2019-2020 LOW INCOME WEATHERIZATION

2019-2020 Impact and Process Evaluation Final Report

Puget Sound Energy

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Table of Contents

List of Figures

List of Tables

Primary Contact: Geoff Barker, Senior Consultant, Markets and Risk DNV Energy Geoff.Barker@dnv.com
Project Sponsor Jon Taffel, Head of Section, Markets and Risk DNV Energy Jonathan.Taffel@dnv.com
PSE Contract Manager Kasey Curtis, Senior Market Analyst, Evaluation and Research Puget Sound Energy Kasey.Curtis@pse.com

1 EXECUTIVE SUMMARY

This report summarizes the results of the impact and process evaluations of Puget Sound Energy's (PSE) 2019 and 2020 Low Income Weatherization program.

1.1 Introduction

1.1.1 Program Description

PSE's Low-Income Weatherization (LIW) program seeks to reduce the energy-cost burden of low-income households by improving the energy efficiency of their homes and by educating them on ways to reduce their energy use. The program targets single family homes, multifamily buildings, and manufactured homes.

LIW provides many cost-effective weatherization measures to participating households at no-cost, including building envelope improvements, heating and water heating systems, lighting, and appliance upgrades. It also provides energy related repairs and education (including repairing roof leaks, water heaters, and furnaces).

The program is implemented by 10 community action agencies (CAA) and installation contractors. The agencies perform customer income eligibility assessments, energy audits of homes, install weatherization measures, and inspect completed projects.

PSE households whose income is at or below 200% of the federal poverty line (FPL) or 60% of the state median income, whichever is greater based on household size, were eligible to participate in the program during the evaluation period. CAAs recruit customers who meet the income eligibility criteria for participation from PSE's Energy Assistance Program, which is a bill pay assistance program.

1.1.2 Study Background and Research Objectives

There are seven key research questions for this evaluation. Research questions 1 through 6 primarily inform the impact evaluation, while questions 7 through 10 primarily inform the process evaluation.

1. What are the claimed and evaluated whole-home electric and gas savings?
2. What percent of savings claimed can be verified?
3. What was the pre-retrofit building condition?
4. What is the post-retrofit building condition?
5. What are the measure level claimed savings?
6. What are the sources of claimed measure level savings?
7. Does the program increase resident comfort?
8. What is the level of resident awareness of the program?
9. What is the level of participants' satisfaction with the program and program process?
10. What are the perceived barriers preventing greater program participation?

1.2 Impact Evaluation Approach

We used data from participants in PSE's 2019 and 2020 LIW program to model change in both electric and gas consumption and quantify energy savings. Our analysis was based on a two-stage modeling approach that estimates the

effect of program measures on energy consumption. The approach uses variable degree-day PRISM-inspired site-level models combined with a matched comparison group to estimate program-level effects in a difference-in-difference (DID) framework.

The two-stage approach has a long track record in energy program evaluation and is attractive for a variety of reasons including:

- Site-level focus
- Full use of weather information at the daily level
- Separation of the weather-normalization process from savings estimation
- Use of a comparison group as a proxy for non-program-related change

This methodology is consistent with the approach laid out in the Uniform Methods Project (UMP) Chapter 8, which provides whole-house savings estimation protocols for energy efficiency interventions that have whole-home impacts like heating and shell measures.[1] It is also closely related to all other forms of program analysis that use energy consumption data, including time-series, cross-section approaches.

1.3 Impact Evaluation Results

We were able to determine 80% of the claimed savings used in the tracking data were deemed savings from PSE's technical reference manual. The remaining 20% were sourced from various calculated and customer studies and adjusted to reflect conditions in PSE's service territory. Our impact evaluation indicated that PSE's LIW program delivered 80% of claimed electric savings over the two program years of 2019 and 2020. This reflects an electric savings realization rate, evaluated savings relative to claimed savings, of 64% for single family homes and 85% for each of multifamily and manufactured homes (Table 1).

Table 1. Total claimed and evaluated electric savings, 2019-2020

Dwelling type	No. of Homes	Claimed (kWh)	Evaluated (kWh)	Realization Rate
Manufactured Home	428	1,310,558	1,118,731	85%
Multifamily	168	1,647,960	1,406,747*	85%
Single family	337	931,502	597,423	64%
Total	933	3,890,020	3,122,901	80%

* Based on proxy savings estimates

On the gas side, our ex-post evaluation indicates PSE's LIW program saved 74% of claimed savings. This reflects a gas savings realization rate of 73% for single family homes, 73% for multifamily and 103% for manufactured homes.

Table 2. Total claimed and evaluated gas savings, 2019-2020

Dwelling type	No. of Homes	Claimed (therms)	Evaluated (therms)	Realization Rate
Manufactured Home	10	896	920	103%
Multifamily	25	16,740	12,229*	73%
Single family	119	23,294	17,017	73%
Total	154	40,930	30,166	74%

* Based on proxy savings estimates

1.4 Process Evaluation Approach

[1] Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. The Uniform Methods Project. https://www.nrel.gov/docs/fy17osti/68564.pdf

The process evaluation was designed to provide information on how to improve program processes and increase program participation. There were three data collection activities that helped inform the process evaluation:

1. A telephone survey of Low Income Weatherization program participants
2. An interview with PSE LIW program staff
3. Interviews with agencies responsible for implementing the LIW program.

The program staff and agency interviews were designed to understand program challenges, opportunities, recent program changes, and planned changes from the perspective of program administrators. The telephone surveys were designed to assess program awareness, satisfaction, program benefits, and motivations for participation from the perspective of program participants.

1.5 Process Evaluation Results

LIW participants who responded to the telephone were asked how they first learned about the program and services made available to them. The most frequently cited sources of first learning about the program were either their housing agency representative (41%) or word of mouth (26%). These results help illustrate that the LIW program is driven and implemented by the community action agencies (CAA) and that participants' first point of contact is often a CAA representative.

Participants were also asked about their satisfaction with various aspects of the program using a 5-point scale, where 5 means "very satisfied" and 1 means "very dissatisfied." Seven distinct aspects were covered with the intention of capturing satisfaction of various aspects of the program, from the home inspection process to the comfort of their home since receiving the upgrades. Respondents were also asked about their satisfaction of the program overall. All categories yielded moderate to high average satisfaction scores, ranging from 4.2 to 4.8. The only two aspects of the program that received an average satisfaction score lower than 4.5 were the home inspection process and energy savings since receiving upgrades; these two aspects received an average satisfaction score of 4.3 and 4.2, respectively. With respect to overall satisfaction with the LIW program, the average rating was 4.5. These results suggest the program is running well and that participants are generally satisfied with their experience and the measures they had installed.

Survey respondents were asked about the primary reason that they decided to participate in the program. Over half of the respondents (53%) said that they participated in the program to save energy and money. The second most cited reason for program participation was due to being qualified for the benefits at no cost (28%).

Evaluators asked LIW participants about program benefits that go beyond saving energy and specifically whether they experienced improved comfort, air quality, safety, or their home being quieter. The vast majority of participants (87%) experienced at least one of these benefits.

DNV discussed barriers to increasing participation in the LIW program with representatives from three housing agencies responsible for implementing the program. Agencies listed several barriers to increasing participation in the program, including constraints related to budget, staffing, and expertise:

- Budget constraints
- Stable and predictable funding from the state
- Staffing shortages or lack of in-house expertise
- Finding and retaining qualified contractors

An agency representative noted that PSE has been helpful with addressing certain funding issues. Particularly, PSE has provided funding for repairs beyond the installation of program measures.

Additional barriers cited include:

- Federal and state rules and regulations, which can become burdensome
- Hiring qualified contractors who meet the state's prevailing wage requirements
- Persuading landlords to make upgrades to their tenants' homes or apartments even when most or all of the cost is covered
- Gaining trust among some low-income customers living in rural areas who are distrustful of government agencies and other non-government organizations

1.6 Findings and Recommendations

The key findings from the impact evaluation include:

- The LIW program met one of its primary goals of reducing the energy cost burden of participating low-income customers. Low-income customers used 14% to 18% less electricity and 17% to 26% less gas.
- Savings from installations were lower than claimed, but still notably high.
    - Electric installations from the LIW program achieved 80% of the claimed savings.
    - Gas installations from the LIW program achieved 74% of the claimed savings.
- Throughout this evaluation, COVID-19 prevented evaluators from conducting any substantial field data (outside of virtual verification efforts). With this limitation, evaluators identified a consumption analysis as the best available evaluation approach. However, in any multifamily program, a consumption analysis faces an array of challenges (such as how to include the savings in public areas and dwelling units and difficulties associated with defining robust comparison groups, etc.). In light of these challenges, the most robust adjustments evaluators could make to multifamily savings estimates were to apply LI single family and mobile home realization rates (based on matching measures) as proxy results.

The key findings from the process evaluation include:

- Customer contact information, particularly for multifamily participants was not provided for all participants.
- The LIW program is driven and implemented by the community action agencies (CAAs) who play a key role in outreach efforts to find low-income candidates for program participation. Findings from the participant telephone surveys suggest that a housing agency representative was often the first point of contact for participants and the source of their awareness of the program.
- Overall satisfaction with the LIW program was high among participants with an average rating of 4.5 on a 5-point scale. Ratings for different aspects of the program generally averaged 4.5 or higher. One notable exception was the average satisfaction score that participants gave with the energy savings they received since receiving upgrades from the program, which was 4.2. Participants may have felt that they would see larger savings on their energy bills than what they actually experienced.
- CAA representatives cited a number of barriers to increasing LIW program participation. Several of these barriers are beyond the control of the CAAs and PSE, such as federal and state regulations and funding constraints. Other

challenges that CAAs mentioned were persuading landlords to make upgrades to their tenants' homes and gaining trust among a segment of low-income customers who are distrustful of government agencies or other agencies that receive federal and/or state funding.

Based on key findings, we have the following recommendations:

- The current electric realization rate of 80% is in line with past evaluations (between 80% and 94% from 2013 to 2015) while the gas realization rate of 74% is lower than prior evaluations (113%-149% from 2013 to 2015). While a pre-post consumption analysis offers the most empirical way to measure savings at the meter, it is not always easy to pinpoint the exact reasons for discrepancies between claimed and measured savings. However, we do note that the LIW participant building stock is especially variable. Pre-intervention building conditions can be dramatically different among participants and deemed savings assumptions. PSE could compile and analyze building characteristic data (vintage, condition, customer interviews and assessment of comfort and energy burden) and a participant profile assessment could help reveal additional insight and actionable steps into a given evaluation's results.
- Some LIW participants may be somewhat disappointed in the energy savings they receive from their upgrades. CAAs should coordinate with their contractors to make sure that they are not overpromising on bill savings that participants see as a result of their program upgrades. CAAs and partner contractors should emphasize the non-energy benefits of the program, such as improved comfort and air quality.

2 INTRODUCTION

In this section, we provide an overview of Puget Sound Energy's (PSE) Low Income program, research objectives, impact evaluation methods, and process evaluation methods.

2.1 Program Overview

PSE's Low-Income Weatherization (LIW) is a compliance program operating under electric and gas Tariff Schedule 201. The program seeks to reduce the energy-cost burden of low-income households by improving the energy efficiency of their homes and by educating them on ways to reduce their energy use. The program targets low-income single family residences, multifamily properties and manufactured/mobile homes for energy efficiency improvement and education aimed at reducing energy use and cost.

The program provides many cost-effective weatherization measures to participating households at no-cost including building envelope improvements, and heating and water heating systems, lighting, and appliance upgrades. It also provides energy related repairs and education (including repairing roof leaks, water heaters, and furnaces).

The program is implemented by 10 community action agencies (CAA) and installation contractors. The agencies perform customer income eligibility assessments, energy audits of homes, install weatherization measures using contractors or their own crew, and inspect completed projects. The program is funded through rate-payer fees (conservation rider), company funds, Microsoft Settlement Funds, BPA credits and other state and federal government programs.

PSE households whose income is at or below 200% of the federal poverty line (FPL) or 60% of the state median income (SMI), whichever is greater based on household size, are eligible to participate in the program. In addition, participation by multifamily properties requires that 50% to 67%[2] or more of the units meet the income eligibility criteria. CAAs recruit customers that meet the income eligibility criteria for participation from PSE's Energy Assistance Program (EAP). They also conduct outreach at various community events and centers, such as food banks and senior centers, streamline multifamily eligibility screening, and send communication, including emails, using social media and advertisements that target eligible populations, to increase participation.

The CAAs work with PSE's LIW program manager to prepare annual budgets and participation goals. Table shows the program's expenditures and savings claimed from program participation in 2019 and 2020 and these values as a percent of savings goal and planned budget.

Table 3. LIW program claimed savings and expenditures, 2019-2020

Year	Savings		Percent of savings goal		Expenditures		Percent of planned budget	
	Electric (kWh)	Gas (therms)	Electric (%)	Gas (%)	Electric	Gas	Electric	Gas
2019	2,648,830	18,830	135%	117%	$6,737,232	$914,253	144%	139%
2020	1,241,190	22,101	63%	88%	$5,380,672	$758,178	88%	60%

Sources: 2019 and 2020 Annual Reports of Energy Conservation Accomplishments, Exhibit 1 Savings and Expenditures
2019 and 2020 PSE tracking data

PSE's LIW program provides funding for the following measure categories:

- **Shell** – air sealing, insulation, windows, and duct insulation and sealing

[2] 50% if entirely PSE-funded and 67% if using federal or state funding.

- **Lighting and Appliances** – LED lamps and fixtures and refrigerators
- **Domestic Hot Water (DHW)** – showerheads, aerators, water heaters, and pipe insulation
- **HVAC** – ductless heat pumps, programmable thermostats, ventilation, and heating system replacements

2.2 Research Objectives

There are thirteen key research questions that are part of this evaluation. Table shows the key research questions and which research activities and data sources served as inputs to help answer each question. Research questions 1 and 2 primarily inform the impact evaluation, while questions 8 through 10 primarily inform the process evaluation. Research questions 3 through 9 inform both impact and process evaluation. The last three research questions (11 through 13) provide a review ex ante savings that are the basis of claimed savings. We describe the data sources and research activities in more detail in the sections below.

Table 4. Key Research Questions and Associated Research Activities and Data Sources, 2019-2020

Research question	Data Sources					
	Phone Survey	Program Staff Interviews	Agency Interviews	Consumption Data Analysis	Claimed Savings Review	Program Tracking Data
1. What are the claimed and evaluated whole-home electric and gas savings?				■		■
2. What percent of savings claimed can be verified?				■		■
3. What was the pre-retrofit building condition?	■					
4. What is the post-retrofit building condition?	■					
5. What are the measure level claimed savings?					■	■
6. What are the sources of claimed measure level savings?					■	■
7. Does the program increase resident comfort?	■		■			
8. What is the level of resident awareness of the program?	■					
9. What is the level of participants' satisfaction with the program and program process?	■					
10. What are the perceived barriers preventing greater program participation?	■	■	■			

2.3 Impact Evaluation Overview

We used data from participants in PSE's 2019 and 2020 LIW program to model change in both electric and gas consumption and quantify energy savings. Our analysis was based on a two-stage modeling approach that estimates the effect of program measures on energy consumption. The approach uses variable degree-day PRISM-inspired site-level models combined with a matched comparison group to estimate program-level effects in a difference-in-difference (DID) framework.

The two-stage approach has a long track record in energy program evaluation and is attractive for a variety of reasons including:

- Site-level focus
- Full use of weather information at the daily level
- Separation of the weather-normalization process from savings estimation
- Use of a comparison group as a proxy for non-program-related change

This methodology is consistent with the approach laid out in the Uniform Methods Project (UMP) Chapter 8, which provides whole-house savings estimation protocols for energy efficiency interventions that have whole-home impacts like heating and shell measures.[3] It is also closely related to all other forms of program analysis that use energy consumption data including time-series, cross-section approaches. Details of the comparison group development, and first stage and second stage models are described in Appendix C.

2.4 Process Evaluation Overview

The process evaluation was designed to provide information on how to improve program processes and increase program participation. There were three data collection activities that helped inform the process evaluation:

4. A telephone survey of Low Income Weatherization program participants
5. An interview with PSE LIW program staff
6. Interviews with agencies responsible for implementing the LIW program.

The program staff and agency interviews were designed to understand program challenges, opportunities, recent program changes, and planned changes from the perspective of program administrators. The telephone surveys were designed to assess program awareness, satisfaction, program benefits, and motivations for participation from the perspective of program participants.

2.5 Report Overview

We have organized the remainder of this report as follows:

- Section 3 describes the evaluation's data sources.
- Section 4 details the results of the impact evaluation.
- Section 5 provides the results of the process evaluation.
- Section 6 includes the evaluation's key findings and recommendations.
- Appendix A details the sample design used for the participant telephone surveys.
- Appendix B provides the data collection instrument used for the participant telephone surveys.
- Appendix C details the methods used for the consumption data analysis.
- Appendix D provides additional details on the impact evaluation results.
- Appendix E includes demographic results from the participant telephone survey.

[3] Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol. The Uniform Methods Project. https://www.nrel.gov/docs/fy17osti/68564.pdf

3 DATA SOURCES

We describe the data sources used to inform the impact and process evaluations in the sections below.

3.1 Program Tracking Data

DNV sourced information about program participation from the 2019 and 2020 tracking data that PSE provided. The tracking data provide the number of all program measures, their installation dates, and the amount of energy savings they are expected to generate.

As noted in section 2.1, the LIW program offered measures that improve the condition of building envelopes and energy efficiency of water and space heating equipment and appliances to reduce the energy cost burden of qualifying low-income households. Table summarizes the electricity-saving measures the program offered, along with the expected savings from these measures and the number of homes that received them in 2019 and 2020. Ductless heat pumps and shell insulation measures were the most frequently installed electric measures in both years.

Table 5. Summary of LIW installed electric measures by program year, 2019-2020

Measure Group	2019			2020		
	Total Savings	No. of Homes	Savings per home	Total Savings	No. of Homes	Savings per home
Aerator	355	6	59	146	2	73
Air Sealing	294,919	185	1,594	161,046	112	1,438
Duct Insulation	2,311	6	385	1,000	3	333
Duct Sealing	1,665	29	57	11,250	19	592
Heat Pump	52,297	9	5,811	82,139	15	5,476
Heat Pump - Ductless	1,711,713	447	3,829	605,566	146	4,148
LED	45,175	154	293	0	0	0
Mobile Home Replacement	8,615	1	8,615	16,942	2	8,471
Pipe Insulation	2,380	119	20	744	36	21
Refrigerator	17,102	34	503	11,020	19	580
Shell Insulation	350,610	203	1,727	271,427	161	1,686
Showerhead	1,175	5	235			
Thermostat ELV	1,519	10	152			
Thermostat ESS	1,004	2	502	10,618	2	5,309
Ventilation	67,067	228	294	22,925	114	201
Water Heater - Heat Pump				1,225	1	
Windows	90,924	23	3,953	45,142	15	3,009

Table 6 provides a summary of the gas-saving measures offered through the LIW program along with the number of homes that received each measure and their expected savings. Overall, there were fewer homes receiving gas measures compared to electric measures through the LIW program. The majority of homes received measures aimed at improving the building envelope and the home's heating systems.

Table 6. Summary of LIW installed gas measures by program year, 2019-2020

Measure Group	2019			2020		
	Total Savings	No. of Homes	Savings per home	Total Savings	No. of Homes	Savings per home
Air Sealing	734	43	17	342	19	18
Boiler	6,180	4	1,545	2,096	3	699
Duct Insulation	865	28	31	405	12	34
Duct Sealing	2,158	47	46	851	18	47
Furnace	3,520	32	110	3,520	32	110
Pipe Insulation	23	28	0.8	7	8	0.8
Shell Insulation	4,838	58	83	3,658	45	81
Space and Water Heater	173	1	173	8,832	20	442
Thermostat ESS				858	26	
Water Heater - Storage	84	3	28	28	1	28
Water Heater - Tankless	255	5	51	1,428	28	51
Windows				77	3	26

3.2 Deemed Savings Documentation

The deemed savings are documented in the PSE technical reference manual (TRM) and associated detail files. We obtained a copy of the PSE technical reference manual dated November 20, 2020. We obtained detail files only for measures listed in the PY2019-2020 tracking data that did not have value in the PSE TRM unit savings field.

3.3 Consumption and Weather Data

DNV used energy consumption data obtained from PSE to analyze energy use patterns and changes related to the installation of the measures installed by the LIW program. The consumption data included daily electricity and gas consumption for all of PSE's residential customers from January 2018 through June 2021. DNV also received supplementary information, primarily account open dates and dwelling types, on residential customers used in the study.

The energy consumption data DNV received served three primary purposes. First, they were used to identify customers who did not get program-provided measures (non-participants) and whose energy use patterns can help inform baseline energy consumption. Second, they served as the basis for site-level modeling used to weather normalize energy consumption. Finally, daily data were included in models used to estimate the effect of the program/measure on energy use. Additional information on data preparation and modeling is provided in Appendix C.

We used the site-level models correlating weather data to energy consumption to put consumption on the same weather basis pre- and post-installation to facilitate the comparison of energy consumption. We sourced weather data for 11 weather stations within PSE's service from Automated Surface Observing Systems (ASOS), joint effort of the National Weather Service (NWS), the Federal Aviation Administration (FAA), and the Department of Defense (DOD).[4] We obtained average daily typical meteorological year (TMY) weather data for the selected weather stations that are useful for long-term weather normalization from the National Oceanic and Atmospheric Administration (NOAA). Figure 1 provides a summary of cooling degree days (CDD) and heating degree days (HDD) based on this data.[5] Both the CDD and HDD panels indicate that all years have had more cooling and fewer heating degrees than normal.[6] The CDD panel indicates that pre-program periods, spanning part of 2018 and 2019, have been slightly hotter than post-installation periods, though CDD levels are low

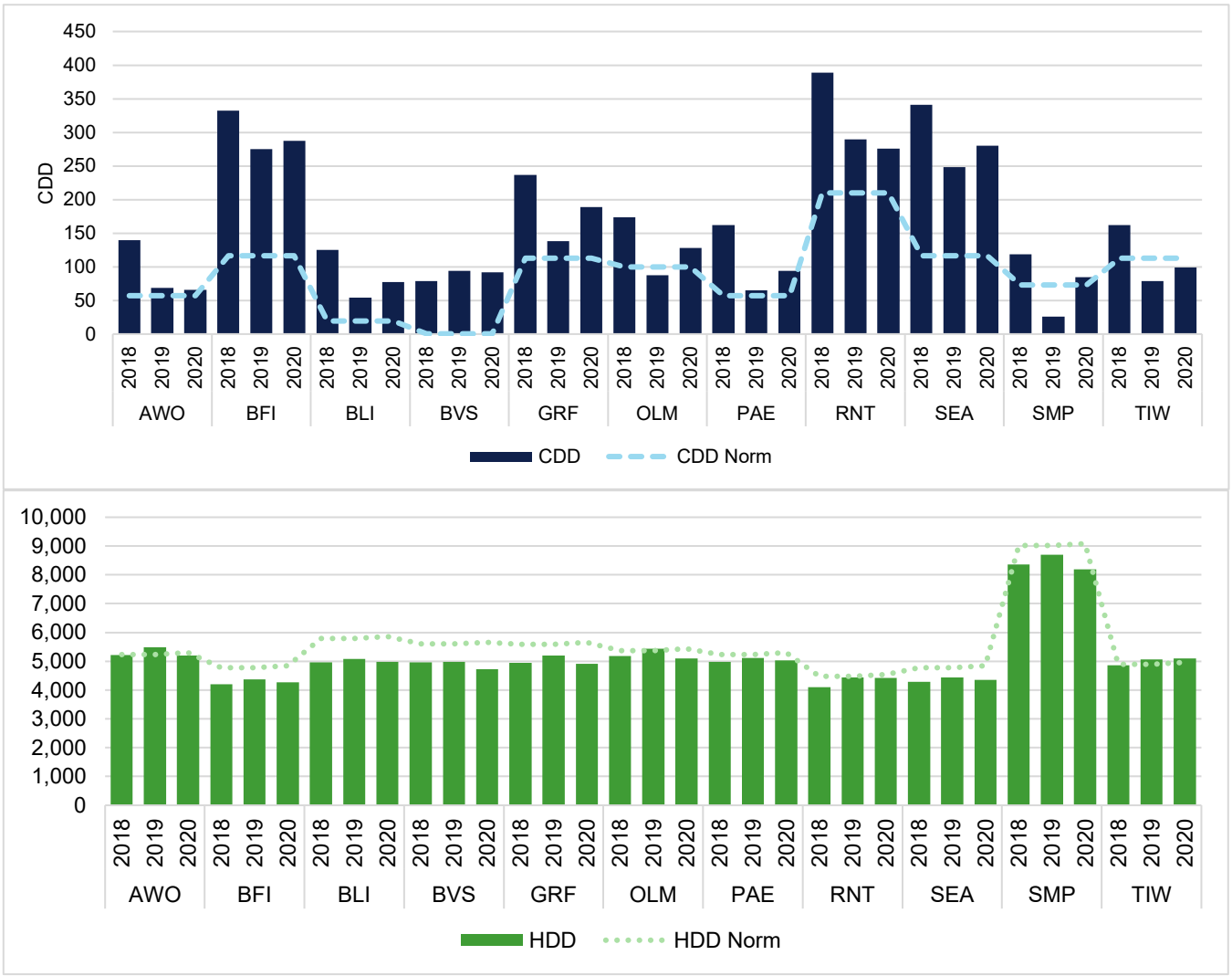
[4] https://www.weather.gov/asos/asostech

[5] HDD and CDD are daily degrees below and above a base temperature, respectively. In this case both HDD and CDD are calculated with average daily temperatures relative to 65 degrees and then summed across the year. Norm CDD and HDD are calculated using the TMY data. TMY data are historical and are not always reflective of recent weather trends. For example, the BVS station TMY data indicates that typical average daily temperatures did not exceed the base temperature for the full year.

[6] For further details on the locations of the weather stations presented in this figure, please see: https://www.faa.gov/air_traffic/weather/asos/?state=WA

throughout. The HDD panel indicates much higher levels of degree days with less obvious variation in heating weather pre- to post-installation periods.

Figure 1. Summary of weather data, 2018-2020, degree days calculated from a base of 65 degrees



3.4 Program Staff Interview

The program staff interview took place in July of 2021 and included PSE's Low Income Weatherization program manager. The primary goals of the program staff interview were to understand any recent and planned program changes, barriers to program participation, marketing and outreach efforts of the program, and PSE's interactions with community action agencies (CAAs) and the low-income customers they serve. Evaluators also inquired about the quality control processes that PSE and the CAAs use with respect to the installation of program measures.

3.5 Agency Interviews

Evaluators spoke with CAA staff responsible for implementing the LIW program in their respective communities. The interviews took place in August of 2021 and involved three agency leads from three different CAAs. Similar to the objectives of the program staff interviews, the primary goals of the agency interviews were to understand any recent and planned

program changes, barriers to program participation, marketing and outreach efforts, and CAA interactions with the low-income customers they serve. Evaluators also inquired about the quality control processes that the agencies use with respect to the installation of program measures.

3.6 Participant Surveys

Evaluators conducted computer-assisted telephone interviews (CATI) with LIW program participants to confirm measure installation and continued operation and to inform the process evaluation. The starting population contained 972 accounts, of which numerous records were missing phone numbers. The sample was significantly improved after PSE provided telephone numbers using its customer account information records and with the assistance of a telephone look up service. After these two processes were completed, the viable sample increased to 790 accounts.

The stratified sample target was 225 respondents with the proportion broken out by home types (50 manufactured homes, 75 multifamily homes, and 125 single family homes). We achieved 100% of the sample target for manufacturer homes, 73% of the target for single family, and only 11% of the target for multifamily homes. The multifamily population significantly fell short of the goal due to incomplete contact information. Across all strata there were 131 fully completed surveys and 135 partially completed surveys, which was 58% of the targeted sample and 17% of the population of participants.

Stratum: Home Type	Population	Sample	Partially Completed Surveys	Fully Completed Surveys	Percent of Target	Percent of Population
Manufactured Home	328	50	50	50	100%	38%
Multifamily	337	75	8	8	11%	2%
Single Family	125	100	77	73	73%	58%
Total	790	225	135	131	58%	17%

4 IMPACT EVALUATION RESULTS

In this section we provide an overview of impact evaluation results, review claimed (ex-ante) savings, and provide details and discussion on evaluated savings results.

4.1 Results Overview

We were able to determine 80% of the ex-ante savings used in the tracking data were deemed savings from PSE's TRM. The remaining 20% were sourced from various calculated and customer studies and adjusted to reflect conditions in PSE's service territory. Our ex-post evaluation indicated that PSE's LIW delivered 80% of claimed electric and 74% of claimed gas savings.

4.2 Reported Savings

1. We performed a review of the reported savings in the tracking data by comparing claimed savings to the deemed savings documented in the PSE TRM. On a savings basis, DNV was able to easily match 80% of the claims in the tracking data to deemed measure savings in the PSE TRM. DNV and PSE are identifying ways to streamline verification efforts in the future for the remaining 20% of claims. These include tracking data can report savings units per ton or per Btu/h

2. When kWh and/or therms savings were missing from the TRM, we noted that the "UnitType" was listed as "custom" or "calculated." For this set of measures, we obtained detailed "measure case" files from PSE to perform further investigation.

For measures with calculated or customer unit types, the savings were generally taken from RTF workbooks, whitepapers, or previous evaluations, and then adjusted to be more specific to PSE's service area and individual projects. Thus, not all measures with claimed savings are strictly deemed, but instead have reported savings that account for variation in climate zone and building type and are based on a lookup table or simple formula.

4.3 Results

DNV evaluated PSE's LIW program based on metered energy consumption changes following program-measure installations. We used two primary models to estimate these changes. First, we used site-level models to control for the effect of weather on energy consumption. Second, we used difference-in-difference (DID) models to model change in weather normalized energy consumption between pre-and post-program intervention. These models were based on data from participants and matched non-participants' data. We provide details on modeling and data preparation in Appendix C.

Due to unresolved data challenges described below in Section 4.4.2, we were unable to get direct estimates of savings for multifamily participants. We used realization rates from single family and mobile home participants to develop proxy savings for multifamily participants. We report savings for the LIW installations at multifamily sites based on these proxy estimates.

Table 7 presents the number of participating households whose consumption data were included in the analysis. The table tracks the attrition of available data based on analysis requirements as described in the table.

Table 7. Household data attrition used in the analysis, 2019-2020

Low-income weatherization analysis data attrition	Electric	Gas
Number of households with savings claims	933	154
Number of customers not participating in other programs	805	139
Number of customers with any usable energy use data*	780	128
Number of customers with sufficient pre-and post-data used in the analysis	440	53

* Customers without multiple meters, negative reads, zero daily reads (electric only), and zero annual reads

Table 8 provides estimates of electric whole-home savings from the LIW program based on DID model estimates and customer data provided above. Average estimated electric savings per home, which includes the savings of all technologies installed, are 2,614 kWh for manufactured homes, 8,373 kWh for multifamily, and 1,773 kWh for single family participants. These savings are 14% to 17% of total annual electricity use.

Table 8. Claimed and estimated electric (kWh) savings per home, 2019-2020

Dwelling type	Claimed (kWh)	Evaluated (kWh)	Average Annual Consumption (kWh)	% savings
Manufactured Home	3,062	2,614	14,932	18%
Multifamily	9,809	8,373*	46,101**	18%
Single family	2,764	1,773	12,390	14%

* Based on proxy savings estimates

** The consumption value provided is 5 times the average consumption of the multifamily sites listed in the tracking data because the tracking data indicates that on average 5 multifamily units received installations through the LIW program.

To calculate total evaluated savings, we multiplied the estimated savings per home by the number of participating homes for each dwelling type. A comparison of the sum of the total evaluated savings to the claimed savings indicate an electric realization rate of 64% for single family homes and 85% for each of multifamily and manufactured homes (Table 9). The overall electric realization rate is 80% and indicates that three-fourths of the program's claimed electricity savings were realized over the two program years of 2019 and 2020.

Table 9. Total claimed and evaluated electric savings, 2019-2020

Dwelling type	No. of Homes	Claimed (kWh)	Evaluated (kWh)	Realization Rate
Manufactured Home	428	1,310,558	1,118,731	85%
Multifamily	168	1,647,960	1,406,747*	85%
Single family	337	931,502	597,423	64%
Total	933	3,890,020	3,122,901	80%

* Based on proxy savings estimates

We provide analogous estimated savings per home for gas installations in Table 10. As the table indicates, gas savings per home were 92 therms for manufactured homes, 489 therms for multifamily participants, and 143 therms for single family homes. These represented 17% of annual whole-home consumption for manufactured homes, 26% for multifamily homes and 24% for single family homes.

Table 10. Claimed and estimated gas (therm) savings per home, 2019-2020

Dwelling type	Claimed (therms)	Evaluated (therms)	Average Annual Consumption (therms)	% savings
Manufactured Home	90	92	528	17%
Multifamily	670	489*	1,851**	26%
Single family	196	143	604	24%

* Based on proxy savings estimates

** The consumption value provided is 5 times the average consumption of the multifamily sites listed in the tracking data because the tracking data indicates that on average 5 multifamily units received installations through the LIW program.

We calculated total evaluated savings for LIW gas installations in the same manner that we did for electric savings, namely, by multiplying the estimated savings per home by the total number of participating homes to derive evaluated savings. When compared to the claimed savings, these evaluated total savings by dwelling type indicate a realization rate of 103% for manufactured homes, and 73% each for multifamily and single family homes (Table). The overall realization rate for gas

saving installation of the LIW program is 74% for program years 2019 and 2020. Similar to electric saving measures, gas-saving installations were able to deliver three-fourths of the claimed savings over the two program years.

Table 11. Total claimed and evaluated gas savings, 2019-2020

Dwelling type	No. of Homes	Claimed (therms)	Evaluated (therms)	Realization Rate
Manufactured Home	10	896	920	103%
Multifamily	25	16,740	12,229*	73%
Single family	119	23,294	17,017	73%
Total	154	40,930	30,166	74%

* Based on proxy savings estimates

4.4 Discussion

Two aspects of the LIW results warrant further discussion.

- The LIW program offers a variety of measures that are installed based on need at the site. As a result, there are many unique measure bundles. Savings are estimated at the household level because of the difficulty of estimating accurate measure level savings under these conditions.
- Challenges with multifamily consumption data necessitated the development of proxy savings estimates. At a minimum, billing analysis requires consumption data for all parts of a building receiving efficiency measures. The IDs in the tracking data appeared to match only one unit at a site while tracking savings across multiple sites. DNV was unable to resolve these issues for this report. Further investigation may be justified, though multifamily data can be intractable. The proxy savings estimate provided here do not represent full evaluation results.

4.4.1 LIW Program Overlap

The LIW program installed multiple measures among participating homes as indicated in Section 3.1. We do not disaggregate whole-home energy use changes into measure level savings to evaluate the program because of the considerable overlap in installed measures. Figure 2 indicates the extent of measure overlap among the most commonly installed electric measures and Figure 3 provides the overlap for gas measures installed through the LIW program in 2019 and 2020. Instead, we evaluate the program by estimating changes in whole-home consumption that reflect the effect of the mix of measures installed in participating homes. DID model results on which whole-home savings estimates are provided in Appendix C. The significance and precision of estimated savings are also provided in Appendix D.

Figure 2. Installed LIW electric measures overlap, 2019-2020

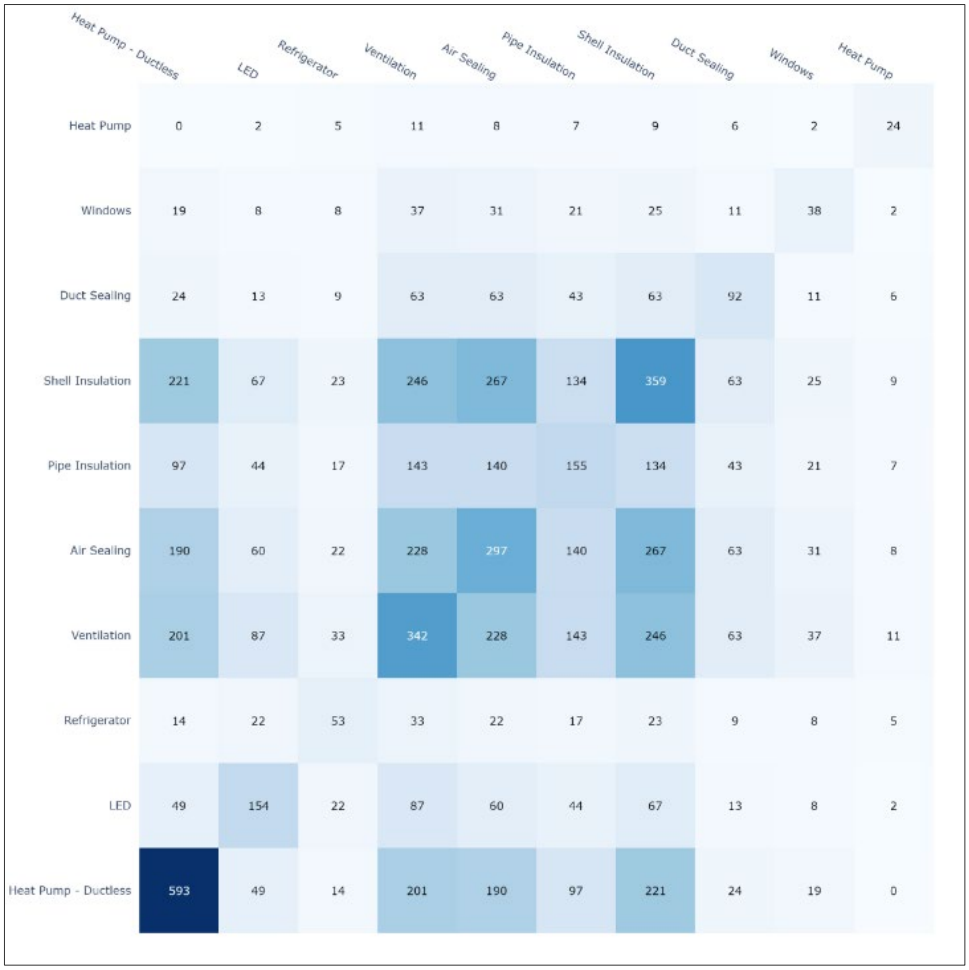
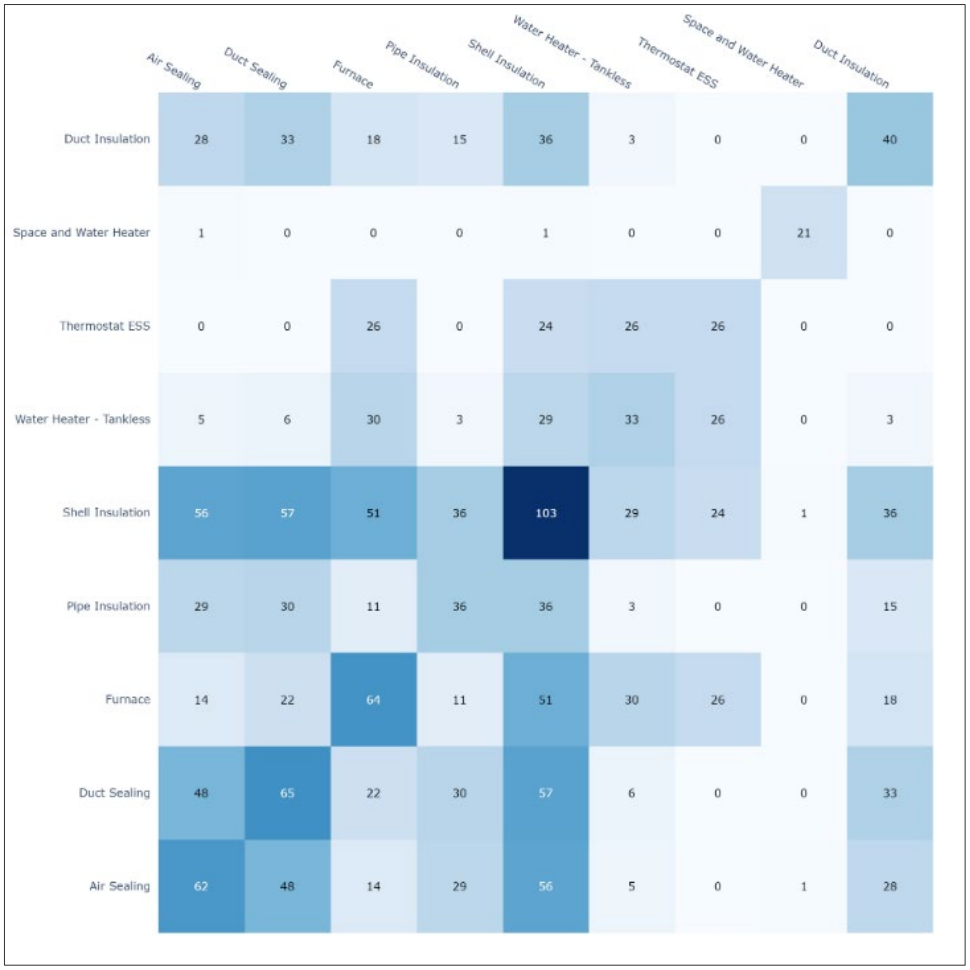


Figure 3. Installed LIW gas measures overlap, 2019-2020

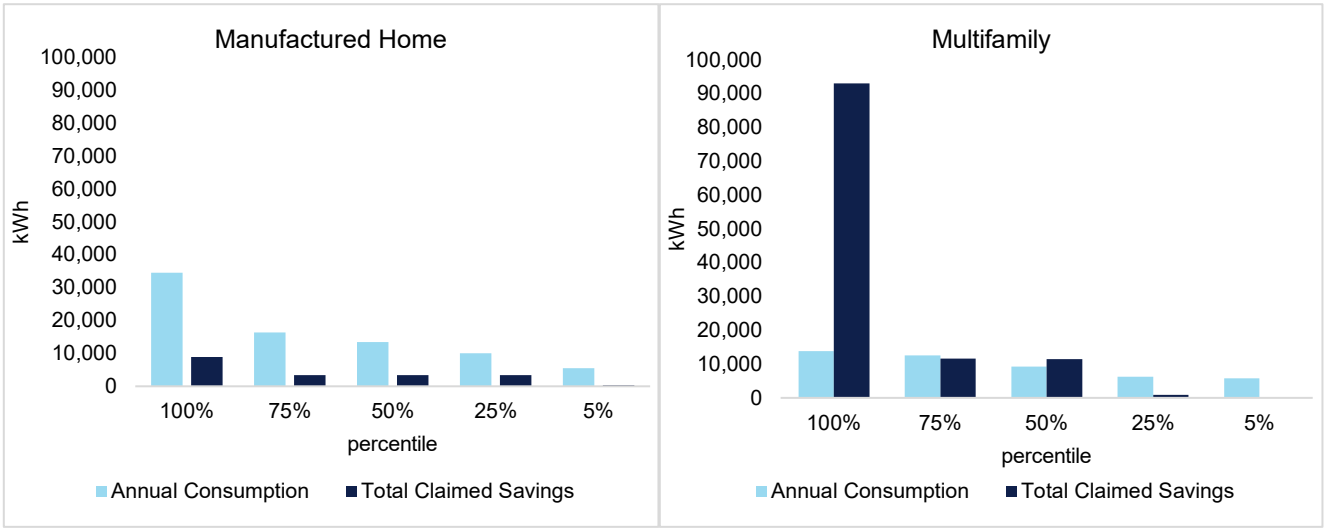


4.4.2 Multifamily installation estimates

Multifamily installations could not be evaluated based on consumption data analysis because the tracking data did not provide the participant IDs for all units that received program measures. For almost all cases, the consumption of the participants for which IDs were provided were a fraction of the claimed savings. It was evident that the IDs either represented one of the units that received program incentivized measures or could have been for common areas of the buildings where the measures were installed.

Figure 4 illustrates the extent to which claimed savings exceeded participant consumption for multifamily. By contrast, the claimed savings for installed measures of manufactured homes were a fraction of the annual consumption participants across the entire distribution of energy use.

Figure 4. Distribution of total claimed electric savings and annual consumption, 2019-2020



In the absence of complete consumption data that could be used to estimate multifamily savings directly, we needed to use something to support a proxy result. We applied the realization rate from manufactured home installations to evaluate electric installation of multifamily participants because multifamily homes received shell measures in proportions that are closer to manufactured homes than to single family homes.

For gas, the choice was simpler. Multifamily gas measures only included boilers and integrated space and water heaters – they did not include any building shell gas measures. Thus, because the single family program included gas HVAC measures whereas manufactured homes received building shell but not HVAC measures, we used to single family results as a proxy for multifamily gas savings.

5 PROCESS EVALUATION RESULTS

This section summarizes the key findings for the LIW process evaluation, including results from the computer-assisted telephone interview (CATI) surveys with LIW program participations, program staff interview, and community action agency (CAA) interviews.

5.1 Overview

The key research questions for the process evaluation include the following:

- Do participants report behavioral changes as a result program participation?
- Does the program increase resident comfort?
- What is the level of resident awareness of the program?
- What is the level of participants' satisfaction with the program and program process?
- What are the perceived barriers preventing greater program participation?

We address these topics as well as recent and planned program changes discussed in Section 5.2 below.

5.2 Recent and Planned Program Changes

Evaluators interviewed the PSE program manager for the low-Income Weatherization program as well as representatives from three CAAs. The interviews covered recent and planned program changes for the LIW program, summarized here, as well as barriers to program participation and marketing and outreach efforts, which we summarize in Section 5.6.

Although the program is referred to as a weatherization program, PSE's LIW program manager pointed out that the program is more comprehensive and includes the installations of efficient space and water heating equipment, lighting and appliances, and health and safety repairs.

The PSE program manager mentioned that they were no fundamental recent changes to the program. However, the PSE and CAAs did need to adjust to the COVID-19 pandemic. This included:

- A reduction in the number of completed projects in 2020, including a full suspension of projects at the start of Washington's Stay Home, Stay Healthy mandate in late March 2020
- Creation of extensive safety protocols for entering customers' homes.
- Overcoming customers' reluctance to allow contractors inside their home and participating in the program

As for the operation of the program going into the future, PSE plans to:

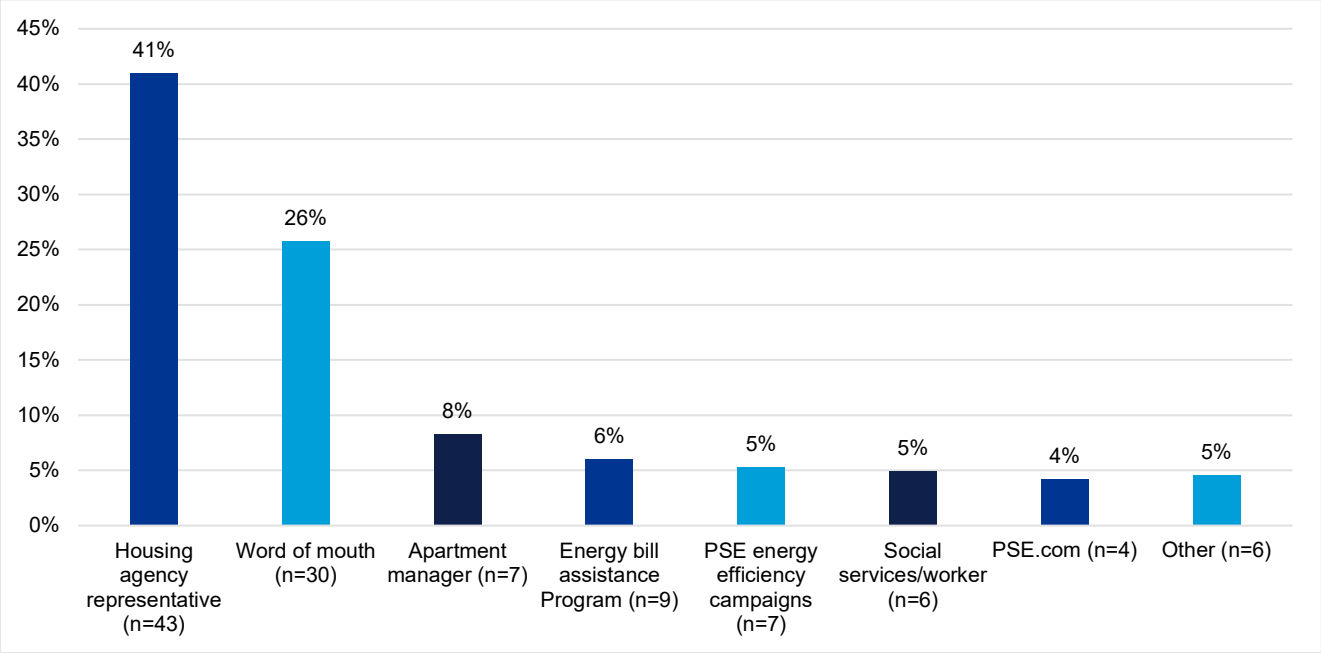
- Be mindful of the Clean Energy and Transformation Act by maximizing project production
- Continue to focus on the CAA network as the primary means to implement the program
- Target marketing and outreach efforts on high need Census blocks with high energy burdens

5.3 Program Awareness

CATI surveys were completed with LIW program participants. This survey evaluated program awareness, summarized here, as well as other process-related results such as program satisfaction, program benefits, and reasons for program participation, summarized in subsequent sections of this report.

LIW participants were asked how they first learned about the program and services made available to them (Figure 5). The most frequently cited sources of first learning about the program were either their housing agency representative (41%) or word of mouth (26%). These results help illustrate that the LIW program is driven and implemented by the housing agencies and that participants' first point of contact is often a housing agency representative.

Figure 5. How did participants first learn about the program?



*Number of respondents = 112

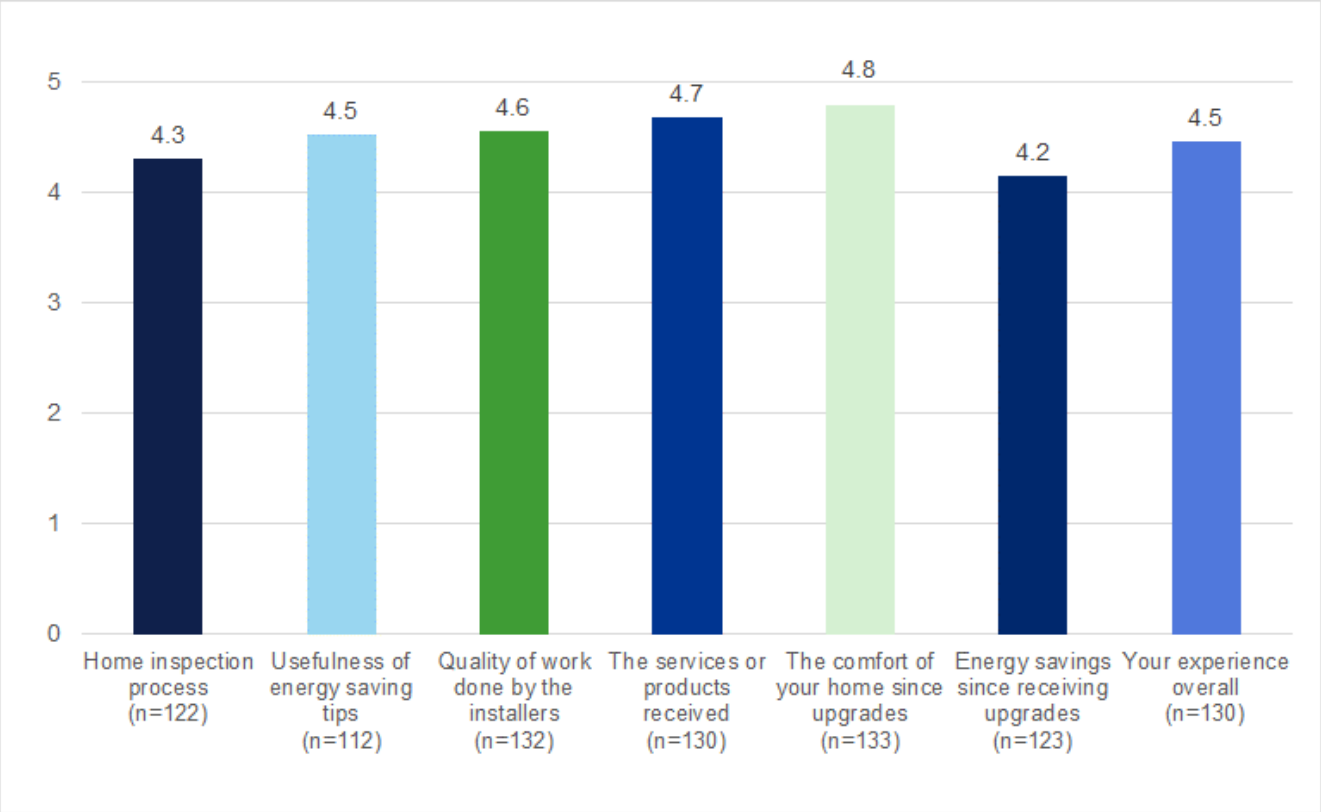
The CATI survey also asked participants if they were familiar with the initial in-home audit that was completed as part of the program. Responses were evenly split, with half (50%) of the 135 surveyed respondents reporting they were aware of the audit and the other half (50%) stating they were not aware.

5.4 Program Satisfaction

The telephone survey also asked participants about their satisfaction with various aspects of the program using a 5-point scale, where 5 means "very satisfied" and 1 means "very dissatisfied." Seven distinct aspects were covered with the intention of capturing satisfaction of various aspects of the program, from the home inspection process to the comfort of their home since receiving the upgrades. Respondents were also asked about their satisfaction of the program overall.

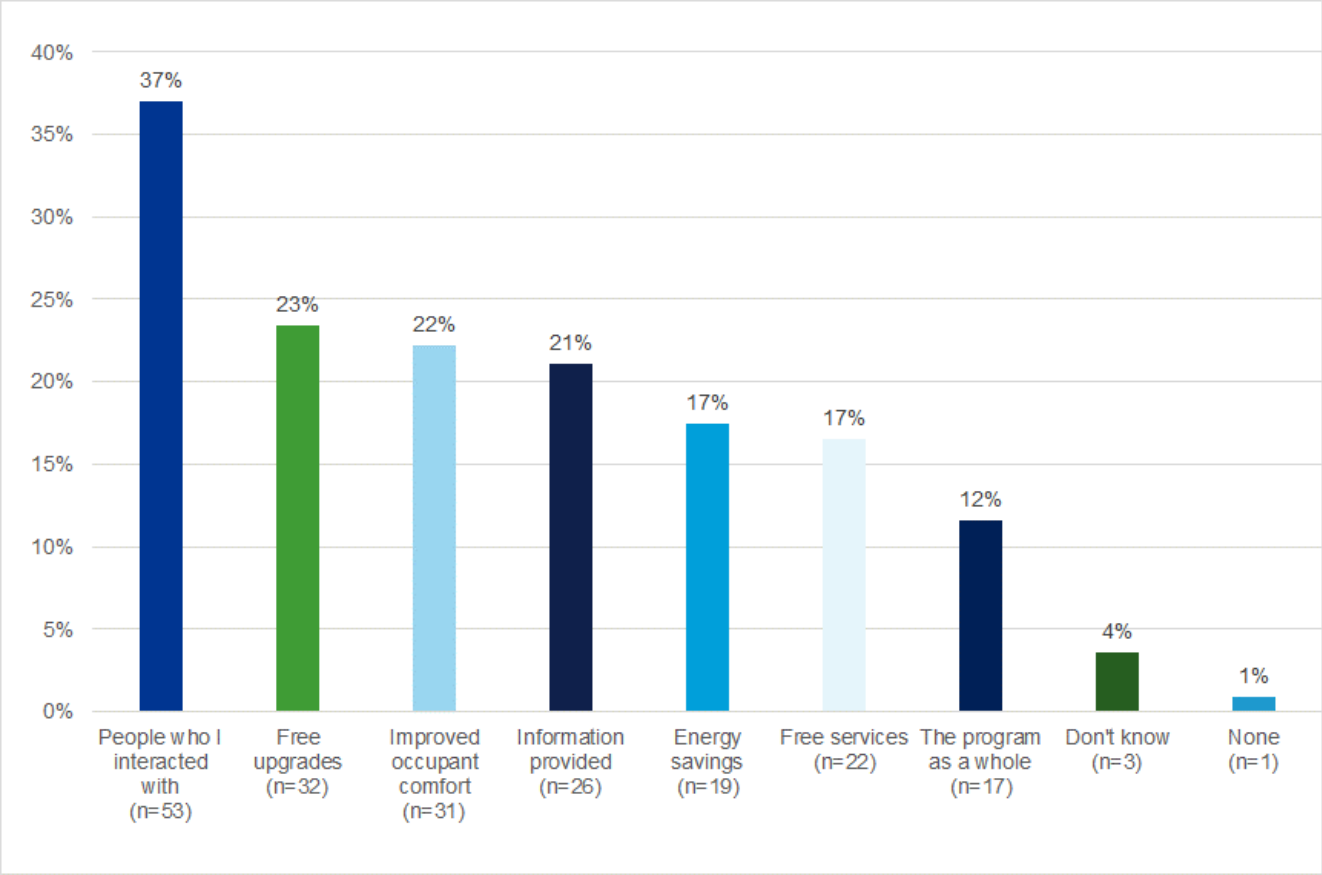
Figure 6 presents the findings surrounding the participant satisfaction with various aspects of the program, as well as satisfaction with overall program experience. All categories yielded a moderate to high average satisfaction scores, ranging from 4.2 to 4.8. The only two aspects of the program that received an average satisfaction score lower than 4.5 were home inspection process and energy savings since receiving upgrades; these two aspects received an average satisfaction score of 4.3 and 4.2, respectively. Participants may have felt that they would see larger savings on their energy bills than what they experienced and that this may help explain a lower overall score for energy savings. While the home inspection process score is only marginally lower than the average score given for other aspects of the program process, it is possible that respondents felt that this process was either burdensome or intrusive (or both).

Figure 6. Participant Satisfaction with the Program



Program participants were also asked what aspects of the program and their overall experience went well. Figure 7 shows that participants most frequently cited people they interreacted with as an aspect of the program that went well (37%). Between one in five and one in four survey respondents thought free upgrades (23%), improved occupant comfort (22%), and the information provided (21%) also were aspects of the program that worked well. These findings suggest that program staff are fostering positive interactions and touch points with customers, and the additional benefits such as the free upgrades, information provided, and improved comfort are also key aspects to the program's success.

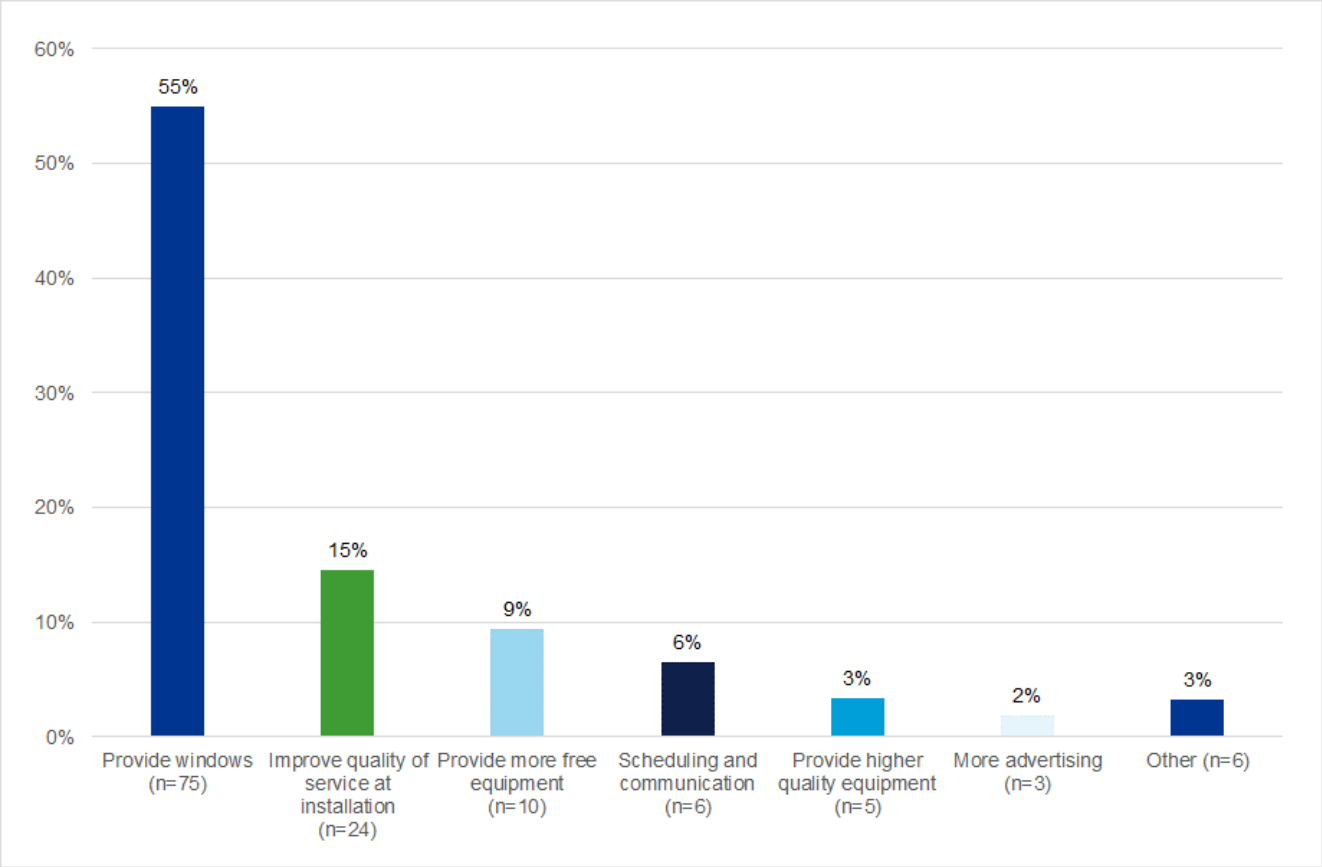
Figure 7. Respondents Report of Program Aspects That Went Well



*Number of respondents = 135. Multiple responses were accepted, so the totals exceed 100%.

Next, survey respondents were asked what aspects of the program could be improved. As shown in Figure 8, the most common recommendation for program improvement was a recommendation to provide participants with new windows (55%). The second most frequently cited growth opportunity was to improve the quality of service at the installation (15%) which may include being more on-time, informative, or more helpful setting up the equipment. Lastly, 9% of participants also stated that the program could improve by offering more free equipment; this result aligns with the most common cited recommendation to provide windows.

Figure 8. Opportunities for Program Improvement



*Number of respondents = 135. Multiple responses were accepted, so the totals exceed 100%. Other responses suggestions for program improvements included providing more services (n=2), providing this service to all customers (n=2), and providing more information at the inspection (n=2)

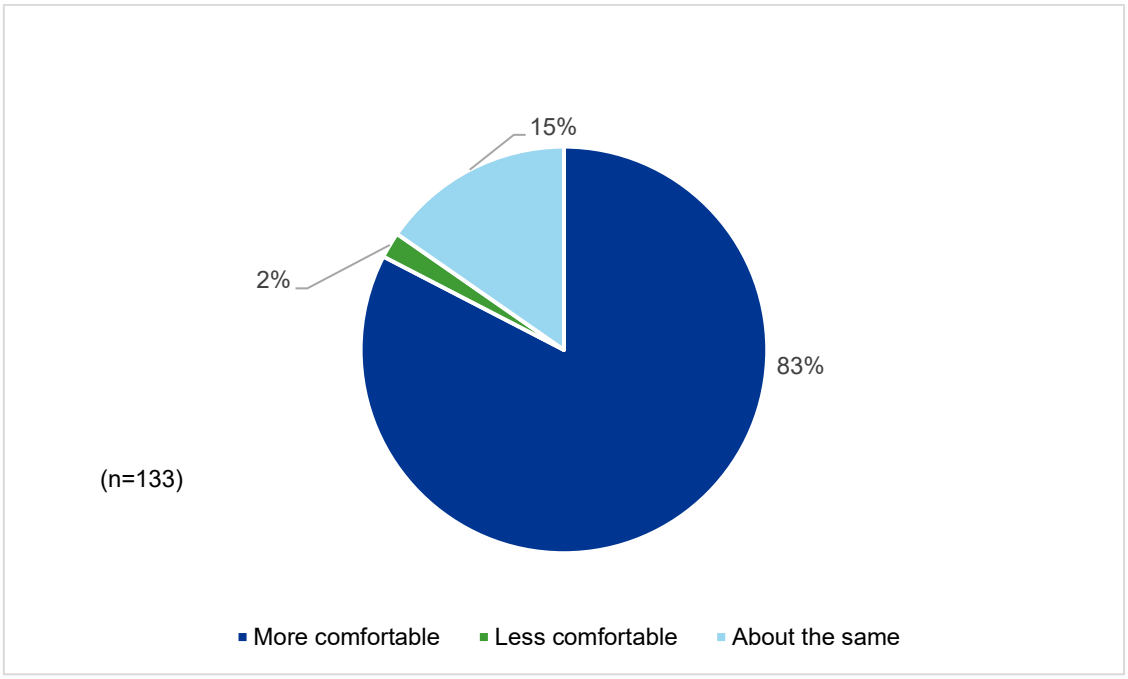
5.5 Program Benefits

One of the ancillary benefits of the measure installations is the improvement in home of comfort (along with energy savings). Participants were asked if they are now more comfortable in their homes since the improvements were made. These findings can be one way the program motivates customers to adopt measures, appealing to their desire for improved savings and comfort. Participants were asked a series of questions on home comfort and the sources of discomfort they previously experienced.

Participants were asked if they experienced any of the following benefits: improved comfort, air quality, safety, or the home being quieter. The vast majority of participants (87%) experienced at least one of these benefits.

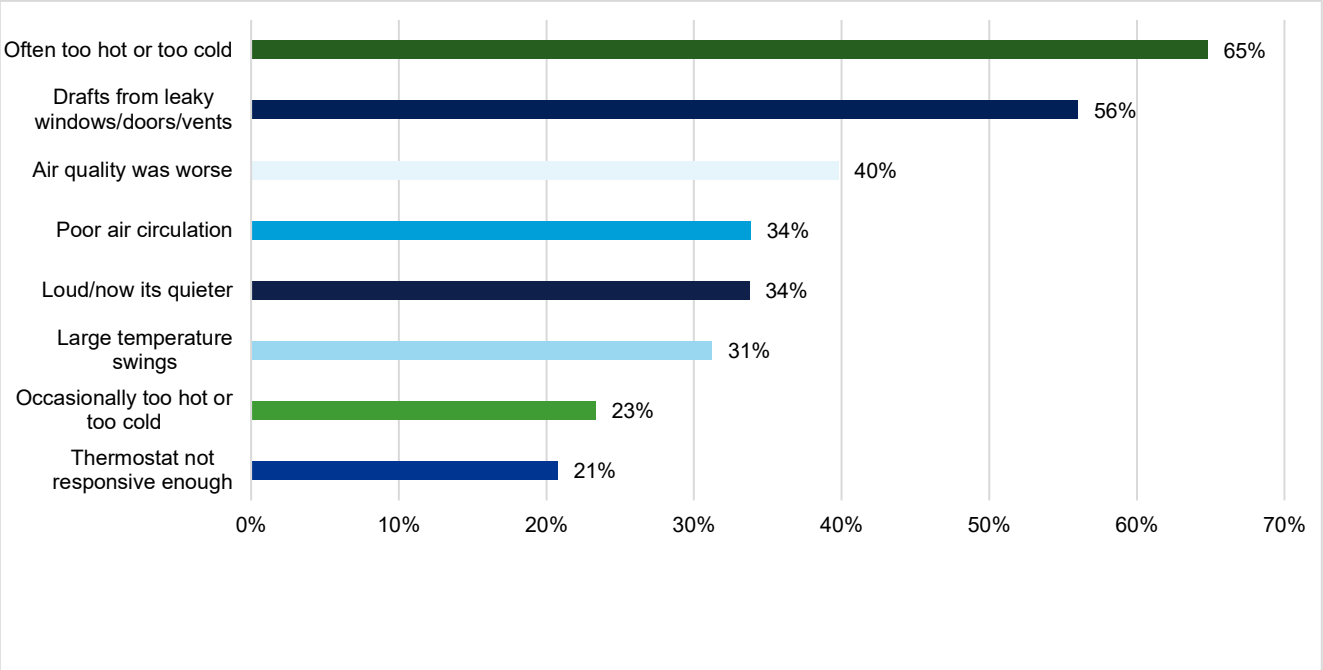
Those who experienced at least one of these benefits were asked whether their level of comfort was more, less, or about the same since the improvements were made (Figure 9). A large majority (83%) reported that they were more comfortable, 15% reported that they experienced the same level of comfort, and 2% of respondents (n=3) reported that they were less comfortable.

Figure 9. Post Installation Home Comfort Level



Respondents were asked about discomforts they experienced in the home prior to the installation of program measure(s); see Figure 10. Nearly two-thirds of respondents mentioned that they had previously been too hot or too cold and more than half (56%) said that they experienced drafts from leaky windows, doors, and/or vents. Notably, 40% of respondents said that the air quality in their home was worse prior to having new measure(s) installed and more than one-third said that air circulation had been poor. These results suggest that the LIW program has significant non-energy savings benefits, including improved comfort with respect to temperature and the elimination of drafts as well as better air quality.

Figure 10. Previous Sources of Discomfort

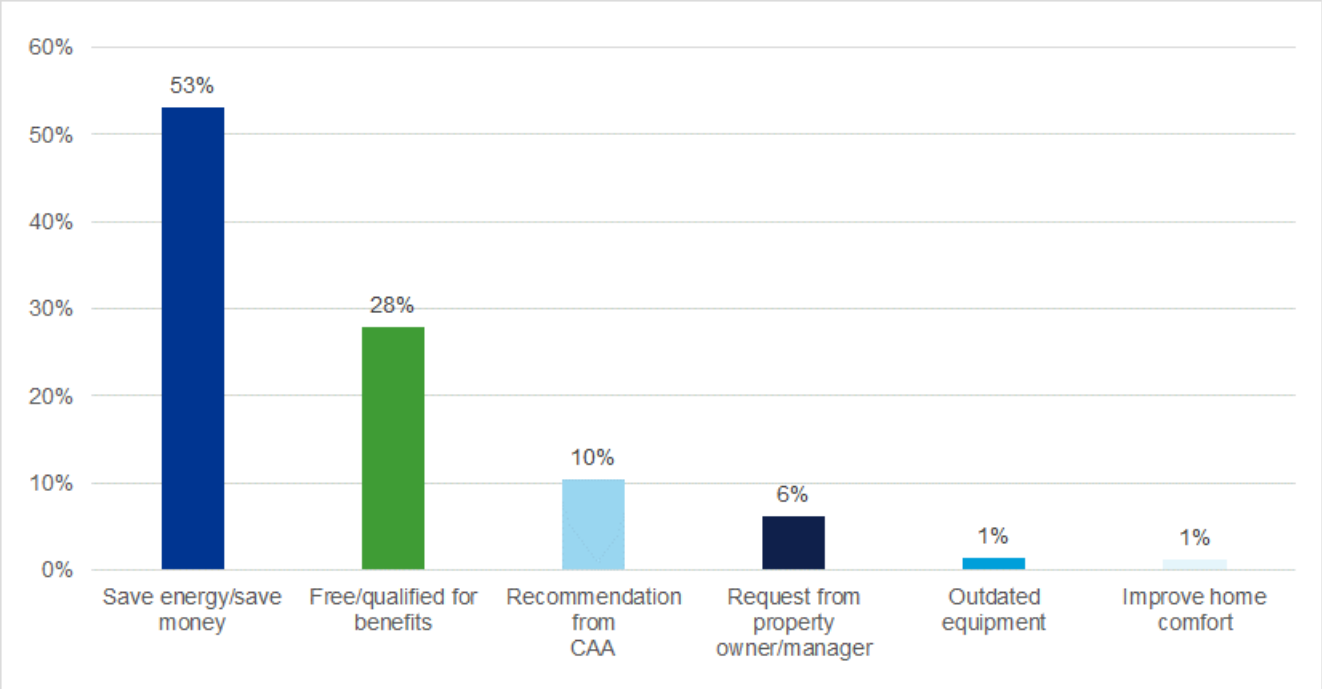


*Number of respondents = 112. Multiple responses were accepted, so the totals exceed 100%.

5.6 Reasons for Program Participation

Survey respondents were asked what their main reason was for deciding to take part in the program. Figure 11 shows that over half (53%) of the respondents reported participating in the program to save energy and money. The second most cited reason for program participation was due to being qualified for the benefits at no cost (28%). These findings align with the participant satisfaction results covered in Section 5.4, namely, the relatively high ratings surrounding the usefulness of the energy savings tips and the services or products received.

Figure 11. Reasons for Participation in the Low Income Weatherization Program



*Number of respondents = 117

5.7 Barriers to Program Participation

DNV discussed barriers to increasing participation in the LIW program with representatives from three housing agencies responsible for implementing the program. Agencies listed several barriers to increasing participation in the program, including constraints related to budget, staffing, and expertise:

- Budget constraints
- Stable and predictable funding from the state
- Staffing shortages or lack of in-house expertise
- Finding and retaining qualified contractors

An agency representative noted that PSE has been helpful with addressing funding issues. Particularly, PSE has responded to the need for funding for repairs beyond the installation of program measures and increased funding in this area.

Additional barriers cited include:

- Federal and state rules and regulations, which can become burdensome
- Hiring qualified contractors who meet the state's prevailing wage requirements
- Persuading landlords to make upgrades to their tenants' homes or apartments even when most or all of the cost is covered
- Gaining trust among some low income customers living in rural areas who are distrustful of government agencies and other non-government organizations

Agency representatives emphasized that PSE has listened to their needs and helped when they are able to (such as increasing funding for needed repairs). The representatives also understand the importance of in-person outreach to help break down barriers with respect to mistrust among low-income customers or resistance to program participation among landlords. However, some barriers are beyond the control of the CAAs and PSE, such as federal and state rules and regulations.

6 FINDINGS AND RECOMMENDATIONS

We summarize overall findings from the LIW evaluation and recommendations based on these findings in this section.

6.1 Findings

The key findings from the impact evaluation include:

- The LIW program met one of its primary goals of reducing the energy cost burden of participating low-income customers. Low-income customers used 14% to 18% less electricity and 17% to 26% less gas.
- Savings from installations were lower than claimed, but still notably high.
    - Electric installations from the LIW program achieved 80% of the claimed savings.
    - Gas installations from the LIW program achieved 74% of the claimed savings.
- Throughout this evaluation, COVID-19 prevented evaluators from conducting any substantial field data (outside of virtual verification efforts). With this limitation, evaluators identified a consumption analysis as the best available evaluation approach. However, in any multifamily program, a consumption analysis faces an array of challenges (such as how to include the savings in public areas and dwelling units and difficulties associated with defining robust comparison groups, etc.). In light of these challenges, the most robust adjustments evaluators could make to multifamily savings estimates were to apply LI single family and mobile home realization rates (based on matching measures) as proxy results.

The key findings from the process evaluation include:

- Customer contact information, particularly for multifamily participants was not provided for all participants.
- The LIW program is driven and implemented by the community action agencies (CAAs) who play a key role in outreach efforts to find low-income candidates for program participation. Findings from the participant telephone surveys suggest that a housing agency representative was often the first point of contact for participants and the source of their awareness of the program.
- Overall satisfaction with the LIW program was high among participants with an average rating of 4.5 on a 5-point scale. Ratings for different aspects of the program generally averaged 4.5 or higher. One notable exception was the average satisfaction score that participants gave with the energy savings they received since receiving upgrades from the program, which was 4.2. Participants may have felt that they would see larger savings on their energy bills than what they actually experienced.
- CAA representatives cited a number of barriers to increasing LIW program participation. Several of these barriers are beyond the control of the CAAs and PSE, such as federal and state regulations and funding constraints. Other challenges that CAAs mentioned were persuading landlords to make upgrades to their tenants' homes and gaining trust among a segment of low-income customers who are distrustful of government agencies or other agencies that receive federal and/or state funding.

6.2 Recommendations

- The current electric realization rate of 80% is in line with past evaluations (between 80% and 94% from 2013 to 2015) while the gas realization rate of 74% is lower than prior evaluations (113%-149% from 2013 to 2015). While a pre-post consumption analysis offers the most empirical way to measure savings at the meter, it is not always easy to pinpoint the exact reasons for discrepancies between claimed and measured savings. However, we do

note that the LIW participant building stock is especially variable. Pre-intervention building conditions can be dramatically different among participants and deemed savings assumptions. PSE could compile and analyze building characteristic data (vintage, condition, customer interviews and assessment of comfort and energy burden) and a participant profile assessment could help reveal additional insight and actionable steps into a given evaluation's results.

- Some LIW participants may be somewhat disappointed in the energy savings they receive from their upgrades. CAAs should coordinate with their contractors to make sure that they are not overpromising on bill savings that participants see as a result of their program upgrades. Contractors should emphasize the non-energy benefits of the program, such as improved comfort and air quality.

7 APPENDICES

7.1 Appendix A: Sample Design

This section describes the applied sampling approach and sample summary for the computer assisted telephone interview (CATI) surveys.

7.1.1 Overview

For this program both electric (kWh) and gas (therm) savings were claimed. In order to understand both electric and gas savings, separate samples were designed for each fuel type.

For the CATI survey, the sampling methodology employs a stratified ratio estimation technique. This stratified ratio estimation approach will study a subset of units, i.e., sample, drawn from the full population. The sample design approach first places participants into groups of interest (home type and fuel type) and then place them into strata by size, measured in terms of kWh and Therm savings. Sample sizes were set at 50 per domain to provide statistically significant results for each domain of interest (by home type and fuel type). In the program there were a total of three building types (Manufactured Homes, Multifamily, and Single Family) and two fuel types (kWh and therms).

7.1.2 Electric Sample Design

For the electric sample design, the population of LIW participants were first grouped based on their respective building type. Table shows the number of accounts and the total savings for each home type within the population. Manufactured homes had the largest share of accounts, accounting for nearly 50% of electric savings claims while Multifamily contributed the most savings to the program (42%).

deliver three-fourths of the claimed savings over the two program years.

Table 12. Low Income CATI Survey Sample Design: Electric Measures (kWh Savings)

Home Type	Accounts	Total Savings (kWh)	Mean	Minimum	Maximum	Standard Deviation
Manufactured Home	410	1,365,512	3,331	41	9,117	1,368
Multifamily	137	1,642,377	11,988	219	93,011	13,199
Single Family	285	902,442	3,166	83	15,531	2,452
Total	832	3,910,331	4,700	41	93,011	

7.1.3 Gas Sample Design

For the gas sample design, the population of LIW participants were again first grouped based on their respective building type. Table 13 presents the number of accounts and the total savings (therms) for each home type within the population. Single family homes account for over 82% of accounts and 53% of therm program savings. Manufactured homes were not included in the gas sample design because participants in this home type did not receive any program gas measures.

Table 13. Low Income CATI Survey Sample Design: Gas Measures (Therm Savings)

Home Type	Accounts	Total Savings (Therms)	Mean	Minimum	Maximum	Standard Deviation
Multifamily	25	19,846	794	368	5,627	1,035
Single Family	115	23,294	203	17	490	89
Total	140	43,140	308	368	490	

7.2 Appendix B: Data Collection Instruments

PSE LOW INCOME WEATHERIZATION (LIW)
PARTICIPANT SURVEY

PARTICIPANT SURVEY

Screener

Hello, My name is [name], and I'm calling on behalf of the Weatherization Assistance Program and Puget Sound Energy. I'm calling to ask you about some free energy saving upgrades that were made to your home through this weatherization program. PSE helps to sponsor this program and <Partner_Company_Name> worked with you to make the upgrades. We would like to know how satisfied you are with the upgrades made to your home. Is now a good time to speak with you?

[IF NEEDED] I'm not selling anything; I'd just like to ask your opinions. Your responses will be kept confidential and your individual responses will not be revealed to anyone.

a1. Agrees to participate a2. Does not agree to participate [T&T]

1. According to [Partner_Company_Name] back in installation date] some upgrades were made to your home to help you save energy. Are you familiar with having received these upgrades?

   If no, use prompt: "One of the upgrades your home received was measure1"]

   a1. Yes a2. No

2. Is there anyone else in the home that maybe familiar with this program?

   a1. Yes a2. No

3. Who would you recommend we speak to? [record]

4. Could I speak to [record name] now?

   a1. Yes a2. No

5. When is a good time could call back? [record]

Verification, Awareness, and Reasons for Participation

6. Do you still receive electric service from PSE at this address: [site_add_line_1?

   a1. Yes
   a2. No

This Section if Skip if [Verification Measure = No]

7. Just to verify, did you receive the following home improvements through the program? < MeasName1 to MeasName5> [Verify Top 5 energy saving measures]?

   a1. Meas1 Yes/No/Don't know
   a2. Meas2 Yes/No/ Don't know
   a3. Meas3 Yes/No Don't know
   a4. Meas4 Yes/No Don't know
   a5. Meas5 Yes/No Don't know

8. [If Q7 = No] Just to confirm, you did not receive a/an < MeasName1 to MeasName5> on behalf of this program?

   a1. Meas1 Yes/No If no – skip to next measure

a2. Meas2 Yes/No If no – skip to next measure

a3. Meas3 Yes/No If no – skip to next measure

a4. Meas4 Yes/No If no – skip to next measure

a5. Meas5 Yes/No If no – skip to next measure

9. Are you still using the upgrades associated with this program or have you removed/replaced it?

a1. Meas1 Using it/remove or replaced/never installed it/Don't know
a2. Meas2 Using it/remove or replaced/never installed it/Don't know
a3. Meas3 Using it/remove or replaced/never installed it/Don't know
a4. Meas4 Using it/remove or replaced/never installed it/Don't know
a5. Meas5 Using it/remove or replaced/never installed it/Don't know

10. [Repeat for each measure where measure = Water Heating] Else Skip to Q11] What was the condition OLD of the watering heating equipment when it was removed, was it…[read list a1, a2, or a3]?

a1. Working but inefficient
a2. Working but in need of minor repair
a3. Working but in need of significant repair
a4. Failed was no longer working
a5. Don't recall

11. [Repeat for each measure where measure = HVAC. Else Skip to Q12] What was the condition of the OLD equipment when it was removed, was it…[read list a1, a2, or a3]?

a1. Working but inefficient
a2. Working but in need of minor repair
a3. Working but in need of significant repair
a4. Failed was no longer working
a5. Don't recall

12. How did you first learn about the program and services that were available to you? Select one response.

a1. Housing agency representative
a2. Energy (Bill Payment) assistance Program
a3. PSE marketing collateral, signage
a4. PSE.com
a5. Word of mouth
a6. PSE Energy Efficiency campaigns (not limited to): email, advertising earned and paid media, press releases, direct mail, PSE outreach
a7. Community events and sponsorships
a8. Energy fairs
a9. TV/radio
a10. Flyer
a11. Someone came to my door/canvassing
a12. Other: specify
a13. Don't recall

13. Thinking back to the time when you were making the decision to participate in this program, what was the main reason you choose to participate? [Select one response]

a1. Save energy/save money
a2. Free/qualified for benefits
a3. Recommendation from PSE
a4. Recommendation from CAA
a5. Request from property owner/manager
a6. Outdated equipment
a7. Improve home comfort
a8. Other
a9. Don't know

Heating and Cooling Your Home

I have a couple questions on heating and cooling of your home.

This Section if Skip if [Verification Measure = Verification Measure]

14. Which of the following natural gas appliances do you use? Select all that apply.

    a1. Gas cook-top/range
    a2. Gas clothes dryer
    a3. Gas water heating
    a4. Gas heater
    a5. None of these
    a6. Don't know

15. What is the main heating system used to heat this home? [Select one]

    a1. Floor or wall heater
    a2. Central furnace/heat pump
    a3. Hot water radiator
    a4. Electric baseboard
    a5. Fireplace (gas/wood)
    a6. Plug-in portable space heater
    a7. Ductless heat pump
    a8. Other [SPECIFY]
    a9. Don't know

16. What other sources, if any, do you use to supplement your heat? Select all that apply.

    a1. No other sources
    a2. Fireplace (gas/wood)
    a3. Plug-in portable space heater
    a4. Floor or wall heater
    a5. Central furnace/heat pump
    a6. Hot water radiator
    a7. Electric baseboard
    a8. Ductless heat pump
    a9. Other [SPECIFY]
    a10. Don't know

17. Do you use air conditioning?

    a1. Yes
    a2. No

18. [if q17=a1] What type of air conditioner do you use? Is it central, window unit, or something else?

    a1. Central air
    a2. Window or portable unit
    a3. Ductless unit
    a4. Other
    a5. Don't know

In-Home Audit and Behavioral Changes

Next, I have a few questions about how your experience with different aspects of the program like the in-home inspection.

19. To identify which improvements needed to be made, the program completed an initial in-home audit. Are you familiar with this audit?

    a1. Yes
    a2. No [If no, skip to the next section]

20. Have you made changes of any kind based on the recommendations from the in-home audit? Yes/No [If no, why not]

    a1. Yes
    a2. No [If no, skip to the next section]

21. [Ask if not captured in above question] What changes did you make in response to the information you received from the in-home audit? [Select all that apply]

a1. Turn off lights when not in use
a2. Improve air circulation (adjust vents, close doors and windows)
a3. Replace light bulbs
a4. Adjust thermostat/heating/cooling
a5. Unplug devices when not in use
a6. Wash clothes in cold water
a7. Turn down temperature on water heater
a8. Replace showerheads
a9. Other
a10. None of these

22. Since your home had improvements made through the Weatherization Assistance program in [month/year], have there been any additional upgrades made to your home?

a1. Yes
a2. No

23. [If Q22= a1] What changes did you make? [record]

Post Installation – Comfort and Savings

Now I'd like to ask about your home comfort and energy savings since these improvements were made.

24. Have you experienced any benefits beyond energy savings as a result of your participation in this program, such as improved comfort, air quality, safety, or the home being quieter?
    a1. Yes
    a2. No

25. Would you say your home comfort, is more comfortable, less, or about the same level of comfort?

a1. More comfortable
a2. Less comfortable
a3. About the same
a4. Don't recall

26. If [Q25 =a1, more comfortable], What are some of the sources of discomfort that you previously experienced, if any? [Such as, read list to probe] Select all that apply.

a1. Often too hot or too cold
a2. Occasionally too hot or too cold
a3. Large temperature swings
a4. Drafts from leaky windows/doors/vents
a5. Poor air circulation
a6. Thermostat not responsive enough
a7. Loud/now its quieter
a8. Air quality was worse
a9. Other
a10. Don't recall

27. If [Q25=a2, less comfortable], What are some of the sources of discomforts that you are currently experiencing? [Such as, read list to probe]. Select all that apply.

a1. Often too hot or too cold
a2. Occasionally too hot or too cold
a3. Large temperature swings
a4. Drafts from leaky windows/doors/vents
a5. Poor air circulation
a6. Thermostat not responsive enough
a7. Loud/now its quieter
a8. Air quality was worse
a9. Other
a10. Don't recall

28. Since these improvements have been made, would you say you're using the heating system more, less, or about the same?

a1. More
a2. Less
a3. About the same
a4. Not applicable (e.g., use Wood heat)

29. If [Q17=a1, has AC], How about cooling, since these improvements have been made would you say you're using the cooling system more, less or about the same?

a1. More
a2. Less
a3. About the same
a4. Not applicable

Satisfaction with the Program

Thinking about your experience with the program, I'd like to ask about various aspects of satisfaction with program delivery.

30. Using a scale of 1 to 5, where 1 means very dissatisfied, 2 is somewhat dissatisfied, 3 is neither satisfied nor dissatisfied, 4 is somewhat satisfied, and 5 is very satisfied, how satisfied are you with the following program components?

Program Components	Rating Use 98 for DK and 99 for NA	For any component of the program, you are less than satisfied with (<4), You gave a <insert rating> for <ATTR>, why did you give it that rating?
a1. Home inspection process	1 2 3 4 5	
a2. Usefulness of the home inspection energy saving tips	1 2 3 4 5	
a3. Quality of work done by the installers/program contractors	1 2 3 4 5	
a4. The services or products received	1 2 3 4 5	
a5. The comfort of your home since receiving these upgrades	1 2 3 4 5	
a6. Energy savings since receiving these upgrades	1 2 3 4 5	
a7. Your experience overall	1 2 3 4 5	

31. Thinking about this program and your overall experience, what aspects of the program went well? [post code responses]

a1. Information provided
a2. Free services
a3. Free upgrades
a4. People who I interacted with
a5. Energy savings
a6. Improved occupant comfort
a7. None
a8. Other
a9. Don't know

32. What aspects of the program could be improved?

[post code responses]

a1. More advertising
a2. Provide more free equipment
a3. Provide higher quality equipment
a4. Provide more information at in-home inspection
a5. Provide this service to all customers
a6. Improve quality of service at install e.g., on-time, more informative, help set up equipment
a7. No suggestions
a8. Other [specify]

ABOUT YOUR HOME & OCCUPANTS

33. Do you own or rent this home?

a1. Own
a2. Rent

34. Which of the following building types best describes your home?

a1. Single-family detached home (home not attached to another home)
a2. Townhouse, duplex, or row house (shares exterior walls with neighboring unit, but not roof or floor)
a3. Apartment in multi-unit structure of 2–4 units
a4. Apartment in multi-unit structure of 5 or more units
a5. Manufactured or mobile home

35. What is the approximate square footage of your home?

a1. Less than 500 square feet
a2. 501-1,000
a3. 1,001-1,500
a4. 1,501-2,000
a5. 2,001-2,500
a6. Greater than 2,500 square feet
a7. Don't know

36. Including yourself, other adults, and children, how many people live in this home at least six months of the year?

a6. Record
a7. Prefer not to say

37. Since [month/year] has the number of household residence, increased, decreased or is it stayed the same? Select all that apply.

a1. Increased
a2. Decreased
a8. Stayed the same
a9. Prefer not to say

38. [If 37= a1 or a2. Else skip]: How many [more/fewer] people live in your home? How has the number of household occupants changed? [Probe for quantity and duration]

a1. Increased by qty:
a2. Decreased by qty:

39. What is the primary language spoken in your home?

a1. English
a2. Spanish
a3. Chinese (including Mandarin and Cantonese)
a4. Tagalog
a5. Vietnamese
a6. Korean
a7. Russian
a8. Other (please specify)
a9. Prefer not to say

40. What is the highest level of education you have completed?

a1. Elementary (grades 1-8)
a2. Some high school (grades 9-12)
a3. High school graduate
a4. Some college/trade/vocational school
a5. College graduate
a6. Postgraduate degree
a7. Don't know

Those are all of the questions I have for you today. Thank you for your time.

7.3 Appendix C: Impact Evaluation Methods

This section provides the details of the two-stage consumption data analysis approach DNV used to estimate the impact of LIW installations.

7.3.1 Data preparation

To prepare the daily data for analysis, we implemented a number of data cleaning processes. First, we screened both the electric and gas data to remove duplicate reads, total zero energy use for the year, and reads that correspond to onsite solar energy production. We also aggregated the billing data to the bill month so that there are 12 reads in a year; billing values that reflect multiple smaller read intervals were summed to the monthly level. We included only customers who have a full year of matching period data in the analysis.

First, we screened the daily data for duplicate reads at the customer and day level and aggregated or removed duplicates depending on the context. We also screened the data for negative values and for values that reflect the lack of electricity use (zero reads) and gas use (annual value of zero therms) over the analysis time period. Further, we also removed customers with multiple meters. Finally, we included data for only those customers with at least 90% of daily values in both the pre- and post-program period.

7.3.2 First-stage models

In the first stage, we estimate individual daily regression models of energy consumption for all customers in the residential analysis population. The models estimate consumption as a function of heating and cooling degree days, using daily data. Consistent with PRISM, these models identify the heating and cooling degree day base that support the best, most informed model. This individualized, site-level approach produces models that reflect the unique heating and cooling consumption dynamics of a house and its occupants. These models are required to put pre- and post-period consumption on a consistent weather basis. They also provide useful information on heating and cooling consumption.

The first-stage regression model used to estimate the effect of weather on energy consumption is given by:

$$E_{im} = \beta_0 + \beta_h H_{im}(\tau_h) + \beta_c C_{im}(\tau_c) + \varepsilon_{im}$$

Where:

E_{im} - Average electric (or gas) consumption per day for participant i during period m.

$H_{im}(\tau_h)$ - Heating degree-days (HDD) at the heating base temperature reference temperature, τ_h.

$C_{im}(\tau_c)$ - Cooling degree-days (CDD) at the cooling base temperature, τ_c, (not included in gas models).

$\beta_0, \beta_h, \beta_c$ – Site-level regression coefficients measuring intercept (base load), heating load, and cooling load, on a single year's energy consumption, respectively.

τ_h - Heating base temperatures, determined by choice of the optimal regression.

τ_c - Cooling base temperatures, determined by choice of the optimal regression.

ε_{im} – Regression residual.

Consumption is estimated over a range of 64°F to 80°F for cooling and 50°F to 70°F for heating to identify the temperature base points for each site (household); statistical tests identify the optimal set of base points. The site-level models produce parameters that indicate the level of energy consumption not correlated with either HDD or CDD (baseload), and the levels of energy consumption correlated with HDD (heating load) or CDD (cooling load). We estimated site-level models using daily

data. First-stage models were screened to remove estimates that had implausible (negative) cooling and heating coefficients.

Model parameter estimates for each site allow the prediction of site-level consumption under any weather condition. For evaluation purposes, all consumption is put on a typical weather basis, using typical meteorological year (TMY) values, and produces an estimate referred to as normalized annual consumption (NAC). NAC for the pre- and post-installation periods are calculated for each site and analysis time frame by combining the estimated coefficients $\hat{\beta}_h$ and $\hat{\beta}_c$with the annual TMY degree days H_0 and C_0 calculated at the site-specific degree-day base(s), $\hat{\tau}_c$ and $\hat{\tau}_h$. NAC is given by:

$$NAC_i = (365 \times \hat{\beta}_0) + \hat{\beta}_h H_0 + \hat{\beta}_c C_0$$

Individual household level regression models are estimated using observed weather data from Automated Surface Observing Systems (ASOS). Associated TMY data are used to weather normalize annual consumption using the estimated model parameters. The process serves two purposes; first, putting pre- and post-installation consumption on the same weather basis so that change in weather is not conflated with program effect, and second, choosing a weather basis that represents a reasonable expectation of future weather for the ex-ante projections.

For each home in the analysis, NAC is determined separately for the pre- and post-installation years, and the pre-post difference ΔNAC_i is calculated. Pre- to post-installation changes in weather normalized energy use formed the basis of the second stage DID models.[7]

7.3.3 Comparison group

The impact evaluation follows site-level billing analysis methodologies to provide valid estimates of changes in gas and electric consumption for program participants. A key challenge for this kind of study is establishing the correct baseline from which to quantify change. The industry-accepted and recommended approach combines pre-installation data and a matched comparison group to produce a baseline that accounts for non-program-related change occurring during the evaluation timeframe.

Developing a well-matched comparison group for the participants is essential to the impact evaluation's success. It involves the identification of non-participant households that are similar to participants in relevant observable characteristics within certain strata such as dwelling type and location. Matching is an art that balances the number and complexity of matching variables with the level of stratification.

We constructed matched comparison groups using data from customers that participate in PSE's Energy Assistance program. Requirements for participation in this program are similar to LIW participation[8] making these customers ideal matching candidates. PSE's CAA partners that implement the LIW program often recruit customers from this pool for participation in LIW. The matching involved identifying 1 household for every participant with similar energy use levels (constructed using daily electric and gas data) and tenure within strata defined by dwelling type. Since PSE's residential customers are primarily located in a single climate zone, the matching did not involve stratification by geographic region.

In all cases, matching models included annual energy use, the ratio of summer-to winter energy use to account for seasonality, and measures of peak demand to construct 1-to-1 matches. For gas, we used daily gas consumption for identified 'cool wave' periods to capture winter peak demand conditions. Such periods were identified for weekdays from December through February where most customers had their maximum daily gas use. For electricity, we identified 'cool wave' period energy consumption similarly and additionally used daily electricity consumption to identify 'heat wave' periods

[7] They were also used to determine and exclude outliers based on statistical tests; DID values exceeding pre-defined DFITS or studentized residual limits were considered outliers and excluded from the second stage DID models. No more than 2-4% of observations were excluded based on such tests.

[8] This program provides services to customers who meet income eligibility criteria of 150% of the FPL; the LIW program requires that customers have income at or below 200% of the FPL for participation.

to capture summer peak demand conditions. 'Heat wave' periods were identified for weekdays from June through September where most customers had their maximum daily kWh.

For both gas and electricity matching, we also used tenure as an additional matching variable. Tenure is the length of time, measured in years, that a customer has resided at a premise. It is based on account start dates available for every customer in PSE's records. We measure tenure as the difference, in years, from such account start dates to the beginning of the analysis period for this study, which is 2018. This measure is rounded to the nearest integer such that households residing less than half year relative to the start of 2018 are considered to have tenure of 0. While load markers such as annual energy use and peak demand identify like customers on the basis on energy use at a particular point in time, tenure helps identify like customers with similar energy use trends or changes in energy use over time.

We used Mahalanobis minimum distance matching without replacement for all matches used in the analysis. Mahalanobis distance matching is scale-invariant and considers correlations of covariates to generate matches that are well-balanced. Balance is tested using standardized mean differences, the ratio of the variance of participant to matched comparison households, and visual inspection of the distribution of covariates of participants to matched comparison households.

Following matching, tests of balance were conducted to test the condition of matches. The tests involved a comparison of the empirical distribution of matching variables via plots of their distribution, and the evaluation of their standardized mean differences and the ratio of their variances for the matched groups. The standardized mean difference is given by:

$$d = \left(\bar{X}_{treatment} - \bar{X}_{comparison}\right) / \sqrt{\left(S^2_{treatment} + S^2_{comparison}\right)/2}$$

A standardized mean difference value that exceeds 0.2 shows extreme imbalance, while the closer to 0 this value gets, the better the condition of matching. For the variance ratio, a value close to 1 indicates balance while values that are 0.5 or less and 2 or greater indicate extreme imbalance.[9]

7.3.4 Second-stage models

We estimated program impacts with a second-stage model that compares the pre-and post-installation site-level normalized annual consumption (NAC) between participant and comparison households. We produced the NACs with the site-level models and then captured the change in NAC between pre-and post-installation periods (∆NAC). Comparison group ∆NAC provided a proxy for the non-program change occurring between the two time-periods. This is a simple but robust model that can be estimated for geographical areas, consumption groupings or within any of the dimensions of interest.

The precision of the program-wide savings estimates is a function of the number of participants that can be incorporated into the analysis. Consumption data analyses for a program of this size estimating changes of this magnitude is expected to provide results with good relative precisions. While the analysis requires a year of pre- and post-installation data, the availability of interval data makes it possible to ease this requirement to 90% of pre- and post-period allowing the retention of data from more customers.

Pre- and post-program periods are based on a definition of a blackout period for each participant. We used installation dates from the tracking data to define a blackout period. While the majority of installations occurred within a single month for which we defined a month blackout periods, we also include projects with 2-month installation periods and defined 2-month blackout periods for these installations.

[9] Details of these tests are provided in http://www.iepec.org/2017-proceedings/65243-iepec-1.3717521/t001-1.3718144/f001-1.3718145/a011-1.3718175/an042-1.3718177.html

The pre to post-installation difference in NAC, which formed the basis of the DID model used to model whole-home energy changes, is given by:

$$\Delta NAC_i = \alpha_0 + \beta T_i + \varepsilon_i$$

In this model, i subscripts a household and T is a treatment indicator that is 1 for participant households and 0 for the matched comparison homes. The effect of program measures is captured by the coefficient estimate of the term associated with the treatment indicator, $\hat{\beta}$.

7.4 Appendix D: Impact Evaluation Details and Results

This appendix contains second-stage model results used to evaluate program installations.

7.4.1 Second-stage model results

Weather-normalized estimates of pre-post consumption difference are summarized in second-stage models. The intercept values from these models provide the percent change in weather normalized energy use that is not program or measure related. Negative intercept coefficients indicate, on average, increases in non-program related energy use while positive coefficients indicate decreases in non-program related energy use.

Table provides coefficient estimates of electric savings per home model runs for NAC by dwelling type. The intercept term estimates are negative for NAC for each dwelling type indicating increasing trend in non-program related electricity use from pre- to post-retrofit periods for both. The table also provides coefficient estimates that estimate change in electricity use (kWh) associated with LIW installations (captured by the estimates for the treat variables). The standard errors, p values that capture statistical significance, and the relative precision of the estimate are also included in the table. All LIW program related load reductions are statistically significant precisely estimated.

Table 14. Electric savings per home models by dwelling type, 2019-2020

Dwelling Type	Variable	Estimate	Standard Error	Relative Precision	P-value
Manufactured Home	Intercept	-424	140.6	-0.5	0.00
	treat	2,614	236.8	0.1	0.00
Single family	Intercept	-311	152.9	-0.8	0.04
	treat	1,773	231.7	0.2	0.00

Table 15 provides model estimates for gas models. The model estimates indicate program related whole-home reductions are statistically significant and precise. Detailed discussion of estimated reductions is provided in the impact result section of the report.

Table 15. Gas savings per home models by dwelling type, 2019-2020

Dwelling Type	Variable	Estimate	Standard Error	Relative Precision	P-value
Manufactured Home	Intercept	-17	20.8	-2.0	0.42
	treat	92	39.6	0.7	0.04
Single family	Intercept	-11	13.4	-2.0	0.41
	treat	143	22.3	0.3	0.00

7.5 Appendix E: Demographics of CATI Survey Respondents

Below we present demographic data from LIW who participated in the CATI survey.

Table 16. Own or Rent Home

Rent/Own	Percent
Own	70%
Rent	30%
Total	**100%**

n=135

Table 17. Home Building Type

Home Type	Percent
Manufactured or mobile home	42%
Single family detached home not attached to another home	39%
Townhouse, duplex, or row house shares exterior walls with neighboring unit, but not roof or floor	7%
Apartment in multi-unit structure of 5 = or more units	7%
Apartment in multi-unit structure of 2–4 = units	5%
Total	**100%**

n=135

Table 18. Living Space Square Footage

Square Footage	Percent
Less than 500 square feet	4%
501 to 1000	36%
1001 to 1500	34%
1501 to 2,000	18%
2,001 to 2,500	5%
Greater than 2,500 square feet	2%
Total	**100%**

n=103

Table 19. Primary Household Language

Primary Language Spoken	Percent
English	95%
Spanish	3%
Other	1%
Total	**100%**

n=133

Table 20. Highest Education Level

Highest Education Level	Percent
Elementary grades 1-8	1%
Some high school grades 9-12	14%
High school graduate	22%
Some college/trade/vocational school	29%
College graduate	28%
Postgraduate degree	7%
Total	**100%**

n=131

About DNV

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PSE PUGET SOUND ENERGY

Evaluation Report Response

Program: Home Energy Reports

Program Manager: Chris Stapleton

Study Report Name: Evaluation of 2020 Home Energy Reports

Draft Report Date: December 23, 2021

Evaluation Analyst: Kasey Curtis, Jesse Durst, Michelle Wildie

Date Final Report provided to Program Manager: February 17, 2022

Date of Program Manager Response: February 18, 2022

Overview:

The Home Energy Reports (HER) program aims to reduce residential energy consumption by motivating no- to low-cost energy conservation actions. Participating households receive periodic reports which offer a mix of energy usage information, energy consumption benchmarking, and personalized advice for saving energy. The reports are designed to encourage energy conservation behavior for electric and gas customers.

The HER program evaluation was broken into two parts: an impact and a process evaluation. The impact evaluation covered the 2020 program year, while the process evaluation covered 2020-2021 biennium. A full impact evaluation of the 2021 program year is expected in Q2 2022.

The 2020 HER program impact evaluation was structured as a randomized controlled trial (RCT) where the eligible population was randomly assigned to treatment and control groups. The RCT design results in precise and unbiased estimates of savings per household since the only systematic difference between randomly assigned treatment and control households is treatment.

The 2020-21 process evaluation was designed to provide information on how the HER program creates savings and how it might increase those savings. This year's evaluation included two components: an interview of PSE HER program staff and a large-scale online survey of HER recipients and non-recipients to understand their behaviors and attitudes. The program staff interview was designed to understand challenges and opportunities from the perspective of a PSE program manager. The online survey was sent to a large sample of HER recipients and non-recipients from different survey waves to better understand customer behaviors that affect energy use, their attitudes toward the home energy reports, and how these might vary between different types of customers.

Key Findings

Key findings from the impact evaluation are as follows:

- Total PSE HER 2020 electric savings are 46.6 million kWh and gas savings are 994,445 therms.
- After averaging more than 300 kWh savings per household for six years, the legacy current group has been generating fewer and fewer electric savings since 2018. Its measured gas savings has also been declining for the past four years.
- The suspended legacy group's electric savings continue to be statistically insignificant while its gas savings is nearly equal to the current legacy group's. This suggests that electric savings have not persisted without messaging from HERs while gas savings continue to maintain some level of persistence. Continued gas savings may be due to the installation of more efficient equipment, which persist after HERs are discontinued, while electric savings may be more dependent on behavioral changes, such as turning off lights and unplugging discretionary loads, which may be more short-lived.
- All previous expansion groups continue to save electricity and gas, with the high-user group generating an increase in electric savings from the previous year and generating nearly the same amount of gas savings as the previous year.
- The two new expansion waves from 2019, the electric only refill and the manufactured homes, show an increase in electric savings in 2020, following similar trajectories as the original expansion trio.
- Evaluators uncovered some extreme values in the consumption data, particularly within gas consumption data. These may be caused by errors at the meter level.

Key findings from the process evaluation include the following:

- Ninety-one percent of HER recipients are aware they receive the report, and 66% are aware of PSE's energy efficiency programs. More than three-quarters of recipients (78%) reported reading at least some of the report. However, fewer than half of recipients remembered seeing any message other than the recommendation to replace light bulbs with LEDs (55% recalled messaging about replacing light bulbs). Additionally, one-third of respondents do not recall any of the messages from HERs.
- Eighty percent of recipients liked the reports and 92% reported that, after receiving the reports, their opinion of PSE was either unchanged or more favorable.
- Home energy reports appear to be an effective method to promote equity in energy savings. Of low-income report recipients, 40% report reading the reports thoroughly, as compared to 32% of non-low-income customers. Low-income recipients are also more likely to find the reports useful to help save energy; eighty percent of low-income recipients report that the energy efficiency tips in the reports are useful compared to 76% of non-low-income recipients.
- PSE customers expect that, on average, they will continue to stay home for about 6% more hours (about 8 hours more per week) in 2022.
- Results show minimal difference in the energy savings behaviors and technologies examined in the survey. It is possible that differences too small to show statistical

significance, over many behaviors and technologies, yield the meaningful savings found in the impact evaluation.

Evaluation Recommendations and Program Responses

Program recommendations are found in the Executive Summary (Section 1), as well as the Findings and Recommendations (Section 6). The report's overall conclusions and recommendations based on the impact and process related findings and program staff responses to those recommendations, are presented below.

- PSE should consider further investigating the source of and reasons for extreme values that appear in the daily consumption data. This could ultimately produce more accurate consumption data and reduce the need to remove extreme values from the analysis.

  Program Response: PSE will review and investigate this recommendation. As stated in the findings of the evaluation extreme values "may be caused by errors at the meter level." PSE will request if the evaluator can provide specific examples at the account level to research whether there is a theme that can be identified that may be causing this issue.

- Because PSE customers expect that they will continue to spend more time at home after the pandemic, technologies and behaviors that save energy by reducing use when customers are away from their homes may be somewhat less important. In contrast, technologies and behaviors that reduce energy use while customers are at home, especially while running work-from-home electronics, may be more important or present increased savings opportunities.

  Program Response: In 2022, PSE will continue to actively promote the online energy saving tools available to customers within their online accounts as a marketing module within the Home Energy Report. This should help customers perform the online assessment to gain better understanding about their home's energy usage and provide tips about how customers can be more energy efficient. Many of the tips apply whether the home is occupied, or not, but PSE does offer saving tips about spotlighting work areas, using electronic equipment (computers, monitors, etc.) efficiently.

- HERs are both an effective way to save energy and are broadly popular. Simple messages are remembered best. If PSE's goals adjust to focus on decarbonization instead of energy efficiency, a similar report recommending simple actions to achieve decarbonization is likely to be effective and popular. However, it is important to note that electrification will increase load and, if unaddressed in the impact evaluation methodology, subsequent evaluations would report lower energy savings. Therefore, if PSE chooses to message electrification measures, it should simultaneously develop an energy savings methodology in coordination with evaluators and the stakeholder groups to ensure it does not unfairly affect its energy savings estimates.

  Program Response: There is not a current plan to shift Home Energy Report messaging from an energy efficiency to a decarbonization focus. If that changes in the future, PSE will work with internal stakeholders and with evaluators to ensure the savings methodology is developed with potential changes in energy load in mind.