs	Short-term Outcomes	Intermediate Outcomes	Long-term Outcomes
Resources to implement activities and produce outputs	Activities implemented to produce outputs	Products and services delivered	Immediate results achieved following delivery of output	Results expected to lead to the end outcome	Ultimate desired change because of program
PSO Staff **Implementation Staff** **PSO Customers** **Budget** **Utility Stakeholders and other Partners** **Data systems** **Social media accounts** **Websites (PSO and EnergyHub)** **ADM Associates** **Participant survey data**	Identify and recruit smart thermostat (Wi-Fi connected) manufacturers to participate in the program	Participating manufacturers	Ensure that most or all smart thermostats are eligible to participate in demand response	Increased engagement among PSO customers with demand response programs	Improved opinion of PSO and demand response programs among customers Increased kWh savings for Power Hours program
	Design and implement an enrollment system	Streamlined and efficient enrollment system	Ensure PSO customers are able to easily enroll in Power Hours	Increased customer satisfaction with Power Hours program	
	Design an outreach and education strategy to increase participation	Effective outreach and education strategy	Increased interest in implementing Wi-Fi connected smart thermostats and participating in PSO's Power Hours program	Change in knowledge and attitude about demand response programs	
	Work to identify any burdens for enrolling in the program	Barriers identified	Decrease the number of barriers for customers to enroll in Power Hours	Increase the number of customers enrolled in the program	
	Monitor program metrics (opt-out rates, event opt-outs)	Program data and metrics available to program administrators, implementers, and evaluators	Identify reasons why program participants opt out of the program and events	Decrease opt-out rates among program participants	
	Explore opportunities to expand the program offerings to various market segments	Novel and unique opportunities to improve program offerings for market segments	Increase interest in demand response programs among identified market segments	Increase participation in Power Hours among target market segments	
Assumptions, Factors, and Barriers impacting Product/Service Delivery			**Assumptions, Factors, and Barriers impact achievement of outcomes**		

4.1.4.3 Participant Survey

ADM administered an online survey to collect information about participants' experiences and satisfaction with the Power Hours program for 2022. Evaluators developed the survey to address general questions that all participants could answer (program awareness, program satisfaction, and demographics).

The online survey was administered in December of 2022 and sent email invitations to 1,271 Power Hours participants to solicit their participation. The following section summarizes the feedback received from a sample of 93 Power Hours participants who completed the 2022 survey (Table 4-12 summarizes the results from the email campaign).

Table 4-12: Power Hours Summary of Email Campaign

Survey Statistics	Count
Number of participants initially contacted by email	1,271
Number of undelivered emails	112
Completed surveys	93
Response rate	8%

Peak Events

Participants provided feedback on their experiences with peak events. Thirty-two percent of survey respondents first became aware of a peak event by seeing the notice on their thermostat (see Table 4-13).

Table 4-13: How Participants First Became Aware of a Peak Event

Response	Percent of Responses (n = 93)
Saw the notice on thermostat	32%
Saw the notice on the app on phone	23%
Noticed the difference in how the home felt	22%
Was not aware of peak events	17%
Other	2%
Did not know	4%

Survey responses suggest that program participants do not find reducing energy during On-Peak hours (2 pm to 7 pm) challenging. Using a five-point Likert scale, 30% of survey respondents did not find it challenging at all to reduce electricity usage during the On-Peak hours, while 1% found it to be a great challenge. See Table 4-14.

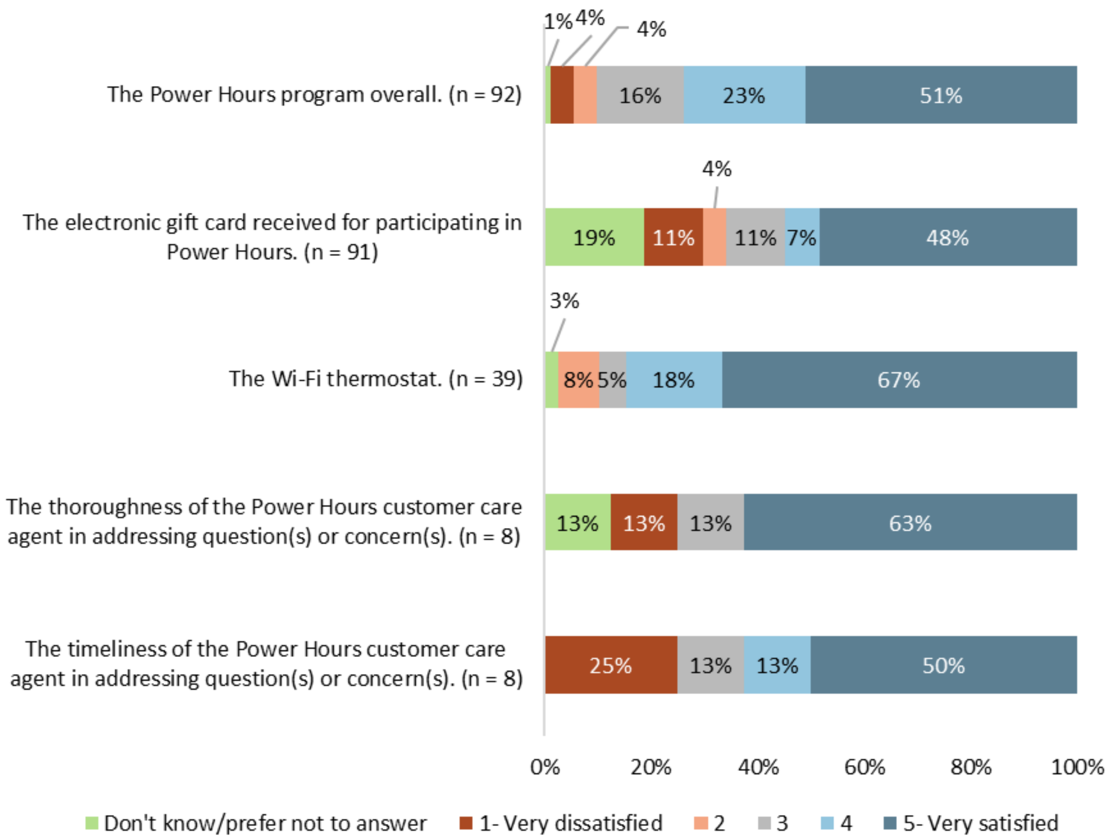
Table 4-14: Degree of Challenge for Households to Reduce Electricity Usage during On-Peak Hours

Response	Percent of Responses (n = 93)
1 – No challenge at all	30%
2	32%
3	22%
4	13%
5 – Great challenge	1%
Don't know	2%

Participant Satisfaction

Many survey respondents (74%) were very or somewhat satisfied with the program overall (see Figure 4-5). Survey respondents left feedback about their dissatisfaction. Most who were dissatisfied with Power Hours indicated they had not received the gift certificate or were not able to redeem an electronic gift card. Others were dissatisfied with the lack of energy savings, and some were dissatisfied with the program requirements. One person indicated the program had changed from previous years and they were not satisfied with the changes (e.g., no more bill credits).

Figure 4-5: Power Hours Participant Satisfaction



4.1.5 Conclusions and Recommendations

The following summarizes the key findings from the evaluation of the Power Hours program:

- PSO called eight DLC events in PY2022. This is the same as PY2021, however, the total duration of DLC events is reduced from 21 hours to 17 hours as there are six two-hour events and two three-hour events in PY2022, compared with three two-hour events and five three-hour events in PY2021.
- The rebound in kWh usage during snapback hours is higher in PY2022 (1.06 kWh) than PY2021 (0.54 kWh) caused by shorter event hours. For the 16 events in PY2021 and PY2022, two-hour events (0.86 kWh) have a significantly higher snapback than three-hour events (0.70 kWh).
- 5,265 participants joined the program during PY2022 (compared to 3,532 in PY2021, 3,369 in PY2020, and 3,463 in PY2019). Most survey respondents found the enrollment process somewhat or very easy. About a quarter of survey respondents had concerns (e.g., home comfort, PSO controlling their thermostat, or privacy concerns) prior to participation. The most influential factors for

customers to enroll in Power Hours were saving money on energy bills, receiving an enrollment incentive, or lowering their electricity usage.

- Thirty-two percent of survey respondents first became aware of a peak event by seeing the notice on their thermostat and 23% through a notice on their app. Forty-four percent of survey respondents reported that they were somewhat less comfortable during an event, 34% were at least as comfortable compared to other times, 18% reported that they were much less comfortable, and 3% were unsure. Customers often ran fans other than their cooling system to remain comfortable during events.
- Thirty-three percent of survey participants stated they or someone in their household overrode the temperature adjustment during a peak event. The most common reason for overriding the event was that the home felt too uncomfortable. Forty-nine percent of survey respondents indicated the number of peak events that occurred over the summer was about what was expected, followed by 19% who indicated it was fewer than expected and 9% who believed it was more than expected.
- Power Hours participants were mostly satisfied with the program. The net promoter score for Power Hours was 17, with 45% of survey respondents being promoters. Seventy-four percent of survey respondents were very or somewhat satisfied with the program overall. Most who were dissatisfied with Power Hours indicated they had not received the gift certificate or were not able to redeem an electronic gift card. Others were dissatisfied with the lack of energy savings, and some were dissatisfied with the program requirements.

The following recommendations are offered for continued improvement of the Power Hours program:

- Develop a follow up protocol to keep participants engaged. Participants expressed a desire for real-time feedback on consumption changes and timely incentives.
- Provide complete tracking information for all participating devices. The tracking information of Google Nest devices for participating individual events is incomplete with account number and/or device serial number missing. This information is critical in determining whether a device has responded to a call for event.
- Consider adjusting the timing of the event hours for future events. Starting the events slightly later could be beneficial, as many events in PY2022 began before the kW consumption reached its peak. Similarly, ending the events later would be preferable, as some events ended exactly at the peak of the baselines.

- Consider longer events, as shorter events tended to have higher snapbacks. Ending an event too soon might cause a secondary peak immediately after the event.
- Continue to educate PSO customers about the benefits of demand response programs. While education may fall outside the bounds of this program, it could be beneficial to provide additional education to customers about how demand response programs operate and the purpose of them. Education campaigns could spur additional participation among various market segments. Providing education in various languages could also increase participation among non-English speaking groups.
- Explore opportunities to increase participation in low-participation areas. Tulsa and Broken Arrow account for most of the Power Hour participation. Program administrators could explore ways to increase participation in regions that do not participate at high rates. This could include customer engagement campaigns that target specific zip codes or promotional efforts.

4.2 Peak Performers Program

This chapter presents findings from the impact and process evaluation of the 2022 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 1st and September 30th, 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 1,525 customers comprising of 1,827 premises participated in the program during PY2022 (program year 2022). Table 4-15 shows the performance metrics achieved by the program.

Table 4-15: Performance Metrics – Peak Performers

Metric	PY2022
Number of Customers	209
Number of Premises	1,827
Budgeted Expenditures	$3,858,567
Actual Expenditures	$3,234,711
Energy Impacts (kWh)	
Projected Energy Savings	60,000
Reported Energy Savings	0
Gross Verified Energy Savings	758,247
Net Verified Energy Savings	758,247
Peak Demand Impacts (kW)	
Projected Peak Demand Savings	60,000
Reported Peak Demand Savings	89,681
Gross Verified Peak Demand Savings	55,192
Net Verified Peak Demand Savings	55,192
Benefit / Cost Ratios	
Total Resource Cost Test Ratio	7.65
Utility Cost Test Ratio	2.45

4.2.2 EM&V Methodologies

The section below presents the impact and process evaluation methodologies to assess the PY2022 Peak Performers program. The purpose of the impact evaluation is to determine gross verified peak demand savings (kW) as well as 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 over the period of 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 the statistical programming language R was 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.
- 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 provided data. These are used to estimate what the demand would have been during an event day had the event not occurred. In PY2022, ADM employed multiple baseline methodologies and selected the best fitting models for each premise number. For a more comprehensive explanation of each baseline methodology and how they are used to create the final counterfactual baseline demand curves, see Appendix G.

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 (07/01/2022, 07/05/2022, 07/08/2022, 07/11/2022, 07/14/2022, 07/15/2022, 07/18/2022, 07/25/2022, 07/27/2022, 07/28/2022, 08/01/2022, 08/02/2022, 08/03/2022, 08/04/2022, 08/05/2022, 08/08/2022, 08/09/2022, 08/10/2022, 08/11/2022, 08/12/2022, 08/15/2022, 08/17/2022, 08/18/2022, 08/19/2022, 08/22/2022, 08/25/2022, 08/26/2022, 08/29/2022, 08/30/2022, 08/31/2022) during typical demand response hours for each premise number. These days were chosen from all non-event, non-holiday[82] weekdays during the months of July to August. 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 four models for each premise number. The weights were the inverse squares of the model RRMSEs. For example, if the four best fitting models have RRMSEs of 5%, 11%, 25%, and 52% respectively, their relative weights will be 80%, 16%, 3%, and 1% respectively.

[82] 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 4-7 shows the formula for calculating demand reduction.

Equation 4-7: 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 4-8.

Equation 4-8: 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 period 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[83]. The equation is shown in Equation 4-9.

Equation 4-9: DR Event Energy Savings (kWh) Calculation

$$kWh_{saved} = \sum_{t \in EventDay} kW_t^{reduction}$$

[83] 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 whole day must be used as the evaluation period to accurately capture energy savings.

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 period 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 2022, the evaluators assessed program design, operations, and delivery through a facilitated discussion about the program logic model and participant surveys.

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

- What changes, if any, have been made to the program design or implementation procedures since previous years?
- 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? What type of participants will be targeted (e.g., types of sectors, business sizes, areas within the service territory? Which marketing methods are most effective?
- Were participants satisfied with their experience? What was the level of satisfaction with the reimbursement amount, the enrollment process, and other aspects of program participation?
- Has participating in the program led to participation in other PSO programs or other energy efficiency actions not recommended by the program?
- What types of businesses participate in the program?
- 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 4-16 below summarizes the data collection activities and corresponding process evaluation research objectives used to complete the process evaluation.

Table 4-16: Peak Performers 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.
Participant Survey	Assess participant's reasons for participating and experience with the program, including satisfaction.
Logic Model Development and Review	Develop program logic models and review with program staff.

A detailed report on the methodologies and findings of the process evaluation was delivered to PSO in January 2023.

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 2022, six Peak Performers Demand Response events were called. The schedule of these events is summarized in Table 4-17.

Table 4-17: Summary of Peak Performers Demand Response Events

Date	Event Start Hour	Event End Hour	Duration (Hours)
07/06/2022	15	17	2
07/07/2022	15	17	2
07/19/2022	15	18	3
07/20/2022	15	17	2
07/26/2022	15	17	2
08/16/2022	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 4-6 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 4-6: Peak Performers Actual vs. Baseline Energy Demand -- Proxy Event Days

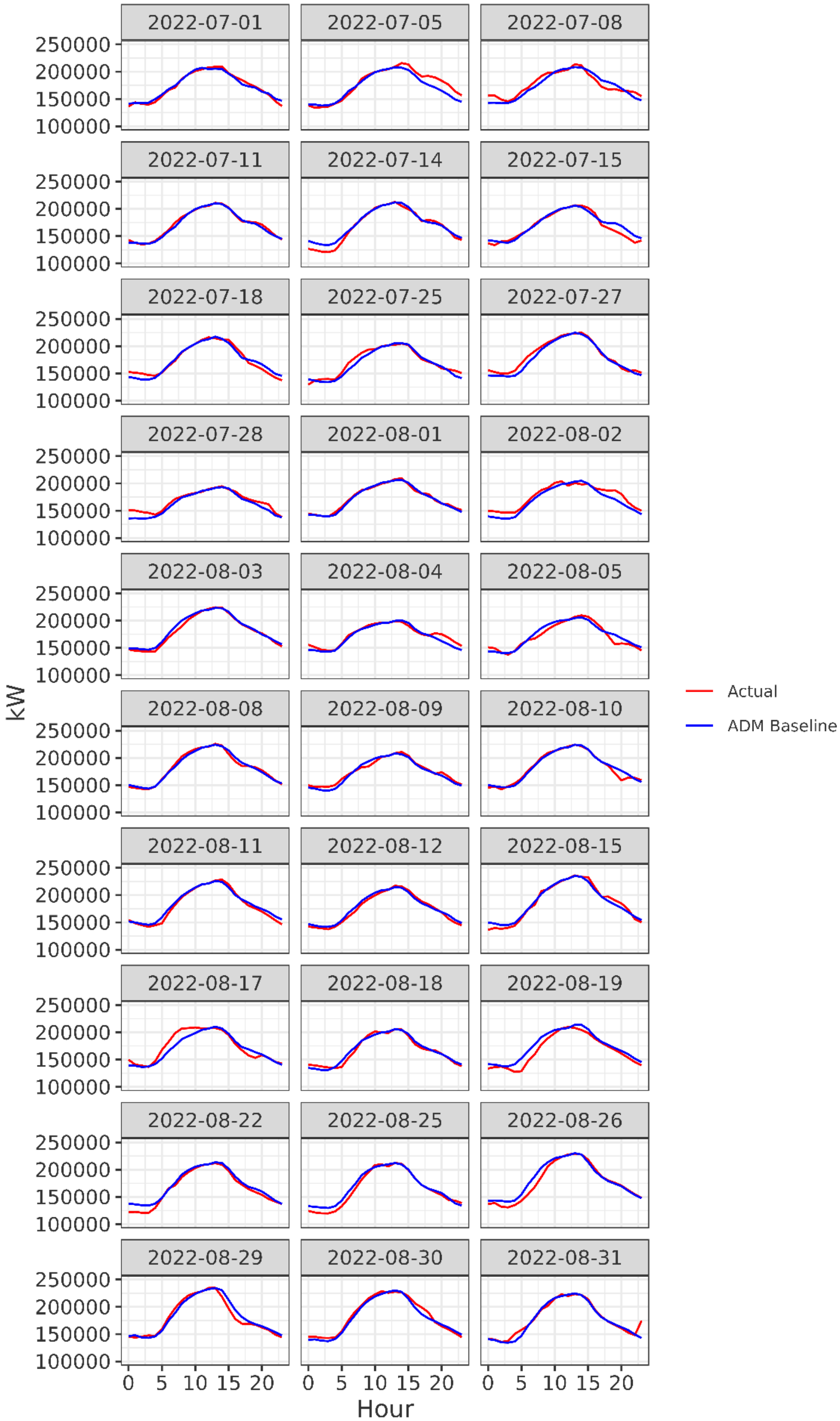
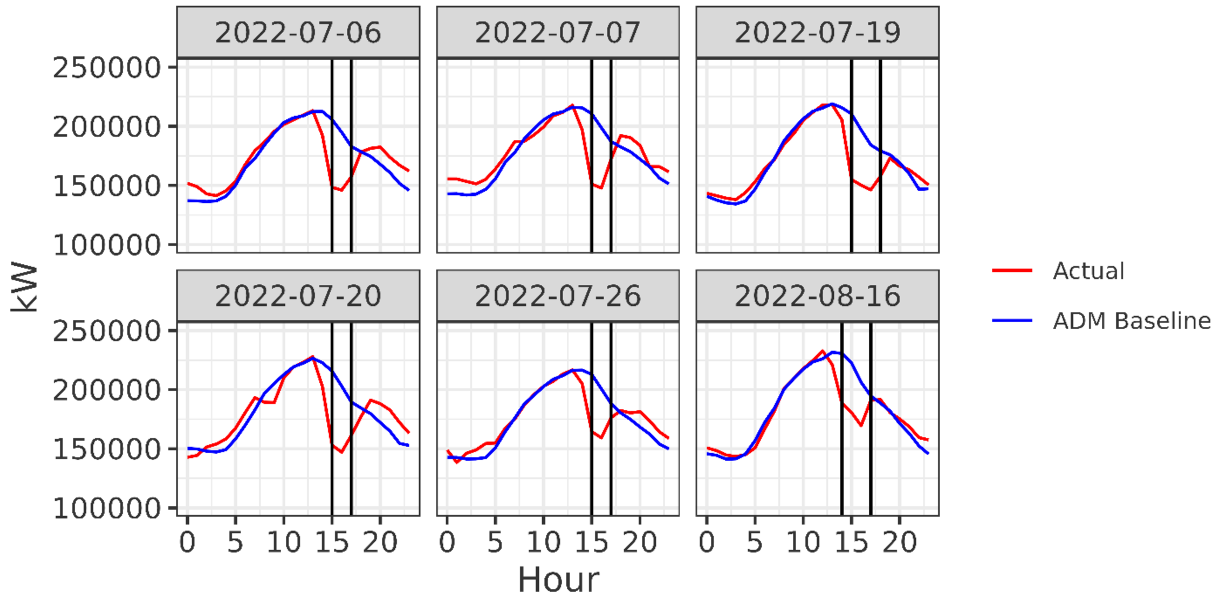


Figure 4-7 shows the sum of actual energy demand as well as the sum of predicted baseline demand during each peak event day, for the entire participant population. The grey area represents the event period.

Figure 4-7: Peak Performers Actual vs. Baseline Energy Demand – Peak Event Days



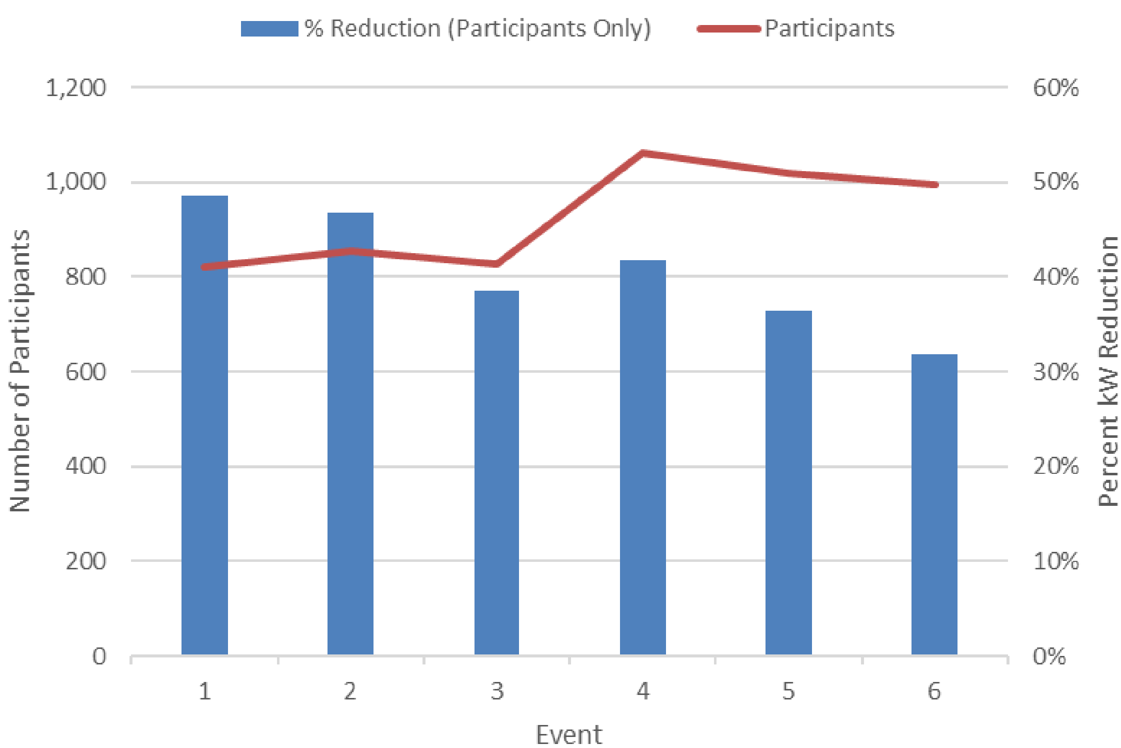
The difference between the modeled baseline and actual demand for each hour of each event was calculated for each premise. Consistent with industry standards for calculating peak demand reduction, such as the Uniform Methods Project (UMP), the peak demand reduction for each event was determined as the 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 4-18 shows the peak demand reduction for each event as well as how many participants curtailed.

Table 4-18: Peak Performers Program-Level Peak Demand Reduction (kW) per Event

Date	Participants	Non-Participants	Peak Reduction per Event (kW)
07/06/2022	821	1,006	59,798.94
07/07/2022	855	972	60,883.89
07/19/2022	828	999	51,090.38
07/20/2022	1,062	765	63,605.32
07/26/2022	1,020	807	50,920.16
08/16/2022	993	834	44,852.87
PY2022 Verified Peak Demand Reduction (kW)			**55,191.93**

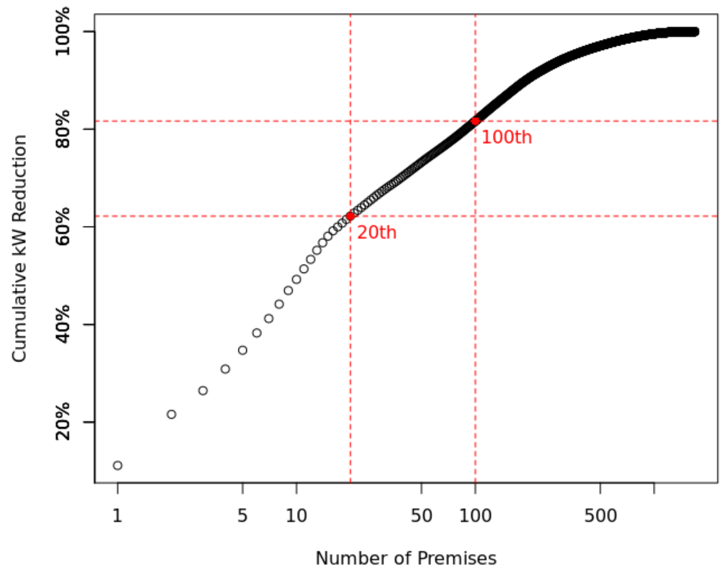
Average peak reduction for the first two events in July demonstrated a slightly higher average curtailment per premise, and the reduction were lower during the last two events. Despite this, the kW reduction percentage never fell below 30%. The number of participants and the kW reduction percentage among all participants for each event is shown in Figure 4-8.

Figure 4-8: Peak Performers Percent kW Reduction per Peak Event



The program total kW peak reduction is largely contributed by the top premises. The cumulative fraction of peak reduction is shown in Figure 1-4. The top 20 premises with the highest kW peak reduction contributed to 62% of the program total, while the top 100 to 81% with the remaining 1586 premises contributing only 19%.

Figure 4-9: Peak Performers Cumulative kW Reduction for top sites



Participant incentives are determined based on reported (reported) estimates of peak demand reduction. A comparison of reported estimates to verified results are shown in Table 4-19.

Table 4-19: Peak Demand Reduction Results

Reported Peak kW	Verified Peak kW	Peak kW Realization Rate
89,681	55,192	62%

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 4-20 shows the total energy savings for each event and the total across all events.

Table 4-20: Energy Savings (kWh) per Event

Date	Total Energy Savings (kWh)
07/06/2022	119,598
07/07/2022	121,768
07/19/2022	153,271
07/20/2022	127,211
07/26/2022	101,840
08/16/2022	134,559
Verified Energy Savings (kWh)	**758,247**

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.

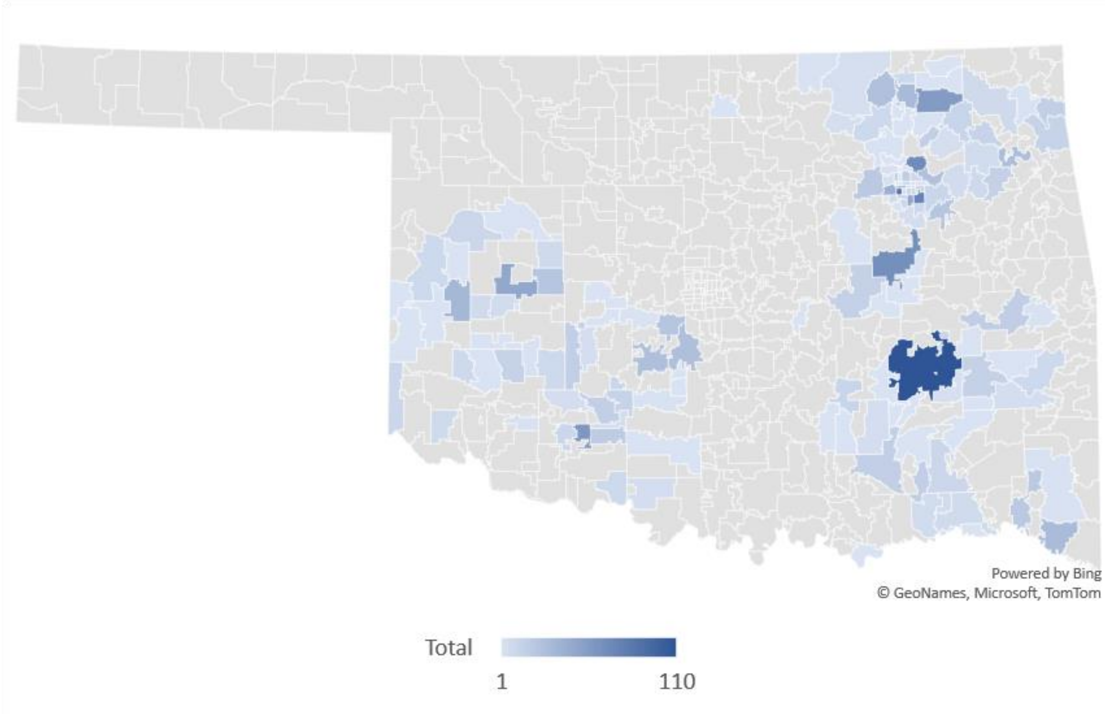
4.2.4 Process Evaluation Findings

The process evaluation included a review of program tracking data, a participant survey, and the development of a logic model through a facilitated discussion with program staff. A process evaluation memo was delivered to PSO after the completion of the 2022 program year which includes details of the methodologies and findings. This section summarizes findings from the process evaluation.

4.2.4.1 Program Activity

Most of the current program participants are located throughout the PSO territory (see Figure 4-10). Most of the organizations are operating in Tulsa (22%), McAlester (6%), Broken Arrow (5%), Lawton (5%), Owasso (4%), Okmulgee (4%), Bartlesville (3%), Nowata (3%), and Clinton (2%).

Figure 4-10: Peak Performers Program Participant Location by Zip Code



4.2.4.2 Logic Model

ADM conducted a logic model discussion with program staff during 2022. The logic model created by the evaluators provided an illustrative overview of the short, intermediate, and long-term goals the program proposes to achieve through a series of inputs, activities, and outputs. Throughout the discussion, the logic model was updated to better reflect program design, delivery, and implementation. According to program staff, the overarching goal of the Peak Performers program is to support PSO's efforts in helping commercial and industrial customers reduce their energy load during times of high energy demand.

The following is a summary of inputs, activities, and outputs of the logic model:

- To implement and constantly improve upon the program, program staff relies on the inputs of PSO staff, utility stakeholders and partners, ADM, PSO business/commercial customers, and program budget. They also use information gathered from their data systems, PSO's website, and participant survey data.
- Over the years, program staff has recruited participants through outreach or having the business seek to partake in the program by contacting PSO or going onto the PSO website. Although participants are encouraged to enroll online and actively engage in the program from its beginning stages to better understand the program, they can also receive enrollment assistance from program staff. Online enrollment has streamlined the enrollment process.

- Education and outreach are important to the program, especially during this new program cycle. Program staff indicated they plan to better support the participating business accounts by understanding how reducing energy load affects their business model and how their participation in the program supports energy saving goals.
- Program staff continue to identify and mitigate the challenges to enrollment and opting out of peak events. Staff indicated they will explore opportunities to expand to various market segments that do not enroll as much compared to other business types. In general, program staff identified small businesses as a potential target group.

The success of the program continues to improve customers' opinion of PSO and of the demand response programs, and it also increases the kW savings of the program long-term. Short-term and intermediate outcomes of the Peak Performers program include increased engagement of PSO business customers by ensuring the appropriate accounts enrolled and actively participating in the program, providing a streamlined enrollment process by decreasing barriers, mitigating barriers to partaking in peak events, and increasing participation among targeted market segments. The developed logic model is shown in Figure 4-11.

Figure 4-11: Peak Performers Logic Model

Inputs	Activities	Outputs	Short-term Outcomes	Intermediate Outcomes	Long-term Outcomes
Resources to implement activities and produce outputs	Activities implemented to produce outputs	Products and services delivered	Immediate results achieved following delivery of output	Results expected to lead to the end outcome	Ultimate desired change because of program
PSO Staff **PSO Business/Commercial Customers** **Budget** **Utility Stakeholders and other Partners** **Data systems** **Website** **ADM Associates** **Participant survey data**	Identify and recruit appropriate business accounts to participate in Peak Performers	Participating business accounts	Ensure the appropriate businesses accounts are participating in demand response program continuously (retainment?)	Increased engagement among PSO customers with demand response programs	Improved opinion of PSO and demand response programs among businesses Increased kW savings for Peak performers program
	Design and implement an enrollment system (online or manual through PSO)	Streamlined and efficient enrollment system	Ensure PSO business accounts can easily enroll in Peak Performers	Increased satisfaction with Peak performers program	
	Design an outreach and education strategy to increase participation	Effective and up-to-date outreach and education strategy	Increased interest and understanding of what it means to be a participant in Peak Performers	Change in knowledge and attitude toward demand response program	
	Identify burdens for enrolling and opting out of the in the program	Burden identified for enrollment for various business accounts	Decrease the number of barriers for businesses to enroll and opt out of Peak Performers	Increase the number of businesses enrolled in the program	
	Monitor program metrics (year to year participants, bonuses, opt-out rates, event opt-outs)	Program data and metrics available to program administrators and evaluators	Identify and address the reasons for event fatigue	Decrease opt-out rates among program participants	
	Explore opportunities to expand the program to various market segments	Opportunities identified to improve program offerings for various business types	Increase interest in demand response programs among identified market segments	Increase participation in Peak Performers among target market segments	
Assumptions, Factors, and Barriers impacting Product/Service Delivery			**Assumptions, Factors, and Barriers impact achievement of outcomes**		

4.2.4.3 Participant Survey

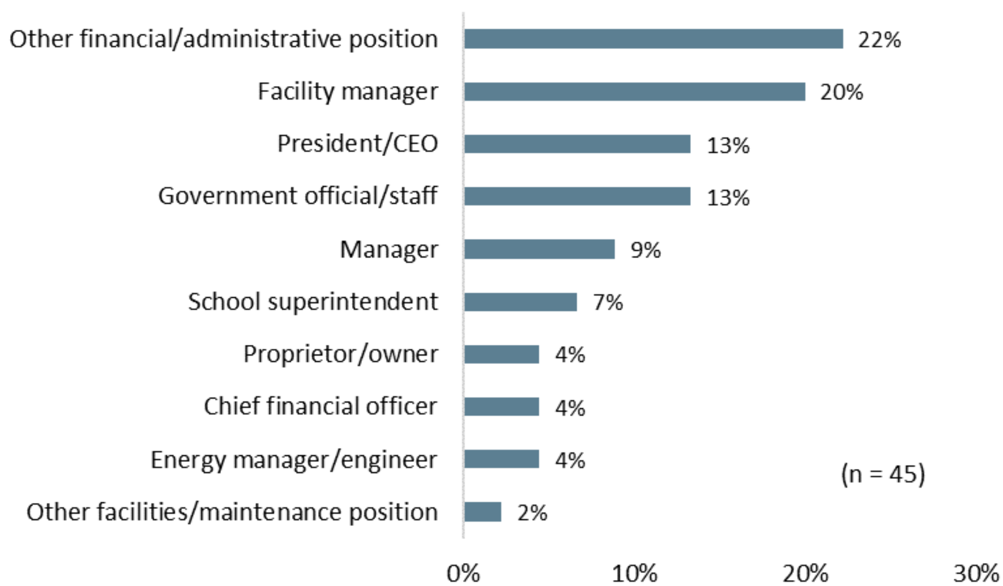
ADM administered an online survey to program participants between December 2022 and January 2023. The survey was conducted to collect data on how participants learned of the program, motivations for participating, and overall program satisfaction. ADM administered the survey to 920 program contacts. Forty-five participants completed the survey. Table 4-21 summarizes the response to the survey.

Table 4-21: Peak Performers Participant Survey Response

Response Metrics	Number of Participant Contacts
Participants Contacted by Email	920
Email Undelivered	173
Completed Surveys	45
Completion Rate	**9.5%**

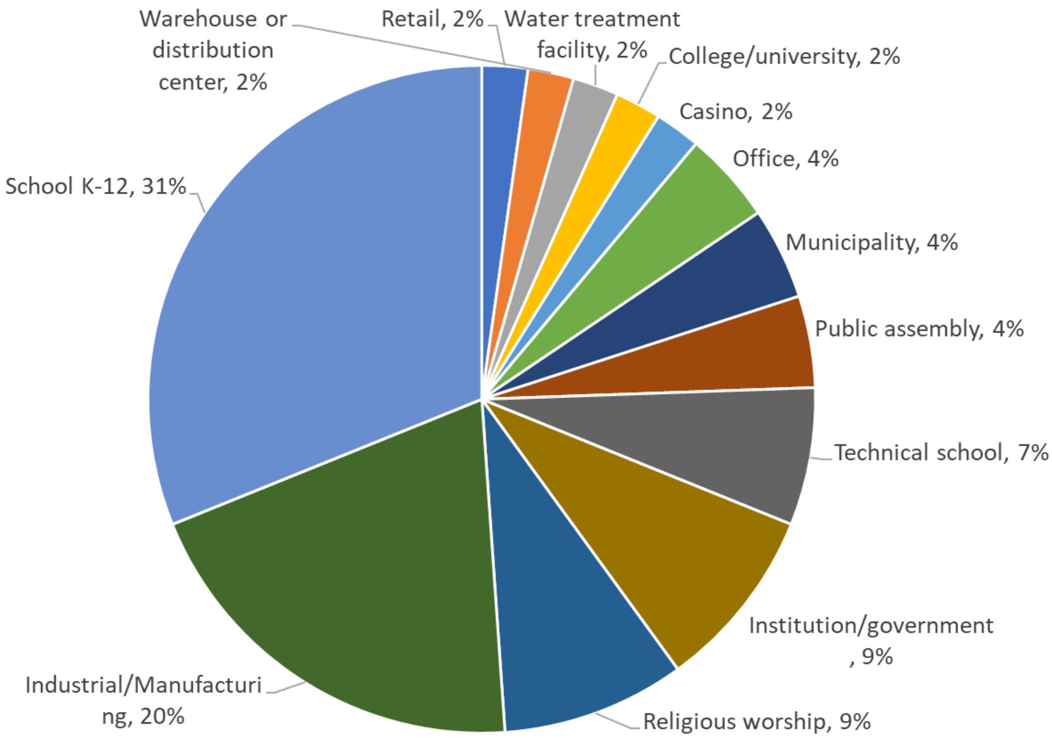
About a quarter of survey respondents (22%) indicated their role was financial or administrative, followed by 20% who reported being a facility manager, 13% who reported being the president or CEO and another 13% who are government officials or staff. See Figure 4-12.

Figure 4-12: Peak Performers Site Respondent's Role



Survey respondents were asked what type of building best describes their organization. Results are shown in Figure 4-13.

Figure 4-13: Peak Performers Facility Type



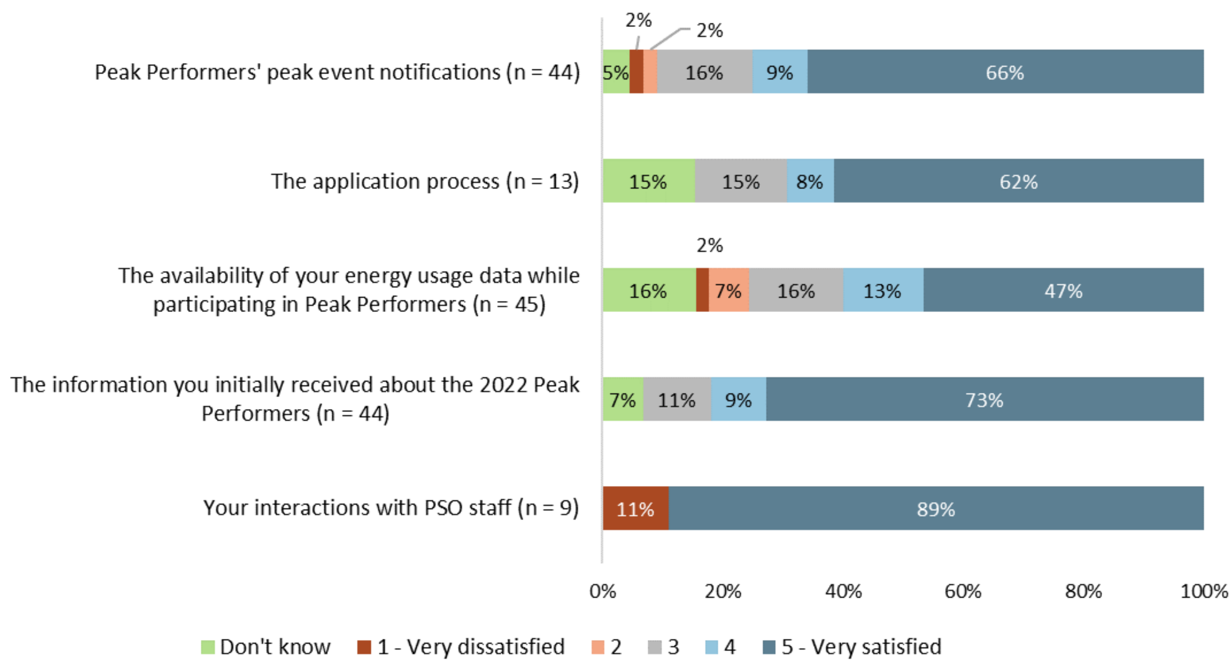
The Peak Performers program description states there could be up to 16 events conducted in a program year and there were six events in 2022. Ninety-eight percent of survey respondents recalled the number of events their organization participated in. Most survey respondents (78%) indicated they did not opt out of any events, followed by 7% who opted out of one event, and 2% who recalled opting out of two events (13% could not recall if they had opted out of any events). Organization representatives provided feedback on their preferred number of events per year. Thirty percent of survey respondents indicated five to seven be their preferred number of events per year and another 30% indicated as many events as needed (see Table 4-22).

Table 4-22: Peak Performers Preferred Number of Events per Year

Response	Percentage per Response (n = 45)
One or less per year	0%
Two to four per year	26%
Five to seven per year	30%
Eight to ten per year	9%
Ten or more per year	0%
As many as needed	30%
Don't know	4%

Most survey respondents indicated they were either somewhat or very satisfied with the event notification process (75%), incentive amount (60%), and the energy usage data available to them while participating in the program (60%) (see Figure 4-14).

Figure 4-14: Peak Performers Participant Satisfaction



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 2022 program year is 55,192 kW, and the verified energy savings for the year is 758,247 kWh.

- Average peak demand reduction per participant was lower for the last two events. The percentage of load reduction ranged from 32% to 49% across six events.
- The program called six DR events in PY2022. This is a one less than PY2021, during which seven events were called.
- The program called four two-hour events and two three-hour events. This is slightly shorter than PY2021, which called four three-hour events and three two-hour events.
- Most participants are satisfied with the Peak Performers program. Eighty two percent of participants are somewhat or very satisfied with the program overall.
- Thirty percent of survey respondents were willing to participate in as many events as are necessary. Of the remaining respondents the threshold is around 2-6 events. Approximately 30% of participants participated in all six peak events.

The following recommendations are offered for continued improvement of the Peak Performers program.

- Work with ADM to frequently produce data and results. The Peak Performers program could potentially benefit from working with ADM evaluators to provide more frequent access to data and results.
- The percentage of load reduction seen across events indicates there may be additional potential for curtailment. While some events saw a high load reduction, other events indicate that there is additional potential. There may be an opportunity to work with participants to help identify ways in which the load can be further reduced.
- While advanced notice of events may not be feasible, increased communication about any key indicators influencing the timing of events and/or reminders about the program may lead to higher satisfaction as well as potentially increased curtailment.

5 Research & Development Pilot Programs

Studies are underway to assess the potential for new energy efficiency and demand response opportunities for PSO customers. The studies include Demand Management Integrated Resources, Efficient Homes and Communities, Non-Wires Alternative Pilot, and a Virtual Diagnostics Tool.

5.1 Efficient Homes and Communities

The purpose of the Efficient Homes and Communities Project is to discover new ideas to improve energy efficiency processes, products, and services in residential new construction. The goal of the project is to develop a residential new construction plan that will consider and compare different design variants and field test as a demonstration project.

5.1.1 Methodology

PSO has created a energy model using Ekotrope[84] scenario modeling and Cove[85] tool and determined energy savings and incremental cost compared to a home built to current Oklahoma residential codes adhering to the Uniform Building Code Commission (IRC 2015).

The home designs were compared based on cost and energy consumption to compare the potential of the designs. Over 50 permutations of home designs were considered to develop four designs providing the highest value to customers.

5.1.2 Model Results

The four selected designs result in energy savings of 22%, 34% (includes geothermal heating), 40%, 100% (in terms of meeting the requirements of a DOE Net Zero Energy Home[86]). Home designs were rated as bronze through platinum.

The bronze level home is similar to PSO certified homes constructed in the Tulsa market during the 2022 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. A majority of

[84] https://www.ekotrope.com/
[85] https://cove.tools/products/load-modeling-tool?utm_term=energy%20simulation&utm_campaign=loadmodeling.tool&utm_source=adwords&utm_medium=ppc&hsa_acc=9686045795&hsa_cam=17817245468&hsa_grp=140787867522&hsa_ad=611667778552&hsa_src=g&hsa_tgt=kwd-305941226337&hsa_kw=energy%20simulation&hsa_mt=b&hsa_net=adwords&hsa_ver=3&gad=1&gclid=EAIaIQobChMIxPrv9fDW_gIVwRnnCh2AAAOIEAAYASAAEgLmofD_BwE
[86] https://www.energy.gov/eere/buildings/zero-energy-ready-home-program

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.

The Platinum home incorporates a fortified wall assembly of insulated concrete forms (ICF). An ICF home has two rigid expanded polystyrene foam panels (EPS) which sandwich a core of reinforced concrete. Due to the continuous insulation on both sides of the concrete, the air exchange through the wall system is virtually zero. Leakage will still occur around doors and windows, but the reduction in air exchange requires an energy recovery ventilation system (ERV) which balances fresh air into the mechanical system. A summary of results for the four designs is shown in Table 5-1.

Table 5-1: Community Demonstration Home Design Summary

Building Components	Baseline	Bronze	Silver	Gold	Platinum
Certification	None	PSO Rebates	EnergyStar v3.1	DOE NZE Home EnergyStar v3.2	DOE NZE Home EnergyStar v3.2
Annual Usage (kWh)	17,030	13,251	10,137	9,031	8,997
Annual Energy Savings	0%	22%	40%	47%	47%
Potential Bill Savings	None	$415	$758	$880	$884
HERS Score	**85**	**60**	**60**	**48**	**45**

The gold and platinum level designs present 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.

5.1.3 Conclusion of Modeling

Evolving technology in energy efficiency provides homebuilders with thousands of possibilities for reducing the energy burden for new construction projects. The four options provided in this report represent the most attainable building practices based on the Oklahoma market today.

The four tiers (Bronze – Platinum) are the best options based on the availability of materials, incremental cost increases, and potential energy savings. Of these four tiers, the top two for implementation are the Silver or Gold level. This will allow the homebuilder to achieve ENERGY STAR v3.1 certification and net zero ready.

5.2 Demand Management Integrated Resources - Behind the Meter Battery Energy Storage System (BTM BESS)

PSO is performing a pilot study to determine customer and grid opportunities with behind-the-meter battery energy storage systems (BTM BESS). BTM BESS refers to electrochemical distributed generation systems that can discharge electricity to the distribution system when needed. These systems may also be referred to as Distributed Energy Resources (DERs).

In combination with connected water heater controls, PSO is going to explore the potential of these DERs supporting load reduction during system peak periods. This will be achieved through demand response events that may span from 1-3 hours, in which the connected water heater will not draw any electricity. The pilot will be implemented by ICF with Sunverge managing the DERs during demand response events.

This study is currently in the implementation stage. Evaluation activities to date have only included a customer enrollment survey to support recruitment.

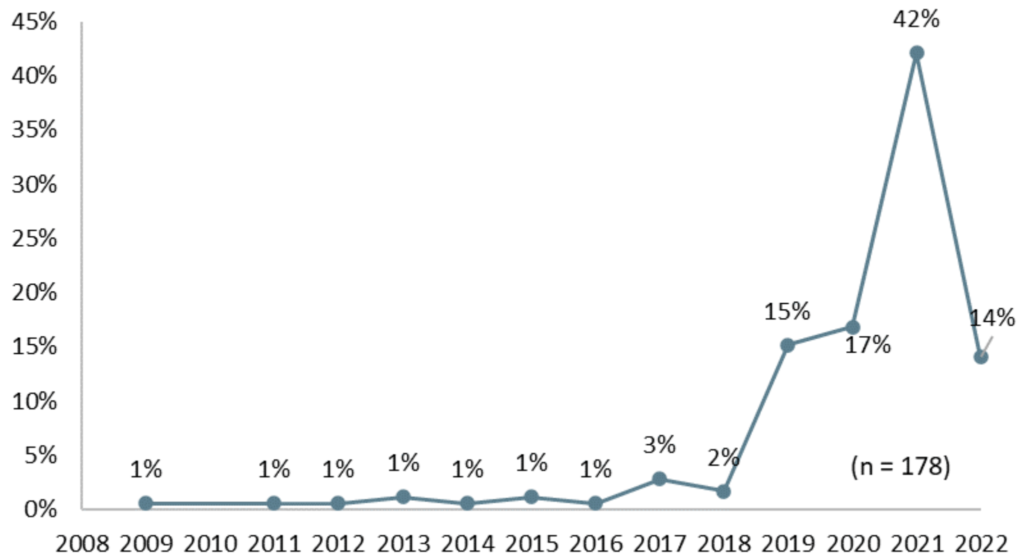
5.2.1 Customer Enrollment Survey

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 which 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. The research questions to consider included:

- Can batteries help lower energy usage by allowing homeowner to self-supply?
- Can batteries help homeowner save on electric bills with the use of special time-of-use rates?
- How well do batteries work for homeowner as a backup power source during an outage?
- How effective are batteries during summertime events when the grid capacity is stressed?

Most surveyed customers installed their solar equipment between 2019 and 2022, with 42% indicating they installed their equipment in 2021 (see Figure 5-1). Ten percent of survey respondents installed their equipment prior to 2016. This suggests that many solar customers have newer equipment (2020 or newer).

Figure 5-1: Year Solar Equipment was Installed



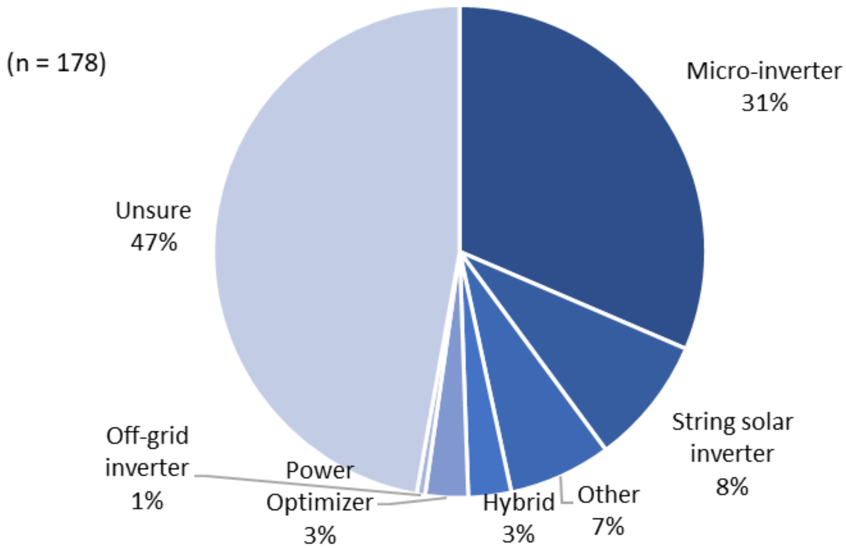
Thirty percent of respondents were unsure of the capacity of their solar system, followed by 25% who indicated they systems' capacity was 6 to 10 kW and 22% who indicated it was greater than 10 kW.

Table 5-2: 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 5-2). Customers provided information about the make and model of their inverter. The Enphase IQ7, SolarEdge, Sunny Boy, and Solar Ark were the most common makes of inverters listed among respondents.

Figure 5-2: Type of Inverter Used by Solar Customers



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 talked them out of the battery equipment (see Table 5-3).

Table 5-3: 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 did 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 5-4).

Table 5-4: 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%

Most survey respondents (91%) were interested in participating in a polit 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.

Table 5-5: 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 who were also interested in participating in the pilot. Many of the respondents had micro-inverters.

5.3 Non-Wires Alternative Pilot Study

This pilot study seeks to implement site-specific energy efficiency measures to reduce the summer demand peak on Oklahoma circuits XG-1 and XG-3 in Owasso from station 691. Energy efficiency measures will be implemented based on current program offerings for residential and commercial customers. Evaluation of these measures will result in verification of gross annual energy savings, gross peak demand reduction, and gross winter peak demand reduction.

ADM will evaluate the NWS program impacts and provide support for the targeting of energy efficiency measures to maximize load reduction. Measures incorporated into the energy efficiency program will be evaluated through those program evaluations for gross annual energy savings and gross summer peak demand reduction. The calculation of winter peak demand reduction will be outside of the scope of program evaluations.

The overall objectives of the impact evaluation is to develop statistically valid estimates of savings impacts for circuits XG-1 and XG-3. This includes:

- Analytical support in energy efficiency measure targeting
- Gross and annual energy savings (kWh)
- Gross Summer Peak Demand Reduction (kW), and

The pilot study is currently in the implementation phase without any evaluation efforts completed.

Appendix A: Glossary

Cash Inducement Costs: Refers to customer and service provider rebate/incentive costs incurred by PSO in the implementation of a program.

Coincidence Factor (CF): For energy efficiency measures, the CF represents the fraction of connected load reduction that occurs during the peak demand period.

Deemed Savings: A savings estimate for relatively homogeneous measures. Generally, an assumed average savings across many rebated units is applied to each individual unit installed.

Effective Useful Life (EUL): The number of years (or hours) that an energy-efficient technology is estimated to function. Also, referred to as "measure life."

EM&V Administrative Costs: EM&V administrative costs include all costs associated with evaluation, measurement and verification of reported energy and demand impacts resulting from the implementation of a program.

Reported: Refers to estimates of energy savings and peak demand reduction developed before program evaluation. Equivalent to "reported impacts" or also "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.

Impact Evaluation: Impact evaluation is the verification and estimation of gross and net impacts resulting from the implementation of one or more energy-efficiency or demand response programs.

Measure: An energy-efficiency "measure" refers to any action taken to increase energy efficiency, whether through changes in equipment, control strategies, or behavior.

Net Savings: The portion of gross savings that is directly attributable to the actions of an energy-efficiency or demand response program.

Net-to-Gross Ratio (NTGR): A factor representing net program savings divided by gross program savings that is applied to gross program impacts to convert them into net program impacts. Generally calculated as 1 – (free-ridership %) + (Spillover %).

Non-Cash Inducement Costs: Non-cash inducement costs include third party implementation costs and advertising costs incurred by PSO in the implementation of a program. PSO earns no incentives on advertising costs.

Non-Energy Benefits: Non-energy benefits refer to any benefits PSO customers may experience due to their participation in PSO programs beyond energy savings. Examples include improved comfort, aesthetic enhancements, better indoor air quality, improved security, better employee productivity, etc.

Non-EM&V Administrative Costs: Non-EM&V administrative costs include PSO staff labor costs and overhead costs associated with implementing a program.

Oklahoma Deemed Savings Documents (OKDSD): Refers to the Oklahoma Deemed Savings, Installation & Efficiency Standards, and associated work papers for small commercial and residential energy efficiency measures. These documents were originally submitted to the OCC as part of Cause No. PUD 201800073. In 2013, the documents were updated to reflect more recent and applicable baseline conditions.

Participant Cost Test (PCT): The PCT examines the cost and benefits from the perspective of the customer installing the energy efficiency measure. Costs include incremental costs of purchasing and installing the efficient equipment, above the cost of standard equipment. Benefits include customer bill savings, incentives received from the utility, and any applicable tax credits.

Peak Demand: For the purposes of this report peak demand refers to the average metered demand during the peak period, defined as 2PM to 9 PM during the summer months, June through September, excluding weekends and holidays. Note that for the 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 programs efficacy or effectiveness.

Projected, Reported, and Verified Savings: Projected impacts refer to the energy savings and peak demand reduction forecasts submitted to the OCC as part of PSO's 2022 - 2024 portfolio filing on June 23, 2021.[87] Reported impacts refer to energy savings and peak demand reduction estimates based on actual program participation in PY2022, before program evaluation activities. Finally, verified impacts refer to energy savings and demand reduction estimates for PY2022 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 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

[87] Cause No. PUD 2021000041.

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 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 2022 energy efficiency and demand response portfolio from January 1, 2022, through December 31, 2022.

The cost-effectiveness of PSO's 2022 programs was calculated based on reported total spending, verified energy savings, and verified demand reduction for each of the energy efficiency and demand response programs. All spending estimates were provided by PSO. The methods used to calculate cost-effectiveness are informed by the California Standard Practice Manual. [88]

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 2022 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.[89] 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.

[88] 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

89 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)[90] 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).[91]
- 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 PY2022, PSO's overall portfolio is cost-effective based on both the UCT and TRC.

Table B-1: Projected by Program, 2022 (Impacts are Net, at Generator)

Program	Projected Peak Demand Reduction (kW)	Projected Annual Energy Savings (kWh)	Annual Gas Savings (Therms)	Program Budget
Business Rebates	8,061	38,878,573	(167,083)	$11,757,461
Residential Energy Services	7,173	40,257,258	1,285,697	$11,069,061
Home Weatherization	983	2,670,356	155,169	$3,415,715
Conservation Voltage Reduction	4,317	16,286,445	-	$857,004
Total – EE Programs	**20,533**	**98,092,632**	**1,273,783**	**$27,099,240**
Power Hours	17,434	-	-	$2,137,400
Peak Performers	64,884	63,408	-	$3,234,711
Total – DR Programs	**82,318**	**63,408**	**-**	**$5,372,110.51**
Total – R&D Programs	**184**	**153,826**	**-**	**$852,902.02**
Total	**103,035**	**98,309,866**	**1,273,783**	**$33,324,253**

90 The UCT is also referred to as the Program Administrator Cost Test (PACT).
91 http://www.occeweb.com/rules/CH35finalrules111819.pdf.

Table B-2: Cost-Effectiveness by Program, 2022 (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	8,456	9,172	41,998,395	44,612,699	$10,865,860	1.58	2.20
Residential Energy Services	10,974	11,904	52,093,194	55,335,876	$11,458,565	1.68	1.74
Home Weatherization	2,228	2,417	3,966,545	4,213,453	$3,361,071	2.67	1.61
Conservation Voltage Reduction	3,578	3,882	15,935,475	16,927,422	$357,203	4.75	4.30
Total – EE Programs	**25,236**	**27,375**	**113,993,608**	**121,089,450**	**$26,042,699**	**2.03**	**2.21**
Power Hours	15,109	16,390	123,313	130,989	$1,723,832	1.80	1.25
Peak Performers	55,192	59,870	758,247	822,519	$3,234,711	7.65	2.45
Total – DR Programs	**70,301**	**76,260**	**881,560**	**953,508**	**$4,958,543**	**4.51**	**2.03**
Total – R&D Programs	**-**	**-**	**-**	**-**	$371,944	-	-
Total	**95,537**	**103,635**	**114,875,168**	**122,042,957**	**$31,373,185**	**2.18**	**2.19**

B.2 Energy-Efficiency Programs

PSO’s energy efficiency portfolio in 2022 consisted of four programs with a verified net peak demand reduction of 27,375 kW and verified net annual energy savings of 121,089,450 kWh (including line-loss estimates of 5.86%). Total spending in 2022 equaled $29,538,130. Table B-3 provides a summary of program participation and verified net impacts for each of the energy-efficiency programs. Table B-4 provides reported costs per program.

Table B-3: Energy-Efficiency Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2021*	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Verified Gas Savings (Therms)
Business Rebates	976	9,172	44,612,699	0
Residential Energy Services	267,390	11,904	55,335,876	658,567
Home Weatherization	1,901	2,417	4,213,453	466,382
Conservation Voltage Reduction	22,062	3,882	16,927,422	0
Total – EE Programs	**292,329**	**27,375**	**121,089,450**	**1,124,950**

*Participants represents 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 1,012,363 products.

Table B-4: Energy-Efficiency Programs – Reported Costs

Program	Annual Non-EM&V Admin Costs ($)[92]	Annual EM&V Admin Costs ($)	Annual Cash Inducement Costs ($)[93]	Annual Non-Cash Inducement Costs ($)[94]
Business Rebates	$343,490	$360,535	$6,354,687	$3,807,148
Residential Energy Services	$300,611	$345,261	$7,144,909	$3,667,784
Home Weatherization	$82,023	$56,713	$3,077,531	$144,805
Conservation Voltage Reduction	$15,625	$63,559	$0	$278,019
Total – EE Programs	**$741,749**	**$826,067**	**$16,577,126**	**$7,897,756**

Table B-5 shows the measures with measure life and associated programs. The measure life for Business Rebates measures is calculated as a weighted average based on kWh savings. The programs for Behavioral Modification, Peak Performers, and Conservation Voltage Reduction each have a Tier 1 EUL of one year.

92 Non-EM&V Admin Costs include PSO staff labor costs and overhead costs.
93 Cash inducement costs refer to customer rebate costs.
94 Non-cash inducement costs include third party implementation costs.

Table B-5: Measure Life

Measure	Measure life		Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
	Tier 1	Tier 2										
Air Sealing Package	11.0	0					X					
Duct Replacement	20.0	0					X					
Duct System Sealing	18.0	0					X					
Central AC	19.0	0					X					
Heat Pump	16.0	0					X					
Insulation - Attic	20.0	0					X					
Insulation - Floor	20.0	0					X					
Insulation - Kneewalls/Vertical Attic Wall	20.0	0					X					
Insulation - Exterior Wall	20.0	0					X					
Central AC	19.0	0					X					
Air Source Heat Pumps	16.0	0					X					
Ground Source Heat Pumps	25.0	0					X					
Insulation - Attic	20.0	0					X					
Pool Pumps	10.0	0					X					
HVAC Tune-Up	10.0	0					X					

Measure	Measure life		Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
	Tier 1	Tier 2										
WiFi Thermostat	11.0	0					X					
New Homes	20.0	0					X					
8760 Lighting	13.0	0	X									
Custom	9.0	0	X									
Exterior Lighting	12.0	0	X									
HVAC	12.0	0	X									
Kitchen & Appliances	13.0	0	X									
NC Lighting	10.0	0	X									
Oil & Gas	11.0	0	X									
Refrigeration	16.0	0	X									
Retrofit Lighting	12.0	0	X									
Lighting	11.0	0	X									
HVAC	14.0	0	X									
Exit Signs	14.0	0	X									
Exterior Lighting	14.0	0	X									
Interior Lighting	14.0	0	X									
Non-Lighting	14.0	0	X									
7-Plug Advanced Power Strip	10.0	0						X				
LED Night Light	8.0	0						X				

Measure	Measure life		Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
	Tier 1	Tier 2										
FilterTone® Furnace Filter Alarm	14.0	0						X				
9-watt LED	1.0	18						X				
Advanced Power Strips - LTO	10.0	0				X						
Advanced Power Strips - Retail	10.0	0				X						
Air Filters - Retail	1.0	0				X						
Bathroom Ventilation Fans - Retail	12.0	0				X						
Clothes Dryers - Downstream	13.0	0				X						
Clothes Washers - Downstream	14.0	0				X						
Door Seals and Sweeps - Retail	15.0	0				X						
Electric Vehicle Chargers - Downstream	10.0	0				X						
Heat Pump Water Heaters - Downstream	10.0	0				X						

Measure	Measure life		Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
	Tier 1	Tier 2										
Room Air Conditioners - Retail	10.5	0				X						
Room Air Purifiers - LTO	9.0	0				X						
Room Air Purifiers - Retail	9.0	0				X						
Spray Foam - Retail	15.0	0				X						
Water Dispensers - Retail	10.0	0				X						
WiFi Thermostat - Downstream	11.0	0				X						
WiFi Thermostat - LTO	11.0	0				X						
Lighting - A19 - FB	1.0	19				X						
Lighting - Candelabra - FB	20.0	0				X						
Lighting - Candelabra - LTO	1.0	19				X						
Lighting - Globe - LTO	1.0	19				X						

Measure	Measure life		Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
	Tier 1	Tier 2										
Lighting - Reflector - LTO	1.0	19				X						
Air Infiltration	11.0	0			X							
Attic Insulation	20.0	0			X							
Duct Sealing	18.0	0			X							
Water Heater Jacket	7.0	0			X							
Water Heater Pipe Insulation	13.0	0			X							
Showerheads - Mobile	10.0	0			X							
LED-Mobile	1.0	18			X							
Faucet Aerators - Mobile	10.0	0			X							
Air Infiltration - Mobile	11.0	0			X							
Dryer	14.0	0		X								
Washing Machine	14.0	0		X								
Air Conditioner	19.0	0		X								
Commercial Lighting (DI)	9.0	0		X								
Commercial Lighting (Non-DI)	9.0	0		X								

Measure	Measure life		Business Rebates	Multifamily	Home Weatherization	Energy Saving Products	Homes Rebates	Education	Power Hours	CVR	Behavioral	Business Demand Response
	Tier 1	Tier 2										
Lighting Controls	8.0	0		X								
NC Lighting	11.0	0		X								
Refrigerator	17.0	0		X								
Low Flow Shower Head	10.0	0		X								
Faucet Aerator	10.0	0		X								
Air Sealing	11.0	0		X								
Attic Insulation	20.0	0		X								
Duct Sealing	18.0	0		X								
Heat Pump	16.0	0		X								
Residential Lighting (DI)	3.0	17		X								
Windows	20.0	0		X								
Home Energy Report	1.0	0									X	
Conservation Voltage Reduction	25.0	0								X		
Business Demand Response	1.0	0										X
DLC Events	1.0	0							X			

In the tables that follow, total costs and benefits, and cost-effectiveness test results are provided for each energy-efficiency program in the program year.

B.2.1 Business Rebates Program

Table B-6: Business Rebates Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**2.20**	**1.58**	**0.52**	**1.78**	**3.31**
Net Benefits ($000s)	12,555.61	9,087.20	(20,925.82)	12,175.81	26,263.79
Total Benefits ($000s)	23,052.05	24,664.60	23,052.05	27,753.21	37,630.58
Total Costs ($000s)	10,496.44	15,577.40	43,977.87	15,577.40	11,366.79

B.2.2 Residential Energy Services Program

Table B-7: 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	**1.74**	**1.68**	**0.38**	**2.30**	**5.37**
Net Benefits ($000s)	8,051.32	8,970.53	(30,769.41)	17,117.83	40,876.98
Total Benefits ($000s)	18,869.87	22,125.79	18,869.87	30,273.10	50,234.78
Total Costs ($000s)	10,818.55	13,155.27	49,639.28	13,155.27	9,357.80

B.2.3 Residential Energy Services: Multifamily SubProgram

Table B-8: Multifamily Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost Test	Participant Cost Test
Benefit/Cost Ratio	**2.86**	**3.13**	**0.48**	**3.67**	**5.93**
Net Benefits ($000s)	1,766.89	2,005.79	(2,919.13)	2,509.88	4,234.58
Total Benefits ($000s)	2,718.03	2,946.60	2,718.03	3,450.69	5,094.17
Total Costs ($000s)	951.15	940.81	5,637.17	940.81	859.59

B.2.4 Residential Energy Services: Home Weatherization SubProgram

Table B-9: Home Weatherization Benefit/Cost Tests

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.61**	**2.67**	**0.62**	**3.19**	**4.19**
Net Benefits ($000s)	2,042.82	5,609.26	(3,277.67)	7,372.82	9,826.32
Total Benefits ($000s)	5,403.89	8,970.33	5,403.89	10,733.89	12,903.85
Total Costs ($000s)	3,361.07	3,361.07	8,681.56	3,361.07	3,077.53

B.2.5 Residential Energy Services: Energy Saving Products SubProgram

Table B-10: 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	**5.03**	**2.46**	**0.33**	**4.77**	**10.65**
Net Benefits ($000s)	6,053.07	3,048.61	(15,044.85)	7,859.30	18,535.18
Total Benefits ($000s)	7,553.85	5,131.30	7,553.85	9,941.98	20,456.46
Total Costs ($000s)	1,500.78	2,082.69	22,598.71	2,082.69	1,921.28

B.2.6 Residential Energy Services: Home Rebates SubProgram

Table B-11: Home Rebates Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**0.89**	**1.36**	**0.43**	**1.65**	**3.08**
Net Benefits ($000s)	(723.74)	2,982.52	(7,909.44)	5,440.55	12,289.73
Total Benefits ($000s)	5,883.39	11,375.29	5,883.39	13,833.32	18,187.39
Total Costs ($000s)	6,607.12	8,392.77	13,792.83	8,392.77	5,897.66

B.2.7 Residential Energy Services: Education SubProgram

Table B-12: Education Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.91**	**1.86**	**0.37**	**2.32**	**5.79**
Net Benefits ($000s)	747.78	705.78	(2,707.98)	1,080.28	3,252.57
Total Benefits ($000s)	1,565.26	1,523.25	1,565.26	1,897.75	3,931.83
Total Costs ($000s)	817.48	817.48	4,273.24	817.48	679.26

B.2.8 Residential Energy Services: Behavioral Modification SubProgram

Table B-13: Behavioral Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.22**	**1.25**	**0.34**	**1.25**	**-**
Net Benefits ($000s)	207.32	227.83	(2,188.00)	227.83	2,564.93
Total Benefits ($000s)	1,149.35	1,149.35	1,149.35	1,149.35	2,564.93
Total Costs ($000s)	942.02	921.51	3,337.34	921.51	-

B.2.9 Conservation Voltage Reduction

Table B-14: CVR Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**4.30**	**4.75**	**0.61**	**5.95**	**-**
Net Benefits ($000s)	11,503.56	13,054.24	(9,666.56)	17,244.63	17,685.94
Total Benefits ($000s)	14,984.25	16,534.93	14,984.25	20,725.32	17,685.94
Total Costs ($000s)	3,480.69	3,480.69	24,650.81	3,480.69	-

B.3 Demand Response Programs

PSO’s demand response portfolio in 2022 consisted of two demand response programs with a verified net peak demand reduction of 76,260 kW[95] and a verified net energy savings of 953,508 kWh. Total spending in 2022 equaled $4,958,543. Table B-15

95 The verified peak demand reduction shown here for the demand response programs includes an adjustment for line-losses (7.81%).

provides a summary of program participation and verified net impacts for the 2022 demand response portfolio. Table B-16 provides a summary of 2022 program costs.

Table B-15: Demand Response Programs – Verified Impacts (Net, at Generator)

Program	Number of Participants in 2022	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Gas Savings (Therms)
Power Hours	11,029	16,390	130,989	0
Peak Performers	1,525	59,870	822,519	0
Total – DR Programs	**12,554**	**76,260**	**953,508**	**0**

Table B-16: 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	$107,801	$66,093	$523,111	$1,026,828
Peak Performers	$89,031	$71,294	$2,933,222	$141,164
Total – DR Programs	**$196,831**	**$137,386**	**$3,456,333**	**$1,167,992**

B.3.1 Power Hours Program

Table B-17: Power Hours Benefit/Cost Test

Metric	Utility Cost Test	Total Resource Cost Test	Ratepayer Impact Measure	Societal Cost test	Participant Cost Test
Benefit/Cost Ratio	**1.25**	**1.80**	**1.25**	**1.80**	**-**
Net Benefits ($000s)	438.29	961.40	428.22	961.40	533.81
Total Benefits ($000s)	2,162.12	2,162.12	2,162.12	2,162.12	533.81
Total Costs ($000s)	1,723.83	1,200.72	1,733.91	1,200.72	-

B.3.2 Peak Performers Program

Table B-18: 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	**2.45**	**7.65**	**2.40**	**7.65**	**4.09**
Net Benefits ($000s)	4,677.76	6,877.68	4,615.82	6,877.68	2,265.71
Total Benefits ($000s)	7,912.47	7,912.47	7,912.47	7,912.47	2,999.02
Total Costs ($000s)	3,234.71	1,034.79	3,296.65	1,034.79	733.31

B.4 Research and Development

PSO's research and development portfolio in 2022 consisted of research and development programs with a verified net peak demand reduction of 0 kW and a verified net energy savings of 0 kWh as the studies will not claim any savings for 2022. The following tables provides a summary of activity and results.

Table B-19: Research and Development Programs - Verified Impacts (Net, at Generator)

Program	Number of Participants in 2022	Verified Peak Demand Reduction (kW)	Verified Annual Energy Savings (kWh)	Verified Gas Savings (Therms)
Research and Development	0	0	0	0
Total – R&D Programs	**0**	**0**	**0**	**0**

Table B-20: 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	$94,297	$13,378	$0	$264,269
Total – R&D Programs	**$94,297**	**$13,378**	**$0**	**$264,269**

Table B-21: 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	**-**	**-**	**-**	**-**	**-**
Net Benefits ($000s)	-	-	-	-	-
Total Benefits ($000s)	-	-	-	-	-
Total Costs ($000s)	-	-	-	-	-

B.5 Avoided Costs

The avoided costs in Table B-22 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).[96]

[96] https://psoklahoma.com/global/utilities/lib/docs/ratesandtariffs/Oklahoma/PSO%20Riders%20Jan%202019.pdf

Table B-22: 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			44,612,699	116,096,391	38%
Residential Energy Services	55,335,876			55,335,876	122,333,178	45%
Home Weatherization	4,213,453			4,213,453	8,011,067	53%
Conservation Voltage Reduction	16,927,422			16,927,422	88,835,153	19%
Energy Efficiency Totals	**121,089,450**			**121,089,450**	**335,275,789**	**36%**
Demand Response Programs						
Power Hours	130,989			130,989	0	-
Peak Performers	822,519			822,519	206,076	399%
Demand Response Totals	**953,508**			**953,508**	**206,076**	**463%**
Research and Development Programs						
Research and Development	-	-	-	-	548,717	0%
R&D Totals	**-**	**-**	**-**	**-**	**548,717**	**0%**
Total	**122,042,957**	**-**	**-**	**122,042,957**	**336,030,581**	**36%**

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			9,172	24,035	38%
Residential Energy Services	11,904			11,904	21,750	55%
Home Weatherization	2,417			2,417	2,948	82%
Conservation Voltage Reduction	3,882			3,882	23,547	16%
Energy Efficiency Totals	**27,375**	**-**	**-**	**27,375**	**72,280**	**38%**
Demand Response Programs						
Power Hours	16,390			16,390	64,008	26%
Peak Performers	59,870			59,870	210,873	28%
Demand Response Totals	**76,260**	**-**	**-**	**76,260**	**274,881**	**28%**
Research and Development Programs						
Research and Development	**-**	**-**	-	-	688	0%
Research and Development Totals	**-**	**-**	**-**	**-**	**688**	**0%**
Portfolio Total	**103,635**	**-**	**-**	**103,635**	**347,849**	**30%**

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			$10,865,860	35,545,622	31%
Residential Energy Services	$11,458,565			$11,458,565	30,549,377	38%
Home Weatherization	$3,361,071			$3,361,071	10,294,676	33%
Conservation Voltage Reduction	$357,203			$357,203	4,555,971	8%
Energy Efficiency Totals	**$26,042,699**	**$-**	**$-**	**$26,042,699**	**80,945,645**	**32%**
Demand Response Programs						
Power Hours	$1,723,832			$1,723,832	6,471,965	27%
Peak Performers	$3,234,711			$3,234,711	12,037,752	27%
Demand Response Totals	**4,958,543**	**$ -**	**$ -**	**4,958,543**	**18,509,717**	**27%**
Research and Development Programs						
Research and Development	371,944			371,944	2,587,706	14%
Research and Development Totals	**371,944**			**371,944**	**2,587,706**	**14%**
Total	**31,373,185**	**$ -**	**$ -**	**31,373,185**	**102,043,068**	**31%**

C.1.5 Cash Inducements

Cash inducements are presented in Table C-4. Cash inducements are generally direct payments to customers or trade allies on behalf of customers, namely rebates and incentives.

Table C-4: Total Cash Inducements by Program

Program	2022	2023	2024	2022-2024	3-Year Goal	% to Goal
Energy Efficiency Programs						
Business Rebates	$6,354,687			$6,354,687	$20,319,592	31%
Residential Energy Services	$7,144,909			$7,144,909	$18,089,672	39%
Home Weatherization	$3,077,531			$3,077,531	$7,999,755	38%
Conservation Voltage Reduction	$0			$0	$-	0%
Energy Efficiency Totals	**$16,577,126**	**$-**	**$-**	**$16,577,126**	**$46,409,019**	**36%**
Demand Response Programs						
Power Hours	$523,111			$523,111	1,561,500	34%
Peak Performers	$2,933,222			$2,933,222	10,019,175	29%
Demand Response Totals	**$3,456,333**	**$-**	**-**	**3,456,333**	**11,580,675**	**30%**
Research and Development Programs						
Research and Development Totals	$-			-	712,152	0%
Total	**$20,033,459**	**$-**	**-**	**20,033,459**	**58,701,846**	**34%**

C.1.6 Cost Effectiveness

Figure C-1 shows the Demand Portfolio's Total Resource Cost Test (TRC) results and Utility Cost Test (UCT)[97] 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).

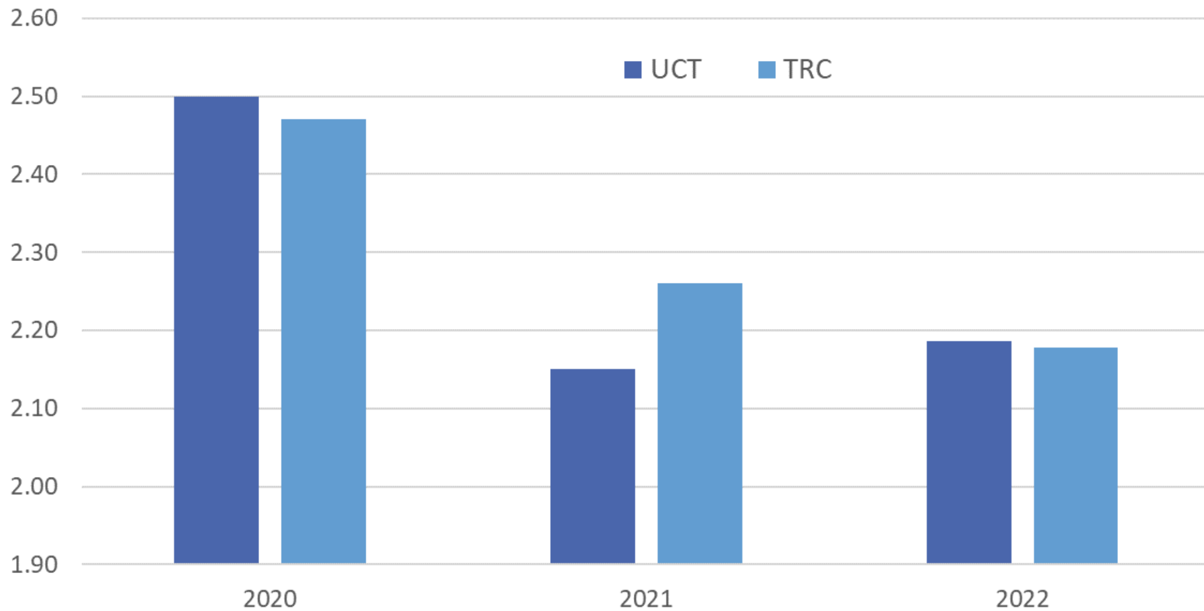
In addition to TRC and UCT results, results from the Ratepayer Impact Measure (RIM), Participant Cost Test (PCT) and Societal Cost Test (SCT) are included in each year's Annual Report. Based on reported program impacts and spending through December 31, 2022, PSO's overall portfolio is cost-effective based on both the TRC and UCT.

Figure C-1 shows the changes in cost effectiveness ratios over the portfolio period.

[97] 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 2022, 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, Energy Saving Products, Home Rebates, Behavioral Modification, and Education Kits. The Business Rebates program consists of the following subprogram: 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, 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, 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 energy saving LED light bulbs, air filters, weatherization measures, electric vehicle chargers, smart thermostats, 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 lighting and 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 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 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 2022 program.

Table D-1: Program Implementer Identification

Program(s)	Implementation Contractor	Contact	Contact Title	Contact Address	Contact Phone	Contact Email
Business Rebates	ICF International	Brett Fidler	Program Manager	7136 S. Yale Ave. #330, Tulsa, OK	918-594-4566	Brett.fidler@icfi.com
Multifamily and Manufactured Homes	ICF International	Jason Fisher	Technical Specialist	7136 S. Yale Ave. #330, Tulsa, OK	918-519-0214	Jason.Fisher@icf.com
Home Weatherization	Titan ES, LLC	Bradley Cockings	President	9700 S. Pole Road, Tulsa, OK 73160	405-632-1700	bcockings@titanes.us
	Revitalize T-Town	Jennifer Barcus - Schafer	Chief Executive Officer	14 E 7th St, Tulsa, OK 74119	918-742-6241	jennifer@revitalizettown.org
	Ki Bois Community Action Foundation	Michael Knapp	Weatherization Director	200 SE A Street Stigler, Oklahoma 74462	918-967-3325	michael.knapp@kibois.org
Energy Saving Products, Home Rebates	ICF International	Andrea Palmer	Program Manager	7136 S. Yale Ave. #330, Tulsa, OK	918-348-0503	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

Program(s)	Implementation Contractor	Contact	Contact Title	Contact Address	Contact Phone	Contact Email
CVR	PSO	Devin Haughn	Smart Grid Systems Mgr	212 E. 6th St. Tulsa, OK 74119	918-599-2840	dlhaughn@aep.com
Behavioral	Oracle	Sharon Giljum	Sr. Client Success Manager	2300 Oracle Way, Austin TX 78741	314-541-9869	Sharon.giljum@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	Event Name	Location	Training/Education Type	Number of Attendees
01/07/2022	PowerForward Overview	Chickasha SC	Portfolio (All Programs)	11-20
01/07/2022	PowerForward Overview	Virtual - Phone/Online	Portfolio (All Programs)	0-10
01/11/2022	HPB Service Provider Training	Broken Arrow	Residential Programs	21-30
01/12/2022	HPH Service Provider Training	Lawton	Residential Programs	0-10
01/19/2022	HPH Service Provider Training	Tulsa	Residential Programs	0-10
01/20/2022	HPH Service Provider Training	Tulsa	Residential Programs	41-50
01/24/2022	HPH Service Provider Training	Tulsa	Residential Programs	0-10
02/02/2022	HPB Service Provider Training	Virtual - Phone/Online	Business Programs	91-100
02/02/2022	Other	Tulsa General Office	Portfolio (All Programs)	11-20
02/09/2022	HPH Service Provider Training	Lawton	Residential Programs	0-10
02/10/2022	Other	Tulsa General Office	Portfolio (All Programs)	11-20
02/14/2022	HPB Lunch and Learn	Clinton SC		31-40
02/14/2022	HPH Service Provider Training	Tulsa	Residential Programs	0-10
02/17/2022	HPB Service Provider Training	Virtual - Phone/Online	Business Programs	61-70
02/17/2022	HPH Service Provider Training	Tulsa	Residential Programs	0-10
02/23/2022	HPH Service Provider Training	Broken Arrow	Residential Programs	0-10
03/07/2022	PowerForward Overview	Tulsa General Office	Residential Programs	11-20
03/07/2022	PowerForward Overview	Virtual - Phone/Online	Portfolio (All Programs)	11-20
03/24/2022	HPH Builder/Rater Training	Owasso	Residential Programs	0-10
03/29/2022	HPH Service Provider Training	Tulsa	Residential Programs	0-10
03/29/2022	HPH Builder/Rater Training	Broken Arrow	Residential Programs	0-10
03/30/2022	HPB Service Provider Training	McAlester	Residential Programs	0-10
03/31/2022	HPH Builder/Rater Training	Tulsa	Residential Programs	0-10
04/07/2022	PowerForward Overview	Tulsa General Office	Residential Programs	11-20
04/07/2022	PowerForward Overview	Virtual - Phone/Online	Portfolio (All Programs)	11-20
04/07/2022	PowerForward Overview	Jay	Portfolio (All Programs)	21-30

Date	Event Name	Location	Training/Education Type	Number of Attendees
04/18/2022	PowerForward Overview	Tulsa General Office	Portfolio (All Programs)	11-20
04/21/2022	PowerForward Overview	Virtual - Phone/Online	Portfolio (All Programs)	21-30
04/21/2022	PowerForward Overview	Tulsa General Office	Portfolio (All Programs)	11-20
04/26/2022	HPB Service Provider Training	Tulsa	Residential Programs	0-10
04/28/2022	HPH Service Provider Training	McAlester	Residential Programs	0-10
05/03/2022	HPH Service Provider Training	McAlester	Residential Programs	0-10
05/04/2022	HPH Service Provider Training	Lawton	Residential Programs	0-10
05/19/2022	HPB Service Provider Training	Woodward	Residential Programs	0-10
05/19/2022	HPB Service Provider Training	Woodward	Residential Programs	0-10
05/19/2022	HPH Service Provider Training	Oologah	Residential Programs	0-10
06/08/2022	PowerForward Overview	Tulsa General Office	Portfolio (All Programs)	11-20
07/05/2022	HPH New Homebuilder/Rater Recruitment	Tulsa Mid Metro SC	Residential Programs	
08/10/2022	HPB Service Provider Training	Tulsa Mid Metro SC	Residential Programs	0-10
08/18/2022	HPH Service Provider Training	Weatherford SC	Residential Programs	
08/18/2022	HPH Service Provider Training	Weatherford SC	Residential Programs	11-20
08/30/2022	HPH Service Provider Training	Tulsa Mid Metro SC	Residential Programs	0-10
09/01/2022	HPH Service Provider Training	Tulsa Mid Metro SC	Residential Programs	0-10
09/16/2022	HPH Service Provider Training	Virtual - Phone/Online	Residential Programs	0-10
09/20/2022	HPB Service Provider Training	Tulsa Mid Metro SC	Residential Programs	0-10
09/20/2022	PowerForward Overview	McAlester	Portfolio (All Programs)	11-20
09/22/2022	HPH Service Provider Training	Tulsa Mid Metro SC	Residential Programs	0-10
09/24/2022	HPH Service Provider Training	Tulsa Mid Metro SC	Residential Programs	
09/28/2022	HPH Service Provider Training	Virtual - Phone/Online	Residential Programs	11-20
10/10/2022	HPH Service Provider Training	Weatherford SC	Residential Programs	0-10
10/10/2022	HPH Service Provider Training	Virtual - Phone/Online	Residential Programs	0-10
10/20/2022	HPH Service Provider Training	Virtual - Phone/Online	Residential Programs	0-10
10/20/2022	HPH Service Provider Training	Virtual - Phone/Online	Residential Programs	0-10
11/01/2022	PowerForward Overview	Tulsa General Office	Residential Programs	11-20
11/08/2022	PowerForward Overview	Virtual - Phone/Online	Portfolio (All Programs)	21-30
11/14/2022	PowerForward Overview	Bartlesville SC	Portfolio (All Programs)	11-20
11/15/2022	PowerForward Overview	Virtual - Phone/Online	Portfolio (All Programs)	11-20
12/07/2022	HPH Service Provider Training	Tulsa General Office	Residential Programs	0-10
12/15/2022	HPH Service Provider Training	Virtual - Phone/Online	Residential Programs	91-100
12/15/2022	HPB Lunch and Learn	Bartlesville SC	Residential Programs	0-10

Date	Event Name	Location	Training/Education Type	Number of Attendees
12/22/2022	HPB Lunch and Learn	Chickasha SC	Residential Programs	0-10

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 2022 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 and engagement. PSO's centralized marketing function ensures strategic planning and execution across all energy efficiency programs, delivering a consistent message and experience for customers regardless of program.

F.1 2022 Program Customer Engagement Goals

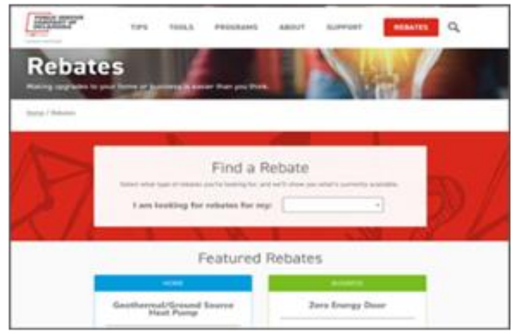
This section presents the methods used to meet PSO's portfolio engagement goals.

F.1.1 Strategies and Tactics

- Identify unknown audiences, reach underserved demographics, segment creative and messaging, with a focus on improving program parity.
- Utilize paid media to deliver targeted messages to customers.
- A/B Message Testing
- Develop content to support paid media and digital channels.
- Transition customer engagement of Power Hours program.
- Improve digital presence.
- 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 customer engagement.

F.1.2 PSO Website

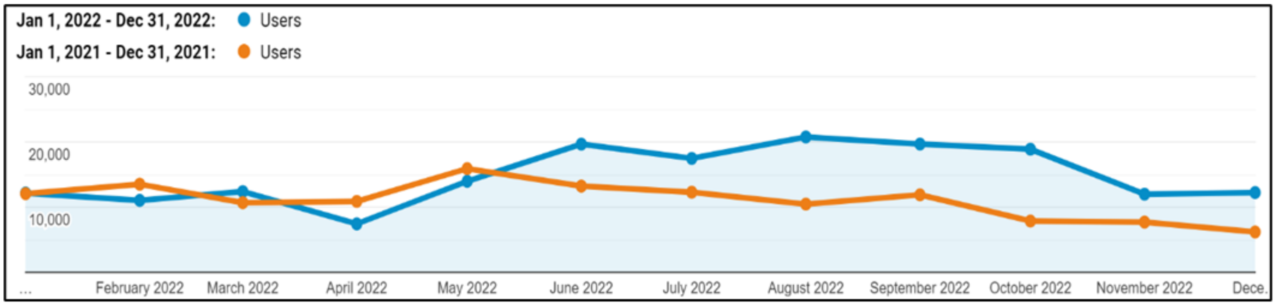
The PSO Power Forward website redesign was finalized in April 2022. The goal being to provide a new design and overall enhanced site experience for customers. Future website updates and learnings will continue to ensure we're building and creating the best website and experience possible for customers. Examples of the website are shown below.

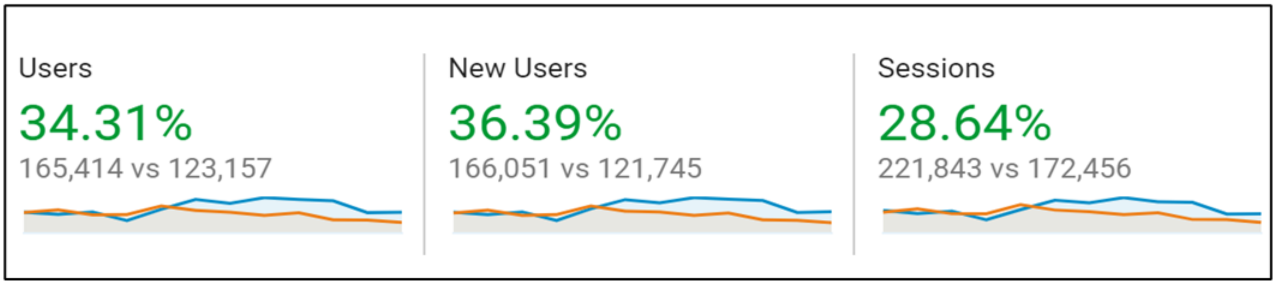


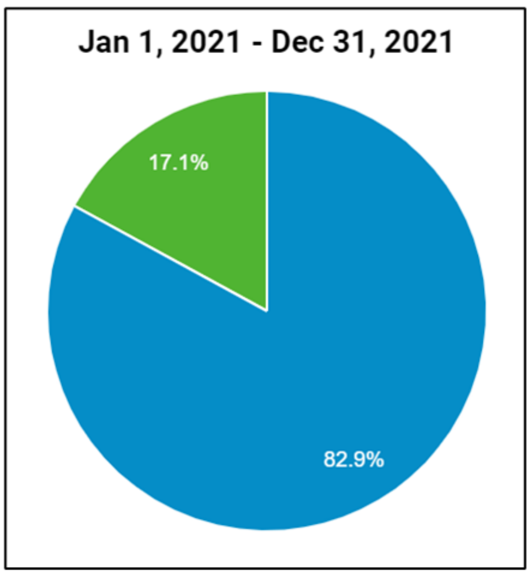
F.2 Overall Website Performance

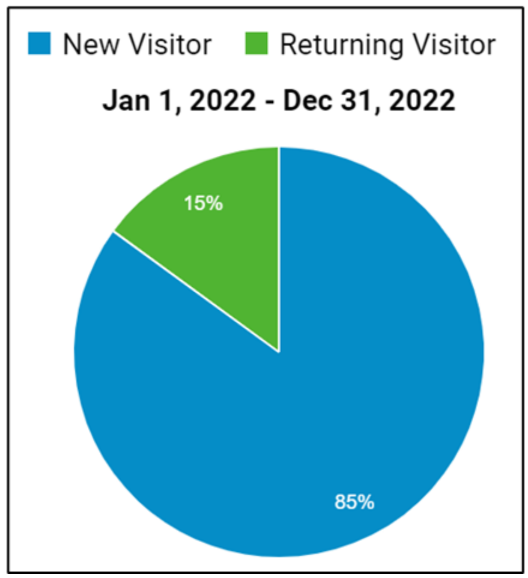
For 2022, there were 165,414 Users, 166,051 New Users, 221,843 Sessions, and 618,115 Pageviews on the Power Forward website. Compared to 2021, Users, New Users and Sessions increased. Page views saw a slight decrease compared to 2021.

Figure F-1: Overall User Visits









F.2.1 Site Visitors: By Age & Gender

Website visitors fluctuated across all age groups, when comparing 2021 to 2022. Website demographic is both male and female with 35–44-year-olds being primary users.

Figure F-2: Age Group Comparison 2021 – 2022

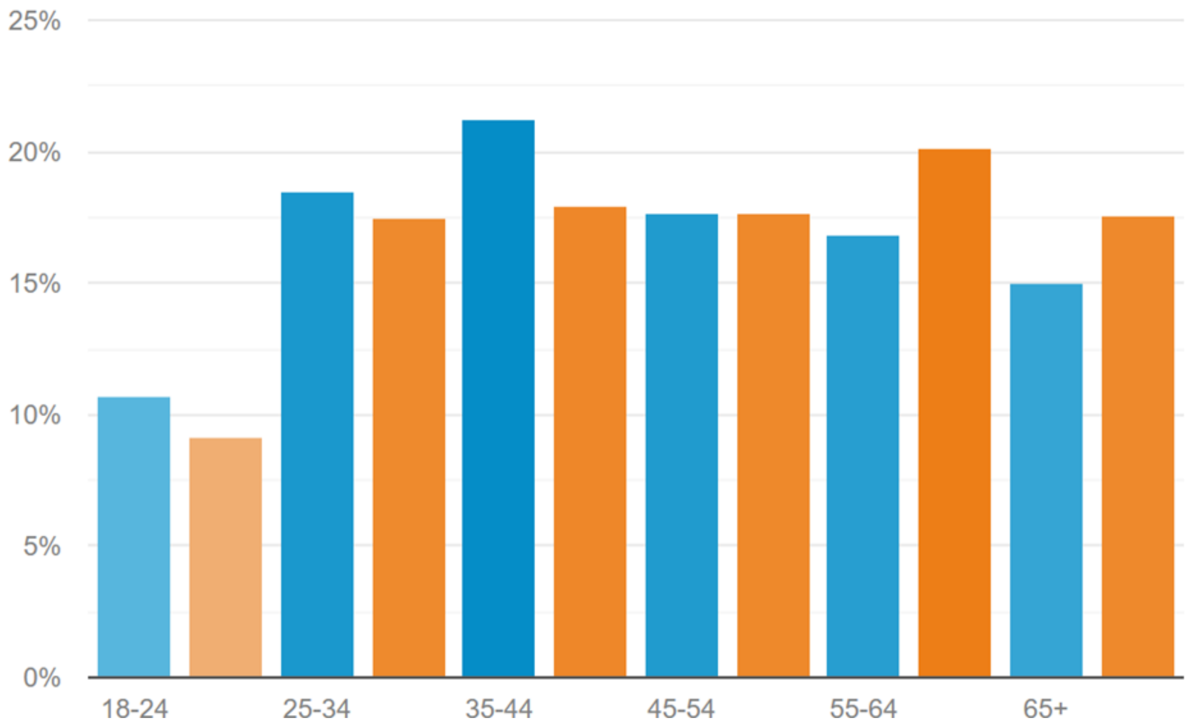
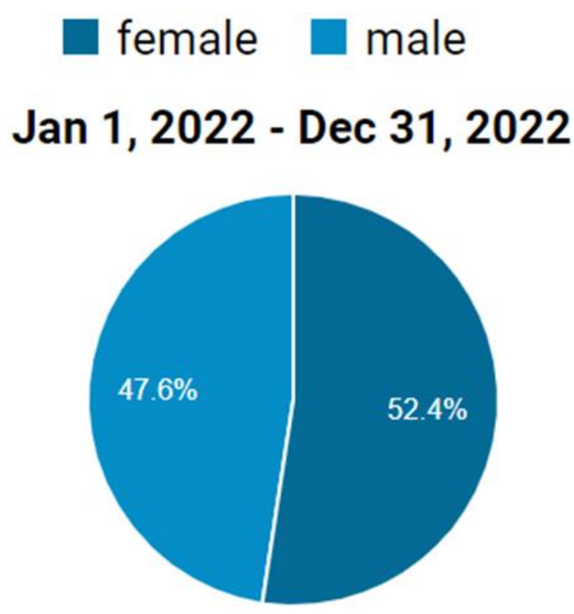


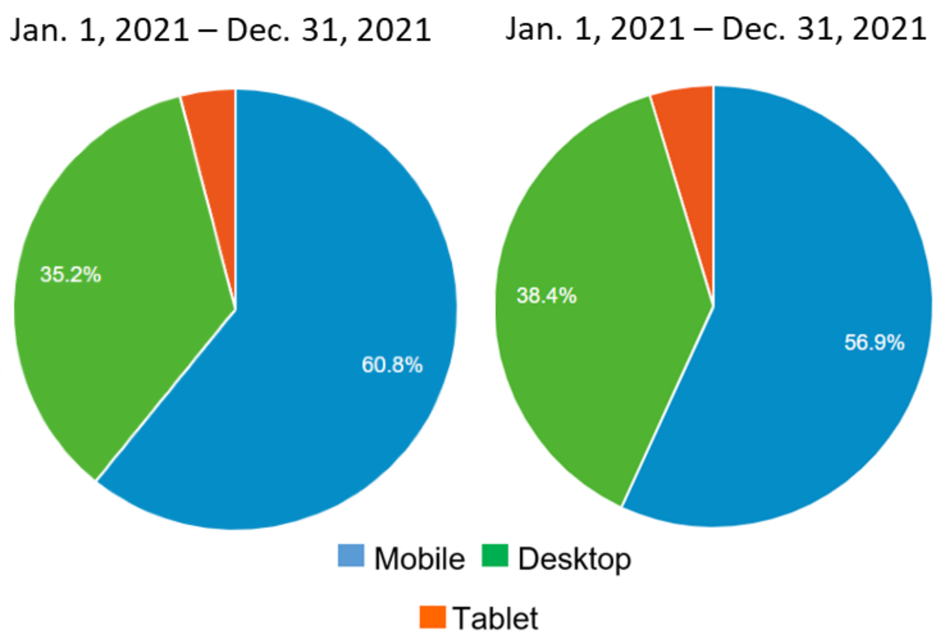
Figure F-3: Gender Comparison



F.2.2 Site Visitors: By Device

Most users in 2022 used mobile devices with being over 60%. Over the last two years mobile performance metrics have remained steady as the primary device used. Desktop users slightly decreased from 2021 to 2022 while tablet usage decreased most likely due to users being out of the home as the pandemic has faded.

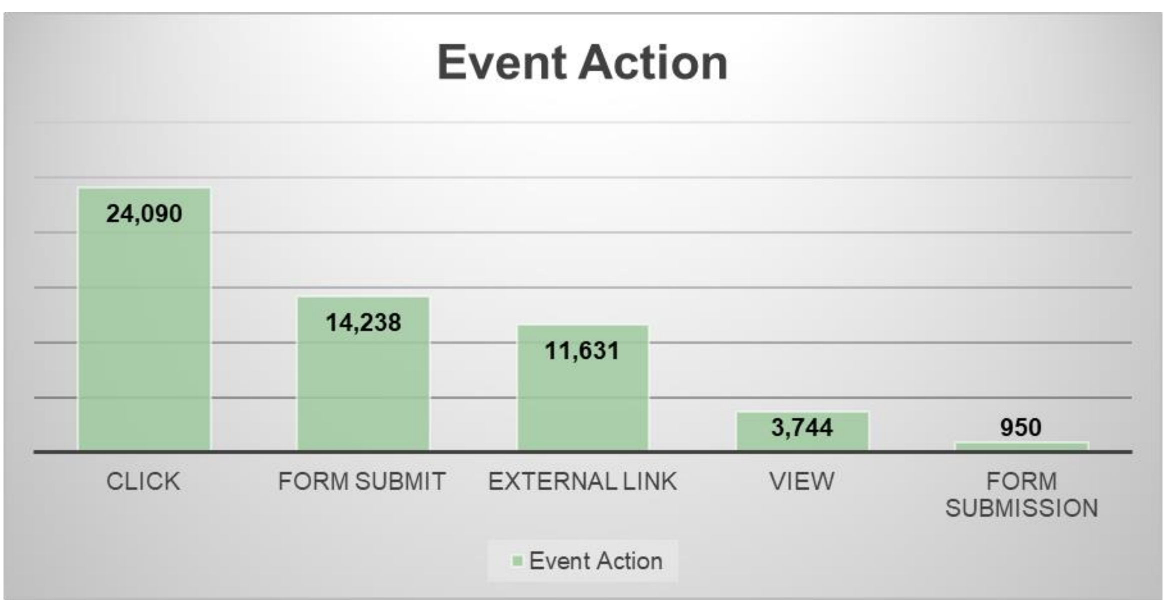
Figure F-4: Site Visitors by Device



F.2.3 Website Events

The data below represents the top events by number of events during 2022.

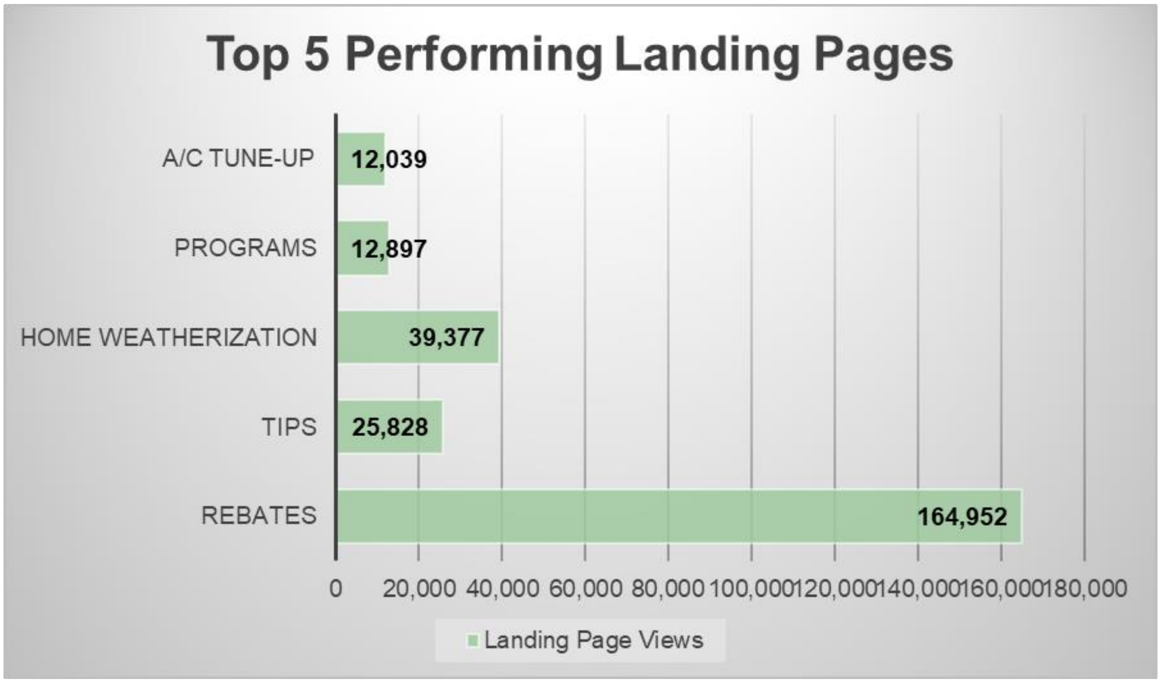
Figure F-5: Website Events 2022



F.2.4 Website Engagement

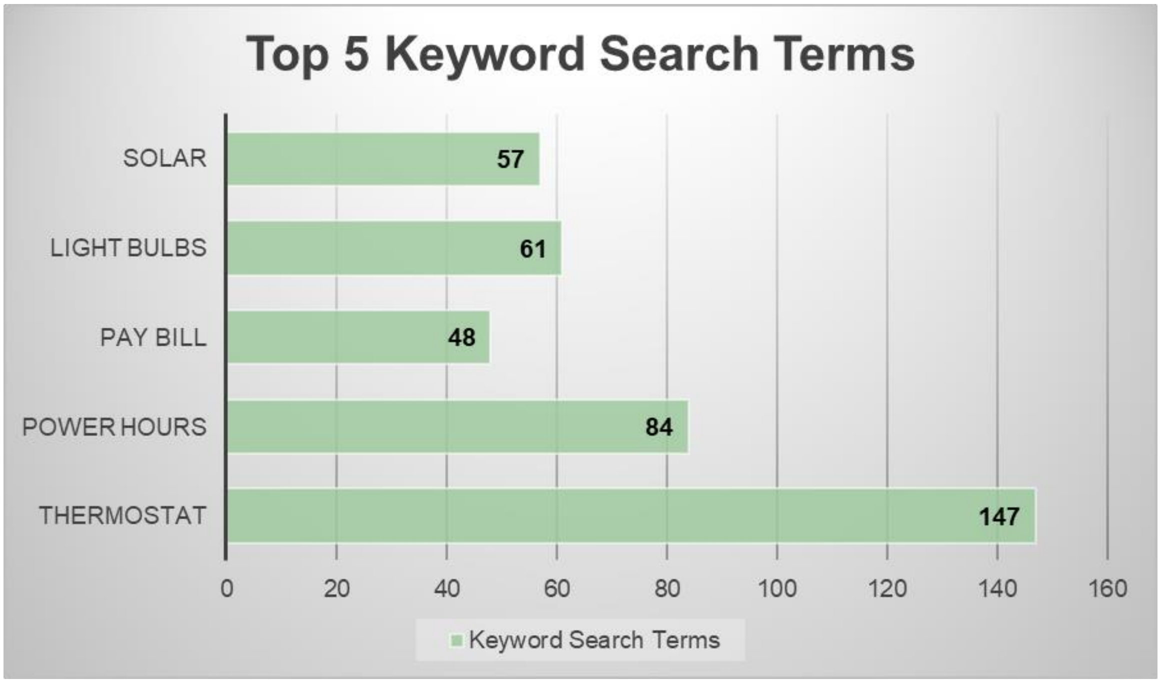
The following pages have the most engagement – determined by total page views. The Rebate's landing page was the top performing landing page in 2022, which was followed by the Home Weatherization landing page.

Figure F-6: Website Engagement 2022



The most searched terms on the Power Forward website were "thermostat", "power hours", "pay bill", "light bulbs", and "solar".

Figure F-7: Website Keyword Search Terms 2022



F.2.5 Paid Search Results

Paid search is being utilized to capture customers at the bottom of the sales funnel. In 2022, we consistently refined search keywords to increase media effectiveness and reduce spend in order to support additional upper funnel marketing tactics, which focus on moving customers from awareness to consideration.

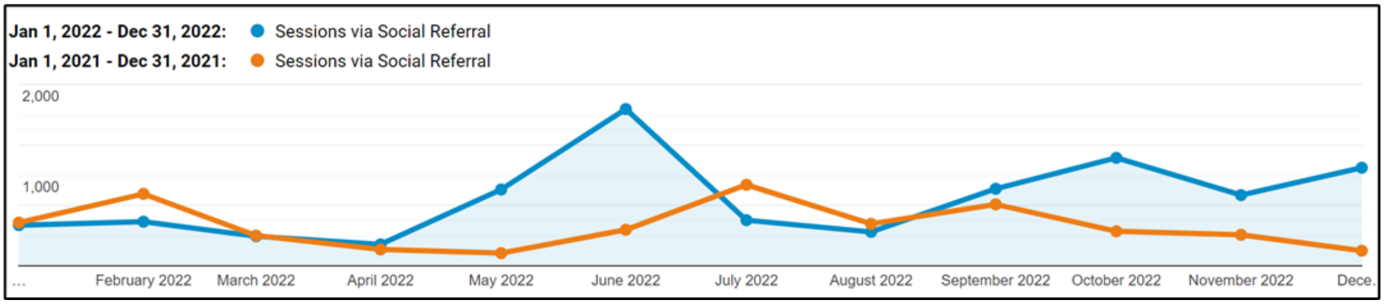
Top Search Terms for 2022

- **Residential:** "electricity rebate", "weatherization assistance", "appliance repair", "pso weatherization program", "smart thermostat"
- **Commercial:** "business rebates", "commercial rebates", "business energy incentives", "energy efficient business"

F.2.6 Web Traffic – Social Media

Social media continues to be a strong driver of traffic to the PSO Power Forward website. In 2022, we continued placements on Facebook/Instagram, LinkedIn, Nextdoor and Pinterest into the media mix in order to diversify and reach customers across a variety of platforms where content is consumed.

Figure F-8: Social Web Referrals



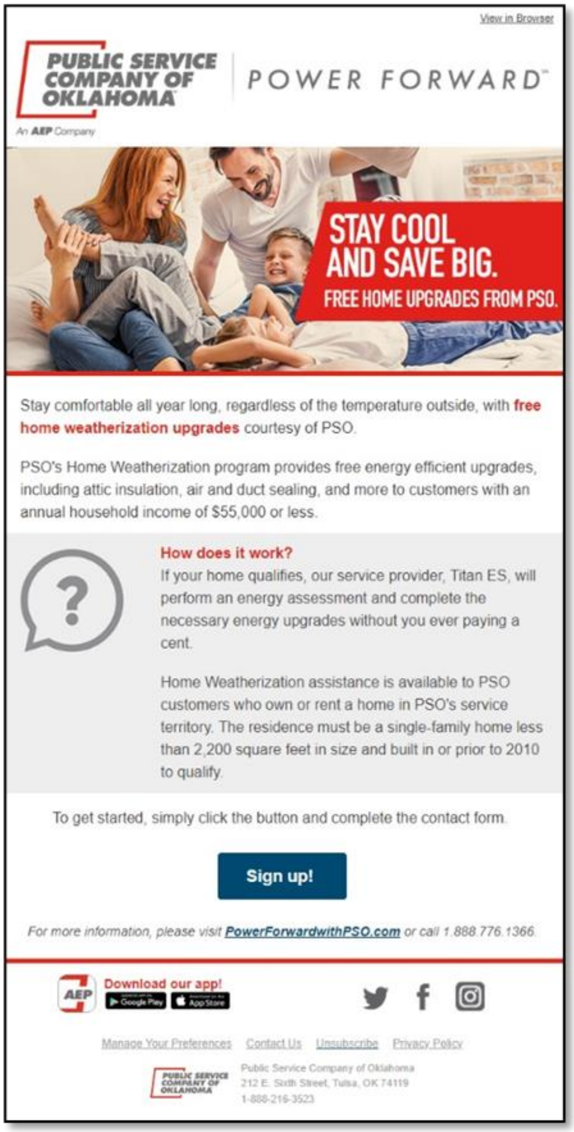
F.3 Videos

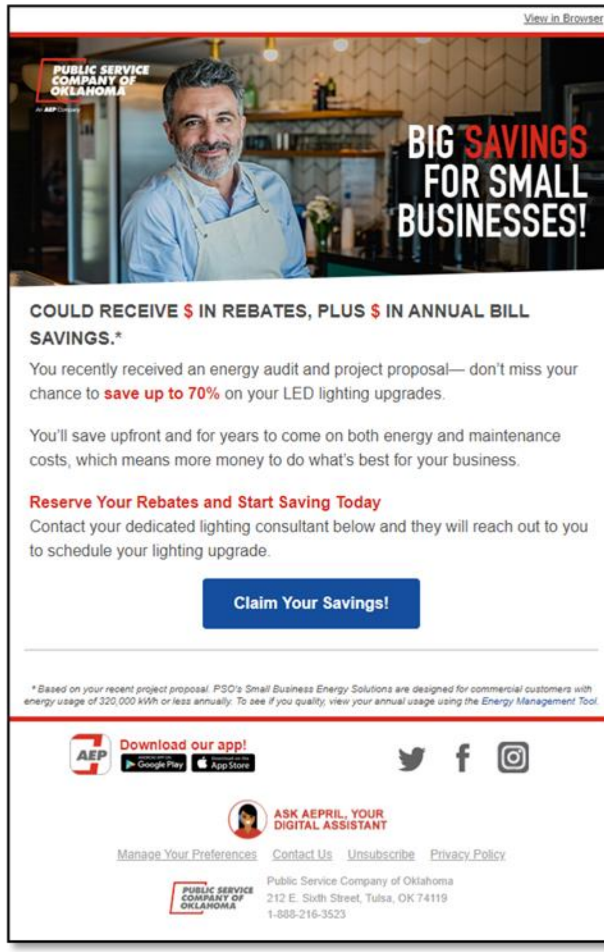
In 2022, the video customer engagement strategy leveraged multiple platforms (YouTube, Facebook/Instagram, LinkedIn, etc.) via programmatic in order to reach a wider customer base. Optimizations focused on fine tuning audience targeting on these platforms to maximize KPIs.

F.4 Email Customer Engagement

PSO utilized email customer engagement to send communications regarding home and business rebates plus energy efficiency programs to various customer segments. Program participation data was utilized to ensure the right customers were targeted with relevant messaging. Emails included clear call to action buttons to improve customer engagement.

Figure F-9: Email Customer Engagement Examples

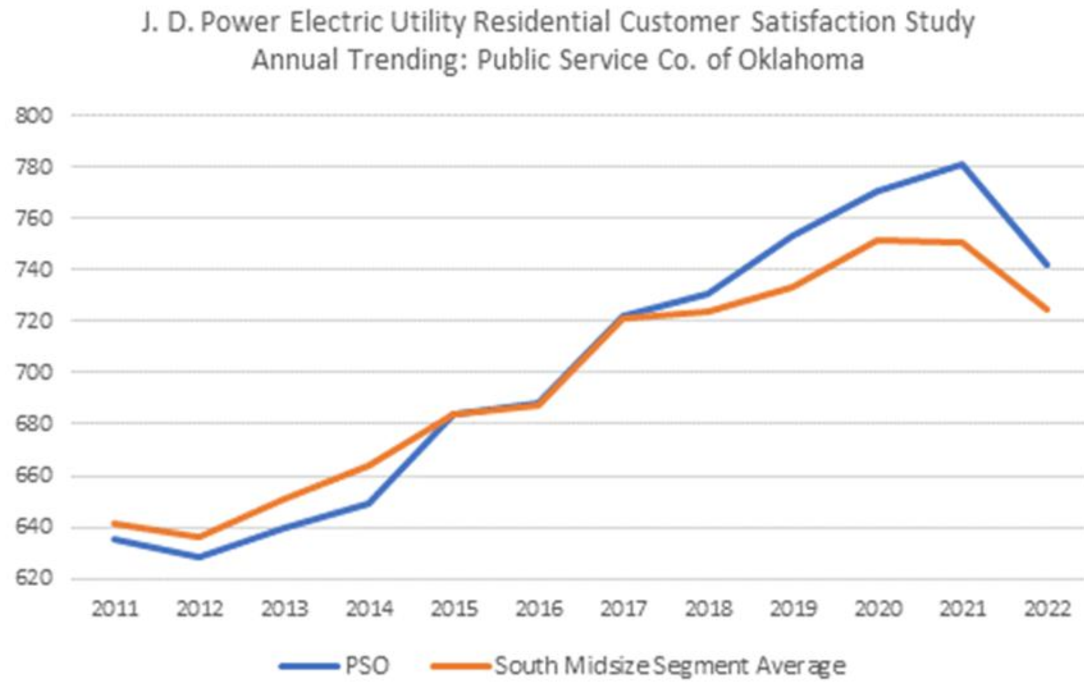




F.5 J.D. Power Scores

PSO's overall J.D. Power score saw a slight dip in 2022 along with the South Midsize Segment Average primarily due to dissatisfaction with economic price increases over the entire utility industry. General research trends and insight indicate that a reinforced message of customer value and options (payment assistance and program offerings) will continue to resonate well.

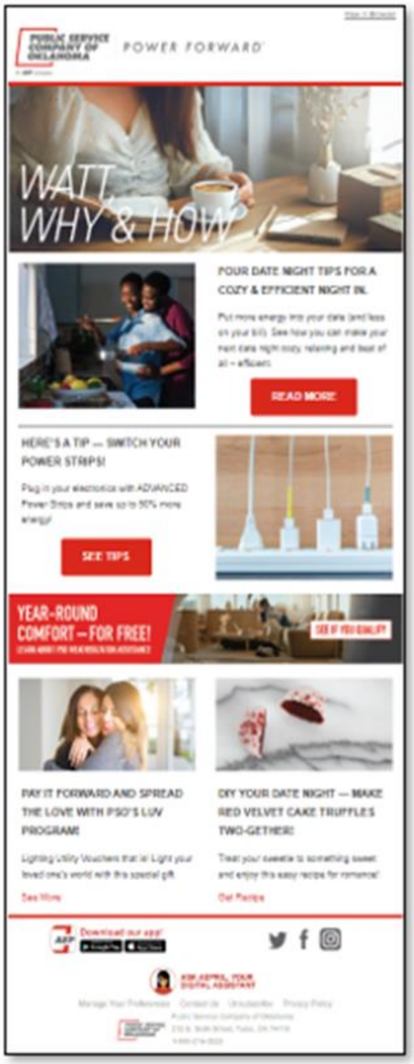
Figure F-10: PSO's J.D. Power Scores



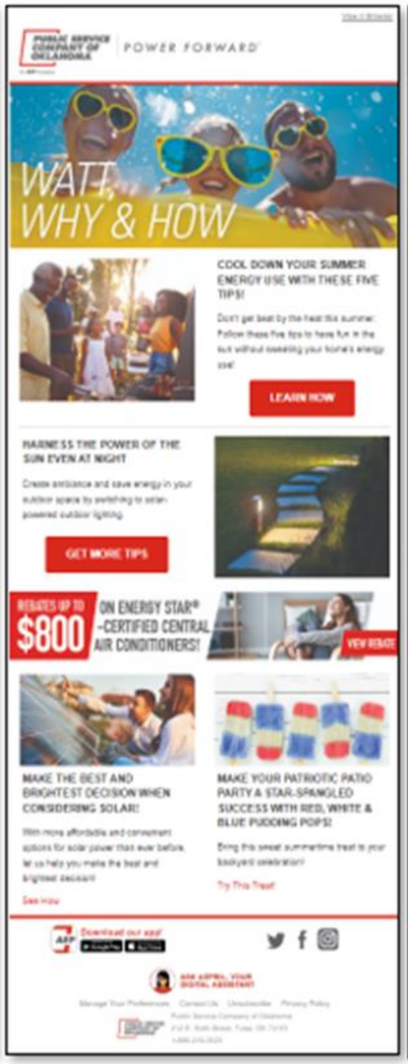
F.6 Creative Examples – Residential

A residential newsletter was sent to approximately 375,000 customers monthly. Content highlights energy-saving blog content, tips and available rebates/limited time offer. Customers are encouraged to visit the Power Forward with PSO website for more information. The images below are examples of the creative content used for the monthly newsletters, home Weatherization, Home Rebates, Power Hours, Small Business, Commercial and Industrial, and Peak Performers.

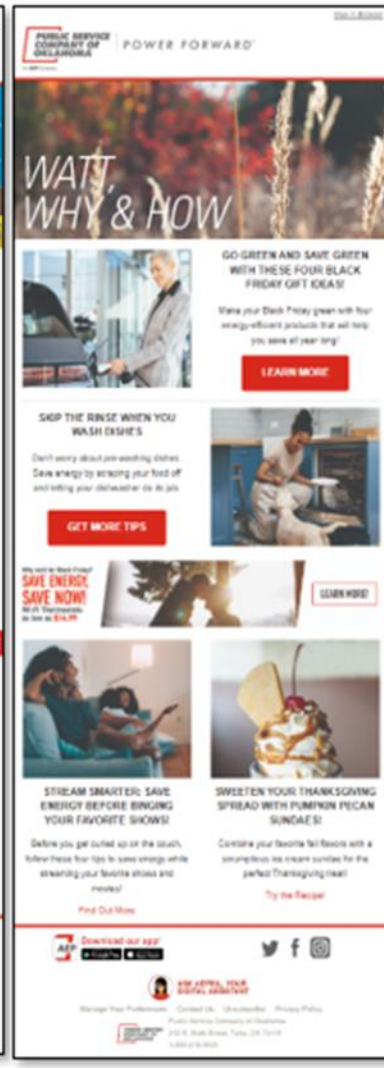
Figure F-11: Residential Monthly Newsletter



February E-Newsletter



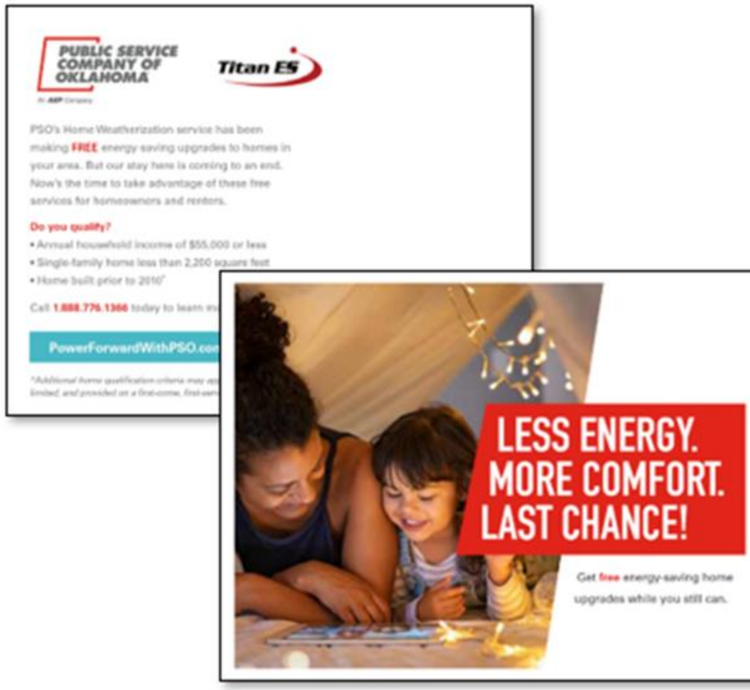
July E-Newsletter



November E-Newsletter

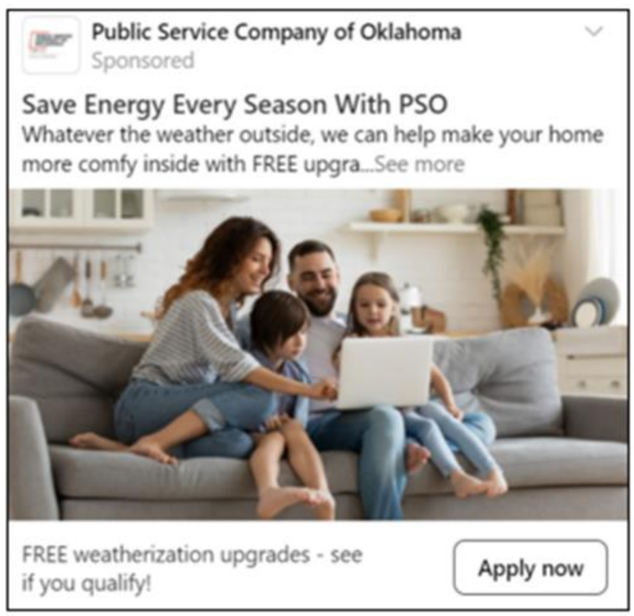
Figure F-12: Home Weatherization Creative Content

Home Weatherization
Print Ad - Spanish



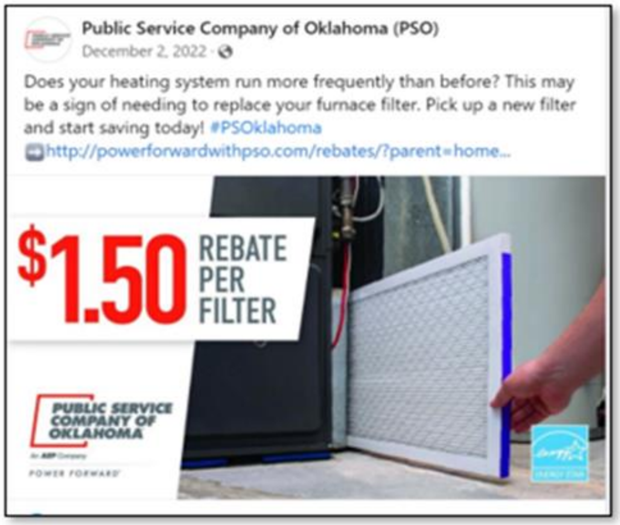
Home Weatherization Direct Mail

Home Weatherization Organic Social



Home Weatherization Paid Social - Nextdoor

Figure F-13: Home Rebates Creative Content



Home Rebates Organic Social

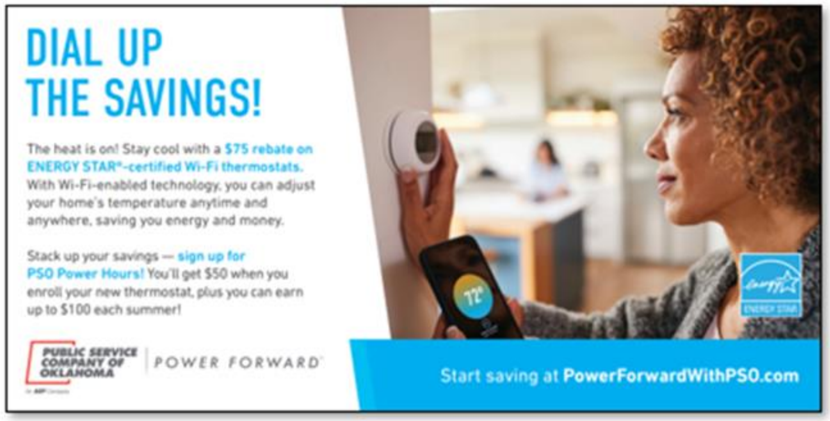
Home Rebates Print Ad – Tulsa People

Home Rebates Email - Limited Time Offer

Home Rebates Display Video - A/C Tune-Up

Figure F-14: EnergyStar® Creative Content

Email – Light the Moment



June Bill Insert

HPWH Display Ad

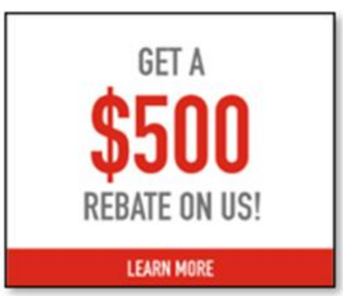


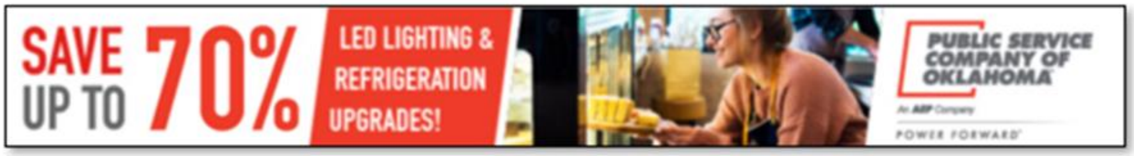
Figure F-15: Power Hours Creative Content

Power Hours Preseason Email

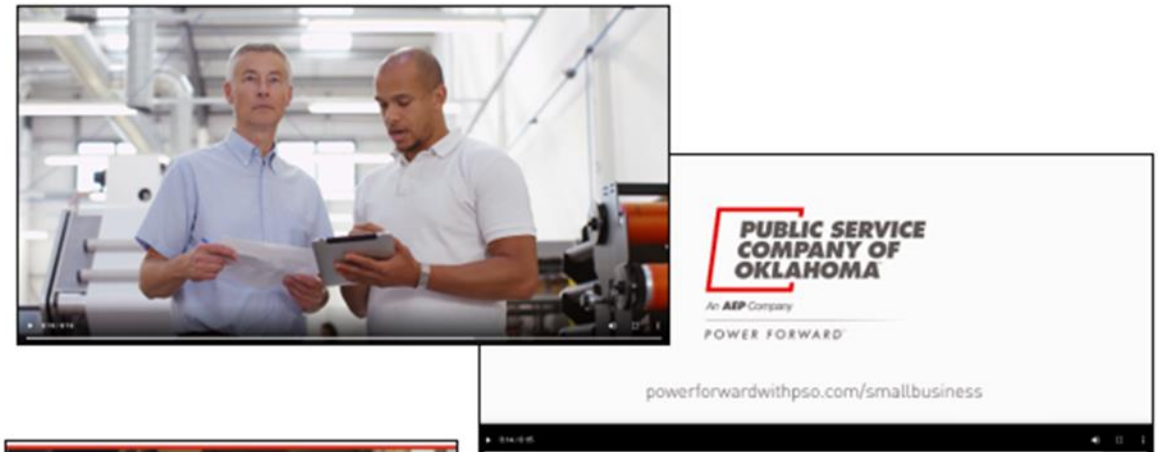
Power Hours Direct Mail

Power Hours Tri-Fold Brochure

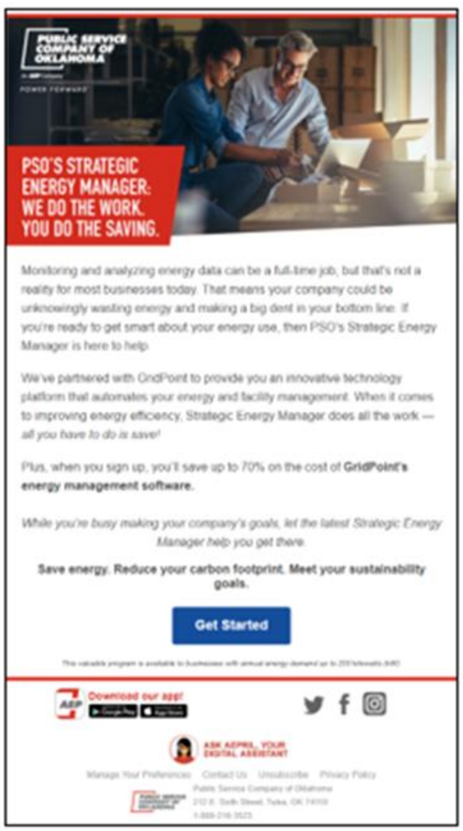
Figure F-16: Small Business Creative Content



Small Business Rebates Display Ad



Small Business OTT/CTV



Email – Strategic Energy Manager

Small Business Print Ad – Tulsa People

Figure F-17: Commercial and Industrial Creative Content

Commercial Rebates Billboard

Commercial Rebates Display Ad

Commercial Rebates Video

Figure F-18: Peak Performers Creative Content

Peak Performers Display Ad

Peak Performers Digital Video

Peak Performers Flyer Handout

F.7 Community Engagement

PSO participates in a variety of community events, including tradeshows, lighting demonstrations, program presentations, seminars and more. Local community events are used to help educate customers and bring awareness to rebates plus energy efficiency program offerings.

- 58+ service provider training events, including programs overview.
- 35+ local community events throughout the state (Grove, Lawton, Tulsa, etc.)

Broken Arrow Rooster Days

Tulsa Enviro Expo

Lawton International Festival

Tulsa Home & Garden Show

Appendix G: Energy Impacts Methodologies

This appendix presents the methodologies and algorithms used for the calculation of verified energy impacts.

G.1 Energy-Efficiency Programs

G.1.1 Business Rebates Program

ADM's approach to project level savings analysis depends on the types of measures installed. Whenever possible, deemed savings and prescribed algorithms from the Arkansas Technical Reference Manual v7.0[98] (AR TRM) will be used to determine verified gross savings. Care will be taken to assure any assumptions are reasonable and current, and that there are no errors in the algorithms. Additionally, where engineering calculations from the AR TRM are applicable to measures installed through the Business Rebates Program, those algorithms may also be used. Care will be taken to ensure that weather conditions and other factors that may vary from Arkansas to Oklahoma will be considered when applying these algorithms. The following discussion describes, in general, ADM's plan for analyzing savings from different measure types:

G.1.1.1 ADM Baseline Methodology

Lighting measures may include retrofits of existing fixtures, lamps and/or ballasts with energy efficient fixtures, lamps and/or ballasts. These types of measures reduce demand, but operating hours for fixtures are generally the same pre- and post-retrofit. Also examined are any proposed lighting control strategies that might include the addition of energy conserving control technologies, such as motion sensors or day-lighting controls. These measures typically involve a reduction in hours of operation and/or lower current passing through the fixtures. New construction lighting projects are also included in the Business Rebates Program, which requires calculating savings in comparison to applicable building codes instead of pre-retrofit conditions.

ADM analyzes the savings from lighting measures using data for new/retrofitted fixtures on (1) wattages before and after retrofit and (2) hours of operation before and after the retrofit. Fixture wattages are generally determined through M&V practices but may be taken from a table of standard wattages or cut sheets when feasible, with corrections made for non-operating fixtures. Prescriptive algorithms for calculating energy savings and demand reductions from the AR TRM or other relevant program sources will be used. Additionally, HVAC interactive effects will be accounted for using partially deemed

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

algorithms from the AR TRM dependent upon heating and cooling systems serving areas where lighting systems are installed.

G.1.1.2 Analyzing Savings from HVAC Measures

For the analysis of non-prescriptive HVAC and control measures, ADM developed estimates of the savings through simulations with energy analysis models (e.g., DOE-2, eQuest). Before making the analytical runs for each sample site with these measures, a Model Calibration Run is prepared. Calibration is based on actual billed usage during actual weather conditions. Once the analysis model has been calibrated for a particular facility, there are three steps in the procedure for calculating estimates of energy savings for HVAC measures installed or to be installed at the facility. First, an analysis of energy use was performed at a facility under the assumption that the energy efficiency measures were not installed. Second, energy use is analyzed at the facility with all conditions the same but with the energy efficiency measures now installed. Third, the results are compared of the analyses from the preceding steps to determine the energy savings attributable to the energy efficiency measure. The compared analysis runs were normalized to a typical meteorological weather year (TMY3). ADM used monitoring data to verify set points and operating characters and to calibrate the simulations, as necessary.

G.1.1.3 Analyzing Savings from Motor and VFDs

Estimates of energy savings from the use of non-prescriptive high efficiency motors or VFDs are derived through an "after-only" analysis. With this method, energy use is measured for the high efficiency motor or VFD and after it has been installed. ADM (1) makes one-time measurements of voltage, current, and power factor of the VFD/motor and (2) use ACR loggers to conduct continuous measurements of amps or watts over a period to obtain the data needed on operating schedules. The data thus collected is then used in estimating what energy use would have been for the motor application if the high efficiency motor or VFD had not been installed. ADM field staff participate in annual safety training to ensure that safety best practices are used.

G.1.1.4 Analyzing Savings from Process Improvements

Analysis of savings from process improvements (including air compressors, process machines, etc.) is inherently project specific. Because of the specificity of such processes, analyzing the processes through simulations is generally not feasible. Rather, engineering analysis of the process affected by the improvements is relied on. Major factors in the engineering analysis of process savings are operating schedules and load factors. ADM developed the information on these factors through energy management system data collection or short-term monitoring of the affected equipment, be it pumps, heaters, compressors, etc. The monitoring was done after the process change, and the data gathered on operating hours and load factors were used in the engineering analysis to define “before” conditions for the analysis of savings.

For large projects, a billing regression analysis is often the most accurate representation of consumption changes due to energy efficiency measures. ADM adheres to ASHRAE Guide 14 to ensure the results are statistically representative. In addition, ADM will interview the site contact to ensure that no other operational changes or other energy efficiency measures are impacting consumption.

G.1.1.5 Retro-commissioning and Enhanced O&M

As is the case for custom measures, the methods used to verify project gross energy impacts were dependent on the specifics of each site and the availability of data. However, the gross savings analysis for each site are more involved based on the additional data and documentation that is included in the savings calculations.

Methods include the range of International Performance Measurement & Verification Protocols, as shown in Table G-3 below. An emphasis is placed on Option D (Building simulation) for commercial facilities and Options B (pre/post monitoring) & C (Billing analysis) for industrial facilities. Often, multiple approaches are used to minimize uncertainty in the verified energy savings estimates. The preceding descriptions of typical gross savings estimation methods by measure type are used for retro-commissioning projects as well.

G.1.1.6 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 were spillover effects associated with non-rebated purchases by program participants.[99] The Custom and Prescriptive and SBES Programs utilized the same NTG methodology.

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

The second criterion was the impact of the Program timing on the decision to implement the energy efficiency measure. The AR TRM stipulates a decision-maker must have installed a measure within one year to be considered a free rider. Consistent with that stipulation, ADM determined customers were not free riders if they stated that they would

99 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.

have installed a measure in more than one year. Specifically, respondents were asked the following questions:

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

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

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

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

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

- The first factor determines if a participant states that they intend to install an energy efficiency measure without the program. Answers to a combination of several questions are used with a set of rules to determine whether a participant's behavior indicated likely free ridership.
- The second factor determines if a customer reported that a recommendation from a program representative or experience with the program was influential in the decision to install a piece of equipment or measure.
- The third factor determines if a participant in the program indicated that he or she had previously installed an energy efficiency measure like one that they installed under the program without an energy-efficiency program incentive during the last three years. A participant indicating that he or she had installed a similar measure is considered to have a likelihood of free ridership.

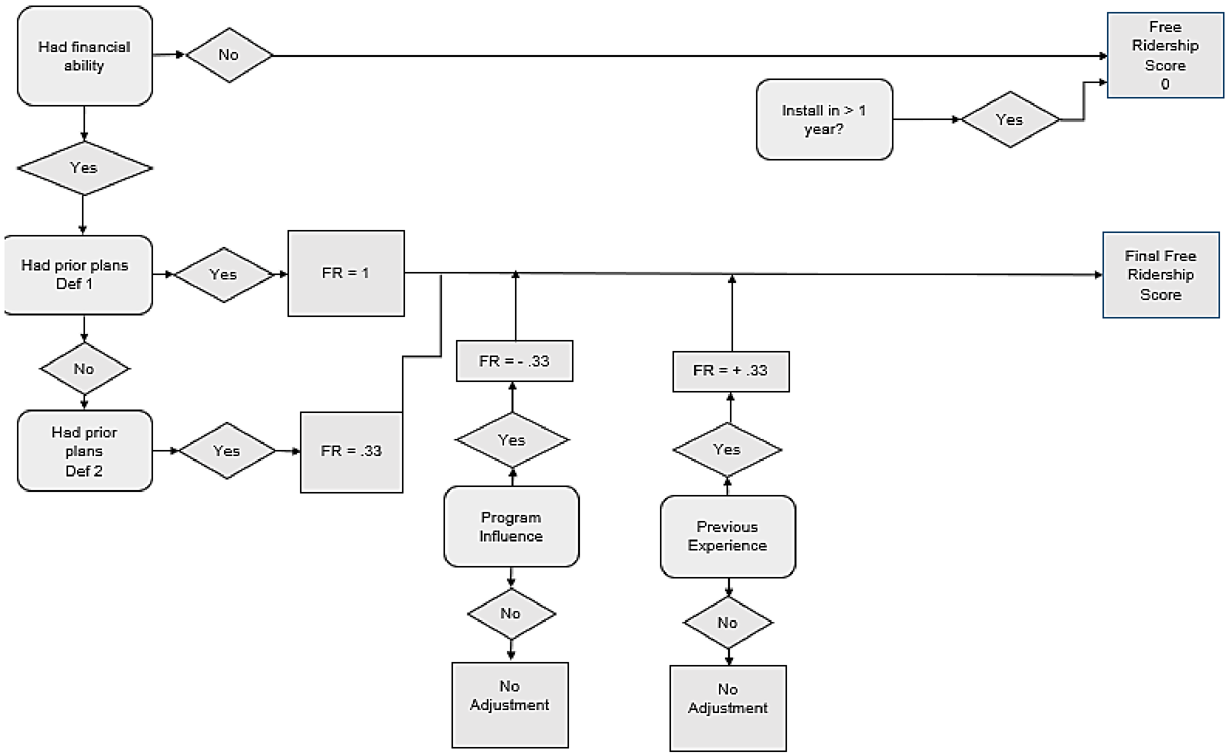
The four factors described above are used to construct four indicator variables that address free ridership behavior. For each customer, a free ridership value is assigned based on the combination of variables. With the four indicator variables, there are 12 applicable combinations for assigning free ridership scores for each respondent, depending on the combination of answers to the questions creating the indicator variables. Table G-1 shows these values.

Table G-1: Free Ridership Scores for Combinations of Indicator Variable Responses

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

Determination of free ridership from the four variables is represented as a flow chart in Table G-2.

Table G-2: Flow Chart of Free Ridership Determination



The customer decision maker survey also includes a series of questions used to analyze whether there are potential spillover effects associated with non-rebated purchases by program participants.[100] Specifically, survey respondents are asked:

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

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

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

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

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

Spillover Score = Average (SP1, SP2)

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

Table G-3: International Performance Measurement & Verification Protocols – M&V Options

M&V Option	How Savings Are Calculated
Partially Measure Retrofit Isolation	Engineering calculations using short term or continuous post-retrofit measurements and stipulations.
Retrofit Isolation	Engineering calculations using short term or continuous measurements.
Whole Facility	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.
Calibrated Simulation	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end-use metering.

G.1.2 Home Weatherization Program

This section includes the measure level algorithms and deemed savings values utilized for the verified kWh and kW savings calculations.

G.1.2.1 Infiltration Reduction

ADM utilized the AR TRM for the savings algorithms. Savings were calculated by multiplying the air infiltration reduction (CFM) with the energy savings factor corresponding to the climate zone / HVAC type. The air infiltration reduction estimate in CFM was obtained through blower door testing performed by the program contractor for each home serviced. Only homes with electric cooling systems are eligible for the measure (central AC or room AC). The algorithms for energy savings listed in the AR TRM are:

Equation G-1: Annual Energy Savings

$$kWh_{Savings} = CFM\ X\ ESF$$

Equation G-2: Peak Demand Savings

$$kW_{Savings} = CFM\ X\ DSF$$

Where:

CFM = Air infiltration reduction in Cubic Feet per Minute at 50 Pascal

ESF = The energy savings value corresponding to the climate zone and heating and cooling type in the following table

DSF = The demand savings value corresponding to the climate zone and heating and cooling type in the following table:

Table G-4: Infiltration Control Deemed Savings Values

Infiltration Control Deemed Savings				
Impact per CFM50 Reduction				
Equipment Type	kWh Savings (ESF)	kW Savings (DSF)	Therm Savings (GSF)	Peak Therms (GPSF)
Zone 9				
Electric AC with Gas Heat	0.166	0.000098	0.095	0.002529
Gas Heat Only (no AC)	0.073	NA	0.099	0.002529
Elec. AC with Resistance Heat	2.344	0.000098	NA	NA
Heat Pump	1.099	0.000098	NA	NA
Zone 8				
Electric AC with Gas Heat	0.188	0.00014	0.0825	0.002325
Gas Heat Only (no AC)	0.062	NA	0.0863	0.002325
Elec. AC with Resistance Heat	2.079	0.00014	NA	NA
Heat Pump	0.942	0.00014	NA	NA
Zone 7				
Electric AC with Gas Heat	0.19	0.00016	0.0707	0.002181
Gas Heat Only (no AC)	0.053	NA	0.0747	0.002181
Elec. AC with Resistance Heat	1.812	0.00016	NA	NA
Heat Pump	0.818	0.00016	NA	NA
Zone 6				
Electric AC with Gas Heat	0.255	0.00017	0.0604	0.001812
Gas Heat Only (no AC)	0.046	NA	0.0639	0.001812
Elec. AC with Resistance Heat	1.641	0.00017	NA	NA
Heat Pump	0.756	0.00017	NA	NA

G.1.2.2 Duct Sealing

ADM utilized the Oklahoma Deemed Savings Document (OKDSD) in conjunction with the duct leakage reduction results to calculate measure savings. ADM modified to the default SEER value used in the algorithm. The default SEER value is 13, but ADM utilized a value of 11.5 SEER because the measure is being implemented in qualified income homes which tend to be older. The 11.5 SEER value is the average of U.S. DOE minimum allowed SEER for air conditioners from 1992-2006 (10 SEER) and after January 23, 2006

(13 SEER). The algorithms for cooling and energy saving listed in the OKDSD for duct sealing are as follows:

Equation G-3: Cooling Savings

$$kWH_{savings,C} = \frac{(DL_{pre} - DL_{\boldsymbol{post}}) X\ EFLH_C\ X\ (h_{out}\rho_{out} - h_{in}\rho_{in})\ X\ 60}{1000\ X\ SEER}$$

Where:

DL_{pre} = Pre-improvement duct leakage at 25 Pa (ft3/min)

DL_{post} = Post-improvement duct leakage at 25 Pa (ft3/min)

$EFLH_c$ = Equivalent full load cooling hours, from Table G-5

h = Outdoor/Indoor seasonal specific enthalpy (Btu/lb), from Table G-6

ρ_{out} = Density of outdoor air (lb/ft3) from Table G-7

ρ_{in} = Density of conditioned air at 75°F (lb/ft3)

= 0.0756

60 = Constant to convert from minutes to hours

1,000 = Constant to convert from W to kW

SEER = Seasonal Energy Efficiency Ratio of existing system (Btu/W·hr)

= 11.5[101]

Table G-5: Equivalent Full-Load Hours for Cooling by Weather Zone for Duct Sealing

Weather Zone	$EFLH_c$
Zone 6: El Dorado, AR [11]	1,738
Zone 7: Lawton, OK [12]	1,681
Zone 8a: Oklahoma City, OK	1,436
Zone 8b: Tulsa, OK	1,486
Zone 9: Fayetteville, AR [13]	1,305

[101] Average of US DOE minimum allowed SEER for new air conditioners from 1992-2006 (10 SEER) and after January 23,2006 (13 SEER).

Table G-6: Seasonal Specific Enthalpy by Weather Zone for Duct Sealing

Weather Zone	h_{out} (BTU/lb)	h_{in} (BTU/lb)	
Zone 6: El Dorado, AR 11	40	30	
Zone 7: Lawton, OK 12	39	29	
Zone 8a: Oklahoma City, OK	39	29	
Zone 8b: Tulsa, OK	39	29	
Zone 9: Fayetteville, AR 13	39	30	

Table G-7: Outdoor Air Density by Weather Zone for Duct Sealing

Weather Zone	Temp. (°F) 16	ρout (lb/ft3)
Zone 6: El Dorado, AR	96	0.0739
Zone 7: Lawton, OK	99	0.0738
Zone 8a: Oklahoma City, OK	97	0.0739
Zone 8b: Tulsa, OK	98	0.0738
Zone 9: Fayetteville, AR	94	0.0741

The algorithms for heating (heat pump) and energy saving listed in the OKDSD for duct sealing are as follows:

Equation G-4: Heating Savings (Heat Pump)

$$kWH_{savings,C} = \frac{\left(DL_{pre} - DL_{\boldsymbol{post}}\right) X\ 60\ X\ 0.77\ X\ HDD\ X\ 24\ X\ .018}{1000\ X\ HSPF}$$

Where:

DL_{pre} = Pre-improvement duct leakage at 25 Pa (ft3/min

DL_{post} = Post-improvement duct leakage at 25 Pa (ft3/min)

60 = Constant to convert from minutes to hours

0.77 = Factor to correlated design load hours to EFLH under actual working conditions (to account for the fact that people do not always operate their heating system when the outside temperature is less than 65°F)

HDD = Heating Degree Day from Table G-8

24 = Constant to convert from days to hours

0.018 = Volumetric heat capacity of air (Btu/ft3°F)

1,000 = Constant to convert from W to kW

HSPF = Heating Seasonal Performance Factor of existing system (Btu/W·hr)

= 7.7 (default)

Table G-8: Heating Degree Days by Weather Zone for Duct Sealing

Weather Zone	HDD
Zone 6: El Dorado, AR 11	2,673
Zone 7: Lawton, OK 12	3,017
Zone 8a: Oklahoma City, OK	3,663
Zone 8b: Tulsa, OK	3,641
Zone 9: Fayetteville, AR 13	4,027

Equation G-5: Heating Savings (Electric Resistance)

$$kWH_{savings,C} = \frac{\left(DL_{pre} - DL_{\boldsymbol{post}}\right) X\ 60\ X\ 0.77\ X\ HDD\ X\ 24\ X\ .018}{3{,}412}$$

Where:

DL_{pre} = Pre-improvement duct leakage at 25 Pa (ft3/min

DL_{post} = Post-improvement duct leakage at 25 Pa (ft3/min)

60 = Constant to convert from minutes to hours

0.77 = Factor to correlated design load hours to EFLH under actual working conditions (to account for the fact that people do not always operate their heating system when the outside temperature is less than 65°F)

HDD = Heating Degree Day from Table G-8

0.018 = Volumetric heat capacity of air (Btu/ft3°F)

3,412 = Constant to convert from Btu to kWh

G.1.2.3 Ceiling Insulation

ADM utilized the AR TRM for the savings algorithms and scaled deemed savings values. Deemed savings provided in the AR TRM are based on the R-value of the baseline insulation. Savings are calculated by multiplying the applicable savings value by the square footage insulated. The savings algorithms require new insulation to meet a minimum R-value of R-38.

Table G-9: Deemed Savings for R-38 Ceiling Insulation

Ceiling Insulation R-38							
Impact per sq. ft.							
Baseline Insulation R-Value	**AC/Gas Heat kWh**	**Gas Heat (No AC) kWh**	**Gas Heat Therms**	**AC/Electric Resistance kWh**	**Heat Pump kWh**	**AC Peak Savings kW**	**Peak Gas Savings Therms**
Zone 9							
0 to 1	1.716	0.254	0.342	9.366	5.071	0.0014	0.00541
2 to 4	0.969	0.141	0.189	5.212	2.764	0.0008	0.00283
5 to 8	0.586	0.084	0.114	3.136	1.653	0.0005	0.00164
9 to 14	0.364	0.052	0.07	1.926	1.013	0.00032	0.001
15 to 22	0.172	0.025	0.034	0.931	0.486	0.00014	0.00047
Zone 8							
0 to 1	1.948	0.227	0.312	9.334	4.669	0.003	0.00539
2 to 4	1.097	0.125	0.172	5.179	2.548	0.002	0.00284
5 to 8	0.642	0.074	0.102	3.145	1.503	0.001	0.00165
9 to 14	0.402	0.044	0.063	1.933	0.933	0.001	0.00099
15 to 22	0.191	0.022	0.031	0.093	0.450	0.000	0.00048
Zone 7							
0 to 1	1.841	0.164	0.233	7.424	3.815	0.002	0.00482
2 to 4	1.027	0.091	0.129	4.117	2.112	0.001	0.00254
5 to 8	0.595	0.053	0.078	2.489	1.245	0.000	0.00149
9 to 14	0.371	0.033	0.047	1.519	0.764	0.000	0.0009
15 to 22	0.178	0.016	0.022	0.728	0.363	0.000	0.00043
Zone 6							
0 to 1	2.213	0.132	0.191	6.761	3.537	0.001	0.0044
2 to 4	1.248	0.074	0.107	3.795	1.991	0.001	0.00235
5 to 8	0.720	0.045	0.065	2.319	1.266	0.000	0.00137
9 to 14	0.448	0.028	0.039	1.427	0.787	0.000	0.00082
15 to 22	0.080	0.004	0.005	0.020	0.121	0.000	0.0004

G.1.2.4 Water Heater Jackets

For water heater jackets, a review of the tracking system showed that conservative assumptions were used to inform the use of the deemed savings. Savings values corresponding to 2” thick jackets on 40-gallon tanks were used for all sites. The deemed savings for this measure depend on 1) insulation thickness and 2) water heater tank size. The table below shows the deemed savings for water heater jackets installed on electric water heaters.

Table G-10: Deemed Savings – Electric Water Heater Jacket

Approximate Tank Size	Electric					
	Energy Savings (kWh)			Peak Savings (kW)		
	40	52	80	40	52	80
2" WHJ savings kWh	68	76	101	0.005	0.006	0.008
3" WHJ savings kWh	94	104	139	0.007	0.008	0.011

G.1.2.5 Water Heater Pipe Insulation

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

Table G-11: Deemed Savings – Electric Water Heater Pipe Insulation

Elec. Water Heater Pipe Insulation		Gas Water Heater Pipe Insulation	
Annual kWh Savings Per home	Peak kW Savings Per Home	Therm Savings Per home	Peak Therm Savings Per Home
44	0.014	4.4	0.00420

G.1.2.6 Low Flow Showerheads

This measure consists of removing existing showerheads and installing low flow showerheads in homes with electric water heating. The deemed savings are per low flow showerhead installed. The newly installed showerheads should not be easily modified to increase the flow rate for the unit to be eligible. The baseline flow rate is 2.5 gallons per minute (gpm) and the efficient showerhead is 1.5 gpm which saves 3,246 gallons of water per year and has a ratio of 0.000104 peak kW demand reduction to annual kWh savings.

ADM used AR TRM 7.0 to determine savings for four weather zones (see Table G-12).

Table G-12: Savings for Low Flow Showerheads (1.5 gpm)[102]

Weather Zone	Average water main temperature (°F)	Mixed water temperature (°F)	Gross kWh savings	Gross Peak kW Demand Savings
9	65.6	103.7	308	0.032
8	66.1	103.9	306	0.032
7	67.8	104.4	296	0.031
6	70.1	105.1	283	0.029

G.1.2.7 Faucet Aerators

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

The AR TRM 7.0 provides deemed savings for four weather zones (see Table G-13).

Table G-13: Savings for Faucet Aerators (1.5 gpm)[103]

Weather Zone	Average water main temperature (°F)	Mixed water temperature (°F)	Gross kWh savings	Gross Peak kW Demand Savings
9	65.6	102.0	35	0.004
8	66.1	102.2	34	0.004
7	67.8	102.7	33	0.003
6	70.1	103.5	32	0.003

G.1.2.8 Advanced Power Strips

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

The AR TRM provides average whole system deemed savings for home office and home entertainment systems. It is most likely that APS will be installed for home entertainment purposes; therefore, ADM will apply the following deemed savings equation that pertains to home entertainment systems using APS. These systems can typically include a

[102] AR TRM 7.0 Table 160 and Table 162.
[103] AR TRM 7.0 Table 155 and Table 157.

television, media player (DVD, Blu-Ray), gaming console (Xbox, PlayStation, Nintendo), and audio equipment. The APS deemed savings are as follows:

$$kWh = 252.2\ kWh$$

$$kW = 0.030\ kW$$

G.1.2.9 ENERGY® STAR Omni-Directional LEDs

ADM will use AR TRM 7.0 to assess savings and demand reduction for the installation of ENERGY STAR® Omni-Directional LEDs (9.5W). The AR TRM v7.0 specifies the following formula for use in calculating energy and demand impacts of ENERGY STAR® Omni-Directional LEDs measures.

Equation G-6: ENERGY® STAR Omni-Directional LED Energy Savings

$$LED\ kWh\ savings\ = \left(\frac{\Delta Watts}{1000}\right) * ISR * Hours * IEF_E$$

Where:

ΔWatts = Average delta watts for specified measure. The baseline wattage for PY2021 is 43W according to EISA 2007 Baselines. The installed LED lightbulb wattage for PY2021 is 9.5W.

ISR = In-Service Rate. The percentage of LEDs distributed that are installed within one year of purchase.

= 0.97 (Table 219 in AR TRM 7.0)

Hours = Average hours of use per year

= 365 days in year * Daily usage (hours/day) for residential lamps. ADM has reviewed all well-regarded and recent metering studies and calculated an unweighted average across HOU per lamp across all studies to reduce the possibility of bias. ADM will use a value of 2.63 hours * 365.25 days in year.

= 960.61 hours

IEFE = Interactive Effects Factor to account for cooling energy savings and heating energy penalties (Table 220 in AR TRM 7.0).

Equation G-7: ENERGY® STAR Omni-Directional LED Summer Peak Demand Savings

$$LED\ kW_{savings} = (\frac{\Delta Watts}{1000}) \times CF \times ISR \times IEF_D$$

Where:

CF = Summer peak coincidence factor for measure, 10% indoor and 0% outdoor (Table 221 in AR TRM v7.0)

IEFD = Interactive Effects Factor to account for cooling demand savings and heating demand penalties; this factor also applies to outdoor and unconditioned spaces (Table 222 in AR TRM v7.0).

Table G-14: ENERGY STAR® Omni-Directional LED – Interactive Effects Factor, Gross kWh Savings, and Peak kW Demand Reduction[104]

Heating Type	IEF_E	IEF_D	Gross kWh savings	Gross Peak kW Demand Savings
Gas Heat with AC	1.10	1.29	34	0.0042
Gas Heat with no AC	1.00	1.00	31	0.0032
Electric Resistance Heat with AC	0.83	1.29	26	0.0042
Electric Resistance Heat with no AC	0.73	1.00	23	0.0032
Heat Pump	0.96	1.29	30	0.0042
Heating/Cooling Unknown	0.97	1.25	30	0.0041

G.1.2.10 Mobile Home Air Infiltration

The prescriptive like savings were calculated using the AR TRM 7.0. The savings are typically calculated by multiplying the leakage improvement (CFM) by the deemed kWh savings. The deemed kWh savings are dependent on heating and cooling type along with the weather zone.

ADM calculated average savings per square feet (kWh/sq.ft.) to adjust savings for each mobile home while minimizing inputs needed (heat/cool type, weather zone, etc). This allows for the implementer to calculate air infiltration savings by simply gathering the homes' square footage.

The proposed air infiltration algorithms are as follows.

$$kWh = 0.416\ \frac{kWh}{sq.ft}\ x\ Homes\ sq.ft.$$

$$kW = 0.00014\ \frac{kW}{sq.ft}\ x\ Homes\ sq.ft.$$

[104] AR TRM 7.0 Table 220 and Table 222.

Where:

$$0.416 \frac{kWh}{sq.ft} = Average\ savings\ per\ sq.ft., calculated\ as\ follows;$$

$$0.416 \frac{kWh}{sq.ft.} = \frac{Average\ Air\ Infiltration\ Savings}{Average\ Home\ Sq.ft.}$$

$$0.416 \frac{kWh}{sq.ft} = \frac{544\ kWh}{1{,}307\ sq.ft.}$$

$$Homes\ sq.ft. = Square\ footage\ of\ home\ being\ serviced\ by\ non\ profit$$

G.1.3 Energy Saving Products Program

This section includes the measure level algorithms and deemed savings values utilized for the verified gross kWh and kW savings calculations. Deemed savings values and guidelines from the OKDSD were used whenever applicable.[105] When deemed savings calculations were not available in the OKDSD, ADM relied on one of the following other technical reference manuals (TRMs): AR TRM, the Illinois TRM v7.0 (IL TRM)[106], the Texas TRM v6.0 (TX TRM)[107], or the 2016 Pennsylvania TRM (PA TRM).[108]

G.1.3.1 ENERGY STAR® LEDs

ADM checked LED model numbers listed in the program tracking system against ENERGY STAR® databases (www.energystar.gov) to verify that each LED distributed during each program year was (1) ENERGY STAR® certified and (2) assigned the correct Watts per lamp.

Deemed kWh savings values for LEDs are unavailable in the OKDSD. However, the baseline wattages from the OKDSD account for Energy Independence and Security Act (EISA) requirements that took effect in 2012, 2013, and 2014. Thus, kWh savings for LEDs were calculated via Table G-14.

Peak demand savings for LEDs discounted through the program were also calculated using the algorithm from the OKDSD, shown in Table G-14.

G.1.3.2 Room Air Purifiers (RAP)

ADM checked room air purifier (RAP) model numbers listed in the program tracking system against ENERGY STAR® databases to verify that each RAP distributed through

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[105] Residential Oklahoma Deemed Savings, Installation & Efficiency Standards, *prepared by* Frontier Associates, LLC; November 27, 2013.
[106] Illinois Statewide Technical Reference Manual for Energy Efficiency, version 7.0 volume 3: Residential Measures, September 28, 2018.
[107] Texas Technical Reference Manual, version 6.0 volume 2: Residential Measures, November 7, 2018.
[108] Pennsylvania Technical Reference Manual, June 2016.

the program each year was ENERGY STAR® certified and assigned the correct capacity and efficiency ratings.

Deemed kWh savings values for RAPs are unavailable in the OKDSD; however, the IL TRM has established deemed kWh savings and peak kW demand values that were used for this analysis.[109] Thus, kWh energy savings for RAPs were calculated via Equation G-8, below.

Equation G-8: Energy Savings (Room Air Purifiers)

$$Room\ Air\ Purifier\ kWh\ savings\ = kWh_{Base} - kWh_{ESTAR}$$

Where:

kWh_{Base} = Baseline kWh consumption per year; based on Table G-15 below

kWh_{ESTAR} = ENERGY STAR® kWh consumption per year; based on Table G-15 below

Table G-15: kWh per Year Usage Based on Clear Air Delivery Rate[110]

Clean Air Delivery Rate (CADR)	CADR used in calculation	Baseline Unit Energy Consumption (kWh/year)	ENERGY STAR® Unit Energy Consumption (kWh/year)	ΔkWH
CADR 51-100	75	441	148	293
CADR 101-150	125	733	245	488
CADR 151-200	175	1,025	342	683
CADR 201-250	225	1,317	440	877
CADR Over 250	300	1,755	586	1,169

The peak demand (kW) savings for RAPs was calculated via Equation G-9, shown below:

Equation G-9: Peak Demand Savings (Room Air Purifiers)

$$Room\ Air\ Purifier\ peak\ kW\ demand = \frac{\Delta kWh}{Hours} * CF$$

Where:

ΔkWh =Gross customer annual kWh savings for the measure

$Hours$ = Average hours of use per year

= 5844[111]

[109] Calculation for kWh savings and peak kW demand are based on the Mid-Atlantic TRM version 4.0. This specifies baseline kWh/year consumption and ENERGY STAR® kWh/year consumption based on the Clean Air Delivery Rate (CADR) for ENERGY STAR® room air purifier.

[110] Reproduced after lookup table on pg. 7 of the IL TRM.

[111] Consistent with ENERGY STAR® Qualified Room Air Clean Calculator; 16 hours a day, 365.25 days a year. As stipulated in the IL TRM, see footnote 7 on pg. 7 of the TRM.

CF = Summer Peak Coincidence Factor for measure

= 0.667[112]

Table G-16: Peak kW Demand Based on Clear Air Delivery Rate

Clean Air Delivery Rate	ΔkW
CADR 51-100	0.034
CADR 101-150	0.056
CADR 151-200	0.078
CADR 201-250	0.100
CADR Over 250	0.133

G.1.3.3 Advanced Power Strips (APS)

ADM verified that each advanced power strip (APS) distributed each year was correctly assigned to the appropriate tier in the tracking system.

Energy savings (kWh) values for APS are not available in the OKDSD; however, deemed savings are described in the AR TRM. APSs are separated into two classifications: Tier 1 and Tier 2; only Tier 1 APSs are discounted through the ESP Program. Tier 1 APS are controlled by a load sensor in the strip, which disconnects power from the control outlets when the master power draw is below a certain threshold. The load sensor feature allows for a reduction of power from peripheral consumer electronics that maintain some load even when off or in the standby position. Deemed savings were calculated for Tier 1 by average complete system as the type of installation was unknown. Additionally, an ISR adjustment was applied to the deemed APS gross savings. The reason for the adjustment is that most people do not install and utilize APS correctly, particularly as an upstream measure. Therefore, ADM relied on an estimated ISR of 50%.

Table G-17: Advanced Power Strip – Deemed Savings in Residential Applications

APS Type	System Type	Peripheral Device	kW Savings	kWh Savings
Tier 1	Average	Whole System Average	0.019	167.40

G.1.3.4 Bathroom Ventilation Fans (BVF)

ADM checked bathroom ventilation fan (BVF) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each BVF distributed via the program each year was ENERGY STAR® certified.

[112] Assumes appliance use is evenly spread throughout the year. As stipulated in the IL TRM, see footnote 8 on pg. 7 of the TRM.

Since deemed energy savings (kWh) values for BVFs are unavailable in the OKDSD, ADM referred to equations provided by the IL TRM. The energy (kWh) savings for BVFs was calculated via the following formula and is set at 27.4 kWh:

Equation G-10: Energy Savings (BVF)

$$BVF\ kWhsavings = CFM\ \times \frac{\frac{1}{\eta_{Baseline}} - \frac{1}{\eta_{Efficient}}}{1000} \times\ Hours = 27.4\ kWh$$

Where:

CFM = Nominal Capacity of the exhaust fan

= 92.4[113]

$\eta_{Baseline}$ = Average efficacy for baseline fan

= 2.2[114]

$\eta_{Efficient}$ = Average efficacy for efficient fan

= 5.3[115]

$Hours$ = Assumed annual run hours for continuous ventilation

= 1,089[116]

Demand savings (kW) were calculated via the following formula, and is set at 0.0034 kW:

Equation G-11: Peak Demand Savings (Ventilation Fan)

$$BVF\ kWsavings = CFM\ \times \frac{\frac{1}{\eta_{Baseline}} - \frac{1}{\eta_{Efficient}}}{1000} \times\ CF =\ 0.0034\ \mathrm{kW}$$

Where:

CFM = Nominal Capacity of the exhaust fan

= 92.4[117]

$\eta_{Baseline}$ = Average efficacy for baseline fan

---

[113] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[114] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[115] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[116] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[117] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.

$= 2.2$[118]

$\eta_{Efficient}$ = Average efficacy for efficient

$= 5.3$[119]

CF = Summer peak coincidence factor for standard usage

$= 0.135$[120]

G.1.3.5 Water Dispensers (WD)

ADM checked water dispenser (WD) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each WD distributed via the program each year was ENERGY STAR® certified.

Deemed savings values for WDs are unavailable in the OKDSD, so the PA TRM was used. The energy savings (kWh) and demand savings (kW) were pulled from Table G-18.

Table G-18: Default Savings for ENERGY STAR® Water Dispensers[121]

Cooler Type	$kWh_{savings}$	kW_{peak}
Cold Only	47.50	0.00532
Hot & Cold Storage	481.80	0.0539
Hot & Cold On-Demand	733.65	0.0821

G.1.3.6 Weatherization Measures (WM)

ADM reviewed all tracking data, tabulating all home weatherization measures (WM) installed via the program each year. Savings from the installation of WMs were calculated based on the PA TRM's Interim Measure Protocol for WS.[122] Energy savings (kWh) and demand savings (kW) were calculated for WMs including door seals, door sweeps, and spray foam insulation using the following equations:

Equation G-12: Energy Savings (WM)

$$WM\ kWh\ savings\ = \mathrm{D}kWh_{cooling} + \mathrm{D}kWh_{heating}$$

[118] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[119] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[120] As stipulated by the IL TRM for standard usage with an unknown minimum and maximum CFM, see pg. 125 of the TRM.
[121] Reproduced after Table 2-95, pg. 165 of the PA TRM.
[122] Addendum document to the 2016 Pennsylvania TRM[105] for weather stripping, caulking, and outlet gaskets.

Equation G-13: Cooling Energy Savings (WM)

$$\mathrm{D}kWh_{cooling} = \frac{1.08 \times \mathrm{D}CFM_{50} \quad \times CDD \times 24 \times LM \times DUA}{N \times \eta_{cool} \times 1{,}000}$$

Equation G-14: Heating Energy Savings (WM)

$$DkWh_{heating} = \frac{1.08 \times DCFM_{50} \times HDD \times 24}{N \times \eta_{heat} \times 3{,}412}$$

Equation G-15: Peak Demand Savings (WM)

$$WM\ kW\ savings = \frac{\mathrm{D}kWh_{cooling} \times PCF}{1{,}000}$$

Where:

1.08 = Conversion factor between CFM air at 70°F to Btu/hr/°F

$\mathrm{D}CFM_{50}$ = Reduction in air leakage

= 100 (spray foam) or 25.5 (door sweeps and seals)[123]

24 = Days to hours conversion factor

N = Correlation factor (accounts for several variables that could influence air infiltration, such as wind shielding, climate, and building leakiness)

= 16.65[124]

CDD = Cooling degree-days per year

= 2,095 [125]

HDD = Heating degree-days per year

= 3,971[126]

η_{cool} = Cooling system efficiency

= 13[127]

[123] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-2, pg. 4 of the IMP. For spray foam, this estimate assumes just over 9 piping/plumbing/wiring penetrations per can.
[124] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.
[125] Average cooling degrees per year derived for the Tulsa International Airport (site #723560) from the National Solar Radiation Data Base, 1991-2005: Typical Meteorological Year 3. Last accessed March 2020 via https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html.
[126] Average heating degrees per year derived for the Tulsa International Airport (site #723560) from the National Solar Radiation Data Base, 1991-2005: Typical Meteorological Year 3. Last accessed March 2020 via https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/by_state_and_city.html.
[127] Assuming central air conditioning installed after 1/23/2006 – see Table 1-4 on pg. 5 of the PA TRM Weather Stripping IMP.

η_{heat} = Heating system efficiency

= 2.3[128]

DUA = Discretionary use adjustment (accounts for uncertainty in residential occupants' cooling system usage patterns)

= 0.75[129]

LM = Latent multiplier for conversion of sensible load to total (sensible and latent) load

= Total load ÷ sensible load = 8.5 ÷ 2.0 = 4.3[130]

$1{,}000$ = Conversion factor between kilowatts and watts

$3{,}412$ = Conversion factor between kilowatt hours and Btu

G.1.3.7 Room Air Conditioners (RAC)

ADM will check room air conditioner (RAC) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each RAC distributed via the program each year was ENERGY STAR® certified.

Deemed savings values for RAC are not available in the OKDSD, so the AR TRM was used. The energy savings (kWh) and peak demand savings (kW) for RAC were calculated via Equation G-16 and Equation G-17, respectively.

Equation G-16: Energy Savings (RAC)

$$RAC\ kWhsavings = CAP\ \times 1\frac{kW}{1000\ W} \times\ RAF\ \times\ EFLH_C\ \times\ (\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}})$$

Equation G-17: Peak Demand Savings (RAC)

$$RAC\ kW\ savings = CAP\ \times 1\frac{kW}{1000\ W} \times \left(\frac{1}{\eta_{base}} - \frac{1}{\eta_{post}}\right) \times CF$$

Where:

CAP = Rated equipment cooling capacity of the new unit (Btu/hr)

η_{base} = Energy efficiency rating (EER) of the baseline cooling equipment, *see* Equation G-17

[128] Assuming air-source heat pumps installed after 1/23/2006 – see Table 1-5 on pg. 5 of the PA TRM Weather Stripping IMP.
[129] As stipulated by the PA TRM Weather Stripping IMP, see Table 1-1, pg. 3 of the IMP.
[130] For Tulsa, OK; *see* Table 2 *in* Harriman III, L. G., Plager, D., and Kosar, D. (1997) Dehumidification and Cooling Loads from Ventilation Air. *ASHRAE Journal*.

η_{post}	= Energy efficiency rating (EER) of the installed cooling equipment, see Equation G-17
RAF	= Room AC adjustment factor
	= 0.49[131]
$EFLH_C$	= Equivalent full-load cooling hours, see Table G-20.
CF	= Coincidence factor
	= 0.87[132]

The η_{base} or energy efficiency rating (EER) of the baseline and η_{post} or energy efficiency rating (EER) of the installed cooling equipment is assigned based on the items listed in Equation G-17*.*

Table G-19: RAC Replacement – Baseline and Efficiency Standards133

Reverse Cycle (Yes/No)	Louvered Sides (Yes/No)	Capacity (Btu/hr)	Baseline Efficiency (CEER)	Efficiency Standard (EER)
No	Yes	< 8,000	11.0	12.1
		≥ 8,000 and < 14,000	10.9	12.0
		≥ 14,000 and < 20,000	10.7	11.8
		≥ 20,000	9.4	10.3
No	No	< 8,000	10.0	11.0
		≥ 8,000	9.6	10.6
Yes	Yes	< 20,000	9.8	10.8
		≥ 20,000	9.3	10.2
Yes	No	< 14,000	9.3	10.2
		≥ 14,000	8.7	9.6

The equivalent full-load cooling hours are based on weather zone as shown below in Table G-20. Since full-load cooling hours are reported in the OKDSD, ADM will use those locally applicable values instead of those listed in the AR TRM.

Table G-20: RAC Replacement – Equivalent Full-Load Cooling Hours

Weather Zone	$EFLH_C$
9	431
8b	490

131 As stipulated by the AR TRM, see derivation described in Table 67, pg. 75 of the TRM.
132 As stipulated by the AR TRM, see pg. 74 and footnote 80 in the TRM.
133 Reproduced after Table 65, pg. 73 of the AR TRM.

7	555
6	573

G.1.3.8 Air Filters (AF)

Deemed savings values for air filters (AF) are not available in the OKDSD, so the TX TRM was used. The energy savings (kWh) and peak demand savings (kW) for AF were calculated via Equation G-18 and Equation G-19, respectively.

Equation G-18: Energy Savings (AF)

$$AF\ kWh\ savings = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times\ EFLH_C\ \times \frac{1\ kW}{1{,}000\ W} \times FL$$

Equation G-19: Peak Demand Savings (AF)

$$AF\ kW\ savings = Capacity \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times\ DF_C\ \times \frac{1\ kW}{1{,}000\ W}$$

Where:

$\mathrm{Capacity}$ = Rated equipment cooling capacity

= for unknown models, assumed value of 3.7 tons[134]

= 44,400 Btu/hr

$\mathrm{EER_{pre}}$ = Cooling efficiency prior to tune-up (Btu/hr)

= $(1 - \mathrm{EL}) \times \mathrm{EER_{post}}$

EL = Efficiency loss due to dirty filter

= 0.05[135]

$\mathrm{EER_{post}}$ = Deemed cooling efficiency of the equipment following tune-up

= 11.2[136]

$\mathrm{EFLH_C}$ = Equivalent full load hours for cooling based on weather zone (see Table G-21*)*

$\mathrm{DF_C}$ = Cooling demand factor

= 0.87[137]

FL = Factor to account for air filter useful life

134 As stipulated by the TX TRM, pg. 2-345.
135 As stipulated by the TX TRM, pg. 2-58.
136 As stipulated by the TX TRM, pg. 2-58 and 2-60.
137 As stipulated by the TX TRM, see footnote 122 on pg. 2-61 of the TRM.

= 0.16667

Table G-21: Equivalent Full Load Hours[138]

Weather Zone	$EFLH_C$
6	1,738
7	1,681
8a	1,436
8b	1,486
9	1,305

G.1.3.9 Heat Pump Water Heaters (HPWH)

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

Deemed energy savings (kWh) values for HPWHs are not available in the OKDSD, so instead ADM has relied on the AR TRM. The variables that affect deemed savings include storage tank volume, energy factor (EF), installation location (conditioned vs. unconditioned space), and weather zone. Weather zones are based on established zones in Arkansas. Energy savings (kWh) for HPWHs were calculated via Equation G-20:

Equation G-20: Energy Savings (HPWH)

$$HPWH\ kWh\ savings = \frac{\rho \times C_p \times V \times \left(T_{SetPoint} - T_{Supply}\right) \times \left(\frac{1}{EF_{pre}} - \left(\frac{1}{\left(EF_{post} \times (1 + PA\%)\right)} \times Adj\right)\right)}{3{,}412\ Btu/kWh}$$

Where:

ρ = Water density

= 8.33

C_p = Specific heat of water (Btu/lb·°F)

= 1

V = Estimated annual hot water use (gal) (shown in Table G-23 below)

$T_{SetPoint}$ = Water heater set point

[138] Reproduced after Table 61 of the OKDSD, pg. 64.

= 120°F[139]

T_{Supply} = Average supply water temperature, determined based on storage volume and draw pattern[140] (shown in Table G-24 below)

EF_{pre} = Baseline energy factor, determined based on storage volume and draw pattern[141]

EF_{post} = Energy Factor of new HPWH

$PA\%$ = Performance adjustment to account for ambient air temperature per DOE guidance

$= 0.00008 \times T_{amb}^3 + 0.0011 \times T_{amb}^2 - 0.4833 \times T_{amb} + 0.0857$[142]

T_{amb} = Ambient temperature dependent on location of HPWH (Conditioned or Unconditioned Space) and Weather Zone.

Adj = HPWH-specific adjustment factor to account for Cooling Bonus and Heating Penalty on an annual basis, as well as backup electrical resistance heating which is estimated at 0.92 EF. Adjustment factors are listed in Table G-22 below.

Table G-22: Arkansas Weather Zone Equivalents, by County, in Oklahoma

Weather Zone	Counties Included
9	Alfalfa, Craig, Dewey, Ellis, Grant, Harper, Kay, Major, Nowata, Ottawa, Roger Mills, Rogers, Washington, Woods, Woodward
8	Adair, Beckham, Blaine, Caddo, Canadian, Cherokee, Creek, Custer, Delaware, Garfield, Kingfisher, Logan, Mayes, Noble, Oklahoma, Okmulgee, Osage, Pawnee, Payne, Tulsa, Wagoner, Washita
7	Atoka, Bryan, Cleveland, Coal, Comanche, Cotton, Garvin, Grady, Greer, Harmon, Haskell, Hughes, Jackson, Kiowa, Latimer, Le Flore, Lincoln, McClain, McCurtain, McIntosh, Murray, Muskogee, Okfuskee, Pittsburg, Pontotoc, Pottawatomie, Seminole, Sequoyah, Stephens, Tillman
6	Carter, Choctaw, Jefferson, Johnson, Love, Marshall, Pushmataha

139 As stipulated by the AR TRM, pg. 128.
140 As stipulated by look up Table 138, pg. 122-123 of the AR TRM.
141 As stipulated by look up Table 138, pg. 122-123 of the AR TRM.
142 As stipulated by the AR TRM, pg. 128.

Table G-23: Estimated Annual Hot Water Use (gal)[143]

Weather Zone	Tank Size (gal) of Replaced Water Heater			
	40	50	65	80
9 Fayetteville	18,401	20,911	25,093	30,111
8 Fort Smith	18,331	20,831	24,997	29,996
7 Little Rock	18,267	20,758	24,910	29,892
6 El Dorado	17,815	20,245	24,293	29,152

Table G-24: Average Water Main Temperature[144]

Weather Zone	Average Water Main Temperature (°F)
9 Fayetteville	65.6
8 Fort Smith	66.1
7 Little Rock	67.8
6 El Dorado	70.1

Table G-25: Water Heater Replacement Baseline Energy Factors (Calculated)

Minimum Required Energy Factors by NAECA After 4/16/2015				
Fuel Type	40	50	65	80
Natural Gas or Propane	0.62	0.6	0.75	0.74
Electric	0.95	0.95	1.98	1.97

Table G-26: Average Ambient Temperatures (T_{amb}) by Installation Location[145]

Weather Zone	Conditioned Space	Unconditioned Space
9 Fayetteville	72.2	69.1
8 Fort Smith	73.4	69.4
7 Little Rock	73.4	71.1
6 El Dorado	72.9	73.3

[143] Reproduced after Table 142, pg. 125 of the AR TRM.
[144] Reproduced after Table 143, pg. 126 of the AR TRM.
[145] Reproduced after Table 144, pg. 128 of the AR TRM.

Table G-27: Table G-5-6: HPWH Adjustment[146]

Weather Zone 9 Fayetteville					
Water Heater Location	***Furnace Type***	***40***	***50***	***65***	***80***
Conditioned Space	Gas	1.02	1.02	1.03	1.04
	Heat Pump	1.46	1.42	1.37	1.33
	Elec.Resistance	2.04	1.94	1.82	1.71
Unconditioned Space	N/A	1.06	1.06	1.06	1.06
Weather Zone 8 Fort Smith					
Water Heater Location	***Furnace Type***	***40***	***50***	***65***	***80***
Conditioned Space	Gas	1.02	1.03	1.03	1.04
	Heat Pump	1.43	1.39	1.35	1.31
	Elec.Resistance	1.95	1.86	1.75	1.66
Unconditioned Space	N/A	1.06	1.06	1.06	1.06
Weather Zone 7 Little Rock					
Water Heater Location	***Furnace Type***	***40***	***50***	***65***	***80***
Conditioned Space	Gas	0.99	1.00	1.01	1.02
	Heat Pump	1.41	1.38	1.34	1.30
	Elec.Resistance	1.96	1.87	1.76	1.66
Unconditioned Space	N/A	1.07	1.07	1.07	1.07
Weather Zone 6 El Dorado					
Water Heater Location	***Furnace Type***	***40***	***50***	***65***	***80***
Conditioned Space	Gas	0.95	0.96	0.98	0.99
	Heat Pump	1.34	1.31	1.28	1.25
	Elec.Resistance	1.84	1.76	1.66	1.58
Unconditioned Space	N/A	1.07	1.07	1.07	1.07

Demand savings (kW) for HPWH were calculated via the following formula:

Equation G-21: Peak Demand Savings (HPWH)

$$kWsavings = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$\mathrm{Ratio}_{\mathrm{Annual\ kWh}}^{\mathrm{Peak\ kW}}$ = 0.0000877[147]

[146] Reproduced after Table 145, pg. 129 of the AR TRM.
[147] As stipulated by the AR TRM, pg. 130.

G.1.3.10 Clothes Dryers (CD)

ADM checked clothes dryer (CD) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each CD distributed via the program each year was ENERGY STAR® certified and assigned the correct type of dryer type (standard or compact) and the product class.

Deemed energy savings (kWh) values for CDs are unavailable in the OKDSD, so the IL TRM was used. The kWh savings for clothes dryers (CD) were calculated via the following formula:

Equation G-22: Energy Savings (CD)

$$CD\ kWhsavings = \left(\frac{Load}{CEF_{base}} - \frac{Load}{CEF_{eff}}\right) \times N_{cycles} \times \%Electric$$

Where:

$Load$ = The average total weight of clothes per drying cycle (lbs)

= 8.45 (standard CD) or 3 (compact CD)[148]

$\mathrm{CEF_{base}}$ = Combined energy factor (CEF) of the baseline unit is based on existing federal standards energy factor and adjusted to CEF as performed in the ENERGY STAR® analysis.

Table G-28: Combined Energy Factor$_{base}$ by Product Class[149]

Product Class	CEF (lbs/kWh)
Vented Electric, Standard (≥ 4.4 ft3)	3.11
Vented Electric, Compact (120 V) (<4.4 ft3)	3.01
Vented Electric, Compact (=240 V) (<4.4 ft3)	2.73
Ventless Electric, Compact (=240 V) (<4.4 ft3)	2.13
Vented Gas	2.84

CEF_{eff} = Combined energy factor of the ENERGY STAR® unit based on ENERGY STAR® requirements. Examples are shown below, though actual values will be taken from ENERGY STAR® for each model.

[148] As stipulated by the IL TRM, see pg. 46 and footnote 115 of the TRM.
[149] Reproduced after CEF$_{base}$ look up table on pg. 46 of the IL TRM.

Table G-29: Combined Energy Factor$_{eff}$ by Product Class[9]

Product Class	CEF (lbs/kWh)
Vented Electric, Standard (≥ 4.4 ft3)	3.93
Vented Electric, Compact (120 V) (<4.4 ft3)	3.80
Vented Electric, Compact (=240 V) (<4.4 ft3)	3.45
Ventless Electric, Compact (=240 V) (<4.4 ft3)	2.68
Vented Gas	3.48

N_{cycles} = Number of dryer cycles per year

= 283[150]

$\%Electric$ = The percent of overall savings coming from electricity

= 100% (electric dryers) or 16% (gas dryers)[151]

Demand savings were calculated via the following formula:

Equation G-23: Peak Demand Savings (CD)

$$CD\ kWsavings = \frac{kWh_{savings}}{Hours} \times CF$$

Where:

$Hours$ = Annual run hours of clothes dryer

= 283[152]

CF = Summer peak coincidence factor

=0.038[153]

G.1.3.11 Clothes Washers (CW)

ADM checked clothes washer (CW) model numbers listed in the program tracking system against the ENERGY STAR® databases to verify that each CW distributed via the program each year was ENERGY STAR® certified.

Deemed savings values from the AR TRM will be used for CWs as savings values for this measure are not provided in the OKDSD. The energy savings (kWh) and demand savings (kW) will be estimated for retrofit and new construction applications based on Table G-30 Since some configurations produce 0 kWh savings, ADM computed a weighted average

150 As stipulated by the IL TRM, see pg. 46 and footnote 120 of the TRM.
151 As stipulated by the IL TRM, see pg. 47 and footnote 121 of the TRM.
152 As stipulated by the IL TRM, see pg. 47 and footnote 122 of the TRM.
153 As stipulated by the IL TRM, see pg. 47 and footnote 123 of the TRM.

savings value for clothes washers and applied that single value to all clothes washers rebated through the program.

Table G-30: ENERGY STAR® Clothes Washer – Deemed Savings in Retrofit or New Construction Applications[154]

Application	Baseline Configuration	Efficient Configuration	Water Heater Fuel Type	Dryer Fuel Type	kWh Savings	kW Savings
Retrofit	Top Loading	Top Loading	Gas	Gas	23	0.005
			Gas	Electric	192	0.045
			Electric	Gas	114	0.027
			Electric	Electric	282	0.067
	Top Loading	Front Loading	Gas	Gas	38	0.009
			Gas	Electric	198	0.047
			Electric	Gas	191	0.045
			Electric	Electric	351	0.083
	Front Loading	Front Loading	Gas	Gas	6	0.002
			Gas	Electric	93	0.022
			Electric	Gas	32	0.008
			Electric	Electric	119	0.028
	Front Loading	Top Loading	Gas	Gas	0	0.000
			Gas	Electric	87	0.021
			Electric	Gas	0	0.000
			Electric	Electric	50	0.012
New Construction	Top Loading	Top Loading	Gas	Gas	23	0.005
			Gas	Electric	192	0.045
			Electric	Gas	114	0.027
			Electric	Electric	282	0.067
	Top Loading	Front Loading	Gas	Gas	38	0.009
			Gas	Electric	198	0.047
			Electric	Gas	191	0.045
			Electric	Electric	351	0.083

[154] Reproduced after Tables 172 and 173, pg. 167 of the AR TRM with additional entries calculated via savings equations provided in the TRM.

G.1.3.12 Refrigerators (RF)

Deemed savings values from the AR TRM were used for RFs. The energy savings (kWh) for "replace-on-burnout" RFs was calculated using Equation G-24.

Equation G-24: Energy Savings for Replace-On-Burnout (RF)

$$RF_{ROB}\ kWh_{savings} = kWh_{baseline} - kWh_{ES}$$

Where:

$kWh_{baseline}$ = Federal standard baseline average energy usage, Table G-30

kWh_{ES} = ENERGY STAR® average energy usage, Table G-30

For RFs that are considered "early retirement" replacements, i.e., units that replaced working RFs, the energy (kWh) and demand (kW) savings must be calculated separately for two time periods: (1) the estimated remaining life of the equipment that is being removed, designated the remaining useful life (RUL); and (2) the remaining time in the EUL period. For the RUL, kWh savings were calculated via Equation G-25. For the remaining time in the EUL period, the annual savings were calculated as would be done for replace-on-burnout as shown above. Peak demand savings (kW) were calculated via Equation G-26.

Equation G-25: Energy Savings for RUL (RF)

$$RF\ kWhsavings_{ER} = (kWh_{manf} \times (1 + PDF)^{n}\ \times SLF) - kWh_{ES}$$

Equation G-26: Peak Demand Savings (RF)

$$RF\ kW\ savings = \frac{kWh_{savings}}{8{,}760\ hrs}\ \times\ TAF \times LSAF$$

Where:

kWh_{manf} = Annual unit energy consumption from the Association of Home Appliance Manufacturers (AHAM) refrigerator database[155]

PDF = Performance degradation factor

= 0.0125 per year[156]

n = Age of replaced refrigerator (years)

SLF = Site/Lab Factor

= 0.81[157]

TAF = Temperature adjustment factor

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155 As stipulated by the AR TRM, see pg. 179 and footnote 240 in the TRM.
156 As stipulated by the AR TRM, see pg. 179 and footnote 241 in the TRM.
157 As stipulated by the AR TRM, see pg. 179 and footnote 242 in the TRM.

= 1.188[158]

$LSAF$ = Load shape adjustment factor

= 1.074[159]

Table G-31: Example Formulas to Calculate the ENERGY STAR® Criteria for Each Refrigerator Product Category by Adjusted Volume[160]

Measure Category	Federal Standard Baseline Energy Usage (kWh/year)	ENERGY STAR® Average Energy Usage (kWh/year)
Refrigerator-only—manual defrost	6.79 × AV + 193.6	6.111 × AV + 174.24
Refrigerator-freezers—manual or partial automatic defrost	7.99 × AV + 225.0	7.191 × AV + 202.5
Refrigerator-only—automatic defrost	7.07 × AV + 201.6	6.363 × AV + 181.44
Built-in refrigerator-only—automatic defrost	8.02 × AV + 228.5	7.218 × AV + 205.65
Refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	8.85 × AV + 317.0	7.965 × AV + 285.3
Built-in refrigerator-freezers—automatic defrost with bottom-mounted freezer without an automatic icemaker	9.40 × AV + 336.9	8.46 × AV + 378.81
Refrigerator-freezers—automatic defrost with bottom-mounted freezer with an automatic icemaker without TTD ice service	8.85 × AV + 401.0	7.965 × AV + 360.9
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer without an automatic icemaker	10.22 × AV + 357.4	9.198 × AV + 321.66
Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	8.51 × AV + 381.8	7.659 × AV + 343.62
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker without TTD ice service	10.22 × AV + 441.4	9.198 × AV + 397.26
Refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	8.54 × AV + 432.8	7.686 × AV + 389.52
Built-in refrigerator-freezers—automatic defrost with side-mounted freezer with an automatic icemaker with TTD ice service	10.25 × AV + 502.6	9.225 × AV + 452.34
Refrigerator freezers—automatic defrost with top-mounted freezer without an automatic icemaker	8.07 × AV + 233.7	7.263 × AV + 210.33

158 As stipulated by the AR TRM, see pg. 180 and footnote 244 in the TRM.
159 As stipulated by the AR TRM, see pg. 180 and footnote 245 in the TRM.
160 Reproduced, in part, after Table 177 on pg. 176-177 of the AR TRM.

G.1.3.13 Electric Vehicle Chargers (EVC)

ADM reviewed all tracking data to ensure that all Level 2 electric vehicles rebated via the program each year were ENERGY STAR® certified. Since there are no established deemed savings calculations for Level 2 electric vehicle chargers in the OKDSD, ADM developed a well-researched approach to estimate energy savings (kWh) for this measure (no appreciable demand savings (kW) were recorded). For each unit rebated through the program, energy savings was calculated using Equation G-27.

Equation G-27: Energy Savings (EVC)

$$EVC\ kWh\ savings = VMT_{OK} * \ avgMPG_e * \left(\frac{1}{EER_{base}} - \frac{1}{EER_{efficient}}\right) + ES_{gain}$$

Where:

VMT_{OK} = Vehicle miles traveled per year for Oklahoma residents

= 14,382[161]

$avgMPG_e$ = Average MPG_e (kWh/100 miles) of electric vehicles currently on the market

= 32[162]

EER_{base} = Energy efficiency rating of the base technology (Level 1 EVC)

= 0.822[163]

$EER_{efficient}$ = Energy efficiency rating of the efficient technology (Level 2 EVC)

= 0.853[164]

ES_{gain} = Efficiency gain of an ENERGY STAR® certified Level 2 EVC[165]

= 56

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161 State and Urbanized Area Statistics (2018) U.S. Department of Transportation, Federal Highway Administration. *Last accessed June 2019 via:* https://www.fhwa.dot.gov/ohim/onh00/onh2p11.htm

162 Value provided by the Implementor, CLEAResult; corroborated by ADM via 2011-2017 sales data from U.S. Department of Energy: Energy Efficiency & Renewable Energy Alternative Fuels Data Center – *Last accessed July 2019 via:* www.afdc.energy.gov/data/ in addition to 2018 and partial 2019 sales data collected from Tesla Quarterly Reports and www.goodcarbadcar.net.

163 Based on results of Level 1 charger high energy (>2kWh) events occurring at temperatures > 70°F – see Table 2 *in* Forward, E., Glitman, K., and Roberts, D. *for* Vermont Energy Investment Corporation (2013) EVT NRA R&D Electric Vehicle Supply Equipment Project Report: An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency, *Efficiency Vermont*.

164 Based on results of Level 2 charger high energy (>2kWh) events occurring at temperatures > 70°F – see Table 2 *in* Forward, E., Glitman, K., and Roberts, D. *for* Vermont Energy Investment Corporation (2013) EVT NRA R&D Electric Vehicle Supply Equipment Project Report: An Assessment of Level 1 and Level 2 Electric Vehicle Charging Efficiency, *Efficiency Vermont*.

165 Environmental Protection Agency (2013) ENERGY STAR® Market and Industry Scoping Report: Electric Vehicle Supply Equipment.

G.1.3.14 Net-to-Gross (NTG) Methodology

This section presents the NTG methodology used for each delivery mechanism.

Lighting

Lighting measures were included in the LTO as well as Foodbank delivery mechanisms. Because of the difference in delivery mechanisms, two different free-ridership and net-to-gross (NTG) calculations were considered.

For LEDs distributed through local food pantries, the NTG ratio is assumed to be 100%. For the 29,712 LED packages (118,848 bulbs) distributed through local food banks, the 100% net-to-gross ratio is assumed because customers do not shop for the lighting products at these locations but rather, they are simply offered LEDs without prompting. Individuals who received LEDs through the food banks are also more likely to represent low-income customers, potentially limiting their ability or willingness to purchase high efficiency lighting products. Overall, the LEDs giveaways represent 45% of reported gross energy savings from the ESP program lighting component.

For LEDs discounted through the LTO, ADM will estimate free ridership as described in this section. Determining the net effects of the discounts requires estimating the percentage of energy savings from efficient lighting purchases that would have occurred without program intervention. For this evaluation of the LTO, ADM developed estimates of free ridership using a survey-based methodology described below.

Survey Based Methodology

The survey methodology is based on self-report surveys with a sample of customers aimed at understanding decision making for light bulb purchases. The goal of these surveys is to elicit information from which to estimate the number of bulbs that the customers would have purchased in the counterfactual scenario where LEDs were not discounted.

Survey respondents were asked a series of questions to elicit feedback regarding influences on their light bulb purchasing decisions. Each respondent was then assigned a free ridership score based on a consistent free ridership scoring algorithm. The free ridership scoring algorithm developed for the survey instruments is shown in Figure 5-3: ESP Free Ridership Scoring for LEDs

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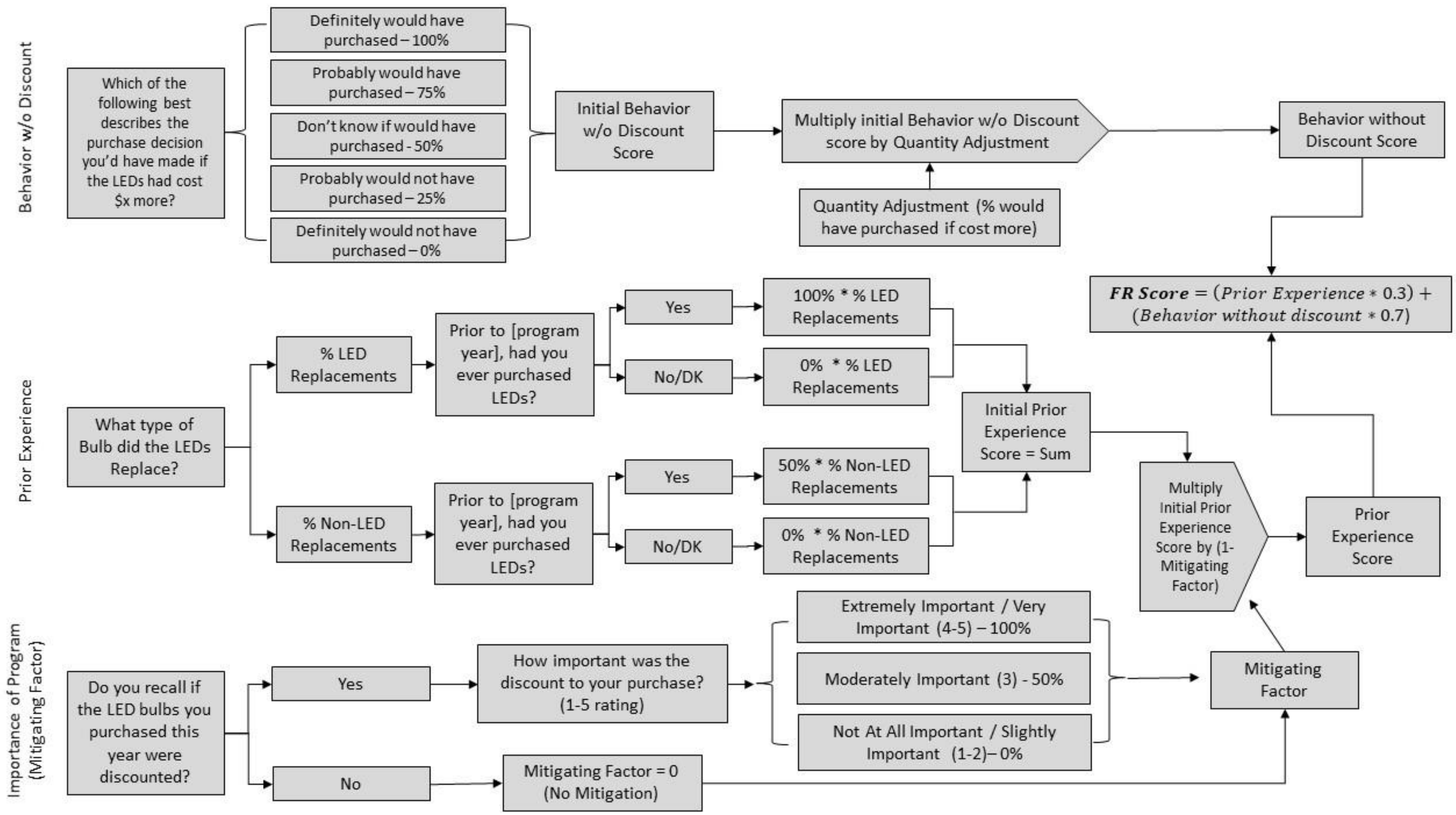
The “behavior without discount” scoring is the primary determinate of respondents’ free ridership scores. This section asked whether the respondent would have purchased the same light bulbs if they had cost the regular retail price. In the survey, each respondent was asked to state light bulb characteristics that are important to them when choosing between available options. If a respondent lists price as the most important characteristic, but then goes on to indicate that they would have still purchased efficient options at full retail price, their response will be eliminated from the data population.

Figure 5-3: ESP Free Ridership Scoring for LEDs



Spillover and Market Effects

Spillover refers to savings that occur because of program influences on customers but for which an incentive or rebate is not given. In the context of a program for LED price markdowns, the following examples illustrate potential sources of spillover:

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

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

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

It is likely that some combination of these effects increases the savings attributable to the ESP lighting portion of the program. However, there is also reason to believe these effects may be small overall.

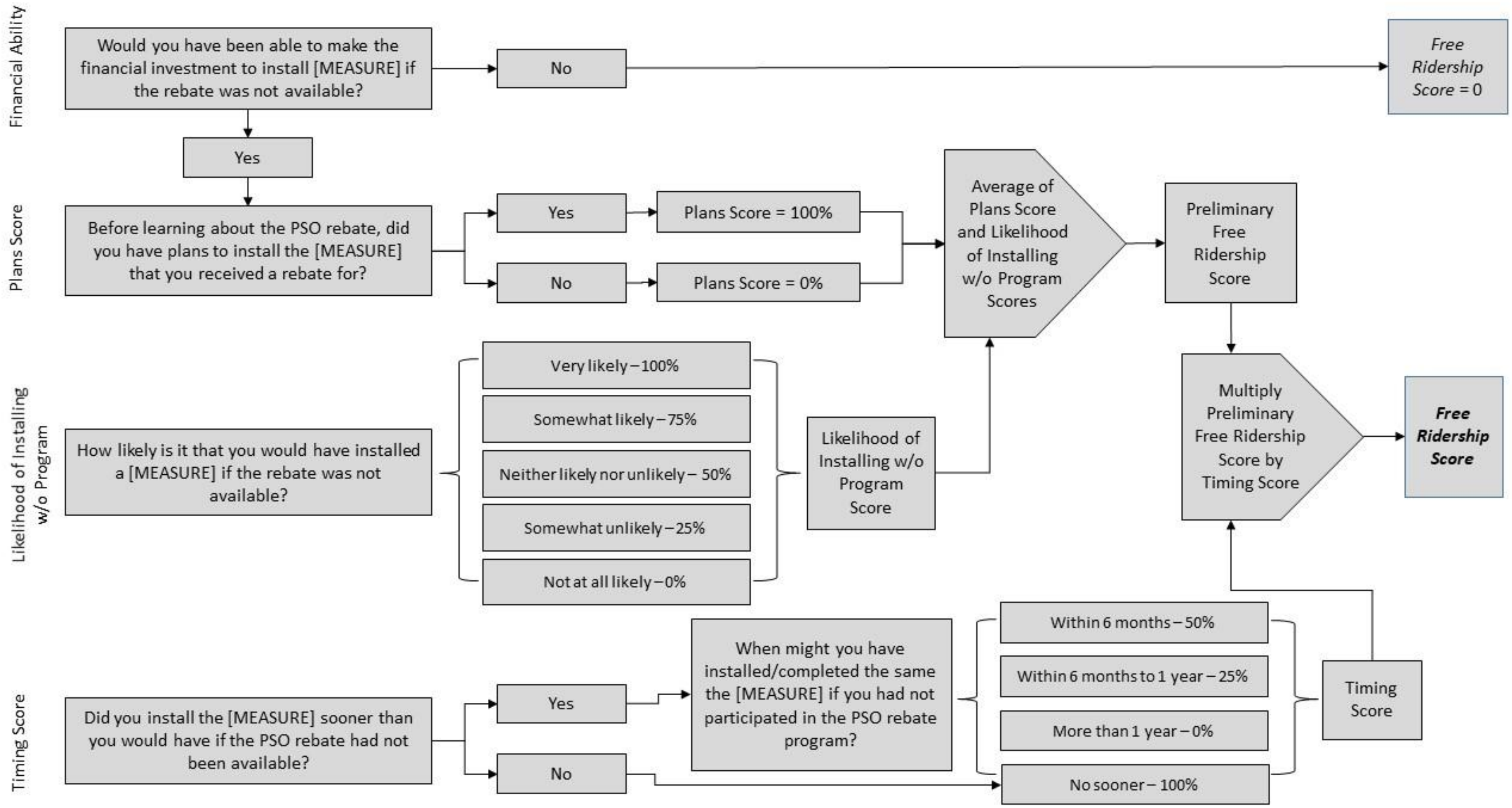
Non-Lighting Measures

Non-lighting measures were offered through the program delivery mechanisms of retail discounts (upstream), rebates for purchases (downstream), and the online LTO.

Non-Lighting LTO NTG

NTG ratios were determined based on participant data gathered from the PY2022 LTO participant survey. All surveys administered by ADM contained questions aimed at assessing the decision-making processes of PSO customers participating in the program. The goal of these survey questions was to elicit information that could be used to estimate the number of customers that would have purchased the more efficient measure in the counterfactual scenario (i.e., where the energy efficient measure was not discounted). A series of questions on participants' financial ability to implement the measure without program incentives, plans to purchase the measure before learning of the program discount or rebate, the likelihood of purchasing the measure in the absence of the program, and the impact of the program on the timing of the purchase were asked. These questions were used to calculate free ridership following the logic shown in Figure 5-4.

Figure 5-4: ESP Free Ridership Scoring for LTO non-LEDs



Non-Lighting Upstream NTG

Retail discounts were provided for advanced power strips, air filters, bathroom ventilation fans, door seals and sweeps, room air conditioners, room air purifiers, spray foam, and water dispensers. Based on prior experience, the ability to capture sufficient purchase information from PSO participants through a general population survey for these measures is not feasible. For this reason, the NTG ratios provided to PSO in their portfolio plan was used for the evaluation.

Non-Lighting Downstream NTG

For rebated downstream measures (clothes dryers, clothes washers, level 2 electric vehicle chargers, heat pump water heaters, and Wi-Fi thermostats) ADM determined free ridership based on responses gathered from participant survey data. The participant survey collected information on participants' financial ability to purchase the measure without program incentives, plans to purchase the measure before learning of the program rebate, the likelihood of purchasing the measure in the absence of the program, and the impact of the program on the timing of their purchase. A flow diagram of the NTG calculation can be seen in Figure 5-5.

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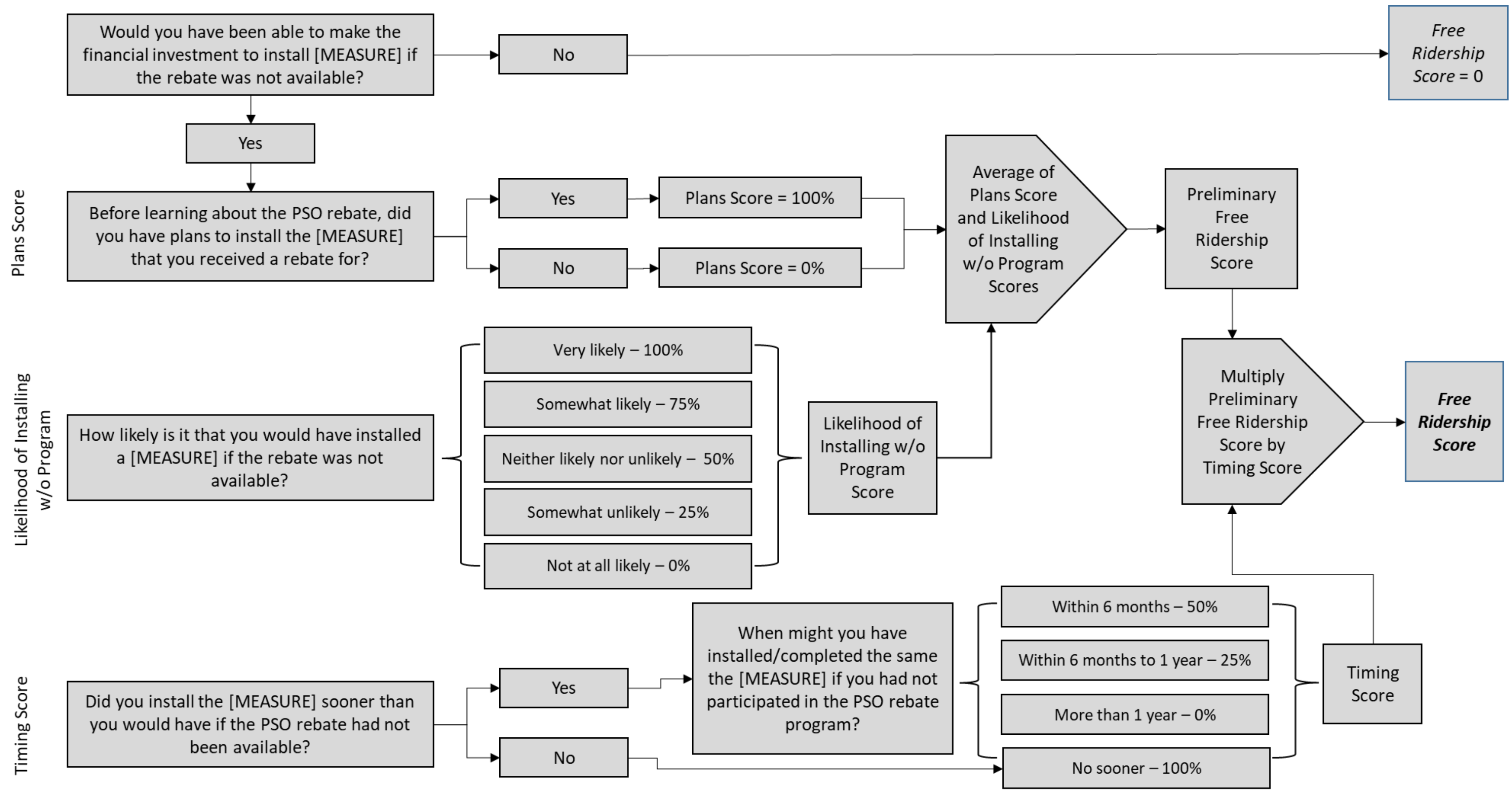
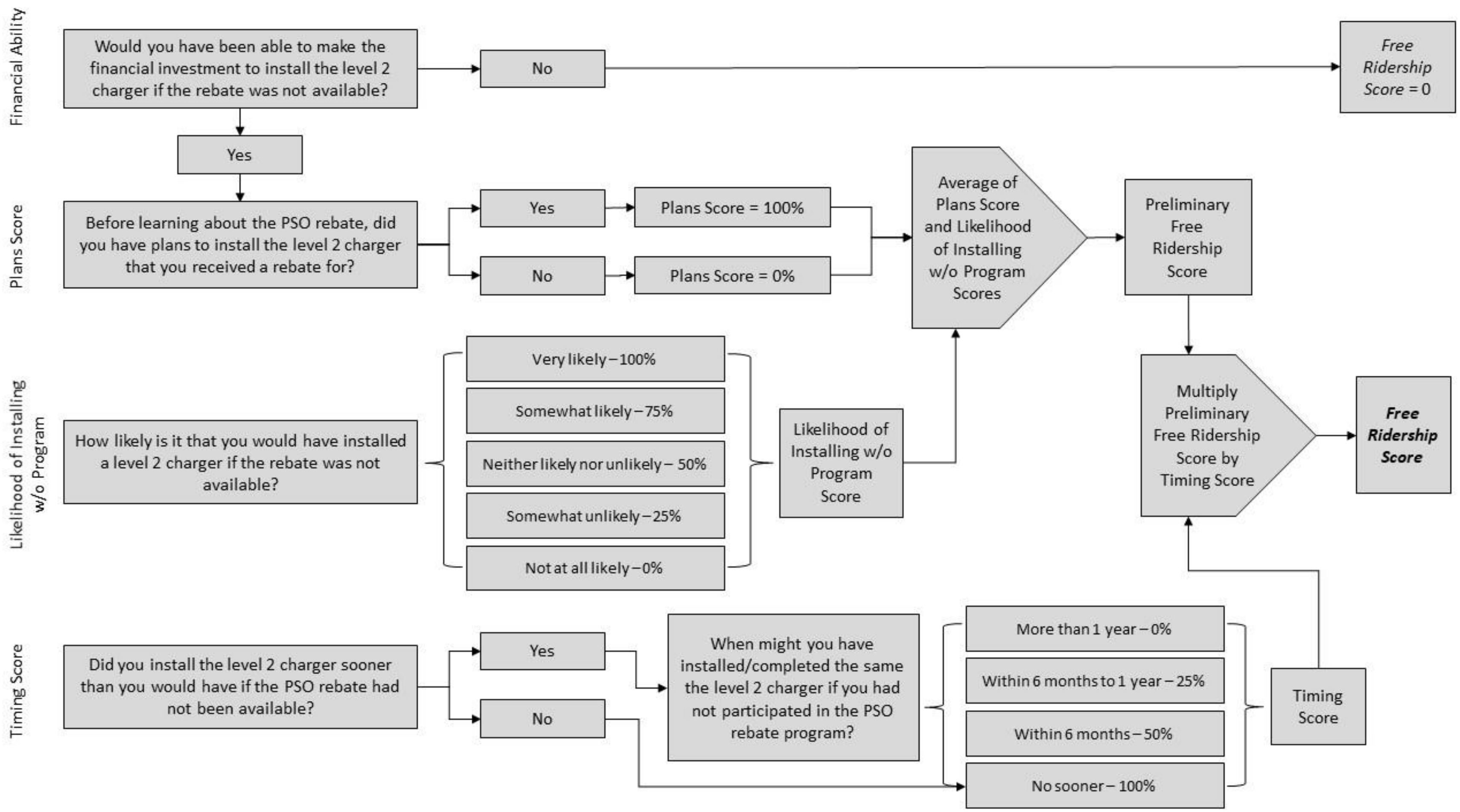
Figure 5-5: Free Ridership Scoring for Downstream non-LEDs



Given the relative novelty of a downstream rebate offering for level 2 electric vehicle charges (EVCs), ADM developed a self-report survey aimed at assessing the decision-making processes of electric vehicle owners participating in the program. The goal of these surveys was to elicit information from which to estimate the number of customers that would have upgraded from a level 1 EVC to a level 2 EVC in the counterfactual scenario (i.e. where the level 2 charger was not discounted). A series of questions on participant financial ability to implement the measure without program incentives, plans to implement the project before learning of the program rebate, the likelihood of implementing the measure in the absence of the program, and the impact of the program on the timing of the project will be asked. These questions will be used to calculate free ridership following the logic shown in Figure 5-6.

Figure 5-6: Free Ridership Scoring for Level 2 Electric Vehicle Chargers Based on Survey Responses



Since there were not enough survey responses in 2022 for the remaining measures, ADM aggregated survey responses from PY2020, PY2021, and PY2022 to determine measure-level free ridership scores.

G.1.4 Home Rebates Program – Single Upgrade and Multiple Upgrades Components

This section includes the measure level algorithms and deemed savings values utilized for the verified gross kWh and kW savings calculations.

G.1.4.1 Air Infiltration Reduction

The AR TRM 7.0 was utilized to calculate energy and demand impacts of air sealing measures. Savings were calculated by multiplying the air infiltration reduction (CFM), with the energy savings factor corresponding to the climate zone and HVAC type. The air infiltration reduction estimate in cubic feet per minute (CFM at 50 Pascal) was obtained through blower door testing performed by the program contractor for each home serviced. ADM utilized the AR TRM for the savings algorithms and deemed savings values shown in Section G.1.2.1 (Equation G-1 and Equation G-2).

G.1.4.2 Duct Sealing and Duct Replacement

All savings for duct replacement projects were captured in the corresponding duct sealing savings. This measure involves replacing/sealing leaks in ducts of the distribution system of homes with either a central AC or a ducted heating system. The post-installation duct leakage is measured by the contractor. Savings were estimated by updating the inputs to the savings algorithm listed in the AR TRM 7.0 for duct sealing, with full load hours and the coincidence factor (CF) value from the OKDSD. Deemed savings factors were based on the location of the ducts (attic or crawlspace). Savings were calculated by multiplying the duct leakage reduction results with the outdoor/indoor seasonal specific enthalpy (OKDSD) corresponding to the climate zone and HVAC type and are divided by the HVAC unit efficiency. The algorithms for cooling and energy saving listed in the OKDSD for duct sealing can be found in Section G.1.2.2 (Equation G-3, Equation G-4, and Equation G-5).

G.1.4.3 Ceiling/Attic Insulation

Savings were estimated by updating the savings algorithm inputs listed in the AR TRM 7.0 for attic insulation and are based on the R-value of the baseline insulation. The savings factor was climate zone specific, determined by the pre-insulation thickness R-value compared to the post-installation thickness R-value. The savings algorithms require new insulation to meet a minimum R-value of R-38. Savings were scaled for installed thickness between the table values of R-38 and R-49. As the AR TRM 7.0 energy and demand savings factors are based on multiple starting insulation R-values, and just two final insulation R-values, an interpolation was completed for those values between R-38 and R-49. Savings were calculated by multiplying the applicable savings value (based on the pre- and post-insulation thickness R-value) by the square footage insulated.

Table G-32: Deemed Savings for R-38 Ceiling Insulation

Climate Zone	Baseline Insulation R-Value	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	1 or less	1.716	0.254	9.366	5.071	0.0014
	>1 and <=5	0.969	0.141	5.212	2.764	0.0008
	>5 and <=8	0.586	0.084	3.136	1.653	0.0005
	>8 and <=15	0.364	0.052	1.926	1.013	0.00032
	>15 and 22	0.172	0.025	0.931	0.486	0.00014
8	1 or less	1.8642	0.2203	8.734	4.572	0.00107
	>1 and <=5	1.0497	0.1215	4.846	2.495	0.00061
	>5 and <=8	0.6330	0.0728	2.909	1.495	0.00038
	>8 and <=15	0.3909	0.0446	1.784	0.917	0.00025
	>15 and 22	0.1847	0.0216	0.858	0.439	0.00011
7	1 or less	1.8820	0.1933	7.936	4.067	0.00201
	>1 and <=5	1.0505	0.107	4.401	2.252	0.00118
	>5 and <=8	0.6315	0.0643	2.643	1.355	0.00073
	>8 and <=15	0.3901	0.0394	1.624	0.834	0.00047
	>15 and 22	0.1854	0.019	0.781	0.4	0.00022
6	1 or less	2.1230	0.1703	7.482	3.873	0.00203
	>1 and <=5	1.1967	0.0954	4.2	2.18	0.00118
	>5 and <=8	0.7242	0.0578	2.545	1.324	0.00073
	>8 and <=15	0.4497	0.0356	1.574	0.82	0.00047
	>15 and 22	0.2116	0.0172	0.753	0.391	0.00021

Table G-33: Deemed Savings for R-49 Ceiling Insulation

Climate Zone	Baseline Insulation R-Value	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	1 or less	1.756	0.260	9.578	5.1820	0.00143
	>1 and <=5	1.009	0.146	5.424	2.8760	0.00084
	>5 and <=8	0.626	0.090	3.348	1.7640	0.00053
	>8 and <=15	0.404	0.057	2.139	1.1240	0.00036
	>15 and 22	0.212	0.031	1.143	0.0597	0.00018
8	1 or less	1.907	0.225	8.931	4.673	0.00109
	>1 and <=5	1.093	0.126	5.043	2.596	0.00064

Climate Zone	Baseline Insulation R-Value	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
	>5 and <=8	0.676	0.077	3.105	1.596	0.00040
	>8 and <=15	0.434	0.049	1.981	1.018	0.00027
	>15 and 22	0.228	0.026	1.055	0.539	0.00013
7	1 or less	1.925	0.198	8.115	4.159	0.00207
	>1 and <=5	1.093	0.111	4.581	2.344	0.00124
	>5 and <=8	0.674	0.069	2.822	1.447	0.00079
	>8 and <=15	0.433	0.044	1.803	0.926	0.00053
	>15 and 22	0.228	0.023	0.96	0.492	0.00027
6	1 or less	2.173	0.174	7.657	3.964	0.00208
	>1 and <=5	1.247	0.099	4.375	2.271	0.00123
	>5 and <=8	0.774	0.061	2.719	1.415	0.00078
	>8 and <=15	0.500	0.039	1.748	0.911	0.00053
	>15 and 22	0.262	0.021	0.928	0.482	0.00027

G.1.4.4 Floor Insulation

Savings were estimated by updating the savings algorithm inputs listed in the OKDSD for floor insulation, along with project-specific data, installed square feet, and insulation R-value. The OKDSD prototype home model considered cell foam insulation for the measure, which is the product used for the insulation rebate. The cell foam insulation provides both sensible and latent cooling season savings. The same algorithm as knee wall insulation was used, with the savings factor from the OKDSD. The savings factor was climate zone specific, and HVAC equipment specific, then factored by the installed area. The deemed savings values are outlined in the following table:

Table G-34: Deemed Savings Values for Floor Insulation

Climate Zone	HVAC Type	kWh savings/SF	kW savings/SF
9	Electric AC with Gas Heat	0.265	0.0001
	Electric AC with Electric Resistance Heat	3.231	0.0001
	Heat Pump	1.981	0.0001
8A	Electric AC with Gas Heat	0.274	0.0001
	Electric AC with Electric Resistance Heat	3.897	0.0001
	Heat Pump	2.257	0.0001
8B	Electric AC with Gas Heat	0.390	0.0001
	Electric AC with Electric Resistance Heat	3.712	0.0001

Climate Zone	HVAC Type	kWh savings/SF	kW savings/SF
	Heat Pump	2.208	0.0001
7	Electric AC with Gas Heat	0.309	0.0001
	Electric AC with Electric Resistance Heat	2.944	0.0001
	Heat Pump	1.713	0.0001
6	Electric AC with Gas Heat	0.358	0
	Electric AC with Electric Resistance Heat	2.520	0
	Heat Pump	1.440	0

G.1.4.5 Wall Insulation

Savings were estimated by updating the savings algorithm inputs listed in the AR TRM 7.0 for wall insulation. The savings algorithm requires new insulation to meet a minimum R-value of R-13. Deemed savings provided in the AR TRM 7.0 are based on the heating and cooling system type of the home and the R-value of the insulation installed. Savings were calculated by multiplying the corresponding savings value by the insulated square footage. The deemed savings values are outlined in the following table:

Table G-35: Deemed Savings Values for Wall Insulation

Climate Zone	Equipment	Savings kWh/SF		Peak Demand Savings kW/SF	
		R-13	R-23	R-13	R-23
9	Electric AC with Gas Heat	0.527	0.563	0.00041	0.00048
	Gas Heat Only (no AC)	0.206	0.226	NA	NA
	Elec. AC with Resistance Heat	6.644	7.324	0.00041	0.00048
	Heat Pump	3.424	3.447	0.00041	0.00048
8	Electric AC with Gas Heat	0.586	0.625	0.00027	0.00029
	Gas Heat Only (no AC)	0.179	0.197	NA	NA
	Elec. AC with Resistance Heat	60.59	6.689	0.00027	0.00029
	Heat Pump	2.946	2.980	0.00023	0.00025
7	Electric AC with Gas Heat	0.570	0.607	0.00047	0.00071
	Gas Heat Only (no AC)	0.156	0.173	NA	NA
	Elec. AC with Resistance Heat	5.315	5.900	0.00047	0.00072
	Heat Pump	2.479	2.592	0.00047	0.00061
6	Electric AC with Gas Heat	0.712	0.751	0.00046	0.00084
	Gas Heat Only (no AC)	0.134	0.151	NA	NA
	Elec. AC with Resistance Heat	4.798	5.389	0.00046	0.00084
	Heat Pump	2.223	2.388	0.00046	0.00071

G.1.4.6 Knee Wall Insulation

Savings were estimated by updating the savings algorithm inputs listed in the AR TRM 7.0 for knee wall insulation. The savings factor was dependent upon climate zone and HVAC equipment type. Additionally, deemed savings are driven by the heating and cooling system type of the home and the post-installation R-value. The TRM table was modeled for a home starting at zero insulation going to a R-19 or R-30 value. The savings estimated considered the initial insulation R-value and adjusted the savings value. The program tracking data indicated an open cell or closed cell foam applied to attic vertical walls. The final R-value was interpolated for the R-values between R-19 and R-30 and all the projects reached a minimum R-value of R-19. Savings were calculated by multiplying the applicable savings value (based on the pre- and post-insulation thickness R-value) by the square footage insulated. The deemed savings values are outlined in the following table:

Table G-36: Deemed Savings Value for Knee Wall Insulation

Climate Zone	Insulation Level Installed	AC/Gas Heat kWh/SF	Gas Heat (No AC) kWh/SF	AC/Electric Resistance kWh/SF	Heat Pump kWh/SF	AC Peak Savings kW/SF
9	R-19	1.104	0.131	5.073465	2.682	0.00079
	R-30	1.166	0.139	5.372651	2.839	0.00083
8	R-19	1.219	0.114	4.804000	2.489	0.00090
	R-30	1.289	0.121	5.086000	2.634	0.00094
7	R-19	1.230	0.100	4.405000	2.298	0.00090
	R-30	1.300	0.106	4.662000	2.430	0.00095
6	R-19	1.389	0.089	4.215000	2.255	0.00091
	R-30	1.468	0.094	4.461000	2.384	0.00096

G.1.4.7 Central Air Conditioner, Air Source Heat Pump, and Ductless Mini-Split Heat Pump Retrofits

Savings were estimated by updating the savings algorithm inputs in the OKDSD blended with the Federal Minimum Efficiency Requirements.[166]. Savings calculations considered right-sizing savings up to a 1-ton difference and are based on the size/efficiency of each unit. ADM utilized the following OKDSD for the savings algorithms:

Equation G-28: Annual Energy Savings – Cooling

$$kWh_{\boldsymbol{savings,Clg}} = \left(Cap_{base}\ X\ \frac{1}{SEER_{Base}} - CAP_{AC}\ X\ \frac{1}{SEER_{post,AC}}\right) X\ \frac{1\ kW}{1{,}000\ W}\ X\ EFLH_C$$

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

Equation G-29: Annual Energy Savings – Heating

$$kWh_{\boldsymbol{savings,Htg}} = \left(Cap_{base}\,X\,\frac{1}{HSPF_{Base}} - CAP_{AC}\,X\,\frac{1}{HSPF_{HP}}\right)X\,\frac{1\,kW}{1{,}000\,W}\,X\,EFLH_{H}$$

Equation G-30: Peak Demand Reduction

$$kW_{\boldsymbol{savings}} = \left(Cap_{base}\,X\,\frac{1}{EER_{Base}} - CAP_{AC}\,X\,\frac{1}{EER_{post,AC/HP}}\right)X\,\frac{1\,kW}{1{,}000\,W}\,X\,CF$$

Where:

Cap_{base} = Rated equipment cooling capacity of the existing unit (BTU/hr)

$Cap_{AC/HP}$ = Rated equipment cooling/heating capacity of the new unit (BTU/hr)[167]

$SEER_{Base}$ = Season Energy Efficiency Ratio of existing cooling equipment

$SEER_{post}$ = Season Energy Efficiency Ratio of installed cooling equipment

EER_{Base} = Energy Efficiency Ratio of the existing equipment

EER_{post} = Energy Efficiency Ratio of the installed equipment

$EFLH_{C}$ = Equivalent full load hours for cooling

$EFLH_{H}$ = Equivalent full load hours for heating

$HSPF_{Base}$ = Heating Seasonal Performance Factor for existing heating equipment

$HSPF_{post,}$ = Heating Seasonal Performance Factor for installed heating equipment

CF = Coincidence Factor

= 0.87 (default)

G.1.4.8 Ground Source Heat Pumps

Savings were estimated by updating the savings algorithm inputs in the OKDSD blended with the Federal Minimum Efficiency Requirements.[168.]

Equation G-31: Annual Energy Savings (Ground Source Heat Pump)

$$kWh_{\boldsymbol{savings,Clg}} = Cap\,X\,\frac{1\,kW}{1{,}000\,W}\,X\,EFLH_{C}\,X\,\left(\frac{1}{EER_{Base}} - \frac{1}{EER_{GSHP}}\right)$$

$$kWh_{\boldsymbol{savings,Htg}} = Cap\,X\,\frac{1\,kW}{3{,}412\,Btu}\,X\,EFLH_{H}\,X\,\left(\frac{1}{COP_{Base}} - \frac{1}{COP_{GSHP}}\right)$$

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[167] Rated capacity of the new unit shall not exceed capacity of the existing unit; if completing this with other measures, use existing unit capacity.

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

Equation G-32: Peak Demand Reduction (Ground Source Heat Pump)

$$kW_{\boldsymbol{savings}} = CAP\ X\ \frac{1\ kW}{1{,}000\ W}\ X \left(\frac{1}{EER_{Base}} - \frac{1}{EER_{post,AC/HP}}\right) X\ CF$$

Where:

CAP = Rated equipment cooling capacity of the new unit (Btu/hr)

$EFLH_C$ = Equivalent full load hours for cooling

$EFLH_H$ = Equivalent full load hours for heating

EER_{base} = Energy Efficiency Ration of the baseline cooling equipment

EER_{GSHP} = Energy Efficiency Ration of the installed GSHP

COP_{Base} = Coefficient of Performance for the baseline heating equipment

COP_{GSHP} = Coefficient of Performance of the GSHP

CF = Coincidence Factor

= 0.87

G.1.4.9 ENERGY STAR® Pool Pumps

Savings were estimated using the deemed savings method in the OKDSD. The savings algorithms inputs are dependent upon the horsepower of the motor, and the seasonal usage (summer or year-round). ADM applied the deemed savings table values from the OKDSD but used the same annual operating days as the tracking data algorithm. The deemed savings values are outlined in the following table:

Table G-37: Deemed Savings for VSD Pumps

Annual Operation	Horsepower (HP)	kWh Savings	kW Savings
Summer only	<1.0 HP	576	0.130
	≥1.0 HP and ≤2.0 HP	1,428	0.395
	>2.0 HP	1,829	0.474
Year round	<1.0 HP	1,256	0.130
	≥1.0 HP and ≤2.0 HP	3,116	0.395
	>2.0 HP	3,991	0.474

G.1.4.10 HVAC Tune-Ups

ADM used Method 2[169] from the AR TRM v7 algorithm and is a change in efficiency based on pre- and post- measurement of the system. This measure involves tuning up existing HVAC units and deemed savings factors were based on the pre- and post-EER of the HVAC unit. For each unit rebated through the program, energy savings and peak demand reduction were calculated using Equation G-33 and Equation G-34.

Equation G-33: Annual Energy Savings (HVAC Tune-Up)

$$\mathrm{kWh}_{savings,c} = \mathrm{CAP}_c \times \frac{1\ \mathrm{kW}}{1{,}000\ W} \times \mathrm{EFLH}_c \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right)$$

$$\mathrm{kWh}_{savings,H} = \mathrm{CAP}_H \times \frac{1\ \mathrm{kW}}{1{,}000\ W} \times \mathrm{EFLH}_H \times \left(\frac{1}{HSPF_{pre}} - \frac{1}{HSPF_{post}}\right)$$

$$\mathrm{kWh}_{savings,HP} = \mathrm{kWh}_{savings,C} + \mathrm{kWh}_{savings,H}$$

Where:

CAP_C = Rated or calculated equipment cooling capacity (Btu/hr)

CAP_H = Rated or calculated equipment heating capacity (Btu/hr)

EER_{pre} = Calculated or measured efficiency of the equipment for cooling before tune-up

EER_{post} = Measured or calculated efficiency of the existing equipment for cooling; if unknown, use 11.2 EER (default)

$\mathrm{HSPF}_{\mathrm{pre}}$ = Calculated or measured efficiency of the equipment for heating before tune-up

[169] Calculation of savings based on pre or pre and post measurement of system efficiency, and age of equipment.

$\mathrm{HSPF_{post}}$ = Measured or calculated efficiency of the existing equipment for heating; if unknown, use 7.7 HSPF (default)

$EFLH_C$ = Equivalent full-load cooling hours

$EFLH_H$ = Equivalent full-load heating hours

Equation G-34: Peak Demand Reduction (HVAC Tune-Up)

$$\mathrm{kW}_{savings,} = \mathrm{CAP}_c \times \frac{1\ \mathrm{kW}}{1{,}000\ W} \times \left(\frac{1}{EER_{pre}} - \frac{1}{EER_{post}}\right) \times \mathrm{CF}$$

Where:

CF = Coincidence Factor

= 0.87 (default)

Other variables as defined above.

G.1.4.11 WiFi Thermostats

Savings for Wi-Fi thermostats (referred to as “Smart Thermostats” in the ARM TRM) were estimated using deemed inputs found in the ARM TRM 8.1 with baseline equipment and heating/cooling information as reported in the program tracking data. Savings were calculated by multiplying the applicable savings value by the square footage of the conditioned space.

G.1.4.12 Drop-Off Energy Kits

Drop-off Energy Kits contained 9W LED lightbulbs, LED nightlights, and filter tone furnace filter alarms. Savings for the premium 9W LED bulb were estimated using algorithms found in the ARM TRM 7.0. A modification to the hours of use per year (960.61 HOU per year) was utilized by ADM. Modification of the hours of use was sourced from a lighting benchmarking study performed in 2016 by ADM and found daily hours of use of 2.63 blended hours for indoor/outdoor applications, or 960.61 hours per year.[170] The algorithm used to determine savings for FilterTone® Alarms is based on the Pennsylvania Technical Reference Manual (PA TRM). The source for the equivalent full load hours (EFLH) for the FilterTone® alarms calculation was the PY2019 – PY2021 Demand Portfolio Model. The algorithm used to determine savings for LED nightlights was from the PA TRM. The savings algorithms and deemed savings are shown in Section G.1.8.1 (Equation G-35 and Equation G-36) for the 9W LED lightbulbs, Section G.1.8.3 (Equation G-37 and Equation G-38) for the filter tone furnace filter alarms, and Section G.1.8.4 for the LED nightlight.

170 ADM HOU Memo, 2016.

G.1.4.13 New Home Construction RESNET Standards

The New Homes Construction savings methodology is followed by the Residential Energy Services Network (RESNET) standards. RESNET standards are industry wide standards that are recognized for verification of building energy performance by the EPA. Savings methodology that is in conformance with these standards are built into the Ekotrope modeling software and approved by RESNET.

G.1.5 Home Rebates Program – New Homes

G.1.5.1 Gross Savings Methodology

A sample of homes were randomly selected following the sample design previously discussed. Site-level gross impacts were then quantified using engineering reviews of the building simulation models used to generate the reported savings estimates. Relevant project documentation, interviews with HERS raters, and implementation QA forms were used to verify building simulation model inputs were consistent with the physical residences.

The process by which ADM executed this engineering review can be formalized into the following steps:

- Review available program documentation related to the specifications of the residence and energy efficiency measures claimed.
- Obtain and initiate review of simulation models.
- Establish appropriate baseline assumptions to measure level savings.
- Verify and adjust simulation model inputs as needed based on findings from project documentation and data collection.
- Execute updated building simulation to quantify savings impacts.

Obtain and Initiate Review of Simulation Models

- The simulation models for each rebated home were created in Ekotrope and initially submitted by participating builders/HERs raters to the implementation contractor.
- ADM engineering staff reviewed these models within the Ekotrope software[171] and confirmed that Ekotrope conforms to RESNET standard algorithms when calculating internal loads (e.g., lighting and appliances). Ekotrope inputs were then compared to the program provided tracking data and each simulation model was

171 ADM purchased a license from Ekotrope to facilitate this evaluation.

verified to ensure reconciliation of the program claimed annual energy savings per home.

Baseline Assumptions Levied for Key Simulation Inputs

- New construction programs are unique in that they must measure energy impacts against a hypothetical baseline as there is no pre-existing structure or equipment to reference. This baseline is the prevailing building codes/standards for the state and/or region. In this case, the applicable building codes are the Oklahoma residential building code which amends the 2015 International Residential Building (IRC) code to 2009 IRC energy code standards. This amended version of the IRC represents the baseline for all homes incentivized through this program.
- The key modeling assumptions impacted by the relevant building energy codes are outlined in Table G-38. Values for the listed parameters were taken from either the Oklahoma residential building code or minimum efficiency values defined by the National Appliance Energy Conservation Act (NAECA). Note that the modeling software used in this evaluation employs the term 'reference home' to denote the baseline home and the term 'design home' to denote the as-built residence. ADM tries to employ similar terminology for consistency, though they can be used interchangeably.

Table G-38: New Homes - Key Baseline Home Assumptions

Input	Verified Reference Home	Source
Attic Insulation	R-30	2009 IRC with amendments
Wall Insulation	R-13	2009 IRC with amendments
Window U	0.50	2009 IRC with amendments
Window SHGC	0.30	2009 IRC with amendments
Infiltration	0.00036 specific leakage area	2009 IRC with amendments
Slab Edge Insulation	0	2009 IRC with amendments
Cooling Efficiency (SEER)	14	NAECA minimum values.
Heating Efficiency (AFUE)	80	NAECA minimum values.
Heat Pump Heating Efficiency (HSPF)	8.2	NAECA minimum values, for both GSHP and ASHP.
Percent Efficient Lighting	75%	2009 IRC with amendments

The reference home assumptions were pre-programmed into the Ekotrope RATER modeling software. Reference home assumptions are to be based on the 2009 International Residential Code[172] and the Oklahoma Building Energy Codes Program[173].

[172] https://codes.iccsafe.org/content/IRC2009/chapter-11-energy-efficiency
[173] https://www.energycodes.gov/status/states/oklahoma

Verification of Key Model Inputs

The measures implemented by this program are represented by above code improvements to key aspects of the participant residences. Typical aspects included envelope improvements (e.g., insulation, windows, and infiltration reduction), HVAC efficiencies, and interior lighting. Each of these aspects have corresponding inputs to define/simulate their physical characteristics within the simulation models. ADM used documentation collected from the HERS raters, virtual and on-site visits to collect data required to substantiate, and in some cases correct, these inputs.

The model inputs representing home improvements seen in this program include:

- Home layout, size, shape, location, and orientation
- Duct sealing test results
- Infiltration test results
- Attic Insulation: R-values and area
- Interior, exterior, and garage lighting counts
- Heating and cooling temperature set points
- HVAC size and efficiencies (Capacity, SEER, EAE, AFUE, HSPF, COP)

Changes made to any of the above inputs represent differences between what was assumed to be present in the reported simulations and what ADM found to be physically present through our evaluation and data collection. The effect of these differences across all sampled homes contributed to the differences in the reported and verified energy savings estimates being reported.

Execute Building Simulation Analysis and Quantify Site Impacts

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

The verified energy and demand savings for each home were calculated by taking the difference in energy consumption between the simulated reference home and simulated design home. Realization rates for gross energy and demand savings were calculated for each sampling strata. Program results were derived by extrapolating the results from each sampling strata to the population of participating homes per the sample weights calculated in the sample design.

G.1.5.2 Net-to-Gross Estimation

Program Components Score

A program components score was calculated based on how influential various program factors were in the builders' decisions to construct efficient homes. Specifically, builders were asked: "How influential were the following factors in your decision to build the program-qualifying energy-efficient homes?" using a scale ranging from 1 to 5 where 1 means "not at all influential" and 5 means "extremely influential".

- Component 1: Technical assistance or information, including from HERs raters;
- Component 2: The rebates provided by the program
- Component 3: Program informational documents or customer engagement materials

A Program Components Score will be assigned to each of the ratings in the following manner:

1 (Not at all influential) = 0
2 = .25
3 = .50
4 = .75
5 (Extremely influential) = 1

The Program Components Score was calculated as equal to the highest rated component: MAX(Component1-3)

Program Influence Score

The Program Influence Score was based on respondents' rating of how likely they would have been to build any of the efficient homes if the rebate and information were not provided by the program. Specifically, builders were asked: "If the following aspects of the program were not available, how likely would you have been to build homes in PSO's service territory to the same energy-efficiency standards?" using a scale ranging from 1 to 5 where 1 means "not at all likely" and 5 means "very likely".

- Component 1: Technical assistance or information, including from HERs raters;
- Component 2: The rebates provided by the program; and
- Component 3: Program informational documents or customer engagement materials.

The Program Influence Score was assigned to each of the ratings in the following manner:

1 (Not at all likely) = 0
2 = .25
3 = .50
4 = .75
5 (Very likely) = 1

The Program Influence Score was calculated as equal to the highest rated component: MAX(Component1-3)

No Program Score

Builders were asked a series of questions about the number of homes that their firm would have likely built that met construction standards without the program. Specifically:

- If the program was not available, would you have built fewer or the same number of homes to PSO's efficiency standards in 2022?
- [IF FEWER] Out of the total homes you built in 2022, what percent of those would you have built to PSO's efficiency standards if the program had not been available?

These questions are intended to capture the influence that the program has had on builder's efficient construction practices. The intent is to capture the effect that prior program educational efforts had on builder's current construction practice, in addition to the available rebates, because a key component of the program is increasing builder's knowledge of, and skill in, efficient construction practices that may lead to long term changes in building practices.

A score was developed based on the percent of homes that the builder reports would have been built if the program had never been available. Specifically, the no program score was calculated using the following formula:

Equation 5-1: Program Score Calculation

$$Program\ Score = 1 - \frac{\%\ \text{Homes Built in Absence of the Program}}{100}$$

Free Ridership Score:

The evaluation team at ADM calculated the final free ridership score for each builder as equal to:

Equation 5-2: Free Ridership Calculation – New Homes

$$Free\ Ridership = 1 - \text{Average (Program Components Score, Program Influence Score, No Program Score)}$$

Historical free ridership scores were considered, going back to 2020, as new construction planning is a long-term process and not all builders were available for interviews. If builders participated in the survey multiple years, then the average scores were considered.

G.1.6 Home Rebates – Multiple Upgrades

G.1.6.1 Gross Savings Methodology

A brief description of each measure calculation method, the measure-level algorithms, and deemed savings values utilized for the energy and peak demand savings algorithms are described in this section.

Air Sealing Package: The AR TRM 8.1 was utilized to calculate energy and demand impacts of air sealing measures. Savings were calculated by multiplying the air infiltration reduction (CFM), with the energy savings factor corresponding to the climate zone and HVAC type. The air infiltration reduction estimate in cubic feet per minute (CFM at 50 Pascal) was obtained through blower door testing performed by the program contractor for each home serviced. A pre-installation blower door test measured by the contractor was required for all air sealing projects. Only homes with electric cooling systems were eligible for the measure (central AC or room AC).

Duct Replacement (Insulation): This measure involves replacing/insulating leaks in ducts of the distribution system of homes with either a central AC or a ducted heating system. The post-installation duct leakage is measured by the contractor. Savings were estimated by updating the inputs to the savings algorithm listed in the AR TRM 8.1 for duct sealing[174], with full load hours and the coincidence factor (CF) value from the OKDSD. Deemed savings factors were based on the location of the ducts (attic or crawlspace). Savings were calculated by multiplying the duct leakage reduction results with the outdoor/indoor seasonal specific enthalpy (OKDSD) corresponding to the climate zone and HVAC type and are divided by the HVAC unit efficiency. The savings calculations for duct replacement are valid up to a maximum pre-installation leakage rate of 40 percent of total fan flow.

Duct Sealing: This measure involves sealing leaks in ducts of the distribution system of homes with either a central AC or a ducted heating system. The post-installation duct leakage is measured by the contractor. Savings were estimated by updating the inputs to the savings algorithm listed in the AR TRM 8.1 for duct sealing, with full load hours and the coincidence factor (CF) value from the OKDSD. Deemed savings factors were based on the location of the ducts (attic or crawlspace). Savings were calculated by multiplying the duct leakage reduction results with the outdoor/indoor seasonal specific enthalpy (OKDSD) corresponding to the climate zone and HVAC type and are divided by the HVAC unit efficiency. The savings calculations for duct sealing are valid up to a maximum pre-installation leakage rate of 40 percent of total fan flow.

[174] The calculations for duct sealing from the AR TRM 8.1 were utilized for all duct replacement projects due to the AR TRM using deemed values based on location zones in Arkansas for duct replacement (insulation) savings. ADM utilized the method in the AR TRM that requires duct leakage testing using either a duct pressurization device (e.g., Duct Blaster), or a combination duct pressurization and blower door.

Attic Insulation: Savings were estimated by updating the savings algorithm inputs listed in the AR TRM 8.1 for attic insulation and are based on the R-value of the baseline insulation. The savings factor was climate zone specific, determined by the pre-insulation thickness R-value compared to the post-installation thickness R-value. The savings algorithms require new insulation to meet a minimum R-value of R-38. Savings were scaled for installed thickness between the table values of R-38 and R-49. As the AR TRM 8.1 energy and demand savings factors are based on multiple starting insulation R-values, and just two final insulation R-values, an interpolation was completed for those values between R-38 and R-49. Savings were calculated by multiplying the applicable savings value (based on the pre- and post-insulation thickness R-value) by the square footage insulated.

Floor Insulation: Savings were estimated by updating the savings algorithm inputs listed in the OKDSD for floor insulation, along with project-specific data, installed square feet, and insulation R-value. The OKDSD prototype home model considered cell foam insulation for the measure, which is the product used for the insulation rebate. The cell foam insulation provides both sensible and latent cooling season savings. The same algorithm as knee wall insulation was used, with the savings factor from the OKDSD. The savings factor was climate zone specific, and HVAC equipment specific, then factored by the installed area. The AR TRM 8.1 for wall insulation was used to calculate incremental cost for all floor insulation projects.

Wall Insulation: Savings were estimated by updating the savings algorithm inputs listed in the AR TRM 8.1 for wall insulation. The savings algorithm requires new insulation to meet a minimum R-value of R-13. Deemed savings provided in the AR TRM 8.1 are based on the heating and cooling system type of the home and the R-value of the insulation installed. Savings were calculated by multiplying the corresponding savings value by the insulated square footage.

Knee Wall Insulation: Savings were estimated by updating the savings algorithm inputs listed in the AR TRM 8.1 for knee wall insulation. The savings factor was dependent upon climate zone and HVAC equipment type. Additionally, deemed savings are driven by the heating and cooling system type of the home and the post-installation R-value. The AR TRM table was modeled for a home starting at zero insulation going to a R-19 or R-30 value. The savings estimated considered the initial insulation R-value and adjusted the savings value. The program tracking data indicated an open cell or closed cell foam applied to attic vertical walls. The final R-value was interpolated for the R-values between R-19 and R-30 and all the projects reached a minimum R-value of R-19. Savings were calculated by multiplying the applicable savings value (based on the pre- and post-insulation thickness R-value) by the square footage insulated.

Central Air Conditioners, Air Source Heat Pumps, Ductless Mini-Split Heat Pumps, and Ground Source Heat Pumps: Savings were estimated by updating the savings algorithm inputs in the OKDSD blended with the Federal Minimum Efficiency Requirements.[175]. OKDSD baseline SEER is 12.44 and baseline HSPF is 7.7, which were updated in the reported savings based on the 2016 federal minimum to 14 SEER and 8.2 HSPF, respectively. Savings calculations considered right-sizing savings up to a 1-ton difference and are based on the size/efficiency of each unit. For any ductless mini-split heat pump replacement in the Multiple Upgrades Program, it must have been combined with a duct replacement/duct sealing project.

Lifetime kWh Savings

Lifetime kWh savings were calculated by multiplying the gross annual kWh savings by the Estimated Useful Life (EUL) for each measure type. EUL values for each measure were based on the assumptions in the AR TRM and OKDSD. Table G-39 shows the EUL and source for each measure type.

Table G-39: Multiple Upgrades – Per Measure Estimated Useful Life (EUL)

Measure Type	EUL (years)
Air Sealing	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

G.1.6.2 Net-to-Gross (NTG) Estimation Methodology

This section provides a summary of the method to score the responses from the online survey of participants for the measure-level free ridership score, project-level free ridership score, and spillover score. The survey results were weighted and extrapolated to the population of participants.

Measure-Level Free Ridership Score

For customers who completed projects that did not include HVAC measures, the free ridership score was based entirely on responses to questions in the participant survey.

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

Program education and outreach efforts for HVAC measures may have influenced service providers' selling of efficient equipment in ways that are not apparent to customers. The assessment of free ridership for HVAC equipment also included a service provider influence component. The following paragraphs summarize the approach to assessing both the participant free ridership score and the service provider component.

Participant Free Ridership Score

The participant free ridership questions addressed several criteria to determine the likelihood that a customer is a free rider. If the respondent reported they had no financial ability to install the measure without the program, then the final participant free ridership score was equal to 0. In that case, no other consideration affected the score.

If the respondent reported they had the financial ability to install the measure without the program, then the final participant free ridership score was a function of three other factors: the respondent's prior plans to implement the project before learning of the program rebate, the reported likelihood of implementing the measure in the absence of the program, and the impact of the program on the timing of the project.

The first questions produced a Plans Score, with a value of 1 or 0, representing the existence of prior plans relating to the energy saving measures installed. Respondents who reported prior plans to implement measures that provided at least as much energy savings as those done through the program received a Plans Score of 1, while all others received a Plans Score of 0.

A separate set of questions produced a Likelihood Score, ranging from 0 to 1, which represented the likelihood that the respondent would have installed the measures without the program rebate. The average of the Plans Scores and the Likelihood Score produced the preliminary participant free ridership score, with a value ranging from 0 to 1.

Finally, the respondent's report of how the program affected the timing of the project produced a Timing Score, with a value ranging from 0 (the program moved the project forward by at least one year) to 1 (the program did not move the project forward). For each respondent, the final participant free ridership score was the product of the preliminary participant free ridership score and the Timing Score.

Service Provider Free Ridership Score

The service provider free ridership score related to the service providers influence of their customer engagement and sales of energy-efficient equipment on the participant, ranging in value from 0 (highest influence) to 1 (lowest influence). A second question assessed whether the program influenced the service provider's recommendations of different equipment types, quantities, or efficiency levels.

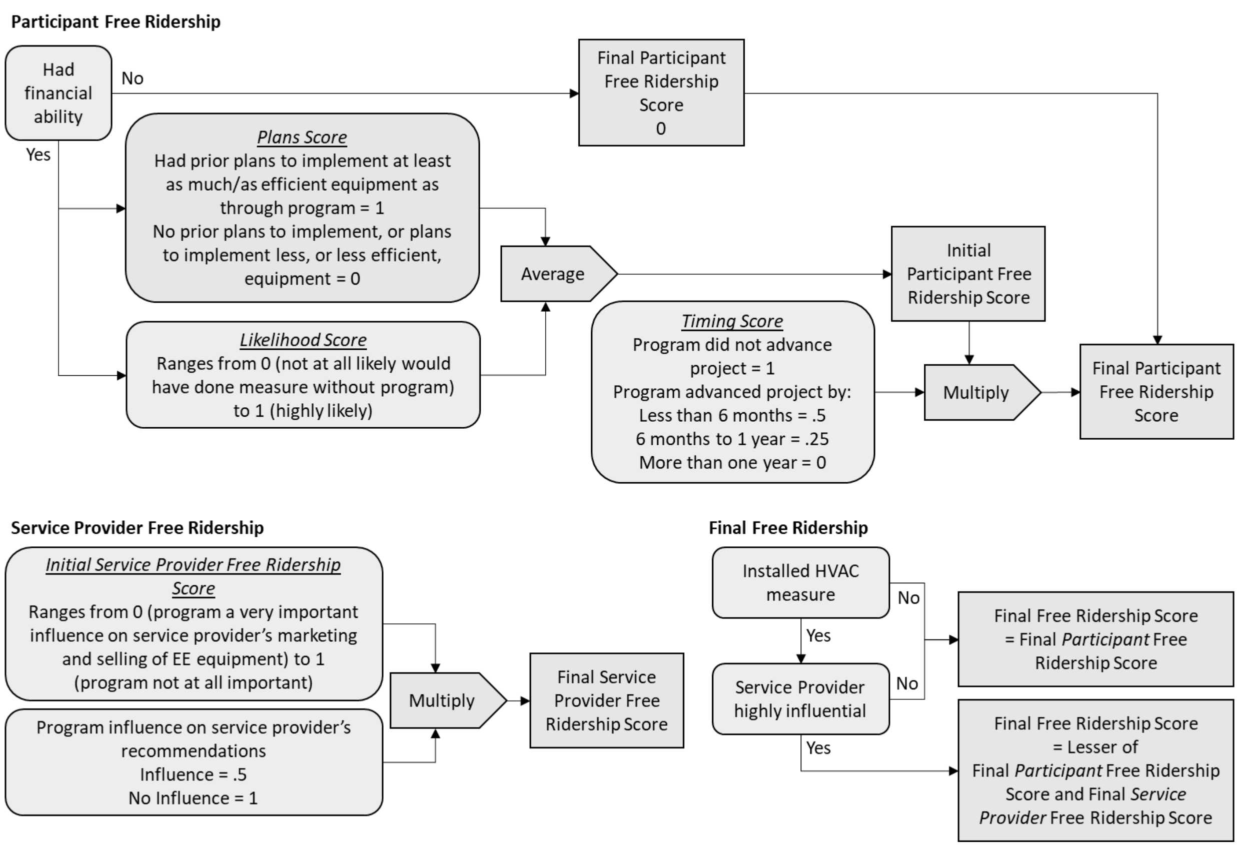
Final Free Ridership Score

The final participant free ridership score represented the final free ridership score in either of two cases: 1) The participant did not have HVAC equipment installed; or 2) the participant had HVAC equipment installed but did not receive any equipment information or recommendation from the service provider who installed it or the participant considered the equipment information or recommendation from the service provider influential in their decision to have the equipment installed.

If, however, a participant installed HVAC equipment and reported that the service provider who installed the equipment provided information or a recommendation and that it influenced their decision to have the equipment installed, then the final free ridership score was the lesser of two scores: 1) That participant's final participant free ridership score; and 2) the service provider free ridership score. For any given participant, if that participant's service provider completed the service provider survey and provided a service provider free ridership score, then the evaluation team at ADM used that service provider's score as the service provider free ridership score for the participant; otherwise, the mean service provider free ridership score was calculated across all surveyed service providers.

Table G-40 illustrates the above process for generating the final participant free ridership score.

Table G-40: Single & Multiple Upgrades - Free Ridership Flow Diagram



Project Level Free Ridership

For each respondent, a project level free-ridership score was determined by weighting the measure-level free-rider scores, over the project energy savings.

Survey responses about other energy-efficient measures installed recently were vetted against their participation in other projects, or programs, and the program influence on their purchase or installation of these measures. Spillover identified by the survey is vetted for influence by the program, then extrapolated to the population.

G.1.7 Single and Multiple Upgrades Net-To-Gross Questions

Questions relating to the assessment of net-to-gross (NTG) address both free ridership and spillover. Both the participant survey and service provider survey include questions relating to program participation and free ridership. For customers who completed projects that did not include HVAC measures, the free ridership score is based entirely on responses to questions in the participant survey. For customers who completed projects that included HVAC measures and who reported that equipment information or a recommendation from their service provider was highly influential in their decision to implement the HVAC measures, the assessment of free ridership includes information from the service provider survey. This is because program education and outreach efforts for HVAC measures may influence service providers' selling of efficient equipment in ways that are not apparent to customers.

The following subsections describe the questions from the participant and service provider surveys that the evaluation team at ADM used to assess free ridership and spillover, as described in Section 3.1.1.3.1 for Multiple Upgrades and Section 3.1.1.4.1 for Single Upgrade of this report.

Participant Free Ridership Questions

The participant free ridership (PFR) questions addressed the following criteria to determine the likelihood that a customer is a free rider:

- Financial ability to install the energy efficiency measures without program support
- Prior plans regarding installation of the energy efficiency measures
- Likelihood of implementing the measures in the absence of the program
- The program's impact on the timing of measure implementation

Financial Ability

Financial ability was assessed with the following question:

- PFR1: Because energy-efficient upgrades are higher in cost, would you have still purchased the [MEASURE] without the PSO rebate/discount?

Respondents who indicated that they were not able to afford the efficiency measure without the financial support provided by the program were deemed to not be free riders. For all others, a free ridership score was assigned based on a combination of their reported prior plans to implement the measure, the reported likelihood they would have installed one without the program, and the reported effect of the program on the likely timing of the installation (as described in following subsections).

Prior Plans

The presence of plans prior to involvement with the program was assessed through the following questions:

- PFR2: Before learning about PSO's Home Rebates Program, did you have plans to purchase the [MEASURE]?
- PFR3: Did you purchase [a more efficient/more] [MEASURE] because of the PSO rebate/discount?
- PFR4: [For duct sealing and knee wall insulation measures] Before participating in PSO's Home Rebates Program, did you know that your [duct system was leaking / knee walls needed more insulation]?
- PFR5: [For duct sealing and knee wall insulation measures] Before participating in PSO's Home Rebates Program, did you know that you could save energy by [sealing your ducts/insulating your knee walls]?

For measures other than duct sealing and knee wall insulation, respondents who answered "Yes" to PFR2 and "No" to PFR3 were assigned a "plans" score of 1. All other respondents were assigned a "plans" score of 0. For duct sealing and knee wall insulation measures, respondents who said "Yes" to PFR4 and PFR5 were assigned a "plans" score of 1 and all other respondents were assigned a "plans" score of 0.

Likelihood of Implementing the Measure in the Absence of the Program

The respondents' stated likelihood of implementing the measure in the absence of the program was assessed through the following question:

- PFR6: How likely would you have been to purchase the [MEASURE] without the PSO rebate/discount?

Based on the responses to the likelihood question, the following point values were assigned to each of the responses:

- 1 (Not at all likely) = 0
- 2 = 0.25
- 3 = 0.5
- 4 = 0.75
- 5 (Very likely) = 1

Program Impact on Timing

The program effect on the timing was assessed with the following two questions:

- PFR7: Did you install the [MEASURE] sooner because of the PSO rebate/discount?
- PFR8: If you had not received a PSO rebate/discount, when would you have installed the [MEASURE]?

The information provided in the response to these questions is used in the following manner:

- If the respondent stated that they would have installed the measure in more than one year, the preliminary free ridership score is multiplied by 0, resulting in a final free ridership score of 0. This is consistent with the AR TRM definition of a free rider as someone who would have implemented a program measure within one year of when it was installed through a program.
- If the respondent stated that they would have installed the measure in 6 months to one year, the preliminary free ridership score is multiplied by 0.25.
- If the respondent stated that they would have installed the measure within 6 months of when it was installed, the preliminary free ridership score is multiplied by 0.5.

Participant Questions to Assess Service Provider Influence on HVAC Installation

The participant survey asked participants:

- PFR9: Was the [MEASURE] recommended by your contractor during the initial visit?
- PFR10: How likely is it that you would have purchased the same [MEASURE] if it was not recommended by your contractor during the initial visit?

A "Yes" response to PFR10 and rating of 5 for PFR11 indicates service provider influence.

Service Provider Free Ridership Questions

The service provider survey included two service providers free ridership (SPFR) questions:

- SPFR1: How important was the PSO Home Rebates Program, including the rebates and information provided through the program, in influencing your level of marketing and selling energy efficient measures to PSO customers during 2022?
- SPFR2: Would you have recommended different equipment types, quantities, or efficiency levels to customers if PSO's Home Rebates Program were not available?

The responses to SPFR1 were scored as following (where higher values indicated higher free ridership):

- 0 (Not at all important) = 1
- 1 = 0.9
- 2 = 0.8
- 3 = 0.7
- 4 = 0.6
- 5 = 0.5
- 6 = 0.4
- 7 = 0.3
- 8 = 0.2
- 9 = 0.1
- 10 (Very important) = 0

If the service provider answered “Yes” to question SPFR2, the score from SPFR1 is reduced by 50%.

Spillover Questions

Spillover (SO) is defined as energy efficiency measures that respondents report installing in their home without receiving additional incentives but that were installed based on program influence. Potential spillover respondents were identified using the question below:

- SO1: Since receiving the PSO rebate/discount, have you purchased and installed any additional energy-efficient equipment or home upgrades in 2022?

Participants indicating that they have purchased and installed one or more energy efficiency projects since participating in the PSO Home Rebates Program were then asked two questions to determine whether the energy savings resulting from those measures may be attributed to the program:

- SO3: How important was your experience with PSO’s Home Rebates Program in your decision to purchase the additional equipment/upgrades?
- SO4: How likely would you have been to purchase the additional equipment/upgrades if you had not participated in PSO’s Home Rebates Program?

The responses to SO2 were scored as following (on a scale of 0 to 10, where higher values indicated higher spillover):

- 0 (Not at all important) = 1
- 1 = 0.9
- 2 = 0.8
- 3 = 0.7

- 4 = 0.6
- 5 = 0.5
- 6 = 0.4
- 7 = 0.3
- 8 = 0.2
- 9 = 0.1
- 10 (Very important) = 0

The responses to SO3 were scored as following (on a scale of 1 to 15, where higher values indicated higher spillover):

- 1 (Not at all likely) = 0
- 2 = 0.25
- 3 = 0.5
- 4 = 0.75
- 5 (Very likely) = 1

Participants responding to question SO3 with a rating of 7 or higher and responding to question SO4 with a rating of 3 or lower, were considered to have been motivated by the program to make these additional purchases, and the energy savings from these items were attributed to the program. Savings for spillover measures like those offered through the program were calculated and then extrapolated to the population of respondents.

G.1.8 Education Program

G.1.8.1 ENERGY STAR® LEDs

The energy savings for ENERGY STAR® LEDs were calculated by using the following equations as specified in the AR TRM, 8.2. Inputs for lighting calculations were determined from the data from the participant surveys in combination with algorithms and inputs found in the AR TRM.

Equation G-35: Energy Savings for LED bulbs

$$kWh_{savings} = \left(\frac{\Delta Watts}{1{,}000}\right) x\ Hours\ x\ ISR\ x\ IEF_E$$

Equation G-36: Demand Reduction LED bulbs

$$kW_{demand\ reduction} = \left(\frac{\Delta Watts}{1{,}000}\right)\ x\ CF\ x\ ISR\ x\ IEF_D$$

Where:

$\Delta Watts$ = The difference in watts between a baseline bulb and the distributed LED. Baseline wattages will be determined based on the wattage and brightness (lumen) of the measure and the EISA baseline standards.

$Hours$ = Average hours of use per year

= 960.61 hours[176]

ISR = In-service rate, the percentage of LEDs distributed that are installed.

CF = Summer Peak Coincidence Factor for measure.[177] An average coincident factor is calculated based on the reported installation location from student survey.

Lamp Location	CF
Indoor	10%
Outdoor	0%

IEF_E = Interactive effects factor to account for cooling energy savings and heating energy penalties as specified in the AR TRM, based on home heating and cooling condition reported in student survey responses.

IEF_D = Interactive effects factor to account for cooling demand savings as specified in the AR TRM, based on home heating and cooling condition reported in student survey responses.

G.1.8.2 Advanced Power Strips (APS)

ADM utilized the deemed savings values for "residential" applications from the AR TRM, version 8.2.

Table G-41: Demand and Annual Energy Savings for Advanced Power Strips[178]

System Type	kW Demand Reduction	kWh Savings
Residential		
Home Entertainment System	0.030	252.2
Home Office	0.008	82.5
Average APS	0.019	167.4

[176] Based on the ADM 2016 benchmarking study.
[177] As stipulated in the AR TRM Version 8.2, Vol. 2, page 219.
[178] As stipulated in the AR TRM, Version 8.2, Vol. 2, page 184.

G.1.8.3 FilterTone® Alarm

The energy savings and peak demand reductions for FilterTone® Alarms were calculated by using the following equations from the PA TRM. Inputs to algorithms were determined from the data from the participant surveys in combination with algorithms and inputs found in the PA TRM.[179]

Equation G-37: Energy Savings for FilterTone® Alarms

$$kWh_{savings} = (EFLH_{Heat} + EFLH_{Cool})\ x\ kW_{motor}\ x\ EI\ x\ ISR$$

Equation G-38: Peak Demand Reduction for FilterTone® Alarms

$$kW_{demand\ reduction} = kW_{motor}\ x\ EI\ x\ ISR\ x\ CF$$

Where:

$EFLH_{Heat}$ = Assumed to be 800 hours[180]

$EFLH_{Cool}$ = Assumed to be 800 hours

kW_{motor} = Average motor full load electric demand (kW), assumed to be 0.377 kW.[181]

EI = Efficiency improvement

= 15%[182]

CF = Coincidence factor for peak demand reduction

= 0.87[183]

ISR = In-service rate, or percentage of units that get installed, from student survey.

G.1.8.4 LED Night Light

ADM utilized the following equation for calculating the kWh savings from the PA TRM.[184] There are no peak demand reductions associated with LED night lights.

Equation G-39: Energy Savings for LED Night Lights

$$kWh_{savings} = \left[\left(W_{base} - W_{post}\right) \times \left(\frac{Hours \times 365\, \frac{days}{year}}{1000\ \frac{W}{kW}} \right) \right] \times ISR$$

[179] As stipulated in the 2021 PA TRM Vol.2, page 45.
[180] $EFLH_{Heat}$ and $EFLH_{Cool}$ based on PSO's 2019-2021 DSM Portfolio Plan.
[181] As stipulated in the 2021 PA TRM Vol.2, page 45.
[182] As stipulated in the 2016 PA TRM Vol.2, page 45.
[183] Coincidence factor for demand reduction HVAC systems, as stipulated in the AR TRM Version 8.1, Vol 2, page 542.
[184] 2021 PA TRM Vol.2, page 7.

Where:

W_{base} = Baseline wattage, assume incandescent night light

= 7 W[185]

W_{post} = Wattage of installed LED night light

= 1 W[186]

$Hours$ = Number of hours per day the nightlight is assumed to operate

= 12 hours[187]

ISR = In-Service Rate, or percentage of delivered units that get installed, based on student survey responses.

G.1.9 Multifamily Program

G.1.9.1 Air Infiltration

ADM utilized the AR TRM for the savings algorithms shown in Section G.1.2.1: Equation G-1 was used annual energy savings (kWh) and Equation G-2 was used to calculate peak demand savings (kW).

G.1.9.2 Ceiling Insulation

ADM utilized the AR TRM for the deemed savings shown in Section G.1.2.3: Table G-32.

G.1.9.3 Duct Sealing

ADM utilized the OKDSD for the savings algorithms shown in Section G.1.2.2: Equation G-3 is used to determine annual cooling savings, and Equation G-4 and Equation G-5 are used to determine heating savings for electric resistance heat and gas heat, respectively.

G.1.9.4 Faucet Aerator

ADM utilized the deemed savings values from the AR TRM for faucet aerator annual savings. Savings are calculated by multiplying the applicable savings value by the number of installed faucet aerators. Deemed savings were calculated under the assumption that all faucet aerators in a home were replaced. All faucet aerators in a home must have been replaced for savings to be applicable.

[185] 2021 PA TRM Vol.2, page 7.
[186] 2021 PA TRM Vol.2, page 7
[187] 2021 PA TRM Vol.2, page 7

Equation G-40: Energy Savings (Faucet Aerator)

$$kWh_{savings} = \frac{\left[\rho \times \mathrm{C_p} \times \mathrm{V} \times \left(\mathrm{T_{Mixed}} - T_{Supply}\right) \times \left(\frac{1}{RE}\right)\right]}{Conversion\ Factor} \times ISR$$

Where:

ρ = Water Density = 8.33 lb/gallon

C_p = Specific heat of water = 1 BTU/lb*˚F

V = gallons of water saved per year per faucet

Flow Rate	Gallons of Water Saved Per Year
1.5 gpm	359
1.0 gpm	599

T_{Mixed} = Mixed water temperature, 105.3 ˚F, see Table G-42

T_{Supply} = Average supply water temperature, see Table G-42

RE = Recovery Efficiency; if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters, or 0.79 for natural gas water heaters

Conversion Factor = 3,412 Btu/kWh

ISR = In-service rate, or percentage of units that get installed.

Equation G-41: Peak Demand Savings (Low Flow Shower Head)

$$kW_{savings} = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$Ratio_{Annual\ kWh}^{Peak\ kW}$ = 0.000104

Table G-42: Mixed Water Temperature Calculation (Faucet Aerator)

Weather Zone	Average Water Main Temperature (˚F)	Percent Hot Water	Mixed Water Temperature (˚F)
9 Fayetteville	65.6	66.9%	104.7
8 Fort Smith	66.1	66.9%	104.8
7 Little Rock	67.8	66.9%	105.4
6 El Dorado	70.1	66.9%	106.2
Average for Arkansas (T_{mixed})			**105.3**

G.1.9.5 Heat Pump

ADM utilized the OKDSD for the savings algorithms shown in Section G.1.4.7, Equation G-28 and Equation G-29 are used to calculate annual energy savings (kWh) and Equation G-30 for peak demand reduction (kW).

G.1.9.6 Low Flow Shower Head

The following equations were used to calculate energy savings for Low Flow Shower Heads. The values used in the calculations come from the AR TRM.

Equation G-42: Energy Savings (Low Flow Shower Head)

$$kWh_{savings} = \frac{\left[\rho \times \mathrm{C_p} \times \mathrm{V} \times \left(\mathrm{T_{Mixed}} - T_{Supply}\right) \times \left(\frac{1}{RE}\right)\right]}{Conversion\ Factor} \times ISR$$

Where:

ρ = Water Density = 8.33 lb/gallon

C_p = Specific heat of water = 1 BTU/lb*˚F

V = Showerhead water gallons saved per year = 2.0 gpm

T_{Mixed} = Mixed water temperature, 107.1 ˚F, see Table G-43

T_{Supply} = Average supply water temperature, see Table G-43

RE = Recovery Efficiency; if unknown, use 0.98 as a default for electric resistance water heaters, 2.2 for heat pump water heaters, or 0.79 for natural gas water heaters

Conversion Factor = 3,412 Btu/kWh

ISR = In-service rate, or percentage of units that get installed.

Equation G-43: Peak Demand Savings (Low Flow Shower Head)

$$kW_{savings} = kWh_{savings} \times Ratio_{Annual\ kWh}^{Peak\ kW}$$

Where:

$Ratio_{Annual\ kWh}^{Peak\ kW}$ = 0.000104

Table G-43: Mixed Water Temperature Calculation (Low Flow Shower Head)

Weather Zone	Average Water Main Temperature (˚F)	Percent Hot Water	Mixed Water Temperature (˚F)
9 Fayetteville	65.6	70.1%	106.5
8 Fort Smith	66.1	70.1%	106.7
7 Little Rock	67.8	70.1%	107.2
6 El Dorado	70.1	70.1%	107.9
Average for Arkansas (T_{mixed})			**107.1**

G.1.9.7 ENERGY STAR® Pool Pump

ADM utilized the AR TRM for calculating energy savings and demand reductions. The following algorithms are sourced from the AR TRM.

Equation G-44: Energy Savings (Pool Pumps)

$$kWh_{savings} = kWh_{conv} - kWh_{vs}$$

Where:

kWh_{conv} = Conventional single-speed pool pump energy (kWh)

kWh_{vs} = ENERGY STAR® variable-speed pool pump energy (kWh)

Algorithms to calculate the above parameters are defined as:

$$kWh_{conv} = \frac{PFR_{conv} * 60 * hours_{conv} * days}{EF_{conv} * 1000}$$

$$hours_{conv} = \frac{V_{pool} * PT}{PFR_{conv} * 60}$$

$$kWh_{ES} = kWh_{HS} + kWh_{LS}$$

$$kWh_{HS} = \frac{PFR_{HS} * 60 * hours_{HS} * days}{EF_{HS} * 1000}$$

$$kWh_{LS} = \frac{PFR_{LS} * 60 * hours_{LS} * days}{EF_{LS} * 1000}$$

$$PFR_{LS} = \frac{V_{pool}}{t_{turnover} * 60}$$

Where:

kWh_{HS} = ENERGY STAR® variable speed pool pump energy at high speed (kWh)

kWh_{LS} = ENERGY STAR® variable speed pool pump energy at low speed (kWh)

$hours_{conv}$ = Conventional single-speed pump daily operating hours (Table G-44)

$hours_{HS,VS}$ = ENERGY STAR® variable speed pump high speed daily operating hours

= 2 hours

$hours_{LS,VS}$ = ENERGY STAR® variable speed pump low speed daily operating hours

= 10 hours

$hours_{HS,MS}$ = ENERGY STAR® multi-speed pump high speed daily operating hours

= 2 hours

$hours_{LS,MS}$ = ENERGY STAR® multi-speed pump low speed daily operating hours (Table G-45)

days = Operating days per year = 7 months x 30.4 days/month

= 212.8 days (default)

PFR_{conv} = Conventional single-speed pump flow rate (gal/min) (Table G-44)

$PFR_{HS,VS}$ = ENERGY STAR® variable speed pump high speed flow rate = 50 gal/min (default)

$PFR_{LS,VS}$ = ENERGY STAR® variable speed pump low speed flow rate (gal/min)

= 30.6 (default)

$PFR_{HS,MS}$ = ENERGY STAR® multi-speed pump high speed flow rate (gal/min) (Table G-45)

$PFR_{HS,MS}$ = ENERGY STAR® multi-speed pump low speed flow rate (gal/min) (Table G-45)

EF_{conv} = Conventional single-speed pump energy factor (gal/W·hr) (Table G-44)

$EF_{HS,VS}$ = ENERGY STAR® variable speed pump high speed energy factor

= 3.75 gal/W·hr (default)

$EF_{LS,VS}$ = ENERGY STAR® variable speed pump low speed energy factor

= 7.26 gal/W·hr (default)

$EF_{HS,MS}$ = ENERGY STAR® multi-speed pump high speed energy factor (gal/W·hr) (Table G-45)

$EF_{LS,MS}$ = ENERGY STAR® multi-speed pump low speed energy factor (gal/W·hr) (Table G-45)

V_{pool} = Pool volume

= 22,000 gal (default)

PT = Pool turnovers per day

= 1.5 (default)

$t_{turnover,VS}$ = Variable speed pump time to complete 1 turnover

= 12 hours (default)

$t_{turnover,MS}$ = Multi-speed pump time to complete 1 turnover (Table G-45)

60 = Constant to convert between minutes and hours

1000 = Constant to convert W to kW

Table G-44: Conventional Pool Pumps Assumptions

Pump HP	$hours_{conv}$	PFR_{conv}(gal/min)	EF_{conv}(gal/W*h)
0.5	11	50.0	2.71
0.75	10.4	53.0	2.57
1	9.2	60.1	2.40
1.5	8.6	64.4	2.09
2	8.5	65.4	1.95
2.5	8.1	68.4	1.88
3	7.5	73.1	1.65

Table G-45: Multi-Speed Pool Pumps Assumptions

Pump HP	$t_{turnover,MS}$	$hours_{MS,LS}$	$PFR_{HS,MS}$ (gal/min)	$EF_{HS,MS}$ (gal/min)	$PFR_{LS,MS}$ (gal/min)	EF_{conv} (gal/W*h)
1	11.8	9.8	56.0	2.40	31.0	5.41
1.5	11.5	9.5	61.0	2.27	31.9	5.43
2	11.0	9.0	66.4	1.95	33.3	5.22
2.5	10.8	8.8	66.0	2.02	34.0	4.80
3	9.9	7.9	74.0	1.62	37.0	4.76

Demand savings were derived using the following:

Equation G-45: Peak Demand Savings (Pool Pumps)

$$kW_{savings} = \left[\frac{kWh_{conv}}{hours_{conv}} - \frac{kWh_{HS} + kWh_{LS}}{hours_{HS} + hours_{LS}}\right] * \frac{CF}{days}$$

Where:

CF = Coincidence factor

= 0.31

G.1.9.8 Clothes Dryer

For the Multifamily program, ADM utilized the deemed values for energy savings and algorithm for demand reduction from the Mid-Atlantic TRM. Energy savings are made available for ENERGY STAR® certified Clothes Dryers.

Table G-46: ENERGY STAR® Clothes Dryer Deemed Savings

Product Class	Algorithm	ΔkWh
Vented or Ventless Electric, Standard (≥ 4.4 ft^3)	= ((8.45/3.11 – 8.45/3.93) * 311 * 100%	176.3
Vented or Ventless Electric, Compact (120V) (< 4.4 ft^3)	= ((3/3.01 – 3/3.80) * 311 * 100%	64.4
Vented Electric, Compact (240V) (< 4.4 ft3)	= ((3/2.73 – 3/3.45) * 311 * 100%	71.3
Ventless Electric, Compact (240V) (< 4.4 ft3)	= ((3/2.13 – 3/2.68) * 311 * 100%	89.9
Vented Gas	= ((8.45/2.84 – 8.45/3.48) * 311 * 16%	27.2

Demand reduction was derived using the following equation:

Equation G-46: Peak Demand Savings (Clothes Dryer)

$$\Delta kW = \frac{\Delta kWh}{Hours} * CF$$

Where:

ΔkWh = Energy Savings

Hours = Annual run hours of clothes dryer.

= 290 hours per year.

CF = Summer Peak Coincidence Factor for measure

= 2.9%

G.1.9.9 ENERGY STAR® Clothes Washers

ADM utilized the AR TRM for the deemed savings values shown in Section G.1.3.11: Table G-30.

G.1.9.10 ENERGY STAR® Windows

ADM utilized the OKDSD for the ENERGY STAR® Window deemed savings values. ADM used the deemed savings values from climate zone 8B.

Table G-47: ENERGY STAR® Windows Deemed Savings

Existing Windowpane Type	AC/Gas Heat kWh	Gas Heat (no AC) kWh	Gas Heat (no AC) Therms	AC/Electric Resistance kWh	Heat Pump kWh	AC Peak Savings kW
	Per sq. ft.	Per sq. ft.	Per sq. ft.	Per sq. ft.	Per sq. ft.	Per sq. ft.
Single Pane	6.9022	0.3863	0.5562	17.8098	13.3434	0.0044
Double Pane	5.0567	0.1777	0.2666	10.4856	8.4996	0.0031

G.1.9.11 Lighting Measures

ADM utilized the AR TRM for the savings algorithms and deemed savings values for the lighting measures as detailed in Section G.1.1.1.

G.1.9.12 Free-Ridership (Non-Direct Install)

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

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

In this methodology, financial ability was a gateway value, in that if a participant did not have the independent financial ability to purchase energy efficient equipment absent an incentive, the other components of free ridership are not considered. The assessment of free ridership scores factored the other components of free ridership if the participant had financial capability. An overall free ridership score was calculated based on participant plans, a likelihood of installing the measure in the absence of the Program score, and a timing score.

Participants’ prior plans to implement a measure using the responses to the following questions:

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

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

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

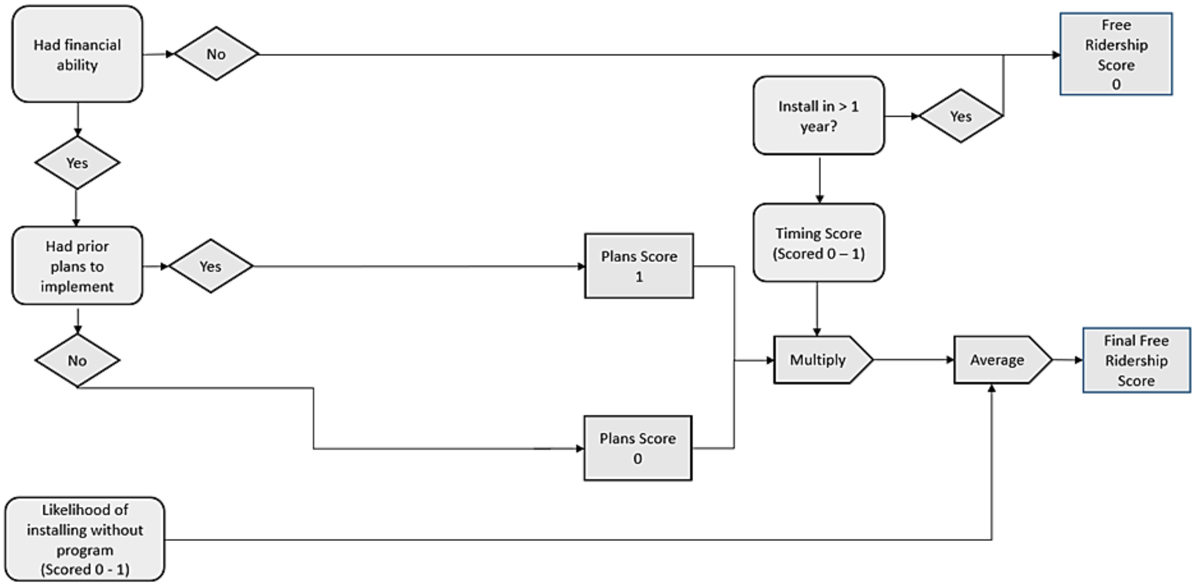
- If the respondent stated that they would have installed the measure in 6 months to one year, then the score is reduced by one-half; and
- If the respondent stated that they would have installed the measure at the same time or within 6 months of when the measure was initially installed, the score is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

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

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

A flow diagram of free ridership scoring of non-direct install measures is shown in Figure G-1.

Figure G-1: Multifamily Non-Direct Install Scoring Flow Chart



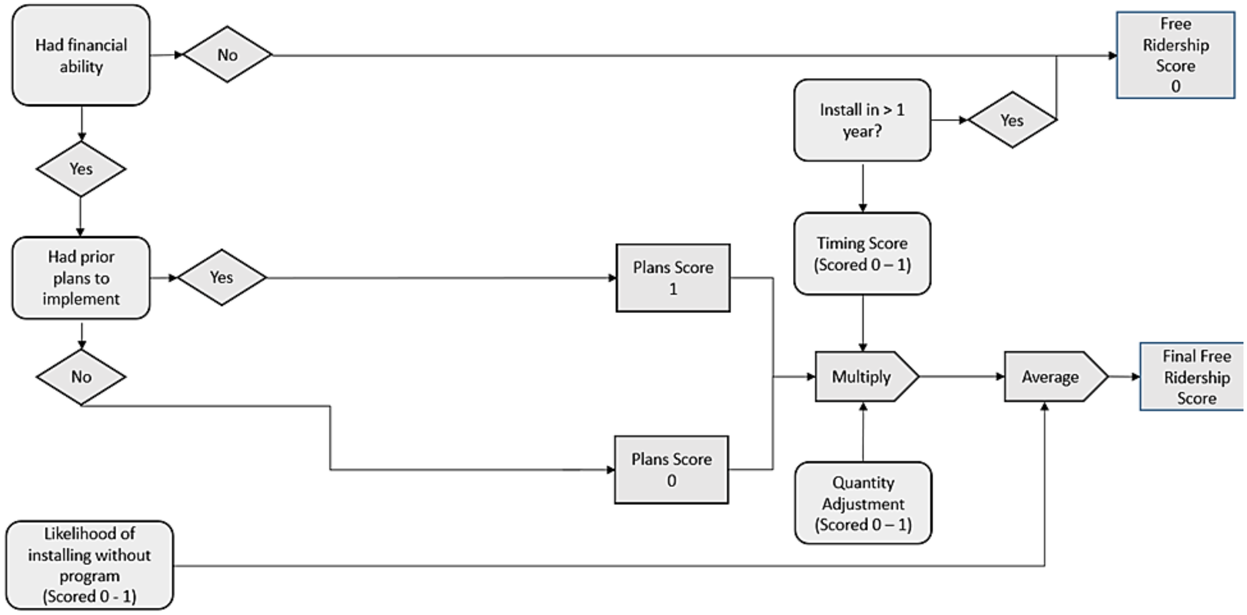
G.1.9.13 Free-Ridership (Direct Install)

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

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

A flow diagram for free ridership scoring of direct install measures is shown in Figure G-2.

Figure G-2: Multifamily Direct Install Scoring Flow Chart



G.1.9.14 Participant Spillover Methodology

To estimate participant spillover impacts, ADM asked participant survey respondents if they had purchased any additional items because of their experience with the program without receiving an incentive. Spillover is defined as the additional energy savings achieved by a participant because of the energy efficiency programs influence.[188] Participants who indicated one or more energy efficiency purchases triggered logic to ask additional questions about what was purchased, and the number of units purchased to estimate the savings impact.

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

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

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

$$\textit{Spillover Score} = \text{Average (SP1, 10-SP2)}$$

[188] The Uniform Methods Project. National Renewable Energy Laboratory (NREL). Chapter 17: Estimating Net Savings: Common Practices.

G.1.10 Behavioral Modification Program

G.1.10.1 Calculation of Average Daily kWh Savings

ADM utilized the mixed effects panel regression model specified in Equation G-47 to determine daily average electricity savings for treatment group members.

Equation G-47: Mixed Effects Panel Regression Model

$$AEC_{i,t} = \alpha_i \mathrm{Customer_i} + \beta_1 CDD_{i,t} + \beta_2 HDD_{i,t} + \beta_3 Post_{i,t} + \beta_4 Post_{i,t} * Treat_{i,t} + \beta_5 Post_{i,t} * CDD_{i,t} + \beta_6 Post_{i,t} * HDD_{i,t} + E_{i,t}$$

Where the subscript i denotes individual customers and t = 1. $T_{(i)}$ serves as a time index, where $T_{(i)}$ is the number of bills available for customer i. The model is defined as “mixed effects” because the model decomposes its parameters into fixed-effects (i.e., Heating Degree Days (HDD), Cooling degree days (CDD), Post-Installation period (Post), treatment (Treat), and various interactions) 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.

The program implementer provided ADM with a dataset that included the participation start date for each treatment group member and their corresponding control group. The first billing period after the beginning of treatment is considered the “deadband period”. Observations that occur in the deadband period are not included in the mixed effects panel regression as they contain a mix of pre-treatment and post-treatment data. For the treatment and control group members, the post period begins in the first billing period following the deadband period. The post variable is defined as a 0 in the billing periods prior to the beginning of treatment and a 1 for billing periods following the deadband period.

Heating degree day (HDD) and cooling degree day (CDD) were used in the model to control for energy demand based on outside temperature. HDD is defined as the monthly average difference between 65 degrees (the outside temperature above which it is assumed that a building needs no heating) and the actual outside air temperature. CDD is defined as the monthly average difference between the actual outside air temperature and 65 degrees (the outside temperature under which it is assumed that a building needs no cooling). A minimum value of 0 is used for both HDD and CDD. A description of the variables used in the regression model is shown in Table G-48.

Table G-48: Description of Variables Used in the Regression Model

Variable	Variable Description
Average Electricity Consumption ($AEC_{i,t}$)	Average daily use of electricity (kWh) for period t for a customer (determined by dividing total usage in a period by number of days in that period)
Customer	A panel of dummy variables that is a 1 for customer i or a 0 if not
Cooling Degree Days (CDD)	The mean cooling degree days per day during the billing period
Heating Degree Days (HDD)	The mean heating degree days per day during the billing period
Post	Post is a dummy variable that is 1 if the monthly period is after the customer received their first energy report and 0 for the periods before
Treatment	Treatment is a dummy variable that is 1 if the customer is a member of the treatment group and a 0 if the customer is a member of the control group
E_t	E_t is the error term

Table G-49 describes the coefficients that were determined by using the mixed effects panel model shown in Equation G-47.

Table G-49: Description of the Coefficients Estimated by the Regression Model

Coefficient	Coefficient Description
α_i	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	β_1 is a coefficient that adjusts for the main effect of cooling
β_2	β_2 is a coefficient that adjusts for the main effect of heating
β_3	β_3 is a coefficient for the main effect of time, i.e., whether an observation falls in the pre-period or post-period
β_4	β_4 is a coefficient that represents the interactive effect of whether an observation falls in the post-period and the treatment effect. This coefficient represents savings attributable to the program.
β_5	β_5 is a coefficient that adjusts for the interactive effect between the post-period and cooling
β_6	β_6 is a coefficient that adjusts for the interactive effect between the post-period and heating

G.1.10.2 Calculation of Annual Energy Savings

The average daily annual energy savings for the post period treatment group is defined as coefficient β_4 in the regression model. 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 2022, were not removed for cross-participation, and had not opted out of the program.

G.1.10.3 Calculation of Coincident Peak Demand Reduction

The peak demand reduction was determined by applying the program annual energy savings to a normalized hourly load shape that represents typical residential energy consumption, resulting in an 8,760 hourly annual savings curve. The selected load shape was the same used to determine estimates for the Behavioral Modification Program during portfolio planning. An average value across the peak demand window was drawn from the energy savings curve. The peak demand window is defined as consumption non-holiday weekdays between 2 PM and 6 PM in the months of June through September.

G.1.11 Conservation Voltage Reduction (CVR)

G.1.11.1 Program Overview

PSO's Conservation Voltage Reduction (CVR) program uses a system of devices, controls, software, and communications equipment to manage reactive power flow and lower voltage level for implemented distribution circuits. Under ANSI Standard C84.1 Electric Power Systems and Equipment, a utility system is to deliver electricity to end-users at a voltage within the range of 120 ± 5% volts (i.e., 114 – 126). With the usual system design, customers close to a substation receive voltages closer to 126 volts and customers farther from the substation receive lower voltages. Because most electric devices are designed to operate most efficiently at 115 volts, any "excess" voltage is typically wasted, usually in the form of heat.[189] PSO's CVR program uses a software program called "Yukon", a control system from Eaton that monitors the voltage and power factor along the distribution circuit and lowers the voltage profile within an acceptable bandwidth. The tighter voltage regulation provided by CVR technology allows end-use devices to potentially operate more efficiently without any action on the part of consumers. Consumers receive a lower but still acceptable voltage and use less energy to accomplish the same tasks.

PSO approached the implementation of CVR in a holistic, system-wide manner, to fully optimize the energy efficiency potential. PSO considered the following three system configurations and decided on full implementation of these configurations.

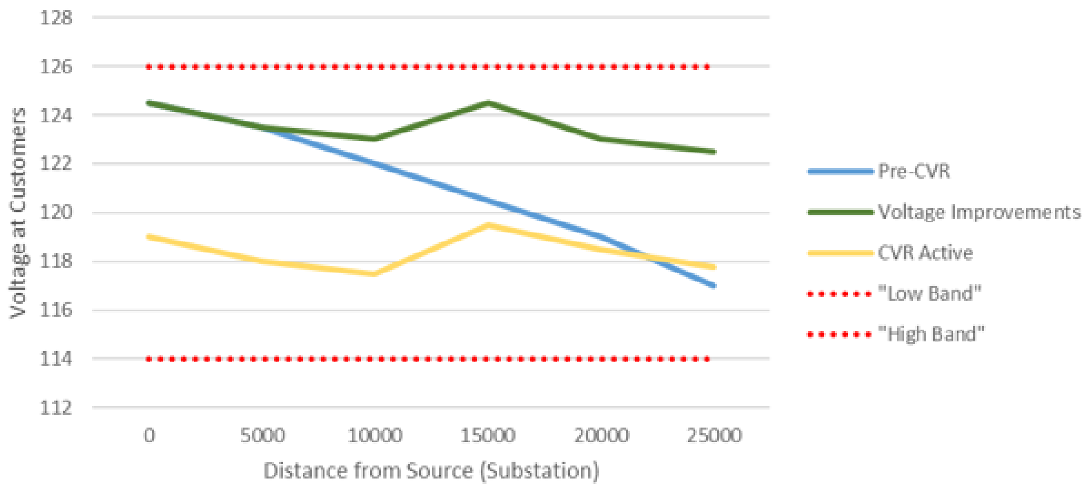
- Typical distribution configuration: This configuration utilizes existing equipment in its current state to assist with distribution operation. It does not include any update to equipment or settings.
- Distribution equipment location optimization: This configuration includes new optimized locations with new equipment and settings for capacitor banks and regulators, which allow the system to operate more efficiently.
- Networked distribution equipment settings optimized: The final stage includes optimized locations for the equipment, along with end of line sensors that monitor the voltage. All the equipment is now communicating with a backend system (Yukon) and a fully implemented CVR system.

The inclusion of systematic upgrades results in a more consistent delivery of voltage to customers. As shown in Figure G-3, blue represents voltage of a typical distribution system configuration, green represents a typical distribution system with equipment locations and settings optimized, and yellow represents the lowered voltage with typical CVR enabled (hardware and software). Keeping the system below 120V provides an

[189] https://www.tdworld.com/grid-opt-smart-grid/cvr-here-stay

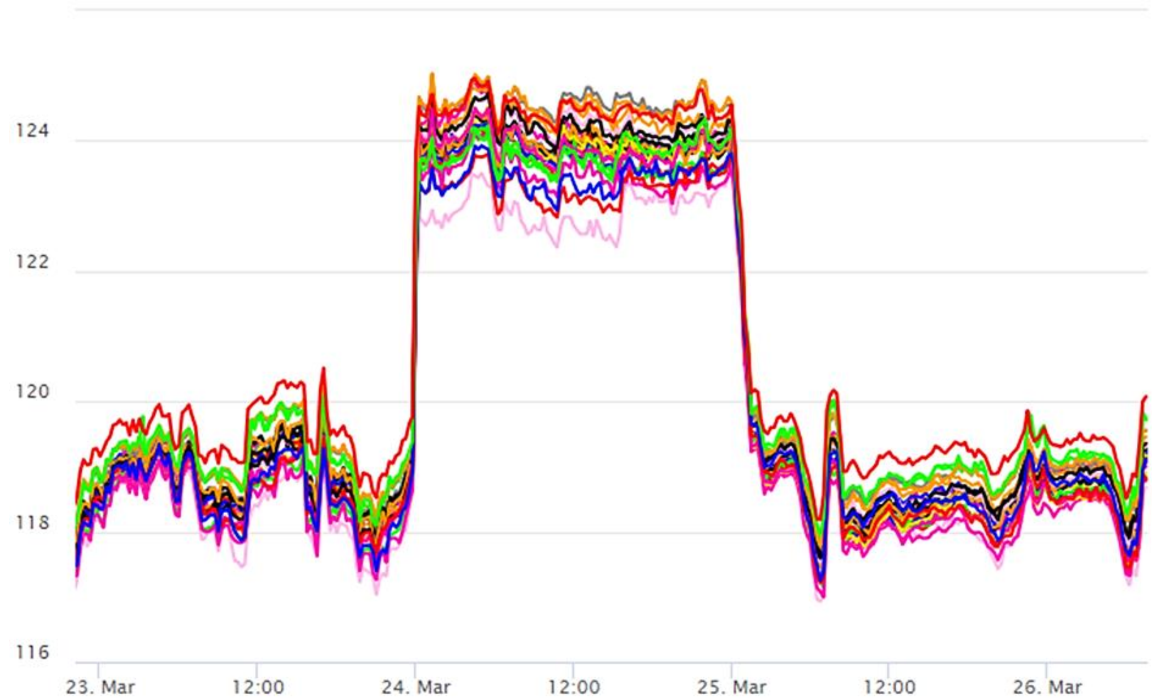
efficient voltage for customers and reduced load demand from the utility and reduced usage from the customer.

Figure G-3: Various Voltage Profiles with Modifications - CVR



A tighter distribution of voltages is evident in PSO's implementation of optimizing networked distribution equipment. As shown in Figure G-4, CVR is enabled on March 23rd, disabled on March 24th, and enabled on March 25th. Each colored line represents a piece of equipment along the feeder providing a unique voltage reading. The tighter the distribution, the tighter bandwidth that PSO is operating at along the entire circuit. A larger distribution of voltages would likely indicate the system could not reduce voltage drop further through the utilization of system upgrades such as a capacitor bank, thus resulting in additional energy losses. When CVR is enabled, there is a significantly lower voltage with a tighter spread between the voltage points, compared to when CVR is disabled.

Figure G-4: Example PSO Circuit with CVR and Upgrades during Evaluation Testing



G.1.11.2 Regression Analysis Methodology

To support CVR at this configuration, PSO had electrical engineers design, model, and coordinate the installation of equipment. Once the equipment was installed, the engineers worked with numerous departments to implement a communication network and install Eaton's Yukon software to get CVR active and online. PSO followed a bid process to select Eaton's Yukon software based on price, features, and operational standards. On / Off Regression Analysis Methodology

ADM performed an extensive review of data which involved both algorithmic and graphical detection of abnormalities. This involves any sudden voltage or consumption spikes, repeating values, or other unusual behaviors not characteristic of typical substation operation. Data identified as capable of biasing the regression analysis was necessarily removed as even small abnormalities can alter results when trying to identify a relatively small effect (less than a 5% change in consumption) due to operation of CVR mode. Various data processing steps are applied to the data before analyzed. These steps include:

Combining substation data from PSO with weather data from NOAA

Local temperature data was retrieved from the National Oceanic and Atmospheric Administration (NOAA). Temperature values were converted to cooling degree days (CDD) and heating degree days (HDD). This was done because CDD and HDD values can quantify how power consumption relates to the weather more effectively than temperature values. The equations below show how temperature is converted to CDD.

$$CDD_t = \begin{cases} 0 & if\ temp_t < cddbase \\ (temp_t - cddbase)\ /\ 24 & if\ temp_t \geq cddbase \end{cases}$$

$$HDD_t = \begin{cases} 0 & if\ temp_t > hddbase \\ (hddbase - \ temp_t)\ /\ 24 & if\ temp_t \leq hddbase \end{cases}$$

Where:

$temp_t$ = temperature at time t

$cddbase$ = CDD base temperature

$hddbase$ = HDD base temperature

To calculate the most accurate CDD and HDD values, the optimal CDD and HDD base temperature for each circuit was interpreted. For a detailed description of how optimal CDD and HDD base temperatures are determined, see Appendix G:.

Identifying CVR Mode for each hour of the year

To determine when CVR is operational (on) and when it is not (off), ADM uses a combination of the enable/disable schedule provided for each bus, and a k-means clustering model (with two centers) fitted to a circuit's voltage data. For this model, hours with voltages assigned to the higher value voltage center is classified as an "on" hour, and hours with voltages assigned to the lower value voltage center is classified as an "off" hour.

The process for integrating the bus enable/disable schedule with k-means clustering was as follows:

- The bus enable/disable schedule was aggregated to hourly, and the last enable/disable value in the schedule was used for each hour with more than 1 value, Then, the schedule data was then joined to the voltage data
- Days where schedule was ENABLED but clustering showed too high of voltage (unscheduled OFF) were removed – ~14% of data
- Days where there was more than 1 transition period were removed –~1% of the data
- Days where there was a transition period, and the day could not be classified as an ON day or an OFF day using k-means clustering–~3% of the data

A manual inspection of all circuits' CVR mode classifications was also performed, and any misclassifications through the k-means clustering method were corrected. Data that was not labeled correctly in the initial bus enable/disable schedule was removed from the final analysis.

Extreme outlier removal

In some instances, usage values can be extremely high or low. There are many different reasons this could occur, such as loads being temporarily shifted between circuits due to substation maintenance, extreme and unusual conditions that impact substation usage, or simple data recording errors. While these extreme values are rare, they have potential to have a large negative impact on the quality of a linear regression model. Due to this, any value that is it is more than 1.5 * IQR above the third quartile or 1.5 * IQR less than the first quartile is considered an extreme outlier and removed from the analysis.

Creating a representative 50:50 sample of ON and OFF days

For the most accurate results, the data that is input into the regression consists of an approximately equal number of data points where CVR was on and off under like conditions. Since the schedule ADM provided to PSO consisted of approximately one day per week where CVR was off to maximize operational time, this meant filtering down to days adjacent to any days where CVR was off to maximize the likelihood of capturing like conditions. Specifically, each datapoint where CVR was operational is matched with a datapoint where CVR was not operational, within two days[190] of the operational datapoint, and had similar weather. This creates a dataset with an equal number of datapoints where CVR was "on" and CVR was "off".

Regression Analysis

The on/off regression analysis for CVR is the accepted industry standard for evaluation of voltage control technologies.[191] The regression model configuration used for this analysis is described in the equation below.

$$kWh_t = \beta_o + \beta_1 * Mode_t + \beta_2 * CDD_t + \beta_3 * WeatherVar2_t + \beta_4 * DayType_t + \beta_\theta * Hour_t + e_t$$

Where:

t = the hourly interval the model is predicting usage for

$Mode_t$ = 1 if CVR is on during time t; 0 otherwise

[190] For the Catoosa substation, three days was used. Downline data was used to evaluate this substation; as a result, there were fewer datapoints available.

[191] 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

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

$DayType_t$ = the hourly interval the model is predicting usage for

$Hour_t$ = 1 if CVR is on during time t; 0 otherwise

The coefficient β_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.

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. The equation below shows how this value is calculated.

$$CVR\ Factor = \frac{\%\Delta\ Energy\ Consumption}{\%\Delta\ Voltage}$$

Where:

$\%\Delta\ Energy\ Consumption$ = the % reduction in energy consumption when CVR is operational vs. not operational, as estimated in the regression analysis

$\%\Delta\ Voltage$ = the average % reduction in voltage when CVR is operational vs. not operational

There were some instances where valid CVR factors could not be generated for a given circuit-phase combination. If a model could not be generated that showed a significant correlation between CVR being on and energy usage or the CVR factor produced was either negative or greater than 2.5, the CVR factor for the given circuit-phase combination was generated through an average of either:

- The other phases on the circuit for the given season
- If none of those circuits had robust models with CVR factors between 0 and

2.5, an average of phases from circuits on the same bus was used

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 as follows.

Where available, ADM uses voltages from circuit regulators. We will take a weighted mean across the line voltage regulators (where the weights are determined by the load for each regulator section) in both their off and on conditions. Regulator voltages represent operating conditions accurately in cases where the substation is operated on a load tap change (LTC) system. LTC's have limited functionality due to operating in a "gang" related manner: if one phase is raised, all three must be raised and vice versa. This creates a limit in the system's ability to lower voltage both due to load imbalances between phases and from geographic limitations. For imbalanced phases, the minimum achievable voltage on one phase limits the change in voltage on the other phases (i.e., Phase B with an operational midline around 120 volts will not be able to achieve lower voltages if Phase A is already at its' lower limit). Geographic limitations exist in systems that include a large variety of conductor sizing and load locations. This mainly applies to rural areas where there may be three feeders on one transformer, but each feeder has a very different distribution of load.

Regulator stations provide the ability to isolate voltages along the line for providing a more accurate representation of the system voltage profiles. If this data is not available, has significant missing data, or if the data is counterfactual (example: voltage is regularly listed as being lower at the circuit's feeder head than at the regulator stations), then this method is not used to determine the voltage profile

Where regulator voltage and kilowatt-hour data are not available, ADM uses the operational voltages from the feeder head, from the year before CVR was installed. In this method, the baseline condition is determined to be the pre-installation operational voltages from the feeder head. Applying the pre-installation voltages helps account for the efficiency improvements made by new equipment (capacitor banks, regulator stations, etc.) that otherwise would not be detected in the "off" condition after the new equipment installation. Note that in some cases pre-installation voltages are not available. In these cases, the baseline voltage profile used is simply the average voltage across all hours where CVR was not operational.

For PY2022, regulator data was available for the Catoosa and Clinton Junction substations, and it was used for circuits within the Catoosa substation only. This determination was made through a comparison of the models produced with the regulator and feeder head voltage data. More than twice the number of circuit-phase combinations in the Catoosa substation produced models with statistically significant response variables when the regulator voltage was applied compared to the feeder head voltage (Table G-50). In contrast, when the same comparison was made, the number of Clinton Junction circuit-phase models with statistically significant response variables decreased by five (Table G-51).

Table G-50: CVR Comparison of Regression Model Results--Catoosa

Cooling Season					
Circuit	**Phase**	**Response Variable T-Statistic from Feeder Head Model**	**Response Variable T-Statistic from Regulator Model**	**CVR Factor from Feeder Head Model**	**CVR Factor from Regulator Model[192]**
O1	A	NS[193]	NS	0.32	0.15
O1	B	NS	-2.70	0.33	0.92
O1	C	NS	-2.61	0.09	0.90
O2	A	-1.72	-2.26	0.58	0.54
O2	B	NS	-1.87	0.17	0.50
O2	C	NS	-4.42	0.13	1.76
O3	A	-2.78	-2.14	0.89	0.52
O3	B	-1.83	NS	0.65	0.41
O3	C	NS	NS	0.19	0.37
O4	A	-4.47	-5.22	1.29	1.16
O4	B	NS	NS	-0.27	-0.06
O4	C	-3.28	-4.07	0.91	1.00
Heating Season					
Circuit	**Phase**	**Response Variable T-Statistic from Feeder Head Model**	**Response Variable T-Statistic from Regulator Model**	**CVR Factor from Feeder Head Model**	**CVR Factor from Regulator Model**
O1	A	NS	-3.27	0.11	1.86
O1	B	NS	-2.80	-0.23	2.24
O1	C	NS	-2.84	-0.05	1.95
O2	A	NS	NS	0.36	-0.28
O2	B	NS	NS	0.35	-0.34
O2	C	NS	2.08	0.35	-0.59
O3	A	-2.19	-3.93	0.76	2.05
O3	B	NS	-4.27	0.40	1.93
O3	C	NS	-4.67	0.33	1.99
O4	A	-1.78	NS	0.28	0.26
O4	B	NS	NS	0.11	0.21
O4	C	NS	-2.27	0.26	0.39

[192] Unadjusted CVR factor
[193] Not statistically significant

Table G-51: CVR Comparison of Regression Model Results—Clinton Junction

Cooling Season					
Circuit	**Phase**	**Response Variable T-Statistic from Feeder Head Model**	**Response Variable T-Statistic from Regulator Model**	**CVR Factor from Feeder Head Model**	**CVR Factor from Regulator Model**[194]
CJ11	A	-2.78	-2.62	0.89	1.64
CJ11	B	-3.09	-2.92	1.06	1.90
CJ11	C	-3.85	-2.93	1.44	2.01
CJ15	A	-2.69	-2.89	1.04	1.99
CJ15	B	-6.49	-3.76	2.15	1.38
CJ15	C	-3.09	-2.38	1.18	1.26
CJ17	A	NS[195]	NS	-0.45	-1.14
CJ17	B	NS	NS	-0.08	-0.32
CJ17	C	NS	NS	0.03	-0.76
Heating Season					
Circuit	**Phase**	**Response T-Statistic from Feeder Head Model**	**Response T-Statistic from Regulator Model**	**CVR Factor from Feeder Head Model**	**CVR Factor from Regulator Model**
CJ11	A	NS	NS	0.39	-0.10
CJ11	B	-1.70	NS	0.64	0.28
CJ11	C	-1.89	NS	0.71	0.20
CJ15	A	-2.20	NS	0.82	0.50
CJ15	B	-4.05	-2.44	1.35	0.63
CJ15	C	-1.80	-1.65	0.61	0.49
CJ17	A	-1.96	NS	0.59	0.28
CJ17	B	-2.24	NS	0.70	0.30
CJ17	C	-2.54	-1.83	0.71	0.55

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. The equation below shows how average daily percent usage reductions are calculated using the CVR factors estimated in previous steps.

$$DailySavingsPercent = CVRFactor * \%\Delta\, Voltage$$

Where:

$CVRFactor$ = The CVR factor

[194] Unadjusted CVR factor
[195] Not statistically significant

$\%\Delta\, Voltage$ = the average % 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 3-7 shows this calculation.

Equation 5-3: Season Savings Calculation

$$SeasonSavings = (DailySavingsPercent * DailyBaselineEnergyUsage) * sdays$$

Where:

$DailySavingsPercent$ = Average daily % reduction in energy consumption

$DailyBaselineEnergyUsage$ = 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.

G.1.11.3 Methodology Changes Unique to Specific Circuits

Most circuits go through the same process for data cleaning, analysis, and results calculation. However, there were some special cases during PY2022 in which certain circuits needed to be evaluated differently than the others. Table G-52 shows each circuit/season combination that had a unique step in its evaluation, as well as the reason this unique step was needed.

Table G-52: Unique On/Off Analysis Steps

Circuits	Season	Description
All Catoosa circuits (O1-O4)	Both	Circuits on this substation showed no correlation between the second weather variables (lagged CDD in the cooling season and CDD in the heating season) and energy usage. Because of this, the regression analysis for this substation did not include the secondary weather variables that were used in all other models.
L8, O1 and O3	Heating	t-tests on the explanatory variables in the heating season models for L8, O1 and O3 showed that the *DayType* variable did not have a significant impact on energy usage. This variable was therefore removed from the models.
L1, L3, L5, L7	Heating	CVR on these circuits was not performed during the heating season. Therefore, ADM assumed zero savings for the heating season.
L2, L4, L6, L8	Heating	CVR on these circuits was not performed until Dec 2022. Therefore, data from Jan. 2023 was also used for modeling these circuits.
CJ17	Cooling	ADM assumed zero savings attributed to CVR for CJ17 in the cooling season. This determination was made because robust models could not be generated for CJ17 in the cooling season, the distribution of energy load between sectors was significantly different between CJ17 and the other two circuits on the Clinton Junction substation (chi-squared test, $p < 0.0001$), and the modeling structure was different for CJ17 compared to CJ11 and CJ15.
O2	Heating	ADM assumed zero savings attributed to CVR for O2 in the heating season because robust models produced negative CVR factors for all phases for this circuit. Additionally, since all Catoosa models used regulator voltage data, CVR factors could not be extrapolated from other circuits on this substation.

G.2 Demand Response Programs

G.2.1 Power Hours Program

The impact of the Power Hours Program is measured by the peak reduction (kW) and energy savings (kWh) during DLC events. This section defines how these savings are calculated.

Power Hours program consists of a direct load control program: DLC. Tracking data for this program, provided by PSO, is used to identify which devices are available to participate in each event. An available device is defined as a device registered with PSO as part of the DLC program. An available device could become unavailable only if the customer in possession of the device decided to permanently opt out of the subprogram.

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. 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. The equation below shows how temperature is converted to CDD.

$$CDD_t = \begin{cases} 0 & if\ temp_t < cddbase \\ (temp_t - cddbase) \ / \ 48 & if\ temp_t \geq cddbase \end{cases}$$

Where,

$temp_t$ = temperature at time t

$cddbase$ = determined CDD base temperature

To calculate the most accurate CDD values, the optimal CDD base temperature for the evaluated population was determined. Intuitively, the CDD base temperature can be thought of as the coolest temperature in which energy usage begins increasing due to the operation of A/C units. The optimal CDD base temperature for the participant population was determined by running several possible CDD base temperature values through the following process.

- Temperature values are converted to CDD using the hypothetical CDD base.
- A linear regression model is fit to predict energy usage during the months of May through August, using only the CDD values.
- The model is scored by calculating the root mean squared error of its predictions.

The CDD base temperature that produced the model with the smallest root mean squared error score is the value chosen. In PY2022, the optimal CDD base temperature for the participant population was determined to be 70°. All weather data is retrieved from airports in the following Oklahoma cities: Tulsa, Lawton, Bartlesville, Chickasha, Elk City, and Okmulgee. Each household is matched with weather data from the location it was nearest to geographically.

Once the necessary data is processed, the devices that participate in the DLC events are identified. Tracking data provided by PSO is used to identify which devices are available to participate in each event. An available device could become unavailable only if the customer in possession of the device decided to permanently opt out of the subprogram.

Because customers can manually override the DLC curtailment signal or various technical failures may occur, not every available device participates in the events. Thus, devices that are non-responsive to the called events need to be identified so that the calculation of energy savings included only devices that participate in the event.

A device is considered a non-responsive device (NRD) if it does not respond to the curtailment signal sent by PSO. NRDs are identified depending on the types of meters. The detailed participating information is available for all devices at every 15-min interval during each DLC event except Google Nest thermometers, which does 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. These three tests are run on every available Google Nest device for every event date.

Tests 1 and 2 analyze the cumulative sum (CSUM) change in energy usage of each device to check for a significant change in energy usage before and during an event. To do this, the cumulative sum of each site's energy usage is calculated as follows.

$$x = (i_1, i_2, i_3, \ldots, i_{48})$$

$$CSUM(x) = (i_1, i_1 + i_2,\ i_1 + i_2, + i_3, \ldots, i_1 + \ldots + i_{48})$$

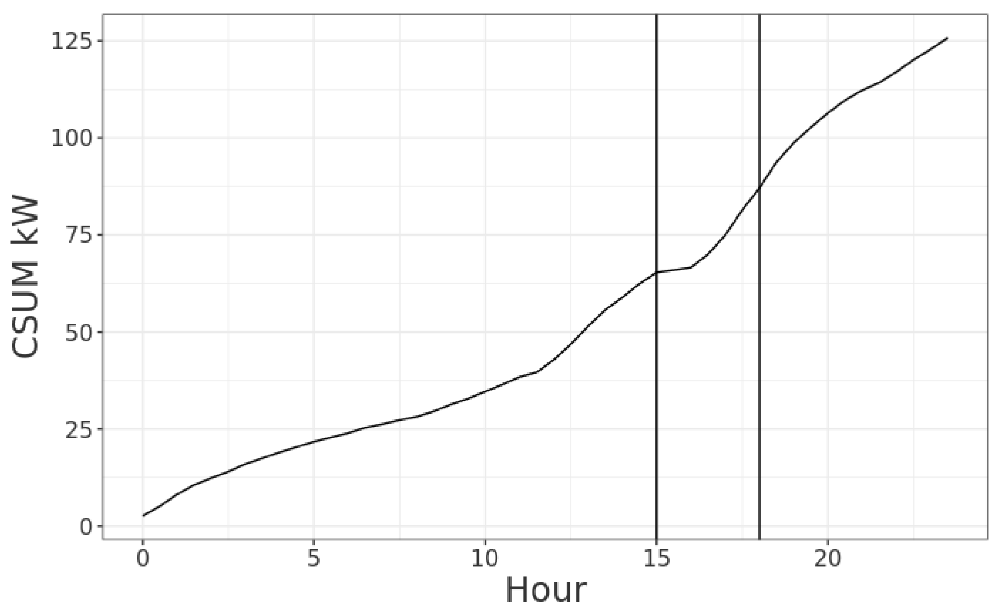
Where,

x = a vector of kW measures taken at 30-minute intervals,

$i_1 : i_{48}$ = the 24-hour interval from 12am to 12am the following day.

This creates a "running total" of power used throughout the day providing a way to quantify how the rate of energy consumption changed throughout the day. Figure G-5 shows an example of the CSUM curve for one responding device during a DLC event. The vertical lines represent the start and end of the event period.

Figure G-5: Example of Site-level CSUM Changes



To quantify how the rate of energy usage changes once the event started, a slope ratio is calculated for the CSUM curve of each device on each event day (Equation G-48).

Equation G-48: Slope Ratio Calculation

$$SlopeRatio = s_{event}/s_{pre.event}$$

Where,

s_{event} = slope of the CSUM curve during the event

$s_{pre.event}$ = slope of the CSUM curve three hours prior to the start of the event

For Test 1, if the slope ratio was greater than or equal to 1 the device was identified as non-responding.

Equation G-49: NRD Test 1

$$NRD_{T1} = SlopeRatio_{event} \geq 1$$

Where,

$SlopeRatio_{event}$ = Slope ratio of the CSUM curve

For Test 2 an expected (or site normal) CSUM curve is created for each site using the average hourly consumption of the previous seven non-event weekdays. Next, the slope ratio is calculated for the actual CSUM curve and the site normal CSUM curve. If the slope ratio for the actual curve is greater than or equal to the slope ratio for the site-normal curve, the device is considered non-responding.

Equation G-50: NRD Test 2

$$NRD_{T2} = SlopeRatio_{event} \geq SlopeRatio_{site.normal}$$

Where,

$SlopeRatio_{event}$ = Slope ratio of the CSUM curve

$SlopeRatio_{site-normal}$ = Slope ratio of the site normal CSUM curve

Finally, Test 3 tests for a 10% reduction in hourly consumption. For each device, the consumption one hour before the event started and the consumption one hour after the event started are tested for a drop greater than 10% (Equation G-51). The value of 10% is the average value found from an extensive review of drop percentages found in similar programs.

Equation G-51: NRD Test 3

$$NRD_{T3} = T1_{kWh} \leq T2_{kWh}$$

Where,

$PreHr_{kW}$ = kW measured one hour before the event start

$EventHr_{kW}$ = kW measured one hour after the event start

$T1_{kWh} = PreHr_{kWh} - EventHr_{kWh}$

$$T2_{kWh} = PreHr_{kWh} * 10\%$$

Next, baseline energy usage curves are developed. These are used to estimate what energy usage would have been during an event day had the event not occurred. For each event, this counterfactual baseline is developed using AMI data from all responding devices during non-event, non-holiday weekdays that had similar weather to that of the event day being analyzed.

The k-means clustering algorithm is used to identify similar weather days to each event day. Average daily temperature and humidity is calculated for every non-holiday weekday from June to August. Then the k-means clustering algorithm is applied to the daily weather data. This method splits every day into one of 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 determined what data is used to calculate each event's baseline curve, a linear regression model is calculated using that data (Equation G-52).

Equation G-52: Baseline Energy Usage Curve Regression Model

$$kW_t = CDD_t + CDD_{t-2} + t$$

Where:

t = the 30-minute interval for which kW usage is being predicted

CDD_t = cooling degree days at time t

CDD_{t-2} = cooling degree days one hour before t

To ensure the baseline curves are as accurate as possible, a normalizing factor is calculated and applied to the baseline curve of each event day (Equation G-53).

Equation G-53: Normalization Factor Calculation

$$nf = kW_{actual.hour=es-2} \,/\, kW_{baseline.hour=es-2}$$

Where:

$kW_{actual.hour=es-2}$ = kW measured two hours before the event

$kW_{baseline.hour=es-2}$ = kW predicted by the baseline two hours before the event

With the baseline curve determined, demand reduction can be calculated. Demand reduction represents the average decrease in energy usage that occurs for the average event participant during a given time interval. Demand reduction is calculated for the event period and the snapback period. Equation G-54 shows the formula for calculating demand reduction.

Equation G-54: Demand Reduction Calculation

$$kW_t^{reduction} = kW_t^{baseline} - kW_t^{actual}$$

Where:

t = the 30-minute interval for which demand reduction is being calculated

$kW_t^{baseline}$ = kW demand predicted by the baseline at time t

kW_t^{actual} = kW demand measured at time t

Demand reduction is then used to calculate average annual energy savings for each event. The equation is shown in Equation G-55.

Equation G-55: DLC Event Energy Savings (kWh) Calculation

$$kWh_{saved} = \sum_{t \in EventPeriod} (\frac{kW_t^{reduction}}{2})$$

Where:

t = the 30-minute interval for which energy savings is being calculated

$EventPeriod$ = all time intervals from event start to two hours after the event end

$kW_t^{reduction}$ = demand reduction calculated at time t

Peak reduction is calculated for each event, representing the maximum drop in energy usage that occurred for the average event participant. The equation is shown in Equation G-56.

Equation G-56: Verified Peak Reduction (kW) Calculation

$$kW_{reduced} = max_{\,t \in EventPeriod}\,(kW_t^{reduction})$$

Where,

t = the 30-minute interval for which energy savings is being calculated

$EventPeriod$ = all time intervals from event start hour to the event end hour

$kW_t^{reduction}$ = demand reduction calculated at time t

G.2.2 Peak Performers Program

Baseline energy demand curves are developed for each premise using the provided data. These are used to estimate what energy demand would have been during an event day had the event not occurred. Baseline demand curves are calculated using a “Best X of Y days” methodology. The baseline curves are calculated by applying the following algorithm to each premise:

1. For an event day *D*, *D(h)* is the participant’s actual electric demand at hour h on *D*.

2. Starting with the day before *D*, the eligible baseline days are the most recent Y all non-event, non-holiday[196] weekdays.
3. For each of the eligible baseline day, the average midday electric demand is calculated. In this context "midday electric demand" is defined as the average demand that occurred during the event period hours of event day D. The eligible baseline days are ranked in descending order of this average peak time demand.
4. The hourly loads are averaged for the top X days identified in the previous step. This is the unadjusted baseline, $\mathrm{B(h)}$. X can be any number from 3 to Y. For example, a model where X = 5, Y = 10 is referred to as a "Best 5 of 10" model.
5. If, calculated baseline is adjusted by three methods to get a normalized baseline $\mathrm{B_n(h)}$.:
    a. Additive adjusted: Calculate the difference between the actual usage and baseline during 11:00~13:00 on event days, and this difference is added to the hourly usage during the whole event day. This means a constant shift of the baseline curve:

    Equation G-57: Additive adjustment method

    $$B_n(h) = B(h) + \frac{1}{3} \sum_{t \in [11,12,13]} \big(A(t) - B(t)\big)$$

    b. Scalar adjusted: Calculate the ratio between the actual usage and baseline during 11:00~13:00 on event days, and this ratio is multiplied with the hourly usage during the whole event day. This means a constant scalar adjustment:

    Equation G-58: Scalar adjustment method

    $$B_n(h) = B(h) \times \frac{\sum_{t \in [11,12,13]} A(t)}{\sum_{t \in [11,12,13]} B(t)}$$

    c. Weather adjusted: A regression relationship is developed between hourly temperature $T(\mathrm{h})$ and usage during all non-weekend, non-holiday, and non-event days during July and August:

    Equation G-59: Temperature-based regression

    $$A(h) = k_h \times T(h) + b_h$$

[196] 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 for a complete list.

where k_h and b_h is regression slope and intercept, respectively. The baseline is then adjusted based on the difference between the hourly temperature during event and non-event days:

Equation G-60: Weather adjustment method

$$B_n(h) = B(h) + k_h \times \left(\frac{1}{N} \sum_{d=1}^{N} T_d(h) - T(h) \right)$$

where d is a non-weekend, non-holiday, and non-event day during July-August 2022, and N is the total number of such days. $T_d(h)$ is the temperature at hour h on day d.

Though the general methodology is the same, ADM calculates multiple different variations of "Best X of Y days" baseline curves. These variations are detailed in Table G-53.

Table G-53: Peak Performers Baseline Models

Model Variation	Description
10 of 10 Unadjusted	Model with 10 baseline days selected and without any adjustment.
10 of 10 Scalar Adjusted	Model with 10 baseline days selected with a scalar adjustment.
10 of 10 Additive Adjusted	Model with 10 baseline days selected with an additive adjusted.
10 of 10 Weather adjusted	Model with 10 baseline days selected with a weather-based adjustment.

ADM then ranks the fitting models for each premise number. To choose the most accurate baseline model for each premise, ADM tests each model's performance on the 30 weekdays during the program year where energy demand is highest during typical demand response hours for a given premise. These days are chosen from all non-event, non-holiday[197] weekdays during the months of June to August. These days will be referred to throughout this document as "proxy event days".

Performance is 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. RRMSE is calculated by taking the root mean squared error (RMSE) of a premise's baseline curve and dividing it by the mean of that premise's actual, observed kW demand values. This provides an error metric that is represented as a percentage,

[197] 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 for a complete list.

allowing ADM to compare model performance across premises with different magnitudes of energy consumption. The RRMSE calculation is defined in Equation G-61.

Equation G-61: Relative Root Mean Squared Error

$$RRMSE = \frac{\sqrt{(\sum_{t=1}^{N}(base_t - act_t)^2)/N}}{(\sum_{t=1}^{N} act\ _t)/N}$$

It has been ADM's experience that baseline estimation methodologies often produce consistent results, but in some cases, these estimations can produce divergent results. To minimize calculation bias, results are combined as a weighted average of the four models for each premise. The weights are calculated by taking the inverse square of the model's RRMSE. For example, if the three best fitting models have RRMSEs of 5%, 11%, 25%, and 52% respectively, their relative weights will be 80%, 16%, 3%, and 1% respectively.

Appendix H: Overview of ADM Associates

ADM Associates is a professional services corporation providing research and consulting services in applied energy engineering and economics to utilities and other clients nationwide. The services ADM provides primarily relate to comprehensive energy research and energy-efficiency program implementation and evaluation. ADM's headquarters are in Sacramento, California with regional field offices in Nevada (Reno), 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. It is trained that body harnesses are required when being lifted by a man lift or bucket, although we also train to avoid the use of lifts. If rooftops need to be accessed, our field staff is trained to identify if it is safe to be there and the requirements for perimeter protection. For those that will make electrical measurements, electrical safety training is given for new hires and periodically reviewed for all employees working in such conditions. Electrical safety training includes the use of PPE and the voltage the PPE is appropriate for use around. Arc flash training reinforces the reason for using PPE. ADM does not conduct any measurement activity on systems over 500 Volts. Other training includes exposure to asbestos, lead, and hydrogen sulfide. Employees are trained to follow safety procedures and there are consequences for not following proper procedures which can include termination of employment.