Puget Sound Energy

2017

Annual Report of Energy Conservation Accomplishments

Volume 2:

- 2016 Evaluation Studies + ERRs

PSE PUGET SOUND ENERGY

Program:

- Home Energy Reports Program

Program Year:

- 2016

Contents:

- Evaluation Report
- PSE Evaluation Report Response

This document contains DNV GL's PSE Home Energy Reports Program - 2016 Impact Evaluation – Final Report, and Puget Sound Energy's Evaluation Report Response (ERR).

In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

PSE program managers and evaluation staff prepare an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Please note that this is an evaluation of the program as it operated during the 2016 program year.

This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx,** search words 'PSE Home Energy Reports Program - 2016 Impact Evaluation'.

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[1] (6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for 2016-2017 PSE Electric Conservation.

[2] PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised August 6, 2015.

[3] Ibid.

PSE HOME ENERGY REPORTS PROGRAM

2017-11-16

Project name:	
Report title:	
Customer:	
Contact person:	Jonathan Taffel
Date of issue:	
Project No.:	10021136
Organization unit:	DNV GL – Energy, SUS-PAR

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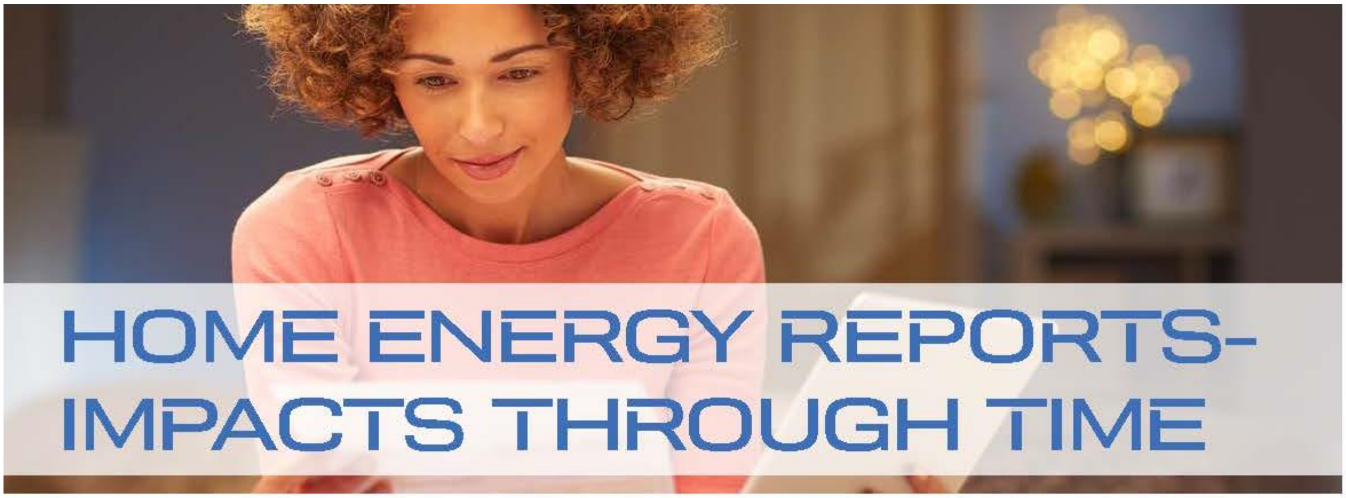
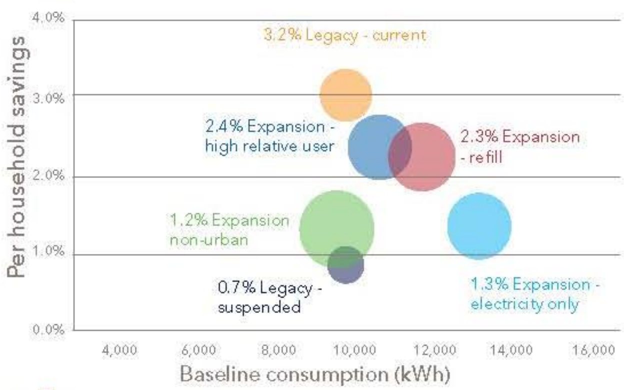


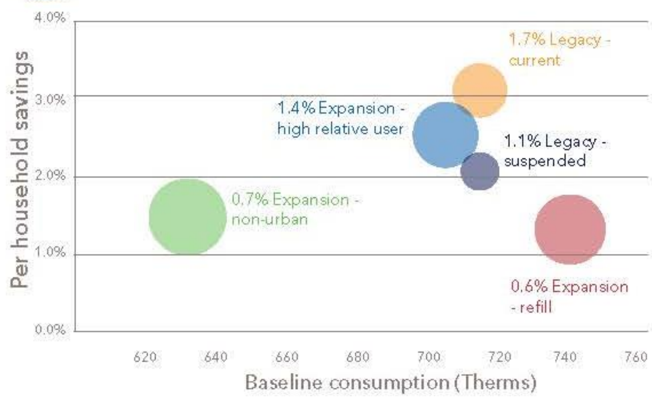
HOME ENERGY REPORTS- IMPACTS THROUGH TIME

The charts below show baseline consumption and per-household savings. The size of each bubble represents the number of customers. The percentage label outside the bubble is the per-household percent savings (Y axis value). The top right indicates high consuming customers with high savings, and bottom left indicates low-consuming customers with low savings.

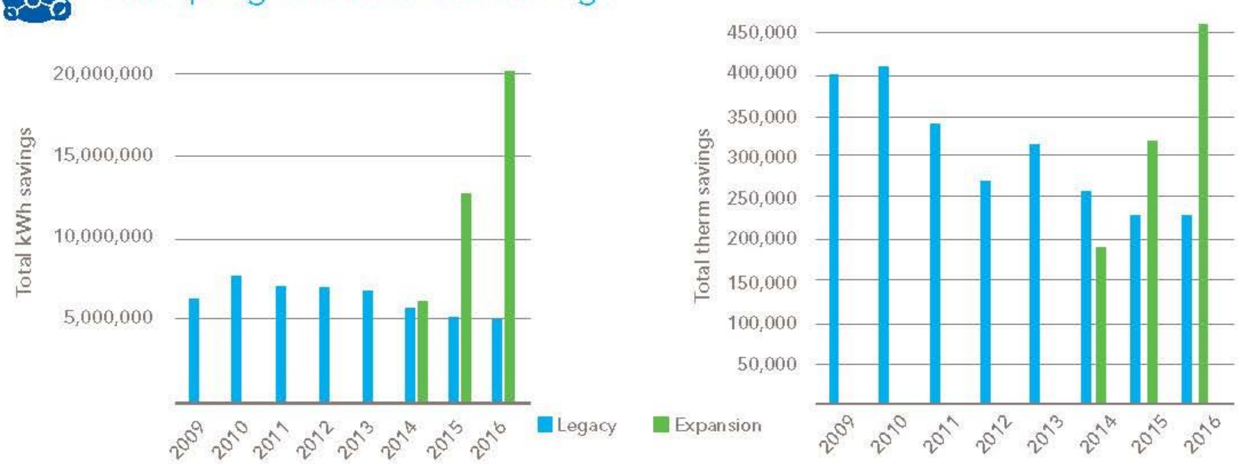
Electric



Gas

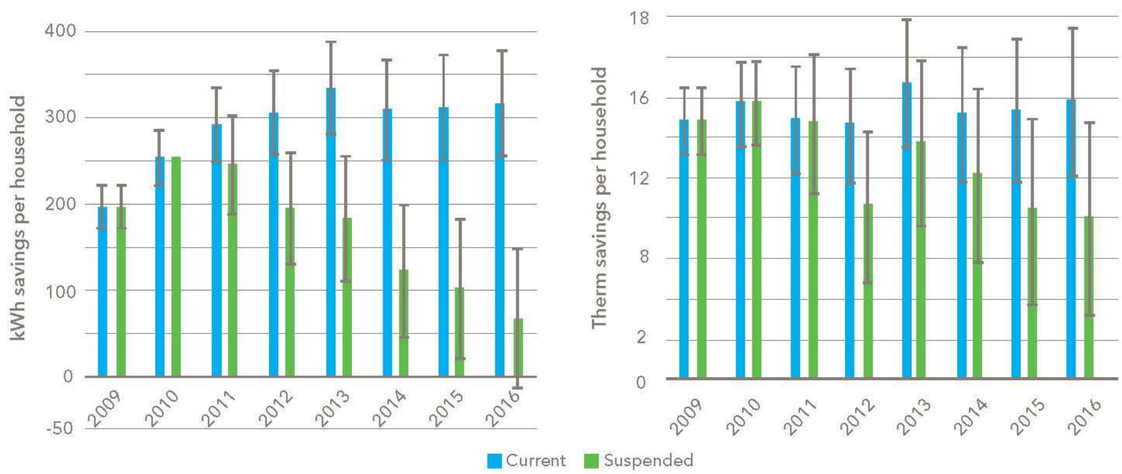


Total program credited savings



Measured Energy Savings

Legacy savings

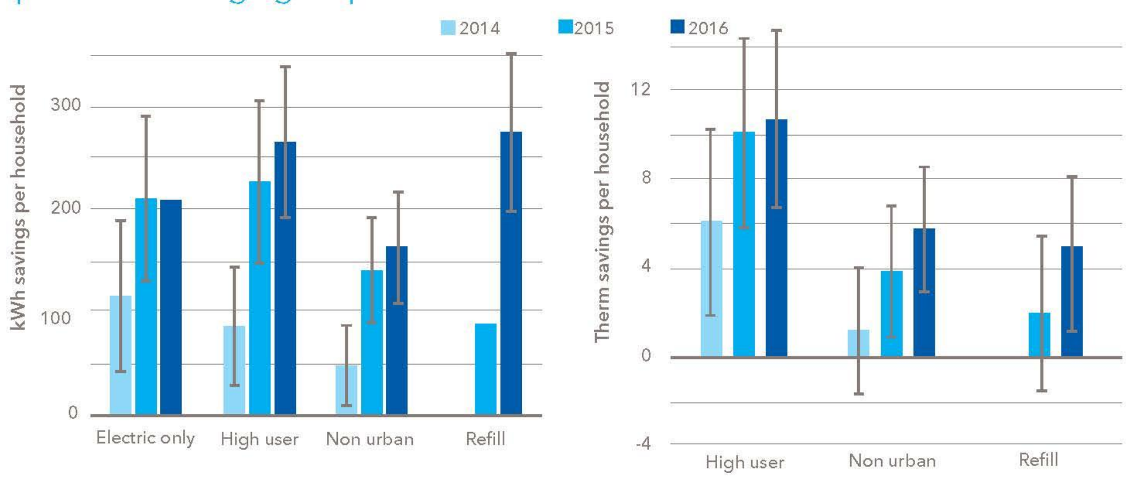


Per household electric and gas savings among the legacy **current** group remain **steady**.

Electric per household savings among the legacy **suspended** group continue to **decline.**

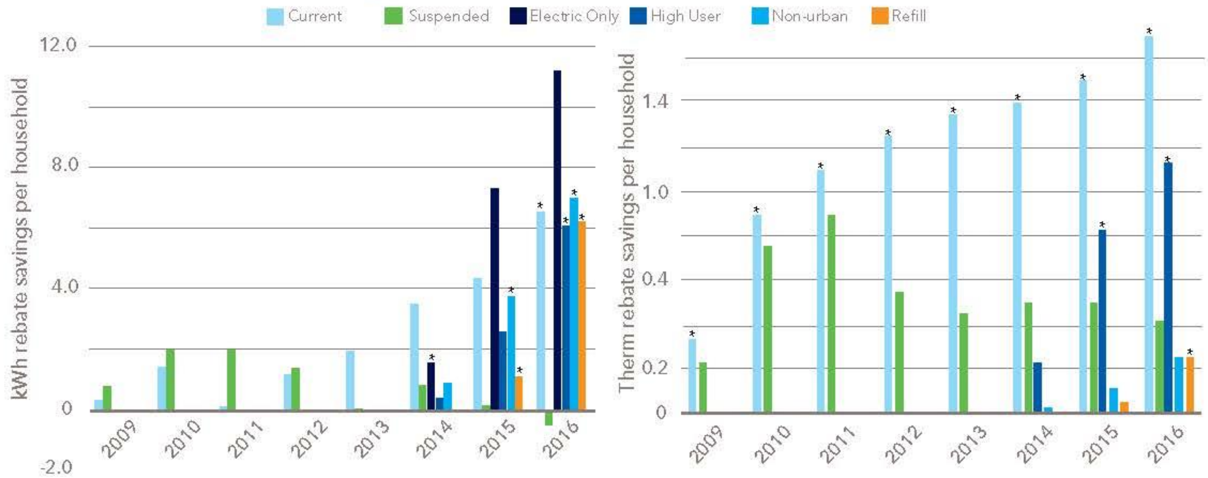
By looking at the **legacy** group over time, per-household electric and gas savings began to **level off after 5 years** of receiving the reports.

Expansion savings groups



Based on the legacy group's trends, we expect to see **expansion group's** per-household savings continue to **increase** annually before they level off.

Joint Savings



*Indicates statistically significant at the 90% confidence level.

Legacy current joint **electric** savings are statistically **significant** in 2016.

Legacy current joint **gas** savings continue to **increase** annually.

The **electric-only** customers had the highest savings attributed to joint savings yet due to high variability, the electric-only joint savings were **not statistically significant.**

Claimed Savings

All groups who received HERs in 2016 achieved **statistically significant** claimed savings.

HER TREATMENT GROUP	BASELINE CONSUMPTION	PER HOUSEHOLD			PER HOUSEHOLD AS PERCENT OF CONSUMPTION		
		MEASURED SAVINGS	JOINT SAVINGS	CLAIMED SAVINGS	MEASURED SAVINGS	JOINT SAVINGS	CLAIMED SAVINGS
Legacy - Current	9,782	316.7*	-6.6*	310.1*	3.2%	-0.1%	3.2%
Legacy - Suspended**		70.2	0	70.2	0.7%	0.0%	0.7%
Expansion - Electric only	13,204	208.6*	-39.4*	169.2*	1.6%	-0.3%	1.3%
Expansion - High relative user	10,656	265.0*	-7.2	257.7*	2.5%	-0.1%	2.4%
Expansion - Non-urban	9,566	163.1*	-30.2*	132.9*	1.5%	-0.3%	1.2%
Expansion - Refill	11,722	274.3*	-6.3	268.0*	2.3%	-0.1%	2.3%

*Indicates statistically significant at the 90% confidence level.
** This group stopped receiving HERs in 2011.

1 EXECUTIVE SUMMARY

1.1 Background

Puget Sound Energy (PSE) implemented the Home Energy Reports (HER) program in 2008. The HER program delivers customized, periodic reports on energy consumption to participating households and compares the households' energy consumption to that of similar neighboring homes. In addition, the reports provide personalized tips on how to save energy based on the energy usage and house profile. The HER program was designed to motivate households to reduce energy consumption through behavioral changes and participation in other PSE energy efficiency programs.

PSE structured the program as a randomized controlled trial (RCT). The RCT experimental design randomly assigns a population of interest to control and treatment groups. Due to this random assignment, the only differentiating factor between the two groups is the receipt of the Home Energy Reports. Thus, the approach produces an unbiased estimated of the change in consumption with a high level of statistical precision due to the treatment. Program energy savings are established by an independent evaluation, based on differences in energy use between these two groups.

HER participant groups have changed over time, either by attrition or by design. This evaluation report identifies gas and electric savings overall and by the following participant groups:

- The initial treatment group (2008): nearly 40,000 dual fuel, single family homes received a Home Energy Report; the control group: 44,000 dual fuel, single family homes did not.
- The suspended group (2010): approximately 10,000 treatment group households stopped receiving the HER, allowing PSE to test the persistence of report-based savings after the cessation of reports.
- The expansion groups (2014): the program added approximately 175,000 households. This was a pilot effort to determine whether adding 1) households with high usage relative to the size of their home (high relative user), 2) electric-only households, and/or 3) non-urban households made a difference in per-participant energy savings and/or customer satisfaction.
- The refill group (2015): PSE added approximately 25,000 treatment households and 10,500 control households to replace households lost due to customer attrition since the start of the program.

1.2 Evaluation goal and objectives

The main goal of the impact evaluation is to estimate HER program savings for the year 2016. Specifically, the objectives are:

1. Calculate Measured Savings: measure the reduction in electric and natural gas consumption between the various control groups and their matched HER treatment groups.
2. Calculate Joint Savings: quantify savings from HER participants' increased participation in other PSE energy efficiency programs:

- An increase in the number of participants and/or extent of participation in PSE rebate programs due to the HER program
- Any HER-related increase in the number of purchased CFL or LED bulbs supported by PSE and BPA upstream lighting programs.

3. Calculate Claimed Savings: provide a final estimate of 2016 HER savings for all legacy and expansion programs, adjusted for double counted savings resulting from participation in PSE rebate and upstream lighting programs in previous HER years.
4. Expand Study to Unmatched Group: measure electric and natural gas measured, joint, and claimed savings for an additional treatment group that had been previously excluded from savings estimates due to lack of a control group.

1.3 Key findings

In this evaluation, key findings include:

1. **All groups who received HERs in 2016 achieved claimed savings that were significantly different from their representative control groups.** The legacy current group achieved the largest per-household claimed savings as a percent of consumption (3.2% out of 9,782 kWh and 1.7% out of 716 therms), while expansion groups, still within their ramp-up period, achieved significant claimed savings for all groups (between 1.3% and 2.4% electric and 0.6% and 1.7% gas). Rebated and/or upstream joint savings ranged from 6.3 to 39.4 kWh for electricity and 0.3 to 1.7 therms for gas. These savings were significant except for the expansion high relative user and refill groups for electricity, and the expansion non-urban group for gas.
2. **HER-related savings persist after customers stop receiving the report, though savings decline over time. In this evaluation, electric savings among customers who stopped receiving the report in 2011 were no longer significant.** Evaluation findings suggest that the measure persistence of the electric HER report is around five years. However, the legacy – suspended gas savings were two-thirds of the legacy current treatment group's gas savings, and remained statistically significant, revealing a stronger persistence of gas savings.
3. **The recently added expansion group has lower savings overall, though the savings are increasing over time.** Per household savings are between 1.3% (Electric only) and 2.4% (High relative user), while the legacy current group, after eight years continues to show 3.2% savings. The expansion groups appear to match the trends of the legacy current group where savings increase annually for the first four years of the HER program. If these groups continue to mirror this program ramp-up trend, we will see additional years of growth in savings among the expansion groups.
4. **While 2016 was its first full program year, the refill group produced the highest measured savings among all expansion groups.** We found that the refill group had the second-highest baseline electric consumption (the electric-only group had the highest baseline electric consumption), and the highest baseline gas consumption across all participant groups.
5. **Over time, treatment households achieve deeper electric savings from participating in additional PSE programs than control households**. For the first time in the history of PSE HER

evaluations legacy current joint electric savings are statistically significant. The non-urban group had the highest electric program participation rate (3.6%), and the legacy current group had the highest gas program participation rate (3.6%). These results suggest that the HERs provide a consistently effective communication channel to engage customers and increase downstream program participation.

Table 1-1 and able 1-2 provide the group-level and overall electric and gas savings estimates, respectively. The overall electric savings were estimated at 90/13 precision and the gas savings were estimated at 90/24 precision. The table includes the unmatched treatment group per household savings. The number of customers shown in this table differs from the original customer count due to attrition (i.e., customer move-outs or program-opt-outs).

Table 1-1. Total credited electric savings for 2016 HER programs (kWH)

HER treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Claimed Savings	No. in group	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy – Current	316.7*	6.6*	310.1*	14,499	4,496,101	3,620,125	5,372,078
Legacy – Suspended	70.2	0	70.2	7,238	507,849	-65,943	1,081,642
Expansion - Electric only	208.6*	39.4*	169.2*	23,050	3,899,808	2,036,349	5,763,267
Expansion - High relative user	265.0*	7.2	257.7*	21,558	5,556,298	3,938,434	7,174,161
Expansion – Non-urban	163.1*	30.2*	132.9*	30,758	4,087,166	2,394,061	5,780,271
Expansion – Refill	274.3*	6.3	268.0*	24,150	6,472,623	4,605,765	8,339,481
Unmatched Group[1]	N/A	N/A	316.5*	3,846	1,217,428	982,279	1,452,239
ALL			209.7	125,099	26,237,273	22,747,556	29,726,654

** Indicates statistically significant at the 90% confidence level. Values in parentheses are the upper and lower bounds at the 90% confidence interval.*
[1]Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (3.2%) by the average household consumption of the unmatched group (9,892 kWh).

Table 1-2. Total credited gas savings for 2016 HER programs (therms)

HER treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Claimed Savings	No. in group	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - Current	13.9*	1.7*	12.2*	14,499	176,932	122,174	231,689
Legacy - Suspended	8.1*	0.4	7.7*	7,238	55,501	20,202	90,799
Expansion - High relative user	10.7*	1.1*	9.6*	21,558	205,862	118,488	293,236
Expansion – Non-urban	5.7*	1.1	4.6*	30,758	141,806	54,035	229,578
Expansion – Refill	5.0*	0.3*	4.7*	24,150	114,099	21,445	206,754
Unmatched Group[1]			13.9	3,846	53,482	36,855	70,063
ALL			7.3	102,049	747,682	571,838	923,481

** Indicates statistically significant at the 90% confidence level. Values in parentheses are the upper and lower bounds at the 90% confidence interval.*
[1]Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (1.7%), by the average household consumption of the unmatched group (818 therms).

For the first time, we report on savings for treatment households that are not matched to a control group (Section 6). We conducted a propensity matching analysis for these unmatched households and found evidence that the unmatched treatment households achieved savings equal to or higher than the legacy current treatment group. Due to specific data uncertainties, we determined that applying the legacy – current's percentage of per household savings to the unmatched group was appropriate in this evaluation. We recommend additional research in the next evaluation.

Table 1-3 summarizes the HER program results as a percent of average consumption. The legacy current treatment group produced credited savings of 3.2% and 1.7% for electric and gas, respectively. After six years of not receiving the report, the legacy suspended treatment group produced only 20% of the electric savings of the legacy current treatment group. For the first time in the history of evaluating the legacy suspended group, the legacy suspended group's electric savings was not significantly different than the legacy control group. This finding suggests that the measure persistence of the electric HER report is around five years. However, the legacy – suspended gas savings were two-thirds of the legacy current treatment group's gas savings, and remained statistically significant, revealing a stronger persistence of gas savings.

Table 1-3. Credited savings per household as a percent of consumption

HER treatment group	Electric (kWh)			Gas (therms)		
	Consumption	Claimed Savings	Percent	Consumption	Claimed Savings	Percent
Legacy program						
Current	9,782	310.1* (249.7,370.5)	3.2%	716	12.2* (8.4,16.0)	1.7%
Suspended		70.2 (-9.1,149.4)	0.7%		7.7* (2.8,12.5)	1.1%
Expansion program						
Electric only	13,204	169.2* (88.3,250.0)	1.3%	N/A	N/A N/A	N/A
High relative user	10,656	257.7* (182.7,332.8)	2.4%	706	9.6* (5.5,13.6)	1.4%
Non-urban	9,566	132.9* (77.8,187.9)	1.4%	632	4.6* (1.8,7.5)	0.7%
Refill	11,722	268.0* (190.7,345.3)	2.3%	742	4.7* (0.9,8.6)	0.6%

** Indicates statistically significant at the 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval and consumption was calculated using the average actual consumption of the control group in post year 2016.*

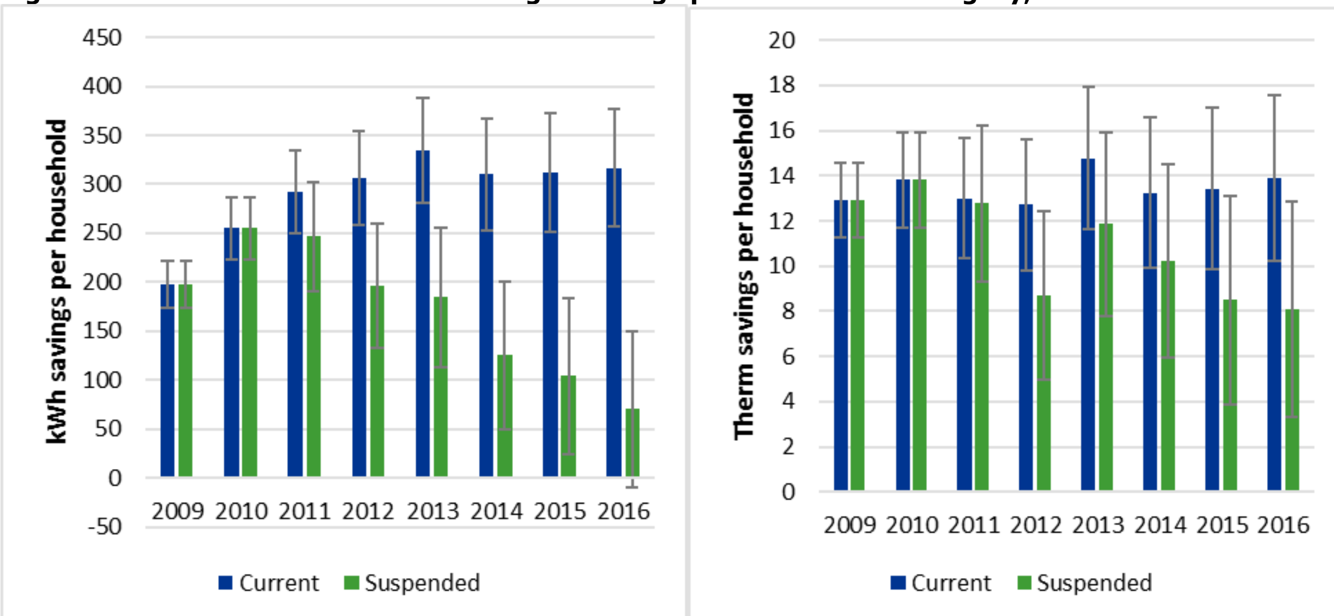
The three HER expansion groups started receiving the reports in March 2014. Percent savings for these groups were within the magnitude of 1% to 3% that were expected from the HER program. The high relative user group generated the highest savings of around 2.4% electric and 1.4% gas while the electric only group produced the lowest electric (1.3%), and the refill group produced the lowest gas (0.6%) savings. Based on the trends that we have seen among the legacy current group, we expect to see per household savings increase annually for the first four to five years of the program. Because the electric only, high relative user, and non-urban groups have only received reports for three years, and the refill group has only received the report for less than two years, we anticipate that per household savings for these groups will continue to increase.

Figure 1-1 provides measured electric and gas savings for the legacy program from 2009 to 2016. The electric savings for the active legacy HER group (legacy current) increased through the fifth year (2013) of the program, but has flattened since then. Legacy current group gas savings have remained relatively flat throughout the history of the program, ranging from 13 to 15 therms per household.

As mentioned above, the electric savings of suspended program participants (legacy suspended) have been in decline since their suspension in 2010 and are now 20% of the legacy current group's electric savings. Figure 1-1 displays that trend over time, and shows that in 2016, these savings are no longer statistically significant.

The gas savings of the legacy suspended group have also decreased since PSE discontinued HER messaging, but at a slower rate than the electric savings. In 2016, measured savings of the legacy suspended group are about 60% of the measured savings of the current legacy treatment households and remained statistically significant.

Figure 1-1. Measured HER electric and gas savings per household for legacy, 2009-2016



Note the figure on the left is for electricity while the one on the right is for gas. Note also that the graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

The HER program exhibited energy usage patterns that differed by participation and fuel type. Households in the legacy current group experienced an increase in kWh savings through the fifth year of receiving HER reports, with savings flattening in the sixth year. Households in the legacy suspended group experienced a decline in kWh and gas savings after they stopped receiving HER reports. While this group continued to observe statistically significant gas savings, this was the first year in which they did not generate statistically significant electrical savings.

The HER program also promotes participation in other energy efficiency programs, in addition to offering energy saving tips. In this evaluation, we observed that joint savings from electric rebate programs were statistically significant for the legacy current group. This is likely due to a combination of treatment households doing deeper retrofits as the program matures and increased number of households from the treatment group taking advantage of other PSE rebate programs.

2 INTRODUCTION

2.1 Program description and objectives

In 2008, Puget Sound Energy (PSE) became the second utility in the U.S. to implement a comparative usage feedback program designed to conserve energy. The Home Energy Reports (HER) program used social normative techniques to encourage responsible energy behavior and choices. Opower administered the program, providing comparative energy usage reports with feedback to households on their energy use as compared to the energy usage of neighboring homes. The program applied the concept of behavioral “nudges” to motivate customers to achieve energy savings. In addition, the reports provided tips for reducing energy consumption through behavioral changes and participation in other PSE energy efficiency programs.

- The program was structured as a randomized controlled trial (RCT) to facilitate precise and unbiased estimates of average per household savings that are small on a percentage basis. The initial treatment group (2008), consisting of nearly 40,000 dual fuel, single family homes, received a Home Energy Report; the control group, consisting of 44,000 dual fuel, single family homes, did not.
- The suspended group (2010): approximately 10,000 treatment group households were chosen to no longer receive the HER, allowing PSE to test the persistence of report-based savings after the cessation of reports.
- The expansion groups (2014): approximately 175,000 households were added. This was a pilot effort to determine whether adding either 1) households with high usage relative to the size of their home (high relative user), 2) electric-only households, or 3) non-urban households made a difference in per-participant energy savings and/or customer satisfaction.
- The refill group (2015): PSE added approximately 25,000 treatment households and 10,500 control households to replace households lost due to customer attrition.

This evaluation focused on energy savings due to the PSE HER program for calendar year 2016. The specific objectives are:

1. Measure the reduction in electric and natural gas consumption between the control group and the HER treatment groups of the legacy and expansion programs.
2. Quantify the savings from HER-related increased uptake of other PSE energy efficiency programs that may be present in the measured consumption reduction due to:
    - An increase in the number of participants and/or extent of participation in PSE rebate programs
    - An increase in the number of purchased CFL or LED bulbs supported by PSE and BPA upstream lighting programs.
3. Provide a final estimate of 2016 HER savings for legacy and expansion programs, adjusted for double counted savings resulting from participation in PSE rebate and upstream lighting programs in previous HER years.

The remaining chapters of this report are organized as follows: Section 3 presents the overall research design and data collection activities. Section 4 discusses the methodology used; Section 5 presents the PSE HER program impact evaluation results, and Section 6 presents preliminary results pertaining to a matched comparison study of the energy savings of legacy treatment households that were not included in the original RCT. Conclusions are offered in Section 7 with appendices appearing in Section 8.

3 RESEARCH DESIGN AND DATA COLLECTION ACTIVITIES

3.1 Experimental design

Legacy program

In 2008, PSE established the legacy HER program. PSE selected a total of 83,881 single family homes located in PSE's combined gas and electric service territory based on the selection criteria in Figure 3-1.

Figure 3-1. Selection criteria for legacy program

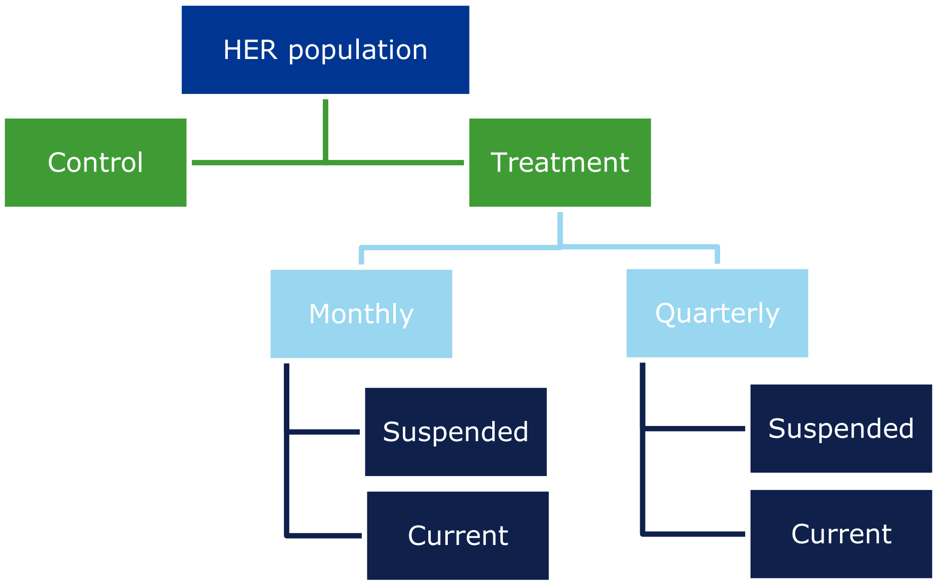
Legacy program

- Dual fuel (home uses both natural gas and electricity, which are both provided to the service address by Puget Sound Energy)
- Single family residential home
- Home does not utilize a solar PV system
- Uses more than 80 MBtu of energy per year
- Address must be available with parcel data from the county assessor
- Has a bill history that starts on or before January 1, 2013
- Home must have 100 similar sized homes (neighbors) within a two mile radius
- Home must have automatic daily meter reads

After selecting participating households, PSE randomly assigned 39,757 homes to the treatment group and the remaining homes were used as a control group. Of the selected treatment homes, 25% were randomly selected to receive HER on a quarterly basis, while the remaining 75% received the report monthly. The random assignment of monthly and quarterly reports allowed PSE and Opower to test if the frequency of receiving the reports affected energy savings.

PSE implemented the legacy program from November 2008 through December 2010. Starting in November 2010, PSE discontinued sending reports to 9,674 treatment homes. This treatment group is now referred to as the "legacy suspended" treatment group; households that continued receiving reports are referred to as the "legacy current" treatment group. Figure 3-2 depicts the different HER groups used in this evaluation.

Figure 3-2. HER control and treatment groups



Expansion program

In 2014, PSE added a new population to the HER program to include a total of 140,000 single family households assigned to the high relative user, non-urban, and electric-only groups. Both the high relative user and electric-only groups consisted of 31,500 homes in the treatment group and 10,500 homes in the control group, while the non-urban group was comprised of 42,000 homes in the treatment group and 14,000 homes in the control group. The household selection criteria used for the three groups in the HER expansion program are provided in Figure 3-3.

Figure 3-3. Selection criteria for expansion program

High relative user

- Dual fuel (home uses both natural gas and electricity, which are both provided to the service address by Puget Sound Energy)
- Single family residential home
- Home does not utilize a solar PV system
- Address must be available with parcel data from the county assessor
- Has a bill history that starts on or before January 1, 2013
- Home must have 100 similar sized homes (neighbors) within a two mile radius
- Home must have automatic daily meter reads

Non-urban

- Must be in one of the selected ‘non-urban’ zip code population (outside PSE's major metropoiltan core)
- Dual fuel (home uses both natural gas and electricity, which are both provided to the service address by Puget Sound Energy)
- Single family residential home
- Home does not utilize a solar PV system
- Address must be available with parcel data from the county assessor
- Has a bill history that starts on or before January 1, 2013
- Home must have 100 similar sized homes (neighbors) within a two mile radius
- Home must have automatic daily meter reads

Electric only

- Home uses electric for space and water heating
- Single family residential home
- Home does not utilize a solar PV system
- Address must be available with parcel data from the county assessor
- Has a bill history that starts on or before January 1, 2013
- Home must have 100 similar sized homes (neighbors) within a two mile radius
- Home must have automatic daily meter reads

Refill program

In May 2015, PSE added a refill group that consisted of households from the remaining population of the HER expansion pool. The refill group included 25,000 treatment households and 10,500 control households that were randomly selected to replace households lost due to customer attrition.

Unmatched treatment customers

At the inception of the HER program, PSE included 4,864 geographically-clustered customers into a treatment group, but did not match these customers to a control group. Of these customers, 4,830 resided in zip code 98006, and the remaining 1% of unmatched treatment customers lived in neighboring zip codes.

3.2 Data sources and disposition

For the impact evaluations, the evaluators used information collected from consumption data, program tracking data, and participant survey data for both the legacy and expansion programs. The evaluators reviewed all datasets for accuracy and completeness. Data sources and data preparation activities are described in the following subsections.

3.2.1 Data sources

Program participants

PSE provided premise numbers, customer account numbers, electric and gas meter numbers, and treatment assignment of HER program participants. This data served as the roster of program participants for the HER evaluation. For legacy, PSE provided additional household information such as zip codes, house square footage, number of bedrooms/bathrooms, and house value.

Daily consumption data

PSE provided daily consumption data of their customers from January 2007 to December 2016 to facilitate the impact analysis. These datasets included meter numbers, daily consumption reads, read dates, and the type of reading (actual or estimated).

Opower data

PSE provided Opower with monthly data that Opower used to generate comparative reports for the HER legacy and expansion participants. Opower then provided PSE with an extract of monthly consumption data with information on households that opted out of receiving the reports. The dataset included monthly billing data through December 2016, participants, site location, treatment assignment, customers who opted out of the program, and dates when customer accounts became inactive. The inactive dates were used to identify participants that moved out during the analysis period.

Rebate program tracking data

The program tracking data included information on PSE customers who participated in other PSE rebate programs in 2016, which facilitated rebate program joint savings calculation for the HER program. The tracking data included participant information, account numbers, program name, measures installed, installation dates, and claimed savings.

3.2.2 Billing data disposition

The daily consumption data were the primary data used to determine impacts from the HER legacy and expansion programs. The evaluators examined the consumption data for completeness and potential data issues such as duplicates, extreme values, missing observations, and other inconsistencies.

Data preparation steps included:

- Removal of duplicate reads. Duplicates were identified using the following criteria:
  - When meters produced two or more identical reads in one day, only one read was included in the analysis.
  - When a meter produced two or more different reads in a day, both reads were excluded from the analysis.
- Exclusion of negative reads.
- Exclusion of extreme values (greater than 150 kWh per day or 11 therms per day).
- Examining missing observations. There were two causes of missing observations:
  - Missing daily observations, caused by missed daily reads, were generally followed by a single read that covered the multiple missing days. Data imputation was employed by distributing energy consumption of that next non-missing meter read. Imputation was only done when

the next non-missing read covered the missing period as indicated by start and end read dates.

    - Incomplete daily consumption data. The number of missing days was very few and not expected to make any substantial impact on the analysis.

- While previous evaluations removed move-outs from the entire analysis, the fixed-effects methodology allows us to incorporate those households into the monthly analyses for which they were active customers. As we do not remove 2016 move-outs in this evaluation, we do not include them in the disposition tables below.

Table 3-1 summarizes the original program population, counts of households removed from the analysis, and the final sample used in billing analysis for the legacy program. After reviewing the distribution of consumption data, we found that 99% of data points were less than 150 kWh or 11 therms. We considered reads higher than these thresholds as outliers, and dropped observations that exceeded them. Note that in the 2015 evaluation, we set thresholds at 400 kWh and 30 therms. While we dropped these individual data points from the analysis, we used these households for the overall analysis, so they are not shown as a line item in Table 3-1 or Table 3-2.

Table 3-1. HER legacy data disposition

Population	Control	Treatment	Total
Original population	**44,124**	**39,757**	**83,881**
Not in customer/billing data	35	42	
Not randomly assigned	N/A	4,864*	
Other Opower program	111	N/A	
Move outs (2007 – 2015)	16,486	13,044	
Inconsistent zip codes	72	70	
Final analysis sample for 2016	**27,420**	**21,737**	**49,157**
Monthly – Current	N/A	10,365	
Monthly – Suspended	N/A	5,196	
Quarterly – Current	N/A	4,134	
Quarterly – Suspended	N/A	2,042	

* *Note that when performing the analysis of the unmatched group, of the 4,864 treatment households that were not assigned a control group, we removed 1,018 due to move-outs.*

In Table 3-1, we list 4,864 legacy customers who were not assigned a control group in the RCT. Over 95% of these customers resided in the 98006 zip code, and the remainder were located neighboring zip codes. In this evaluation, we refer to these households as the "unmatched group." Consistent with previous PSE HER evaluations, we excluded the expansion group from the main analysis. However, we further researched the savings impact of these households by conducting a matching procedure. In this exercise, we selected a control group based on common consumption characteristics, and found that the unmatched households produced significant savings. Yet because we also observed data trends that suggested the analysis may have captured additional, non-behavioral impacts, we felt additional analysis was required before assigning these full savings estimates to this group. Given the evidence that all groups have demonstrated steady and statistically significant energy savings over time, and the matching analysis showed statistically significant savings for the unmatched group, we recommend applying legacy current per-household savings as a percent of consumption to these households. This is a conservative savings estimate; additional analysis in the 2017 evaluation is advised with an expanded pool of potential control households. We discuss this further in Section 6.

The data disposition for the HER expansion program is provided in Table 3-2. Data processing steps applied were consistent with the steps applied to the HER legacy program (as described in earlier in this section).

Table 3-2. HER expansion data disposition

Population	Control	Treatment	Total
Original population	**45,500**	**130,000**	**175,500**
Electric only	10,500	31,500	
High relative user	10,500	31,500	
Non-urban	14,000	42,000	
Refill	10,500	25,000	
Missing consumption data	645	1805	
Move outs (2007-2015)	9,702	28,679	
Final sample in 2016	**35,153**	**99,516**	**134,669**
Electric only	7,646	23,050	
High relative user	7,098	21,558	
Non-urban	10,263	30,758	
Refill	10,146	24,150	

One percent or less of the households in the legacy and expansion treatment groups opted to not receive the reports at some point during the treatment period, but remained designated as members of the treatment group. Removing opt-out households would undermine the similarity between the two groups that is established by the program's experimental design. This is referred to as testing the "intent to treat" and is necessary to produce an unbiased estimate of the reports' effect.[4]

Overall, any data issues identified impacted less than 5% of observations, and should not bias the results as they were equally shared between the treatment and control groups.

Appendix 8.1 presents the test of randomization using the final samples for legacy and expansion programs.

[4]The RCT design creates treatment and control groups that are similar, on average, by design. The RCT approach avoids the possible negative effects of self-selection on the savings estimates. The RCT approach, and its associated un-biased savings estimates, has made it possible for the HER programs to flourish across the country. Only certain kinds of households can be removed from either treatment or control groups while maintaining the validity of the RCT. Customer attrition that is not correlated with the treatment (in this case, the reports) can be removed from the analysis without undermining savings. For instance, occupants who leave the address where they received the reports are dropped from the analysis. We do not see evidence that the home energy reports have affected the moving rate among households. In fact, moving rates are similar across treatment and control groups. Households that opted out of the program, did so because they disliked the treatment. Removing opt-outs would change the make-up of the treatment group and would undermine the RCT. Households that opted out of the program remain in the treatment group and will affect the results much the same way as people who ignore the reports (passively opt out). Savings estimates are the average savings across all treatment group households, including opt-outs. Opt-outs are also included in the treatment group counts with which total savings are calculated.

3.2.3 2015 participant survey data collection

In 2015, the evaluators implemented an online survey to collect data needed for the analysis of the upstream lighting program, assess customer awareness of PSE's energy efficiency programs and offerings, and solicit feedback on the HER program. This was the second consecutive year of the online survey after the prior three annual evaluations used a telephone survey. Given the robust nature and the currency of this survey data, the evaluation team leveraged results from the 2015 survey and rather than conduct an updated survey.

The 2015 online survey was open from June 22 to July 25, 2016, and was split into five waves: wave 1 included a small sample to test the online survey system (n=225) and waves 2 through 5 contained the remainder of the sample provided from PSE and was staggered for ease of implementation with each wave containing a relatively equal number of customers (~16,000 each). Each wave was sent one reminder email after the initial invitation. Most of the survey focused on CFL and LED purchases in the past year, which was necessary to assess the upstream lighting program savings.

The overall response rate for the survey was 7%, and the total number of completes was 4,228. Table 3-3 provides a summary of the completed surveys and response rates by HER groups.

Table 3-3. Online survey response summary by HER group

Treatment groups		2015 total population	2015 web survey sample	Total responses	Response rate (%)
Legacy	Control	27,592	11,065	846	8%
	Current	21,872	6,092	482	8%
	Suspended	49,464	3,001	220	7%
	Total	**98,928**	**20,158**	**1,548**	**8%**
Expansion	Electric-only control	7,148	2,776	186	7%
	Electric-only treatment	21,660	8,469	592	7%
	High relative user control	7,205	3,638	182	5%
	High relative user treatment	21,908	10,886	538	5%
	Non-urban control	9,594	4,401	288	7%
	Non-urban treatment	28,878	13,373	894	7%
	Total	**96,393**	**43,543**	**2,680**	**6%**
Total (legacy + expansion)		**195,321**	**63,701**	**4,228**	**7%**

3.2.4 Survey data disposition

Upstream lighting program

Table 3-4 provides a summary of the number of surveyed households and response rates for the HER legacy group. Around 1% of these households were determined ineligible due to the following reasons: respondent or respondent's relative works at an IOU, wrong address, or respondent is unfamiliar with household's purchases of light bulbs. Of the valid sample, we achieved 1,265 survey completions with households that had at least one CFL or LED purchase. We also have 68 completed surveys from respondents who indicated they did not make any CFL or LED purchases in the last year. While we screened out these 68 respondents, we did track their purchase answers as zeroes in the upstream participation analyses. Taken together, we obtained a response rate of 6.6%, which is a typical rate for the upstream lighting survey.

Because we did not stratify the survey to include a representative sample of the refill group, we did not have sufficient data to report individual results for the refill group. Rather, we considered the legacy survey results representative of the refill group because refill households were designed to replace the attrition of legacy households.

Table 3-4. HER legacy survey dispositions

Legacy	Control		Current		Suspended	
	Number	Percent	Number	Percent	Number	Percent
Starting	11,065		6,092		3,001	
Known not eligible	122	1.1%	65	1.1%	28	0.9%
Valid sample	10,943		6,027		2,973	
Full completes	687	6.3%	395	6.6%	183	6.2%
No eligible purchases	37	0.3%	22	0.4%	9	0.3%
No response	10,219	93.4%	5,610	93.1%	2,781	93.5%

Table 3-5, Table 3-6, and Table 3-7 summarize the survey disposition for the HER expansion electric-only group, high relative user group, and non-urban group, respectively. The evaluation team started with a total of 28,653 households with email addresses in the HER expansion program. Similar to HER legacy, around 1% of these households were not eligible for the survey. We completed a total of 2,755 surveys with households that had at least one CFL or LED purchase and 501 surveys with households with no eligible purchases. The overall response rate for the HER expansion survey was 11%.

Table 3-5. HER expansion survey dispositions for electric-only group

Electric only	Control		Treatment	
	Number	Percent	Number	Percent
Starting	2,776		8,469	
Known not eligible	32	1.2%	108	1.3%
Valid sample	2,744		8,361	
Full completes	146	5.3%	454	5.4%
No eligible purchases	8	0.3%	30	0.4%
No response	2,590	94.4%	7,877	94.2%

Table 3-6. HER expansion survey dispositions for high relative user group

High relative user	Control		Treatment	
	Number	Percent	Number	Percent
Starting	4,401		10,886	
Known not eligible	33	0.7%	88	0.8%
Valid sample	4,368		10,798	
Full completes	141	3.2%	415	3.8%
No eligible purchases	8	0.2%	35	0.3%
No response	4,219	96.6%	10,348	95.8%

Table 3-7. HER expansion survey dispositions for non-urban group

Non-urban	Control		Treatment	
	Number	Percent	Number	Percent
Starting	4,401		13,373	
Known not eligible	57	1.3%	122	0.9%
Valid sample	4,344		13,251	
Full completes	216	5.0%	727	5.5%
No eligible purchases	15	0.3%	45	0.3%
No response	4,113	94.7%	12,479	94.2%

4 METHODOLOGY

This evaluation used daily household energy consumption data to estimate the reduction in energy consumption resulting from HER. This consumption reduction is the full measure of savings caused by mailing of reports and is referred to here as measured savings. While in prior evaluations, we estimated savings using the difference-in-differences methodology, in this evaluation, we estimated program savings using a pooled fixed-effects model. Relative to difference-in-differences, the fixed-effects methodology is a more flexible characterization of the effect of the treatment on household consumption. It allows us to estimate the effect of treatment outcome over time while controlling for household- and time-specific characteristics that results in more precise estimates. We also calculated savings using a difference-in-differences model specification that we have used in prior PSE HER evaluations. We included these results in the appendix for comparison and consistency purposes. We compared measured savings for the following groups:

Legacy program

- Control vs. current and suspended treatment groups
- Current vs. suspended treatment groups
- Monthly recipients vs. quarterly recipients

Expansion program

- High relative user: control vs. treatment groups
- Non-urban: control vs. treatment groups
- Electric only: control vs. treatment groups

Refill program

- Control vs. treatment groups

Unmatched Customers

- Matched control vs. treatment groups

The HER program has a secondary objective of promoting other energy efficiency programs within PSE. If successful, the measured consumption reduction will include the savings from any increased uptake of these other energy efficiency programs. We refer to this as joint program savings since credit for these savings is shared by both the HER program and other PSE rebate programs.

To account for joint savings, the evaluation team use PSE tracking data and end-use load shape data to quantify the potential for double counting of energy savings with PSE rebate programs (Section 4.2.1). We also use the 2015 household survey to address joint savings potential due to participation in upstream CFL/LED programs for which there is no tracking data.

Joint savings analysis is discussed in the subsequent sections and these joint savings estimates were ultimately removed from the 2016 savings estimate to avoid double counting. The measured savings with joint savings removed is referred to as "credited savings" in this report.[5]

4.1 Fixed-Effects

For this 2016 evaluation, we estimated monthly savings using a fixed-effects regression model that is standard for evaluating behavioral programs like HER. The fixed effects model specification estimates

[5] We explicitly avoid using the gross/net terminology here to avoid confusion with the more typical free-ridership/spillover usage of those terms. Free-ridership is not an issue in this evaluation because of the experimental design framework of the HER program.

program savings by comparing consumption of the treatment group to the control group before and after program implementation. The change that occurs in the treatment group is adjusted to reflect any change that occurred in the control group to isolate changes attributable to the program.

In all prior PSE HER evaluations, we employed the difference-in-differences approach. The difference-in-differences methodology is a simple, robust approach to measure program-related savings in a randomized experimental design framework. The approach compares mean energy consumption between the pre- and post-report periods for the treatment and control groups. While the difference-in-differences methodology performed well through prior PSE HER evaluations, the industry has moved toward the pooled fixed-effects model as the standard methodology. Not only does this change align the PSE HER evaluation with the industry standard, it also captures savings at a monthly level, and thus recognizes savings for households that opted-out in the middle of the year. While savings for the 2016 HER program were established applying the fixed-effects approach, the difference-in-difference approach was also applied to enable comparison of results with prior evaluations. We provide savings results using the difference-in-differences methodology in Appendix 8.3.

4.2 Joint savings analysis

DNV GL conducted a joint savings analysis for rebate program and upstream lighting programs to assess the impact of the HER program on the uptake of other PSE programs and to avoid double counting of savings. The PSE rebate programs included purchases of energy-efficient measures such as heating and cooling systems, water-heating systems, insulation, and appliances. We tracked all rebated measures at the household level so it is possible to directly calculate the number installed and savings claimed for all the treatment and control groups. The goal of the joint savings[6] analysis was to quantify savings that were included in the measured HER program savings but already credited to other PSE energy efficiency programs. These joint savings were deducted from the HER measured savings to avoid double counting.

4.2.1 Rebate program joint savings

PSE tracked energy efficiency purchases that occurred directly through rebate program. The team analyzed this tracking data to identify possible increased uptake of other PSE energy efficiency programs by the treatment groups (legacy current, legacy suspended, and the expansion groups) and the control group. These programs included clothes washers and energy-efficient heating systems, among others. In these program tracking data systems, rebate program participation and associated savings were tied directly to the customer within the HER program treatment and control groups. The experimental design framework made it possible to accurately measure any increased activity in programs made by the HER treatment groups.

For this analysis, we added 2016 data to the compiled data on all rebated installations, for both treatment and control groups. We assigned daily savings starting with the installation date and carrying forward to the measure life.[7] We apportioned savings across the days of the year based on measure-level load shapes so that savings occurred during the year when they would be captured in the fixed-effect calculations. For the 2016 rebate program joint savings calculation, we subtracted the control group's total tracked savings from rebated measures installed since program inception from the total tracked savings of the treatment group.

[6] Sometimes referred to as uplift in other evaluations.

[7] All measure lives are at least as long as the five years the HER program has been in place.

The difference in energy use was the effect of HER on rebate program activity. We removed this difference from the overall measured consumption reduction, since the rebate programs that facilitated the participation already claim the savings.

4.2.2 Upstream program joint savings

DNV GL used a similar process to estimate joint savings associated with the upstream CFL/LED lighting programs by using the 2015 survey data in place of the rebate program tracking data. The survey gathered store-specific information on the purchase and installation of CFLs and LEDs for the HER program treatment and control groups for calendar year 2015. We used the data from participating retailers to calculate the number of purchased CFLs associated with the upstream program.

We calculated the difference in PSE-sponsored CFLs and LEDs between the treatment and control group households to determine the average number of additional CFL or LED bulbs per treatment household. The number of bulbs is multiplied by the average claimed savings for bulbs of that type to determine the additional savings associated with CFLs and LEDs purchased due to the HER program.

Table 4-1 provides the average claimed savings per bulb. The numbers are a weighted average of the different specific bulb types using the program-level counts of bulbs claimed under PSE retail lighting programs in 2014. For this evaluation, since we collected survey data so recently in 2015, we assumed results would be comparable in 2016.

Table 4-1. Weighted average claimed savings per bulb type

Bulb type	Weighted average claimed savings (kWh/unit)
CFL	16.3
LED	17.0

In the analysis, we assume these bulbs were all installed on the first day of each program year (January 1st) and the joint savings carried forward on a load shape-weighted basis. Because we do not have survey results for lamps installed prior to 2011, we assume bulb purchases made prior to 2011 using 2011 upstream purchase data. To calculate 2012-2016 lamp purchases, we use survey data. We assume that the bulbs stay in place for the full five-year measure life. The upstream joint savings were cumulative through the eighth year.

Section 8.5 provides the web survey instrument used to gather CFL and LED purchase and installation data for the HER program.

5 IMPACT EVALUATION RESULTS

The measured, joint, and claimed savings results in this section can be used to support PSE savings claims for the 2016 HER program. Section 5.1 provides the overall actual savings achieved in calendar year 2016. The results include average household and total savings for the different treatment groups in legacy and expansion programs.

5.1 Legacy program

5.1.1 2016 program savings

The objective of this evaluation was to calculate credited savings that represent the final program savings after deducting both the downstream rebate and upstream joint savings. This adjustment eliminated the potential to double count savings already accounted for in other energy efficiency programs. The three components of program savings were:

- **Measured savings** represented the average difference in consumption between HER treatment groups and the control group. It is calculated using a fixed effects approach that compares treatment and control group consumption in the pre- and post-report periods.
- **Downstream rebate program joint savings** represented the increased activity in PSE rebate programs as a result of receiving, or having received, the report. This is the difference in PSE rebate program savings between the two PSE HER treatment groups (legacy current and legacy suspended) and the control group.
- **Upstream program joint savings** represented the increased use of PSE-supported CFL and LED bulbs as a result of receiving the HER. This is the difference in PSE upstream program savings between the PSE HER treatment groups (legacy current and legacy suspended) and the control group.

Table 5-1 provides components of savings estimates used to calculate credited savings for the HER legacy program. We calculated per household savings separately for legacy current and legacy suspended treatment groups.

Table 5-1. HER savings per household based on actual consumption in 2016

Treatment groups	HER measured savings (per household)	Joint savings (per household)		Credited savings (per household)
		Rebate Savings	Upstream Program	
Electric (kWh)				
Current	316.7*	6.6*	0	310.1*
	(256.6,376.9)	(1.3,12.0)		(249.7,370.5)
Suspended	70.2	0	0	70.2
	(-9.1,149.4)	N/A	N/A	(-9.1,149.4)
Gas (therms)				
Current	13.9*	1.7*	N/A	12.2*
	(10.2,17.6)	(0.9,2.5)		(8.4,16.0)
Suspended	8.1*	0.4	N/A	7.7*
	(3.3,12.8)	(-0.6,1.4)		(2.8,12.5)

*Note: * Indicates statistically significant at the 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval. The joint savings for upstream programs were specifically for PSE upstream lighting programs and were not relevant in gas savings calculation.*

To estimate credited savings per household, we subtracted rebate and upstream program joint savings from the measured savings derived from consumption analysis. The joint savings per household from rebate programs were positive and were removed from measured savings. No adjustments were made from the measured savings due to HER–related uptake in upstream programs. Section 5.4 presents the results of the joint savings analysis for downstream rebate and upstream lighting programs.

Table 5-2 summarizes the HER program results with respect to average actual consumption. The legacy current treatment group produced credited savings at 3.2% and 1.7% for electric and gas, respectively. The legacy suspended treatment group generates a fifth as much electric savings when compared to the legacy current treatment group. For gas, the suspension of treatment has maintained just under two-thirds of the gas savings of the legacy current group. The PSE HER reports for the legacy program have consistently produced greater electric savings as a percent of consumption than gas savings. Research has not been able to definitively identify the varied sources of HER program end-use savings, but we hypothesize that the greater number of electric end uses and the more discretionary aspect of many electric end uses (lighting, electronics) makes savings more feasible.[8,9]

8 Puget Sound Energy, 2012. Puget Sound Energy's Home Energy Reports Program: Three Year Impact, Behavioral and Process Evaluation. April 2012. https://conduitnw.org/Pages/File.aspx?rid=849

9 This study pointed toward water heating savings as an area with statistically significant evidence of savings actions. Other evaluations of other HER-type programs have found limited and inconsistent evidence of specific end-use savings. The RCT design allows for a highly precise estimate of the small overall savings estimate, but getting definitive estimates of the varied sources of savings within those overall savings has not been possible.

Table 5-2. Credited savings per household as a percent of consumption

HER treatment group	Electric (kWh)			Gas (therms)		
	Consumption	Savings	Percent	Consumption	Savings	Percent
Legacy program						
Current	9,782	310.1*	3.2%	716	12.2*	1.7%
		(249.7,370.5)			(8.4,16.0)	
Suspended		70.2	0.7%		7.7*	1.1%
		(-9.1,149.4)			(2.8,12.5)	

** Indicates statistically significant at 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval. Consumption is based on average actual consumption of the control group in 2015.*

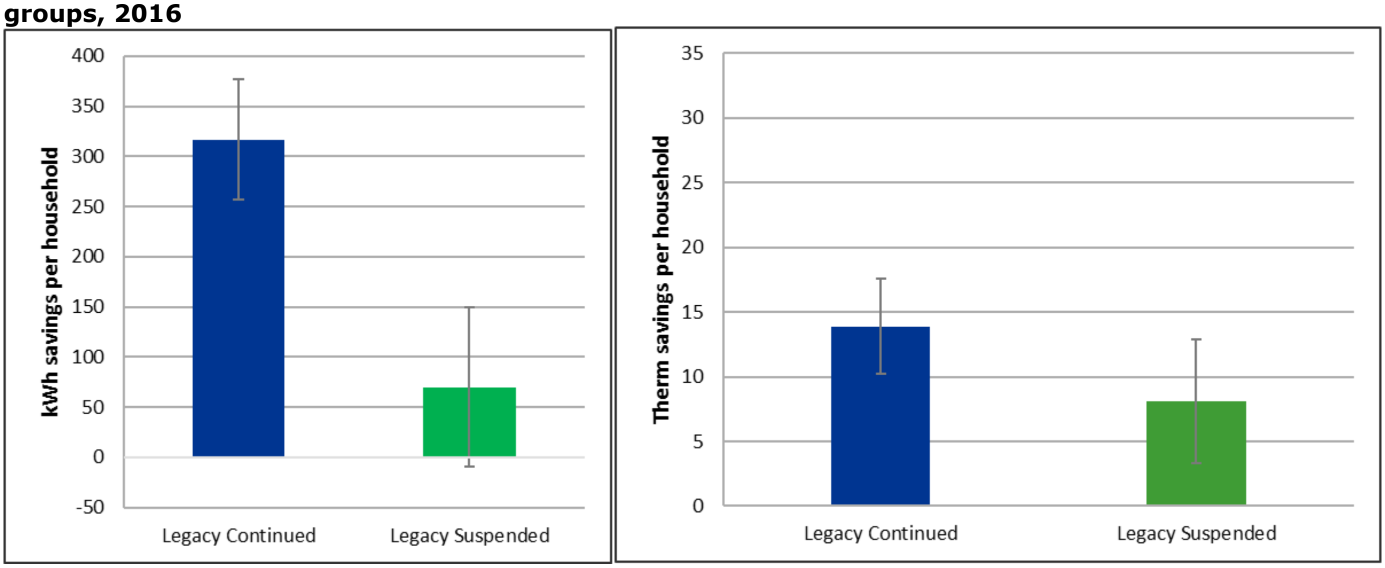
5.1.2 Measured program savings

This section provides a comparison of measured electric and gas savings per household by the different treatment groups in the HER legacy program.

Legacy current vs. legacy suspended treatment groups

Figure 5-1 summarizes the calendar year 2016 measured savings for the legacy current and legacy suspended treatment groups. Electric and gas savings for the legacy current group were significantly different from zero based on a 90% confidence interval, two-tailed test. The legacy suspended group's electric savings were not statistically significant, but its gas savings were.

Figure 5-1. Average annual measured savings for legacy current and legacy suspended treatment groups, 2016

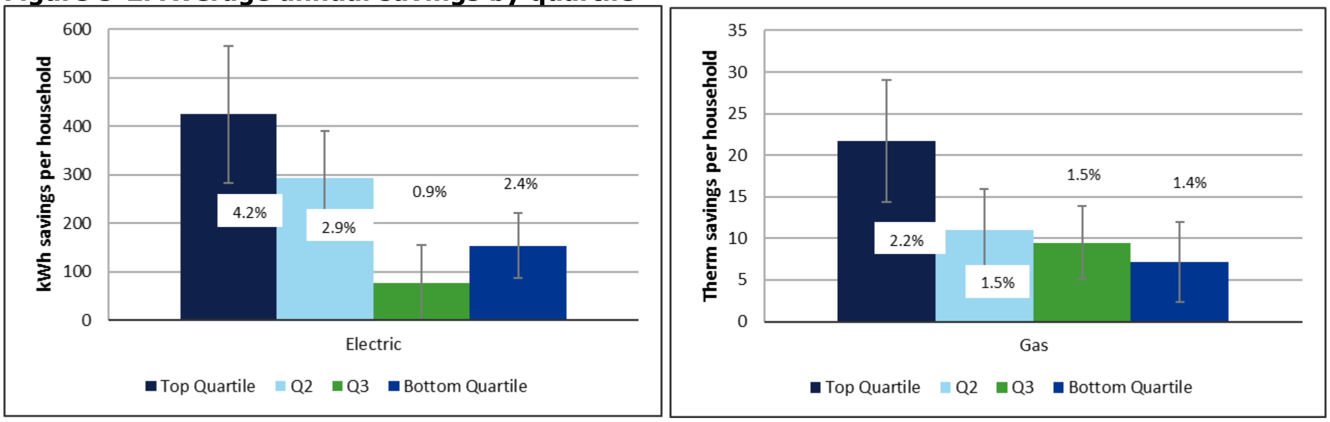


Note the figure on the left is for electricity while the one on the right is for gas. Note also that the graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

Annual savings by consumption quartile

This study and similar studies have found a correlation between higher household consumption and higher savings. In the case of the legacy program, the savings were higher even on a percentage basis. Figure 5-2 shows the savings in energy consumption (kWh and therms) by quartile. We term the highest quartile the "top quartile", the second-highest, "Q2," the third-highest "Q3", and lowest the "bottom quartile." The top consumption quartile households saved electricity at a rate of 4.2%, which is statistically higher than Q3 (0.9%) and the bottom quartile (2.4%). For gas, top quartile households saved at a rate of 2.2%, which was also statistically higher than Q3 (1.5%) and Q4 (1.4%). These findings consistently show that the highest-consuming households save statistically significantly more energy than the lowest-consuming customers among legacy current households.

Figure 5-2. Average annual savings by quartile



Note the figure on the left is for electricity while the one on the right is for gas. Note also that the graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

Table 5-3 provides the percentiles and the mean consumption within each quartile. For both electric and gas, the top quartile households used more than twice the energy of the bottom quartile households.

Table 5-3. Average annual consumption by quartile - average consumption and percentiles

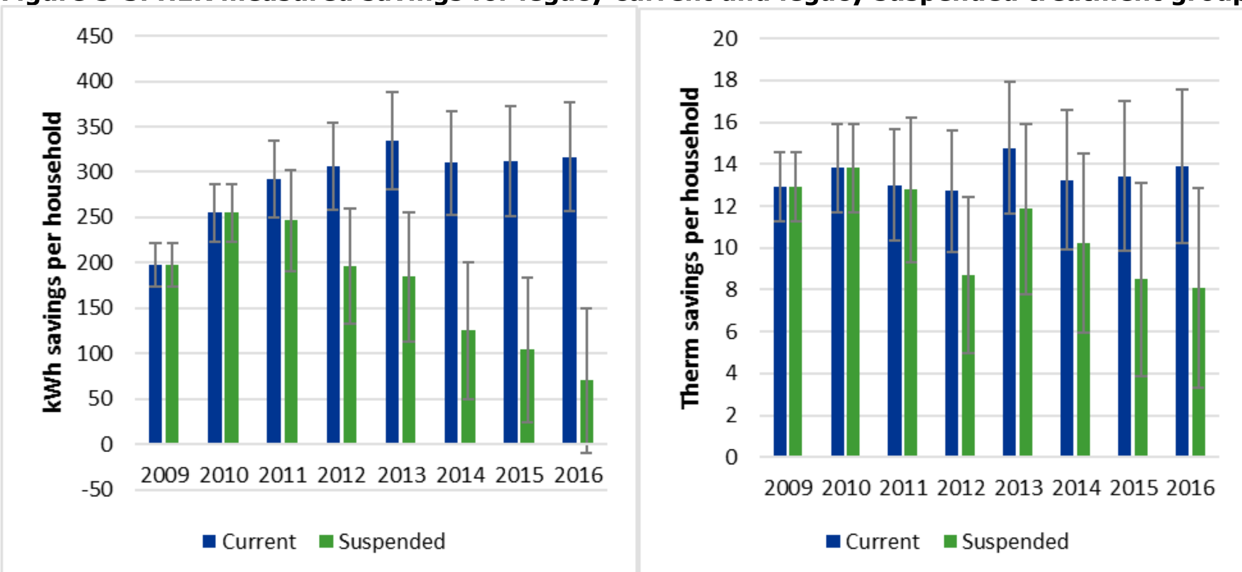
Quartile	Percentile	Electric		Gas	
		Lower bound (kWh)	Quartile mean	Lower bound (Therms)	Quartile mean
Top	**75th percentile**	13,179	17,688	1,153	1,421
Q2	**Median**	9,944	11,513	943	1,052
Q3	**25th percentile**	7,654	8,860	774	870
Bottom		0	6,300	0	637

HER measured savings from 2009 to 2016

The HER program generated statistically significant electric and gas savings from 2009 to 2016.

Figure 5-3 provides the historical measured savings for the HER legacy program since the first year of inception.

Figure 5-3. HER measured savings for legacy current and legacy suspended treatment groups



Note the figure on the left is for electricity while the one on the right is for gas. Note also that the graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

While the HER program also continued to generate gas savings from the legacy suspended treatment group, the legacy suspended treatment group's electric savings are no longer significant. Electric savings from the legacy suspended group decreased by 32% from 2015 to 2016, and gas savings from the legacy suspended group decreased by 9% in the same period. In addition, per household electric savings (70 kWh per household) from the legacy suspended group were 77% less than electric savings of the legacy current treatment group in 2016; and per household gas savings (7.67 therms) were 37% less than gas savings from the legacy current treatment group (12.20 therms) in 2016.

Section 8.2 provides the historical measured savings along with the upper and lower bounds at the 90% confidence interval.

5.2 Expansion program

The expansion program was a study PSE launched in March 2014 that targeted three different groups theorized to provide relatively high per-customer savings: electric-only, high relative user, and non-urban households. Since we present 2016 and 2015 expansion program results at the annual level, we chose to define the pre-treatment period as March 2013 to February 2014, and the post period as January 2015 to December 2016. These results represent full calendar years, and are thus comparable to annual results from other groups. Where we present 2014 results for the expansion groups, we consider the pre-treatment period to be March 2013 to February 2014, and the post-treatment period to be March 2014-December 2014. This section presents billing analysis results for the HER expansion program.

5.2.1 2016 program savings

Table 5-4 and Table 5-5 summarize the HER program measured and credited savings for the three different groups in the expansion program. All the expansion groups produced measured and credited savings that were statistically significant at the 90% confidence level. The high relative user group produced the highest savings in terms of quantity and percentage while the non-urban group produced the lowest savings.

Table 5-4. HER savings per household based on actual consumption in 2016

Treatment groups	HER measured savings (per household)	Joint savings (per household)		Credited savings (per household)
		Rebate Savings	Upstream Program	
Electric (kWh)				
Electric only	208.6*	11.3	28.1*	169.2*
	(129.9,287.3)	(-1.7,24.3)	(6.5,49.7)	(88.3,250.0)
High relative user	265.0*	6.2*	1.0	257.7*
	(191.4,338.5)	(0.7,11.7)	(-22.1,24.1)	(182.7,332.8)
Non-urban	163.1*	7.1*	23.2*	132.9*
	(109.2,217.0)	(3.7,10.4)	(5.7,40.7)	(77.8,187.9)
Refill	274.3*	6.3*	0.00	268.0*
	(197.7,350.9)	(4.3,8.3)		(190.7,345.3)
Gas (therms)				
High relative user	10.7*	1.1*	N/A	9.6*
	(6.7,14.7)	(0.5,1.7)		(5.5,13.6)
Non-urban	5.7*	0.3	N/A	4.6*
	(2.9,8.6)	(-0.1,0.6)		(1.8,7.5)
Refill	5.0*	0.3*	N/A	4.7*
	(1.1,8.8)	(0.0,0.5)		(0.9,8.6)

** Indicates statistically significant at the 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval.*

Table 5-5. Credited savings per household as a percent of consumption

HER treatment group	Electric (kWh)			Gas (therms)		
	Consumption	Savings	Percent	Consumption	Savings	Percent
Expansion program						
Electric only	13,204	169. 2*	1.3%	N/A	N/A	N/A
		(88.3,250.0)			N/A	
High relative user	10,656	257.7*	2.4%	706	9.6	1.4%
		(182.7,332.8)			(5.5,13.6)	
Non-urban	9,566	132.9*	1.4%	632	4.6	0.7%
		(77.8,187.9)			(1.8,7.5)	
Refill	11,722	268.0*	2.3%	742	4.7	0.6%
		(190.7,345.3)			(0.9,8.6)	

** Indicates statistically significant at the 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval. Consumption is based on average actual consumption of the control group in 2015.*

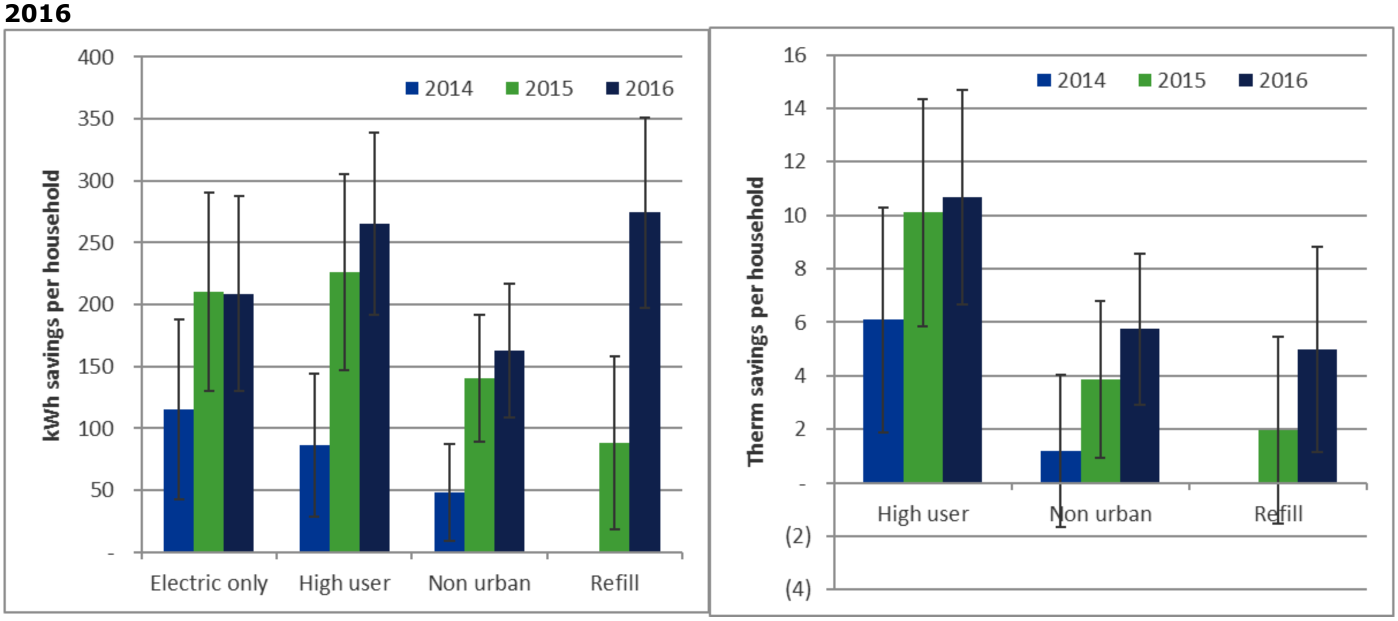
5.2.2 Measured savings

This section provides historical program savings for the expansion group and comparison of program savings per household between the expansion groups and legacy program.

Measured electric and gas savings from 2014 to 2016

Figure 5-4 provides the measured savings for the HER expansion program in 2014, 2015 and 2016. The expansion group (except for the refill group) started receiving the reports in March 2014, thus the 2014 savings reflected savings from March to December. For these groups, the 2015 and 2016 savings were for the full calendar year. The refill group began receiving reports in May, 2015, and savings thus represent May, 2015 through December, 2016. As documented in most HER evaluations for PSE and other programs, the first year HER savings are generally lower than savings generated in the subsequent years. While only in its first full year of participation, the refill group's electric per-household savings are the highest among the expansion groups. This is a reasonable finding based on this group's higher electric and gas baseline consumption, as we will discuss in Section 5.3. Typically, the refill group is comprised of sample points that remain after the original RCT. After the RCT had drawn from the non-legacy sample points, it appears that these households skewed towards higher consumption.

Figure 5-4. Measured electric and gas savings per household for expansion groups from 2014 to 2016



Note the figure on the left is for electricity while the one on the right is for gas. Note also that the graph above shows the savings with upper and lower bounds at the 90% confidence intervals. Also note that the for non-refill groups, households started to receive reports in March, 2014, and the refill group households started to receive reports in May, 2015.

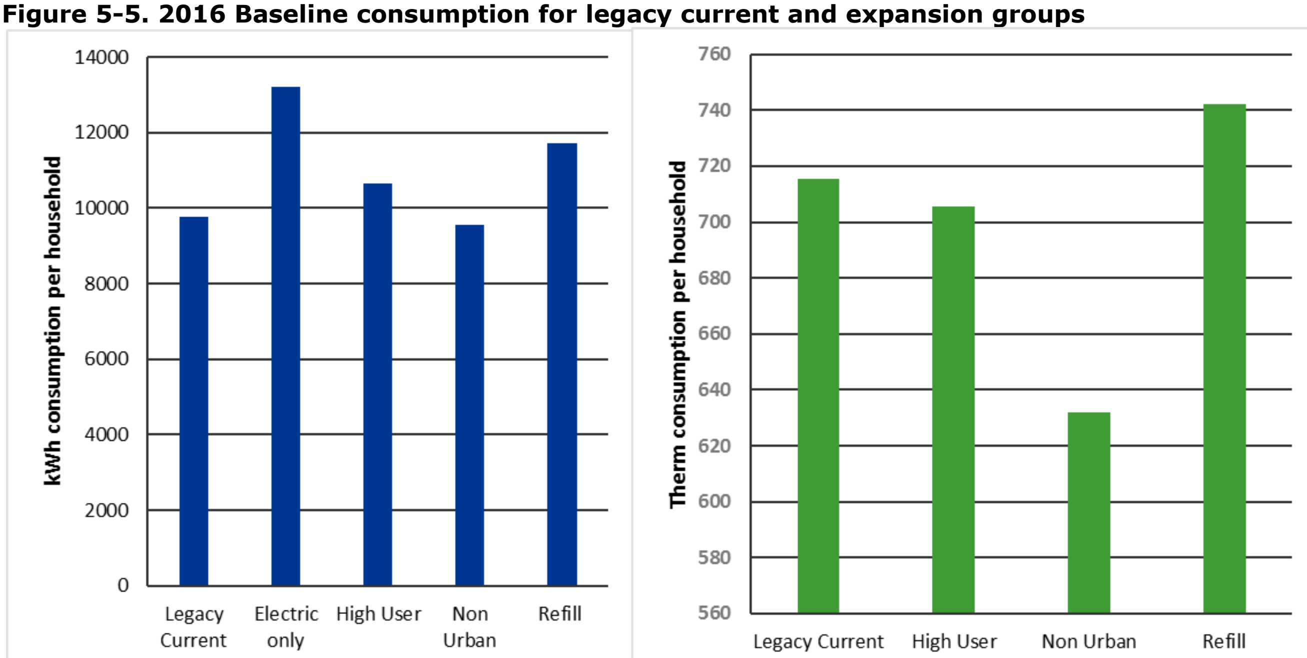
5.3 Comparison of legacy current and expansion groups

This section provides a comparison across legacy current and the three expansion groups in terms of baseline consumption and measured savings.

5.3.1 Baseline consumption and savings – legacy current vs. expansion groups

Figure 5-5 provides a comparison of the average 2016 electric and gas baseline consumption across legacy current and expansion control groups. The electric only group has the highest electric consumption among all HER groups. The baseline consumption for this group was relatively higher than the others due to electric-only households using electricity as the primary source of space and water heating. Among the dual-fuel homes, the refill group has the highest electric baseline consumption level; followed by the legacy current and the non-urban groups. Gas consumption between legacy current and high relative user groups was similar.

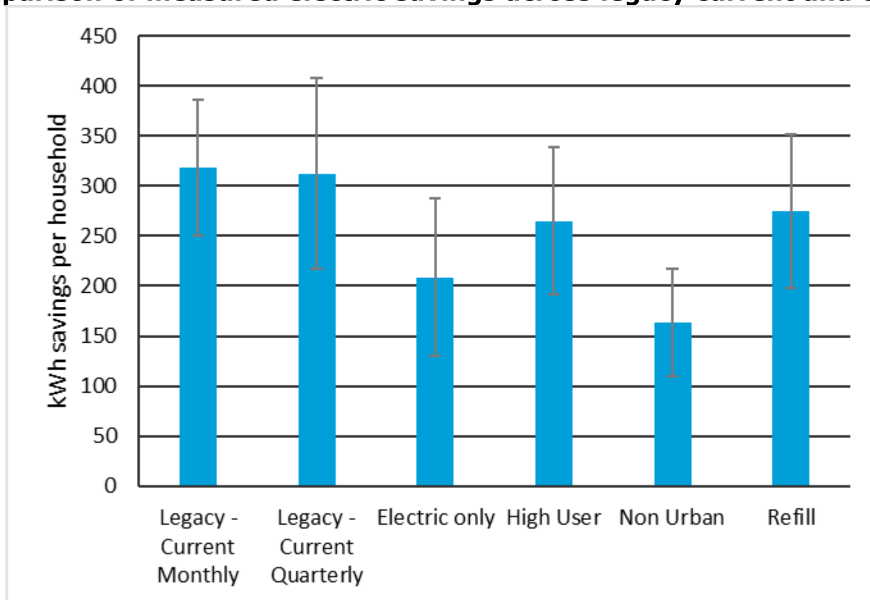
Figure 5-5. 2016 Baseline consumption for legacy current and expansion groups



Note the figure on the left is for electricity while the one on the right is for gas.

Figure 5-6 presents a comparison of measured electric savings of the three different expansion groups and the monthly and quarterly recipients from the legacy current group. For this analysis, we provided savings separately for monthly and quarterly recipients in the legacy current group for a better comparison with the high relative user group that also received the reports quarterly. The measured electric savings for the monthly and quarterly recipients in the legacy current group were 3.3% and 3.2% of consumption, respectively. For the expansion group, the percent savings for the electric only, high relative users, non-urban, and refill groups were 1.6%, 2.5%, 1.7% and 2.3%, respectively. However, for comparison purposes, we also considered measured savings percentages from the third program year (2011) of the legacy current monthly and quarterly households. From a percentage perspective, the measured electric savings for legacy monthly and quarterly recipients were 2.8% and 1.9% of consumption, respectively, suggesting that the expansion results remain in the range of earlier legacy results. Electric savings were highest for the legacy current group receiving the reports monthly and lowest for the non-urban group.

Figure 5-6. Comparison of measured electric savings across legacy current and expansion groups



Note: The graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

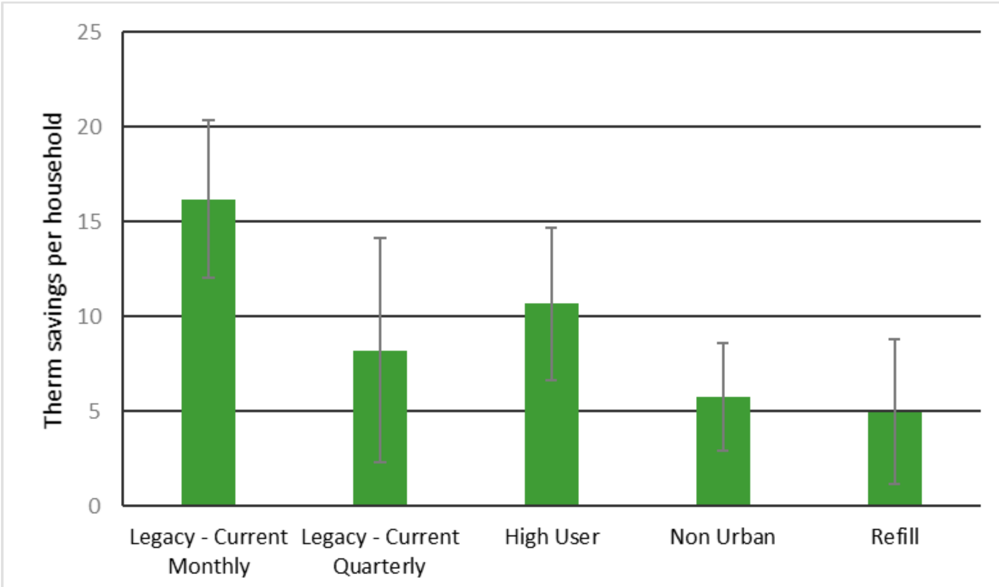
The differences in magnitude of savings across the treatment groups could be attributed to the different characteristics of the population targeted by the program; frequency of reports received, and program duration. The households in the legacy current group were in their eighth year of receiving the reports while the expansion groups represented households that were relatively new to the program. The average savings from the legacy current group represented a full year of savings for a mature program while savings from the expansion groups were likely just beginning to ramp up.

While being in the field for less than three years, the high relative user group produced savings similar to the mature legacy current group. Both legacy current and high relative user groups targeted dual fuel and single family homes with high energy consumption. The treated households in the high relative user group who received the reports quarterly and produced electric savings that were only 15% lower than savings produced by the legacy current quarterly group. The difference in savings between these two groups was not statistically significant at the 90% confidence interval. Also striking are the savings of the refill group, which has received the report for just a year and a half, and is achieving electric savings on par with the high-user group and the legacy current group.

Figure 5-7 presents a comparison of gas savings of the two expansion groups (high relative users and non-urban groups) relative to the legacy current savings. From a percentage perspective, the measured gas savings for the monthly and quarterly recipients in the legacy current group were 1.8% and 1.1% of consumption, respectively. For the expansion groups, the percent gas savings were 1.5% and 0.9% for the high relative users and non-urban groups, respectively. The non-urban group has the lowest gas baseline of any group, which could explain that group's relatively low savings. Gas savings among the refill group were 0.7% for 2016. Similar to the findings for electric savings, the legacy current group receiving the reports monthly produced the highest gas savings and the non-urban group produced the lowest savings. The high relative user group produced gas savings that were greater, though not statistically different from the savings produced by the legacy current quarterly group (despite being in the field for less than three years).

And unlike electric savings, the refill group savings were lower than the high user and legacy current groups; however, this result is expected within the ramp-up period.

Figure 5-7. Comparison of measured gas savings across legacy and expansion groups



Note: The graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

5.3.2 Comparison of early stage savings – legacy vs. expansion groups

The expansion program was a pilot effort to determine how savings differ from the three distinct target groups. Households with relatively high consumption produced the highest savings while households outside urban areas produced the lowest. These results from the expansion group were consistent with other HER evaluations that targeted similar groups. In addition, the percent savings from the electric-only group were also consistent with the results from other HER program evaluations.

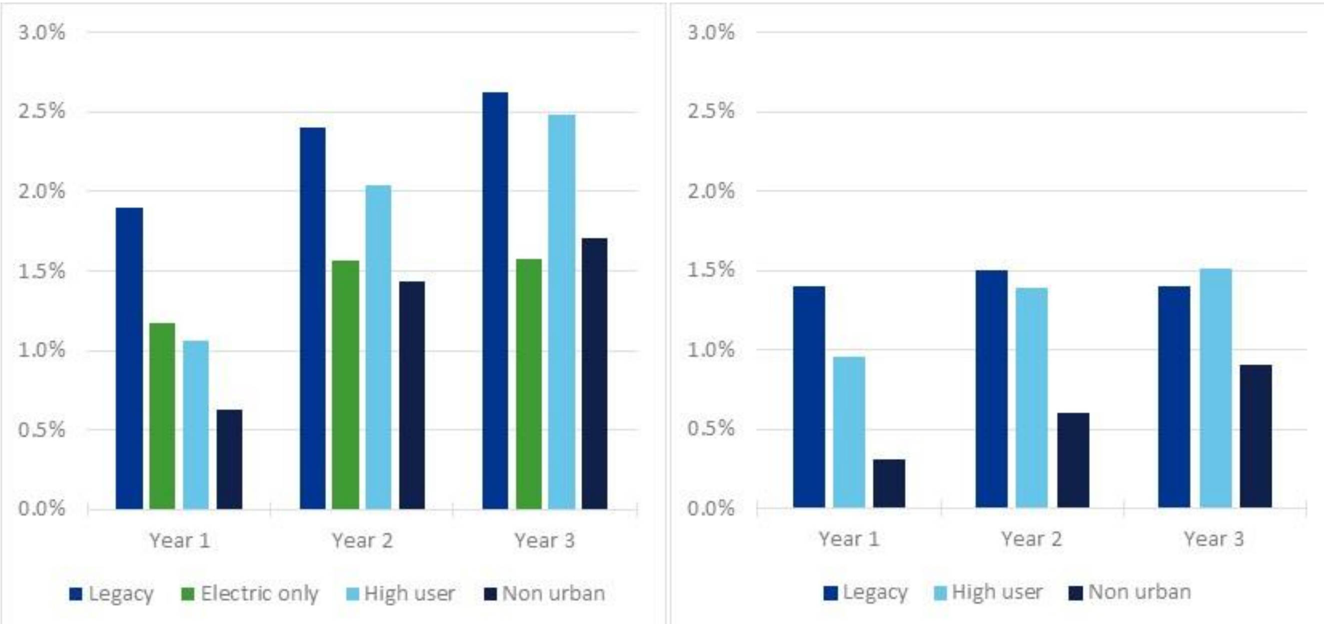
Overall, the levels of savings produced by the expansion group were relatively smaller than the average savings produced by the legacy group. The savings produced by the expansion groups were still within the 1% to 3% range that is expected from behavioral programs such as the HER program. The percent savings and increase in savings between Years 1 and 2 for the expansion groups were comparable to the savings and trends observed from other HER program evaluations in other jurisdictions.

DNV GL compared percent electric and gas savings of the first three years of the legacy group to the savings of the first three years of the expansion groups.

For legacy, Year 1 covered the post-periods from November 2008 to October 2009 and the results were based on PSE HER 20-Month Impact Evaluation report. For expansion, Year 1 covered the post-periods from March 2014 to February 2015 and the results were based on PSE HER 2014 Impact Evaluation and monthly results for January and February 2015 from the fixed effects model (Section 8.4).

Figure 5-8 provides the percent electric and gas savings between Year 1 and Year 3 of the legacy and expansion programs. Both HER legacy and expansion groups showed an increase in savings from Year 1 to Year 3. The rate of increase in electric and gas savings of the high relative user and non-urban groups were higher than that of the legacy group, while the rate of increase for legacy and electric-only groups were comparable.

Figure 5-8. Percent measured electric and gas savings for legacy and expansion groups (excluding refill group)



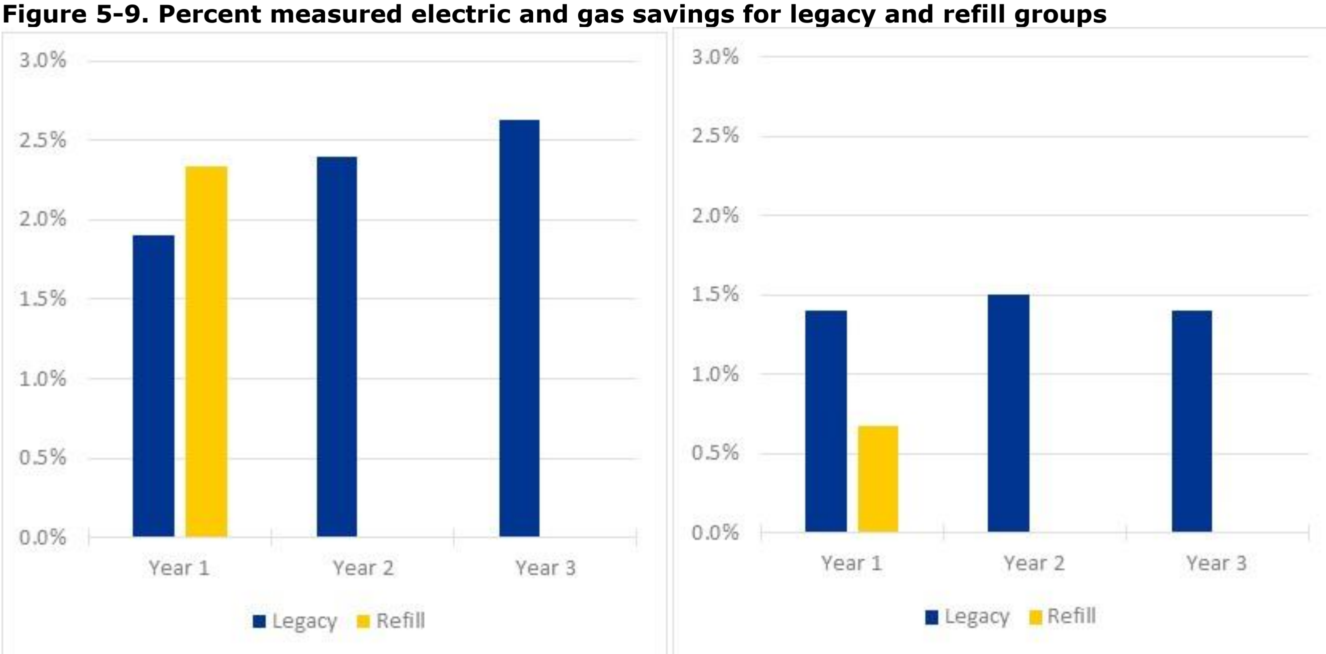
Note the figure on the left is for electricity while the one on the right is for gas. Note also that in year 3, the legacy group split into legacy current and legacy suspended. For the purposes of graphical comparison, we use the legacy current group to represent legacy households in year 3.

Among the expansion groups, the high relative user group had the highest measured electric and gas savings in terms of quantity and percentage, while the non-urban group had the lowest savings. These findings were consistent with the results in quartile analysis in Section 5.1.2 where savings percentages generally increased with higher consumption.

All non-refill expansion groups, including the high-user group, produced relatively lower electric savings in years 1, 2 and 3 when compared to all treated households in the legacy group. However, all groups showed upward trends over the first three years, and the high-user group achieved electric savings in year 3 that were just shy of the legacy current group. We observe similar trends for gas savings; in fact, the high user group exceeded legacy current savings in year 3.

While the refill group has only completed one complete year, we present a similar comparison against the legacy group in Figure 5-9. Most notably, the electric percent savings for the first year of the refill group is higher than the legacy group. Gas savings followed the trend of the other expansion groups, and yielded lower percent savings than the legacy group.

Figure 5-9. Percent measured electric and gas savings for legacy and refill groups



Note the figure on the left is for electricity while the one on the right is for gas.

5.4 Joint savings analysis

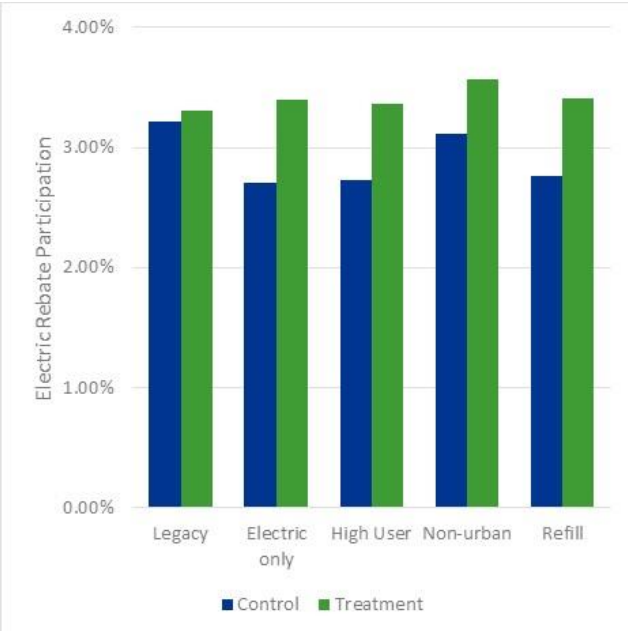
This section presents the results of the rebate program and upstream lighting joint savings analysis for the different treatment groups in HER legacy and expansion programs.

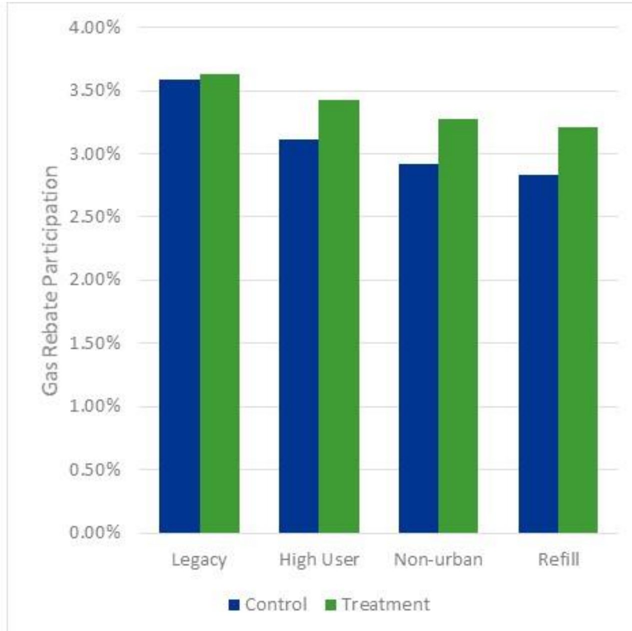
5.4.1 Rebate program joint savings

While electric joint savings for the legacy current group remained insignificant for the first seven years of the program, several of the expansion groups show significant downstream joint savings just three years into the program, including the high-relative users, the non-urban, and the refill groups. Gas savings show significant savings only for the high-user group, and the refill group in 2016. Taken together, we conclude that HERs do provide an increase in rebate program participation rates, and this participation tends to lead to an increase in savings achieved, although these trends appear to function differently among different groups and fuels. While further research can attempt to clarify participation drivers (i.e., what measures are driving savings) and participant decision-making, we note that it remains exceptionally difficult to identify what drives such small differences between the groups even when statistically significant.

Figure 5-10 shows the percent of HER households participating in other PSE rebate programs in 2016, such as the Single Family Weatherization Program, Smart Thermostat Program, Shop PSE etc. About 3% to 3.5% of the households in the treatment group participated in electric rebate programs while 2.5% to 3% of the treatment households participated in gas rebate programs. Gas participation is statistically higher for non-urban and refill treatment groups, relative to their control groups. Participation in both electric treatment and electric control groups is about 1 percentage points lower than seen in 2015. Conversely, gas participation increased by about 0.5 percentage points in 2016, compared to 2015.

Figure 5-10. Percent of HER households participating in other PSE rebate programs in 2016





Note the figure on the left is for electricity while the one on the right is for gas.

Table 5-6 shows a tabular representation of the illustrations above with the difference in percent participation between the treatment and control groups. This table also presents the difference in participation as a percent of the control participation rate. Participation is relative to the post-treatment period. In other words, if a treatment customer only participated in a program before receiving HERs, they were not included as a downstream program participant. It is notable that relative to 2015 participation, 2016 electric program participation decreased by around one percentage point in both treatment and control groups. Conversely, gas participation exhibited the opposite trend, and increased by around 0.5 percentage points. Furthermore, in 2016, the delta between treatment and control participation in electric programs was significant for all expansion groups, and was significant for the non-urban and refill groups.

It is also worth recognizing that the legacy current group exhibited statistically similar participation percentage between the treatment and control households for both electric and gas fuels, suggesting that the report's ability to boost program participation may decline over time. Among the non-urban group, on the other hand, the difference between treatment and control percent participation was significant this year for both electric and gas, suggesting an increase in the HER's ability to encourage program participation among households during the ramp up period.

Looked at another way, the difference in participation as a percent of the control group's participation, we see that households within the electric-only, high-relative user (electric), and refill (electric) groups are all around 25% more likely to have participated in energy efficiency programs than their control counterparts, while the non-urban electric treatment households were 14% more likely to participate than the control households. Regarding participation in gas programs, all treatment households within the refill groups were between 10%-15% more likely to participate than the refill group control households.

Table 5-6. Treatment and control participation in 2016 PSE rebate programs

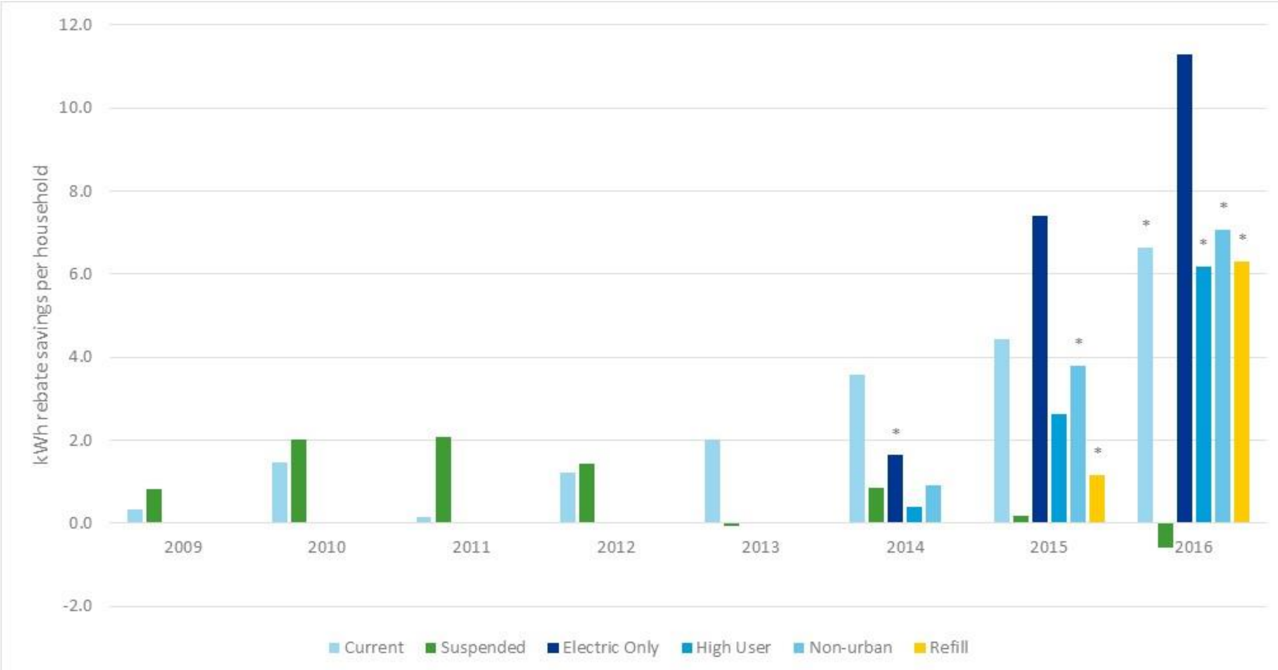
Electric	% Participation		Difference (treatment - control)	Difference as percent of control participation	Lower limit at 90% CI	Upper limit at 90% CI	Tstat	Pvalue
	Control	Treatment						
2016 Electric rebate participation								
Legacy-current	3.21%	3.31%	0.10%	3%	-0.26%	0.45%	0.54	0.59
Electric only	2.71%	3.39%	0.69%*	25%	0.23%	1.14%	2.94	0.00
High relative User	2.73%	3.37%	0.63%*	23%	0.16%	1.11%	2.63	0.01
Non-urban	3.12%	3.56%	0.45%*	14%	0.04%	0.85%	2.14	0.03
Refill	2.76%	3.41%	0.65%*	24%	0.24%	1.06%	3.11	0.00
2016 Gas rebate participation								
Legacy-current	3.58%	3.63%	0.05%	1%	-0.33%	0.42%	0.26	0.79
High relative user	3.11%	3.42%	0.31%	10%	-0.17%	0.79%	1.26	0.21
Non-urban	2.92%	3.27%	0.35%*	12%	-0.04%	0.74%	1.75	0.08
Refill	2.84%	3.21%	0.37%*	13%	-0.03%	0.78%	1.83	0.07

** Indicates statistically significant at the 90% confidence level.*

This suggests that through the installation of higher-impact measures, and/or the cumulative year-on-year savings of previously-installed program measures, legacy treatment households have achieved deeper savings than control households, despite similar rates of participation in 2016.

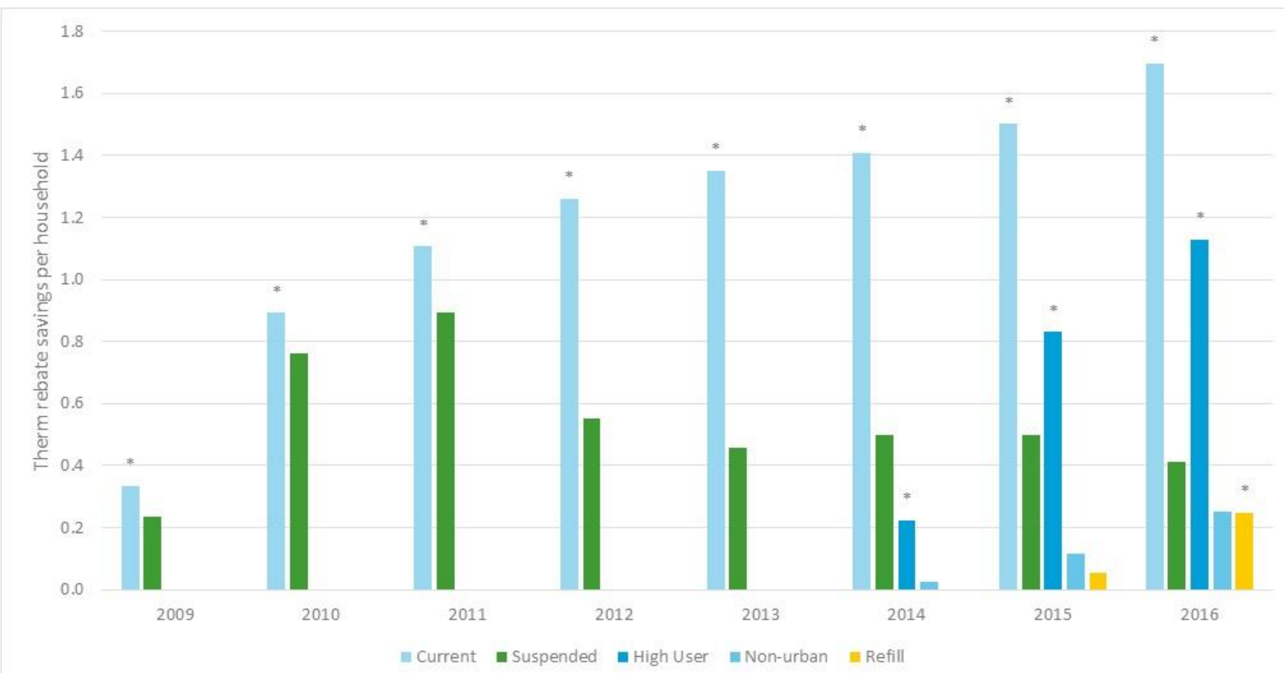
Figure 5-11 and Figure 5-12 provide historical rebate joint savings per household for legacy and expansion groups. In prior HER evaluations, electric joint savings have consistently been relatively small, and not statistically significant. In this evaluation, while the participation rates among legacy current treatment households are not significantly different from their control counterparts; their higher electric joint savings is statistically significant. Gas savings among the legacy current group have continued to grow throughout the lifetime of the program, and remain statistically significant.

Figure 5-11. Annual electric joint rebate savings per household for legacy and expansion groups, 2009-2016



*Indicates significance at the 90% confidence level

Figure 5-12. Annual gas joint rebate savings per household for legacy and expansion groups, 2009-2016



*Indicates significance at the 90% confidence level

5.4.2 Upstream program joint savings

The upstream joint savings measured the effect of the HER program on reduced-price retail sales of CFLs and LED bulbs. LED bulbs were included in the estimated upstream joint savings for the first time in the 2013 evaluation.[10]

Table 5-7 provides the number of CFL and LED bulbs annually purchased for the control, legacy current, and legacy suspended treatment groups.

Table 5-7. Count of CFL and LED bulbs purchased annually per household

Upstream lighting measures	HER groups		
	Control	Current	Suspended
CFLs	2.08	1.93	1.34
LEDs	4.74	4.88	4.48

The survey results indicated that households across all legacy groups purchased an average of more than four LED bulbs. In contrast to the 2014 evaluation results, 2015 survey results found LED purchases were more than double CFL purchases.

Table 5-8 provides the joint rebate counts per household for the legacy current and legacy suspended treatment groups. Joint rebate counts per household measured the increased uptake in upstream lighting due to HER, calculated as the difference in CFL and LED purchases between the treatment group and control group. To estimate upstream savings, the joint rebate counts per household for each lighting measure were multiplied by the corresponding average bulb savings.

Table 5-8. Savings from CFL and LED bulbs purchased annually per household

Upstream lighting measures	Joint rebate counts per household		Weighted average deemed savings (kWh per unit)	Legacy current group upstream savings	Suspended group upstream savings
	Current	Suspended			
CFLs	-0.2 (-0.6,0.3)	-0.7 (-1.3,-0.2)	16.3	-2.5 (-10.4,5.4)	-12.1 (-20.8,-3.5)
LEDs	0.1 (-0.7,1.0)	-0.3 (-1.3,0.8)	17	2.5 (-12.6,17.5)	-4.4 (-22.8,14.1)
Total upstream lighting savings				-0.04	-16.5

** Indicates statistically significant at the 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval.*

The small and negative joint savings indicate that the program was no longer increasing uptake of the upstream program offerings with any kind of discernable pattern at the time of the survey. A negative savings result means that, during this period, treatment households installed fewer bulbs than the control group. This is consistent with HER programs initially causing an acceleration of such installations in early

[10] LED were not included in the 2012 upstream survey because LED sales prior to 2013 were small.

years with an eventual return to equilibrium. Both positive and negative results were integrated into the cumulative calculations of upstream joint savings weighted by bulb-type savings. The individual and combined joint savings results were not statistically significant.

Table 5-9 provides the annual joint savings estimates from CFLs and LEDs purchased across all post years. Each year was additive on the prior year until Year 6 when the first year savings dropped out because the measure life for CFLs was five years. In year 7, the second year, and in year 8, the third year, savings also were removed along with the first year savings.

Table 5-9. Annual joint upstream savings per household for legacy current and legacy suspended treatment groups

Program year	Lighting measures	Treatment group	
		Current	Suspended
Year 1[a]	CFL	0.86	
Year 2	CFL	1.59	
Year 3	CFL	2.32	15.26
Year 4	CFL	5.47	10.49
Year 5	CFL and LED	7.32	17.99
Year 6	CFL and LED	-3.26	8.05
Year 7	CFL and LED	-4.49	-8.45
Year 8	CFL and LED	-6.85	-40.21

Note: *Upstream survey was only starting Year 3 for PSE HER. The upstream values from Years 1 and 2 were extrapolated values using results for the legacy current treatment group in Year 3. Year 1 also includes November and December of 2008.*

Both legacy current and legacy suspended treatment group joint savings were negative and no upstream savings deductions were made to measured electric savings. In prior years, PSE HER evaluations removed positive upstream joint savings from measured savings, despite not being statistically significant, as they provided some evidence of possible double counting. Now that cumulative upstream joint savings for the legacy current treatment group have become negative, these negative upstream savings were not deducted from measured savings. In other words, no adjustments were made that would result in an overall increase in measured savings.

We used the joint savings analysis to provide an estimate of credited savings for PSE HER. Combining rebate and upstream joint savings, the legacy current treatment group shared around 6.64 kWh and 1.7 therms savings per household between HER and other PSE programs. For the legacy suspended group, HER and other PSE programs share no kWh and 0.4 therms savings per household. These joint savings were deducted from the HER measured savings to avoid double counting savings with other PSE programs. The HER legacy credited savings for 2016 had these joint program savings netted out.

We also calculated upstream joint savings for the three non-refill groups in the HER expansion program, and applied the joint savings of the legacy current group to the refill group, as these customers replaced legacy customers due to attrition. Table 5-10 presents the number of CFLs and LEDs purchased for the expansion control and treatment groups. Similar to legacy findings, LED purchases were above the CFL levels for all expansion groups. Also, the total number of LEDs purchased annually by the treatment groups was higher than the total number of LEDs purchased by the control groups.

Table 5-10. Count of CFL and LED bulbs purchased annually per household, HER expansion

Upstream lighting measures	Electric only		High relative user		Non-urban		Refill	
	Control	Treatment	Control	Treatment	Control	Treatment	Control	Treatment
CFLs	2.57	2.23	2.64	2.13	2.61	2.16	2.08	1.93
LEDs	3.32	4.21	3.06	3.96	3.48	4.23	4.74	4.88

Table 5-11 provides the joint rebate counts per household for the different expansion groups. Overall, results showed that the total upstream lighting savings were positive and can be attributed to the increase in LED purchases among the expansion treatment groups.

Table 5-11. Savings per household from annual CFL and LED purchases, HER expansion

Upstream lighting measures	Joint rebate counts per household				Bulb type savings	Upstream savings			
	Electric only	High relative user	Non-urban	Refill		Electric only	High relative user	Non-urban	Refill
CFLs	-0.3 (-1.0,0.3)	-0.5 (-1.5,0.4)	-0.5 (-1.1,0.2)	-0.5 (-1.1,0.2)	16.3	-5.7 (-16.4,5.1)	-8.4 (-23.7,6.8)	-7.4 (-18.1,3.3)	-2.5 (-10.4,5.4)
LEDs	0.9 (-0.2,2.0)	0.9 (-0.1,1.9)	0.7 (-0.1,1.6)	0.7 (-0.1,1.6)	17	15.2 (-3.6,33.9)	15.3 (-2.1,32.7)	12.7 (-1.2,26.6)	2.5 (-12.6,17.5)
Total upstream lighting savings						9.5	6.9	5.3	-0.04

** Indicates statistically significant at the 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval.*

As we summed cumulative savings for the legacy group in Table 5-9, Table 5-12 provides the cumulative estimates of the expansion groups' upstream joint savings. Per household joint savings between HER program and upstream programs amounted to 28 kWh, 1 kWh, and 23 kWh for electric only, high relative user, and non-urban groups, respectively. Because high relative user upstream savings were negative in Year 1 and Year 2, only measured savings for the electric-only and non-urban groups were adjusted with upstream savings to avoid double counting.

Table 5-12. Annual joint upstream kWh savings per household for HER expansion

Program year	Treatment group			
	Electric only	High relative user	Non-urban	Refill
Year 1	9.09	-12.76	12.61	-0.04
Year 2	18.59	-5.86	17.87	N/A
Year 3	28.09	1.04	23.17	N/A

5.5 2016 total program savings

Table 5-13 and Table 5-14 provide the wave-level and overall electric and gas credited savings estimates, respectively. The overall electric savings were estimated at 90/15 precision and the gas savings were estimated at 90/27 precision. In total, the legacy current and legacy suspended groups together generated around 5.0 GWh and 232 thousand therms in savings while the expansion program generated around 20.0 GWh and 462 thousand therms in savings. Overall, PSE HER program produced savings of 25 GWh and 694 thousand therms in 2016.

Table 5-13. Total credited electric savings for 2016 HER programs

HER treatment group	Electric (kWh)				
	Per household	# households with reports	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - current	310.1*	14,499	4,496,101	3,620,125	5,372,078
Legacy – suspended[1]	70.16	7,238	507,849	-65,943	1,081,642
Expansion - electric only	169.2*	23,050	3,899,808	2,036,349	5,763,267
Expansion - high relative user	257.7*	21,558	5,556,298	3,938,434	7,174,161
Expansion – non-urban	132.9*	30,758	4,087,166	2,394,061	5,780,271
Expansion - Refill	268.0*	24,150	6,472,623	4,605,765	8,339,481
ALL	206.34*	121,253	25,019,846	21,302,215	28,737,477

** Indicates statistically significant at the 90% confidence level.*
[1]Note that the number of legacy-suspended households represents households that received reports through 2010. Per the nature of the suspended group, these households no longer receive reports, but do remain active PSE customers.

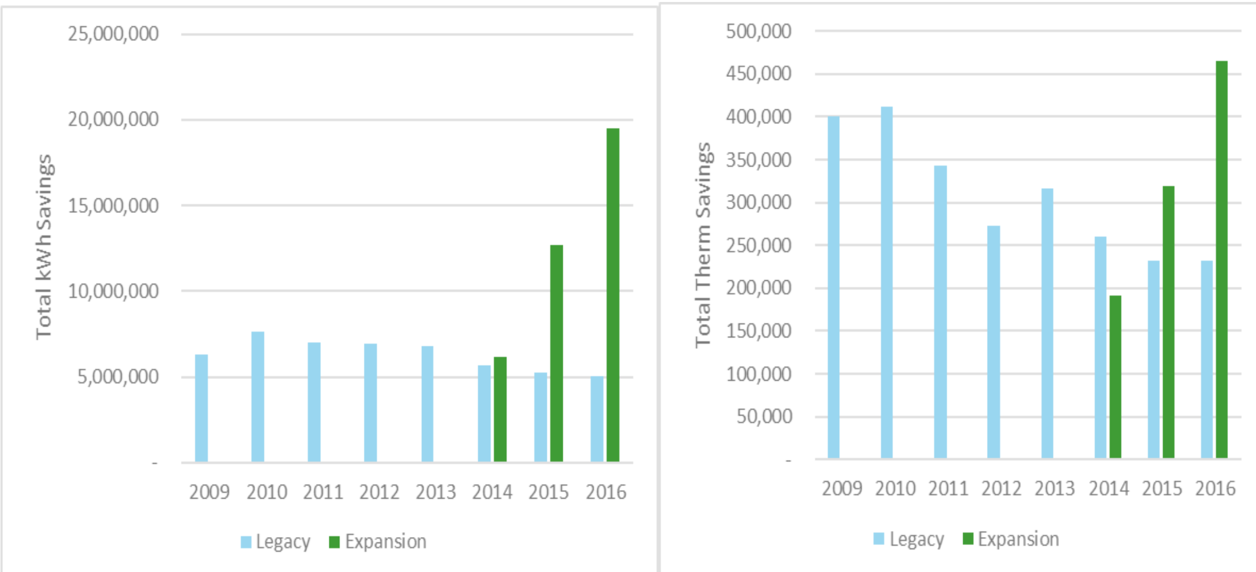
Table 5-14. Total credited gas savings for 2016 HER programs

HER treatment group	Gas (therms)				
	Per household	# households with reports	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - current	12.2*	14,499	176,932	122,174	231,689
Legacy – suspended[1]	7.7*	7,238	55,501	20,202	90,799
Expansion - high relative user	9.6*	21,558	205,862	118,488	293,236
Expansion – non-urban	4.6*	30,758	141,806	54,035	229,578
Expansion - Refill	4.7*	24,150	114,099	21,445	206,754
ALL	7.1*	98,203	694,200	510,124	878,277

** Indicates statistically significant at the 90% confidence level.*
[1]Note that the number of legacy-suspended household represents households that received reports through 2010. Per the nature of the suspended group, these households no longer receive reports, but do remain active PSE customers.

Figure 5-13 provides the total credited program savings for the HER legacy and expansion programs from 2009 to 2016. Total program savings for electric started to decline in 2011 despite increasing the per household savings rate from 2009 to 2013. Similarly, total program savings for gas peaked in 2010 and started declining in 2011. The decrease in total savings over the years is expected for this kind of program due to customer attrition. In 2016, total program electric savings from the legacy group were 20% less than their savings in the first year of the legacy program, and gas savings were 42% less than savings achieved in the first year of the legacy program. The expansion groups' annual electric savings tripled relative to their first year savings, and annual gas savings are 150% of first year savings. As savings from the expansion group start ramping up, the three HER expansion groups are expected to compensate for the diminishing savings from the HER legacy program. We note additionally that the number of households in the expansion groups is substantially higher than the legacy group.

Figure 5-13. Total program credited savings from 2009 to 2016



Note the figure on the left is for electricity while the one on the right is for gas.

6 SAVINGS FOR THE UNMATCHED

The legacy treatment group includes a small subset of households, mostly concentrated in 98006 zip code, that have participated in the HER program since its inception but differed from other participants in that they have not been matched to a randomly assigned group of control households against which to compare their post-HER consumption changes. Historically, as a conservatism savings from this group have not been included in program savings totals. For 2017, DNV GL explored the possibility capturing savings from this customer group by creating a post hoc matching group.

6.1 Matching Procedure

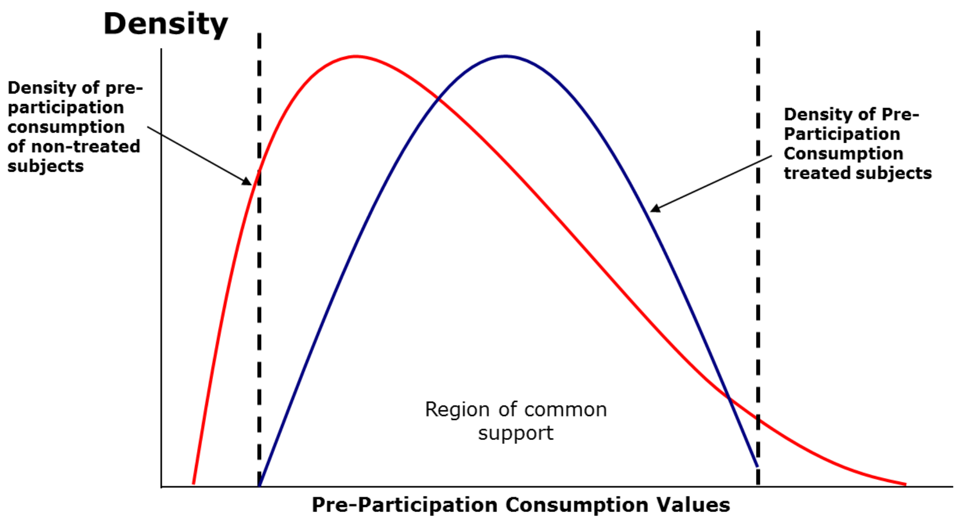
Matching aims to replicate the RCT design by identifying comparison subjects whose characteristics match those of the treated closely. There are various matching techniques that attempt to mimic the RCT design. In this study, we use propensity score matching (PSM) to match treated with comparison households. As the name indicates, PSM is based on propensity scores, which are probabilities that subjects are assigned to the treatment group given their match with certain observable characteristics. Subjects are matched based on these probability scores.

Matching is based on subject/household characteristics that are likely to affect treatment assignment, but not treatment outcome. Such variables can include any characteristics such as household size, heating and cooling source, income, location, and rate groups that may affect treatment assignment. They can also include variables measured before participation, such as pre-program consumption. It is also possible to match on pre-treatment period consumption if we model treatment effects to reflect this choice.[11] This is the approach we take as comprehensive data on household characteristics are not readily available.

Prior to estimating a propensity score model, we identify a first round of common support for matching by trimming the data based on the distribution of pre-treatment consumption. Variable values of the non-treated subjects that do not overlap with the values of the treated subjects are trimmed. In the current case, trimming pre-treatment consumption values of the non-treated subjects that are outside of the 1st and 99th percentiles result in the overlap of the distribution of these values with those of the treated. Figure 6-1 provides an example of how we establish a region of common support.

[11] The post-treatment model that we discuss in section 6.6 is a result of this choice.

Figure 6-1. Region of common support for matching



Logistic regression is fit to the data that reflects common support of the type described above. This model aims to generate propensity scores that indicate the probability of receiving treatment given the level of pre-participation monthly consumption. The estimated propensity scores from this model are used to establish a second-round of common support by trimming values of the comparison group whose scores are above the maximum and below the minimum of those of the treated subjects.

The remaining scores are used to find matches for each treated subject based on k-to-one $(k{:}1)$ matches. We use the nearest neighbor matching (NN) algorithm for this purpose. The approach produces matches for each treated subject, selected in random order, by searching for k propensity scores that are nearest to those of the treated subject's. We select 1 for such match ($k = 1$) without replacement. Thus, a comparison subject selected as a match for a given treated subject is not available for matching again. This type of matching algorithm does not affect the condition of balance.

6.2 Test of Balance

The final step in the matching process is to check that the generated matches are well-balanced. This helps to establish that treatment outcomes are not dependent on the probability of treatment assignment. Checking that matches are well-balanced involves determining that the distribution of the variables (on which matching is done) of the comparison and treated subjects are the same.

We check matching balance in two different ways. First, we examine the distribution of matched pre-treatment consumption for treated and comparison subjects using density plots. In addition, we examine the quality of matches using propensity score diagnostics. Such diagnostics includes evaluating the mean difference in propensity scores using the standardized difference of the scores. A standardized difference is the difference in the mean values of the scores for the treatment and comparison groups relative to the standard error of the difference. A standardized difference that exceeds the value of 0.2 shows imbalance. However, the lower this difference, the better the balance. Another diagnostic check of balance is the ratio of the variances of the propensity scores in the two groups. A value that is close to 1 indicates balance whereas values that are close to 1/2 or 2 indicate extreme imbalance.

6.3 Matching Data

We started with 4,864 unmatched legacy treatment households. Of these, 6 did not have billing data and, thus, 4,858 were considered for matching. While most of the unmatched legacy treatment households are in 98006, there were only 14 such households in the control group in this zip code. Therefore, matching was based on the entire control group. We had data for 27,420 such households.

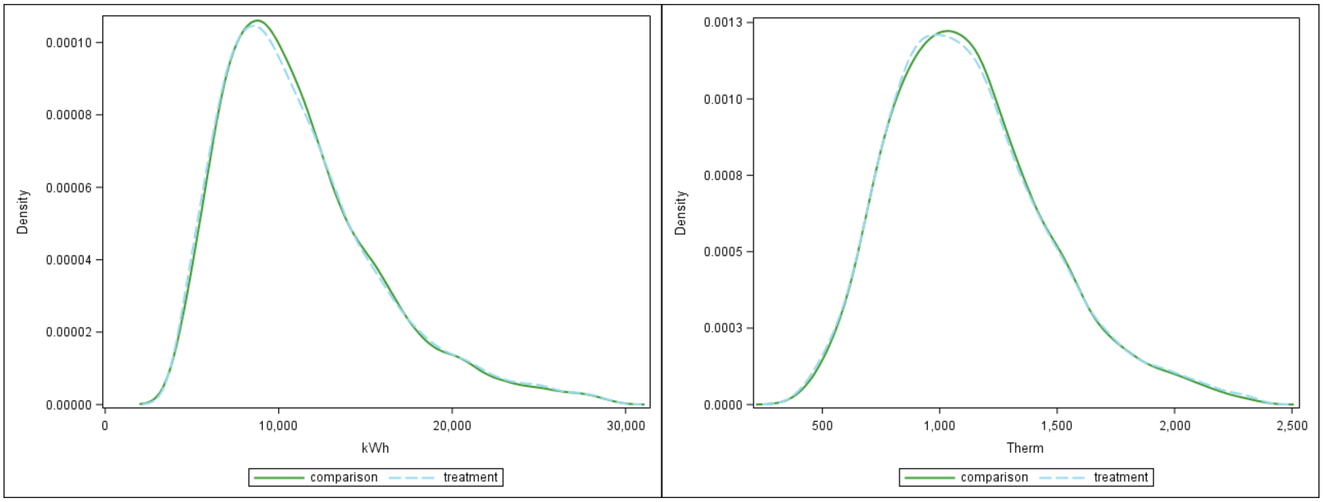
Before the matching procedure, we did further data quality checks to exclude households that did not have 12 months of pre- and post-period energy use data that were non-negative. Households with extreme values, greater than 150 kWh per day or 11 therms per day, were also excluded. This resulted in 25,095 control and 3,846 unmatched treatment households. When the program was initially launched in late 2008, there were about 40,000 control and 4,800 unmatched treatment households. Due to attrition and data quality issues, there are about 37% and 20% fewer control and unmatched treatment households, respectively, in the current program evaluation year of 2016.

In addition, consumption values that are below the 1st percentile and above the 99th percentile were trimmed. After these exclusions, the final number of households available for matching were 3,702 legacy treatment and 24,216 control households, which made it possible to have 6 potential matches for each unmatched legacy treatment household.

6.4 Matching Outcome

As a test of balance, we start by examining the distribution of consumption of the treatment and comparison households. Figure 6-2 provides a (kernel) density plot of pre-treatment consumption of treated and comparison households. Visual inspection of the figure makes it evident that the samples are well-balanced (matched). The values of consumption for the treatment and matched comparison groups are very close across the entire consumption range for both electricity and gas.

Figure 6-2. Consumption-Billing Data Matched kWh and therms for Dual-Fuel Households[12]



The standardized difference and the ratio of variance of a variable or characteristics of two different populations are statistics that characterize the distribution of the populations. The standardized difference provides information on differences of a characteristic at the center of the data while the ratio of the variance provides the difference across the entire range of the data. A value of 0.2 (20%) or greater for the standardized difference and 2 or greater for the ratio of the variance indicate two populations are different. The results in Table 6-1 indicate the distributions of the unmatched populations are different, but those of the matched are the same.

Table 6-1. Propensity score diagnostics

Status	Standardized Difference	Ratio of Variance
Unmatched	0.69	2.70
Matched	0.01	1.07

Taken together, these results indicate well-balanced matched groups whose data we use to examine the impact of HER treatment.

[12] A density plot is a visual presentation of the distribution of pre-treatment consumption data of the given households. The horizontal axis presents the range of consumption of households over a specified period, say from 0 to 30,000 kWh per year, while the vertical axis depicts the concentration of consumption across the range. The density plot presents information that could be depicted by a histogram, but over a continuous interval rather than discrete intervals. While values on the vertical axis of histograms indicate the number of observations/households whose consumptions lies in a specified range, the vertical axis of a density plot provides the probability of consumption within the same range. Essentially, the density plot provides a smooth distribution of consumption that is depicted in discrete forms by a histogram.

6.5 Energy consumption and impact modeling

Using the matched data, we evaluate the effect of HER treatment on energy consumption by estimating a post-treatment energy consumption model with a difference-in-difference structure. This model identifies the effect of treatment through an indicator value for the treated in the treatment period after controlling of pre-treatment consumption, which is partly a proxy for household fixed-effects, and other time specific effects.

We use average daily consumption per month as the unit of the analysis in the model. Our methodological approach is based on identifying changes in this level of consumption after HER treatment over the specified pre- and post-periods for the two groups. We present the model in the next section.

6.6 Post-treatment energy use model

We specify a post-treatment model that estimates HER treatment effects based on a panel data, where monthly observations for each treated and comparison household are stacked. In addition to treatment effect, we also include terms that capture time-specific effects and lagged values of consumption.

The model is given by:

$$Cjt = \alpha_0 + \beta_{0jt}Month_{jt} + \beta_{1jt}Month_{jt} * lagC_{jt} + \beta_2 Ij + \varepsilon_{jt}$$

Cjt = average daily consumption during interval t for household k

$Month_{jt}$ = 0/1 indicator taking the value of 1 when j=t or when the jth month is t (captures monthly fixed effects)

$lagC_{jt}$ = average daily consumption of household j in the same calendar month of the pre-treatment year as the calendar month of post-treatment

Ij = 0/1 dummy variable equal to 1 if household j is in the HER treatment group, 0 if household j is in the comparison group

ε_{jt} = error term of the model

The parameter β_2 captures the effect of HER treatment. It reflects the extent of average daily consumption change due to receiving HER messaging.

6.7 Results

We provide the impact of the program on electric and gas consumption of the unmatched legacy treatment group in 2016 in this section. Table 6-2 provides a summary of measured savings per household.

Table 6-2. Summary of measured annual savings for the unmatched legacy treatment group in 2016

HER treatment group	Electric (kWh)			Gas (therms)		
	Consumption	Savings	Percent	Consumption	Savings	Percent
Legacy unmatched	9,892	755.8* (628.6,883.1)	7.6%	818	18.2* (10.1,26.4)	2.2%

** Indicates statistically significant at the 90% confidence level. The values in parentheses are the upper and lower bounds at the 90% confidence interval.*

The unmatched group produced measured electric and gas savings of 7.6% and 2.2%, respectively. These savings were statistically significant and indicate average savings per household of 755.8 kWh and 18.2 therms for 2016. The kWh savings are more than double those saved by the legacy current treatment group while the therm savings are one-third above those saved by the same group.

These savings reflect the effect of HER treatment on the unmatched legacy treatment group relative to its comparison group. While the test of balance indicates a well-balanced sample using pre-treatment consumption as a basis for matching, it is possible that there are other factors (such as weather, income, solar use) that are unaccounted for in the matching process that could confound the effect of treatment. As almost all the unmatched households reside in one zip code, we suggest that the matching exercise be conducted using data from the larger PSE customer base in this zip code using additional information on factors such income and solar use to prevent the possible confounding of HER treatment with other effects.

Upon further investigation, we identified that these households were in higher-income neighborhoods, and because our pool of available control households within the same zip code was very limited, we pulled control households from neighboring zip codes. We were also unsure whether these households served as primary or secondary homes to their occupants. We thus recommend revisiting this analysis again in the 2017 evaluation by including an expanded pool of potential control households within the same zip code and conducting a deeper investigation into customer installation of solar and customer use of the home as primary or secondary residence. Nevertheless, this exercise demonstrates that the savings among legacy current households can serve as a conservative estimate for the unmatched households. We thus calculated electric and gas savings for the unmatched group by applying the per household savings as a percent of consumption of the legacy current group to the average per household consumption of the unmatched group. Table 6-3 provides the credited savings estimates for the legacy unmatched group using this approach.

Table 6-3. Comparison of credited savings between legacy current and legacy unmatched groups

<table>
<tr><th rowspan="2">HER treatment group</th><th colspan="3">Electric (kWh)</th><th colspan="3">Gas (therms)</th></tr>
<tr><th>Consumption</th><th>Savings</th><th>Percent</th><th>Consumption</th><th>Savings</th><th>Percent</th></tr>
<tr><td rowspan="2">Legacy - Current</td><td rowspan="2">9,782</td><td>310.1*</td><td rowspan="4">3.20%</td><td rowspan="2">716</td><td>12.2*</td><td rowspan="4">1.70%</td></tr>
<tr><td>(249.7,370.5)</td><td>(8.4,16.0)</td></tr>
<tr><td rowspan="2">Legacy Unmatched</td><td rowspan="2">9,892</td><td>316.5</td><td rowspan="2">818</td><td>13.9</td></tr>
<tr><td>(252.5,374.7)</td><td>(9.6,18.3)</td></tr>
</table>

7 CONCLUSIONS

With eight years of historical program data and insights, as well as the strategic design and expansion of the program, this report is uniquely positioned to identify patterns among the different participant groups over time. Among legacy current customers, savings relative to their control group remained steady, at around 3.2% of annual electric, and 1.7% of gas consumption. For the past three years, per-household savings among the expansion groups have grown consistently. In general, these groups are consistent with the ramp-up trend of the legacy group, which achieved a consecutive annual increase in per-household savings for the first six years of the program. It is also notable that the legacy suspended group, which has not received reports for six years, continues to achieve statistically significant gas savings, but no longer achieves statistically significant electric savings relative to their respective control groups.

While with any evaluation, it would be preferable to have a better understanding of what drives the savings, which is typically accomplished with a process evaluation. As discussed below, HER programs are difficult to evaluate from a process perspective. It is extremely difficult to establish, with any confidence, what actions are driving the savings estimates. In addition, the vendor, in this case Opower, is clear that they are constantly trying to improve the messaging in their reports, so it could be that the activities or even the subset of active customers are evolving from year to year. Nevertheless, given the sizeable participant population, results prove that relatively small per-household savings add up to program annual savings of 26,237,273 kWh and 747,682 therms.

Legacy – current group

Results confirmed that savings for legacy current households remained, and were similar to previous years. While most jurisdictions with HER program have assigned a measure life of one year; due to the persistence of savings over the period of time, PSE is using a two year measure life. The results of this evaluation and the previous evaluations tend to indicate that savings for the households that continue to receive the reports remain statistically significant. Given this result, it is reasonable for PSE to use a two-year measure life.

For the first time in PSE HER's evaluation history, the legacy current treatment group demonstrated significantly higher joint savings than its control counterpart, yet program participation rates between these two groups remained similar. This seemingly paradoxical finding suggests that initially, HER treatment households participate significantly more than control households. While this increased participation may wane, treatment households appear to achieve deeper levels of per-household savings in the long-term.

Total credited savings for the legacy program have decreased year over year due to customer move-outs. This kind of attrition is expected for a program where the experimental design was set and cannot be altered. As the new expansion groups get up to speed, these groups are expected to compensate for the dwindling total savings from the legacy group.

From these conclusions, we recommend PSE continues the HER program for the legacy current group, recognizing that overall legacy current savings will likely continue to diminish over time due to attrition.

Legacy suspended group

This is the sixth year of evaluating the legacy suspended treatment group and is the first evaluation in which the legacy suspended electric savings were not significantly different from the control group. In 2016, measured electric savings of the legacy suspended group declined from about one third to about one fifth of what the continuing treatment group was saving. Measured gas savings, on the other hand, remained at about 60% of continuing group savings levels.

From these conclusions, we recommend that future evaluations continue to track the decrease in suspended electric and gas savings. We also note that while the suspended group stopped receiving reports after two years, the energy savings ramp for this group continued through the fifth year of the program.

Expansion groups

The 2016 credited savings for the various expansion groups ranged from 1.3% to 2.4% for electric, and 0.6% to 1.4% for gas. This ramp-up pattern appears similar to that of the legacy current group in its first several years of participation. Assuming this trend continues, per-household savings among the expansion groups will increase.

In 2016, electric rebate joint savings from the high relative users, non-urban, and refill groups were statistically significant. Gas rebate joint savings were only significant for the high relative user and refill groups. This further suggests that HERs boost participation in other energy efficiency programs, but exhibit different patterns between groups. Historically, all four expansion groups have shown an increase in magnitude of rebate savings annually from 2014 to 2016, with the electric-only group producing the highest electric rebate savings and the high-relative users group producing the lowest.

Lastly, we have consistently observed higher savings among the top consumption quartile of the legacy group. In this evaluation, we also saw high savings for the refill group, which further suggests large energy consumers save more energy as a percent of their consumption.

From these conclusions, we recommend that future evaluations analyze per-household savings among quartiles of the various expansion groups to observe whether they follow similar patterns to the legacy treatment group. We also recommend PSE continue to better investigate more specifically how HERs drive or change customer participation in non-HER PSE efficiency programs.

Unmatched group

In this evaluation, we assigned a control group for the previously unmatched group. Through this analysis, we found that the previously unmatched households observed statistically significant electric and gas savings. These savings were so substantial that they were even significantly higher than the per-household gas and electric savings of the legacy-current group. However, upon further investigation, we also found that the characteristics of the unmatched group and their data were unusual and merited additional research. We first recognized that these customers resided in a relatively high-income zip code, suggesting that the control matching analysis would benefit from further constraining the control customers to only households in the same zip code. In addition, we noticed an increase in data abnormalities among the unmatched treatment customers. For instance, we noticed a relative abundance of very low daily consumption reads (10% of a given household’s average consumption). We thus concluded through our analysis, and evidence of sustained savings among the legacy group, that the unmatched group is achieving significant savings. However, due to the prevalence of unusual data points, and the potential to further refine the matching analysis by including additional constraint criteria, we advise further research to justify the higher-level of per-household savings among the unmatched group. In this analysis, we applied the legacy current treatment group's household savings, considering it the most conservative estimate of savings.

From these conclusions, we recommend more research in the next program year, including creating matches using households from the zip code the unmatched legacy households come from, to estimate the savings for this group.

8 APPENDICES

8.1 Randomization test

DNV GL applied statistical t-tests to the final sample to test the randomness of the treatment and control group allocations. For legacy, the pre-program period was from October 2007 to September 2008. We compared the electric and gas consumption for each month in the pre-program period. The test of differences in consumption is presented in Table 8-1, while Table 8-2 presents the test of differences in various household characteristics for participants in the legacy program.

Table 8-1. Test of differences in pre-period consumption between legacy treatment and control groups

Fuel	Month	Treatment			Control			Control-Treatment	
		Count	Mean	Std Error	Count	Mean	Std Error	Difference	Pr > |t|
Electric Consumption (kWh)	Oct-2007	21,737	921	2.86	27,420	921	2.56	0.28	0.94
	Nov-2007	21,737	996	3.17	27,420	995	2.78	-0.29	0.95
	Dec-2007	21,737	1,218	4.05	27,420	1,219	3.53	0.59	0.91
	Jan-2008	21,737	1,100	3.67	27,420	1,100	3.23	-0.28	0.95
	Feb-2008	21,737	941	3.09	27,420	942	2.74	0.69	0.87
	Mar-2008	21,737	975	3.18	27,420	977	2.82	2.10	0.62
	Apr-2008	21,737	873	2.83	27,420	875	2.52	1.70	0.65
	May-2008	21,737	836	2.66	27,420	837	2.38	1.58	0.66
	Jun-2008	21,737	809	2.60	27,420	811	2.34	2.37	0.50
	Jul-2008	21,737	811	2.74	27,420	815	2.48	3.57	0.34
	Aug-2008	21,737	845	2.80	27,420	849	2.54	4.31	0.26
	Sep-2008	21,737	798	2.53	27,420	800	2.31	2.22	0.52
Gas Consumption (therms)	Oct-2007	21,737	79	0.20	27,420	79	0.18	-0.15	0.58
	Nov-2007	21,737	114	0.26	27,420	114	0.23	-0.11	0.75
	Dec-2007	21,737	148	0.32	27,420	148	0.29	-0.11	0.81
	Jan-2008	21,737	162	0.35	27,420	162	0.31	0.47	0.76
	Feb-2008	21,737	119	0.26	27,420	119	0.24	0.35	0.48
	Mar-2008	21,737	123	0.28	27,420	122	0.25	0.37	0.74
	Apr-2008	21,737	95	0.23	27,420	94	0.20	0.30	0.45
	May-2008	21,737	51	0.15	27,420	51	0.13	0.20	0.35
	Jun-2008	21,737	42	0.15	27,420	42	0.13	0.20	0.61
	Jul-2008	21,737	21	0.12	27,420	21	0.11	0.16	0.65
	Aug-2008	21,737	21	0.11	27,420	21	0.11	0.16	0.54
	Sep-2008	21,737	29	0.13	27,420	29	0.12	0.17	0.65

**Indicates statistically significant at the 90% confidence interval.*

Table 8-2. Test of differences in household characteristics between legacy treatment and control groups

Characteristics	Treatment			Control			Control-Treatment	
	Count	Mean	Std Err	Count	Mean	Std Err	Diff	Probt
Age	21,737	30.9	0.105	27,420	30.8	0.094	-0.106	0.454
Number of bathrooms	21,737	2.3	0.004	27,420	2.3	0.003	0.003	0.583
Number of bedrooms	21,713	3.6	0.005	27,366	3.6	0.004	-0.008	0.203
House value ($)	21,736	347,596	1,159	27,419	347,981	1,033	385	0.804
Number of occupancy	19,163	2.3	0.008	24,054	2.3	0.007	0.002	0.844
House size (sqft)	21,737	2,165	4.269	27,420	2,162	3.820	-2.090	0.715

In each month during the pre-program period, consumption differences and household characteristics were not statistically significant at 90% confidence. These results indicate that pre-period consumption and household characteristics were balanced between the treatment and control groups and site exclusion criteria applied to the legacy program should not bias savings estimates.

We performed the randomized selection of treatment and control groups for PSE HER expansion program. At that time, PSE only provided information on annual combined usage and square footage. To test randomness of the treatment allocation, we applied statistical tests on consumption for the 12 months before the first report was sent, which was March 2014. Results from the tests for the high relative user, non-urban, and electric-only groups are presented in Table 8-3, Table 8-4, Table 8-5 and Table 8-7, respectively.

Table 8-3. Test of differences in pre-period consumption between treatment and control groups, expansion program high relative user

Fuel	Month	Treatment			Control			Control-Treatment	
		Count	Mean	Std Err	Count	Mean	Std Err	Difference	Pr > |t|
Electric	Mar-2013	21,418	30,658	128.54	7,051	30,509	219.65	-148.65	0.56
	Apr-2013	21,431	26,561	109.59	7,055	26,482	187.87	-79.34	0.72
	May-2013	21,440	25,546	107.80	7,057	25,493	185.26	-53.40	0.80
	Jun-2013	21,458	23,899	105.63	7,066	23,774	179.21	-124.89	0.55
	Jul-2013	21,448	26,641	122.30	7,062	26,467	210.48	-174.90	0.48
	Aug-2013	21,460	26,795	122.32	7,061	26,524	212.43	-271.03	0.27
	Sep-2013	21,486	24,583	104.74	7,074	24,462	185.31	-121.39	0.57
	Oct-2013	21,493	29,010	121.20	7,081	28,950	212.90	-60.26	0.80
	Nov-2013	21,518	30,333	126.02	7,087	30,335	223.76	1.51	1.00
	Dec-2013	21,546	38,176	163.92	7,091	38,224	290.12	47.76	0.89
	Jan-2014	21,534	33,896	145.99	7,088	33,843	255.83	-52.64	0.86
	Feb-2014	21,533	28,415	123.97	7,079	28,335	217.65	-80.58	0.75
Gas	Mar-2013	20,871	3,030	10.19	6,855	3,022	17.63	-8.27	0.69
	Apr-2013	20,937	2,209	7.96	6,874	2,201	13.48	-7.55	0.63
	May-2013	21,053	1,236	5.91	6,927	1,229	9.77	-6.84	0.56
	Jun-2013	21,097	730	4.85	6,945	732	8.36	2.02	0.84
	Jul-2013	21,155	607	4.89	6,954	616	8.51	9.00	0.36
	Aug-2013	21,243	588	5.06	6,990	602	9.69	13.71	0.19
	Sep-2013	21,325	856	4.99	7,023	861	8.39	4.62	0.64
	Oct-2013	21,421	2,341	8.76	7,052	2,316	14.52	-25.07	0.15
	Nov-2013	21,441	3,127	10.51	7,061	3,101	17.82	-26.12	0.21
	Dec-2013	21,453	4,395	13.59	7,066	4,363	23.41	-32.31	0.24
	Jan-2014	21,515	2,936	9.38	7,080	2,923	16.17	-13.32	0.48
	Feb-2014	21,522	3,616	11.12	7,085	3,592	19.14	-23.64	0.29

*Indicates statistically significant at the 90% confidence interval.

Table 8-4. Test of differences in pre-period consumption between treatment and control groups, expansion program, non-urban

Fuel	Month	Treatment			Control			Control-Treatment	
		Count	Mean	Std Err	Count	Mean	Std Err	Difference	Pr > |t|
Electric	Mar-2013	30,523	26,012	93.38	10,176	26,334	169.78	321.66	0.09
	Apr-2013	30,567	22,572	79.33	10,196	22,774	144.35	202.62	0.21
	May-2013	30,617	22,077	77.72	10,205	22,322	141.59	244.49	0.12
	Jun-2013	30,624	21,229	76.65	10,202	21,458	140.35	229.26	0.14
	Jul-2013	30,629	24,390	91.09	10,208	24,647	165.32	256.61	0.16
	Aug-2013	30,648	24,640	91.32	10,219	24,867	166.11	227.66	0.22
	Sep-2013	30,669	21,991	76.46	10,226	22,117	138.85	125.70	0.42
	Oct-2013	30,676	25,165	86.19	10,226	25,342	158.51	177.40	0.31
	Nov-2013	30,702	26,527	91.80	10,236	26,614	166.32	87.33	0.64
	Dec-2013	30,719	33,779	122.65	10,255	33,946	221.11	167.38	0.50
	Jan-2014	30,705	29,474	108.12	10,252	29,572	192.38	97.76	0.65
	Feb-2014	30,723	24,657	91.46	10,256	24,767	163.03	110.25	0.55
Gas	Mar-2013	30,144	2,570	7.02	10,062	2,592	12.44	21.08	0.14
	Apr-2013	30,224	1,858	5.39	10,087	1,877	9.60	19.22	0.08
	May-2013	30,347	1,071	3.83	10,141	1,088	6.77	16.36	0.03
	Jun-2013	30,375	676	3.16	10,155	690	5.73	13.72	0.03
	Jul-2013	30,425	587	3.09	10,166	602	5.78	14.62	0.02
	Aug-2013	30,528	567	2.97	10,197	583	5.80	15.18	0.01
	Sep-2013	30,599	765	2.92	10,218	786	6.02	20.30	0.00
	Oct-2013	30,637	2,006	5.90	10,229	2,019	10.43	12.96	0.27
	Nov-2013	30,661	2,706	7.24	10,229	2,722	12.59	16.33	0.26
	Dec-2013	30,656	3,849	9.68	10,229	3,880	16.82	30.38	0.12
	Jan-2014	30,686	2,555	6.82	10,231	2,564	11.96	9.07	0.51
	Feb-2014	30,712	3,126	8.08	10,248	3,146	14.11	20.43	0.21

**Indicates statistically significant at the 90% confidence interval.*

Table 8-5. Test of differences in consumption between treatment and control groups, expansion program electric only

Fuel	Month	Treatment			Control			Control-Treatment	
		Count	Mean	Std Err	Count	Mean	Std Err	Difference	Pr > |t|
Electric	Mar-2013	22,828	42,123	177.49	7,589	42,340	307.79	217.69	0.54
	Apr-2013	22,855	34,017	141.32	7,593	34,213	244.58	195.72	0.49
	May-2013	22,871	28,208	115.10	7,589	28,254	197.59	45.54	0.84
	Jun-2013	22,883	24,015	99.99	7,586	24,044	174.21	28.98	0.89
	Jul-2013	22,875	25,604	110.30	7,589	25,581	191.45	-22.79	0.92
	Aug-2013	22,889	25,565	109.30	7,591	25,520	186.07	-45.49	0.83
	Sep-2013	22,921	25,064	101.12	7,608	25,011	170.97	-53.70	0.79
	Oct-2013	22,950	36,063	148.34	7,610	36,288	257.97	225.24	0.45
	Nov-2013	22,963	42,506	176.65	7,618	42,783	307.09	276.91	0.43
	Dec-2013	23,030	57,961	246.07	7,641	58,308	428.42	347.13	0.48
	Jan-2014	23,016	50,047	214.65	7,639	50,307	373.91	259.56	0.55
	Feb-2014	23,029	44,925	194.53	7,643	45,043	337.54	117.91	0.76

Table 8-6. Test of differences in consumption between treatment and control groups, expansion refill

Fuel	Month	Treatment			Control			Control-Treatment	
		Count	Mean	Std Err	Count	Mean	Std Err	Difference	Pr > |t|
Electric	May-2014	23,727	26,693	96.77	9,954	26,749	150.87	56.04	0.75
	Jun-2014	23,700	25,700	94.77	9,956	25,733	147.67	32.87	0.85
	Jul-2014	23,702	32,069	197.45	9,952	32,070	195.98	1.38	1.00
	Aug-2014	23,674	32,196	121.38	9,953	32,252	194.93	56.38	0.80
	Sep-2014	23,724	26,931	97.22	9,959	26,897	155.27	-34.33	0.85
	Oct-2014	23,846	29,006	118.07	10,015	28,899	230.57	-106.14	0.65
	Nov-2014	23,942	32,648	215.06	10,045	33,090	217.24	442.65	0.22
	Dec-2014	23,927	37,829	154.22	10,049	37,905	224.18	75.97	0.79
	Jan-2015	23,911	34,994	136.33	10,043	35,060	191.28	66.20	0.92
	Feb-2015	23,875	27,124	102.06	10,041	27,106	144.28	-17.70	0.96
	Mar-2015	23,900	30,195	111.32	10,050	30,186	159.31	-8.93	0.15
	Apr-2015	23,904	26,621	96.83	10,047	25,485	1202.04	-1136.79	0.75
Gas	May-2014	23,873	1,134	19.49	10,023	1,162	9.27	27.86	0.36
	Jun-2014	23,874	1,022	147.14	10,027	889	24.60	-133.49	0.56
	Jul-2014	23,880	614	40.80	10,033	573	64.69	-41.25	0.59
	Aug-2014	23,903	543	45.85	10,044	600	45.81	57.07	0.46
	Sep-2014	23,925	641	43.52	10,057	724	32.30	82.87	0.24
	Oct-2014	23,933	1,329	29.39	10,057	1,318	65.32	-11.07	0.86
	Nov-2014	23,992	3,271	20.00	10,085	3,486	225.49	214.55	0.15
	Dec-2014	23,975	3,498	25.31	10,074	3,544	35.42	45.46	0.32
	Jan-2015	23,939	3,453	26.36	10,050	3,402	40.18	-50.85	0.29
	Feb-2015	23,894	2,312	22.77	10,028	2,348	31.08	35.23	0.38
	Mar-2015	23,934	2,277	23.41	10,052	2,321	14.23	44.05	0.24
	Apr-2015	23,939	1,893	17.95	10,046	1,928	18.35	34.49	0.25

The randomization test showed that differences in electric and gas consumption between treatment and control groups are not statistically significant for the high relative user and electric-only groups. The results from the non-urban group showed similar electric consumption between treatment and control but the differences in gas consumption from May to September in the pre-program period are statistically significant at the 90% confidence interval.

Further tests were applied on gas consumption of the non-urban group. Overall t-tests also showed that annualized gas consumption of the control group is relatively higher by around 7.1 therms (1.0%) than that of the treatment group and the difference is statistically significant at the 90% confidence level. The difference-in-differences approach used to estimate savings should control for any imbalance between the treatment and control groups with respect to consumption. While it is unfortunate that the sample is not balanced for some months, this fact does not undermine savings estimates produced in this evaluation.

8.2 HER measured savings from 2009 to 2016

Table 8-7. HER legacy measured savings based on actual consumption from 2009 to 2016

Year and Group	Electric (kWh)	+/-	Gas (therms)	+/-
2009	197.7 (158.2,237.2)	23.99	12.9 (10.2,15.6)	1.65
2010	254.9 (203.3,306.4)	31.34	13.8 (10.3,17.3)	2.13
2011- Current	292.2 (222.8,361.6)	42.2	13.0 (8.6,17.4)	2.68
2012 - Current	306.0 (227.3,384.8)	47.87	12.7 (8.0,17.5)	2.89
2013 - Current	334.3 (246.5,422.1)	53.37	14.8 (9.6,20.0)	3.16
2014 - Current	310.1 (216.4,403.8)	56.95	13.2 (7.8,18.7)	3.32
2015 - Current	311.5 (212.2,410.8)	60.37	13.4 (7.6,19.3)	3.56
2016 - Current	316.7 (217.8,415.7)	60.18	13.9 (7.8,20.0)	3.68
2011- Suspended	246.4 (155.2,337.7)	55.48	12.8 (7.1,18.4)	3.43
2012- Suspended	196.0 (91.9,300.1)	63.26	8.7 (2.6,14.8)	3.72
2013- Suspended	184.3 (67.8,300.9)	70.85	11.9 (5.2,18.5)	4.04
2014 - Suspended	125.6 (1.8,249.3)	75.23	10.2 (3.2,17.3)	4.28
2015 - Suspended	104.4 (-26.4,235.3)	79.56	8.5 (0.9,16.1)	4.60
2016 - Suspended	70.2 (-60.2,200.6)	79.27	8.1 (0.2,15.9)	4.77

**Indicates statistically significant at the 90% confidence interval.*

Table 8-8. HER expansion measured savings based on actual consumption from 2009 to 2016

Year and Group	Electric (kWh)	+/-	Gas (therms)	+/-
2014 - Electric only	115.7 (43.1, 188.3)	44.15	N/A	N/A
2014 - High relative User	86.6 (29.1, 144.0)	34.94	6.1 (1.9, 10.3)	2.56
2014 - Non-Urban	48.4 (9.3, 87.6)	23.79	1.2 (-1.6, 80.3)	1.73
2015 - Electric only	210.7 (130.7, 290.7)	48.64	N/A	N/A
2015 - High relative User	226.3 (147.3, 305.4)	48.06	10.1 (5.8, 14.4)	2.59
2015 - Non-Urban	140.9 (89.6, 192.2)	31.19	3.9 (0.9, 6.8)	1.79
2016 - Electric only	208.6 (129.9, 287.3)	47.85	N/A	N/A
2016 - High relative User	265.0 (191.4, 338.5)	44.69	10.7 (6.7, 14.7)	2.44
2016 - Non-Urban	163.1 (109.2, 217.0)	32.77	5.7 (2.9, 8.6)	1.72
2016 - Refill	253.0 (166.4, 339.6)	52.66	5.1 (-0.5, 10.7)	3.43

8.3 HER results from the difference-in-differences model

The difference-in-differences approach is a simple, robust approach to measure program-related savings in a randomized experimental design framework. The approach compares mean energy consumption between the pre- and post-report periods for the treatment and control groups.

A simple pre-post comparison of treatment group consumption, without a control group, does not account for systemic effects (economic factors, fuel prices, etc.) that impact all households' consumption patterns during the measurement periods. It is possible that these systemic effects will increase or decrease consumption in the post-report period unrelated to the effects of the reports. This would bias the estimate of consumption reduction, a particular concern when expected reduction is relatively small. The difference in consumption between pre- and post- period of the control group is unrelated to the HER program and provides a robust estimate of the non-program, systemic effects on consumption that are observed in the post-report period. Because the control group was randomly assigned, their response to the systemic effects is representative of the treatment group response. The term "difference-in-differences" refers to the removal of the control group difference (systemic effects only) from the treatment group difference (program effects and systemic effects).

8.4 Impact methodology

Fixed effects model

For this evaluation, we estimated monthly savings using a fixed-effects regression model that is standard for evaluating behavioral programs like HER. The fixed effects model specification estimates program savings by comparing consumption of the treatment group to the control group before and after program implementation. The change that occurs in the treatment group is adjusted to reflect any change that occurred in the control group, in order to isolate changes attributable to the program.

The fixed effects equation is:

$$E_{it} = \mu_i + \lambda_t + \beta_t P_{it} + \varepsilon_{it}$$

Where:

E_{it}	=	Average daily energy consumption for account i during month t
P_{it}	=	Binary variable: one for households in the treatment group in the post period month t, zero otherwise
λ_t	=	Monthly effects
μ_i	=	Account level fixed effect
ε_{it}	=	Regression residual

This model produces estimates of average monthly savings using the following equation:

$$\bar{S}_t = \hat{\beta}_t$$

Where:

$\bar{S}_t$	=	Average treatment related consumption reduction during month t
$\hat{\beta}_t$	=	Estimated parameter measuring the treatment group difference in the post period month t

The model also includes site-specific and month/year fixed effects. The site-specific effects control for mean differences between the treatment and control groups that do not change over time. The month/year fixed effects control for change over time that is common to both treatment and control groups. The monthly post-program dummy variables pick up the average monthly effects of the treatment. This model is consistent with best practices as delineated in State and Local Energy Efficiency Action Network's (SEE Action) Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations.[13]

Difference-in-differences

The difference-in-differences approach is a direct and simple way of leveraging the experimental design of the HER program. The approach compares the difference in the average consumption of the treatment group between the pre- and post-report period with the same difference for the control group. The treatment group pre-post difference captures all changes between the two periods including those related to receiving the reports. The control group captures all changes with the exception of those related to the report, because the control group did not receive the reports. The random selection of the treatment and control groups ensures that, on average, the control group will appropriately reflect the non-report related changes experienced by treatment and control group alike between the pre-and post-report periods. Removing the non-report differences, as represented by the control group difference, from the treatment difference produces an estimate of the report's isolated effect on consumption.

The average energy consumption is calculated for both treatment and comparison group in both pre- and post-report periods. The difference-in-differences estimate is then produced with the following equation.

$$\Delta C_i = \alpha + \beta T_i + \varepsilon_i$$

where:

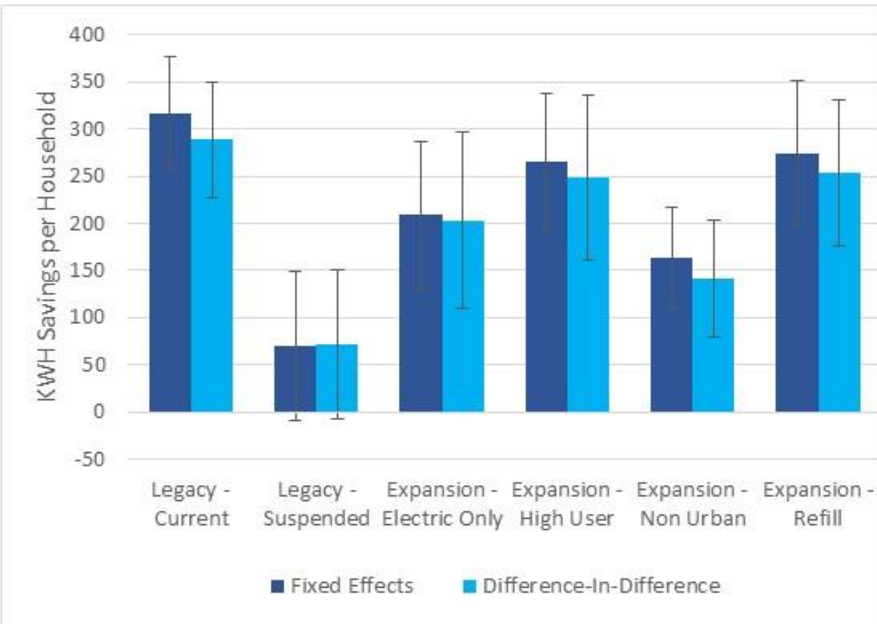
ΔC_i	=	Pre-post difference in annual consumption for household i
α	=	Intercept
T	=	Treatment indicator (value of 1 if treatment and 0 otherwise)
β	=	Treatment effect or savings estimate
ε	=	error term

[13] State and Local Energy Efficiency Action Network. 2012. *Evaluation, Measurement, and Verification (EM&V) of Residential Behavior-Based Energy Efficiency Programs: Issues and Recommendations*. Prepared by A. Todd, E. Stuart, S. Schiller, and C. Goldman, Lawrence Berkeley National Laboratory. http://behavioranalytics.lbl.gov.

The difference-in-differences approach can be applied on a monthly or seasonal basis. As long as time periods are balanced in the pre- and post-report periods, the savings estimate will be consistent for that time period.[14]

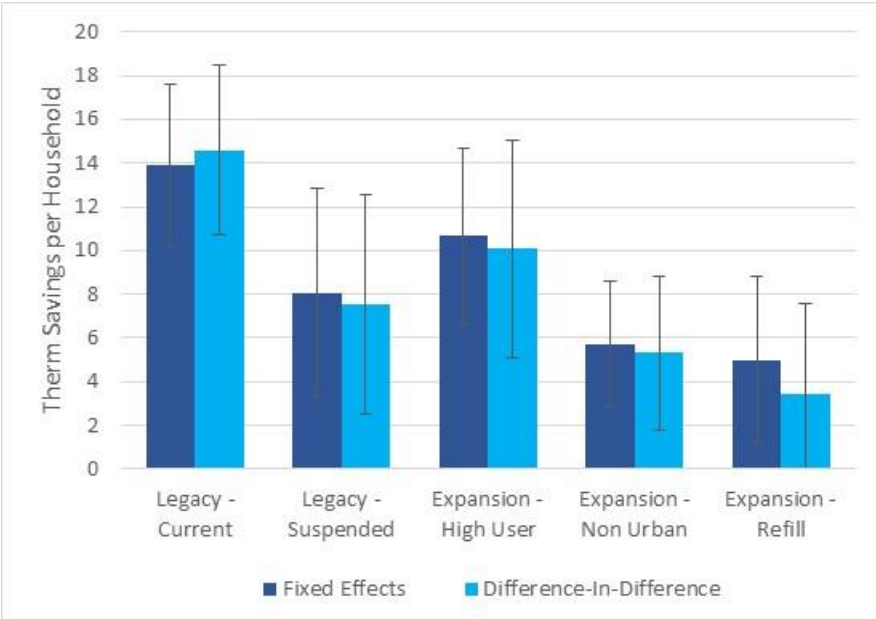
Figure 8-1 and Figure 8-2 show the legacy and expansion results using both the Fixed Effects and Difference-in-Difference methodologies. In all groups, the two results are statistically similar, although the Fixed Effects trends slightly higher. One reason the Fixed Effects results may trend higher is that they capture partial-year savings while the Difference-in-Differences methodology does not.

Figure 8-1. Legacy Difference-in-Difference, 2016



[14] This analysis used the two-stage, difference in difference approach to maintain consistency with prior PSE HER evaluations. We estimated savings at the annual level, thus there is no need to cluster errors.

Figure 8-2. Expansion Difference-in-Difference, 2016



8.5 Survey instrument

Puget Sound Energy

Home Energy Report Program 2015

Web Survey

INTRODUCTION EMAIL [Subject line: We'd like to hear from you – Upcoming survey on PSE Energy Use]

We'd like to hear from you!

To help us make improvements to existing programs and rebates, PSE has asked the **DNV GL** research firm to survey PSE customers on how you use energy. The survey will arrive to you via email in the next three days. The survey should only take 5 minutes, and your responses will be kept anonymous.

If you have any questions about the survey, please contact the PSE Energy Efficiency Evaluations Group at: ***EESEvaluations@PSE.com***

We really appreciate your input!

If you no longer wish to receive these emails, you may unsubscribe by clicking the link below.
^insert_unsubscribe_link^

Reminder email:

PSE PUGET SOUND ENERGY

Recently Puget Sound Energy invited you to participate in a survey. We would greatly appreciate your input, please see the message below:

[Introduction Email]

INTRODUCTION SCREEN

We'd like to hear from you!

To help us make improvements to existing energy efficiency programs and rebates, we are surveying you and other customers to learn more about your energy use. The survey should only take 5 minutes, and your responses are completely anonymous.

Please do not use your browser buttons to navigate the survey. Instead use the buttons at the bottom of each screen.

Please answer all questions as completely and accurately as possible.

If you have any questions about the survey, please contact the PSE Energy Efficiency Evaluations Group at: ***EESEvaluations@PSE.com.***

SURVEY SCREENING

Any terminate points in the screening portion of the survey can be redirected to a link or to a screen asking if they would like more information and offer a link or multiple links to PSE programs or the main PSE site. Screening termination points:

- Work or someone in household works for PSE or other utility – *Generic end screen with thank you.*
- Wrong address - *Generic end screen with thank you or screen offering more program information.*
- Unfamiliar with household light bulb purchases - *Generic end screen with thank you or screen offering more program information.*
- Unfamiliar with CFL and LED light bulbs – *Most likely to want a screen offering more program information.*

I WEB SURVEY

Customer Questions. First, we want to ask you a few background questions before we proceed to energy use questions.

I1.Do you or anyone else in your household work for a gas or electric utility, including Puget Sound Energy?

1 Yes SPECIFY:____________________ ➔**THANK & TERMINATE**
2 No ➔**GOTO I2**

* **I2.** Do you live at <**ADDRESS**>?

1 Yes ➔**GOTO I3**
2 No ➔ **Thank and Terminate**
97 DON'T KNOW ➔ **Thank and Terminate**

* **I3.** Are you familiar with this household's purchases of light bulbs in the past year?

1 Yes ➔ **GOTO L1**
2 No ➔ **THANK & TERMINATE INTERVIEW**
97 DON'T KNOW ➔**THANK & TERMINATE INTERVIEW**

Lighting Intro:

In the next two sections, we would like to ask you a few questions about light bulbs that you purchased in 2015. First, we will ask about any LED bulbs that you purchased in 2015. Second, we will ask about CFL bulbs. Please think about these different types of light bulbs separately. For your reference, the image below shows what a typical LED, CFL, and incandescent bulb looks like.

L LED PURCHASE(S)

LED Bulbs. In this section please only think about LED bulbs that you purchased for your home in 2015. LEDs are the most efficient light bulbs available today and come in many shapes and sizes. The image below shows a typical LED bulb.

L1 Did you or anyone in your household purchase any LED bulbs in 2015?

1 Yes
2 No ➔ **SKIP TO C1**
97 DON'T KNOW ➔ **SKIP TO C1**

L2 Approximately, how many LED bulbs did your household purchase in 2015? If you purchased any multi-packs, please list the total number of BULBS you purchased. [For example, a pack with three bulbs would count as three. Your best estimate is fine.]

[Free-form entry] ➔ **GO TO L3**

L3 The following question is about **the store** where you purchased the **majority** of LED bulbs in 2015. At what store did you buy the most LEDs?

[DROP DOWN LIST] [ACCEPT ONLY ONE RESPONSE]

1.	ACE HARDWARE
2.	ALBERT'S RED APPLE
3.	ALBERTSONS
4.	ARIRANG ORIENTAL MARKET
5.	ASIAN FOOD CENTERS
6.	BARTELL DRUGS
7.	BATTERIES PLUS

8.	BEAVER VALLEY GENERAL STORE
9.	BEST BUY
10.	BIG LOTS
11.	BRIDLE TRAILS RED APPLE MARKET
12.	CARNATION MARKET
13.	CARNICERIA LA CHIQUITA
14.	COSTCO
15.	DO IT BEST - ISLAND LUMBER & HARDWARE
16.	DO IT BEST HARDWARE CENTER
17.	DODSON'S IGA
18.	DOLLAR TREE
19.	FOOD MARKET AT LEA HILL
20.	FOSS' GROCERY
21.	FRED MEYER
22.	FRONT STREET RED APPLE MARKET
23.	FRY'S ELECTRONICS
24.	GARGUILES RED APPLE MARKET
25.	GOODWILL
26.	GROCERY OUTLET
27.	H MART
28.	HADLOCK BUILDING SUPPLY
29.	HAGGEN
30.	HARDWARE SALES
31.	HOME DEPOT
32.	INTERCONTINENTAL FOODS
33.	LOWE'S
34.	MAPLE VALLEY MARKET
35.	MCLENDON HARDWARE
36.	MOUNT VERNON RED APPLE MARKET
37.	OLYMPIA LIGHTING CENTER
38.	ONLY A DOLLAR PLUS
39.	PIONEER MARKET
40.	PIONEER ROBERTS MARKET
41.	PRAIRIE CENTER RED APPLE MARKET
42.	PUGET PANTRY
43.	RALPH'S RED APPLE MARKET
44.	SAM'S CLUB
45.	SCOTT LAKE GROCERY
46.	SEBO'S DO IT CENTER

47.	SEBO'S HARDWARE AND EQUIPMENT RENTAL
48.	THE MARKETS
49.	THE STAR STORE, INC.
50.	TRUE VALUE HARDWARE
51.	VALLEY HARVEST MARKET
52.	VASHON MARKET
53.	VASHON THRIFTWAY
54.	WALGREENS
55.	WALMART
56.	WALT'S LYNWOOD CENTER
57.	WESTSIDE BUILDING SUPPLY DO IT CENTER

95 OTHER (SPECIFY) ____________________
97 DON'T KNOW → **SKIP TO L5**

L4 In what city or town was this store located?

[DROP DOWN LIST] [ACCEPT ONLY ONE RESPONSE]

1 ANACORTES
2 AUBURN
BAINBRIDGE
3 ISLAND
4 BELLEVUE
5 BELLINGHAM
6 BLAINE
7 BONNEY LAKE
8 BOTHELL
9 BREMERTON
10 BURIEN
11 BURLINGTON
12 CARNATION
13 CLE ELUM
14 CLINTON
15 CONCRETE
16 COUPEVILLE
17 COVINGTON
18 DES MOINES
19 EDGEWOOD
20 ELLENSBURG
21 ENUMCLAW

22 EVERSON
23 FEDERAL WAY
24 FERNDALE
25 FREELAND
26 GRAHAM
27 ISSAQUAH
28 KENMORE
29 KENT
30 KINGSTON
31 KIRKLAND
32 LA CONNER
33 LACEY
34 LANGLEY
35 LYNDEN
36 MAPLE VALLEY
37 MERCER ISLAND
38 MOUNT VERNON
39 NEWCASTLE
40 NORTH BEND
41 OAK HARBOR
42 OLYMPIA
43 POINT ROBERTS
44 PORT HADLOCK
45 PORT LUDLOW
46 PORT ORCHARD
47 PORT TOWNSEND
48 POULSBO
49 PUYALLUP
50 REDMOND
51 RENTON
52 ROSLYN
53 SAMMAMISH
54 SEDRO WOOLLEY
55 SILVERDALE
56 SUMNER
57 TENINO
58 TUKWILA
59 TUMWATER
60 VASHON
61 WOODINVILLE

62 YELM

95 OTHER (SPECIFY) _______________
97 DON'T KNOW → **GOTO L5**

L5 How many of the LED bulbs that you purchased in 2015 are currently installed in or around your home?

[Free-form entry] → GO TO L6

L6 What type of bulb did *the majority* of these LED bulbs replace? Was it . . .

1 CFLs,
2 Regular/incandescent bulbs,
3 Halogen bulbs,
4 A mix of CFL and other bulbs, or
5 Did not replace other bulbs
95 OTHER, SPECIFY___
97 DON'T KNOW

[If bulb count reported in L5 is < L2, ask L7]

L7 What did you do with the bulbs you did NOT install? Did you….?

[SHOW 1-4. ACCEPT MULTIPLE ANSWERS]
1 store them in your home,
2 give them away,
3 return them to the store, or
4 I INSTALLED THEM ALL
95 do something else with them? (SPECIFY: ____________)
97 DON'T KNOW

C CFL PURCHASE(S)

Compact Fluorescent Light (CFL) Bulb Purchases. In this section please only think about CFL bulbs that you purchased for your home in 2015. Remember, *CFL bulbs come in many shapes and sizes. The most common type of CFL is made with a glass tube bent into a "twisty" shape and fits in a regular light bulb socket.*

CFL Bulbs

C1. Did you or anyone in your household purchase any **CFL bulbs** in 2015?

1 Yes → **GO TO C2**
2 No → **SKIP TO HER1**
97 DON'T KNOW → **SKIP TO HER1**

C2. Approximately, how many CFL **bulbs** did your household purchase in 2015? If you purchased any multi-packs, please enter the total number of **bulbs** you purchased. [For example, a pack with three bulbs would count as three. Your best estimate is fine.]

[Free-form entry] → GO TO C3

C3. The following question is about **the store** where you purchased the majority of CFL bulbs in 2015. At what store did you buy the **most** CFL bulbs?

[DROP DOWN LIST] [ACCEPT ONLY ONE RESPONSE]

58.	ACE HARDWARE
59.	ALBERT'S RED APPLE
60.	ALBERTSONS
61.	ARIRANG ORIENTAL MARKET
62.	ASIAN FOOD CENTERS
63.	BARTELL DRUGS
64.	BATTERIES PLUS
65.	BEAVER VALLEY GENERAL STORE
66.	BEST BUY
67.	BIG LOTS
68.	BRIDLE TRAILS RED APPLE MARKET

69.	CARNATION MARKET
70.	CARNICERIA LA CHIQUITA
71.	COSTCO
72.	DO IT BEST - ISLAND LUMBER & HARDWARE
73.	DO IT BEST HARDWARE CENTER
74.	DODSON'S IGA
75.	DOLLAR TREE
76.	FOOD MARKET AT LEA HILL
77.	FOSS' GROCERY
78.	FRED MEYER
79.	FRONT STREET RED APPLE MARKET
80.	FRY'S ELECTRONICS
81.	GARGUILES RED APPLE MARKET
82.	GOODWILL
83.	GROCERY OUTLET
84.	H MART
85.	HADLOCK BUILDING SUPPLY
86.	HAGGEN
87.	HARDWARE SALES
88.	HOME DEPOT
89.	INTERCONTINENTAL FOODS
90.	LOWE'S
91.	MAPLE VALLEY MARKET
92.	MCLENDON HARDWARE
93.	MOUNT VERNON RED APPLE MARKET
94.	OLYMPIA LIGHTING CENTER
95.	ONLY A DOLLAR PLUS
96.	PIONEER MARKET
97.	PIONEER ROBERTS MARKET
98.	PRAIRIE CENTER RED APPLE MARKET
99.	PUGET PANTRY
100.	RALPH'S RED APPLE MARKET
101.	SAM'S CLUB
102.	SCOTT LAKE GROCERY
103.	SEBO'S DO IT CENTER
104.	SEBO'S HARDWARE AND EQUIPMENT RENTAL
105.	THE MARKETS
106.	THE STAR STORE, INC.
107.	TRUE VALUE HARDWARE
108.	VALLEY HARVEST MARKET

109.	VASHON MARKET
110.	VASHON THRIFTWAY
111.	WALGREENS
112.	WALMART
113.	WALT'S LYNWOOD CENTER
114.	WESTSIDE BUILDING SUPPLY DO IT CENTER

95 OTHER (SPECIFY) ___________________
97 DON'T KNOW → **SKIP TO C5**

C4. In what city or town was this store located?

[DROP DOWN LIST] [ACCEPT ONLY ONE RESPONSE]

1 ANACORTES
2 AUBURN
BAINBRIDGE
3 ISLAND
4 BELLEVUE
5 BELLINGHAM
6 BLAINE
7 BONNEY LAKE
8 BOTHELL
9 BREMERTON
10 BURIEN
11 BURLINGTON
12 CARNATION
13 CLE ELUM
14 CLINTON
15 CONCRETE
16 COUPEVILLE
17 COVINGTON
18 DES MOINES
19 EDGEWOOD
20 ELLENSBURG
21 ENUMCLAW
22 EVERSON
23 FEDERAL WAY
24 FERNDALE
25 FREELAND
26 GRAHAM
27 ISSAQUAH

28 KENMORE
29 KENT
30 KINGSTON
31 KIRKLAND
32 LA CONNER
33 LACEY
34 LANGLEY
35 LYNDEN
36 MAPLE VALLEY
37 MERCER ISLAND
38 MOUNT VERNON
39 NEWCASTLE
40 NORTH BEND
41 OAK HARBOR
42 OLYMPIA
43 POINT ROBERTS
44 PORT HADLOCK
45 PORT LUDLOW
46 PORT ORCHARD
47 PORT TOWNSEND
48 POULSBO
49 PUYALLUP
50 REDMOND
51 RENTON
52 ROSLYN
53 SAMMAMISH
54 SEDRO WOOLLEY
55 SILVERDALE
56 SUMNER
57 TENINO
58 TUKWILA
59 TUMWATER
60 VASHON
61 WOODINVILLE
62 YELM

95 OTHER (SPECIFY) _______________
97 DON'T KNOW

C5. How many of the CFL bulbs that you purchased in 2015 are currently installed in or around your home?

[Free-form entry] → GO TO C6

C6. What type of bulb did *the majority* of these CFL bulbs replace? Was it . . .

1 Other CFL bulbs,
2 Regular/incandescent bulbs,
3 Halogen bulbs,
4 A mix of CFL and other bulbs, or
5 Did not replace other bulbs
6 OTHER, SPECIFY____
97 DON'T KNOW

[If bulb count reported in C5 is < C2, ask C7]
C7. What did you do with the bulbs you did NOT install? Did you….?

[SHOW 1-5. ACCEPT MULTIPLE ANSWERS]
1 Store them in your home,
2 Give them away,
3 Return them to the store, or
4 Installed them all
5 Do something else with them? (SPECIFY: ____________)
97 DON'T KNOW

HER HOME ENERGY REPORT

PUGET SOUND ENERGY Experience

HER1. How familiar are you with energy efficiency or conservation programs from Puget Sound Energy to help you with ways to use less energy and lower your bill?

1 Not at all familiar

2 Not very familiar

3 Somewhat familiar

4 Very familiar

HER2. Are you aware of Puget Sound Energy offering discounts on energy efficient lighting in retail stores?

1 Yes
2 No

HER3. Has your household received a Home Energy Report listing your home's energy use and comparing it with similar homes in the area?

1 Yes → **GO TO HER4**
2 No → **SKIP TO HER6**

97 DON'T KNOW ➔ **SKIP TO HER6**

[IF HER3 = 1] HER4. Do you remember seeing any of the following advertisements or messages in your Home Energy Report? [Check all that apply]

a. Get a warmer home and a hot deal ready – Home heating (Real, attached)

b. Upgrade your fridge or clothes washer for free – Energy Star appliances (Real, attached)

c. Old fridges can help feed families – Refrigerator Recycling (Real, attached)

d. Be prepared. Stay connected – Outage app (Real, attached)

HER5. Taking into consideration all aspects, please rate Home Energy Reports overall.

1=Unacceptable
2
3
4
5=Average
6
7
8
9
10=Outstanding

W WRAP UP

W0 Is there anything that you want to pass on to PUGET SOUND ENERGY?

[Free-form entry]

W1. Thank you very much for your time and opinions.

If you would like more information about PUGET SOUND ENERGY programs and rebates available in your area click on the "more information" button below. [pse.com/rebates]

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter and greener.

Evaluation Report Response

Program: Home Energy Reports

Program Manager: Zach Bates

Study Report Name: PSE Home Energy Reports Program - 2016 Impact Evaluation – Final Report

Report Date: November 2017

Evaluation Analyst: Jim Perich-Anderson

Date Final Report provided to Program Manager: 11/28/2017

Date of Program Manager Response: 12/9/2017

Overview: Puget Sound Energy (PSE) implemented the Home Energy Reports (HER) program in 2008. The HER program delivers customized, periodic reports on energy consumption to participating households and compares the households' energy consumption to that of similar neighboring homes. In addition, the reports provide personalized tips on how to save energy based on the energy usage and house profile. The HER program was designed to motivate households to reduce energy consumption through behavioral changes and participation in other PSE energy efficiency programs.

PSE structured the program as a randomized controlled trial (RCT). The RCT experimental design randomly assigns a population of interest to control and treatment groups. Due to this random assignment, the only differentiating factor between the two groups is the receipt of the Home Energy Reports. Thus, the approach produces an unbiased estimated of the change in consumption with a high level of statistical precision due to the treatment. Program energy savings are established by an independent evaluation, based on differences in energy use between these two groups.

HER participant groups have changed over time, either by attrition or by design. This evaluation report identifies gas and electric savings overall and by the following participant groups:

- The initial treatment group (2008): nearly 40,000 dual fuel, single family homes received a Home Energy Report; the control group: 44,000 dual fuel, single family homes did not.
- The suspended group (2010): approximately 10,000 treatment group households stopped receiving the HER, allowing PSE to test the persistence of report-based savings after the cessation of reports.
- The expansion groups (2014): the program added approximately 175,000 households. This was a pilot effort to determine whether adding 1) households with high usage

relative to the size of their home (high relative user), 2) electric-only households, and/or 3) non-urban households made a difference in per-participant energy savings and/or customer satisfaction.

- The refill group (2015): PSE added approximately 25,000 treatment households and 10,500 control households to replace households lost due to customer attrition since the start of the program.

Evaluation goal and objectives

The main goal of the impact evaluation is to estimate HER program savings for the year 2016. Specifically, the objectives are:

5. Calculate Measured Savings: measure the reduction in electric and natural gas consumption between the various control groups and their matched HER treatment groups.
6. Calculate Joint Savings: quantify savings from HER participants' increased participation in other PSE energy efficiency programs:
    - An increase in the number of participants and/or extent of participation in PSE rebate programs due to the HER program
    - Any HER-related increase in the number of purchased CFL or LED bulbs supported by PSE and BPA upstream lighting programs.
7. Calculate Claimed Savings: provide a final estimate of 2016 HER savings for all legacy and expansion programs, adjusted for double counted savings resulting from participation in PSE rebate and upstream lighting programs in previous HER years.
8. Expand Study to Unmatched Group: measure electric and natural gas measured, joint, and claimed savings for an additional treatment group that had been previously excluded from savings estimates due to lack of a control group.

Key findings

In this evaluation, key findings include:

6. **All groups who received HERs in 2016 achieved claimed savings that were significantly different from their representative control groups.** The legacy current group achieved the largest per-household claimed savings as a percent of consumption (3.2% out of 9,782 kWh and 1.7% out of 716 therms), while expansion groups, still within their ramp-up period, achieved significant claimed savings for all groups (between 1.3% and 2.4% electric and 0.6% and 1.7% gas). Rebated and/or upstream joint savings ranged from 6.3 to 39.4 kWh for electricity and 0.3 to 1.7 therms for gas. These savings were significant except for the expansion high relative user and refill groups for electricity, and the expansion non-urban group for gas.

7. **HER-related savings persist after customers stop receiving the report, though savings decline over time. In this evaluation, electric savings among customers**

who stopped receiving the report in 2011 were no longer significant. Evaluation findings suggest that the measure persistence of the electric HER report is around five years. However, the legacy – suspended gas savings were two-thirds of the legacy current treatment group's gas savings, and remained statistically significant, revealing a stronger persistence of gas savings.

8. **The recently added expansion group has lower savings overall, though the savings are increasing over time.** Per household savings are between 1.3% (Electric only) and 2.4% (High relative user), while the legacy current group, after eight years continues to show 3.2% savings.

   The expansion groups appear to match the trends of the legacy current group where savings increase annually for the first four years of the HER program. If these groups continue to mirror this program ramp-up trend, we will see additional years of growth in savings among the expansion groups.

9. **While 2016 was its first full program year, the refill group produced the highest measured savings among all expansion groups.** The evaluation found that the refill group had the second-highest baseline electric consumption (the electric-only group had the highest baseline electric consumption), and the highest baseline gas consumption across all participant groups.

10. **Over time, treatment households achieve deeper electric savings from participating in additional PSE programs than control households**. For the first time in the history of PSE, HER evaluations legacy current joint electric savings are statistically significant. The non-urban group had the highest electric program participation rate (3.6%), and the legacy current group had the highest gas program participation rate (3.6%). These results suggest that the HERs provide a consistently effective communication channel to engage customers and increase downstream program participation.

Recommendations

In the Conclusions section (p. 47) of the report, the evaluator offered recommendations for the next HER evaluation. The recommendations and PSE's responses are presented below:

1. Legacy – current group: Savings for the legacy program have decreased year over year due to customer move-outs. This kind of attrition is expected. As the new expansion groups get up to speed, these groups are expected to compensate for the dwindling total savings from the legacy group. The report states that *'From these conclusions, we recommend PSE continues the HER program for the legacy current group, recognizing that overall legacy current savings will likely continue to diminish over time due to attrition (p. 47).'*

PSE response: PSE has continued to offer the program to the legacy – current group in 2017, and based on the report findings and recommendations, PSE will also continue offering the program to the legacy – current group in 2018.

2. Legacy – suspended group: In the sixth year of evaluating the legacy suspended treatment group, this is the first evaluation in which the legacy suspended electric savings were not significantly different from the control group. The report states that *'From these conclusions, we recommend that future evaluations continue to track the decrease in suspended electric and gas savings. We also note that while the suspended group stopped receiving reports after two years, the energy savings ramp for this group continued through the fifth year of the program (p. 48).'*

   PSE response: PSE has continued to offer the program to the legacy – suspended group in 2017, and based on the report findings and recommendations, PSE will also continue offering the program to the legacy – suspended group in 2018.

3. Unmatched group: In previous study years, savings from a subgroup of treatment households had been excluded because a control (comparison) group had not been developed for that subgroup. To include the savings during the 2016 program period, the evaluator conducted a propensity matching analysis for these unmatched households and found evidence that the unmatched treatment households achieved savings equal to or higher than the legacy current treatment group. Based on this finding, the evaluators applied the average savings value (3.2%) from the legacy current treatment group. The report notes that *'However, due to the prevalence of unusual data points, and the potential to further refine the matching analysis by including additional constraint criteria, we advise further research to justify the higher-level of per-household savings among the unmatched group. In this analysis, we applied the legacy current treatment group's household savings, considering it the most conservative estimate of savings (p.49).'*

   PSE response: Based on the results of the initial analysis of the unmatched group, we support further research into energy consumption and energy saving behaviors of the unmatched group. For the upcoming evaluation of the 2017 HER program, PSE has provided additional energy consumption data for the unmatched group as requested by the evaluator, and will provide additional data as requested by the evaluator.

Date of Program Action: Home Energy Report program management has approved of the findings in the HER Evaluation and require no corrections or additional actions. The findings in the evaluation have been used for our ex-post savings claim for 2016

Program(s):

- Residential Single Family Dealer Channel
    - Water Heat
    - Space Heat
    - Weatherization

Program Year(s):

- 2013-2015 (Impact evaluation); 2015-2016 (Process evaluation)

Contents:

- Evaluation Report
- PSE Evaluation Report Response

This document contains Puget Sound Energy's (PSE) Residential Single Family Dealer Channel Evaluation Report and Evaluation Report Response (ERR). In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

PSE program managers and evaluation staff prepare an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Please note that this is an evaluation of the program as it operated during the 2013-2016 program years, and does not necessarily reflect the program as currently implemented, or measures currently deployed by the program.

This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx**

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[1] (6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for 2016-2017 PSE Electric Conservation.

[2] PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised August 6, 2015.

[3] Ibid.

PUGET SOUND ENERGY

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Evaluation Report Response

Program:	Residential Single Family Dealer Channel
Program Manager(s):	Sean Gorton, Chris Boroughs
Study Report Name:	Single-Family Dealer Channel Programs Final Evaluation Report
Primary Author(s):	Cadmus
Report Date:	October 2017
Evaluation Analyst(s):	Michael Noreika
Date of ERR:	December 2017

Evaluation Overview, Key Findings, Recommendations and Program Responses:

I. Abstract

Through its Single-Family Dealer Channel (DC) Programs, Puget Sound Energy (PSE) seeks to reduce energy consumption by providing rebates to single-family households for installing energy efficiency and conservation measures. In 2016, PSE contracted with Cadmus to evaluate impacts and program processes for several residential DC program initiatives: Weatherization, Space Heat, and Water Heat. This research included performing billing analysis to evaluate energy savings impacts, assessing non-energy benefits (NEBs), reviewing savings calculations used in program planning, conducting participant phone surveys, interviewing stakeholders, and developing a framework to begin considering key performance indicators (KPIs) specific to these DC programs. Specifically, the impact evaluation focused on the 2013–2015 program period, while the process evaluation focused on the most recent periods of program activity (i.e., 2015 and 2016).

PSE improved household energy efficiency by working directly with contractors and resellers to provide program training and assist customers with accessing rebates. The DC programs are achieving their overall objective of providing energy savings to PSE customers. PSE programs met their savings targets, but in some cases, did not achieve their reported savings.

Customers reported a high level of program satisfaction; 96% of participants reported being very satisfied (73%) or somewhat satisfied (23%) with the DC programs. Respondents who received a water heater through

the program reported the highest levels of satisfaction, with 88% saying they were very satisfied with the program. All active contractors interviewed for the evaluation were very satisfied or somewhat satisfied with the programs; however, they did indicate some dissatisfaction with various administrative aspects of Contractor Alliance Network (CAN) membership and the referral process.

A. Evaluation Context

A variety of discrete PSE programs comprise the DC delivery channel under the E/G 214 Tariff Schedule. Evaluations over the last few years have addressed several DC subprograms (i.e., Mobile Home Duct Sealing, HEA, and Fuel Conversion); however, while Cadmus performed a 2012 billing analysis on a weatherization measure bundle to assess Regional Technical Forum (RTF) savings estimates, this evaluation provides the first comprehensive evaluation of the Space Heat, Water Heat, and Weatherization subprograms. This evaluation includes a billing analysis to comprehensively assess the programs' impacts on energy savings, a process evaluation, and a suggested framework for tracking key performance indicators (KPI).

II. Conclusions, Recommendations, and PSE Responses

A. Overall Performance

Conclusion: The DC programs met their overall 2015 energy savings goals, but fell short of gas reported savings. A billing analysis found that the three DC programs evaluated for this study achieved savings that met or surpassed PSE's 2015 savings targets, with the exception of Space Heat gas savings. However, evaluated savings fell short of reported 2015 savings for two programs, with a 91% realization rate for Weatherization electric savings and an 82% realization rate for Space Heat gas savings. Table 33 provides the overall realization rates and evaluated savings as a percentage of annual savings targets, by program and fuel.

Table 1. Overall 2015 Program Performance

Measure/Program	Electric		Gas	
	Realization Rate	% of Target	Realization Rate	% of Target
Space Heat	106%	108%	82%	75%
Water Heat	119%	171%		
Weatherization	91%	122%	100%	127%
Overall	**103%**	**115%**	**92%**	**99%**

Three-year combined electric savings from the three DC programs evaluated were 94% of target (79% realization rate) and three-year gas savings were 66% of target (75% realization rate), with the electric shortfall driven primarily by weatherization. Table 34 provides a similar summary of realization rates and target achievement, by program and fuel for the 2013-2015 period.

Table 2. Overall 2013-2015 Program Performance

Measure/Program	Electric		Gas	
	Realization Rate	% of Target	Realization Rate	% of Target
Space Heat	93%	96%	78%	69%
Water Heat	133%	151%		
Weatherization	54%	81%	72%	63%
Overall	**79%**	**94%**	**75%**	**66%**

Conclusion: DC program participants experience a high level of program satisfaction. Ninety-six percent of participants reported being very satisfied (73%) or somewhat satisfied (23%) with the DC programs. Respondents who received a water heater through the program reported the highest levels of satisfaction, with 88% saying they were very satisfied with the program. Although seventy-one percent of customers had no suggestions to improve the program, 7% suggested improving the program by offering a larger rebate and 7% suggested better communication.

Conclusion: Rebates are a primary motivator for program participation. Seventy percent of program participants identified rebates or discounts when asked what motivated them to participate in the PSE DC programs. Survey respondents also identified saving money on their utility bill (54%) and improved comfort (50%), and to a lesser degree environmental benefits (32%), as motivating factors.

Conclusion: Contractors, who are vital to the successful delivery of the DC programs, have experienced delivery challenges. PSE has taken some steps to resolve these challenges, but additional attention may be warranted. PSE program managers cited delivery challenges including contractor turnover, geographic delivery gaps for heat pump water heaters, and administrative burden associated with CAN participation. All active contractors interviewed for the evaluation were very satisfied or somewhat satisfied with the programs; however, they did indicate some dissatisfaction with various administrative aspects of CAN membership and the referral process. In particular, 28% reported being somewhat dissatisfied with the time it took to receive a rebate check, and 18% were somewhat dissatisfied with the referral system.

PSE is working to find and recruit additional HPWH contractors in regions where a shortage exists and to improve contractor satisfaction by engaging with contractors more frequently through quarterly contractor roundtable discussions and providing regular updates about program changes through e-mail. To address the administrative burden associated with having to use two different database portals—one to enter customer rebate information and one to check on training and other CAN requirements—PSE is upgrading to a new system where a single portal will serve both purposes. The new system will allow contractors to submit rebates electronically, do their own forecasting, and keep track of the requirements they need to maintain their status in the CAN.

B. Planning, Savings Estimation, and Evaluability

Conclusion: A substantial proportion of program participants increased electric load as a result of the DC program. Among the program participants in the billing analysis sample, 63% of those who installed heat pumps, 39% of those who installed ductless heat pumps (DHPs), and 30% of those who installed HPWHs increased household electric load. For those households that are also PSE gas customers, gas consumption decreased by approximately 393 therms for customers who installed heat pumps and 224 therms for customers who installed DHPs.

Conclusion: There may be an opportunity for PSE to include an early retirement option in its program design. Billing analysis results indicate that a substantial proportion of DC participants replaced existing equipment that was less efficient than the assumed baseline corresponding to the reported savings approach. Although some participants' existing equipment may have been inoperable at the time of replacement (with savings appropriately determined using a market baseline), the participant survey indicated that a substantial proportion of participants replace existing equipment prior to burnout. Thus, an early retirement scenario could generate greater savings than would be estimated using standard or market baselines. Additional data are required to understand this potential and the portion of customers who are eligible for earlier retirement savings compared to time of replacement.

Conclusion: PSE improved the accuracy of reported savings estimates between 2013 and 2015. With the exception of Water Heat, all DC electric saving programs showed 2015 improvements in realization rates. A comparison of three-year (2013–2015) electric realization rates to 2015 electric realization rates show the following changes by program:

- Space Heat – from 93% to 106%
- Weatherization – from 54% to 91%
- Water Heat – from 133% to 119%

For the Weatherization program, this improvement is driven by both decreasing average reported savings for windows measures in 2015 (suggesting more accurate planning estimates) and by increasing average evaluated savings for weatherization measures (suggesting changes in delivery or measure performance).

The Weatherization program gas savings realization rate showed a similar pattern: 90% for the three year period versus 120% in 2015. This improvement was primarily driven by decreasing average reported savings for windows measures in 2015 (suggesting more accurate planning estimates). Other weatherization measures show both increases in evaluated savings and decreases in reported savings (each contributing to an increase in realization rate).

Conclusion: PSE's savings estimation methods and input data are reasonably accurate; however, several measures have outdated planning assumptions, and opportunities exist to improve the accuracy of savings estimates. A detailed savings review revealed that unit energy savings (UES) values for shell, duct, heat pump water heater, and lockout controls measures relied on outdated RTF sources, and the fireplace measure contained incomplete documentation of savings sources. In addition, Cadmus identified an opportunity to improve the accuracy of the savings calculation approach for DHP, ground source heat pump (GSHP), furnace replacement, and fireplace measures.

> **Recommendation:** Update UES values for several measures and revisit RTF-deemed savings estimates annually for revisions. Given RTF frequently updates energy-saving source documentation, PSE should revisit RTF-deemed savings estimates annually for any changes that may be relevant to delivery or design adjustments. Specifically, PSE should revise current UES savings estimates for: all shell measures (e.g., insulation, air sealing, and windows), duct sealing and insulation, HPWHs, GSHPs, and heat pump sizing and lockout control measures.

> **PSE Response:** PSE has updated UES values for the 2018-19 program period. The program also reviews RTF updates on an ongoing basis. PSE is not obligated to adopt any RTF updates that occur after September 1 of each calendar year. Thus, there may be time periods when PSE is not using the most current RTF UES for certain measures.

> **Recommendation:** Provide complete documentation for fireplace savings calculations and consider adopting Cadmus' proposed calculation approach. The review of gas fireplaces measures did not support PSE's documented gas savings. Cadmus suggests PSE consider the calculation presented (showing documented assumptions, resulting in savings of 17.9 therms per unit).

> **PSE Response:** PSE will review its current calculation methodology and input assumptions. PSE will consider revising to use the methodology presented in the evaluation report.

Conclusion: The DC programs resulted in quantifiable non-energy benefits (NEBs). Cadmus confirmed monetized values for four distinct NEBs associated with program performance: economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits. Table 35 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

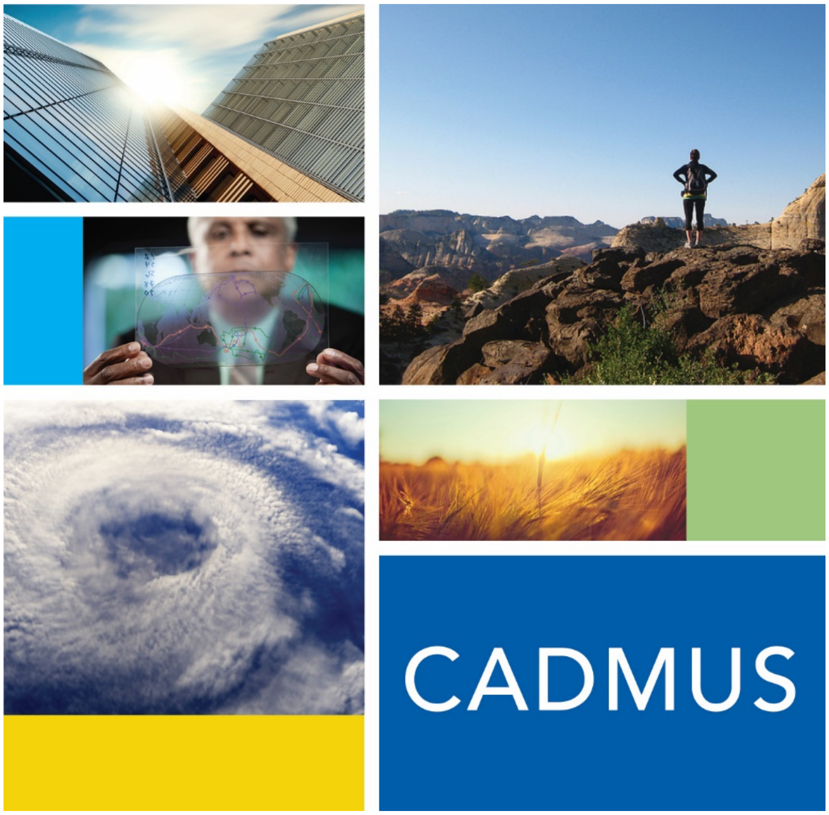
Table 3. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted
	Electric	Gas	
Participant Ancillary Benefits	$227		TRC, PCT
Economic Impacts	$786		TRC
Environmental – Avoided Compliance Costs	$28.66	$17.20	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$35.56	$21.34	PTRC

Recommendation: Include NEBs in program cost-effectiveness scenarios. A complete benefit and cost analysis considers not only direct financial costs and benefits experienced by an individual or firm, but also costs and benefits accruing to society as a whole (Boardman et al. 2006). Based on Cadmus' analyses and consistent with the 2016-2017 Biennial Conservation Plan, PSE should run cost-effectiveness scenarios for DC that include consideration of NEBs values assessed through this study.

PSE Response: PSE will consider including NEBs in the cost-effectiveness calculations.

Conclusion: Customer contact information for the DC programs is not consistently captured. Cadmus found that program tracking data contained incomplete contact information for program participants; this presented challenges in drawing an e-mail survey sample from the participant population and potentially introduced bias.



Single-Family
Dealer Channel Programs
Final Evaluation Report

October 31, 2017

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Table of Contents

Acronyms and Definitions

Acronym	Definition
ASHP	Air source heat pump
CAN	Contractor Alliance Network
CAR	Washington Clean Air Rule
CDD	Cooling degree day
CFM	Cubic feet per minute
CO_2e	Carbon dioxide equivalent
DC	Single-Family Dealer Channel
DHP	Ductless heat pump
EPA	Environmental Protection Agency
ERUs	Emission reduction units
GHG	Greenhouse gas
GSHP	Ground source heat pump
GTD	Generation, transmission, and distribution
HDD	Heating degree day
HPWH	Heat pump water heater
IO	Input-output
IRP	Integrated resource plan
IMPLAN	Impact Analysis for Planning
LBNL	Lawrence Berkley National Labs
KPI	Key performance indicator
NEBs	Non-energy benefits
NOAA	National Oceanic and Atmospheric Administration
PCT	Participant Cost Test
PRENAC	Pre-installation weather-normalized annual consumption
PRISM	Princeton Scorekeeping Method
PTRC	Total Resource Cost Test + Conservation Adder (essentially Societal Cost Test)
RDP	Regional Domestic Product
RTF	Regional Technical Forum
RPC	Regional Purchase Coefficient
TRC	Total Resource Cost Test
TRM	Technical Reference Manual
UCT	Utility Cost Test
UES	Unit Energy Savings
UMP	Uniform Methods Project
WTP	Willingness to pay

Abstract

Through its Single-Family Dealer Channel (DC) Programs, Puget Sound Energy (PSE) seeks to reduce energy consumption by providing rebates to single-family households for installing energy efficiency and conservation measures. In 2016, PSE contracted with Cadmus to evaluate impacts and program processes for several residential DC program initiatives: Weatherization, Space Heat, and Water Heat. This research included performing billing analysis to evaluate energy savings impacts, assessing non-energy benefits (NEBs), reviewing savings calculations used in program planning, conducting participant phone surveys, interviewing stakeholders, and developing a framework to begin considering key performance indicators (KPIs) specific to these DC programs. Specifically, the impact evaluation focused on the 2013–2015 program period, while the process evaluation focused on the most recent periods of program activity (i.e., 2015 and 2016).

PSE improved household energy efficiency by working directly with contractors and resellers to provide program training and assist customers with accessing rebates. The DC programs are achieving their overall objective of providing energy savings to PSE customers. PSE programs met their savings targets, but in some cases, did not achieve their reported savings.

Customers reported a high level of program satisfaction; 96% of participants reported being *very satisfied (73%)* or *somewhat satisfied (23%)* with the DC programs. Respondents who received a water heater through the program reported the highest levels of satisfaction, with 88% saying they were *very satisfied* with the program. All active contractors interviewed for the evaluation were *very satisfied* or *somewhat satisfied* with the programs; however, they did indicate some dissatisfaction with various administrative aspects of Contractor Alliance Network (CAN) membership and the referral process.

Executive Summary

As part of the Single-Family Existing compliance program, Puget Sound Energy's (PSE) Single-Family Dealer Channel (DC) programs are designed to reduce energy consumption by providing rebates to single-family households for installing energy efficiency and conservation measures, and by directly engaging and training contractors in delivery of program measures and assisting customers to access rebates. In 2016, PSE contracted with Cadmus to conduct evaluations of impacts and processes related to several programs within the Residential Single-Family Dealer Channel: Space Heat, Water Heat, and Weatherization (excluding Mobile Home Duct Sealing, Home Energy Assessment (HEA), Fuel Conversion, and Home Energy Reports). Specifically, the impact evaluation focused on the 2013–2015 program period, while the process evaluation focused on the most recent periods of program activity (i.e., 2015 and 2016).

Evaluation Context

A variety of discrete PSE programs comprise the DC delivery channel under the E/G 214 Tariff Schedule. Evaluations over the last few years have addressed several DC subprograms (i.e., Mobile Home Duct Sealing, HEA, and Fuel Conversion); however, while Cadmus performed a 2012 billing analysis on a weatherization measure bundle to assess Regional Technical Forum (RTF) savings estimates, this evaluation provides the first comprehensive evaluation of the Space Heat, Water Heat, and Weatherization subprograms. This evaluation includes a billing analysis to comprehensively assess the programs' impacts on energy savings, a process evaluation, and a suggested framework for tracking key performance indicators (KPI).

Conclusions, Recommendations, and Considerations

Overall Performance

Conclusion: The DC programs met their overall 2015 energy savings goals, but fell short of gas reported savings. A billing analysis found that the three DC programs evaluated for this study achieved savings that met or surpassed PSE's 2015 savings targets, with the exception of Space Heat gas savings. However, evaluated savings fell short of reported 2015 savings for two programs, with a 91% realization rate for Weatherization electric savings and an 82% realization rate for Space Heat gas savings.

Three-year combined electric savings from the three DC programs evaluated were 94% of target (79% realization rate) and three-year gas savings were 66% of target (75% realization rate), with the electric shortfall driven primarily by weatherization.

Conclusion: DC program participants experience a high level of program satisfaction. Ninety-six percent of participants reported being *very satisfied (73%)* or *somewhat satisfied (23%)* with the DC programs. Respondents who received a water heater through the program reported the highest levels of satisfaction, with 88% saying they were *very satisfied* with the program. Although seventy-one percent of customers had no suggestions to improve the program, 7% suggested improving the program by offering a larger rebate and 7% suggested better communication.

Conclusion: Rebates are a primary motivator for program participation. Seventy percent of program participants identified rebates or discounts when asked what motivated them to participate in the PSE DC programs. Survey respondents also identified saving money on their utility bill (54%) and improved comfort (50%), and to a lesser degree environmental benefits (32%), as motivating factors.

Suggestion for consideration: Given PSE plans to discontinue downstream space and water heating programs, closely monitor program participation and customer satisfaction for any impacts.

Conclusion: Contractors, who are vital to the successful delivery of the DC programs, have experienced delivery challenges. PSE has taken some steps to resolve these challenges, but additional attention may be warranted. PSE program managers cited delivery challenges including contractor turnover, geographic delivery gaps for heat pump water heaters, and administrative burden associated with Contractor Alliance Network (CAN) participation. All active contractors interviewed for the evaluation were *very satisfied* or *somewhat satisfied* with the programs; however, they did indicate some dissatisfaction with various administrative aspects of CAN membership and the referral process. In particular, 28% reported being *somewhat dissatisfied* with the time it took to receive a rebate check, and 18% were *somewhat dissatisfied* with the referral system.

PSE is working to find and recruit additional heat pump water heater (HPWH) contractors in regions where a shortage exists and to improve contractor satisfaction by engaging with contractors more frequently through quarterly contractor roundtable discussions and providing regular updates about program changes through e-mail. To address the administrative burden associated with having to use two different database portals—one to enter customer rebate information and one to check on training and other CAN requirements—PSE is upgrading to a new system where a single portal will serve both purposes. The new system will allow contractors to submit rebates electronically, do their own forecasting, and keep track of the requirements they need to maintain their status in the CAN.

Suggestion for consideration: Conduct additional research with Tier 1 contractors to better understand perceived issues with the referral system.

Suggestion for consideration: Track contractor retention and turnover by measure category and region.

Planning, Savings Estimation, and Evaluability

Conclusion: A substantial proportion of program participants increased electric load as a result of the DC program. Among the program participants in the billing analysis sample, 63% of those who installed heat pumps, 39% of those who installed ductless heat pumps (DHPs), and 30% of those who installed HPWHs increased household electric load. For those households that are also PSE gas customers, gas consumption decreased by approximately 393 therms for customers who installed heat pumps and 224 therms for customers who installed DHPs.

Conclusion: There may be an opportunity for PSE to include an early retirement option in its program design. Billing analysis results indicate that a substantial proportion of DC participants replaced existing equipment that was less efficient than the assumed baseline corresponding to the reported savings approach. Although some participants' existing equipment may have been inoperable at the time of replacement (with savings appropriately determined using a market baseline), the participant survey indicated that a substantial proportion of participants replace existing equipment prior to burnout. Thus, an early retirement scenario could generate greater savings than would be estimated using standard or market baselines. Additional data are required to understand this potential and the portion of customers who are eligible for earlier retirement savings compared to time of replacement.

> ***Suggestion for consideration: Collect additional program information around equipment replacement to determine potential for early retirement measure replacement delivery option and opportunity for increased savings.***

Conclusion: PSE improved the accuracy of reported savings estimates between 2013 and 2015. With the exception of Water Heat, all DC electric saving programs showed 2015 improvements in realization rates. A comparison of three-year (2013–2015) electric realization rates to 2015 electric realization rates show the following changes by program:

- ***Space Heat*** – from 93% to 106%
- ***Weatherization*** – from 54% to 91%
- ***Water Heat*** – from 133% to 119%

For the Weatherization program, this improvement is driven by both decreasing average reported savings for windows measures in 2015 (suggesting more accurate planning estimates) and by increasing average evaluated savings for weatherization measures (suggesting changes in delivery or measure performance).

The Weatherization program gas savings realization rate showed a similar pattern: 90% for the three-year period versus 120% in 2015. This improvement was primarily driven by decreasing average reported savings for windows measures in 2015 (suggesting more accurate planning estimates). Other weatherization measures show both increases in evaluated savings and decreases in reported savings (each contributing to an increase in realization rate).

Conclusion: PSE's savings estimation methods and input data are reasonably accurate; however, several measures have outdated planning assumptions, and opportunities exist to improve the accuracy of savings estimates. A detailed savings review revealed that unit energy savings (UES) values for shell, duct, heat pump water heater, and lockout controls measures relied on outdated RTF sources, and the fireplace measure contained incomplete documentation of savings sources. In addition, Cadmus identified an opportunity to improve the accuracy of the savings calculation approach for DHP, ground source heat pump (GSHP), furnace replacement, and fireplace measures.

Recommendation: Update UES values for several measures and revisit RTF-deemed savings estimates annually for revisions.

Recommendation: Provide complete documentation for fireplace savings calculations and consider adopting Cadmus' proposed calculation approach.

Suggestion for consideration: Revise the approach, input assumptions, or available source documentation used in several RTF or PSE-deemed savings estimates.

Suggestion for consideration: Track additional equipment information for DHP, GSHP, heat pumps, and heating system replacement measures.

Conclusion: The DC programs resulted in quantifiable non-energy benefits (NEBs). Cadmus confirmed monetized values for four distinct NEBs associated with program performance: economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits. Table 1 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

Recommendation: Include NEBs in program cost-effectiveness scenarios.

Table 1. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted
	Electric	Gas	
Participant Ancillary Benefits	$227		TRC, PCT
Economic Impacts	$786		TRC
Environmental – Avoided Compliance Costs	$28.66	$17.20	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$35.56	$21.34	PTRC

Conclusion: Customer contact information for the DC programs is not consistently captured. Cadmus found that program tracking data contained incomplete contact information for program participants; this presented challenges in drawing an e-mail survey sample from the participant population and potentially introduced bias.

Suggestion for consideration: To gather sufficient information from an evaluability perspective, collect complete contact information for all program participants (including names and e-mails).

Introduction

Program Description

Through the DC programs, Puget Sound Energy (PSE) seeks to reduce energy consumption by providing rebates to single family households for installing energy efficiency and conservation measures. PSE's DC programs are housed under its Residential Single Family Existing Compliance Program, which includes the three DC programs that are the focus of this evaluation (i.e., Weatherization, Space Heat, and Water Heat), within Tariff Schedule E/G 214.

Program Delivery

PSE's DC Programs provide rebates for the following measure categories:

- ***Weatherization*** – air sealing, insulation, windows, and duct insulation and sealing
- ***Space Heat –*** heat pumps, ductless heat pumps, fireplaces, and heating system replacements
- ***Hot Water –*** water heaters

The programs deliver equipment to customers primarily through contractors although customers can directly submit rebate applications to PSE for most of the equipment types. The DC programs consist primarily of resellers and contractors who sell, install and maintain heating and cooling equipment, water heating systems, windows, insulation, and other shell retrofits. Each of the three DC Programs are managed by a different PSE program manager who provides planning, budgeting, forecasting and contractor management support.

PSE's Contractor Alliance Network (CAN) is a network of qualified contractors who receive additional support from PSE to participate and promote PSE's energy efficiency rebate programs. The CAN is based on a tiered structure. Members of Tier 2 receive access to select marketing materials, the ability to supply instant discounts to customers, and additional program training to implement PSE's rebate programs successfully. Along with the Tier 2 benefits, members of Tier 1 also receive customer referrals if they are interested. PSE includes a referral fee for all referrals they receive.

Evaluation Overview

Cadmus conducted various research activities to meet PSE's evaluation objectives related to program impacts, delivery, and customer experience. Table 2 lists each task and provides a brief description. An overview of the methodology for each task is provided in Appendix A. Methodology.

Table 2. Evaluation Tasks

Evaluation Focus	Research Task	Description
Impact: What did the programs achieve?	Billing Analysis	Assess gas and electric energy impacts through regression analysis of consumption changes before and after measure installation
	Savings Review	Review algorithms and input assumptions associated with PSE's energy savings estimates used for program planning and reporting
	Non-Energy Benefits (NEBs): Economic Impacts	Estimate economic and employment impacts associated with the investment of program dollars
	NEBs: Environmental Impacts	Assess environmental impacts associated with reduced emissions from offsetting generation and avoided environmental compliance costs
	NEBs: Participant Impacts	Estimate the value of select participant benefits (e.g., comfort) using a valuation approach through participant phone surveys
Process: What opportunities exist to improve program delivery?	Stakeholder Interviews	Assess program delivery and design elements through in-depth interviews with program managers and contractors
	Participant Surveys	Assess customer experience through a telephone survey focused on awareness, satisfaction, challenges, and behavioral changes
	Process Flow Diagram	Characterize the program process by illustrating the sequence of key stages of activity, decision making, and contributing parties
	Key Performance Indicator Framework	Develop a data-driven framework specific to DC for tracking (and measuring) program performance improvements

Program Activity

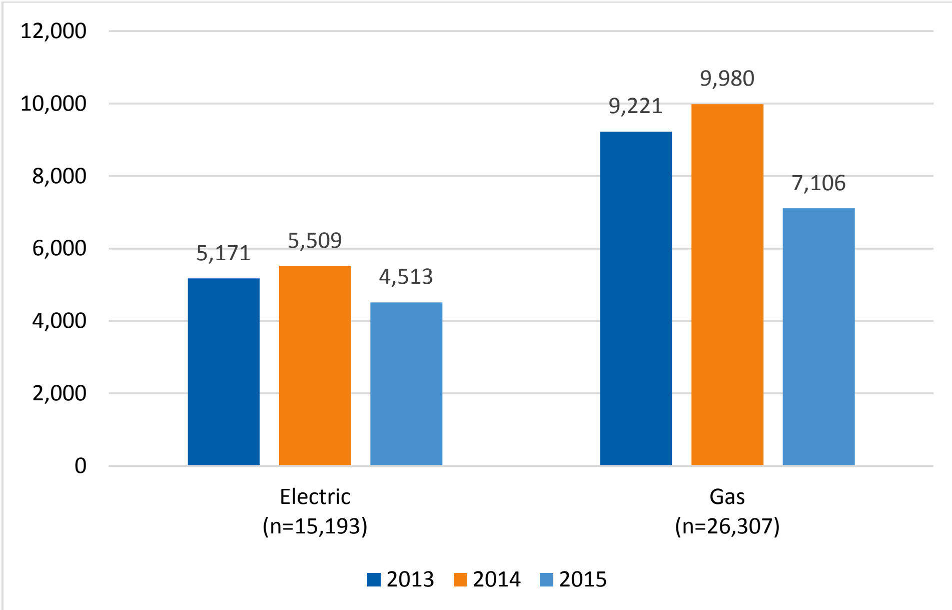
The figures below summarize DC Program activity, by measure category, from 2013 through 2015.[1]

Customers by Year

Figure 1 shows the total electric and gas savings projects during the 2013 through 2015 period.

[1] At the time Cadmus received program data, a full year of 2016 activity was unavailable.

Figure 1. DC Programs—Completed Projects by Year and Fuel Savings



Source: PSE DC program tracking data (2013-2015)

Reported Budgets and Savings by Year

Table 3 and Table 4 show allocated budgets, savings targets, and PSE-reported achievements for each DC program, by year and fuel.[2] As shown, reported savings and budget targets exceed 100% in most years.

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[2] Puget Sound Energy. *Energy Efficiency: 2015 Annual Report of Energy Conservation Accomplishments.* 2016. Available online: https://pse.com/aboutpse/Rates/Documents/ees_2015_annual_rpt_energy_conservation_accomplishments.pdf

Puget Sound Energy. *Energy Efficiency: 2014 Annual Report of Energy Conservation Accomplishments.*2015. Available online: https://pse.com/aboutpse/Rates/Documents/ees_00_ann_rpt_energy_conservation_accomplishments.pdf

Puget Sound Energy. *Energy Efficiency: 2013 Annual Report of Energy Conservation Accomplishments*. 2014

Table 3. Reported Savings and Costs, by Year and Program – Electric

DC Program	Year	Budget			Savings (in MWh)		
		Budget Allocation	$ Spent	% Budget Spent	Savings Target [A]	Reported Savings [B]	% Savings Target Achieved [A/B]
Weatherization	2013	$3,432,000	$3,466,305	101%	10,242	9,902	97%
	2014	$1,346,334	$1,636,404	122%	3,607	5,736	159%
	2015	$1,227,724	$1,683,131	137%	2,610	3,509	134%
Space Heat	2013	$3,004,000	$3,275,154	109%	6,138	8,085	132%
	2014	$4,109,360	$3,687,729	90%	10,132	8,811	87%
	2015	$4,061,640	$4,090,312	101%	7,842	8,009	102%
Water Heat	2013	$589,000	$500,414	85%	857	874	102%
	2014	$357,004	$411,640	115%	568	545	96%
	2015	$400,630	$503,757	126%	635	911	143%

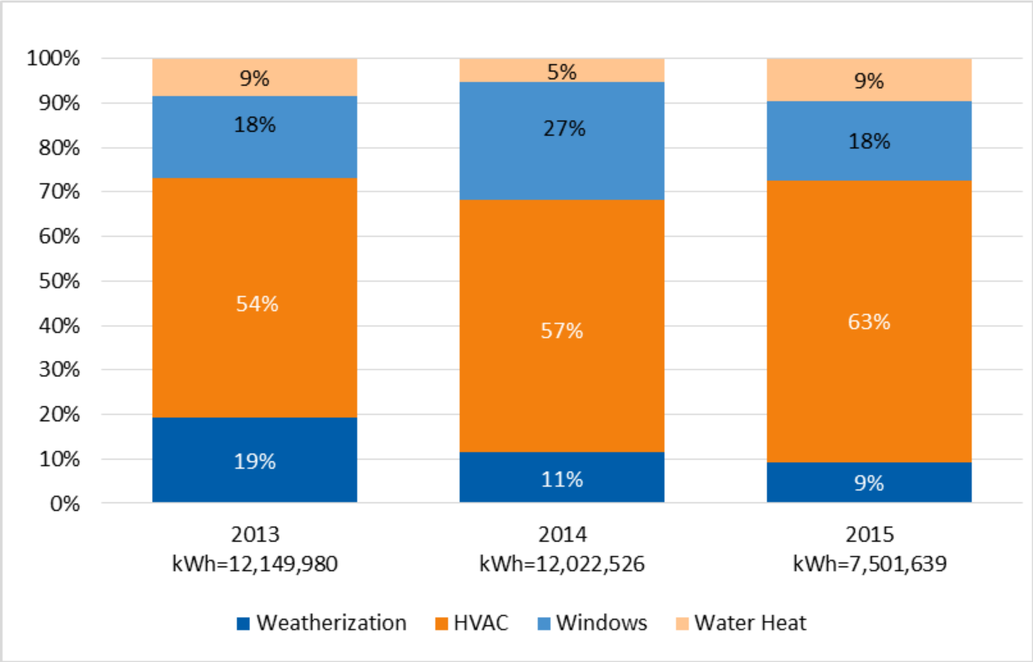
Table 4. Reported Savings and Costs, by Year and Program – Gas

DC Program	Year	Budget			Savings (in therms)		
		Budget Allocation	$ Spent	% Budget Spent	Savings Target [A]	Reported Savings [B]	% Savings Target Achieved [A/B]
Weatherization	2013	$2,922,000	$2,604,223	89%	553,238	422,735	76%
	2014	$3,178,169	$4,120,712	130%	763,940	560,960	73%
	2015	$3,171,545	$3,937,956	124%	432,015	551,364	128%
Space Heat	2013	$2,355,000	$1,612,308	68%	747,889	571,028	76%
	2014	$1,632,744	$1,548,363	95%	519,800	528,266	102%
	2015	$1,595,778	$1,364,348	85%	531,650	485,321	91%

Savings by Measure Type

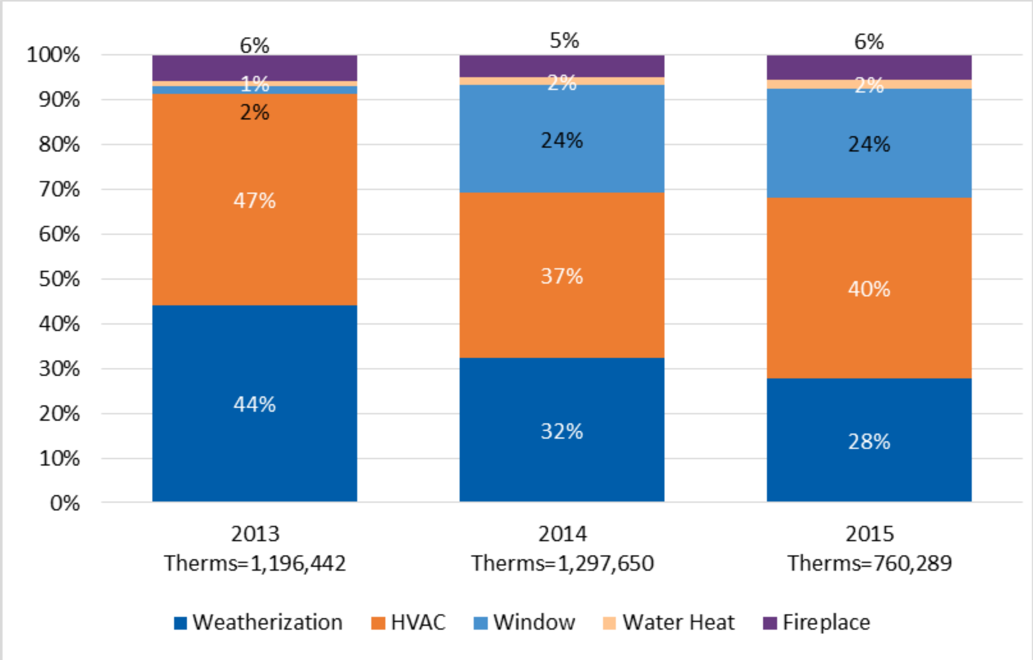
HVAC measures comprised the largest share of electric and gas savings for these DC programs across the three-year period, as shown in Figure 2 and Figure 3; this is primarily driven by DHP measures for electric and heating system replacement for gas. Windows and weatherization measures represent the next highest savings measures by fuel. Gas window savings represented approximately 24% of total savings in 2014 and 2015, but were negligible in 2013 (at 2%).

Figure 2. Distribution of Reported Savings by Measure Type – Electric



Source: PSE DC program tracking data (2013-2015)

Figure 3. Distribution of Reported Savings by Fuel and Measure Type - Gas



Source: PSE DC program tracking data (2013-2015)

Impact Evaluation Findings

Through the impact evaluation, Cadmus assessed energy and non-energy achievements, which included verifying energy impacts, assessing NEBs, and reviewing the inputs and calculation approach used in developing PSE's reported savings estimates.

Billing Analysis

Cadmus conducted a billing analysis to evaluate electric and natural gas savings for the DC programs, addressing both measure-category and measure-level results where possible. All evaluation findings are presented using adjusted gross savings values (excluding load increasing measures) from combined fixed-effects regression models, unless otherwise noted. See Appendix A. Methodology and Appendix C. Model Specification for additional model details.

The evaluation compared modeled savings to PSE's reported planning estimates using a common evaluation metric, the realization rate. Notably, billing analysis captures a variety of effects that influence energy consumption and are not reflected in engineering-based planning estimates. These factors include measure interactive effects, measure persistence, measurement error, behavioral changes (e.g., take back), household changes, and weather effects.

Cadmus estimated billing analysis savings that reflect existing household conditions prior to installation (i.e., using pre-period consumption data compared to a post-period). As noted in Appendix A. Methodology, Cadmus adjusted savings for several equipment measures (i.e., heat pumps, DHPs, and HPWHs) to reflect the market baselines that align with DC program design and delivery.

Annual Evaluated Savings Summary

Table 5 and Table 6 provide an overview of annualized evaluated and reported gas and electric savings, by DC program, for both the 2013-2015 evaluation period and 2015.[3] Realization rates are applied to PSE reported savings to estimate the annual evaluated electric and gas savings totals. Annual evaluated savings are also compared to reported PSE savings targets. With the exception of gas savings for Space Heat, all DHCD programs achieved their 2015 electric and gas savings goals.

Table 5. Annual Savings Summary by DC Program and Evaluation Period – Electric

Program	Year	Electric Savings	Performance Against Target

[3] Weatherization program realization rates reflect an average using the model estimates for windows and weatherization measure categories, as presented below. Weatherization program annual reported savings (from Energy Conservation Accomplishments reports) were disaggregated into category savings (for windows and weatherization measures) using the distribution of reported savings from the tracking system. Evaluated savings realizations were then applied by measure category and then aggregated to report on Weatherization overall.

		Evaluated Savings (MWh) [A]	Reported Savings (MWh)	Realization Rate	Reported Savings Target (MWh) [B]	% Evaluated Savings Achieved [A/B]
Space Heat	2015	8,474	8,009	106%	7,842	108%
	Overall	**23,157**	**24,905**	**93%**	**24,112**	**96%**
Weatherization	2015	3,184	3,509	91%	2,610	122%
	Overall	**10,388**	**19,147**	**54%**	**12,852**	**81%**
Water Heat	2015	1,083	911	119%	635	171%
	Overall	**3,105**	**2,330**	**133%**	**2,060**	**151%**

Table 6. Annual Savings Summary by DC Program and Evaluation Period - Gas

Program	Year	Gas Savings			Performance Against Target	
		Evaluated Savings (Therms) [A]	Reported Savings (Therms)	Realization Rate	Reported Savings Target (Therms) [B]	% Evaluated Savings Achieved [A/B]
Space Heat	2015	399,737	485,321	82%	531,650	75%
	Overall	**1,237,378**	**1,584,615**	**78%**	**1,799,339**	**69%**
Weatherization	2015	549,969	551,364	100%	432,015	127%
	Overall	**1,106,161**	**1,535,059**	**72%**	**1,749,193**	**63%**

The subsequent findings section provides more detail regarding the modeling results and additional savings summaries.

Electric Energy Savings – Measure-Category

Table 7 lists DC program electric savings by distinct measure categories, comparing changes in energy consumption before and after installation for 2013-2015 program participants in the analysis sample. As shown, savings for Space Heat and Water Heat measures averaged 9% and 8% savings, respectively, with realization rates of 93% and 133%. Weatherization and Windows measures achieved approximately 5% to 6% savings each, with realization rates estimated at 62% and 48%, respectively.[4]

[4] Cadmus calculated estimated adjusted gross savings based on the "percentage of pre" approach discussed in the Savings Calculation section of the methodology.

Table 7. Dealer Channel Electric – Overall Measure-Category Savings

Group	Measure Category	n	PRENAC	Average Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings % of Pre-Use	
				Model	Reported			Model	Reported
Participant	Space Heat	3,432	19,690	1,637	1,911	±4%	86%	8%	10%
	Water Heat	1,097	17,275	1,186	994	±9%	119%	7%	6%
	Weatherization	882	18,746	790	1,588	±22%	50%	4%	8%
	Windows	1,719	15,699	765	1,962	±13%	39%	5%	12%
Comparison	Comparison	2,412	16,114	-173		±48%	0%	-1%	0%
Adj. Gross	**Space Heat**	**3,432**	**19,690**	**1,777**	**1,911**	**±4%**	**93%**	**9%**	**10%**
	Water Heat	**1,097**	**17,275**	**1,324**	**994**	**±9%**	**133%**	**8%**	**6%**
	Weatherization	**882**	**18,746**	**992**	**1,588**	**±18%**	**62%**	**5%**	**8%**
	Windows	**1,719**	**15,699**	**934**	**1,962**	**±14%**	**48%**	**6%**	**12%**

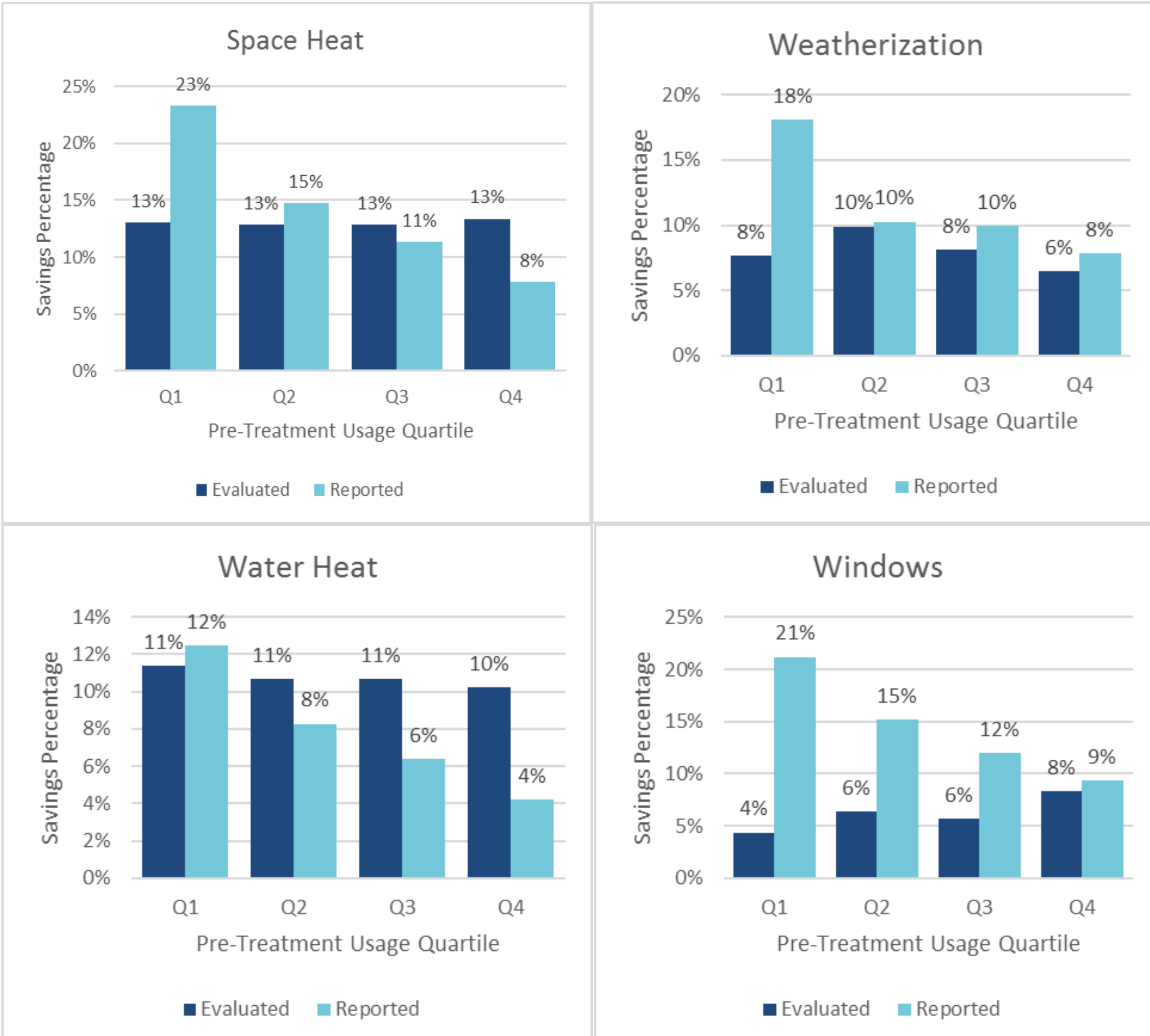
Table 8 summarizes impacts by measure category, comparing the most recent program period (2015) to the 2013-2015 range. For Space Heat, Weatherization, and Windows measures, 2015 realization rates were substantially higher in 2015 than over the 3-year period, while Water Heat measures decrease from 133% to 119%. The higher 2015 realization rates suggest improvement, possibly due to revisions to planning estimates (affecting reported savings) or changes in program delivery (affecting evaluated savings). In particular, for Water Heat and Windows, these improvements to realization rates appear to be driven by changes to reported savings values. For Weatherization, this appears to be driven by a lift in average evaluated savings per household.

Table 8. Dealer Channel Electric – 2015 Measure-Category Savings

Measure Category	Year	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as % of Pre-Use	
				Model	Reported			Model	Reported
Space Heat	2015	1,057	19,186	1,858	1,756	±7%	106%	10%	9%
	Overall	**3,432**	**19,690**	**1,777**	**1,911**	**±4%**	**93%**	**9%**	**10%**
Water Heat	2015	267	16,877	1,351	1,136	±12%	119%	8%	7%
	Overall	**1,097**	**17,275**	**1,324**	**994**	**±9%**	**133%**	**8%**	**6%**
Weatherization	2015	215	17,586	1,382	1,437	±21%	96%	8%	8%
	Overall	**882**	**18,746**	**992**	**1,588**	**±18%**	**62%**	**5%**	**8%**
Windows	2015	537	15,072	1,090	1,263	±18%	86%	7%	8%
	Overall	**1,719**	**15,699**	**934**	**1,962**	**±14%**	**48%**	**6%**	**12%**

Figure 4 provides evaluated savings by pre-installation use levels (binned into quartiles) for the complete 2013–2015 analysis sample, compared to corresponding reported savings percentages per usage quartile. For each measure category, the reported percentage of savings decreased as usage increased, which may indicate that individual household characteristics (e.g., pre-treatment usage, square footage) and existing measure conditions (e.g., equipment efficiency) were not accounted for in the reported savings values.

Figure 4. DC Electric – Savings Comparison by Pre-Usage Quartile[5]



For both Space Heat and Water Heat measures, the evaluated percentage of savings are relatively flat across consumption quartiles, while the Weatherization and Windows categories demonstrate some variation.

5 Quartile models are summarized using evaluated savings estimates based on PRISM results for participants with single measure installations (i.e., without measure interaction), in an effort to summarize at the measure category-level (e.g., weatherization). These samples represent a subset of the full analysis samples reported using fixed-effect models. The PRISM summaries presented reflect the following proportions of the full fixed effects analysis samples: 57% Space Heat, 30% Weatherization, 87% Windows, and 68% Water Heat.

Electric Energy Savings – Measure-Level

As shown in Table 9, Cadmus ran additional models that targeted measure-level impacts. In some cases, we omitted measures installed in lower frequencies or in consistent combinations with other measures (resulting in what is referred to as collinearity), due to insufficient precision.[6] Heat pumps and HPWHs achieved high realization rates, at 109% and 134%, respectively. DHP savings were close to reported savings (94% realization rate) and reflected the highest percentage of savings at 18%. Evaluated savings for all weatherization measures were lower than reported savings, which was consistent with the measure category realization rate of 62%.

Table 9. Dealer Channel Electric – Measure-level Savings*

Measure Category	Measure**	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as % of Pre-Use	
				Model	Reported			Model	Reported
Space Heat	DHP	1,503	17,225	3,034	3,243	±5%	94%	18%	19%
	Heat Pump	1,378	21,110	707	648	±7%	109%	3%	3%
	Heat Pump Sizing and Lockout Controls	537	22,697	968	1,370	±35%	71%	4%	6%
Water Heat	HPWH	822	17,815	1,669	1,243	±8%	134%	9%	7%
Weatherization	Ceiling Insulation	273	17,863	1,117	1,930	±27%	58%	6%	11%
	Duct Sealing + Insulation	185	20,746	809	1,839	±50%	44%	4%	9%
	Floor Insulation	297	17,899	881	1,329	±35%	66%	5%	7%
Windows	Windows	1,719	15,699	934	1,962	±14%	48%	6%	12%

* Measures presented with relative precision within ±50%.

** All reported savings estimates are outside of the precision bounds of modeled evaluated savings, indicating significant different.

To provide additional insight into the impact of measure-interactive effects, Table 10 compares measure-level estimates from the combined fixed-effects billing analysis models (same as in Table 9) to savings estimates from Princeton Scorekeeping Method (PRISM) models for participants that installed the measure in isolation. The table only includes measures for which precision is sufficient in both models.

6 Measures installed in combination result in challenges for the regression model to disentangle the impacts due to high collinearity (i.e., high correlation between the measure indicators). This results in poor precision for these measures, since the model cannot isolate impacts with accuracy.

Table 10. Dealer Channel Electric – Measure-level Savings by Model*

Measure	Model	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as %. of Pre-Use	
				Model	Reported			Model	Reported
DHP	FE	1,503	17,225	3,034	3,243	±5%	94%	18%	19%
	PRISM	1,165	17,277	3,386	3,242	±4%	104%	20%	19%
Heat Pump	FE	1,378	21,110	707	648	±7%	109%	3%	3%
	PRISM	746	20,097	759	672	±7%	113%	4%	3%
HPWH	FE	822	17,815	1,669	1,243	±8%	134%	9%	7%
	PRISM	667	17,569	1,913	1,234	±6%	155%	11%	7%
Ceiling Insulation	FE	273	17,863	1,117	1,930	±27%	58%	6%	11%
	PRISM	115	16,032	1,564	1,978	±24%	79%	10%	12%
Floor Insulation	FE	297	17,899	881	1,329	±35%	66%	5%	7%
	PRISM	102	15,431	1,027	1,366	±44%	75%	7%	9%
Windows	FE	1,719	15,699	934	1,962	±14%	48%	6%	12%
	PRISM	1,498	15,419	1,032	1,963	±13%	53%	7%	13%

* Measures presented with relative precision within ±50%.

In each case, evaluated savings associated with measures installed in combination (fixed-effects models) are slightly lower than measures installed in isolation (PRISM). Some variation in evaluated savings estimates are likely driven by different sample sizes and modeling approaches; however, these PRISM estimates are more comparable to reported savings (based on engineering) which reflect standalone measure installations (rather than in combination with other measures).

Table 11 shows measure-level savings, comparing the 2015 installations to those across the 2013-2015 period. Aside from HPWHs, all measures achieved higher realization rates in 2015 than for the overall three-year evaluation period. For Windows and DHPs, average reported savings varied, which suggests changes to the savings estimation approach may have occurred. Ceiling and floor insulation measures show higher average evaluated savings in 2015 compared to the three-year period.

Table 11. Dealer Channel Electric – Measure-level Savings: 2015 and Overall*

Measure	Year	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as % of Pre-Use	
				Model	Reported			Model	Reported
DHP	2015	496	16,815	3,081	2,817	±7%	109%	18%	17%
	Overall	1,503	17,225	3,034	3,243	±5%	94%	18%	19%
Heat Pump	2015	402	20,712	699	629	±11%	111%	3%	3%
	Overall	1,378	21,110	707	648	±7%	109%	3%	3%
HPWH	2015	187	18,392	1,875	1,522	±11%	123%	10%	8%
	Overall	822	17,815	1,669	1,243	±8%	134%	9%	7%
Ceiling Insulation	2015	70	17,853	1,738	1,621	±28%	107%	10%	9%
	Overall	273	17,863	1,117	1,930	±27%	58%	6%	11%
Floor	2015	78	17,113	1,326	1,148	±37%	116%	8%	7%

Measure	Year	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as % of Pre-Use	
				Model	Reported			Model	Reported
Insulation	Overall	297	17,899	881	1,329	±35%	66%	5%	7%
Windows	2015	537	15,072	1,090	1,263	±18%	86%	7%	8%
	Overall	1,719	15,699	934	1,962	±14%	48%	6%	12%

* Measures presented with relative precision within ±50%.

For every measure, relative precision was worse for 2015 than for the overall 2013-2015 period, due to fewer projects (i.e., smaller sample sizes). For most measures, the evaluated savings were relatively similar between both models. However, in some cases (e.g., geothermal heat pump), fewer projects in 2015 resulted in a more dynamic difference between model savings estimate, with poorer precision (and thus, omitted). However, when precision values between the two models are comparable, the updated 2015 reported savings results in a higher realization rate than the overall model (e.g., Windows measures).

Electric Load Increasing

Through the screening process, Cadmus identified several equipment measures that ***increased*** participants' electric loads over their pre-installation consumption levels, specifically for heat pumps, DHPs, HPWHs, and water heater replacements. The following percentage of participants in the analysis sample experienced increased electric loads for each of the measures listed: 63% of heat pump participants, 39% of DHP participants, and 30% of HPWH participants.[7] Table 12 compares measure-level model savings of the final analysis sample to the full sample of installations, including participants with increased electric loads.

As the intent of DC equipment incentives is to encourage customers to select high-efficiency equipment over standard-efficiency units, Cadmus excluded participants with increased electric loads when considering the broader impacts within each DC program category.

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7 Model results showed that approximately 7% (n=11) of participants who replaced water heaters increased their electric load; however, this estimate was not within a sufficient precision threshold (i.e., greater than ±50% relative precision) and we did not include in subsequent reporting.

Table 12. Dealer Channel Electric – Load-Increasing Measure-Category Savings*

Measure	Group	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as % of Pre-Use	
				Model	Reported			Model	Reported
DHP	With Load Increase	2,453	15,897	869	3,250	±19%	27%	5%	20%
	Analysis Sample	1,503	17,225	3,034	3,243	±5%	94%	18%	19%
Heat Pump	With Load Increase	3,713	15,491	-223	648	±15%	-34%	-1%	4%
	Analysis Sample	1,378	21,110	707	648	±7%	109%	3%	3%
HPWH	With Load Increase	1,177	16,989	657	1,228	±27%	54%	4%	7%
	Analysis Sample	822	17,815	1,669	1,243	±8%	134%	9%	7%

* Measures presented with relative precision within ±50%.

Several factors may explain increased electric loads. Increased loads may result after participants add appliances (rather than replace) or switch from a non-electric source. For example, the participant survey found that one-third of participants who installed a heat pump previously used a natural gas furnace as their primary heating system, 23% of those who installed a DHP previously used a wood or pellet stove or fireplace for their primary heating, and the majority of DHP recipients previously had either no cooling equipment (36%) or cooled their homes with fans (41%). The survey also found that 89% percent of customers who installed heat pumps as part of the program use a backup heating system.

Furthermore, Cadmus found that 75% of heat pump participants with load increases had PSE gas accounts, while only 1% of DHP participants had a PSE gas account. This indicates that fewer DHP participants were PSE gas customers, suggesting either using alternative heating (e.g., wood, pellet stove) or gas from another utility provider. Table 13 provides additional model details regarding the gas reduction for the sample of PSE customers with both gas and electric accounts that received these measures and increased electric loads.

Table 13. Gas Reduction for PSE Customers with Heat Pump and DHP Electric Load Increase

Measure	Fuel	n	PRENAC (kWh/Therms)	Model Savings (kWh/Therms)	Savings % of Pre-Use	Relative Precision at 90%
Heat Pump	Electric	1,031	10,650	-3,052	-29%	±5%
	Gas		894	393	44%	±3%
DHP	Electric	19	11,686	-1,554	-13%	±59%
	Gas		827	224	27%	±26%

Gas Energy Savings – Measure-Category

Table 14 provides DC gas savings by measure categories and compares the changes in energy consumption before and after installation for the 2013-2015 analysis sample. As shown, savings for

Space Heat and Weatherization measures both averaged 9% savings, with realization rates of 74% and 90%, respectively. Windows achieved approximately 7% savings, with a realization rate of 57%.[8][9]

Table 14. Dealer Channel Gas – Overall Measure-Category Savings

Group	Quartile	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as %. of Pre-Use	
				Model	Reported			Model	Reported
Participant	Space Heat*	8,662	897	63	106	±4%	59%	7%	12%
	Weatherization	5,712	876	53	85	±7%	63%	6%	10%
	Windows	3,078	806	37	102	±9%	37%	5%	13%
Comparison	Comparison	4,248	861	-22	N/A	±11%	0%	-3%	0%
Adj. Gross	**Space Heat***	**8,662**	**897**	**79**	**106**	**±4%**	**74%**	**9%**	**12%**
	Weatherization	**5,712**	**876**	**76**	**85**	**±5%**	**90%**	**9%**	**10%**
	Windows	**3,078**	**806**	**58**	**102**	**±7%**	**57%**	**7%**	**13%**

* Space Heat category savings aggregates measure-level model savings estimates for all measures except fireplaces, as model savings for this measure could not be estimated using billing analysis due to the nature of these installations (i.e., no existing fireplace replacement). Instead, Cadmus applied 17.9 therms as the evaluated savings estimate for fireplace installations, based on the engineering review (more detail provided in Appendix D. Savings Review Details).

Table 15 summarizes impacts by measure category, comparing 2015 savings to the overall 2013-2015 evaluation period. In particular for Weatherization and Water Heat, realization rates were substantially higher for 2015 than the three-year average. Average reported savings for both Weatherization and Windows measures decreased between the 2013-2015 period and 2015.

Table 15. Dealer Channel Gas – Measure-Category Savings by Year

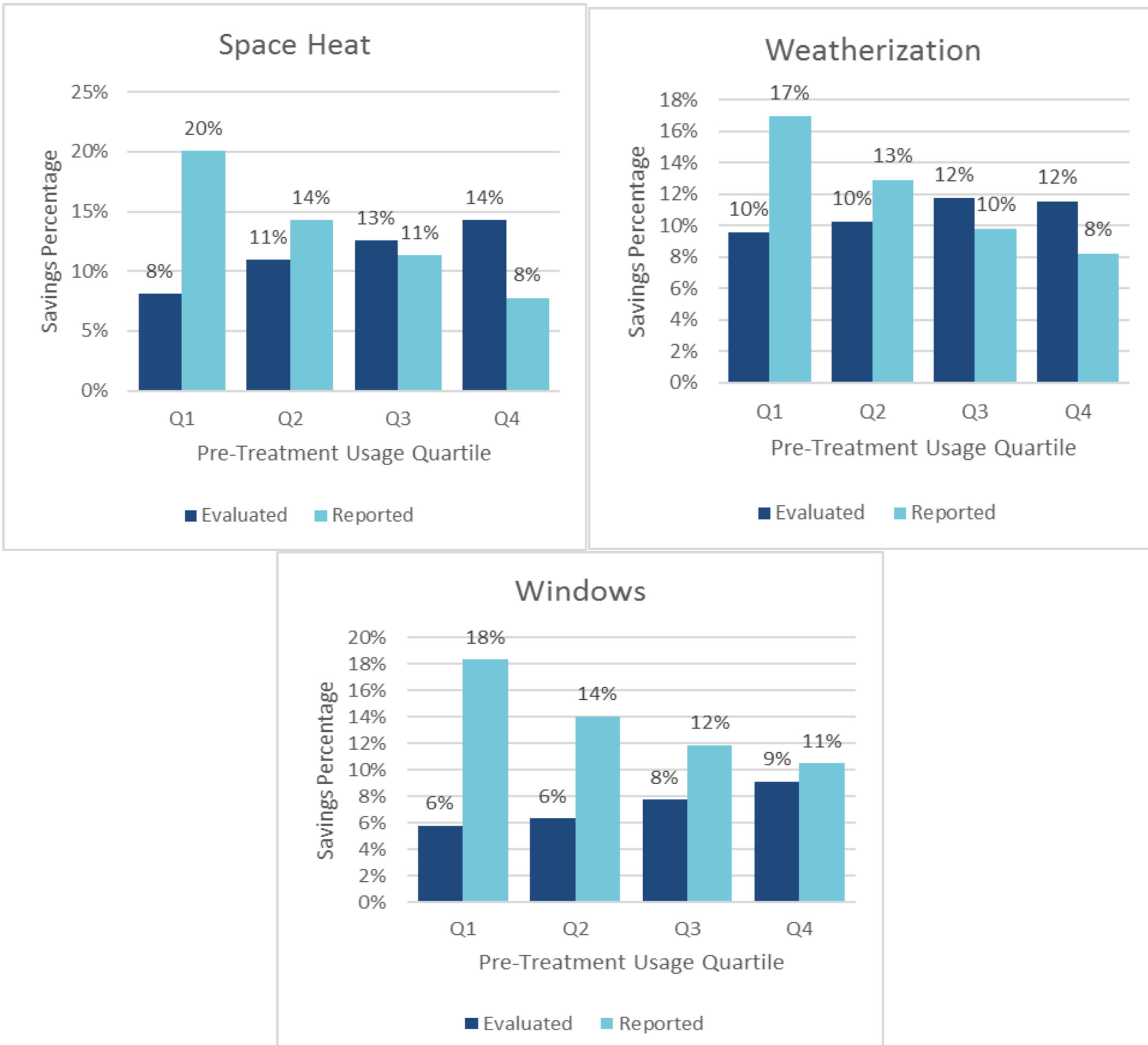
Measure Category	Year	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as % of Pre-Use	
				Model	Reported			Model	Reported
Space Heat	2015	1,956	890	88	107	±5%	82%	10%	12%
	Overall	**8,662**	**897**	**83**	**106**	**±4%**	**78%**	**9%**	**12%**
Weatherization	2015	1,663	885	86	72	±7%	120%	10%	8%
	Overall	**5,712**	**876**	**76**	**85**	**±5%**	**90%**	**9%**	**10%**
Windows	2015	1,387	812	66	80	±8%	83%	8%	10%
	Overall	**3,078**	**806**	**58**	**102**	**±7%**	**57%**	**7%**	**13%**

8 Cadmus calculated estimated adjusted gross savings based on the "percentage of pre" approach discussed in the Savings Calculation section of the methodology.

9 Approximately 188 participants within the analysis received energy-efficient showerheads, possibly through the HEA program. Associated savings did not produce estimates within a sufficient precision threshold (i.e., under ±50%) and are not included in subsequent reporting.

Figure 5 shows evaluated savings by pre-installation use levels (binned into quartiles) for the complete 2013–2015 analysis sample and compares them to the corresponding reported savings per usage quartile.

Figure 5. DC Gas – Savings Comparison by Pre-Usage Quartile[10]



[10] Quartile models are summarized using evaluated savings estimates based on PRISM results for participants with single measure installations (i.e., without measure interaction), in an effort to summarize at the measure category-level (e.g., weatherization). These samples represent a subset of the full analysis samples reported using fixed-effect models. The PRISM summaries presented reflect the following proportions of the full fixed effects analysis samples: 91% Space Heat, 28% Weatherization, and 87% Windows

Reported savings for each measure category show a higher percentage of savings in lower usage quartiles, with decreasing savings in the higher-usage quartiles; this suggests input assumptions for savings calculations may not account for household consumption or other factors that may distinguish household-usage levels such as square footage or heating equipment. Alternatively, evaluated savings increase as household consumption increases across the participant quartile groups, which indicates that households with higher pre-installation energy consumption achieve greater savings.

Gas Energy Savings – Measure-Level

As shown in Table 16, Cadmus ran additional models that targeted measure-level impacts. In some cases, we omitted measures installed with less frequency or in consistent combinations with other measures (resulting in what is referred to as collinearity), due to insufficient precision.[11]

Ceiling insulation and duct measures achieved high realization rates, at 98% and 95%, respectively. Heating system replacements occurred with the greatest frequency over the 2013-2015 period and achieved a realization rate of 84%, and 10% savings relative to pre-installation consumption. Gas savings for window installation achieved 7% savings, with a 57% realization rate; this is similar to electric savings (i.e., 6% savings with 47% realization rate).

Table 16. Dealer Channel Gas – Measure-level Savings *

Measure Category	Measure*	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as Pct. of Pre-Use	
				Model	Reported			Model	Reported
Space Heat	Heating System Replacement**	7,404	902	92	111	±4%	84%	10%	12%
	Integrated SH WH	95	981	152	173	±22%	88%	15%	18%
Weatherization	Ceiling Insulation	1,502	837	114	116	±6%	98%	14%	14%
	Floor Insulation**	1,615	892	57	72	±14%	80%	6%	8%
	Wall Insulation**	483	766	51	74	±22%	70%	7%	10%
	Air Sealing**	190	833	48	68	±39%	71%	6%	8%
	Duct Sealing + Insulation	1,922	923	71	75	±10%	95%	8%	8%
Windows	Windows**	3,078	806	58	102	±7%	57%	7%	13%

* Measures presented with relative precision within ±50%.

** Reported savings estimates are outside of the precision bounds of modeled evaluated savings, indicating significant different.

To provide additional insight into the impact of measure interactive effects, Table 17 compares measure-level estimates from the combined fixed-effects billing analysis models (same as in Table 16) to savings estimates from PRISM models for participants who installed the measure in isolation. The table only includes measures for which precision is sufficient in both models.

[11] Measures installed in combination result in challenges for the regression model to disentangle the impacts due to high collinearity (i.e., high correlation between the measure indicators). This results in poor precision for these measures, since the model cannot isolate impacts with accuracy.

Table 17. Dealer Channel Gas – Measure-level Savings by Model*

Measure	Model	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as Pct. of Pre-Use	
				Model	Reported			Model	Reported
Heating System Replacement	FE	7,404	902	92	111	±4%	84%	10%	12%
	PRISM	6,861	904	92	111	±4%	83%	10%	12%
Duct Sealing + Insulation	FE	1,922	923	71	75	±10%	95%	8%	8%
	PRISM	526	941	79	75	±12%	105%	8%	8%
Floor Insulation	FE	1,615	892	57	72	±14%	80%	6%	8%
	PRISM	225	839	78	71	±15%	111%	9%	8%
Ceiling Insulation	FE	1,502	837	114	116	±6%	98%	14%	14%
	PRISM	683	825	116	120	±7%	97%	14%	15%
Wall Insulation	FE	483	766	51	74	±22%	70%	7%	10%
	PRISM	142	720	84	81	±16%	104%	12%	11%
Windows	FE	3,078	806	58	102	±7%	57%	7%	13%
	PRISM	2,670	805	62	103	±6%	60%	8%	13%

* Measures presented with relative precision within ±50%.

In each case, evaluated savings associated with measures installed in combination (fixed-effects models) were slightly lower than measures installed in isolation (PRISM), with the exception of heating system replacements.[12] Some variation in evaluated savings estimates are likely driven by different sample sizes and modeling approaches; however, these improved realization rates reflect a greater similarity between the PRISM estimates and reported savings, the latter based on engineering assumptions typically reflecting standalone measure installation (rather than in combination with other measures).

Table 18 compares measure-level savings from 2015 installations to those across the 2013-2015 period. Ceiling, wall, and floor insulation measures and windows demonstrate a 30% to 40% difference in realization rate; for ceiling and floor insulation, there is a noticeable decrease in average reported savings, which may be attributed to changes in planning assumptions. For wall insulation, reported savings are minimally affected and the change is driven primarily through average evaluated savings. Contributing factors may include changes in delivery (e.g., quality installation), QC/QC protocols during this period, or household changes affecting the installation (e.g., measure persistence).

[12] Approximately 93% of heating system replacements occurred in isolation, without measures installed in combination, suggesting interactive effects are less prevalent within the fixed-effects model sample.

Table 18. Dealer Channel Gas – Fixed-effects Measure-level Savings: 2015 and Overall*

Measure	Year	n	PRENAC	Average Participant Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings as Pct. of Pre-Use	
				Model	Reported			Model	Reported
Heating System Replacement	2015	1,694	893	96	111	±6%	87%	11%	12%
	Overall	7,404	902	92	111	±4%	84%	10%	12%
Duct Sealing + Insulation	2015	576	933	79	75	±15%	106%	8%	8%
	Overall	1,922	923	71	75	±10%	95%	8%	8%
Floor Insulation	2015	462	899	63	56	±20%	112%	7%	6%
	Overall	1,615	892	57	72	±14%	80%	6%	8%
Ceiling Insulation	2015	448	832	119	87	±9%	136%	14%	11%
	Overall	1,502	837	114	116	±6%	98%	14%	14%
Wall Insulation	2015	128	810	84	76	±23%	109%	10%	9%
	Overall	483	766	51	74	±22%	70%	7%	10%
Windows	2015	1,387	812	66	80	±8%	83%	8%	10%
	Overall	3,078	806	58	102	±7%	57%	7%	13%

* Measures presented with relative precision within ±50%.

Savings Review

Cadmus' review of PSE energy savings revealed several instances where the estimation method and/or input data may benefit from either refreshed values or a revised approach.

The DC programs include several major measure categories, with multiple versions of each measure listed in PSE's tracking database (depending on baseline or system configurations). For example, insulation measures contained 42 unit-energy-savings (UES) values, differentiated by baseline and post-installation conditions. The primary sources of reported savings estimates include UES values sourced from RTF workbooks, and UES values that PSE has adapted from RTF or other evaluation work (i.e., PSE deemed values).

While many nationwide technical standards for determining UES values focus on simple engineering equations, the RTF focuses on providing UES values based on statistical methods and calibrated engineering approaches. Both methods characterize typical savings across a broad population of potential participants within the Pacific Northwest.

Upon review of the algorithms and input assumptions used in current UES values, Cadmus determined that the majority are reasonably accurate for the purposes of planning estimates and identified discrete recommendations and considerations for further refinement. Cadmus is suggesting these refinements for measures where more current or accurate values may be available to align more closely with RTF UES values, which receive frequent updates (e.g., the RTF updated single-family weatherization UES values five times in 2015). Given this variability, Cadmus' recommendations do not point to specific RTF workbooks and data, but serve as guidelines for applying RTF data to UES values. Table 19 summarizes

Cadmus' measure recommendations and considerations. Appendix D. Savings Review Details provides detailed findings of Cadmus' savings review and specific proposed updates, by measure.

Table 19. Summary of Recommended Updates for Each Measure

Measure Category	Measure Name	Recommendations/Considerations
Weatherization	Air Sealing/Structural Sealing	Review UES values annually to reflect most recent RTF sources
	Floor Insulation	
	Attic Insulation	
	Wall Insulation	
	Duct Insulation and Sealing	
	Windows	
Water Heat	Heat Pump Water Heaters	Update to most recent RTF sources
Space Heat	Heat Pump (Air Source)	Collect nominal capacity and installed efficiency of heat pumps.
	Heat Pump (Geothermal)	Collect replaced system type, and installed de-superheater
	Ductless Heat Pump	Revise estimate to use actual replaced heating system type rather than an average assumption
	Heat Pump Sizing/Lock Out	Update to most recent RTF sources
	Ventilation	Revise cubic feet per minute (CFM)/watt assumptions used in current calculation (from 1.4 to 3.1 for baseline and from 10 to 8.3 for efficient condition)
	Heating System Replacement	Revise estimate to use actual installed heating system capacities rather than an average assumption
	Fireplace	Update therm savings to 17.9/unit and incorporate Cadmus savings method

Non-Energy Benefits Assessments

Cadmus performed analyses to assess DC programs' non-energy impacts and quantified estimates of economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits. Table 20 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

Table 20. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted***
	Electric	Gas	
Participant Ancillary Benefits	$227		TRC, PCT
Economic Impacts*	$786		TRC
Environmental – Avoided Environmental Compliance Costs**	$28.66	$17.20	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$35.56	$21.34	PTRC

* Represents the average contribution to Regional Domestic Product (i.e., Value Added impacts from IMPLAN model) per 2015 program participant

** Represents the 2018 per participant benefits using the PSE IRP Scenario 12 CO_2 compliance price assumptions (High CO_2 Cost Scenario)

*** Definition of acronyms include: Total Resource Cost Test (TRC), Participant Cost Test (PCT), Utility Cost Test (UCT), and the PTRC is the Total Resource Cost Test + Conservation Adder (essentially Societal Cost Test)

NEBs: Economic Impacts

The following section presents the gross, baseline, and net regional economic impacts within PSE's electric and gas service territories, attributable to the DC programs.

To calculate net economic impacts, it is necessary to first estimate a baseline scenario. The baseline scenario assumes DC program expenditures were spent instead on a mix of typical utility-sector expenditures (e.g., purchasing coal or natural gas for electricity generation, importing electricity from out of state, and construction).[13] The gross program scenario estimates economic impacts resulting from the DC program. Using these scenario estimates, Cadmus subtracted baseline impacts from the gross program impacts to determine net impacts for program year 2015.

Gross Economic Impacts

Table 21 shows gross direct, indirect, induced, and total effects[14] on several economic indicators (i.e., regional employment, labor income, value added, and output) attributable to DC gas and electric program expenditures, bill savings, utility avoided cost and revenue loss. Cadmus determined gross

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[13] The baseline scenario expenditures are assigned based on the IMPLAN-defined sector for utility services – *Utility Generation, Transmission, and Distribution (GTD).*

[14] ***Direct effects*** represent regional production changes brought by increases in regional demand. ***Indirect effects*** are changes in demand for intermediate inputs necessary for directly affected industries. ***Induced effects*** result from the ways households and employees of directly and indirectly affected industries spend money on regional goods and services. ***Total effects*** are the sum of direct, indirect, and induced effects. See Model Inputs in Appendix A. Methodology for further detail and examples of these three impact types.

impacts on regional employment of approximately 167 job-years for program gas and electric investments.[15]

Table 21. 2015 Gross DC Program Impact on Key Economic Indicators

Impact Type	Key Economic Indicator			
	Employment (Job-Years)	Labor Income (USD)	Value Added (USD)	Output (USD)
Direct Effect	104	$7,962,644	$4,865,273	$8,846,089
Indirect Effect	39	$2,493,042	$3,236,551	$5,381,427
Induced Effect	24	$1,267,856	$2,293,225	$3,751,302
Total Effect	**167**	**$11,723,541**	**$10,395,049**	**$17,978,818**

Baseline Economic Impacts

Table 22 presents effects attributable to 2015 baseline ratepayer expenditures. Cadmus modeled the hypothetical baseline ratepayer expenditures with no energy savings attributed to this scenario. The baseline scenario assumed all program expenditures associated with the DC programs were spent on the typical distribution of electric and gas utility industry expenditures in Impact Analysis for Planning (IMPLAN) model, such as raw fuel and energy imports, new construction, wages, and consulting. To estimate overall direct baseline expenditures, Cadmus assumed a cost-effectiveness ratio of 1.0, so that direct expenditures in the baseline scenario are equivalent to direct expenditures in the program scenario.

Table 22. 2015 Baseline Ratepayer Expenditure Impact on Key Economic Indicators

Impact Type	Key Economic Indicator			
	Employment (Job-Years)	Labor Income (USD)	Value Added (USD)	Output (USD)
Direct Effect	10	$1,434,220	$6,237,064	$13,034,611
Indirect Effect	10	$733,367	$1,638,711	$3,087,988
Induced Effect	-69	-$3,715,028	-$6,608,025	-$10,844,518
Total Effect	**-50**	**-$1,547,441**	**$1,267,749**	**$5,278,081**

The table also shows the direct, indirect, induced, and total effects on the same key economic indicators attributable to 2015 baseline ratepayer expenditures. As Cadmus modeled hypothetical baseline

[15] Approximately 75% of the total gross impacts on employment in PSE's service territory came from direct effects. The remaining 25% came from predicted indirect and induced effects. Induced impacts represent the economic activity that occurs because of changes in household income.

ratepayer expenditures as an increase in household payments for energy, IMPLAN predicted positive direct and indirect effects and negative induced effects. [16]

A substantial portion of typical household expenditures flow to industries such as retail and construction, which tend to be concentrated within the study region. Expenditures in the utility sector, on the other hand, rely heavily on inputs from outside the study region. PSE imports approximately 50% of its energy from out of state, either in the form of electricity imports or raw fuel imports, so a sizable percentage of the funds that are collected from ratepayers in the baseline scenario immediately flow out of the study region. Unlike in the program scenario, those funds are no longer available for job creation within the study region.

When estimating these effects, IMPLAN accounted for leakage out of the regional economy, which occurred because of the location of utility sector supply chain resources and because PSE meets a portion of local energy demand with fuel and power purchased from outside of PSE's service territory.[17]

Net Economic Impacts

Cadmus determined net regional economic impacts from the DC programs, summarized in Table 23, by subtracting hypothetical baseline scenario effects from gross program scenario effects.

Table 23. 2015 Net DC Program Impact on Key Economic Indicators

Impact Type	Key Economic Indicator			
	Employment (Job-Years)	Labor Income (USD)	Value Added (USD)	Output (USD)
Direct Effect	94	$6,528,424	-$1,371,791	-$4,188,522
Indirect Effect	29	$1,759,674	$1,597,840	$2,293,439
Induced Effect	93	$4,982,884	$8,901,250	$14,595,820
Total Effect	**216**	**$13,270,982**	**$9,127,300**	**$12,700,737**

Non-Energy Benefits: Environmental Impacts

The following section summarizes DC program impacts associated with greenhouse gas (GHG) emissions reduction and associated benefits.

[16] The direct and indirect impacts are positive, attributable to increased expenditures in the utility sector and utility sector supply chain. The negative induced effects are caused by decreased household expenditures on the typical basket of household consumption because of higher costs per unit of energy.

[17] Through the use of Regional Purchase Coefficients (RPC), IMPLAN explicitly accounts for the share of factor inputs to productions that are imported to the study region from another county, state, or country. For example, the *Electric Generation, Transmission, and Distribution (Electric GTD)* IMPLAN sector in PSE's electric service territory has an RPC of less than 1% for the Coal Mining sector, indicating that less than 1% of coal used by the Electric GTD sector comes from within PSE's electric service territory.

DC Program Emissions Reduction

At the program-level, combined electric and gas single-family participants reduced annual greenhouse gas (GHG) emissions by 11,077 tons of carbon dioxide equivalent (CO_2e) per year (shown in Table 24).

Table 24. 2015 Total DC Program Emissions Benefits by Fuel Savings

Fuel	Measure Category	Average GHG Emissions Avoided (Short Tons)		Total Program Emissions Avoided (Short Tons)	
		Annual GHG Emissions Avoided	Lifetime GHG Emissions Avoided	Annual GHG Emissions Avoided	Lifetime GHG Emissions Avoided
Electric	Space Heat	1.3	22.9	4,371	79,604
	Weatherization	0.7	17.1	323	8,250
	Water Heat	0.7	8.4	646	8,281
	Windows	0.4	10.7	569	14,832
	Overall	**0.9**	**17.5**	**5,909**	**110,967**
Gas	Space Heat	0.6	10.6	2,140	39,700
	Weatherization	0.8	23.1	1,884	56,232
	Water Heat	0.2	1.8	25	252
	Windows	0.4	10.0	1,119	28,877
	Overall	**0.6**	**13.6**	**5,169**	**125,061**
Overall	**Overall**	**0.7**	**15.2**	**11,077**	**236,028**

On average, electric and gas participants saw reductions of 0.9 tons and 0.6 tons, respectively, of CO_2e per year. Electric program participants achieved larger GHG savings over the life of installed measured, given the larger savings from electric Space Heat measures compared with other measures.

Comparison with Other Energy Efficiency Programs

Cadmus found data on annual GHG emissions reductions for single-family programs occurring in two jurisdictions: Massachusetts and Wisconsin. As shown in Table 25, annual GHG emissions savings from these programs were higher than those quantified for the PSE DC programs. This is likely due to greater available savings in the colder climates of Massachusetts and Wisconsin and generation fuel mix.

Table 25. Emissions Reductions from Comparable Energy Efficiency Programs

Jurisdiction	Fuel	Program Year	Annual GHG Reductions (CO_2e/participant)
Massachusetts	Electric	2015	2.3
Massachusetts	Gas	2015	1.5
Wisconsin (HPwES)	Electric and Gas	2015	1.2
PSE	Electric and Gas	2015	0.7

Avoided Emissions Applicability

Emission reductions are one benefit of participation in energy efficiency programs. Emissions reduced by the DC programs can help PSE as it develops plans for compliance with existing and future climate change regulations. The Washington State Clean Air Rule (CAR)[18] requires that owners of power plants and natural gas distributors in Washington that emit more than 100,000 metric tons CO_2e each year reduce emissions from an established baseline, beginning in calendar year 2017. Entities covered by this rule can reduce emissions through changes in operations or by purchasing emission reduction units (ERUs) from others.

Furthermore, energy efficiency in excess of the minimum required under the Washington Energy Independence Act can create ERUs that PSE can sell to other entities, creating a new potential funding stream for energy efficiency measures. In addition to CAR compliance, energy efficiency can help PSE meet compliance obligations under potential future federal policies aimed at reducing GHG emissions.

Avoided Emissions Benefits

Cadmus measured the NEBs from avoided GHG emissions in two ways. The first approach quantifies the avoided environmental compliance costs that result from energy efficiency programs. Avoided compliance costs are costs associated with complying with state and federal regulations aimed at reducing GHG emissions, such as CAR. In the second approach, Cadmus quantifies the social benefit associated with reduced emissions using Environmental Protection Agency (EPA) social cost of carbon, described below. Table 26 provides a summary of these benefits by type and fuel.

Table 26. Average Annual Environmental NEBs Values

Measure Category	Avoided Environmental Compliance Costs*		Social Benefit of Avoided Emissions	
	Electric	Gas	Electric	Gas
Space Heat	$38.57	$17.53	$47.85	$21.74
Weatherization	$20.57	$23.73	$25.53	$29.44
Water Heat	$20.22	$5.57	$25.09	$6.91
Windows	$12.60	$11.85	$15.63	$14.71
Overall	$28.66	$17.20	$35.56	$21.34

* Represents the 2018 per participant benefits using the PSE IRP Scenario 12 CO_2 compliance price assumptions (High CO_2 Cost Scenario)

[18] Washington Administrative Code, Chapter 173-442, Clean Air Rule

Avoided Compliance Costs

To quantify avoided environmental compliance costs, Cadmus used assumptions from the 2017 PSE Integrated Resource Plan (IRP) development process. Due to uncertainty on the timing and structure of future GHG compliance programs, Cadmus developed two scenarios of future regulations consistent with the IRP. In developing its IRP, PSE estimated GHG compliance costs assuming various state and federal regulatory scenarios, including these:

- ***High CO_2 Cost (Scenario 12: Base w/ CAR only).*** In scenario 12, PSE assumed compliance only with the Washington CAR (not the federal Clean Power Plan). This scenario resulted in estimated compliance costs of **$30.71 per ton** in 2018, rising to over $111/ton CO_2e in 2037. At this estimated price, the DC electric programs would be expected to generate an average annual benefit per participant of $28.66 in 2018, rising to $46.05 in 2025. The gas program would be expected to generate an average annual benefit per participant of $17.20 in 2018, rising to $27.64 in 2025. In total, under this price scenario, the DC programs would generate $12,448,651 in benefits over the lifetime of measures installed in 2015. As this scenario includes only currently implemented state regulations, Cadmus presents it for use in future PSE planning in Table 26.
- ***Low CO_2 Cost (Scenario 10: Base + Low CAR CO_2***). Scenario 10 in the IRP contains a more conservative estimate of GHG compliance costs. Within this scenario, PSE assumes lower CAR compliance costs until 2021, followed by a program similar to the Clean Power Plan. This scenario resulted in estimated compliance costs of **$14.36 per ton** in 2018, rising to over $51/ton CO_2e in 2037. Using these compliance prices, the DC programs generates emissions reduction benefits of $5,819,180 over the lifetime of measures installed, or a benefit for participants in the electric program of $13.40 per participant in 2018, rising to $21.53 per participant in 2025 and a benefit for participants in the gas program of $8.04 in 2018, rising to $12.92 in 2025.

Social Benefit of Avoided GHG Emissions

In addition to estimated avoided compliance costs from GHG regulations, Cadmus also estimated the social benefit of avoided GHG emissions. The social benefit uses a social cost of carbon as an estimate approximating future climate change damages that are avoided by reducing GHG emissions through the DC programs. The social benefit accrues to all members of society and includes a variety of climate change impacts, such as changes in agricultural productivity, human health, and property damages from increased flood risk.

While there are currently a variety of social cost of carbon estimates available, Cadmus used a conservative value for this evaluation, developed by the EPA, for use by federal agencies in valuing the climate change impacts of rulemakings.[19] Cadmus used the EPA social cost of carbon with a 3% discount rate, which ranges from $39.68 per ton CO_2 in 2015 to $60.63 per ton CO_2 in 2035.

The reduced emissions associated with the 2015 DC programs' combined gas and electric savings lead to a total social benefit of $9,541,404, or an annual benefit of $35.56 per electric-saving participant and $21.34 per gas-saving participant (Table 26).

NEBs: Ancillary Participant Benefits

Cadmus established dollar values for ancillary participant benefits that accrue to DC program participants, expecting primary ancillary benefits associated with single-family programs to include comfort (due to reduced drafts and more efficient equipment) and health (due to more reliable heating and cooling). Assessment of these benefits relied on the contingent valuation method—an approach commonly used in economics literature to solicit information about individuals' willingness to pay (WTP) values for goods not traded in markets. By asking respondents whether they value the benefit at one of several "bid amounts" for each benefit in question, and through logistical regression modeling (logit), Cadmus estimated the mean participant value of that benefit.

Cadmus estimated an average "overall" benefits of **$227 per participant** and "comfort" benefits of **$120 per participant.**

This estimate indicates that, on average, participants in the DC programs value the overall improvement in quality of life at $227 and the additional comfort they gain at approximately $120. This value accrues to participants, in addition to the direct bill savings they also experience. Additional details regarding modeling approach, parameters, and outputs are provided in Appendix A. Methodology.

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19 U.S. Environmental Protection Agency. "Social Cost of Carbon: Technical Documentation." 2017. Available online: https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon-technical-documentation_.html

Process Evaluation Findings

Through the process evaluation, Cadmus identified opportunities to improve program delivery to PSE's customers. We designed our research to investigate the following topics:

- Organizational barriers to program effectiveness
- Customer and contractor satisfaction with program components and the program overall
- Motivation for participation
- Program challenges and barriers
- Energy education and behavior changes

Table 27 lists the research activities for the evaluation. Cadmus completed the program manager interviews in 2016 and completed the other activities in 2017.

Table 27. Process Evaluation Research Activities

Research Activity	Number Completed	Approach
PSE program manager interviews	3	Telephone
Contractor interviews with active members of the CAN	35*	E-mail invitation from PSE for online survey about equipment followed by in-depth interviews by telephone
Inactive contractor interviews	4	Telephone
Nonparticipant contactor interviews	1	Telephone
Participant surveys	1,068**	Online

*Twenty-three Tier 1 contractors and 12 Tier 2 contractors.

**Cadmus designed two shorter surveys to address separate topics and to reduce the burden on individual respondents, so not every respondent answered every question.

Program Objectives

PSE designed the DC programs to provide single-family residential households with rebates and instant discounts for energy-efficient improvements such as installing space or water heating equipment or making windows or weatherization improvements like air and duct sealing and insulation. The objectives of the programs, mentioned in program documentation and confirmed in the program manager interviews, is to improve household energy efficiency and work directly with contractors and resellers to provide program training and assist customers with accessing rebates to ensure an "excellent customer experience."[20]

[20] Puget Sound Energy. *Energy Efficiency Exhibit 3 2016-2017 Program Details*. p.26.

KPI Framework

At PSE’s request, Cadmus developed a KPI framework and recommended KPIs that PSE can use to track program performance over time (Table 28).

Cadmus developed the following framework according to the following principles and best practices for performance tracking and continuous improvement:

- **Related to Goals.** The framework is organized by program goals identified in the program documentation and described in the program manager interview; each recommended KPI framework relates to one of these goals.
- **Focused.** The number of recommended KPIs is limited to ensure focus on the metrics that are most critical to the success of the program.
- **Controllable.** The KPIs are limited to metrics that PSE can influence and control.
- **Balanced**. Recommended KPIs include a mix of retrospective metrics and process indicators to support timely adaptive management.
- **Measurable.** Recommended KPIs are relatively easy to measure and track on an ongoing basis; each metric requires a set of input variables, some of which PSE may not currently track electronically, but should be available from agency documentation.

Table 29 includes a supplementary list of performance and diagnostic metrics. We recommend PSE periodically investigate these additional measures to inform ongoing adaptive management; however, they may be a lower priority for continuous performance tracking because they do not relate to PSE’s goals as directly as the suggested KPIs or they are more difficult to measure or control.

Table 28. Key Performance Indicator Framework*

No	Program Goal	KPI	Description	Data Source
1	Customer Satisfaction/ Experience	Average customer satisfaction**	Customer reported top 2-box program satisfaction using Likert scale, or net promoter score using 10-point scale	PSE follow-up survey or evaluation research
2		Customer satisfaction with contractors**	Customer reported top 2-box contractor satisfaction using Likert scale	PSE follow-up survey or evaluation research
3	Contractor Training to ensure excellent customer experience	Total number of trained contractors	Total number of trained contractors by program measure category and region (if applicable)	PSE tracking database
4		Contractor Evaluation	Proportion of contractors with satisfactory evaluation score	PSE tracking database
5	Quality Assurance	Inspection pass rate	Proportion of total project inspections that passed.	PSE tracking database
6	Contractor Retention	Average contractor satisfaction**	Contractor reported top 2-box program satisfaction using Likert scale	PSE follow-up survey or evaluation research
7		Contractor turnover	Proportion of contractors who stop participating in the CAN annually (by tier and measure category)	PSE tracking database
8	Energy Savings	Total projects	Total projects (monthly, quarterly, or YTD, by subprogram)	PSE tracking database
9		Average per household energy savings	Average kWh and therm savings across all households (monthly, quarterly, or YTD, by subprogram)	PSE tracking database

*PSE may currently collect and track some of these metrics.

**Best practice for some metrics (e.g., satisfaction) may include tracking proportions or inner-quartile ranges (e.g., 9-10 responses out of 10-point scale) rather than presenting a simple average. Median is not always preferred, since it can obscure outliers, such as potential customer experience issues.

Table 29. Supplementary Metrics

No	Category	Metric	Description	Data Source
1		Pre/post cross-program participation	Proportion of participants who participated in other PSE energy efficiency programs before and after	PSE tracking database
2	Participation	Total number recommended measures	If participant received a Home Energy Assessment (HEA) program audit, number of installed measures relative to the total number of recommended measures	PSE tracking database
4		Total number of rebates by measure category	Total number of rebates/installations in each measure or measure category annually or year to date	PSE tracking database
5	Resource Acquisition Costs	Average PSE dollars per kWh or therm	PSE dollars per unit energy savings	PSE tracking database
6		Percentage of savings per household	Proportion of savings relative to pretreatment annual consumption, by fuel and overall (or reporting behavior change)	PSE tracking database; PSE consumption data
7	Impact	Percentage of recommended savings	If participant received an HEA audit, percentage of installed savings relative to the total savings based on recommended measures	PSE tracking database
8		NEBs (average benefit per customer)	Discrete suite of NEBs and consistent calculation approach and input assumptions	PSE follow-up survey or evaluation research

Program Delivery and Process Flow

Each program is implemented following three main program delivery steps:

- **Pre-participation.** Customers hear about the program.
- **Installation and Rebate Process.** PSE delivers rebates to customers in two ways: an instant discount offered by the contractor or a customer-submitted rebate. Contractors or customers may perform installations. Customers submit rebate forms if they have performed the installation themselves or used a contractor who did not submit a rebate form for them.
- **Verification and Payment.** PSE verifies projects by sending staff to homes to confirm application details. If a project is selected for verification, PSE verifies the project prior to payment; otherwise, PSE sends payment to the customer after the rebate processing team approves it.

Cadmus developed a process flow diagram that represents program activities from pre-participation through post-installation verification and payment (Figure 6). Appendix E. Program Delivery provides additional detail about program delivery.

Contractor Training and Orientation

Participating contractors can either be part of the CAN or not. To become a member of the CAN, contractors must pass a background and business license check. Additionally, contractors must submit an application, attend a program orientation and program training, and sign a memo of understanding with PSE.

Contractors attend an orientation to learn about the program and the requirements of the CAN. Two contractors (6%; n=35) provided suggestions for improving the orientation. One said more time should be spent on reviewing the eligibility requirements, and one said the presentations could be shortened and streamlined since the contractors already have program documents they can read prior to the orientation. The others did not have any suggestions for improvement.

Seventy-four percent (n=34) of active contractors said that they have attended a PSE program-specific training. Table 30 shows the trainings contractors have attended. Contractors who attended trainings for the measures included in this evaluation answered questions about the training. These contractors (100%; n=22) said they agreed that the trainings provided enough information to understand the requirements of the program, determine customer eligibility, and provide customers with information about the benefits of installing energy efficient equipment.

Table 30. Program-Specific Trainings Attended by Contractors

Program	Participant Attendance
Single-Family Existing Homes Weatherization	29%
Multifamily Retrofit	29%
Single-Family Existing Homes Windows	21%
Single-Family Existing Space and Water Heat	15%
HEA	15%
Home Performance with ENERGY STAR®	12%
Other	12%
Did not attend a training	**26%**

Source: Survey question, “For which programs have you attended a PSE training?” (n=34, multiple responses allowed)

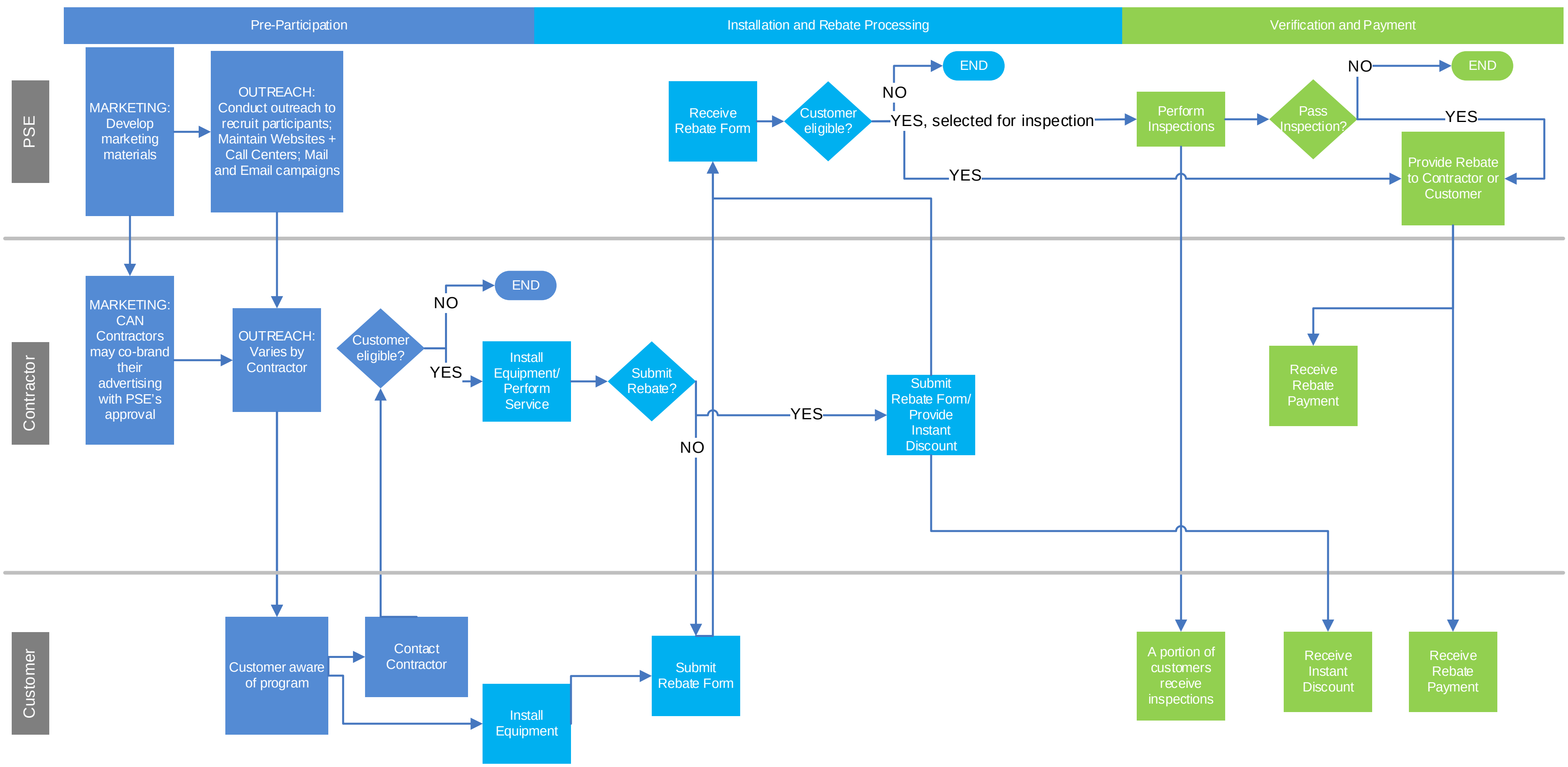
PSE evaluates contractors every six months to determine whether they are fulfilling the training, quality, completed job goals, and customer satisfaction requirements. PSE provides additional communication through quarterly roundtables, e-mail messages, and online webinars. They use these communication channels to maintain positive contractor relationships.

Program Delivery Challenges

PSE program managers described the following program delivery challenges during the interviews:

- **Contractor turnover.** One program manager said contractor was turnover a challenge. PSE is working to improve this by holding quarterly contractor round table discussions and providing regular updates about program changes through email. A different program manager said there are challenges in certain geographic locations where there are limited contractors in the CAN to install HPWHs; PSE is working to find and recruit additional contractors so that one contractor is not overwhelmed by referrals and questions.
- **Administrative burden.** The requirements to be a member of the CAN are challenging for some contractors. According to PSE program managers, successful contractors are those who are willing to fully participate in and promote the program. Program managers said Tier 1 contractors who build the referral fee into their marketing budget instead of passing it along to customers are more successful at winning jobs.
- **Tracking CAN paperwork.** In early 2016, contractors used two different interfaces: one to enter customer rebate information and one to check on training and other CAN requirements. To resolve this challenge, PSE is upgrading to a new system where CAN requirements are easily tracked, along with rebates, in the same database portal. This will allow contractors to submit rebates electronically, do their own forecasting, and keep track of the requirements they need to maintain their status in the CAN.

Figure 6. Process Flow Diagram



Customer Experience

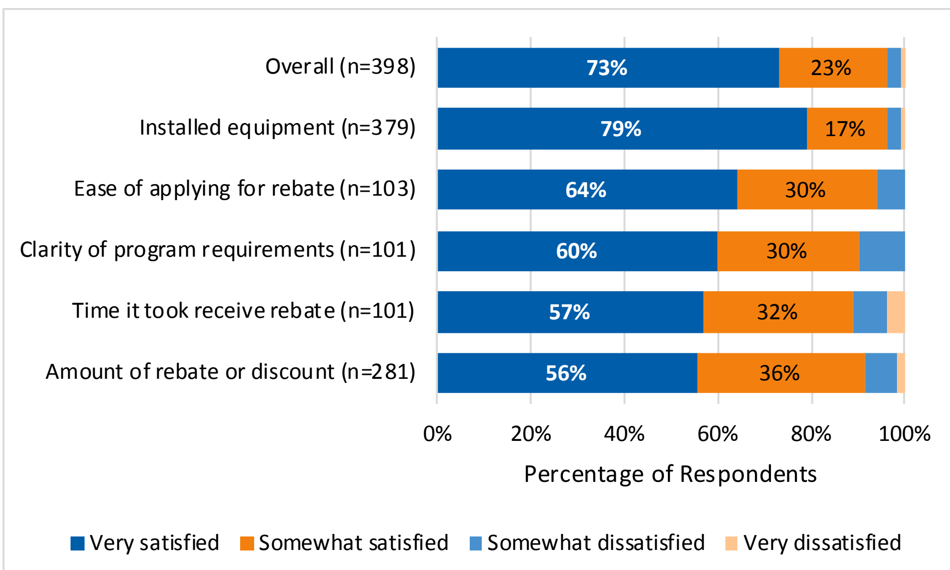
Program Satisfaction

Customer survey respondents are satisfied with the program. Seventy-three percent (n=398) said they were *very satisfied,* and 23% said they were *somewhat satisfied* with the program.

Respondents who received a water heater through the program reported significantly higher satisfaction than respondents who installed other program measures: 88% of participants who installed water heaters (n=49) said they were *very satisfied,* compared to 74% of those who installed space heating equipment (n=189), 63% of those who installed weatherization equipment (n=70), and 70% of those who installed windows (n=90).[21]

Figure 7 shows details about respondents' satisfaction with various program components. The component resulting in highest overall satisfaction was the installed equipment, while respondents cited lower satisfaction with clarity of program requirements and rebate processing time.

Figure 7. Respondent Satisfaction by Program Component



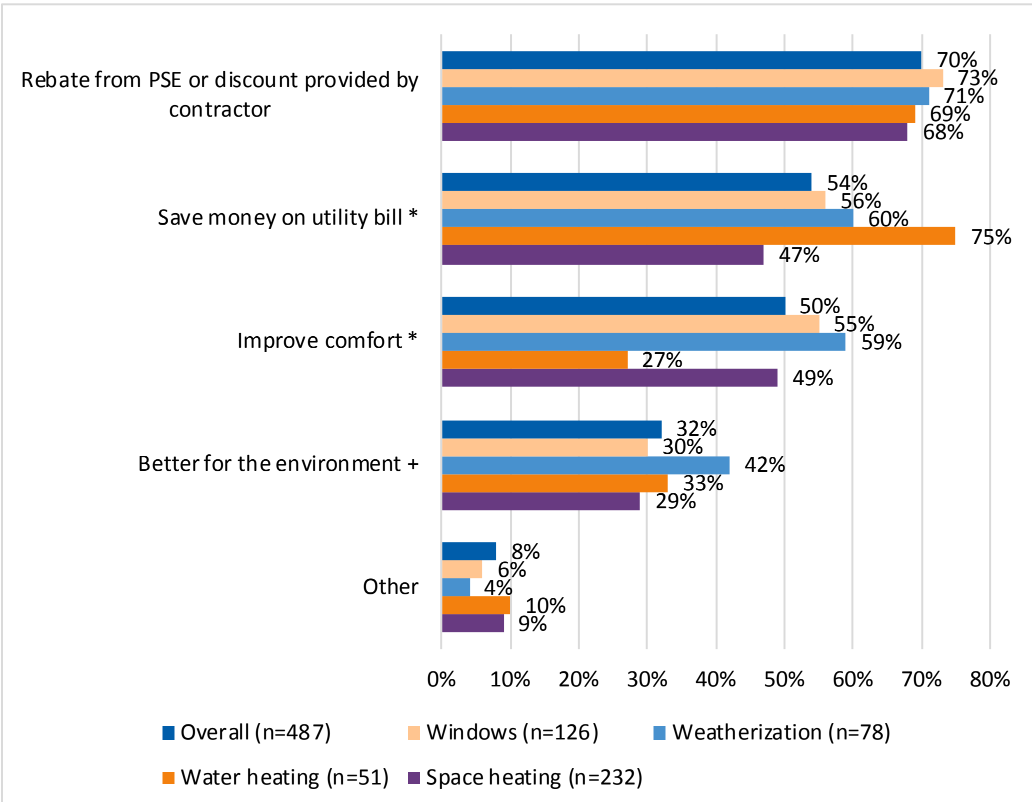
Source: Survey question asked of respondents who submitted rebate request to PSE themselves, "I'll read a few statements. Please tell me how satisfied you are with each one. Let's start with [statement 1]. Would you say you are very satisfied, somewhat satisfied, somewhat dissatisfied, or very dissatisfied?"

[21] Cadmus used a t-test to compare proportions and means to determine if statistically significant differences exist between equipment groups. Cadmus tested at the 10% (p≤0.10) significance levels.

Motivation

Figure 8 lists the reasons customers were motivated to participate in the DC programs. Water heating customers (75%; n=51) said they were significantly more motivated to install equipment to save money on bills than customers who installed the other three equipment types. Weatherization participants were significantly more motivated to make improvements (42%; n=78) because it was better for the environment than customers who installed space or water heating equipment.

Figure 8. Customer Motivation



Source: Survey question, "What motivated you to participate in PSE's rebate program? Please select all that apply." multiple responses allowed

*Difference between water heating and the other measure categories is significant (p≤0.10).

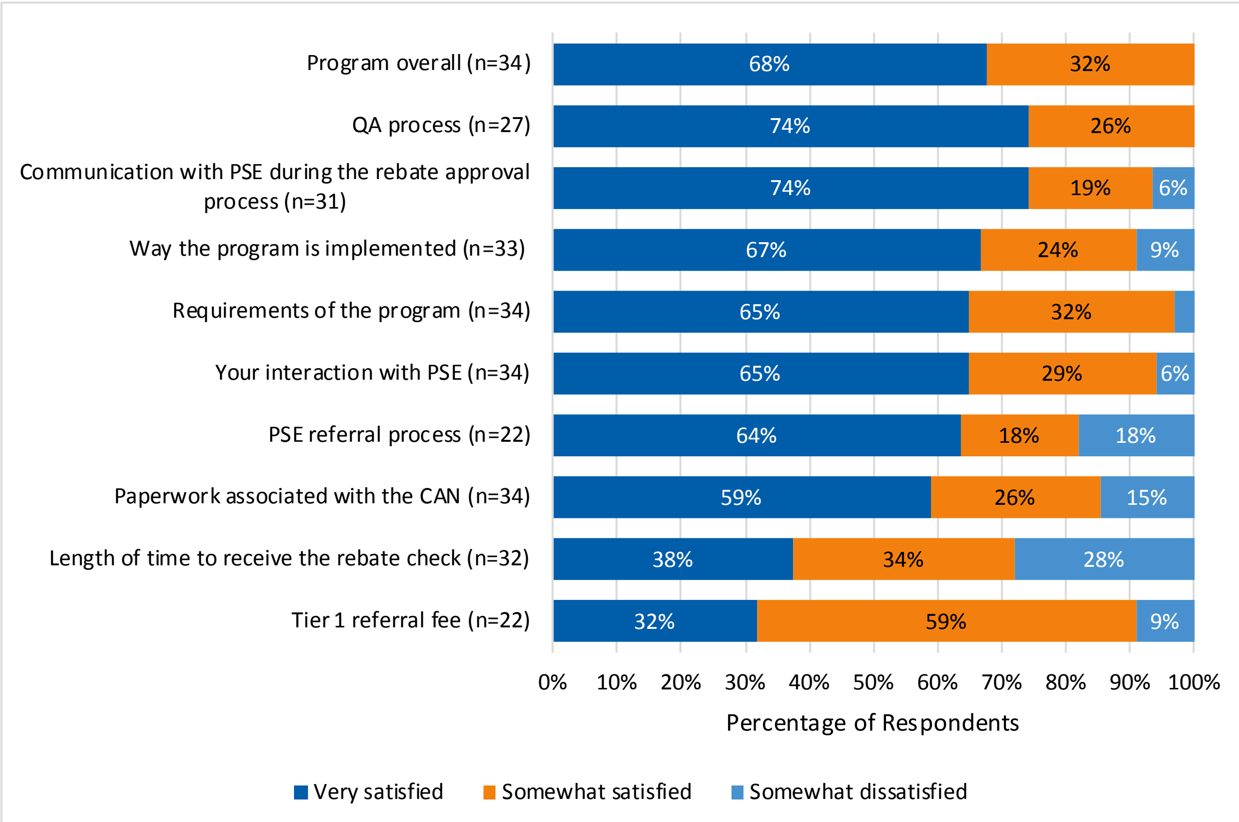
+Difference between weatherization and space heating and windows is significant (p≤0.10).

Active Contractor Experience

Program Satisfaction

All active contractors interviewed were *very* or *somewhat satisfied* with the programs overall. They did indicate some dissatisfaction, however, with various administrative aspects of CAN membership and the referral process. Figure 9 details their responses to these questions. Notably, all contractors reported satisfaction with the overall program. Similar to customer respondents, contractors cited the highest dissatisfaction with rebate processing time.

Figure 9. Active Contractor Program Satisfaction



Source: Interview question, "Using the scale very satisfied, somewhat satisfied, somewhat dissatisfied, or very dissatisfied, please tell me how satisfied you are with the following items regarding your participation in the CAN." While all 35 active contractors were asked the satisfaction questions, the number of responses vary as "don't know" responses are not included and only Tier 1 contractors were asked the two questions regarding the Tier 1 referral process and fee.

Program Concerns

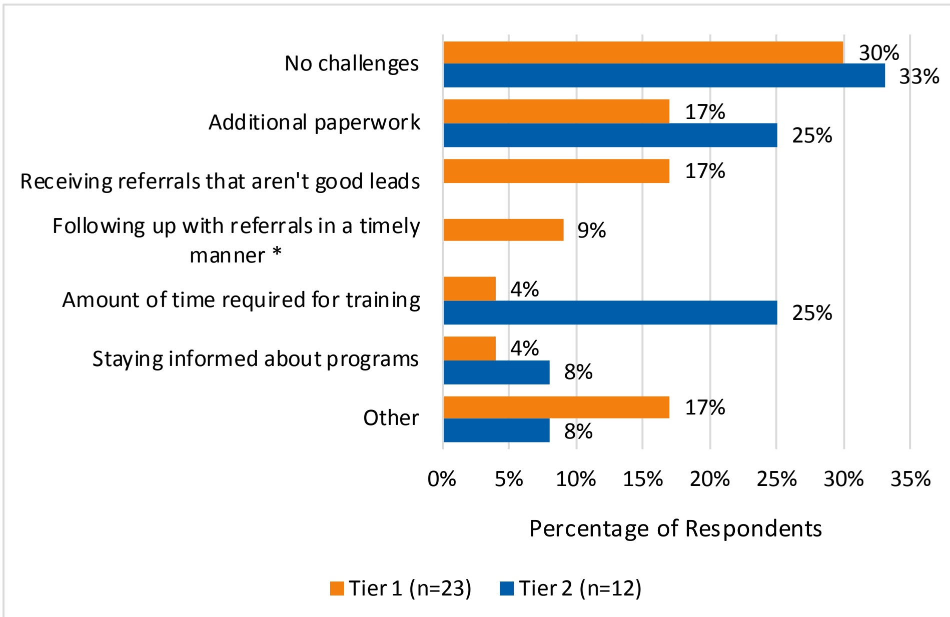
Eighteen percent of Tier 1 CAN members surveyed indicated they were *somewhat dissatisfied* with the referral process; when asked for additional comments at the close of the survey, two contractors[22] specified concerns about the referral system and fee. Both contractors said PSE's 6% referral fee was too high and one suggested that 3% would be more reasonable. Both contractors also expressed concern that PSE was charging a referral fee for jobs they had sold before their customers contacted PSE. One contractor explained that some of their existing customers "call PSE just to confirm rebates [and] get put into referral system." The other contractor said they recently switched to Tier 2 because they "were getting referrals on jobs that [they] had already…bid and sold."

[22] One was a Tier 1 contractor and one was a Tier 2 contractor.

Participation Barriers

Cadmus asked active contractors what the main challenges were with being a part of the CAN. Figure 10 details their responses. The challenges most frequently mentioned by Tier 2 contractors were additional paperwork and the amount of time required for training. Notably, 17% of Tier 1 contractors mentioned receiving referrals that are not good leads.

Figure 10. Active Contractors' Challenges with the CAN



Source: Survey question, "What do you think are the main challenges with being part of the CAN?" (n=34).
* Tier 2 contractors do not receive referrals so did not identify this as a challenge

Motivation and Impact

Cadmus asked active contractors what motivated them to participate in the CAN. The top three reasons were referrals, rebates, and increased sales, each of which was cited as a motivation by 7 out of 28 respondents.

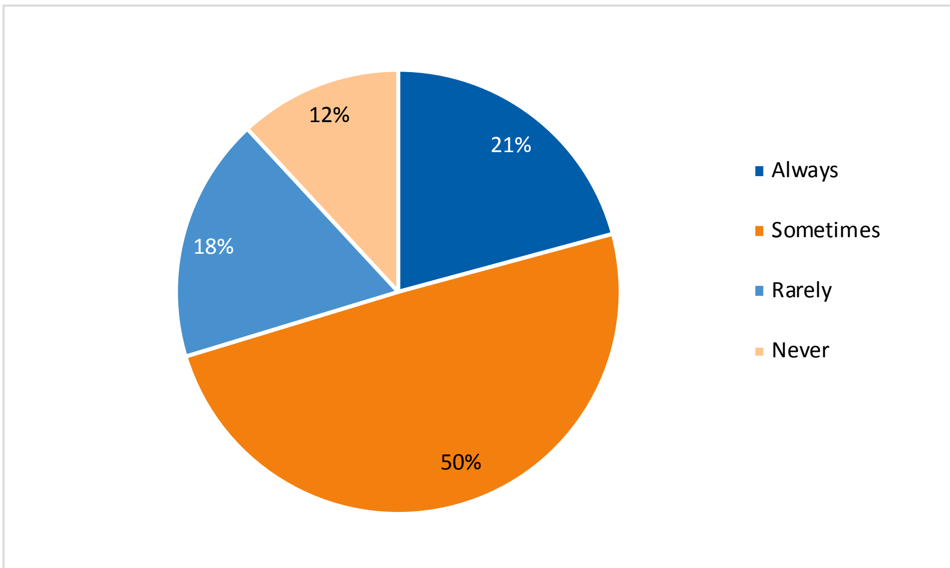
Cadmus also asked active contractors about the impact CAN participation had on their sales and the number of employees in their company. Eighty-six percent (n=35) of active contractors said their sales increased as a result of participating in the CAN, while 11% said their sales had stayed the same, and one contractor said sales decreased. Additional information about the impact of the program on sales is in Appendix F. Additional Contractor Findings.

When asked if the number of employees in their business had changed as a result of participating in the CAN, 60% (n=35) of contractors reported no change in number of employees, 37% reported an increase in number of employees, and one contractor reported a decrease in their number of employees. This was the same contractor who reported a decrease in sales. Of the 13 people who reported an increase in the number of employees, 12 also reported an increase in sales.

Contractor Recommendation

Figure 11 summarizes responses regarding how often active contractors encouraged customers to install additional PSE program-eligible equipment (not including equipment customers initially contacted contractors about). Only 21% of these contractors made these recommendations consistently, while approximately 30% either never or rarely made these recommendations, suggesting the potential for lost opportunity to influence these captive customers.

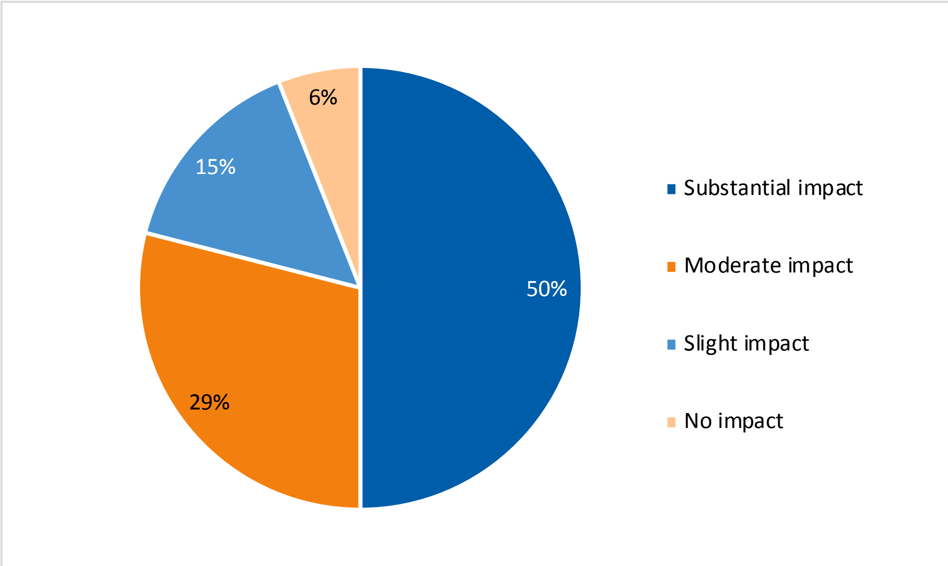
Figure 11. How Often Active Contractors Encourage Customers to Install Additional Program-Eligible Equipment



Source: Survey question, "How often do you encourage customers to install additional PSE eligible energy efficiency equipment--would you say always, sometimes, rarely or never?" (n=34).

As shown in Figure 12, approximately 93% active contractors felt PSE rebates had an impact on their customers' decisions to install energy-efficient equipment.

Figure 12. Impact of Rebate on Customer Decision-Making

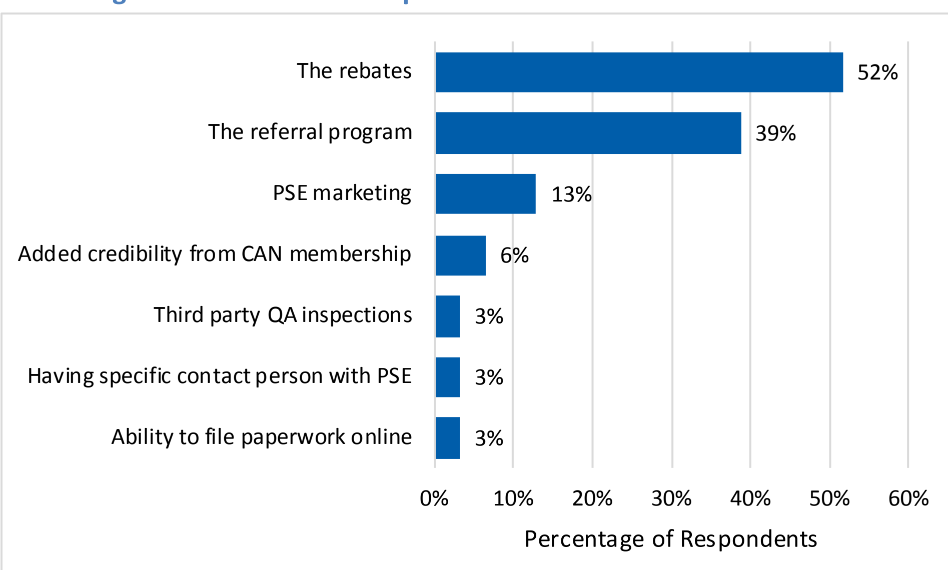


Source: Survey question, "What impact do the PSE rebates have on residential customer's decisions to install energy efficient equipment?" (n=34).

Useful Aspects

As shown in Figure 13, active contractors said rebates (16 of 31) and the referral program (12 of 31) were the most useful aspects of the program. All four inactive contractors interviewed who had participated in the CAN said the PSE rebates were the most useful aspect of the CAN.

Figure 13. Most Useful Aspects of the CAN to Active Contractors



Source: Survey question, "What aspects of the CAN do you find the most useful to your business?" (n=31; multiple responses allowed; don't know responses removed).

Inactive Contractor Experience

Satisfaction

Cadmus asked four inactive contractors who had previously participated in the CAN about their satisfaction with PSE rebate programs. Three of the four said they were *somewhat satisfied* with the program overall and one said he was *somewhat dissatisfied*.

Cadmus asked inactive contractors what PSE could change about the CAN to make it easier for them to participate. Three inactive contractors made the following suggestions:

- Make sure there are "worthwhile referrals" for contractors
- Be more selective about who can join the CAN
- Follow the model of other regional utilities' rebate programs

Participation Barriers

Cadmus asked inactive contractors about the main challenges with being a part of the CAN. Two of the four inactive contractors who had participated in the CAN did not provide any challenges. One said the rebate amounts were small and that PSE "made a sales pitch but didn't follow through." This was the same contractor who was *somewhat dissatisfied* with the program. The other inactive contractors said they were confused by the rebate process and had difficulty inputting the details of their custom projects into the online system.

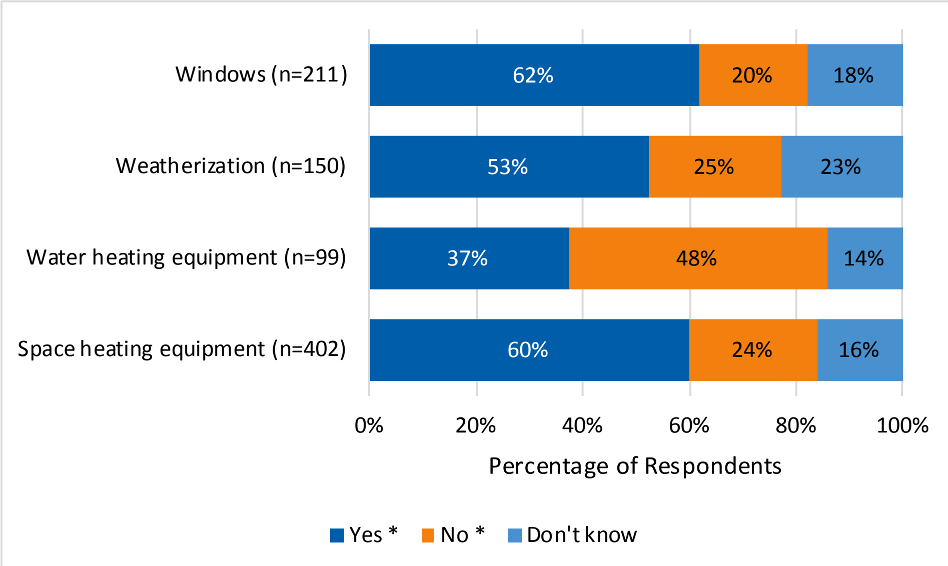
Additional findings from inactive and nonparticipating contractor interviews are found in Appendix G. Inactive and Nonparticipating Contractor Experience.

Impact of Improvements

Along with asking customers about program satisfaction, the survey asked participants about positive and negative impacts in addition to energy savings, as a result of the changes made to their homes.[23] A significantly smaller percentage of customers who installed water heating equipment (37%; n=99) said they noticed positive impacts compared to the other three equipment categories (Figure 14). While weatherization customers said they noticed fewer negative impacts than the other three equipment categories the differences were not significant (Figure 15).

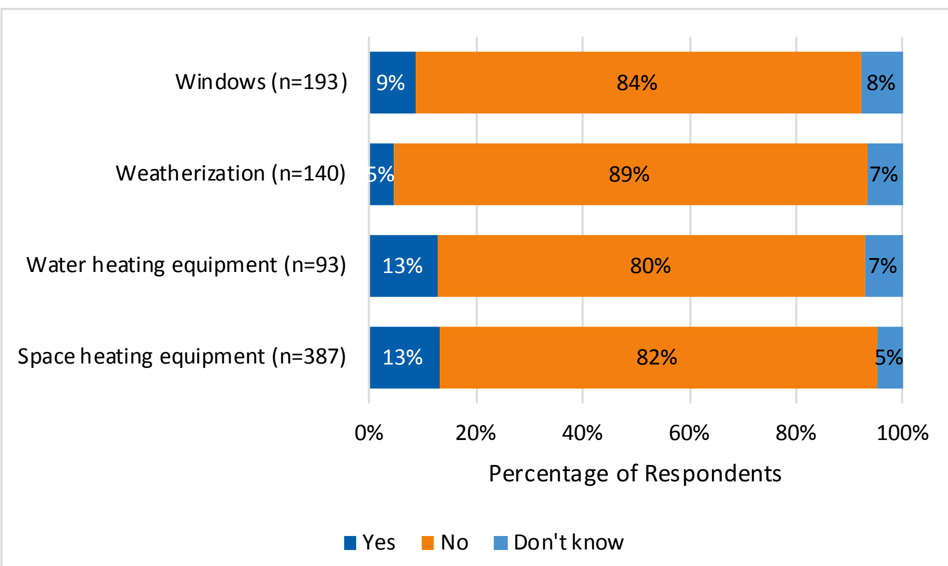
[23] The questions about positive and negative impacts were asked independently of each other.

Figure 14. Positive Impact of Improvements



Source: Survey question, "In addition to energy savings, have you noticed any other positive impacts resulting from the energy efficiency improvements made to your home? *The difference between water heating equipment and the other three equipment categories is significant (p≤0.10).

Figure 15. Negative Impact of Improvements



Source: Survey question, "Have you noticed any negative impacts resulting from the energy efficiency improvements made to your home?"

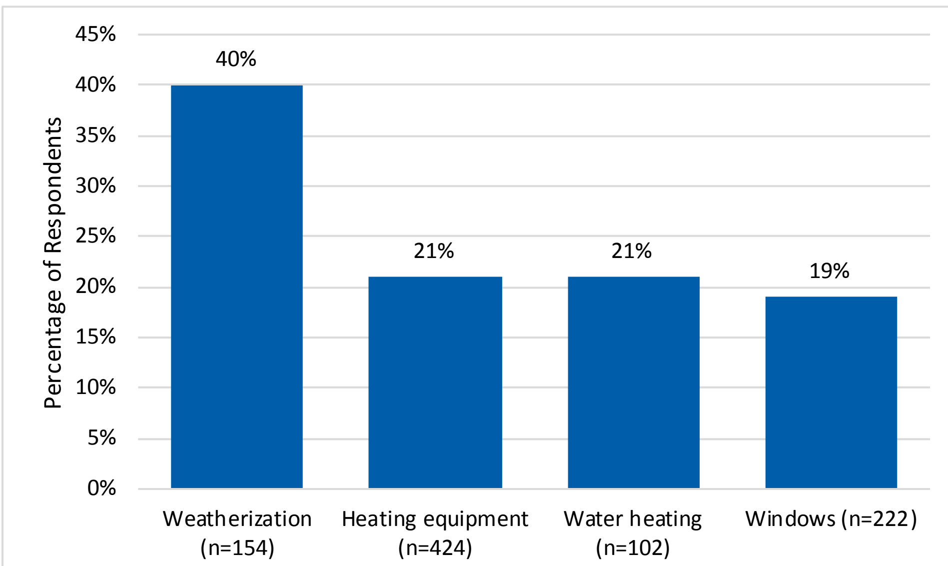
Of those who said they noticed positive impacts, the top two positive impacts are lower energy bills (27%) and increased comfort (24%).

Of the customers who stated they experienced negative impacts as a result of the improvements, 33% (n=91) said their energy bill increased and 16% said their home (or areas of their homes) were too hot or too cold. Of the 30 respondents who said their energy bill increased, 10 of them said they used heat pumps or DHPs to cool their homes. Eight of those 10 respondents said, before installation, they were either using fans to cool their home or were not using any cooling equipment at all. This may be a reason they noticed an increase in their energy bill after installing the new equipment.

Past Experience

The survey asked questions to assess participants' past experience with PSE's home energy audit programs. Twenty-four percent (n=902) of survey respondents reported they had participated in one of these programs (Figure 16). Moreover, those respondents receiving weatherization measures through the program were significantly more likely to report having participated in one of the programs.[24]

Figure 16. HEA Program Participation



Source. Survey question, "Have you ever participated in PSE's Home Energy Assessment or Homeprint programs?" (n=902)

Marketing and Outreach

The evaluation assessed how contractors and program participants learned about the program and how customers wanted to learn about program.

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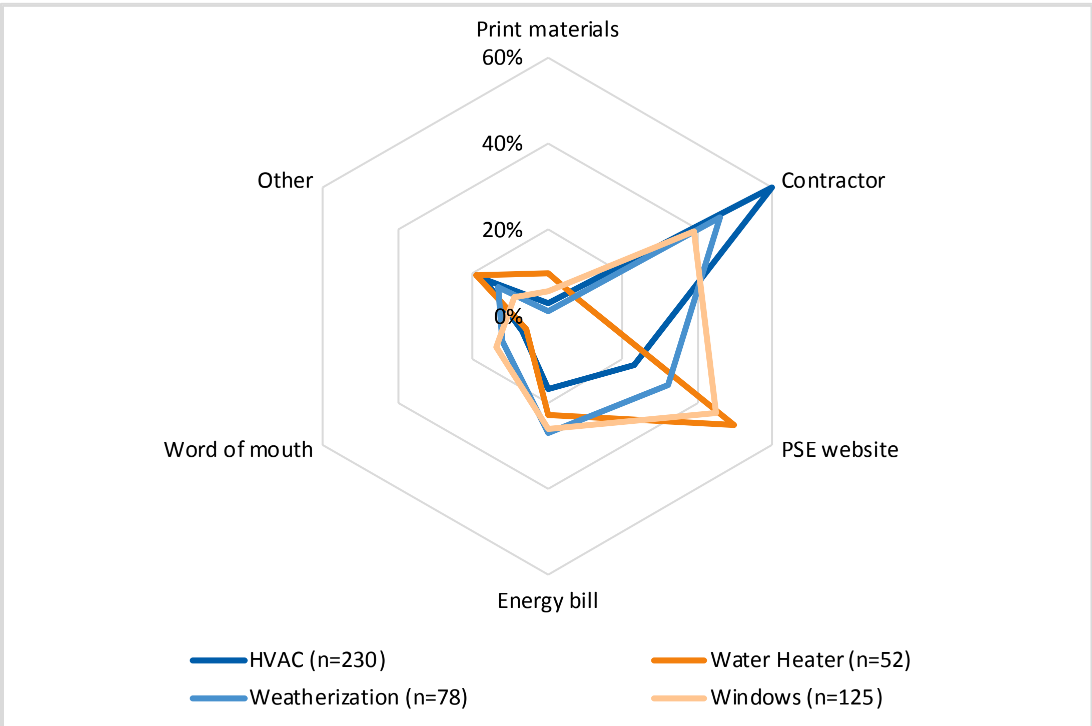
24 Cadmus used a t-test to compare proportions and means to determine if statistically significant differences exist between equipment groups. Cadmus tested at the 10% (p≤0.10) significance levels.

Customers

PSE program managers said customers learn about PSE rebates mainly from contractors and energy advisors. According to PSE program managers, well-informed and persuasive energy advisors are providing useful information to customers about program rebates and equipment.

Figure 17 lists the ways customers learned about the DC programs. Customer survey respondents most commonly learned about the program through their contractor (47%, n=485). Those respondents receiving Space Heat measures were significantly more likely to hear about the program from their contractor compared to the other three measure groups.[25] Respondents who installed water heaters and windows were significantly more likely to learn about the program from the PSE website than those who installed HVAC equipment or implemented weatherization improvements.[26] Additional differences between methods exist by measure type but they were not significant.

Figure 17. Respondents Methods of Learning About the Program



Source. Survey question, "How did you hear about the PSE rebate program?" (multiple responses allowed)

[25] Cadmus used a t-test to compare proportions and means to determine if statistically significant differences exist between equipment groups. Cadmus tested at the 5% (p≤0.05) significance levels.

[26] Cadmus used a t-test to compare proportions and means to determine if statistically significant differences exist between equipment groups. Cadmus tested at the 10% (p≤0.10) significance levels.

Results from contractor interviews reinforce the responses provided by the customers. Active contractors said customers learn about the program from contractors (85%; n=26) followed by PSE bill inserts (19%), PSE advertising (19%), and PSE website (8%).[27]

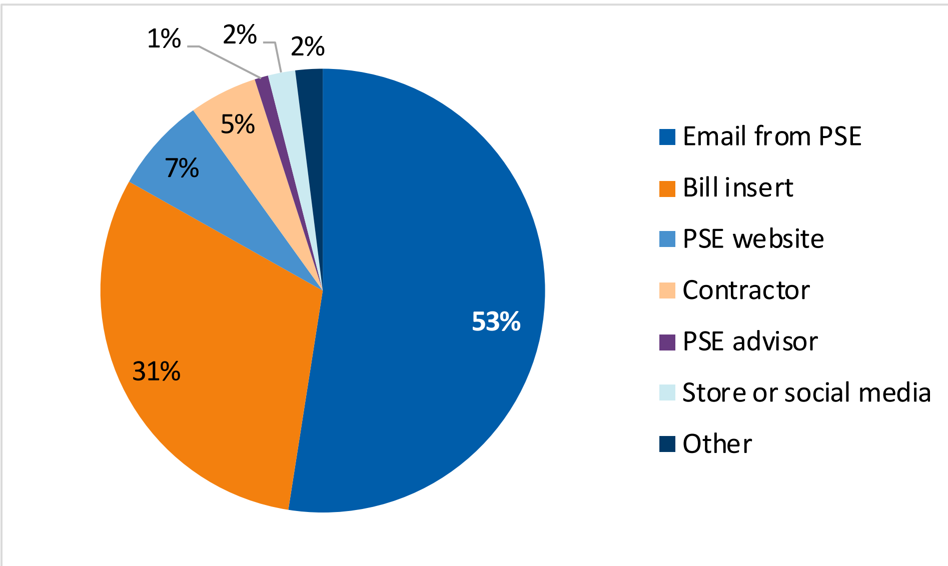
Contractors

Thirty-four percent (n=35) of active contractors said they could not remember how they learned about the program. Of the ones who did remember, 63% (n=22) said they first heard about the CAN through a PSE representative. Findings about how inactive contractors learned about the program are in Appendix G. Inactive and Nonparticipating Contractor Experience.

Future Communication

Fifty-three percent of customer survey respondents (n=497) said the best way for PSE to inform them about energy-efficiency programs in the future is via e-mails, and nearly one-third (31%) said through bill inserts (Figure 18). The preference for e-mail communication could be challenging if accurate e-mail addresses are not captured in the program tracking database.

Figure 18. Best Way for PSE to Inform Customers About Energy Efficiency Programs



Source: Survey question, "Please select the best way for PSE to inform you about energy-efficiency programs and rebates." (single response) (n=497)

Cadmus asked active contractors about the best way for PSE to alert their business about changes to PSE rebate programs and the CAN. The contractors were unanimous (33 out of 33) in responding that e-mail was the best way to provide this information to their business.

[27] Multiple responses allowed.

Marketing Materials

Fifty-seven percent (n=35) of active contractors do not use CAN branding in their marketing materials to advertise their business, 40% use CAN branding, and one contractor (3%) did not use CAN branding, but did use PSE branding in advertisements.

Cadmus asked active contractors about the impact that eligibility requirements had on the way they marketed PSE's rebate programs. Sixteen active contractors (59%; n=27) reported that PSE's eligibility requirements had impacted their marketing practices; seven of these 16 said they check customer eligibility before mentioning possible rebate opportunities.

Energy Education

Sixty-eight percent (n=387) of survey respondents learned about ways to save energy in their homes within the past six months. Thirty percent of these respondents (n=162) learned how to save energy through the internet, 26% learned from bill inserts or other PSE mailers, and 26% learned from printed ads or articles.

Customer Energy-Related Behavior Changes

Changes to Energy Consuming Equipment

Survey respondents were asked if they have changed anything else related to energy-efficiency in their home. Fourteen percent (n=314) have not made any changes. Fifty-one percent (n=314) of the respondents have added LED lights to their homes, while 15% said that they are using less energy in general, and 13% have installed efficient appliances.

Take Back

The customer survey was designed to identify take-back effects, including several questions about how the home was heated and cooled before and after the installation. These questions were answered by customers who installed windows, space heating equipment or weatherization products. The survey included questions about the temperature settings on their thermostat. As shown in Table 31, 58% (n=739, n=179) did not make any changes to the heating or cooling of their homes after installing windows, space heating equipment or making weatherization improvements, while 26% (n=739) decreased their heating temperature and 30% (n=174) increased their cooling temperature.

Table 31. Take Back Effect

Home Conditioning Type	Percentage Increasing Temperature	Percentage Decreasing Temperature	Percentage with No Change
Heating (n=739)	16%	26%	58%
Cooling (n=174)	30%	12%	58%

Source: Survey questions, "Please indicate the temperature you typically set your thermostat at for heating in the winter both BEFORE and AFTER you installed the new equipment." (n=739); and "Please indicate the temperature your typically set your thermostat at for cooling in the summer both BEFORE and AFTER you installed the new equipment." (n=174)

Suggested Program Improvements

Seventy-one percent (n=341) of survey respondents said there was nothing PSE could change to improve the program (Table 32).

Table 32. Respondents Ideas for Program Improvement

Improvement Idea	Percentage
No changes	71%
Larger rebate	7%
Better communication	7%
More savings from improvements	5%
Increased professionalism	4%
Faster response	3%
Other	4%

Source: Survey question, "What, if anything, could have been improved?" (n=341; total exceeds 100% due to rounding.

Cadmus asked active contractors for suggestions of ways PSE could change their rebate programs to make it easier for customers to participate. Three-quarters of the active contractors (75%; n=20) did not have any suggestions. The top three responses were to simplify or relax eligibility requirements (35%), increase rebate amounts (25%), and reintroduce rebates for double-pane aluminum windows (15%).[28]

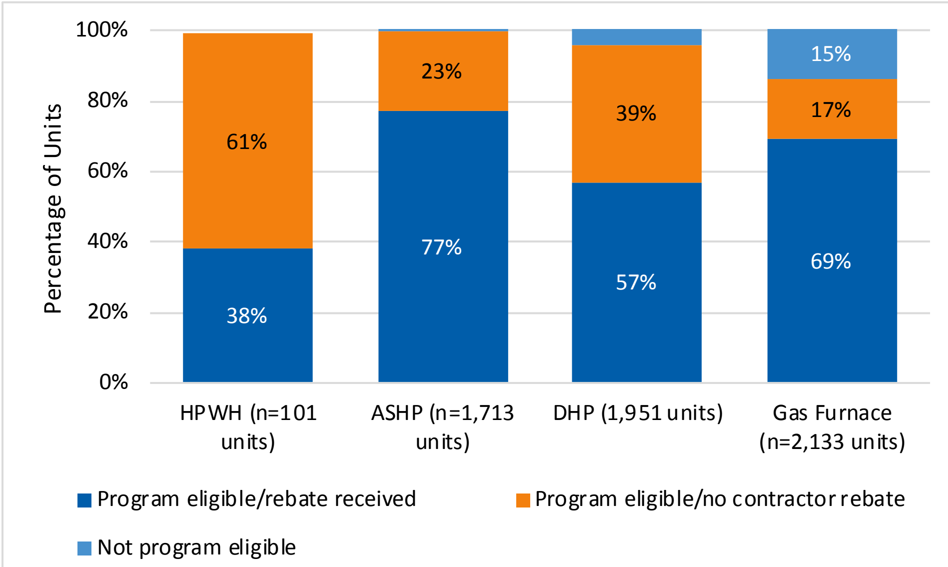
Program Equipment

Equipment Installed by Contractors

Cadmus asked active contractors about the equipment they installed and whether it was installed as part of the program or not. Figure 19 shows the percentage of equipment contractors installed eligible for a PSE rebate (program eligible/rebate received), the percentage eligible for a rebate but did not receive one from the contractor (program eligible/no contractor rebate), and the percentage of units not eligible for a rebate (not program eligible). Additional detail can be found in Appendix F. Additional Contractor Findings.

[28] Multiple responses allowed.

Figure 19. Installed Equipment



Source: Contractor online survey, Q's 3,4,6, and 7: "Please indicate the percentage of gas furnace units you install in each of the efficiency categories below and what percentage received a rebate through PSE?" Percentages do not total 100% due to rounding.

Market Trends

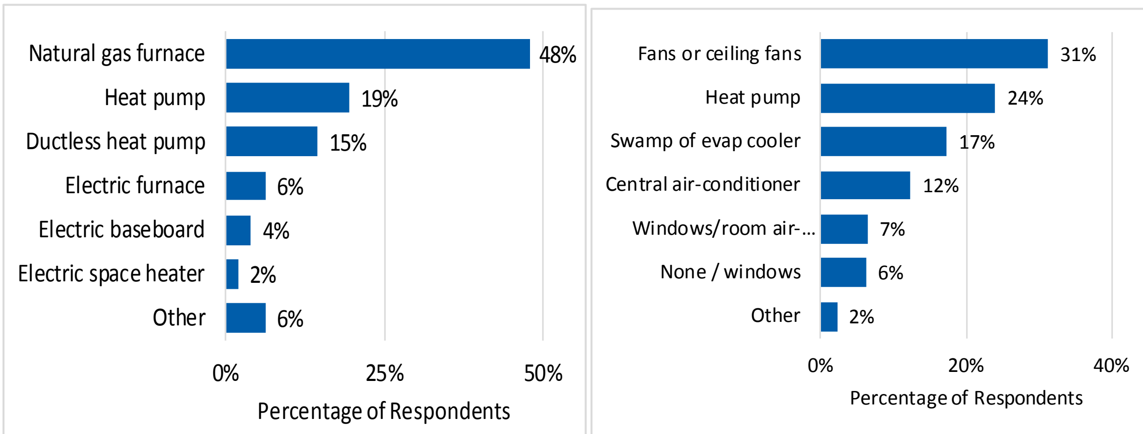
Contractors identified these trends or changes in the type of equipment they have installed:

- Space and water heating installation contractors (13 of 16) have not noticed customers switching from natural gas to electricity for space or water heating.
- Eleven of 20 window and weatherization contractors have noticed an increasing need among customers for weatherization and efficient windows.
- Contractors said PSE should consider adding solar PV (2 of 35), double paned aluminum windows (2 or 35), and inverter heat pumps to their program (2 of 35).
- Contractors suggested PSE add other technologies such as carbon dioxide HPWHs, solar hot water heaters, boilers, storm windows, ventilation controls, and other rebates for "super-efficient" homes (one response per measure) to their program.

Current Heating and Cooling Equipment

Figure 20 provides information about the heating and cooling equipment respondents use most often.

Figure 20. Heating and Cooling Equipment Used Most Often



Source: Participant survey questions: "Please indicate which of the following sources do you use most often to heat your home." (n=909); "Please indicate which of the following sources you use most often to cool your home" (n=826)

The survey asked customers how they are currently using the DHPs and heat pumps they installed through the DC programs. Ninety percent of customers who installed heat pumps and 85% of customers who installed DHPs are using the equipment for both heating and cooling.

Eighty-nine percent of customers (n=65) who installed heat pumps as part of the program use a backup heating system, and nearly half of these respondents (49%, n=65) use an existing backup heating system while 40% said they installed a new system at the same time as the heat pump.

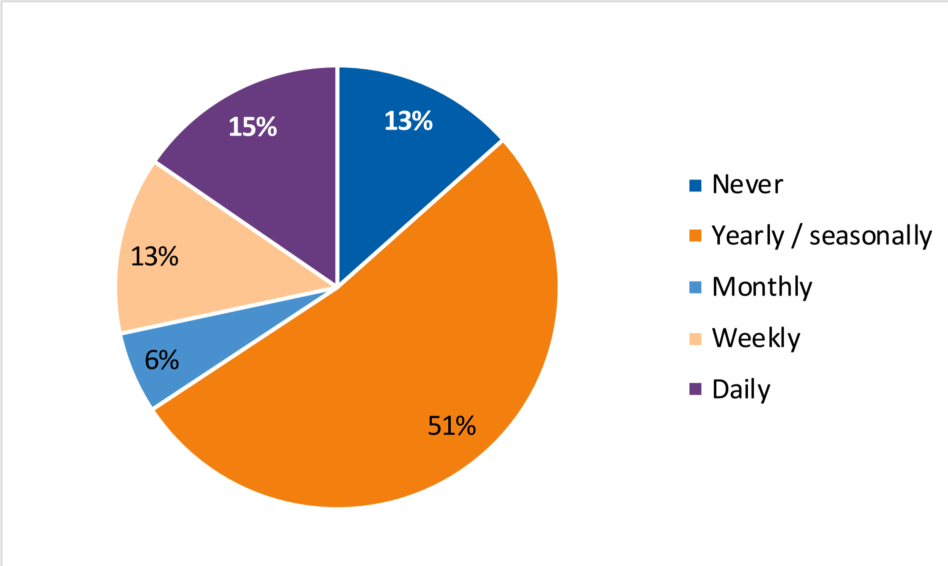
Thermostat Usage

Seventy-six percent (n=815) of the survey respondents indicated they had programmable thermostats installed in their home, while nearly one-fifth (19%) are using either smart or Wi-Fi-enabled thermostats.

Seventy-one percent (n=594) of respondents with programmable thermostats and respondents with smart or Wi-Fi-enabled thermostats (82%, n=144) are programming their thermostats.

Figure 21 shows the frequency survey respondents who have either a programmable, smart, or Wi-Fi-enabled thermostat manually change the temperature.

Figure 21. Frequency of Changing Temperature Manually



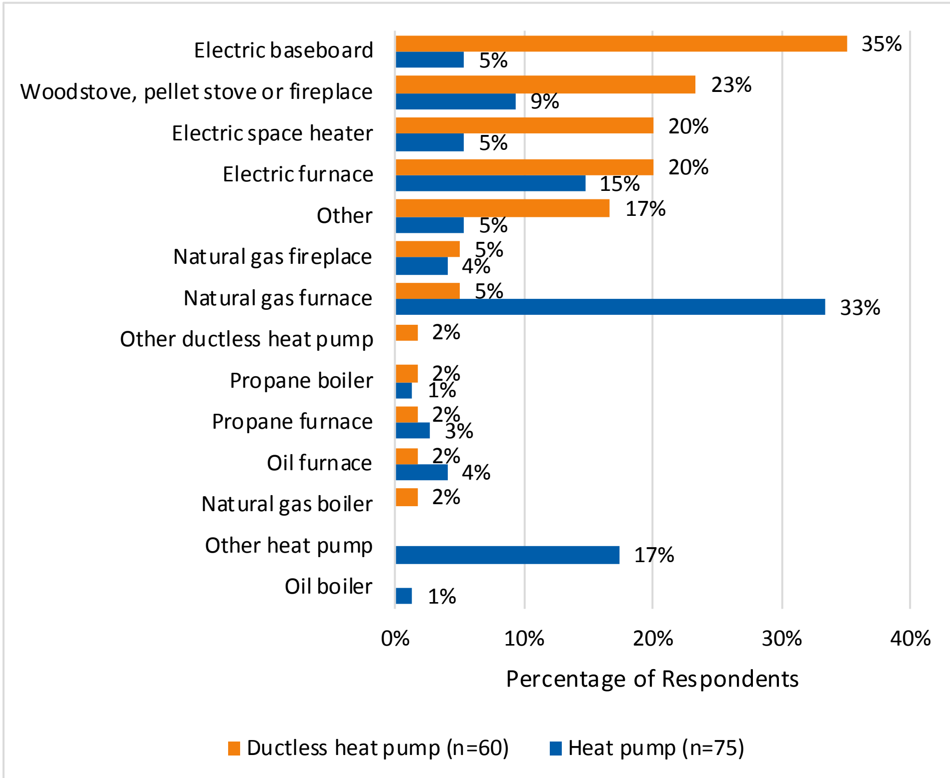
Source: Participant survey, "Since you participated in the program, how frequently do you manually change the temperature on your thermostat?" (n=678). Question for respondents with programmable or Wi-Fi-enabled thermostats.

More than half of the survey respondents who have a smart or Wi-Fi-enabled thermostat (55%, n=145) did not receive a rebate from PSE for the thermostat, 27% were not sure, and only 18% were sure that they did indeed receive a rebate from PSE for the thermostat.

Previous Heating Equipment

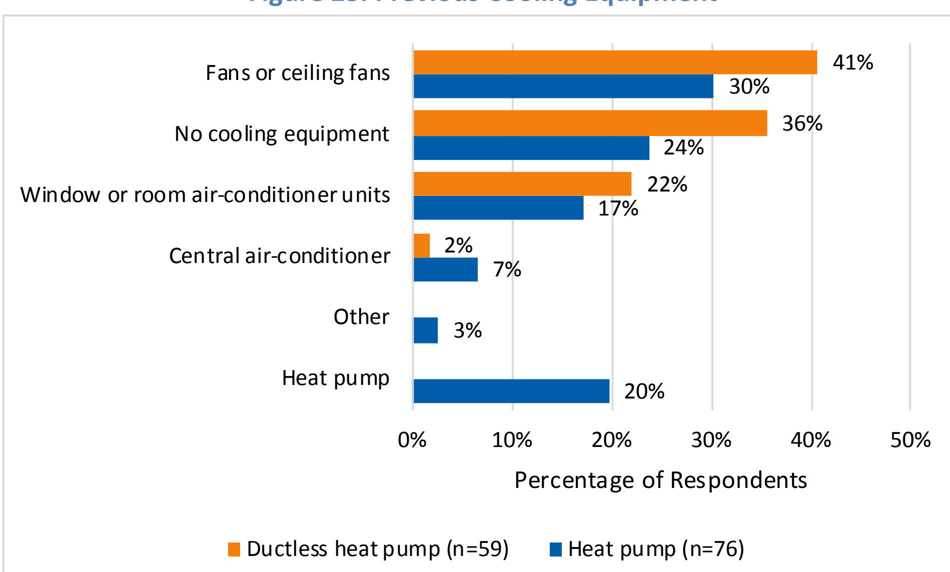
Figure 22 and Figure 23 show previous heating and cooling equipment for customers who installed DHPs and heat pumps through the DC programs.

Figure 22. Previous Heating Equipment



Source: Survey question, "Before you installed the new heating equipment, what heating system did you use most often in your home?" Multiple responses allowed.

Figure 23. Previous Cooling Equipment



Source: Survey question, "Before you installed the new equipment, how did you cool your home?" Multiple responses allowed.

Conclusions, Recommendations, and Considerations

This section summarizes key findings and conclusions, along with associated recommendations and suggestions for PSE's consideration.

Overall Performance

Conclusion: The DC programs met their overall 2015 energy savings goals, but fell short of gas reported savings. A billing analysis found that the three DC programs evaluated for this study achieved savings that met or surpassed PSE's 2015 savings targets,[29] with the exception of Space Heat gas savings. However, evaluated savings fell short of reported 2015 savings for two programs, with a 91% realization rate for Weatherization electric savings and an 82% realization rate for Space Heat gas savings. Table 33 provides the overall realization rates and evaluated savings as a percentage of annual savings targets, by program and fuel.

Table 33. Overall 2015 Program Performance

Measure/Program	Electric		Gas	
	Realization Rate	% of Target	Realization Rate	% of Target
Space Heat	106%	108%	82%	75%
Water Heat	119%	171%		
Weatherization	91%	122%	100%	127%
Overall	**103%**	**115%**	**92%**	**99%**

Three-year combined electric savings from the three DC programs evaluated were 94% of target (79% realization rate) and three-year gas savings were 66% of target (75% realization rate), with the electric shortfall driven primarily by weatherization. Table 34 provides a similar summary of realization rates and target achievement, by program and fuel for the 2013-2015 period.

Table 34. Overall 2013-2015 Program Performance

Measure/Program	Electric		Gas	
	Realization Rate	% of Target	Realization Rate	% of Target
Space Heat	93%	96%	78%	69%
Water Heat	133%	151%		
Weatherization	54%	81%	72%	63%
Overall	**79%**	**94%**	**75%**	**66%**

Conclusion: DC program participants experience a high level of program satisfaction. Ninety-six percent of participants reported being *very satisfied (73%)* or *somewhat satisfied (23%)* with the DC

[29] PSE energy savings targets are derived from the PSE *Annual Report of Energy Conservation Accomplishments* for 2013, 2014, and 2015.

programs. Respondents who received a water heater through the program reported the highest levels of satisfaction, with 88% saying they were *very satisfied* with the program. Although seventy-one percent of customers had no suggestions to improve the program, 7% suggested improving the program by offering a larger rebate and 7% suggested better communication.

Conclusion: Rebates are a primary motivator for program participation. Seventy percent of program participants identified rebates or discounts when asked what motivated them to participate in the PSE DC programs. Survey respondents also identified saving money on their utility bill (54%) and improved comfort (50%), and to a lesser degree environmental benefits (32%), as motivating factors.

> ***Suggestion for consideration: Given PSE plans to discontinue downstream space and water heating programs, closely monitor program participation and customer satisfaction for any impacts.*** As PSE changes this delivery model, Cadmus suggests performing additional research through contractor and participant surveys to assess perceptions of these changes.

Conclusion: Contractors, who are vital to the successful delivery of the DC programs, have experienced delivery challenges. PSE has taken some steps to resolve these challenges, but additional attention may be warranted. PSE program managers cited delivery challenges including contractor turnover, geographic delivery gaps for heat pump water heaters, and administrative burden associated with CAN participation. All active contractors interviewed for the evaluation were *very satisfied* or *somewhat satisfied* with the programs; however, they did indicate some dissatisfaction with various administrative aspects of CAN membership and the referral process. In particular, 28% reported being *somewhat dissatisfied* with the time it took to receive a rebate check, and 18% were *somewhat dissatisfied* with the referral system.

PSE is working to find and recruit additional HPWH contractors in regions where a shortage exists and to improve contractor satisfaction by engaging with contractors more frequently through quarterly contractor roundtable discussions and providing regular updates about program changes through e-mail. To address the administrative burden associated with having to use two different database portals—one to enter customer rebate information and one to check on training and other CAN requirements—PSE is upgrading to a new system where a single portal will serve both purposes. The new system will allow contractors to submit rebates electronically, do their own forecasting, and keep track of the requirements they need to maintain their status in the CAN.

> ***Suggestion for consideration: Conduct additional research with Tier 1 contractors to better understand perceived issues with the referral system.*** While 18% indicated dissatisfaction with the referral fee, two contractors expressed concern that PSE was charging a referral fee for jobs sold prior to contacting PSE (e.g., customers inadvertently being assigned as referrals when calling PSE to confirm rebate levels). Additional contractor outreach may help confirm this potential error and help assess and mitigate other perceived issues regarding the referral system.

> ***Suggestion for consideration: Track contractor retention and turnover by measure category and region.*** Since the current program is primarily focused on contractors and resellers, contractors are

vital to its success. Tracking retention and turnover will help PSE identify deficits early and on an ongoing basis and address them before they affect program performance. This is one of the metrics suggested as part of the KPI framework.

Planning, Savings Estimation, and Evaluability

Conclusion: A substantial proportion of program participants increased electric load as a result of the DC program. Among the program participants in the billing analysis sample, 63% of those who installed heat pumps, 39% of those who installed ductless heat pumps (DHPs), and 30% of those who installed HPWHs increased household electric load. For those households that are also PSE gas customers, gas consumption decreased by approximately 393 therms for customers who installed heat pumps and 224 therms for customers who installed DHPs.

Conclusion: There may be an opportunity for PSE to include an early retirement option in its program design. Billing analysis results indicate that a substantial proportion of DC participants replaced existing equipment that was less efficient than the assumed baseline corresponding to the reported savings approach. Although some participants' existing equipment may have been inoperable at the time of replacement (with savings appropriately determined using a market baseline), the participant survey indicated that a substantial proportion of participants replace existing equipment prior to burnout. Thus, an early retirement scenario could generate greater savings than would be estimated using standard or market baselines. Additional data are required to understand this potential and the portion of customers who are eligible for earlier retirement savings compared to time of replacement.

> ***Suggestion for consideration: Collect additional program information around equipment replacement to determine potential for early retirement measure replacement delivery option and opportunity for increased savings.*** If participants opt to install heat pumps and HPWHs prior to failure of existing equipment, there is an opportunity for PSE to claim additional savings associated with the remaining effective useful life of the existing equipment. Typically, early retirement programs for market-rate programs require discrete delivery design and data collection requirements to verify existing equipment is in operation at the time of replacement. At the time of this study, PSE did not actively track whether participants installed heat pumps or HPWHs prior to failure of existing equipment. There is an opportunity for PSE to begin tracking additional project information to verify whether these measures should allow additional savings associated with the remaining effective useful life of the existing equipment.

Conclusion: PSE improved the accuracy of reported savings estimates between 2013 and 2015. With the exception of Water Heat, all DC electric saving programs showed 2015 improvements in realization rates. A comparison of three-year (2013–2015) electric realization rates to 2015 electric realization rates show the following changes by program:

- ***Space Heat*** – from 93% to 106%
- ***Weatherization*** – from 54% to 91%
- ***Water Heat*** – from 133% to 119%

For the Weatherization program, this improvement is driven by both decreasing average reported savings for windows measures in 2015 (suggesting more accurate planning estimates) and by increasing average evaluated savings for weatherization measures (suggesting changes in delivery or measure performance).

The Weatherization program gas savings realization rate showed a similar pattern: 90% for the three-year period versus 120% in 2015. This improvement was primarily driven by decreasing average reported savings for windows measures in 2015 (suggesting more accurate planning estimates). Other weatherization measures show both increases in evaluated savings and decreases in reported savings (each contributing to an increase in realization rate).

Conclusion: PSE's savings estimation methods and input data are reasonably accurate; however, several measures have outdated planning assumptions, and opportunities exist to improve the accuracy of savings estimates. A detailed savings review revealed that unit energy savings (UES) values for shell, duct, heat pump water heater, and lockout controls measures relied on outdated RTF sources, and the fireplace measure contained incomplete documentation of savings sources. In addition, Cadmus identified an opportunity to improve the accuracy of the savings calculation approach for DHP, ground source heat pump (GSHP), furnace replacement, and fireplace measures.

Recommendation: Update UES values for several measures and revisit RTF-deemed savings estimates annually for revisions. Given RTF frequently updates energy-saving source documentation, PSE should revisit RTF-deemed savings estimates annually for any changes that may be relevant to delivery or design adjustments. Specifically, PSE should revise current UES savings estimates for: all shell measures (e.g., insulation, air sealing, and windows), duct sealing and insulation, HPWHs, GSHPs, and heat pump sizing and lockout control measures.

Recommendation: Provide complete documentation for fireplace savings calculations and consider adopting Cadmus' proposed calculation approach. The review of gas fireplaces measures did not support PSE's documented gas savings. Cadmus suggests PSE consider the calculation presented (showing documented assumptions, resulting in savings of 17.9 therms per unit).

Suggestion for consideration: Revise the approach, input assumptions, or available source documentation used in several RTF or PSE-deemed savings estimates. Consider taking the following actions related to measure savings calculations:

- Provide complete documentation for GSHP, update the savings using the most recent RTF workbooks (noted above), and collect additional project data to revise weighted input assumptions (noted below).
- Update the CFM per-watt input assumption ventilation fan estimates to reflect a more typical testing pressure.

Suggestion for consideration: Track additional equipment information for DHP, GSHP, heat pumps, and heating system replacement measures. The following information would support revisions to the listed savings estimates and evaluation research:

- **Nominal size of installed gas heating system replaced**. Uniform Method Project protocols recommend heating system size as a dependent variable to estimate energy savings for gas heating systems.
- **Type of heating system displaced or augmented by DHP.** The RTF shows a range of UES savings depending on the assumed heating system type. Although homes with electric zonal heating are generally good candidates for DHP retrofits, DHPs can displace a variety of heating system types. Using the actual heating system types will improve the accuracy of this savings estimate.
- **Nominal size and efficiency of installed air source heat pump.** Updated in 2015, the federal standard efficiency for air source heat pumps does not currently impact the market baseline, though we expect this may change in the near future. Collecting size and efficiency will allow for more thorough evaluation and accurate estimates if the RTF updates the market baseline.
- **GSHP installation details, including existing heating and cooling system types and whether de-superheater is installed.** Due to sensitivity in the current weighted input assumptions for existing equipment and home size, actual participant data on installation specifications will help to refine estimated savings.

Conclusion: The DC programs resulted in quantifiable non-energy benefits (NEBs). Cadmus confirmed monetized values for four distinct NEBs associated with program performance: economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits. Table 35 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

Table 35. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted
	Electric	Gas	
Participant Ancillary Benefits	$227		TRC, PCT
Economic Impacts	$786		TRC
Environmental – Avoided Compliance Costs	$28.66	$17.20	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$35.56	$21.34	PTRC

Recommendation: Include NEBs in program cost-effectiveness scenarios. A complete benefit and cost analysis considers not only direct financial costs and benefits experienced by an individual or firm, but also costs and benefits accruing to society as a whole (Boardman et al. 2006). Based on Cadmus' analyses and consistent with the *2016-2017 Biennial*

Conservation Plan,[30] PSE should run cost-effectiveness scenarios for DC that include consideration of NEBs values assessed through this study.

Conclusion: Customer contact information for the DC programs is not consistently captured. Cadmus found that program tracking data contained incomplete contact information for program participants; this presented challenges in drawing an e-mail survey sample from the participant population and potentially introduced bias.

Suggestion for consideration: To gather sufficient information from an evaluability perspective, collect complete contact information for all program participants (including names and e-mails). Complete contact information will ensure that customer outreach is not limited to a sample that only contains participants with available e-mail addresses within the program population, which has the potential to introduce bias.

30 PSE’s plan highlights moving to include NEBs for the majority of prescriptive measures using RTF UES values, either using RTF-calculated NEBs or those validated in evaluation research.

Future Work

Based on these evaluation results, Cadmus suggests that PSE consider the following activities for future research.

KPI Scorecard

Cadmus developed a KPI framework with recommended KPIs that PSE could use to continuously improve performance of DC programs over time (Table 28). Cadmus suggests that PSE review the framework and metrics with the appropriate management staff to determine which performance metrics it considers most important to measure over time. Once the scorecard metrics are finalized, Cadmus suggests that PSE collaborate with agencies to identify efficient ways to begin tracking KPIs to assess performance against goals.

Contractor Market Assessment

Cadmus suggests that PSE consider feature research aimed at better understanding the obstacles to contractor satisfaction to identify possible program implementation and design changes and in turn improve retention and decrease turnover. Cadmus recommends conducting a focus group or a facilitated round table discussion to gain nuanced insight into program design and delivery.

Opportunity Assessment and Efficient Targeting

Although the majority of savings for Space Heat, Water Heat, and Weatherization programs derive from midstream channels (contractor-direct installation), the HEA program serves as a point of entry for participation in these rebate programs and offers a rich source of audit data for eligible DC program participants. There is an opportunity to mine historical HEA audit data to identify measure recommendations and expected energy savings and to cross-check against DC rebates to identify the outstanding savings potential and opportunities for efficient targeting.

Depending on the granularity of the HEA tracking data, there may be several research options. If electronic data are captured on all recommendations, PSE can compare the proportion of savings installed through rebate programs to the recommended savings still available to PSE as potential savings. However, if specific audit recommendations have not been captured, at a minimum PSE can compare participants who have and have not installed equipment or shell improvements.

PSE could then use consumption data and home characteristics (e.g., square footage) to rank the participants who still have potential energy savings. For example, PSE could prioritize by high consumption households, expected household savings, or specific measures with outstanding recommendations. Further, these data can help inform participant targeting, outreach campaigns, or region-specific delivery strategies that consider both geographic trends and customer ranking (e.g., for energy saving potential or high consumption).

Targeting On-Site Savings Assessment

Although standard approaches to verification often involve selecting samples randomly from the participant population, PSE can gain additional insights on realization rate drivers by using a more targeted approach and taking advantage of the recent billing analysis to select participant based on their impacts.

The purpose of this research is to determine specific factors influencing the success of energy savings. Using consumption analysis results, the team can identify household-specific impacts, which allow specific targeting to assess on-site performance. Potential factors may include changes in participant behavior (e.g., take-back, effects of energy education, changes in occupancy), changes in household (e.g., remodel that alters the intended effect of efficiency measures), measurement error, contractor performance (e.g., quality of installation), or other factors that affect measure installation and savings persistence.

Given some uncertainty around clear realization rate drivers, this type of targeted assessment is a next step to firm up factors that contribute to performance and in considering changes to design or delivery to adopt program improvements.

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Appendix A. Methodology

Appendix A includes the methodology for each evaluation task included in Table 36.

Table 36. Evaluation Tasks

Area	Task
Impact: What did the programs achieve and was it done cost-effectively	Billing Analysis
	Savings Review
	NEBs: Economic Impacts
	NEBs: Environmental Impacts
	NEBs: Participant Impacts
Process: Were the programs delivered efficiently	Stakeholder Interviews
	Participant Survey
	Process Flow
	KPI Framework

Billing Analysis—Estimating Energy Savings

To estimate actual changes in energy consumption within participating homes, Cadmus performed a consumption analysis. This involved testing multiple model specifications for robustness, including combined fixed-effects models and individual, household-level, PRISM-like regressions. Using historical billing data from up to a year before and after participation, Cadmus assessed program-level and measure-level impacts associated with DC program installations to estimate electric and gas energy savings. The analysis period included participation from 2013, 2014, and 2015 program years. Cadmus used a comparison group (selected from late-2015 and 2016 participants) to control for exogenous factors that could have affected energy consumption during the 2013–2015 timeframe.

The industry considers regression-based consumption analysis as a best practice for estimating impacts associated with programs offering multiple measure installations (e.g., shell improvements, equipment replacement), as noted in the Uniform Methods Project.[31] The consumption analysis provided an estimate of the actual program impacts, controlling for interactive effects between measures as well as for changes in occupants or usage behaviors (e.g., takeback effect).

[31] National Renewable Energy Laboratory. *The Uniform Methods Project Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol*. "Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol." Prepared by Ken Agnew and Mimi Goldberg, DNV KEMA. April 2013. Available online: https://www1.eere.energy.gov/wip/pdfs/53827-8.pdf

Data Sources

Cadmus used the following data sources in performing the consumption analysis:

- ***Program tracking data*** for all electric and gas participants from January 2013 through July 2016. These data included participant names, contact information (e.g., addresses), unique customer identifiers, participation dates, and total PSE-reported savings estimates per participant. These data also included detailed measure information, such as measure names, descriptions, per-unit measure savings, and assumptions (e.g., quantities and efficiency levels) associated with PSE-deemed and RTF-savings calculations.
- ***Consumption data*** for DC participants, provided by PSE and for electric and gas usage at the monthly billing level. These data included monthly readings of electricity and gas consumption, by participant account, from January 2012 through December 2016.
- ***Washington weather data***, including daily average temperatures from January 2012 through December 2016 for 15 Weather Bureau Army Navy weather stations. Cadmus used zip codes to match daily heating and cooling degree days to respective monthly bill read dates. Cadmus obtained TMY3 (typical meteorological year), 15-year normal weather values from 1991 to 2005 from the National Oceanic and Atmospheric Administration, and used these to assess energy use under normal weather conditions.

Participant and Comparison Group Designation

Cadmus gathered data from a participant (treatment) group composed of DC program customers who had measures installed between January 1, 2013, and October 31, 2015.

To isolate the impact of exogenous factors (e.g., rate changes, economic conditions changes, non-programmatic effects) on energy use, Cadmus utilized a quasi-experimental design, involving selection of a comparison group composed of participants with installation dates from November 2015 through 2016. Using this approach, pre- and post-changes in the treatment group's energy use (assumed due to program treatment) were compared to the comparison group's changes in energy use (reflecting what would have happened in the program absence). For this design to succeed, the two groups had to be very similar, on average.

To ensure this similarity, Cadmus opted to use future participants (late PY2015 through PY2016, outside of the analysis period) as the comparison group; they would have similar income qualifications and could be assumed not to have participated in energy efficiency prior to program treatment.

Final Treatment and Comparison Samples

Cadmus started with a census of participants, and filtered out those who did not pass certain validation or data requirements. Table 37 provides the final analysis samples for each year, compared to the original population for participant and comparison groups overall.

Table 37. Final Treatment and Comparison Groups

Fuel	Year	DC Programs		
		Model (n)	Population	% Remaining
Electric	2013	3,102	5,171	60%
	2014	3,503	5,509	64%
	2015	2,796	4,513	62%
	Treatment Total	**9,401**	**15,193**	**62%**
	Comparison Total	**2,412**	**4,239**	**57%**
Gas	2013	3,968	9,221	43%
	2014	6,337	9,980	63%
	2015	4,214	7,106	59%
	Treatment Total	**14,519**	**26,307**	**55%**
	Comparison Total	**4,248**	**6,849**	**62%**

Savings Calculation

To estimate program-level impacts, Cadmus employed pre- and post-installation savings analysis using two distinct modeling approaches: household-level PRISM models; and the combined fixed-effects modeling method using pooled, daily time-series (panel) billing data. Both approaches accounted for differences in pre- and post-installation weather conditions. The fixed-effects modeling approach also corrected for differences in usage consumption between participants. Fixed-effects and PRISM estimates produced nearly identical model savings and precision values at the program and measure-category levels.

Given complexities of running measure-level fixed-effects models (see Appendix C. Model Specification), this report presents measure-category and measure-level results using the combined fixed-effects models, and relies on PRISM to produce additional savings summaries, such as measure-category level savings percentages by usage quartile.[32]

Cadmus derived gross energy savings using the following equation to adjust evaluated participant savings, based on changes in the comparison group's energy use. This adjustment accounted for exogenous factors occurring outside of the program effect (i.e., all terms in the equation were

[32] For these summaries, to aggregate impacts to the four distinct measure categories, Cadmus used PRISM estimates for participants only receiving single measure installations in isolation. This ensured evaluated savings estimates only accounted for impacts for an individual measure, rather than measures installed in combination (potentially across category groupings). Measure-level savings estimates were then weighted up to the category level and summarized accordingly. Total sample sizes for these PRISM summaries are less than the total analysis samples used in the fixed effects models, as only participants with single measure installations (installed in isolation) are included.[33] This estimate reflects the degraded performance of an 18-year old 6.8 HSFP heat pump, at 1.4% degradation per year to estimate current HSPF.

averages). This approach was similar to a straight difference-in-difference approach, but accounted for potential distinctions between each groups' average annual weather-normalized pre-treatment usage:

$$Adj.\,Gross\ Savings = (Pre\ Usage_{Treat.})\left(\frac{Change\ In\ Usage_{Treat.}}{Pre\ Usage_{Treat.}} - \frac{Change\ In\ Usage_{Comp.}}{Pre\ Usage_{Comp.}}\right)$$

Regression Models

Cadmus developed different models for use in estimating energy and demand impacts (see Appendix C. Model Specification for additional detail). Ultimately, Cadmus selected estimates from the most robust models for final reporting:

- ***Household-level PRISM models.*** Cadmus ran individual customer regression models comparing weather-normalized consumption, pre- and post-measure installation, then averaged the results across the sample to determine savings impacts by measure category, as well as additional summaries (e.g., isolated measure installations, savings by usage quartile).
- ***Combined fixed-effects models.*** Cadmus ran fixed-effects models, which controlled for household-specific factors (e.g., home size and age, participant demographics) that did not vary over time. This approach accounted for preexisting differences in energy use between homes. Unlike PRISM models constructed for each home individually, the fixed-effects models used entire samples of participants and nonparticipants. Program level as well as measure category impacts were also estimated using the fixed effects models.

Equipment Baseline Adjustments

Billing analysis results characterize the program impacts based on the existing conditions before installation. However for some measures, existing conditions do not reflect the appropriate baseline needed to remain consistent with PSE's program design and planning assumptions. Cadmus developed adjustment factors for several equipment measure categories to determine the incremental impacts from the program baseline, which ensures consistency between modeled savings and reported savings values. The approach is similar to interpolation, by comparing the expected existing efficiency of the equipment to the installed efficiency and program baseline efficiency (η indicating efficiency):

$$Savings\ Adjustement\ Factor\ = \frac{Existing\ Basline\ \eta}{Program\ Baseline\ \eta}\left(\frac{Installed\ \eta - Program\ Baseline\ \eta}{Installed\ \eta\ - Existing\ Baseline\ \eta}\right)$$

Table 32 provides a list of specific equipment measures where baseline adjustments merited consideration. Based on assumptions regarding existing baseline compared to the program-assumed baseline (consistent with PSE savings sources), Cadmus identified three measures to which this adjustment applies: HPs, HPWHs, and electric water heater replacement.

Table 38. Baseline Adjustment Factors by Measure and Fuel

Fuel	Measure	n	Units	Average Baseline Efficiency		Average Installed Efficiency	Savings Adjustment Factor
				Existing	Program		
Electric	DHP*	1,503	HSPF	3.4†	3.4†	10.0†	1.00
	Heat Pump	1,378	HSPF	6.1**	8.5†	9.5†	0.21
	Heat Pump Sizing and Lockout Controls*	537	Units	1.0*	1.0*	1.0†	1.00
	Geothermal Heat Pump*	14	HSPF	3.4*	3.4*	10.0†	1.00
	HPWH	822	EF	0.87‡‡	0.94†	1.29‡	0.77
	Water Heat Replacement	149	EF	0.87‡‡	0.94†	0.96†	0.21
Gas	Heating System Replacement*	7,404	AFUE	0.80†	0.80†	0.96†	1.00
	Fireplace	1,163	EF	N/A	N/A	0.71†	N/A
	Integrated Space Water Heat*	95	AFUE	0.80†	0.80†	0.95†	1.00

* Assuming same baseline efficiencies between existing conditions occurring in the billing analysis sample and engineering assumptions used in reported savings.

** Degraded performance of an 18-year-old heat pump, originally at 6.8 HSPF assuming 1.4% degradation in performance per year

† PSE/RTF Savings Approach – assumed baseline or installed efficiency

‡ Adapted efficiency based on PSE savings approach and reflecting installed efficiency tiers weighted by program tracking data

‡‡ Pre-2006 Federal Standard

For heat pump installations, the PSE savings estimate assumes a market baseline of 8.5 HSPF, while existing conditions for households in the analysis sample may range from existing lower efficiency heat pumps to electric resistance. Given an unknown distribution of existing equipment and the associated efficiency, Cadmus assumed an average of 6.1 HSFP, which is the average between 5.3 HSFP[33] heat pump and 6.8 HSPF (federal standard prior to 2006).

For HPWH and electric water heater replacement installations, Cadmus assumed existing conditions were a legacy electric 40-50-gallon water heater with 0.87 EF (federal standard prior to 2006). The program assumes a 0.94 EF[34] baseline with the measure upgrading to tank style water heaters or HPWH.

Fireplace installations could not be properly modeled using the pre/post billing analysis, due to inability to capture the savings by considering the difference in usage before the installation. New measures are not replacing existing fireplaces; rather, the DC program provides an incentive for customers to select a

[33] This estimate reflects the degraded performance of an 18-year old 6.8 HSFP heat pump, at 1.4% degradation per year to estimate current HSPF.

[34] The RTF market baseline for electric water heaters

higher efficient fireplace, with the assumption that energy savings occur relative to the counterfactual (i.e., purchase of as less efficient fireplace). For this reason, Cadmus applied 17.9 therms as the evaluated savings estimate for fireplace installations for any summaries of billing analysis savings for the Space Heat category. This estimate was based on the engineering review (see Appendix D. Savings Review Details for more information).

Data Screening

Starting with a census of participants for treatment and comparison groups, Cadmus identified the final analysis samples after cleaning the data and screening for several criteria, noted below. Cadmus conducted the consumption analysis using participants who had not moved since participation and who had at least 10 months of pre- and post-period billing data. Cadmus performed account-level reviews of all individual-participant pre- and post-period monthly consumption to identify anomalies (e.g., periods of unoccupied units) that could bias the results.

Cadmus used the following screenings to remove anomalies, incomplete records, and outlier accounts:

- Inability to merge the participant program tracking data with the consumption data (e.g., missing records or accounts).
- Insufficient consumption data for accounts with fewer than 300 days (i.e., approximately 10 months) of use data in the pre- or post-period.
- Accounts that changed electric use from the pre- to post-period by more than 70%. Rather than program effects, usage changes of this magnitude likely resulted from vacancies, home remodeling or additions, seasonal occupation, or fuel switching.
- Accounts with low annual use in the pre- or post-period (e.g., less than 1,200 kWh or 150 therms).[35]
- Customer with the wrong signs on PRISM parameter estimates.
- Customers for whom the Technical Reference Manual (TRM) savings estimate exceeded pre-period use or where the TRM savings estimate was less than 1% of the pre-period use.
- Customers who participated in another program.
- Other anomalous values, including vacancies in billing data (outliers), heating or cooling system changes (e.g., adding or removing heating or cooling loads), baseload equipment changes, or changes in occupancy.[36] This included screening for accounts with large gaps in interval data (i.e., zero consumption across months, distinct from missing values).

[35] Average households used approximately 1,475 kWh and 73 therms each month. Therefore, annual use of less than 1,200 kWh would be very low for residential households in Washington.

[36] Baseload changes could include adding or removing appliances (e.g., refrigerator, water heater) or changes in occupancy; in either case, this could complicate analysis for distinguishing program effects.

Model Attrition

After matching participants with consumption data and applying all screens, Cadmus derived the final analysis samples by program and fuel, as shown in Table 37 (see Appendix B. Model Attrition Summary for additional detail). The main sources of attrition were driven by the following:

- An insufficient number of months of pre- and/or post-period usage data
- Outliers screened through account-level inspections of pre-and post-period 12-month usage

Measure Distribution of Final Analysis Sample

Table 39 shows the frequency distribution of measure installations occurring in the overall (2013–2015) participant analysis samples, along with average reported savings per measure type. This detail level provided context for understanding the model results. Additionally, tables comparing measure distributions between the analysis sample and program populations were important in demonstrating that, despite participant screening, the sample sufficiently reflected the population's measure mix and did not appear biased.

Table 39. Measure Distributions of Final Treatment Samples, by Fuel

Category	Measure	Electric			Gas		
		% of Sample	% of Pop.	Avg. Reported Savings (kWh)	% of Sample	% of Pop.	Avg. Reported Savings (Therms)
Space Heat	Heating Sys Replacement	n/a	n/a	n/a	51%	46%	111
	Fireplace	n/a	n/a	n/a	8%	9%	75
	Duct Sealing and Insulation	2%	3%	1,837	13%	16%	75
	Heat Pump	39%	33%	655	n/a	n/a	n/a
	GSHP	>1%	>1%	4,037	n/a	n/a	n/a
	HP Sizing and Lockout Controls	9%	8%	1,370	n/a	n/a	n/a
	DHP	26%	25%	3,268	n/a	n/a	n/a
	Ventilation	>1%	>1%	101	n/a	n/a	n/a
	Int. Space Water Heat	n/a	n/a	n/a	1%	1%	173
Shell	Air Sealing	1%	1%	1,203	1%	1%	74
	Ceiling Insulation	3%	6%	1,869	10%	14%	116
	Floor Insulation	4%	7%	1,291	11%	15%	71
	Wall Insulation	1%	1%	1,047	3%	5%	75
	Windows	19%	22%	1,984	21%	19%	101
Water Heat	HE WH Replacement	2%	4%	144	n/a	n/a	n/a
	HPWH Replacement	13%	11%	1,235	n/a	n/a	n/a
Sample (n)		**9,401**	**15,193**	**2,073**	**14,519**	**26,307**	**124**

Savings Review

Cadmus performed a comprehensive review of major measures delivered through PSE's DC program. In discussions with PSE and through summarizing program tracking data, Cadmus identified priority measures that contributed to a large proportion of program savings or proved of strategic importance to

PSE program managers. Reported energy savings estimates in the tracking system were derived from the RTF methodology directly or had been adapted by PSE (i.e., informed by RTF, regional studies, or past evaluations).

In performing this review, Cadmus relied on the following data (see References for full list of sources):

- Regional measure-specific and evaluation studies, and research Cadmus performed specific to Washington-state deemed savings algorithms
- Data collected through the participant survey and stakeholder interviews
- State TRMs providing measure-level savings estimates
- Results from Cadmus' RTF measure review for PSE's single-family weatherization program, which analyzed savings estimates using simulation modeling and billing analysis

In this review, Cadmus performed the following research steps:

- **Identify DC measure offerings.** Cadmus reviewed PSE source of savings workbooks, outlining current measure names, descriptions UES values, and date of adoption. Cadmus then cross-referenced measures to the participant tracking data to determine measures for the 2013-2015 period.
- **Review PSE measure source documentation.** Cadmus reviewed savings documentation provided by PSE for DC measures, including: RTF workbooks, PSE markups on RTF workbooks, PSE deemed savings workbooks (based on business cases and prior evaluation studies). Where source documentation indicated using RTF values, Cadmus attempted to verify the RTF source directly; however, in some cases the material was unavailable from the current RTF website or Cadmus RTF data archives. In those cases, Cadmus reviewed whether the available data were reasonable through benchmarking and secondary sources.
- **Benchmark UES data.** Where the RTF source changed compared to the version sourced in PSE's documentation, Cadmus reviewed those changes to determine if values warranted updates to align with the most current RTF sources. For these instances, Cadmus reviewed archived RTF sources (if available), and benchmarked against secondary sources for additional context.
- **Provide recommendations and considerations.** Where Cadmus found outdated UES values or more relevant sources available, Cadmus provided recommendation and considerations to update UES values or revise estimate approach where appropriate.

Non-Energy Benefits Assessment

Table 40 lists the key NEBs analyses Cadmus will perform for each program, with more detailed discussion of each type of analysis provided below.

Table 40. Non-Energy-Benefit Tasks

Tasks	Description
Economic Impacts	Using input/output modeling tools (e.g., IMPLAN), Cadmus estimated economic and employment impacts associated with investment of program dollars and the flow of these dollars throughout different local markets.
Environmental Impacts	This assessment explored environmental impacts associated from reduced emissions from offsetting generation, in terms of both societal benefits and in reduced compliance costs.
Ancillary Participant Benefits	Employing responses from the participant phone survey, Cadmus used a hybrid contingent/relative valuation research approach to monetize specific participant benefits attributed to program effects (e.g., increased comfort).

Economic Impact Analysis

The following sections describe the IMPLAN model, model inputs and outputs, and model scenarios used to determine gross and net impacts.

The IMPLAN Model

IMPLAN is a static input-output (IO) model used to conduct region-specific economic analyses. As a static model, it cannot accept multiyear inputs or produce year-over-year results.[37] The IMPLAN model selected by Cadmus was based on 2015 state and county economic data, captured in a set of matrices describing the Washington economy for counties within PSE service territory.

These IO multiplier matrices allow IMPLAN to account for the following:

- Spending patterns and relationships between households and industries within PSE's service territory
- Regional purchasing coefficients, which account for supply chain leakage from the regional economy

[37] IMPLAN is used to estimate economic impacts using static assumptions based on real Washington state and county economic data. These assumptions do not account for dynamic changes that occur over time, such as labor migration, price responses, or general equilibrium, which would likely diminish the positive impact of future-year energy savings benefits. For example, program-induced increases in demand for certain industries cause labor to migrate to the study region but only to the point of saturation; then, ongoing impacts result largely in local job displacement and minimally in local job creation. As a static IO model, IMPLAN does not account for such dynamic changes. In effect, the results from this study are reasonable but possibly slightly overstated.

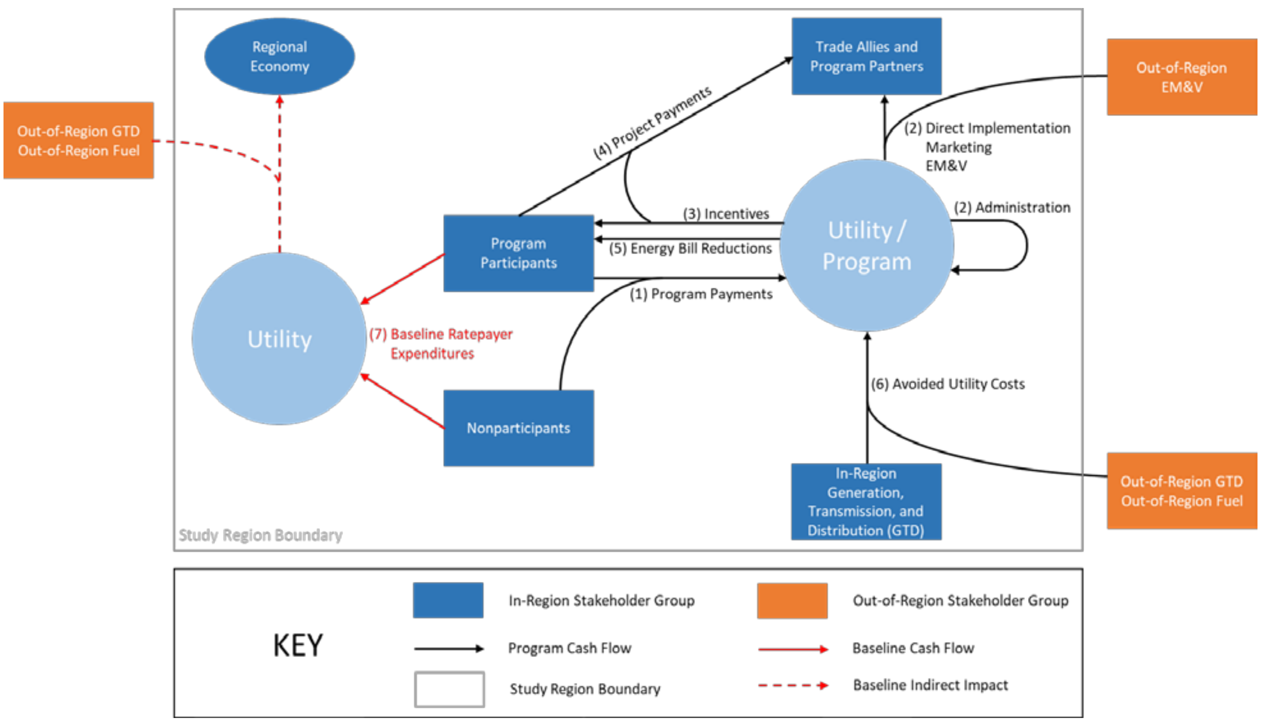
- Sector-level productivity and wage data, which enabled IMPLAN to calculate impacts on employment, income, and production variables (e.g., value added, output).

Model Inputs

Model inputs represented changes to default cash flows in the economy. Cadmus modeled the program in IMPLAN by inputting changes to any of nine household income categories; or by changing final demand for goods and services in any of IMPLAN's 536 industrial sectors. As no money is created or destroyed within the economy, all changes entered in the model summed to zero, except for changes into or out of the region.

The diagram in Figure 24 illustrates the SF program scenario and hypothetical baseline scenario inputs. Black lines denote expenditures associated with the program, while red lines represent expenditures associated with the hypothetical baseline scenario. Dashed red lines represent indirect impacts resulting from utility expenditures in the baseline scenario.

Figure 24. Single-Family Program and Baseline Scenario Cash Flow Diagram



Modeled Cash Flows

As shown in Figure 24, these cash flows relate to the regional economy in multiple ways:

1. **Program Payments.** Monies funding efficiency programs come from revenues collected from ratepayers.

2. **Admin, Implementation, Marketing, and EM&V.** Funds spent on in-house program administration, implementation, and evaluation activities provided by program trade allies and partners.
3. **Incentives.** Paid to program participants to compensate them for a portion of the measure cost.
4. **Project Payments.** Expenditures from program participants to trade allies for measure installation.
5. **Energy Bill Reductions.** Participants save energy while installed measures remain operational, benefitting from energy bill reductions, while utilities forego those revenues.
6. **Avoided Utility Costs.** PSE benefits from avoided fuel and capacity costs due to decreased demand for energy resources.
7. **Baseline Ratepayer Expenditures.** In the programs' absence, collected revenue would be spent on other expenses relating to operating and maintaining the regional electric and gas transmission and distribution networks (rather than on energy efficiency programs).

Table 41 shows positive and negative SF-induced changes by relevant stakeholder groups for each type of cash flow illustrated above. Negative inputs represent decreased final demand or income, and positive inputs represent increased final demand or income. Program payments represent ratepayer expenditures resulting in payments to program administration labor, trade allies, and partners. Baseline ratepayer expenditures represent a hypothetical scenario where revenue is spent on projects other than energy efficiency.

Table 41. SF: Positive and Negative Impacts by Cash Flow Type and Stakeholder Group

Cash Flow	Stakeholder Group				
	Program Participants	Nonparticipants	PSE/SF	Trade Allies and Partners	Out-of-Region Utilities
Program Payments	Negative	Negative	--	--	--
Program Spending	--	--	Positive	Positive	--
Incentives	Positive	--	Negative	--	--
Project Payments	Negative	--	--	Positive	--
Energy Bill Reductions	Positive	--	Negative	--	--
Avoided Utility Costs	--	--	Positive	--	Negative
Baseline Ratepayer Expenditures	Negative	--	Positive	--	--

The following sections describe the inputs required for these modeled cash flows in greater detail. For this study, Cadmus analyzed impacts on the regional economy from the SF program, which required assuming income-bracket and sector-level breakouts for all IMPLAN model inputs describing regionwide cash flows between stakeholder groups.

Program Payments, Program Spending, and Project Payments

To develop accurate sector-level IMPLAN model inputs for relevant program spending cash flows, Cadmus' economic impacts summarized spending within the following cost categories: administration, implementation, marketing, EM&V, and incentives. Table 42 summarizes these spending categories, including the IMPLAN sectors impacted by each category. Program spending data used in this study were self-reported by PSE, with Cadmus assuming all program spending data were in nominal dollars.

Table 42. 2015 SF Program-Level Spending Categories

Category Name	Electric Amount	Gas Amount	Category Description	IMPLAN Sector Impacted
Administration	$112,460	$51,567	Spending on program administration staff and related administrative services.	Office administrative services.
Implementation	$136,311	$64,748	Spending on program implementation.	Management, scientific, and technical consulting services.
Marketing	$388,264	$149,604	Program advertising and participant outreach.	Advertising and related services.
EM&V	$110,887	$260,189	Paid to Cadmus for PY 2015 evaluation. Flows out of the regional economy.	Not applicable. Treated as leakage from the regional economy.
Other	-$61,225	-$14,305	Undesignated funds.	Allocated evenly among the four sectors above.
Incentives	$6,947,784	$4,790,502	Paid directly to trade allies for measure installation in single-family households.	See list on the following page.
Co-Funding	$14,858,225	$17,446,671	Paid to trade allies by program participants for measure installation.	See list on the following page.
Total	**$22,492,706**	**$22,748,975**	**Total program expenditures**	

These seven categories encompass all the ways that 2015 SF program expenditures were modeled. Separating program-level SF spending into multiple categories allowed Cadmus to assign expenditures to specific IMPLAN sectors, thus maximizing the accuracy of the IMPLAN models. The following list shows the sectors to which project expenditures were assigned:

- Management, scientific, and technical consulting services
- Environmental and other technical consulting services
- Maintenance and repair construction of residential structures
- Maintenance and repair construction of nonresidential maintenance and repair
- Wholesale trade
- Air conditioning, refrigeration, and warm air heating equipment manufacturing

- Heating equipment manufacturing (except warm air furnaces)
- Automatic environmental control manufacturing
- Mineral wool manufacturing
- Urethane and other foam product manufacturing (except polystyrene)
- Other plastics product manufacturing
- Waste management and remediation services

Cadmus also modeled cash flows resulting from customer bill savings, utility revenue loss, and utility avoided costs. These inputs were built using energy savings estimates from the billing analysis and applying weighted average measure life estimates from the program data. Cadmus then calculated nominal retail rate and avoided cost forecasts from the present value forecasts provided by PSE to estimate bill savings, utility revenue loss, and avoided costs over the life of the measure. Finally, using an 8% utility discount rate, Cadmus calculated the net present value of these savings. Cadmus then input these results into the IMPLAN model as cash flows 4 and 5 (see Figure 24). The nominal retail rate and avoided cost forecasts used by Cadmus follow in Table 43.

Table 43. Nominal Avoided Cost and Retail Rate Forecasts

Year	Utility Avoided Cost		Retail Rate		
	($/kWh)	($/therm)	($/kWh)	Delivery ($/therm)*	Total Retail ($/therm)
2015	$0.0837	$0.46	$0.1026	$0.36	$0.82
2016	$0.0855	$0.56	$0.1060	$0.37	$0.93
2017	$0.0903	$0.61	$0.1094	$0.39	$1.00
2018	$0.0954	$0.66	$0.1127	$0.40	$1.06
2019	$0.1004	$0.71	$0.1160	$0.42	$1.13
2020	$0.1010	$0.75	$0.1193	$0.43	$1.18
2021	$0.1044	$0.78	$0.1226	$0.44	$1.22
2022	$0.1056	$0.79	$0.1261	$0.46	$1.25
2023	$0.1084	$0.82	$0.1297	$0.47	$1.29
2024	$0.1102	$0.83	$0.1331	$0.49	$1.32
2025	$0.1125	$0.86	$0.1363	$0.50	$1.36
2026	$0.1151	$0.89	$0.1394	$0.51	$1.40
2027	$0.1171	$0.90	$0.1424	$0.52	$1.42
2028	$0.1200	$0.93	$0.1454	$0.53	$1.46
2029	$0.1222	$0.96	$0.1483	$0.54	$1.50
2030	$0.1242	$0.99	$0.1511	$0.56	$1.55
2031	$0.1273	$1.03	$0.1539	$0.57	$1.60
2032	$0.1287	$1.05	$0.1573	$0.58	$1.63
2033	$0.1315	$1.08	$0.1608	$0.59	$1.67
2034	$0.1285	$1.10	$0.1644	$0.61	$1.71

* Cadmus noted that the gas retail rates provided by PSE were lower than the gas avoided costs. Cadmus assumed that the gas rate provided by PSE is the delivery charge and excludes the gas cost rate, and added the gas avoided

Year	Utility Avoided Cost		Retail Rate		
	($/kWh)	($/therm)	($/kWh)	Delivery ($/therm)*	Total Retail ($/therm)

costs to this rate to approximate the retail rate experienced by PSE customers.

Model Outputs

The model outputs included the following:

- ***Direct effects*** represent regional production changes brought by increases in regional demand. These include direct **program and participant expenditures** on goods and services from program trade allies and partners. For example, program expenditures increase final demand for "repair and maintenance of residential structures."
- ***Indirect effects*** are changes in **demand for intermediate inputs** necessary for directly affected industries.
- ***Induced effects*** result from the ways households and employees of directly and indirectly affected industries spend money on regional goods and services. **Spending of increased income triggers further production in local industries, leading to multiple iterations of additional economic activity.** These effects reflect predicted impacts on industries in the PSE service territory not directly involved with the SF program or supplying intermediate factor inputs.
- ***Total effects*** are the sum of direct, indirect, and induced effects.

For each model scenario, IMPLAN produced direct, indirect, induced, and total effects on multiple-key, interrelated economic indicators, including the following:

- ***Employment*** represents the number of **job-years created**—the only indicator variable unaffected by the discount rate; each job-year represents **one job for one year** (i.e., 2,080 hours).
- ***Employee compensation*** represents the total cost employers pay for employees, including **wages plus benefits**; it does not include proprietor (i.e., owner) incomes and serves as the best indicator for estimating wage impacts.
- ***Labor income*** represents the sum of all forms of employment income, including **employee compensation (i.e., wages plus benefits) and proprietor incomes**; it serves as the best indicator for estimating total **household income and savings impacts**.
- ***Value added*** represents all **profits (i.e., operating surpluses), indirect business taxes, and employee compensation**; it accounts for all non-commodity payments associated with industry production and serves as the best indicator for estimating marginal impacts on **regional domestic product. *This is the most appropriate impact type to include in a cost-effectiveness assessment.***
- ***Output*** equals value added plus intermediate expenditures, representing the total value of industry production; it serves as the best indicator for estimating sector-level impacts on business revenue and industry production.

Model Scenarios

Cadmus created two IMPLAN models, one each for PSE's gas and electric service territories. Each model contained two scenarios:

- The first (the program scenario) represents gross impacts where ratepayer funds are collected and reallocated to program spending. These are compared to the baseline scenario to calculate net impacts.
- The second (the baseline scenario) allows Cadmus to create net impacts, where no efficiency program occurred and ratepayer dollars were spent on other utility industry expenditures (e.g., fuel, infrastructure, energy imports).

To estimate net economic impacts, Cadmus subtracted the baseline scenario from the program scenario.

Environmental Impact Analysis

Cadmus quantified the avoided GHG emissions associated with the DC programs' energy efficiency impacts using a standard approach that multiplied evaluated energy savings by fuel-specific emissions factors. Emissions factors—the rate at which a pollutant is emitted per unit of energy—are most often expressed in tons of pollutant per energy unit: electric in tons/megawatt hour (MWh), and gas in tons/thousand therms (MThm). The product of the emissions factor and the energy savings provides an estimate of the total weight of air pollutant offset or avoided by the program.

For this assessment, Cadmus used average evaluated savings from the 2015 program year, presenting annual and lifetime emissions avoided for the average participant as well as total emissions avoided by all measures installed as part of the 2015 program year.

The natural gas emissions factor used in the analysis, derived from EPA's Center for Corporate Climate Leadership Emissions Factor Hub, was based on national average natural gas composition and heat content.[38] To quantify GHG emissions avoided from reducing electricity usage, the chosen emissions factor should represent the utility's marginal emissions rate, as reducing electricity usage will avoid production at whatever power plant is on the margin during each hour of the year.

According to the 2015 PSE GHG Inventory, electricity dispatch modeling of PSE's service territory has identified that the marginal plant within the Northwest Power Pool will likely be a combined cycle, natural gas-fired turbine with a heat input rate of 7,000 Btu/kWh.[39] Therefore, to remain consistent with

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[38] U.S. Environmental Protection Agency. "Center for Corporate Climate Leadership GHG Emission Factors Hub." November 2015. https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub

[39] Environmental Resources Management. *2015 Greenhouse Gas Inventory*. p. 30. Prepared for Puget Sound Energy. September 2016. Available online: https://pse.com/aboutpse/Environment/Documents/GHG_Inventory_2015.pdf

PSE's GHG inventory, Cadmus assumed a model natural gas plant with these characteristics on the margin during all hours of the year.

Table 44 lists emissions factors used in the analysis.

Table 44. Emissions Factors

Service Fuel Type	CO_2e
Electric Emissions Factor (tons/MWh)	0.376
Gas Emissions Factor (tons/MThm)	5.84

Environmental Benefits

Cadmus measured the NEBs from avoided GHG emissions in two ways. The first quantifies the avoided environmental compliance costs the result from the DC programs. Avoided compliance costs are costs associated with complying with state and federal regulations aimed at reducing GHG emissions, such as the Washington CAR. In the second approach, Cadmus quantifies the social benefit associated with reduce emissions

Table 45 provides a summary of the assumptions used in valuing avoided emissions from both approaches, the social benefit and avoided compliance cost perspectives.

Table 45. Environmental Benefit Assumptions

Year	Social Cost of Carbon ($/ton CO_2)	Avoided Environmental Compliance Costs ($/ton CO_2e)*	
		PSE IRP Scenario 12 – High Cost Scenario	PSE IRP Scenario 10 – Low Cost Scenario
2015	$39.68		
2018	$46.30	$30.71	$14.36
2020	$46.30	$35.18	$16.45
2030	$55.12	$69.21	$32.35
2035	$60.63	$97.05	$45.37

*PSE IRP modeling covers 2018-2037 only. Cadmus has assumed $0 in CO_2 compliance costs for calendar years 2015-2017.

To quantify avoided environmental compliance costs, Cadmus used assumptions from the 2017 PSE Integrated Resource Plan (IRP) development process. Due to uncertainty on the timing and structure of future GHG compliance regulations, Cadmus selected two out of 14 scenarios from the PSE IRP with different GHG regulation assumptions for use in this analysis. Cadmus chose the scenarios as realistic estimates of future policy that provide a range of compliance costs. The scenarios include one that considers costs for compliance with the Washington CAR[40] with no future federal GHG regulation (Scenario 12: Base w/ CAR only) and one that includes lower CAR compliance costs, coupled with base case assumptions of compliance with the U.S. Environmental Protection Agencies Clean Power Plan after 2022 (Scenario 10: Base + Low CAR CO_2). For this study Cadmus has characterized these two high- and low-cost scenarios:

- ***High CO_2 Cost (Scenario 12: Base w/ CAR only)*** –In scenario 12, PSE assumed compliance only with the Washington CAR (with no federal Clean Power Plan). This scenario resulted in estimated compliance costs of $30.71 per ton in 2018 and rising to over $111/ton CO_2e in 2037.
- ***Low CO_2 Cost (Scenario 10: Base + Low CAR CO_2)*** – Scenario 10 in the IRP contains a more conservative estimate of GHG compliance costs. Within this scenario, PSE assumes lower Clean Air Rule compliance costs until 2021, followed by a program similar to the U.S. Environmental Protection Agencies Clean Power Plan. This scenario resulted in estimated compliance costs of $14.36 per ton in 2018 and rising to over $51/ton CO_2e in 2037.

In addition to estimate avoided compliance costs from GHG regulations, Cadmus also estimated the social benefit of avoided GHG emissions. The social benefit uses a social cost of carbon, meant to be an estimate of future climate change damages that are avoided by reducing GHG emissions through the DC programs. The social benefit accrues to all members of society and includes a variety of climate change impacts, such as changes in agricultural productivity, human health, and property damages from increased flood risk.

Despite being a range of available estimates for the social cost of carbon, for this analysis, Cadmus used a conservative value developed by the U.S. Environmental Protection Agency for use by federal agencies in valuing the climate change impacts of rulemakings.[41] Cadmus used the EPA social cost of carbon for with a 3% discount rate which ranges from $39.68/ton CO_2 in 2015 to $60.63/ ton CO_2 in 2035.

Ancillary Participant Benefit Analysis

As part of the evaluation, Cadmus sought to establish dollar values for ancillary participant benefits accruing to DC program participants. While there is a wide range of potential benefits to energy

40 Washington Administrative Code, Chapter 173-442, Clean Air Rule

41 U.S. Environmental Protection Agency. "Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." May 2013 (Revised August 2016). Available online: https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon-technical-documentation_.html

efficiency from the participant perspective,[42] Cadmus expected primary ancillary benefits associated with DC program measures to be comfort (due to reduced drafts and more efficient equipment) and health[43] (due to more reliable heating and cooling). The following paragraphs describe the methodology used.

Contingent Valuation Approach

Cadmus estimated ancillary participant benefits using the contingent valuation method. Contingent valuation is an approach commonly adopted in economics literature to solicit information about individuals' values for goods not traded in markets. With this method, Cadmus used discrete response techniques, where survey respondents were asked to provide a series of "yes/no" responses to questions that ask whether the respondent would be willing to pay a stated price (i.e., a bid amount).[44] Bid amounts were anchored by average bill savings experienced by program participants.

The discrete response approach, which simulates market decision making, has been strongly endorsed by the National Oceanic and Atmospheric Administration (NOAA) Panel on Contingent Valuation[45] (i.e., a panel of leading economists, including two Nobel prize winners, assigned the task of evaluating the reliability of the contingent valuation method for use by public agencies, especially for litigation purposes).

Cadmus conducted two separate participant phone surveys (described in the Participant Survey section below) to solicit responses to an array of bid amounts for "overall," "comfort," and "health" benefits.

Valuation Modeling – Logistic Regression

Cadmus estimated three valuation models via logistic regression (logit), with the following general functional form:

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[42] Skumatz, Lisa, M.S. Khawaja, and R. Krop. "Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California." Section 4. Revised report, May 11, 2010. Available online: http://liob.cpuc.ca.gov/docs/LIEE%20Non-Energy%20Benefits%20Revised%20report.pdf

[43] Cadmus developed mean WTP estimates for "Health" of $3.24 per participant per year. These estimates were derived from a model with overall model and bid amount statistical significance at better than the 0.0001 level. While the coefficient estimates exceed the statistical significance threshold of 0.05, a benefit estimate of $3.24 may not be meaningful in a practical sense. Therefore, Cadmus does not recommend using this "Health" benefit estimate in future cost-effectiveness analyses.

[44] Cadmus used a bounded logit approach, where each "Yes" response was followed by a higher bid amount, and each "No" response was followed by a lower bid amount until three yes or no responses had been recorded. This resulted in up to three bid/response observations for each survey respondent. Some survey respondents declined to answer the valuation portion of the survey.

[45] Arrow, Kenneth, R. Solow, P.R. Portney, E.E. Leamer, R. Radner, and H. Schuman. "Report of the NOAA Panel on Contingent Valuation." January 11, 1993. Available online: http://www.economia.unimib.it/DATA/moduli/7_6067/materiale/noaa%20report.pdf

$$Prob(Yes) = f(BID, X)$$

Where f(BID,X) is a function of the bid amount and a vector of participation and demographic characteristics, X_i (e.g., the types of measures installed and whether the respondent owned or rented their residence).[46] Assuming a logistic functional form, Cadmus estimated the following logit model:

$$Prob(Yes) = f(BID, X) = 1 - \frac{1}{1 + e^{(\alpha - \beta_1 BID - \beta_i X_i)}}$$

Cadmus tested several available demographic and control variables expected to influence a respondent's WTP, including household income, respondent age, square footage, program satisfaction, residence age, and number of residents. None of these variables met the 5% threshold of statistical significance.

Mean WTP Calculation

Using the parameter estimates from the logit model, the team then estimated mean willingness to pay (WTP), using the formula developed by Hanemann (1989).[47]

$$Mean\ WTP = \left(\frac{1}{\beta_1}\right) * \ln(1 + e^{\beta_0})$$

Where β_1 is the coefficient on the bid variable, and β_0 is the following equation:

$$\beta_0 = \alpha + \sum(\beta_i * Mean_i)$$

In other words, β_0 is the sum of all coefficient estimates, β_i (except the bid amount), multiplied by their mean value, *Mean*$_i$, added to the intercept coefficient.

Model Output

Mean WTP represents the average monetized value per participant per year for ancillary benefits such as comfort and health. PSE can use this value as an additional benefit-side input for a cost effectiveness analysis to gain a more complete understanding of the total social benefits that arise from an efficiency program like DC programs.

Table 46. Model Specification and Mean WTP for Overall Benefits (n=791)

Symbol	Parameter	Estimate	Standard Error	P-Value	Grand Constant (β0)	Mean WTP
α	Intercept	-0.2742	0.1194	0.0216	-0.2742	**$ 227.07**
β1	Bid Amount	0.0025	0.0005	<0.0001		

46 The DC models did not have statistically significant control variables (e.g., household income, rent/own), besides the bid amount and intercept term, so in this case the grand constant is simply the parameter estimate for the intercept term.

47 Hanemann, M. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Response Data: Reply" American Journal of Agricultural Economics (1989): 71 (4), pp. 1057–1061.

Table 47. Model Specification and Mean WTP for Comfort Benefits (n=942)

Symbol	Parameter	Estimate	Standard Error	P-Value	Grand Constant (β0)	Mean WTP
α	Intercept	-0.7023	0.1117	<0.0001	-0.7023	**$ 119.77**
β1	Bid Amount	0.0034	0.0005	<0.0001		

Table 48. Model Specification and Mean WTP for Health Benefits (n=958)

Symbol	Parameter	Estimate	Standard Error	P-Value	Grand Constant (β0)	Mean WTP
α	Intercept	-3.4595	0.1915	<0.0001	-3.4595	**$ 3.24**
β1	BidAmount	0.0096	0.0008	<0.0001		

Cadmus applied these mean values and parameter estimates to the Mean WTP formula, arriving at average annual benefit estimates of **$227 per participant** for overall benefits, **$120 per participant** for comfort benefits, and **$3 per participant** for health[48] benefits. Note that the overall benefit estimate is larger than the sum of the comfort and health benefit estimates, suggesting that participants may have additional non-energy benefits beyond comfort and health. See the NEBs: Ancillary Participant Benefits section for additional results discussion.

Process Evaluation

The process evaluation included four primary activities, outlined in Table 49.

Table 49. Process Evaluation Activities

Activities	Purpose
In-Depth Interviews	Assess stakeholder perspectives on program implementation, communication, marketing, barriers, and program successes.
Participant Surveys	Verify measure installations, assess satisfaction and awareness, and investigate NEBs and household behavior changes.
Process Flow	Identify and diagram customer journey.
Secondary Research	Provide a framework to identify KPI.

48 Cadmus developed mean WTP estimates for "Health" of $3.24 per participant per year. These estimates were derived from a model with overall model and bid amount statistical significance at better than the 0.0001 level. While the coefficient estimates exceed the statistical significance threshold of 0.05, a benefit estimate of $3.24 may not be meaningful in a practical sense. Therefore, Cadmus does not recommend using this "Health" benefit estimate in future cost-effectiveness analyses.

In-Depth Interviews

Cadmus conducted in-depth interviews with PSE program managers and contractors. Table 50 identifies the sampling approach for these in-depth interviews.

The primary research questions for these interviews included:

- Clarify and review implementation processes
- Assess overall program successes and challenges
- Identify the types of equipment contractors install
- Assess contractor education
- Assess program marketing and outreach
- Assess customer experience

Table 50. In-Depth Sampling Approach

<table>
<tr><th>Interview Audience</th><th>Population</th><th>Number of Targeted Interviews</th><th>Number of Completed Interviews</th><th>Date Interview was Completed</th></tr>
<tr><td>Program staff</td><td>3</td><td>3</td><td>3</td><td>June and August 2016</td></tr>
<tr><td>Active contractors in the Contractor Alliance Network (CAN)*</td><td>227</td><td>35</td><td>35</td><td>June and July 2017</td></tr>
<tr><td>Inactive contractors in the CAN</td><td>328</td><td rowspan="2">5</td><td>4</td><td rowspan="2">June and July 2017</td></tr>
<tr><td>Nonparticipating contractors in the CAN</td><td>326</td><td>1</td></tr>
</table>

*Twenty-three Tier 1 contractors and 12 Tier 2 contracts.

We conducted the contractor interview with active contactors in two-parts. First, contractors were invited to complete an online survey to identify the type of residential energy-efficient equipment they install. PSE sent an initial e-mail invitation for this part of the research. Following the completion of the online survey Cadmus contacted the contractors via telephone to conduct an in-depth interview. If contractors did not respond to the online survey invitation, Cadmus called them and completed both parts of the interview over the phone.

Inactive and nonparticipating contractors completed a different interview with fewer questions. Cadmus contacted these contractors via telephone.

Participant Survey

Cadmus conducted an online survey using unique participants (n=23,621) of the DC programs from 2015 and 2016. This included asking questions to gain insights into the general customer experience, perspective, and satisfaction with the program. The survey collected primary data on both process-oriented information as well as several impact-oriented elements, including:

- Program awareness
- Satisfaction with program components and the program overall
- Challenges and barriers
- Motivation and NEBs including total benefits and health and comfort benefits
- Impact of energy education and other possible behavioral changes due to program participation including take-back behavior
- Verification of equipment installation
- Previous and current heating equipment

Given the survey length, Cadmus designed two shorter surveys to address separate topics, thus reducing the burden on individual respondents. Table 51 shows the key survey topics included in each Survey A and Survey B.

Table 51. Key Survey Topics

Key Survey Topic	Survey A	Survey B
Measure verification	✓	
Previous and current heating equipment	✓	✓
Take-back behavior	✓	✓
Awareness	✓	
Motivators	✓	
Total non-energy benefits	✓	✓
Health and comfort non-energy benefits		✓
Program satisfaction		✓
Challenges with energy efficiency	✓	
Household behavior changes		✓
Demographics	✓	✓

Cadmus selected a stratified random sample of participants in four equipment categories: windows, weatherization, space heating and water heating. To prepare the sample frames, we merged the 2015 and 2016 participants and removed any records without a valid e-mail address. The large number of records removed for incomplete e-mail information (36% of records) made it challenging to select an e-mail survey sample potentially introducing bias.

If a participant installed multiple measures, we assigned the equipment category based on the most recently installed equipment type. We removed duplicate participants within and across equipment categories. Finally, we randomized each equipment list and split each list in half; using one-half for survey A and one-half for survey B.

We originally targeted 70 completes per survey per equipment category, to achieve ±10% precision at 90% confidence but increased the target to complete as many as possible to increase the number of valid responses to the non-energy benefits questions. Unfortunately, we were unable to reach the targeted 70 completes per survey within the water heater group because of the limited number of unique participants.

We launched the survey in replicate batches so we could review survey responses and determine if additional replicates needed to be released to reach the overall survey target. We sent each participant an initial e-mail invite, followed by two e-mail reminders five to ten days later. Some customers e-mailed or called Cadmus following the e-mail invitation with questions or to request not to be contacted again. Cadmus forwarded this information to PSE as it was received and, where requested, removed participants from subsequent e-mail reminders.

Table 52 shows the participant survey attrition.

Table 52. Survey Attrition Table

Outcome	Space Heat		Water Heat		Weatherization		Windows	
	A	B	A	B	A	B	A	B
Population*	**14,114**		**1,332**		**6,506**		**6,490**	
Unique Population	**12,481**		**1,227**		**4,126**		**5,787**	
Removed: invalid or missing e-mail	6,080		419		1,459		2,288	
Removed: duplicate record	32		4		7		62	
Used for Survey Sample	**3,184**	**3,185**	**401**	**403**	**1,328**	**1,332**	**1,719**	**1,718**
E-mailed	**3,184**	**2,485****	**401**	**403**	**1,328**	**1,332**	**1,719**	**1,718**
Completed Surveys	**265**	**242**	**56**	**52**	**100**	**95**	**140**	**118**
Opted out	46	29	5	7	26	24	44	21
Not delivered	112	97	13	10	42	36	53	57
Did not complete survey	2,761	2,117	327	332	1,160	1,177	1,482	1,522
Response rate***	**8%**	**10%**	**14%**	**13%**	**8%**	**7%**	**8%**	**7%**
Planned Completes	**70**	**70**	**70**	**70**	**70**	**70**	**70**	**70**

*Not unique participants

**All records were not needed.

***Completed surveys divided by number e-mailed

Appendix H. Survey Demographics presents tables outlining answers to each demographic question from the customer surveys.

Process Flow Diagram

Cadmus developed a process flow diagramming program activities from pre-participation outreach through post-installation verification and payment. The diagram was developed by reviewing program materials, and through discussions with the PSE program managers and participating contractors.

KPI Framework

To establish discrete metrics for tracking and measuring ongoing program performance, Cadmus developed a list of recommended KPIs. Cadmus identified KPIs based on program goals confirmed through the program manager interviews. Cadmus also developed a supplementary list of metrics, distinguished from KPIs, but that may still be useful and interesting for PSE to track and consider occasionally with regard to program performance.

Appendix B. Model Attrition Summary

Table 53 and Table 54 provide details of the screening process for the DC programs electric and gas impact models, respectively.

Table 53. Dealer Channel Model Screening—Electric

Screen	Treatment Group		Comparison Group	
	Accounts Remaining	Percentage Remaining	Accounts Remaining	Percentage Remaining
Original electric accounts	15,193	100%	4,239	100%
Did not match to billing data provided	15,092	99%	4,239	100%
Insufficient pre- and post-period days of use	10,538	69%	2,575	61%
Changed use from the pre to post by >70%	10,478	69%	2,538	60%
Pre- or post-period use less than 1,000 kWh	10,462	69%	2,535	60%
Wrong signs on PRISM parameters	10,387	68%	2,509	59%
Reported savings higher than or <1% of pre-use	10,042	66%	2,509	59%
Participated in another program	10,041	66%	2,509	59%
Inspection of pre/post use (e.g., vacancies)	9,401	62%	2,412	57%
Final Analysis Group	**9,401**	**62%**	**2,412**	**57%**

Table 54. Dealer Channel Model Screening—Gas

Screen	Treatment Group		Comparison Group	
	Accounts Remaining	Percentage Remaining	Accounts Remaining	Percentage Remaining
Original electric accounts	26,307	100%	6,849	100%
Did not match to billing data provided	26,232	100%	6,842	100%
Insufficient pre- and post-period days of use	17,366	66%	4,526	66%
Changed use from the pre to post by >70%	17,043	65%	4,502	66%
Pre- or post-period use less than 150 therm	16,755	64%	4,443	65%
Wrong signs on PRISM parameters	16,614	63%	4,414	64%
Reported savings higher than or <1% of pre-use	16,479	63%	4,414	64%
Participated in another program	16,422	62%	4,413	64%
Inspection of pre/post use (e.g., vacancies)	14,519	55%	4,248	62%
Final Analysis Group	**14,519**	**55%**	**4,248**	**62%**

Appendix C. Model Specification

PRISM Models

Cadmus estimated the heating and cooling PRISM model for various heating and cooling bases in the pre- and post-period for each customer, using the following specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer '*i*' and day '*t*':

ADC_{it} = Average daily kWh consumption in the pre- or post-program period

α_i = The participant intercept, representing the average daily kWh baseload

β_1 = The model space heating slope (used just in the heating only, heating + cooling model) – average change in daily usage resulting from an increase of one daily heating degree day (HDD)

$AVGHDD_{it}$ = The base 45–65 average daily HDDs for the specific location (used just in the heating only, heating + cooling model)

β_2 = The model space cooling slope (used only in the cooling only, heating + cooling model) – average change in daily usage resulting from an increase of one daily cooling degree day (CDD)

$AVGCDD_{it}$ = The base 65–85 average daily CDDs for the specific location (used just in the cooling only, heating + cooling model)

ε_{it} = The error term

Using the above model, Cadmus computed weather-normalized annual kWh consumption as:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_{it} + \beta_2 LRCDD_{it}$$

Where, for each customer '*i*' and annual time period '*t*':

NAC_i = Normalized annual kWh consumption

$\alpha_i * 365$ = Annual baseload kWh usage (non-weather sensitive)

$LRHDD_{it}$ = Annual, long-term HDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location

$\beta_1 LRHDD_{it}$ = Weather-normalized, annual weather-sensitive (heating) usage (i.e., HEATNAC)

$LRCDD_{it}$ = Annual, long-term CDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location

$\beta_2 LRCDD_{it}$ = Weather-normalized, annual weather-sensitive (cooling) usage (i.e., COOLNAC)

Combined Fixed Effects—Whole House Models

To estimate electric energy savings, Cadmus employed a pre- and post-installation savings analysis fixed-effects modeling method using pooled daily time-series (panel) billing data. The fixed-effects modeling approach corrected for the following:

- Differences between pre- and post-installation weather conditions
- Differences in usage consumption between participants, through inclusion of a separate intercept for each participant

This modeling approach ensured that savings estimates were not skewed by unusually high-usage or low-usage participants. Cadmus used the following model specification to determine overall savings:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_3 POST_i + \beta_4 POST_i * AVGHDD_{it} + \beta_5 POST_i * AVGCDD_{it} + \varepsilon_{it}$$

Where, for each participant or comparison customer 'i' and day 't':

ADC_{it}	=	Average daily kWh consumption during the pre- or post-installation program period
α_i	=	Average daily kWh baseload intercept for each customer (part of the fixed-effects specification)
β_1	=	Average daily per-HDD usage in the pre-period
$AVGHDD_{it}$	=	Average daily base 56 HDDs,[49] based on home location
β_2	=	Average daily per-CDD usage in the pre-period
$AVGCDD_{it}$	=	Average daily base 69 CDDs, based on home location
β_3	=	Average daily whole-house program baseload kWh savings
$POST_i$	=	An indicator variable equaling 1 in the post-period (after the latest measure installation) and 0 in the pre-period
β_4	=	Whole-house heating kWh savings per HDD
$POST_i * AVGHDD_{it}$	=	An interaction between the POST indicator variable and the HDDs (AVGHDD)
β_5	=	Whole-house cooling kWh savings per CDD
$POST_i * AVGCDD_{it}$	=	An interaction between the POST indicator variable and the CDDs (AVGCDD)
ε_{it}	=	The modeling estimation error

49 Cadmus estimated fixed-effects models using average PRISM reference temperatures of 56°F for heating and 69°F for cooling.

Combined Fixed Effects—Measure-Level Models

Though the measure-level fixed effects models follow a similar form to whole-house fixed effects models, they are fairly complex and not easily presented due to the extent of parameters used (i.e., up to 10 measures, including indicators for each and interactions with HDDs, CDDs, the post period, and both post and weather distinctions. For these reasons, Cadmus included an abridged version of the model specification, only showing a single measure, along with tables presenting estimates of model parameters of all measures:

$$ADC_{it} = \alpha_i + \beta_1 DuctEff * AVGHDD_{it} + \beta_2 DuctEff * AVGCDD_{it} + \beta_3 DuctEff * POST_i + \beta_4 DuctEff * POST_i * AVGHDD_{it} + \beta_5 DuctEff * POST_i * AVGCDD_{it} + \varepsilon_{it}$$

Where, for participant customers '*i*' and day '*t*':

ADC_{it} = Average daily kWh consumption during the pre- or post-installation program period

α_i = Average daily kWh baseload intercept for each customer (part of the fixed-effects specification)

$DuctEff_i$ = An indicator variable that equals 1 if an account received a given measure (i.e., duct efficiency) and 0 if not

β_1 = Average daily per-HDD usage for homes with a given measure

$DuctEff_i * AVGHDD_{it}$ = An interaction between the DuctEff indicator variable and the HDDs (AVGHDD)

β_2 = Average daily per-CDD usage in the pre-period for homes with a given measure

$DuctEff_i * AVGCDD_{it}$ = An interaction between the DuctEff indicator variable and the CDDs (AVGCDD)

β_3 = Average daily whole-house program baseload kWh savings

$DuctEff_i * POST_i$ = An interaction between the DuctEff indicator variable and the POST indicator variable

β_4 = The whole-house heating kWh savings per HDD for homes with a given measure

$DuctEff_i * POST_i * AVGHDD_{it}$ = An interaction between the DuctEff indicator variable, the POST indicator variable, and the HDDs (AVGHDD)

β_5 = Whole-house cooling kWh savings per CDD for homes with a given measure

$DuctEff_i * POST_i * AVGCDD_{it}$ = An interaction between the DuctEff indicator variable, the POST indicator variable, and the CDDs (AVGCDD)

Appendix D. Savings Review Details

This appendix provides additional detail from Cadmus' review of PSE energy savings estimates.

Shell Measures

Cadmus reviewed all shell measures and identified two potential revisions for updating future savings methods (see Conclusions, Recommendations, and Considerations section for additional detail):

- Revise UES values for air sealing, insulation, windows, and duct sealing/insulation to reflect the most recent RTF sources
- Review RTF sources of UES values for shell and duct measures annually to consider potential revisions

Table 55 provides additional details on these suggestions to improve the accuracy of savings estimates.

Table 55. Shell Measures Sources and Considerations

Measure	Savings Source		UES Measure Identifiers	
	Current	Proposed	Current	Proposed
Air Sealing/Structural Sealing	RTF; Version 2 and 3 Weatherization Workbooks and PSE SEEM Modeling Runs	***Recommend using most recent RTF sources available***	Pre/post cubic-feet-per-minute 50 values	No Changes
			Heating fuel	
			Heating zone	
Floor Insulation			Pre/post R-values	No Changes
			Installed sq ft	
			Heating fuel	
Attic Insulation			Heating zone	No Changes
Windows			Pre/post widow type	No Changes
			Installed sq ft	
			Heating fuel	
			Heating zone	
Duct Insulation and Sealing	RTF; Version 2 Duct Sealing Workbooks	***Recommend using most recent RTF sources available***	Heating fuel	No Changes
			Heating zone	

*As noted, recommendations do not point to specific RTF workbooks and data due to continuous revisions these measure estimates receive per year.

For shell measures, current reported savings estimates use older RTF weatherization UES workbooks (i.e., 2012). Starting in 2015, the RTF completed calibrated models for weatherization measures, which provide more accurate savings.

Domestic Hot Water

Cadmus reviewed DHW measures and recommends PSE update the source for estimating HPWH savings (Table 56).

Table 56. DHW Sources and Considerations

Measure	Savings Source		UES Measure Identifiers	
	Current	Proposed	Current	Proposed
HPWH	RTF	***Consider using most recent RTF sources available***	Per unit	No change

Heat Pumps Water Heaters

HPWH replacement savings rely on RTF UES values for specific efficiency tiers, based on custom SEEM model calculations.[50] Current reported savings estimates are sourced from a 2012 RTF HPWH workbook, while subsequent RTF revisions to HPWH savings occurred in 2014 and 2015,[51] with additional revisions anticipated for late 2017.[52]

Space Heat

Cadmus reviewed Space Heat measures and identified the following suggestions for PSE to revise savings sources and UES measure identifiers (summarized in Table 57):

- Consider incorporating project-specific, existing heating system types from current RTF calculations for ductless heat pump measures
- Consider collecting the nominal capacity and efficiency of installed heat pumps to inform future research and evaluation.
- Update sizing and lockout controls savings using the most recent RTF workbooks
- Consider tracking additional inputs to revise GSHP savings calculations, including replaced heating system type, replaced cooling system type, and presence of installed de-superheater (PSE should also provide complete documentation on assumptions used to develop the weighted average distribution of existing conditions)
- Consider updating the CFM per-watt assumptions used for ventilation fans
- Consider tracking installed gas heating system capacities as dependent variables for savings calculations
- Recommend PSE provide complete documentation for fireplace savings calculations and consider adopting the proposed calculation approach (resulting in savings of 17.9 therms)

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50 NEEA. "Residential Water Heaters – Advanced Water Heater Specification." 2016. Available online: http://neea.org/docs/default-source/default-document-library/advanced-water-heater-specification.pdf?sfvrsn=0

The RTF updated to version 2.0 workbooks in January 2014, with additional updates in 2015 that incorporated SEEM simulations for HPWH savings in version 3.0 workbooks.

52 RTF. *RTF Research Plan: Residential Heat Pump Water Heaters*. 2016. Available online: https://nwcouncil.app.box.com/s/ftk0313lkter7gw54pzq9nadfxg4l2q7

Table 57. Space Heat Sources and Considerations

Measure	Source of Savings		UES Metrics	
	Current	Proposed	Current	Proposed
Ductless Heat Pump	Energy Trust of Oregon and RTF data	No Change	Per Unit	Per Unit
			Home Type	Home Type
				Include replaced heating system type
Air Source Heat Pumps	RTF data with PSE weighting estimates	No Change	Per Unit	Per Unit
				Nominal Capacity
				Installed SEER & HSPF
Heat Pump Sizing and Lock Out Controls	RTF data with PSE weighting estimates	***Recommend using most recent RTF sources available***	Per Unit	Per Unit
Geothermal Heat Pumps	RTF data with PSE weighting estimates	***Recommend using most recent RTF sources available***	Per Unit	Include, replaced heating systems type and de-superheater
Ventilation	PSE and manufacturer data	***Consider updating baseline CFM/watt from 1.4 to 3.1 and efficient values from 10 to 8.3.***	Home Type	No Change
Heating System Replacement (Gas Furnace)	2009 KEMA Furnace Study	No Change	Home Type	Home Type
				Include installed heating capacity of furnace
Fireplaces	PSE Data & Calculations	***Recommend revision to estimate, example using LBNL, RTF, & ETO data sources***	Per Unit	No Change

Ductless Heat Pumps

PSE's DHP savings calculation is based on documentation from the RTF, which references several recent Northwest studies. However, while the RTF distinguishes between DHP savings for different baseline equipment (e.g., electric forced air furnaces compared to zonal heat), PSE's deemed DHP savings value uses an average of those specific system types.

PSE currently tracks project-specific heating system information for existing equipment prior to replacement. Cadmus suggests that PSE consider using these project-specific data to estimate DHP reported savings relative to existing heating systems, selecting the RTF estimate specific to a heating system rather than using an average. This will produce more accurate estimates of energy savings.

Air Source Heat Pumps

For air source heat pumps, current reported savings estimates are sourced from 2015 RTF workbooks.[53]

The current RTF calculation assumes a market baseline of 8.5 HSPF and 14 SEER, which was established in 2009 when the federal minimum efficiency was at 7.7 HSPF and 13 SEER. In 2015, the U.S. Department of Energy required manufacturing and importation of heat pumps in Washington to meet or exceed a new minimum of 8.2 HSPF and 14 SEER. While the current RTF market baseline is above this standard, the change in federal regulation will likely shift the market to a higher efficiency, and we expect RTF savings calculations will soon update to reflect these changes in market conditions.

Cadmus suggests PSE begin tracking efficiencies and capacity of installed equipment to understand the distribution of installations, in anticipation of further changes to the RTF baseline and the impact it may have on PSE's program.

Heat Pumps Sizing and Lock Out Controls

PSE provides rebates for properly sizing heat pumps and setting lock out controls at temperatures to minimize the reliance on emergency or backup heat sources. These rebates are offered both to new installations and existing systems (less than 12 years old) for which customers can provide documentation of proper sizing and lock out control settings.

Cadmus found current UES savings for this measure in an older 2012 RTF workbook. We suggest PSE consider updating to the most recent RTF source,[54] as SEEM calibration has further refined savings estimates for this measure.

Geothermal Heat Pumps

PSE developed deemed savings estimates for GSHP installations based on RTF calculations, and adapting to use a weighted average distribution of existing equipment conditions (based on an assumed program population). Upon review, Cadmus found measure savings are extremely sensitive to these weighting assumptions, depending on installation conditions (e.g., home size and existing equipment types), savings can vary widely (i.e., from 1,699 kWh to 12,804 kWh).[55]

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[53] RTF Measure Workbook: RESSFExistingHVAC_v3_1.xlsx

[54] Current RTF source: Commissioning, Controls & Sizing SF https://rtf.nwcouncil.org/measure/commissioning-controls-sizing-sf

[55] RTF Measure Workbook: ResGSHP_v2_6.xls (SEEM model output not published in measure table for Heating Zone 1 and Cooling Zone 1).

Cadmus suggests that PSE consider tracking additional project-specific data to refine the estimated savings for this measure, including home size, replaced heating system type, replaced cooling system type, and whether installation includes a de-superheater. PSE should also provide clear documentation on the source for weighted existing equipment distribution.

Ventilation Fans

PSE's savings estimate for efficient ventilation fans are calculated using manufacturer data and the minimum requirements of the ENERGY STAR criteria. The efficiency criteria cited in the ENERGY STAR specification references a testing pressure of 0.25 in-H_2O. However, this assumption better reflects test conditions to qualify products rather than typical operating conditions; per the Home Ventilation Institute, typical operating pressures are approximately 0.1 to 0.2 in-H_2O (depending on types and installation conditions).[56] The current PSE inputs assume a 700% increase in efficiency above a standard efficiency ventilation fan, compared to an approximate 260% increase when using these revised assumptions. PSE should consider updating the baseline and installed efficiencies using a source that reflects typical testing pressure (e.g., Vermont TRM).

Cadmus suggests the following equation and methodology for ventilation fans:

$$\Delta kWh = \left(CFM * \frac{\left(\frac{1}{CFM\ per\ Watt_{Baseline}} - \frac{1}{CFM\ per\ Watt_{Efficient}}\right)}{1{,}000} \right) * 8{,}760\ hours$$

Table 58 provides the associated deemed savings values.

Table 58 Ventilation Savings – Suggested Inputs

Source	Baseline Efficiency	Usage (CFM)	Installed Efficiency	Estimated Savings (kWh/year)
PSE	1.4	30	10	161
Suggested	**3.1***	**50****	**8.3***	**89**

* *Vermont Technical Reference Manual*. 2013. Available online: http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf

** ASHRAE 62.2-2010, with assumptions of three bedrooms and a 2,000 sq ft dwelling size.

Heating System Replacement (Gas Furnace)

PSE's current approach for estimating gas savings from heating system replacements uses a per-unit deemed savings approach from a 2009 evaluation study that used billing analysis to assess impacts for 92 AFUE furnace installations. As the PSE requires installation of 95 AFUE furnaces, the current savings

56 *HVI Product Performance Certification Procedure Including Verification and Challenge*. 2009. Available online: https://www.hvi.org/publications/pdfs/HVI920_1March2009.pdf

calculation extrapolates the impact of 92 AFUE furnaces to represent higher efficiency 95 AFUE furnaces.

Cadmus finds this approach reasonable for establishing measure UES savings; however, there are additional factors that PSE should consider in improving savings estimates. First, as noted in the 2009 study, relative energy usage and associated savings are both dependent on home size, but are non-linear, decreasing as home size increases. While a home's envelope load increases with its size, the load increases at a lower rate than floor area. Furthermore, the *Uniform Methods Project* recommends calculating savings for furnace measures using the capacity of installed heating systems as a dependent variable.[57]

Based on PSE tracking data, it does not appear that PSE is currently collecting data on the size of installed heating systems. Going forward, Cadmus suggest that PSE begin tracking installed heating system capacities (in Btu per hour) as a variable to inform future evaluations.

Fireplaces

For efficient fireplace measures, PSE uses a deemed savings of 72 therms per year based on PSE assumptions, which assume savings attributed to installation of units with Canadian P4 efficiency ratings (70% or higher) with electronic ignition. [58] While documentation notes the assumed savings of 9 therms per month for eight months, no additional detail is provided on baseline assumptions.

Typically, there are two potential sources of energy savings for fireplace installations: higher heating efficiency during operation and use of electronic ignition resulting in standby losses (relative to pilot light). However, details regarding these savings assumptions are not available from the source documentation.

Review of secondary data available on fireplace usage and efficiency does not support the current savings estimate (72 therms). For example, a LBNL study found typical homeowners do not operate their gas fireplaces as their primary heating source but operate as desired, potentially supplementing primary heat (as a source of space heating), rather than displacing it (averaging approximately 234 hours per year).[59]

[57] Uniform Methods Project. *Methods for Determining Energy Efficiency Savings for Specific Measures*. 2013. Available online: https://www.nrel.gov/docs/fy13osti/53827.pdf

[58] Puget Sound Energy. Source of Savings and Measure Life/Cost: 2016-2017 Singe-family Existing. 2016.

[59] LBNL. "Survey of Hearth Products in U.S. Homes 2017." Available online: https://eta.lbl.gov/sites/default/files/publications/lbnl-2001030.pdf

Furthermore, electronic ignition requirements were not substantiated as a critical component of energy savings. A 2014 Energy Trust of Oregon survey of Washington new construction homes found that 94% of fireplaces installed include an electronic ignition.[60]

Cadmus recommends PSE provide more complete savings documentation and consider revising fireplace deemed savings to align with available research. Table 59 provides a comparison of assumptions from several sources and includes a possible deemed savings estimate using these inputs in application with the subsequent equation for characterizing gas fireplace savings. Cadmus adapted this equation based on the Uniform Methods Project (UMP) recommended savings algorithm for gas furnace installations.

$$\Delta Therms = \frac{Fireplace\ BTU\ Output * Hours\ of\ Use}{100{,}000\ ^{BTU}/_{Therms}} * \left(\frac{1}{FE_{Baseline}} - \frac{1}{FE_{Efficient}}\right) + Standby\ Pilot\ Usage_{Baseline} * \%\ of\ Systems\ with\ Pilot$$

Table 59. Efficient Fireplace Savings Inputs and Savings[61]

Inputs	2008 ETO	2014 ETO NC Study	2017 LBNL	Recommended Values
Fireplace BTU Output	32,558	-	-	32,558
Hours of Use		213.2	234	234
$FE_{Baseline}$	61%	57%	-	61%
Standing Pilot $Usage_{Baseline}$	-	-	45.93	45.93
% of Systems with Pilot	-	4%	67%	4%
Therm Savings	**-**	**-**	**-**	**17.9**

60 Energy Trust of Oregon. “Summary of Gas Fireplace Research – New Homes.” 2014. Available online: https://www.energytrust.org/wp-content/uploads/2016/12/NewHomes_Gas_Fireplace_Studies.pdf

61 See References section for full study citations.

Appendix E. Program Delivery

This section gives additional detail regarding the three main program delivery steps: pre-participation, the rebate processing, and verification and payment.

Pre-participation

Marketing Tools

PSE uses various methods to promote rebates through the DC programs. It uses mail and e-mail campaigns, participates in booths at community fairs, and works with contractors to provide co-branding opportunities, collateral materials, and google ads. Contractors can advertise PSE's rebate programs but must receive approval from PSE prior to the campaign. One of the most successful ways to provide outreach, according to PSE program managers, is through customer conversations with PSE's Energy Advisors. PSE's Energy Advisors answer customer calls about a variety of topics, and during these calls they often field questions about ways customers could reduce their energy bills. Energy Advisors use this opportunity to provide customers with information about energy efficiency improvements.

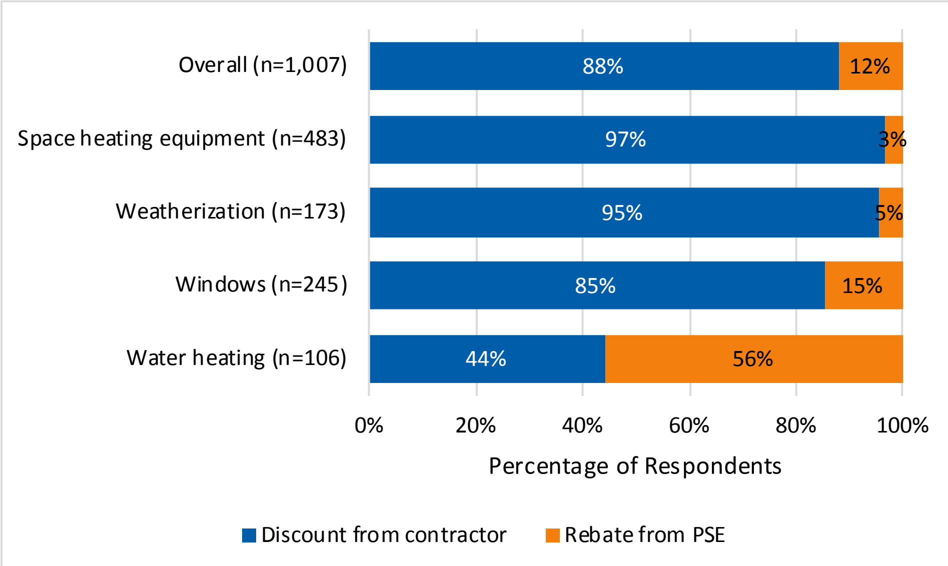
Rebate Processing

Customers or contractors submit rebate forms. According to PSE program managers, the most common way for PSE to receive a rebate through this program is from an instant discount from a contractor. When a customer receives an instant discount from a contractor, the customer receives a discount on the invoice and then the contractor submits the rebate application to PSE and receives a reimbursement for the discount they provided to the customer.

Although it is less common, customers can submit rebate forms directly to PSE. Customers submit rebates directly to PSE by sending the completed form through e-mail or through regular mail. PSE is working to modify its rebate application process to include a way for participants to submit rebate applications electronically.

Cadmus asked program participants to indicate whether they received a discount from the contractor for installing equipment and 88% (n=1,007) said they did. Customers who installed space heating equipment, windows, or made weatherization improvements were more likely to receive a discount from the contractor, while customers who installed water heaters were more likely to submit the rebate application directly to PSE (Figure 25).

Figure 25. Rebate Submission by Equipment Type



Source: Survey question, "Our records show you recently installed some energy efficiency equipment. For each of these items, please indicate whether you installed the equipment yourself or if it was installed by a contractor with a rebate or discount from the contractor."

Each rebate form indicates the requirements for receiving a rebate for installing the equipment. Program managers say it can be challenging when customers install equipment directly without the help of a contractor because they do not always follow the eligibility requirements and sometimes do not qualify for a rebate. This is not a problem for contractors because they are familiar with the equipment and PSE's rebate programs.

PSE regularly re-evaluates rebate requirements and adjusts language to provide more clarity so customers can accurately determine how to install energy-efficient equipment and receive a rebate. PSE also works with retailers and contractors to provide clear language to use when discussing equipment with customers.

Verification and Payment

Contractors or PSE staff enter program data into PSE's database system. PSE's rebate processing team reviews all rebate applications after they are submitted. If everything is accurate, the rebate is approved.

At least 10% of applications are selected for verification. PSE verifies projects by sending staff to homes to confirm application details such as model numbers and other installation specifics. If a project is selected for verification, PSE verifies the project prior to sending payment; otherwise, rebate processing team sends payment to the customer immediately after approval.

Program managers use the tracking system for many reasons. One of the system's main functions is forecasting. They also use the system to ensure the program is on track to meet its energy saving goals and to review program design and rebate amounts.

Appendix F. Additional Contractor Findings

Appendix F provides additional details from active contractor interviews.

Program Impact

Most (30 of 35) active contractors said their sales increased as a result of participating in the CAN, while four contractors said their sales had stayed the same. One contractor said sales decreased. The contractor whose sales decreased explained that PSE had increased the requirements for duct sealing, thereby increasing the amount of labor while decreasing the rebate amount for a “certain customer class.” He said the rebate amounts for manufactured homes often do not cover the costs, so people choose not to have the duct sealing done.

Contractors who said their sales had increased as a result of participation in the CAN were asked to estimate the percentage their sales had increased. Six were unable to provide an estimate. The remaining 24 contractors provided estimates ranging from less than 10% up to a range of 50% to 65% (Table 60).

Table 60. Percentage of Sales Increase as Result of CAN Participation

Sales Increase	Number of Responses
Up to 10%	10
11-20%	6
21-30%	3
31-50%	3
50-65%	2

Source: Survey question, “About how much have your sales increased as a result of participating in the CAN?” (n=24)

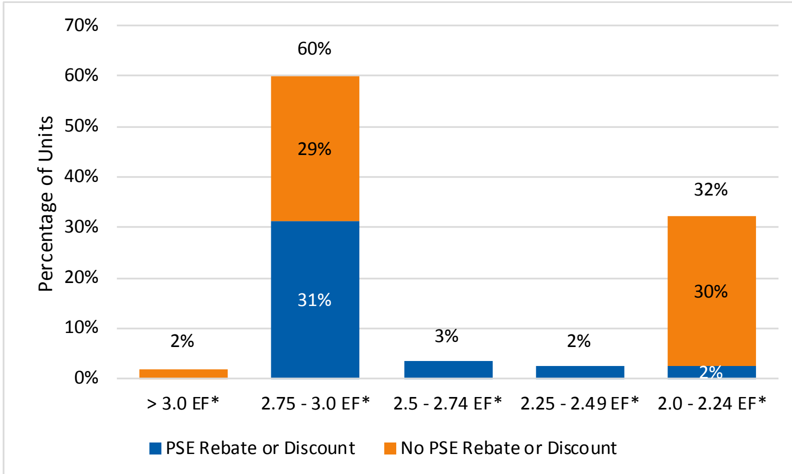
Equipment Installed

Cadmus asked active contractors to identify the types of equipment they installed and what percentage of their installed equipment fell into each efficiency category. For each efficiency category that qualified for rebates through a PSE program, contractors answered questions to identify what percentage of the equipment was installed through a PSE program and received a rebate or discount.

Heat Pump Water Heaters

Five contractors installed a combined total of 101 heat pump water heaters in the past 12 months. To qualify for a rebate through PSE, HPWHs needed an energy factor of at least 2.0. Even though all of the installed HPWHs had an energy factor of at least 2.0, contractors reported that only 38% of those eligible for a rebate received a rebate or discount. Figure 26 shows the details.

Figure 26. Heat Pump Water Heater Efficiency Ratings

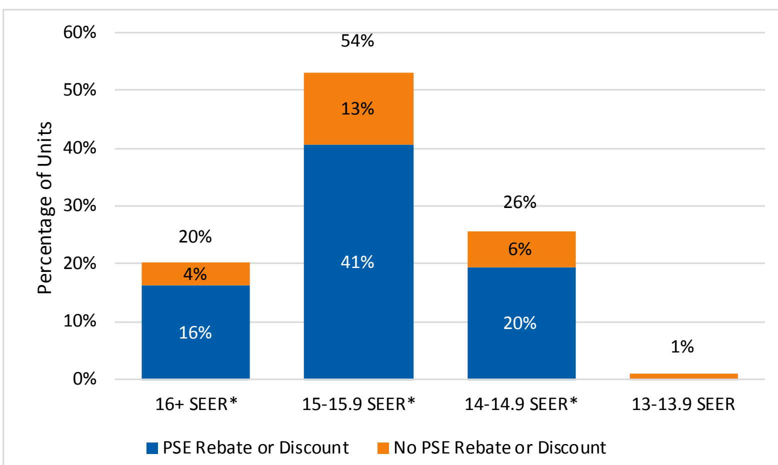


Source: Online survey question, Q.8 "Please indicate the percentage of heat pump water heater units you installed in each of the categories below and what percentage received a rebate through PSE." (n=5 contractors representing 101 water heater units).
*EF = energy factor; Program eligible rebates include those with an energy factor of 2.0 or higher.
Percentages may not sum to 100% due to rounding. Percentages do not match Figure 19 due to rounding.

Air Source Heat Pumps

Fourteen contractors installed a combined total of 1,713 ASHPs in the past 12 months. To qualify for a rebate through PSE, the ASHP needed to be 14 SEER or higher. Ninety-nine percent of ASHPs installed by surveyed CAN contractors met this efficiency level, with 74% at 15 SEER or higher. Approximately three-quarters of program-qualified heat pumps received a PSE rebate (Figure 27).

Figure 27. Air Source Heat Pump Efficiency Ratings

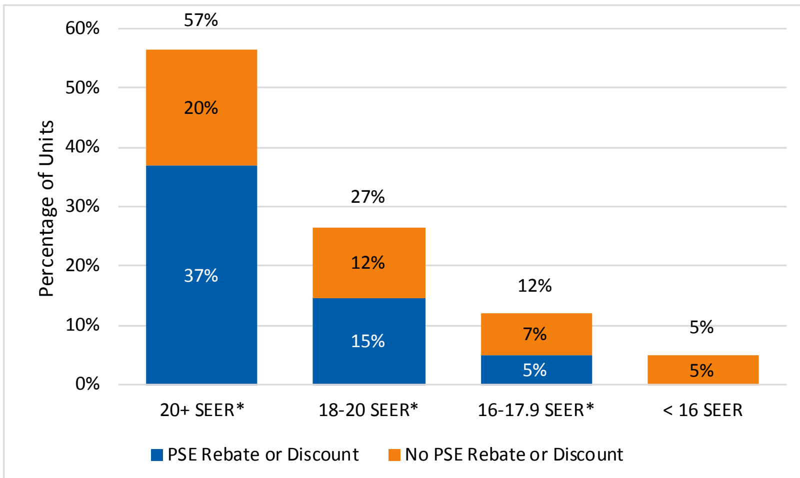


Source: Online survey question, Q. 5 "Please indicate the percentage of air source heat pump units you installed in each of the categories below and what percentage received a rebate through PSE." (n=14 contractors representing 1,713 ASHPs).
*Program eligible rebates include those with an efficiency rating of 14 SEER or higher.
Percentages may not sum to 100% due to rounding. Percentages do not match Figure 19 due to rounding.

Ductless Heat Pumps

Eighteen contractors installed a combined total of 1,951 DHPs in the past 12 months. To qualify for a rebate through PSE, DHPs are required to be 16 SEER or higher. As shown in Figure 28, 95% of installed DHPs met this program requirement, with the majority (57%) having a SEER rating of 20 or greater. Ninety-five percent of equipment installed is eligible for a PSE rebate, while 57% of those units eligible for a rebate received a rebate or discount.

Figure 28. Ductless Heat Pumps Efficiency Ratings

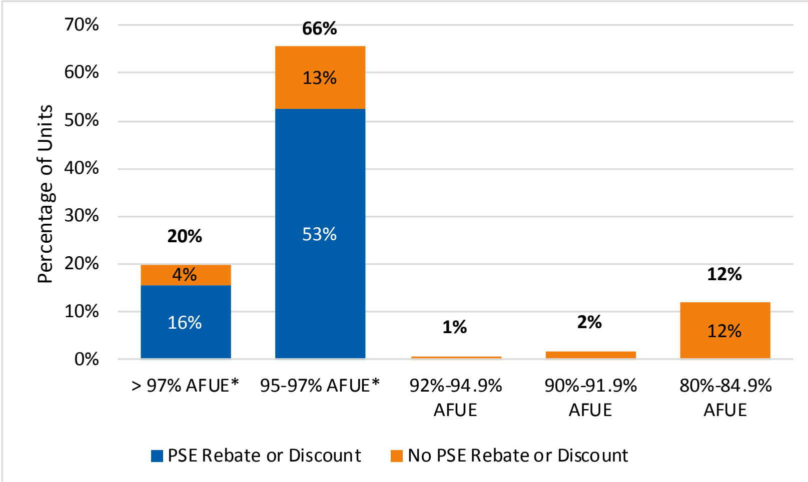


Source: Online survey question, Q. 6 "Please indicate the percentage of ductless heat pump units you installed in each of the categories below and what percentage received a rebate through PSE."; (n=14 contractors representing 1,951 DHPs).
*Program eligible rebates include those with an efficiency rating of 16 SEER or higher.
Percentages may not sum to 100% due to rounding. Percentages do not match Figure 19 due to rounding.

Gas Furnaces

Thirteen contractors indicated they had installed a combined total of 2,133 gas furnaces in the past 12 months. To qualify for a rebate through PSE, gas furnaces needed to have an AFUE of at least 95%. As shown in Figure 29, contractors reported the majority (86%; n=13) of gas furnaces installed met the PSE rebate requirement of at least 95% AFUE, and 69% of eligible gas furnaces received PSE rebates.

Figure 29. Distribution of Installed Gas Furnaces, by Efficiency Rating



Source: Contractor online survey, Q.3: "Please indicate the percentage of gas furnace units you install in each of the efficiency categories below and what percentage received a rebate through PSE" (n=13 contractors representing 2,133 gas furnaces installed)
*Program eligible efficiency ratings.
Percentages may not sum to 100% due to rounding. Percentages do not match Figure 19 due to rounding.

Previous Equipment

Cadmus asked active contractors in the CAN who installed heating and cooling equipment several questions about the typical equipment they install. Contractors who installed gas furnaces, ASHPs, DHPs, and HPWHs were asked about the typical age and efficiency of the heating system or water heating system that they are replacing. Table 61 provides detail about the age of the equipment and Table 62 provides the efficiency of the previous equipment.

Most contractors who were asked about DHPs did not provide details of the systems they were replacing and instead suggested that either this technology is too new to answer (6 of 12) or that the DHPs are not usually replacing a heating system, but rather supplementing it and/or providing a cooling system for the home (3 of 12). Of the remaining three contractors, two indicated that DHPs were typically replacing electric furnaces (no age or efficiency indicated), and one reported that DHPs were replacing electric wall heating (no age or efficiency detail provided).

Table 61. Age of Previous Equipment

Age	12-15 years old	15-20 years old	20+ years old
Gas furnace (n=15)	4	6	3
ASHPs (n=14)	8	6	0
HPWHs (n=2)	1	1	0

Source: Survey question, "Do you have a sense for the typical age and efficiency level of the [INSERT MEASURE] that customers are replacing?"

Table 62. Efficiency of Previous Equipment

Equipment Type	Efficiency of Previous Equipment	Number of Responses
Gas furnace (n=12)	70-80% AFUE	2
	80% AFUE	9
	88% AFUE	1
Air source heat pump (n=10)	10-12 SEER	7
	13-14 SEER	3
Heat pump water heater	0.87 EF	1

Source: Survey question, “Do you have a sense for the typical age and efficiency level of the [INSERT MEASURE] that customers are replacing?”

Appendix G. Inactive and Nonparticipating Contractor Experience

This appendix provides additional findings from the interviews with inactive and nonparticipating contractors.

CAN Orientation and Training

Inactive contractors were asked about their attendance and experiences with CAN orientations and program-specific trainings. Two of the four inactive contractors had attended a CAN orientation, while the other two did not remember. One of the two contractors who had attended a CAN orientation criticized the orientation in strong language, saying that it "was a joke," but did not provide additional detail except that a different regional utility's "program is much better." The other contractor who attended orientation was neutral on their experience, saying that "it was okay, [but] could have been more detailed." Three of the four inactive contractors said they had not attended any program-specific training, while the fourth thought he had probably attended a program-specific training, but it was "too long ago to remember" for sure.

Program Awareness

Cadmus asked the four inactive contractors and one nonparticipant contractor about their awareness of PSE rebates. The nonparticipant contractor was aware of PSE's rebates for residential customers, but not unaware of the CAN. Two of the inactive contractors could not remember how they first learned about the CAN, one learned about the CAN through involvement with "energy programs" (presumably energy efficiency programs), and one learned about the CAN through radio ads.

Participation Challenges

Cadmus asked the four inactive contractors why they decided to stop participating in the CAN. Several reasons the inactive contractors stopped participating in CAN include:

- Business slowed down during a recent economic downturn
- No clear reason, simply hadn't sold jobs through PSE programs in the past year
- CAN was "too difficult to deal with," and did not provide significant enough benefits. A different regional utility offered zero interest loans that were more useful to customers than rebates
- PSE had discontinued the rebates most relevant to the contractor's business[62]

62 The contractor did not specify the rebates, but his business includes insulation, air sealing, and ductless heat pumps.

Appendix H. Survey Demographics

This appendix contains tables outlining the answers to each of the demographic questions in the customer survey.

Table 63. Type of Home

What type of home do you live in?	Space Heat (n=199)	Weatherization (n=73)	Water Heat (n=50)	Windows (n=107)
Mobile/manufactured home	9%	0%	4%	6%
Single-family home, detached house	88%	93%	86%	84%
Attached house (townhouse, row house, or duplex)	2%	1%	4%	3%
Multifamily apartment or condo building with four or more units	1%	1%	2%	6%
Co-op/retirement community	0%	0%	0%	0%
Other	1%	5%	4%	2%

Table 64. Square Footage of Home

Approximately how many square feet of living space does your home have?	Space Heat (n=200)	Weatherization (n=72)	Water Heat (n=50)	Windows (n=108)
Less than 800 square feet	1%	0%	0%	2%
800 to less than 1,200 square feet	12%	13%	22%	15%
1,200 to less than 1,500 square feet	15%	22%	16%	14%
1,500 to less than 2,000 square feet	26%	24%	22%	31%
2,000 to less than 2,500 square feet	15%	22%	28%	20%
2,500 to less than 3,000 square feet	18%	11%	8%	9%
3,000 to less than 4,000 square feet	9%	7%	2%	6%
4,000 or more square feet	2%	0%	2%	1%
Don't know	3%	1%	0%	1%

Table 65. Own or Rent Home

Do you or members of your household own this home or do you rent?	Space Heat (n=200)	Weatherization (n=73)	Water Heat (n=50)	Windows (n=108)
Own/buying	98%	97%	98%	97%
Rent/lease	0%	2%	2%	2%
Occupied without payment of rent	0%	0%	0%	0%
Other	2%	0%	0%	1%
Don't know	0%	1%	0%	0%

Table 66. Payment of Energy Bills

Which best describes how your energy bills are paid?	Space Heat (n=200)	Weatherization (n=71)	Water Heat (n=50)	Windows (n=108)
I pay the energy bills	98%	94%	98%	98%
My landlord pays the energy bills	0%	0%	0%	0%
A relative pays the energy bills	1%	4%	2%	0%
Community assistance	0%	0%	0%	0%
Other	1%	2%	0%	2%

Table 67. Number of Household Members

Including yourself, how many people live in your home full-time?	Space Heat (n=189)	Weatherization (n=66)	Water Heat (n=46)	Windows (n=101)
1 person	11%	18%	17%	17%
2 people	59%	42%	57%	42%
3-4 people	25%	29%	19%	23%
5-6 people	6%	14%	6%	11%
7 or more people	0%	3%	2%	0%

Table 68. Survey Participants Age

What is your age?	Space Heat (n=193)	Weatherization (n=69)	Water Heat (n=49)	Windows (n=106)
18 to 24 years of age	0%	1%	0%	0%
25 to 34 years of age	3%	10%	6%	9%
35 to 44 years of age	8%	26%	22%	15%
45 to 55 years of age	18%	17%	16%	14%
55 to 64 years of age	26%	16%	18%	32%
65 to 74 years of age	34%	22%	31%	25%
75 years of age or older	11%	7%	6%	4%

Table 69. Survey Participants Education

What is the highest level of school you have completed?	Space Heat (n=192)	Weatherization (n=68)	Water Heat (n=50)	Windows (n=105)
Less than ninth grade	0%	0%	0%	0%
Ninth to twelfth grade; no diploma	1%	1%	0%	1%
High school graduate	5%	12%	12%	6%
Some college, no degree	18%	12%	18%	16%
Associate's degree	13%	6%	18%	10%
Bachelor's degree	30%	31%	38%	33%
Graduate or professional degree	34%	49%	14%	33%

Program(s):

- Low Income Weatherization

Program Year(s):

- 2013-2015 (Impact evaluation); 2015-2016 (Process evaluation)

Contents:

- Evaluation Report
- PSE Evaluation Report Response

This document contains Puget Sound Energy's (PSE) Low Income Weatherization (LIW) Evaluation Report and Evaluation Report Response (ERR). In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

PSE program managers and evaluation staff prepare an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Please note that this is an evaluation of the program as it operated during the 2013-2016 program years, and does not necessarily reflect the program as currently implemented, or measures currently deployed by the program.

This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx**

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[1] (6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for 2016-2017 PSE Electric Conservation.

[2] PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised August 6, 2015.

[3] Ibid.

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Evaluation Report Response

Program:	Low Income Weatherization
Program Manager(s):	Sandy Sieg
Study Report Name:	Low-Income Weatherization Program Final Evaluation Report
Primary Author(s):	Cadmus
Report Date:	October 2017
Evaluation Analyst(s):	Michael Noreika
Date of ERR:	December 2017

Evaluation Overview, Key Findings, Recommendations and Program Responses:

I. Abstract

Through its Low-Income Weatherization (LIW) program, Puget Sound Energy (PSE) seeks to reduce lower-income customers' energy costs by improving their residences' energy efficiency and by educating consumers on routine ways to reduce energy use and costs. In 2016, PSE contracted with Cadmus to evaluate LIW's impacts and program processes. The evaluation research included performing billing analysis to evaluate energy savings impacts, assessing non-energy program impacts, reviewing savings calculations used in program planning, conducting participant phone surveys, interviewing stakeholders, and developing a framework for tracking key performance indicators (KPIs).

Overall, LIW met its goal of reducing the energy cost burden of low-income customers by improving the energy efficiency of their residences and by educating them on ways to reduce energy use. As a result of the program, participants consumed 18% less electricity and 24% less gas, on average--among the highest relative impacts compared to other low-income weatherization programs benchmarked from across the country. Overall electric realization rates averaged 79% across the 2013–2015 period, with the realization rate increasing in 2015 to 94%. Overall gas realization rates averaged 118% across the 2013–2015 period, with the realization rate increasing in 2015 to 149%. A review of PSE's measure-level savings estimates revealed several calculations that might benefit from revised input assumptions or estimation approach.

With respect to customer education, 83% of program participants remember receiving the energy education materials and recommendations from their energy auditor, and 93% found these tips useful. Both program participants and delivery agencies report high satisfaction with LIW. Ninety-two percent of program participants reported being very (72%) or somewhat (20%) satisfied with the program overall.

A. Evaluation Context

As part of PSE's Business-to-Business residential delivery channel, the LIW serves as its own independent compliance program (i.e., Low Income Weatherization) under the E/G 201 Tariff Schedule. Prior to the current study, Cadmus' 2012 LIW evaluation provided the most recent evaluation report, largely focusing a savings review, NEB assessment, and broad process research (e.g., stakeholder interviews, participant surveys). The current evaluation covers some of the same research tasks and also includes a comprehensive billing analysis to assess the program's impact on energy savings and a suggested framework for tracking key performance indicators (KPIs).

The primary goals of this evaluation are to independently verify energy savings and to identify recommendations for program improvement. Specific objectives of the impact evaluation are reporting realization rates for the evaluated energy savings, evaluating measure life and risks to the persistence of savings. For the process evaluation, objectives include identifying best practices, reviewing the rebate structure, and exploring trends in measures, savings, and program performance.

II. Conclusions, Recommendations, and PSE Responses

A. Overall Performance

Conclusion: The LIW program is achieving its overall objectives. LIW met its goal of reducing the energy cost burden of low-income customers by improving the energy efficiency of their residences and by educating them on ways to reduce energy use. As a result of the program, participants consumed 18% less electricity and 24% less gas, on average. With respect to customer education, 83% of program participants remember receiving the energy education materials and recommendations from their energy auditor, and 93% of respondents found these tips useful. Both program participants and delivery agencies reported high satisfaction with LIW. Ninety-two percent of program participants reported being very (72%) or somewhat (20%) satisfied with the program overall.

Conclusion: Average per household electric energy savings were lower than reported savings in 2013 and 2014 but were high relative to benchmarked low income programs. Overall electric realization rates averaged 79% across the 2013–2015 period, with the realization rate increasing in 2015 to 94%. The average three-year realization rate was significantly higher for participants who installed a ductless heat pump (DHP) versus those who did not (95% vs. 71%). Although realization rates were below 100% in 2013 and 2014, average electric savings was 18% of pre-installation usage, which was on the high end of benchmarked program savings. These findings suggest that recent changes to RTF/PSE-deemed savings estimates are increasing reporting accuracy and that PSE's program is exhibiting high performance with regard to lowering participant energy costs.

Conclusion: Average per household gas energy savings exceeded reported savings, and were high relative to other LI programs. Overall gas realization rates averaged 118% across the 2013–2015 period, with the realization rate increasing in 2015 to 149%. Gas savings averaged 24% of pre-installation usage, which was the highest among similar programs benchmarked. These findings suggest that recent changes to reported savings estimates may have resulted in underestimated actual savings and that PSE's program is exhibiting high performance with regard to lowering participant energy costs.

Conclusion: Frequent and open communication between agencies and PSE is one key to program success. Stakeholders and agencies characterized PSE as easy to communicate with, forward thinking, service-oriented, and collaborative. Agencies said that PSE provides sufficient information during annual meetings to implement the program and is consistently available and helpful, providing support throughout the year when needed. Stakeholders agree that PSE and agencies work well together, maintaining productive communication that is beneficial to customers.

B. Planning, Savings Estimation, and Evaluability

Conclusion: PSE's savings estimation methods and input data are reasonably accurate; however, several measures have outdated planning assumptions, and opportunities exist to improve the accuracy of savings estimates. A detailed savings review revealed that unit energy savings (UES) values for shell and duct measures relied on outdated Regional Technical Forum (RTF) sources, and refrigerator replacement and pipe insulation measures contained incomplete documentation of savings sources. In addition, Cadmus identified an opportunity to improve the accuracy of the savings calculation approach for DHP and heating system replacement measures.

> **Recommendation:** Update UES values for shell and duct measures and revisit RTF-deemed savings estimates annually for revisions. Given frequently updated energy-saving source documentation, PSE should revisit RTF-deemed savings estimates annually for any changes that may be relevant to delivery or design adjustments. Specifically, for shell measures (including insulation, air sealing, and windows) and duct sealing and insulation, PSE should revise current UES savings estimates to account for recent updates to the RTF weatherization UES workbooks.

PSE Response: PSE has updated UES values for the 2018-19 program period. The program also reviews RTF updates on an ongoing basis. PSE is not obligated to adopt any RTF updates that occur after September 1 of each calendar year. Thus, there may be time periods when PSE is not using the most current RTF UES for certain measures.

Conclusion: Billing analysis may provide PSE with more accurate savings estimates than the current engineering analysis-based approach. Billing analysis is industry best practice for evaluating energy savings of whole-house energy efficiency programs like LIW. This method has the advantage of capturing measure interactive effects, energy education, behavioral changes, and other factors that directly contribute to program impacts. The current evaluation produced whole-house savings estimates at ±13% and ±11% precision for electric and gas, respectively, in contrast with engineering-based approaches which typically cannot quantify a level of uncertainty associated with the variety of measures installed.

Conclusion: The LIW program resulted in quantifiable non-energy benefits (NEBs). Cadmus confirmed monetized values for four distinct NEBs associated with program performance: economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits.

Table 1 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

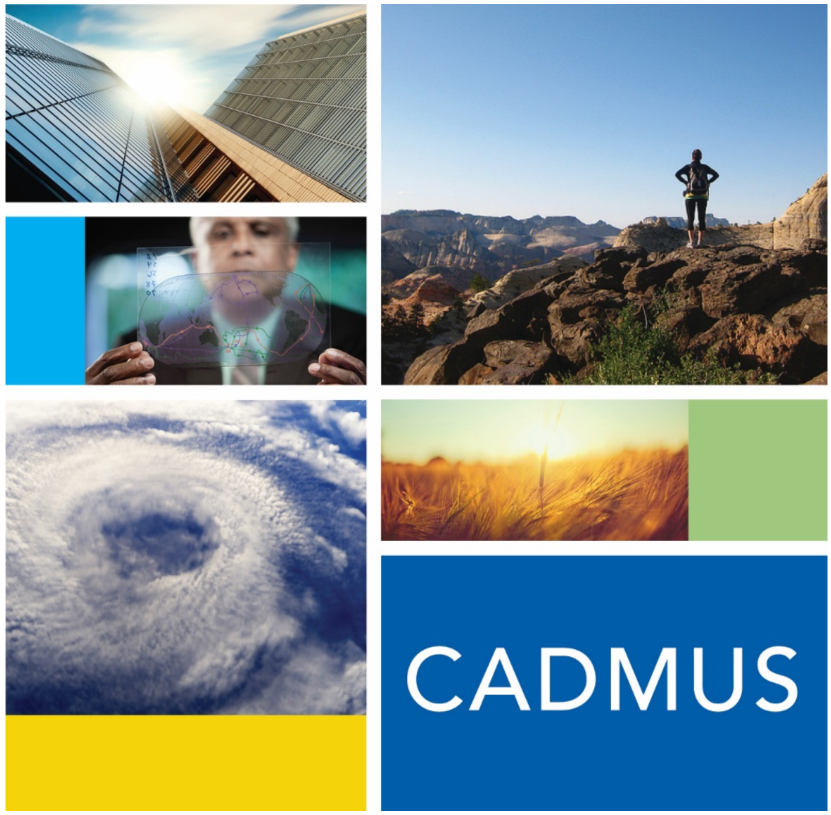
Recommendation: Include NEBs in program cost-effectiveness scenarios. A complete benefit/cost analysis considers not only direct financial costs and benefits experienced by an individual or firm, but also costs and benefits accruing to society as a whole (Boardman et al. 2006). Based on Cadmus' analyses and consistent with the 2016-2017 Biennial Conservation Plan, PSE should run cost-effectiveness scenarios for LIW that include consideration of NEBs values assessed through this study.

PSE Response: PSE will consider including NEBs in the cost-effectiveness calculations.

Table 1. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted
	Electric	Gas	
Participant Ancillary Benefits	$100		TRC, PCT
Economic Impacts	$2,313		TRC
Environmental – Avoided Compliance Costs	$33.88	$33.88	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$41.97	$42.03	PTRC

Conclusion: LIW customer contact information is not consistently captured. Cadmus found that program tracking data contained incomplete contact information for program participants, providing challenges in drawing a phone survey sample from the participant population and potentially introducing bias. For multifamily projects, the tracking data did differentiate property manager participants from in-unit occupants, but this information was inconsistently populated.



Low-Income Weatherization Program Final Evaluation Report

October 27, 2017

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Acronyms and Definitions

Acronym	Definition
AMI	Area median income
CAAs	Community action agencies
CAN	Contractor Alliance Network
CAR	Washington Clean Air Rule
CDD	Cooling degree day
CFLs	Compact fluorescent lamps
CFM	Cubic feet per minute
DHP	Ductless heat pump
DI	Direct install
DIY	Do-it-yourself
DOE	U.S. Department of Energy
EISA	Energy Independence Security Act
FPL	Federal poverty level
GTD	Generation, transmission, and distribution
HDD	Heating degree day
IC	Implementation contractor
IO	Input-output
LIHEAP	Low-Income Home Energy Assistance Program
LIW	PSE’s Low-Income Weatherization Program
KPI	Key performance indicator
NOAA	National Oceanic and Atmospheric Administration
PCT	Participant Cost Test
PRENAC	Pre-installation weather-normalized annual consumption
POSTNAC	Post-installation weather-normalized annual consumption
PRISM	Princeton Scorekeeping Method
PTRC	Total Resource Cost Test + Conservation Adder (essentially Societal Cost Test)
QA/QC	Quality assurance/quality control
RDP	Regional Domestic Product
RTF	Regional Technical Forum
RPC	Regional Purchase Coefficient
T&D	Transmission and distribution
TMY3	Typical meteorological year
TRC	Total Resource Cost Test
TRM	Technical Reference Manual
UCT	Utility Cost Test
UES	Unit Energy Savings
UMP	Uniform Methods Project
WAP	Weatherization Assistance Program
WTP	Willingness to pay

Abstract

Through its Low-Income Weatherization (LIW) program, Puget Sound Energy (PSE) seeks to reduce lower-income customers' energy costs by improving their residences' energy efficiency and by educating consumers on routine ways to reduce energy use and costs. In 2016, PSE contracted with Cadmus to evaluate LIW's impacts and program processes. The evaluation research included performing billing analysis to evaluate energy savings impacts, assessing non-energy program impacts, reviewing savings calculations used in program planning, conducting participant phone surveys, interviewing stakeholders, and developing a framework for tracking key performance indicators (KPIs).

Overall, LIW met its goal of reducing the energy cost burden of low-income customers by improving the energy efficiency of their residences and by educating them on ways to reduce energy use. As a result of the program, participants consumed 18% less electricity and 24% less gas, on average--among the highest relative impacts compared to other low-income weatherization programs benchmarked from across the country. Overall electric realization rates averaged 79% across the 2013–2015 period, with the realization rate increasing in 2015 to 94%. Overall gas realization rates averaged 118% across the 2013–2015 period, with the realization rate increasing in 2015 to 149%. A review of PSE's measure-level savings estimates revealed several calculations that might benefit from revised input assumptions or estimation approach.

With respect to customer education, 83% of program participants remember receiving the energy education materials and recommendations from their energy auditor, and 93% found these tips useful. Both program participants and delivery agencies report high satisfaction with LIW. Ninety-two percent of program participants reported being very (72%) or somewhat (20%) satisfied with the program overall.

Executive Summary

Through its Low-Income Weatherization (LIW) program, Puget Sound Energy (PSE) seeks to reduce -income customers' energy costs by improving their residences' energy efficiency and by educating consumers on routine ways to reduce energy use and costs. In 2016, PSE contracted with Cadmus to conduct evaluations of LIW's impacts and program processes. Specifically, the impact evaluation focused on the 2013–2015 program period, while the process evaluation focused on more recent periods of program activity (i.e., 2015 and 2016).

Evaluation Context

As part of PSE's Business-to-Business residential delivery channel, the LIW serves as its own independent compliance program (i.e., Low Income Weatherization) under the E/G 201 Tariff Schedule. Prior to the current study, Cadmus' 2012 LIW evaluation provided the most recent evaluation report, largely focusing a savings review, NEB assessment, and broad process research (e.g., stakeholder interviews, participant surveys). The current evaluation covers some of the same research tasks and also includes a comprehensive billing analysis to assess the program's impact on energy savings and a suggested framework for tracking key performance indicators (KPIs).

Conclusions, Recommendations, and Considerations

Overall Performance

Conclusion: The LIW program is achieving its overall objectives. LIW met its goal of reducing the energy cost burden of low-income customers by improving the energy efficiency of their residences and by educating them on ways to reduce energy use. As a result of the program, participants consumed 18% less electricity and 24% less gas, on average. With respect to customer education, 83% of program participants remember receiving the energy education materials and recommendations from their energy auditor, and 93% of respondents found these tips useful. Both program participants and delivery agencies reported high satisfaction with LIW. Ninety-two percent of program participants reported being very (72%) or somewhat (20%) satisfied with the program overall.

Conclusion: Average per household electric energy savings were lower than reported savings in 2013 and 2014 but were high relative to benchmarked LI programs. Overall electric realization rates averaged 79% across the 2013–2015 period, with the realization rate increasing in 2015 to 94%. The average three-year realization rate was significantly higher for participants who installed a ductless heat pump (DHP) versus those who did not (95% vs. 71%). Although realization rates were below 100% in 2013 and 2014, average electric savings was 18% of pre-installation usage, which was on the high end of benchmarked program savings. These findings suggest that recent changes to RTF/PSE-deemed savings estimates are increasing reporting accuracy and that PSE's program is exhibiting high performance with regard to lowering participant energy costs.

Conclusion: Average per household gas energy savings exceeded reported savings, and were high relative to other LI programs. Overall gas realization rates averaged 118% across the 2013–2015 period, with the realization rate increasing in 2015 to 149%. Gas savings averaged 24% of pre-installation usage, which was the highest among similar programs benchmarked. These findings suggest that recent changes to reported savings estimates may have resulted in underestimated actual savings and that PSE's program is exhibiting high performance with regard to lowering participant energy costs.

Conclusion: Frequent and open communication between agencies and PSE is one key to program success. Stakeholders and agencies characterized PSE as easy to communicate with, forward thinking, service-oriented, and collaborative. Agencies said that PSE provides sufficient information during annual meetings to implement the program and is consistently available and helpful, providing support throughout the year when needed. Stakeholders agree that PSE and agencies work well together, maintaining productive communication that is beneficial to customers.

Planning, Savings Estimation, and Evaluability

Conclusion: PSE's savings estimation methods and input data are reasonably accurate; however, several measures have outdated planning assumptions, and opportunities exist to improve the accuracy of savings estimates. A detailed savings review revealed that unit energy savings (UES) values for shell and duct measures relied on outdated Regional Technical Forum (RTF) sources, and refrigerator replacement and pipe insulation measures contained incomplete documentation of savings sources. In addition, Cadmus identified an opportunity to improve the accuracy of the savings calculation approach for DHP and heating system replacement measures.

> ***Recommendation: Update UES values for shell and duct measures and revisit RTF-deemed savings estimates annually for revisions.***

> ***Suggestion for consideration: Revise approach, input assumptions, or available source documentation used in several RTF or PSE-deemed savings estimates.***

> ***Suggestion for consideration: Track additional equipment system information for DHP and heating system replacement measures.***

Conclusion: Billing analysis may provide PSE with more accurate savings estimates than the current engineering analysis-based approach. Billing analysis is industry best practice for evaluating energy savings of whole-house energy efficiency programs like LIW. This method has the advantage of capturing measure interactive effects, energy education, behavioral changes, and other factors that directly contribute to program impacts. The current evaluation produced whole-house savings estimates at ±13% and ±11% precision for electric and gas, respectively, in contrast with engineering-based approaches which typically cannot quantify a level of uncertainty associated with the variety of measures installed.

> ***Suggestion for consideration: Use average household-level savings generated from billing analysis models to develop savings estimates.***

Conclusion: The LIW program resulted in quantifiable non-energy benefits (NEBs). Cadmus confirmed monetized values for four distinct NEBs associated with program performance: economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits.

Table 1 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

Recommendation: Include NEBs in program cost-effectiveness scenarios.

Table 1. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted
	Electric	Gas	
Participant Ancillary Benefits	$100		TRC, PCT
Economic Impacts	$2,313		TRC
Environmental – Avoided Compliance Costs	$33.88	$33.88	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$41.97	$42.03	PTRC

Conclusion: LIW customer contact information is not consistently captured. Cadmus found that program tracking data contained incomplete contact information for program participants, providing challenges in drawing a phone survey sample from the participant population and potentially introducing bias. For multifamily projects, the tracking data did differentiate property manager participants from in-unit occupants, but this information was inconsistently populated.

Suggestion for consideration: To ensure that sufficient information is collected from an evaluability perspective, PSE should ensure agencies provide complete contact information for all participants (including names, phone numbers, and e-mails) for all program participants.

Introduction

Program Description

Through its Low-Income Weatherization (LIW) program, Puget Sound Energy (PSE) seeks to lessen lower-income customers' energy-cost burdens by improving their residences' energy efficiency and by educating consumers on routine ways to reduce energy use and costs. PSE's Residential Business-to-Business Delivery Channel includes the LIW program within Tariff Schedule E/G 201. The program provides free energy efficiency measures to qualified residential customers residing in single-family residences, multifamily structures, or manufactured/mobile homes. The program is designed to adhere to state and federal low-income weatherization program guidelines and is implemented by community action agencies. While PSE oversees the program, in order to verify that agencies spend funding appropriately, it also provides guidance to agencies and allows them the flexibility to implement the program in ways that work best for their communities.

Program Delivery

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

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

The program is implemented by 11 community action agencies who recruit customers, determine income eligibility, complete the initial audit of households, and inspect the household once a contractor has completed the work. The initial audit is conducted by agency staff or subcontractors while the installation work is almost always completed by independent contractors.

Evaluation Overview

Cadmus conducted various research activities to meet PSE objectives in effectively assessing various elements of LIW focused on program impacts, delivery, and customer experience. Table 2 lists each task and provides a brief description. An overview of the methodology for each task is provided in Appendix A. Methodology.

Table 2. Evaluation Tasks

Evaluation Focus	Research Task	Description
Impact: What did the programs achieve?	Billing Analysis	Assess gas and electric energy impacts through regression analysis of consumption changes before and after measure installation
	Savings Review	Review algorithms and input assumptions associated with PSE's energy savings estimates used for program planning and reporting
	NEB s: Economic Impacts	Estimate economic and employment impacts associated with the investment of program dollars
	NEBs: Environmental Impacts	Assess environmental impacts associated with reduced emissions from offsetting generation and avoided environmental compliance costs
	NEBs: Participant Impacts	Estimate the value of select participant benefits (e.g., comfort) using a valuation approach through participant phone surveys
Process: What opportunities exist to improve program delivery?	Stakeholder Interviews	Assess program delivery and design elements through in-depth interviews with program managers, agencies, and other regional players
	Participant Surveys	Assess customer experience through a telephone survey focused on awareness, satisfaction, challenges, and behavioral changes
	Process Flow Diagram	Characterize the program process by illustrating the sequence of key stages of activity, decision making, and contributing parties
	Key Performance Indicator Framework	Develop a data-driven framework specific to LIW for tracking (and measuring) program performance improvements

Program Activity

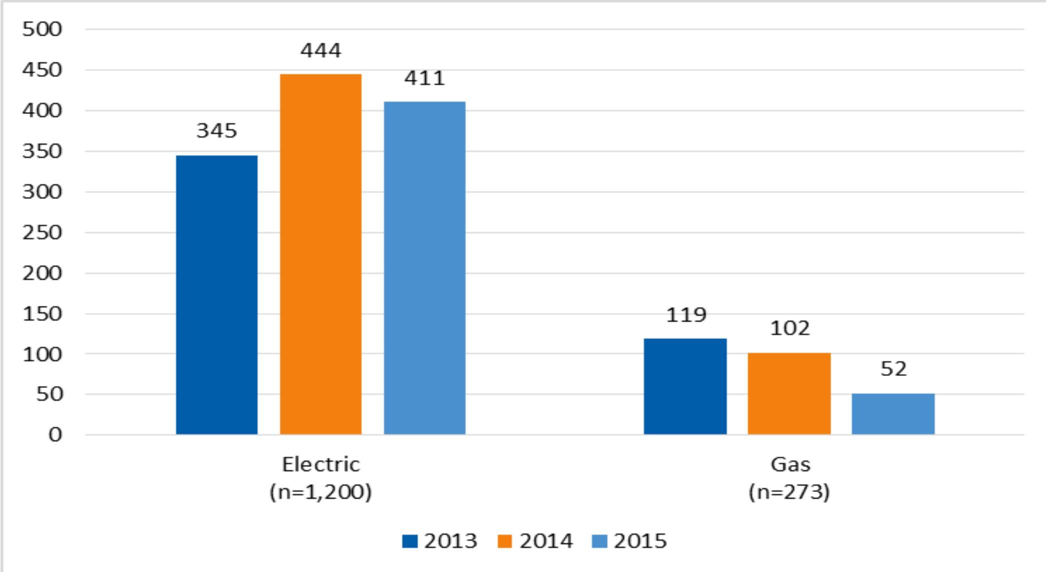
The figures outlined by subcategory below summarize the program period from 2013 through 2015.[1]

Customers by Year

Figure 1 shows the total electric and gas savings projects during the 2013 through 2015 period (including dual fuel households). As shown in Table 3, the decline in completed gas projects corresponds to a reduction in budget allocation and savings targets.

[1] At the time Cadmus received program data, a full year of 2016 activity was unavailable.

Figure 1. LIW Program—Completed Projects by Year and Fuel Savings



Source: PSE LIW program tracking data (2013-2015)

Reported Budgets and Savings by Year

Table 3 shows reported LIW allocated budgets, savings targets, and PSE-reported achievements for each, by year and fuel.[2]

2 Puget Sound Energy. *Energy Efficiency: 2015 Annual Report of Energy Conservation Accomplishments.* 2016. Available online: https://pse.com/aboutpse/Rates/Documents/ees_2015_annual_rpt_energy_conservation_accomplishments.pdf

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Puget Sound Energy. *Energy Efficiency: 2013 Annual Report of Energy Conservation Accomplishments.* 2014

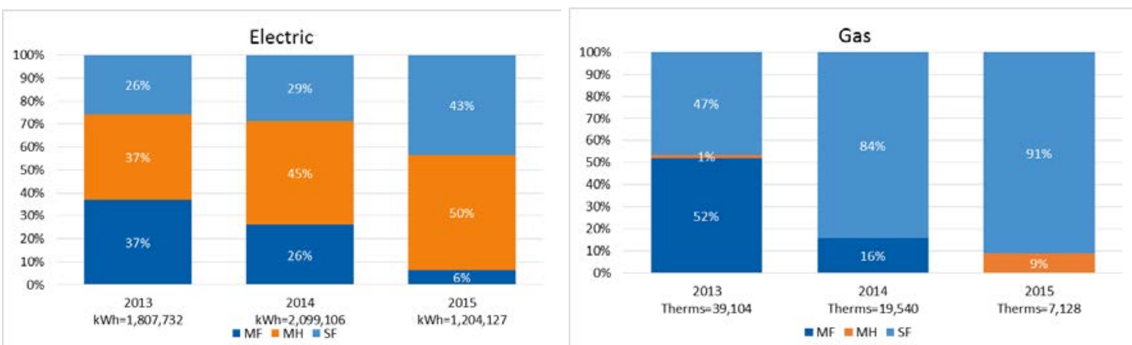
Table 3. PSE Reported Savings by Year and Fuel

Fuel	Year	Budget			Savings (in MWh and Therms)		
		Budget Allocation	$ Spent	Pct Budget Spent	Savings Target	Savings Achieved	Pct Savings Achieved
Electric	2013	$2,425,000	$2,373,466	98%	1,201	1,591	132%
	2014	$3,098,684	$2,846,848	92%	1,571	1,767	112%
	2015	$3,318,140	$3,489,481	105%	1,571	1,739	111%
Gas	2013	$301,000	$372,176	124%	21,179	32,948	156%
	2014	$369,443	$305,326	83%	27,391	24,370	89%
	2015	$268,098	$174,171	65%	18,815	10,707	54%

Savings by Housing Type

Figure 2 shows distributions of reported electric and gas savings by year and housing type. Manufactured homes comprised a substantial portion of electric savings. The proportion of multifamily gas and electric savings decreased substantially between 2013 and 2015, while manufactured homes comprised a larger portion of gas savings starting in 2015.

Figure 2. Distribution of Reported Savings by Fuel and Building Type

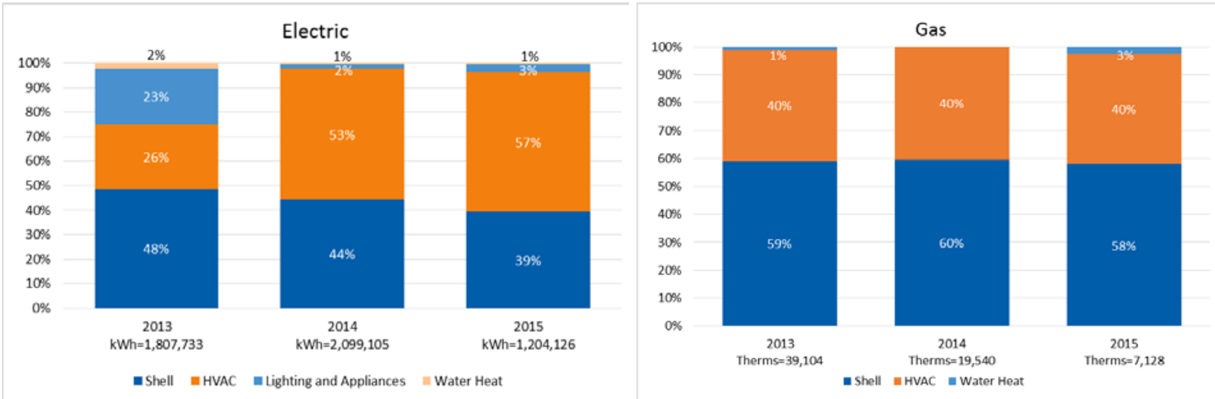


Source: PSE LIW program tracking data (2013-2015)

Savings by Measure Type

Shell measures comprised the largest share of electric savings in 2013, as shown in Figure 3, while HVAC savings made up the majority of savings in 2014 and 2015 (primarily driven by ductless heat pump installations). Over the 2013 through 2015 period, gas savings distribution remained constant, driven by approximately 60% shell and 40% HVAC measures savings.

Figure 3. Distribution of Reported Savings by Fuel and Measure Type



Source: PSE LIW program tracking data (2013-2015)

Impact Evaluation Findings

The impact evaluation seeks to assess program energy and non-energy achievements, including verifying energy impacts, assessing NEBs, and reviewing the inputs and calculation approach used in developing PSE reported savings estimates.

Billing Analysis

Cadmus conducted a billing analysis to evaluate electric and natural gas savings for LIW, addressing both program and measure-level results, where possible.

The evaluation compared model savings to PSE's reported planning estimates through development of a common evaluation metric, the realization rate. Notably, there are a variety of effects that billing analysis captures, which may influence energy consumption and are not reflected in planning estimates. These factors include measure interactive effects, installations by non-utility funding, energy education effects, measure persistence, measurement error, behavioral changes (e.g., take back), household changes, and weather effects.

Electric Energy Savings—Program-Level

Table 4 provides LIW electric savings based on the billing analysis regression model output, comparing changes in energy consumption from the pre- to post-program periods for the analysis sample (2013–2015). As shown, LIW participants achieved approximately an 18% reduction in electric usage, saving an average of 2,928 kWh per year. The table includes estimated adjusted gross savings, which Cadmus calculated based on a "percentage of pre" approach (more detail provided in Appendix A. Methodology).

Table 4. LIW Electric—Overall Program-Level Savings

Group	n	PRENAC*	Average Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings Pct. of Pre-Use	
			Model	Reported			Model	Reported
Participant	562	15,963	2,285	3,690	±9%	62%	14%	23%
Comparison	99	13,858	-558	n/a	±57%	n/a	-4%	n/a
Adj. Gross	**562**	**15,963**	**2,928**	**3,690**	**±13%**	**79%**	**18%**	**23%**

* Pre-installation weather normalized annual consumption (PRENAC)

Figure 4 summarizes the distribution of *reported* savings by measure category for the analysis sample. As shown, DHP and shell measures represent the highest proportion of reported savings.

Figure 4. LIW Electric—Measure Contributions to Program Savings

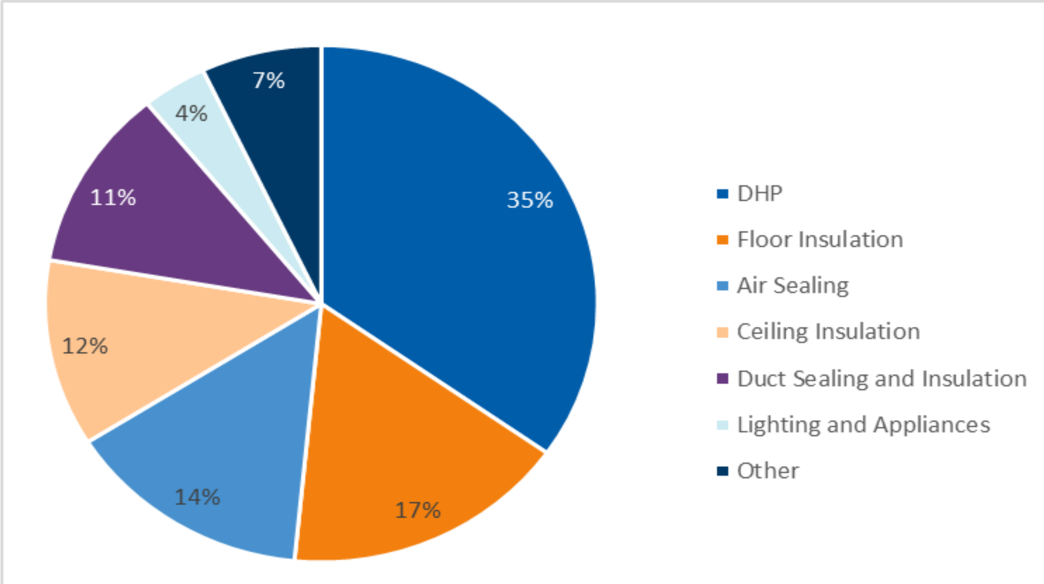


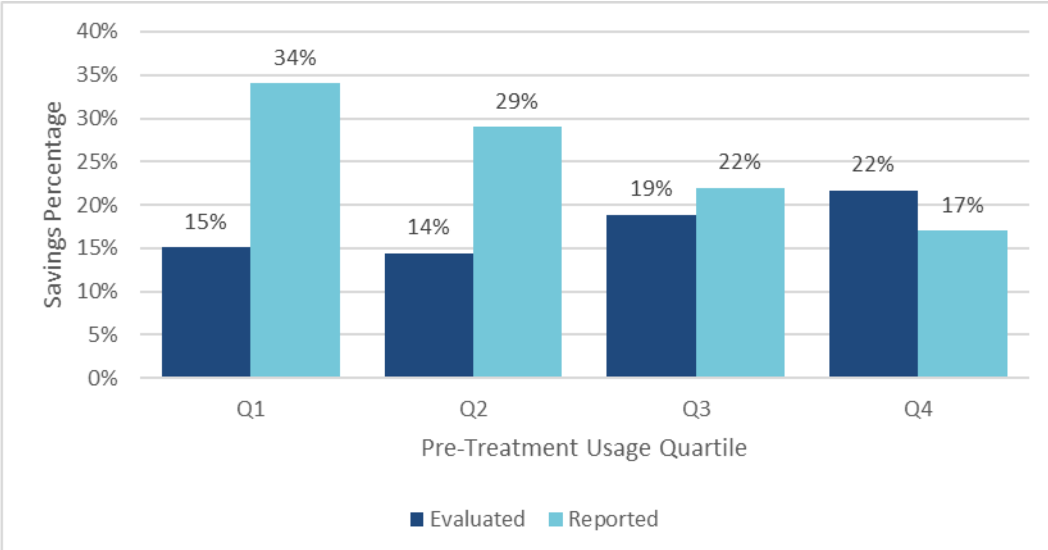
Table 5 summarizes participant impacts by year (defined by project completion date). Although the 2014 realization rate was lower than in 2013 and 2015, this rate approximated 94% in 2015, suggesting improvements occurred due to revisions to planning estimates.

Table 5. LIW Electric—Overall Savings by Year

Year	n	PRENAC	Average Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings Pct. of Pre-Use	
			Model	Reported			Model	Reported
2013	119	17,370	2,976	3,595	±18%	83%	17%	21%
2014	264	15,787	2,840	3,976	±15%	71%	18%	25%
2015	179	15,289	3,118	3,332	±15%	94%	20%	22%
Overall	**562**	**15,963**	**2,928**	**3,690**	**±13%**	**79%**	**18%**	**23%**

Figure 5 provides evaluated savings by pre-installation use levels (binned into quartiles) for the complete 2013–2015 analysis sample, compared to corresponding reported savings percentages per usage quartile. The decrease in reported percentage savings occurring as usage increases may indicate a lack of accounting for individual household characteristics (e.g., pre-treatment usage, square footage, existing measure conditions (such as efficiencies) in estimating reported savings values.

Figure 5. LIW Electric—Savings Comparison by Pre-Usage Quartile

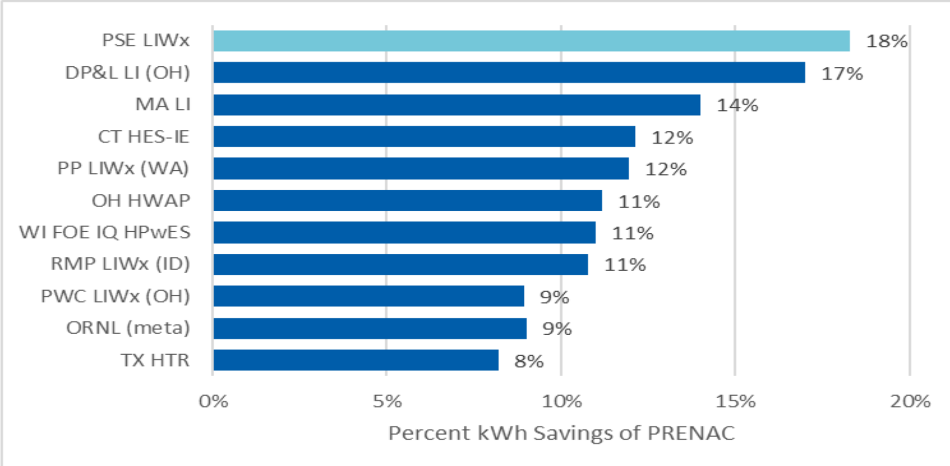


Compared to other, similar, low-income weatherization programs, PSE's program demonstrated high average electric energy savings—18% of pre-treatment consumption levels, compared to the 9% to 12% of average household electric consumption typical of low-income weatherization programs. The high savings performance of PSE's program likely relates to multiple factors:

- PSE experienced a high frequency of DHP installations.
- Higher saturations of electrically heated homes appeared in PSE's territory (compared to benchmarked projects from the Midwest and Northeast).[3]

[3] Studies used in benchmarking are all evaluations of low-income programs using billing analysis, each with distinct measure mixes, similarly aimed at delivering whole-house treatment. These studies focused on programs for the following program administrators: Dayton Power and Light, Massachusetts statewide program administrators, Connecticut statewide utilities, Pacific Power (WA), State of Ohio Developmental Service Agency, Wisconsin Focus on Energy, Rocky Mountain Power (ID), People Working Cooperatively (OH), Oak Ridge National Laboratory (meta-evaluation), and Texas statewide electric utilities.

Figure 6. Benchmarking—Electric Savings as a Percentage of Pre-Usage



Electric Energy Savings—Measure-Level

As shown in Table 6, Cadmus ran additional models that targeted measure-level impacts. Due to smaller sample sizes and the high frequency of measures installed in consistent combinations (resulting in what is referred to as collinearity), few measure estimates were reported with sufficient precision to earn consideration. Specifically, only DHPs were reported with tight model precision (±14%) and—interestingly—validated reported savings estimates with a realization approximating 100%.

Table 6. LIW Electric—Measure-Level Savings Summary

Measure Category*	n	PRENAC	Average Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings Pct. of Pre-Use	
			Model	Reported			Model	Reported
Floor Insulation	330	16,783	1,301	1,161	±47%	112%	8%	7%
DHP	**214**	**15,136**	**3,318**	**3,386**	**±14%**	**98%**	**22%**	**22%**

* Measures presented with relative precision (within ±50%).

DHP's contribute substantially to overall LIW electric savings. Table 7 summarizes the savings of households with and without DHP installations and shows that participant households with a DHP saved an estimated additional 17% of pre-installation electricity consumption (30% vs. 13% for households with no DHP).

Table 7. LIW Electric—Program-Level Savings, With and Without DHP

Model	n	PRENAC	Average Savings (kWh)		Relative Precision at 90%	Realization Rate	Savings Pct. of Pre-Use	
			Model	Reported			Model	Reported
No DHP	348	16,472	2,124	2,988	±18%	71%	13%	18%
With DHP	214	15,136	4,611	4,832	±10%	95%	30%	32%
Overall	**562**	**15,963**	**2,928**	**3,690**	**±13%**	**79%**	**18%**	**23%**

Gas Energy Savings—Program-Level

Table 8 provides LIW gas savings based on the billing analysis regression model output. As shown, LIW participants achieved approximately a 24% reduction in gas usage, saving an average of 188 therms per year. Poor precision in the comparison group model estimates (likely resulting from low sample sizes) provides inconclusive evidence of a significant exogenous effect; hence, Cadmus decided not to apply the comparison group adjustment and simply reported savings based on the participant analysis sample.

Table 8. LIW Gas—Overall Program-Level Savings

Group	n	PRENAC	Average Participant Savings (Therms)		Relative Precision at 90%	Realization Rate	Savings Pct. of Pre-Use	
			Model	Reported			Model	Reported
Participant	152	788	188	160	±11%	118%	24%	20%
Comparison	*27*	*832*	*2*	*n/a*	*±1636%*	*n/a*	*0.3%*	*n/a*
Adj. Gross	**152**	**788**	**188**	**160**	**±11%**	**118%**	**24%**	**20%**

Figure 7 summarizes the distribution of *reported* savings (by measure category) for the analysis sample. Shell measures (including air sealing, duct sealing, and insulation) account for approximately 84% of reported savings, with heating system replacements contributing the remainder.

Figure 7. LIW Gas—Measure Contributions to Program Savings

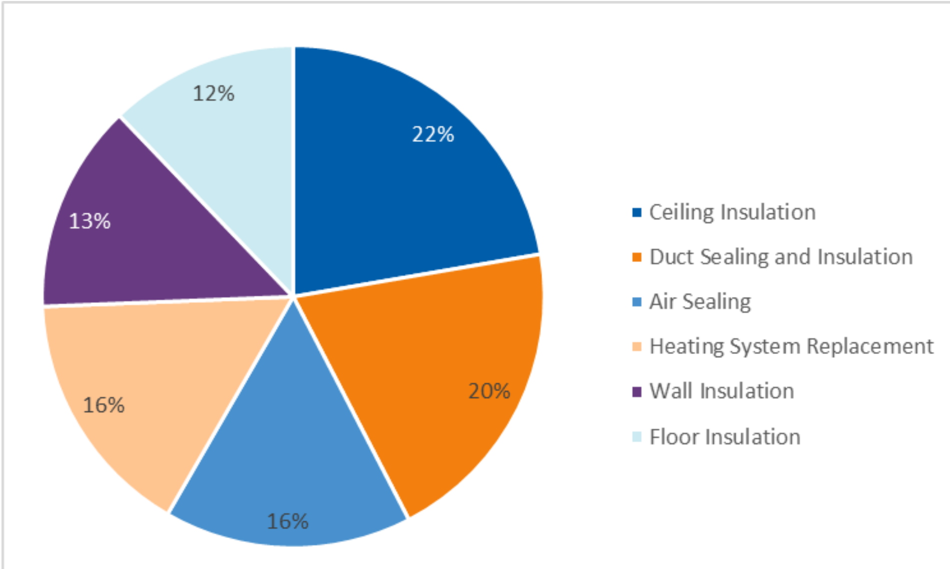


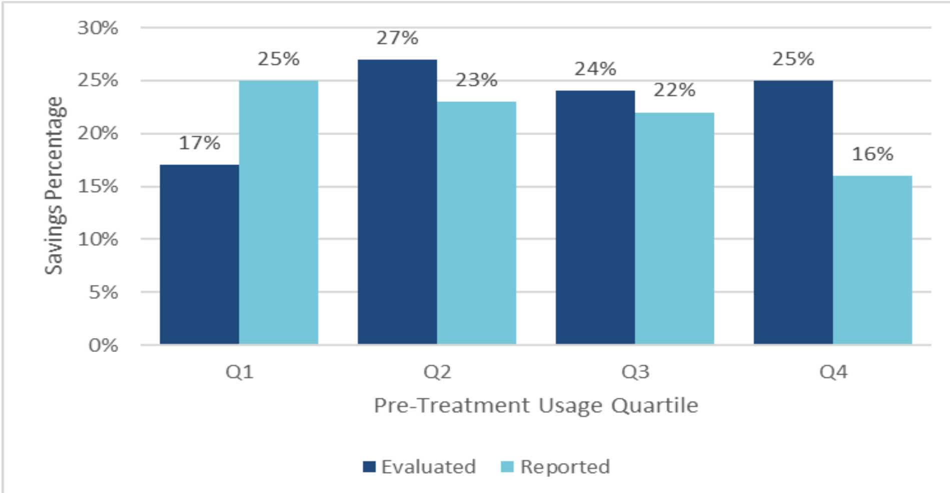
Table 9 summarizes participant impacts by year (defined by project completion dates). Increases in realization rates appear to be driven by adjustments to reported savings estimates used for planning (as evident by relatively flat average evaluated savings). Due to lower sample sizes, evaluated savings estimates for individual years demonstrated lower precision than the combined analysis sample.

Table 9. LIW Gas—Overall Savings by Year

Year	N	PRENAC	Average Savings (Therms)		Relative Precision at 90%	Realization Rate	Savings Pct. of Pre-Use	
			Model	Reported			Model	Reported
2013	49	867	193	172	±20%	113%	22%	20%
2014	75	759	185	163	±15%	113%	24%	21%
2015	28	730	194	130	±29%	149%	27%	18%
Overall	**152**	**788**	**188**	**160**	**±11%**	**118%**	**24%**	**20%**

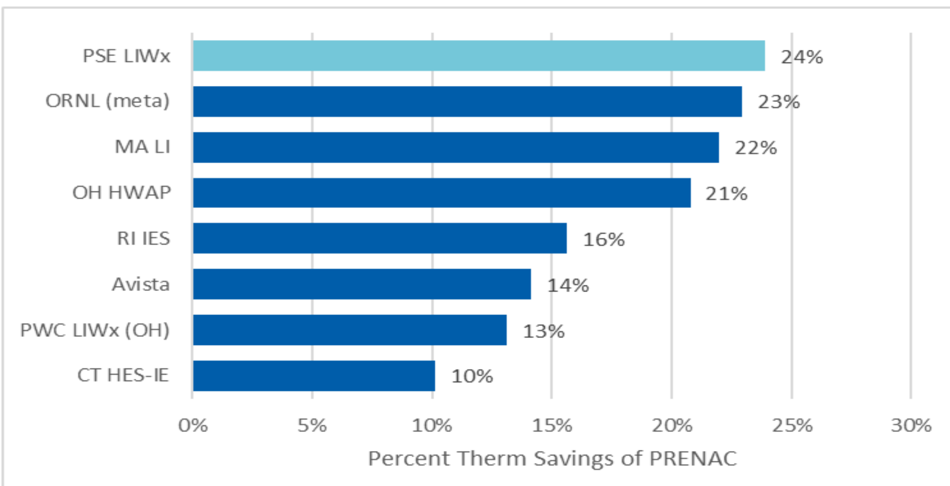
Figure 8 provides evaluated savings by pre-installation use levels (binned into pre-consumption quartiles) for the full 2013–2015 analysis sample, compared to corresponding, reported savings percentages by usage quartile. Reported savings decreased by quartile, while evaluated savings were higher for the top three quartiles.

Figure 8. LIW Gas—Savings Comparison by Pre-Usage Quartile



Compared to other similar low-income weatherization programs, PSE's LIW program demonstrated high average gas savings—24% of pre-treatment gas consumption levels, the highest savings among benchmarked programs, as shown in Figure 9.[4]

Figure 9. Benchmarking—Gas Savings as a Percentage of Pre-Usage



[4] Studies used in benchmarking are all evaluations of low-income programs using billing analysis, each with distinct measure mixes, similarly aimed at delivering whole-house treatment. These studies focused on programs for the following program administrators: Oak Ridge National Laboratory (meta evaluation), Massachusetts statewide program administrators, State of Ohio Developmental Service Agency, Rhode Island statewide program administrators, Avista Utilities (WA and ID), People Working Cooperatively (OH), and Connecticut statewide utilities.

Gas Energy Savings—Measure-Level

Table 10 shows the measure-level savings results for which the billing analysis model yielded acceptable precision. Adequate precision was achieved for only a few measures, largely due to participants installing multiple measures in combination. This made it difficult to isolate savings estimates for specific measures. Ceiling insulation was estimated as saving 137 therms per household at ±23% precision. Notably, reported savings fell outside of the model estimate's bounds and were substantially lower than evaluated savings. This suggests savings calculations used for program planning substantially underestimated actual savings.

Table 10. LIW Gas—Measure-Level Savings Summary

Measure Category	n	PRENAC	Average Savings (Therms)		Relative Precision at 90%	RR	Savings Pct. of Pre-Use	
			Model	Reported			Model	Reported
Ceiling Insulation	**89**	**794**	**137**	**70**	**±23%**	**195%**	**17%**	**9%**
Duct Sealing and Insulation	82	800	112	70	±47%	159%	14%	9%
Wall Insulation	59	767	91	60	±39%	152%	12%	8%
Heating System Replacement	15	875	141	103	±57%	137%	16%	12%

Savings Review

Cadmus' review of PSE energy savings revealed several instances where the estimation method and/or input data may benefit from either refreshed values or a revised approach.

The LIW program includes several major measure categories, with multiple versions of each measure listed in PSE's tracking database (depending on baseline or system configurations). For example, insulation measures contained 23 UES values, differentiated by baseline and post-installation conditions. The two primary sources of reported savings estimates include UES values sourced from RTF workbooks, and UES values that PSE has adapted from RTF or other evaluation work (i.e., PSE deemed values).

While many nationwide technical standards for determining UES values focus on simple engineering equations, the RTF focuses on providing UES values based on statistical methods and calibrated engineering approaches. Both methods characterize typical savings across a broad population of potential participants within the Pacific Northwest region.

Upon review of the algorithms and input assumptions used in current UES values, Cadmus determined that the majority are reasonably accurate for the purposes of planning estimates, and identified eight discrete recommendations and considerations for further refinement. Cadmus is suggesting these refinements for measures where more current or accurate values may be available, in order to align closely with RTF UES values, which receive frequent updates (for example, the RTF updated single-family weatherization UES values five times in 2015). Given this variability, Cadmus' recommendations do not point to specific RTF workbooks and data, but serve as guidelines for applying RTF data to UES values. Table 11 summarizes Cadmus' measure recommendations and considerations. Appendix D. Savings

Review Details provides detailed findings of Cadmus' savings review and specific proposed updates, by measure.

Table 11. Summary of Suggested Updates for Each LIW Measure

Measure Category	Measure Name	Recommendations/Considerations
Shell	Air Sealing / Structural Sealing	Review UES values annually to reflect most recent RTF sources Consider revising shell measure UES estimates to account for project-specific heating system types
	Floor Insulation	
	Attic Insulation	
	Wall Insulation	
	Duct Insulation and Sealing	
	Windows	
Lighting & Appliances	Refrigerator Replacement	Provide complete documentation for savings calculation approach, and consider revising the method if necessary (see example in Appendix D. Savings Review Details)
	LED Fixtures	None
	LED Lamp	
Domestic Hot Water	Showerheads	None
	Faucet Aerators	
	Water Heater Replacement	
	Pipe Insulation	Consider revised deemed savings estimate (from 20 kWh to 31 kWh), using a source with proper documentation
HVAC	Ductless Heat Pump	Consider revising estimate to use actual replaced heating system type rather than an average assumption
	Programmable Thermostat	None
	Ventilation	Consider revising CFM/watt assumptions used in current calculation (from 1.4 to 3.1 for baseline and from 10 to 8.3 for efficient condition)
	Heating System Replacement	Consider revising estimate to use actual installed heating system capacities rather than an average assumption
	Integrated Space & Water Heat	None

Non-Energy Benefits Assessments

Cadmus performed analyses to assess LIW program NEBs, quantifying estimates of economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits. Table 12 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

Table 12. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted
	Electric	Gas	
Participant Ancillary Benefits	$100		TRC, PCT
Economic Impacts*	$2,313		TRC
Environmental – Avoided Environmental Compliance Costs**	$33.88	$33.88	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$41.97	$42.03	PTRC

* Represents the average contribution to RDP (i.e., Value Added impacts from IMPLAN model) per 2015 program participant

** Represents the 2018 per participant benefits using the PSE IRP Scenario 12 CO_2 compliance price assumptions (High CO_2 Cost Scenario)

NEBs: Economic Impacts

The following section presents the gross, baseline, and net regional economic impacts within PSE's electric and gas service territories, attributable to the LIW program.

In order to calculate net economic impacts, it is necessary to first estimate a baseline scenario. The baseline scenario assumes LIW program expenditures were spent instead on a mix of typical utility-sector expenditures (e.g., purchasing coal or natural gas for electricity generation, importing electricity from out of state, and construction).[5] The gross program scenario estimates economic impacts resulting from the LIW program. Using these scenario estimates, Cadmus subtracted baseline impacts from the gross program impacts to determine net impacts for program year 2015.

Gross Economic Impacts

Table 13 shows gross direct, indirect, induced, and total effects[6] on several economic indicators (i.e., regional employment, labor income, value added, and output) attributable to LIW program expenditures, bill savings, utility avoided cost and revenue loss. Cadmus determined gross impacts on regional employment of approximately six job-years for LIW investments.[7]

5 The baseline scenario expenditures are assigned based on the IMPLAN-defined sector for utility services – *Utility Generation, Transmission, and Distribution (GTD).*

6 ***Direct effects*** represent regional production changes brought by increases in regional demand. ***Indirect effects*** are changes in demand for intermediate inputs necessary for directly affected industries. ***Induced effects*** result from the ways households and employees of directly and indirectly affected industries spend money on regional goods and services. ***Total effects*** are the sum of direct, indirect, and induced effects. See **Error! Reference source not found.** in **Error! Reference source not found.** for further detail and examples of these three impact types.

7 Approximately 23% of the total gross impacts on employment in PSE's service territory came from direct effects. The remaining 77% came from predicted indirect and induced effects. Induced impacts represent the economic activity that occurs because of changes in household income.

Table 13. 2015 Gross LIW Impact on Key Economic Indicators

Impact Type	Key Economic Indicator			
	Employment (Job-Years)	Labor Income (USD)	Value Added (USD)	Output (USD)
Direct Effect	3.6	$541,431	$88,250	$263,279
Indirect Effect	3.2	$199,998	$192,283	$316,607
Induced Effect	8.8	$468,245	$798,805	$1,302,975
Total Effect	**15.6**	**$1,209,675**	**$1,079,339**	**$1,882,861**

Baseline Economic Impacts

Table 14 presents effects attributable to 2015 baseline ratepayer expenditures. Cadmus modeled the hypothetical baseline ratepayer expenditures with no energy savings attributed to this scenario. The baseline scenario assumed all program expenditures associated with LIW were spent on the typical distribution of electric and gas utility industry expenditures in IMPLAN, such as raw fuel and energy imports, new construction, wages, and consulting. To estimate overall direct baseline expenditures, Cadmus assumed a cost-effectiveness ratio of 1.0, so that direct expenditures in the baseline scenario are equivalent to direct expenditures in the program scenario.

Table 14. 2015 Baseline Ratepayer Expenditure Impact on Key Economic Indicators

Impact Type	Key Economic Indicator			
	Employment (Job-Years)	Labor Income (USD)	Value Added (USD)	Output (USD)
Direct Effect	2.2	$340,466	$2,142,421	$4,076,220
Indirect Effect	2.2	$185,645	$543,291	$1,044,179
Induced Effect	-28.2	-$1,515,956	-$2,633,219	-$4,309,538
Total Effect	**-23.8**	**-$989,844**	**$52,493**	**$810,861**

The table also shows the direct, indirect, induced, and total effects on the same key economic indicators attributable to 2015 baseline ratepayer expenditures. As Cadmus modeled hypothetical baseline ratepayer expenditures as an increase in household payments for energy, IMPLAN predicted positive direct and indirect effects and negative induced effects. [8]

A substantial portion of typical household expenditures flow to industries such as retail and construction, which tend to be concentrated within the study region. Expenditures in the utility sector, on the other hand, rely heavily on inputs from outside the study region. PSE imports approximately 50% of its energy from out of state, either in the form of electricity imports or raw fuel imports, so a sizable

[8] The direct and indirect impacts are positive, attributable to increased expenditures in the utility sector and utility sector supply chain. The negative induced effects are caused by decreased household expenditures on the typical basket of household consumption because of higher costs per unit of energy.

percentage of the funds that are collected from ratepayers in the baseline scenario immediately flow out of the study region. Unlike in the program scenario, those funds are no longer available for job creation within the study region.

When estimating these effects, IMPLAN accounted for leakage out of the regional economy, which occurred because of the location of utility sector supply chain resources and because PSE meets a portion of local energy demand with fuel and power purchased from outside of PSE's service territory.[9]

Net Economic Impacts

Cadmus determined net regional economic impacts from the LIW program, summarized in Table 15, by subtracting hypothetical baseline scenario effects from gross program scenario effects.

Table 15. 2015 Net LIW Electric Impact on Key Economic Indicators

Impact Type	Key Economic Indicator			
	Employment (Job-Years)	Labor Income (USD)	Value Added (USD)	Output (USD)
Direct Effect	1.3	$200,965	-$2,054,171	-$3,812,942
Indirect Effect	1.1	$14,353	-$351,008	-$727,572
Induced Effect	37.1	$1,984,201	$3,432,024	$5,612,513
Total Effect	**39.5**	**$2,199,519**	**$1,026,846**	**$1,072,000**

Non-Energy Benefits: Environmental Impacts

The following section summarizes LIW impacts associated with greenhouse gas (GHG) emissions reduction and associated benefits.

LIW Emissions Reduction

At the program-level, considering both electric and gas reductions, the 2015 LIW program reduced annual emissions by 510 tons of CO_2e per year (shown in Table 16).

9 Through the use of Regional Purchase Coefficients (RPC), IMPLAN explicitly accounts for the share of factor inputs to productions that are imported to the study region from another county, state, or country. For example, the *Electric Generation, Transmission, and Distribution (Electric GTD)* IMPLAN sector in PSE's electric service territory has an RPC of less than 1% for the Coal Mining sector, indicating that less than 1% of coal used by the Electric GTD sector comes from within PSE's electric service territory.

Table 16. 2015 Total LIW Program Emissions Benefits by Fuel Savings

Fuel	Average GHG Emissions Avoided (Short Tons)		Total Program Emissions Avoided (Short Tons)	
	Annual GHG Emissions Avoided	Lifetime GHG Emissions Avoided	Annual GHG Emissions Avoided	Lifetime GHG Emissions Avoided
Electric	1.1	21.8	453	8,976
Gas	1.1	25.6	57	1,329
Overall	**1.1**	**22.3**	**510**	**10,306**

On average, electric and gas participants saw reductions of 1.1 tons of carbon dioxide equivalent (CO_2e) per year. Gas program participants achieved slightly larger GHG savings over the life of installed measures, given the longer average measure life for the gas compared with the electric program.

Comparison with Other Energy Efficiency Programs

Cadmus found data on annual GHG emissions reductions for low-income home weatherization programs occurring in two jurisdictions: Massachusetts and Wisconsin. As shown in Table 17, annual GHG emissions savings from these programs were comparable to those quantified for the PSE LIW program.

Table 17. Emissions Reductions from Comparable Energy Efficiency Programs

Jurisdiction	Sector	Fuel	Program Year	Annual GHG Reductions (CO_2e/participant)
Massachusetts	Low Income	Electric	2015	0.8
Massachusetts	Low Income	Gas	2015	1.1
Wisconsin (HPwES IE)	Low Income	Electric and Gas	2015	1.6
PSE	Low Income	Electric and Gas	2015	1.1

Avoided Emissions Applicability

Emission benefits can be used to tout the benefits of participation in energy efficiency programs. Emissions reduced by the LIW also can help PSE as the company develops plans for compliance with existing and future climate change regulations. The Washington State Clean Air Rule (CAR)[10] requires that owners of power plants and natural gas distributors in Washington that emit more than 100,000 metric tons CO_2e each year reduce emissions from an established baseline, beginning in calendar year 2017. Entities covered by this rule can reduce emissions through changes in operations or by purchasing Emission Reduction Units (ERUs) from others.

Furthermore, energy efficiency in excess of the minimum required under the Washington Energy Independence Act can create ERUs that PSE could sell to other entities, creating a new potential funding stream for energy efficiency measures. In addition to CAR compliance, energy efficiency can help PSE meet compliance obligations under potential future federal policies aimed at reducing GHG emissions.

[10] Washington Administrative Code, Chapter 173-442, Clean Air Rule

Avoided Emissions Benefits

Cadmus measured the NEBs from avoided GHG emissions in two ways. The first approach quantifies the avoided environmental compliance costs that result from energy efficiency programs. Avoided compliance costs are costs associated with complying with state and federal regulations aimed at reducing GHG emissions, such as CAR. In the second approach, Cadmus quantifies the social benefit associated with reduced emissions using EPA social cost of carbon, described below. Table 18 provides a summary of these benefits by type and fuel.

Table 18. Average Annual Environmental Non-Energy Benefits Values

Non-Energy Benefit	Per Participant Impact	
	Electric	Gas
Environmental – Avoided Environmental Compliance Costs*	$33.88	$33.88
Environmental – Social Benefit of Avoided Emissions	$41.97	$42.03

* Represents the 2018 per participant benefits using the PSE IRP Scenario 12 CO_2 compliance price assumptions (High CO_2 Cost Scenario)

Avoided Compliance Costs

To quantify avoided environmental compliance costs, Cadmus used assumptions from the 2017 PSE Integrated Resource Plan (IRP) development process. Due to uncertainty on the timing and structure of future GHG compliance programs, Cadmus developed two scenarios of future regulations consistent with the IRP. In developing its IRP, PSE estimated GHG compliance costs assuming various state and federal regulatory scenarios.

- ***High CO_2 Cost (Scenario 12: Base w/ CAR only)*** – In scenario 12, PSE assumed compliance only with the Washington CAR (with no federal Clean Power Plan). This scenario resulted in estimated compliance costs of **$30.71 per ton** in 2018 and rising to over $111/ton CO_2e in 2037. At this estimated price, the LIW gas and electric program would be expected to generate an average annual benefit per participant of $33.88 in 2018, rising to $54.43 in 2025. In total under this price scenario the LIW program would generate $494,350 in benefits over the lifetime of measures installed in 2015. As this scenario includes only currently implemented state regulations, Cadmus presents it for use in future PSE planning in Table 18.
- ***Low CO_2 Cost (Scenario 10: Base + Low CAR CO_2)*** – Scenario 10 in the IRP contains a more conservative estimate of GHG compliance costs. Within this scenario, PSE assumes lower CAR compliance costs until 2021, followed by a program similar to the Clean Power Plan. This scenario resulted in estimated compliance costs of **$14.36 per ton** in 2018 and rising to over $51/ton CO_2e in 2037. Using these compliance prices, the LIW program generates emissions reduction benefits of $231,086 over the lifetime of measures installed, or a benefit of $15.82 per participant in 2018, rising to $25.44 per participant in 2025.

Social Benefit of Avoided GHG Emissions

In addition to estimated avoided compliance costs from GHG regulations, Cadmus also estimated the social benefit of avoided GHG emissions. The social benefit uses a social cost of carbon as an estimate approximating future climate change damages that are avoided by reducing GHG emissions through the LIW program. The social benefit accrues to all members of society and includes a variety of climate change impacts, such as changes in agricultural productivity, human health, and property damages from increased flood risk.

While there are currently a variety of social cost of carbon estimates available, Cadmus used a conservative value for this evaluation, developed by the U.S. Environmental Protection Agency for use by federal agencies in valuing the climate change impacts of rulemakings.[11] Cadmus used the EPA social cost of carbon with a 3% discount rate which ranges from $39.68/ton CO_2 in 2015 to $60.63/ ton CO_2 in 2035.

The reduced emissions associated with the 2015 LIW program's combined gas and electric savings lead to a total social benefit of $407,680, or an ***annual benefit of $41.97 per electric-saving participant and $42.03 per gas-saving participant*** (noted above in Table 18).

Non-Energy Benefits: Ancillary Participant Benefits

Cadmus sought to establish dollar values for ancillary participant benefits that accrue to LIW program participants, expecting primary ancillary benefits associated with low-income weatherization programs to include comfort (due to reduced drafts and more efficient equipment) and health (due to more reliable heating and cooling). Assessment of these benefits relied on the contingent valuation method—an approach commonly used in economics literature to solicit information about individuals' willingness to pay (WTP) values for goods not traded in markets. By asking respondents whether they value the benefit at one of several "bid amounts" for each benefit in question, and through logistical regression modeling (logit), Cadmus estimated the mean participant value of that benefit.

Cadmus estimated an average benefit value of ***$99.62 per participant***, associated with the increased comfort resulting from LIW program participation. This estimate indicates that, on average, participants in the LIW program value the additional comfort they gain at approximately $100. This value accrues to participants in addition to the direct bill savings they experience. The respondent subsample for health-related benefits proved too small to develop statistically meaningful estimates for this benefit. Additional details regarding modeling approach, parameters, and outputs are provided in Appendix A. Methodology.

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[11] U.S. Environmental Protection Agency. "Social Cost of Carbon: Technical Documentation. https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon-technical-documentation_.html

Process Evaluation Findings

The process evaluation sought to identify opportunities for improving program delivery to PSE's customers. Cadmus designed its research to investigate the following topics:

- Organizational barriers to program effectiveness
- Participant satisfaction with the program and program components
- Motivations for program participation
- Program challenges and barriers
- Participant behavior changes

Table 19 lists the process evaluation research activities; Cadmus completed the program manager interviews in 2016 and completed the other activities in 2017.

Table 19. Process Evaluation Research Activities

Research Activity	Number Completed
PSE Program Manager Interview	1
Stakeholder Interviews*	2
Agency Interviews	5
Participant Surveys	111

*Washington State Department of Commerce and the Energy Project (a division of the Opportunity Council).

Program Objectives

PSE's LIW program seeks to lessen the energy-cost burden of lower-income customers by improving their residences' energy efficiency and by educating customers about routine ways to reduce their energy use and costs. Community action agencies implement the program, which adheres to state and federal guidelines. PSE oversees the program, providing implementation guidance and verifying appropriate use of funding, but allows agencies the flexibility to implement the program in ways that works best for their communities.

The agencies reported the program's purposes as reducing energy consumption and lowering the energy burdens for a wide-range of low-income customers. In addition, stakeholders cited improving the health and safety of homes through energy efficiency improvements as another program objective.

Program Goals

Every year, when agencies receive funding to implement PSE's LIW program, they set goals based on spending the money received in the best way possible to serve the most customers. The agencies said they met their goals in 2016 and considered the program successful. Energy Project staff said PSE provided a model program for helping low-income customers reduce their energy bills, with PSE willing to work with agencies to adjust budgets where necessary, and to make funds available to repair homes.

Energy Project staff reported agencies very effectively delivered services through PSE's program as they utilized different delivery methods, based on different populations they served (e.g., rural and urban). Close collaboration between PSE and the agencies worked well and contributed to program success.

Program Changes

While the state weatherization program has experienced several changes over the past couple of years, agencies said these changes did not greatly impact the way they implemented PSE's low-income weatherization program. Changes to the state weatherization program included:

- **Enacting more stringent guidelines regarding inspections.** Inspections must be completed by certified contractors and a different person must complete the initial audit and the final inspection.
- **Providing an improved but slightly more complex priority measure list.** The previous measure list was used across building types. The current list categorizes measures by building type making it more complex to navigate.

KPI Framework

At PSE's request, Cadmus developed a KPI framework and recommended KPIs that PSE can use to track program performance over time (Table 20). Cadmus developed the framework according to the following principles and best practices for performance tracking and continuous improvement:

- **Related to Goals.** The framework is organized by program goals outlined in the 2016-2017 PSE Biennial Conservation Plan Overview[12] or mentioned in the program manager interview; each recommended KPI framework relates to one of these goals
- **Focused.** The number of recommended KPIs is limited, to ensure focus on the metrics that are most critical to the success of the program
- **Controllable.** The KPIs are limited to metrics that PSE can influence and control
- **Balanced**. Recommended KPIs include a mix of retrospective metrics and process indicators, to support timely adaptive management
- **Measurable.** Recommended KPIs are relatively easy to measure and track on an ongoing basis; each metric requires a set of input variables, some of which PSE may not currently track electronically, but should be available from agency documentation.

A supplementary list of performance and diagnostic metrics is presented in Table 20. Cadmus believes these additional metrics are worthy of periodic investigation and can inform PSE adaptive management, but they may not be as high a priority for continuous performance tracking either because they are not as directly related to PSE goals as the suggested KPIs and/or more difficult for PSE to measure or control.

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[12] Puget Sound Energy. *2016-2017 Biennial Conservation Plan Overview*. Available online: https://www.pse.com/aboutpse/Rates/Documents/ees_2016-2017_conservation_planning_docs.pdf

Table 20. Key Performance Indicator Framework*

No.	Program Goal	KPI	Description	Data Source
1	Maximize Customers Served	Total number of annual participants	Annual production levels by agency and overall	PSE tracking database; agency reporting
2		Eligible Customer Conversion Rate	Proportion of eligible customers that receive initial audit	Agency reporting
3		Audit Conversion Rate	Proportion of audited customers eligible that receive recommended measure installation	Agency reporting
4	Improve EE/Reduce Burden	Average per-household savings	Average kWh and therm savings across all households (annually or year-to-date)	PSE tracking database; agency reporting
5		Percentage savings per household	Proportion of savings relative to pre-treatment annual consumption, by fuel and overall (or reporting behavior change)	PSE tracking database; PSE consumption data; agency reporting
6	Educate Customers	Proportion of customers receiving educational information	Proportion of participants who report receiving useful information on ways to reduce use/costs	PSE follow-up survey or Evaluation research
7	Customer Satisfaction	Average customer satisfaction**	Discrete satisfaction battery with consistent conventions, categories (e.g., program vs. agency/contractor), and scale (e.g., Likert vs. 10-point).	PSE follow-up survey or Evaluation research
8	Process Efficiency/ Customer Experience	Average audit wait time**	Average length of time per project between eligibility determination (and audit scheduling) and audit completion	Agency reporting
9		Average installation wait time**	Average length of time per project between audit measure eligibility determination and installation beginning	Agency reporting
10	Quality Control	Inspection pass rate	Percentage of projects that pass final inspections (both by agency and contractor)	Agency reporting

* PSE may currently collect and track some of these metrics.

** Best practice for certain metrics (e.g., satisfaction) may include tracking proportions or inter-quartile ranges (e.g., 9-10 responses out of 10-point scale) rather than presenting a simple average. Median is not always preferred, since it can obscure outliers, such as potential customer experience issues.

Table 21. Supplementary Metrics

No	Category	Metric	Description	Use	Data Source
1	Participation	Eligibility Ratio	Proportion of recruited customers (i.e., assessed for eligibility) who are eligible	Assess effectiveness of marketing/outreach targeting	Agency reporting
2		Deferral percentage	Proportion of eligible customers that receive an audit but are deferred, by deferral reason (e.g., insufficient repair dollars, health and safety issues)	Understand deferral rates and causes	Agency reporting
3		Pre/post cross-program participation	Proportion of LIW participants that participated in other PSE energy efficiency programs before and after LIW enrollment	Assess cross program influence and impacts	PSE tracking database
4	Resource Acquisition Costs	Average PSE dollars per kWh/therm	PSE dollars per unit energy savings	Assess PSE ROI (only PSE funds) with easily benchmarked metric	Agency reporting
5		Average SIR	Average per-project SIR value	Assess YTD average program cost-effectiveness (all funds)	Agency reporting
6	Cost	Average per-project cost	Total dollar amount per project, averaged across all projects (including installation and administration costs)	Understand trends in project budgets	PSE tracking database; agency reporting
7		PSE funding percentage	Proportion of project budgets funded by PSE	Understand agency leveraging of PSE dollars	Agency reporting
8		Administrative funding percentage	Proportion of project budgets used to fund administrative expenses	Understand and track project budget components	Agency reporting
9		Health and Safety funding percentage	Proportion of project budgets used to fund health and safety expenses		
10		Repair funding percentage	Proportion of project budgets used to fund repairs		
11	Impact	Track Non-Energy Benefits (Average benefit per customer)	Discrete suite of NEBs and consistent calculation approach/input assumptions	Quantify NEBs per customer	PSE follow-up survey or Evaluation research
12		Annual program savings penetration percentage	Total annual savings for participating households/Total potential savings associated with all eligible households	Track program penetration	Agency reporting; PSE Tracking database; Evaluation research

Program Delivery and Process Flow

During the interviews, Cadmus asked agencies to outline their implementation processes. Each agency implemented the program in a slightly different manner, but they generally followed the three main program delivery steps:

- **Pre-participation:** agencies recruit customers and determine participant eligibility
- **Installation process:** agencies assess the home, make recommendations, and complete improvements
- **Post-installation:** agencies inspect the home and submit the final paperwork

Cadmus developed a process flow diagram that represents program activities from pre-participation outreach through post-installation payment (Figure 10). Appendix E. Program Delivery provides additional detail about program delivery.

Pre-Participation

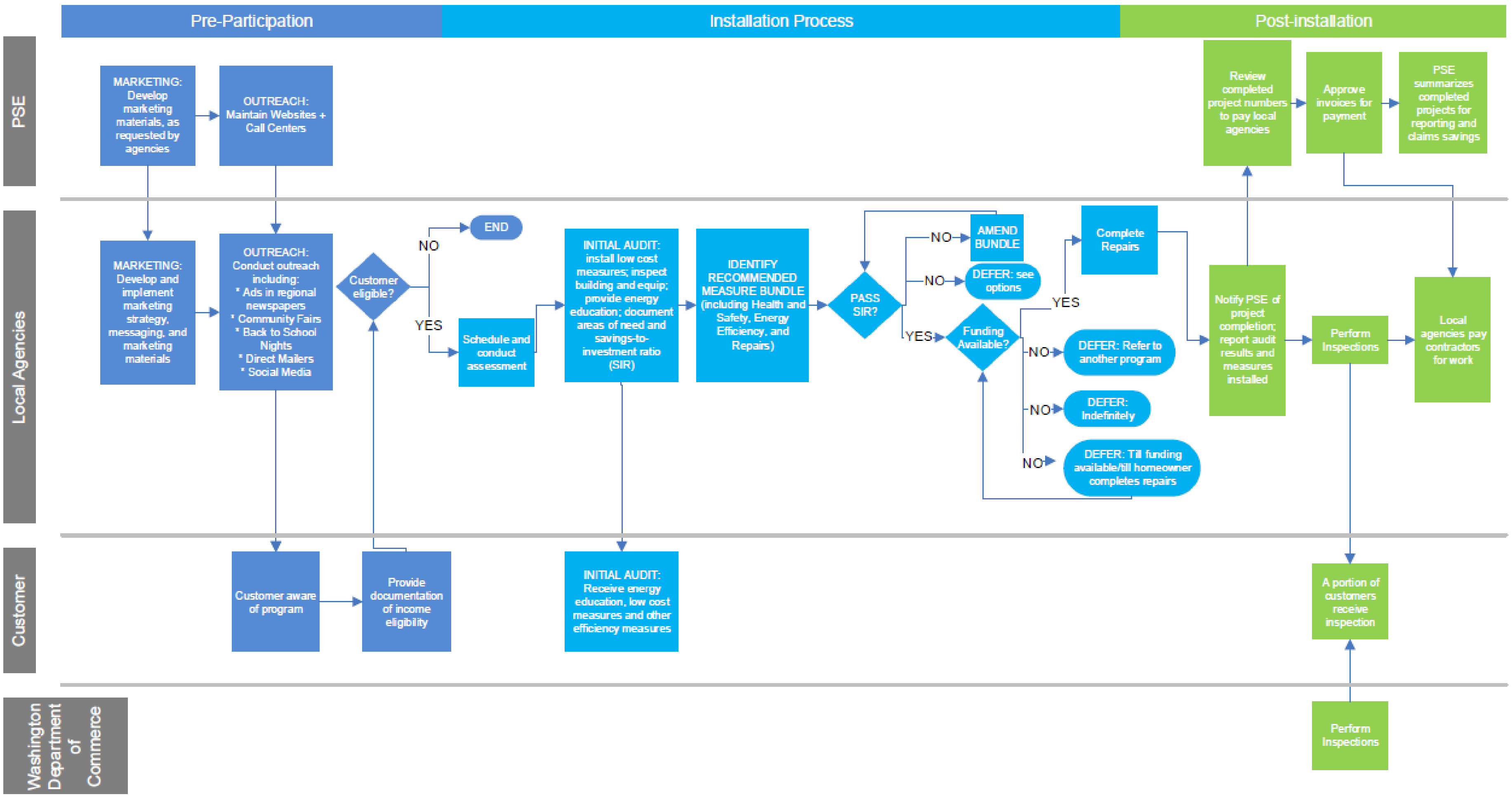
All agencies determined income eligibility by requiring proof of income from pay stubs, tax forms, or other documents. According to the agencies, gathering income documentation presented one of the biggest challenges for customers participating in the program. Three agencies implemented a waitlist for customers, though all reported they eventually contacted all customers on the waitlist. One agency prioritized its customers based on when the customer made contact and the type of measures they sought. Another agency maintained its customers on a waitlist for two to three months (other agencies did not know how long customers remained on waitlists).

While the program allows agencies to use 30% of their budget for health and safety and other repairs, all agencies (n=5) reported most commonly deferring participants due to the number and type of repairs necessary before beginning weatherization (i.e., the homes can participate in the program once home repairs have been completed). Four of the five agencies deferred fewer than 2% of homes, though one agency deferred up to 20% of customers. Two agencies reported no additional funding sources were available to handle deferments. Another two said they may be able to find funding, but doing so depended on the severity of improvements needed, with one saying they could generally use funding from community block grants to make homes eligible for participation in the weatherization program. Two agencies did not track customers with deferrals, but three others did. None of the agencies offered suggestions for reducing the number of deferrals.

Installation Process and Post Installation

Two of the five agencies delivered the program to gas and electric customers, two delivered to electric customers only, and one delivered to gas customers only. Agencies performed initial audits of each household. Following the audit, four of the five agencies used a Washington State Department of Commerce savings-to-investment ratio (SIR) priority list to determine which measures each household could install. Assessing SIR through these tools was relatively easy and did not create barriers. One agency used the Targeted Retrofit Energy Analysis Tool to determine measures for installation.

Figure 10. Low-Income Weatherization Process Flow Diagram



Program Satisfaction

Overall, agencies and customers expressed satisfaction with the program. All five agencies reported being *very* or *somewhat satisfied* with the program, while 92% of customer survey respondents (n=105) were *very* or *somewhat satisfied* with the program.

Agency Experience

Regarding the overall program, four agencies were *very satisfied*, and one was *somewhat satisfied*. The agency with lower satisfaction said they would be more satisfied if the program offered more measures but did not specify the types of measures.

Communication

As with the LIW program's 2012 evaluation findings, all five agencies were *very satisfied* with their communications with PSE, which held annual meetings with agencies to discuss program changes for the new year. The agencies found these yearly meeting provide sufficient information to implement the program successfully each year. Further, the agencies considered PSE's program manager extremely helpful and quick to respond to their inquiries. They were very enthusiastic about PSE's support and considered it one reasons for the program's success.

Stakeholders said PSE and agencies support and work well together, maintaining productive communication that proved highly beneficial to customers.

Incentive Amount

Four agencies were *very satisfied* with the incentive amount, and one was *somewhat satisfied*. Agencies said PSE's ability to provide additional funding if an agency needs it represents another area of satisfaction. One agency said they were satisfied with incentive amounts as PSE allowed some funding to be used for maintenance and operations.

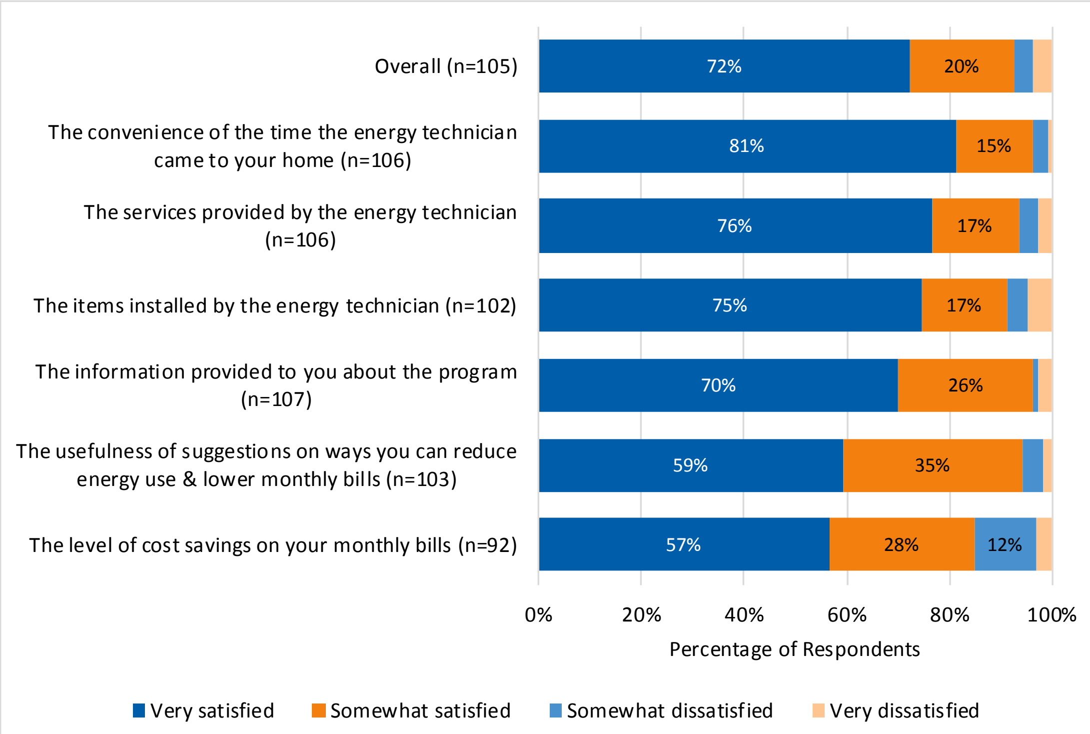
Contents of Program

Four of five agencies were *very* or *somewhat satisfied* with the contents of the program. One agency said they were *somewhat dissatisfied* with program contents due to the number and types of measures, but they did not provide suggestions for improvements. This agency rated their overall satisfaction with the program as *somewhat satisfied*.

Customer Experience

Customer survey respondents were satisfied with the program: 72% (n=105) were *very satisfied* with the program, and 20% were *somewhat satisfied*. Customers answering questions about their satisfaction levels with various program components were most satisfied with the home visit's convenience. Figure 11 presents details about these program component satisfaction levels.

Figure 11. Respondent Satisfaction by Program Component



Source: Survey question, "I'll read a few statements. Please tell me how satisfied you are with each one. Let's start with [statement 1]. Would you say you are very satisfied, somewhat satisfied, somewhat dissatisfied, or very dissatisfied?"

When the agencies administered surveys to customers for all their programs, not specifically for PSE's LIW, they generally received positive feedback. In some cases, where customers provided suggestions, agencies have implemented changes to improve the program.

Program Successes

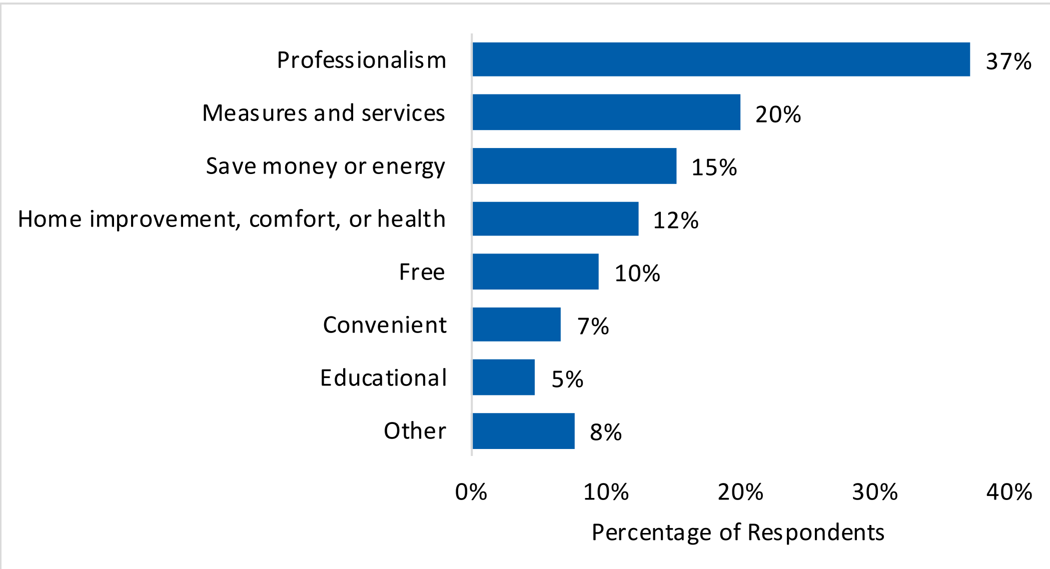
Overall, the program ran well and agencies were pleased with the ease of working with PSE. Agencies considered PSE as a great partner and felt supported. One agency was pleased with the program as payments were always on time.

Agencies reported customer success stories. One agency said a customer had horrible asthma prior to the audit; after participating in the program, the asthma improved. Another agency said customers occasionally brought gifts to the office and thanked the agency for helping them lower their energy bills.

Stakeholders characterized PSE as forward thinking and always finding new ways to reach customers and serve them effectively. They said PSE focused on providing excellent service and was very open to new ideas. Further, they were easy to communicate with and expressed interest in partnering in any way possible.

Customer survey respondents could explain what they liked most about the program. As shown in Figure 12, Cadmus categorized these comments into seven response categories, with more than one-third of respondents praising the technicians' professionalism (37%, n=105). Notably, respondents cited energy/cost savings (15%) as only marginally higher than home improvements (12%), including non-energy benefits such as increased comfort and improved health.

Figure 12. Program Aspects Most Liked by Customers



Source: Survey question, "What did you like most about these services?" (n=105).
Total does not add up to 100% because multiple responses were allowed.

Impact of Improvements

Along with asking about program satisfaction, the customer survey asked whether respondents noticed positive or negative impacts due to changes made to their homes. In response, 57% (n=105) reported positive impacts, with consistent temperatures (32%, n=60) and lower energy bills (25%) as the most common positive impacts mentioned.

Only 23% of survey respondents (n=109) noted negative impacts, with eight of 25 reporting their energy bills increased, and five report their homes were hotter or colder than before.

Program Barriers

Agencies

Four out of five agencies reported challenges in the interviews. Two agencies cited funding challenges, two cited issues with contractors, and two cited other challenges. Table 22 lists all challenges agencies reported in the interviews.

Table 22. Agency Challenges Implementing the LIW Program

Category	Specific Challenge
Funding	• PSEs funding does not cover the full cost of a measure when administrative costs are higher than PSEs 20% cap, requiring the agency to leverage other sources to cover a measure's full cost (one response) • Difficulties in blending funding sources (one response) • Availability of repair dollars (one response)
Contractors	• Insufficient contractors and/or auditors to implement jobs quickly enough (one response) • Contractors disinterested in participating due to statewide policies and procedures regarding measure installation (one response)
Other	• The dwindling price of gas meant the program could not serve as many gas homes (one response) • Finding eligible customers with homes in reasonable shape to treat (one response)

Stakeholders

Overall, stakeholders cited the same challenges as agencies, noting that the existing condition of homes requiring repairs prior to weatherization presented a participation challenge. Availability of administrative funds also presented a challenge for agencies and utilities implementing weatherization programs. PSE capped funding amounts available for administering each measure at 20%, but some individual measures took more administrative time. Consequently, agencies used funds from other sources to cover administration.

Stakeholders also said blending funds presented a challenge for agencies as every program had slightly different implementation policies. Funding fluctuations presented additional challenges to agencies, especially in blending resources.

Stakeholders stated increased new construction presented challenges in finding contractors interested in participating in low-income weatherization programs, an issue compounded by the funds required to train and retain contractors to meet low-income weatherization demand.

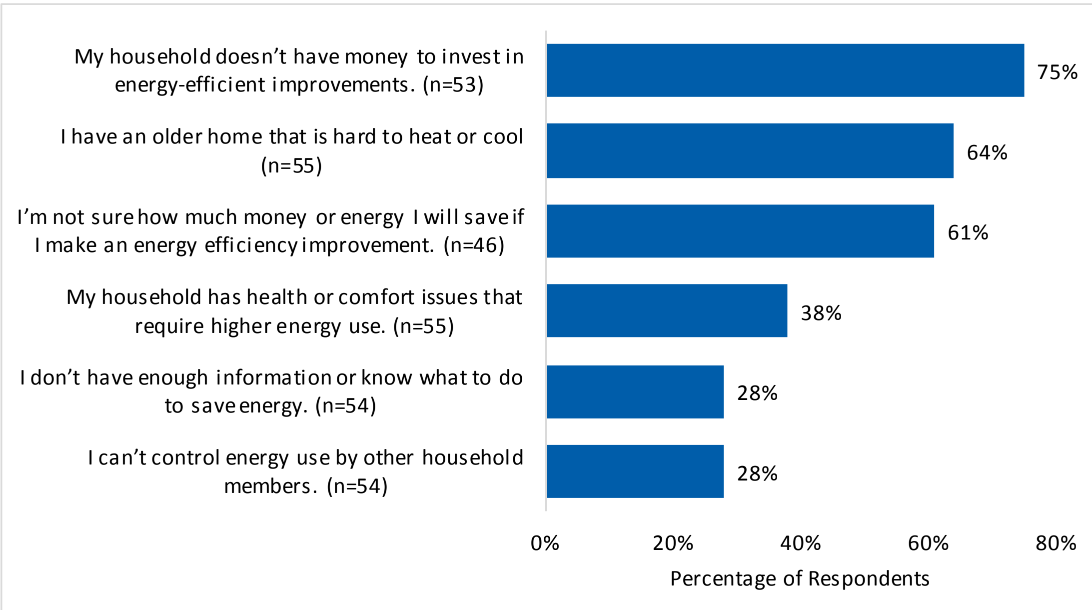
Finally, per stakeholders, challenges arose in finding customers who could benefit from the program; doing so could require additional outreach spending and reduce the number of customers served.

Customers

According to the agencies, the top customer challenges for program participation included completing paperwork and scheduling appointments. Undocumented workers also presented challenges as they feared participating in a program could affect their status in the country. Two agencies found multifamily properties more difficult to engage as property owners and managers may be concerned about their properties not being up to code. All but one agency said PSE's funding met the needs of their customers; the one agency said it did not meet the needs of its gas customers.

As shown in Figure 13, the participant survey asked respondents to indicate whether various statements applied to them regarding energy efficiency improvements.

Figure 13. Statements about Energy Efficiency Improvements



Source: Survey question, "I'll read a few situations people might face when purchasing new appliances or considering energy-efficient improvements to their home. For each situation I read, please indicate whether or not it applied to you."

Motivation

The interviews asked the agencies about their motivations to participate in the program and why their customers participated (the survey also asked customers why they participated in the program). Both agencies and customers said households primarily participated to save energy and money.

Agencies

One agency said it was motivated to implement PSE's LIW program due to state matching funds; others were motivated to participate as the program aligned with the agencies' mission to serve low-income customers.

Customers

A majority of survey respondents (40 of 55) reported being motivated to participate to save money or energy, though 10 cited comfort, nine cited home improvements, and six cited receiving new measures (multiple responses were allowed). Similarly, most agency interviewees (four of five) said customers participated in the program to save energy. Two agencies said customers participate to improve their homes' comfort, and one said multifamily owners participated to enhance their property's value.

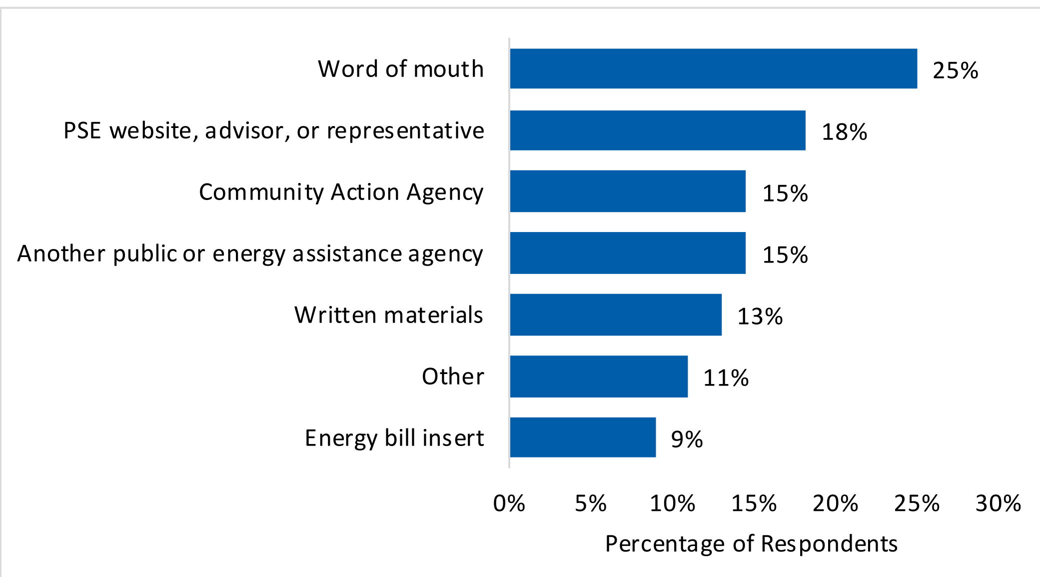
Marketing and Outreach

Program Discovery and Awareness

Three agencies said most of their customers learned of the program from the Low-Income Home Energy Assistance Program's (LIHEAP) Energy Assistance[13] and two said they learned of the program through word of mouth. The agencies also said customers learned of the program through PSE referrals, direct mail, regional news stories, and advertising at events.

Customer survey respondents most commonly learned about the program through word-of-mouth (25%, n=55), a finding consistent with survey respondents in 2012, who also most commonly learned about the program this way (29%; n=114). Figure 14 provides further details on the ways 2017 survey respondents learned about the program.

Figure 14. Respondents Methods of Learning about the Program



Source: Survey question, "How did you hear about this program that installed your new light bulbs and other energy efficiency upgrades?" (n=55). Multiple responses allowed.

[13] A federally funded program administered by the U.S. Department of Health and Human Services, LIHEAP assists low-income households in meeting their immediate home energy needs.

Awareness of PSE Funding

Cadmus asked customer survey respondents whether they knew PSE helped pay for services received through the program; most respondents (64%, n=47) knew of PSE's involvement. This represented an increase over the 2012 results, when 45% responded they knew of PSE's role (n=114).

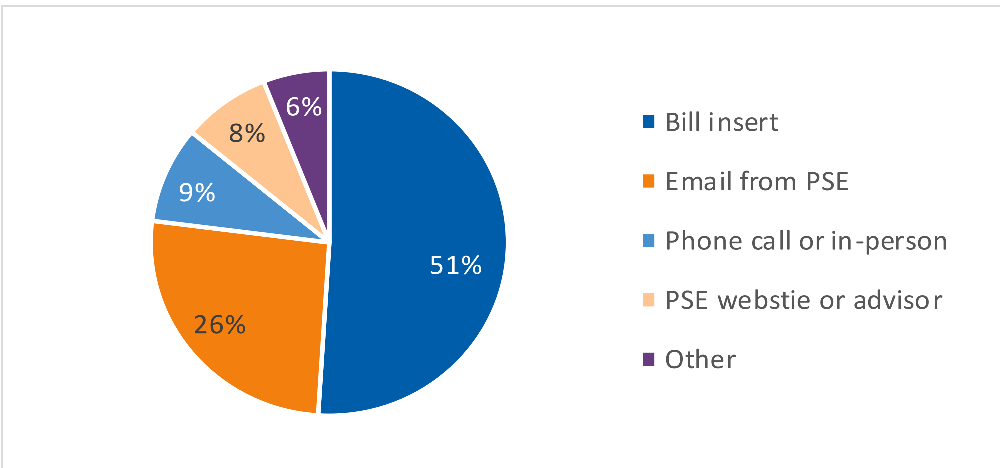
Home Energy Audit Participation

Nearly one-half of respondents (48%, n=96) previously participated in PSE's HEA program.[14] Cadmus did not assess whether participation in PSE's HEA programs took place before or after their participation in PSE's LIW program.

Future Communication

As shown in Figure 15, over one-half of the customer survey respondents (51%, n=53) said they could best be informed about future energy efficiency programs through bill inserts, though more than one-quarter (26%) preferred email.

Figure 15. Best Way for PSE to Inform about Energy Efficiency Programs



Source: Survey question, "What is the best way for PSE to inform you about energy efficiency programs and savings opportunities?" (n=53). Single response.

Energy Education

The agencies provided education to customers who participated in the program. Two agencies said PSE provided energy education materials that they could share with customers, particularly when they met with customers individually.

[14] It is possible respondents confused Home Energy Assessment with the audit performed as part of the LIW program.

The agencies reported customers' interest in ways to reduce cold zones, adjust thermostat settings, install efficient lighting and windows, and other general tips to reduce their energy bills. Some customers appreciated additional energy education information, but others did not express high levels of interest.

Eighty-three percent of survey respondents (n=53) said auditors provided energy education tips or suggestions during visits and 93% of respondents (n=42) found auditors' tips *very* or *somewhat useful*.

Customer Changes

Behavior Changes

Program objectives included using education to promote behavioral changes among customers. The agencies, however, found it difficult to determine whether customers changed their behaviors following program participation. Most commonly, the agencies knew of customers adjusting their heating and water heating thermostats, changing fixtures from incandescent bulbs to CFL or LED bulbs, and changing furnace filters.

Of 44 respondents who reported receiving energy-saving tips from auditors, 70% (31 of 44) said they implemented one or more of these tips. Respondents mentioned turning off lights when not in use as the most implemented tip. Table 23 shows the full list of actions participants took based on the recommendations they received.

Table 23. Energy Savings Tips Implemented

Actions Taken	2017 Evaluation (n=31)
Turn off lights when not in use	26%
Improve air circulation (adjust vents, close doors and windows)	19%
Replace light bulbs	16%
Adjust thermostat/heating/cooling	13%
Unplug devices when not in use	13%
Wash clothes in cold water	13%
Turn down temperature on water heater	10%
Replace showerheads	6%

Source: Survey question, "What energy saving actions did you take based on the energy savings recommendations you received?" (n=31). Multiple responses allowed.

Of 103 respondents, 34% reported making changes to the ways they heated or cooled their home since the program, as shown in Table 24. Just under a third of these respondents indicated changing heating and cooling behavior resulting in reducing energy usage.

Table 24. Respondents' Changes to Conditioning Homes

Conditioning Changes Made	Number of Respondents
Using the heat pump more and the furnace / central air conditioner less	13
Heating or cooling the home less	11
Installed insulation or air sealing measures	4
Installed or purchased other new energy efficient measures	3
More reliance on the thermostat for heating and cooling	2
Other	2

Source: Survey question, "Since you participated in the program, what changes, if any, have you made to the way you heat or cool your home?" (n=35).

Take Back

Cadmus designed the customer survey to identify take-back effects, including several questions about how respondents' homes were heated and cooled before and after the installation. The survey also included questions about thermostat temperature settings. As shown in Table 25, nearly one-half of the survey respondents did not make changes to heating or cooling temperatures of their homes, while the percentage who increased or decreased their heating temperatures was nearly split. Of respondents using cooling equipment, more respondents increased their cooling temperatures than decreased them.

Table 25. Take Back Effect

Home Conditioning Type	Percent Increasing Temperature	Percent Decreasing Temperature	Percent Without Change
Heating (n=88)	24%	27%	49%
Cooling (n=20)*	45%	10%	45%

Source: Survey questions, "Before you installed the equipment, what temperature did you typically set your thermostat at for [heating/cooling] in the [winter/summer]?" (n=88) and survey question, "Before you installed the equipment, what temperature did you typically set your thermostat at for [heating/cooling] in the [winter/summer]?" (n=20).
* Responses reflect respondents who said they used cooling in the summer and answered both questions (before and after installation).

Suggested Program Improvements

Cadmus asked agencies, stakeholders and customers for ways to improve the program. This section summaries their responses.

Agencies and Stakeholders

Two agencies offered suggestions for program improvements:

- One said PSE should be more creative with equipment and measures offered, but did not have specific suggestions on how to do this.

- One suggested reducing the overall number of inspections required for high-performing contractors, thus reducing project costs.

Stakeholders suggested agencies and PSE should continue to recognize the importance of providing funding for repairs, and they suggested looking for methods to provide more administrative money for agencies. This could aid agencies in effectively coordinating between funding sources and in implementing the program. They also suggested agencies leverage PSE's Contractor Alliance Network (CAN) to identify and encourage contractors to implement low-income programs.

Customers

Though over one-half of survey respondents (52%; n=98) said there was nothing PSE could change to improve the program. The top two suggestions for improvements included 15% of customers who said PSE could improve communication, and 11% said they could provide additional measures and services. Of those that recommended improved communication four respondents mentioned more information regarding what to expect during the installation as well as how to use the equipment after the installation. One person asked that the length of the visit be communicated ahead of time.

Table 26 provides further detail about respondents' ideas for program improvements.

Table 26. Respondent Ideas for Program Improvement

Improvement Idea	Percentage
No Changes	52%
Better Communication	15%
Additional Measures and Services	11%
Higher-Quality Installs	8%
Less Home Damage	5%
Increased Professionalism	5%
Other	3%
More Savings from Improvements	2%

Source: Survey question, "What, if anything, could have been improved?" (n=98). Multiple responses allowed.

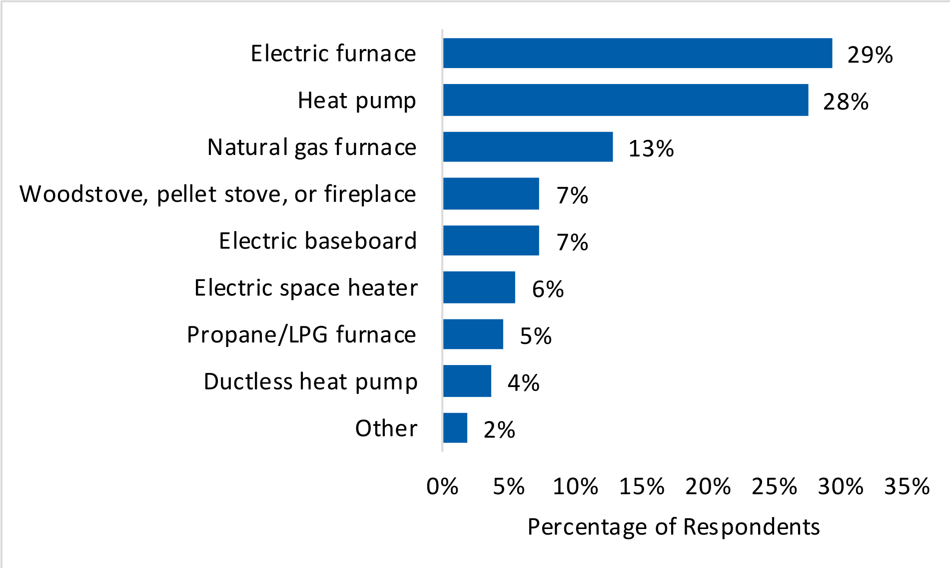
Survey Participant's Equipment

This section outlines types of heating and cooling equipment survey participants used and how survey respondents used their thermostats.

Heating and Cooling Equipment

Approximately 74% of survey respondents use electricity to heat their home, with 57% using central electric heating. Figure 16 provides further details on heating equipment used most often by survey respondents.

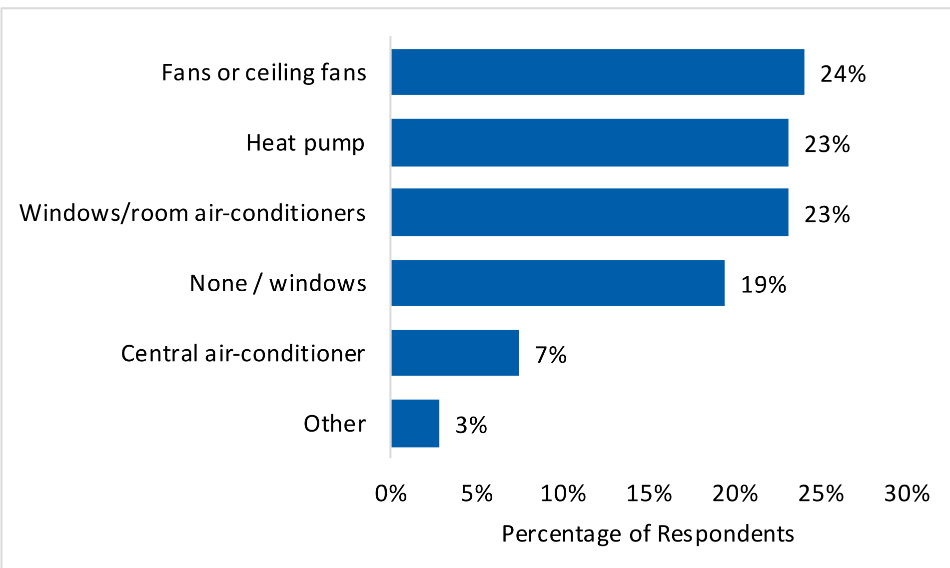
Figure 16. Current Heating Equipment



Source: Participant survey, "What is the heating equipment you use most?" (n=109).

As shown in Figure 17, approximately 54% of survey respondents said they have either central or room cooling equipment, while 34% use fans and 19% have no cooling.

Figure 17. Current Cooling Equipment

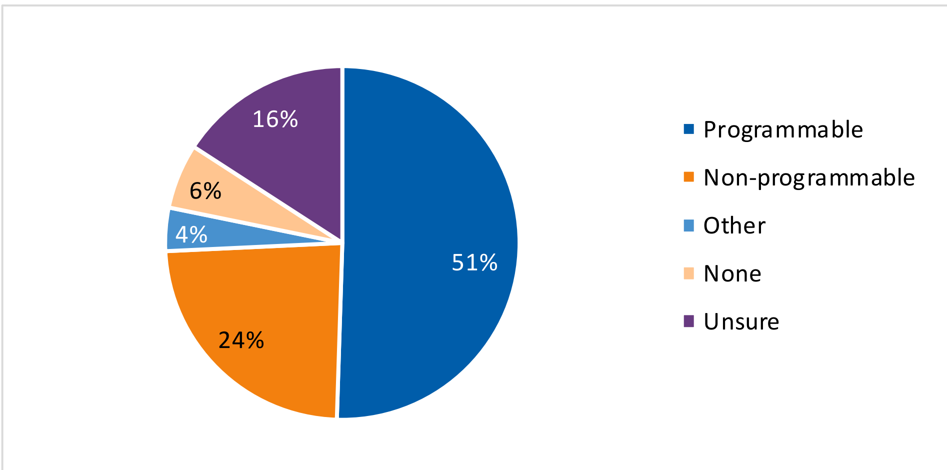


Source: Participant survey, "What type of cooling system do you use most often to cool your home in the summer?" (n=108).

Thermostat Usage

As shown in Figure 18, over one-half of survey respondents (51%, n=102) indicated they had programmable thermostats installed in their homes, while nearly one-quarter of respondents (24%) used non-programmable thermostats, and over one-fifth (16%) were unsure about their thermostat types. Over one-half of survey respondents (56%, n=41) said they had a Honeywell-brand thermostat. None of the customer survey respondents used a smart or Wi-Fi enabled thermostat.

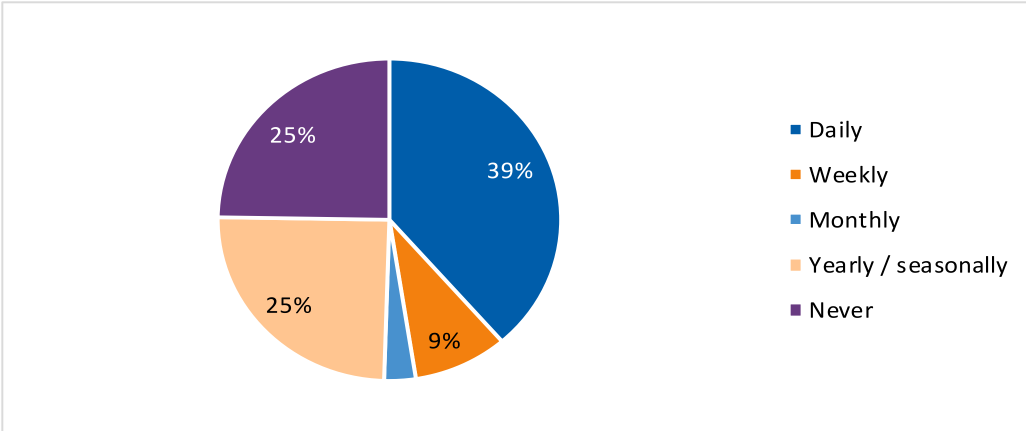
Figure 18. Thermostat Type



Source: Participant survey, "What kind of thermostat do you currently have installed in your home?" (n=102).

Fifty-nine percent of survey respondents (n=49) with programmable thermostats set them manually, while 37% programmed them, and two respondents (4%) both programmed and set their programmable thermostats manually. Moreover, of survey respondents with programmable thermostats, 38% (n=52) manually changed their thermostat daily. Figure 19 provides further information on the frequency with which respondents changed temperatures on their programmable thermostats.

Figure 19. Frequency of Manually Changing Temperature on Programmable Thermostat

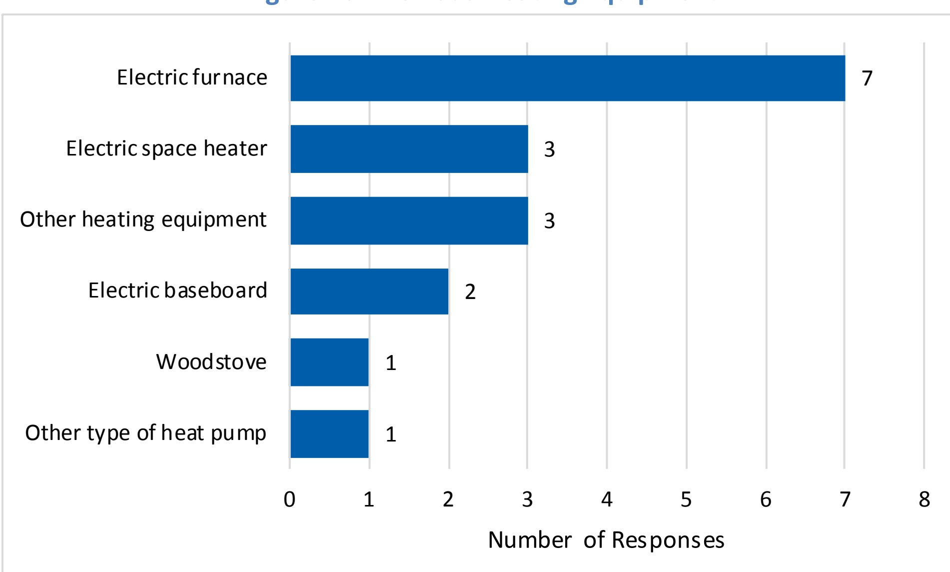


Source: Participant survey, "Since you participated in the program, how frequently do you manually change the temperature on your thermostat?" (n=80).

Ductless Heat Pump Usage

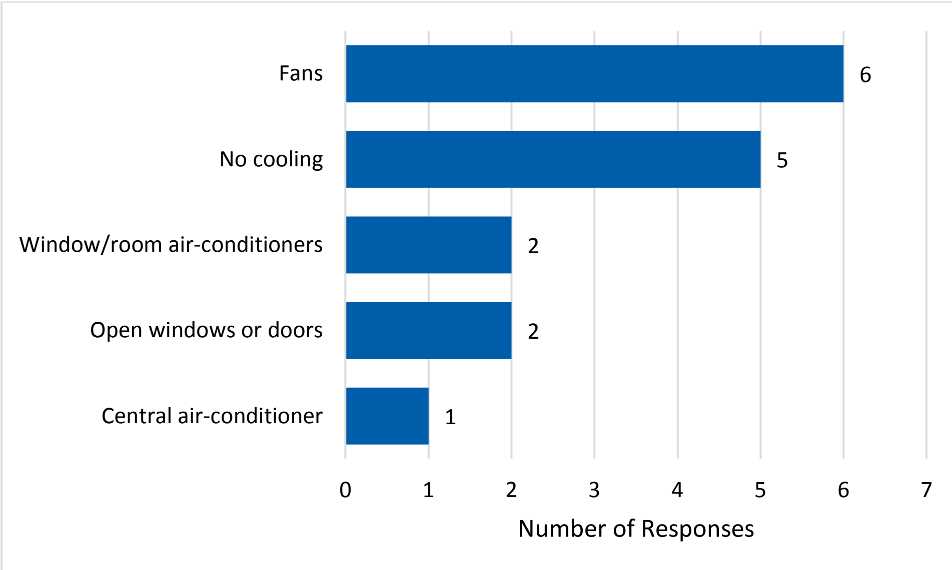
Cadmus spoke with 15 survey respondents receiving a DHP through the LIW program, asking them what types of heating and cooling equipment they had before installing the DHP. As shown in Figure 20, most respondents (seven responses from 15 respondents) used electric furnaces to heat their homes. Figure 21 shows six respondents used fans to cool their homes.

Figure 20. Previous Heating Equipment



Source: Survey question, "Before you installed the new heating equipment, what heating system did you use most often in your home? (n=15). Multiple responses allowed.

Figure 21. Previous Cooling Equipment



Source: Survey question, “Before you installed your new equipment, how did you cool your home?” (n=15). Multiple responses allowed.

Further, Cadmus asked these respondents how they used their DHPs. Of the 15 survey respondents installing DHPs, nine said DHPs served their main living areas, four said they served the entire home, four said they served the kitchen area, and one did not know. DHPs also served bedrooms, auxiliary spaces, and basements.

Eleven of fifteen respondents said they used their DHP for both heating and cooling, though two used the equipment only for heating, one used it only for cooling, and one was unable to answer. All but two respondents (n=15) said the new DHP increased their comfort, though one found it less comfortable, and one refused to respond.

Eight of the respondents who installed a DHP through the LIW program said they used DHPs to cool their homes during the summer for a few times a week or more. One-half of the respondents who answered this question (6 of 12) cooled their homes more frequently than before installations, five said they cooled less frequently, and one said they cooled the same amount.

Conclusions, Recommendations, and Considerations

This section summarizes key findings and conclusions, along with associated recommendations and suggestions for PSE consideration.

Overall Performance

Conclusion: The LIW program is achieving its overall objectives. LIW met its goal of reducing the energy-cost burden of low-income customers by improving the energy efficiency of their residences and by educating them on ways to reduce energy use. A billing analysis found that the program resulted in participants consuming 18% less electricity and 24% less gas, on average. With respect to customer education, most program participants (83%) remember receiving the energy education materials and recommendations from their energy auditor, and the vast majority of respondents (93%) found these tips useful. Both program participants and delivery agencies report high satisfaction with LIW. Ninety-two percent of program participants reported being very (72%) or somewhat (20%) satisfied with the program overall.

Conclusion: Average per household electric energy savings were lower than reported savings in 2013 and 2014, but were high relative to benchmarked LI programs. Overall electric realization rates averaged 79% across the 2013–2015 period, with the realization rate increasing in 2015 to 94%. The average three-year realization rate was significantly higher for participants who installed a DHP versus those who did not (95% vs. 71%). While realization rates were below 100% in 2013 and 2014, average electric savings as a percentage of pre-installation usage (18%) were on the high end of benchmarked program savings. These findings suggest that recent changes to RTF/PSE-deemed savings estimates are increasing reporting accuracy and that PSE's program is exhibiting high performance with regard to lowering participant energy costs.

Conclusion: Average per household gas energy savings exceeded reported savings, and were high relative to other LI programs. Overall gas realization rates averaged 118% across the 2013–2015 period, with the realization rate increasing in 2015 to 149%. Gas savings averaged 24% of pre-installation usage, which was the highest among similar programs benchmarked. These findings suggest that recent changes to reported savings estimates may have resulted in underestimated actual savings and that PSE's program is exhibiting high performances with regard to lowering participant energy costs.

Conclusion: Frequent and open communication between agencies and PSE is one key to program success. Stakeholders and agencies characterized PSE as easy to communicate with, forward thinking, service-oriented, and collaborative. Agencies said that PSE provides sufficient information during annual meetings to implement the program and is consistently available and helpful, providing support throughout the year when needed. Stakeholders agree that PSE and agencies work well together, maintaining productive communication that proves highly beneficial to customers.

Planning, Savings Estimation, and Evaluability

Conclusion: PSE's savings estimation methods and input data are reasonably accurate; however, several measures have outdated planning assumptions, and opportunities exist to improve the accuracy of savings estimates. A detailed savings review revealed that UES values for shell and duct measures relied on outdated RTF sources, and refrigerator replacement and pipe insulation measures contained incomplete documentation of savings sources. In addition, Cadmus identified an opportunity to improve the accuracy of the savings calculation approach for DHP and heating system replacement measures.

> ***Recommendation: Update UES values for shell and duct measures and revisit RTF-deemed savings estimates annually for revisions.*** Given frequently updated energy-saving source documentation, PSE should revisit RTF-deemed savings estimates annually for any changes that may be relevant to delivery or design adjustments. Specifically, for shell measures (including insulation, air sealing, and windows) and duct sealing and insulation, PSE should revise current UES savings estimates to account for recent updates to the RTF weatherization UES workbooks.

Suggestion for consideration: Revise approach, input assumptions, or available source documentation used in RTF or PSE-deemed savings estimates. Cadmus suggests PSE consider the following actions related to measure savings calculations:

- Calculate shell measure UES values using project-specific heating system rather than a weighted average assumption.
- Provide complete documentation for refrigerator replacement savings.
- Update the ventilation fan estimates' cubic feet per minute (CFM) per watt input assumption to reflect a more typical testing pressure.
- Provide complete documentation for pipe insulation and consider using an alternative UES source, based on benchmarking.
- Revise heating system replacement savings calculation to incorporate actual heating system capacity.
- Revise the DHP savings calculation to incorporate actual existing heating system type.

Suggestion for consideration: Track additional equipment system information for DHP and heating system replacement measures. The following information would support revisions to savings estimates and evaluation research:

- **Nominal size of installed gas heating system replaced**. Uniform Method Project protocols recommend heating system size as a dependent variable to estimate energy savings for gas heating systems.

- **Type of heating system displaced or augmented by DHP.** The RTF shows a range of UES savings depending on the assumed heating system type. Although homes with electric zonal heating are generally good candidates for DHP retrofits, DHPs can displace a variety of heating system types. Using the actual heating system types will improve the accuracy of this savings estimate.

Conclusion: Billing analysis may provide PSE with more accurate savings estimates than the current engineering analysis-based approach. Billing analysis is industry best practice for evaluating energy savings of whole-house energy efficiency programs like LIW. This method has the advantage of capturing measure interactive effects, energy education, behavioral changes, and other factors that directly contribute to program impacts. The current evaluation produced whole-house savings estimates at ±13% and ±11% precision for electric and gas, respectively, in contrast with engineering-based approaches which typically cannot quantify a level of uncertainty associated with the variety of measures installed.

> ***Suggestion for consideration: Use average household-level savings generated from billing analysis models to develop savings estimates.*** Using estimates of annual completed projects, PSE could project savings based on average household savings, rather than measure-level savings, to benefit program planning using household-level estimates. This is similar to approaches used by other utilities within the state and throughout the country. As noted, billing analysis estimates account for both existing baselines and non-utility-funded measures, as well as other influential factors not typically captured through engineering estimates.

Conclusion: The LIW program resulted in quantifiable non-energy benefits. Cadmus confirmed monetized values for four distinct NEBs associated with program performance: economic benefits, environmental benefits (social value and avoided compliance costs), and participant comfort benefits. Table 27 provides a summary of annual, monetized benefits per participant for each NEB. Additional detail is provided in the subsequent NEBs findings sections.

Table 27. Average Annual NEBs Values

Non-Energy Benefit	Per Participant Impact		Perspective Adjusted
	Electric	Gas	
Participant Ancillary Benefits	$100		TRC, PCT
Economic Impacts	$2,313		TRC
Environmental – Avoided Compliance Costs	$33.88	$33.88	TRC, UCT
Environmental – Social Benefit of Avoided Emissions	$41.97	$42.03	PTRC

> ***Recommendation: Include NEBs in program cost-effectiveness scenarios.*** A complete benefit/cost analysis considers not only direct financial costs and benefits

experienced by an individual or firm, but also costs and benefits accruing to society as a whole (Boardman et al. 2006). Based on Cadmus' analyses and consistent with the *2016-2017 Biennial Conservation Plan*,[15] PSE should run cost-effectiveness scenarios for LIW that include consideration of NEBs values assessed through this study.

Conclusion: LIW customer contact information is not consistently captured. Cadmus found that program tracking data contained incomplete contact information for program participants, providing challenges in drawing a phone survey sample from the participant population and potentially introducing bias. For multifamily projects, the tracking data did differentiate property manager participants from in-unit occupants, but this information was inconsistently populated.

Suggestion for consideration: To ensure that sufficient information is collected from an evaluability perspective, PSE should ensure agencies provide complete contact information for all participants (including names, phone numbers, and e-mails) for all program participants. Complete contact information will ensure that customer outreach is not limited to a sample containing available data within the program population, which has the potential to introduce bias.

[15] PSE's plan highlights moving to include NEBs for the majority of prescriptive measures using RTF UES values, either using RTF-calculated NEBs or those validated in evaluation research.

Future Work

Based on these evaluation results, Cadmus suggests considering the following activities for future research.

KPI Scorecard

Cadmus developed a KPI framework with recommended KPIs that PSE could use to assess LIW continuously improve performance over time (Table 20). Cadmus suggests PSE review the framework and metrics with the appropriate management staff to determine which performance metrics it considers most important to measure over time. Once the scorecard metrics are finalized, Cadmus suggests PSE collaborate with agencies to identify efficient ways to begin tracking KPIs to assess performance against goals.

Market/Participant Assessment

Cadmus suggests PSE consider future research aimed at better understanding the market for income eligible customers, including gaps in delivery, underserved areas, and opportunities to expand participation. In the 2012 LIW evaluation, Cadmus provided a gap analysis that assessed regional program participation, underserved areas, and characteristics of eligible participants. Cadmus created a targeting framework that considered energy usage intensity (i.e., usage per square foot) of eligible participants to help PSE target customers with the greatest savings potential. PSE should consider a follow-up to these analyses to assess any changes in delivery and penetration over the last five to seven years and provide insights to guide future program planning.

The gap analysis will identify underserved regions by comparing historical program participation and census data to identify high concentration of eligible households. This will allow PSE to assess trends in annual participation to see how delivery has changed geographically and identify particularly hard-to-reach, underserved areas with greater potential for program services. These data will also serve to analyze participation and identify geographic trends, which program staff can use to identify and target geographic regions for future outreach campaigns, including targeted mailing, creation of neighborhood initiatives, and region-specific program delivery adjustments.

Subsequent Billing Analyses

To continue estimating savings accurately, Cadmus suggests continuing to perform whole-house billing analysis for LIW on a periodic basis. As noted, billing analysis is industry best practice for evaluating holistic energy-efficiency programs such as LIW. Furthermore, billing analysis savings estimates account for non-PSE funded measures, interaction effects, behavioral change (e.g., educational effects, take-back, spillover), and other factors that directly contribute to program impacts. Considering these impact estimates will allow PSE to track the affect design and delivery changes (e.g., changes in funding allocation, measure saturations) on program savings and overall performance improvements. Furthermore, if PSE considers shifting to using household-level savings for planning, periodic revisions of this estimate will ensure reflection of any change in program delivery, measure offerings, or customer makeup.

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Appendix A. Methodology

Appendix A includes the methodology for each evaluation task included in Table 28.

Table 28. Evaluation Tasks

Area	Task
Impact: What did the programs achieve and was it done cost-effectively	Billing Analysis
	Savings Review
	NEBs: Economic Impacts
	NEBs: Environmental Impacts
	NEBs: Participant Impacts
Process: Were the programs delivered efficiently	Stakeholder Interviews
	Participant Survey
	Process Flow
	KPI Framework

Billing Analysis—Estimating Energy Savings

To estimate actual changes in energy consumption within participating homes, Cadmus performed a consumption analysis. This involved testing multiple model specifications for robustness, including combined fixed-effects models and individual, household-level, Princeton Scorekeeping Method (PRISM)-like regressions. Using historical billing data from up to a year before and after participation, Cadmus assessed program-level and measure-level impacts associated with LIW program installations to estimate electric and gas energy savings. The analysis period included participation from 2013, 2014, and 2015 program years. Cadmus used a comparison group (selected from late-2015 and 2016 participants) to control for exogenous factors that could have affected energy consumption during the 2013–2015 timeframe.

The industry considers regression-based consumption analysis as a best practice for estimating impacts associated with programs offering multiple measure installations (e.g., shell improvements, equipment replacement), as noted in the Uniform Methods Project.[16] The consumption analysis provided an estimate of the actual program impacts, controlling for interactive effects between measures as well as for changes in occupants or usage behaviors (e.g., takeback effect). Accounting for these factors proved particularly beneficial when estimating the impacts from shell and HVAC measures offered through the programs.

[16] National Renewable Energy Laboratory. *The Uniform Methods Project Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol*. “Chapter 8: Whole-Building Retrofit with Consumption Data Analysis Evaluation Protocol.” Prepared by Ken Agnew and Mimi Goldberg, DNV KEMA. April 2013. Available online: https://www1.eere.energy.gov/wip/pdfs/53827-8.pdf

Data Sources

Cadmus used the following data sources in performing the consumption analysis:

- ***Program tracking data*** for the LIW program, provided by PSE for all electric and gas participants from January 2013 through July 2016. These data included participant names, contact information (e.g., addresses), unique customer identifiers, participation dates, and total PSE-reported savings estimates per participant. These data also included detailed measure information, such as measure names, descriptions, per-unit measure savings, and assumptions (e.g., quantities and efficiency levels) associated with PSE-deemed and RTF-savings calculations.
- ***Consumption data*** for LIW participants, provided by PSE and for electric and gas usage at the monthly billing level. These data included monthly readings of electricity and gas consumption, by participant account, from January 2012 through December 2016.
- ***Washington weather data***, including daily average temperatures from January 2012 through December 2016 for 15 Weather Bureau Army Navy weather stations. Cadmus used zip codes to match daily heating and cooling degree days to respective monthly bill read dates. Cadmus obtained TMY3 (typical meteorological year), 15-year normal weather values from 1991 to 2005 from the National Oceanic and Atmospheric Administration, and used these to assess energy use under normal weather conditions.

Participant and Comparison Group Designation

Participant Group

Cadmus gathered data from a participant (treatment) group composed of LIW program customers who had measures installed between January 1, 2013, and October 31, 2015.

Comparison Group

To isolate the impact of exogenous factors (e.g., rate changes, economic conditions changes, non-programmatic effects) on energy use, Cadmus utilized a quasi-experimental design, involving selection of a comparison group composed of participants with installation dates from November 2015 through 2016. Using this approach, pre- and post-changes in the treatment group’s energy use (assumed due to program treatment) were compared to the comparison group’s changes in energy use (reflecting what would have happened in the program absence). For this design to succeed, the two groups had to equal, on average.

To ensure this similarity, Cadmus opted to use future participants (late PY2015 through PY2016, outside of the analysis period) as the comparison group; they would have similar income qualifications and could be assumed not to have participated in energy efficiency prior to program treatment.

Final Treatment and Comparison Samples

Cadmus started with a census of participants, and filtered out those who did not pass certain validation or data requirements. Table 29 provides the final analysis samples for each year, compared to the original population for participant (i.e., treatment) and comparison groups overall.

Table 29. Final Treatment and Comparison Groups

Fuel	Year	LIW		
		Model (n)	Pop	Percentage Remaining
Electric	2013	119	345	34%
	2014	264	444	59%
	2015	179	411	44%
	Treatment Total	**562**	**1,200**	**47%**
	Comparison Total*	**99**	**293**	**34%**
Gas	2013	49	119	41%
	2014	75	102	74%
	2015	28	52	54%
	Treatment Total	**152**	**273**	**56%**
	Comparison Total*	**27**	**54**	**50%**

* The comparison group was drawn from participation between November 2015 and 2016.

Savings Calculation

To estimate program-level impacts, Cadmus employed pre- and post-installation savings analysis using two distinct modeling approaches: household-level PRISM models; and the combined fixed-effects modeling method using pooled, daily time-series (panel) billing data. The overall and measure-level evaluated savings estimates are from the combined fixed-effects model, and the quartile and yearly savings estimates are from the PRISM models. Both approaches accounted for differences in pre- and post-installation weather conditions. The fixed-effects modeling approach also corrected for differences in usage consumption between participants. Savings estimates between PRISM and fixed-effects models were nearly identical. PRISM estimates produce slightly better model precision for electric savings, while fixed-effects estimates produce slightly better model precision for gas savings.

Cadmus derived gross energy savings using the following equation to adjust evaluated participant savings, based on changes in the comparison group's energy use. This adjustment accounted for exogenous factors occurring outside of the program effect (i.e., all terms in the equation were averages). This approach was similar to a straight difference-in-difference approach, but accounted for potential distinctions between each groups' average annual weather-normalized pre-treatment usage:

$$Adj.Gross\ Savings = (Pre\ Usage_{Treat.})\left(\frac{Change\ In\ Usage_{Treat.}}{Pre\ Usage_{Treat.}} - \frac{Change\ In\ Usage_{Comp.}}{Pre\ Usage_{Comp.}}\right)$$

Comparison group savings lacked statistical significance for analysis of the gas model. Therefore, the report presents all evaluated savings for the treatment group without a comparison group adjustment.

Regression Models

Cadmus developed different models for use in estimating energy and demand impacts (see Appendix C. Model Specification for additional detail). Ultimately, Cadmus selected estimates from the most robust models for final reporting:

- ***Household-level PRISM models.*** Cadmus ran account-level regression models comparing weather-normalized consumption, pre- and post-measure installation, then averaged the results across the sample to determine utility-specific and statewide program findings.
- ***Combined program-level fixed-effects models.*** Cadmus ran fixed-effects models, which controlled for household-specific factors (e.g., home size and age, participant demographics) that did not vary over time. This approach accounted for preexisting differences in energy use between homes. Unlike PRISM models constructed for each home individually, the fixed-effects models used entire samples of participants and nonparticipants.
- ***Combined measure-level fixed-effects models.*** Cadmus ran measure-level fixed-effects models, which incorporated measure group indicator variables to differentiate use patterns and estimate impacts for specific measure categories.

Data Screening

Starting with a census of participants for treatment and comparison groups, Cadmus identified the final analysis samples after cleaning the data and screening for several criteria, noted below. Cadmus conducted the consumption analysis using participants who had not moved since participation and who had at least 10 months of pre- and post-period billing data. Cadmus performed account-level reviews of all individual-participant pre- and post-period monthly consumption to identify anomalies (e.g., periods of unoccupied units) that could bias the results.

Cadmus used the following screenings to remove anomalies, incomplete records, and outlier accounts:

- Inability to merge the participant program tracking data with the consumption data (e.g., missing records or accounts).
- Insufficient consumption data for accounts with fewer than 300 days (i.e., approximately 10 months) of use data in the pre- or post-period.
- Accounts that changed electric use from the pre- to post-period by more than 70%. Rather than program effects, usage changes of this magnitude likely resulted from vacancies, home remodeling or additions, seasonal occupation, or fuel switching.
- Accounts with low annual use in the pre- or post-period (e.g., less than 1,200 kWh or 150 therms).[17]
- Customer with the wrong signs on PRISM parameter estimates.
- Customers for whom the TRM savings estimate exceeded pre-period use or where the TRM savings estimate was less than 1% of the pre-period use.
- Customers who participated in another program.
- Other anomalous values, including vacancies in billing data (outliers), heating or cooling system changes (e.g., adding or removing heating or cooling loads), baseload equipment changes, or changes in occupancy.[18] This included screening for accounts with large gaps in interval data (i.e., zero consumption across months, distinct from missing values).

Model Attrition

After matching participants with consumption data and applying all screens, Cadmus derived the final analysis samples by program and fuel, as shown in Table 30 (see Appendix B. Model Attrition Summary for additional detail). The main sources of attrition were driven by the following:

- An insufficient number of months of pre- and/or post-period usage data
- Outliers screened through account-level inspections of pre-and post-period 12-month usage

17 Average low-income households used approximately 1,330 kWh and 66 therms each month. Therefore, annual use of less than 1,000 kWh would be very low for residential households in Washington.

18 Baseload changes could include adding or removing appliances (e.g., refrigerator, water heater) or changes in occupancy; in either case, this could complicate analysis for distinguishing program effects.

Table 30. Final Treatment and Comparison Groups

Fuel	Year	LIW		
		Model (n)	Pop	Percentage Remaining
Electric	2013	119	345	34%
	2014	264	444	59%
	2015	179	411	44%
	Treatment Total	**562**	**1,200**	**47%**
	Comparison Total*	**99**	**293**	**34%**
Gas	2013	49	119	41%
	2014	75	102	74%
	2015	28	52	54%
	Treatment Total	**152**	**273**	**56%**
	Comparison Total*	**27**	**54**	**50%**

* The comparison group was drawn from participation between November 2015 and 2016.

Measure Distribution of Final Analysis Sample

Table 31 shows the frequency distribution of measure installations occurring in the overall (2013–2015) participant analysis samples, along with average reported savings per measure type. This detail level provided context for understanding the model results.

Additionally, tables comparing measure distributions between the analysis sample and program populations were important in demonstrating that, despite participant screening, the sample sufficiently reflected the population's measure mix and did not appear biased.

Table 31. Measure Distributions of Final Treatment Samples, by Fuel

Category	Measure	LIW Elec			LIW Gas		
		% of Sample	% of Pop.	Reported kWh per Household	% of Sample	% of Pop.	Reported Therms per Household
HVAC	Heating System Replacement	N/A	N/A	N/A	10%	14%	293
	Duct Sealing and Insulation	37%	33%	1,387	54%	44%	68
	DHP	38%	32%	4,114	N/A	N/A	N/A
	T-Stat Replacement	0.18%	0.25%	348	N/A	N/A	N/A
	Ventilation	52%	49%	162	N/A	N/A	N/A
Lighting and Appliances	CFL	8%	8%	634	N/A	N/A	N/A
	LED	12%	21%	199	N/A	N/A	N/A
	Refrigerator	8%	9%	1,209	N/A	N/A	N/A
Shell	Air Sealing	59%	52%	1,102	53%	49%	55
	Ceiling Insulation	44%	39%	1,193	59%	55%	69
	Floor Insulation	59%	54%	1,277	39%	38%	57

Category	Measure	LIW Elec			LIW Gas		
		% of Sample	% of Pop.	Reported kWh per Household	% of Sample	% of Pop.	Reported Therms per Household
	Wall Insulation	7%	8%	980	39%	44%	63
	Windows	5%	5%	2,169	N/A	0.37%	1,675
Water Heat	Pipe Insulation	38%	34%	32	12%	12%	1
	Showerheads	9%	8%	475	N/A	0.37%	48
	Aerator	N/A	1%	261	N/A	N/A	N/A
	HE Water Heat Replacement	N/A	0.17%	149	N/A	N/A	N/A
Other	Integrated Space Water Heat	N/A	N/A	N/A	N/A	0.7%	281
Common	Common Area Lighting	N/A	0.25%	82,582	N/A	N/A	N/A
	Common Area DHW	N/A	N/A	N/A	N/A	1.1%	1,980
	Common Area HVAC	N/A	0.08%	30,500	N/A	1.5%	1,824

Savings Review

Cadmus performed a comprehensive review of major measures delivered through PSE's LIW program. In discussions with PSE and through summarizing program tracking data, Cadmus identified priority measures that contributed to a large proportion of program savings or proved of strategic importance to PSE program managers. Reported energy savings estimates in the tracking system were derived from the RTF methodology directly or had been adapted by PSE (i.e., informed by RTF, regional studies, or past evaluations).

In performing this review, Cadmus relied on the following data (see References for full list of sources):

- Regional low-income weatherization studies, and research Cadmus performed specific to Washington-state deemed savings algorithms
- Data collected through the participant survey and stakeholder interviews
- The Washington State Low-Income Weatherization Manual
- State TRMs providing low-income-specific, measure-level savings estimates
- Results from Cadmus' RTF measure review for PSE's single-family weatherization program, which analyzed savings estimates using simulation modeling and billing analysis

In this review, Cadmus performed the following research steps:

- **Identify LIW measure offerings.** Cadmus reviewed PSE source of savings workbooks, outlining current measure names, descriptions UES values, and date of adoption. Cadmus then cross-referenced measures to the participant tracking data to determine measures for the 2013-2015 period.
- **Review PSE measure source documentation.** Cadmus reviewed savings documentation provided by PSE for LIW measures, including: RTF workbooks, PSE markups on RTF workbooks, PSE deemed savings workbooks (based on business cases and prior evaluation studies). Where source documentation indicated using RTF values, Cadmus attempted to verify the RTF source directly; however, in some cases the material was unavailable from the current RTF website or Cadmus RTF data archives. In those cases, Cadmus reviewed whether the available data were reasonable through benchmarking and secondary sources.
- **Benchmark UES data.** Where the RTF source changed compared to the version sourced in PSE's documentation, Cadmus reviewed those changes to determine if UES values warranted updates to align with the most current RTF sources. For these instances, Cadmus reviewed archived RTF sources (if available), and benchmarked against secondary sources for additional context.
- **Provide recommendations and considerations.** Where Cadmus found outdated UES values or more relevant sources available, Cadmus provided recommendation and considerations to update UES values or revise estimate approach where appropriate.

Non-Energy Benefits Assessment

Table 32 lists key NEBs analyses that Cadmus performed, with more detailed overviews of each methodology provided below.

Table 32. Non-Energy-Benefit Tasks by Program

Tasks	Description
Economic Impacts	Using input/output modeling tools (e.g., IMPLAN), Cadmus estimated economic and employment impacts associated with investment of program dollars and the flow of these dollars throughout different local markets.
Environmental Impacts	This assessment explored environmental impacts associated from reduced emissions from offsetting generation, in terms of both societal benefits and in reduced compliance costs.
Ancillary Participant Benefits	Employing responses from the participant phone survey, Cadmus used a hybrid contingent/relative valuation research approach to monetize specific participant benefits attributed to program effects (e.g., increased comfort).

Economic Impact Analysis

The following sections describe the IMPLAN model, model inputs and outputs, and model scenarios used to determine gross and net impacts.

The IMPLAN Model

IMPLAN is a static input-output (IO) model used to conduct region-specific economic analyses. As a static model, it cannot accept multiyear inputs or produce year-over-year results.[19] The IMPLAN model selected by Cadmus was based on 2015 state and county economic data, captured in a set of matrices describing the Washington economy for counties within PSE service territory.

These IO multiplier matrices allow IMPLAN to account for the following:

- Spending patterns and relationships between households and industries within PSE's service territory
- Regional purchasing coefficients, which account for supply chain leakage from the regional economy
- Sector-level productivity and wage data, which enabled IMPLAN to calculate impacts on employment, income, and production variables (e.g., value added, output).

Model Inputs

Model inputs represented changes to default cash flows in the economy. Cadmus modeled the program in IMPLAN by inputting changes to any of nine household income categories; or by changing final demand for goods and services in any of IMPLAN's 536 industrial sectors. As no money is created or destroyed within the economy, all changes entered in the model summed to zero, except for changes into or out of the region.

The diagram in Figure 22 illustrates the LIW program scenario and hypothetical baseline scenario inputs. Black lines denote expenditures associated with the program, while red lines represent expenditures associated with the hypothetical baseline scenario. Dashed red lines represent indirect impacts resulting from utility expenditures in the baseline scenario.

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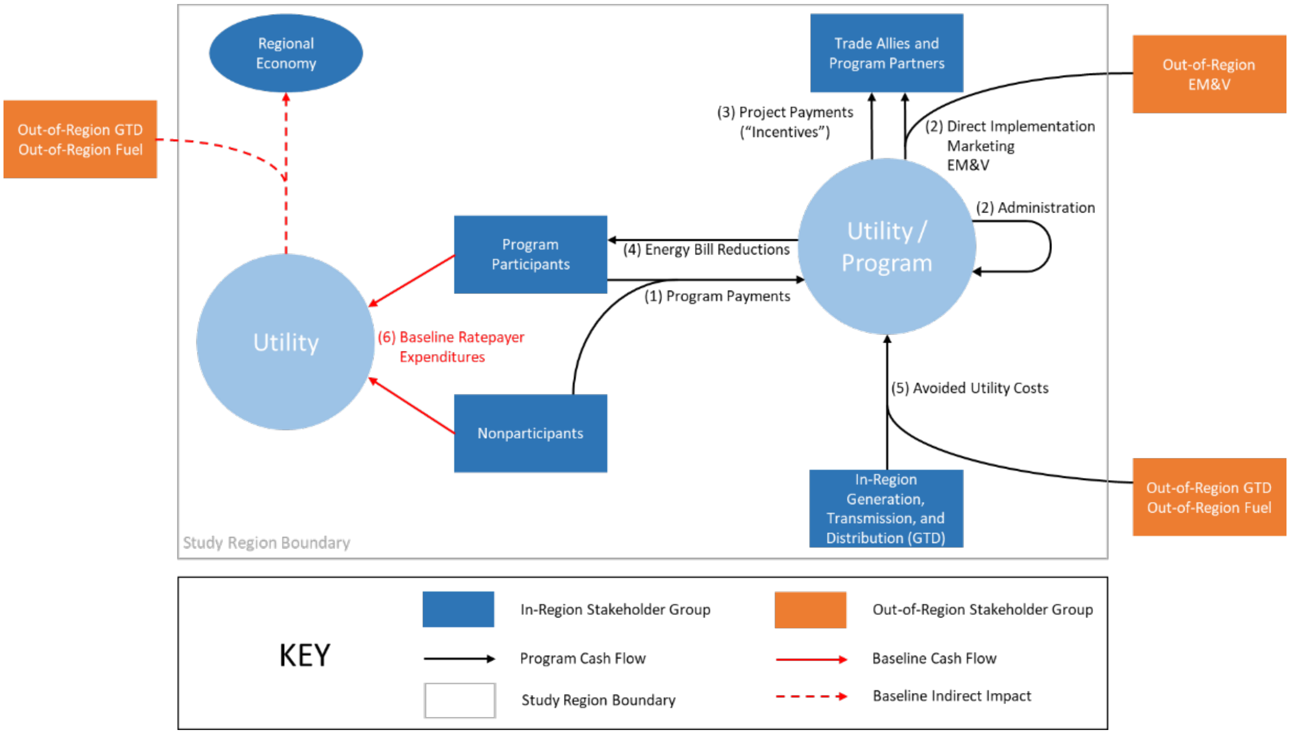
[19] IMPLAN is used to estimate economic impacts using static assumptions based on real Washington state and county economic data. These assumptions do not account for dynamic changes that occur over time, such as labor migration, price responses, or general equilibrium, which would likely diminish the positive impact of future-year energy savings benefits. For example, program-induced increases in demand for certain industries cause labor to migrate to the study region but only to the point of saturation; then, ongoing impacts result largely in local job displacement and minimally in local job creation. As a static IO model, IMPLAN does not account for such dynamic changes. In effect, the results from this study are reasonable but possibly slightly overstated.

Figure 22. Low-Income Program and Baseline Scenario Cash Flow Diagram



Modeled Cash Flows

As shown in Figure 22, these cash flows related to the regional economy in multiple ways:

1. **Program Payments.** Monies funding efficiency programs come from revenues collected from ratepayers.
2. **Admin, Implementation, Marketing, and EM&V.** Funds spent on in-house program administration, implementation, and evaluation activities provided by program trade allies and partners.
3. **Project Payments (“Incentives”).** For the LIW program, incentives and project payments are the same cash flow, with incentives paid directly to measure installers and program participants receiving the measure at no cost.
4. **Energy Bill Reductions.** Participants save energy while installed measures remain operational, benefitting from energy bill reductions, while utilities forego those revenues.
5. **Avoided Utility Costs.** PSE benefits from avoided fuel and capacity costs due to decreased demand for energy resources.
6. **Baseline Ratepayer Expenditures.** In the programs’ absence, collected revenue would be spent on other expenses relating to operating and maintaining the regional electric and gas transmission and distribution networks (rather than on energy efficiency programs).

Table 33 shows positive and negative LIW-induced changes by relevant stakeholder groups for each type of cash flow illustrated above. Negative inputs represent decreased final demand or income, and positive inputs represent increased final demand or income. Program payments represent ratepayer expenditures resulting in payments to program administration labor, trade allies, and partners. Baseline ratepayer expenditures represent a hypothetical scenario where revenue is spent on projects other than energy efficiency.

Table 33. LIW: Positive and Negative Impacts by Cash Flow Type and Stakeholder Group

Cash Flow	Stakeholder Group				
	Program Participants	Nonparticipants	PSE/LIW	Trade Allies and Partners	Out-of-Region Utilities
Program Payments	Negative	Negative	--	--	--
Program Spending	--	--	Positive	Positive	--
Project Payments ("Incentives")	--	--	Negative	Positive	--
Energy Bill Reductions	Positive	--	Negative	--	--
Avoided Utility Costs	--	--	Positive	--	Negative
Baseline Ratepayer Expenditures	Negative	--	Positive	--	--

The following sections describe the inputs required for these modeled cash flows in greater detail. For this study, Cadmus analyzed impacts on the regional economy from the LIW program, which required assuming income-bracket and sector-level breakouts for all IMPLAN model inputs describing regionwide cash flows between stakeholder groups.

Program Payments, Program Spending, and Project Payments

To develop accurate sector-level IMPLAN model inputs for relevant program spending cash flows, Cadmus' economic impacts summarized spending within the following cost categories: administration, implementation, marketing, EM&V, and incentives. Table 34 summarizes these spending categories, including the IMPLAN sectors impacted by each category. Program spending data used in this study were self-reported by PSE, with Cadmus assuming all program spending data were in nominal dollars.

Table 34. 2015 LIW Program-Level Spending Categories

Category Name	Electric Amount	Gas Amount	Category Description	IMPLAN Sector Impacted
Administration	$71,700	$11,773	Spending on program administration staff and related administrative services.	Office administrative services.
Implementation	$101,317	$17,157	Spending on program implementation.	Management, scientific, and technical consulting services.
Marketing	$8,317	$511	Program advertising and participant outreach.	Advertising and related services.
EM&V	$37,704	$3,407	Paid to Cadmus for PY 2015 evaluation. Flows out of the regional economy.	Not applicable. Treated as leakage from the regional economy.
Other	$943	$124	Undesignated funds.	Allocated evenly among the four sectors above.
Incentives	$3,614,37	$156,091	Paid directly to trade allies for measure installation in low-income households.	See list on the following page.
Total*	**$3,834,354**	**$189,065**	**Total program expenditures reported by PSE.**	

* This total does not match the "Spent" total for 2015 in Table 3 because it includes $359,768 in shareholder-funded incentive payments. These funds are allocated between gas and electric programs by share of total expenditures; $344,874 was allocated to electric and $14,894 was allocated to gas.

These six categories encompass all the ways that 2015 LIW program expenditures were modeled. Separating program-level LIW spending into multiple categories allowed Cadmus to assign expenditures to specific IMPLAN sectors, thus maximizing the accuracy of the IMPLAN models. The following list shows the sectors to which incentive expenditures were assigned.

- Management, scientific, and technical consulting services
- Environmental and other technical consulting services
- Maintenance and repair construction of residential structures
- Maintenance and repair construction of nonresidential maintenance and repair
- Wholesale trade
- Air conditioning, refrigeration, and warm air heating equipment manufacturing
- Heating equipment manufacturing (except warm air furnaces)

- Automatic environmental control manufacturing
- Mineral wool manufacturing
- Urethane and other foam product manufacturing (except polystyrene)
- Other plastics product manufacturing
- Waste management and remediation services

Cadmus also modeled cash flows resulting from customer bill savings, utility revenue loss, and utility avoided costs. These inputs were built using energy savings estimates from the billing analysis and applying weighted average measure life estimates from the program data. Cadmus then calculated nominal retail rate and avoided cost forecasts from the present value forecasts provided by PSE to estimate bill savings, utility revenue loss, and avoided costs over the life of the measure. Finally, using an 8% utility discount rate, Cadmus calculated the net present value of these savings. Cadmus then input these results into the IMPLAN model as cash flows 4 and 5 (see Figure 22). The nominal retail rate and avoided cost forecasts used by Cadmus follow in Table 35.

Table 35. Nominal Avoided Cost and Retail Rate Forecasts

Year	Utility Avoided Cost		Retail Rate		
	($/kWh)	($/Therm)	($/kWh)	Delivery ($/Therm)*	Total Retail ($/Therm)
2015	$0.0837	$0.46	$0.1026	$0.36	$0.82
2016	$0.0855	$0.56	$0.1060	$0.37	$0.93
2017	$0.0903	$0.61	$0.1094	$0.39	$1.00
2018	$0.0954	$0.66	$0.1127	$0.40	$1.06
2019	$0.1004	$0.71	$0.1160	$0.42	$1.13
2020	$0.1010	$0.75	$0.1193	$0.43	$1.18
2021	$0.1044	$0.78	$0.1226	$0.44	$1.22
2022	$0.1056	$0.79	$0.1261	$0.46	$1.25
2023	$0.1084	$0.82	$0.1297	$0.47	$1.29
2024	$0.1102	$0.83	$0.1331	$0.49	$1.32
2025	$0.1125	$0.86	$0.1363	$0.50	$1.36
2026	$0.1151	$0.89	$0.1394	$0.51	$1.40
2027	$0.1171	$0.90	$0.1424	$0.52	$1.42
2028	$0.1200	$0.93	$0.1454	$0.53	$1.46
2029	$0.1222	$0.96	$0.1483	$0.54	$1.50
2030	$0.1242	$0.99	$0.1511	$0.56	$1.55
2031	$0.1273	$1.03	$0.1539	$0.57	$1.60
2032	$0.1287	$1.05	$0.1573	$0.58	$1.63
2033	$0.1315	$1.08	$0.1608	$0.59	$1.67
2034	$0.1285	$1.10	$0.1644	$0.61	$1.71

* Cadmus noted that the gas retail rates provided by PSE were lower than the gas avoided costs.

Year	Utility Avoided Cost		Retail Rate		
	($/kWh)	($/Therm)	($/kWh)	Delivery ($/Therm)*	Total Retail ($/Therm)

Cadmus assumed that the gas rate provided by PSE is the delivery charge and excludes the gas cost rate, and added the gas avoided costs to this rate to approximate the retail rate experienced by PSE customers.

Model Outputs

The model outputs included the following:

- ***Direct effects*** represent regional production changes brought by increases in regional demand. These include direct **program and participant expenditures** on goods and services from program trade allies and partners. For example, program expenditures increase final demand for "repair and maintenance of residential structures."
- ***Indirect effects*** are changes in **demand for intermediate inputs** necessary for directly affected industries.
- ***Induced effects*** result from the ways households and employees of directly and indirectly affected industries spend money on regional goods and services. **Spending of increased income triggers further production in local industries, leading to multiple iterations of additional economic activity.** These effects reflect predicted impacts on industries in the PSE service territory not directly involved with the LIW program or supplying intermediate factor inputs.
- ***Total effects*** are the sum of direct, indirect, and induced effects.

For each model scenario, IMPLAN produced direct, indirect, induced, and total effects on multiple-key, interrelated economic indicators, including the following:

- ***Employment*** represents the number of **job-years created**—the only indicator variable unaffected by the discount rate; each job-year represents **one job for one year** (i.e., 2,080 hours).
- ***Employee compensation*** represents the total cost employers pay for employees, including **wages plus benefits**; it does not include proprietor (i.e., owner) incomes and serves as the best indicator for estimating wage impacts.
- ***Labor income*** represents the sum of all forms of employment income, including **employee compensation (i.e., wages plus benefits) and proprietor incomes**; it serves as the best indicator for estimating total **household income and savings impacts**.
- ***Value added*** represents all **profits (i.e., operating surpluses), indirect business taxes, and employee compensation**; it accounts for all non-commodity payments associated with industry production and serves as the best indicator for estimating

marginal impacts on **regional domestic product.** ***This is the most appropriate impact type to include in a cost-effectiveness assessment.***

- ***Output*** equals value added plus intermediate expenditures, representing the total value of industry production; it serves as the best indicator for estimating sector-level impacts on business revenue and industry production.

Model Scenarios

Cadmus created two IMPLAN models, one each for PSE's gas and electric service territories. Each model contained two scenarios:

- The first (the program scenario) represents gross impacts where ratepayer funds were reallocated to program spending. These are compared to the baseline scenario to calculate net impacts.
- The second (the baseline scenario) allows Cadmus to create net impacts, where no efficiency program occurred and ratepayer dollars were spent on other utility industry expenditures (e.g., fuel, infrastructure, energy imports).

To estimate net economic impacts, Cadmus subtracted the baseline scenario from the program scenario.

Environmental Impact Analysis

Cadmus quantified the avoided greenhouse gas (GHG) emissions associated with the LIW program's energy efficiency impacts using a standard approach that multiplied evaluated energy savings by fuel-specific emissions factors. Emissions factors—the rate at which a pollutant is emitted per unit of energy—are most often expressed in tons of pollutant per energy unit: electric in tons/megawatt hour (MWh), and gas in tons/thousand therms (MThm). The product of the emissions factor and the energy savings provides an estimate of the total weight of air pollutant offset or avoided by the program.

For this assessment, Cadmus used average evaluated savings from the 2015 program year, presenting annual and lifetime emissions avoided for the average participant as well as total emissions avoided by all measures installed as part of the 2015 program year.

The natural gas emissions factor used in the analysis, derived from EPA's Center for Corporate Climate Leadership Emissions Factor Hub, was based on national average natural gas composition and heat content.[20] To quantify GHG emissions avoided from reducing electricity usage, the chosen emissions factor should represent the utility's marginal

[20] U.S. Environmental Protection Agency. "Center for Corporate Climate Leadership GHG Emission Factors Hub." November 2015. https://www.epa.gov/climateleadership/center-corporate-climate-leadership-ghg-emission-factors-hub

emissions rate, as reducing electricity usage will avoid production at whatever power plant is on the margin during each hour of the year.

According to the 2015 PSE GHG Inventory, electricity dispatch modeling of PSE's service territory has identified that the marginal plant within the Northwest Power Pool will likely be a combined cycle, natural gas-fired turbine with a heat input rate of 7,000 Btu/kWh.[21] Therefore, to remain consistent with PSE's GHG inventory, Cadmus assumed a model natural gas plant with these characteristics on the margin during all hours of the year.

Table 36 lists emissions factors used in the analysis.

Table 36. Emissions Factors

Service Fuel Type	CO_2e
Electric Emissions Factor (tons/MWh)	0.376
Gas Emissions Factor (tons/MThm)	5.84

Environmental Benefits

Cadmus measured the NEBs from avoided GHG emissions in two ways. The first quantifies the avoided environmental compliance costs the result from the LIW program. Avoided compliance costs are costs associated with complying with state and federal regulations aimed at reducing GHG emissions, such as the Washington CAR. In the second approach, Cadmus quantifies the social benefit associated with reduce emissions

Table 37 provides a summary of the assumptions used in valuing avoided emissions from both approaches, the social benefit and avoided compliance cost perspectives.

Table 37. Environmental Benefit Assumptions

Year	Social Cost of Carbon ($/ton CO_2)	Avoided Environmental Compliance Costs ($/ton CO_2e)*	
		PSE IRP Scenario 12 – High Cost Scenario	PSE IRP Scenario 10 – Low Cost Scenario
2015	$39.68		
2018	$46.30	$30.71	$14.36
2020	$46.30	$35.18	$16.45
2030	$55.12	$69.21	$32.35
2035	$60.63	$97.05	$45.37

*PSE IRP modeling covers 2018-2037 only. Cadmus has assumed $0 in CO_2 compliance costs for calendar years 2015-2017.

[21] Environmental Resources Management. *2015 Greenhouse Gas Inventory*. p. 30. Prepared for Puget Sound Energy. September 2016. Available online: https://pse.com/aboutpse/Environment/Documents/GHG_Inventory_2015.pdf

To quantify avoided environmental compliance costs, Cadmus used assumptions from the 2017 PSE Integrated Resource Plan (IRP) development process. Due to uncertainty on the timing and structure of future GHG compliance regulations, Cadmus selected two out of 14 scenarios from the PSE IRP with different GHG regulation assumptions for use in this analysis. Cadmus chose the scenarios as realistic estimates of future policy that provide a range of compliance costs. The scenarios include one that considers costs for compliance with the Washington CAR[22] with no future federal GHG regulation (Scenario 12: Base w/ CAR only) and one that includes lower CAR compliance costs, coupled with base case assumptions of compliance with the U.S. Environmental Protection Agencies Clean Power Plan after 2022 (Scenario 10: Base + Low CAR CO_2). For this study Cadmus has characterized these two high- and low-cost scenarios:

- ***High CO_2 Cost (Scenario 12: Base w/ CAR only)*** –In scenario 12, PSE assumed compliance only with the Washington CAR (with no federal Clean Power Plan). This scenario resulted in estimated compliance costs of $30.71 per ton in 2018 and rising to over $111/ton CO_2e in 2037.
- ***Low CO_2 Cost (Scenario 10: Base + Low CAR CO_2)*** – Scenario 10 in the IRP contains a more conservative estimate of GHG compliance costs. Within this scenario, PSE assumes lower Clean Air Rule compliance costs until 2021, followed by a program similar to the U.S. Environmental Protection Agencies Clean Power Plan. This scenario resulted in estimated compliance costs of $14.36 per ton in 2018 and rising to over $51/ton CO_2e in 2037.

In addition to estimate avoided compliance costs from GHG regulations, Cadmus also estimated the social benefit of avoided GHG emissions. The social benefit uses a social cost of carbon, meant to be an estimate of future climate change damages that are avoided by reducing GHG emissions through the LIW program. The social benefit accrues to all members of society and includes a variety of climate change impacts, such as changes in agricultural productivity, human health, and property damages from increased flood risk.

Despite being a range of available estimates for the social cost of carbon, for this analysis, Cadmus used a conservative value developed by the U.S. Environmental Protection Agency for use by federal agencies in valuing the climate change impacts of rulemakings.[23] Cadmus

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[22] Washington Administrative Code, Chapter 173-442, Clean Air Rule

[23] U.S. Environmental Protection Agency. "Social Cost of Carbon for Regulatory Impact Analysis Under Executive Order 12866." May 2013 (Revised August 2016). Available online: https://19january2017snapshot.epa.gov/climatechange/social-cost-carbon-technical-documentation_.html

used the EPA social cost of carbon for with a 3% discount rate which ranges from $39.68/ton CO_2 in 2015 to $60.63/ ton CO_2 in 2035.

Ancillary Participant Benefit Analysis

As part of the evaluation of the LIW program, Cadmus sought to establish dollar values for ancillary participant benefits accruing to LIW program participants. While there is a wide range of potential benefits to energy efficiency from the participant perspective,[24] Cadmus expected primary ancillary benefits associated with a low-income program to be comfort (due to reduced drafts and more efficient equipment) and health[25] (due to more reliable heating and cooling). The following paragraphs describe the methodology used.

Contingent Valuation Approach

Cadmus estimated ancillary participant benefits using the contingent valuation method. Contingent valuation is an approach commonly adopted in economics literature to solicit information about individuals' values for goods not traded in markets. With this method, Cadmus used discrete response techniques, where survey respondents were asked to provide a series of "yes/no" responses to questions that ask whether the respondent would be willing to pay a stated price (i.e., a bid amount). Bid amounts were anchored by average bill savings experienced by program participants.

The discrete response approach, which simulates market decision making, has been highly endorsed by the NOAA Panel on Contingent Valuation[26] (i.e., a panel of leading economists, including two Nobel prize winners, assigned the task of evaluating the reliability of the contingent valuation method for use by public agencies, especially for litigation purposes).

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24 Skumatz, Lisa, M.S. Khawaja, and R. Krop. "Non-Energy Benefits: Status, Findings, Next Steps, and Implications for Low Income Program Analyses in California." Section 4. Revised report, May 11, 2010. Available online: http://liob.cpuc.ca.gov/docs/LIEE%20Non-Energy%20Benefits%20Revised%20report.pdf

25 Cadmus could not develop mean WTP estimates for "Health" or "Overall" benefits due to limitations in the number of survey responses. The subsample for the "Health" benefit proved too small to develop statistically meaningful estimates for this benefit. Wording for the "Overall" benefit led Cadmus to believe this question unintentionally valued "Comfort" benefits rather than "Overall" benefits. Thus, Cadmus combined responses to the "Overall" question for Survey A with responses to the "Comfort" question for Survey B, leading to a combined sample with a substantially higher number of observations and a model with statistical significance at a better than 0.001% level.

26 Arrow, Kenneth, R. Solow, P.R. Portney, E.E. Leamer, R. Radner, and H. Schuman. "Report of the NOAA Panel on Contingent Valuation." January 11, 1993. Available online: http://www.economia.unimib.it/DATA/moduli/7_6067/materiale/noaa%20report.pdf

Cadmus conducted two separate participant phone surveys (described in the Participant Survey section below) to solicit responses to an array of bid amounts for "overall" and "comfort" benefits. The phrasing of the "overall" question led Cadmus to believe that its responses should be combined with those from the "comfort" question. The final model achieved statistical significance at better than 0.001% level, using 262 observations from the 95 completed survey respondents. [27]

Valuation Modeling – Logistic Regression

Cadmus estimated the valuation model via logistic regression (logit), with the following general functional form:

$$Prob(Yes) = f(BID, X)$$

Where f(BID,X) is a function of the bid amount and a vector of participation and demographic characteristics, X_i (e.g., the types of measures installed and whether the respondent owned or rented their residence). Assuming a logistic functional form, Cadmus estimated the following logit model:

$$Prob(Yes) = f(BID, X) = 1 - \frac{1}{1 + e^{(\alpha - \beta_1 BID - \beta_i X_i)}}$$

Cadmus tested several available demographic and control variables expected to influence a respondent's WTP, including household income, respondent age, square footage, program satisfaction, residence age, and number of residents. The only control variables that were statistically significant at the 5% significance threshold were "Own" and "Heating Equipment Installed."

Mean WTP Calculation

Using the parameter estimates from the logit model, the team then estimated mean willingness to pay (WTP), using the formula developed by Hanemann (1989).[28]

$$Mean\ WTP = \left(\frac{1}{\beta_1}\right) * \ln(1 + e^{\beta_0})$$

Where β_1 is the coefficient on the bid variable, and β_0 is the following equation:

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[27] Cadmus used a bounded logit approach, where each "Yes" response was followed by a higher bid amount, and each "No" response was followed by a lower bid amount until three yes or no responses had been recorded. This resulted in up to three bid/response observations for each survey respondent. Some survey respondents declined to answer the valuation portion of the survey.

[28] Hanemann, M. "Welfare Evaluations in Contingent Valuation Experiments with Discrete Response Data: Reply" American Journal of Agricultural Economics (1989): 71 (4), pp. 1057–1061.

$$\beta_0 = \alpha + \sum(\beta_i * Mean_i)$$

In other words, β_0 is the sum of all coefficient estimates, β_i (except the bid amount), multiplied by their mean value, $Mean_i$, added to the intercept coefficient.

Model Output

Mean WTP represents the average monetized value per participant per year for an ancillary benefit such as comfort. PSE can use this value as an additional benefit-side input for a cost effectiveness analysis to gain a more complete understanding of the total social benefits that arise from an efficiency program like LIW.

Using the combined "Comfort" sample, Cadmus developed the logit model and mean ancillary participant benefit estimates shown in Table 38 and Table 39.

Table 38. Logit Model Specification for Comfort Benefits (n=262)

Parameter	Estimate	Standard Error	Wald Chi-Square	Pr > ChiSq
Intercept	-1.8151	0.3812	22.68	<.0001
Bid Amount	0.0035	0.0009	15.08	0.0001
Heating Equipment Installed	1.1388	0.3031	14.12	0.0002
Own	0.7320	0.3107	5.55	0.0185

Table 39. Mean Values for Grand Constant Calculation with Combined Sample (n=262)[29]

Parameter	Mean
Heating Equipment Installed	0.37
Own	0.71

The non-bid variables in Table 38 (i.e., "Heating Equipment Installed" and "Own") allow us to control for other factors that may influence the respondent's willingness to pay response, such as the bias that may be introduced by installing a relatively expensive heating system in one residence and installing shell measures in another. For example, a respondent that had a heating measure such as a ductless heat pump installed through the program may be more likely to accept a higher bid amount than a respondent that only had weather stripping installed.

29 The coefficient on the "Bid Amount" parameter represents the change in the probability of a "yes" response as the bid amount changes. The "Heating Measure Installed" and "Own" parameters are binary control variables where a value of 1 indicates that the effect is active and a value of 0 indicates it is not. Specifically, a value of 1 for "Own" indicates that the respondent owns their residence and a value of 0 indicates that they do not; a value of 1 for "Heating Equipment Installed" indicates that the respondent received heating equipment through the program.

Cadmus applied these parameter estimates and mean values to the Mean WTP formula, arriving at the average ancillary participant benefits of ***$99.62 per participant***.

Process Evaluation

The process evaluation included four primary activities, outlined in Table 40.

Table 40. Process Evaluation Activities

Activities	Purpose
In-Depth Interviews	Assess stakeholder perspectives on program implementation, communication, marketing, barriers, and program successes.
Participant Surveys	Verify measure installations, assess satisfaction and awareness, and investigate NEBs and household behavior changes.
Process Flow	Identify and diagram customer journey.
Secondary Research	Provide a framework to identify KPI.

In-Depth Interviews

Cadmus conducted in-depth interviews with PSE program managers, stakeholders identified by PSE's program manager, and community action agencies. Table 41 identifies the sampling approach for these in-depth interviews.

The primary research questions for these interviews was to:

- Review program design and implementation
- Assess barriers to participation
- Assess overall program successes and challenges
- Assess communication among PSE's program staff, community action agencies, and low-income stakeholders

Table 41. In-Depth Sampling Approach

Interview Audience	Number of Targeted Interviews	Number of Completed Interviews	Date Interview was Completed
Program staff	1	1	July 2016
Stakeholders*	2	2	May 2017
Community Action Agencies	5	5	May 2017

*Cadmus interviewed a stakeholder from Washington State Department of Commerce and one stakeholder from the Energy Project as suggested by PSE's program manager.

Participant Survey

Cadmus conducted a phone survey using all participants (n=741)[30] of the LIW program from 2015 and 2016. This included asking questions to gain insights into the general customer experience, perspective, and satisfaction with the program. The survey collected primary data on both process-oriented information as well as several impact-oriented elements, including:

- Program awareness
- Satisfaction with program components and the program overall
- Challenges and barriers
- Motivation and NEBs including total benefits and health and comfort benefits
- Impact of energy education and other possible behavioral changes due to program participation including take-back behavior
- Verification of equipment installation
- Previous and current heating equipment

Given the survey length, Cadmus designed two shorter surveys to address separate topics, thus reducing the burden on individual respondents. Table 42 shows key survey topics included in Survey A and Survey B.

Table 42. Key Survey Topics

Key Survey Topic	Survey A	Survey B
Measure verification	✓	
Previous and current heating equipment	✓	✓
Take-back behavior	✓	✓
Awareness	✓	
Motivators	✓	
Total non-energy benefits	✓	
Health and comfort non-energy benefits		✓
Program satisfaction	✓	✓
Challenges with energy efficiency	✓	
Household behavior changes		✓
Demographics	✓	✓

Cadmus used a census of 2015 and 2016 LIW program participants as the survey sample. To prepare the sample frames, Cadmus merged the 2015 and 2016 participants and removed any records without a valid telephone number. Cadmus then removed duplicate

30 The total population was 821 but after removing records with invalid or duplicate contact information, the total was 741.

participants, selecting the record with the most recent participation date. Finally, the sample was randomized and divided in half, using one-half for survey A and one-half for survey B. This effort targeted 70 completes per survey to achieve 90% confidence at ±10% precision. However, due to limited samples with available contact information and the split surveys, the final completes for individual surveys A and B achieved less than this target (with certain questions included in both surveys achieving samples higher than this target). In an effort to achieve the target completes, Cadmus attempted every available record up to five times over two weeks, during days, evenings, and weekends.

Table 43 provides details regarding the telephone survey's planned and achieved completes.

Table 43. LIW Participant Telephone Survey Sampling Plan

Disposition	Number of Records	
	Survey A	Survey B
Population	**821**	
Removed: Invalid Phone Number	53	
Removed: Duplicate Record	27	
Used for Survey Sample	**371**	**370**
Completed Surveys	**55**	**56**
Refused	30	17
Nonworking	60	54
Wrong Number	18	13
Language Barrier	11	16
Not Eligible (Did not Participate in Program)	3	5
Eligible but Terminated	6	4
No Answer/Answering Machine/Phone Busy	183	205
Callback	5	0
Response Rate	15%	15%
Planned Completes	**70**	**70**

Appendix F. Survey Demographics presents tables outlining answers to each demographic question from the customer surveys.

Process Flow Diagram

Cadmus developed a process flow diagramming program activities from pre-participation outreach through post-installation payment. The diagram was developed by reviewing program materials, and through discussions with the PSE program manager and community action agencies.

KPI Framework

To establish discrete metrics for tracking and measuring ongoing program performance, Cadmus developed a list of recommended KPIs. Cadmus identified KPIs based on program goals outlined in the 2016-2017 PSE Biennial Conservation Plan Overview[31] or mentioned in the program manager interview. Cadmus also developed a supplementary list of metrics, distinguished from KPIs, but that may still be useful and interesting for PSE to track and consider occasionally with regard to program performance.

[31] Puget Sound Energy. 2016-2017 PSE Biennial Conservation Plan Overview. URL: https://www.pse.com/aboutpse/Rates/Documents/ees_2016-2017_conservation_planning_docs.pdf

Appendix B. Model Attrition Summary

Table 44 and Table 45 provide details of the screening process for LIW electric and gas impact models, respectively.

Table 44. LIW Model Screening—Electric

Screen	Treatment Group		Comparison Group	
	Accounts Remaining	Percentage Remaining	Accounts Remaining	Percentage Remaining
Original electric accounts	1,200	100%	293	100%
Did not match to billing data provided	1,199	100%	214	73%
Insufficient pre- and post-period days of use	757	63%	111	38%
Changed use from the pre to post by >70%	750	63%	110	38%
Pre- or post-period use less than 1,000 kWh	749	62%	108	37%
Wrong signs on PRISM parameters	747	62%	108	37%
Reported savings higher than or <1% of pre-use	663	55%	108	37%
Participated in another program	662	55%	107	37%
Inspection of pre/post use (e.g., vacancies)	562	47%	99	34%
Final Analysis Group	**562**	**47%**	**99**	**34%**

Table 45. LIW Model Screening—Gas

Screen	Treatment Group		Comparison Group	
	Accounts Remaining	Percentage Remaining	Accounts Remaining	Percentage Remaining
Original electric accounts	273	100%	54	100%
Did not match to billing data provided	270	99%	39	72%
Insufficient pre- and post-period days of use	181	66%	29	54%
Changed use from the pre to post by >70%	177	65%	29	54%
Pre- or post-period use less than 150 therm	169	62%	28	52%
Wrong signs on PRISM parameters	166	61%	28	52%
Reported savings higher than or <1% of pre-use	165	60%	28	52%
Participated in another program	165	60%	28	52%
Inspection of pre/post use (e.g., vacancies)	152	56%	27	50%
Final Analysis Group	**152**	**56%**	**27**	**50%**

Appendix C. Model Specification

PRISM Models

Cadmus estimated the heating and cooling PRISM model for various heating and cooling bases in the pre- and post-period for each customer, using the following specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer '*i*' and day '*t*':

ADC_{it}	=	Average daily kWh consumption in the pre- or post-program period
α_i	=	The participant intercept, representing the average daily kWh baseload
β_1	=	The model space heating slope (used just in the heating only, heating + cooling model) – average change in daily usage resulting from an increase of one daily heating degree day (HDD)
$AVGHDD_{it}$	=	The base 45–65 average daily HDDs for the specific location (used just in the heating only, heating + cooling model)
β_2	=	The model space cooling slope (used only in the cooling only, heating + cooling model) – average change in daily usage resulting from an increase of one daily cooling degree day (CDD)
$AVGCDD_{it}$	=	The base 65–85 average daily CDDs for the specific location (used just in the cooling only, heating + cooling model)
ε_{it}	=	The error term

Using the above model, Cadmus computed weather-normalized annual kWh consumption as:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_{it} + \beta_2 LRCDD_{it}$$

Where, for each customer '*i*' and annual time period '*t*':

NAC_i	=	Normalized annual kWh consumption
$\alpha_i * 365$	=	Annual baseload kWh usage (non-weather sensitive)
$LRHDD_{it}$	=	Annual, long-term HDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location
$\beta_1 LRHDD_{it}$	=	Weather-normalized, annual weather-sensitive (heating) usage (i.e., HEATNAC)

$LRCDD_{it}$	=	Annual, long-term CDDs of a TMY3 in the 1991–2005 series from NOAA, based on home location
$\beta_2 \, LRCDD_{it}$	=	Weather-normalized, annual weather-sensitive (cooling) usage (i.e., COOLNAC)

Combined Fixed Effects—Whole House Models

To estimate electric energy savings, Cadmus employed a pre- and post-installation savings analysis fixed-effects modeling method using pooled daily time-series (panel) billing data. The fixed-effects modeling approach corrected for the following:

- Differences between pre- and post-installation weather conditions
- Differences in usage consumption between participants, through inclusion of a separate intercept for each participant

This modeling approach ensured that savings estimates were not skewed by unusually high-usage or low-usage participants. Cadmus used the following model specification to determine overall savings:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \beta_3 POST_i + \beta_4 POST_i * AVGHDD_{it} + \beta_5 POST_i * AVGCDD_{it} + \varepsilon_{it}$$

Where, for each participant or comparison customer ‘i' and day ‘t’:

ADC_{it}	=	Average daily kWh consumption during the pre- or post-installation program period
α_i	=	Average daily kWh baseload intercept for each customer (part of the fixed-effects specification)
β_1	=	Average daily per-HDD usage in the pre-period
$AVGHDD_{it}$	=	Average daily base 54 HDDs,[32] based on home location
β_2	=	Average daily per-CDD usage in the pre-period
$AVGCDD_{it}$	=	Average daily base 69 CDDs, based on home location
β_3	=	Average daily whole-house program baseload kWh savings
$POST_i$	=	An indicator variable equaling 1 in the post-period (after the latest measure installation) and 0 in the pre-period
β_4	=	Whole-house heating kWh savings per HDD

[32] Cadmus estimated fixed-effects models using average PRISM reference temperatures of 54°F for heating and 69°F for cooling.

$POST_i * AVGHDD_{it}$ = An interaction between the POST indicator variable and the HDDs (AVGHDD)

β_5 = Whole-house cooling kWh savings per CDD

$POST_i * AVGCDD_{it}$ = An interaction between the POST indicator variable and the CDDs (AVGCDD)

ε_{it} = The modeling estimation error

Combined Fixed Effects—Measure-Level Models

Though the measure-level fixed effects models follow a similar form to whole-house fixed effects models, they are fairly complex and not easily presented due to the extent of parameters used (i.e., up to 10 measures, including indicators for each and interactions with HDDs, CDDs, the post period, and both post and weather distinctions. For these reasons, Cadmus included an abridged version of the model specification, only showing a single measure, along with tables presenting estimates of model parameters of all measures:

$$ADC_{it} = \alpha_i + \beta_1 DuctEff * AVGHDD_{it} + \beta_2 DuctEff * AVGCDD_{it} + \beta_3 DuctEff * POST_i + \beta_4 DuctEff * POST_i * AVGHDD_{it} + \beta_5 DuctEff * POST_i * AVGCDD_{it} + \varepsilon_{it}$$

Where, for participant customers '*i*' and day '*t*':

ADC_{it} = Average daily kWh consumption during the pre- or post-installation program period

α_i = Average daily kWh baseload intercept for each customer (part of the fixed-effects specification)

$DuctEff_i$ = An indicator variable that equals 1 if an account received a given measure (i.e., duct efficiency) and 0 if not

β_1 = Average daily per-HDD usage for homes with a given measure

$DuctEff_i * AVGHDD_{it}$ = An interaction between the DuctEff indicator variable and the HDDs (AVGHDD)

β_2 = Average daily per-CDD usage in the pre-period for homes with a given measure

$DuctEff_i * AVGCDD_{it}$ = An interaction between the DuctEff indicator variable and the CDDs (AVGCDD)

β_3 = Average daily whole-house program baseload kWh savings

$DuctEff_i * POST_i$ = An interaction between the DuctEff indicator variable and the POST indicator variable

β_4 = The whole-house heating kWh savings per HDD for homes with a given measure

$DuctEff_i * POST_i * AVGHDD_{it}$ = An interaction between the DuctEff indicator variable, the POST indicator variable, and the HDDs (AVGHDD)

β_5 = Whole-house cooling kWh savings per CDD for homes with a given measure

$DuctEff_i * POST_i * AVGCDD_{it}$ = An interaction between the DuctEff indicator variable, the POST indicator variable, and the CDDs (AVGCDD)

Appendix D. Savings Review Details

This appendix provides additional detail from the review of PSE energy savings estimates.

Shell Measures

Cadmus reviewed all shell measures and identified three suggested revisions for updating future savings methods (see Conclusions, Recommendations, and Considerations section for additional detail):

- Revise UES values for air sealing, insulation, windows, and duct sealing/insulation to reflect the most recent RTF sources
- Review RTF sources of UES values for shell and duct measures annually to consider revisions
- Consider revising shell measure UES estimates to account for project-specific heating system types (currently documented for all projects within the program tracking database)

Table 46 provides additional details.

Table 46. Shell Measures Sources and Considerations

Measure	Savings Source		UES Measure Identifiers	
	Current	Proposed	Current	Proposed
Air Sealing / Structural Sealing	RTF; Version 2 and 3 Weatherization Workbooks and PSE SEEM Modeling Runs	***Recommend using most recent RTF sources available***	Pre/post CFM50 values	Pre/post CFM50 values
			Heating fuel	Heating fuel
			Heating zone	Heating zone
				Heating system type
Floor Insulation			Pre/post R-values	Pre/post R-values
			Installed sq ft	Installed sq ft
			Heating fuel	Heating fuel
Attic Insulation			Heating zone	Heating zone
Wall Insulation				***Heating system type***
Windows			Pre/post widow type	Pre/post widow type
			Installed sq ft	Installed sq ft
			Heating fuel	Heating fuel
			Heating zone	Heating zone
				Heating system type
Duct Insulation and Sealing	RTF; Version 2 Duct Sealing Workbooks	***Recommend using most recent RTF sources available***	Heating fuel	Heating fuel
			Heating zone	Heating zone
				Heating system type

* As noted, recommendations do not point to specific RTF workbooks and data due to continuous

revisions these measure estimates receive per year.

For shell measures, current reported savings estimates are sourced from older RTF weatherization UES workbooks (i.e., 2012). Starting in 2015, the RTF completed calibrated models for weatherization measures, which provide more accurate savings.

In addition, PSE calculates a weighted average savings estimate using RTF sources, assuming a fixed distribution of heat pumps, zonal heat, and electric furnaces.[33] Weighting UES values by fixed heating system types will misrepresent savings for program populations with different equipment distributions.[34] Estimating accurate savings using this weighted approach merits revising this average periodically to account for changes in program delivery, offerings, and customer makeup. As an alternative, Cadmus suggests using project-specific heating systems to estimate savings, as program tracking currently collects these data.

Lighting and Appliances

In reviewing lighting and appliance measures, Cadmus found that PSE's savings estimates are reasonable; however, documentation on the refrigerator replacement savings source was insufficient to verify inputs (as shown in Table 47). PSE should consider standard documentation for refrigerator measures since the RTF does not include a current measure that is well-suited for a direct exchange, low-income program.

33 RTF heating distribution assumes 42% zonal, 36% electric furnace, and 22% heat pumps, where tracking data from 2014 through 2015 shows 50% zonal, 36% electric furnaces, and 14% heat pumps.

34 The RTF makes the following recommendation: "For example, the savings from ceiling and floor insulation will vary significantly depending the whether the home is heated by heat pump or electric resistance. These measures should include an identifier of the heating system type so separate savings are estimated."
Regional Technical Forum. *Roadmap for the Assessment of Energy Efficiency Measures*. December 8, 2015. Available online: https://nwcouncil.app.box.com/v/OperativeGuidelines-20151208

Table 47. Lighting and Appliances Sources and Considerations

Measure	Savings Source		UES Measure identifiers	
	Current	Proposed	Current	Proposed
Refrigerator Replacement	PSE algorithm and inputs	***Consider standardizing methods and improving documentation***	One per home	No change
LED Fixtures	RTF algorithm with PSE sales data	No change	Quantity installed	No change
LED Lamp				

Refrigerator Replacement

In reviewing lighting and appliance UES values, Cadmus identified a program requirement that replacement refrigerators must be ENERGY STAR-qualified units of a similar size and must replace a primary refrigerator, operable at the time of replacement and manufactured before 1993. As of 2016, PSE used its own UES estimate for refrigerator replacements, which was similar to Cadmus' estimate using current RTF sources. However, multiple savings values were recorded across program years, as shown in Table 48, with none of the values matching PSE's documented savings source.[35]

While all documented savings values are reasonable for this measure, Cadmus suggests that PSE revise the savings documentation to provide complete documentation and ensure consistency between sources. Table 48 provides a potential approach that adapts RTF estimates to reflect the LIW direct-install, early retirement design.

Table 48. Refrigerator Replacement Savings Estimates

Source	Annual Consumption (kWh)		Interactive Effect Factor	Estimated Savings (kWh)
	Replaced Refrigerator	ENERGY STAR Refrigerator		
PSE 2014 Savings	N/A	N/A	N/A	679
PSE 2015 Savings	N/A	N/A	N/A	666
PSE 2016 Savings	N/A	N/A	N/A	503
PSE Estimate Documented	1,136	347	0.735	580
RTF Adapted Estimate*	1,239	419	0.804	659

* Estimate developed using RTF data (workbook v3.1), combining the baseline of refrigerator recycling and ENERGY STAR consumption of refrigerator replacement measures.

LED Lighting

PSE currently uses accurate energy savings equations and input assumptions that reflect best practices for LED energy savings calculations. While low-income programs often

[35] PSE Documented Savings Source: Refrigerator Repalcement_2014_08_22.xls

measure savings relative to existing conditions (rather than against standard or market baselines), the current engineering approach (lumen equivalent method) reflects a conservative estimate of savings. Given the approach and relatively small portion of lighting savings, Cadmus has no suggested changes to the current approach.

Domestic Hot Water

Cadmus reviewed DHW measures and suggests that PSE consider updating the source for estimating pipe insulation savings (noted below in Table 49).

Table 49. DHW Sources and Considerations

Measure	Savings Source		UES Measure Identifiers	
	Current	Proposed	Current	Proposed
Showerheads	Methodology based on Arkansas study, using RTF numbers and Seattle-specific inputs	No change	Per unit	No change
Faucet Aerators		No change	Per unit	No change
Water Heater Replacement	RTF	No change	Per unit	No change
Pipe Insulation	RTF	***Consider revising deemed estimate (from 20 kWh to 31 kWh)***	Per unit (3 feet)	No change

Showerheads

For residential direct-install showerhead replacements, PSE uses the RTF "Residential Showerhead Workbook" Version 2.1 (issued November 2011), which assumes savings relative to an electric resistance water heater. In benchmarking PSE's savings against the various sources shown in Table 50, Cadmus found that the current estimates are reasonable and are based on local Northwest research on shower usage and water heating efficiency. PSE's estimates are within the range of electric energy savings from several other programs, and Cadmus has no recommended changes to the PSE's current deemed values for showerheads.

Table 50. Showerhead Measure Savings Benchmarking

Source	Annual Showerhead Savings (kWh)
2013–2015 PSE	139
2015 NEEP	148
2013 Massachusetts TRM	237
2013 Arkansas TRM	140
2015 Vermont TRM – Low Income	158

Faucet Aerators

PSE's documentation of algorithm and associated inputs for faucet aerator savings (workbook from May 28, 2015) are similar to those used in several benchmarked documents (including a 2015 NEEP study and the Arkansas TRM, where the climate is most similar to PSE's). Table 51 provides benchmarking values. Given similarities and soundness of approach, Cadmus has no recommended changes in approach for this measure.

Table 51.Single Family Faucet Aerator Measure Benchmarking kWh

Source	Annual Aerator Savings (kWh)
PSE 2016	37 (single family) 45 (multifamily)
2013 Arkansas TRM	35
2015 Pennsylvania TRM	26
2015 Vermont TRM – Low Income	45

Water Heater Replacement

PSE conventional water heater replacement measures rely on an RTF UES of 149 kWh for electric resistance water heaters; however, RTF deactivated this UES measure on April 16, 2015, as new U.S. Department of Energy Amended Standards were published earlier the same month. Additionally, while new ENERGY STAR standards terminated certification for electric water heaters in April 2015, gas storage water heaters are still being certified. As of 2017, new U.S. Department of Energy standards for gas storage water heater are planned for later this year (to become effective 2021). Based on these changes and in expectation of shifting federal requirements in 2021, PSE should anticipate changes to RTF's deemed value for gas storage water heaters in the next few years.

PSE has not claimed savings for electric water heater replacements since 2014, and Cadmus assumes these measures have been removed from future offerings, per changes in codes noted above. In other jurisdictions, income-qualified programs are moving to replace standard efficiency electric water heater with ENERGY STAR-certified heat pump water heaters, or to continue to replace electric water heaters as a health and safety measure (not claiming savings).[36]

36 Efficiency Maine. "Low Income Water Heater Program." Accessed January 10, 2017. http://www.efficiencymaine.com/at-home/low-income-water-heaters/

Wisconsin Focus on Energy. "Heating and Cooling Improvements." Accessed January 10, 2017. https://focusonenergy.com/residential/efficient-products-appliances/residential-rewards?utm_source=vanity-url&utm_medium=vanity&utm_campaign=heatingandcooling

Pipe Insulation

PSE relies on RTF deemed savings of 20 kWh per measure for insulating DHW piping within three feet of the water heater (with R-3 or greater closed cell foam insulation); however, details for the UES calculations are not available from this source. Pipe insulation has historically had a wide variation of deemed savings values—from 20 kWh to 77 kWh across the sources reviewed.[37] A recent Cadmus evaluation reviewing *in situ* performance testing across several TRM sources determined 10.4 kWh per linear foot of piping as a reasonable estimate (approximately 50% higher than current PSE estimate; Cadmus 2014).

Since the current RTF-derived energy savings estimate provided little detail on how the UES value was developed, Cadmus is unable to directly compare methodologies. Due to a lack of documentation, Cadmus recommends that PSE consider revising its pipe insulation UES value to clarify source assumptions for method and inputs. The equation below is one approach, using the more conservative 10.4 kWh per linear foot value noted above:

$$\Delta kWh = 10.4\ kWh_{ln-ft} *\ 3\ ft = 31.2\ \text{kWh}$$

HVAC

Cadmus reviewed HVAC measure offerings and identified several suggestions for revising savings sources and UES measure identifiers, summarized in Table 52:

- Consider incorporating project-specific, existing heating system types from current RTF calculations for ductless heat pump measures

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New York State Energy Research and Development Authority. "Assisted Home Performance with ENERGY STAR." Accessed January 10, 2017. https://www.nyserda.ny.gov/All-Programs/Programs/Assisted-Home-Performance-with-ENERGY-STAR

37 Illinois Stakeholder Advisory Group. (2015). Illinois Statewide Technical Reference Manual for Energy Efficiency. Retrieved from http://ilsagfiles.org/SAG_files/Technical_Reference_Manual/Version_4/2-13-15_Final/Updated/Illinois_Statewide_TRM_Effective_060115_Final_02-24-15_Clean.pdf

Pennsylvania Public Utility Commission. (2015, April 15). Pennsylvania Technical Reference Manual Version 5. Retrieved from puc.pa.gov: http://www.puc.pa.gov/pcdocs/1333318.docx

Mass Save. (2013). Massachusetts Technical Reference Manual for Estimating Savings from Energy Efficiency Measures. Retrieved from http://ma-eeac.org/wordpress/wp-content/uploads/TRM_PLAN_2013-15.pdf

The Cadmus Group. *Final Report Impact Evaluation: Home Energy Services—Income-Eligible and Home Energy Services Programs (R16)*. Prepared for Connecticut Energy Efficiency Fund. p. 166. December 31, 2014. Available online: http://www.energizect.com/sites/default/files/HES%20and%20HES-IE%20Impact%20Evaluation%20%28R16%29%2C%20Final%20Report%2C%2012-31-14.pdf

- Consider updating the cubic feet per-minute (CFM) per-watt assumptions used for ventilation fans
- Consider tracking installed heating system capacities as dependent variables for savings calculations

Table 52. HVAC Sources and Considerations

Measure	Savings Source		UES Measure Identifiers	
	Current	Proposed	Current	Proposed
Ductless Heat Pump	Energy Trust of Oregon and RTF data	No change	Per unit Home type	Per unit Home type ***Include replaced heating system type***
Programmable Thermostat	RTF	No change	Per thermostat	No change
Ventilation	PSE and manufacturer data	***Consider updating baseline CFM/watt from 1.4 to 3.1 and efficient values from 10 to 8.3.***	Home type	No change
Heating System Replacement (Gas Furnace)	2009 KEMA furnace study	No change	Home type	Home type ***Include installed heating capacity of furnace***

Ductless Heat Pumps

PSE's DHP savings calculation is based on documentation from the RTF, which references two recent Northwest studies (including metering projects using single-family and multifamily homes types, and a heating load study for manufactured homes). However, while the RTF distinguishes between DHP savings for different baseline equipment (e.g., electric forced air furnaces compared to zonal heat), PSE's deemed DHP savings value uses an average of those specific system types.

PSE currently tracks project-specific heating system information for existing equipment prior to replacement. Cadmus suggests that PSE consider using these project-specific data to estimate DHP reported savings relative to existing heating systems, thereby selecting the RTF estimate specific to a heating system rather than using an average. This will produce more accurate estimates of energy savings.

Programmable Thermostats

PSE currently uses the 2011 RTF workbook as the source for programmable thermostat savings. While a more recent RTF programmable thermostat workbook (i.e., Electronic

Thermostats V3, 2016) includes an assumption of market conditions (i.e., assuming that a certain percentage of systems would replace line voltage thermostats), Cadmus does not suggest revising this calculation for PSE's LIW program, as the RTF revision reflects the market condition rather than conditions likely approximating an existing baseline.

Ventilation Fans

PSE's savings estimate for efficient ventilation fans are calculated using manufacturer data and the minimum requirements of the ENERGY STAR criteria. The efficiency criteria cited in the ENERGY STAR specification references a testing pressure of 0.25 in-H_2O. However, this assumption better reflects test conditions to qualify products rather than typical operating conditions; per the Home Ventilation Institute, typical operating pressures are approximately 0.1 to 0.2 in-H_2O (depending on types and installation conditions).[38] The current PSE inputs assume a 700% increase in efficiency above a standard efficiency ventilation fan, compared to an approximate 260% increase when using these revised assumptions. PSE should consider updating the baseline and installed efficiencies using a source that reflects typical testing pressure (e.g., Vermont TRM).

Cadmus suggests the following equation and methodology for ventilation fans:

$$\Delta kWh = \left(CFM * \frac{\left(\frac{1}{CFM\ per\ Watt_{Baseline}} - \frac{1}{CFM\ per\ Watt_{Efficient}} \right)}{1{,}000} \right) * 8{,}760\ hours$$

Table 53 provides the associated deemed savings values.

38 Home Ventilating Institute. *HVI Product Performance Certification Procedure Including Verification and Challenge*. March 1, 2009. Available online: https://www.hvi.org/publications/pdfs/HVI920_1March2009.pdf

Table 53. Ventilation Fan Savings – Suggested Inputs

Building Type	Source	Baseline Efficiency	Usage (CFM)	Installed Efficiency	Estimated Savings (kWh/year)
Single Family	PSE	1.4	30	10	161
	Suggested	**3.1***	**50****	**8.3***	**89**
Multifamily	PSE	1.4	30	10	161
	Suggested	**3.1***	**30****	**8.3***	**53**

* *Vermont Technical Reference Manual*. 2013. Available online: http://www.greenmountainpower.com/upload/photos/371TRM_User_Manual_No_2013-82-5-protected.pdf

** ASHRAE 62.2-2010, with assumptions for number of bedrooms (one for multifamily, three for single family) and dwelling sizes (1,500 sq ft for multifamily and 2,000 sq ft for single family).

Heating System Replacement (Gas Furnace)

PSE's current approach for estimating gas savings from heating system replacements uses a per-unit deemed savings approach from a 2009 evaluation study that used billing analysis to assess impacts for 92 AFUE furnace installations. As the PSE requires installation of 95 AFUE furnaces, the current savings calculation extrapolates the impact of 92 AFUE furnaces to represent higher efficiency 95 AFUE furnaces.

Cadmus finds this approach reasonable for establishing measure UES savings; however, there are additional factors that PSE should consider in improving savings estimates. First, as noted in the 2009 study, relative energy usage and associated savings are both dependent on home size, but are non-linear, decreasing as home size increases. While a home's envelope load increases with its size, the load increases at a lower rate than floor area. Furthermore, the *Uniform Methods Project* recommends calculating savings for furnace measures using the capacity of installed heating systems as a dependent variable.[39]

Based on PSE tracking data, it does not appear that PSE is currently collecting data on the size of installed heating systems. Going forward, Cadmus suggest that PSE begin tracking installed heating system capacities (in Btu per hour) as a variable to inform future evaluations.

[39] National Renewable Energy Laboratory. *The Uniform Methods Project: Methods for Determining Energy Efficiency Savings for Specific Measures*. April 2013. Available online: https://www.nrel.gov/docs/fy13osti/53827.pdf

Appendix E. Program Delivery

This section gives additional detail regarding the three main program delivery steps: pre-participation, the installation process, and post-installation.

Pre-Participation

Customer Recruitment

The agencies implemented their own outreach and marketing, although PSE assisted the agencies with mail campaigns upon their request. Different methods used by agencies to promote the program included the following:

- Advertisements in regional newspapers
- Booths at community fairs
- Back-to-school night presentations
- Direct mailers
- Social media (e.g., city Facebook pages)

The agencies did not know which method of outreach worked best; one reported that recipients perceived mailers as junk mail. Typically, agencies do not promote other PSE programs unless customers have questions.

Marketing Tools

Four of the agencies used PSE-provided marketing materials, including brochures, sandwich boards, and multilingual flyers. One agency suggested that PSE should brand its other programs better to preclude customers from confusing those programs with the LIW program. Another agency thought a PSE radio advertisement would help in promoting the program.

Determine Eligibility

All agencies determined income eligibility by requiring proof of income from pay stubs, tax forms, or other documents. They also used energy bills and income to determine energy burdens. According to the agencies, gathering income documentation presented one of the biggest challenges for customers participating in the program.

Three agencies implemented a waitlist for customers, though all reported they eventually contacted all customers on the waitlist. One agency prioritized its customers based on when the customer made contact and the type of measures they sought. Another agency maintained its customers on a waitlist for two to three months (other agencies did not know how long customers remained on waitlists).

While the program allows agencies to use 30% of their budget for health and safety and other repairs, all agencies (n=5) reported most commonly deferring participants due to the number and type of repairs necessary before beginning weatherization (i.e., the homes can participate in the program once home repairs have been completed). Four of the five agencies deferred fewer than 2% of homes, though one agency deferred up to 20% of customers. Two agencies reported no additional funding sources were available to handle deferments. Another two said they may be able to find funding, but doing so depended on the severity of improvements needed, with one saying they could generally use funding from community block grants to make homes eligible for participation in the weatherization program. Two agencies did not track customers with deferrals, but three others did. None of the agencies offered suggestions for reducing the number of deferrals.

Installation Process

Initial Home Assessment and Measure Recommendation

Agencies performed initial audits of each household. Following the audit, four of the five agencies used a Washington State Department of Commerce savings-to-investment ratio (SIR) priority list to determine which measures each household could install. Assessing SIR through these tools was relatively easy and did not create barriers. One agency used the Targeted Retrofit Energy Analysis Tool to determine measures for installation.

Complete Improvements

Two of the five agencies delivered the program to gas and electric customers, two delivered to electric customers only, and one delivered to gas customers only.

Before the agencies replaced equipment (e.g., HVAC systems, water heaters), they tested the equipment for functionality. Three agencies reported they may not replace functional equipment if equipment repairs and maintenance prove more cost-effective. Four agencies tracked whether replaced units continue to work and what equipment the units replaced. Two agencies stored these data in a spreadsheet; two stored the information in the individual customer files.

Four agencies installed heat pumps, basing their decision to do so on the efficiency of existing heating systems and on a home’s size and layout. Three agencies knew of homes that experienced increased energy costs after installing heat pumps as the homes did not use heating or cooling equipment prior to the installations.

Post-Installation

Inspect Home and Submit Paperwork

Agencies inspected households while work remained in progress and at the conclusions of the job, with inspections completed by entities other than the contractor: two agencies used the auditors who originally inspected the home before treatment; the other agencies used other inspector combinations for the final inspection.

Tracking and Quality Control

Though PSE employed an online tracking system (PSE Online Tracking and Reporting System for Low-Income Weatherization), the agencies managed their own customer files. Still, they had to track information for each project: two agencies updated the system each week; one agency updated it daily; one agency updated it monthly; and one updated it as needed. While all agencies found PSE's tracking and reporting system easy to use, two offered suggestions for improvements:

- One considered how measures are organized on different screens confusing and could be streamlined to improve searching.
- One agency regularly requested that PSE provide reports that could be given to their fiscal departments as PSE's report only tracked energy savings and did not have the financial information the agency needed.

In turn, agencies had to provide PSE with projections, with one agency expressing concerns regarding these projections as contractors could not always finish jobs on time.

Each agency monitored program performance at different frequencies, but all used databases and Excel workbooks to track jobs, customers, and costs. The agencies offered the following details about performance monitoring:

- One agency generated a quarterly report, updating this through a dashboard provided to board members.
- One agency tracked funding amounts it received and reviewed costs on a monthly, quarterly, and annual basis. This agency used Excel spreadsheets to track average incentives and costs per home.
- One agency separated its job tracking database from its fiscal tracking.
- One agency determined how to achieve its goals through monthly meetings that reviewed program spending and customer eligibility.
- One agency held weekly meetings with its auditors to review expenditures and progress toward quarterly goals.

Quality Control

PSE reviewed savings and incentive amounts, but did not require agencies to upload invoices. Typically, PSE inspected two to three invoices each month as the Washington Department of Commerce monitored and visited a sufficient number of households.

Though the Department of Commerce monitored, at a minimum, 5% of all weatherization jobs, they did not target specific funding sources or regions. They shared the monitoring results with PSE, but did not provide PSE with formal reports on these results. Still, PSE could request the monitoring results from the agencies. Over the past couple of years, these visits to PSE homes did not produce findings resulting in concern from PSE's perspective—a result consistent with findings reported in the 2012 evaluation.

Appendix F. Survey Demographics

This section presents tables outlining answers to each demographic question from the customer surveys.

Table 54. Type of Home

What type of home do you live in?	n=105
Mobile/manufactured home	57%
Single-family home, detached house	28%
Attached house (townhouse, row house, or duplex)	11%
Multifamily apartment or condo building with four or more units	3%
Co-op/retirement community	0%
Other	1%

Table 55. Square Footage of Home

Approximately how many square feet of living space does your home have?	n=105
Less than 800 square feet	9%
800 to less than 1,200 square feet	33%
1,200 to less than 1,500 square feet	19%
1,500 to less than 2,000 square feet	6%
2,000 to less than 2,500 square feet	4%
2,500 to less than 3,000 square feet	0%
3,000 to less than 4,000 square feet	1%
4,000 or more square feet	1%
Don't know	28%

Table 56. Own or Rent Home

Do you or members of your household own this home or do you rent?	n=105
Own/Buying	74%
Rent/Lease	25%
Occupied without payment of rent	0%
Other	0%
Don't know	1%

Table 57. Payment of Energy Bills

Which best describes how your energy bills are paid?	n=105
I pay the energy bills	87%
My landlord pays the energy bills	2%
A relative pays the energy bills	3%
Community assistance	5%
Other	4%

Table 58. Number of Household Members

Including yourself, how many people live in your home full-time?	n=105
1 person	38%
2 people	23%
3 to 4 people	25%
5 to 6 people	10%
7 or more people	4%

Table 59. Survey Participants Age

What is your age?	n=102
18 to 24 years of age	1%
25 to 34 years of age	16%
35 to 44 years of age	14%
45 to 55 years of age	12%
55 to 64 years of age	25%
65 to 74 years of age	22%
75 years of age or older	12%

Table 60. Survey Participants Education

What is the highest level of school you have completed?	n=103
Less than ninth grade	2%
Ninth to twelfth grade; no diploma	9%
High school graduate	24%
Some college, no degree	31%
Associate's degree	15%
Bachelor's degree	14%
Graduate or professional degree	6%

2014-2015 Direct-to-Customer Impact and Process Evaluation and Evaluation Report Response

Contents:

- Impact and Process Evaluation Report
- Evaluation Report Response

This document combines Itron's 2014-2015 Direct-to-Consumer Impact and Process Evaluation, and Puget Sound Energy's Evaluation Report Response (ERR). The Direct-to-Consumer program includes:

- Advanced Power Strip Rebate
- Appliance Decommissioning
- Appliance Replacement
- Appliance Rebate
- Residential Lighting Rebate
- Residential Showerhead

PSE program managers and evaluation staff prepare an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation. This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx,** search words '2014-2015 Direct-to-Consumer Evaluation'.

- **Please note that this is an evaluation of the program as it operated during the 2014-2015 program years, and does not necessarily reflect the program as currently implemented, or measures currently deployed by the program.**

- In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator. Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC. Evaluations are conducted using best-practice approaches and techniques.

2014-2015 DIRECT-TO-CONSUMER IMPACT AND PROCESS EVALUATION

Final Report

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1 EXECUTIVE SUMMARY

This report presents the results of the impact and process evaluation of Puget Sound Energy's 2014 and 2015 Direct-to-Consumer (DtC) Residential programs. While this evaluation primarily focused on how the programs performed in these two program year (2014 and 2015), the evaluation team has attempted to call out wherever possible updates and improvements to the programs in 2016 and 2017 and have structured the process evaluation to be a forward looking assessment. The DtC programs included in this evaluation are the following: Residential Lighting, Residential Showerheads (including ShowerStart measures), Appliance Decommissioning (Refrigerators and Freezers), Appliance Replacement (Refrigerators and Clothes Washers), and Appliance Rebates (Advanced Power Strips, Clothes Washers, Refrigerators and Freezers).

1.1 EVALUATION OVERVIEW

The primary objectives of this evaluation were to:

1. Verify PSE's 2014 and 2015 reported savings based on program tracking data and the deemed Unit Energy Savings (UES) estimates as defined in the 2014 and 2015 Business Cases (Stage 1).
2. Estimate ex-post program savings and determine the percentage of the deemed savings that were realized to inform future savings estimates (Stage 2).
3. Examine program processes, compare them to best practices, and identify opportunities for future program improvement.
4. Review and benchmark 2014, 2015, and 2016 measure costs to identify measures that may be in need of measure cost updates.

1.2 IMPACT RESULTS SUMMARY

Table 1-1 below summarizes the overall gross electric and gas savings from PSE's 2014 and 2015 DtC programs. This table includes PSE's reported ex-ante gross savings estimates, as well as the verified savings estimates and realization rates developed by the evaluation team. The verified realization rates express the percentage of ex-ante savings realized by the verified savings estimates.

These savings estimates are defined as:

- **Ex-Ante Savings:** The ex-ante savings estimates come directly from the 2014 and 2015 Energy Efficiency Services (EES) tracking and forecasting system savings reports that were provided to the evaluation team.
- **Verified Savings:** The verified savings estimates are calculated by the evaluation team by applying the verified RTF and PSE deemed UES estimates to the verified program measure sales.[1] These savings estimates are used to confirm that PSE accurately reported program accomplishments.

As shown in Table 1-1 below, overall the DtC programs exceeded both their 2014 and 2015 electric goals; however, fell short of their gas goal in the 2015 program year. The primary drivers of this gas shortcoming were changing efficiency standards and lack of customer demand for the clothes washer rebate measure.[2] The verified savings realization rates indicate that for the most part PSE accurately calculated and reported 2014 and 2015 DtC program savings. The only significant discrepancy identified was for 2015 gas savings (82% realization rate) and was the result of errors identified in the deemed gas UES estimates for ShowerStart measures sold through the Showerhead Program.[3] [4] The 2015 Showerhead Program made up approximately 80% of the 2015 in-scope DtC gas savings and hence had a big impact on the overall gas savings realization rate. It is important to note that the ex-ante gas savings across all DtC programs (135,324 therms) made up only 10% of the total Residential Energy Management (REM) gas savings in 2015[5] and thus the impact to the overall REM portfolio of this reduction in gas savings from the ShowerStart measures is very small (less than 2%).

1 Verification of the deemed UES estimates and measures sales were two of the primary results of the Stage 1 evaluation activities.

2 Based on PSE's *2015 Annual Report of Energy Conservation Accomplishments*, March 1, 2016.

3 The 2015 ShowerStart measures had an overall verified savings realization rate of 55% for kWh savings and 41% for therm savings due to issues identified by the evaluation team in the calculation of the deemed savings estimates. ShowerStart measures were not included in the 2014 program.

4 In 2016 PSE began using the RTF UES values for the ShowerStart measures.

5 Based on Exhibit 01 from the 2015 Annual Report, the total gas savings across the Residential Energy Management programs was 1,283,247 therms.

TABLE 1-1: 2014 AND 2015 DTC GROSS SAVINGS ESTIMATES (EX-ANTE VS. VERIFIED)

Savings Category	2014[6]		2015	
	MWh	Therms	MWh	Therms
Program Goals	81,386	111,794	82,134	177,896
Ex-Ante Gross Savings	91,903	170,825	84,958	135,319
Verified Gross Savings	91,928	168,451	84,688	111,118
Verified Savings Realization Rate	100%	99%	100%	82%

Source: Evaluation Team Analysis

Table 1-2 and Table 1-3 provide, by program and measure, the ex-ante and verified savings estimates, as well as the verified realization rates[7] for the 2014 and 2015 program years.

TABLE 1-2: 2014 DTC MEASURE-LEVEL SAVINGS COMPARISON (EX-ANTE VS. VERIFIED)

Program	Measure	Ex-Ante Savings		Verified Savings		Verified Savings Realization Rate	
		MWh	Therms	MWh	Therms	MWh	Therms
Lighting	Standard CFLs	28,040	-	28,040	-	100%	-
	Specialty CFLs	11,033	-	11,033	-	100%	-
	Standard LEDs	18,403	-	18,403	-	100%	-
	Specialty LEDs	17,312	-	17,312	-	100%	-
	Fixtures	3,828	-	3,828	-	100%	-
Showerheads	Showerheads	4,302	129,287	4,327	126,914	101%	98%
Leave Behind / Thank You Kits	CFLs	42	-	42	-	100%	-
	LEDs	91	-	91	-	100%	-
	Showerheads	1,099	17,580	1,099	17,580	100%	100%
Appliance Decommissioning	Refrigerator	1,809	-	1,809	-	100%	-
	Freezer	818	-	818	-	100%	-
Appliance Replacement	Refrigerator	2,139	-	2,139	-	100%	-
	Clothes Washer	1,341	-	1,341	-	100%	-
Appliance Rebate	Refrigerator	177	-	177	-	100%	-
	Freezer	27	-	27	-	100%	-
	Clothes Washer	1,049	7,468	1,049	7,468	100%	100%
	APS	392	-	392	-	100%	-

Source: Evaluation Team Analysis

6 The 2014 savings verification activities included a review of the tracking data, invoices/applications, and application of the deemed UES. The in-depth deemed UES review was only completed for the 2015 program year, however for some in-scope programs the deemed UES were unchanged from 2014 to 2015.

7 The ex-post realization rates are calculated as the Ex-Post Savings/Ex-Ante Savings.

TABLE 1-3: 2015 DTC MEASURE-LEVEL SAVINGS COMPARISON (EX-ANTE VS. VERIFIED)

Program	Measure	Ex-Ante Savings		Verified Savings		Verified Savings Realization Rate	
		MWh	Therms	MWh	Therms	MWh	Therms
Lighting	Standard CFLs	14,067	-	14,067	-	100%	-
	Specialty CFLs	4,097	-	4,097	-	100%	-
	Standard LEDs	24,887	-	24,887	-	100%	-
	Specialty LEDs	23,900	-	23,900	-	100%	-
	Fixtures	3,285	-	3,285	-	100%	-
Showerheads	Showerheads	2,225	71,193	2,240	70,157	101%	99%
	ShowerStart	282	39,263	156	16,076	55%	41%
Leave Behind / Thank You Kits	LEDs	102	-	118	-	116%	-
	Showerheads	874	15,680	874	15,680	100%	100%
Appliance Decommissioning	Refrigerator	906	-	906	-	100%	-
	Freezer	481	-	481	-	100%	-
Appliance Replacement	Refrigerator	1,410	-	1,410	-	100%	-
	Clothes Washer	1,419	-	1,419	-	100%	-
Appliance Rebate	Refrigerator	58	-	58	-	100%	-
	Freezer	3	-	3	-	100%	-
	Clothes Washer	1,451	9,184	1,451	9,184	100%	100%
	APS	820	-	805	-	98%	-

Source: Evaluation Team Analysis

1.3 PROCESS RESULTS SUMMARY

PSE's DtC programs were rated as best in class by many of the implementers and trade allies, describing the programs as "one of the strongest programs in the US" and "one of the easiest programs to work with, PSE and the implementers have been very communicative, flexible, understanding and easy to work with."

On the whole, the evaluation found that the programs are performing very well. Participant and trade ally satisfaction with the programs is very high. Awareness of programs varies, with room for additional marketing to broaden the demographics of those in the program and help increase future program participation. PSE's DtC programs also appear to be following industry best practices across several areas including program theory and design, program management, and program processes.

Program Theory and Changes

The process evaluation explored whether the DtC program theory, and changes over time, were well documented. While not explicitly laid out in a program theory and logic model, the PSE programs are described in annual and biennial plans and reports. In general, most of the programs are well-established and have an understood theory (i.e., the residential lighting, showerhead, and rebate programs). Our research also documented that these programs are having an effect in the market; lighting manufacturers estimated that the program had led to an average 53% increase in sales, showerhead manufacturers estimated a 63% increase while lighting retailers estimated a 24% increase in sales. Note that these were straight averages—rather than sales weighted —but they give a sense of the magnitude of the effect of these programs.

Among the five DtC programs, there are two where the theory is not as well established and/or the markets are changing.

- The APS program is a newer program model among energy efficiency programs, with several options for who to target and how the program will be delivered. PSE is currently exploring APS options through additional research in this area.
- Appliance Decommissioning and Replacement Programs have a market that may be changing in a way that could affect program success (e.g. due to volatile scrap metal markets). PSE has started to think about some of these issues and made several programs changes (e.g., changing qualifying products) to adjust to the changing market.

Over time, the implementers and PSE have updated and adjusted the program designs to ensure that they run well. These changes have been well documented in the business cases for the program. These business cases also describe the changes to measures, incentives, qualifying populations and savings estimates. Through discussions with PSE, this evaluation also documented the roles of the key players in each DtC program.[8]

Data Tracking

The evaluation team found that in general the tracking databases were comprehensive in terms of variables included and the frequency with which they were populated. A few instances were identified where variables needed to track program performance and optimally evaluate the program were missing. In addition, not all data collected on the application forms for rebated appliances was being transferred to PSE's Appliance Rebate tracking database. The evaluation team had some difficulty conducting the verification of applications and invoices; roughly a third of the appliance rebate applications could not be reviewed as no application or online confirmation page was provided[9] and while the sample of invoices reviewed generally aligned with the program tracking data, some

[8] Included in Appendix H.

[9] Based on the variables included in the tracking data provided to the evaluation team, there is no way to determine if these missing applications are associated with mail or online applications.

challenges linking the two data elements occurred. These issues, however, did not lead to any significant changes in results.

PSE updated their program tracking systems and processes in the 2016-2017 period. Details on any missing, duplicative, and misaligned information were provided to PSE at the conclusion of Stage 1 of the evaluation and PSE has begun working with vendors and staff to ensure these variables are included in the tracking data going forward as they transition to their new DSMc database and processes. In addition, PSE also worked with the evaluation team to complete a mapping of the types of data that should be collected by each of the major players in the delivery of this program is provided in Appendix H.

Participant Demographics

PSE uses a multi-channel approach to reaching customers through the DtC programs, and as such can reach a range of customers. Participants in the Appliance Decommissioning, Replacement and Rebate Programs tend to be single-family customers in detached homes, which is as expected since these customers are more likely to purchase large appliances such as refrigerators, freezers and clothes washers. The demographics of individuals purchasing energy efficient lighting and showerheads, however, appears to more closely mirror ownership and housing types within PSE’s general population (e.g., slighting over 60% owners, and just under 40% renters).

Notably, purchasers of APS’s are more likely to be early adopters of new technologies, whereas energy efficient lighting and low-flow showerheads are purchased by a much broader audience.

Program Awareness

The process evaluation also explored awareness of the DtC program offerings. Half of residential customers are aware of PSE’s Lighting Program the largest DtC program; and nearly half (47%) are aware of the Appliance Rebate Program. Among participants, awareness of PSE program offerings is much higher, indicating that some cross-program marketing is occurring.

When looking across programs, awareness of the Appliance Replacement Program (for clothes washers) is lower than for any other program (23%); however, this is as expected given that this program targets pre-1997 clothes washers.

Opportunities for increasing awareness exist for all of the DtC programs, but in particular, for the ShopPSE website since this is a channel that can be used by all of PSE’s residential customers.

TABLE 1-4: AWARENESS OF RESIDENTIAL DTC PROGRAMS, PARTICIPANTS VERSUS GENERAL POPULATION

Awareness of Other Residential Programs	Rebate Participants			Clothes Washer Participants		Decommissioning Participants		All Parts	GenPop
	APS	Refrigerator	Freezer	Rebate	Replacement	Refrigerator	Freezer		
Lighting Program	92%	88%	85%	86%	85%	82%	84%	86%	50%
Appliance Rebate Pgm	90%	-	-	85%	80%	86%	85%	85%	47%
Decommissioning Pgm	73%	61%	61%	64%	70%	-	-	64%	40%
Showerhead Program	85%	76%	86%	83%	85%	85%	89%	83%	37%
ShopPSE Website	66%	40%	54%	45%	48%	37%	41%	45%	27%
CW Replacement Pgm	54%	45%	44%	49%	-	44%	48%	49%	23%
N	143	168	60	1,194	143	269	134	1,194	640

Satisfaction with Programs and PSE

Residential participant and trade ally satisfaction with the program processes is extremely high. Overall more than 90% of DtC participants in the Appliance Programs reported they were satisfied (somewhat or extremely) with the programs, 7% were neutral and only 2% were dissatisfied. The primary reasons reported for dissatisfaction by participants was that the rebate they received was too small or was never received. The Decommissioning and Replacement programs received more "Extremely Satisfied" rankings than the Rebate programs.[10]

TABLE 1-5: SATISFACTION WITH THE DTC APPLIANCE PROGRAMS

Satisfaction with the Program	Rebate			Clothes Washer		Decommissioning		Total
	APS	Refrigerator	Freezer	Rebate	Replacement	Refrigerator	Freezer	
Extremely Satisfied	-	60%	60%	56%	71%	79%	82%	68%
Somewhat Satisfied	-	32%	19%	30%	22%	14%	14%	23%
Neutral	-	7%	14%	11%	5%	4%	3%	7%
Somewhat Dissatisfied	-	1%	4%	2%	2%	1%	0%	1%
Extremely Dissatisfied	-	0%	4%	1%	0%	2%	1%	1%
N	-	166	57	273	142	265	133	1,036
Mean Ranking	-	4.5	4.3	4.4	4.6	4.7	4.8	4.6

Where rebates are required (i.e., appliance rebates), the rebate form appears to be easy to use and available to be submitted both online and in hard copy. PSE and implementers report few issues related to participation processes.

Notably, overall satisfaction with PSE was significantly higher among program participants, indicating that the positive customer experience with the programs reflects back on the organization as a whole.

[10] The percent of decommissioning and replacement participants who provided a satisfaction score of 5 (extremely satisfied) was 77.6% (+/- 3.0%), compared to 58.1% (+/- 3.7%) of the rebate participants. This difference is statistically significant.

For the lighting and showerhead programs, trade ally satisfaction was also very high. Lighting manufacturers rated the program a 9.3 out of ten, showerhead manufacturers at a 9.8 and lighting retailers rated the program an 8.5. The lighting and showerhead manufacturers all stated that the PSE programs were very effective and all would like to participate in the program in the future.

Opportunities by Program

The primary opportunities for process related improvement identified during the evaluation were:

- **APS:** There are opportunities for additional education through the current delivery channels, as well opportunities to expand the current efforts to include promotions or giveaways to get greater adoption of this energy saving technology. In exploring these opportunities, however, PSE should be aware that satisfaction with this technology is lower than with other energy saving measures, and there may be a need to revisit both the theory behind the program, and whether there are any technology or educational updates that could improve customer satisfaction.
- **Appliance Decommissioning and Replacement Programs**: The primary opportunities for the Appliance Decommissioning and Appliance Replacement programs may be in more aggressive marketing of the programs. The program implementer, ARCA, may be able to assist in this area. PSE should also continue to monitor changes in the market that can affect the viability of the program models.
- **Appliance Rebates:** This program continues to adapt to increasing energy efficiency standards. While additional marketing may help encourage greater participation, some opportunities may also lie in exploring mid-stream regional implementation models.
- **Lighting:** PSE is continually updating its Lighting Program, which is considered to be among the most innovative in the country. The primary opportunities for the Lighting Program appear to be around increased communication, additional market, and looking to incorporate smart or connected lighting technologies in the future.
- **Showerheads:** Showerhead manufacturers felt that the program was adhering to best practices, but offered some opportunities for program improvements, including: staying at the forefront of changing lower-flow technologies,[11] offering differentiated rebates by technology, co-marketing or co-branding,[12] and keeping manufacturers informed of a broader range of PSE offerings.

[11] PSE incentivizes all WaterSense rated technology and includes a link on the PSE website to the WaterSense website for customers to review and locate where to purchase products.

[12] In the past, PSE has approached showerhead manufacturers to discuss co-marketing opportunities, however there has been little interest on the part of the manufacturers. In 2015, PSE able to engage Kohler and High Sierra in a PSE marketing campaign.

Interviews with showerhead trade allies identified a few program misperceptions primarily regarding opportunities that exist to co-market the program. Program staff should review how these opportunities are being presented and promoted to showerhead manufacturers to determine if additional communication channels are need to ensure there is clarity among all parties regarding the programs operation.

1.4 RECOMMENDATIONS FOR UPDATES TO FUTURE UES

This section presents the results of the ex-post savings analysis and the resulting recommendations for updates to future UES algorithms and parameter estimates based on this ex-post savings review. The ex-post savings estimates were derived based on Stage 2 primary and secondary data collection and analysis.[13] These savings estimates are not intended for backwards adjustments of reported savings, rather are presented to inform future program planning efforts. This section is intended to provide a high-level summary of the types of UES changes recommended going forward table. The details behind these changes are presented for each program in the ex-post UES adjustments sections found within each of the program-specific chapters (Chapters 3-8) of this report.

The overall ex-post realization rates across all in-scope DtC programs was 124% for electric savings and 82% for gas savings (Table 1-6), indicating that overall the ex-ante deemed savings slightly underrepresented the evaluation team's best estimate of actual program savings based on ex-post primary and secondary data collection. As this table shows, the electric realization rates range from a high of 145% to a low of 79% and for gas range from a high of 163% to a low of 52%, but are primarily driven by the lighting and showerhead program savings, which make up the majority of electric and gas savings, respectively.

[13] Much of the data used to estimate the ex-post savings estimates were not available to PSE at the time the 2014 and 2015 UES were deemed. Thus, the findings presented here are not indicative of errors in the deemed estimates, rather recommended forward looking updates based on data that was not available at the time PSE's measure savings were deemed.

TABLE 1-6: 2015 DTC MEASURE-LEVEL SAVINGS COMPARISON (EX-ANTE VS. EX-POST)

DtC Program	Ex-Ante Savings		Ex-Post Savings		Ex-post Realization Rate[14]	
	MWh	Therms	MWh	Therms	MWh	Therms
Lighting Program	70,236	-	88,865	-	127%	-
Showerheads Program	2,507	110,455	3,624	87,561	145%	79%
Appliance Rebate Program	2,332	9,184	2,206	15,006	95%	163%
Appliance Decommissioning Program	1,387	-	1,096	-	79%	-
Appliance Replacement Program	2,829	-	2,675	-	95%	-
Leave Behind/Thank You Kits	976	15,680	849	8,154	87%	52%
Total DtC Programs	80,268	135,319	98,892	135,158	124%	82%

Source: Evaluation Team Analysis

Table 1-7 below presents at a high-level the primary changes to the UES inputs that led to the program level realization rates presented above. Complete detail on these changes is presented in the Ex-Post UES Adjustment sections found in each of the program specific chapters later in this report. The evaluation team recommends that PSE consider these changes in light of changes that have been made to the lighting UES algorithm and parameter estimates since the 2015 program year and incorporate them into future UES estimates as appropriate.

14 These ex-post realization rates are on the 2015 ex-ante energy savings and may differ from the 2015 measure-level UES realization rates presented in the subsequent chapters due to 2014 sales being included in the 2015 program tracking data.

TABLE 1-7: UES INPUTS AFFECTING EX-POST REALIZATION RATES

<table>
<tr><th rowspan="2">DtC Program</th><th colspan="2">Ex-post RR</th><th rowspan="2">UES parameters updated during Ex-post analysis:
Areas for future updates or additional exploration</th></tr>
<tr><th>MWh</th><th>Therms</th></tr>
<tr><td>Lighting</td><td>127%</td><td>-</td><td>• Delta watts – revise measures and baseline values to better reflect program sales and current market
• Interactive Effects – refine estimate to reflect SF/MF split and heating fuel distribution
• Hours-of-Use – update to reflect Res v. Nonres installs and lumen output of program bulbs</td></tr>
<tr><td>Showerheads</td><td>145%</td><td>79%</td><td>Showerhead Only measures:
• Persons per SH, water heating saturations, and ISR from part survey data
• Shower duration based on secondary data
• Hot water mix and waste water savings updated to reflect RTF changes
ShowerStart measures:
• Align UES algorithm more closely with the showerhead only measure
• ShowerStart Use Factor from secondary research
• Electric water heating saturation updates based on part survey data</td></tr>
<tr><td>Appliance Rebate</td><td>95%</td><td>163%</td><td>Clothes Washer Rebate:
• Annual loads washed from participant data/RBSA
• Capacity of rebated unit from program tracking data
• Gallons/year, moisture content in clothes from updated CEC database
• ES® clothes washer saturation based on ES® shipment data.
Refrigerator/Freezer Rebate:
• Refrigerator door configuration, freezer type from program tracking data
• UEC from updated CEC database
• HVAC interactive effects based on evaluation research and participant data
APS Rebate:
• Base energy savings adjustment
• APS ISR from participant survey data
• HVAC interactive effects based on evaluation research and participant data</td></tr>
<tr><td>Appliance Decommission-ing</td><td>79%</td><td>-</td><td>• Apply Uniform Method Project methodology
• Part–use factor, decommissioned units' disposition, replacement outcomes, new vs. used replacement unit rate updated based on participant survey data
• UEC of standard efficiency units from Energy Star website</td></tr>
<tr><td>Appliance Replacement</td><td>95%</td><td>-</td><td>• Annual loads washed, % loads dried in clothes dryer from part survey data
• Rated UEC, capacity and MEF of replacement unit from program sales data</td></tr>
<tr><td>Kits</td><td>87%</td><td>52%</td><td>LEDs – same changes as listed in lighting section above
Showerheads:
• Align UES algorithm more closely with the showerhead only measure
• Engagement/kit ISR from the part survey data
• Electric water heating saturation for the Engagement measure</td></tr>
</table>

2 INTRODUCTION

2.1 BACKGROUND

PSE's Direct-to-Consumer (DtC) Channel collaborates with retailers and manufacturers of energy efficient products to ensure that customers have access to a wide variety of efficient product options. The DtC Programs provide incentives and promotions for efficient products to PSE's residential customers through agreements with retailers and/or manufacturers. This evaluation is focused on several distinct programs offered through the DtC channel, including: Residential Lighting, Residential Showerheads, Appliance Rebates (Clothes Washer, Refrigerators, Freezers, and Advanced Power Strips), Appliance Replacement (Clothes Washer and Refrigerators) and Appliance Decommissioning (Refrigerators and Freezers). This evaluation of the 2014/2015 DtC Programs offers both a retrospective examination of program impacts and processes, as well as prospective guidance in changes that may be warranted to these programs. The evaluation objectives are presented below.

2.2 EVALUATION OBJECTIVES

The evaluation objectives answer the following key impact and process questions.

2.2.1 Key Impact Questions

- Are the 2015 RTF/PSE Deemed UES appropriate and applied accurately for program measures?
- Has the program accurately tracked and reported unit measure sales for the 2014 and 2015 program years?
- What is the level of total annual energy savings (kWh and therms), based on the verified deemed savings estimates and the evaluation research ex-post savings estimates?[15]
- What percentage of ex-ante savings are realized within the verified savings estimates (verified savings / ex-ante reported) and the evaluation research ex-post savings estimates (evaluation research ex-post savings / ex-ante reported)?
- Are there changes that should be considered to update future RTF or PSE deemed UES estimates to improve their accuracy?

[15] Stage 1 ex-post verified savings will be calculated based on the results of the Stage 1 tracking data and RTF/PSE Deemed UES verification efforts. Stage 2 will estimate evaluation research ex-post estimates that will incorporate recommended changes to Deemed UES estimates identified in Stage 1, as well as results from the ex-post primary research conducted during Stage 2.

- Are the current measure cost estimates appropriate?

2.2.2 Key Process Questions

- How have the DtC programs changed over time? Is this well-documented?
- Are the programs following industry best practices? How do they benchmark against industry[16] best practices for program theory and design, program management, reporting and tracking of energy savings, quality control, program processes, and marketing and outreach?
- What data are currently being collected to support the programs and how is this data being used? And what additional research is needed for each program area?
- Who is currently participating in these programs (demographically) and where may additional opportunities may lie?
- What are the current knowledge levels and acceptance rates of measures such as water savings devices, advanced power strips, and LED technologies, and what barriers exist to installation?
- What is the level of residential participant and trade ally satisfaction with the program processes, and what areas of improvement exist?
- How aware are residential customers of the DtC program offerings and what channels are most effective to increasing awareness?

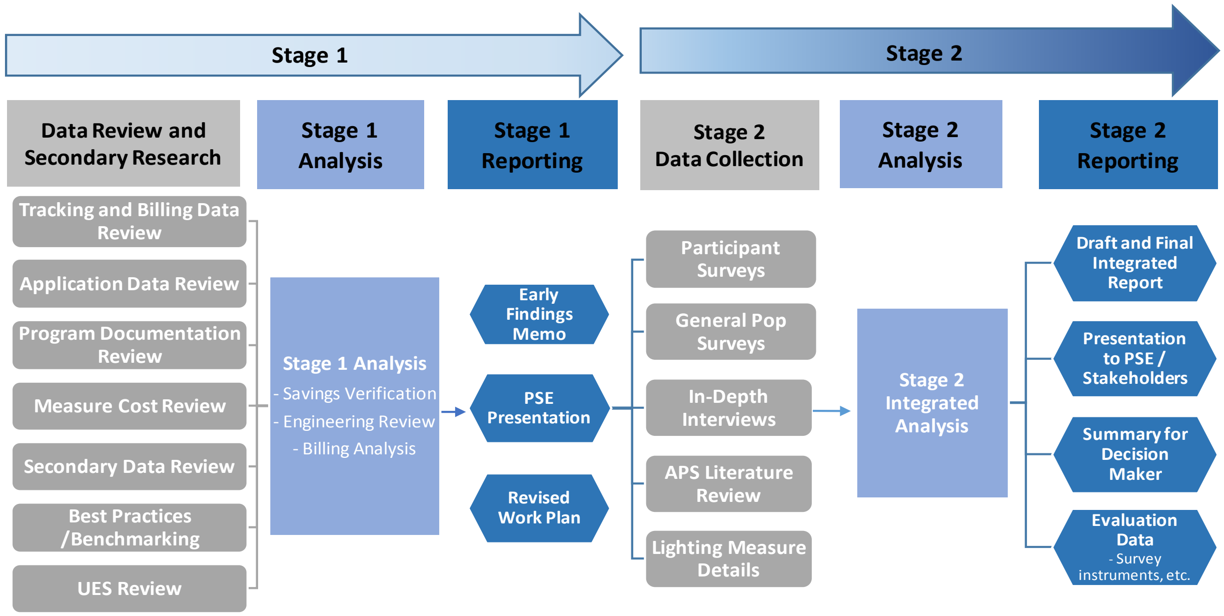
The evaluation will also assist PSE in the development of optimal data flow diagrams to support the tracking data development process which will improve program tracking, reporting, and evaluation.

2.3 EVALUATION APPROACH

For the evaluation of the DtC Channel programs, the evaluation team used a two-stage approach, which allowed for a rapid turnaround of preliminary impact and process findings (Stage 1) that also informed the primary data collection and research activities conducted in Stage 2 to maximize the overall evaluation value to PSE. Figure 2-1 below provides a conceptual overview of the two-stage approach.

[16] The process evaluation will also assess the programs against best practices outside of the industry with respect to program marketing, outreach, and delivery.

FIGURE 2-1: OVERVIEW OF THE TWO-STAGE APPROACH FOR DTC PROGRAM EVALUATION[17]



The first stage of this evaluation, which was completed in the fall of 2016, included a verification of PSE reported savings, based on a tracking data and deemed UES review, a preliminary process evaluation (including a Best Practices assessment and a market research review), and a measure cost analysis. The Stage 1 analysis found that overall the DtC programs were doing a good job accurately reporting the quantity of measures sold through the program and calculating program savings based on the deemed (PSE or RTF) UES estimates. The Stage 2 impact assessment focused on ex-post evaluation research, utilizing primary data collected from program participants and the general population, to estimate the percentage of the ex-ante deemed savings realized by each of the programs. The general population survey was a key element for both the lighting and showerhead evaluations as it allowed for data collection from PSE customers regarding their lighting and showerhead purchases which was used as a proxy for participant data for these upstream programs. It also supported the appliance program evaluations as it allowed for an assessment of standard practice behaviors outside of the PSE programs. The evaluation team also assessed the currency of the UES estimates with a prospective focus to determine if UES changes were appropriate for future program years). The Stage 2 process evaluation focused on targeted areas such as residential customer and trade ally satisfaction and levels of program awareness and knowledge gaps that can lead to improved program performance in the future.

[17] Due to the current RBSA work that is being conducted (which is collecting lighting inventories during customer on-sites), the lighting mailer Stage 2 data collection effort has been dropped.

2.4 OVERVIEW OF DATA COLLECTION ACTIVITIES

Table 2-1 below presents the primary and secondary data collection activities conducted as part of this evaluation.

TABLE 2-1: SUMMARY OF EVALUATION COMPONENTS BY DTC PROGRAM

Evaluation Component	Lighting/ Showerheads		Home Appliances			
	Lighting	Showerheads	APS	Rebates	Replacement	Decommissioning
Tracking Data Review	●	●	●	●	●	●
Invoice Review	●	●	●		●	●
Application Review				●		
Deemed UES Review	●	●	●	●	●	●
Program Documentation Review	●	●	●	●	●	●
Measure Cost Review	●	●	●	●	●	●
Secondary Data Assessment	●	●	●	●	●	●
PSE Data Review: - Market Research Surveys - RBSA Data and Instruments - 2014/2015 BECAR Reports	●	●	●	●	●	●
Best Practices / Benchmarking	●	●	●	●	●	●
Trade Ally Interviews	●	●		●		
Participant Surveys			●	●	●	●
General Population Surveys	●	●	●	●	●	●

2.4.1 Tracking Data Review

Stage 1 of the evaluation included a thorough review of the 2014 and 2015 tracking databases for all in-scope DtC programs. The goal of the tracking data review was to verify annual reported program accomplishments (in terms of units sold or distributed and total savings achieved) and report any observed differences as a tracking review realization rate. Within this review the evaluation team sought to verify that the PSE and RTF deemed UES estimates, as documented in the 2014 and 2015 Business Cases, had been applied correctly at the individual measure level.

2.4.2 Application and Invoice Review

During Stage 1, an application review was conducted on a random sample of 50 refrigerator and clothes washer program applications submitted to PSE as part of the 2014 and 2015 Appliance Rebate program. This review was conducted to verify that the data being captured is complete and accurate and that it includes all variables required to calculate program incentives and estimate program savings. Also during Stage 1, an invoice review was completed during which a random sample of vendor invoices was reviewed to confirm that the program measure counts were accurately entered and matched program tracking data.

2.4.3 UES Review

The UES review was comprised of two distinct components; the first sought to verify the deemed UES algorithms and values were calculated and applied correctly, and the second to assess from an ex-post perspective the accuracy of the deemed estimate. The first component occurred as part of Stage 1 of the evaluation and included an in-depth review of the 2015[18] PSE and RTF Deemed UES estimates for all in-scope DtC measures to verify that these deemed UES estimates were: 1) based upon well documented and defensible algorithms, 2) reproducible based upon the workbooks and documentation provided by PSE, and 3) reflected the current appliance standards and best available data at the time the estimates were deemed. The RTF and PSE Deemed UES estimates were also evaluated for their accuracy, their appropriateness for PSE's service territory, and their conformance to industry standard practice and the Uniform Methods Project (UMP) protocols.[19] The second component occurred as part of Stage 2 and included primary data collection to assess the UES estimates from an ex-post perspective (as opposed to a deemed perspective). This effort resulted in the calculation of ex-post realization rates and recommendations for updates to UES input parameter for future program years based on the primary data collected.

2.4.4 Measure Cost Review

To identify measure cost estimates and/or assumptions that may need updating, the evaluation team benchmarked PSE's full and incremental measure cost estimates of its residential deemed measures against the best available data in the public domain. To the maximum extent possible, the hedonic price models recently developed for the CPUC were leveraged to estimate average prices for the specific deemed residential measures being offered by PSE, and benchmarked those predicted prices against the measure cost estimates currently being used by PSE. Wherever possible, the evaluation team also benchmarked current PSE cost values against those recommended by the RTF, the USDOE, and other publicly-available data sets, including published retail prices in the greater Puget Sound region. The complete results from this effort are included in Appendix I.

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[18] The UES review will focus on the 2015 PSE and RTF estimates but the findings will be presented in light of changes made to the UES estimates in 2016 (i.e. if a UES estimate appears to be high or low based on secondary research but the UES is changed in 2016 the UES review will note this).

[19] http://www.energy.gov/sites/prod/files/2013/11/f5/53827-7.pdf

2.4.5 Best Practices/Benchmarking Review

The Best Practices Review explored the following six best practice areas identified within the National Energy Efficiency Best Practices Study: (1) Program theory and design, (2) Program management, (3) Reporting and tracking, (4) Quality control, (5) Participation processes, and (6) Marketing and outreach. The evaluation team assessed these areas based on data collected during interviews with PSE staff and implementers,[20] as well as the program tracking data review. The objective of this effort was to determine program strengths and areas for improvement, and then to identify strategies for improving them.

2.4.6 PSE Market Research Review

PSE conducts a rolling satisfaction survey with participants in the following DtC programs: Appliance Decommissioning, Appliance Replacement, Appliance Rebate and ShopPSE purchasers (including APS, lighting and showerhead measures).[21] The evaluation team assessed PSE's current market research web surveys to determine if these surveys could be levered to enhance evaluation findings and reduce participant survey burden, as well as to determine if adjustments or changes to these surveys could improve program knowledge. Documentation of the types of data collected, and recommendations for revisions were provided to PSE during Stage 1. The complete results of the market research review are included in Appendix K. At the time of this final report, the PSE program managers were reviewing these surveys and suggesting revisions that would ensure that each program collects data to support key performance indicators (KPIs) for their program.

2.4.7 Residential Customer Web Surveys

A series of four distinct web surveys were conducted during Stage 2. These surveys included:

1. Appliance Rebate Participant Web Survey
2. Appliance Decommissioning Participant Web Survey
3. Clothes Washer Rebate and Replacement Participant Web Survey
4. General Population Web Survey

[20] In total, we conducted eight interviews with program staff and five interviews with program implementers.

[21] Two of the key DtC programs, Lighting and Showerheads, are upstream programs that do not lend themselves to customer follow-up since the customers who purchase lighting or showerheads in the retail stores are not tracked in an upstream program model. Some programs do not have email addresses for all program participants which limits the participants that can be surveyed.

Table 2-2 below provides a participant web survey disposition summary by measure offering. As this table shows, the overall response rates across these participant web surveys ranged from a low of 9% to a high of 15% and across all surveys averaged 9.5%. These web survey response rates are similar to typical CATI phone survey response rates. The response rates include surveys sent to invalid email addresses which made up about 14% of the sample, excluding these invalid addresses the response rate increases to 11%. An advantage of web surveys is that larger samples sizes can be achieved at no additional cost per complete; however only customers for whom PSE has a valid email address can be surveyed. As the table below shows, the final number of completed surveys exceeded the set quota in nearly every segment by about 40%. Samples for these surveys were randomly pulled from all participants with valid email addresses (from both the participant tracking data and myPSE Account emails) and care was taken to ensure customers who participated in multiple programs were not contacted more than once. Because the sample was selected at random from all available participants, no weighting was used in the analysis of the responses. The evaluation team worked with PSE to avoid contacting PSE customers who had formally requested to be excluded from PSE surveys, as well as those customers who had been surveyed in the last six months by the Market Research group.

TABLE 2-2: DISPOSITION SUMMARY OF PARTICIPANT WEB SURVEYS

Survey Disposition	Rebate			Clothes Washer		Decommissioning		Total
	APS	Refrigerator	Freezer	Rebate	Replacement	Refrigerator	Freezer	
Population	7,283	4,465	866	26,166	4,278	7,829	2,863	53,750
Population w/email	6,142	2,242	438	14,395	2,802	4,956	1,848	32,823
% of Pop w/email	84%	50%	51%	55%	65%	63%	65%	61%
Unique Participants	6,463	3,074	597	24,167	4,037	6,451	2,083	46,872
Overlap Participants	820	1,391	269	1,999	241	1,378	780	6,878
% that overlap	11%	31%	31%	8%	6%	18%	27%	13%
Invitations Sent	1,500	1,500	405	3,000	1,500	3,000	1,500	12,405
Quotas	100	100	50	200	100	200	100	850
Bad Emails								1,780
Unsubscribes	15	9	2	31	16	24	19	119
Completes	140	168	59	275	138	264	130	1,174
Partial Completes	12	4	1	6	6	14	10	53
Response Rate	9%	11%	15%	9%	9%	9%	9%	9.5%

Appliance Rebate Participant Web Survey

As the table above shows, a total of 367 Appliance Rebate (APS, Refrigerator, and Freezer[22]) participants completed the web survey. This survey was used to:

[22] Clothes Washer rebate participant surveys were fielded in a standalone clothes washer survey with clothes washer replacement participants.

- Verify program participation;
- Support ex-post adjustments to the deemed UES parameter estimates (such as a first-year installation rate and distribution of heating and cooling fuels and types across participants);
- Estimate interactive effects related to heating penalties or cooling benefits resulting from new appliance installation; and
- Assess customer awareness and satisfaction with the programs.

Clothes Washer Rebate and Replacement Participant Web Survey

A total of 413 Clothes Washer Rebate and Replacement participants completed the web survey. This survey was used to:

- Verify program participation;
- Support ex-post adjustments to the deemed UES parameter estimates (in particular, averages of the annual number of loads washed and the percent of loads dried);
- Estimate a first-year persistence rate; and
- Assess customer awareness and satisfaction with the programs.

Appliance Decommissioning Participant Web Survey

A total of 394 Refrigerator and Freezer Decommissioning participants completed this web survey. This survey was used to:

- Verify program participation;
- Support ex-post adjustments to the deemed UES parameter estimates (in particular, the part-use factor, percent of units in unconditioned space, and unit disposition absent the program); and
- Assess customer awareness and satisfaction with the programs.

General Population Web Survey

To support the impact evaluation of PSE's lighting measures, a general population web survey of a random sample of PSE's residential customers was developed and fielded to gather data to estimate current CFL and LED installation rates. To support the process evaluation, data was also collected during this survey on customer familiarity with and prior usage of high efficiency lighting and showerhead measures, barriers to purchase of these measures, and their awareness of the energy efficiency programs PSE offers to its residential customers. This survey included batteries on four DtC appliance measures (Advanced Power Strips, Refrigerator and Freezer Decommissioning, Clothes Washer Rebate, and Clothes Washer Replacement) to gather data from the general population to support the impact evaluations of these measures.

The general population web survey was administered to two distinct samples, an email and panel sample, as seen in Table 2-3. The reasoning for the dual sample approach was that each sample on its own may not fully represent the PSE general population due to bias that may exist with respect to who is included in each of the samples. Because of the web-based implementation of this survey, customers could only be included in the sample if PSE had a valid email address for them.[23] Conversely, the panel sample was selected from all individuals signed up for SSI's (a market research firm used by PSE's market research group) panel that had a zip code within PSE's service territory. The team believed that using the dual sample approach would allow the survey to capture different segments of the PSE residential population and would also provide valuable feedback to PSE for future research efforts regarding the differences between respondents in the two samples.

The sampling plan developed for this survey called for a 50/50 split between the two samples with a target of 600 total responses. The designs for the panel and email were a simple random sampling of their prospective sample frames. After the cleaning the general population responses, removing incomplete and terminated responses, the panel and email samples consisted of 294 and 367 responses, respectively. The full general population disposition can be found in Table 2-3 below.

[23] PSE provided the evaluation team with a list of all residential customer email addresses they had based on the customer's registration for a myPSE Account. Since not all customers have signed up for a myPSE Account, it is possible that this population of customers for whom PSE has an email address is biased.

TABLE 2-3: DISPOSITION OF GENERAL POPULATION WEB SURVEYS

Gen Pop Survey Disposition	Panel	Email	Total
Population w/ email	n/a	537,716	n/a
Invitations Sent	N/A	8,830	n/a
Quotas	300	300	600
Bad Emails	n/a	558	558
Unsubscribe Requests	n/a	66	66
Incompletes	160	83	243
Dropped Completes	10	7	17
Terminated	20	2	22
Overall Completes	294	367	661
Overall Response Rate	N/A	4.2%	N/A
APS Battery Completes	294	91	385
Clothes Washer Battery Completes	294	83	377
Refrigeration Battery Completes	294	95	389
Freezer Battery Completes	294	98	392

The evaluation team reviewed the email and panel responses to demographic questions to assess differences between the two populations and to determine how representative the samples are of PSE's residential customer base. Table 2-4 presents the email, panel and census data shares of various demographic variables. Several differences between the sample groups appeared, most notably the presence of a retired person, the share of homeowners versus renters, the distribution of home types (SFD, SFA, Apartment, Condo or Mobile Home), and the type of heating fuel. The email sample contained a higher percentage of homeowners than the panel sample (88% versus 49%) and a higher percentage of homes with at least one resident who was retired (39% versus 29%, respectively). The panel sample also contained a higher percentage of respondents with electric heating (59% versus 28%) and a lower percentage of homes with gas heating (29% versus 61%). This is likely driven by lower concentrations of respondents residing in single family detached homes within the panel sample which are more likely to have gas heating than other home types (single family attached, condos, apartments and mobile homes).

Because the designs for the panel and email were a simple random sampling of their prospective sample frames, is it statistically valid to post-stratify these populations and assume that within each stratum that the samples were also drawn randomly. These two samples (email and panel) can be considered independent of each other, and are essentially producing two independent results. Therefore, a simple average of the two results, or a 50-50 weighting, is also valid.

Due to the demographic differences between the panel and email samples, it was necessary to weight the survey responses so that they would be more representative of PSE's overall residential population. To support the development of the general population weights, the evaluation team used census data[24] to estimate the distribution of PSE's residential customer base across these same demographic variables. The census data contains household and individual level demographic variables, including own/rent dispositions, housing and building type characteristics, the presence of persons aged 65 and older (used as a proxy for the presence of a retired resident), and home heating fuel types. A PSE territory dataset was created from the census data using a list of in service territory zip codes provided by PSE. These zip codes were mapped to the public use microdata area (PUMA) codes in the PUMA dataset to extract the census data corresponding to PSE service territory.

As seen in Table 2-4 below, the proportion of both homeowners and single family detached (SFD) residents were underrepresented by the panel respondents and overrepresented by the email respondents when compared to the census data. Additionally, both email and panel respondents overrepresented the percent of homes with a retired resident. Interestingly, for most of the demographic variables, the panel and email shares of responses tended to straddle the census shares, suggesting that each sample individually does not capture the true demographic shares, however, combined the two samples appear to more representative of the general population of PSE residential customers.

TABLE 2-4: PANEL, EMAIL, AND CENSUS SHARES OF DEMOGRAPHIC VARIABLES

Demographic Category	Census	Panel	Email
Own	62%	49%	88%
Rent	38%	51%	12%
Single Family Detached	62%	59%	81%
Other Housing Type	38%	41%	19%
Presence of a Retired Resident[25]	25%	29%	39%
Electric Heating Fuel	52%	29%	62%
Natural Gas Heating Fuel	38%	62%	30%
Other Heating Fuel	10%	9%	9%

To accommodate the difference between the panel and email demographics and the census data, a weighting scheme was developed using the strata presented in Table 2-4. Each respondent was placed into a stratum based on a combination of home ownership, home type, and the presence of a retired

[24] The evaluation team used the 2015 1-year American Community Survey (ACS) public use microdata set (PUMS) provided by the US Census Bureau.

[25] The census data did not include presence of a retired resident and so presence of a resident older than 65 was used as a comparison group to the survey retired resident segment.

resident. Each stratum then received a weight designed to make the panel and email shares equal to the census share of that stratum and create a 50/50 split in email and panel representation as per the sampling plan. For example, 36% of the general population fell into stratum 2 (homeowners residing in SFD homes with no retired residents), per the US census data. The panel and email respondents in stratum 2 were 46% and 26% respectively and were therefore assigned weights to better align their representation with the census data estimate (36% percent) and make the panel and email samples proportionally equal. The distribution of email and panel respondents across the eight strata, along with their final weights, is provided in the table below.

This weighting scheme was not implemented with the objective of improving statistical confidence and precision (i.e., to reduce sampling error). Theoretically, this approach should have no effect on the statistical confidence and precision relative to combining all the responses together into a single stratum. However, because we are fairly certain a strong self-selection bias is present in each of the two samples, the objective of this approach was to reduce that bias. If there was no self-selection bias in the responses, we would also expect to see the same resulting means from both approaches (as well as statistical confidence and precision). But given the significant differences in population characteristics across the two samples, and relative to other estimates of the general population characteristics, we know the samples are biased. By post stratifying these biased samples, it is possible that the statistical confidence and precision could both improve or worsen depending on how the sample is biased (for example, if the sample was biased towards respondents that have more variation in their responses, then correcting for this bias might improve precision). But, we would expect that the results of this approach will reduce the bias in the mean results (although, the extent of this is difficult to say as we cannot completely measure the underlying bias).

TABLE 2-5: GENERAL POPULATION STRATA DISTRIBUTIONS AND WEIGHTS

Strata	Home Ownership	Home Type	Presence of Retired Resident[26]	Census%	Email%	Panel%	Email Weight	Panel Weight
1	Own	SFD	Presence	16%	31%	16%	0.41	1.03
2	Own	SFD	No Presence	36%	46%	26%	0.62	1.36
3	Own	Other	Presence	4%	5%	3%	0.64	1.08
4	Own	Other	No Presence	6%	6%	4%	0.81	1.55
5	Rent	SFD	Presence	1%	0.5%	4%	1.88	0.31
6	Rent	SFD	No Presence	9%	4%	13%	2.14	0.75
7	Rent	Other	Presence	4%	2%	6%	1.56	0.69
8	Rent	Other	No Presence	23%	6%	28%	3.28	0.84

[26] The census data did not include presence of a retired resident and so presence of a resident older than 65 was used as a comparison group to the survey retired resident segment.

To limit customer survey fatigue for the email sample, email survey respondents were randomly assigned to only one of the individual appliance measure batteries (Advanced Power Strip, Clothes Washer, Refrigerator, or Freezer).[27] As a result the there was a reduced quantity of email respondents in those batteries and the eight strata presented above resulted in segments that were too small to be relied on for statistical purposes. As a result, it was necessary to collapse the eight strata down to two for the email sample, one for homeowner and one for renter, and to use a weighting cap of four times the average uncapped weights so that no segments were overly represented in the overall results. These email sample weights were only used for the appliance measure battery questions. The general population weights were used for the panel sample for all questions as the panel sample was asked all of the appliance battery questions. Table 2-6 presents the distributions and weights for each appliance battery for the email sample.

TABLE 2-6: EMAIL SAMPLE STRATA DISTRIBUTIONS AND WEIGHTS - APPLIANCE BATTERIES

Home Ownership	Census	APS Battery		CW Battery		Refrig. Battery		Freezer Battery	
	%	%	Weight	%	Weight	%	Weight	%	Weight
Own	62%	90%	2.21	90%	2.41	87%	2.18	85%	2.25
Rent	38%	10%	8.95	10%	9.66	13%	7.68	15%	7.05

2.4.8 Trade Ally Interviews

A total of 18 trade ally interviews were conducted with lighting and showerhead retailers, manufacturers, and appliance dealers. These in-depth qualitative interviews were used to gather program feedback and insights from those responsible for delivering the programs to customers. Specifically, the trade allies' experiences with the program, satisfaction with the program's features and administrative functions, their motivations for or barriers to participation, and areas where the programs could be improved. It is important to note that during these interviews trade allies provided their *perceptions* of the DtC programs they had participated in, however in some cases (as called out in the text below), the trade ally responses indicated a misunderstanding of the programs operation and performance.

2.5 ORGANIZATION OF THE REPORT

This final report is presented in two volumes for the ease of the reader. The first volume contains the main body of the report which presents the high-level findings and recommendations from the Stage 1

[27] Panel respondents were asked to respond to all batteries as they opted into participating in customer surveys, and receive an incentive from SSI for being included in the panel and thus were considered more likely to respond to a longer survey.

and Stage 2 evaluation activities. The second volume is made up of appendices that contain Stage 1 program-level analysis results, primary data collection instruments, and detailed results from the measure cost, best practices and market research assessments.

Volume 1 contains the following 8 chapters:

- **Chapter 1: Executive Summary** – summarizes the high-level impact and process findings from the evaluation and provides recommendations for future analysis.
- **Chapter 2: Introduction** – states the primary objectives of the evaluation, and summarizes the research activities and data collection efforts of this evaluation.
- **Chapters 3 - 8: Evaluation Results by DtC Program** – presents for each DtC program the results of the gross impact evaluation, including both verified and ex-post impact estimates and realization rates, as well as program specific process results, and overall program findings and recommendations.

Volume 2 contains the following Appendices:

- **Appendix A: Summary of In-scope Programs.**
- **Appendices B - F: Stage 1 Evaluation Results –** Stage 1 impact evaluation results by DtC Program (Appliance Rebates, Decommissioning, and Replacement, Lighting, and Showerheads).
- **Appendix G: Data Collection Instruments** – Participant and General Population Web Survey Instruments.
- **Appendix H: Optimal Data Flow Model.**
- **Appendix I: Measure Cost Results** – provides the high-level findings from the measure cost review.
- **Appendix J: Best Practices/Benchmarking Results** – provides the high-level findings from the measure cost review.
- **Appendix K: PSE Market Research Results** – provides the high-level findings from the measure cost review.
- **Appendix L: Advanced Power Strip Options and Opportunities**.

3 ADVANCED POWER STRIPS

In 2014 and 2015 PSE offered a $50 incentive to all PSE residential electric customers purchasing a Tier 2 Advanced Power Strip (APS) through an online retail store (previously TechniArt's online store, now ShopPSE). These measures were mailed to the customer for self-installation. The Tier 2 APS measure included in this program generates savings through shutting down AV equipment that has been left on unattended (based on a lack of infra-red or motion detected by the unit for a specified period) which also effectively eliminates the standby function and the associated "phantom" load. PSE introduced the Tier 2 APS measure in 2014 and has since applied the RTF deemed UES estimate used by programs in region to estimate program savings. The RTF and PSE recognize issues with the current UES estimate and are in discussions about conducting an APS metering study locally. Overall, the APS Program makes up a small percentage of the DtC portfolio, accounting for only 1% of the DtC reported ex-ante electric savings.

3.1 TIER 2 APS EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the Advanced Power Strip Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), in-depth reviews of program tracking databases, web surveys of both program participants and non-participating PSE residential customers, and a review of secondary data collected to support similar programs across the US.

Table 3-1 below presents a comparison of the RTF deemed, evaluation verified, and evaluation ex-post Unit Energy Savings (UES) estimates and realization rates for the 2014 and 2015 Advanced Power Strip Rebate Program. As this table shows, the program had a 100% verified realization rate indicating the quantity of measures sold through the program was accurate and the RTF deemed UES was applied correctly. The ex-post realization rate for Tier 2 APS was 24% as a result of ex-post changes to the following parameters included in the UES algorithm:

- Adjusted Energy Savings estimate
- Unit Installation Rate – research indicated that a large percentage of these measures are either not being installed or are being installed and removed due to confusion with proper installation or dissatisfaction with the units' operation.

- Interactive Effects – primary heating penalties resulting from an increase in heating required to offset the heat loss associated with a customer's AV equipment being used shut down when not in use.

Additional details on the ex-post UES estimates and realization rates are provided in Section 3.3 below.

TABLE 3-1: 2014/2015 ADVANCED POWER STRIP UES ESTIMATES (KWH)

Measure	RTF Deemed UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
Tier 2 APS	300	300	100%	73	24%

Results of the process analysis and overall findings and recommendations for the Tier 2 APS program are provided in the sections below.

3.2 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of a review of program tracking and invoice data to verify the volume of units sold through the program and a review of calculation and application of the deemed unit energy savings (UES) estimates applied.

3.2.1 Tracking and Invoice Data Review

The tracking data review for Advanced Power Strip Program found that overall the tracking data was comprehensive and contained all variables needed for program tracking and evaluation. This review did identify 52 rebated APS units that appeared to be duplicates. The evaluation team worked with the program implementer who did confirm these records were duplicates. These customers did not receive two APS units; however, PSE was invoiced twice for them and savings for these duplicates were counted in the ex-ante totals. Due to the small magnitude of this issue (52 out of 3,988, ~1%), the APS program tracking data realization rate was 100%. Issues related to missing, duplicative or misaligned data are discussed within the process section of this chapter.

3.2.2 UES Algorithm

The RTF Deemed UES estimate applied by PSE to Tier 2 APS units sold in 2014 and 2015 was calculated based on the following algorithm:

Tier 2 APS Deemed UES = AverageAdjustedkWh * HVAC_Yield

= 371 kWh * 86%

= 300 kWh (rounded to one significant digit)[28]

Where:

AverageAdjustedkWh = The average adjusted kWh saving across 3 small-scale field trials[29]

HVAC_Yield = % of savings realized after offsetting any HVAC interactive effects

The evaluation team reviewed the three field trials used to estimate the **AverageAdjustedkWh** parameter and identified issues that caused concern regarding the applicability of these study results to PSE's program participants. PSE is aware of these issues and has been working with the evaluation team on a proposal for a separate APS metering study that will address these areas of uncertainty and applicability.

The **HVAC_Yield** parameter represents an interactive effect applied to the **AverageAdjustedkWh** estimate to account for changes in space conditioning energy use (both heating penalties and cooling benefits) due to the reduced heat output from the AV equipment controlled by APS measure. The HVAC_Yield parameter applied in 2014 and 2015 was 86%, which is the percentage of lighting located within interior locations. While the evaluation team agrees in theory that the application of an HVAC interactive effect parameter may be warranted for Tier 2 APS measures, the parameter estimate used to calculate savings is inappropriate for APS measures[30] and thus the evaluation team recommends additional research be conducted to estimate a more appropriate IE factor for this technology.

3.2.3 Verified Savings

While the evaluation team believes that there is room for improvement in the determination of the appropriate UES estimate for Tier 2 Advanced Power Strips going forward, our assessment of the 2014 and 2015 Deemed UES for Advanced Power Strips concluded that the algorithm and parameter inputs for this measure were based on the best available data at the time they were deemed and they were applied correctly to the program tracking data. As a result, no adjustments to the 2014 or 2015 UES estimates were applied and a verified savings realization rate of 100% was calculated.

[28] Per a decision by the RTF, the resulting UES estimate was rounded to one significant digit.

[29] Details on the field trials are included in Appendix B.

[30] The interactive effect parameter used within the RTF deemed savings estimate corresponded to the percent of lighting located within conditioned spaces.

3.3 STAGE 2 EX-POST IMPACT ANALYSIS

3.3.1 Ex-Post UES Adjustments

In Stage 2 of the evaluation, web surveys were administered to APS Rebate participants to gather data to calculate ex-post UES parameters estimates. For APS, this included estimating a first-year installation rate (ISR) which considered unit persistence and estimating an interactive effect parameter to account for any heating penalties or cooling benefits that result from the installation of the new power strip. The interactive effect estimate utilized local weather data and the 2015 appliance efficiency standards (to determine COPs[31] pertaining to the cooling and heating efficiencies of Heat Pumps and Central Air Conditioning). And lastly, a literature review of recent Tier 2 APS metering studies (conducted in jurisdictions which were more representative of PSE service territory than those included in the ex-ante UES) were reviewed to estimate the energy savings (kWh) of an installed Tier 2 APS unit.

Unit Installation and Persistence

The 2015 RTF deemed UES estimate assumes that 100% of units sold through the program are installed within the residential customer's home.[32] The Stage 2 APS participant web surveys were used to verify receipt of the rebated APS and estimate the first-year installation rate. Based on survey responses, a 100% verification rate will be assumed for the ex-post impacts as the 90% CI on the surveyed-based verification rate (98%) included 100%. As shown in Table 3-2 below, 25% of APS rebate participants surveyed who recalled purchasing an APS reported it was never installed within their home and an additional 11% reported it has been installed but was removed within the first year (32% reported it was installed for less than a month and 41% reported it was installed between 2-6 months, on average removed units were installed for 29% of the first year). Based on these data, the ex-post estimated first-year installation rate was estimated to be 66% (+/- 5%).

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[31] COP = Coefficient of Performance which is a measurement of how efficiently a heating or cooling system operates.

[32] It also assumes none of the units are removed before the end of their EUL.

TABLE 3-2: REBATED APS VERIFICATION AND INSTALLATION RATES

Purchased Rebated APS	Installed?	% of 1st Year Installed	n	Rate	90% CI
No	N/A	N/A	4	2%	0%-3%
Yes	Yes	100%	129	63%	58%-69%
	Yes, but removed	29%	23	11%	8%-15%
	No	0%	52	25%	20%-31%
First Year Installation Rate				66%	61%-72%

Source: Evaluation Team Analysis

The most common reasons reported by participants for not installing or for removing the rebated APS were that the APS made it more difficult or inconvenient to turn on their AV devices and that it caused devices to turn off unexpectedly while in use. These reported barriers to installation or unit persistence are primarily related to a misunderstanding or dislike of how the unit operates. While additional installation education may help, for some customers the underlying way in which the APS unit operates will always be undesirable. Additionally, education on unit installation and configuration is more difficult than for many other EE measures as it varies based on customers' equipment holdings and usage profile. Only about one-fifth of those who had not installed or had removed the APS said that they were likely to install the APS in the future.

Interactive Effects (HVAC Yield)

Interactive effects (IE) were calculated for Tier 2 APS based on data collected from the participant web surveys and estimates of the average heating and cooling coefficients of performance (COP) based on data from the 2015 RBSA regarding the installed heating and cooling types in PSE service territory and the average installed efficiencies of these units.[33] The formula used to estimate the IE was:

Interactive Effects = 1 + (Cooling Benefit - Heating Penalty)

Where:

Cooling Benefit = % Parts with AC * % of year Cooling * % APS_CondSpace * (CoolType Distribution (%) * COP_{AC})

Heating Penalty = % of year Heating * % APS_CondSpace * (HeatType Distribution (%) * COP_{HT})

[33] 2015 Appliance Standards as reported in https://appliance-standards.org/product/central-air-conditioners-and-heat-pumps.

Table 3-3 below shows the parameter inputs to this formula along with the APS participant survey sample size and 90% confidence interval on the parameter estimate. The overall result of this analysis is a net interactive effect of 0.81, which serves to reduce the energy savings of the APS by nearly 20% due to the incremental heating that is necessary to offset the lost heat from the AV devices that are shut down due to the Tier 2 APS.[34]

TABLE 3-3: TIER 2 APS INTERACTIVE EFFECTS

Parameter	Ex-Post Estimate	n	90% CI	Source
Participants with AC	31%	140	24%-37%	APS Participant Survey
Percent of Year Cooling	20%	n/a	n/a	2014/15 weather data, RBSA 2010 cooling set-points[35]
APS in Conditioned Space	100%	n/a	n/a	Assumed
COP - CAC	3.15	n/a	n/a	2010 RBSA average cooling efficiency of CAC
COP - ASHP	3.56	n/a	n/a	2010 RBSA average cooling efficiency of ASHP
Cooling Type - CAC	32%	n/a	n/a	2010 RBSA
Cooling Type - ASHP	52%	n/a	n/a	
Cooling Benefit	**0.0181**			
Percent of Year Heating	63%	n/a	n/a	2014/15 weather data, RBSA 2010 heating set-points[36]
APS in Conditioned Space	100%	n/a	n/a	Assumed
COP – ASHP	2.44	n/a	n/a	2010 RBSA average heating efficiency of ASHP
Heat Type - Elec - Strip/BB/Furn	22%	140	16%-28%	APS Participant Survey
Heat Type - Elec - Heat Pump	25%		19%-31%	
Heat Type - Gas	39%		32%-46%	
Heat Type - Other	14%		9%-18%	
Heating Penalty	**0.2051**			
Interactive Effect	**0.81**			

[34] It is important to note that this estimate represents only a 5% larger degradation than the ex-ante estimate of 0.86. This IE estimate was primarily driven by the participants self-reported heating type (APS participant survey, Table 3-3 below). Using PSE heat type distributions from the RBSA increases the IE to 0.86 (the deemed rate). However, the low APS ex-post realization rate (24%) is more tied to the APS installation rate and the unadjusted kwh savings estimate (see table 3-6).

[35] Self-reported data was also collected from APS Survey respondents on the percentage of the year they cool their homes. The average of the participants' responses was 23% +/-5% (90% CI) and so the point estimate used to estimate the IE – cooling benefit for APS falls within the 90% confidence interval of the web survey response.

[36] Self-reported data was also collected from APS Survey respondents on the percentage of the year they heat their homes. The average of the participants' responses was 62% +/-2.5% (90% CI) and so the point estimate used to estimate the IE – heating penalty for APS falls within the 90% confidence interval of the web survey response.

Average kWh Savings

As mentioned above, the ex-ante Deemed UES estimate derived the average kWh savings of an APS from three small metering studies conducted in Australia, South Africa and California. The results of these studies varied significantly from one another (and hence had a very large standard error associated with them) and were based off small samples of customers that were not very representative of PSE's customer base. As part of this study, the evaluation team conducted a literature review of primary and secondary research conducted between 2014 and 2016 that led to estimates of Tier 2 APS savings. In lieu of any PSE primary research, the evaluation team recommends using the results of this literature review to update the APS savings value used within the UES calculation. The results of the literature review are presented below along with findings from the participant web surveys on the typical connected load and unit operation of rebated APS units.

APS Literature Review

To gain a better understanding for the research that has been done on Tier 2 APS savings and assess the range of deemed savings estimates being used in programs across the US, the evaluation team conducted a literature review of relevant studies and reports (that used primary or secondary data to determine unit savings). The table below presents the results of this review. As this table shows, the savings for this measure based on primary research range from a high of 385 kWh to a low of 110 kWh. That range places PSE's 2014/2015 Deemed UES of 300 kWh on the mid to high range of estimated savings, however the higher savings estimates shown in the table below come primarily from studies that used a simulated methodology which is believed by most in the industry to over-estimate unit savings.[37] Excluding the simulated savings estimates, the range of savings from primary research is between 100 – 150 kWh, with the mean being 138 kWh.[38] In lieu of any PSE primary research, the evaluation team recommends using this savings value within the UES calculation.

As the table below shows, the amount of research that has been conducted to date across the US to measure the kWh impacts resulting from the installation of Tier 2 Advanced Power Strips has been fairly minimal. Much of the research conducted has been done in either controlled environments (simulated) or has been focused on the measurement of professionally installed devices and so does not account for non-installation or removal of the APS units. The evaluation team was unable to find any studies that tried to measure the interactive effects resulting from the use of an APS in a residential home. Utilities around the country that are distributing these units through their energy efficiency programs are often relying on impact estimates from APS manufacturers or the limited primary research shown below. All of this points to a need for a larger more comprehensive study that would estimate load reduction,

37 The simulated method is thought to over-estimate savings since it does not account for AV equipment this is turned back on after being shut down by the APS.

38 These estimates exclude any installation rate or interactive effects.

HVAC IE, as well as unit installation and persistence. Conducting this study across a number of jurisdictions would allow for larger samples sizes (past studies have often had limited sample sizes due to cost) that would then allow for further investigation into the relationship between unit impacts and the customer type and usage profile of those installing APS.

TABLE 3-4: APS LITERATURE REVIEW SUMMARY

Research Type	Research Sponsor	Year Published	Sample	Savings	Methodology / Source
Primary	CalPlug	2014	100	206 kWh to 385 kWh, Average = 346 kWh	Simulated
Primary	SDG&E	2014	42	149 kWh	Simulated, pre-post adjusted
			9	134 kWh	Pre-post
Primary	Silicon Valley Power	2015	34	164 kWh	Metering study of DI Pilot
Primary	PG&E	2016	94	214 kWh	Simulated
			9	125 kWh	Pre-post
			52	118 kWH	Simulated
			56	110 kWH	Pre-post
Secondary	SDG&E Workpaper	2015	n/a	212 kWh	CalPlug and SDGE Field Study data
Secondary	CPUC Workpaper	2015	n/a	212 kWh	Review of other studies
Secondary	NYSERDA	2014	n/a	398 kWh	Review of other studies
Secondary	NEEP Lit Review	2015	n/a	300 kWh - 327 kWh	BPA Secondary Research
				242 kWh	MASS SAVE
				306 kWh - 386 kWh	2013 CalPlug (Embertec)
				323 kWh	2014 CalPlug (TrickleStar)
				164 kWh	SVP
				79 kWh - 334 kWh	UL Environment
Secondary	IL TRM	2015	n/a	300 kWh	Manufacturer Proposal
Secondary	PA TRM	2016	n/a	307 kWh	CalPlug Study

Connected Load

Surveyed APS participants were asked what devices they had plugged into their rebated APS. As the table below shows, the most common device plugged into the APS was a television (82%). The most common types of TVs plugged in to the APS were LED/LCD TVs (85%) or Plasma TVs (9%). The remaining six percent didn't specify television type. Twelve percent indicated they were using it for their computer (the Tier 2 APS units sold through the program were specifically designed for AV systems and not for computers). Thirteen percent of respondents indicated they had plugged in another device. These devices ranged from phone chargers to a mini fridge, sauna and treadmill. Using the APS units to power devices other than the AV systems for which they were designed may impact customer satisfaction with the devices and the resulting energy savings.

TABLE 3-5: REPORTED DEVICES PLUGGED INTO REBATED APS

Device	% of Respondents
Television	82%
DVD/Blu-Ray Player	55%
DVR / Cable Box	53%
Stereo/Receiver	26%
Game Console (Xbox, PlayStation)	24%
Amplifier/Speakers	24%
Internet Video Player	22%
VCR	14%
Lamp	13%
Desktop Computer	12%
Computer Monitor	7%
Other	13%

Unit Operation

Surveyed APS respondents were asked about the operation of their rebated APS and reported the following:

- 94% of respondents reported the unit was programmed to turn off after 1 or 2 hours of inactivity. Only one customer reported they overrode the settings so it would turn off after 8 hours.
- 32% reported the APS turned off equipment that had been left on very or somewhat frequently, 43% reported it did so never or very infrequently, and 26% reported they were unsure of the frequency with which it turned off equipment that had been left on.
- 32% of respondents reported that prior to installing the APS their TV or other AV equipment was frequently left on for an hour or more while no one was actively using it (includes falling asleep while it is on). 62% reported this never occurred or occurred very infrequently and 6% reported they were unsure how often this occurred.

3.3.2 Ex-Post Savings Estimate

As mentioned above, the evaluation team recommends that PSE expand the algorithm used to estimate the UES for Tier 2 APS to include a parameter to account for the percent of program APS installed in customers' homes during the first program year (ISR = first-year installation rate). The revised algorithm becomes:

Tier 2 APS Ex-Post UES = AverageAdjustedkWh * HVAC_Yield * ISR

Applying the ex-post UES parameter updates presented below results in an ex-post UES estimate for Tier 2 APS of 73 kWh.

Tier 2 APS Ex-Post UES (73 kWh) = AverageAdjustedkWh (137 kWh) * HVAC_Yield (81%) * ISR (66%)

As the table below shows, the realization rate on this estimate is 24%.[39] The parameter with the lowest realization rate, and the primary driver of this low realization rate, is the kWh savings parameter. As mentioned above, this parameter was calculated as the average of the savings estimates of primary research studies conducted between 2014 and 2016 in California, which in the absence of a metering study in the NW is believed to be the best estimate of an installed Tier 2 APS reduction in load absent any interactive effects.

TABLE 3-6: REBATED APS EX-POST SAVINGS ESTIMATE AND REALIZATION RATE

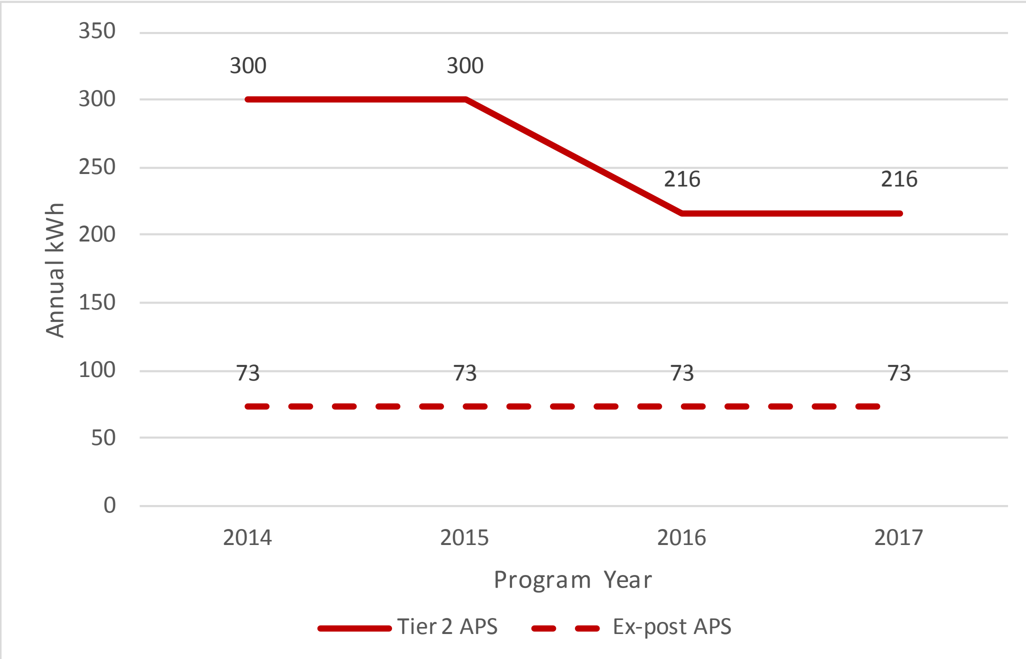
Parameter	Ex-Ante	Ex-Post	90% CI	Ex-Post Realization Rate
kWh Savings	371 kWh	137 kWh	n/a	37%
HVAC Yield	86%	81%	n/a	94%
Installation Rate (ISR)	100%	66%	61%-72%	66%
APS UES	300 kWh[40]	73 kWh	n/a	24%

Figure 3-1 below compares the RTF deemed UES estimates for program years 2014 to 2017 to the ex-post UES estimate derived by the evaluation team. As shown in this figure, the ex-post UES is not only significantly smaller than the 2014/2015 deemed UES, but it is also less than 50% of the 2016/2017 UES.

[39] The UES for Tier 2 APS was reduced for the 2016 and 2017 program years to 216 kWh. The realization rate on that revised UES is 34%.

[40] The Ex Ante UES was rounded to 1 significant digit which took it from 319 kWh to 300 kWh.

FIGURE 3-1: ADVANCED POWER STRIP DEEMED UES 2014-2017 VS. EX-POST ESTIMATE (KWH)



3.4 ADVANCED POWER STRIP PROCESS ANALYSIS

The process evaluation for PSE's APS efforts relied on data collected from customers who purchased an APS through ShopPSE, a general population web survey to explore APS awareness, a review of APS offerings and evaluation results from across the US, and interviews with program staff.

The process analysis around APS's sought to answer the process-related questions laid out in the introduction:

- **Program Theory and Changes:** Have there been changes over time? Is this well-documented?
- **Data Tracking:** What data are currently being collected and how is this data being used? And what additional research is needed for each program area?
- **Awareness:** How aware are residential customers of Tier 2 APS's?
- **Demographics of Participation:** Who is currently purchasing APS's (demographically)?
- **Participant Satisfaction:** What is the level of residential participant and satisfaction with the APS, and what areas of improvement exist?
- **Best Practices and Opportunities:** Is PSE following industry best practices? Where may additional opportunities lie?

3.4.1 Program Theory and Changes

Since PSE added the Tier 2 APS measure to its DtC portfolio offerings in 2014, there have been a number of changes that have impacted the product offerings and delivery channel. Key changes include adding APS units to the program (the program now offers units from the two primary manufacturers in the US), increasing incentives (they are currently $70 per unit, up from $50), and changes to the delivery channel. PSE brought the primary retail channel, ShopPSE (online retailer) in-house at PSE, which improved their ability to administer and track data for the program. In addition, APS units also started to be sold through PSE pop-up events in 2016.

PSE currently documents its program efforts, and changes to the program, through their annual and biennial reporting. These documents, however, do not explicitly lay out the program theory for how and why APS's are provided to customers. While this may not be critical for well-established programs, programs related to APS's, however, are newer and not as established as other rebate efforts such as lighting and appliance based rebates. There are multiple possible target audiences (e.g., early adopters, multi-family, etc.) and delivery channels—explored further below—which PSE may want to explore in the future.

Because there is no explicit theory for this program, it is currently unclear how customers will learn about these units, be educated on how to properly install them, and ultimately increase their demand for this product. Some of the newer units are Bluetooth enabled with links to app that can educate customers about the units, but other options are available to PSE, such as educating through direct interactions with consumers or other video-based messaging. The evaluation team explored delivery channel options and opportunities on PSE's behalf, and presents these findings in Section 3.4.6.

3.4.2 Data Tracking

A number of minor data tracking discrepancies were identified during the verification analysis; however none impacted estimated program savings. There are, however, small changes that could be made going forward to improve the accuracy of the data. These items include:

1. Program qualification criteria allows only one rebated APS per qualifying household, however program tracking data included a handful of records (less than 2% of program sales) with duplicate email and shipping addresses.
2. APS Model number was not fully populated in the program tracking data. Although this did not impact the 2014/2015 program years (as only one unit was eligible for a PSE rebate), PSE began offering incentives on multiple APS units in later years so this missing data could be problematic in tracking and evaluating more recent savings.

3. A few fields were missing from two of the APS invoices. Details on the missing fields were provided to PSE in a mid-evaluation report so PSE could ensure these fields are included in future invoices.

PSE has reported that issues 1 and 2 above have been resolved with ShopPSE being brought in-house at PSE and PSE is working with program vendors to ensure all necessary data fields are included in all invoices.

3.4.3 Awareness of Programs

At this point in time, consumers are unlikely to demand this product on their own (i.e., without education and marketing) because most are not aware or familiar with the measure. During the general population surveys, respondents were provided a description of a Tier 2 APS and were asked whether they were familiar with this technology. More than 70% of respondents reported they were not familiar with Tier 2 APS, and of those who reported they were familiar, the majority stated they were only somewhat familiar. As such, consumers are generally not aware of the benefits of advanced power strips and need some instruction or knowledge on where to use them and how to appropriately install and program the units.

Those who were familiar were asked whether they had ever purchased a Tier 2 APS and 39% reported they had, which would indicate approximately 10% of the general population has purchased a Tier 2 APS for their home. While the general population survey provided a detailed description of Tier 2 Advanced Power Strips, the evaluation team acknowledges that familiarity and possession of Tier 2 APS are likely overstated due to possible confusion between the different types of APS units (basic, Tier 1, and Tier 2) that cannot be easily assessed via a web survey. This confusion is likely prominent due to the fact that currently Tier 2 APS have limited availability in the US outside of utility programs and online manufacturer or retailer websites.

Most customers are also not aware of ShopPSE, which is the primary channel for getting Tier 2 APS units to customers. Only 27% of the residential population was familiar with the fact that PSE sells energy efficient devices through their online website.

APS program participants were asked how they first became aware of Tier 2 APS and the majority (91%) reported it was from information provided to them from PSE (either via an email, PSE.com, a bill insert, direct mail or an outreach booth). PSE is the primary source of marketing of this technology to their customer base.

3.4.4 Demographics of APS Program Participants

APS Program participants frequently described themselves as "early adopters" (41% self-reported they were either the first or among the first to try new technologies). Additionally, demographic data collected from APS participant survey respondents indicated that the majority of APS participants owned their own home (92%) and lived in single family detached home (76%). One other notable finding was that 31% of APS participants reported having central air conditioning (AC) which is significantly higher than the percent of the general population (23%) and higher than other rebate participants who reported having central AC.

3.4.5 Participant Satisfaction

Sixty-one percent of APS purchasers reported they were satisfied (extremely or somewhat) with the APS they purchased through the program (16% were dissatisfied and 22% had neutral feelings about it). This is significantly lower than the percent of participants who reported they were satisfied with other DtC appliance measures (82%). The primary reasons reported for dissatisfaction with the APS was that it didn't work with their AV equipment and that it was difficult or inconvenient to use. A higher percentage of participants (73%) reported they were satisfied with the ease of installation and setup of the APS (10% were dissatisfied and 17% had neutral feelings about it), however the majority of customers who were dissatisfied reported that the directions for set-up were unclear and complicated.

These reported reasons for dissatisfaction with the APS units and installation are difficult for the program to overcome since they are tied closely to the technology, not PSE's program or program delivery. While additional educational materials could be provided regarding the proper installation of these units, due to the wide variety individual AV equipment holdings, set-ups and usages, developing a common set of installation guidelines that will be beneficial to all or even the majority customers may be difficult.

Based on the level of dissatisfaction reported it is not surprising that only 62% of APS participants said they would recommend a Tier 2 APS to a friend or family member. The reasons provided by those who reported they would not recommend it to another included the units was difficult to use, inconvenient, confusing, broken, rudimentary, immature, frustrating, not user friendly, incompatible with equipment, and useless.

Program participants were asked their reason for purchasing an APS and the primary reason reported was to save energy in their home (61%, followed by 30% who reported for the PSE rebate and 10% to test a new technology). Despite this overwhelming desire to save energy, less than half (46%) of those who purchased one thought it was saving any energy in their home.

3.4.6 Delivery Channel Options and Opportunities

As mentioned above, PSE currently provides access to Tier 2 APS's through the following channels:

- Direct-to-Consumer program channels for distributing APS's:
  - ShopPSE.com, PSE's online retail site
  - Pop-up retail events by TechniArt

In addition, PSE also has other programs that distribute APS's, including:

- Multifamily Direct Install
  - Installers provide homeowners with device when they feel that it would work in the customer's home. Note that the APS unit is not directly installed (unless the occupant requests help) due to concerns around the moving furniture and working around expensive TV and audio-visual systems.
- Low-income (as an unutilized option)
  - While community agency programs (CAPs) are given the option of installing APS's as a qualifying measure, to date, PSE indicated that the agencies generally do not choose to install this measure because they tend to focus on required measures.

Based on a review of the literature and discussions with APS manufacturers, the primary channels used to distribute APS's to customers across the country include direct install, which is not a channel currently in use in the DtC programs, as well as buy downs, promotions, and giveaways:

- **Giveaways**: The APS device is included in an energy savings kits or provided to customers for free.
- **Promotions**: Program administrators sometimes offer limited time promotions for customers, providing reduced-cost or free APS's.
- **Buy downs or instant rebates**: APS's are sold through retail channels, including online retail, pop-up event based retailers, and traditional brick and mortar retail stores.

Below we provide the benefits and drawbacks of each of these options, as well as the opportunities that may exist for the PSE DtC programs in the future. Note that some of these channels (e.g., pop-up retail and online stores) are already being used by the PSE DtC programs.

Giveaway Opportunities. For a giveaway model, APS's are included in energy saving kits or given away through events. For PSE, there may be opportunities for adding Tier 2 to leave behind kits, thank you kits, and school-based kits if PSE can find ways to ensure that these measures get installed. The Bluetooth application (with video) could help encourage and verify installation; however, installation rates without customized education are expected to be low. PSE would need to consider ways to increase installation from this channel, and look at costs versus savings.

- **Benefits:** Giveaways move APS's into the market, and into homes, quickly.
- **Drawbacks:** APS's don't always get installed, and even if installed, they may not be installed properly. Tier 2 APS's are expensive to give away if no savings occur and they do not get installed. Missouri saw 48% installation rate for kits.

Promotion Opportunities. During a promotion, APS's are sold at reduced prices during limited time promotions either online, or through mailers or catalogs. According to one manufacturer (TrickleStar), the ideal times for special retail promotion are in the Fall and the Spring as it applies to AV products and applications. The key to the online promotion is advertising. According to the same manufacturer, the best form is via email blast, which can result in an open rate of 40%, 20% click through and 40% conversion rate. Some California-based municipals are considering a promotional model where the APS units are sold at some discount, but then are rebated fully (so that they are free to the household) once the unit has been installed. This is a new model being considered by municipal utilities in California. It does not appear to be in place yet. There may be some opportunity for PSE to distribute APS's through this model.

- **Benefits:** Promotions move APS's into the market, and into homes, quickly.
- **Drawbacks:** APS's don't always get installed, and even if installed, they may not be installed properly. Tier 2 APS's are expensive to give away if no savings occur and they do not get installed.

The opportunities related to buy downs are more limited since PSE already sells APS's through pop-up retail and online stores, and brick and mortar stores have not shown as much interest in participating. There are, however, some opportunities for additional education and/or coupling these channels with promotional efforts. Overall, the current delivery in these areas follows best practices from other areas of the country, but it should be recognized that the APS program model is still evolving. We lay out the details of each of the buy-down delivery channels below. PSE added APS to their pop up retail in 2017.

Pop up Retail Opportunities. This option allows for sale of Tier 2 APS's at mobile education events where consumers may be purchasing other energy efficient products. PSE currently has a vendor conduct these events on their behalf at work "campuses", office buildings, universities, home shows, public festivals and other community events. This channel allows for a one-on-one direct interaction with customers. In this channel, the customer learns about the technology prior to purchase. Additional opportunities are limited since PSE already effectively uses this channel; however, PSE could consider additional education or displays related to APS's at the pop-up retail site, or expanding the number of pop-up events within PSE's territory.

- **Benefits:** The customer is provided with one-on-one assistance and education about the unit and how to install the APS in their home's application.
- **Drawbacks:** Because of the nature of PSE's territory, pop-up retail events will serve both PSE customers and customers from surrounding utilities, which means that the energy savings cannot be counted for all APS devices sold.

Online Store Opportunities. The online store provides a consistent location where Tier 2 APS can be purchased, which could also be coupled with "limited time" promotions (see above). This is a stable distribution channel, and can be used with digital and social media to target the residential customer base. There are additional opportunities for PSE to couple the purchase of the technology with education through information and videos. There may also be an opportunity to ensure installation and better understand connected loads using APS's that are Bluetooth-enabled with a downloadable app.

- **Benefits:** There are no direct installation labor costs or retailer overhead in this distribution channel; however, there will be some postage cost. APS's can be available to users without disruption. It is also likely that customers will want to install since they purchased the unit.
- **Drawbacks:** This delivery method may tend to attract early adopters of the technology rather than the full general population. PSE also needs to actively drive customers to the website.

Traditional Brick and Mortar Store Opportunities. This includes working with manufacturers and retailers (similar to lighting and showerhead efforts) to get stores to stock APS's at a cost that is bought down through the program. The opportunities appear to be limited as PSE and the manufacturers of APS's have been exploring this option for several years. May need additional research with retailers to explore what they would need to stock APS's in the stores, or if they see it as a possibility in the future.

- **Benefits:** APS's would be accessible to the general population. This would be an important step if the long-term objective is to have households purchase on their own outside of the program.
- **Drawbacks:** Sales of APS's without assistance have been proven to be low. Margins are also low. This method of delivery does not allow for education (unless coupled with a special event), nor does it ensure installation of the APS.

Additional information on APS options available to PSE are provided in Appendix L.

3.5 APS REBATE PROGRAM FINDINGS AND RECOMMENDATIONS

The evaluation team provides the following findings and recommendations for PSE's Advanced Power Strip Rebate Program.

Finding APS1: PSE sells rebated Tier 2 APS units through their ShopPSE website, but has not been able to expand the program delivery to retail stores as retailers are currently carrying them. In 2016, PSE started to sell these units through their Pop-up Retail channel. At this point in time, consumers are unlikely to demand this product primarily due to very limited product awareness (72% of general population respondents reported they were not at all familiar or unsure about Tier 2 APS). Additionally, even APS purchasers who are aware of the technology, are in need of additional education on where to use them and how to appropriately install and program the units to maximize energy savings and satisfaction with the units.

Recommendation APS1: Currently it is unclear how PSE customers will learn about these units, be educated on how to properly install them, and ultimately increase their demand for this product. If PSE decides to scale this effort, the theory behind this component should be explored further.

Finding APS2: The data used to estimate the 2014/2015 deemed UES was collected from a small sample of homes that are likely not representative (with respect to viewing habits and connected loads) of PSE's participant population. Additionally, the relative precision on this estimate is more than 20% which is significantly higher than what is typically acceptable in the industry.

Recommendation APS2: If PSE plans to continue rebating this measure they should further discussions with the RTF and regional parties to co-sponsor a primary research study aimed at reliably quantifying the UES resulting from the installation and use of residential Tier 2 Advanced Power Strips.

Finding APS3: Satisfaction with Tier 2 APS units is significantly lower (61%) than participant satisfaction with other DtC appliance measures (82%). The primary reasons reported for dissatisfaction with the APS was that it didn't work with their AV equipment, that it was difficult or inconvenient to use, and that the directions for set-up were unclear and complicated.

Recommendation APS3: Customer awareness and satisfaction with Tier 2 APS are going to continue to be the primary barriers this program faces until these products become more widely available and accepted in the market place. PSE has expressed interest in marketing Tier 2 APS units to specific user "types" (i.e. gamers, cable viewers, etc.), however without additional research to understand how the devices operate for these customer "types" (i.e. do gamers encounter any issues with the unit that other customers do not) and a metering study to determine the impacts for these populations, this type of targeting may not produce the desired outcomes. Evaluation research did find these devices are utilized more frequently by "early adopters" and so PSE could work with their marketing group to see what segmentation data is available to identify and target this population to see if it gives them more traction in the market.

Finding APS4: With Tier 2 APS devices being a newer energy savings technology in the market place there are a number of areas where collecting additional data via one of the current touchpoints PSE has with its customers (such as the post-participation market research surveys) could increase their understanding of the program's operation, customer satisfaction and understanding, and the resulting measure impacts.

Recommendation: The evaluation team recommends expanding the data collected from APS participants during one of these touchpoints to explore:

- APS installation and removal – this data could be used to annually update installation rates used to calculate program impacts and would allow PSE to better understand the barriers customers face to APS installation and usage.
- Connected Devices - plug loads that are currently being controlled by the rebated APS units.

4 APPLIANCE DECOMMISSIONING PROGRAM

In 2014 and 2015 PSE offered a $25 incentive (per unit), plus free pick-up and recycling, to all PSE residential electric customers who recycled an old inefficient refrigerator or freezer that was in working order through PSE's Appliance Decommissioning Program. The primary objectives of this program are to decrease the retention of high energy-use refrigerators and freezers, deliver long-term energy savings, and to dispose of units in an environmentally safe manner. This program also distributed high efficiency light bulbs and showerheads via no-cost kits that were given to program participants at the time their refrigerator or freezer was picked up. Overall, the Appliance Decommissioning Program makes up a small percentage of the DtC portfolio, accounting for only 2% of the DtC reported ex-ante electric savings (excluding savings from kit measures).

4.1 APPLIANCE DECOMMISSIONING EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the Appliance Decommissioning Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), in-depth reviews of program tracking databases, and web surveys of both program participants and PSE residential customers.

Table 4-1 below presents a comparison of the RTF deemed, evaluation verified, and evaluation ex-post Unit Energy Savings (UES) estimates and realization rates for the 2014 and 2015 Appliance Decommissioning Program. As this table shows, the program had a 100% verified realization rate indicating the quantity of measures sold through the program was accurate and the RTF deemed UES was applied correctly. The ex-post realization rates for both the refrigerator and freezer decommissioning were less than 100% (95% for refrigerators and 52% for freezers) as a result of the following ex-post changes to the parameters included in the UES algorithm:

- Unit energy consumption (UEC) of a decommissioned refrigerator decreased from 1,274 kWh to 1,137 kWh and a decommissioned freezer decreased from 1,509 kWh to 941 kWh based on the regression coefficients from the 2013–2014 Pacific Power Washington "See ya later, refrigerator®" Program evaluation, 2015 tracking data, and data collected from participant surveys.
- UEC of new standard efficiency refrigerator increased from 523 kWh to 534 kWh and decreased from 500 kWh to 485 kWh for freezers based on data from the Energy Star website.[41]

[41] https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

- Part–use factor – the part-use factor accounts for the percentage of the year the decommissioning appliance was plugged in. This parameter decreased from 91% to 90% for refrigerators and decreased from 91% to 86% for freezers based on data collected from participants during the web surveys.
- Disposition of decommissioned units absent the program – the participant web surveys were used to collect data from customers about what their actions would have been absent the program (kept, sold, disposed). The adjustments made to these distributions are presented in Table 4-4.
- Replacement outcome/induced replacement – This percent increased for both refrigerators and freezers and was based on self-reported data collected via participant web surveys. Table 4-5 presents the ex-ante and ex-post estimates of the percent of program induced replacements for refrigerators and freezers.

Additional details on the ex-post UES estimates and realization rates are provided in Section 4.3 below.

TABLE 4-1: 2015 REFRIGERATOR AND FREEZER DECOMMISSIONING UES ESTIMATES (KWH)

Decommissioning Measure	RTF Deemed UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
Refrigerator	356	356	100%	340	95%
Freezer	570	570	100%	295	52%

Source: Evaluation Team Analysis

Results of the process analysis and overall findings and recommendations for the Appliance Decommissioning program are provided in the sections below.

4.2 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of two components. The first component was a review of program tracking and invoice data to verify the volume of units sold through the program. The second component was a review of calculation and application of the deemed unit energy savings (UES) estimates applied.

4.2.1 Tracking and Invoice Data Review

The tracking data review for the Appliance Decommissioning Program found that overall the tracking data unit and savings totals matched the ex-ante estimates for the decommissioned refrigerators and freezers and only differed with respect to the UES values assigned to the LEDs distributed to 2015 program participants via the Leave Behind Kits. The tracking data indicated that these measures were assigned a UES of 13.48 kWh (the 2014 deemed value) rather than 16.02 kWh (the 2015 deemed value).

This resulted in a slight underestimation of reported ex-ante claimed savings (5,984 kWh, 116% RR), however due to the small magnitude of the LED savings relative to the decommissioned appliance savings the overall tracking data realization rate for the 2015 program was 100%. Issues related to missing, duplicative or misaligned data are discussed within the process section of this chapter.

4.2.2 UES Algorithm

The framework used to estimate the UES of measures collected through the program is designed to yield an estimate of net program savings. The framework steps through a series of calculations, starting with an estimate of Unit Energy Consumption (UEC), which represents year-round 8,760-hour operation of each unit, and applying a series of adjustment factors to yield an estimate of gross savings based on the actual (planned) operation of the unit. Following this, the net savings portion of the algorithm is applied. This net-to-gross framework seeks to identify all possible alternative disposal methods in the program's absence. Responses that correspond to an alternative method that permanently removes the unit from the grid are considered free riders and are excluded from Unit Energy Savings credited to the program. The algorithm assigns probabilities to each of these outcomes. The outcomes that the algorithm differentiates between include:

Disposition of unit without program outcome:

- $LeftOnGrid_{SD}$ = % of participants that would have sold/donated unit in absence of program
- $LeftOnGrid_{kept}$ = % of participants that would have kept the unit in absence of program
- LeftOffGrid = % of participants that would have not used/stored unit in absence of program

Replacement Outcome:

- Replaced = % of participants that would have replaced their refrigerator
- NonReplaced = % of participants that would not have replaced their refrigerator
- $Replace_{Ind}$ = % of participants that replaced their unit due to the program (Induced)

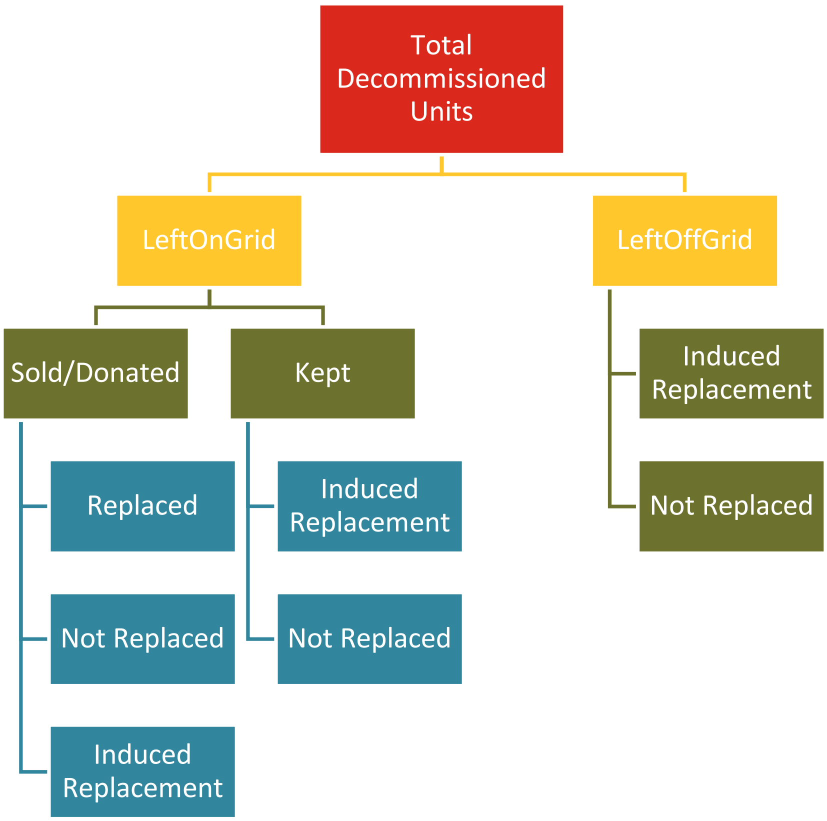
Assumptions about UEC of old and replacement units:

- PartUse = Portion of the year the unit is in-use
- InsituAdj = Adjustment factor that accounts for field conditions
- C-Factor = Factor to Adjust for increasing Energy Efficiency over time
- UEC_{old} = Unit Energy Consumption of the Decommissioned Unit
- UEC_Replace1 = Unit Energy Consumption of the Replacement Unit

- UEC_Replace2 = Unit Energy Consumption of the Induced Replacement Unit

The figure below illustrates the range of outcomes included in the UES algorithm.

FIGURE 4-1: APPLIANCE DECOMMISSIONING DISPOSITION OUTCOMES



4.2.3 Verified Savings

The UES review sought to comprehensively assess the 2015 RTF deemed UES. While the evaluation team recommends updates to the UES estimates for the refrigerator and freezer decommissioning measures in future program years, our conclusions from the assessment of the 2015 RTF deemed UES estimates for these measures are that the algorithm and parameter inputs for these measures are defensible, reproducible and were appropriate at the time they were deemed. As a result, no adjustment to the 2015 UES estimates was applied and a verified savings realization rate of 100% was calculated.

4.3 STAGE 2 EX-POST IMPACT ANALYSIS

4.3.1 Ex-Post UES Adjustments

In Stage 2 of the evaluation, web surveys were administered to Appliance Decommissioning participants to gather data to support ex-post adjustments to the UES deemed parameter estimates such as part-use factor, percent of units in unconditioned space, and what the participant would have done with the unit in the absence of the program. Web surveys were also administered to the general residential population to gather data on how customers are disposing of their old refrigerators and freezers.

Additionally, for the ex-post calculations, the Unit Energy Consumption (UEC) estimates and the methods for net adjustments were updated to align with the latest UMP methods. The UMP recommends estimating the UEC for the recycled unit using a regression derived from an in-situ metering study. Since the evaluation budget did not support a PSE-specific metering study, the Pacific Power Washington "See ya later, refrigerator®" Program study is the most current and relevant Appliance Recycling Program study identified through the evaluation team's literature review. The findings from this study are based on primary metered data collected within the Pacific Northwest, and therefore are a good proxy for PSE program participants. This makes it preferable to an alternative specification, such as the regression formula included in the UMP which is based on national data.[42]

Because the UMP method differs from the method used by the RTF, the two are not easily comparable. However, the parameters used to calculate savings do overlap somewhat, but the way they are applied are slightly different.

Regression-Based UEC Estimation

Updates were made to the UEC estimates for the decommissioned units (UEC_{old}) using the industry standard practice method as detailed in the Uniform Methods Project (UMP)[43] protocols and using a regression specification from a metering study published in February 2016 for the 2013–2014 Pacific Power Washington (PPW) "See ya later, refrigerator®"[44] Program evaluation, conducted by The Cadmus Group. The RTF conducted an examination of the differences between the existing and UMP methods back in 2011, and although the recommendation based on this comparison was to implement the UMP

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42 While the Pacific Power Washington regression was used to estimate the UEC, PSE specific weather data was used for the HDD and CDD terms in the regression thereby adjusting it to make it representative of local weather conditions.

43 http://www.energy.gov/sites/prod/files/2013/11/f5/53827-7.pdf

44 Source: https://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Demand_Side_Management/2016/SYLR_2013-2014_Washington_Final_Report.pdf

method, a last-minute decision was made to stick with the existing method since "the difference in savings is miniscule and (it will be updated in a year and a half)". This update would have occurred in July 2014 and so would have been too late for the 2014 and 2015 programs. The evaluation team did notice that the 2016 UES is the same as the 2015 UES indicating the RTF did not adopt the UMP method as originally planned in 2014. The evaluation team recommends PSE follow up with the RTF to determine why the UES for this measure was not updated using the recommended UMP methodology.

The UEC regression specifications per the PPW study are:

Existing Refrigerator UEC = Intercept + β_1*Age + β_2*Pre-1990 + β_3*Size + β_4*Single Door + β_5*Side-by-Side + β_6*Primary Unit + β_7*Uncond_HDD + β_8*Uncond_CDD

Existing Freezer UEC = Intercept + β_1*Age + β_2*Pre-1990 + β_3*Size + β_4*ChestFreezer + β_7*Uncond_HDD + β_8*Uncond_CDD

Where:

Age	= Age of retired unit
Pre-1990	= Pre-1990 dummy (1 if manufactured pre-1990, else 0)
Size	= Capacity (cubic feet) of retired unit
Single Door	= Single-door dummy (1 if single-door, else 0)
Side-by-Side	= Side-by-side dummy (1 if side-by-side, else 0)
Primary Unit	= Primary usage (in absence of the program) dummy (1 if primary, else 0)
Chest Freezer	= Chest freezer dummy (1 if chest freezer, else 0)
Uncond_HDD	= Unit located in unconditioned space interacted with HDDs
	= 1 * HDD/365.25 if in unconditioned space, else 0
HDD	= Heating Degree Days (dependent on location)
Uncond_CDD	= Unit located in unconditioned space interacted with CDDs
	= 1 * CDD/365.25 if in unconditioned space, else 0
CDD	= Cooling Degree Days (dependent on location)

TABLE 4-2: HEATING AND COOLING DEGREE DAY ESTIMATES USED IN UEC REGRESSION

Climate Zone (City based upon)	SEA-TAC AIRPORT[45]	Source
HDD 65	4,697	National Climatic Data Center, calculated from 1981-2010 climate normals with a base temp of 65°F.
HDD/365.25	12.86	
CDD 65	189	
CDD/365.25	0.52	

The UEC regression coefficients per the PPW study are:

TABLE 4-3: UEC REGRESSION COEFFICIENT ESTIMATES FOR DECOMMISSIONED REFRIGERATORS AND FREEZERS

Independent Variable	Refrigerator Coefficient (βx)	Freezer Coefficient (βx)	Source
Intercept	0.805	-0.955	Pacific Power Washington See ya later, refrigerator® Program, 2013–2014 Evaluation Report
Age (Years)	0.021	0.045	
Pre-1990	1.036	0.543	
Size (Cubic Feet)	0.059	0.12	
Single Door	-1.751	n/a	
Side-by-Side	1.12	n/a	
Primary Unit	0.56	n/a	
Chest Freezer	n/a	0.298	
Uncond_HDD	-0.04	-0.031	
Uncond_CDD	0.026	0.082	

The UEC for recycled refrigerators and freezers was calculated using the coefficients (βx) provided in Table 4-3, program tracking data, and participant survey data. While several of the variables needed for the regression were not included in the tracking database, the evaluation team obtained them from PSE through a separate data request.

The refrigerator existing UEC was adjusted from 1,274 kWh in the ex-ante calculation to 1,137 kWh (an 11% reduction) in the ex-post calculation as a result of employing the UMP methodology to estimate the existing UEC based on actual data on the units recycled.

[45] Olympia Airport, Anacortes, Bremerton, and Bellingham Airport weather stations were also assessed to test the sensitivity of the results based on utilizing the Sea-Tac Airport weather station. The evaluation team found that the UEC for refrigerators decreased by 0.3% to 1.6% and the UEC for freezers decreased by 0.7% to 3.1% when using these other weather stations indicating the UEC is insensitive to utilizing a single weather station.

- **Ex-Ante Estimate:** 1,274 kWh for the existing UEC was used in the 2015 RTF deemed UES estimate. The source provided for this number was the average UEC of recycled units in 2012-2013 JACO data (adjusted using C-Factor to account for increase in efficiency).
- **Ex-Post Estimate:** 1,137 (+/- 11)[46] kWh for the existing UEC was calculated using the regression coefficients from the 2013–2014 Pacific Power Washington "See ya later, refrigerator®" Program evaluation, 2015 tracking data, and data collected from participant surveys.

The freezer existing UEC was adjusted from 1,509 kWh in the ex-ante calculation to 941 kWh (38% reduction) in the ex-post calculation as a result of employing the UMP methodology to estimate the existing UEC based on actual data on the units recycled.

- **Ex-Ante Estimate:** 1,509 kWh existing UEC was used in the 2015 RTF deemed UES estimate. The source provided for this number was the average UEC of recycled units in 2012-2013 JACO data (adjusted using C-Factor to account for increase in efficiency).
- **Ex-Post Estimate:** 941 (+/- 19) kWh existing UEC was calculated using the regression coefficients from the 2013–2014 Pacific Power Washington "See ya later, refrigerator®" Program evaluation, 2015 tracking data, and data collected from participant surveys.

Standard Efficiency UEC for Replaced Units

The refrigerator UEC for a new, standard efficiency unit was adjusted from 523 kWh in the ex-ante calculation to 534 kWh in the ex-post calculation.

- **Ex-Ante Estimate:** 523 kWh was used as the UEC for a new, standard efficiency unit in the 2015 RTF deemed UES estimate. The source provided for this number was JACO data, RTF Residential Refrigerator Measure Workbook v3.0, and the RBSA refrigerator distribution.
- **Ex-Post Estimate:** 534 kWh for the standard efficiency UEC was calculated from the Energy Star website[47] based on door configuration, age, and capacity.

The freezer UEC for a new, standard efficiency unit was adjusted from 500 kWh in the ex-ante calculation to 485 kWh in the ex-post calculation.

- **Ex-Ante Estimate:** 500 kWh was used as the UEC for a new, standard efficiency unit in the 2015 RTF deemed UES estimate. The source provided for this number was the 2001 NAECA Federal Standard.

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[46] The 90% Confidence Intervals on the ex-post estimate provided are in parentheses after the estimate whenever possible.

[47] https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

- **Ex-Post Estimate:** 485 kWh for the standard efficiency UEC was calculated from the Energy Star website[48] based on door configuration, age, and capacity.

Part-Use Factor

The refrigerator Part-Use Factor was adjusted from 91% in the ex-ante calculation to 90% in the ex-post calculation.

- **Ex-Ante Estimate:** A 91% Part-Use Factor was used in the 2015 RTF deemed UES estimate for refrigerators. This estimate was a weighted Part-Use Factor from three regional studies (Avista, 2011; CADMUS, PacifiCorp ID, 2011-2012; CADMUS, PacifiCorp WA, 2011-2012).
- **Ex-Post Estimate:** A 90% (+/- 2.9%) ex-post Part-Use Factor was calculated based on self-reported data collected via the Refrigerator Decommissioning participant web surveys. While this ex-post estimate is not statistically different from the ex-ante estimate, it was used to calculate the UES as it is the best data available.

The freezer Part-Use Factor was adjusted from 91% in the ex-ante calculation to 86% in the ex-post calculation.

- **Ex-Ante Estimate:** A 91% Part-Use Factor was used in the 2015 RTF deemed UES estimate for Freezers. This estimate was a weighted Part-Use Factor from three regional studies (Avista, 2011; CADMUS, PacifiCorp ID, 2011-2012; CADMUS, PacifiCorp WA, 2011-2012).
- **Ex-Post Estimate:** An 86% (+/- 4.3%) ex-post Part-Use Factor was calculated based on self-reported data collected via the Freezer Decommissioning participant web surveys.

Disposition of Decommissioned Unit in the Absence of the Program

Table 4-4 presents the ex-ante and ex-post estimates of the decommissioned refrigerator and freezer disposition in the absence of the program.

[48] https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

TABLE 4-4: UNIT DISPOSITION IN THE ABSENCE OF THE PROGRAM

Measure	If the Program Did Not Exist We Would Have:	2015 RTF Deemed Estimate	Participant Web Survey Results
Refrigerator	Kept the refrigerator	7%	13%
	Sold or donated the refrigerator (transfer)	55%	45%
	Disposed of the refrigerator (destroy)	38%	42%
	Replaced the refrigerator	75%	71%
	Not replaced the refrigerator	25%	29%
Freezer	Kept the freezer	13%	8%
	Sold or donated the freezer (transfer)	53%	52%
	Disposed of the freezer (destroy)	34%	40%
	Replaced the freezer	75%	61%
	Not replaced the freezer	25%	39%

Source: RTF and Evaluation Team Analysis of participant web survey self-reported data

- Kept, sold/donated, and disposed of units
  - **Ex-Ante Estimate:** based on the weighted average from four northwest refrigerator program studies.[49]
  - **Ex-Post Estimate:** based on 2014 and 2015 participant web survey self-reported results.
- Replaced units
  - **Ex-Ante Estimate:** source not provided.
  - **Ex-Post Estimate:** based on 2014 and 2015 participant web survey self-reported results.

Replacement Outcome/Induced Replacements

Table 4-5 presents the ex-ante and ex-post estimates of the percent of program induced replacements for refrigerators and freezers. The ex-ante percent of program induced replacements was estimated based on the average from two northwest refrigerator program studies.[50] The ex-post percent of program induced replacements was estimated based on self-reported data collected via several questions from the refrigerator and freezer rebate participant web surveys.

[49] Avista, 2010-2011, Cadmus report page 25; ETO, 2011, Fast track Feedback final report 2011; Rocky Mountain Power Idaho SYL, Refrigerator Program Evaluation Report 2011-2012; Pacific Power Washington SYL, Refrigerator Program Evaluation Report 2011-2012

[50] Rocky Mountain Power Idaho SYL, Refrigerator Program Evaluation Report 2011-2012; Pacific Power Washington SYL, Refrigerator Program Evaluation Report 2011-2012

TABLE 4-5: PERCENT OF PROGRAM INDUCED REPLACEMENT

Measure	2015 RTF Deemed Estimate (Ex-Ante)	Participant Survey Results (Ex-Post)
Refrigerator	6%	12%
Freezer	6%	14%

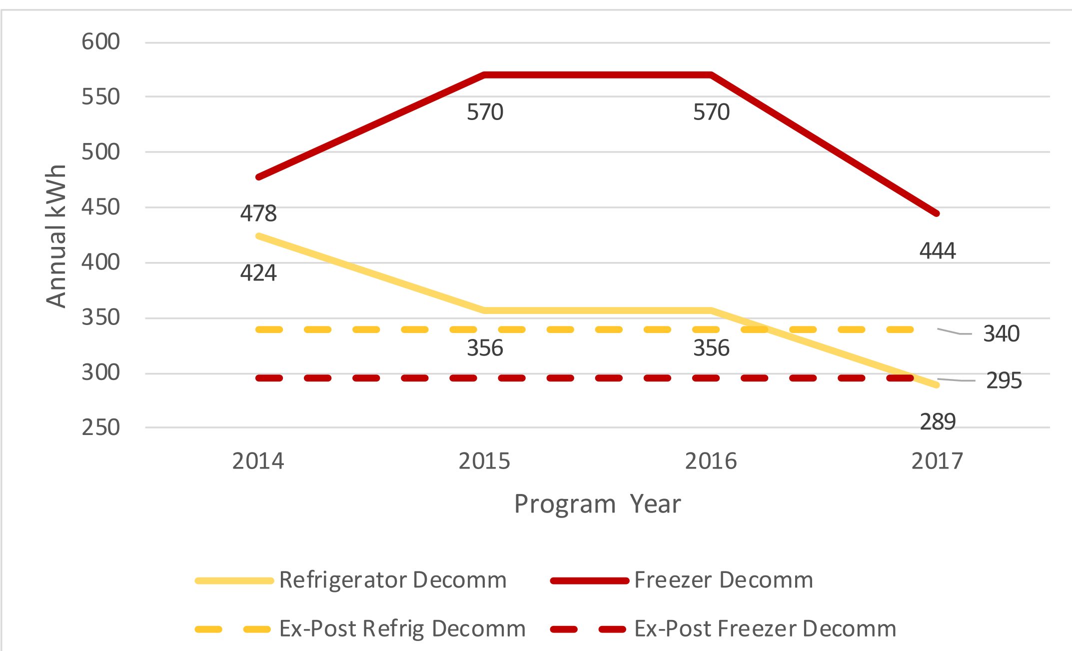
Source: RTF and Evaluation Team Analysis

4.3.2 Ex-Post Savings Estimate

Applying the ex-post UES adjustments described above, the ex-post UES estimate for refrigerators decreases by 16 kWh, to 340 kWh (95% realization rate when compared to the ex-ante estimate) and for freezer it decreases by 275 kWh, to 295 kWh (52% realization rate).

Figure 4-2 below compares the RTF deemed UES estimates for program years 2014 to 2017 to the ex-post UES estimate derived by the evaluation team. As this figure shows, the 2017 RTF deemed UES estimates for refrigerator and freezer decommissioning decreased from the 2015 and 2016 deemed estimates, and the ex-post freezer estimate is below even the 2017 UES value. The evaluation team recommends that PSE review the 2017 UES deemed estimates based on these ex-post findings and make any adjustments necessary to the deemed parameters to improve the deemed UES for future program years.

FIGURE 4-2: REFRIGERATOR AND FREEZER DECOMMISSIONING SAVINGS (KWH) BY YEAR



4.4 APPLIANCE DECOMMISSIONING PROCESS ANALYSIS

The process analysis for the Appliance Decommissioning Program sought to answer the process-related questions laid out in the introduction:

- **Program Theory and Changes:** How have the Appliance Decommissioning Programs changed over time? Is this well-documented?
- **Data Tracking:** What data are currently being collected to support the Appliance Decommissioning Programs and how is this data being used? And what additional research is needed for each program area?
- **Awareness:** How aware are residential customers of the Appliance Decommissioning Program offerings and what channels are most effective to increasing awareness?
- **Demographics of Participation:** Who is currently participating in the Appliance Decommissioning Programs (demographically)?
- **Participant Satisfaction:**[51] What is the level of residential participant and satisfaction with the Appliance Decommissioning Program processes, and what areas of improvement exist?
- **Best Practices and Opportunities:** Are the Appliance Decommissioning Programs following industry best practices? How do they benchmark against industry best practices for program theory and design, program management, reporting and tracking of energy savings, quality control, program processes, and marketing and outreach? Where may additional opportunities lie?

4.4.1 Program Theory and Changes

While the Program Theory for the Decommissioning Program is not explicitly laid out in a program theory and logic model, all PSE programs are described in annual and biennial plans and reports and changes are documented in the annual businesses cases. In general, PSE's programs are well-established and have an understood theory, but for the Appliance Decommissioning program, there are threats to the model that should be kept in mind.

- Threats to stability of the decommissioning/recycling business model currently exist due to the decline in the price of scrap metal. This has caused some vendors to exit the market, as they can no longer afford to implement such programs under the existing terms. PSE experienced this with the changeover of program implementers (from JACO to ARCA) in late 2015.

[51] Note that the Appliance Programs look at participant satisfaction rather than trade ally satisfaction.

- PSE should continue to closely monitor the situation via conversations with their program vendor and other market intelligence. In the future, PSE may be required to research alternative program designs to ensure they are able to find vendors who can make a business case that supports implementing this important energy saving program.

The Appliance Decommissioning Program relies on a team effort, with several organizations playing a key role in the program delivery. For this program, there are six groups, including:

- PSE program management and staff that oversee the program
- PSE marketing, which conducts all marketing of the program
- PSE market research, which collects feedback from Appliance Decommissioning participants on a rolling basis
- The program implementer (ARCA, formerly JACO), that provides services on behalf of PSE to support this program
- The Leave Behind kits vendor (TechniArt), which provides the implementer with Leave Behind kits for Appliance Decommissioning participants
- The rebate processing firm (Black Hawk) that provides rebates to customers

Each of these groups plays a role in the program delivery and implementation, and collects data that contributes to the program's success, as shown in the figure below.

FIGURE 4-3: APPLIANCE DECOMMISSIONING ROLES*

	ARCA	TechniArt	Black Hawk	PSE Marketing	PSE PM and staff
Roles	Schedules, picks up and recycles appliances	Provides "Leave Behind" kits to ARCA	Performs QA/QC on data entry; pays customer	Implements satisfaction survey of customers with email	Oversees all processes; approves invoices
Data	Participant, unit, and kit distribution data	Kit data	Payments to customers and vendors	Follow up survey data	Customer and billing data

* Note that these roles have been simplified. More details on each of the roles are available from PSE's program management staff.

Over time, the program has updated savings and measure life assumptions for refrigerator and freezer decommissioning due to updates in the RTF. The program also updated measure costs. These changes are documented in the 2014-2015 Business Case. The program also continues to evolve, with additional changes documented in the 2016-2017 Direct-To-Consumer Business Case.

4.4.2 Data Tracking

Stage 1 of the evaluation reviewed program tracking data, applications, and invoices, and found the Appliance Decommissioning Program is collecting sufficient data to be able to document the accomplishments of the program, but there is room for some improvements. During the verification of the data, the evaluation team found that the 2015 tracking data for the Appliance Decommissioning Program were fairly comprehensive, however did not contain all variables needed to evaluate the program using the recommended methods outlined in the Uniform Method Project (UMP) protocols. There were also a few other data tracking data issues.

- Missing Variables – a number of variables pertaining to the unit being recycled (such as age, door configuration, size in cubic feet, and installation location) were missing from PSE's Appliance Decommissioning tracking data. Many of these missing variables were being collected by the program implementers but were not being retained within the PSE tracking database. While not required to ensure effective program implementation, PSE may want to request this data in the future since this it is needed (for program planning and evaluation) to fully understand the energy saving impacts of the program. Additionally, retaining the account number and email address for all participants would aid in any follow up with customers and would allow a better assessment of cross-program participation.
- Data Discrepancies - There were small discrepancies with duplicate records, missing data, and misaligned UES estimates for the Leave Behind kits distributed to Decommissioning participants. These do not appear to be persistent issues (most likely just confined to the 2014-2015 period) but continuous QA/QC of data tracking can help identify and remove duplicate records and ensure that there is no missing data.
- Mismatched Emails - The evaluation team identified a problem with mismatched email addresses in the tracking database (i.e. some of the email addresses seem to be appended to the wrong records in the database). The source of this error was not identified but QA/QC going forward and a review of the process of entering emails into the database can ensure it is not a problem in the future.

Since the initial review of the data, PSE has worked with the evaluation team to document the types of data that should be collected by each of the key players in the program delivery to ensure success for the future. A full mapping of the data that should be collected by each of the key group is included in Appendix H.

4.4.3 Awareness of Programs

Among PSE's residential customers, 40% are aware that PSE offers an Appliance Decommissioning program (based on the General Population survey). Awareness of this program is low compared to the other DtC programs, but part of this might be because it targets only customers who are replacing refrigerators or freezers—not necessarily all PSE customers.

In general, marketing and outreach has been a strong focus for PSE over the 2014-2015 period, as documented in PSE's planning and reporting. PSE conducts the marketing of this program, and ARCA (the primary implementer) focuses on support and fulfilment services. While ARCA is not used for marketing, it should be noted that they do help with marketing in other jurisdictions. In their own words, they are "very aggressive" with marketing and could support PSE in this area, if needed.

Our evaluation did not explore all of the ways in which program participants heard about the program since the PSE market research group has ongoing data collection efforts to understand how participants hears about the program, but the majority of survey respondents learned about the program prior to purchase. Among survey respondents:

- **For refrigerators:** 17% recall seeing or hearing about the program in the store where they purchased their new refrigerator.
- **For freezers**: 14% recall seeing or hearing about the program in the store where they purchased their new freezer.

Cross-Marketing: Awareness of All DtC Programs

Generally, there appears to be cross-marketing of programs. Among participants in the Appliance Decommissioning program, awareness of PSE's Lighting, Showerhead, and Appliance Rebate Programs were quite high (mid- to high-80% range). Overall, customers who fell into the general population (not specifically program participants), had significantly lower awareness of PSE's energy efficiency (EE) programs than participants across the board, indicating that customers who participate in one of PSE's EE programs are more likely to be aware (possibly due to cross marketing on the part of PSE) of the other EE programs available to them. Part of this may have resulted from program materials included in the Leave Behind kit given to program participants that included efficient light bulbs and showerheads.

Similar to findings among the general population of customers, awareness of ShopPSE was much lower (37-41%) among Appliance Decommissioning participants; but these participants were more aware of ShopPSE than the general population (27% among the general population). There may, however, be an opportunity to expand the marketing of this online channel within the Leave Behind kit materials.

TABLE 4-6: AWARENESS OF RESIDENTIAL DTC PROGRAMS, PARTICIPANTS VERSUS GENERAL POPULATION

Awareness of Other Residential Programs	Decommissioning Participants		All Participants*	General Population
	Refrigerator	Freezer		
Lighting Program	82%	84%	86%	50%
Appliance Rebate Program	86%	85%	85%	47%
Heating Rebate Program	74%	75%	73%	42%
Decommissioning Program	-	-	64%	40%
Showerhead Program	85%	89%	83%	37%
ShopPSE Website	37%	41%	45%	27%
CW Replacement Program	44%	48%	49%	23%
N	269	134	1,194	640

4.4.4 Demographics of Appliance Decommissioning Participants

Participants in the Decommissioning Program tend to be home owners who live in single-family detached homes, as would be expected since these populations are more likely to own their refrigerators and freezers. Participants who recycled freezers are even more likely to live in a single-family detached home, which tend to be larger and have more room for a stand-alone freezer unit.

- Demographics of the Refrigerator Decommissioning surveyed participants:
  - 95% own their home.
  - 89% live in a single-family detached home.
- Demographics of the Freezer Decommissioning surveyed participants:
  - 94% own their home.
  - 93% live in a single-family detached home.

The participant web surveys also collected additional details that may be useful for the program team. This includes the following refrigerator decommissioning survey responses:

- 49% of the recycled refrigerators were being used as the primary unit before participating in the program, 44% were secondary units and 7% were being stored unplugged. Units that are stored unplugged for most the year (accounted for in the part-use factor described in the impacts section above) result in significantly lower savings.

When asked about the main reasons for getting rid of the refrigerator or freezer:

- For refrigerators, 45% of respondents said the refrigerator was old, 33% said they wanted something more efficient, and 19% said it was expensive to run. Other reasons mentioned were: the appliance was a spare that was not used very much, they wanted something with more modern features, they wanted a different size appliance, it stopped working or was not working properly, they were moving or remodeling, and they bought or acquired a better one.

- For freezers, 58% of respondents said the freezer was old, 36% said they wanted something more efficient, and 23% said it was expensive to run. Other reasons mentioned were: the appliance was a spare that was not used very much, they wanted something with more modern features, they wanted a different size appliance, it stopped working or was not working properly, they were moving or remodeling, and they bought or acquired a better one.

4.4.5 Participant Satisfaction

Participant satisfaction with the Decommissioning Program is extremely high. Overall 93-96% of Decommissioning participants reported they were somewhat or extremely satisfied with the program, with only 1-3% being dissatisfied. The primary reasons reported for dissatisfaction by participants was that the rebate they received was too small or was never received. The Decommissioning and Replacement programs received more "Extremely Satisfied" rankings than the Rebate programs.[52]

TABLE 4-7: SATISFACTION WITH THE DTC PROGRAM

Satisfaction with the Program	Decommissioning Participants		All DtC Participants
	Refrigerator	Freezer	
Extremely Satisfied	79%	82%	68%
Somewhat Satisfied	14%	14%	23%
Neutral	4%	3%	7%
Somewhat Dissatisfied	1%	0%	1%
Extremely Dissatisfied	2%	1%	1%
N	265	133	1,036
Mean Ranking	4.7	4.8	4.6

Participant satisfaction with the program is higher than satisfaction with PSE. Participant satisfaction with PSE is also much higher than that of the general population. Table 4-8 shows that approximately 80% of participants reported they were satisfied with PSE (extremely or somewhat). The mean satisfaction ranking across refrigerator participants was 4.2, just slightly higher than for freezer participants (4.1). The primary reasons reported by participants for dissatisfaction with PSE were related to rates being too high (48%), poor customer service (20%), or power outages (9%).

52 The percent of decommissioning and replacement participants who provided a satisfaction score of 5 (extremely satisfied) was 77.6% (+/- 3.0%), compared to 58.1% (+/- 3.7%) of the rebate participants. This difference is statistically significant.

TABLE 4-8: CUSTOMER SATISFACTION WITH PSE OVERALL

Satisfaction with the Program	Decommissioning Participants		All DtC Participants	General Population
	Refrigerator	Freezer		
Extremely Satisfied	43%	43%	40%	25%
Somewhat Satisfied	39%	36%	40%	43%
Neutral	12%	15%	14%	24%
Somewhat Dissatisfied	4%	5%	5%	5%
Extremely Dissatisfied	3%	2%	2%	3%
N	267	134	1,183	655
Mean Ranking	4.2	4.1	4.1	3.8

Most participants in the Appliance Decommissioning Program stated that their satisfaction with PSE was unchanged by their participation in the program, however roughly one-third of reported it increased their satisfaction with PSE. Very few respondents (3% for those who decommissioned a refrigerator, 0% for freezers) indicated that their level of satisfaction decreased after their program participation. The reasons reported for a decline in satisfaction were similar to the reasons reported for dissatisfaction with PSE reported above (rates were too high, rebate was never received or was too small, and poor customer service).

TABLE 4-9: CHANGE IN SATISFACTION WITH PSE POST-PROGRAM PARTICIPATION

Change in Satisfaction with PSE Post Program Participation	Decommissioning Participants		All DtC Participants
	Refrigerator	Freezer	
Higher	37%	30%	32%
About the Same	59%	68%	65%
Lower	3%	0%	2%
Don't Know	1%	2%	1%
N	265	132	1,041

4.4.6 Leave Behind and Thank You Kits

Participants in the Appliance Decommissioning Program also received a Leave Behind kit, which included LEDs and showerheads. These kits are distributed to increase customers' exposure to new products, and to garner additional energy and water savings. Based on an analysis of all Leave Behind and Thank

You kit respondents,[53] we found that many already had experience with the measures, but that the exposure was new for some participants:

- A majority of respondents who received a kit were actively purchasing LED bulbs prior to receiving the kit.
  - 73% of participant respondents purchased or installed an LED bulb in their home prior to receiving an LED through the kit.
  - 77% of participant respondents purchased an LED bulb after receiving an LED through the kit.
- 50% of survey respondents that received a showerhead in their kit said they had purchased or installed a water saving showerhead prior to receiving a showerhead through the program.

Most also installed the measures. Additional details on the installation of the measures, which may be useful to program managers, include:

- 75% of survey respondents said that the LED bulbs that didn't get installed or were removed were in storage, another 13% said they threw them away.
  - 52% of survey respondents said the LEDs were not installed because they didn't need them, 29% never got around to installing them, 8% didn't like them, and 4% broke.
  - 38% were removed because they burnt out, 31% didn't like the bulb, 25% burned out.
- LED bulbs provided in the kits are mainly being installed inside the home (96%). Very few were installed in an outdoor location (4%).
- 13% of the showerheads in the kits were never installed and 4% were removed. 54% are in storage, 32% were given away, 8% were installed in another location, and 3% were thrown away.
  - 52% of survey respondents that never installed the kit showerhead said it was because they didn't need it, another 18% didn't like the look/fit, 16% were concerned about water pressure, and 12% just never got around to installing it.
  - 50% of survey respondents that removed the kit showerhead said it was because of water pressure issues, 20% didn't need it, 15% didn't like the look/fit, and 10% reported it broke.

[53] Thank You kits are a different kit that is sent to Appliance Rebate participants. For the purposes of this analysis, however, we combined all data to report results from all kit recipients.

4.4.7 Best Practices and Opportunities

The DtC were compared to six best-practice areas identified within the National Energy Efficiency Best Practices Study[54] in order to identify program strengths, areas for improvement, and strategies for improving them. These included: (1) program theory and design, (2) program management, (3) reporting and tracking of energy savings, (4) quality control, (5) program processes, and (6) marketing and outreach. This program seemed to meet best practices in most areas. Additional opportunities for this program include:

- Improving data tracking through minor adjustments described above,
- Increased marketing to attract new customers, potentially relying more on ARCA to help reach additional customers, and
- Continued monitoring of the viability of the program given changes in the scrap metal markets.

4.5 APPLIANCE DECOMMISSIONING PROGRAM FINDINGS AND RECOMMENDATIONS

The evaluation team provides the following findings and recommendations for PSE's Appliance Decommissioning Program.

Finding AD1: In 2011, the RTF conducted an examination of the differences between the using the existing RTF methodology and the methodology recommended within Uniform Methods Product (UMP) to estimate the UEC of recycled refrigerators and freezers. The recommendation based on this comparison was to implement the UMP method as it was more robust and represented industry standard practices, however a last-minute decision was made to stick with the existing methodology for the time being as the "the difference in savings is miniscule" and the UES was due to be updated in a year. This update should have occurred in July 2014 (making it too late for PSE's 2014 and 2015 program planning and UES deeming), early enough to go into place for the 2016 program year. The evaluation team reviewed the 2016 UES and found it is the same as the 2015 UES and thus the methodology still has not transition to the UMP recommended methodology.

Recommendation AD1: PSE should research why the RTF has not transitioned the UES algorithm for appliance recycling programs to use the UMP methodology for estimating the UEC of a recycled unit.

[54] http://www.eebestpractices.com/ The goal of the study was to develop and communicate national excellent practices, built off the experience and knowledge gained through 25 years of program implementation, to enhance the design, implementation, and evaluation of energy efficiency programs.

The UMP methodology is the preferred methodology as it is more accurate as it utilizes actual program tracking data to estimate the UEC of the units recycled through the program.

Finding AD2: The participant survey conducted through this evaluation found that the part-use factor and the disposition of the decommissioned units in the absence of the program (90% for refrigerators and 86% for freezers) were slightly different from the estimates used in the RTF deemed calculation (91% for refrigerators and freezers).

Recommendation AD2: Consider creating a PSE deemed UES for the Appliance Decommissioning Program that utilizes PSE-specific part-use factors and decommissioned unit dispositions for future program years. These parameters could come from evaluation based research or could be estimated from questions on the Decommissioning market research surveys that are emailed to all program participants soon after their participation in the program.

Finding AD3: The evaluation team found that the 2015 tracking data for the Appliance Decommissioning Program were fairly comprehensive, however did not contain all variables needed to evaluate the program using the recommended methods outlined in the Uniform Method Project (UMP) protocols. Many of these missing variables were being collected by the program implementers but were not being retained in the tracking database.

Recommendation AD3: The evaluation team recommends that the following variables be added to the tracking database regarding the unit recycled: door configuration, size, age, installation location, and house type.[55] Also, retaining the account number and email address for all participants would allow for web-based follow up with customers as well as a better assessment of cross-program participation.

Finding AD4: The evaluation team identified a problem with mismatched email addresses in the tracking database (i.e. some of the email addresses seem to be appended to the wrong records in the database).

Recommendation AD4: The evaluation team recommends that PSE review the process of entering email addresses into the tracking database. This will help identify how this problem occurred and what can be done to ensure that it doesn't happen in future program years.

Finding AD4: Awareness of ShopPSE was low (37-41%) amongst Appliance Decommissioning participants.

Recommendation AD4: The evaluation team recommends that PSE consider expanding the marketing of this online channel within the Leave Behind kit materials.

[55] Per PSE, this is being tracked beginning in 2017.

5 APPLIANCE REPLACEMENT PROGRAM

In 2014 and 2015, PSE's Appliance Replacement Programs provided free replacement clothes washers and refrigerators to PSE residential electric customers who resided in single family or manufactured homes and had a working clothes washer or refrigerator installed in their home that was manufactured in 1997 (clothes washer)/1992 (refrigerator[56]) or earlier. The goal of this program is to encourage customers to remove and safely dispose of old inefficient appliances. PSE coordinates the free pickup of the old unit from participants' homes and provides a new, more efficient replacement unit. In 2014 and 2015 this program also distributed high efficiency light bulbs and showerheads via no-cost kits given to program participants at the time the unit was replaced. Overall, the Appliance Replacement Program makes up a small percentage of the DtC portfolio, accounting for only 4% of the DtC reported ex-ante electric savings (excluding savings from kit measures).

5.1 CLOTHES WASHER REPLACEMENT EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the clothes washers replaced through PSE's Appliance Replacement Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), in-depth reviews of program tracking databases, and web surveys of both program participants and PSE residential customers. Per PSE, this program is to be discontinued in 2018.

Table 5-1 below presents a comparison of the PSE deemed, evaluation verified, and evaluation ex-post unit energy savings (UES) estimates and realization rates for the 2015 Clothes Washer Replacement Program. The evaluation team verified the quantity of clothes washers replaced through the program was accurate and the PSE deemed UES estimate was applied correctly (resulting in a 100% verified realization rate). The ex-post realization rate for Clothes Washer Replacement was 89% as a result of ex-post changes to the following parameters included in the UES algorithm:

- Number of annual loads washed – This parameter decreased from 256 to 226 loads based on data collected from participants during the web surveys.
- Rated Unit Energy Consumption (UEC) of the replacement units decreased from 159 to 130 kWh. 130 kWh was the average UEC of the replacement units in the 2015 tracking data.

[56] The refrigerator program also required that the old unit must be the primary refrigerator installed in their kitchen.

- Percent of loads dried in the clothes dryer – This parameter decreased from 100% to 94.2% based on data collected from participants during the web surveys.
- Capacity of the replacement clothes washer increased from 3.64 to 3.81 cubic feet. 3.81 cubic feet was the average capacity of the replacement units in the 2015 tracking data.
- Modified Energy Factor (MEF) of the replacement clothes washer increased from 2.48 to 2.51. 2.51 was the average MEF of the replacement units in the 2015 tracking data.

Additional details on the ex-post UES estimates and realization rates are provided in Section 5.3 below.

TABLE 5-1: 2015 CLOTHES WASHER REPLACEMENT UES ESTIMATES (KWH)

Replacement Measure	PSE Deemed UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
Clothes Washer	764	764	100%	681	89%

Source: Evaluation Team Analysis

Results of the process analysis and overall findings and recommendations for the Appliance Replacement program are provided in the sections below.

5.2 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of two components. The first component was a review of program tracking and invoice data to verify the volume of units sold through the program. The second component was a review of calculation and application of the deemed unit energy savings (UES) estimates applied.

5.2.1 Tracking and Invoice Data Review

The tracking data review for the Clothes Washer Replacement Program found that overall the tracking data unit and savings totals matched the ex-ante estimates for the clothes washers and only differed with respect to the UES values assigned to the LEDs distributed to 2015 program participants via Leave Behind Kits. The tracking data indicated that the LEDs were assigned a UES of 13.48 kWh (the 2014 deemed value) rather than 16.02 kWh (the 2015 deemed value). This resulted in a slight underestimation of reported ex-ante savings claimed for the LEDs provided in the Leave Behind Kits (underestimated by 10,345 kWh[57]), however due to the small magnitude of the LED savings relative to the clothes washer replacement savings the realization rate for the 2015 program was 100%. Issues

[57] This value is for the whole Appliance Replacement Program, which included clothes washers and refrigerators in 2015. The Refrigerator Replacement Program results are presented in the next chapter.

related to missing, duplicative or misaligned data are discussed within the process section of this chapter.

5.2.2 UES Algorithm

The algorithm used to estimate the 2015 PSE deemed UES for Clothes Washer Replacements is:

Annual kWh Savings = Baseline kWh consumption - Measure kWh consumption

Where the kWh consumption of the Baseline and energy-efficient (Measure) units are calculated as the sum of three components:

> $\mathbf{UEC_{CW}}$ = the energy consumption (kWh) of the clothes washer attributable to the clothes washer primary functions (agitating, spinning, etc.)
>
> $\mathbf{UEC_{WH}}$ = the energy consumption (kWh) attributable to electric water heating, and
>
> $\mathbf{UEC_{CD}}$ = the energy consumption (kWh) related to electric clothes drying
>
> **kWh Consumption** = $UEC_{CW} + UEC_{WH} + UEC_{CD}$

The equations used to calculate each of these energy consumption components are the following:

$\mathbf{UEC_{CW}}$ = %Savings_CW * AdjustedRatedUEC

Where:

> %Savings_CW = Percent of total Clothes Washer savings attributable to the Clothes Washer unit
>
> AdjustedRatedUEC = $RatedUEC_x$ * AnnualLoads / ReferenceLoads
>
> $RatedUEC_x$ = Rated UEC of Clothes Washer (if x = “b” then unit = baseline, if x = “m” then unit = measure)
>
> AnnualLoads = Average annual loads of clothes washed
>
> ReferenceLoads = Reference Loads to normalize the UEC

$\mathbf{UEC_{WH}}$ = %Savings_WH * AdjustedRatedUEC

Where:

> %Savings_WH = Percent of total Clothes Washer savings attributable to Water Heating
>
> AdjustedRatedUEC = defined above

$\textbf{UEC}_{\textbf{CD}}$ = (TotalElectricity - AdjustedRatedUEC) * %LoadsDried

Where:

TotalElectricity = CW_Capacity / MEF * AnnualLoads

CW_Capacity = Capacity of Clothes Washer (cubic feet)

MEF = Modified Energy Factor

AdjustedRatedUEC = defined above

%LoadsDried = Percent of loads dried in Clothes Dryer

5.2.3 Verified Savings

The UES review sought to comprehensively assess the 2015 PSE deemed UES. While the evaluation team recommends updates to the UES estimates for the clothes washer replacement measure in future program years, our conclusions from the assessment of the 2015 PSE deemed UES estimates is that the algorithm and parameter inputs are defensible, reproducible and were appropriate at the time they were deemed. As a result, no adjustments to the 2015 UES estimates were applied and a verified savings realization rate of 100% was calculated.

5.3 STAGE 2 EX-POST IMPACT ANALYSIS

5.3.1 Ex-Post UES Adjustments

In Stage 2 of the evaluation, web surveys were administered to clothes washer replacement participants to gather data to determine if ex-post adjustments to any UES parameters or assumptions are needed and to assess if the UES estimates are realistic for the participant population. For clothes washer replacement, this included estimating a first-year persistence rate, the average annual number of loads washed, and the average percent of loads dried. Tracking data was also used to adjust some ex-post UES parameters, including the rated UEC, the capacity, and the Modified Energy Factor (MEF) of the replacement clothes washer.

Unit Persistence

The 2015 PSE deemed UES estimate assumes that 100% of the units replaced through the program stay installed within the residential customer's home for the first year. The Stage 2 participant web surveys verified receipt of the replacement clothes washer and estimated a first-year persistence rate. All but one respondent said they received a clothes washer from PSE through the program. The one customer that didn't recall participating had a relatively new clothes washer, so the evaluation team assumed that the customer participated but did not recall doing so. Additionally, three participants who received a replacement clothes washer indicated they removed it within the first year. These three clothes washers were installed for an average of eight months in the first year, resulting in a persistence rate of 99.3% (+/- 0.8%).[58] A 100% persistence rate will be assumed for the ex-post impacts as the 90% CI on the persistence rate includes 100%. The respondent reported disposition of these three removed clothes washers were: it was moved to a location outside of PSE's service territory, it broke and was recycled, and the customer didn't like it so it was given away.

Annual Loads Washed

The number of annual loads washed was adjusted from 256 in the ex-ante calculation to 226 in the ex-post calculation.

- **Ex-Ante Estimate:** 256 loads washed per year was used in the 2015 PSE deemed UES estimate. The source of this number was the 2011 RBSA.
- **Ex-Post Estimate:** 226 (+/- 18.8) loads washed per year was calculated based on self-reported data collected via web surveys with 2014 and 2015 Clothes Washer Replacement participants.

Rated Unit Energy Consumption (UEC) for the Replacement Unit

The rated UEC for the replacement unit was adjusted from 159 kWh in the ex-ante calculation to 130 kWh in the ex-post calculation.

- **Ex-Ante Estimate:** the 2015 PSE deemed UES estimate used an average UEC value of 159 kWh for the replacement clothes washer. The source provided for this number was "EPA research on available models, 2011" with no additional information provided.
- **Ex-Post Estimate:** 130 kWh was the average UEC of replacement units per the 2015 tracking data. Rated UEC was not specifically provided in the 2015 tracking data, but the evaluation team used make and model number to look up the Rated UEC of the four replacement units. The evaluation team recommends that Rated UEC be added to the tracking database and reviewed each year to determine if an adjustment to the UES is warranted.

Percent of Loads Dried in Clothes Dryer

The percent of washed loads that were dried in participants' clothes dryers was adjusted from 100% in the ex-ante calculation to 94.2% in the ex-post calculation.

[58] The 90% Confidence Intervals on the ex-post estimate provided are in parentheses after the estimate whenever possible.

- **Ex-Ante Estimate:** the 2015 PSE deemed UES estimate assumed 100% of washed loads were dried in the participants' clothes dryer. This value was the Energy Star calculator default value.
- **Ex-Post Estimate:** 94.2% (+/- 1.9%) of washed loads dried in the participants' clothes dryer was estimated based on participant self-reports to the web survey. The Stage 1 UES review found that data to support this parameter was collected during the 2011 RBSA and the resulting percent dried was 90.2%. PSE should review the results of the current RBSA to see how well they align with the results of the participant web survey.

Capacity of the Replacement Clothes Washer

The capacity in cubic feet of the 2015 replacement clothes washers was assumed to be 3.64 in the ex-ante calculation and was increased to 3.81 for the ex-post calculation.

- **Ex-Ante Estimate:** the 2015 PSE deemed UES estimated assumed the average capacity of a replacement clothes washer was 3.64 cubic feet. This value was the Energy Star calculator default value.
- **Ex-Post Estimate:** 3.81 cubic feet was the average size of a replacement clothes washer based on 2015 program tracking data. The new unit's capacity was not provided in the 2015 tracking data, however the evaluation team used make and model number to look up the capacity of the four replacement units. The evaluation team recommends that capacity of the replacement unit be added to the tracking database and reviewed each year to determine if an adjustment to the UES is warranted based on changes to the replacement units being distributed.

Modified Energy Factor (MEF) of the New Clothes Washer

The MEF was adjusted from 2.48 in the ex-ante calculation to 2.51 in the ex-post calculation.

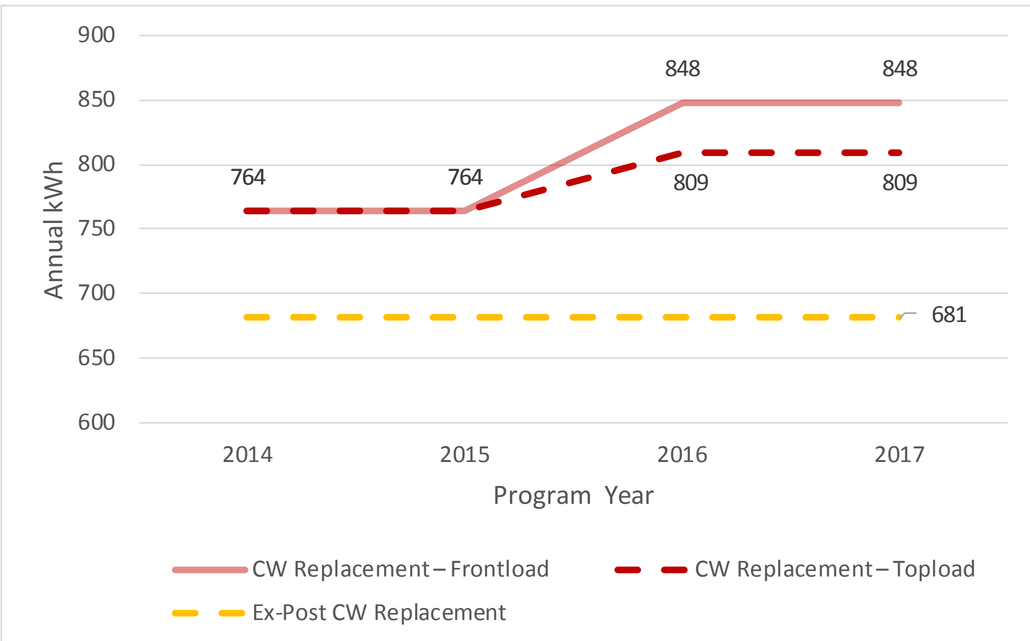
- **Ex-Ante Estimate:** the 2015 PSE deemed UES estimated assumed the average MEF of a replacement clothes washer was 2.48. The value was the default value in the Energy Star calculator.
- **Ex-Post Estimate:** 2.51 MEF was the average MEF of a replacement clothes washer based on the 2015 tracking data. Similar to the unit's capacity, the MEF was not provided in the tracking data, however the evaluation team used make and model number to look up the MEF of the four 2015 replacement units. The evaluation team recommends that MEF be added to the tracking database and reviewed each year to determine if an adjustment to the UES is warranted based on changes to the replacement units being distributed.

5.3.2 Ex-Post Savings Estimate

Applying the ex-post UES adjustments described above to the 2015 deemed UES calculation the ex-post UES estimate decreases by 83 kWh, to 681 kWh (89% realization rate when compared to ex-ante).

Figure 5-1 below compares the PSE deemed UES estimates for program years 2014 to 2017 to the ex-post UES estimate derived by the evaluation team. As this figure shows, in 2016 and 2017 the UES for clothes washer replacements has increased when compared to 2014 and 2015. PSE should review the 2016 and 2017 deemed UES algorithm to see if any of the parameters updated in the ex-post adjustments should be updated for future program years.

FIGURE 5-1: CLOTHES WASHER REPLACEMENT DEEMED UES 2014-2017 VS. EX-POST ESTIMATE (KWH)[59]



5.4 REFRIGERATOR REPLACEMENT EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the refrigerators replaced through the Appliance Replacement Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), and in-depth reviews of program tracking databases.

59 In 2014 and 2015 there was no distinction in savings for front versus top-loaders.

Table 5-2 below presents a comparison of the PSE deemed, evaluation verified, and evaluation ex-post unit energy savings (UES) estimates and realization rates for the 2015 Refrigerator Replacement Program. The evaluation team verified that the quantity of refrigerators replaced through the program was accurate and the PSE deemed UES estimates were applied per the 2015 Business Case. The UES algorithm for refrigerator replacements was verified to be 494 kWh for years 1-14 and 86 kWh for years 1-20 (the total savings in years 1-14 are the sum of the two savings estimates, 580 kWh) and thus a 100% verified realization rate was calculated. Because this program was discontinued at the end of 2016, the evaluation team conducted no ex-post research.

TABLE 5-2: 2015 REFRIGERATOR REPLACEMENT UES ESTIMATES (KWH)

Replacement Measure	PSE Deemed UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
Refrigerator (Years 1-14)	494	494	100%	n/a	n/a
Refrigerator (Years 1-20)	86	86	100%	n/a	n/a

Source: Evaluation Team Analysis

5.5 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of two components. The first component was a review of program tracking and invoice data to verify the volume of units sold through the program. The second component was a review of calculation and application of the PSE deemed unit energy savings (UES) estimates applied.

5.5.1 Tracking and Invoice Data Review

The tracking data review for the Refrigerator Replacement Program found that overall the tracking data unit and savings totals matched the ex-ante estimates for the refrigerators and only differed with respect to the UES values assigned to the LEDs distributed to 2015 program participants via the Leave Behind Kits and the number of units reported in 2014 and 2015.

The tracking data indicated that the LEDs were assigned a UES of 13.48 kWh (the 2014 deemed value) rather than 16.02 kWh (the 2015 deemed value). This resulted in a slight underestimation of reported savings claimed for the LEDs provided in the Leave Behind Kits (underestimated by 10,345 kWh[60]), however due to the small magnitude of the LED savings relative to the refrigerator replacement savings

[60] This value is for the whole Appliance Replacement Program, which included clothes washers and refrigerators in 2015. The Clothes Washer Replacement Program results are presented in the previous chapter.

the realization rate for the 2015 program was 100%. Issues related to missing, duplicative or misaligned data are discussed within the process section of this chapter.

5.5.2 UES Algorithm

The algorithm used to estimate the 2015 PSE Deemed UES for the Refrigerator Replacement Program was made up of the following two components:

1. Existing Unit Baseline Savings - this component utilizes the average existing unit UEC (the 1992 or older fridge) as the baseline for the savings during the remaining useful life (RUL) of the existing unit (which in 2015 was assumed to be 14 years). These savings are realized in years 1-14 after unit replacement.
2. Standard Efficiency Baseline Savings - this component utilizes the standard efficiency unit UEC as the baseline for the remainder of the new unit EUL (6 years).[61] These savings are realized in years 15-20 after unit replacement.

The algorithms used to estimate the 2015 PSE deemed UES for these two components were:

UES Years 1-14 = (UEC_Existing - UEC_New) – ElecHeatSat * SpaceCond_Inc

UES Years 15-20[62] = ((UEC_Standard - UEC_New) / (UEC_Existing - UEC_New)) * (UES Years 1-14)

Where:

UEC_Existing = Unit Energy Consumption of the existing unit that was replaced

UEC_New = Unit Energy Consumption of the new replacement unit

UEC_Standard = Unit Energy Consumption of a standard efficiency unit

ElecHeatSat = Electric Heating Saturation

SpaceCond_Inc = Increased kWh consumption due to the need for additional space conditioning (heat) due to the loss of heat from the old replaced unit.

[61] The EUL of the new unit was assumed to be 20 years. The RUL of the existing unit was assumed to be 14 years. Based on these two assumptions the RUL of the new unit that is subject to the standard efficiency baseline is 20 – 14 = 6 years.

[62] This algorithm effectively is applying the ratio of the difference between standard and new units and the existing and new units to the UES estimate for years 1 to 14 to estimate the reduced savings assume a standard efficiency baseline.

5.5.3 Verified Savings

The 2015 Refrigerator Replacement UES review found the deemed estimates to defensible, reproducible and appropriate at the time they were deemed. Because this program was discontinued at the end of 2016, the evaluation team conducted no ex-post research.

5.6 APPLIANCE REPLACEMENT PROCESS ANALYSIS

The process analysis for the Appliance Replacement Program sought to answer the process-related questions laid out in the introduction:[63]

- **Program Theory and Changes:** How have the Appliance Replacement Programs changed over time? Is this well-documented?
- **Data Tracking:** What data are currently being collected to support the Appliance Replacement Programs and how is this data being used? And what additional research is needed for each program area?
- **Awareness:** How aware are residential customers of the Appliance Replacement Program offerings and what channels are most effective to increasing awareness?
- **Demographics of Participation:** Who is currently participating in the Appliance Replacement Programs (demographically)?
- **Participant Satisfaction:** What is the level of residential participant and satisfaction with the Appliance Replacement Program processes, and what areas of improvement exist?
- **Best Practices and Opportunities:** Are the Appliance Replacement Program following industry best practices? How do they benchmark against industry[64] best practices for program theory and design, program management, reporting and tracking of energy savings, quality control, program processes, and marketing and outreach? Where may additional opportunities lie?

In addition, the evaluation team collected additional details on the measures and how customers were using these measures. This information is presented in bulleted form under “Other Detailed Findings” at the end of the process write-up.

In 2017 the program was updated to only focus on clothes washers given the limited opportunities with older refrigerators. As such, this process section focuses solely on replacement of clothes washers.

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[63] Note that the Appliance Programs do not work as closely as the lighting and showerhead programs with trade allies (such as manufacturers or retailers), so trade allies are not covered in the appliance process write-up.

[64] The process evaluation will also assess the programs against best practices outside of the industry with respect to program marketing, outreach, and delivery.

5.6.1 Program Theory and Changes

While the Program Theory for the Appliance Replacement Program is not explicitly laid out in a program theory and logic model, all PSE programs are described in annual and biennial plans and reports and changes are documented in the annual businesses cases.

The Appliance Replacement Program relies on a team effort, with several organizations playing a key role in the program delivery. The program includes the same implementation team as the Decommissioning Program. The recycling processes within this program are similar to that of the Decommissioning Program, but this program also includes delivery of new energy efficient measures. For this program, there are five groups (each shown as a column below). Each of these groups plays a role in the program delivery and implementation, and collects data that contributes to the program's success, as shown in the figure below.

FIGURE 5-2: APPLIANCE REPLACEMENT ROLES*

	ARCA	TechniArt	Black Hawk	PSE Marketing	PSE PM and staff
Roles	Schedules and replaces clothes washers	Provides "Leave Behind" kits to ARCA	Performs QA/QC on database	Implements satisfaction survey of customers with email	Oversees all processes; approves invoices
Data	Participant, unit, and kit distribution data	Kit data	Payment to vendor	Follow up survey data	Customer and billing data

* Note that these roles have been simplified. More details on each of the roles are available from PSE's program management staff.

Over time, this program has evolved to reflect opportunities in the market. As documented in the 2014-2015 Business Case, in 2014-2015 this program:

- Updated savings due to adjustment in measure qualifying baseline (from 2003 to 1997) and the RTF deemed average washes per week.
- Updated measure costs.

5.6.2 Data Tracking

Stage 1 of the evaluation reviewed program tracking data, applications, and invoices, and found the Appliance Replacement Program is collecting sufficient information to document success, but there is room for some improvements. During the verification of the data, the evaluation team found that the 2015 tracking data for the Appliance Replacement Program were fairly comprehensive, however did not contain all variables needed to evaluate the program. There were also a few other data tracking data issues.

- Missing Variables – adding variables pertaining to the replacement unit to the tracking database would improve the ease and accuracy of evaluation and program planning efforts. The algorithm used to calculate the UES uses the average MEF, capacity, and Rated UEC of the replacement units as parameter inputs. While these variables can be looked up based on the units make and model (if make and model are included in the tracking data), it is more efficient to also include the parameter inputs directly.
- Data Discrepancies - The evaluation team found that some of the Leave Behind kits included in the tracking data could not be merged to a clothes washer replacement record by account number, name or address. Conversely, some of the clothes washer replacement participants did not have a corresponding Leave Behind kit in the tracking data.
- Missing Participants – The initial Appliance Replacement file PSE provided to the evaluation team did not include a complete list of 2015 participants.[65] PSE provided a second file with the missing participants; however this second file included different variables than the original file.

The issues described above were minor and reflected older program practices. Since then, PSE has updated their program tracking systems. While this evaluation did not comprehensively review the newer system, PSE worked with the evaluation team to document the types of data that should be collected by each of the key players in the delivery of the Appliance Replacement Program to ensure success for the future. A full mapping of the data that should be collected by each of the key group is included in Appendix H.

5.6.3 Awareness of Programs

Among PSE's residential customers, 23% are aware that PSE offers an Appliance Replacement program (based on the General Population survey). This is lower than any other DtC program, but can be explained by the fact that this program targets only customers with clothes washers that were manufactured in 1997 or earlier.

[65] The file provided was missing November 2015 participants.

TABLE 5-3: AWARENESS OF RESIDENTIAL DTC PROGRAMS, PARTICIPANTS VERSUS GENERAL POPULATION

Awareness of Other Residential Programs	Clothes Washer Replacement Participants	All Participants*	General Population
Lighting Program	85%	86%	50%
Appliance Rebate Program	80%	85%	47%
Heating Rebate Program	61%	73%	42%
Decommissioning Program	70%	64%	40%
Showerhead Program	85%	83%	37%
ShopPSE Website	48%	45%	27%
CW Replacement Program	-	49%	23%
N	143	1,194	640

In general, marketing and outreach has been a strong focus for PSE over the 2014-2015 periods, as documented in PSE's planning and reporting. PSE conducts the marketing of this program, and ARCA (the primary implementer) focuses on support and fulfilment services. While ARCA is not used for marketing, it should be noted that they do help with marketing in other jurisdictions. In their own words, they are "very aggressive" with marketing and could support PSE in this area, as needed.

5.6.4 Demographics of Appliance Replacement Participants

Participants in the Appliance Replacement Program tend to be home owners who live in single-family detached homes, as would be expected.

- Demographics of the Clothes Washer Replacement survey respondents:
  - 86% own their home, 14% rent their home.
  - 89% live in a single family detached home, 7% live in a single family attached home, and 4% live in a mobile or manufactured home.
  - Households had an average of 2.3 full-time residents.

The major barriers survey respondents reported for not buying a new unit were: the cost of a new machine, no need for a new unit since the old one was still operational, and not knowing how inefficient their old unit was.

5.6.5 Participant Satisfaction

Participants in the Appliance Replacement program were asked about their satisfaction with both the program and PSE. We present these findings below, along with comparable data for other programs and the general population to provide context.

Participant Satisfaction with Program

Overall 93% of clothes washer replacement participants reported they were satisfied (somewhat or extremely) with the programs, 5% were neutral and only 2% were dissatisfied. Nearly 15% more clothes washer replacement participants reported being "Extremely Satisfied" than clothes washer rebate participants. The Decommissioning and Replacement programs received more "Extremely Satisfied" rankings than the Rebate programs.[66]

TABLE 5-4: SATISFACTION WITH THE APPLIANCE REPLACEMENT PROGRAM

Satisfaction with the Program	Clothes Washer Replacement	Clothes Washer Rebate	All DtC Participants
Extremely Satisfied	71%	56%	68%
Somewhat Satisfied	22%	30%	23%
Neutral	5%	11%	7%
Somewhat Dissatisfied	2%	2%	1%
Extremely Dissatisfied	0%	1%	1%
N	142	273	1,036
Mean Ranking	4.6	4.4	4.6

Participant versus General Population Satisfaction with PSE

Satisfaction with PSE is much higher among participants in the Clothes Washer Replacement Program than among the general population of residential customers (80% v. 67%). Table 5-5 below shows that 80% of participants in this program reported they were satisfied with PSE (extremely or somewhat), 13% were neutral and 7% were dissatisfied. The mean satisfaction ranking across all program participants is 4.1. This is similar to the other DtC programs shown below. The primary reasons reported by participants for dissatisfaction with PSE were related to rates being too high (48%), poor customer service (20%), or power outages (9%).

[66] The percent of decommissioning and replacement participants who provided a satisfaction score of 5 (extremely satisfied) was 77.6% (+/- 3.0%), compared to 58.1% (+/- 3.7%) of the rebate participants. This difference is statistically significant.

TABLE 5-5: PARTICIPANT VS. GENERAL POPULATION SATISFACTION WITH PSE OVERALL

Satisfaction with the Program	Clothes Washer Replacement	All DtC Participants	General Population
Extremely Satisfied	43%	40%	25%
Somewhat Satisfied	37%	40%	43%
Neutral	13%	14%	24%
Somewhat Dissatisfied	6%	5%	5%
Extremely Dissatisfied	1%	2%	3%
N	142	1,183	655
Mean Ranking	4.1	4.1	3.8

The web surveys also investigated how DtC program participants' satisfaction with PSE changed after they participated in one or more of the programs. Not surprisingly, most clothes washer replacement participants (who received a brand new efficient clothes washer from PSE as opposed to clothes washer rebate participants who only received a discount on a new unit) reported an increase in their satisfaction with PSE post-participation. Very few respondents (2% across all programs) indicated that their level of satisfaction decreased after program participation. The reasons reported for a decline in satisfaction were similar to the reasons reported for dissatisfaction with PSE reported above (rates were too high; rebate was never received or was too small, and poor customer service).

TABLE 5-6: CHANGE IN SATISFACTION WITH PSE POST-PROGRAM PARTICIPATION

Change in Satisfaction with PSE Post Program Participation	Clothes Washer Replacement	Clothes Washer Rebate	All DtC Participants
Higher	57%	18%	32%
About the Same	38%	79%	65%
Lower	4%	2%	2%
Don't Know	1%	2%	1%
N	141	275	1,041

5.6.6 Other Detailed Appliance Replacement Findings

The survey also collected additional details that may be useful for the program team. This includes the following survey responses on clothes washer replacements:

- Most respondents (75%) reported the number of loads they washed per week did not change with their new unit and nearly equal numbers reported an increase or a decrease in the number of loads. Across all respondents, a 1% net increase in loads was calculated after receiving the replacement machine which is not a statistically significant change.

- Most respondents (89%) reported the number of loads they dried per week did not change after receiving their new unit. The data for those that did report a change did not clearly identify if the number of loads dried went up or down with the new unit.
- The Clothes Washer Replacement Program requires that participants have an electric water heater and dryer. These criteria appear to be enforced as 96% of respondents reported having an electric water heater and 99% reported having an electric dryer. The evaluation team did not reduce the savings estimate based on these results as the water heater or dryer could have been changed after program participation.
- Per the PSE deemed UES algorithm, 80% of Clothes Washer Replacement savings comes from a reduction in water heating with the new unit.[67] Surveyed respondents reported that, on average, 45% of their clothes are washed in cold water, 41% in warm water, and 15% in hot water. Because the deemed algorithm does not provide any documentation on the percentage of loads washed in warm or hot water that goes into this 80% water heating savings assumption, it is not possible to determine if an adjustment to UES savings is appropriate based on the water temperature findings from the participant survey.
- The majority (94%) of respondents reported that their old clothes washer was either in good working condition (77%) or in need of repairs (17%) at the time it was replaced and 98% of these respondents said they would have likely kept their old unit until it stopped working or replaced in more than a year had the program not existed. These findings indicate that the program is functioning as it should be with respect to getting old inefficient units off the grid that otherwise would be in use.
- Only a quarter of respondents reported they had noticed a reduction in either their PSE bill or their water usage since receiving the new unit.

Participants in the Appliance Replacement Program also received a Leave Behind kit, which included LEDs and showerheads. These kits are distributed to increase customers' exposure to new products, and to garner additional energy and water savings. Based on an analysis of all Leave Behind and Thank You kit respondents,[68] we found that many already had experience with the measures, but that the exposure was new for some participants. The evaluation also collected information on installation of these measures, which is described in section 4.4.6.

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[67] This 80% assumption comes from the Energy Star calculator. This calculator does not provide any information regarding the source of this 80% water heating assumption.

[68] Thank You kits are a different kit that is sent to Appliance Rebate participants. For the purposes of this analysis, however, we combined all data to report results from all kit recipients.

5.7 APPLIANCE REPLACEMENT PROGRAM FINDINGS AND RECOMMENDATIONS

The findings and recommendations for PSE's Clothes Washer Replacement Program are presented below. Because the refrigerator replacement program was discontinued at the end of 2016, the evaluation team has no further recommendations.

Finding AR1: The evaluation team found that the 2015 tracking data for the Clothes Washer Replacement Program were fairly comprehensive, however adding some additional variables to the database would improve the ease and accuracy of evaluation efforts. Some of the parameters used in the UES algorithm can be estimated based on the characteristics of the replacement units offered. Make and model lookups of the four units offered in 2015, provided the evaluation team with the average MEF, capacity, and Rated UEC of the actual 2015 replacement units, which were then used to calculate the UES of a replacement clothes washer.

Recommendation AR1: Add the following variables to the tracking database regarding the clothes washer being recycled: age, door configuration, and size in cubic feet;[69] as well as details on the new replacement unit: door configuration, capacity in cubic feet, installation location, MEF, water factor, and Rated UEC; and house type. If the replacement units being offered for the upcoming program year are known by September 1, the UES can be updated based on an expected distribution of the actual replacement units. If the units are not known by this time, the previous year's units could be used as a proxy for the deemed estimate for the subsequent program year.

Finding AR2: The evaluation team found that some of the Leave Behind kits included in the tracking data could not be merged to a clothes washer replacement record by account number, name or address. Conversely, some of the Clothes Washer Replacement participants did not have a corresponding Leave Behind kit in the tracking data. The kit participants who did not have an associated clothes washer likely may have not qualified for the Appliance Replacement program,[70] however there are still additional Clothes Washer Replacement participants who did not appear to receive a kit based on the tracking data received.

Recommendation AR2: Making sure each record has a valid PSE account number and email address would facilitate follow up with program participants and allow for a better assessment of cross-program

[69] Per PSE, this is being tracked starting in 2017.

[70] We are unable to confirm this as NQC records were not provided in the tracking data.

participation.[71] PSE should also consider creating a variable to contain the reason that a kit record does not have a corresponding clothes washer measure where applicable (i.e. didn't qualify for program, customer refused the kits, etc.). This information could also be helpful to the post-participation surveys implemented by PSE's market research group.

Finding AR3: The initial Appliance Replacement file PSE provided to the evaluation team did not include a complete list of 2015 participants.[72] PSE provided a second file with the missing participants; however this second file included different variables than the original file.

Recommendation AR3: The evaluation team recommends that PSE review the process of collecting and exporting measure level data for this program to determine what caused missing records in the first file and why the layouts/variables between the two files differed.

[71] Per PSE, this has been added to program tracking data requirements.

[72] The file provided was missing November 2015 participants.

6 APPLIANCE REBATE PROGRAM

PSE's Appliance Rebate Program provides incentives in the form of rebates to increase customer adoption and market share of efficient energy appliances for the home. In 2014 and 2015, PSE's Appliance Rebate Program offered incentives towards the purchase of a high efficiency clothes washer, refrigerators and freezers to PSE residential electric customers. In 2014 and 2015 this program also distributed high efficiency light bulbs via no-cost kits that were mailed to program participants (referred to as Thank You kits). Overall, the Appliance Rebate Program makes up a small percentage of the DtC portfolio, accounting for only 2% of the DtC reported ex-ante electric savings and 8% of the ex-ante gas savings (excluding savings from kit measures).

6.1 CLOTHES WASHER REBATE EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the Clothes Washer Rebate Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), in-depth reviews of program tracking databases, web surveys of both program participants and PSE residential customers, trade ally interviews, and a secondary literature review.

Table 6-1 and Table 6-2 below present a comparison of the RTF deemed, evaluation verified, and ex-post unit energy savings (UES) estimates and realization rates for the 2015 Clothes Washer Rebate Program. The evaluation team verified the quantity of clothes washers rebated through the program was accurate and the RTF deemed UES estimate was applied correctly (resulting in a 100% verified realization rate). The ex-post realization rates for various clothes washer rebate models ranged from 57% to 146% for kWh and 114% to 163% for therms. The 2015 program sales weighted overall realization rates are 122% for kWh savings and 144% for therm savings as a result of ex-post changes to the following parameters included in the UES algorithm:

- Number of annual loads washed – This parameter decreased from 257 to 256 loads based on data collected from participants during the web surveys.
- Gallons of water used per year for washing – Ex-post calculations were updated with a newer version of the CEC database, including all units as of 12/31/2014. The value varies as it is averaged across different tiers, however, across all clothes washer tiers, there was a very minimal change (less than a 2% difference).

- Moisture content remaining in clothes – Similarly, to the gallons of water used for washing per year, the evaluation team also updated the remaining moisture content in clothes, based on an update of the CEC database. These findings resulted in a more significant change shown in Table 6-4.
- Energy Star clothes washer saturation rate was adjusted from 54% in the ex-ante calculation to 56% in the ex-post calculation based on 2015 Energy Star unit shipment data.73
- Capacity of the new clothes washer increased from 3.54 to 4.44 cubic feet. 4.44 cubic feet was the average capacity of the replacement units in the 2015 tracking data.
- Waste water energy savings – This parameter decreased from 5.29 to 3.68 based on the new RTF Standard Information Workbook v2.6.
- DeltaT – This parameter increased from 65 degrees to 75 degrees based on the DOE test procedure and the new RTF calculator v5.3.
- Percent of homes with electric dryers – This parameter decreased from 95% to 88% based on data from the participant web surveys, general population survey, and the 2015 program tracking data.

Additional details on the ex-post UES estimates and realization rates are provided in Section 6.3 below.

TABLE 6-1: 2015 CLOTHES WASHER REBATE UES ESTIMATES (KWH)

Measure				RTF Deemed UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
Dryer	DHW	MEF	WF	kWh	kWh	kWh	kWh	kWh
Gas	Gas	>=2.4	<=4.0	16	16	100%	9	55%
Gas	Elec			63	63	100%	77	122%
Elec	Gas			105	105	100%	119	113%
Elec	Elec			151	151	100%	187	124%
Any	Any			126	126	100%	143	113%
Gas	Gas	>=3.2	<=2.9	24	24	100%	25	103%
Gas	Elec			84	84	100%	132	157%
Elec	Gas			151	151	100%	162	107%
Elec	Elec			211	211	100%	269	127%
Any	Any			177	177	100%	204	116%

Source: Evaluation Team Analysis

73 https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2015_USD_Summary_Report.pdf?1ccd-a8b5

TABLE 6-2: 2015 CLOTHES WASHER REBATE UES ESTIMATES (THERMS)

Measure				RTF Deemed UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
Dryer	DHW	MEF	WF	Therms	Therms	Therms	Therms	Therms
Gas	Gas	>=2.4	<=4.0	5.5	5.5	100%	7.3	132%
Gas	Elec			3.4	3.4	100%	4.2	123%
Elec	Gas			2.1	2.1	100%	3.1	147%
Elec	Elec			-	-	n/a	-	-
Any	Any			1.1	1.1	100%	1.9	171%
Gas	Gas	>=3.2	<=2.9	7.6	7.6	100%	10.1	133%
Gas	Elec			4.9	4.9	100%	5.2	107%
Elec	Gas			2.7	2.7	100%	4.9	180%
Elec	Elec			-	-	n/a	-	-
Any	Any			1.5	1.5	100%	2.8	187%

Source: Evaluation Team Analysis

Results of the process analysis and overall findings and recommendations for the Clothes Washer Rebate Program are provided in the sections below.

6.2 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of two components. The first component was a review of program tracking and invoice data to verify the volume of units sold through the program. The second component was a review of the calculation and application of the RTF deemed unit energy savings (UES) estimates applied.

6.2.1 Tracking and Invoice Data Review

The tracking data review for the Clothes Washer Rebate Program found that overall the tracking data unit and savings totals matched the ex-ante estimates and only differed with respect to one unit in the 2015 Clothes Washer Rebate tracking data that was missing the UES therm savings (6 therms). Due to the small magnitude of this, the clothes washer rebate realization rate for 2015 was 100%. Issues related to missing, duplicative or misaligned data are discussed within the process section of this chapter.

6.2.2 UES Algorithm

The algorithm used to estimate the 2015 RTF deemed UES for rebated energy efficient clothes washers is similar to that used to estimate the savings from clothes washers replaced through the Appliance Replacement Program:

Annual kWh Savings = Baseline kWh consumption - Measure kWh consumption

Where the kWh consumption of the baseline and energy-efficient (measure) units are calculated as the sum of three components:

UEC_{CW} = the energy consumption (kWh) of the clothes washer attributable to the clothes washer primary functions (agitating, spinning, etc.)

UEC_{WH} = the energy consumption (kWh) attributable to electric water heating, and

UEC_{CD} = the energy consumption (kWh) related to electric clothes drying

Total Consumption (kWh) = $UEC_{CW} + UEC_{WH} + UEC_{CD}$

The equations used to calculate each of these energy consumption components are:

UEC_{CW} = $UEC_{load} * Annual_{Loads}$

Where:

UEC_{load} = Unit energy consumption of clothes washer per load

$Annual_{Loads}$ = Annual clothes washing loads per year

$UEC_{WH} = Gallons_{yr} * HW\_fraction * WaterSH * DeltaT/ElecWHeff$

Where:

$Gallons_{yr}$ = Gallons of water used per year for washing clothes

HW_fraction = Percent of water used for washing clothes that is heated

WaterSH = Specific Heat of Water

DeltaT = Difference between inlet and outlet temperatures

ElecWHeff = Efficiency of electric water heater

UEC_{CD} = (%Moisture * Slope + Constant) * AnnualLoads

Where:

%Moisture = % remaining moisture in clothes

Slope and Constant = Slope and constant from linear regression on residential clothes washer DOE data

AnnualLoads = See above

The % of each component's energy contribution is then calculated as:

CW_energy% = UECCW / (UECCW + UECWH + UECCD)

Finally, CW_energy% is applied to the normalized UEC (kWh/year) derived from the CEC database[74] for each efficiency tier (CEE Tier 1, CEE Tier 2, etc.) to determine the energy use of each component. Therm savings were determined by converting kWh savings to therms and applying a gas dryer factor (GasDryerFactor) to dryer savings and gas water heater efficiency (GasWHeff) to water heater savings. A constant representing wastewater energy savings (ww_savings) is added to the final kWh savings estimates.

The assumed electric domestic hot water (DHW) and electric dryer saturations applied to each measure case are provided in the table below:[75]

TABLE 6-3: ELECTRIC DHW AND ELECTRIC DRYER FOR EACH MEASURE CASE

Measure Case	% Electric DHW	% Electric Dryer
Electric DHW, Electric Dryer	100	100
Electric DHW, Gas Dryer	100	0
Gas DHW, Electric Dryer	0	100
Gas DHW, Gas Dryer	0	0
Any DHW, Any Dryer	55	95

6.2.3 Verified Savings

The UES review sought to comprehensively assess the 2015 RTF deemed UES. While the evaluation team recommends updates to the UES estimates for the clothes washer rebate measure in future program years, our conclusions from the assessment of the 2015 RTF deemed UES estimates for this measure is that the algorithm and parameter inputs for these measures are defensible, reproducible

[74] California Energy Commission Appliance Database. Accessed 9/6/2013. http://energy.ca.gov/appliances/.

[75] 'Any WH/Any Dryer' distribution based on 2012 RBSA data. Stage 2 evaluated this to determine if this distribution was accurate. Results are found in Table 6-5 below.

and were appropriate at the time they were deemed. As a result, no adjustments to the 2015 UES estimates were applied and a verified savings realization rate of 100% was calculated.

6.3 STAGE 2 EX-POST IMPACT ANALYSIS

6.3.1 Ex-Post UES Adjustments

In Stage 2 of the evaluation, web surveys, a tracking data review, and secondary data review were administered to gather data to determine if ex-post adjustments to any UES parameters or assumptions are advised and to assess if the UES estimates are realistic for the participant population. For the Clothes Washer Rebate Program, this included estimating a first-year persistence rate, the average annual number of loads washed, the gallons of water used for washing per year, the moisture content remaining in the clothes, the Energy Star® clothes washer saturation rate, the capacity of the new clothes washer, and the waste water savings.

Unit Persistence

The 2015 RTF deemed UES estimate assumes that 100% of the units rebated through the program stay installed within the residential customer's home for the first year. The Stage 2 clothes washer participant web surveys verified receipt of the rebated clothes washer and estimated a first-year persistence rate. Fifteen of the people surveyed reported they did not recall receiving a rebate from PSE for purchasing their clothes washer. However, all but one of these 15 customers purchased a clothes washer recently, so the evaluation team assumed that the customers participated, but did not recall doing so. The resulting verification rate was 99.7% (+/- 0.6%), however a 100% verification rate will be assumed for the ex-post impacts as the 90% confidence interval on the verification rate includes 100%. Additionally, one participant reported removing their rebated clothes washer in the first year. This clothes washer was removed within six months of purchase, resulting in a persistence rate of 99.7% (+/- 0.4%). Again a 100% persistence rate will be assumed for the ex-post impacts as the 90% confidence interval on the persistence rate includes 100%.

Annual Loads Washed

The number of annual loads washed was adjusted from 257 in the ex-ante calculation to 256 in the ex-post calculation.

- **Ex-Ante Estimate:** 257 loads washed per year was used in the 2015 RTF deemed UES estimate. The source of this number was the 2011 RBSA.

- **Ex-Post Estimate:** 256 (+/- 14.8) loads washed per year was calculated based on self-reported data collected via web surveys with 2014 and 2015 Clothes Washer Rebate participants.[76] This number is not statistically significantly different from the ex-ante estimate but was applied none-the-less to calculate ex-post savings as it is the most recent estimate available.

Annual Gallons of Water Used for Washing

The 2015 RTF deemed UES algorithm includes a parameter for the average gallons of water used for washing per year. This value varies as it is averaged across different tiers. Across all clothes washer tiers, there was a very minimal change – less than a 2% difference. The updated numbers were used in the ex-post calculations.

- **Ex-Ante Estimate:** Source for 2015 RTF deemed UES estimate: CEC Database dated 09/06/2013.
- **Ex-Post Estimate:** Ex-post calculations were updated with a newer version of the CEC database, including all units as of 12/31/2014.

Remaining Moisture in Clothes

Similarly, to the gallons of water used for washing per year, the evaluation team also updated the remaining moisture content in clothes, based on an update of the CEC database. These findings resulted in a more significant change shown below in Table 6-4.

- **Ex-Ante Estimate:** Source for 2015 RTF deemed UES estimate: CEC Database dated 09/06/2013.
- **Ex-Post Estimate:** Ex-post calculations were updated with a newer version of the CEC database, including all units as of 12/31/2014. Within the new CEC database, the remaining moisture in clothes was 0.4% to 19.6% lower than the estimates in the version used to calculate the deemed UES estimate (shown in the table below).

[76] This ex-post estimate is 30 loads more (about 10%) than the ex-post estimate for the CW replacement program. This is to be expected as the average number of residents per household was 2.8 for the CW rebate program versus 2.3 for the CW replacement program (based on web survey self-reported responses).

TABLE 6-4: DIFFERENCE IN EX-ANTE VERSUS EX-POST REMAINING MOISTURE CONTENT INPUT VALUES

	Current Practice Baseline	Energy Star (January 2011)	CEE Tier 3 (MEF>=2.4, WF<=4)	Energy Star Top 10% (MEF>=3.2, WF<=2.9)
Ex-Ante	41	35	33	31
Ex-Post	38	30	27	31
% Difference	5.9%	15.4%	19.6%	0.4%

Energy Star Clothes Washer Saturation

The Energy Star clothes washer saturation was adjusted from 54% in the ex-ante calculation to 56% in the ex-post calculation.

- **Ex-Ante Estimate:** the 2015 RTF deemed UES estimate used a 54% Energy Star clothes washer saturation. The source of this number was the D&R International 2013 retail sales data.
- **Ex-Post Estimate:** The evaluation team updated this parameter to 56% was from the 2015 Energy Star unit shipment data.[77]

Capacity of the Rebated Clothes Washer

The capacity of the rebated clothes washer was adjusted from 3.54 cubic feet in the ex-ante calculation to 4.44 cubic feet in the ex-post calculation.

- **Ex-Ante Estimate:** the 2015 RTF deemed UES estimated assumed the average capacity of a rebate clothes washer was 3.54 cubic feet. The source of this number was the average capacity of the units (unweighted) found in the CEC database.
- **Ex-Post Estimate:** 4.44 cubic feet was the average size of the rebated units based on the 2015 program tracking data. The rebated unit's capacity was not specifically provided in the 2015 tracking data, however the evaluation team used make and model number to look up the capacity of the units rebated in 2015. The evaluation team recommends that cubic feet be added to the tracking database and reviewed each year to see if an adjustment to the UES is warranted based on changes to the rebated units being distributed.

Wastewater Savings

The wastewater savings was adjusted from 5.29 kWh/1,000 gallons of water in the ex-ante calculation to 3.68 kWh/1,000 gallons of water in the ex-post calculation.

77 https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2015_USD_Summary_Report.pdf?1ccd-a8b5

- **Ex-Ante Estimate:** 5.29 kWh/1,000g was used in the 2015 RTF deemed UES estimate. The source of this number was the RTF Standard Information Workbook (SIW) v1.5.
- **Ex-Post Estimate:** 3.68 kWh/1,000g is from the new RTF Standard Information Workbook v2.6.

DeltaT

The DeltaT was adjusted from 65 degrees in the ex-ante calculation to 75 degrees in the ex-post calculation.

- **Ex-Ante Estimate:** 65 degrees was used in the 2015 RTF deemed UES estimate. The source of this number was the Northwest Council 6th Plan Conservation Supply Curve Files (2009).
- **Ex-Post Estimate:** 75 degrees is from the DOE test procedure for residential clothes washers, which generally agrees with draft findings from NEEA HPWH study (Heat Pump Water Heater Model Validation Study, prepared by Ecotope Consulting).[78] This is also consistent with the new RTF calculator v5.3.

Percent of Homes with Electric Appliances

In the ex-ante calculation, the 'Any WH/Any Dryer' measure assumes 55% of homes have electric water heat and 95% of homes have electric dryers. No adjustment was made to the percent of homes with electric water heat, but the number of homes with electric dryers was adjusted to 88% in the ex-post calculation.

- **Ex-Ante Estimate:** 55% of homes with electric water heat and 95% of homes with electric dryers was sourced from the 2012 RBSA.
- **Ex-Post Estimate:** 55% of homes with electric water heat and 88% of homes with electric dryers was estimated based on data from the participant web surveys, general population survey, and the 2015 program tracking data.

[78] http://neea.org/docs/default-source/reports/heat-pump-water-heater-saving-validation-study.pdf?sfvrsn=8

TABLE 6-5: PERCENT OF HOMES WITH ELECTRIC APPLIANCES

Percent of Homes with an Electric:	2012 RBSA (%)	2015 Tracking Data Average (%)	Participant Survey		General Population Survey	
			Average (%)	90% CI	Average (%)	90% CI
Water Heater	55	52	37	33%-42%	57	52%-62%
Clothes Dryer	95	88	87	84%-90%	88	83%-93%

6.3.2 Ex-Post Savings Estimate

Applying the ex-post UES adjustments described above to the 2015 RTF deemed UES algorithm led to ex-post UES estimates that were larger than the deemed estimates for all but one of the 2015 clothes washer rebate measures (gas dryer, gas DHW, 2.4-3.1 MEF). The 2015 program sales weighted overall realization rate were 122% for kWh savings and 144% for therm savings. The resulting ex-post savings estimates are shown in Table 6-6 below.

TABLE 6-6: 2015 CLOTHES WASHER REBATE EX-POST UNIT ENERGY SAVINGS AND PARTICIPATION DISTRIBUTION

Measure				Ex-Post UES	Ex-Post UES	2015 Participation Distribution
Dryer	DHW	MEF	WF	kWh	Therms	
Gas	Gas	>=2.4	<=4.0	9	7.3	3%
Gas	Elec			77	4.2	1%
Elec	Gas			119	3.1	12%
Elec	Elec			187	-	16%
Any	Any			143	1.9	11%
Gas	Gas	>=3.2	<=2.9	25	10.1	5%
Gas	Elec			132	5.2	1%
Elec	Gas			162	4.9	17%
Elec	Elec			269	-	22%
Any	Any			204	2.8	13%

Source: Evaluation Team Analysis

In 2016 PSE reduced the number of clothes washer rebate measures from ten to four (two measures for Tier 1 and one measure for Tiers 2 and 3, all of which were any DWH and Any Dryer) and in 2017 the program decreased the number of measures down to only a single measure (Energy Star CW Any DHW, Any Dryer). The savings for these 2016 and 2017 measures are provided in Table 6-7 below. As this table shows, the 2017 UES estimates for the clothes washer rebate measure, at 64 kWh and 0.86 therms, were significantly lower than the 2015 ex-post estimates, however they are hard to compare as the measure shifted in 2017 to be any Energy Star clothes washer.[79] Energy Star performance levels often align with CEE tier 1 within a product category; however this is not always the case.

TABLE 6-7: 2016 AND 2017 RTF DEEMED UNIT ENERGY SAVINGS

Program Year	Measure	Deemed UES kWh	Deemed UES Therms
2016	CEE Tier 1 Any WH/Any Dryer - Topload	65	0.9
	CEE Tier 1 Any WH/Any Dryer - Frontload	82	1.2
	Tier 2 MEF 3.2 or Higher - Any WH/Any Dryer	114	1.9
	CEE Tier 3 Any WH/Any Dryer	134	2.0
2017	ES CW Any WH/Any Dryer	64	0.86

Source: 2106 and 2017 PSE Source of Savings workbooks

6.4 REFRIGERATOR AND FREEZER REBATE EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the Refrigerator and Freezer Rebate Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), in-depth reviews of program tracking databases, and web surveys of both program participants and PSE residential customers.

Table 6-8 below presents a comparison of the RTF deemed, evaluation verified, and evaluation ex-post unit energy savings (UES) estimates and realization rates for the 2014 and 2015 Refrigerator and Freezer Rebate Programs. The evaluation team verified the quantity of measures sold through these programs was accurate and the RTF deemed UES estimates were applied correctly (resulting in a 100% verified realization rate). As shown in Table 6-8 below, the overall ex-post realization rate for Tier 2 refrigerators was 138%, for Tier 3 refrigerators was 100%, and for freezers was 104%. No ex-post UES estimate was calculated for Tier 1 refrigerators because there was no program participation in that tier in 2015. These realization rates are a result of ex-post changes to the following parameters included in the UES algorithm:

- HVAC interactive effect – This parameter increased from 0.86 to 0.90 for refrigerators and increased from 0.928 to 0.98 for freezers based on data collected from participants during the web surveys, along with 2014/2015 weather data and 2010 RBSA results.

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[79] Per the Energy Star website, the performance of an Energy Star clothes washer often aligns with CEE Tier 1.

- Average unit energy consumption (UEC) – The ex-post evaluation assessment derived these UECs from an updated version of the CEC database that included units as of 12/31/2014. Across all door configurations and tiers, the delta between the UECs increased by 32% (weighted by 2015 rebated units) due to the CEC database update.
- Door configurations of rebated appliances – This parameter adjustment varied by tier as shown in Table 6-11 and Table 6-12 and is based on 2015 program tracking data.

Additional details on the ex-post UES estimates and realization rates are provided in Section 6.6 below.

TABLE 6-8: 2015 REFRIGERATOR AND FREEZER REBATE UES ESTIMATES (KWH)

Rebate Measure	RTF Deemed UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
Refrigerator – Tier 1	22	22	100%	n/a	n/a
Refrigerator – Tier 2	47	47	100%	64	138%
Refrigerator – Tier 3	88	88	100%	88	100%
Freezer – Energy Star	40	40	100%	42	104%

Source: Evaluation Team Analysis

Results of the process analysis and overall findings and recommendations for the Refrigerator and Freezer Rebate Program are provided in the sections below.

6.5 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of two components. The first component was a review of program tracking and invoice data to verify the volume of units sold through the program. The second component was a review of calculation and application of the deemed unit energy savings (UES) estimates applied.

6.5.1 Tracking and Invoice Data Review

The tracking data review for the Refrigerator and Freezer Rebate Programs found that overall the tracking data unit and savings totals matched the ex-ante estimates for the rebated refrigerators and freezers,[80] which led to a 2015 tracking data realization rate of 100%. Issues related to missing, duplicative or misaligned data are discussed within the process section of this chapter.

[80] The reported savings and tracking data were off by a single unit with 22 kWh of savings.

6.5.2 UES Algorithm

Energy savings for refrigerators are closely tied to the door configuration and the efficiency tier of the new unit. Similarly, for freezers, they are tied to the freezer type (chest vs. upright, automatic vs. manual defrost). As a result, the RTF deemed UES estimates for refrigerator and freezers incentivized through the Appliance Rebate Program are calculated using the following steps:

1. Calculate Unit Energy Consumption (UEC) estimates for baseline and rebated efficient units. For refrigerators, UEC's were calculated for each door configuration (bottom freezer with ice through door, side-by-side with ice through door, etc.) and efficiency tier (CEE Tier 1, Tier 2, Tier 3, and baseline). For Freezers, they were calculated for each freezer type (Chest - any defrost, Upright – automatic defrost, Upright – manual defrost) and efficiency level (Energy Star or baseline).
2. Using these UEC estimates, calculate Unit Energy Savings (UES) for each door configuration/efficiency tier (refrigerator) or unit type (freezer) as the difference between the baseline UEC and efficient UEC.
3. To reduce the number of RTF deemed UES estimates, calculate UES estimates representing "Any" refrigerator door configuration and "Any" freezer type as the weighted average UES across all door configurations (refrigerator) or unit types (freezer). This results in three UES estimates for refrigerators (one for each CEE Tier) and one UES estimate for freezers.
4. Calculate the RTF deemed UES estimates by multiplying the weighted average UES estimates from the last step by an HVAC interactive effect.

Algorithmically this is represented as:

Refrigerator Rebate UES Tier X= Weighted ∑ DoorConf% * (UEC_{base} – UEC_{effX}) * HVAC_IE

Freezer Rebate UES = Weighted ∑ UnitType% * (UEC_{base} – UEC_{effX}) * HVAC_IE

Where:

> **UEC_{base}** = Average energy consumption of the old unit, by door configuration (refrigerator) or unit type (freezer). UEC_{base} is calculated as the average UEC across all refrigerators/freezers within the CEC appliance database[81] that meet the minimum federal standards.
>
> **UEC_{effX}** = Average energy consumption of Tier X efficient rebated unit, by refrigerator door configuration (X = 1, 2 or 3) or freezer type (X = Energy Star). UEC_{effX} is calculated as the average

[81] California Energy Commission Appliance Database. http://energy.ca.gov/appliances/

UEC across all refrigerators/freezers within the CEC appliance database that meet the Tier X/Energy Star efficiency standards.

DoorConf% = The distribution of door configurations for each efficiency tier. Used to weight the difference in UEC estimates between the baseline and rebated refrigerator across to estimate the average difference for each efficiency tier across all door configurations.

UnitType% = The distribution of freezer unit types. Used to weight the difference in UEC estimates between the baseline and rebated freezers across to estimate the average difference for each across all unit types.

HVAC_IE = HVAC Interactive Effect factor which accounts for changes in space conditioning resulting from the installation of a high efficiency refrigerator (includes both heating penalties and cooling benefits)

6.5.3 Verified Savings

The UES review sought to comprehensively assess the 2015 RTF deemed UES. While the evaluation team recommends updates to the UES estimates for the Refrigerator and Freezer Rebate measures in future program years, our conclusions from the assessment of the 2015 RTF deemed UES estimates for these measures is that the algorithm and parameter inputs are defensible, reproducible and were appropriate at the time they were deemed. As a result, no adjustments to the 2015 UES estimates were applied and a verified savings realization rate of 100% was calculated.

6.6 STAGE 2 EX-POST IMPACT ANALYSIS

6.6.1 Ex-Post UES Adjustments

In Stage 2 of the evaluation, web surveys were administered to refrigerator and freezer rebate participants to gather data to support ex-post adjustments to the deemed UES parameter estimates. This included estimating a first-year installation persistence rate, the unit energy consumption of the old and new appliances, the distribution of refrigerator door configurations and freezer types, and an HVAC interactive effect factor.

Unit Verification and Installation Persistence

The 2015 RTF deemed UES estimate assumes that 100% of the units replaced through the program stay installed within the residential customer's home in the first year. The Stage 2 refrigerator and freezer rebate participant web surveys verified receipt of the rebated refrigerators and freezers and estimated a first-year persistence rate. All but 13 of the participants surveyed recalled receiving a rebate from PSE for their new refrigerator or freezer. The 13 individuals that did not had relatively new refrigerators or freezers, so they were assumed to have participated. None of the participants who recalled receiving the rebate reported they had removed it during the first year. This resulted verification and installation persistence rates of 100%.

HVAC Interactive Effect Factor

Interactive effects (IE) were calculated for rebated refrigerator and freezers based on data collected from the participant web surveys and estimates of average heating and cooling coefficients of performance (COP) based on data from the 2015 RBSA regarding the installed heating and cooling types in PSE service territory and the average installed efficiencies of these units.[82] The formula used to estimate the IE was:

IE = 1 + (Cooling Benefit - Heating Penalty)

Where:

> **Cooling Benefit =** %Parts_w/AC * %Year_Cooling * %Units_CondSpace * (CoolType Distribution(%) * COP_{AC})
>
> **Heating Penalty =** %Year_Heating * %Units_CondSpace * (HeatType Distribution(%) * COP_{HT})

Table 6-9 and Table 6-10 below show the parameter inputs to this formula, along with the participant web survey sample size and 90% confidence intervals, for the refrigerator and freezer rebate interactive effects parameter estimates. The overall ex-post results of these analyses are interactive effect factors of 0.90 for refrigerators and 0.98 for freezers. The ex-ante estimates used to calculate the 2015 RTF deemed UES were 0.86 for refrigerators and 0.928 for freezers. The refrigerator parameter was reportedly estimated based on the percent of lighting installed within conditioned space which is not correlated with the interactive effects estimate for this measure. The freezer parameter was from the 6th Plan Freezer Analysis.[83] The ex-post IE estimates are both higher than the ex-ante parameters and so translate into a smaller reduction in refrigerator and freezer savings due to the interactive effects (primarily heating penalties) associated with the new efficient appliances.

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[82] 2015 Appliance Standards as reported in https://appliance-standards.org/product/central-air-conditioners-and-heat-pumps

[83] 6th Plan Freezer Analysis- EStarResFreezersFY09v1_0.xls.

TABLE 6-9: REFRIGERATOR REBATE INTERACTIVE EFFECTS

Parameter	Ex-Post Estimate	n	90% CI	Source
Participants with AC	30%	n/a	n/a	Evaluation Team Assumption[84]
Percent of Year Cooling	20%	n/a	n/a	2014/15 weather data, RBSA 2010 cooling set-points[85]
Refrigerators in Cond Space	96%	172	93%-98%	Refrigerator Rebate Participant Survey
COP - CAC	3.15	n/a	n/a	2010 RBSA average cooling efficiency of CAC
COP - ASHP	3.56	n/a	n/a	2010 RBSA average cooling efficiency of ASHP
Cooling Type - CAC	32%	n/a	n/a	2010 RBSA
Cooling Type - ASHP	52%	n/a	n/a	
Cooling Benefit	**0.0169**			
Percent of Year Heating	63%	n/a	n/a	2014/15 weather data, RBSA 2010 heating set-points[86]
Refrigerators in Cond Space	96%	172	93%-98%	Refrigerator Rebate Participant Survey
COP – ASHP	2.44	n/a	n/a	2010 RBSA average heating efficiency of ASHP
Heat Type - Elec - Strip/BB/Furn	11%	167	7%-15%	Refrigerator Rebate Participant Survey
Heat Type - Elec - Heat Pump	19%		14%-24%	
Heat Type - Gas	61%		55%-67%	
Heat Type - Other	9%		5%-13%	
Heating Penalty	**0.1151**			
Interactive Effect	**0.90**			

84 The estimate coming out of the Refrigerator Rebate Participant Survey was 45% (n=167, 90% CI 39%-51%) which the evaluation team believed was a significant over-estimation of central AC ownership for PSE service territory based on a review of other data sources: 1) 2010 PSE-specific RBSA data (23% PSE-E, 16.5% PSE-G), 2) general population survey (29% for homeowners, 6% for renters), and 3) participant surveys (29% for Freezer and 31% for APS). Thus, a value of 30% was assumed as a reasonable estimate. PSE could collect data during their post-participation market research surveys to revisit this value. Utilizing the 45% assumption (from the web surveys) only increases the resulting IE by 0.01 from 0.90 to 0.91.

85 Self-reported data was also collected from refrigerator survey respondents on the percent of the year they cool their homes. The average self-reported response was 23% +/-2.5% (90% CI) and so the point estimate used to calculate the cooling benefit falls within the 90% confidence interval of the web survey estimate.

86 Self-reported data was also collected from refrigerator survey respondents on the percent of the year they heat their homes. The average self-reported response was 62% +/-2% (90% CI) and so the point estimate used to estimate the heating penalty falls within the 90% confidence interval of the web survey estimate.

TABLE 6-10: FREEZER REBATE INTERACTIVE EFFECTS

Parameter	Ex-Post Estimate	n	90% CI	Source
Participants with AC	29%	59	19%-39%	Freezer Rebate Participant Survey
Percent of Year Cooling	20%	n/a	n/a	2014/15 weather data, RBSA 2010 cooling set-points[87]
Freezer in Cond Space	15%	n/a	n/a	Estimated from Freezer Rebate Survey data
COP - CAC	3.15	n/a	n/a	2010 RBSA average cooling efficiency of CAC
COP - ASHP	3.56	n/a	n/a	2010 RBSA average cooling efficiency of ASHP
Cooling Type - CAC	32%	n/a	n/a	2010 RBSA
Cooling Type - ASHP	52%	n/a	n/a	
Cooling Benefit	**0.0026**			
Percent of Year Heating	63%	n/a	n/a	2014/15 weather data, RBSA 2010 heating set-points[88]
Freezer in Cond Space	15%	n/a	n/a	Estimated from Freezer Rebate Survey data
COP – ASHP	2.44	n/a	n/a	2010 RBSA average heating efficiency of ASHP
Heat Type - Elec - Strip/BB/Furn	12%	60	5%-19%	Freezer Rebate Participant Survey
Heat Type - Elec - Heat Pump	28%		19%-38%	
Heat Type - Gas	53%		42%-64%	
Heat Type - Other	7%		1%-12%	
Heating Penalty	**0.0227**			
Interactive Effect	**0.98**			

Unit Energy Consumption

The 2015 RTF deemed UES calculations for refrigerator and freezer rebates included an estimate of the unit energy consumption (UEC) of the baseline and rebated units (delta UEC) for each refrigerator door configuration / freezer unit type and efficiency tier. The source of these ex-ante UECs was the CEC Database (dated 4/3/2013) and 2001 Federal Standards. The ex-post evaluation assessment derived these UECs from an updated version of the CEC database that included units as of 12/31/2014. Across all door configurations and tiers, the delta between the UECs increased by 32% (weighted by 2015 rebated units) due to the CEC database update. This was primarily driven by ex-post increases to the

[87] Self-reported data was also collected from freezer survey respondents on the percent of the year they cool their homes. The average self-reported response was 18% +/-6 (90% CI) and so the point estimate used to calculate the cooling benefit falls within the 90% confidence interval of the web survey estimate.

[88] Self-reported data was also collected from refrigerator survey respondents on the percent of the year they heat their homes. The average self-reported response was 66% +/-4% (90% CI) and so the point estimate used to estimate the heating penalty falls within the 90% confidence interval of the web survey estimate.

baseline UEC (for all but one refrigerator configuration) and a drop in the measure UEC for the refrigerator configuration and efficiency tier that made up the largest percentage of 2015 sales.

Door Configuration

Table 6-11 compares the deemed distribution of refrigerator door configurations, based on the units included the CEC database, to those rebated through the 2015 Refrigerator Rebate Program (based on program tracking data).[89] Similarly, Table 6-12 compares the deemed distribution of freezer unit types, based on the 2012 RBSA and the CEC database,[90] to those rebated in 2015 (again, based on program tracking data). The deemed distributions are used to weight the refrigerator door configuration/freezer unit type savings to derive the 2015 deemed UES estimates. As these tables show, the deemed distribution of units used to estimate the deemed UES estimates poorly represents the actual units rebated through the program.

TABLE 6-11: DISTRIBUTION OF REFRIGERATOR DOOR CONFIGURATION (DEEMED VS. 2015 PSE PARTICIPANTS)

Refrigerator Door Configuration	Deemed Distribution			Distribution of 2015 Refrigerator Rebate Participants		
	CEE Tier 1	CEE Tier 2	CEE Tier 3	CEE Tier 1	CEE Tier 2	CEE Tier 3
Bottom Freezer w/ Ice thru door	6%	20%	9%	-	0%	0%
Bottom Freezer w/o Ice thru door	16%	60%	9%	-	84%	83%
Side-by-Side w/ Ice thru door	47%	0%	36%	-	16%	15%
Side-by-Side w/o Ice thru door	6%	0%	0%	-	0%	0%
Top Freezer w/ Ice thru door	0%	0%	0%	-	0%	0%
Top Freezer w/o Ice thru door	24%	20%	45%	-	0%	2%

Source: Source of Savings workbook and Evaluation Team analysis

[89] For freezers, the model numbers in the program tracking database were used to look up the door configuration from the Qualified Product List (QPL). The QPL did not provide information on the defrost type and thus no differentiation between 2015 defrost types was possible.

[90] The 2012 RBSA was used to estimate the market share of chest versus upright freezers. The upright units were split by defrost type (auto versus manual) based on the market share of auto defrost uprights found in the CEC database.

TABLE 6-12: DISTRIBUTION OF FREEZER UNIT TYPE (DEEMED VS. 2015 PSE PARTICIPANTS)

Freezer Unit Type	Deemed Distribution	Distribution of 2015 Freezer Rebate Participants
Chest, Any Defrost	41%	18%
Upright, Automatic Defrost	42%	57%[91]
Upright, Manual Defrost	18%	26%

Source: Source of Savings workbook and Evaluation Team analysis

6.6.2 Ex-Post Savings Estimate

Applying the ex-post UES adjustments described above to the 2015 deemed UES calculations, the ex-post UES estimate for Tier 2 refrigerators is increased by 17 kWh (to 64 kWh, 138% realization rate on ex-ante estimate), the Tier 3 refrigerator UES stays the same (at 88 kWh, 100% realization rate), and the freezer UES increases by 2 kWh (to 42 kWh, 104% realization rate).

Table 6-13 and Table 6-14 below provide the 2015 RTF deemed UES estimates for rebated refrigerators and freezers based on the 2015 UEC estimates, the deemed distributions of units, and the HVAC Interactive Effect factor applied.

[91] The split between manual and automatic defrost is not known based on the data provided in the tracking data or QPL. This split was estimated based on the market share of auto defrost uprights, as a percentage of all uprights based on the CEC database. Including a variable to indicate the defrost type of a freezer (either in the tracking data or in the QPL) would improve future UES estimates.

TABLE 6-13: CALCULATION OF 2015 DEEMED UES ESTIMATES FOR REFRIGERATORS

Refrigerator Door Configuration	Deemed ΔUEC (baseline – efficient)			Ex-Post ΔUEC (baseline – efficient)		
	Tier 1	Tier 2	Tier 3	Tier 1	Tier 2	Tier 3
Bottom Freezer w/Ice thru door	8.1	33.6	66.4	-3.6	28.2	76.1
Bottom Freezer w/o Ice thru door	12.1	57.4	69.4	34.7	66.7	90.9
Side-by-Side w/Ice thru door	22.2	68.1	90.6	59.5	99.4	132.1
Side-by-Side w/o Ice thru door	23.9	45.4	81.1	71.1	111.1	141.8
Top Freezer w/Ice thru door	23.9	54.1	81.7	44.4	73.4	99.7
Top Freezer w/o Ice thru door	45.8	65.7	125.1	56.3	83.3	118.0
Weighted Average of Savings[92]	25.6	54.3	102.2	-	71.8	97.6
HVAC Interactive Factor	86%			90%		
Weighted Average of Savings * HVAC Interactive Factor	**22**	**47**	**88**	**-**	**64**	**88**
Refrigerator Ex-Post Realization Rate				**n/a**	**138%**	**100%**

Source: Source of Savings workbook and Evaluation Team analysis

TABLE 6-14: CALCULATION OF 2015 DEEMED UES ESTIMATES FOR FREEZERS

Freezer Unit Type	Deemed Distribution	Deemed ΔUEC (baseline – efficient kWh)	Ex-Post Distribution	Ex-Post ΔUEC (baseline – efficient kWh)
Chest, Any Defrost	41%	30	18%	27 kWh
Upright, Automatic Defrost	42%	60	57%	51 kWh
Upright, Manual Defrost	18%	60	26%	32 kWh
Weighted Average of Savings		43		42 kWh
HVAC Interactive Factor		0.928		0.98
Weighted Average of Savings * HVAC Interactive Factor		**40 kWh**		**42 kWh**
Freezer Ex-Post Realization Rate				**104%**

Source: Evaluation Team analysis

Figure 6-1 below compares the RTF deemed UES estimates for the Refrigerator Rebate Program years 2014 to 2017 to the ex-post UES estimate derived by the evaluation team. As this figure shows, ex-post Tier 2 refrigerator savings estimate is higher than the deemed estimate in every year. Also, the ex-post Tier 3 refrigerator savings is similar to the deemed estimate for all years except 2017.

92 Weighted based on Deemed or Ex-post unit type distributions shown in Table 6-11 above.

FIGURE 6-1: REFRIGERATOR REBATE DEEMED UES 2014-2017 VS. EX-POST ESTIMATE (KWH)

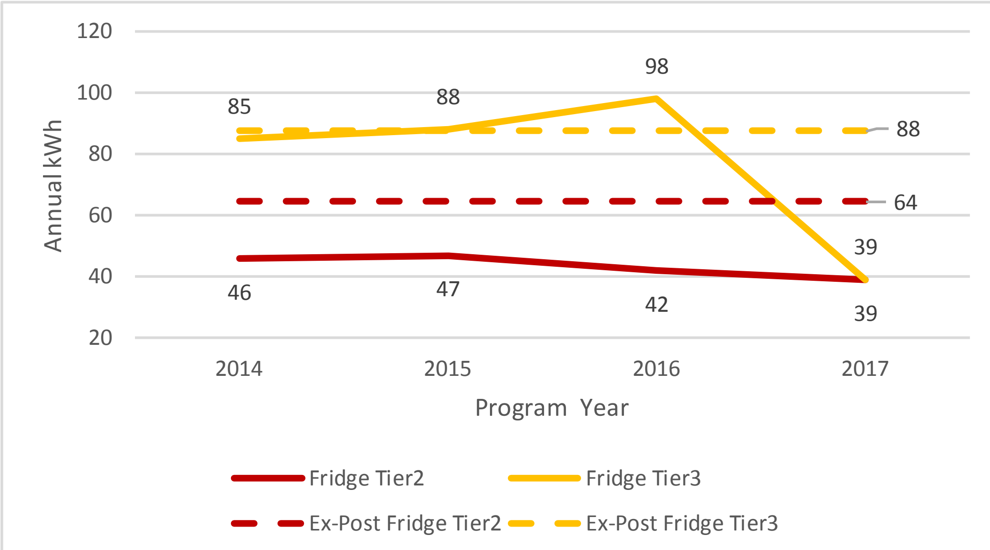
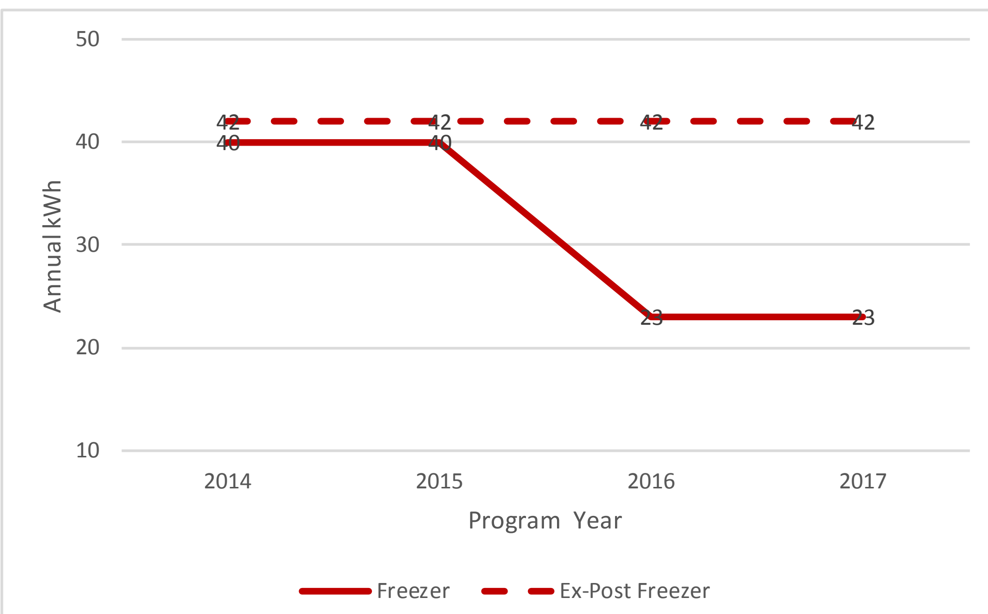


Figure 6-2 below compares the RTF deemed UES estimates for the Freezer Rebate Program years 2014 to 2017 to the ex-post UES estimate derived by the evaluation team. As this figure shows, the ex-post freezer savings estimate is similar to the deemed estimate in 2014 and 2015 and then drops well below the ex-post estimate in 2016 and 2017.

FIGURE 6-2: FREEZER REBATE DEEMED UES 2014-2017 VS. EX-POST ESTIMATE (KWH)



6.7 APPLIANCE REBATE PROCESS ANALYSIS

The process analysis for the Appliance Rebate Program sought to answer the process-related questions laid out in the introduction:

- **Program Theory and Changes:** How has the Appliance Rebate Program changed over time? Is this well-documented?
- **Data Tracking:** What data are currently being collected to support the Appliance Rebate Programs and how is this data being used? And what additional research is needed for each program area?
- **Awareness:** How aware are residential customers of the Appliance Rebate Program offerings and what channels are most effective to increasing awareness?
- **Demographics of Participation:** Who is currently participating in the Appliance Rebate Programs (demographically)?
- **Participant Satisfaction:**[93] What is the level of residential participant and satisfaction with the Appliance Rebate Program processes, and what areas of improvement exist?
- **Best Practices and Opportunities:** Are the Appliance Rebate Programs following industry best practices? How do they benchmark against industry best practices for program theory and design, program management, reporting and tracking of energy savings, quality control, program processes, and marketing and outreach? Where may additional opportunities lie?

In addition, the evaluation team collected additional details on the measures and how customers were using these measures. This information is presented in bulleted form under "Other Detailed Findings" at the end of the process section.

6.7.1 Program Theory and Changes

While not explicitly laid out in a program theory and logic model, the PSE programs are described in annual and biennial plans and reports and changes are documented in the annual businesses cases. In general, the theory behind the Appliance Rebate program is well-established. Given the history of these programs in the market, the implementers and PSE have updated and adjusted the program designs to ensure that they run well; however, there are some aspects related to appliance rebates that are new and changing in the industry, and thus should be monitored by PSE.

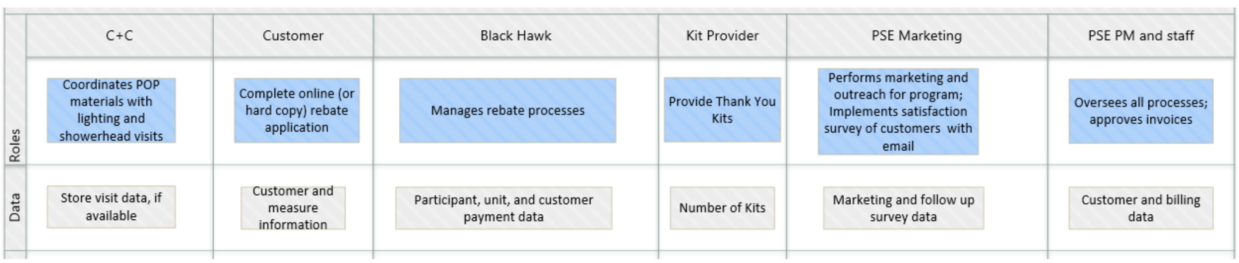
- Changing energy efficiency standards for appliances, the incentive amount relative to overall costs, and the number of retailers, have led implementers across the country to explore the

93 Note that the Appliance Programs do not work as closely as the lighting and showerhead programs with trade allies (such as manufacturers or retailers), so trade allies are not covered in the appliance process write-up

option of a mid-stream appliance model (incentives are provided directly to the retailers who stock and sell the energy efficient appliances to consumers). PSE implementers are also working on pilot efforts to explore this option. As interest in mid-stream appliance programs grows, PSE should work with stakeholders to lay out the theory behind both the downstream and mid-stream components and how they interact in the market.

PSE's Appliance Rebate Program is a downstream program overseen by the PSE program staff and marketing by PSE's marketing team. It is supported by Black Hawk, which processes the rebates, and C+C, which coordinates the delivery of POP materials with their lighting and showerhead efforts. In addition, there are Thank You Kits that are sent out to rebate participants.

FIGURE 6-3: APPLIANCE REBATE ROLES*



* Note that these roles have been simplified. More details on each of the roles are available from PSE's program management staff.

Over time, the program has updated savings, measure life assumptions and measure costs. Specifically, for the Appliance Rebate program, the following changes are documented in the 2014-2015 Business Case:

- Energy Star Refrigerators – Due to RTF updates; updated savings, measure life and incremental costs.
- Energy Star Freezers – Due to RTF updates; updated savings, measure life, and incremental costs
- Energy Star Clothes Washers – Due to RTF updates; updated tier structure, measure cost and savings.
- New Measures: Added Infrared Advanced Power Strips (APS). Note that APS units are discussed in a separate chapter.

This program also experienced significant changes in 2016-2017, as documented in the 2016-2017 Direct to Consumer Business Case.

6.7.2 Data Tracking

Stage 1 of the evaluation reviewed program tracking data, applications, and invoices, and found the Appliance Rebate Program is collecting sufficient information to document success, but there is room for some improvements. The evaluation team found that the 2015 tracking data for the Appliance Rebate Program was comprehensive, however adding additional variables could improve the ease and accuracy of program planning and evaluation efforts.

Related to the refrigerator and freezer data:

- Missing Variables – adding variables to the tracking data pertaining to the rebated unit, such as the make and model, refrigerator door configuration and capacity (in cubic feet), and freezer type (chest vs. upright, automatic vs. manual defrost). would improve the ease and accuracy of evaluation and program planning efforts. Retaining participant account numbers94 and email addresses would also allow for post-participation follow up with participants and a better assessment of cross-program participation. For example, without a fully populated account number on both the kit tracking database and the Appliance Rebate tracking database it is difficult to accurately map which participants received kits.

Related to the clothes washer data:

- Missing Variables – adding variables to the tracking data pertaining to the rebated unit, such as the make and model, unit type (front versus top-loader), and average capacity (in cubic feet) would improve the ease and accuracy of evaluation and program planning efforts. Retaining participant account numbers95 and email addresses would also allow for post-participation follow up with participants and a better assessment of cross-program participation.
- Data Discrepancies - There were 48 units in the tracking data that appear to be duplicates (totaling 96 records). These units were not removed from the unit totals reported, but these records were reviewed by PSE and Vendor staff which indicated that these units were a mix of duplicates and valid records. These records account for less than 0.5% of the appliance units rebated in 2015. The issue that led to the duplicates has been identified by the program vendor and corrected.

Related to Thank You Kit data:

- For refrigerators/freezers, the evaluation team found that some of the Thank You kits included in the tracking data could not be merged to an appliance rebate record.

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[94] Less than 1% of 2015 tracking records were missing an account number.

[95] Less than 1% of 2015 tracking records were missing an account number.

- For clothes washers, the evaluation team found that some of the Thank You kits included in the tracking data did not appear to be associated with a Clothes Washer Rebate participant.

Since the initial review of the data, PSE worked with the evaluation team to document the types of data that should be collected by each of the key players in the program delivery to ensure success for the future. A full mapping of the data that should be collected by each of the key group is included in Appendix H.

6.7.3 Awareness of Programs

Among PSE's residential customers, 47% of the residential population is aware that PSE offers an Appliance Rebate Program (based on the General Population survey). Awareness of this program is high relative to the other DtC programs. Moreover, participants in other DtC programs are even more aware of the Appliance Rebate Program, with 85% of participants in other programs having awareness that PSE offers rebates for appliances. This indicates that some form of cross-marketing is occurring.

TABLE 6-15: AWARENESS OF RESIDENTIAL DTC PROGRAMS, PARTICIPANTS VERSUS GENERAL POPULATION

Awareness of Other Residential Programs	Rebate Participants			All Participants*	General Population
	Refrigerator	Freezer	Clothes Washer		
Lighting Program	88%	85%	86%	86%	50%
Appliance Rebate Program	-	-	-	85%	47%
Heating Rebate Program	73%	82%	73%	73%	42%
Decommissioning Program	61%	61%	64%	64%	40%
Showerhead Program	76%	86%	83%	83%	37%
ShopPSE Website	40%	54%	45%	45%	27%
CW Replacement Program	45%	44%	49%	49%	23%
N	168	60	1,194	1,194	640

In general, marketing and outreach has been a strong focus for PSE over the 2014-2015 period, as documented in PSE's planning and reporting, contributing to the levels of awareness shown above.

- Among participants who received a rebate for a clothes washer, 53% of respondent's recall seeing or hearing about the program in the store where they purchased their new clothes washer. Additionally:
  - 53% knew the clothes washer qualified for a PSE rebate before they purchased it
  - 39% reported the rebate encouraged them to buy the model they did
  - 37% reported the PSE endorsement made them feel better about their purchase
  - 22% reported the rebate had no effect on their purchase

- 15% reported the salesman at the store used the PSE rebate to encourage them to buy the model they purchased

- Among those who received a rebate for a freezer, only 39% of respondents recall seeing or hearing about the Freezer Rebate Program in the store where they purchased their new freezer. Additionally:
  - 52% knew the freezer qualified for a PSE rebate before they purchased it
  - 37% reported the rebate encouraged them to buy the model they did
  - 37% reported the PSE endorsement made them feel better about their purchase
  - 25% reported the rebate had no effect on their purchase
  - 15% reported the salesman at the store used the PSE rebate to encourage them to buy the model they purchased

6.7.4 Demographics of Appliance Rebate Participants

Participants in the Appliance Replacement program are home owners, primarily living in single family detached homes. The specific characteristics of individuals receiving rebates are bulleted below.

- Demographics of Refrigerator Rebate participant survey respondents:
  - 99% own their home, 1% rent their home
  - 88% live in a single family detached home, 10% in a single family attached home, and 2% in a mobile or manufactured home
  - Heating type: 61% natural gas/31% electric/4% propane/4% other
  - 45% have central air conditioning.
- Demographics of Freezer Rebate respondents:
  - 97% own their home, 3% rent their home
  - 93% live in a single family detached home, 2% in a single family attached home, 5% in a manufactured or mobile home
  - Heating type: 52% natural gas/40% electric/3% propane/5% other
  - 29% have central air conditioning
- Demographics of Clothes Washer Rebate survey respondents:
  - 98% owned their home, 2% rent their home.
  - 91% live in a single family detached home, 8% in a single family attached home, and 1% in a mobile or manufactured home.

— Households had an average of 2.8 full-time residents.

— Water heater type: 37% electric/58% gas/4% propane

— Clothes dryer type: 87% electric/12% gas/1% propane

6.7.5 Participant Satisfaction

Participant satisfaction with the Appliance Rebate Program, and participant satisfaction compared to general population satisfaction with PSE are presented below.

Participant Satisfaction with Program

Participant satisfaction with the Appliance Rebate Program was generally very high. The table below shows respondents reported satisfaction with each of the DtC programs. Participant satisfaction ranged from 79% for participants who received a freezer rebate to 92% for participants who received a refrigerator rebate (including both extremely and somewhat satisfied). The primary reasons reported for dissatisfaction by participants was that the rebate they received was too small or was never received. The Decommissioning and Replacement programs received more "Extremely Satisfied" rankings than the Rebate programs.

TABLE 6-16: SATISFACTION WITH THE APPLIANCE REBATE PROGRAM

Satisfaction with the Program	Rebate			All DtC Participants
	Clothes Washer	Refrigerator	Freezer	
Extremely Satisfied	56%	60%	60%	68%
Somewhat Satisfied	30%	32%	19%	23%
Neutral	11%	7%	14%	7%
Somewhat Dissatisfied	2%	1%	4%	1%
Extremely Dissatisfied	1%	0%	4%	1%
N	273	166	57	1,036
Mean Ranking	4.4	4.5	4.3	4.6

Participant versus General Population Satisfaction with PSE

Participants reported that they were much more satisfied with PSE (extremely or somewhat), than residential customers who responded to our general population survey (80% compared to 68%). The mean satisfaction ranking across all program participants is 4.1. The primary reasons reported by participants for dissatisfaction with PSE were related to rates being too high (48%), poor customer service (20%), or power outages (9%).

TABLE 6-17: PARTICIPANT SATISFACTION WITH PSE OVERALL

Satisfaction with PSE Overall	Rebate				All DtC Participants	General Population
	APS	Refrigerator	Freezer	Clothes Washer		
Extremely Satisfied	36%	44%	28%	35%	40%	25%
Somewhat Satisfied	42%	40%	46%	43%	40%	43%
Neutral	18%	9%	18%	17%	14%	24%
Somewhat Dissatisfied	4%	6%	5%	4%	5%	5%
Extremely Dissatisfied	0%	1%	4%	1%	2%	3%
N	143	167	57	273	1,183	655
Mean Ranking	4.1	4.2	3.9	4.1	4.1	3.8

As the table below shows, most participants across the Rebate Programs stated that their satisfaction remained about the same, roughly one-third of program participants stated their participation in the program increased their satisfaction with PSE. Very few respondents (2% across all programs) indicated that their level of satisfaction decreased after program participation. The percentage among participants who received rebates for a freezer appears a bit higher (5%), but this represents only three individuals compared to one to five in the other categories. The reasons reported for a decline in satisfaction were similar to the reasons reported for dissatisfaction with PSE reported above (rates were too high, rebate was never received or was too small, and poor customer service).

TABLE 6-18: CHANGE IN SATISFACTION WITH PSE POST-PROGRAM PARTICIPATION

Change in Satisfaction with PSE Post Program Participation	Rebate			All DtC Participants
	Refrigerator	Freezer	Clothes Washer	
Higher	27%	25%	18%	32%
About the Same	72%	70%	79%	65%
Lower	1%	5%	2%	2%
Don't Know	1%	0%	2%	1%
N	168	60	275	1,041

6.7.6 Best Practices and Opportunities

The DtC were compared to six best-practice areas identified within the National Energy Efficiency Best Practices Study[96] to identify program strengths, areas for improvement, and strategies for improving them. These included: (1) program theory and design, (2) program management, (3) reporting and tracking of energy savings, (4) quality control, (5) program processes, and (6) marketing and outreach. This program appears to be strong in most areas. Where rebates are required (i.e., appliance rebates),

[96] http://www.eebestpractices.com/ The goal of the study was to develop and communicate national excellent practices, built off the experience and knowledge gained through 25 years of program implementation, to enhance the design, implementation, and evaluation of energy efficiency programs.

the rebate form appears to be easy to use and available to be submitted both online and in hard copy. PSE and implementers report few issues related to participation processes.

Additional marketing may be needed to try to keep up with rising efficiency levels (which make it difficult to meet goals). In addition, there may be opportunities in the mid-stream market. This is currently being explored on a regional level. PSE should monitor the interaction of downstream versus mid-stream opportunities for Appliance Rebates to stay at the forefront of similar program models.

6.7.7 Other Detailed Appliance Rebate Findings

In addition to the specific areas covered in the process evaluation, the survey collected data that may be of interest to the program managers. This additional data is provided in bulleted form below.

Analysis of the clothes washer rebate survey responses led to the following additional findings:

- Most clothes washer rebate respondents (79%) reported the number of loads they washed per week did not change with their new unit, 15% reported they did fewer loads, and 6% reported they did more loads.
- Respondents reported that they dry 92% of loads washed in their new clothes washer. The 2015 deemed algorithm indirectly assumes 100% are dried. No adjustments were made to the ex-post UES calculation based on this finding as the current algorithm does not allow for such an adjustment. Further research could be conducted to determine if an update to the algorithm should be made to account for the reduced drying loads.
- The vast majority of respondents (89%) reported the number of loads they dried per week did not change after purchasing their new clothes washer. 8% reported the number of loads they dried decreased.
- Surveyed respondents reported that, on average, 42% of their clothes are washed in cold water, 46% in warm water, and 11% in hot water. However, no adjustments were made to the ex-post UES calculation based on this finding as the HW_fraction variable takes on an unsourced value of 13% in the deemed estimate and so lacking documentation on this variable it is not clear what the assumptions are behind it.

Analysis of the Refrigerator Rebate Program survey responses led to the following additional findings:

- 96% of rebated refrigerators were purchased as primary units.
- 88% of respondents reported that the rebated refrigerator was purchased to replace another refrigerator.

- 72% of those old units were in working order when they were replaced. The primary reasons given for replacing their old refrigerator were (in descending order) that the previous unit was old, the previous unit was inefficient, their kitchen was remodeled, and they just didn't like the old unit.
- The majority of units (52%) were removed by the retailer who delivered the new unit. Another 14% were recycled through PSE's Appliance Recycling Program, 13% were given away for free, and 11% were kept as a secondary unit.
- 53% of respondents recall seeing or hearing about the Refrigerator Rebate Program in the store where they purchased their new refrigerator. Additionally:
  - 59% knew the refrigerator qualified for a PSE rebate before they purchased it
  - 38% reported the rebate encouraged them to buy the model they did
  - 38% reported the PSE endorsement made them feel better about their purchase
  - 21% reported the rebate had no effect on their purchase
  - 13% reported the salesman at the store used the PSE rebate to encourage them to buy the model they purchased

Analysis of the Freezer Rebate Program survey responses led to the following additional findings:

- 72% of respondents reported that the rebated freezer was purchased to replace another freezer.
  - 67% of the old units were in working order when they were replaced. The majority were replaced because the previous freezer was old or inefficient.
  - The majority of units (63%) were removed by the retailer who sold the new unit. Another 9% were recycled through PSE's Appliance Recycling program, 9% were sold to a private party, 5% were given away for free, 5% were taken to the landfill, and 2% were kept as a secondary unit.

Participants in the Appliance Rebate Program also received a Thank You kit, which included LEDs and showerheads. These kits are distributed to increase customers' exposure to new products, and to garner additional energy and water savings. Based on an analysis of all Leave Behind and Thank You kit respondents,[97] we found that many already had experience with the measures, but that the exposure was new for some participants. The evaluation also collected information on installation of these measures, which is described in Section 4.4.6.

[97] Leave Behind kits are a different kit that is given to Appliance Decommissioning and Appliance Replacement participants. For the purposes of this analysis, however, we combined all data to report results from all kit recipients.

6.8 APPLIANCE REBATE PROGRAM FINDINGS AND RECOMMENDATIONS

The evaluation team provides the following findings and recommendations for PSE's Appliance Rebate Programs (clothes washer, refrigerator, and freezer).

Finding REB1: As indicated in the process evaluation section, several variables were missing from the appliance rebate tracking data files that would improve the ease and accuracy of evaluation and program planning efforts. Additionally, some Thank You kits included in the tracking data did not appear to be associated with an appliance rebate participant.

Recommendation REB1: The evaluation team recommends adding the following variables to the appliance rebate tracking databases:

- Clothes Washer Rebates: door configuration (top vs. front-loader),[98] capacity of the unit in cubic feet, dryer and water heater fuel type.
- Refrigerator and Freezer Rebates: house type, door configuration, capacity in cubic feet, and freezer defrost type.
- Retaining account numbers[99] and email addresses for all participants would aid in follow up with customers (including market research post-participation surveys) and would allow a better assessment of cross-program participation.

Finding REB2: There were 48 units in the tracking data that appeared to be duplicates. These units were reviewed by PSE and vendor staff and were found to be a mix of duplicates and valid records. These records account for less than 0.5% of the appliance units rebated in 2015 and thus no adjustment was made to program saving. According to the program vendor, the issue that led to these duplicate records has been identified and corrected.

Recommendation REB2: PSE should insure their QA/QC processes are correctly checking to ensure duplicate records are not present in the program tracking data.

Finding REB3: During the ex-post evaluation an updated version of the CEC Database[100] was used to estimate two of the ex-post UES parameters (the annual gallons of water used for washing and the moisture content remaining in clothes) as the version used for the deemed estimates was a bit outdated

[98] The 2016 UES differed for Tier 1 front versus top-loading units.

[99] Less than 1% of 2015 tracking records were missing an account number.

[100] The 2015 deemed UES used the CEC database as of 9/6/2013 whereas the ex-post UES used the CEC database as of 12/31/2014.

at the time the measure savings were deemed. Both of these parameters decreased with CEC database update and led to an increase in measure level savings.

Recommendation REB3: Whenever possible, the evaluation team recommends updating the clothes washer UES parameters annually based on the most current version of the CEC database available.

7 RESIDENTIAL LIGHTING PROGRAM

In 2015, PSE's Residential Lighting program offered incentives towards the purchase of standard and specialty CFLs, LED bulbs, retrofit kits and fixtures, and Induction A-lamps to PSE residential electric customers. PSE utilizes several different delivery mechanisms to distribute incentivized high efficiency lighting measures to its residential customers. In 2014 and 2015, PSE customers could access rebated high efficiency lighting measures through the following channels:

- Retail – instant discounts on ENERGY STAR® qualified CFL and LED bulbs and LED fixtures sold to PSE residential customers through program retailers. This channel is administered by two implementers: C+C and Blackhawk administer the core program at retailers located concretely within PSE territory, and CLEAResult administers the Simple Steps program, which is a multi-jurisdictional program targeted towards retail outlets located along the border of utilities' service territories.
- ShopPSE – online retail sales of LED bulbs and retrofit kits.
- Pop-up Events – sales of kits that include LEDs at events (such as fairs or large work campuses) managed by TechniArt.
- Direct Mail & Door-to-Door - Approximately 14,000 CFLs were distributed in 2014 via Direct Mail & Door-to-Door effort.[101]

High efficiency lighting measures were also distributed in 2014 and 2015 through PSE's Appliance Replacement and Decommissioning program via no-cost kits left with program participants.[102] Although these lighting measures share the same UES savings estimates, they are tracked and reported upon separately.

Overall, the Residential Lighting Program makes up the majority of the DtC portfolio, accounting for 88% of the DtC reported ex-ante electric savings.

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[101] The bulbs distributed via this channel accounted for less than 1% of the CFLs distributed in 2014. This channel was not utilized in 2015 and the program has no future plans to distribute bulbs via this channel. For this reason, this evaluation only verified that the reported quantity of bulbs distributed via this channel aligned with program tracking data and the UES estimates were applied correctly. No additional evaluation activities were conducted for these lamps.

[102] Leave Behind kits, which included Low-flow Showerheads and A-lamp LEDs, were given to customers participating in the Appliance Decommissioning and Replacement programs. These measures were left with the homeowner and were not installed by the appliance program vendors. The majority of bulbs distributed through the program are sold at a discount to PSE residential customers. Bulbs distributed to customers for free accounted for approximately 0.2% of the program in 2014 and 2015.

7.1 RESIDENTIAL LIGHTING EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the Residential Lighting Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), in-depth reviews of program tracking databases, web surveys PSE residential customers (general population), trade ally interviews, and a review of secondary data collected to support similar programs across the U.S.

Table 7-1 below presents a comparison of the PSE deemed, evaluation verified, and evaluation ex-post Unit Energy Savings (UES) estimates and realization rates for the 2014 and 2015 Residential Lighting Program. As this table shows, the program had a 100% verified realization rate for nearly all lighting measures indicating the quantity of measures sold through the program was accurate and the PSE deemed UES was applied. For two measures, LED Retrofit Kits and LED Indoor Fixtures, the 2014 UES value was mistakenly applied to units sold in 2015 rather than the 2015 value. The UES change between 2014 and 2015 was small and hence there was only a minor reduction in verified savings (99% and 90%, respectively). The ex-post realization rates for the lighting measures were all nearly all more than 100% (the exception being Globe LEDs which were only 98%) as a result of ex-post changes to the following parameters included in the UES algorithm:

- Increases to the Delta Watts parameter updates based on updates to both the measure and baseline wattage based on the actual bulbs sold through the program in 2015 and the estimated 2015 market share of various bulb types,
- Reductions to the Interactive Effects (IE) parameter based on applying the 2017 IE methodology adjusted to account for the single-family vs. multi-family and heating fuel type split in PSE service territory,
- Increases to the Hours-of-Use (HOU) parameter based on updates to the ratio of Residential vs. Nonresidential installations and applying the 2017 deemed residential HOU methodology adjusted to represented the lumen output of 2015 program bulbs.

TABLE 7-1: 2015 RESIDENTIAL LIGHTING UES ESTIMATES (KWH)

Lighting Measure	Ex-Ante UES	Verified UES	Verified Realization Rate	Ex-Post UES	Ex-Post Realization Rate
A-Lamp LED	16.02	16.02	100%	17.90	112%
Reflector LED	28.23	28.23	100%	40.14	142%
Retrofit Kit LED	19.99[103]	19.71	99%	37.10	188%
Indoor LED Fixture	21.70[104]	21.70	90%	40.62	187%
Outdoor LED Fixture	58.47	58.47	100%	76.31	131%
Candelabra LED	17.76	17.76	100%	21.97	124%
Globe LED	15.71	15.71	100%	15.44	98%
MR16 LED	25.42	25.42	100%	25.98	102%
A-Lamp Induction	10.53	10.53	100%	N/A	N/A
Standard CFL	9.09	9.09	100%	12.22	134%
Specialty CFL	15.09	15.09	100%	22.10	147%

Source: Evaluation Team Analysis

Additional details on the ex-post UES estimates and realization rates are provided in Section 7.3 below.

7.2 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of a review of program tracking and invoice data to verify the volume of units sold through the program and a review of calculation and application of the deemed unit energy savings (UES) estimates applied.

7.2.1 Tracking and Invoice Data Review

The tracking data review completed for PSE's Residential Lighting program found that the 2014 and 2015 tracking data files were missing several variables that provide important information about the characteristics of the program measures needed to accurately characterize program sales and calculate measure savings. These missing variables included the measure wattage, lumen output, baseline wattage equivalent, bulb description (such as reflector type - R20, BR30, PAR38, specialty CFL type – globe, reflector, candelabra, and fixture type), and retailer where the measure was sold. PSE has reported that it is working with program vendors to ensure these data fields are included in the program

[103] The PSE deemed UES estimate in 2015 PSE was 19.71 but to calculate 2015 savings PSE applied 19.99 kWh (the 2014 UES estimate). Therefore, the realization rate on the ex-ante savings was 99%

[104] The SOS workbook provided to the evaluation team had a PSE Deemed UES of 18.02 kWh for this measure but that estimate, however that estimate reflected an error in the calculation of the IE estimate. The correct 2015 UES value is 21.70 kWh. The ex-ante savings were calculated with 23.99, which was the 2014 UES, and led to an ex-ante savings realization rate of 90% for this measure.

tracking data going forward, however this has not been confirmed by the evaluation team. Additionally, an issue was identified in the assignment of the 2015 deemed UES for Indoor LED fixtures and LED Retrofit Kits. Both of these measures were mistakenly assigned the 2014 UES value rather than the 2015 value. This resulted in measure level realization rates of 90% and 99% respectively, and an overall verified realization rate of 99% across all the measures. Issues related to missing, duplicative or misaligned data are discussed within the process section of this chapter.

Table 7-2 and Table 7-3 below provide the distribution of 2014 and 2015 program sales across the five primary delivery channels (excluding thank you and leave behind kits distributed to appliance program participants). As these tables show, in both 2014 and 2015 the program distributed around 4.5 million lamps and fixtures, however, the type of bulbs sold through the program shifted significantly from CFLs in 2014 (52% of sales) to LEDs in 2015 (65% of sales). Additionally, the upstream channel made up 83% of 2014 sales and 95% of 2015 sales. This increased reliance on the upstream channel was driven primarily by a reduction in sales through ShopPSE in 2015.

TABLE 7-2: 2014 PROGRAM SALES BY DELIVERY METHOD

Measure Type	Upstream	Engage-ment	ShopPSE	Simple Steps	Events	Total	% of Total
A-Lamp LED	1,180,411	317	87,424	15,440	22,495	1,306,087	28%
Reflector LED	395,042	0	26,632	17,054	2,456	441,184	10%
Retrofit Kit LED	61,773	0	22,109	2,526	0	86,408	2%
Indoor LED Fixture	69,662	0	2,301	412	0	72,375	2%
Outdoor LED Fixture	26,796	0	2,686	0	0	29,482	1%
Candelabra LED	168,538	0	918	0	144	169,600	4%
Globe LED	90,123	0	36	5,758	116	96,033	2%
MR16 LED	5,283	0	1,203	0	124	6,610	0.1%
Standard CFL	1,368,894	13,815	291,749	46,204	32,567	1,753,229	38%
Specialty CFL	467,122	0	123,434	18,054	36,812	645,422	14%
CFL Fixtures[105]	2,439	0	3,202	5	12	5,658	0.1%
Total	3,836,083	14,132	561,694	105,453	94,727	4,612,089	100%
% of Total	83%	0.3%	12%	2%	2%	100%	

105 Indoor and Outdoor CFL fixtures were combined due to the low volume distributed.

TABLE 7-3: 2015 PROGRAM SALES BY DELIVERY METHOD[106]

Measure Type	Upstream	ShopPSE	SimpleSteps	Events	Total	% of Total
A-Lamp LED	1,501,478	47,801	31,141	28,685	1,609,105	36%
Reflector LED	672,653	89	23,671	5,117	701,530	16%
Retrofit Kit LED	181,733	158	7,626	2,948	192,465	4%
Indoor LED Fixture	69,673	0	0	0	69,673	2%
Outdoor LED Fixture	48,651	0	0	0	48,651	1%
Candelabra LED	145,607	13	3,749	252	149,621	3%
Globe LED	89,381	0	4,162	143	93,686	2%
MR16 LED	11,022	3	0	13	11,038	0.2%
Standard CFL	1,272,302	8	32,439	3,118	1,307,867	29%
Specialty CFL	250,439	0	6,672	2,399	259,510	6%
Total	4,242,939	48,072	109,460	42,673	4,443,144	100%
% of Total	95%	1%	2%	1%	100%	

7.2.2 UES Algorithm

The PSE Deemed UES estimates for each of the lighting measures were based upon a single algorithm, however the source of the parameters used within the algorithm varied by measure. The algorithm used in 2015 to calculate measure-level UES estimates was the following:

Annual kWh Savings = ($Watt_b$ - $Watt_m$) * Daily_HOU * 365 days * HVAC_IE / 1000

Where:

$Watt_b$ = Baseline Bulb Wattage

$Watt_m$ = Program Bulb Wattage

Daily_HOU = Average number of hours per day the program bulb is in use

HVAC_IE = HVAC Interactive Effect factor which accounts for changes in space conditioning resulting from the installation of high efficiency lighting (includes both heating penalties and cooling benefits)

106 Excludes all non-qualified (NQC) records in the tracking database. In 2015 these made up approximately 11,650 records.

The PSE Deemed algorithm is similar to the RTF UES algorithm but utilizes PSE-specific input parameters for program measure wattage, baseline wattage, and hours-of-use so the resulting PSE Deemed UES estimate more accurately reflects the energy savings within PSE's service territory. This algorithm is consistent with UMP methodology, except that it did not address program measure installation.[107] As noted in the UMP, upstream programs, such as PSE's lighting program, often have first-year installation rates (ISR) below 100% due to "(1) the often deeply discounted price, (2) the inclusion of program multipacks, and (3) the common practice among consumers of waiting until a bulb burns out before replacing it." This issue will be discussed in further detail the ex-post impacts section below.

7.2.3 Verified Savings

The evaluation team's overall assessment of the 2015 UES estimates for residential lighting measures concluded that the algorithm and parameter inputs for these measures are defensible, reproducible and appropriate at the time they were deemed. The only issue identified during the Stage 1 verification was the incorrect application of the UES estimates for LED Retrofit kits and Indoor LED Fixtures. For both measures the 2014 UES was mistakenly applied to 2015 program sales and thus the resulting overall verified savings realization rate was 99%.

7.3 STAGE 2 EX-POST IMPACT ANALYSIS

7.3.1 Ex-Post UES Adjustments

Research conducted during Stage 2 of the evaluation led to several updates to the UES parameters used to calculate the ex-post UES estimates for the lighting program. These updates were based upon analysis of 2014/2015 program tracking data, results of the general population web surveys, and a review of newly available data used to estimate the 2017 deemed UES for the lighting program. A-Lamp induction LEDs were not included in the ex-post analysis as none were sold through the program in 2015.

Measure Wattage

A limitation of the 2014 and 2015 UES estimates identified during Stage 1 of the evaluation was that the measure wattage used to calculate delta watts ($Watt_b$ - $Watt_m$) was based on data that was not necessarily representative of the 2014 and 2015 program offerings. The source of the measure wattage data varied by lighting measure, but was often based on very small samples of data, program data that was old, or data collected via online surveys of available products at a limited number of program

[107] A storage rate (which is 1 minus the installation rate) was applied for CFLs in the 2016 program year and will be applied for LEDs in the 2017 program year.

retailers. Unfortunately, the 2014 and 2015 program tracking data did not include important measure-level characteristics, such as wattage of the units sold through the program. For the ex-post analysis, the evaluation team requested from C+C (the program implementer) files that included program bulb wattage and lumen output for the 2014 and 2015 sales. C+C could provide this data for 62% and 82% of the measures sold in 2014 and 2015, respectively. The table below shows the 2015 ex-ante wattage by lighting measure, as well as the ex-post measure wattage based on the C+C files, and the percent change between these estimates. As this table shows, across all lighting measures the program sales-weighted difference was only -0.5%. However, on an individual measure basis, the difference ranged from -10% to 47%. Since UES are calculated on a measure-level, these differences can cause significant changes to the UES estimates.

TABLE 7-4: AVERAGE MEASURE WATTAGE ESTIMATES

Lighting Measure	2015 Ex-Ante	2014 Ex-Post	2015 Ex-Post	2015 %Δ
A-Lamp LED	9.37	9.57	9.33	0%
Reflector LED	12.82	12.49	11.51	-10%
Retrofit Kit LED	13.07	17.37	16.18	24%
Indoor LED Fixture	15.36	21.33	18.52	21%
Outdoor LED Fixture	9.68	22.07	14.27	47%
Candelabra LED	3.65	4.90	4.14	13%
Globe LED	5.31	7.88	7.56	42%
MR16 LED	6.31	7.09	7.20	14%
Standard CFL	17.00	16.51	16.49	-3%
Specialty CFL	14.89	14.74	15.05	1%
Average across all Measures	12.45	13.42	12.40	-0.5%

Baseline Wattage

The 2015 Deemed baseline wattage was calculated using the 2010 RBSA data (PSE-specific sample) as the average installed wattage across similar measures. This methodology assumes the baseline condition is what was installed and at the time of the last RBSA was primarily a mix of incandescent, halogen and CFL bulbs (the socket saturation of LED bulbs was very low in 2010 when the RBSA data was collected). The rapid uptake of CFL and LED lighting technologies in residential customer homes between 2011 and 2014/2015, as well as the implementation of the EISA 2007 standards,[108] made the 2010 RBSA somewhat outdated as a source to calculate the 2014 and 2015 UES estimates. Additionally, using such a methodology assumes the program incentivized measures are adequately represented by

[108] The EISA 2007 standards increased minimum efficiency standards (by ~30%) for general purpose lamps and let to the elimination of 40W, 60W, 75W and 100W lamps.

the installed lighting stock per the RBSA. This assumption can be erroneous especially for Indoor and Outdoor fixtures, where the program may tend to incentivize a limited range of replacement lighting fixtures.

In an attempt to circumvent these issues and align the evaluation with the approach recommended by the Uniform Methods Project,[109] the evaluation team used a lumen mapping methodology that maps the lumen output of a program bulb to an equivalent EISA adjusted baseline wattage bin.[110] Similar to measure wattage above, lumen output was not included in PSE's residential lighting program tracking data but was available for a large share of the measures in the files provided by C+C. Lumen output was missing for roughly 20% of the records in the file from C+C and so the top 20 measures missing lumen output (based on sales volume) were manually looked up by the evaluation team based on model number. All other lamps with missing lumen output were mapped using the program measure wattage and the average baseline wattage of all other program bulbs. Requiring all manufacturers to provide lumen output in their sales data and ensuring it is retained in the program tracking data will eliminate this step in the future.

Another issue encountered by the evaluation team in trying to determine baseline wattage was that lamp type information was not provided for Outdoor LED Fixtures and Specialty CFL lamps. Absent this information, the evaluation team assumed all outdoor fixtures were directional in nature and utilized the reflector lumen mapping (although some portion of the outdoor fixtures are likely omni-directional). Similarly, neither the C+C file nor the tracking data contained specialty CFLs lamp type (3-way, directional, globe, etc.). Specialty CFL lamp type is needed for lumen mapping due to differences in EISA standards for various types of specialty bulbs. Whenever possible, the evaluation team merged on lamp type by model number using an internal specialty CFL dataset and by make and model lookups for the top specialty CFL models.

Table 7-5 presents the average lumen values for residential lamps in the C+C data for program years 2014 and 2015. As this table shows, the lumen output of program lamps changes annually based on the mix of program bulb offerings and sales, and thus using data from the actual program bulb sales to estimate program energy savings is recommended whenever possible.

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109 Uniform Methods Project, chapter 6: Residential Lighting Evaluation Protocol. Pages 6-10. National Renewable Energy Laboratory. February 2014.

110 The lumen mapping used for this study was taken from the Illinois Technical Reference Manual version 5.0. http://www.ilsag.info/il_trm_version_5.html.

TABLE 7-5: AVERAGE LUMEN OUTPUT OF 2014 AND 2015 PROGRAM BULBS

Lighting Measure	2014 Average Lumens	2015 Average Lumens
A-Lamp LED	675	749
Reflector LED	740	721
Retrofit Kit LED	1,006	972
Indoor LED Fixture	1,286	1,322
Outdoor LED Fixture	1,436	1,158
Candelabra LED	296	301
Globe LED	493	482
MR16 LED	432	458
Standard CFL	1,103	1,124
Specialty CFL	736	813
Average across all Measures	855	860

Because PSE is interested in gross savings, rather than net, using the baseline wattages from the lumen mappings without any adjustment would overstate the baseline wattage since it would assume the baseline condition for all program lamps sold is the minimum efficiency available. To rectify this, the evaluation team applied the estimated 2015 bulb type market shares used within the 2017 PSE deemed savings files to degrade the baseline wattage values for program lamps that were replacing CFL and LED lamps (and thus would have significantly lower baseline wattage values). The table below shows the resulting 2015 ex-ante baseline wattage by lighting measure, as well as the calculated ex-post baseline wattage based on the C+C files, and the percent change between the estimates. As this table shows, across all lighting measures the change was 5% (program sales-weighted). On an individual measure basis, the ex-post baseline wattage differed from the deemed estimate by -21% to 25%.

TABLE 7-6: AVERAGE BASELINE WATTAGE ESTIMATES

Lighting Measure	2015 Ex-Ante	2015 Ex-Post	2015 %Δ
A-Lamp LED	32.8	32.95	0%
Reflector LED	48.9	55.27	10%
Retrofit Kit LED	44.1	55.73	19%
Indoor LED Fixture	57.4	70.13	16%
Outdoor LED Fixture	51.8	71.38	24%
Candelabra LED	37.4	36.15	-3%
Globe LED	38.9	36.09	-7%
MR16 LED	43.8	35.53	-21%
Standard CFL	32.8	n/a	23%
Specialty CFL	41.3	32.78	25%
Average across all Measures	37.22	39.09	5%

Delta Watts

Delta Watts is the calculated as the difference between the baseline and the program measure wattage ($Watt_b$ - $Watt_m$). The table below shows the 2015 PSE deemed delta watt estimates by lighting measure, as well as the ex-post estimate, and percent change between the deemed and ex-post estimates. As this table shows, across all lighting measures the change between the 2015 deemed and ex-post delta watts was 8% (program sales-weighted). On an individual measure basis, the deemed to ex-post delta watts difference ranged from -24% to 36%.

TABLE 7-7: AVERAGE DELTA WATTS ESTIMATES

Measure	2015 Ex-Ante	2015 Ex-Post	2015 %Δ
A-Lamp LED	23.4	23.6	1%
Reflector LED	36.1	43.8	21%
Retrofit Kit LED	31.0	39.6	27%
Indoor LED Fixture	42.0	51.6	23%
Outdoor LED Fixture	42.1	57.1	36%
Candelabra LED	33.7	32.0	-5%
Globe LED	33.6	28.5	-15%
MR16 LED	37.5	28.3	-24%
Standard CFL	15.8	16.3	3%
Specialty CFL	26.4	26.3	-1%
Average across all Measures	24.8	26.7	8%

Hours-of-Use (HOU)

Hours-of-Use is a key parameter in the estimation of savings resulting from a program bulb. The more hours an efficient bulb is in use (turned on) the greater the annual savings resulting from the installation of the high efficiency bulb. The annual number of hours a bulb is in use can vary significantly for CFL and LED lamps depending on the location where the bulb is installed. Key locational factors affecting the HOU estimates include:

- Residential versus Nonresidential - nonresidential HOU are typically 4-5 times higher than residential HOU,
- Indoor versus Outdoor – outdoor lamps are more frequently left on all night and so typically have significantly longer HOU, and
- Room Type – room type is often correlated with bulb type (i.e., globe lamps tend to be installed in bathrooms and candelabra lamps in dining rooms, etc.).

The ex-ante HOU estimates were derived using the RTF methodology (which utilizes HOU data from a 2010 KEMA study and backfilled where needed with DOE estimates) applied to PSE-specific lighting inventory data collected during the 2010 RBSA study. A-lamp LEDs and Reflector LEDs were also adjusted to account for a percentage of the lamps being installed in non-residential locations.[111]

The ex-post HOU estimates were calculated using a similar methodology but updated based on changes to the following key HOU parameter assumptions:

- Residential versus Nonresidential – the 2015 LED Lamp purchase study results were applied by bulb type rather than overall to account for the differences found with respect to the variation found in the Res/NonRes split for different bulb types (see Table 7-8 below). The "overall" estimate (0.92 / 0.08) was used to estimate ex-ante savings, whereas the ex-post estimates used individual bulb type splits.[112]
- HOU estimates
  - Residential – the residential HOU estimates were updated to reflect the 2017 deemed UES source data but adjusted based on the actual lumen output distribution of 2015 program bulbs.
  - Nonresidential HOU estimates – the nonresidential HOU estimate was also updated to reflect the 2017 deemed estimate (8.0 vs 11.01, source not documented).

[111] Based on the results of a 2015 LED Lamp purchase study conducted by Itron to determine the percentage of LED bulbs sold through PSE's residential lighting program that were installed in non-residential locations.

[112] The 2017 deemed UES estimates used an assumption that 0% of LED fixtures were installed in nonresidential spaces which differs from the findings of the 2015 LED lamp purchase study.

TABLE 7-8: RES/NONRES SPLIT ASSUMPTIONS FOR HOU ESTIMATION

Bulb Type	Res Share	NonRes Shares	Retailer Type Adjustment	Adjusted Res/NonRes Share
A-Lamp	0.89	0.11	1.02	0.91 / 0.09
Reflector	0.90	0.10	1.02	0.92 / 0.08
Globe	0.91	0.09	1.02	0.93 / 0.07
Candelabra	0.94	0.06	1.02	0.96 / 0.04
Fixture	0.88	0.12	1.02	0.90 / 0.10
MR16	1.00	0.00	1.02	1.00 / 0.00
Overall (ex-ante)	0.90	0.10	1.02	0.92 / 0.08

Applying these updated parameters resulted in the 2014 / 2015 ex-post HOU estimates shown in the table below. The table below compares these ex-post HOU estimates to the 2015 PSE deemed estimates by lighting measure, and provides the percent change between the deemed and ex-post estimates. As this table shows, across all lighting measures the change between the deemed and ex-post HOU was 22% (program sales-weighted), indicating in the majority of cases the deemed HOU estimate was found to be a low. On an individual measure basis, the deemed to ex-post HOU difference ranged from -4% to 50%.

TABLE 7-9: RESIDENTIAL HOURS-OF-USE ESTIMATES

Measure	2015 Deemed	2014 / 2015 Ex-Post	2015 %Δ
A-Lamp LED	2.23	2.47	11%
Reflector LED	2.54	2.98	17%
Retrofit Kit LED	2.10	3.06	46%
Indoor LED Fixture	1.71	2.57	50%
Outdoor LED Fixture	3.80	3.66	-4%
Candelabra LED	1.75	2.26	29%
Globe LED	1.58	1.80	14%
MR16 LED	2.20	2.98	36%
Standard CFL	1.88	2.47	31%
Specialty CFL	1.87	2.78	48%
Engagement A-Lamp LED	2.23	1.92	-14%
Weighted Average[113]	2.13	2.59	22%

The overall weighted 2015 ex-post HOU estimate was also compared to the average using the 2017 deemed HOU estimates, and the difference was negligible at 3% overall. An additional small change

[113] Excludes Engagement A-Lamp LEDs

that was made when calculating the annual HOU, was that the number of days per year was increased from 365 to 365.25.

Installation Rate

Using data collected from the general population survey, installation rates (IR) were calculated for CFL and LED lamps. As seen in Table 7-10, LED lamps have a slightly higher installation rate (82.6%) then CFLs (77.4%). These values are not significantly different on a 90% confidence level.

TABLE 7-10: CFL AND LED INSTALLATION RATES

Lamp Type	IR	90% CI
LED	82.6%	79.9% - 85.3%
CFL	77.4%	73.5% - 81.2%

Household removal rates were also calculated for CFL and LED Lamps. The removal rate is defined by the removal of at least one of the LED or CFL lamps that the respondent indicated has been purchased within the last three years. Lamp removal was higher for CFLs, with 36% of households having removed a CFL and only 18% having removed an LED. Although respondents were more likely to remove a CFL, the reasons for removing the CFLs were very similar. The majority of survey respondents reported they had removed the bulb due to breakage or burn out (79% and 75% for LEDs and CFLs, respectively). Many fewer (16% for both CFL and LEDs) reported it was removed due to dissatisfaction with a feature of the bulb, such as color, light output, etc. Breakage and burnout of a lamp should be accounted for within the estimation of the effective useful life (EUL) of the lamp and thus should not be used to measure-level savings.

In 2016, PSE updated the UES for standard and specialty CFLs to include a storage and removal rate[114] of 26% for all CFLs sold through the program which reduced the UES by more than a quarter. In 2017, the UES algorithm separated the factor that accounted for bulb storage from that of bulb removal and applied estimates of these two factors to LED lamps and fixtures. Table 7-11 below presents the 2017 PSE deemed storage and removal rates applied to estimate measure-level UES estimates.

[114] The storage and removal rate is equivalent to 1 minus the installation rate.

TABLE 7-11: 2017 PSE DEEMED STORAGE AND REMOVAL RATES

Measure	Storage	Removal
A-Lamp LED	10%	2%
Reflector LED	10%	2%
Retrofit Kit LED	0%	2%
Indoor LED Fixture	0%	2%
Outdoor LED Fixture	0%	2%
Candelabra LED	10%	2%
Globe LED	10%	2%
MR16 LED	10%	2%
Engagement A-Lamp LED	24%	2%

The issue with applying a storage rate in the absence of a mechanism in place to account for carryover (the industry standard term for the delayed installation of program bulbs in future years) is that the savings from these stored bulbs installed in future program years are never accounted for in utility savings claims. In the past many utilities utilized a carryover savings mechanism based on the estimation of when the stored bulbs would be installed (typically over the following two program years) and then claimed the savings for the stored bulbs in those future program years. However, since in each program year utilities were claiming savings for first-year installs and two years of carryover savings from the previous program years stored bulbs, employing the carryover mechanism mostly led to accounting challenges and did little to alter the annual program savings estimates. As a result, in recent years many utilities have begun moving away from applying a first-year installation rate and utilizing carryover to account for delayed savings, and instead have applied the estimated life-time installation rate in the year the bulbs were sold and claimed all life-time installed savings in year one.[115]

To estimate the ex-post savings, the evaluation team utilized this non-carryover approach and applied life-time installation rates by bulb type (97% for CFLs lamps, 98% for LEDs lamps, 100% for LED fixtures, and 93% for LEDs distributed via kits) based on secondary research of life-time installation rates conducted by the evaluation team.

Interactive Effects

The interactive effects (IE) estimates used to estimate the 2015 deemed UES were calculated based on assumptions from the RTF's 6th power plan load profile. The evaluation team identified a number of

[115] This is a UMP-approved approach. The state of California switched to this approach in 2016 for the evaluation of the statewide 2013 and 2014 lighting programs (http://www.calmac.org/publications/2013%2D2014%5FCalifornia%5FUpstream%5Fand%5FResidential%5FLighting%5FImpact%5FEvaluation%5FReport%5FFINALV2%2Epdf).

issues with the assumptions that went into this IE calculation and thus utilized the methodology from the RTF's 7th power plan (used to estimate the IE for the 2017 program year), but with the following modifications to increase their representativeness of PSE's residential population:

- Home Type and Heating Fuel Adjustment – The heating and cooling interactions used to estimate the 2017 deemed IE were based on the average single family (SF) home. Census data for PSE service territory indicated only 62% of PSE customers lived in SF detached homes. This SF / MF split is important as MF residents are more likely to have electric heat and thus have higher electric IE. To account for this, the evaluation team created blended heating and cooling IE estimates based on the SF / MF distribution found in the census data. As shown in Table 7-12 below, this adjustment in home type led to a gas vs. electric heating fuel split of 48% vs. 52% which also aligned with the estimate from the census data.
- Lumen Distribution – The lumen distribution assumptions used to estimate the percentage of lamps installed in conditioned space assumed all 2015 program bulbs have low lumens output. The evaluation team updated these distributions to make them representative of the actual lumen output of 2015 program sales.

TABLE 7-12: HEATING AND COOLING INTERACTIVE EFFECTS BY HOME TYPE

Home Type	Elec Heat	Gas Heat	HVAC IE - Heating	HVAC IE - Cooling
Average Single-Family	30%	70%	-0.091	0.0056
Average Multi-Family	88%	12%	-0.291	0.0052
SF (62%) / MF (38%)	52%	48%	-0.167	0.0054

Based on this updated methodology and the updates to the input assumptions, the ex-post IE estimates dropped by around 10% from the 2015 deemed IE estimates (shown in Table 7-13 below).

Itron

TABLE 7-13: AVERAGE INTERACTIVE AFFECTS ESTIMATES

Measure	2015 Ex-Ante	2015 Ex-Post	2015 %Δ
A-Lamp LED	-0.16	-0.14	-11%
Reflector LED	-0.16	-0.14	-10%
Retrofit Kit LED	-0.17	-0.16	-5%
Indoor LED Fixture	-0.17	-0.16	-7%
Outdoor LED Fixture	0.00	0.00	0%
Candelabra LED	-0.17	-0.15	-12%
Globe LED	-0.19	-0.16	-15%
MR16 LED	-0.16	-0.14	-10%
Standard CFL	-0.16	-0.14	-11%
Specialty CFL	-0.17	-0.14	-13%
Engagement A-Lamp LED	-0.16	-0.14	-11%

7.3.2 Ex-Post Savings Estimate

Applying the ex-post UES adjustments described above to the 2015 deemed UES algorithm for the Lighting measures led to the ex-post UES estimates shown in Table 7-14 below.

TABLE 7-14: 2015 EX-POST PARAMETERS AND RESULTING UES ESTIMATES

Measure	Delta Watt	Annual HOU	HVAC IE	ISR_{LT}	Ex-Post UES
A-Lamp LED	23.6	901	-0.14	98%	17.90
Reflector LED	43.8	1,089	-0.14	98%	40.14
Retrofit Kit LED	39.6	1,118	-0.16	100%	37.10
Indoor LED Fixture	51.6	938	-0.16	100%	40.62
Outdoor LED Fixture	57.1	1336	0.00	100%	76.31
Candelabra LED	32.0	827	-0.15	98%	21.97
Globe LED	28.5	657	-0.16	98%	15.44
MR16 LED	28.3	1,089	-0.14	98%	25.98
Standard CFL	16.3	901	-0.14	97%	12.22
Specialty CFL	26.3	1,014	-0.14	97%	22.10
Engagement A-lamp LEDs	23.6	700	-0.14	93%	13.21

Table 7-15 below compares the deemed UES to ex-post UES by lighting measure. As this table shows, for all measures but two the ex-post realization rate was greater than 100% indicated the ex-post UES was higher than the deemed estimate. The 2015 program sales weighted realization rate across all measures was 130%.

TABLE 7-15: COMPARISON OF 2015 DEEMED TO EX-POST UES ESTIMATES

Measure	Deemed UES	Ex-Post UES	2015 Ex-Post UES Realization Rate
A-Lamp LED	16.02	17.90	112%
Reflector LED	28.23	40.14	142%
Retrofit Kit LED	19.71	37.10	188%
Indoor LED Fixture	21.70	40.62	187%
Outdoor LED Fixture	58.47	76.31	131%
Candelabra LED	17.76	21.97	124%
Globe LED	15.71	15.44	98%
MR16 LED	25.42	25.98	102%
Standard CFL	9.09	12.22	134%
Specialty CFL	15.09	22.10	147%
Engagement A-Lamp LED	16.02	13.21	82%

7.4 RESIDENTIAL LIGHTING PROCESS ANALYSIS

The process evaluation for residential lighting relied on data collected from the general population and participant web surveys and in-depth interviews with lighting trade allies (program retailers and manufacturers). The process analysis for the Residential Lighting Program sought to answer the process-related questions laid out in the introduction regarding the following areas:

- **Program Theory and Changes:** How has PSE's Residential Lighting Program changed over time? Is this well-documented?
- **Data Tracking:** What data are currently being collected to support the Residential Lighting Program and how is this data being used? And what additional research is needed for each program area?
- **Awareness:** How aware are residential customers of the Residential Lighting Program offerings and what channels are most effective to increasing awareness?
- **Demographics of Participation:** Who is currently participating in the Residential Lighting Program (demographically)?
- **Trade Ally Satisfaction:** What is the level of trade ally (i.e., manufacturer and retailer) satisfaction with Residential Lighting Program processes, and what areas of improvement exist?
- **Best Practices and Opportunities:** Is the Residential Lighting Program following industry best practices? How does it benchmark against industry best practices for program theory and

design, program management, reporting and tracking of energy savings, quality control, program processes, and marketing and outreach? Where may additional opportunities lie?

7.4.1 Program Theory and Changes

While not explicitly laid out in a program theory and logic model, the Lighting Program is described in annual and biennial plans and reports and changes are documented in the annual businesses cases. In general, lighting programs are well-established and have an understood theory.

PSE's lighting program has remained fairly stable over the last few years, with the primary change being the transition of program bulbs from CFLs to LEDs. Other changes documented in the 2014-2015 Business Case include:

- Discontinuation of CFL fixtures
- Updating of savings and measure costs for specialty CFLs due to RTF updates
- Changing PSE deemed savings and measure costs for LED bulbs and fixtures using RTF deemed measure life. LED Measures were added, which included LED Globe and Retrofit Kit LED.
- Adding CFL Door-to-Door and Direct Mail measures as new measures

The programs also continued to evolve in 2016-2017, as documented in the 2016-2017 DtC Business Case, including changes to incentive amounts.

As described earlier in this chapter, lighting is distributed through multiple channels including retail stores, in-person pop up events, online through ShopPSE, and through giveaways in Leave Behind and Thank You kits.[116] Across these channels, there are several different groups that work as a team to implement these efforts. These groups include:

Retail Channels

- Manufacturers who work with PSE to determine products and buy-down amounts
- Retail stores, that play a more limited role selling the products in store
- An implementer (C+C) that negotiates program MOUs and works closely with the retailers

Online through ShopPSE

- PSE staff that manage the website working with an implementer that fulfills web orders

[116] Leave Behind kits are distributed to Appliance Replacement and Decommissioning participants. Thank You kits are distributed to Rebate participants and those who did not qualify for the programs.

Pop-up Events

- An implementer (TechniArt) that sells products, including lighting, at pop-up events

Thank You Kits[117]

- An implementer (EFI) that manages sends out lighting in Thank You Kits

Marketing and support (cross-channel efforts)

- An implementer (Black Hawk) that processes manufacturer and retailer sales, and invoices PSE
- PSE management staff and marketing team that oversee the implementation of the program, and markets energy efficient lighting

FIGURE 7-1: RESIDENTIAL LIGHTING ROLES*

	C+C	Manufacturers	Retailers	ShopPSE group within PSE	TechniArt	Black Hawk	EFI	PSE Marketing Group	PSE PM and systems channel staff
Roles	Creates and manages MOUs; categorizes SKUs; works with Manufacturers and Retailers	Signs MOU agreeing to products; Submits invoice and sales data to BES online portal	Sells incentivized product in stores; allows in-store signage (POP); provides data to Manufacturer	Sells lighting and showerheads sold online	Sells measures through pop up events	Performs QA/QC on data; Reports DB information to PSE; pays manufacturers	Mails out lightbulbs, showerheads and aerators in "thank you" kits (in support of Rebate programs)	Oversees all marketing efforts	Oversees all processes (including MOU and changes); approves invoices; uploads data; calculates savings; determines forecasts
Data	MOUs and data from store visits/ customer intercepts	Lighting and showerhead data and retailer/manufacturer for in-store sales, invoices		Lighting, showerhead, and customer data for online sales	Unit data (lighting, showerheads, kits) and purchaser zip code for event-based sales	Aggregated manufacturer invoice amount (and quantities) for PSE	Light., showerhead/ aerator, and customer data for thank you kits		

7.4.2 Data Tracking

A review of the data tracking for the Lighting program showed that this program is collecting sufficient information to document success. During the Stage 1 verification effort, the evaluation team found that the data for the Lighting program was detailed and specific. There were only a couple of minor issues that arose:

- There were two parameters needed for the algorithm that were not available in the databases. Program bulb wattage was not in the tracking data for 2014 or 2015, nor was a bulb description variable which would provide detailed information about the bulb type (such as the type of reflector – R20, BR30, PAR38, etc.). Wattage has since been added to the database by the implementer to assist with future research efforts and to allow PSE to better document program accomplishments.
- In the review of lighting invoices, the tracking data often provided store numbers instead of the retail establishment, limiting the development of findings by retailer unless a mapping can be provided.

The evaluation team also worked with PSE during Stage 2 to document the types of data that should be collected by each of the key players in the program delivery to ensure success for the future. A full mapping of the data that should be collected by each of the key group is included in Appendix H.

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117 Note that Leave Behind Kits are discussed under Appliance Decommissioning and Replacement programs since those savings are counted under the appliance programs.

7.4.3 Awareness of PSE's Energy Efficient Lighting and PSE's Lighting Program

The general population survey found that PSE customers were very familiar with high efficiency lighting (CFLs – 96% familiar and LEDs – 95% familiar) was very high amongst PSE customers. This familiarity also appears to be grounded in experience with the bulbs with LEDs being purchased most often:

- 75% of customers familiar with LEDs have purchased at least one in the past year and on average this group of customers has purchased 10.4 lamps.
- 51% of customers familiar with CFLs have purchased at least one in the past year and on average this group of customers has purchased 6.5 lamps.

TABLE 7-16: AWARENESS OF CFL AND LED LIGHT BULBS

Percent of customers who are familiar with …	General Population
LED bulbs	95%
CFL bulbs	96%
n	578

Awareness of PSE's Lighting program is relatively high: 50% of the population is aware of PSE's Lighting Program, which higher than any of the other DtC programs. Awareness of the Lighting program is even higher among participants in the DtC Appliance Decommissioning, Replacement and Appliance programs. Some 86% of these participants were aware that PSE also has a program to encourage the installation of energy efficient lighting.

TABLE 7-17: AWARENESS OF RESIDENTIAL DTC PROGRAMS, PARTICIPANTS VERSUS GENERAL POPULATION

Awareness of Other Residential Programs	All DtC Participants	General Population
Lighting Program	86%	50%
Showerhead Program	83%	37%
Decommissioning Program	64%	40%
CW Replacement Program	49%	23%
Appliance Rebate Program	85%	47%
ShopPSE Website	45%	27%
Heating Rebate Program	73%	42%
N	1,194	640

Marketing of this program is done by PSE, which has focused on multiple campaigns and outreach channels; but manufacturers and retailers also play a role. Manufacturer and Retailer perspectives on marketing the lighting program are described below.

Manufacturer Perspectives on Raising Customer Awareness of Lighting Program

Manufacturers supported a combination of television and radio advertising, social media and geographically targeted advertising, mailings, websites, bill inserts and community and store events. Feedback from manufacturers on marketing energy efficient lighting includes:

- We already do a lot of marketing, doing door knocking, radio, and transit advertisement. I don't know if there is anything above and beyond that.
- Events. PSE has a wonderful field staff through C+C. And, when they engage customers face to face it is one of the most effective ways to educate the public.
- Communication via bills or e-mails blasts. And, point-of-sale. And, special promotions.
- Direct advertising to the zip codes that the programs are in. Maybe a website opportunity to find local stores in their neighborhood. Possibly direct radio advertising.

Two lighting manufacturers also explicitly expressed confidence in the current marketing approach to raise customer awareness, stating that the program should continue to do what they do now through their websites and social media approach.

When asked about specific marketing approaches, manufacturers (7 of 12) rated implementing PSE branding on packaging and placing PSE rebated products on end caps as very effective methods for increasing awareness (Table 7-18). Five of the manufacturers report that they currently place PSE products on end caps while two report including PSE branding on their packaging (Table 7-19). Four of the manufacturers report that they believe that advertising the PSE program on store PA systems, TV monitors and store flyers would be very effective approaches to increasing customer awareness of the PSE rebated products. One of the manufacturers stated that they currently advertise the PSE programs over store PA systems or TV monitors while two advertise the program via store flyers. Given the perceived effectiveness of PSE branding and end caps, PSE may want to discuss using these types of approaches with all participating lighting manufacturers.

TABLE 7-18: EFFECTIVENESS OF CUSTOMER AWARENESS METHODS RATED BY LIGHTING MANUFACTURERS

Effectiveness of:	We Already Do This	Very Effective	Somewhat Effective	Not at all Effective	DK/NA
PSE Branding on Packaging		7	2	3	
PSE Products on End Caps	2	7	3		
Advertise PSE Programs over Store PA System or TV Monitors		4	3	5	
Advertise PSE Programs on Store Receipts			6	5	1
Advertise PSE Programs on Store Flyers		4	7	1	

TABLE 7-19: DIFFICULTY OF CUSTOMER AWARENESS METHODS RATED BY LIGHTING MANUFACTURERS

Difficulty with:	We Already Do This	Very Easy	Somewhat Easy	Somewhat Difficult	Very Difficult	DK/NA
PSE Branding on Packaging	2	1	2	2	2	
PSE Products on End Caps	5		3	3		
Advertise PSE Programs over Store PA System or TV Monitors	1		1	1	5	
Advertise PSE Programs on Store Receipts					6	1
Advertise PSE Programs on Store Flyers	2		1	3	5	

Retailer Perspectives on Raising Customer Awareness of Lighting Program

Retailers also described the best ways to raise customer awareness of PSE's residential lighting program and why they chose their approach. Many of the retailers' approaches to raise customer awareness are very similar to approaches proposed by manufacturers. The proposed customer awareness approaches include the following:

- Direct bill inserts and radio ads focused around a promotion.
- Direct mailers to the customers.
- Advertisement on buses.
- Flyers are the best and easiest.

All four of the lighting retailers suggested their approach would catch the consumer's attention. Direct mailers are in the "person's line of sight at home", bus advertisement catch people's attention while people are in traffic just looking at those bus ads", and store flyers can be taken "with them and have them at work, at home, or in their truck".

Retailers rated placing PSE's rebated products on end caps and advertising the PSE program in store flyers as the two most effective methods for increasing customer awareness (see Table 7-20). The lighting manufacturers' responses felt that end cap placement as a top method for increasing awareness. Manufacturers and retailers differed slightly in their ranking of PSE branding on rebated products and advertising in store flyers.

Lighting retailers ranked placing PSE's rebated products on end caps as the easiest approach to increasing customer awareness, closely followed by advertising in store flyers about PSE programs.

Given the retailers feel that these are both the most effective and the least difficult approaches to increasing awareness, PSE should encourage these methods to increase awareness.

TABLE 7-20: EFFECTIVENESS OF CUSTOMER AWARENESS METHODS RATED BY LIGHTING RETAILERS

Effectiveness of:	Very Effective	Somewhat Effective	Not at all Effective
PSE Branding on Packaging		3	1
PSE Products on End Caps	1	3	
Advertise PSE Programs over Store PA System or TV Monitors		1	3
Advertise PSE Programs on Store Receipts		2	2
Advertise PSE Programs on Store Flyers	1	3	

TABLE 7-21: DIFFICULTY OF CUSTOMER AWARENESS METHODS RATED BY LIGHTING RETAILERS

Effectiveness of:	Very Easy	Somewhat Easy	Somewhat Difficult	Very Difficult
PSE Branding on Packaging		2		2
PSE Products on End Caps	2	1	1	
Advertise PSE Programs over Store PA System or TV Monitors			1	
Advertise PSE Programs on Store Receipts			2	
Advertise PSE Programs on Store Flyers	1	2	1	

7.4.4 Demographics of Efficiency Lighting Purchasers

Purchasers of energy efficient lighting tend to mirror the general population in terms of home ownership—about two thirds owners and one third renters. While there are small differences, it's clear that the energy efficient lighting is appealing to renters as well.

Interestingly, unlike with other DtC measures such as low-flow showerheads and APSs, energy efficient lighting purchasers are in the majority—including a much wider population than just the early adopters of technologies.

TABLE 7-22: DEMOGRAPHICS OF EFFICIENT LIGHTING PURCHASERS

Demographic	Efficient Lighting Purchasers[118]	General Population
Own	66%	61%
Rent	34%	39%
Single-Family Detached	66%	62%
Single-Family Attached/Mobile Home	33%	37%
Knowledgeable About Ways to Save Energy		
Very	28%	27%
Somewhat	65%	64%
Not at All	7%	9%
I am generally … to try a new technology product		
The Last	8%	9%
Among the Last	18%	20%
In the Middle	44%	46%
Among the First	26%	22%
The First	4%	4%

7.4.5 Trade Ally Satisfaction

The level of trade ally satisfaction with PSE's residential lighting and showerhead programs is very high. PSE's programs were described as "one of the strongest programs in the US" and "one of the easiest programs to work with, C+C has been very communicative, flexible, understanding and easy to work with." Lighting manufacturers rated the program a 9.3 out of ten, showerhead manufacturers at a 9.8, and lighting retailers rated the program an 8.5. The lower rating from lighting retailers may be due in part to the medium to smaller size of lighting retailers contacted for the survey, but these retailers expressed a general satisfaction for the program with a desire for more communication.

The lighting manufacturers all stated that the PSE programs were very effective and all would like to participate in the program in the future. The lighting retailers stated that the program was somewhat effective with one retailer labeling the program very effective. The lighting manufacturers estimated that the program had led to an average 53% increase in sales. The lower estimated increase in sales by lighting retailers likely contributes to their rating the program somewhat effective instead of very effective. The lower effectiveness rating for lighting retailers may point to a need to increase communication and training among medium and small sized retailers.

[118] General Population survey respondents that purchased an LED or CFL light bulb since January 2016.

The PSE residential program achieved exceptionally high ratings for satisfaction and effectiveness. Lighting retailers who responded to the survey are slighting less satisfied with the program than manufacturers. Some of the reduced satisfaction may be due to the unique characteristics of the lighting retailers included in the survey, they tended to be medium and small sized retailers. C+C did not provide Itron with contract information for larger retailers that participate in the program because lighting manufacturers generally provide the interface with the program for larger retailers. Additional communication, meetings, or calls with retailers and additional retail staff training on the programs may lead to increased satisfaction by retailers and manufacturers.

PSE should take satisfaction in knowing that all surveyed trade allies report a desire to continue to participate in their program. The PSE programs were rated best in class by many of their trade allies and their implementer, C+C was one of the highest rated elements of the program across all three trade allies.

The detailed manufacturer and retailer results are provided below.

Lighting Manufacturer Process Survey Results

Satisfaction Score

The lighting manufacturer survey began with questions designed to determine the manufacturers' satisfaction with different elements of PSE's residential lighting program and their satisfaction with the program overall. Manufacturers were asked to rate the program and program elements on a 0 to 10 scale, with 0 representing very dissatisfied and 10 representing very satisfied. All manufacturers surveyed were asked why they gave the program the score they did, what were the benefits and drawbacks of participation to their organization, and what they would change about the program. Respondents who rated any program element a 7 or below were asked to explain why they provided the score and what they thought that PSE could do to improve that aspect of the program. The average score for each question and the number of manufacturers providing specific scores are presented in Table 7-23.

The responses show a very high degree of satisfaction with PSE's residential lighting program. The average reported satisfaction with the program was 9.3 out of 10 (see Table 7-23). Manufacturers gave the following responses when asked why they rated the program so highly:

- They (PSE) have been one of the easiest programs to work with. The team at C+C has been very communicative, flexible, understanding, and easy to work with. The only reason I am not giving a 10 is because they ran out of budget.
- It's one of the strongest programs in the U.S.

- They are usually very responsive and open to new product categories. They pay on time. Communication is easy.
- Their team has been good to work with. Every time there is confusion or a misunderstanding they are willing to work with us.
- The program manager was great to talk to, very responsive…. Communication is key. It has been pleasure working with a partner that is very open and has open dialogue.
- They look at this with a passion.... I help manage 120 programs across the country. PSE is head and shoulders above the rest.

Two lighting manufacturers who gave the program an overall rating of an 8, offered the following explanations:

- The third party that handles the processing of the payments, if they could choose a different vendor for that it would be better. And, their marketing spiff program Upgrades Campaign is a little rich to get into.
- I think back on the rebate. They have dropped some of their rebates which has an impact on the program.

When asked to list the benefits of participating in the program, some of the highlights include:

- Increased sales. Increased exposure.
- The product marketing…the creativity of promoting incentive products through the marketplace. Supporting it with local initiatives.
- We get more of our SKU's into their program than any other program.
- Their marketing is tremendous. They are one of the best utilities in the country about using their local resources, educating the public, engaging the community.
- It is the premier program in the country. What PSE does now, other programs start doing in 3 or 4 years. And, they are just really nice people.
- Sales lift, customer recognition, and helping promote the Energy Star brand. PSE is open and willing to try new things. It creates customer awareness of these programs. It is obvious on the sales side.

When asked to list the drawbacks of participating in the program, six of the twelve manufacturers stated that there were no drawbacks. Drawbacks listed by the other manufacturers included the following:

- Waiting for our money.
- Maybe a little more checking in on everyone. A little bit more interaction.

The survey asked lighting manufacturers to rate ten program elements. For five of the program elements (selecting lighting products to be rebated, the training of store staff about the lighting program, interactions with C+C staff, communications with the program, and marketing material provided by PSE to retailers), all manufacturers who provided a score, scored the program element at 8 or higher on the 0 to 10 scale.

TABLE 7-23: AVERAGE SATISFACTION SCORE AND NUMBER OF MANUFACTURERS PROVIDING A GIVEN SCORE FOR ELEMENTS OF PSE'S RESIDENTIAL LIGHTING PROGRAM (10 = VERY SATISFIED, 0 = VERY UNSATISFIED)

Satisfaction Element	Average Score	10	9	8	7	6	5	4	3	NA
Satisfaction with Lighting Program Overall	9.3	6	3	3						
Satisfaction with Program Elements										
Interactions with C+C Staff	9.7	8	4							
Communications with the Program	9.7	9	2	1						
Selecting Lighting Products to be Rebated	9.5	7	4	1						
Enrollment Process	9.3	7	2	2	1					
Marketing Material provided by PSE to Retailers	9.2	5	1	3						3
Coordination with Retailers	9.1	6	2	2		1				1
Sales Tracking, Reporting and Verification	9	6	3	2			1			
Processes Incentive Payments	8.8	7	2	1		1			1	
Training of Store Staff about Lighting Program	8.6	1	3	4						4
Rebate Levels	7.9	1	4	2	4		1			

The level of program rebates was the lowest scored program element at a 7.9 with five out of twelve manufacturers rating the program a 7 or below. Manufacturers who scored the rebates a 7 or below were asked why they rate the rebates at these levels. Responses included the following:

- Historically, I have seen higher incentive levels.[119]
- They are a little bit on the low end. But they are feasible and still make for successful programs.

One respondent was unhappy with the price floor that is implemented with the rebate levels, stating that "when there is a retail price limit," retailer X "can't offer the best, most competitive price." When this manufacturer was asked how the program should set its rebates, the manufacturer requested that

[119] It is important to note that while incentives have fallen a bit for LEDs, this has been primarily driven by the significant decrease in LED prices in the marketplace and thus a corresponding reduction in the incentives being offered. This has occurred in programs nationwide.

there not be a price floor. Suggestions by other manufacturers who rated the rebate levels a 7 or below included:

- I see an average of $8-$10 per product. And, PSE is at $4. Increase them to at least $6.
- It's difficult for us to make changes if it changes by even a couple of cents. There were some changes that were in excess of 50 cents. If the reason for not keeping it at a consistent rebate level is running out of funds, then I would prefer it to just run out.
- I wouldn't say to necessarily increase the rebate levels. Costs are coming down.
- I would love to have more budget.

The second lowest scoring program element was training of store staff which received an average score of 8.6. No manufacturers scored the training a 7 or below.

Processing of incentive payments was rated as an 8.8 with two manufacturers scoring the program element a 7 or below. Both manufacturers requested a faster turnaround for payment processing. One of the two manufacturers suggested that the program provide a "tracking portal that would let you walk through the process when an invoice or payment is in the process."

Sales tracking, reporting, and verification processes were rated as a 9 with one manufacturer giving the program element a 5. The lower scoring manufacturer requested a faster turnaround for payment. This manufacturer also scored the processing of incentive payments a 3, clearly indicating that they desire a faster payment process.

Coordination the lighting program's efforts with retailers scored a 9.1, with one manufacturer scoring the program element a 6. This manufacturer suggested that the program "do a better job on their website lining the existing programs back out into the retail market for their customer."

Future Participation

The survey asked manufacturers about their likelihood of participating in PSE's lighting program in the future and gathered information on things that would make them want to, and not want to, continue their participation in the future. Eleven of the twelve lighting manufacturers stated that they were very likely to continue to participate in PSE's residential lighting program in the future while one manufacturer was somewhat likely to continue. The things that make the manufacturers want to continue their relationship with PSE further illustrates the high level of satisfaction they have with the program.

Highlights include the following:

- Increased sales and exposure.
- Strong communication. They are successful in doing things to market those products in their utility footprint.
- PSE is a best-case scenario… PSE allows us the flexibility in terms of promotion. And, they allow more items to be added to the markdown program. There is more flexibility with the PSE program.
- The open-minded approach to energy efficiency as a resource. I know that PSE is doing really progressive things on the marketing and awareness side. They are driving people to stores and driving up sales for manufacturers.
- It continues to allow us to expand into other areas with PSE. It has been a fruitful relationship both ways.
- There is no one else out there that can get the results that PSE does. That's the capitalist part. The other part is the benefit of the energy efficiency.
- Helping the utility support their energy efficiency goals.
- It's been a great relationship over the years. And, we look forward to continuing that relationship.

When asked if there are reasons why their organization (or other similar organizations) might not participate in the PSE program in the future, 4 of the 12 manufacturers said they knew of no reasons and one said that they didn't know. However, participating manufacturers mentioned that they are not sure if all manufacturers can keep up with the sales reporting and logistical requirements, or can wait the 30 to 60 days to be paid. Manufacturers providing reasons why their organization might not participate in the future included the following potential issues:

- If it became too complicated or tedious to participate.
- If the price of the product dropped so low that the effort involved in participating might lose its benefit.

The questions concerning future program participation indicate a very high likelihood that the participating lighting manufacturers will continue in the program and that they have a high degree of satisfaction with the current program and PSE relationships. When asked to provide reasons why their organization might not participate in the future they provided potential issues that could lead to their discontinuing participation, but did not list current problems or issues that would lead to them dropping their participation.

Effect of Current Program

All lighting manufacturers rated the program as very effective, stating that their high efficiency bulbs sales would be lower without the program. Manufacturers estimated that their high efficiency bulbs sales would be 25% to 85% lower without the program. Taking a straight average of the manufacturers' estimates, lighting sales were estimated to be 53% lower without the PSE program.

Manufacturers where asked "how different are unit prices for standard versus high efficiency light bulbs?" One manufacturer responded that differences with no rebates ranged from $5 to $10 while another estimated the difference at $6. Many of the manufacturers, however, appear to have responded with post-rebate price differences, estimating a price differential ranging from $0.5 to $5 with most estimates in the $1-$2 range. Following the price differential question, manufacturers were asked if they thought that the "incentives are set at about the right amount?" Seven of the twelve manufacturers responded that the incentives are set at about the right amount, while five thought that they could be higher. Highlights from manufacturers who thought that incentives should be higher include the following:

- Increase them to at least $6.
- PSE has cut the rebate for fixtures in half. They are the lowest in the country.
- They could be a little bit higher. But as pricing continues to come down, the current incentives will work.

Lighting Retailer Process Survey Results

Satisfaction Score

Four lighting retailers responded to the lighting process survey. The lighting retailer survey asked retailers the same set of questions as those asked of lighting manufacturers. The survey began with questions designed to determine the retailers' satisfaction with different elements of PSE's residential lighting program and their satisfaction with the program overall. Retailers were asked to rate the program and program elements on a 0 to 10 scale, with 0 representing very dissatisfied and 10 representing very satisfied. All retailers surveyed were asked why they gave the program the score they did, what were the benefits and drawbacks of participation to their organization, and what they would change about the program. Respondents who rated any program element a 7 or below were asked to explain why they provided the score and what they thought that PSE could do to improve that aspect of the program. The average score for each question and the number of retailers providing specific scores are presented in Table 7-24.

The responses show that lighting retailers have a high degree of satisfaction with PSE's residential lighting program. The average reported satisfaction with the program was 8.5 out of 10, with one of the four retailers expressing less satisfaction with the program. Retailers gave the following responses when asked why they gave the program this rating:

- They don't communicate.
- It's really easy once you get the hang of it. Customer service has been great. They always get back to us in 24 hours. The processing time was a problem for a while. But, that is better.
- They are easy to deal with. No issues. They talk with the sales people and make the process painless.
- We've had good luck with being flexible and the product assortment is good.

When asked to list the benefits of participating in the program, the responses focused on the rebates and the increase in sales associated with the rebates. When asked to list the drawbacks of participating in the program, two the four retailers stated that there were no drawbacks. Drawbacks listed by the other retailers included "heavy competition because there are incentives all around" and "they could do a better job communication with us, letting us know about new rebates."

The survey asked retailers to rate ten program elements. The responses to the program elements are provided in Table 7-24. Responses to satisfaction with program elements continued to illustrate that three of the four retail respondents were highly satisfied with the program while one was less happy. The retailer that expressed issues with the programs communication, provided no answer (NA) to four of the program element questions.

TABLE 7-24: AVERAGE SATISFACTION SCORE AND NUMBER OF RETAILERS PROVIDING A GIVEN SCORE FOR ELEMENTS OF PSE'S RESIDENTIAL LIGHTING PROGRAM (10 = VERY SATISFIED, 0 = VERY UNSATISFIED)

Questions	Average Score	10	9	8	7	6	5	NA
Satisfaction with Lighting Program Overall	8.5	1	2			1		
Satisfaction with Program Elements								
Interactions with C+C Staff	9.7	2	1					1
Marketing Material provided by PSE to Retailers	9.3	1	2					1
Sales Tracking, Reporting and Verification	9.3	1	2					1
Selecting Lighting Products to be Rebated	9	2	2					
Coordination with Retailers	8.5	2	1				1	
Communications with the Program	8.5	1	2			1		
Rebate Levels	8.3		2	1	1			
Processes Incentive Payments	8.3	1	1		2			
Enrollment Process	8.3	1	2				1	
Training of Store Staff about Lighting Program	7.5			1	1			2

Training of store staff about PSE's lighting program was the lowest scored program element, though only two retailers provided a response. The retailer who scored program training a 7, reported that "there wasn't any training. The written instructions were good. But there were some questions we had at the time of setup." This retailer suggested that PSE provide "better instructions or in-person support. Making sure everyone is well informed and knows how to setup the portals."

The level of program rebates, the processing of incentives, and the enrollment process received a score of 8.3. The retailer that scored the rebates a 7 stated that "we could use more incentive on some key categories like reflectors or A lamps." One of the retailers that rated the processing of incentives a 7 stated that there was "not enough people to handle the projects that are coming in. They need more communication." The other retailer who rated the processing of incentives a 7, provided comments associated with a commercial program and it is not clear that their response is appropriate for the PSE residential lighting program. The retailer that rated the enrollment process a 5 responded that "it takes weeks for a response. Hire more people." Three of the four retail lighting respondents are highly satisfied with the program while the fourth retailer is expressing a need for more communication and quicker responses from PSE.

Future Participation

The survey questioned retailers about their likelihood of participating in PSE's lighting program in the future and gathered information on things that would make them want to, and not want to, continue their participation. All lighting retailers stated that they were very likely to continue to participate in

PSE's residential lighting program. Highlights to why retailers want to continue their relationship with PSE include the following:

- Gives our stores the best opportunity when it comes to products and pricing.
- It helps build goodwill and return customers.

When asked if there are reasons why their organization (or other similar organizations) might not participate in the PSE program in the future, 3 of the 4 retailers said they knew of no reasons. But 2 of the 4 retailers commented that if the rebate levels became too low they or similar organizations might not participate. As with lighting manufacturers, the responses from lighting retailers indicate a very high likelihood that they will continue in the program and that they find good value in the program.

Effect of Current Program

The lighting retailer survey closed with a series of question about the effectiveness of the current program, its impact on lighting sales and prices, and the adequacy of current rebate levels. The survey also asked lighting retailers about future lighting trends that may require program adjustments and how the new Energy Star 2.0 LED specifications had impacted the lighting manufacturer's organization.

Three of the four lighting retailers rated PSE's residential lighting program as somewhat effective at increasing high-efficiency light bulb sales and one retailer ranked it as very effective. The retailers' assessment of the program's impact is less positive than the assessment of lighting manufacturers who unanimously rated the program as very effective. Lighting retailers estimated that their high efficiency bulb sales would be 10% to 40% lower without the program, with an average of 24% lower. The retailers' assessment of the change in sales due to the program is substantially less than the manufacturers' 53% average drop in sales without the program.

Lighting retailers where asked "how different are unit prices for standard versus high efficiency light bulbs?" One retailer estimated that the prices differed by about $1 while another stated that higher efficiency lighting is somewhat higher. The retailers and manufacturers appear to have a similar assessment of the price differential between standard and high efficiency lighting as most manufacturers responded with estimates in the $1-$2 range.

Following the price differential question, retailers were asked if they thought that the "incentives are set at about the right amount?" One of the four retailers responded that the incentives are set at about the right amount while two thought that they could be higher and one did not respond to the question.

7.4.6 Best Practices and Opportunities

The DtC were compared to six best-practice areas identified within the National Energy Efficiency Best Practices Study[120] in order to identify program strengths, areas for improvement, and strategies for improving them. These included: (1) program theory and design, (2) program management, (3) reporting and tracking of energy savings, (4) quality control, (5) program processes, and (6) marketing and outreach. As described above, this program is very strong in all six of these areas. In Stage 2, PSE and the evaluation team also documented roles, and the types of data that each of the key players should track to ensure that they can report success.

While PSE's Lighting program is considered to be among the most innovative in the country—adhering to best practices across the country—lighting manufacturers and retailers did talk about future trends that could lead to opportunities for the program. The primary opportunities appear to be around increased communication, additional marketing and looking to incorporate smart or connected lighting technologies in the future.

Manufacturers

When asked about future lighting trends that may require program adjustments, the manufacturers remarked on decreased lighting prices, increased customer acceptance, changes in lighting features, and smart/connected lighting technologies. Six of the twelve manufacturers mentioned smart or connected lighting as a trend that PSE needs to follow to determine if they need to make program adjustments.

The manufacturers were asked how they would recommend PSE update the program to account for these changes. Manufacturers that stressed the availability of new lighting features and smart lighting generally believed that PSE should expand the lighting products that are eligible for rebates. One manufacturer, however, acknowledged that smart and connected lighting are a "different play than pure energy. It's a health and human safety type of sell." When determining if PSE should rebate smart lighting, it may be necessary to determine if these technologies are used to reduce energy usage and/or improve safety and how these issues impact rebate eligibility and incentive levels.

The lighting manufacturers' survey also asked about the impact of the new Energy Star 2.0 LED specification on the manufacturer's operations. The responses to this question covered the spectrum. Three manufacturers remarked that it had increased their cost, including manufacturing and recertification costs. Three manufacturers responded that it had increased their sales. Two

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120 http://www.eebestpractices.com/ The goal of the study was to develop and communicate national excellent practices, built off the experience and knowledge gained through 25 years of program implementation, to enhance the design, implementation, and evaluation of energy efficiency programs.

manufacturers replied that the 2.0 LED specifications had no effect, that they were prepared. Highlights from the responses include the following:

- We had to adjust to meet the requirements of the program and for Energy Star. We don't carry any of the older style bulbs anymore.
- It's been tremendous. It has thoroughly helped manufacturers of quality products keep inefficient, short-life LED bulbs out of the market.

The manufacturers' survey finished with a few general questions, asking the manufacturers for suggestion on how the program could work with the manufacturer and learn from the manufacturers' experiences in other areas of the country to improve the PSE residential lighting program. The manufacturers had the following responses for how they and PSE could work together to co-market and/or raise awareness of the products marked down by PSE:

- It would be nice to have more collaboration, maybe check in every quarter. Have a meeting in person.
- Demonstration events. Having field staff talk with customers in the stores. We help coordinate that.
- We are already doing as much in-store and in-aisle advertising as the retailer allows. I know PSE is really good in terms of reaching out to their customers.
- Not really. They do a good job of recruiting folks to participate with them on limited time promotions. They make themselves available for special events. PSE is a best in class program.
- We could implement the co-branding as well as participate in some of their field events. We are happy to team up with them and send some of our staff out there with them.
- Different promotions. Parking lot events. Deeper discounts. Stuff to bring excitement to the category.

When asked, "based on your organizations experience in other areas of the country, are there any other best practices that you have seen in energy efficiency programs that PSE should be considering?" Eight of the twelve manufacturers responded that PSE was implementing best practices. Survey response highlights included:

- A better tie-out, meetings, conference calls.
- Expanding to smart lighting will be the best of the best. Keeping up with the new products.

- They could look at adding portable fixtures to their program like desk lamps and shop lights.[121]
- I think they are fairly trend setting on some of this stuff. They are pretty good about what they need to do to impact their customer base.

When asked if there is any other support that their organization needs from PSE or their implementers, 10 of the 12 lighting manufacturers stated that there was no additional support needed. Two of the ten who stated that they needed no additional support added that “they do a great job” and “they have been a pleasure to work with”. One manufacturer requested more funding while another asked to be made aware of commercial and direct install programs. They requested “a newsletter or some other type of communication. To say to vendors, if you want to participate this is how you do that.” These responses clearly illustrate that lighting manufacturers have enjoyed and appreciated working with PSE on the residential lighting program. These manufacturers are asking for opportunities to continue and expand their partnership.

When asked for final suggestions on how PSE could improve the residential lighting program, 7 of the manufacturers had no suggestions. Final suggestions provided by the lighting manufacturers included:

- Revamp the Upgrade Campaign. Different ways to be involved without just writing them a check for participation.
- More communication.
- It would be nice to know if there are any low-income or multifamily opportunities.
- Emulate what they have done in the past with the events. The events drove the sales that got the savings that they were looking for.
- Make sure it goes well into the future. We want to keep being a part of it

Retailers

When questioned about future lighting trends that may require program adjustments, the retailers remarked on decreased lighting prices and the importance of LEDs. One lighting retailer focused on the future of LED troffers, stating that these fixtures were really starting to take off in industrial new construction. None of the lighting retailers mentioned smart or connected lighting, a high priority for lighting manufacturers. The retailers were asked how they would recommend PSE update the program to account for these changes. The lighting retailer concerned with the falling price of LEDs suggested that the program allow more LED outdoor and indoor fixtures.

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[121] T8 shop lights were added to the program in March 2017. This manufacturer we talked with was apparently unaware of this addition to the program.

The lighting retailers' survey asked a question about the impact of the new Energy Star 2.0 LED specification on the retailer's operations. The lighting retailers commented that their stock has shifted to the new standards and they were still selling the bulbs.

The lighting retailer's survey finished with a few general questions, asking the retailers for suggestions on how the program could work with the retailer and learn from the retailers' experiences in other areas of the country. The lighting retailers had the following responses for how they and PSE could work together to co-market and/or raise awareness of the products marked down by PSE:

- We would like to do limited-time pricing promotions. Maybe a month long with higher incentives.
- Advertising through our store magazine for instant rebates.

When asked, "based on your organizations experience in other areas of the country, are there any other best practices that you have seen in energy efficiency programs that PSE should be considering?" Two of the four lighting retailers responded no, there were no additional best practices and two response highlights included:

- There was a good promotion where utility reps. came into our store on Saturdays and set up a booth. That got their name out there and helped us with sales.[122]
- No, PSE's got one of the better ones out there.

Three of the four lighting retailers stated that there was no additional support that their organization needed from PSE or the program implementers. The fourth retailer stated "we need to work with someone that can keep us updated on the latest rebates for the newer products." Final suggestions provided by the lighting retailers included:

- Automatically getting the updated spreadsheets, potentially issuing checks faster than they are now.
- Just slightly higher incentives and offerings for limited time promotions.

[122] PSE currently and in past years has conducted these types of in-store promotional events.

7.4.7 Other Detailed Lighting Findings

Analysis of the lighting questions on the general population survey led to the following findings:

- 75% of general population respondents had purchased at least one LED for their home in the last year and 51% had purchased at least one CFL for their home in that time.
  - The average number of LED bulbs purchased was 10.4 and the average number of CFL bulbs purchased was 6.5.
  - LEDs and CFLs most frequently replaced incandescent bulbs (36%, 47%), followed by a mix of CFL and other bulb types (34%, 19%) and CFLs only (14%, 15%). Very few respondents reported they were replacing halogen bulbs (5%. 7%) or another LED (both 5%).
  - 37% of those who were familiar with LEDs but had not purchased one for their home in the past year had one or more currently installed in their home, the majority of which they purchased for their home (60%)
  - Those who had never purchased an LED for their home reported their primary barriers were:
    - Cost (32%)
    - Dislike the light they emit (30%)
    - No need for a bulb (15%)
  - The majority of LED purchasers had bought a general purpose LED (90%). Specialty LED purchases were much lower: reflector (36%), candelabra (18%) and a globe (16%). Similarly, the majority of CFL purchasers had bought a general purpose LED (94%). Specialty CFLs purchases were much lower: reflector (20%), candelabra (4%) and a globe (8%).
  - More than half said some of the LEDs they had purchased had been discounted (53%), 27% said none were discounted, and 20% were not sure if they were discounted.
  - A majority of general population respondents were satisfied with the LEDs they had purchased in the last year (with an average rating of 4.3 out of 5).
    - The majority of dissatisfaction was related to the light the LED emitted or the bulb burning out quickly.

7.5 RESIDENTIAL LIGHTING PROGRAM FINDINGS AND RECOMMENDATIONS

The evaluation team provides the following findings and recommendations for PSE's Residential Lighting Program.

Finding L1: The tracking data review completed for PSE's Residential Lighting program found that the tracking data files were missing several key measure variables needed to accurately characterize program sales and accurately calculate savings. These missing variables included: measure wattage, lumen output, baseline wattage equivalent, bulb description (such as reflector type, specialty bulb type, and fixture type), and retailer where the program measure was sold.

Recommendation L1: PSE has reported that it has begun working with program vendors to ensure these variables are included in the program tracking data going forward. The evaluation team recommends PSE audit these changes to ensure they are consistently reported for all measures sold through the program.

Finding L2: An issue was identified in the assignment of the 2015 deemed UES for Indoor LED fixtures and LED Retrofit Kits. Both measures were mistakenly assigned the 2014 UES value rather than the 2015 value. This resulted in measure level realization rates of 90% and 99% respectively.

Recommendation L2: The evaluation team recommends that PSE review its QA/QC steps to ensure there is an audit step in place to confirm the deemed UES estimates have been assigned correctly.

Finding L3: During Stage 2 of this evaluation a number of parameters in the lighting UES algorithm were updated using program sales data and data collected from program participants in order to estimate ex-post savings.

Recommendation L3: The evaluation team recommends that PSE review each of these parameter updates, in light of additional changes that have occurred to the savings algorithms since 2015, to determine if updates to the deemed parameters are warranted.

Finding L4: The level of trade ally satisfaction with PSE's residential lighting program is very high. PSE's programs were described as "one of the strongest programs in the US" and "one of the easiest programs to work with, C+C has been very communicative, flexible, understanding and easy to work with." Lighting manufacturers rated the program a 9.3 out of ten and lighting retailers rated the program an 8.5.

Recommendation L4: Lighting retailers and manufactures were asked to provide recommendations for improvements to the programs and responses included:

- Co-marketing with Manufacturers – team up for in-store or field events
- Communications – increase frequency, decrease response time to questions, quarterly in-person meetings

- Program marketing – advertise in the store magazine, offering limited-time pricing promotions, parking lot events
- Training – increase in-person training opportunities
- New products – smart and connected lighting
- Incentives – larger and faster turnaround

8 RESIDENTIAL SHOWERHEAD PROGRAM

In 2014 and 2015 the Residential Showerhead program used a number of delivery mechanisms to sell low-flow showerheads and ShowerStart measures to PSE residential customers. These channels included:

- Retail – which provides instant discounts on low-flow showerheads sold through partner stores to PSE customers. This channel includes two components, the core program administered by C+C and Blackhawk, and the Simple Steps program administered by CLEAResult (a joint utility program for retail outlets located along the border of PSE service territory),
- ShopPSE – which provides instant discounts on low-flow showerheads through PSE's online retail store, and
- TechniArt Pop-up Events – kits containing a low-flow showerhead are sold at events (fairs, large work campuses, etc.) by TechniArt.

Low-flow showerheads were also distributed in 2014 and 2015 through PSE's Appliance Replacement and Decommissioning (2014 only) programs via no-cost kits left with program participants.[123] [124]

Overall, the Residential Showerhead Program makes up only a small percentage of the DtC portfolio's electric savings (3%) but accounts for 78% of the reported ex-ante gas savings.

8.1 RESIDENTIAL SHOWERHEAD EVALUATION RESULTS

This section presents the high-level results of the impact and process analysis activities for the Residential Showerhead Program. The analyses conducted for this program relied heavily on data collected through interviews with program staff (the PSE program manager, as well as vendors that support program implementation), in-depth reviews of program tracking databases, web surveys of both participants who have received showerhead measures through Thank You or Leave Behind kits and PSE residential customers, trade ally interviews, and a review of secondary data collected to support similar programs across the U.S. In many cases the deemed UES values for these showerhead measures

[123] Leave Behind kits, which included Low-flow Showerheads and A-lamp LEDs, were given to customers participating in the Appliance Decommissioning and Replacement programs. These measures were not installed by the appliance program vendors.

[124] The majority of showerheads distributed through the program are sold at a discount to PSE residential customers. Showerheads distributed to customers for free accounted for 15% of the program during the 2014 and 2015 program years.

are calculated using inconsistent algorithms, increasing the complexity and opportunity for error for these measures. Within the ex-post analysis, the evaluation team attempted to update and align the savings algorithms and parameter estimates wherever appropriate.

Table 8-1 below presents a comparison of the PSE deemed, evaluation verified, and evaluation ex-post unit energy savings (UES) estimates and realization rates for the 2015 Residential Showerhead Program. The ex-post realization rates for various Showerhead models ranged from 126% to 177% for kWh and 87% to 163% for therms. The 2015 program sales weighted overall realization rates are 152% for kWh savings and 97% for therm savings as a result of ex-post changes to the following parameters included in the UES algorithm:

- Persons per showerhead – Based on data collected during the Stage 2 surveys, the evaluation team estimated the average number of residents per showerhead to be 1.52 (2.74 average residents per HH / 1.81 average showers per HH = 1.52 residents/SH), resulting a 15% increase over the Stage 1 estimate (1.32 residents/SH).
- Shower duration – Ex-ante updated from 7.84 minutes/shower to 8.2 - 9.2 minutes/shower (depending on the SH flow rate) based on an analysis of data from the Water Resource Foundation.
- Hot water mix – The ex-ante calculations used a varying hot water mix, based on the showerhead flow rate. The evaluation team updated the Hot Water Mix Percentage, based on RTF updates, to 71%, which accounted for both warm-up and the active showering periods.[125]
- Water heating saturations –water heater saturations by customer type (gas, electric or combo) were updated based on data collected during the general population web surveys.
- Installation rates – Installation rates increased for Showerhead and ShowerStart measures from 70%-90% to 90.2% and decreased for engagement showerheads from 62%-66% to 55.6% based on data collected via the general population and appliance participant web surveys.
- Waste water savings – updated to reflect the newest RTF assumptions based on the RTF Standard Information Workbook v2.6 (estimate dropped from 5.3 kWh/1,000g to 3.7 kWh/1,000g).

Additional details on the ex-post UES estimates and realization rates are provided in Section 8.3 below.

[125] This parameter was also added into the ShowerStart Adapter measures, as the ex-ante estimates did not include it.

TABLE 8-1: 2015 RESIDENTIAL SHOWERHEAD ONLY UES ESTIMATES

Flow	Service Type	DHW Type	Units	Deemed UES	Verified UES	Verified RR	Ex-Post UES	Ex-Post RR
<= 1.5 gpm	Elec-Only	Elec	kWh	239	217	91%	300	126%
1.51-1.75 gpm	Elec-Only	Elec	kWh	185	176	95%	241	130%
1.76-2.0 gpm	Elec-Only	Elec	kWh	123	130	106%	172	140%
<= 1.5 gpm	Combo	Any	kWh	122	119	98%	194	159%
1.51-1.75 gpm	Combo	Any	kWh	94	96	102%	156	166%
1.76-2.0 gpm	Combo	Any	kWh	63	71	113%	111	177%
<= 1.5 gpm	Elec-Only	Any	kWh	145	141	97%	182	126%
1.51-1.75 gpm	Elec-Only	Any	kWh	112	114	102%	146	131%
1.76-2.0 gpm	Elec-Only	Any	kWh	75	84	112%	105	140%
<= 1.5 gpm	Gas-Only	Gas	Therms	10.2	9.7	95%	13.0	127%
1.51-1.75 gpm	Gas-Only	Gas	Therms	7.9	7.9	100%	10.4	133%
1.76-2.0 gpm	Gas-Only	Gas	Therms	5.3	5.8	110%	7.5	142%
<= 1.5 gpm	Combo	Any	Therms	5.1	4.8	95%	4.4	87%
1.51-1.75 gpm	Combo	Any	Therms	3.9	3.9	100%	3.5	90%
1.76-2.0 gpm	Combo	Any	Therms	2.6	2.9	110%	2.5	96%
<= 1.5 gpm	Gas-Only	Any	Therms	5.3	5.0	95%	7.8	146%
1.51-1.75 gpm	Gas-Only	Any	Therms	4.1	4.1	100%	6.2	152%
1.76-2.0 gpm	Gas-Only	Any	Therms	2.7	3.0	110%	4.5	163%

Source: Evaluation Team Analysis

As shown in the table below, the ex-post realization rates for the ShowerStart measures were less than 100% for all measures but one (showerhead + adapter, Combo service, Any DHW). The primary drivers of these low realization rates were:

- Changes to the algorithms used for ShowerStart measures to make them consistent, wherever possible, with the showerhead only algorithms.
- Inclusion of a ShowerStart use factor to account for the percent of showers that utilize the thermostatic restrictor value functionality.
- Increase in the percent of combo service customers with electric water heating based on responses to the general population survey (for the Showerhead + Adapter measure - Combo service, Any DHW).

TABLE 8-2: 2015 RESIDENTIAL SHOWERSTART MEASURES UES ESTIMATES

ShowerStart Measures	Service Type	DHW Type	Units	Deemed UES	Verified UES	Verified RR	Ex-Post UES	Ex-Post RR
Showerhead + Adapter	Elec-Only	Elec	kWh	230	163	71%	216	94%
Adapter Only	Elec-Only	Elec	kWh	131	49	37%	60	46%
Showerhead + Adapter	Combo	Any	kWh	190	135	71%	230	121%
Adapter Only	Combo	Any	kWh	108	40	37%	64	59%
Showerhead + Adapter	Gas-Only	Gas	Therms	13.67	6.43	47%	9.26	68%
Adapter Only	Gas-Only	Gas	Therms	8.06	1.92	24%	2.29	28%
Showerhead + Adapter	Combo	Any	Therms	8.39	6.15	73%	5.24	63%
Adapter Only	Combo	Any	Therms	4.93	1.83	37%	1.30	26%

Source: Evaluation Team Analysis

The majority of showerhead measures given to customers at no-cost (Engagement or Kits) had ex-post realization rates that were less than 100%. Similar to the ShowerStart measures, the primary drivers for the low realization rates were:

- Changes to the UES algorithm to align it more closely with the showerhead only measure,
- Application of an engagement/kit showerhead installation rate,[126] and
- An increase in the percentage of electric water heating for the Engagement measure (Combo service, Any DHW).

TABLE 8-3: 2015 RESIDENTIAL ENGAGEMENT AND LEAVE-BEHIND SHOWERHEAD UES ESTIMATES

Showerhead Measure	Service Type	DHW Type	Units	Deemed UES	Verified UES	Verified RR	Ex-Post UES	Ex-Post RR
Engagement[127]	Elec-Only	Elec	kWh	125	125	100%	110	88%
Engagement	Combo	Any	kWh	103	103	100%	116	113%
Engagement	Combo	Any	Therms	5	5	100%	2.6	52%
Leave Behind	Combo	Any	kWh	226	226	100%	189	84%
Leave Behind	Combo	Any	Therms	10.5	10	100%	8.0	77%

Source: Evaluation Team Analysis

Additional details on the ex-post UES estimates and realization rates are provided in Section 8.3 below.

[126] Measures, such as showerheads, that are given to a customer for free typically have lower installation rates since the customer may not be interested in the new measure and as they didn't have to pay may be less inclined to install it.

[127] In 2015, the UES for the Engagement measure was applied to all showerheads distributed via Thank You and Leave Behind kits.

8.2 STAGE 1 VERIFIED IMPACT ANALYSIS

The Stage 1 impact verification efforts consisted primarily of a review of program tracking and invoice data to verify the volume of units sold through the program and a review of calculation and application of the deemed unit energy savings (UES) estimates applied.

8.2.1 Tracking and Invoice Data Review

The tracking data review did not identify any major discrepancies for 2014 or 2015 with respect to claimed savings. A discrepancy was found with respect to the quantity of units rebated in service territories where PSE provides both electric and gas service. These measures were correctly assigned both gas and electric deemed savings, however the units were double counted in the unit totals, once for the gas savings and once for the electric savings. This resulted in the 2015 tracking data showing 20,845 units sold with gas savings and 23,570, units sold with electric savings (which are both correct), however the total unique quantity of unique units sold in 2015 was only 27,948. This method of tracking gas and electric savings separately is acceptable; however, program staff should take care to ensure they are accurately reporting the volume of units sold (such as in PSE's Annual Report).

8.2.2 UES Algorithms

Showerhead Only UES Algorithm

For PSE's Residential Showerhead program, PSE deemed UES estimates for the showerhead only measures are derived from the RTF Deemed estimates and modified using PSE specific data from the 2010 RBSA to more accurately represent the water heating fuel mix in PSE's service territory. A single algorithm is used to estimate gas and electric savings, however the source of the parameters used within the algorithm vary by water heating fuel type and showerhead flow rate (2.0, 1.75 and 1.5 gpm).

The algorithm used in 2015 to calculate measure-level UES estimates is the following:

Ex-Ante Annual Showerhead UES (kWh or therms) =

$$\#ShowerHH_{ann} * Length * ((FlowRate_{b} - FlowRate_{e}) * HW\_Mix) * DeltaT / WHeff * WH_{energy} * ISR * WH_{sat} + WW\_savings$$

Where:

$\#ShowerHH_{ann}$ = Annual Showers per Household = PersonsHH * DailyShowers * $Days_{ann}$

PersonsHH = Average number of people (>6 yrs. old) per household

DailyShowers = Average number of showers per person per day

$Days_{ann}$ = Number of days the home is occupied per year

Length = Average length of a shower in minutes

$FlowRate_b$ = Baseline flow rate in gallons per minute

$FlowRate_e$ = Efficient flow rate in gallons per minute, varies based on showerhead

HW_Mix = Percent of Hot Water

DeltaT = Difference in degrees between inlet and outlet temperature

WHeff = Domestic Water Heater Efficiency, varies by fuel type

WH_{energy} = Energy required to heat one gallon of water, varies by fuel type

ISR = Installation Rate, varies based on flow rate

WH_{sat} = Water Heating Saturation, varies by service territory

WW_savings = Waste water savings (electric savings only)

During Stage 1, evaluation team recommended revising the annual "showerhead use" term to represent the annual number of showers taken per showerhead ($\#ShowerSH_{ann}$) rather than the number taken per household ($\#ShowerHH_{ann}$). This revised parameter was calculated using the average number of persons per showerhead in a home ($\#Persons_{SH}$) and the average number of annual showers per person ($Showers_{person}$) as:

$\#ShowerSH_{ann}$ = $\#Persons_{SH}$ * $Showers_{person}$

The verified UES algorithm then becomes the following:

Verified Annual Showerhead UES (kWh or therms) =

$\#ShowerSH_{ann}$ * (($FlowRate_b$* $Length_b$ - $FlowRate_e$* $Length_e$) * HW_Mix) * DeltaT / WHeff * WH_{energy} * ISR * WH_{sat} + WW_savings

To enable consistency across the various showerhead measures, the evaluation team recommends creating a base savings term that includes all terms except for the installation rate and water heater saturations. This consistent term can then be included in all of the showerhead measure savings algorithms. This base savings term is defined as:

SHBaseSavings = $\#ShowerSH_{ann}$ * (($FlowRate_b$* $Length_b$ - $FlowRate_e$* $Length_e$) * HW_Mix) * DeltaT / WHeff * WH_{energy}

Using the term, the ex-post savings for the showerhead only measures were calculated as:

Ex-post Annual Showerhead UES (kWh or therms) =

$$SHBaseSavings * ISR * WH_{sat} + WW\_savings$$

ShowerStart UES Algorithms

ShowerStart showerheads include a thermostatic restrictor valve that reduced the shower's flow to a trickle once the water reaches bathing temperature (95 degrees). This feature reduces hot water usage between the time when the water reaches the specified temperature and when the individual enters the shower. Two types of measures were incentivized by PSE, ShowerStart Showerheads and ShowerStart Adapters. The ShowerStart showerhead is a 1.5 gpm model that includes the thermostatic restrictor valve feature, while the ShowerStart adapter provides just the thermostatic restrictor valve feature. A single algorithm is used to estimate gas and electric savings for the ShowerStart measures, however the source of the algorithm's parameters varies by water heating fuel type. The algorithms used in 2015 to calculate measure-level PSE Deemed UES estimates are the following:

Ex-Ante ShowerStart Showerhead Annual UES (kWh or therms) =

$$(Saving_{SH} + Savings_{adapter}) / IR_{RTF} * IR_{PSE} * WH_{sat}$$

Ex-Ante ShowerStart Adapter Annual UES (kWh or therms) =

$$Savings_{adapter} / IR_{RTF} * IR_{PSE} * WH_{sat}$$

Where:

$Saving_{SH}$ = RTF Workbook Savings for Direct Install measures (flow rate = 1.5 gpm)

$Savings_{adapter}$ = $\#ShowerSH_{ann}$ * $Waste_{sec}$/60 seconds * $FlowRate_b$ * DeltaT /WHeff * WH_{energy}

- $\#ShowerHH_{ann}$ = Annual Showers per Household (defined above in Showerhead only section)
- $Waste_{sec}$ = Average length of water flow savings from ShowerStart technology
- $FlowRate_b$ = Baseline flow rate in gallons per minute
- DeltaT = Difference in degrees between inlet and outlet temperature
- WHeff = Domestic Water Heater Efficiency, varies by fuel type
- WH_{energy} = Energy required to heat one gallon of water, varies by fuel type

IR_{RTF} = Installation Rate applied by RTF to the deemed value for $Savings_{SH.}$

IR_{PSE} = PSE Installation Rate

WH_{sat} = Water Heating fuel type Saturation, varies by service territory

The Stage 1 UES review for the ShowerStart measures uncovered an error with respect to the application of Installation rates for ShowerStart adapters. The algorithm divided both the ShowerStart adapter and ShowerStart showerhead savings by the RTF ISR (90%), effectively backing it out, before applying the PSE ISR (70%). A review of the UES input parameters found that only the ShowerStart showerhead had the RTF ISR applied, and thus the RTF ISR was being unnecessarily backed out from the adapter savings estimate. The evaluation team also updated the showerhead savings estimate ($Saving_{SH}$), as it is based on the savings from a Direct-Install program, and replacing it with the findings from the Showerhead only section above. The Showerhead only savings estimate already has the PSE ISR applied and thus the RTF ISR does not need to be backed out, nor does the PSE ISR need to be applied to the showerhead savings estimate. Additionally, the savings resulting from the thermostatic restrictor valve (of both the showerhead and the adapter units) are only realized if the ShowerStart functionality is used. The 2015 algorithm did not apply a “use factor” and thus the savings reflected a 100% use of the ShowerStart functionality. The evaluation team updated the algorithm to reflect a ShowerStart “use factor” parameter based on data from the RTF workbook for Thermostatic Restrictor Valves.

The verified UES algorithm for the ShowerStart measures is the following:

ShowerStart Showerhead Annual kWh Savings = $(Saving_{SH} + (Savings_{adapter} * ShowerStart_{use} * ISR_{PSE})) * WH_{sat}$

ShowerStart Adapter Annual kWh Savings = $Savings_{adapter} * ShowerStart_{use} * ISR_{PSE} * WH_{sat}$

Where:

$ShowerStart_{use}$ = Variable to account for the percent of time that the ShowerStart function is used.[128]

For the ex-post analysis, a Hot Water mix parameter was also included in the ShowerStart adapter savings variable and both the ShowerStart showerhead and adapter algorithms were updated to include a variable to account for waste water savings. Including the showerhead base savings term discussed in the showerhead only section above, the ex-post UES algorithm for the ShowerStart measures becomes the following:

Ex-Post ShowerStart Showerhead Annual Savings (kWh or Therms) =

$$(SHBaseSavings + (Savings_{adapter} * ShowerStart_{use})) * ISR * WH_{sat} + WW\_savings$$

Ex-Post ShowerStart Adapter Annual kWh Savings (kWh or Therms) =

$$Savings_{adapter} * ShowerStart_{use} * ISR * WH_{sat} + WW\_savings$$

[128] All other algorithm parameters are listed above.

Engagement and Leave-Behind Showerhead Measures

PSE's Engagement and Leave-Behind Showerhead measures uses PSE Deemed UES estimates for the no-cost engagement and kit measures based upon the RTF Deemed estimates, but modified using PSE specific data from the 2010 RBSA to more accurately represent the water heating fuel mix in PSE's service territory. A single algorithm was used to estimate gas and electric savings, however the source of the parameters used within the algorithm vary by water heating fuel type.

The algorithms used in 2015 to calculate measure-level deemed UES estimates is the following:

Ex-Ante Annual Engagement Showerhead UES (kWh or therms) =

$$\%PSECust_{Confirmed}*WH_{Sat}*ISR*(Share_{Primary}*Saving_{SHPrimary}+Share_{Secondary}*Saving_{Secondary})$$

Ex-Ante Annual Leave-Behind Showerhead UES (kWh or therms) =

$$ISR*(Share_{Primary}*Saving_{SHPrimary}+Share_{Secondary}*Saving_{Secondary})$$

Where:

$\%PSECust_{Confirmed}$ = Percent of engagement showerhead recipients who are confirmed to be PSE customers

ISR = Installation Rate, varies based electric or gas customers

WH_{sat} = Water Heating Saturation, varies by service territory

$Share_{Primary}/Share_{Secondary}$ = Share of primary versus secondary showers where the unit is installed

$Saving_{SHPrimary}/Saving_{SHSecondary}$ = RTF Workbook Savings for Primary versus Secondary showerheads (flow rate = 1.5 gpm)

The evaluation team approves of this algorithm, however believes that consistency should be upheld between this measure and the other showerhead measures. The other showerhead measures do not differentiate between Primary and Secondary showers. Different approaches in calculating savings for similar measures introduce additional bias in the calculations. Therefore, to estimate ex-post savings, the evaluation team updated the UES algorithms for these measures to be consistent with other showerhead measures shown above.

The algorithm used by the evaluation team to estimate the 2015 ex-post saving are as following:

Ex-Post Annual Engagement Showerhead UES (kWh or therms) =

$$SHBaseSavings * \%PSECust_{Confirmed} * WH_{Sat} * ISR + WW\_savings$$

Ex-Post Annual Leave-Behind Showerhead UES (kWh or therms) =

$$SHBaseSavings * ISR + WW\_savings$$

8.2.3 Verified Savings

Showerhead Only Measures

The evaluation team's Stage 1 verified savings review determined the showerhead only algorithm to be sound and defensible and applied correctly to estimate program savings. Therefore a 100% verified realization rate was assumed. The evaluation team did however identify two updates to algorithm parameters that should be made going forward to improve the accuracy of the UES estimate. These updates are:

- *Replace the term representing the annual showerhead*. The deemed UES algorithm utilized a variable representing the annual number of showers per household (#ShowerHH$_{ann}$) rather than the annual number of showers per showerhead (#ShowerSH$_{ann}$). This assumes a single showerhead is present in each household. The evaluation team recommends updating the algorithm to include the annual showers per showerhead parameter.
- *Utilize the mean flowrate rather than the median value*. The 2015 deemed algorithm assumes a baseline flowrate of 2.2 GPM, which is the median flowrate from a 2007 Seattle City Light showerhead evaluation. The evaluation team recommends updating this parameter to the mean flowrate of 2.3 GPM. This value is also consistent with the 2011 RBSA and used within the updated RTF Showerheads and RTF Thermostatic Valves workbooks.
- *Create a Showerhead Base Savings term* – This term which account for all savings parameters except for the installation rate, water heater saturations, and waste water savings, will facilitate the creation of consistent savings algorithms for all showerhead measures. These algorithms can then be easily adjusted to account for the installation rate and water heater saturations associated with each of the individual measures.

The impact of these updates to the showerhead only measures result in verification adjustments to the UES from 91% to 113%, but largely cancel each other out.

ShowerStart Showerheads and Adapters

The evaluation team's Stage 1 assessment of the 2015 UES estimates for the ShowerStart measures determined the UES algorithms to be reasonably sound and defensible, and applied correctly to program sales. Therefore a 100% verified realization rate was assumed. However, the evaluation team did identify several areas where adjustments to the UES algorithms and input parameters are advised in order to improve the accuracy of the resulting UES estimates. These adjustments include:

- *Revise the UES algorithm to estimate the annual energy savings for a single showerhead measure.* The 2015 deemed algorithm produces an energy savings estimate based on annual household shower usage rather than on a per showerhead basis, thus overestimating individual measure savings by nearly a factor of 50%.

- *Update the length of water waste estimate.* The 2015 deemed algorithm uses a value which is undocumented (80.8 seconds). The evaluation team recommends updating this value to 66 seconds based on an evaluation of a California ShowerStart Pilot program.[129]
- *Include a term to represent the percent of showers where the thermostatic restrictor valve (TRV) is used.* The current savings assumptions assume that for all showers taken, the TRV eliminates waste (aka turns off flow to an unoccupied shower). If a resident is standing waiting to get into the shower there is no waste to eliminate. The use term is taken from the RTF workbook for thermostatic restrictor valves.
- *Update parameters to align with the showerhead UES estimates.* The evaluation team recommends updating the following parameters so that they are consistent with the showerhead only savings estimates.
  - WHSat (Gas Only)
  - Flowrateb
  - DeltaT
  - Showerhead Base Savings – use the base showerhead savings estimates calculated for the Showerhead only measures. The RTF deemed savings estimate used a base savings estimate corresponding to a direct install showerhead which is incorrect as these measures are not distributed via a direct install delivery method. Utilizing this consistent term (which does not include an installation rate term) will also eliminate the need to back out the ISR for another program (that was required in the ex-ante algorithm) which can and did lead to errors.

The impact of these updates to the ShowerStart measures savings algorithms result in adjustments to the verified UES estimates for ShowerStart showerhead measures ranging from 47% to 73% and adjustments to the verified UES estimates for ShowerStart adapter measures of 37%.

Engagement and Leave Behind Showerheads

The evaluation team inadvertently did not include engagement and leave behind showerheads in the Stage 1 verification effort. However due to the small magnitude of savings of these measures recommends a 100% verified realization rate. A thorough review of this measure was conducted during Stage 2 of the evaluation.

[129] ShowerStart Pilot Project White Paper. City of San Diego Water Conservation Program, August 2008.

8.3 STAGE 2 EX-POST IMPACT ANALYSIS

8.3.1 Ex-Post UES Adjustments

Ex-post adjustments in Stage 2 of the evaluation came from two main sources - web surveys administered to a random sample (General Population Survey) and literature reviews for more recent and up to date input parameters. For showerhead-only measures, the following parameters were modified: Number of Persons per Showerhead, Shower Duration, Hot Water Mix, Water Heater Saturations, Installation Rates, and Waste Water Savings.

Persons per Showerhead

As mentioned above, the evaluation team recommends updating the showerhead savings algorithms so that the savings are reflective of the average energy savings per showerhead, not per household (which would assume the average household only has one shower). During the Stage 1 verification activities, the evaluation team used an estimate an average of 1.32 residents per showerhead to calculate savings on a per showerhead basis. In Stage 2 of the evaluation, questions were asked of general population web survey respondents to determine the average number of residents per household (residents who live in the home at least six months a year), and the average number of showers per household. The responses to these two questions are provided in Table 8-4 and Table 8-5 below. Using the data from these two questions, the evaluation team re-calculated the average number of residents per showerhead in a home to be 1.52 (2.74 average residents per HH / 1.81 average showers per HH = 1.52 residents per SH), resulting an approximately 15% increase over the Stage 1 estimate.

TABLE 8-4: HOW MANY PEOPLE LIVE IN YOUR HOME AT LEAST SIX MONTHS OF THE YEAR?

Question Z10	ALL	Own	Rent
Max	12	12	10
Mean	2.74	2.73	2.71
Min	1	1	1
n	647	450	190

Source: Evaluation Team Analysis – General Population Survey

TABLE 8-5: HOW MANY SHOWERS DO YOU HAVE IN YOUR HOME?

Showers per Household	All	Own	Rent
One shower	35%	21%	59%
Two showers	48%	55%	37%
Three showers	14%	21%	3%
Four or more showers	1%	2%	0%
Unsure	1%	2%	0%
n	661	461	193

Source: Evaluation Team Analysis – General Population Survey

Shower Duration & Hot Water Mix

The ex-ante UES estimates used a value of 7.84 minutes per shower, based on a 2000 Seattle Home Water Conservation Study, based on single family homes.[130] This value was cited by RTF and used in the RTF calculations. As the study was 14 years old at the time of the program, the evaluation team determined that it was worth reviewing and seeing if there were more appropriate sources available. The most recent version of the RTF calculations (Showerheads v3.1) used an analysis of data from Aquacraft Inc., provided by the Water Resource Foundation. This data, shown in the RTF calculator, found an increase in shower durations for showerheads with decreased flow rates. Some of this increased shower length was noted to have come from the increase in warm-up times due to the decreased flow. The evaluation team determined that using these updated values from RTF reflected the most recent data available, and would stay consistent with the RTF source. The revised shower durations and the increase in gallons per year used in the calculations are shown in the table below.

Additionally, the ex-ante calculations used a varying hot water mix, based on the showerhead flow rate. These were based on previous versions of the RTF calculations, however the newer RTF calculator noted that the data to support the relationship was not statistically significant. Therefore, the evaluation team updated the Hot Water Mix Percentage, based on the new RTF calculations, to 71%, which accounted for both warm-up and the active showering periods.[131]

The overall effect on savings from these updates to the shower duration and the hot water mix are shown below in Table 8-6. For electric water heating, this decreases savings by 11 kWh to 51 kWh effect

[130] Seattle Home Water Conservation Study. The Impacts of High Efficiency Plumbing Fixture Retrofits in Single-Family Homes. Submitted to: Seattle Public Utilities and the U.S. EPA. Prepared by: Peter W. Mayer, William B. DeOreo, David M. Lewis of Aquacraft, Inc. (December 2000)

[131] This parameter was also added into the ShowerStart Adapter measures, as the ex-ante estimates did not include it.

on savings, while for gas water heating, this would have between 0.53 therms and 2.3 therms effect on savings.

TABLE 8-6: SHOWER DURATIONS BY SHOWER FLOW RATE

Flow Rate (GPM)	Shower Duration (Minutes)		Gallons per Year		Hot Water Gallons per Year	
	Ex-Ante	Ex-Post	Ex-Ante	Ex-Post	Ex-Ante	Ex-Post
2.5	7.84	8.2	6,970	7,157	5,095	5,082
2.0	7.84	8.43	5,730	5,758	4,306	4,088
1.75	7.84	8.7	4,990	5,200	3,835	3,692
1.5	7.84	9.21	4,277	4,718	3,345	3,350

Source: Evaluation Team Analysis

Water Heating Saturations

For showerhead measures sold through the retail channel it is impossible to know whether the customer receives electric, gas, or both services from PSE and whether the customer has electric or gas water heating (DHW). Both of these parameters significantly impact the savings associated with the showerhead measures, and thus deemed UES estimates are developed by PSE service types (and applied based on the zip code of the store where the showerhead was purchased) and water heater saturations are estimated for each PSE service type.

The ex-ante estimates of electric versus gas water heater saturations by service type came from analysis of the 2010 RBSA for PSE customers. The ex-post estimates were calculated using data collected by the evaluation team during the general population web surveys. The ex-ante versus ex-post water heating saturations is shown in the table below. As this table shows, all the ex-ante estimates are within the 90% CI of the ex-post estimate except for customers having gas water heating and residing in combined service territories. The large increase (nearly 15%) in the electric DHW saturation for customers receiving both gas and electric service from PSE (Combo) led to large increases in electric savings for ShowerStart and Engagement measures.

TABLE 8-7: WATER HEATER SATURATION ESTIMATES

DHW Type	Service Type	Ex-Ante	Ex-Post	90% CI
Electric	Elec Only	58.9%	59.5%	48.9%-70.1%
Electric	Combo	48.7%	63.5%	55.5%-71.5%
Gas	Combo	49.7%	33.8%	25.9%-41.6%
Gas	Gas Only	52%	59.7%	48.9%-70.5%

Source: Evaluation Team Analysis – General Population Survey

Installation Rates

The ex-ante installation rates (ISR) used for the showerhead only and ShowerStart measures ranged from 70%–90% based on the flow rate and the type of service the customer received from PSE (Combo, Electric Only or Gas Only). The source of these estimates was PSE deemed values. The Gas Only measure used a direct-install ISR which is why it is so much higher than the others. The Stage 2 general participant web surveys sought to identify customers who had purchased a low-flow showerhead for their home in the last three years[132] and estimated for that group of customers a first-year installation rate. Thirty-nine percent of the general population survey respondents indicated they had purchased a water saving showerhead in the past 3 years. Of those respondents, 96% reported they had installed this showerhead in their home, and out of those installed, 94% were reported to still be installed. This resulted in an ex-post ISR of 90.2% which was used for the showerhead only and ShowerStart measures.

The ex-ante calculations for showerhead measures distributed via kits used a separate installation rate (IR) for electric versus gas customers and the source of these installation rates was not evident. During Stage 2 of the evaluation, ex-post ISR estimates were derived for showerheads distributed via kits based on data collected during the Appliance participant web surveys. As shown in the table below, out of the 151 respondents who received kits, only 84 of them confirmed installing the showerhead, leading to a showerhead ISR of 55.6% for the kit measures which is a 7%-10% lower than the ex-ante estimates. The ex-ante and ex-post ISR estimates are provided in Table 8-8 below.

132 For an upstream program, such as the retail portion of the showerhead program, general population survey is used in place of participant survey data since no information on program participants is available due to the method of program delivery.

TABLE 8-8: EX-ANTE VERSUS EX-POST INSTALLATION RATES

Measure	Service Type	Ex-Ante	Ex-Post
Showerhead Only	Elec Only or Combo	70-80% by flowrate	90.2%
Showerhead Only	Gas Only	90%	90.2%
ShowerStart	All	70%	90.2%
Engagement/Kits	Gas	66%	55.6%
Engagement/Kits	Elec	62%	55.6%

Customers surveyed as part of the general population survey who did not install, or had removed the showerhead were also asked a follow up question about why the showerhead was removed or not installed. Almost 50% of the respondents replied that they had a problem with the water pressure. Another quarter of the respondents stated that they never got around to installing it, and finally, 10% of respondents did not like the look or the fit of the showerhead.

Waste Water Savings

Waste water savings are calculated by RTF, to account for the reduction in electric power required from water treatment plants in treating the reduced water load from the reduced water usage. The evaluation team was not able to identify another jurisdiction that included savings that occur outside of the site itself, in the program-level savings. Additionally, it is not clear that RTF's assumptions are based solely on water treatment plants that are within PSE's service territory. The newest RTF assumptions for water savings were based on the RTF Standard Information Workbook v2.6, which updated the estimate from 5.3 kWh per 1,000 gallons down to 3.7 kWh per 1,000 gallons. As this is a more conservative number, the evaluation team has accepted this revision, and implemented it into the ex-post savings estimates.

8.3.2 Ex-Post Savings Estimate

Applying the ex-post UES adjustments described above to the 2015 deemed UES algorithm led to ex-post UES estimates that were larger than the deemed estimates for all of the 2015 showerhead only measures. The 2015 program sales weighted overall realization rate were 152% for kWh savings and 97% for therm savings. The resulting ex-post UES savings estimates and realization rates are shown in Table 8-9 below.

TABLE 8-9: 2015 SHOWERHEAD ONLY EX-POST UNIT ENERGY SAVINGS

Flow	Service Type	DHW Type	Units	Deemed UES	Ex-Post UES	Ex-Post RR
<= 1.5 gpm	Elec-Only	Elec	kWh	239	300	126%
1.51-1.75 gpm	Elec-Only	Elec	kWh	185	241	130%
1.76-2.0 gpm	Elec-Only	Elec	kWh	123	172	140%
<= 1.5 gpm	Combo	Any	kWh	122	194	159%
1.51-1.75 gpm	Combo	Any	kWh	94	156	166%
1.76-2.0 gpm	Combo	Any	kWh	63	111	177%
<= 1.5 gpm	Elec-Only	Any	kWh	145	182	126%
1.51-1.75 gpm	Elec-Only	Any	kWh	112	146	131%
1.76-2.0 gpm	Elec-Only	Any	kWh	75	105	140%
<= 1.5 gpm	Gas-Only	Gas	Therms	10.2	13.0	127%
1.51-1.75 gpm	Gas-Only	Gas	Therms	7.9	10.4	133%
1.76-2.0 gpm	Gas-Only	Gas	Therms	5.3	7.5	142%
<= 1.5 gpm	Combo	Any	Therms	5.1	4.4	87%
1.51-1.75 gpm	Combo	Any	Therms	3.9	3.5	90%
1.76-2.0 gpm	Combo	Any	Therms	2.6	2.5	96%
<= 1.5 gpm	Gas-Only	Any	Therms	5.3	7.8	146%
1.51-1.75 gpm	Gas-Only	Any	Therms	4.1	6.2	152%
1.76-2.0 gpm	Gas-Only	Any	Therms	2.7	4.5	163%

Source: Evaluation Team Analysis

Applying the ex-post UES adjustments described above to the 2015 deemed UES algorithm for the ShowerStart measures led to ex-post UES estimates that were smaller than the deemed estimates for all but one of the measures. The 2015 program sales weighted overall realization rate were 89% for kWh savings and 47% for therm savings. The resulting ex-post UES savings estimates and realization rates are shown in Table 8-10 below.

TABLE 8-10: 2015 SHOWERSTART EX-POST UNIT ENERGY SAVINGS

ShowerStart Measures	Service Type	DHW Type	Units	Deemed UES	Ex-Post UES	Ex-Post RR
Showerhead + Adapter	Elec-Only	Elec	kWh	230	216	94%
Adapter Only	Elec-Only	Elec	kWh	131	60	46%
Showerhead + Adapter	Combo	Any	kWh	190	230	121%
Adapter Only	Combo	Any	kWh	108	64	59%
Showerhead + Adapter	Gas-Only	Gas	Therms	13.67	9.26	68%
Adapter Only	Gas-Only	Gas	Therms	8.06	2.29	28%
Showerhead + Adapter	Combo	Any	Therms	8.39	5.24	63%
Adapter Only	Combo	Any	Therms	4.93	1.3	26%

Source: Evaluation Team Analysis

Applying the ex-post UES adjustments described above to the 2015 deemed UES algorithm for the Engagement and Leave-Behind measures led to ex-post UES estimates that were smaller than the deemed estimates for all but one of the measures. The 2015 program sales weighted overall realization rate were 111% for kWh savings and 52% for therm savings.[133] The resulting ex-post UES savings estimates and realization rates are shown in Table 8-11 below.

TABLE 8-11: 2015 ENGAGEMENT AND LEAVE-BEHIND SHOWERHEAD EX-POST UNIT ENERGY SAVINGS

Showerhead Measure	Service Type	DHW Type	Units	Deemed UES	Ex-Post UES	Ex-Post RR
Engagement[134]	Elec-Only	Elec	kWh	125	110	88%
Engagement	Combo	Any	kWh	103	116	113%
Engagement	Combo	Any	Therms	5	3	52%
Leave Behind	Combo	Any	kWh	226	189	84%
Leave Behind	Combo	Any	Therms	10.5	8	77%

Source: Evaluation Team Analysis

8.4 RESIDENTIAL SHOWERHEAD PROCESS ANALYSIS

The process evaluation for showerheads mirrored that of lighting since both programs run through similar channels. Data collection included a general population survey which included questions about

[133] These weighted overall realization rates are only for those claimed under the Showerhead Program. The ones claimed under the Appliance Programs can be found in the Appliance Program sections.

[134] In 2015, the UES for the Engagement measure was applied to all showerheads distributed via Thank You and Leave Behind kits.

showerheads, and in-depth interviews with trade allies (specifically, four showerhead manufacturers—two of which also sell lighting). The process analysis for showerheads sought to answer the process-related questions laid out in the introduction. Where these areas are similar to lighting, we refer the reader back to the lighting chapter. The areas of inquiry for the process evaluation included:

- **Program Theory and Changes:** How has the Residential Showerhead Program changed over time? Is this well-documented?
- **Data Tracking:** What data are currently being collected to support the Residential Showerhead Program and how is this data being used? And what additional research is needed for each program area?
- **Awareness:** How aware are residential customers of the Residential Showerhead Program offerings and what channels are most effective to increasing awareness?
- **Demographics of Participation:** Who is currently purchasing program showerheads (demographically)?
- **Trade Ally Satisfaction:** What is the level of trade ally (i.e., manufacturer and retailer) satisfaction with the Residential Showerhead Program processes, and what areas of improvement exist?
- **Best Practices and Opportunities:** Is the Residential Showerhead Program following industry best practices? How do they benchmark against industry best practices for program theory and design, program management, reporting and tracking of energy savings, quality control, program processes, and marketing and outreach? Where may additional opportunities lie?

8.4.1 Program Theory and Changes

Program efforts related to showerheads are described in annual and biennial plans and reports and changes are documented in the annual businesses cases.

The showerhead efforts, like the Lighting Program, rely on three sales channels including retailer-stores, online and pop-up events. In addition, showerheads are distributed to rebate participants and those who were rejected from the rebate program through Thank You Kits. Across these channels, there are several different groups that work as a team to implement these efforts. These groups include:

Retail Channels

- Manufacturers who work with PSE to determine products and buy-down amounts
- Retail stores, that play a more limited role selling the products in store
- An implementer (C+C) that negotiates program MOUs and works closely with the retailers

Online through ShopPSE

- PSE staff that manage the website working with an implementer that fulfills web orders

Pop-up Events

- An implementer (TechniArt) that sells products, including showerheads, at pop-up events

Thank You Kits

- An implementer (EFI) that manages sends out showerheads in Thank You Kits

Marketing and support (cross-channel efforts)

- An implementer (Black Hawk) that processes manufacturer and retailer sales, and invoices PSE
- PSE management staff and marketing team that oversee the implementation of the program, and markets energy efficient showerheads

FIGURE 8-1: SHOWERHEAD PROGRAM ROLES

	C+C	Manufacturers	Retailers	ShopPSE group within PSE	TechniArt	Black Hawk	EFI	PSE Marketing Group	PSE PM and systems channel staff
Roles	Creates and manages MOUs; categorizes SKUs; works with Manufacturers and Retailers	Signs MOU agreeing to products; Submits invoice and sales data to BES online portal	Sells incentivized product in stores; allows in-store signage (POP); provides data to Manufacturer	Sells lighting and showerheads sold online	Sells measures through pop up events	Performs QA/QC on data; Reports DB information to PSE; pays manufacturers	Mails out lightbulbs, showerheads and aerators in "thank you" kits (in support of Rebate programs)	Oversees all marketing efforts	Oversees all processes (including MOU and changes); approves invoices; uploads data; calculates savings; determines forecasts
Data	MOUs and data from store visits/ customer intercepts	Lighting and showerhead data and retailer/manufacturer for in-store sales, invoices		Lighting, showerhead, and customer data for online sales	Unit data (lighting, showerheads, kits) and purchaser zip code for event-based sales	Aggregated manufacturer invoice amount (and quantities) for PSE	Light., showerhead/ aerator, and customer data for thank you kits		

In 2014-2015, PSE made several changes that were documented in the 2014-2015 Business Case. These include:

- Changes for existing high performance showerheads – 1) tiered showerheads within PSE combined service territory to be both electric and natural gas, 2) updated savings to more accurately reflect our PSE service territory fuel source mix, 3) added an engagement showerhead measure
- New measures -- added ShowerStart adapters and ShowerStart showerheads

While the evaluation covered 2014-2015, we note that the program continues to evolve. The program made additional changes to ShowerStart adapters and ShowerStart showerheads in 2016 and 2017, and added aerator measures, as documented in the 2016-2017 Business Case for the Direct-To-Consumer Programs.

8.4.2 Data Tracking

Data tracking for showerheads mirrors that of lighting. In the review of the 2015 data, there were slight differences in the unit quantities of electric showerheads and electric ShowerStart adapters, however the electric energy savings matched between the two sources. These two measures where a discrepancy was found were both noted as “NQC”, and no savings were claimed for these measures.

The main discrepancy found in the tracking data review for showerheads resulted from the fact that some measures in 2015 were assigned both gas and electric deemed savings. For these measures, the unit is counted twice in the unit totals, once for the gas savings and once for the electric savings. This is a frequent occurrence, so while the 2015 tracking data shows the total number of units with gas savings is 20,845 and the total number of units with electric savings is 23,570, the total number of units sold in 2015 is actually 27,948, meaning that nearly half of the measures are double counted with respect to units sold.

Since the initial review of the data, PSE worked with the evaluation team to document the types of data that should be collected by each of the key players in the program delivery to ensure success for the future. A full mapping of the data that should be collected by each of the key group is included in Appendix H.

8.4.3 Awareness of Water Saving Showerheads and PSE’s Showerhead Program

Among the residential customers (i.e., general population), 78% of customers reported being familiar with water saving showerheads. Homeowners were more likely to be aware of water saving showerheads than renters and people living in single-family detached homes were more likely to be aware of water saving showerheads than people living in single-family attached and manufactured homes.

Also among this population, 37% of customers are aware that PSE offers rebates on energy efficient showerheads, and only 27% are aware of ShopPSE, which is one of the channels that PSE uses to sell efficient showerheads. This is much lower than awareness of lighting, which is sold through similar retail channels. Notably, however, there are many more retailers and manufacturers involved in the Lighting Program. Nearly half of those aware of the program heard about the program from PSE bill insert or through the mail and a quarter of those aware of the program heard about the program through the PSE website.

Awareness among DtC participants in the Appliance Programs (i.e., Rebate, Replacement and Decommissioning) is much higher. This may be because many of these participants receive Leave Behind or Thank You Kits which may include information on other PSE programs.

TABLE 8-12: AWARENESS OF RESIDENTIAL DTC PROGRAMS, PARTICIPANTS VERSUS GENERAL POPULATION

Awareness of Other Residential Programs	All DtC Participants	General Population
Lighting Program	86%	50%
Appliance Rebate Program	85%	47%
Heating Rebate Program	73%	42%
Decommissioning Program	64%	40%
Showerhead Program	83%	37%
ShopPSE Website	45%	27%
CW Replacement Program	49%	23%
N	1,194	640

Manufacturer Perspective on Customer Awareness

The four showerhead manufacturers described the best ways to raise customer awareness of PSE's residential showerhead program and why they chose their approach. Many of the proposed approaches to raise customer awareness are similar to approaches proposed by lighting manufacturers. The proposed customer awareness approaches and why they believe their approach will increase customer awareness include the following:

- Direct mailers to customers, TV, and radio ads.
  - This approach will make them aware of what's available.
- Bill stuffers
  - Effective and direct
- End cap promotions
  - Increases sales and awareness. Proven track record. We know this.
- Social media outlets. PSE field reps highlighting the program to store associates.
  - More effective way of managing the brand awareness and the effectiveness of rebate programs.

Manufacturers also rated a set of approaches to raise customer awareness. These questions were customized to the respondents because of the variation among this group: (1) one of the showerhead manufacturers only sells their incentivized product through ShopPSE, an online store, (2) two manufacturers participate in both PSE's showerhead and lighting rebate programs in stores, and (3) one of the manufacturers sells only showerheads—not lighting--in brick and mortar stores.

Table 8-13 lists the manufacturers' ratings of the effectiveness of alternative approaches for increasing customer awareness in stores and Table 8-14 lists the manufacturers' perception of difficulty.

TABLE 8-13: EFFECTIVENESS OF CUSTOMER AWARENESS METHODS RATED BY SHOWERHEAD MANUFACTURERS[135]

Questions	Very Effective	Somewhat Effective	Not at all Effective
PSE Branding on Packaging	1	1	1
PSE Products on End Caps	2		1
Advertise PSE Programs over Store PA System or TV Monitors	1	1	1
Advertise PSE Programs on Store Receipts		2	1
Advertise PSE Programs on Store Flyers		2	1

Showerhead manufacturers scored placing PSE's rebated products on end caps as the most effective methods for increasing customer awareness (see Table 8-14). The manufacturers rating end caps placement as effective, however, were dual lighting and showerhead manufacturers. The showerhead only manufacturer replied that end cap placement was not at all effective. The showerhead only manufacturer stated that PSE branding on packaging as somewhat effective and replied that all other methods to improve customer awareness would be not at all effective.

The showerhead manufacturer that sells incentivized product at ShopPSE was not asked how to increase customer awareness of PSE programs in brick and mortar stores. They were asked to state how effective it would be to sell their product through a retail store. The ShopPSE showerhead manufacturer thought that it would be somewhat effective to sell their product through a retail store but they also stated that it would be somewhat difficult for their organization to do so.

TABLE 8-14: DIFFICULTY OF CUSTOMER AWARENESS METHODS RATED BY SHOWERHEAD MANUFACTURERS

Questions	We Already do it	Very Easy	Somewhat Easy	Somewhat Difficult	Very Difficult
PSE Branding on Packaging	1			1	
PSE Products on End Caps	1		1		
Advertise PSE Programs over Store PA System or TV Monitors					2
Advertise PSE Programs on Store Receipts					2
Advertise PSE Programs on Store Flyers				1	1

135 The manufacturer who only sells through ShopPSE is not included. The two manufacturers who produce both showerheads and lighting were questioned jointly about how to increase lighting and showerhead awareness in their customers. Their responses to these questions are not specific to either lighting or showerheads but represent how to increase customer awareness for both products.

8.4.4 Demographics of Efficient Showerhead Purchasers

Purchasers of water saving showerheads tend to mirror those in the general population. While slightly more owners (68% compared to 61% in the general population) and households with kids (37% v. 34%) purchase these units, the program is appealing to renters as well (32% of water savings purchasers are renters). Purchasers tend to be more knowledgeable about energy efficiency, but generally don't describe themselves as more likely to be early adopters of technologies (e.g. data show that non-purchasers are about as likely as purchasers to be early adopters, and a larger percentage of purchasers of water-saving devices describe themselves as "among the last" to adopt new technologies).

TABLE 8-15: DEMOGRAPHICS OF WATER SAVINGS SHOWERHEAD PURCHASERS AND NONPURCHASERS

Demographic	Water Saving Showerhead Purchasers	Water Saving Showerhead Non-Purchasers	General Population
Own	68%	63%	61%
Rent	32%	36%	39%
Single-Family Detached	65%	65%	62%
Single-Family Attached/Mobile Home	33%	35%	37%
House with Retired Person	27%	28%	26%
House with Kids	37%	29%	34%
Water Heater Fuel Type			
Electric	50%	55%	52%
Natural Gas	41%	38%	35%
Propane	5%	3%	4%
Knowledgeable About Ways to Save Energy			
Very	39%	27%	27%
Somewhat	56%	69%	64%
Not at All	5%	4%	9%
I am generally … to try a new technology product			
The Last	6%	7%	9%
Among the Last	23%	15%	20%
In the Middle	38%	55%	46%
Among the First	24%	22%	22%

8.4.4 Trade Ally Satisfaction Results: Showerhead Manufacturers

Four showerhead manufacturers responded to the process survey, two of the manufacturers were both showerhead and lighting manufacturers. The showerhead manufacturer survey asked manufacturers the same set of questions as those asked of lighting manufacturers.

The responses show that manufacturers have a high degree of satisfaction with PSE's showerhead program. The average reported satisfaction with the program was a 9.8 out of 10 (see Table 8-16), with three of the four retailers giving the program a 10. Showerhead manufacturers report the highest level of general program satisfaction of the three groups of trade allies surveyed for this process effort. Manufacturers gave the following responses when asked why they rated the program so highly:

- It's pretty straightforward…The group has been easy to work with. It has delivered the results.
- We haven't had any issues. Good communication with C+C and PSE.
- It's been good. We've had great sales. The rebate levels are significant.
- They helped to expand our business.

When asked to list the benefits of participating in the program, the responses focused on increased opportunities and sales associated with the rebates. When asked to list the drawbacks of participating in the program, all four manufacturers stated that there were no drawbacks.

Manufacturers were also asked if they could change one thing about the program, what they would change. Each showerhead manufacturer had a different response. One manufacturer replied "nothing" and one suggested an increase in the incentives. Increased marketing dollars for special promotions was suggested while the final manufacturer stated that they would like a way to participate without providing the sell-through because the sell-through takes resources to collect the information.

The showerhead manufacturers were asked to rate ten program elements. The responses to the program elements are provided in Table 8-16.[136]

[136] The two showerhead manufacturers who are also lighting manufacturers were asked their satisfaction with the lighting and showerhead program elements, they were not asked their satisfaction separately. The program element satisfaction for these manufacturers is presented in both the lighting and showerhead section.

TABLE 8-16: AVERAGE SATISFACTION SCORE AND NUMBER OF SHOWERHEAD MANUFACTURERS PROVIDING A GIVEN SCORE FOR ELEMENTS OF PSE'S SHOWERHEAD PROGRAM (10 = VERY SATISFIED, 0 = VERY UNSATISFIED)

Questions	Average Score	10	9	8	7	6	5	NA
Satisfaction with Showerhead Program	9.8	3	1					
Satisfaction with Program Elements								
Selecting Showerhead Products to be Rebated	9.5	3		1				
Interactions with C+C Staff	9.5	3		1				
Sales Tracking, Reporting and Verification	9.3	2		1				1
Enrollment Process	9	1	1	1				1
Rebate Levels	9	1	1	1				1
Marketing Material provided by PSE to Retailers	9	1		1				2
Training of Store Staff about Showerhead Program	8.5		1	1				2
Processes Incentive Payments	8.3	1		1	1			1
Communications with the Program	8.3	2		1			1	
Coordination with Retailers	7	1				1	1	1

Coordination with retailers about PSE's showerhead program was the lowest scored program element (a score of 7). One showerhead manufacturer responded that they were not aware of what PSE was doing. This manufacturer suggested that PSE do a better job of letting manufacturers know how the program is coordinating with retailers. The other low scoring manufacturer believes that the issue is the program's requirement that retailers provide proof of performance monthly; the program is requiring too much coordination with retailers for a retailer to have eligibility. Given the coordination responses, better communication may help to provide showerhead manufacturers more information on how the program is coordinating with retailers and help them understand the importance of the proof of performance data.

Communication with the program was the second lowest scoring program element at an 8.25 (rounded to 8.3). The showerhead manufacturer who provided the low program element score stated that communication could be improved if "there was a way that the PSE staff could check in and see if we have any new products. A five-minute call would benefit the relationship."

The third lowest scoring program element was the processing of incentive payments at an 8.3. The manufacturer who scored this element of the program a 7 stated that "there's not really anything you can do to streamline it." The manufacturer appears to be unhappy with the need to go to the retailer to collect the necessary information on a regular basis.

Future Participation

All showerhead manufacturers stated that they were very likely to continue to participate in PSE's program. Manufacturers' reasons to continue their relationship with PSE include the following:

- Sales lift and delivering on our strategic intent of offering conservation products.
- All the people we work with are great.
- The way they work together with us and how we work as a partnership to take the position in the marketplace.

When asked if there are reasons why their organization (or other similar organizations) might not participate in the PSE program in the future, 1 of the 4 manufacturers said they knew of no reasons. One manufacturer stated that it was difficult to get the necessary sell through information to PSE; one mentioned financial positions and a third stated that manufacturers who don't support the technologies rebated by the utility would not be interested in participating. As with lighting manufacturers, the responses from showerhead manufacturers indicate a very high likelihood that they will continue in the program.

Effect of Current Program

All four showerhead manufacturers rated PSE's residential showerhead program as very effective at increasing the sales of low-flow showerheads in PSE's territory. The showerhead manufacturers' assessment of the program's impact is equivalent to the assessment of lighting manufacturers, who unanimously rated the program as very effective. Showerhead manufacturers estimated that their low-flow showerhead sales would be 50% to 80% lower without the program, with an average of 63% lower. The showerhead manufacturers' assessment of the uplift in sales due to the program is higher than the lighting manufacturers' 53% average drop in sales without the program. Both lighting and showerhead manufacturers believe that the PSE residential programs are having a positive, significant impact on sales.

Showerhead manufacturers where asked "how different are unit prices for standard versus low-flow showerheads?" Two manufacturers stated that the prices are comparable for standard and low-flow showerheads while two manufacturers estimated that low-flow showerheads cost 15% to 30% more than standard showerheads. All manufacturers believe that the incentives are set at about the right amount.

8.4.5 Best Practices and Opportunities

Showerhead manufacturers felt that the program was adhering to best practices, but offered some ideas including: staying at the forefront of changing lower-flow technologies, offering differentiated rebates by technology, co-marketing or co-branding, and keeping manufacturers informed of a broader range of PSE offerings.

The four showerhead manufacturers were asked, "Based on your organizations experience in other areas of the country, are there any other best practices that you have seen in energy efficiency programs that PSE should be considering?" Responses included:

- They are pretty on the forefront. They are more of a pioneer than a follower.
- I consider the PSE program to be one of the better ones that we are involved in.

When asked about future showerhead trends that may require program adjustments, the manufacturers remarked on low and lower flow showerheads and showerhead designs and features. One manufacturer suggested that the program may want to adopt differentiated rebates based on the flow of the showerhead, with lower flow rates associated with higher rebates. Another manufacturer stated that the program needed to promote and direct the "consumer through the utility programs and show them what there is to offer."

Showerhead manufacturers also suggested that they and PSE could work together to co-market and/or raise awareness of the products marked down by PSE:

- Happy to participate in customer awareness days, conferences, exhibitions.
- It would be good to understand the marketing dollars available and coordinate our efforts.
- We are always open to work together, to try to make things viable on both sides.

All four showerhead manufacturers stated that there was no additional support that their organization needed from PSE or the program implementers. Final suggestions provided by the showerhead manufacturers included:

- Possibly experiment with branding our products. They brand the packaging. They could also brand the product.
- More communication on what they are doing with other retailers for the same product.

8.4.6 Other Detailed Showerhead Findings

Analysis of the showerhead questions on the general population survey led to the following findings:

- 40% of general population respondents had purchased at least one water saving showerhead in the last 3 years.
  - 28% had purchased more than one water saving showerhead in the last 3 years.
  - Owners are more likely to have purchased a water saving showerhead than renters.
  - 70% of those purchased the showerhead(s) at a retail store, 8% through ShopPSE, 7% through a PSE sponsored event, 6% from an online retailer (that was not ShopPSE).
- A majority of general population respondents were satisfied with the showerheads they had purchased in the last 3 years (with an average rating of 4.1 out of 5).
  - 76% of respondents were satisfied with the showerheads, 18% were indifferent, and 6% were dissatisfied.
  - The majority of dissatisfaction was related to the low-flow showerhead not providing strong enough pressure.
- 78% of general population respondents are unaware of thermostatic restrictor valves, another 3% are unsure.
- 27% of general population respondents said they leave the water on unattended all the time or frequently, another 28% said they sometimes leave the water on unattended, and 44% said they never leave it unattended.

8.5 RESIDENTIAL SHOWERHEAD PROGRAM FINDINGS AND RECOMMENDATIONS

The evaluation team provides the following findings and recommendations for PSE's Residential Showerhead Program.

Finding S1: During Stage 2 of this evaluation a number of parameters in the showerhead UES algorithm were updated using program sales data, data collected from program participants, and secondary research of recent showerhead measurement studies in order to estimate ex-post savings.

Recommendation S1: The evaluation team recommends that PSE review each of these parameter updates presented in this chapter, in light of additional changes that have occurred to the savings algorithms since 2015, to determine if updates to the deemed parameters are warranted in the future.

Finding S2: There was much inconsistency across the UES algorithm used to estimate showerhead savings for the showerhead only measures, the ShowerStart measures, and the kit measures.

Recommendation S2: The ex-post impact analysis made numerous changes to the deemed UES algorithms to align them and provide a consistent foundation for various showerhead measures. The evaluation team recommends that PSE review these alignments and consider adopting them for future program years to ensure a clear and consistent foundation for calculating program savings.

Finding S3: The level of trade ally satisfaction with PSE's residential showerhead programs is very high. PSE's programs were described as "one of the strongest programs in the US" and "one of the easiest programs to work with, C+C has been very communicative, flexible, understanding and easy to work with." Showerhead manufacturers rated the program a 9.8 out of ten.

Recommendation S3: Showerhead retailers and manufactures were asked to provide recommendations for improvements to the programs and responses included:

- Increase customer awareness through direct mail, bill stuffers, end cap promotions, social media outlets, branding on packaging
- Co-marketing with Manufacturers – team up for in-store or field events, in-store marketing
- Communications – increased communication regarding new products and how products are being marketed at retailers.

Evaluation Report Response

Program: Direct to Consumer

Program Managers: Holly Mulvenon, Jenna Haskins

Study Report Name: 2014-2015 Direct-to-Consumer Impact and Process Evaluation

Report Date: August, 2017

Evaluation Analyst: Jim Perich-Anderson

Date of ERR: September 22nd, 2017

Overview:

This report presents the results of the impact and process evaluation of Puget Sound Energy's 2014 and 2015 Direct-to-Consumer (DtC) Residential programs. While this evaluation primarily focused on how the programs performed in these two program year (2014 and 2015), the evaluation team has attempted to call out wherever possible updates and improvements to the programs in 2016 and 2017 and have structured the process evaluation to be a forward looking assessment. The DtC programs included in this evaluation are the following: Residential Lighting, Residential Showerheads (including ShowerStart measures), Appliance Decommissioning (Refrigerators and Freezers), Appliance Replacement (Refrigerators and Clothes Washers), and Appliance Rebates (Advanced Power Strips, Clothes Washers, Refrigerators and Freezers).

The primary objectives of this evaluation were to:

1. Verify PSE's 2014 and 2015 reported savings based on program tracking data and the deemed Unit Energy Savings (UES) estimates as defined in the 2014 and 2015 Business Cases (Stage 1).
2. Estimate ex-post program savings and determine the percentage of the deemed savings that were realized to inform future savings estimates (Stage 2).
3. Examine program processes, compare them to best practices, and identify opportunities for future program improvement.
4. Review and benchmark 2014, 2015, and 2016 measure costs to identify measures that may be in need of measure cost updates.

Key Findings, Recommendations and Program Responses:

Residential Lighting Rebate Program
The evaluation team provides the following findings and recommendations for PSE's Residential Lighting Rebate Program.
Finding L1: The tracking data review completed for PSE's Residential Lighting program found that the tracking data files were missing several key measure variables needed to accurately characterize program sales and accurately calculate savings. These missing variables included: measure wattage, lumen output, baseline wattage equivalent, bulb description (such as reflector type, specialty bulb type, and fixture type), and retailer where the program measure was sold.

<table>
<tr><td>Recommendation L1: PSE has reported that it has begun working with program vendors to ensure these variables are included in the program tracking data going forward. The evaluation team recommends PSE audit these changes to ensure they are consistently reported for all measures sold through the program.</td><td>PSE Response: PSE's program vendors now include the new measure variables (wattage, lumens per watt, bulb description, and retailer) in their sales data submissions to PSE. PSE has begun work to upload these additional data fields into DSMc, the system for tracking incentives and energy savings.</td></tr>
<tr><td colspan="2">Finding L2: An issue was identified in the assignment of the 2015 deemed UES for Indoor LED fixtures and LED Retrofit Kits. Both measures were mistakenly assigned the 2014 UES value rather than the 2015 value. This resulted in measure level realization rates of 90% and 99% respectively.</td></tr>
<tr><td>Recommendation L2: The evaluation team recommends that PSE review its QA/QC steps to ensure there is an audit step in place to confirm the deemed UES estimates have been assigned correctly.</td><td>PSE Response: PSE has moved to a new system for tracking incentives and energy savings, DSMc. This new system includes a new QA/QC process for confirming that deemed UES estimates have been assigned correctly.</td></tr>
<tr><td colspan="2">Finding L3: During Stage 2 of this evaluation a number of parameters in the lighting UES algorithm were updated using program sales data and data collected from program participants in order to estimate ex-post savings.</td></tr>
<tr><td>Recommendation L3: The evaluation team recommends that PSE review each of these parameter updates, in light of additional changes that have occurred to the savings algorithms since 2015, to determine if updates to the deemed parameters are warranted.</td><td>PSE Response: In Q4 2016 PSE worked with a third party vendor to review and update the deemed savings values. Our current savings values and measure life are a well-researched and documented blend of the RTF methodology, PSE’s sales data, and NEEA shelf studies.</td></tr>
<tr><td colspan="2">Finding L4: The level of trade ally satisfaction with PSE’s residential lighting program is very high. PSE’s programs were described as “one of the strongest programs in the US” and “one of the easiest programs to work with, C+C has been very communicative, flexible, understanding and easy to work with.” Lighting manufacturers rated the program a 9.3 out of ten and lighting retailers rated the program an 8.5.</td></tr>
<tr><td>Recommendation L4: Lighting retailers and manufactures were asked to provide recommendations for improvements to the programs and responses included:

1) Co-marketing with Manufacturers – team up for in-store or field events</td><td>PSE Response: PSE's successful Upgrades Campaign features partnerships with lighting manufacturers and co-branded advertising. The most recent 2016-2017 Upgrades Campaign was offered to all lighting partners each year. In 2016 four lighting manufacturers and five retailers participated in the Upgrades Campaign. In 2017 four lighting partners and six retailers participated in the Upgrades Campaign. 2016 and 2017 campaign activities included in-store and field events as well as co-branded advertising.</td></tr>
</table>

2) Communications – increase frequency, decrease response time to questions, quarterly in-person meetings	**PSE Response:** PSE increased the frequency of communications with partners in 2016 and 2017. In person meetings were scheduled for Light Fair and the Energy Star Partners meetings each year. Weekly phone conference meetings were scheduled with Upgrades Campaign partners to ensure that campaign deliverables and milestones were on track. Changes to PSE's lighting policy, incentive levels, and eligible measures were communicated to all partners via email, and larger partners also received a personal phone call from the PSE Program Manager informing them of the updates. The PSE Program Management, including PSE's retail field services and MOU administrator vendor, responds promptly to emails and inquiries from lighting partners.
3) Program marketing – advertise in the store magazine, offering limited-time pricing promotions, parking lot events	**PSE Response:** PSE's successful Upgrades Campaign includes co-branded advertising. In 2016 and 2017 limited time offers were advertised in a variety of mediums including email, web banners, digital video, radio, cinema, direct mail, social media, web, bill inserts, and transit. The 2016 and 2017 Upgrades Campaign also included in-store and field events.
4) Training – increase in-person training opportunities	**PSE Response:** In 2017 PSE Program Management and PSE's retail field services and MOU administrator vendor developed a lighting guide to be utilized for customer and sales associate training on energy efficient lighting. The lighting guide was introduced in retail locations in Q3 2017. PSE's retail field services and MOU administrator vendor conducts sales associate training throughout the year. Additionally, PSE Program Management and PSE's retail field services and MOU administrator vendor are piloting a new high impact event in Q4 2017 that will focus on customer and sales associate energy efficient lighting education. The high impact events are planned to be fully launched in 2018.
5) New products – smart and connected lighting	**PSE Response:** PSE has offered rebates on qualifying smart and connecting LED lighting measures since 2016. PSE has also added several new measures in 2016 and 2017 such as T8 fixtures, T8 retrofit, LED string lights, and value LEDs.
6) Incentives – larger and faster turnaround	**PSE Response:** Incentive amounts have decreased over time because LED retail prices have also decreased. PSE Program Management continually monitors the lighting market to determine appropriate incentive amounts that encourage adoption of energy efficient lighting and responsibly utilize rate payer dollars. PSE's rebate processing vendor turns around lighting partners' point of sales data submissions as quickly as possible, while still confirming the accuracy of the sales data and incentive payments. This careful review is necessary in order to responsibly utilize rate payer dollars.

APS Rebate Program	
The evaluation team provides the following findings and recommendations for PSE's Advanced Power Strip Rebate Program.	
Finding APS1: PSE sells rebated Tier 2 APS units through their ShopPSE website, but has not been able to expand the program delivery to retail stores as retailers are currently carrying them. In 2016, PSE started to sell these units through their Pop-up Retail channel. At this point in time, consumers are unlikely to demand this product primarily due to very limited product awareness (72% of general population respondents reported they were not at all familiar or unsure about Tier 2 APS). Additionally, even APS purchasers who are aware of the technology, are in need of additional education on where to use them and how to appropriately install and program the units to maximize energy savings and satisfaction with the units.	
Recommendation APS1: Currently it is unclear how PSE customers will learn about these units, be educated on how to properly install them, and ultimately increase their demand for this product. If PSE decides to scale this effort, the theory behind this component should be explored further.	**PSE Response:** This evaluation focuses on the APS measures deployed through a customer-install (vs. direct or coached install) delivery during the 2014-2015 impact evaluation period. APS program is being revised based on feedback from the Itron Evaluation. PSE is currently considering removing the measure from ShopPSE and focusing on the Multifamily program with coached installs when possible to increase customer awareness of and satisfaction of their installed APS unit.
Finding APS2: The data used to estimate the 2014/2015 deemed UES was collected from a small sample of homes that are likely not representative (with respect to viewing habits and connected loads) of PSE's participant population. Additionally, the relative precision on this estimate is more than 20% which is significantly higher than what is typically acceptable in the industry.	
Recommendation APS2: If PSE plans to continue rebating this measure they should further discussions with the RTF and regional parties to co-sponsor a primary research study aimed at reliably quantifying the UES resulting from the installation and use of residential Tier 2 Advanced Power Strips.	**PSE Response:** PSE will take this recommendation into account and redesigning the program.
Finding APS3: Satisfaction with Tier 2 APS units is significantly lower (61%) than participant satisfaction with other DtC appliance measures (82%). The primary reasons reported for dissatisfaction with the APS was that it didn't work with their AV equipment, that it was difficult or inconvenient to use, and that the directions for set-up were unclear and complicated.	

Recommendation APS3: Customer awareness and satisfaction with Tier 2 APS are going to continue to be the primary barriers this program faces until these products become more widely available and accepted in the market place. PSE has expressed interest in marketing Tier 2 APS units to specific user "types" (i.e. gamers, cable viewers, etc.), however without additional research to understand how the devices operate for these customer "types" (i.e. do gamers encounter any issues with the unit that other customers do not) and a metering study to determine the impacts for these populations, this type of targeting may not produce the desired outcomes. Evaluation research did find these devices are utilized more frequently by "early adopters" and so PSE could work with their marketing group to see what segmentation data is available to identify and target this population to see if it gives them more traction in the market.	**PSE Response:** At this point PSE is considering an APS pilot in Multifamily direct install program. Data collected from the potential pilot delivery mechanism will be used to assess user satisfaction, usability and savings for this sector. Newer generation APS devices that provide installation verification capabilities and plug load monitoring will be explored.
Finding APS4: With Tier 2 APS devices being a newer energy savings technology in the market place there are a number of areas where collecting additional data via one of the current touchpoints PSE has with its customers (such as the post-participation market research surveys) could increase their understanding of the program's operation, customer satisfaction and understanding, and the resulting measure impacts.	
Recommendation: The evaluation team recommends expanding the data collected from APS participants during one of these touchpoints to explore: 1) APS installation and removal – this data could be used to annually update installation rates used to calculate program impacts and would allow PSE to better understand the barriers customers face to APS installation and usage. 2) Connected Devices - plug loads that are currently being controlled by the rebated APS units.	**PSE Response:** See previous response for APS3.

APPLIANCE DECOMMISSIONING
The evaluation team provides the following findings and recommendations for PSE's Appliance Decommissioning Program.

<table>
<tr><td colspan="2">Finding AD1: In 2011, the RTF conducted an examination of the differences between the using the existing RTF methodology and the methodology recommended within Uniform Methods Product (UMP) to estimate the UEC of recycled refrigerators and freezers. The recommendation based on this comparison was to implement the UMP method as it was more robust and represented industry standard practices, however a last-minute decision was made to stick with the existing methodology for the time being as the “the difference in savings is miniscule” and the UES was due to be updated in a year. This update should have occurred in July 2014 (making it too late for PSE’s 2014 and 2015 program planning and UES deeming), early enough to go into place for the 2016 program year. The evaluation team reviewed the 2016 UES and found it is the same as the 2015 UES and thus the methodology still has not transition to the UMP recommended methodology.</td></tr>
<tr><td>Recommendation AD1: PSE should research why the RTF has not transitioned the UES algorithm for appliance recycling programs to use the UMP methodology for estimating the UEC of a recycled unit. The UMP methodology is the preferred methodology as it is more accurate as it utilizes actual program tracking data to estimate the UEC of the units recycled through the program.</td><td>PSE Response: PSE reached out the RTF as to why the UMP methodology was not implemented. The RTF's response is that they feel although the RTF Logic map may not look the same, the factors do align with the UMP methodology. The RTF Logic map and UMP arrangement calculate similar savings values for the measure, with only approximately 1.5 kWh difference. For this reason, the RTF continues with the use of the logic map when calculating measure savings.</td></tr>
<tr><td colspan="2">Finding AD2: The participant survey conducted through this evaluation found that the part-use factor and the disposition of the decommissioned units in the absence of the program (90% for refrigerators and 86% for freezers) were slightly different from the estimates used in the RTF deemed calculation (91% for refrigerators and freezers).</td></tr>
<tr><td>Recommendation AD2: Consider creating a PSE deemed UES for the Appliance Decommissioning Program that utilizes PSE-specific part-use factors and decommissioned unit dispositions for future program years. These parameters could come from evaluation based research or could be estimated from questions on the Decommissioning market research surveys that are emailed to all program participants soon after their participation in the program.</td><td>PSE Response: PSE has provided the findings of the Itron Evaluation with the RTF. The RTF plans to utilize information from the report in the next revision of the savings calculations for the measure.</td></tr>
<tr><td colspan="2">Finding AD3: The evaluation team found that the 2015 tracking data for the Appliance Decommissioning Program were fairly comprehensive, however did not contain all variables needed to evaluate the program using the recommended methods outlined in the Uniform Method Project (UMP) protocols. Many of these missing variables were being collected by the program implementers but were not being retained in the tracking database.</td></tr>
<tr><td>Recommendation AD3: The evaluation team recommends that the following variables be added to the tracking database regarding the unit recycled: door configuration, size, age, installation location, and house type.   Also, retaining the account number and email address for all participants would allow for web-based follow up with customers as well as a better assessment of cross-program participation.</td><td>PSE Response: PSE's program vendor now includes the new measure variables (door configuration, size, age, installation location, house type, and email) in their reporting data submissions to PSE. PSE has begun work to upload these additional data fields into DSMc, the system for tracking incentives and energy savings.</td></tr>
<tr><td colspan="2">Finding AD4: The evaluation team identified a problem with mismatched email addresses in the tracking database (i.e. some of the email addresses seem to be appended to the wrong records in the database).</td></tr>
</table>

Recommendation AD4: The evaluation team recommends that PSE review the process of entering email addresses into the tracking database. This will help identify how this problem occurred and what can be done to ensure that it doesn't happen in future program years.	**PSE Response:** Previously customer contact emails were tracked separately from reporting by the Appliance Decommissioning vendor. As part of PSE's new customer information system upgrade, a new reporting template was created for vendors that track customer account and contact information in the same location.
Finding AD4: Awareness of ShopPSE was low (37-41%) amongst Appliance Decommissioning participants.	
Recommendation AD4: The evaluation team recommends that PSE consider expanding the marketing of this online channel within the Leave Behind kit materials.	**PSE Response:** PSE will take the recommendation into consideration when designing the program for 2018-19.

APPLIANCE REPLACEMENT PROGRAM	
The evaluation team provides the following findings and recommendations for PSE's Appliance Replacement Program.	
Finding AR1: The evaluation team found that the 2015 tracking data for the Clothes Washer Replacement Program were fairly comprehensive, however adding some additional variables to the database would improve the ease and accuracy of evaluation efforts. Some of the parameters used in the UES algorithm can be estimated based on the characteristics of the replacement units offered. Make and model lookups of the four units offered in 2015, provided the evaluation team with the average MEF, capacity, and Rated UEC of the actual 2015 replacement units, which were then used to calculate the UES of a replacement clothes washer.	
Recommendation AR1: Add the following variables to the tracking database regarding the clothes washer being recycled: age, door configuration, and size in cubic feet; as well as details on the new replacement unit: door configuration, capacity in cubic feet, installation location, MEF, water factor, and Rated UEC; and house type. If the replacement units being offered for the upcoming program year are known by September 1, the UES can be updated based on an expected distribution of the actual replacement units. If the units are not known by this time, the previous year's units could be used as a proxy for the deemed estimate for the subsequent program year.	**PSE Response:** PSE's program vendor now includes the new measure variables (door configuration, size, age, installation location, house type, and email) in their reporting data submissions to PSE. PSE began work in 2017 to upload the additional data fields into DSMc, the system for tracking incentives and energy savings.
Finding AR2: The evaluation team found that some of the Leave Behind kits included in the tracking data could not be merged to a clothes washer replacement record by account number, name or address. Conversely, some of the Clothes Washer Replacement participants did not have a corresponding Leave Behind kit in the tracking data. The kit participants who did not have an associated clothes washer likely may have not qualified for the Appliance Replacement program, however there are still additional Clothes Washer Replacement participants who did not appear to receive a kit based on the tracking data received.	

Recommendation AR2: Making sure each record has a valid PSE account number and email address would facilitate follow up with program participants and allow for a better assessment of cross-program participation. PSE should also consider creating a variable to contain the reason that a kit record does not have a corresponding clothes washer measure where applicable (i.e. didn't qualify for program, customer refused the kits, etc.). This information could also be helpful to the post-participation surveys implemented by PSE's market research group.	**PSE Response:** Leave Behind kits are distributed to any customer that participates in the Appliance Replacement program, regardless if it is later found that the customer is not eligible to participate. This would account for Leave Behind kit customers that did not have a corresponding Clothes Washer measure. The Clothes Washer Appliance Replacement program will end in 2017. Moving forward, PSE will take Itron's recommendations for kits and apply them to other programs with similar models that are continuing in 2018-19.
Finding AR3: The initial Appliance Replacement file PSE provided to the evaluation team did not include a complete list of 2015 participants. PSE provided a second file with the missing participants; however this second file included different variables than the original file.	
Recommendation AR3: The evaluation team recommends that PSE review the process of collecting and exporting measure level data for this program to determine what caused missing records in the first file and why the layouts/variables between the two files differed.	**PSE Response:** PSE will take suggestions from Itron and apply them to programs with similar attributes that are continuing in 2018-19. PSE's new customer information system upgrade, reporting templates, and reporting procedure will also aid to mitigate the issue of variances and missing data in program reporting.

APPLIANCE REBATE PROGRAM FINDINGS	
The evaluation team provides the following findings and recommendations for PSE's Appliance Rebate Programs (clothes washer, refrigerator, and freezer).	
Finding REB1: As indicated in the process evaluation section, several variables were missing from the appliance rebate tracking data files that would improve the ease and accuracy of evaluation and program planning efforts. Additionally, some Thank You kits included in the tracking data did not appear to be associated with an appliance rebate participant.	
Recommendation REB1: The evaluation team recommends adding the following variables to the appliance rebate tracking databases: 1) Clothes Washer Rebates: door configuration (top vs. front-loader), capacity of the unit in cubic feet, dryer and water heater fuel type. 2) Refrigerator and Freezer Rebates: house type, door configuration, capacity in cubic feet, and freezer defrost type. 3) Retaining account numbers and email addresses for all participants would aid in follow up with customers (including market research post-participation surveys) and would allow a better assessment of cross-program participation.	**PSE Response:** PSE's program rebate processing vendor now includes the new measure variables (door configuration, size, age, installation location, house type, and email) in their reporting data submissions to PSE. PSE began work in 2017 to upload the additional data fields into DSMc, the system for tracking incentives and energy savings.
Finding REB2: There were 48 units in the tracking data that appeared to be duplicates. These units were reviewed by PSE and vendor staff and were found to be a mix of duplicates and valid records. These records account for less than 0.5% of the appliance units rebated in 2015 and thus no adjustment was made to program saving. According to the program vendor, the issue that led to these duplicate records has been identified and corrected.	

Recommendation REB2: PSE should insure their QA/QC processes are correctly checking to ensure duplicate records are not present in the program tracking data.	**PSE Response:** PSE has followed up with vendor and vendor has implemented new QC/QA to ensure the error does not reoccur. PSE has been monitoring vendor to ensure resolved.
Finding REB3: During the ex-post evaluation an updated version of the CEC Database was used to estimate two of the ex-post UES parameters (the annual gallons of water used for washing and the moisture content remaining in clothes) as the version used for the deemed estimates was a bit outdated at the time the measure savings were deemed. Both of these parameters decreased with CEC database update and led to an increase in measure level savings.	
Recommendation REB3: Whenever possible, the evaluation team recommends updating the clothes washer UES parameters annually based on the most current version of the CEC database available.	**PSE Response:** PSE constantly monitors and reviews values adopted by the RTF and adjusts UES accordingly.

RESIDENTIAL SHOWERHEAD PROGRAM	
The evaluation team provides the following findings and recommendations for PSE's Residential Showerhead Program.	
Finding S1: During Stage 2 of this evaluation a number of parameters in the showerhead UES algorithm were updated using program sales data, data collected from program participants, and secondary research of recent showerhead measurement studies in order to estimate ex-post savings.	
Recommendation S1: The evaluation team recommends that PSE review each of these parameter updates presented in this chapter, in light of additional changes that have occurred to the savings algorithms since 2015, to determine if updates to the deemed parameters are warranted in the future.	**PSE Response:** PSE constantly monitors and reviews values adopted by the RTF. The RTF has updated savings for showerhead measures twice since the 2014-2015 program year. PSE has adjusted the UES values accordingly for the program.
Finding S2: There was much inconsistency across the UES algorithm used to estimate showerhead savings for the showerhead only measures, the ShowerStart measures, and the kit measures.	
Recommendation S2: The ex-post impact analysis made numerous changes to the deemed UES algorithms to align them and provide a consistent foundation for various showerhead measures. The evaluation team recommends that PSE review these alignments and consider adopting them for future program years to ensure a clear and consistent foundation for calculating program savings.	**PSE Response:** RTF values were not available when PSE created the ShowerStart measure in 2014-15. Several studies were utilized to calculate savings for the measure. In 2016, PSE adopted the RTF values for the measure. PSE monitors and reviews values adopted by the RTF for all the measures across all showerhead measures to ensure clear and consistent foundation for calculating program savings.

<table>
<tr><td colspan="2">Finding S3: The level of trade ally satisfaction with PSE’s residential showerhead programs is very high. PSE’s programs were described as “one of the strongest programs in the US” and “one of the easiest programs to work with, C+C has been very communicative, flexible, understanding and easy to work with.” Showerhead manufacturers rated the program a 9.8 out of ten.</td></tr>
<tr><td>Recommendation S3: Showerhead retailers and manufactures were asked to provide recommendations for improvements to the programs and responses included:

1) Increase customer awareness through direct mail, bill stuffers, end cap promotions, social media outlets, branding on packaging

2) Co-marketing with Manufacturers – team up for in-store or field events, in-store marketing

3) Communications – increased communication regarding new products and how products are being marketed at retailers.</td><td>PSE Response: PSE appreciates the feedback from our partners. We are continually looking for ways to improve our programs and will take the suggestions into consideration. The findings point to some communication gaps with manufacturers that PSE will address as many of the methods suggested, such as but not limited to end cap promotions, social media outlets and co-marketing, are already in place and used to promote the program.</td></tr>
</table>

Program(s):

- Industrial Systems Optimization Program

Program Year(s):

- 2012-2015

Contents:

- Evaluation Report
- PSE Evaluation Report Response

This document contains DNV GL's Industrial Systems Optimization Program (ISOP) Evaluation Report, and Puget Sound Energy's Evaluation Report Response (ERR). In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

PSE program managers and evaluation staff prepare an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Please note that this is an evaluation of the program as it operated during the 2012-2015 program years, and does not necessarily reflect the program as currently implemented, or measures currently deployed by the program.

This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx**

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[1] (6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for 2016-2017 PSE Electric Conservation.

[2] PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised August 6, 2015.

[3] Ibid.

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Evaluation Report Response

Program:	Industrial Systems Optimization Program Evaluation
Program Manager(s):	Dave Montgomery, Chao Chen
Study Report Name:	Industrial Systems Optimization Program (ISOP) Evaluation Report
Primary Author(s):	DNV GL
Report Date:	July 2017
Evaluation Analyst(s):	Michael Noreika
Date of ERR:	September 2017

Evaluation Overview, Key Findings, Recommendations and Program Responses:

A. Overview

This evaluation report documents the results of the impact and process evaluations of the PSE 2012-2015 Industrial Systems Optimization Program (ISOP). DNV GL was selected to conduct an integrated impact and process evaluation of the program. Through ISOP, participating PSE electric industrial customers receive financial and technical assistance to help them to identify and implement low-cost or no-cost operations and maintenance (O&M) improvements and procedural adjustments. The program focuses on energy intensive systems such as refrigeration, compressed air, pumping, fans, and blowers. This report is the first evaluation of this program and covers the 2012-13 and 2014-15 program periods.

Objectives of the Evaluation

The primary goals of this evaluation are to independently verify energy savings and to identify recommendations for program improvement. Specific objectives of the impact evaluation are reporting realization rates for the evaluated energy savings, evaluating measure life and risks to the persistence of savings. For the process evaluation, objectives include identifying best practices, reviewing the rebate structure, and exploring trends in measures, savings, and program performance.

B. Key Findings

Program delivery

- **Energy savings at lower-cost:** PSE staff targeted delivering program energy savings at a maximum of $0.13 per annual kWh; however, ISOP performed better than the target with savings delivered at $0.10 per annual kWh.
- **Meets best practices:** Overall, the program meets and in some areas, exceed best practices for program delivery and measurement and verification;
  - **Well executed:** In terms of delivery, all parties clearly understand their roles and responsibilities. They execute program processes consistently and project documentation and program tracking data are detailed and complete.
  - **Excellent documentation:** Project and program documentation are detailed and comprehensive. Project folders contained complete information on baseline usage estimates, recommended action items, estimated savings and the savings estimation approach. Program implementation tracking workbooks include substantial detail that facilitated a thorough evaluation.
- **Satisfied participants:** According to the survey, program participants are very satisfied with many aspects of the program and with the interactions with the program staff.
- **Program influence.** The program is generating increased participation in other PSE programs. Participants state (via the survey) that their experience with the ISOP program influenced their decision to try other PSE programs as they implement other capital projects.

Program impacts

Overall, the ISOP program appears quite successful and has achieved nearly 90% of ex ante savings. Key findings regarding program impacts follow:

- **Substantial savings**: The program achieved significant savings while focusing only on O&M activities. The evaluation verified 18.2 GWh of energy savings, representing an average of 8 percent reduction of electricity consumption from the baseline of ISOP participants. These savings were achieved with a realization rate of 89 percent compared to the ex-ante savings, as shown in Table 1.

Table 1. Verified electricity savings

Program measure group	Sample n	Population N	Total ex-ante Savings (kWh)	Total ex-post Savings (kWh)	Realization Rate	Relative Precision at 90% Confidence
Refrigeration	17	29	17,601,885	15,369,129	87%	5.0%
Pumps, Fans, Blowers	5	6	2,514,062	2,363,924	94%	3.6%
Compressed Air	2	5	313,765	370,807	118%	14.7%
Other (primarily HVAC)	1	1	80,600	80,600	100%	0.0%
Overall	**25**	**41**	**20,510,312**	**18,184,459**	**89%**	**4.2%**

- **Evidence of persistence** Almost all action items continue to persist across all categories, including behavior/maintenance, settings (set-point and schedule adjustments), and hardware (purchased items). The evaluation found that 97 percent of the action items completed at time of measurement and verification (M&V), were still in place at the time of the evaluation site visits. Although the evaluation occurred less than five years after the performance period (between 6 months and 30 months), 9 percent more action items were completed since the conclusion of the program M&V and payment of the incentive. These observations, as well as the literature review suggest that five years is a reasonable measure life.
- **Highest savings for refrigeration projects:** Refrigeration measures drive overall program results with 71 percent of projects and 85 percent of program savings. The success for this measure is due largely to targeting customers with large refrigeration loads with opportunities for substantial savings and to the program implementer's specific and deep expertise in this area.

C. Evaluation Recommendations and Program Responses

While overall, the program is meeting and exceeding targets, the team offers the following recommendations to improve savings calculation accuracy:

1. Reform calculation methods.

The team recommends the program select model variables and relationships that are consistent with the energy consumption of the operations and to avoid use of calculated variables unless there is a demonstrable reason why the variable drives energy consumption. While the overall realization rate was high, the team found that site-level realization rates varied considerably. This variability could be due to incorrectly estimating savings based on factors with a high correlation to usage for the performance period even though those factors were not drivers of energy consumption.

- **PSE Response:**

  The third-party implementer develops the energy consumption model using the best available data for each project. All models are validated for statistical validity by the third party and PSE staff. Beginning immediately upon receiving the evaluation report recommendation, PSE set additional requirements for the third-party implementer to thoroughly document all variables and assumptions as well as detailed explanations for the final included and excluded variables. Additionally, PSE evaluation staff has been utilized to review energy models prior to project completion.

2. **Extend the minimum performance period.**

   The current 60-day minimum is very brief and the evaluation team believes that this brevity reduces the accuracy of the savings estimates. The evaluation team recommends a period of 90 days for facilities with consistent plant loads with even longer periods for inconsistent or seasonal plant loads. The length of the periods sufficient to capture seasonality should be assessed on a case-by-case basis for facilities considering the site-specific seasonal loads. The goal of the longer periods is to capture a more representative of the annual range of conditions, thereby improving savings accuracy.

- **PSE Response:**

  PSE acknowledges this recommendation. However, both the mean and the median overall length of project engagement times are over 60 days. While an additional 30 days or more of M&V could improve the accuracy of the savings estimates, the additional time could also unduly burden the program participants by extending the overall project engagement time. At this time, PSE does not agree with the recommendation because of the potential negative effects of a longer engagement time. PSE will consider extending the M&V period for projects with statistically unpredictable energy consumption on a case-by-case basis.

INDUSTRIAL SYSTEMS OPTIMIZATION PROGRAM EVALUATION

Evaluation Report

Puget Sound Energy

Date: June 13, 2017

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1 EXECUTIVE SUMMARY

DNV GL was selected to conduct an integrated impact and process evaluation of Puget Sound Energy's (PSE's) Industrial Systems Optimization Program (ISOP). Through ISOP, participating PSE electric industrial customers receive financial and technical assistance to help them to identify and implement low-cost or no-cost operations and maintenance (O&M) improvements and procedural adjustments. The program focuses on energy intensive systems such as refrigeration, compressed air, pumping, fans, and blowers. This report is the first evaluation of this program and covers the 2012-13 and 2014-15 program periods.

1.1 Objectives

The primary goals of this evaluation are to independently verify energy savings and to identify recommendations for program improvement. Specific objectives of the impact evaluation are reporting realization rates for the evaluated energy savings, evaluating measure life and risks to the persistence of savings. For the process evaluation, objectives include identifying best practices, reviewing the rebate structure, and exploring trends in measures, savings, and program performance.

1.2 Key findings

1.2.1 Program delivery

- **Energy savings at lower-cost:** PSE staff targeted delivering program energy savings at a maximum of $0.13 per annual kWh; however, ISOP performed better than the target with savings delivered at $0.10 per annual kWh.
- **Meets best practices:** Overall, the program meets and in some areas, exceed best practices for program delivery and measurement and verification;
  - **Well executed:** In terms of delivery, all parties clearly understand their roles and responsibilities. They execute program processes consistently and project documentation and program tracking data are detailed and complete.
  - **Excellent documentation:** Project and program documentation are detailed and comprehensive. Project folders contained complete information on baseline usage estimates, recommended action items, estimated savings and the savings estimation approach. Program implementation tracking workbooks include substantial detail that facilitated a thorough evaluation.
- **Satisfied participants:** According to the survey, program participants are very satisfied with many aspects of the program and with the interactions with the program staff.
- **Program influence.** The program is generating increased participation in other PSE programs. Participants state (via the survey) that their experience with the ISOP program influenced their decision to try other PSE programs as they implement other capital projects.

1.2.2 Program impacts

Overall, the ISOP program appears quite successful and has achieved nearly 90% of ex ante savings. Key findings regarding program impacts follow:

- **Substantial savings**: The program achieved significant savings while focusing only on O&M activities. The evaluation verified 18.2 GWh of energy savings, representing an average of 8 percent reduction of electricity consumption from the baseline of ISOP participants. These savings were achieved with a realization rate of 89 percent compared to the ex-ante savings, as shown in Table 1.

Table 1. Verified electricity savings

Program measure group	Sample n	Population N	Total ex-ante Savings (kWh)	Total ex-post Savings (kWh)	Realization Rate	Relative Precision at 90% Confidence
Refrigeration	17	29	17,601,885	15,369,129	87%	5.0%
Pumps, Fans, Blowers	5	6	2,514,062	2,363,924	94%	3.6%
Compressed Air	2	5	313,765	370,807	118%	14.7%
Other (primarily HVAC)	1	1	80,600	80,600	100%	0.0%
Overall	**25**	**41**	**20,510,312**	**18,184,459**	**89%**	**4.2%**

- **Evidence of persistence** Almost all action items continue to persist across all categories, including behavior/maintenance, settings (set-point and schedule adjustments), and hardware (purchased items). The evaluation found that 97 percent of the action items completed at time of measurement and verification (M&V), were still in place at the time of the evaluation site visits. Although the evaluation occurred less than five years after the performance period (between 6 months and 30 months), 9 percent more action items were completed since the conclusion of the program M&V and payment of the incentive. These observations, as well as the literature review suggest that five years is a reasonable measure life.
- **Highest savings for refrigeration projects:** Refrigeration measures drive overall program results with 71 percent of projects and 85 percent of program savings. The success for this measure is due largely to targeting customers with large refrigeration loads with opportunities for substantial savings and to the program implementer’s specific and deep expertise in this area.

1.3 Recommendations for adaptive management

While overall, the program is meeting and exceeding targets, the team offers the following recommendations to improve savings calculation accuracy:

- **Reform calculation methods.** The team recommends the program select model variables and relationships that are consistent with the energy consumption of the operations and to avoid use of calculated variables unless there is a demonstrable reason why the variable drives energy consumption. While the overall realization rate was high, the team found that site-level realization rates varied considerably. This variability could be due to incorrectly estimating savings based on factors with a high correlation to usage for the performance period even though those factors were not drivers of energy consumption.
- **Extend the minimum performance period.** The current 60-day minimum is very brief and the evaluation team believes that this brevity reduces the accuracy of the savings estimates. The evaluation team recommends a period of 90 days for facilities with consistent plant loads with even longer periods for inconsistent or seasonal plant loads. The length of the periods sufficient to capture seasonality should be assessed on a case-by-case basis for facilities considering the site-specific seasonal loads. The goal of the longer periods is to capture a more representative of the annual range of conditions, thereby improving savings accuracy.

1.4 Suggestions for consideration

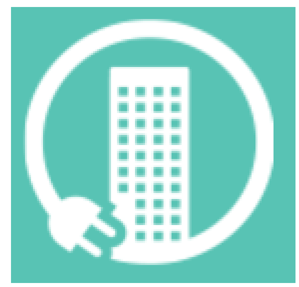
In addition to the above recommendations, the research team offers the following for PSE's consideration for prospective program delivery.

- **Expand the program to address a wider range of industries within PSE's service territory.** The program has addressed cold storage and food processing, but not many other sectors. The program can bring in deep expertise in a wider range of industrial systems to increase savings and provide ISOP services to a broader range of PSE industrial customers. PSE can achieve this by identifying and contracting with industry specific experts for specific sites.
- **Incorporate action items that facilitate ongoing maintenance practices to increase savings retention.** Maintaining maintenance practices and optimal settings can be challenging, especially when routines are not established or personnel change. The research team identified multiple approaches used by similar programs to address this risk, such as; training facility personnel, requiring new practices are added to the facility SOP or similar document, continuous monitoring, and delaying incentives.
- **Offer higher incentives for completing implementation steps within a specified timeframe.** Two of the comparison programs were successful in using financial incentives to accelerate project completion. The program could use this approach to accelerate the customer commitments to an optimization event and to accelerate implementation. Providing incentives for rapid commitment to an optimization event may also reduce the number of scoping studies needed to meet program goals.

2 INTRODUCTION

Puget Sound Energy (PSE) engaged DNV GL to perform an impact and process evaluation of its Industrial Systems Optimization Program (ISOP). DNV GL conducted the impact evaluation and DNV GL's subcontractor, Btan Consulting, conducted the process evaluation. For the purpose of this study, DNV GL and Btan are referred to as the research team. The evaluation covers program activities from the first two program cycles, 2012-13 and 2014-15. The overall goals of the evaluation are to provide independent, verified ex-post energy savings (kWh) and to identify recommendations for program improvement.

2.1 Program description



PSE offers ISOP to targeted electric industrial customers to identify and implement low-cost energy saving operation and maintenance (O&M) actions. The program focuses on energy intensive systems such as refrigeration, compressed air, pumping, fans and blowers, and also offers performance tracking systems. Cascade Energy is the program implementer for PSE, managing most aspects of the program, from participant recruitment to incentive payment. The program offers both technical assistance and financial incentives to participants who implement recommended action items.

The program has three key implementation phases: scoping, optimization, and verification. Program engineers review potential customers' energy usage history and conduct a scoping study to determine if the facility has sufficient potential savings for participation. Customers who meet requirements and agree to program participation have a one to three-day optimization event, during which program and facility staff identify "action items" for improving energy efficiency. Action items include changes to settings and maintenance practices, as well low-cost measures (e.g., sensors and controls) to facilitate operational efficiency.[1] Action items that can be completed immediately are implemented during the optimization event.

Participants have 120 days from the optimization event to complete the remaining action items. Cascade Energy verifies installation and estimates kWh savings based on a minimum of 60 days of post installation usage. The facility receives incentives of $0.05 per kWh saved per the estimates.[2]

The program completed 41 projects during the first two program cycles. It exceeded savings goals by 20 percent with expenditures of only 79 percent of budgeted, shown in Table 2. This is impressive given that some program start-up costs are included in these expenditures. Costs per kWh are lower than the $0.13 PSE planning estimate for resource acquisition. Program ex-post savings were 89 percent of ex-ante savings (Table 3).

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[1] Any action item with an implementation cost of greater than $5,000 must be approved.

[2] Section 3.2 includes a more detailed program description.

Table 2. Program goals and achievements as evaluated

	ISOP 2012-15	
	Costs[1]	Ex-post Savings
Planned	$2,305,000	15,000,000 kWh
Spent/Achieved	$1, 813,635	18,341,504 kWh
Spent/Achieved as % of Planned	79%	122%
Resource Acquisition Cost per kWh		$0.10

1 Planned and spent cost, and kWh savings goals are based on Cascade Energy's tracking sheets.

Program ex-post savings were 89 percent of ex-ante savings (Table 3).

Table 3. Program savings and realization rate

Completed Projects	Ex-ante Savings	Ex-post Savings	Overall Realization Rate
41	20,510,312 kWh	18,341,504 kWh	89.4%

The program implementer assigned each project to one of four program measure groups, 1) refrigeration, 2) compressed air, 3) pumps, fans and blowers, or 4) other, based on the primary system targeted for energy saving action items. The program also identified action items for other systems besides the primary system. Refrigeration was the dominant measure groups with roughly three-fourths of the projects. The was only one project in the "other" measure group.

2.2 Evaluation objectives

The primary impact evaluation objectives were to:

- Develop ex-post gross electrical energy savings estimates
- Report relative precision of ex-post estimates at 90 percent confidence level
- Report realization rates for the evaluated energy savings
- Evaluate PSE's current measure life of five years
- Explore risks to the persistence of savings

The process evaluation objectives were to:

- Identify best practices implementing and estimating savings
- Review the program's ex-ante measurement and verification (M&V) procedures relative to industry best practices
- Review rebate structure

- Identify and explore trends in measures, savings, and program performance
- Assess customer satisfaction, motivations to participate, barriers to implementation
- Compare expenditures and achievements to budget and goals
- Assess project timeline characteristics

2.3 Evaluation methods

The impact evaluation was designed to estimate energy savings and realization rates, and to assess measure life and persistence of savings. Information collected during project site visits (i.e., verification of action items and surveys with facility staff) were used to address all impact evaluation objectives.

The process evaluation covered multiple areas of program delivery, including; best practices in implementing and estimating savings and M&V; reviewing the rebate structure, exploring trends in measures, savings and program performance; and assessing participant perspectives. The research team conducted in-depth interviews (IDIs) with program staff, as well as reviewed program documents to inform the evaluation. The team relied on a literature review and program comparisons to address best practices, the rebate structure, and M&V practices and used an on-line survey to address participant perspectives

Both the impact and process evaluation methods are described in more detail in Appendix A.

2.4 Report organization

This report is designed to provide an understanding of the evaluation methods, results, and findings. The main text is supported by several appendices that provide detailed descriptions of the research methods and savings results, as well as data collection instruments.

Following this introductory section, this report contains:

- Section 3, findings: the results of the evaluation are presented in this section.
- Section 4, best practices: literature review and program comparison are presented.
- Section 5, conclusions and recommendations: impact and process evaluation conclusions and recommendations are provided.

The following appendices provide details of the evaluation methods and findings:

- Appendix A: Evaluation Methods
- Appendix B: Sample Design Memorandum
- Appendix C: Tracking Data Memorandum
- Appendix D: Data Collection Instruments
- Appendix E: Site Savings Memorandum
- Appendix F: Extrapolation of the Sample Results to the Population

- Appendix G: Best Practices Review

3 FINDINGS

This section discusses the analysis and detailed findings from the evaluation effort. The research team investigated 41 distinct projects; the sum total of program activities at a given site is considered a single project. The implementer assigned a program measure group to each project that identified the primary focus for O&M actions. The program implementer identified O&M action items at each site during an optimization event. The participant then had a performance period of a few months to complete the action items, prior to a review by the implementer. Evaluation of the 2012-13 and 2014-15 program was conducted in mid-2016, from six to 30 months after the program performance period ended.

3.1 Program savings

After projecting program sample savings to the population, the findings indicate program savings of more than 18 GWh of annual energy savings. Table 4 provides the program evaluated gross savings for each of the four measure groups as designated by the program implementer. The savings achieved represent a realization rate of 89 percent of ex ante forecast, which was 9 percent of baseline energy consumption. The savings are a result of action items identified and completed; the differences in savings by measure group results from the number and effectiveness of the action items completed. Appendix E provides individual results on the savings analysis of the sampled sites.

Table 4. Program evaluated savings

Program Measure Group	Sample n	Population N	Savings (kWh)	Savings (kWh)	Realization Rate
Refrigeration[1]	17	29	17,601,885	15,369,129	87%
Pumps, Fans, Blowers	5	6	2,514,062	2,363,924	94%
Compressed Air	2	5	313,765	370,807	118%
Other[2]	1	1	80,600	80,600	100%
Overall	**25**	**41**	**20,510,312**	**18,184,459**	**89%**

1 As noted in the methods discussion in Section 3.2.2, the research team was not able to evaluate savings for two sites, although action items were evaluated for these sites. Thus 17 refrigeration sites had savings estimates and 19 refrigeration sites had action item verification.

2 The program identified one facility as other, without a dominant energy system addressed by the program. Action items completed were related to HVAC, lighting, refrigeration, and plug load items.

The research team determined gross savings using the realization rates achieved based on the savings estimates for each program measure group included in the sample, as discussed in detail in Appendix F.

The research team calculated the standard error on the realization rate, which was used to determine the 90 percent confidence interval. Results are presented in Table 5.

Table 5. Ex-post savings summary

Program Measure Group	Ex-post Savings	Realization Rate	Relative Precision at 90% Confidence	Error Bound at 90% Confidence (kWh)	Error Ratio
Refrigeration	15,369,129	87%	5.0%	768,973	0.23
Pumps, Fans, and Blowers	2,363,924	94%	3.6%	86,260	0.13
Compressed air	370,807	118%	14.7%	54,573	0.21
Other	80,600	100%	0.0%	-	0.00
Overall	**18,184,459**	**89%**	**4.2%**	**775,718**	**0.21**

The overall program realization rate was driven by the refrigeration measure group realization rate, which is 87 percent. The research team found considerable variation in this program measure group, although there was one large refrigeration site with an 83 percent realization rate that accounted for much of the discrepancy for this measure group. Similarly, a 60 percent realization rate result at one pumps, fans and blowers site resulted in lower savings for this group, and the single "other" site achieved a 100 percent realization rate.

The high realization rate of 118 percent for the compressed air measure group was in large part to one site that substantially increased its operating hours since the program period, resulting in higher than expected savings. This project's savings were based on a calculation of key measures, all of which included operating hours in the calculation.

3.1.1 Tracking data review and project-specific documentation

As part of the tracking data review, the research team found that all the claimed savings in the M&V reports exactly matched with the values in the tracking database. The research team also found that the documentation provided was consistent and each project file was complete. Savings methods, savings achievements, and action items completed were provided in clear formats. The tracking data review memorandum in Appendix B provides additional detail on the data review.

The research team found that the documentation for this program was particularly strong, allowing a deeper level of analysis on the identified action items and calculation approach. Detailed information was available to assess each action item identified, and why it was completed or not.

3.1.2 Reduction in energy consumption

Overall, program savings was 8 percent of baseline energy consumption. This is a significant achievement for a mostly O&M program.[3] Table 6, shows the average percent reduction in annual energy consumption by program measure group. As shown, projects that addressed refrigeration, and pumps, fan, and blower program measure groups had higher savings versus their baseline consumption than the other measure groups. This is due to the action items addressed at these sites covering the large energy-consuming equipment for these facilities.

Table 6. Reduction in annual energy consumption

Program Measure Group	Baseline Consumption	Ex-ante Savings	Ex-post Savings	Percent Reduction in Annual Energy Consumption	
				Ex-ante percent	Ex-post percent
Refrigeration	170,653,154	17,601,885	15,506,219	10.3%	9.1%
Pumps, Fans, and Blowers	27,470,587	2,514,062	2,363,924	9.2%	8.6%
Compressed air	25,817,123	313,765	370,807	1.2%	1.4%
Other	5,579,259	80,600	80,600	1.4%	1.4%
Total	**229,520,123**	**20,510,312**	**18,321,549**	**8.9%**	**8.0%**

[3] SEM programs have achieved from 1 to 8%. See ACEEE 2014 paper by Heidi Ochsner, et al, Does SEM Achieve Verifiable Savings? A summary of evaluation results. http://aceee.org/files/proceedings/2015/data/papers/1-121.pdf.

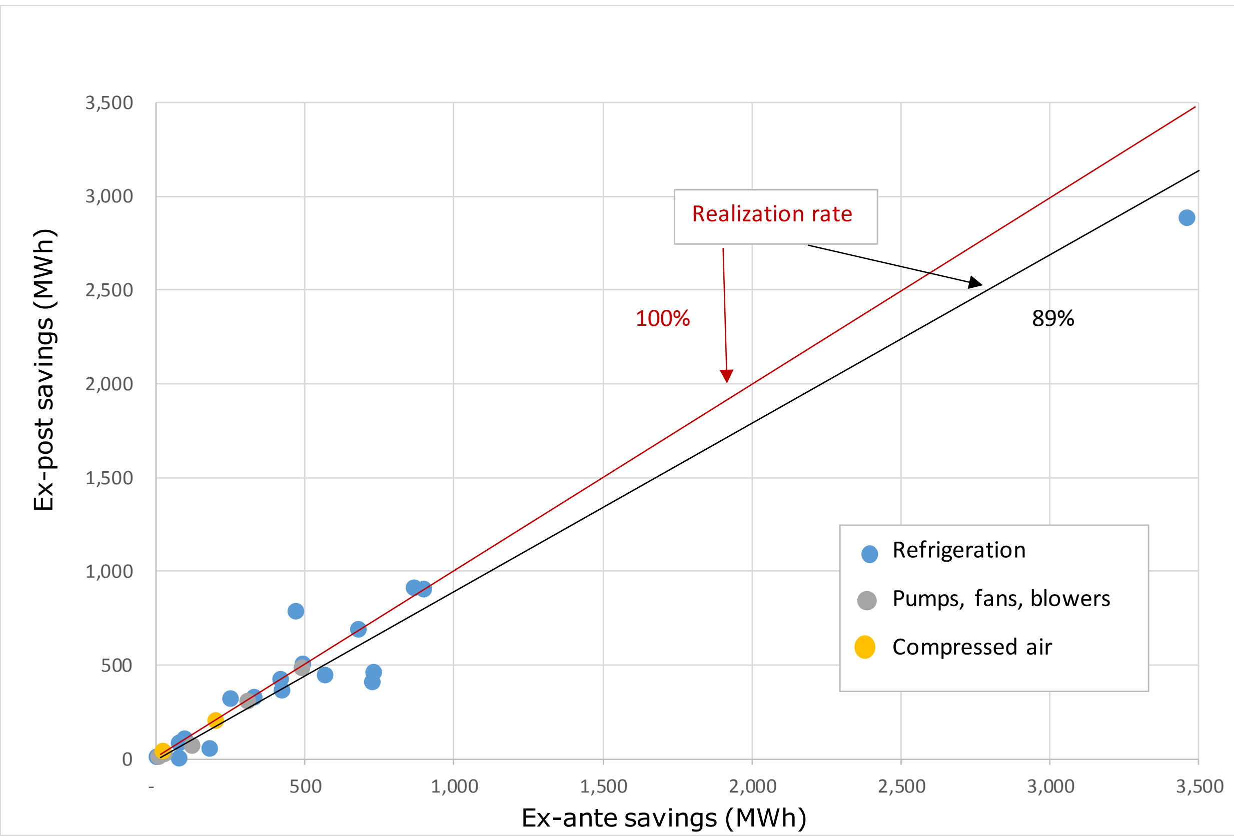
3.1.3 Differences between ex-ante and ex-post savings

As shown in Table 7, two broad reasons for discrepancies between ex-ante and ex-post savings were identified. First, changes at sites that increased or decreased operating hours affected four projects. The second is variability in the regression analysis once the performance period was extended for a longer evaluation period.

In general, there was high variability in the regression analysis results for individual sites across all program measure groups, with project-level realization rates ranging from slightly negative to 164 percent. However, there is no indication of a systematic bias; the errors are expected to be around the mean.

Figure 1 shows the relationship between the ex ante and ex post savings for each sampled project. If ex ante equaled ex post, the points would fall on the 100 percent realization rate line. Thus, the distance from the 100 percent realization line indicates how far each project is from 100 percent. Many are close to 100 percent, but several are not. The achieved realization rate is represented by the 89 percent realization rate line. The figure shows the influence of the one very large project in determining the overall realization rate.

Figure 1. Comparison of ex-ante and ex-post savings



For some projects, the ex-ante regression results were used as the evaluation (ex-post) results because necessary additional data to extend the performance period for the evaluation were not available. After determining the ex-ante findings satisfactory, the research team assigned 100 percent realization rates these projects. However, when sufficient data were available and an extended evaluation period was used, the evaluation results varied from the program estimates. The wide range of results is not surprising for this method, because factors outside of the program affect facility consumption that may not be captured in the baseline model. The research team believes that there are two possible issues that may be contributing to this variability:

- First, the performance periods are not representative of the entire year, especially at facilities with seasonal energy use fluctuation or weather-dependent energy usage. Therefore, when the performance period is extended, the savings fraction does not hold up.
- Second, in some cases, the ex-ante regression models were "over fitted" to produce a high correlation rate at the expense of model efficacy. The risk of a whole-facility regression analysis approach is overfitting the baseline model and selecting relevant variables that may yield good statistical parameters without representing future consumption patterns well. The research team observed some models with variables that seemed selected or manipulated to meet statistical requirements or because the data were available rather than representative of how energy is actually consumed.[4]

For five projects, an extended performance period from a few months during the program resulted in discrepancies compared to the ex-ante savings (both higher and lower values). The performance period of the program did not allow for seasonal or other variation.

The reasons for the differences between savings estimates and whether these factors can be influenced by PSE are provided in Table 7.

Table 7. Reasons for differences between ex-ante and ex-post results

Reasons for Discrepancy	Number of Occurrences	PSE Influence
Operating hours/changes in operations	4	Outside of PSE influence
Seasonal variation/short performance period and variability in the regression analysis.	7	Within PSE influence
No difference (within 5%)	14	Not Applicable
Total	25	

In one case, the research team found that an energy-efficiency capital project was implemented during the performance period. These savings were subtracted from the ex-ante model because they are not part of the ISOP program. However, the capital project savings were small relative to the ISOP project savings, and the ex-post savings were within 5 percent of the ex-ante savings for the project.

[4] Examples include labor hours raised to the power of 0.7 and the square root of production.

In several cases, the research team discovered that for projects data points were excluded from the baseline regression because they were deemed “out of range”. The omission of these data points improved the correlation statistics for these regressions, but there was no other justification given for excluding these points. The main issue with these exclusions is inconsistency because the same “range test” was not applied to the performance period data and no performance period data points were excluded for the program savings. In these cases, the research team included all the point and re-ran the regressions. In these projects, the variances in projects savings from re-running were minimal. However, this approach, the exclusion of baseline data points, has the potential to skew the savings for a project. Any exclusion of baseline data points should be well-justified, clearly documented, and the same exclusion criteria should be applied to the performance period data.

3.1.4 Measure life and persistence

The research team verified that 97 percent of the action items identified as completed under the program were in place at the time of the evaluation site visit, as shown in Table 8. The research team did not identify a pattern in the types of action items that were discontinued; the 13 action items discontinued fell in all categories at similar rates to action items completed. The reasons the participants cited for abandoning these action items included inconsistent load required changing the set-points and planned or completed upgrades. One facility representative cited food safety regulations that prohibited an action item from being implemented.

Table 8. Action items verified as completed during site visits

Program Measure Group	Sampled Projects	Action Items Completed			
		Program M&V	Evaluation[1]	Percent Verified	Additional Completed at Evaluation[2]
Refrigeration	19	409	399	98%	39
Pumps, fans, and blowers	5	45	42	93%	2
Compressed air	2	13	13	100%	2
Other	1	18	18	100%	2
Total	**27**	**485**	**472**	**97%**	**45**

1 Represents completed action items in M&V report observed complete at the evaluation site visit.
2 Represents incomplete action items in M&V report, observed complete at the evaluation site visit.

Given that the evaluation occurred between six to 30 months after the projects were, the level of persistence is high. This high level of continuation of the action items indicates that a five-year measure life is reasonable. PSE could get a stronger indication of persistence by performing another verification of action items in a few years. This might allow the use of quantitative methods to predict measure life.

Forty-five action items that were not completed during the program were found to be complete at the time of the evaluation (9 percent of total verified). Sixteen were items that required a capital investment; three were projects with incentives sought from PSE. Others were items that took more time to completely implement; such as performing maintenance tests or completing repair of multiple air leaks had not been implemented until after the performance period ended.

A brief literature review found similar periods of persistence for O&M activities to the five-year measure life that PSE uses for this program. There are little data on industrial O&M or retro-commissioning persistence, although the research team located two studies that quantified commercial retro-commissioning persistence on a case study basis, and a third study that addressed O&M measure persistence described as follows:

- In one study, Lawrence Berkeley National Laboratory (2004) found a measure life of four years for retro-commissioning projects in large commercial buildings.
- A Texas A&M University study (Toole and Claridge 2010) looked at persistence across ten commercial buildings for more than ten years, and found a measure life of six to 12 years, depending on the type of activity. This study reports an average annual savings degradation for heating, cooling, and non-cooling electricity use at eight percent, six percent, and four percent per year at ten campus buildings.
- A Public Service Commission of Wisconsin (2009) measure life study identified two years for compressed air and vacuum pump servicing, and five years for HVAC services.

Although these studies are not investigating measure life of industrial O&M projects like the ISOP, many of the activities investigated in these studies are similar. Although these studies alone can't justify ISOP's five-year measure life estimate, they do largely agree that the estimate is reasonable. A potentially a longer life is possible for the many of action items implemented under ISOP, especially hard-wired retrofit actions.

To support the understanding of the persistence of the action items, the research team asked the facilities what actions or procedures have been undertaken to ensure the action item stays in effect. In particular, the research team asked if the action item had been incorporated into their standard operating procedures. Of the 517 completed action items in our sample, facility staff stated that 96 had been incorporated into their written standard operating procedures. Note that not all plants use formalized standard operating procedures. For another 41 action items, other actions such as hardwiring equipment or locking in controls were taken to make sure the energy saving actions were maintained.

Overall, the facilities took additional action to improve the persistence of these actions in about 20 percent of the cases. This varied more by facility than by action item. Some facilities took no action; others demonstrated proactive responses to most action items.

The actions taken are expected to persist through the measure life with limited degradation. The high level of retention of completed action items for as long as 30 months since the project was complete suggests that the program impacts are likely to persist.

3.1.5 Uncertainties in estimates

Statistical estimates of confidence intervals account only for sampling error and assume random selection of the sample from the study population. The research team identified two factors that introduce additional uncertainty to the savings estimates: self-selection non-response bias and measurement error.

Non-response bias. Non-response bias occurs when the sampled population does not fully represent the program population. The research team contacted 39 of the 41 program sites to complete 27 site visits. Ten of the participants either refused the site visit or did not respond to multiple efforts to make contact. One site no longer had someone who knew about the program. One facility was decommissioned and two were not contacted, as the program M&V had found no savings.

The research team compared sites with and without site-visits to identify potential non-response (self-selection) bias. The two groups were comparable in average baselines, average targeted savings and percent of targeted savings achieved,[5] incentive amount, and the number of action items identified. The research team did note two differences: sites visited completed a greater percentage of action items: 67 percent compared to 51 percent for those not visited. Also, seven of the eight participants who installed performance tracking systems (PTS) through the program had a site visit. These differences may reflect a greater focus on energy use, which could result in higher savings and longer retention of savings.

Measurement error. Measurement error is the difference between what is measured and the true value. Measurement error can be systematic (i.e., creates bias in one direction or another) or it can be more random. Savings estimates based on regression models for individual sites are not highly accurate. The models explain only a portion of the energy consumption and can result in inaccurate estimate. There is no reason to believe that this introduces a bias towards higher or lower savings estimates—it is more random. The research team assumes that the error is equally distributed around the mean and that across the projects it averages out.

3.2 Program measure trends

This section identifies and explores patterns in action items, savings, and overall performance of program measure trends. Analysis was limited to 27 of the 41 completed projects that had evaluation site-visits. When ex-post savings estimates were required, analysis was limited to the 25 projects where these were calculated.

What the research team looked at and why the research team limited the exploration to a subset of characteristics are summarized in Table 9.

Table 9. Participant and project characteristics explored

Characteristic	Outcome	Explored Further
Program measure group	Too few sites in groups other than refrigeration for comparison	No
Subsystem	Too many groups of small size Difficult to tie to other characteristics Cannot tie to savings or costs	No
Industry type	Some differences associated with measure group/end-use	Yes

[5] Savings comparisons are based on ex-ante values. The two sites with zero savings were included in the analysis.

Characteristic	Outcome	Explored Further
Number of action items recommended/adopted	Correlated with measure group and industry type	Yes
Percent of actions items adopted	Correlated with measure group and industry type	Yes
Operating hours: • fewer than 85 hr/week • more than 120 hr/week	No differences in average percent of baseline saved No difference in kWh saved	No
Is there a person responsible for energy management? yes -19 no- 8	No statistically significant difference for: • percent of action items adopted • percent of baseline saved • number of days to complete the program	No
Maintenance practices: • predictive • preventive • both	Not enough differentiation in responses or sites to determine.	No
Incorporation of action item into standard operating procedure	Many organizations did not use or incorporate items into standard operating procedures. No pattern observed in savings or persistence.	No
Three action types: • Behavior • Hardware • Settings	Different adoption rates by industry type	Yes

In the next section, the research team begins by discussing the challenges in identifying trends for the program. The research team follows this with a brief discussion of our major findings. Although the research team has identified patterns across program measure groups, the research team does not have evidence to establish causal relationships. Next, the research team provides graphics and tables that look at the groups of projects from various perspectives.

3.2.1 Challenges in identifying trends

There are multiple features of the program and participation characteristics that made it challenging to identify patterns or trends that would lead to improved program efficacy:

- **Small participant population.** The size of the participant population limited comparisons across participants, especially because there are few participants in measure groups other than refrigeration.
- **Whole-facility savings estimates that are robust only in aggregate.** The savings were calculated for most projects using regression models. The accuracy of the regression models varies across projects, precluding analysis across individual projects.
- **Site-specific and unique action-item lists.** The action items identified by the Program are specific to the type of equipment and the participant's needs, which are driven by a wide variety of factors (e.g., industry, current equipment condition and maintenance practices, and production

specifics). No two projects are identical, and there is likely to be substantial variation within project groups (i.e., measure groups and industry types).

- **Few metrics for easy comparisons across participants.** Projects varied substantially in baseline usage, absolute energy savings targeted, and energy savings as a percent of baseline targeted. This leaves percent of targeted savings achieved as the most meaningful measure of savings across projects.
- **Inability to tie savings to specific action items.** ISOP projects include many small items that in aggregate can result in substantial savings. Savings for most projects are calculated based on overall facility usage. This does not provide any indication of if the action items contributed to savings. And, we cannot identify missed opportunities, both for the systems targeted or for additional energy consuming systems at the facility.

3.2.2 Key findings

The evaluated annual energy savings for the program is 18.2 GWh. The 18.2 GWh represents a gross realization rate of 89 percent. The savings equate to eight percent of baseline usage.

Refrigeration dominates and drives the program's success. Seventy-one percent of participant projects were identified as refrigeration, and were responsible for 85 percent of ex-post savings. **Error! Reference source not found.** shows that projects focused on refrigeration were the most successful on multiple metrics. Refrigeration projects have:

- The highest average ex-post kWh savings
- The highest number of identified action items per site
- The highest action item completion rate
- The highest percent of ex-post to targeted savings

The pumps, fans, and blower projects (six) were responsible for 13 percent of ex-post savings. These projects achieved 91 percent of their targeted savings, but the targets were 40 percent lower than those for refrigeration. The number of action items identified per project was lower, as was the percent of action items completed.

The compressed air projects (5) were the smallest in terms of both targeted savings and percent of targeted savings achieved. The number of action items identified and the percent completed was comparable to pumps, fans and blowers.

Table 10. Comparison of Project Characteristics Across Measure Group

Area	Refrigeration (n=17)	Pumps, fans and blowers (n=5)	Compressed Air (n=2)[4]
Completed projects [1]	29	6	5
Percent ISOP ex-post savings [1]	85%	13%	2%
Average ex-post savings per project (kWh) [1]	534,697	393,987	74,161
Targeted savings achieved (percent) [1]	91%	87%	36%
Direct costs per project	$36,184	$23,295	$18,703
Action items [2]			
Average IDed per project (count)	28	17	16
IDed targeting named system (percent)	62%	45%	38%
Completed (percent)	77%	51%	47%

1 Calculations based on all projects within that group

2 Calculations based on projects that had site visits

3 Direct costs include program implementer labor for projects plus incentives. They do not include all program costs (e.g. marketing, program management).

4 Project total is 40 because project identified as "other" is not included in the table.

Projects that focused on refrigeration were the most successful using multiple metrics. Refrigeration projects will likely continue to have substantial savings, a large number of action items, and high action item completion rates. The pumps, fans and blowers group is mostly comprised water and wastewater treatment plants, and provides a good indication of what to expect from that industry only. Appendix D presents details of the variation among projects within the groups.

3.2.3 Participant and project characteristics explored

The research team identified multiple characteristics to better understand the program and explored a subset of them.

The research team uses two project groupings in our analysis: program measure group and an industry type group developed by the research team. The research team developed industry types for two reasons. The first was to have a sufficient number of cases within groups to make comparisons. The second was to look at the industry types rather than measure groups to explore patterns. Table 11 shows the measure groups included in each industry type, as well as the counts of sites with completed site visits and with evaluated savings.

Table 11. Completed site visits and analysis by industry type and measure group

Industry Type	ISOP Measure Groups Included	Site Visits	Completed Savings Analysis
Cold storage	Refrigeration	10	9
Food processing	Refrigeration	8	7
Water/wastewater treatment	Pumps, fans, and blowers	4	4
Other industry type	1 Refrigeration 1 Pumps, Fans, Blowers 2 Compressed air 1 Other	5	5
Total		**27**	**25**

The industries included in the "Other" industry type are listed next with the program measure group in parenthesis:

- One ice arena (refrigeration)
- Three manufacturing facilities (one compressed air, one pumps, fans, and blowers, one other)
- One food processing facility (compressed air)[6]

The program focused on different systems in each of the manufacturing facilities. The manufacturing facility in the "Other" industry type identified action items for a range of end-uses: 13 HVAC, three compressed air, two refrigeration, two lighting, and three other action items. The food processing facility in the "Other" industry type was in the compressed air measure group and also identified action items for a range of (non-refrigeration) action items: five compressed air, three lighting, and two settings (one for a heater, one for a conveyer).

3.2.4 Action-item completion rates

The research team explored the relationship of action item adoption to program measure group and industry type.

Overall, 73% of the action items identified during the optimization event were completed at the time of the evaluation. Table 12 shows the number of action items identified and completed by program measure group. It also shows the average number of recommendations per site. The refrigeration

[6] ISOP focused on the compressed air system for this food processing facility, so the project did not fit well with the other food processing projects.

program measure group had both a higher number of action items identified and a higher completion rate.

Table 12. Action items identified and completed, at sampled sites

Program Measure Group	Sampled Sites	Action Items		Average per site		Percent Complete
		Identified	Completed	Identified	Completed	
Refrigeration	19	570	438	30	23	77%
Pumps, fans, and blowers	5	87	44	17	9	51%
Compressed air	2	32	15	16	8	47%
Other	1	24	20	24	20	83%
Total	**27**	**713**	**517**	**26**	**19**	**73%**

The research team categorized action items into three types: behavior, hardware and settings. The purpose was to identify any differences in the adoption of the different action item types[7].

Behavior. Maintenance and other on-going behavior practices.

Hardware. Action items that require a purchase (e.g. occupancy sensors)

Settings. Adjustments to schedules, timing cycles and other controls or valves.

Action item adoption rates are high overall, and high for each of the action item types, as shown in Table 1. The adoption rate by type varies somewhat overall, but only the difference in adoption of hardware relative to settings is statistically significant at the 90 percent confidence level. These differences can be explained, in part, by the differences in the types:

- Settings are a key focus of the optimization event and many adjustments to schedules and set-points are made during the event.
- Behavior and maintenance related items are generally no or low-cost and can be handled by internal staff. Some of these are addressed during the optimization event.

[7] See Appendix A for a more detailed description of the action item types

- Hardware requires purchasing equipment or updated controls. Although the equipment included in action items is relatively low-cost, it may be a barrier for some organizations. Items that cost more than $5,000 must get program approval.

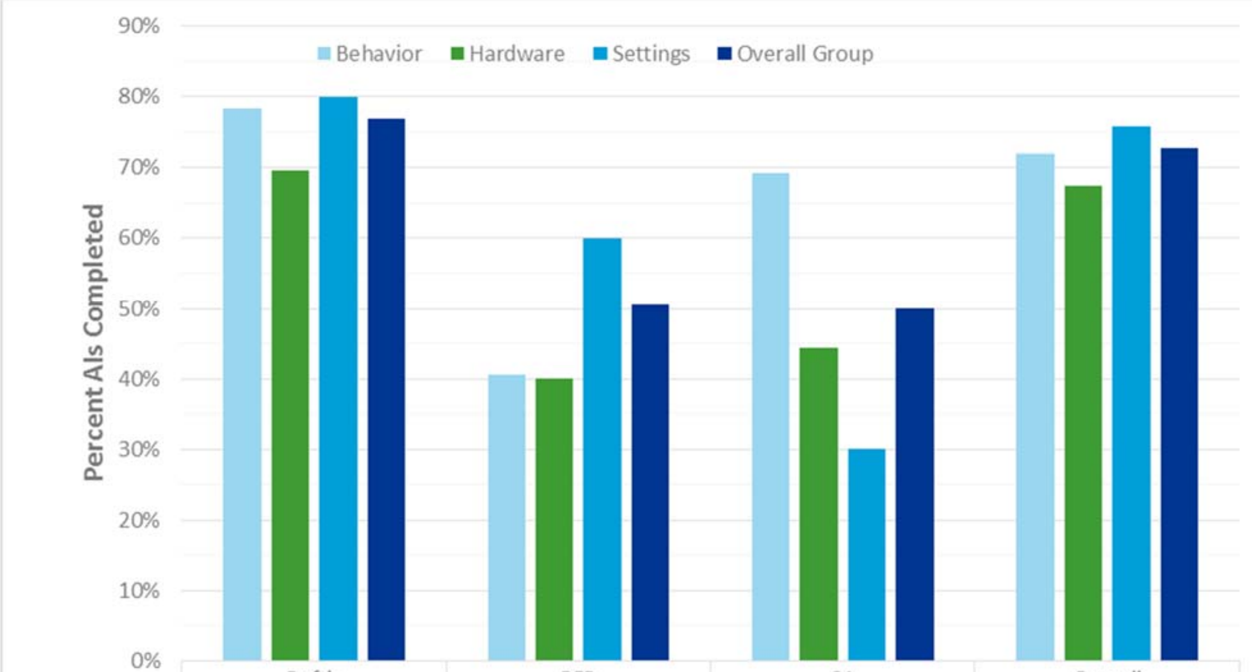
Table 13. Action item completion by action item type

Action item type	Action items		Percent Completed
	Identified	Completed	
Behavior	229	165	**72%**
Hardware	166	112	**67%**[1]
Settings	318	241	**76%**[1]
Total	**713**	**518**	**73%**

1 This difference is significant at the 95 percent confidence level

The research team provide information on the percentage of action item types completed by program measure group and by industry type in Figure 1 and Figure 2. Although the number of action items is high, the number of sites for program measure groups other than refrigeration are low. These groups are less likely to be representative of the range of future participants in those groups. Figure 2, which is broken out by industry types, is more likely to represent future participants of that industry type. The differences in adoption of different action item types may be exaggerated in the figures due to the low numbers of action items. The difference in overall group values are more indicative of real differences than differences within the small groups, or by type of action item across groups.

Figure 2. Action item completion rate by measure group and action item type



	Refrig (19 sites -570 AIs)	PFB (5 sites - 87 AI)	CA (2 site - 32 AI)	Overall (27 sites - 713 AIs)
Behavior	78%	41%	69%	72%
Hardware	70%	40%	44%	67%
Settings	80%	60%	30%	76%
Overall Group	77%	51%	50%	73%

PFB stands for pumps, fans, and blowers and CA for compressed air

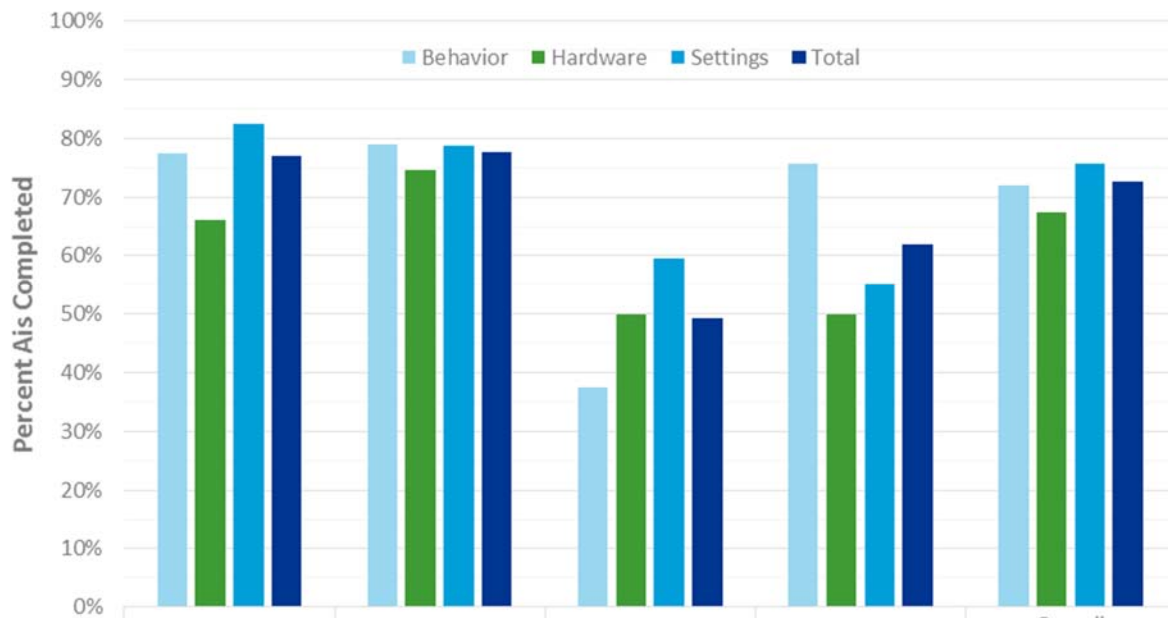
Figure 2 shows that participants implemented behavior, hardware, and setting action items, regardless of measure group. For all measure groups except compressed air, set-point and schedule changes (which are relatively easy to implement) were the most likely to be implemented.

The pumps, fans, and blower program measure group had savings that were comparable to the refrigeration group (both were 9 percent of baseline energy consumption), despite the low adoption rate of action items. These projects were water and wastewater treatment facilities whose primary electric usage is for the targeted systems. Two of the projects had over 80 percent of the savings. Fewer behavior items were identified for the pumps, fans, and blower program measure group. Many of the behavior items that were identified were not well defined (e.g., "complete pump tests") which may be why there was a lower completion rate.

The low savings for the air compressor program measure group are consistent with the lower number and types of action items completed. Quick fixes like repairing air leaks were the most common action items completed associated with compressed air. Less than half of the identified action items in this program measure group related to the air compressor.

The program measure groups and industry types with fewer action items per site compared to the groups that averaged more than 25 action items per site and also had lower completion rates, as shown in Figure 3. In other words, fewer identified action items is associated with a lower percentage of action items being completed.

Figure 3. Action-item completion rate by industry and action-item type



	Cold Storage (10 sites-283 AIs)	Food Processing (8 sites - 273 AIs)	WWTP (4 sites - 73 AIs)	Other (5 sites -84 AIs)	Overall (27 sites - 713 AIs)
Behavior	77%	79%	38%	76%	72%
Hardware	66%	75%	50%	50%	67%
Settings	82%	79%	59%	55%	76%
Total	77%	78%	49%	62%	73%

WWTP stands for wastewater treatment plant, AI for action items

Possible explanations for action item completion rates lower than 70 percent include:

- **The type of business**. Some businesses may have higher aversion to risk than others. For example, wastewater treatment plants tend to be risk averse and are very hesitant to make changes that may possibly affect their effluent.
- **Lack of clarity in recommendations.** The team found that some action items, (e.g., "do pump tests") were not sufficiently specific and actionable. This makes such action items more difficult to implement.
- **Insufficient industry-specific or subsystem expertise among program technical staff.** Having sufficient expertise in a wide range of industrial systems is a common challenge for

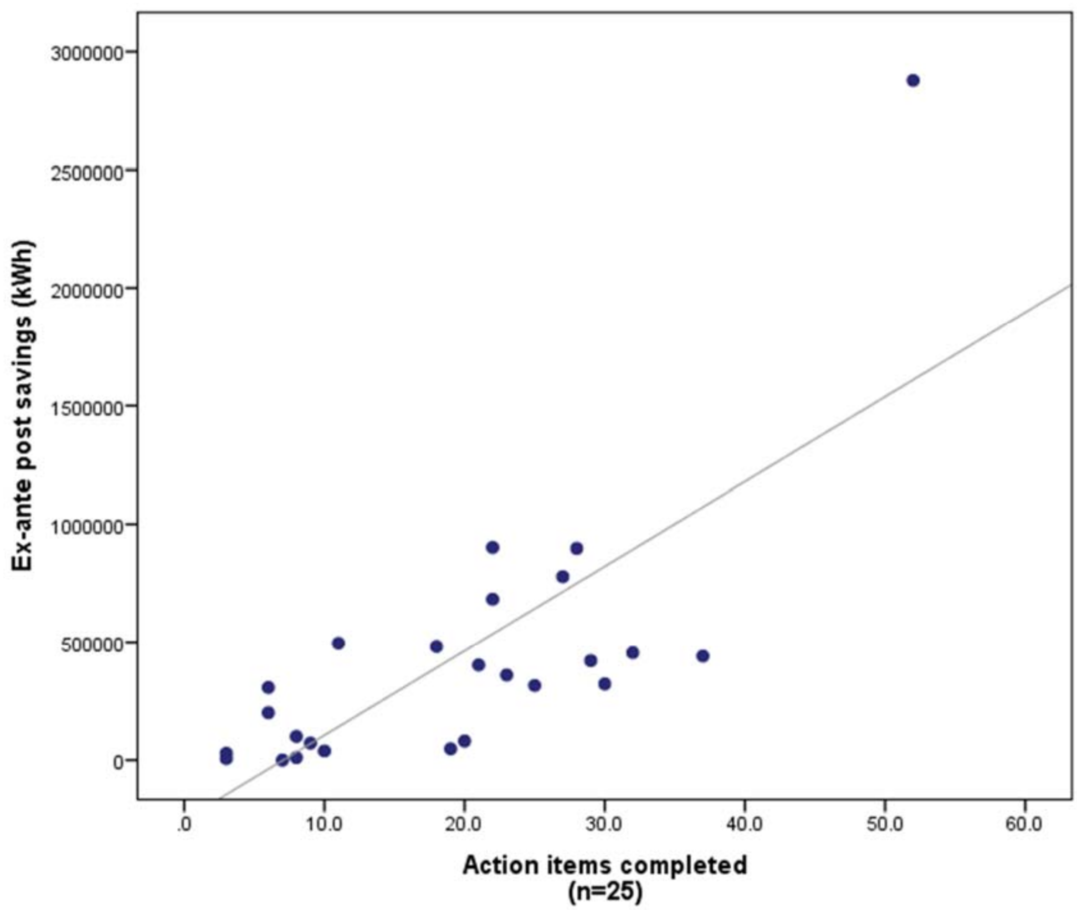
industrial programs. This may explain why some projects have a small number of action items and lower adoption rates.

- **Indicative of more challenging opportunities.** Some action items may have required more effort or funding, or would disrupt facility operations.

3.2.5 Action item completion relationship to savings

Figure 4 plots the relationship between the number of action items completed and the percent of baseline electrical energy saved. The overall trend shows the expected relationship that the more action items completed, the greater the savings. The low correlation rate, $R^2 = 0.19$, indicates that the number of action items is not the only factor that drives savings. This is because some types of action items save more energy than others and the savings of any given action item is driven by other factors such as facility schedule, equipment sizes, or the intensity of the load on the equipment in question.

Figure 4. Number of action items by percent of baseline saved



3.3 Program delivery and processes

This section provides a detailed program description that defines and illustrates the steps to complete each program project, from marketing through final inspection. The description is informed by program staff interviews, program documents, project documentation, participant surveys, and program implementer project tracking.

PSE offers ISOP to electric industrial customers billed under Conservation Schedule 250 to identify and implement low-cost energy-saving action items. Action items developed through the program address maintenance, calibration and settings, and controls and other hardware to optimize the energy consuming systems. The program focuses on energy-intensive systems such as refrigeration, compressed air, and pumps, fans, and blowers. It offers participants both technical and financial assistance to implement recommended action items. The program also included incentives for performance tracking systems (PTS) during the first program cycle. PSE began offering the program in 2012, with the first projects completed in 2013. In the first two program cycles (2012-15) the program completed 41 projects, of which eight included PTS.

PSE designed the program to fill a gap in the energy efficiency portfolio. Other programs available to the industrial sector focused on capital projects. The objective of ISOP was to give industrial customers opportunities to save energy through modifications to facility operations rather than upgrades to capital equipment.

PSE selected the ISOP program implementer for the initial two-year program cycle based on the firm's experience and qualifications through a competitive bid process. PSE has repeated the selection process for each of the subsequent two program cycles (the third one began in 2016), selecting the incumbent program implementer each time. The implementer has primary responsibility for recruiting customers, delivering program services, verifying savings, and processing customer incentives.

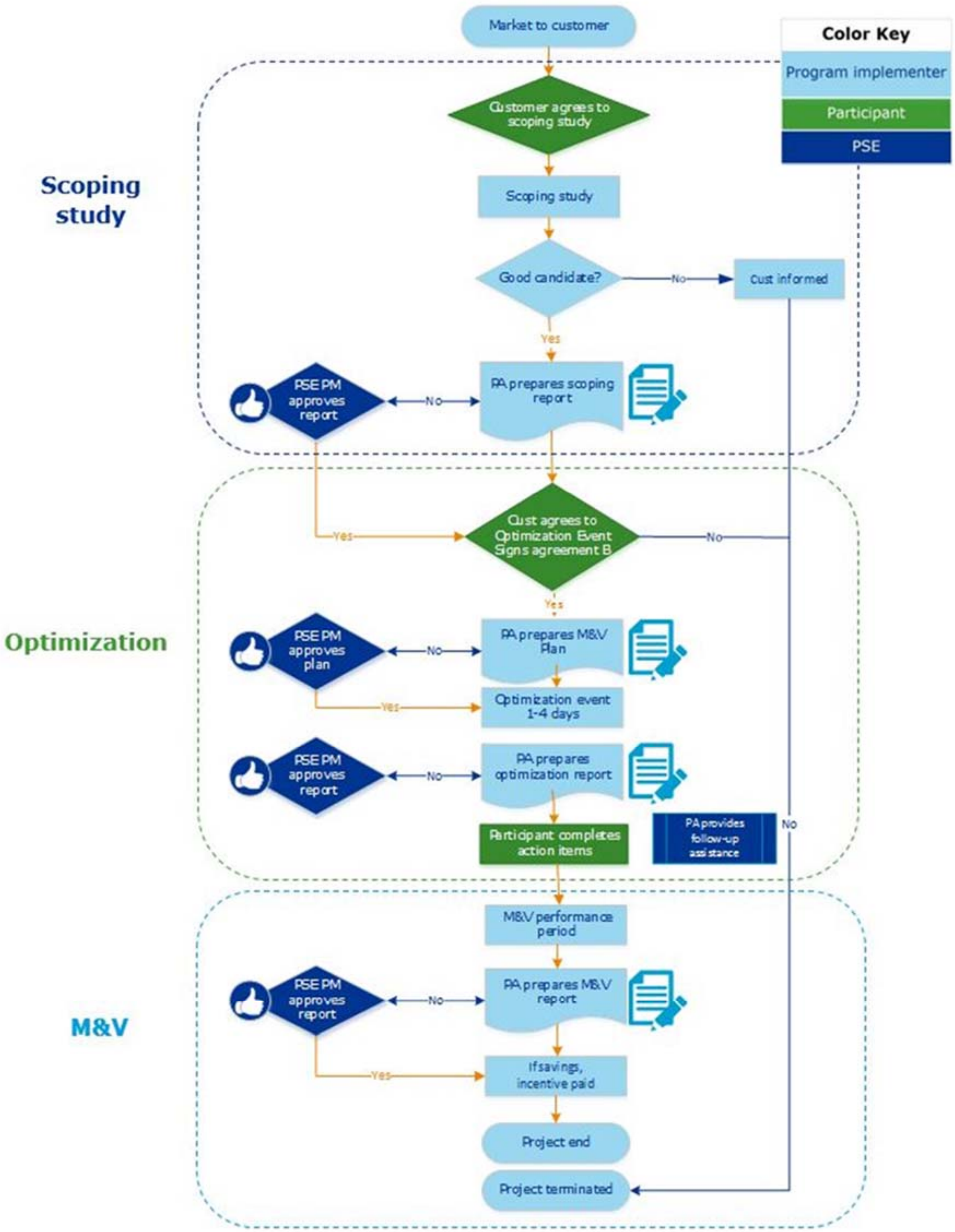
The program manager from the implementation firm is a mechanical engineer with substantial experience in industrial refrigeration. The program manager provides much of the program services to customers; however, other engineers or technicians have also led or assisted in optimization events. Those interviewed also had substantial experience conducting industrial refrigeration "tune-ups," which is one of the implementation firm's specialties. Program implementer administrative staff obtain energy data from PSE and prepare invoices for delivery to PSE. Given the relatively low number of projects completed per program cycle, program implementer labor on the program is less than one full-time-equivalent staff person.

The implementer's program manager tracks ISOP activity and costs using excel workbooks—one for each program cycle. These workbooks track estimated and actual costs for discreet program activities by project. The program manager also tracks the dates of key milestones as projects progress through the program. These data contributed substantial information in the development of this detailed description.

The PSE ISOP program manager is a PSE consulting engineer trained in mechanical engineering with 18 years of industry experience. He assumed the program manager responsibilities in early 2016, notably after the program years included in the evaluation. He spends approximately 20 percent of his time on the program, including time on the strategic energy management (SEM) pilot currently underway within in the program. He is responsible for reviewing and approving program reports, as well as working with the implementer to address program challenges and changes.

The program has three key implementation stages: marketing and scoping, optimization, and verification, shown in detail in Figure 5:

Figure 5. ISOP program participation process



3.3.1 Marketing and project scoping

The program implementer is responsible for recruiting customers into the program. Sometimes major account representatives (MARs) or energy management engineers (EMEs) suggest a customer., When the current program implementer joined the project, the firm brought a network of potential industrial customers. Simultaneously, PSE provided a targeted list of potential customers on Conservation Schedule 250. From these sources the program implementer prioritized accounts based on the enthusiasm of the customers, the customer's systems, and sites with potential for large savings from refrigeration.

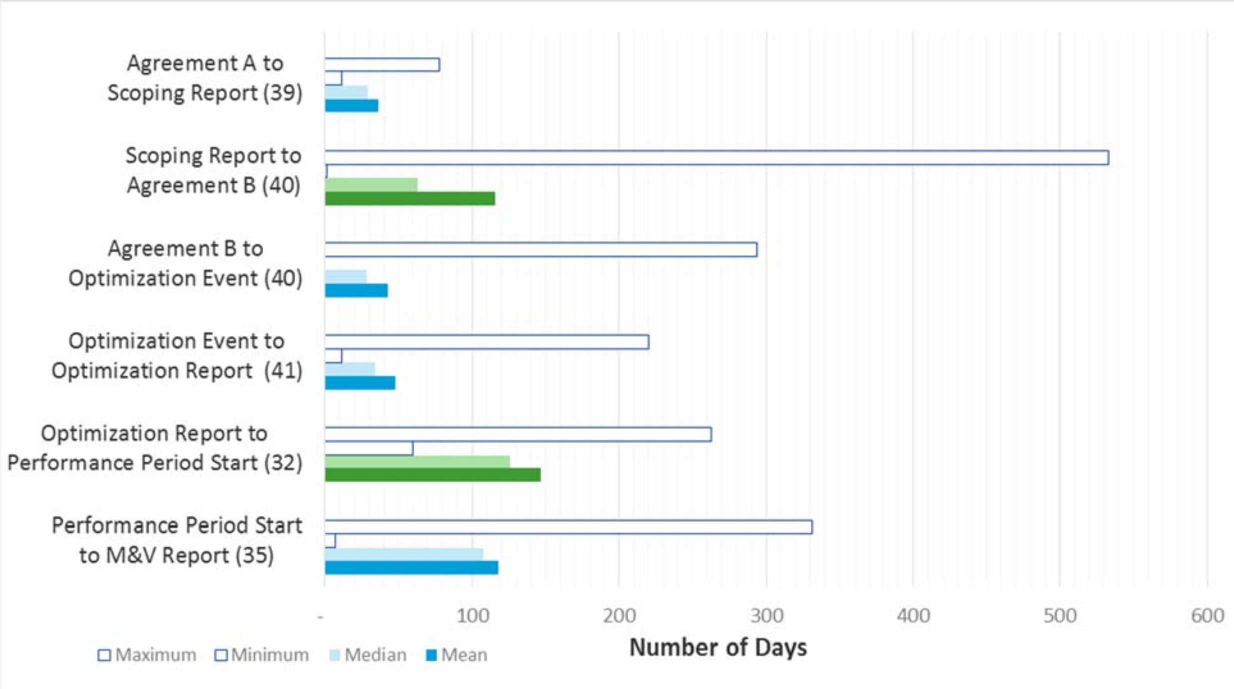
To initiate contact with the customer, the program implementer contacts the MAR to introduce the program. In half or more of the cases, the MAR telephones or emails the customers. The initial contact is generally with a maintenance or facilities manager, as these are the staff members responsible when there is an outage or power quality problem. The program implementer tries to have at least one PSE person at the initial customer meeting. The program implementer keeps track of customer contacts using Microsoft OneNote.

Customers who agree to the scoping visit sign Agreement A that authorizes the release of their PSE electric usage to the implementer. The implementer uses the data to establish baseline consumption to estimate potential savings during the scoping visit. The agreement also includes the customer's commitment to active participation in the scoping event. Scoping visits take a few hours. During the visit the engineer develops a list of potential action items to estimate potential costs, paybacks, and financial incentives for program participation. The engineer may also identify capital projects, most often lighting or HVAC related, and provides similar information.

The implementer completed the scoping study report, on average, 36 days after the customer agreed to participate, as shown in Figure 6. This figure shows the median, mean, minimum and maximum days to completed project steps. Scoping visits were, on average, three days after Agreement A was signed. The program implementer experienced some delays getting PSE energy data when PSE stopped supporting the old billing system. In the old system, the program implementer had direct access to usage data for sites for which a participant had signed Agreement A. They do not yet have that capability for the new system and instead receive monthly spreadsheets for each project via email. PSE and the program implementer are working on re-establishing direct access.

In the first two program cycles 78 sites had scoping studies, with 41 (52 percent) continuing in the program to the optimization event and through the performance period. The implementer followed up with customers periodically to move them to full participation. The research team was unable to find scoping reports for 12 of the partial participants.

Figure 6. Length of ISOP participation steps for completed projects (2012-15)



3.3.2 Optimization

As shown previously in Figure 6, customers took an average of about four months (118 days) from the scoping report to signing Agreement B. Half signed within 30 days, while the longest delay was more than 9 months (294 days). The program implementer identified two reasons for the delay. The first was knowing who had the authority to sign Agreement B, which was likely to be someone at the corporate, not facility level. The second reason for delay was on the customer side: although the project looked good to them other priorities took precedent.

Signing Agreement B starts full participation in the program. The customer agrees to participate and comply with specific and detailed program requirements. The program implementer commits to completing its responsibilities: establish a baseline and M&V Plan, conduct the multi-day (1-3) optimization event, provide a summary report, provide implementation support, and verify savings.

A feature of the agreement is the participant requirement to assign a company Energy Champion and an Executive Sponsor to the project. These roles are assigned to assure that sites have both technical and corporate level support to successfully complete the program. The Energy Champion acts as the "boots on the ground" at the site and is the main contact person to the program implementer throughout the program. If the participant uses a "qualified trade ally" to complete some of the action items, the Energy Champion is their contact person for the program. The Energy Champion is likely to be the facility or plant manager and is responsible for all participant commitments including:

- Assisting the program implementer in identifying action items and tracking techniques
- Providing necessary customer information (e.g., usage and product data)
- Participating in the optimization event, assisting in the action item (optimization) report

- Completing action items and submit the ISOP Action Item Completion Report

Agreement B states that the Executive Sponsor is responsible for allocating "budget, personnel and other resources to implement all phases of the ISOP program." During Cycle 2 the program implementer started identifying a "data master" in accounting who could provide the data linked to drivers in energy consumption. The role of data master was added to Agreement B for the third program cycle.

To keep project costs down for smaller sites the program implementer streamlined the optimization event. The following changes were made:

- The optimization event was limited to one engineer and a technician, or a technician only.
- The amount of time spent on the optimization event was scaled to the site's potential savings.
- The onsite efforts were focused on the 20 percent of action items likely to result in the bulk of the savings. Participants are left with information to complete the remaining items.

During the optimization event program implementation and facility staff go through the facility identifying and implementing action items. Implementation staff bring along measurement tools (e.g. thermometers, data loggers to measure current and pressure, and light meters). They use a proprietary "tune-up tool" to estimate savings on site for many measures. This tool is focused on refrigeration equipment, but includes calculations for compressed air and lighting measures.

Following the optimization event the project engineer prepares, with assistance from the Energy Champion, an action item (optimization) report that summarizes the status of each action item and identifies a plan for action items not yet completed. The Optimization Report numbers the action items, making them easy to track from optimization event to M&V and through to an independent evaluation. It is rare to find this level of detail in a program implementation tracking system.

The participant has 120 days from receipt of the report to submit the ISOP Action Item Completion Report. The program implementer reports that they did not strictly enforce this requirement and that many participants did not complete the items within 120 days.[8] This results in a group of projects getting completed at the end of a program cycle and temporarily increasing work load.

3.3.3 Measurement and Verification

The verification process involves two steps: on-site verification of action items and estimation of project energy savings. The program implementer conducts a site visit to verify that the work has been completed. Inspection dates vary substantially from the optimization event and are often completed right before or during the performance period. This provides the implementer with the most up-to-date look at the action items completed. Some participants continue to make changes after filling out the Completion Form.

The program implementer must estimate savings based on a minimum of 60 days of usage data. The savings performance period averaged 88 days, with a median of 69. Only one site had a performance

[8] The program implementer project manager tracks the agreed upon date for completion for project management purposes, but does not always update the information when the action items are completed.

period shorter than 60 days (at 42 days). The longest performance period was 244 days following the submission of the Action Item Completion Report. The implementer extended the performance period for sites that have substantial seasonal differences in consumption or were expected to have small savings. Program implementation staff started performance periods early (before the optimization report was approved) when they expected savings to be small, or when usage is highly dependent on the season.[9] Detecting small savings requires longer measurement periods. For seasonal variations, the program wanted data for multiple seasons to capture the magnitude of the differences. These are examples of program implementation staff thoughtfully addressing specific situations.

For six sites the program implementer verified savings using a bottom-up approach. Five of these sites had small savings (they had implemented few action items) or small savings relative to baseline, making it difficult to estimate through regression. The sixth site shared the electric meter with tenants, and tenant changes during the program period made it impossible to disaggregate the usage of the tenants.

Next the program implementer prepares an M&V report that includes an updated status of action items, fully documents the approach to estimating savings, and calculates participant incentives.

PSE reviews and approves the M&V report. The implementer then provides PSE with the Project Packet, which is a pdf file that includes the final project invoice with participant implementation incentive, copies of signed agreements, and all reports (scoping, optimization, and M&V) with approvals, and documentation of all customer project expenses.

For the second cycle (2014-15) the program implementer calculates the participant incentive as the lesser of $0.05 per kWh saved or 70 percent of project costs. The program implementer must provide the incentive within 30 days of receipt of incentive monies from PSE, which is more than 30 days after the M&V report is approved.

This incentive approach was simplified from the approach used in Cycle 1, which participants found confusing. Several changes were made:

- **PTS incentives were paid up-front in Cycle 1, not in Cycle 2.** The PTS incentive was paid up front with the objective of getting the systems functional for the Optimization. It did not achieve this objective, and put the program at risk if the site did not save enough energy to justify the PTS incentive. Currently PTS costs are factored into the overall project cost when calculating the incentive.
- **PTS incentives were limited to the first 10 percent of baseline saved in Cycle 1, not in Cycle 2.** When the program was new there was uncertainty about the magnitude of savings from individual projects. The 10 percent of baseline cap on incentives reduced the risk that one or two projects would get the bulk of the program budget. Cycle 1 demonstrated that this was unlikely, and the limit was removed.

The research team calculated the total number of implementation days for 39 of the completed projects. Two sites received scoping studies without signing Agreement A. To calculate implementation

[9] These were mostly water treatment plants.

days, the research team used the date Agreement A was signed for implementation start and the date PSE approved the M&V Plan as the project end. This calculation does not include initial meetings with participants before they sign Agreement A, nor the lag between M&V report approval the customer receiving the program incentive. This lag is a minimum of 9 weeks.[10] The average implementation time was 67 weeks or about 15 months. The minimum was approximately 30 weeks (7 months) and the maximum was 148 weeks (32 months).

Table 14. ISOP overall project time

Statistics	Weeks
Mean	67
Median	64
Minimum	30
Maximum	148

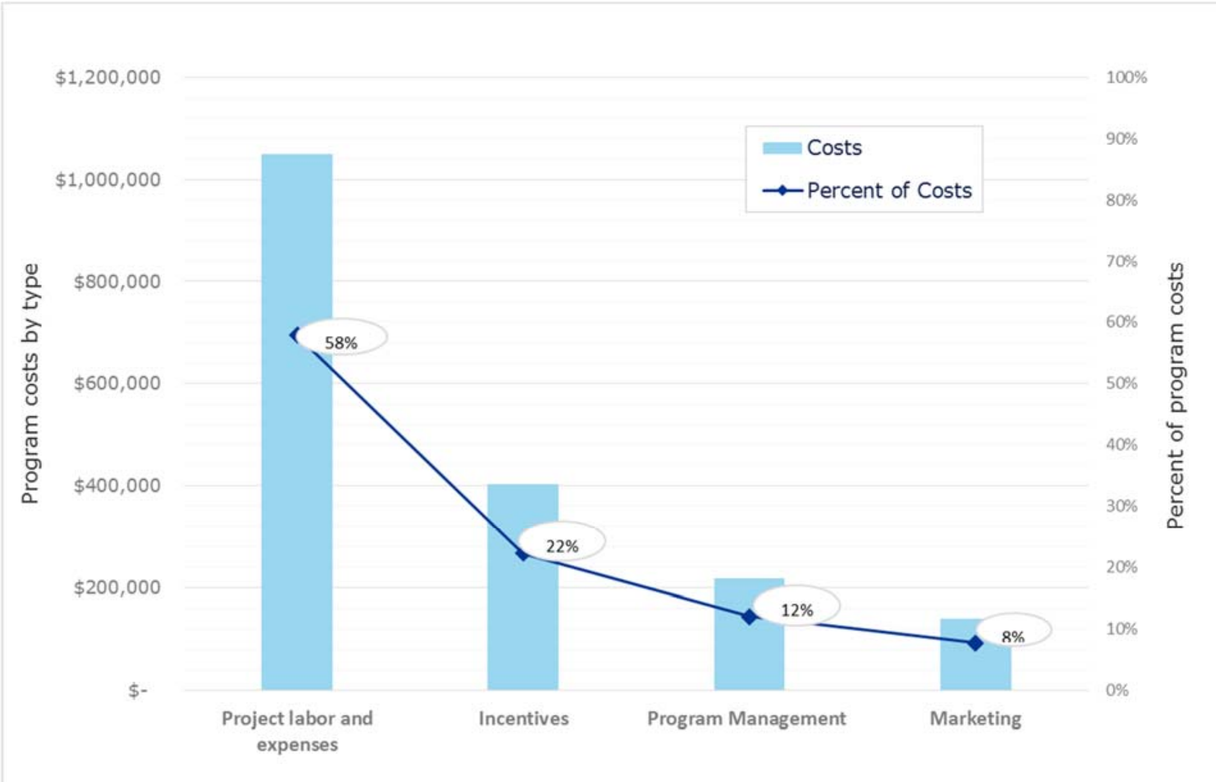
Two projects did not include dates for Agreement A.

3.3.4 Program and resource acquisition costs

Program implementation costs totaled $1,813,635 for the first two program cycles (2012-15). The majority of the implementation costs (58 percent) were for labor associated with specific sites. Another 20 percent of costs are labor for marketing and overall program management (e.g., tracking and reporting, customer service), as shown in Figure 7. Incentives comprise 22 percent of costs.

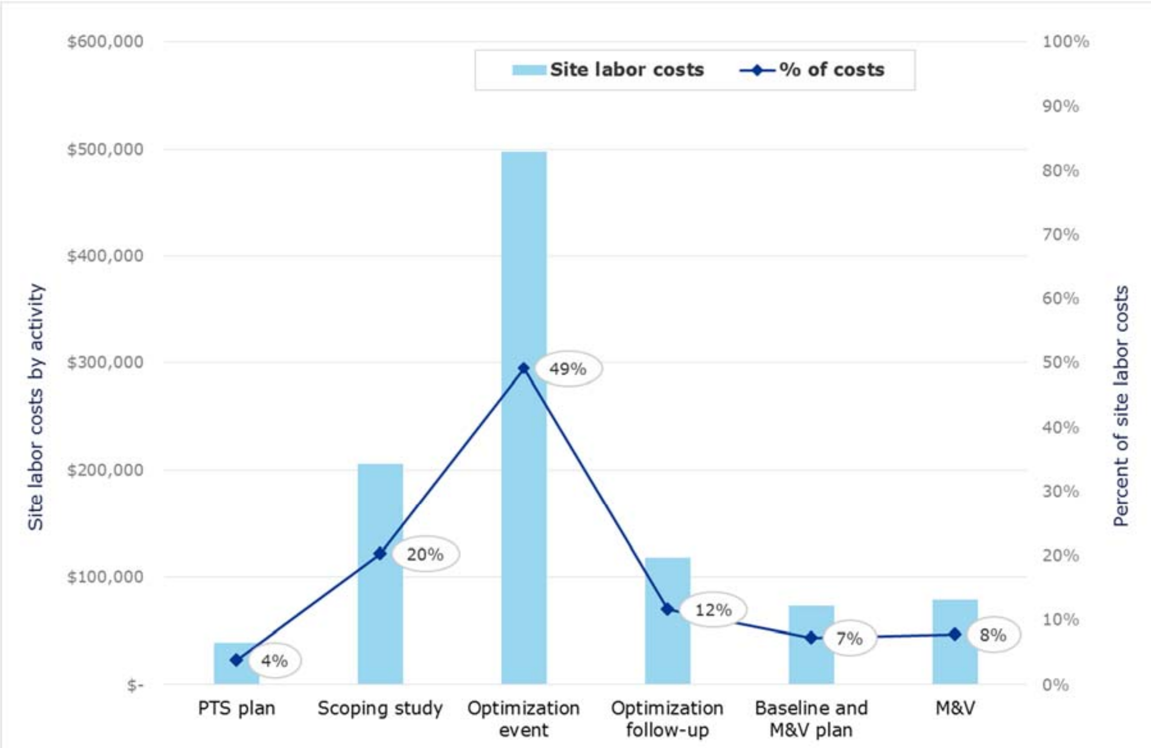
[10] We did not ask participants about their satisfaction with the time it took to get the incentive payment.

Figure 7. Percent of implementation costs by category (2012-15)
(Total implementation costs of $1,813,635)



On-site labor costs cover implementer time on program activities associated with projects. As shown in Figure 8, the majority (60 percent) of site labor costs are for optimization, which is the event itself and for follow-up assistance during the participant's implementation period. Scoping study costs constituted 20 percent of expenditures. One-half of the scoping study costs were for sites that did not result in completed projects. M&V activities were 15 percent of site labor costs. These include establishing the baseline, developing an M&V plan, and completing the M&V analysis and reporting. PTS plan costs were high in Cycle 1 (primarily for two projects) and negligible in Cycle 2.

Figure 8. Project specific labor costs by program activity



The research team was able to look at the costs per kWh saved for each project, and therefore explore differences across projects. The research team calculated the cost per kWh two ways. The first calculation included only direct costs: site labor costs and incentives. In the second calculation, the research team added indirect costs: project management, marketing, and scoping costs for "dead" projects. The research team allocated these indirect costs in proportion to the direct labor costs.

The costs per kWh vary substantially across program measure groups, as shown in Table 15. The refrigeration and the pumps, fans and blowers measure groups had substantially lower costs than the "compressed air" group and the "other" project.

Table 15. Cost per kWh by measure group

Measure Group	Sites	Ex-post Savings kWh	Direct costs		All Costs	
			Site Costs + Incentives	$ / kWh	Direct plus Allocated Indirect	$ / kWh
Refrigeration	29	15,506,219	1,049,329	$ 0.07	$ 1,451,024	0.09
Pumps, Fans, Blowers	6	2,363,924	139,772	$ 0.06	$ 197,805	0.08
Compressed Air	5	370,807	93,516	$ 0.25	$ 138,410	0.37
Other	1	80,600	17,605	$ 0.22	$26,395	0.33
Total	**41**	**18,321,550**	**1,300,223**	$ 0.07	$ 1,813,634	**0.10**

3.4 Participant perspectives (online survey)

This subsection reports on the results of the online survey of program participants and partial-participants. The overall purpose of the survey was to assess customer satisfaction with the program, as well as motivations and barriers to participation. A total of 15 participants (with 19 projects) and four partial-participants [11] responded to the survey. Participant respondents represented all four measure groups; measure groups for partial participants were not provided.

Respondents were asked:

- How they heard about the program
- Role of listed reasons for initial participation and for having an optimization event
- Significance of listed internal challenges to participating in the program
- Reasons for not fully participating in the program (partial-participants only)
- Satisfaction with multiple aspects of the program
- PSE program participation prior to and post ISOP participation, and influence of ISOP on program participation

Responses are provided as counts of respondents (not percentages) due to the low number of respondents.[12] Counts include full and partial-participants, unless otherwise identified. The research team present the findings under three headings:

- Information sources and scoping study
- Optimization event and other program processes
- ISOP influence on program participation

[11] Partial-participants received a scoping report but did not participate beyond that point.

[12] Percentages would exaggerate differences and could lead to erroneous conclusions.

- Summary

3.4.1 Information sources and scoping study

Respondents were asked "from which of the following sources did you hear about PSE's ISOP program?" The majority identified PSE, a program representative or Cascade as a source (Table 16). These findings are consistent with PSE's approach of using targeted marketing by Cascade and referrals from PSE account representatives to identify sites.

Table 16. Program information sources

Heard about program	Number of Responses
PSE Representative	7
Program representative *(or Cascade)*	6
Someone within organization	2
Colleague outside organization	
Other *(contractor, worked with PSE in past, "searched it out")*	3
Don't remember	3
Total*	**19**

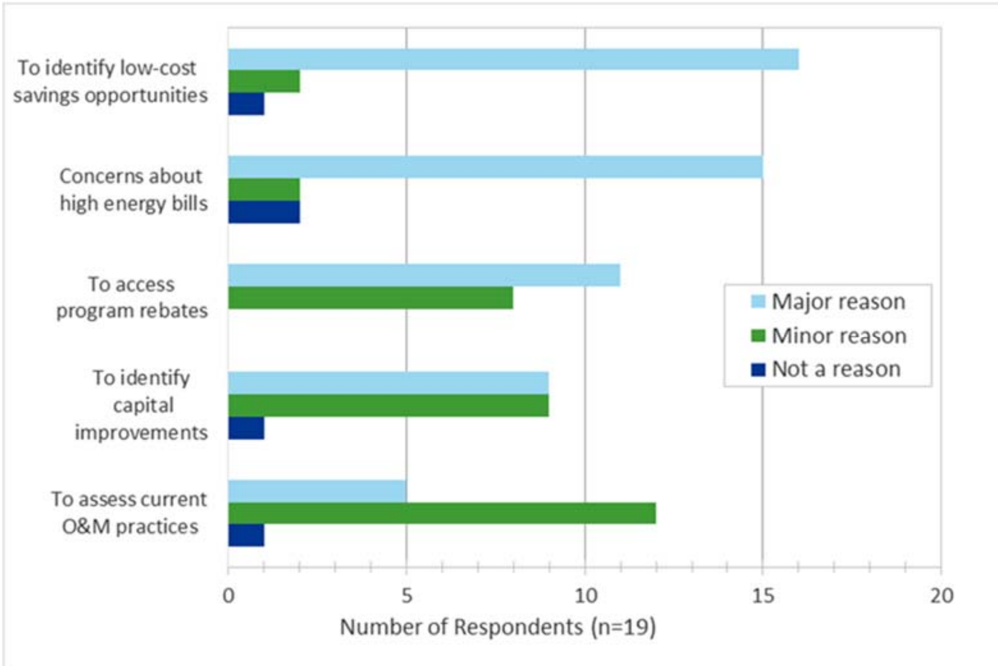
* Total number of responses greater than respondents because more than one answer allowed.

Next, respondents were asked to identify whether each in a list of reasons to participate was a major, minor, or not a reason for their company's initial participation in ISOP (i.e., agreeing to a scoping study).

Figure 9 shows that the great majority of respondents indicated identifying "low-cost savings opportunities" and "concerns about high energy bills" as major reasons to participate. More than half identified "to access program rebates" as a major reason, the remaining identified it as a minor reason.

All but two respondents identified capital improvements as at least a minor reason for participating, although this is not a focus of the program. Respondents did not provide any responses to a question asking if there were other reasons that played a role in their participation.

Figure 9. Reason for initial participation

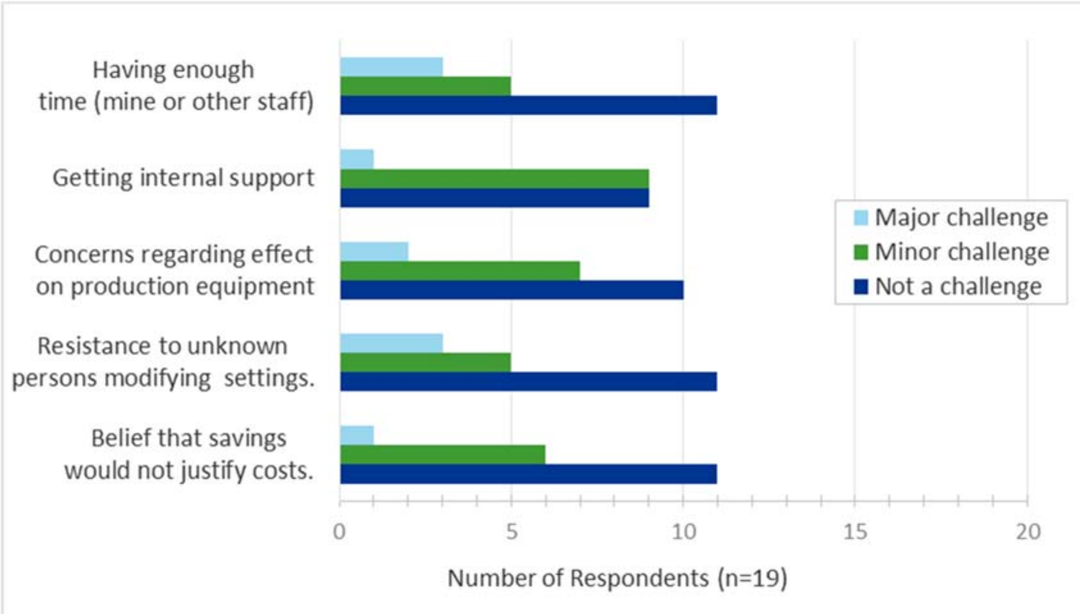


Understanding the challenges to program participation that customers face is helpful for identifying potential program improvements. Although the program exceeded its goals, modifications that result in higher recruitment rates could reduce resource acquisition costs. The research team asked respondents to identify whether each of a list of challenges was a major, minor, or not a challenge to participating in the program. The questions focused on challenges internal to the organizations and were based, in part, on challenges that the program implementer had encountered when promoting the program (Figure 10).

More than half of all responses were "not a challenge." Few respondents identified any of the listed items as a major challenge. Three respondents, including one partial-participant, indicated "not a challenge" for all of the reasons listed.

These findings do not necessarily suggest that industrial customers do not experience these challenges. These respondents were able to participate in the program, all but four completing the program steps. Most of the participants experience one or more of these challenges.

Figure 10. Challenges to participation



Two respondents checked "I don't know" for all items and are not included in the figure.

To further address challenges, the research team asked partial-participants "for what reasons did your organization stop participating in the program?" Answers varied and are provided verbatim as follows:

- "Program seems to be set for perfect conditions with no variables. Had to fit in their scope of set points."
- "Knew our issues and wanted to move on them. As an aside, I know PSE looks at energy savings. It is difficult to get anyone to look at Total Cost of Ownership"
- "Still waiting for the final study."
- "Not sure that we were asked."

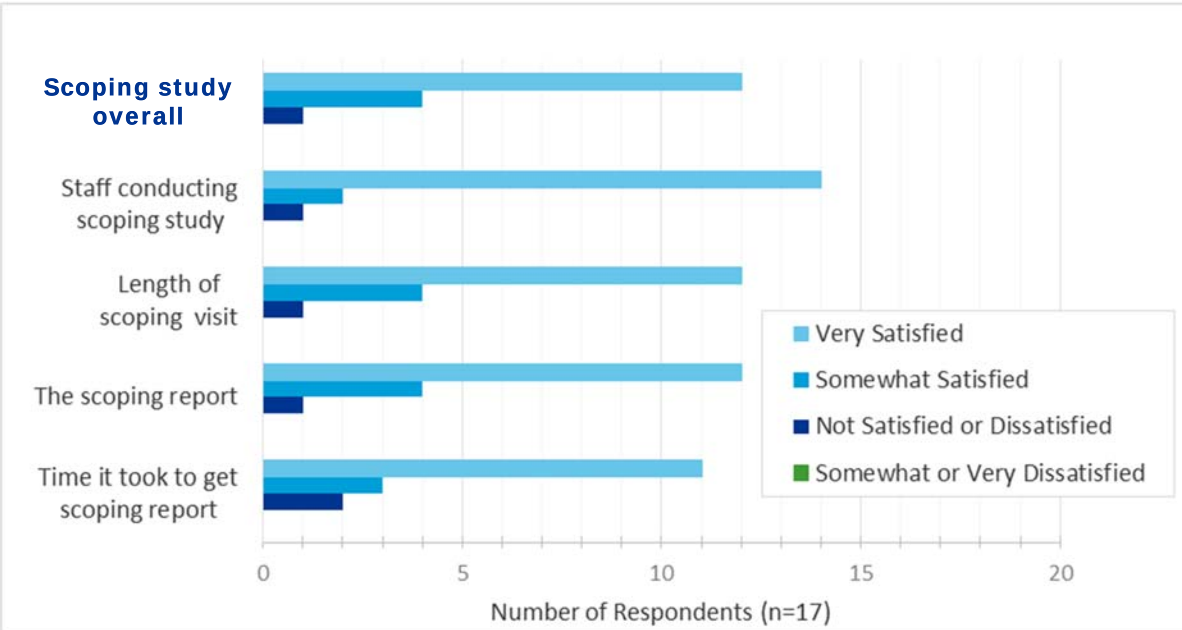
Respondents were asked to indicate their satisfaction with various aspects of the scoping study, and for the scoping study overall. They could check boxes corresponding to "Very Satisfied," "Somewhat Satisfied," "Not Satisfied nor Dissatisfied," "Somewhat Dissatisfied," and "Very Dissatisfied."

Satisfaction with the scoping study overall and for each of the aspects queried was high as shown in Figure 11. Fifteen out of 17 respondents checked the same level of satisfaction across all scoping aspects. Only two respondents reported different levels of satisfaction across the various scoping study aspects. The other respondents reported the following levels of satisfaction across all the study questions:

- Eleven were "very satisfied"
- Three were "somewhat satisfied"

- One was “not satisfied nor dissatisfied” and provided the following explanation “I knew my issues, this was more of a "go-between." Once I made that part clear I was immediately dumped to PSE engineer making me wonder "why the go between?"

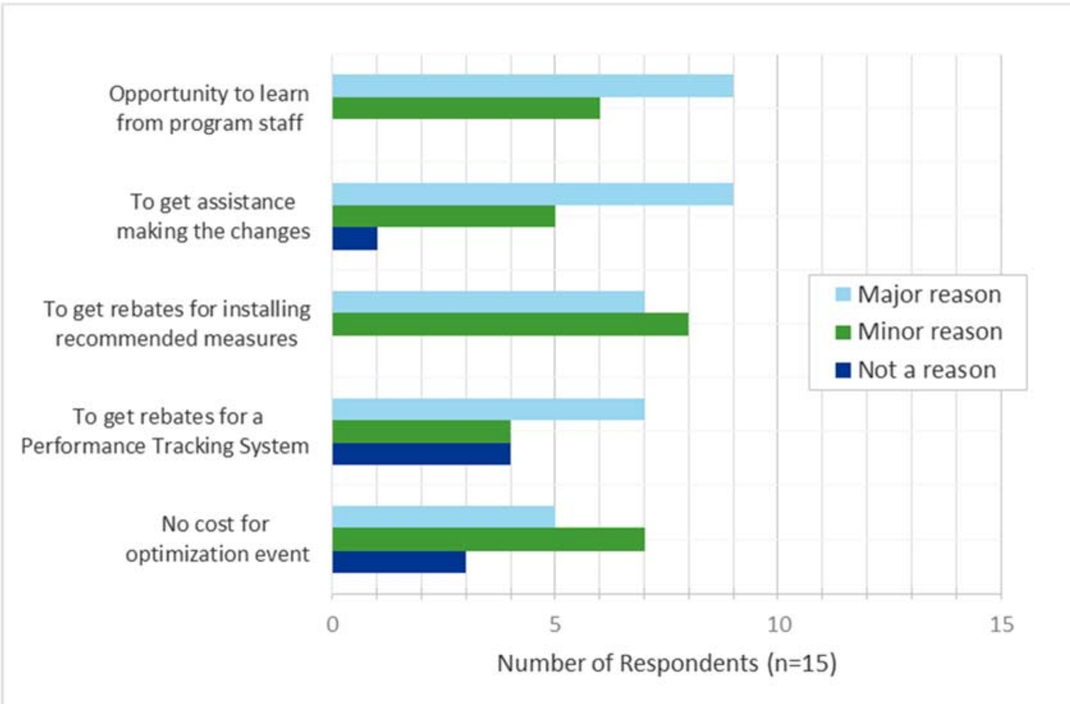
Figure 11. Satisfaction with scoping study



3.4.2 Optimization event and other program processes

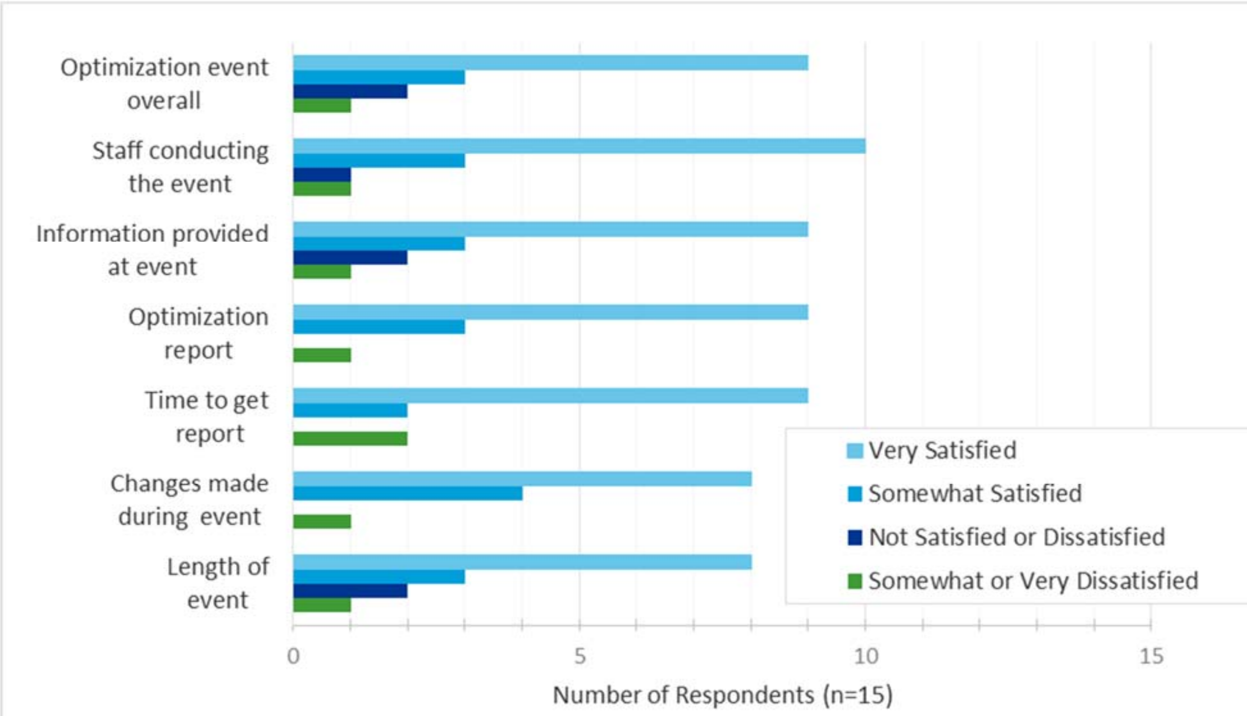
The research team asked participants to rate a list of reasons for agreeing to the optimization event as either major, minor, or not a reason. The majority of participants indicated that each of the queried reasons was a factor in their organization having an optimization event (Figure 12). All respondents identified “the opportunity to learn from program staff” and “to get rebates” as at least minor reasons to participate. All but one identified “getting assistance making changes” as a reason.

Figure 12. Reasons for agreeing to the optimization event



Satisfaction with the optimization event was also high. Nine respondents were "very satisfied," and three were either "very" or "somewhat satisfied" with all aspects of the optimization event. Three respondents were less than satisfied overall with the optimization event and identified specific aspects of the process (Figure 13).

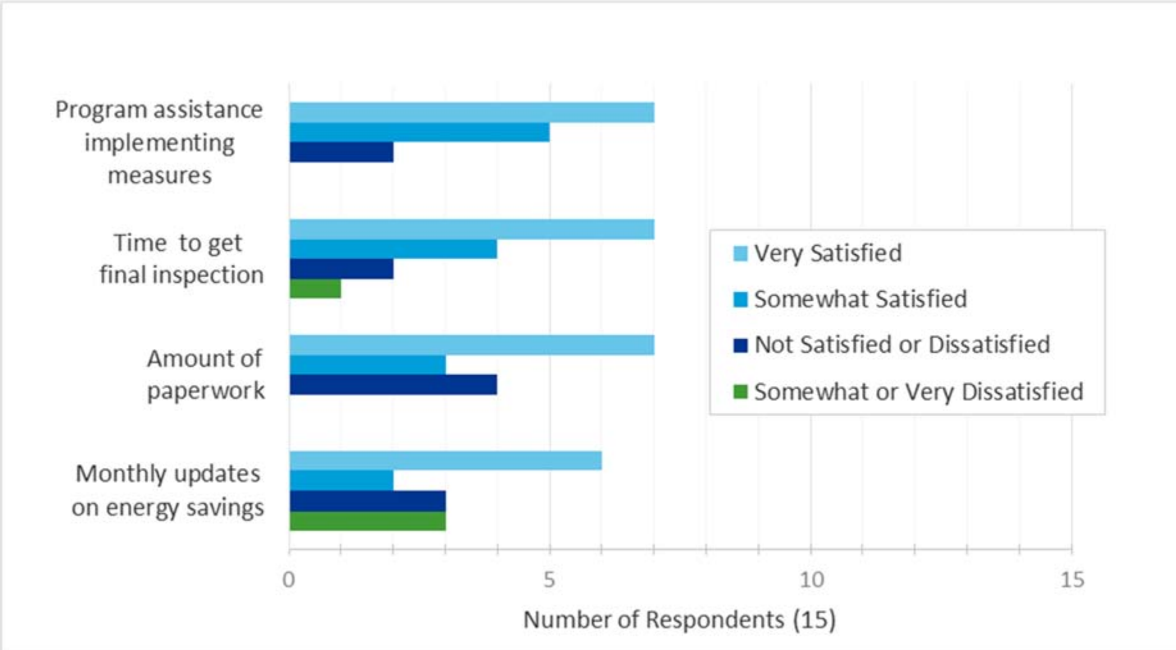
Figure 13. Satisfaction with optimization event



The research team also asked the participants to rate their satisfaction on aspects of the program after the optimization event and with the amount of paperwork. Satisfaction with these aspects of the program were somewhat lower than the previous items, with less than half "very satisfied" with any of them (Figure 14). Of note is that six of 15 respondents were less than satisfied with the monthly updates on energy savings.

Only one respondent provided a comment about why he or she was less than satisfied, saying "The initial report was very helpful, but it was not as easy to get follow-up information and help us around implementation." This respondent was referring to either the scoping study or optimization report, not the monthly updates.

Figure 14. Satisfaction with other program features



The research team asked all respondents (including partial-participants) to rate their overall satisfaction with the program and to tell us why they provided that rating. The research team also asked them if they had anything else to say, or any suggestions for improving ISOP.

Overall satisfaction is high, with 14 of the 15 participant respondents satisfied (very or somewhat) and 2 of the 4 partial-participants satisfied (Table 17).

Table 17. Overall program satisfaction

Satisfaction Level	Respondents
Very satisfied	10
Somewhat satisfied	6
Neither satisfied nor dissatisfied*	2
Somewhat dissatisfied*	1
Total	**19**

*These respondents included 1 partial-participant.

Multiple respondents shared why they had provided the overall satisfaction rating. Reasons for satisfaction varied[13].

[13] Those that were "very satisfied" identified the following reasons:

3.4.3 Influence of ISOP on program participation

The research team asked all respondents if they had participated in PSE programs prior to and after participating in ISOP. Approximately one-third of program participants participated in other PSE programs after completing ISOP (Table 19).

Table 18. Pre- and post-participation in other PSE programs

Participated in a PSE Program		
	Prior to ISOP	**Post ISOP***
Yes	8	6
No	2	8
I don't know	9	5
Total	**19**	**19**

*One respondent reported participating in a program after ISOP, but did not indicate the program or level of influence.

For those who said they participated in a PSE program after ISOP, the research team asked what program and to indicate the level of influence ISOP had on their participation: major, minor, or no influence (Table 19). Respondents participated in a range of PSE programs. All respondents who participated indicated that ISOP had an influence (major or minor) on their decision to participate in at least one program.[14]

[14] Six respondents participated in other PSE programs after ISOP, five indicated which programs and the influence of ISOP on their decision to participate.

- "The program went very smoothly. All representatives were very professional and the program was a huge success at [company name redacted]."
- "Incredibly smart people coming into the building and identifying saving opportunities is never a bad thing. They were so great to work with and I always get with PSE before I purchase equipment to see how they can help."
- "The improvements and changes have proven to be sustainable and easy to achieve."
- "Because it shows our company is trying to be more cost effective (partial-participant)."

Another participant who was "somewhat satisfied" noted "Great program but need more assistance after initial report."

A partial-participant who was neither satisfied nor dissatisfied said, "Basically because I don't know what this means - the consultant or PSE engineers or both together. The process to me is cobbled." A somewhat dissatisfied partial-participant noted that the "Model doesn't fit all applications."

Table 19. ISOP influence on PSE program participation

		ISOP Influence on Program Participation		
Program	**Respondents**	**Major**	**Minor**	**None**
Business lighting	4	2	1	1
Custom grants	3	1	1	1
RCM	1		1	
Other	2	1	1	
Total*	**6**	**3**	**3**	**2**

*Number of responses greater than number of respondents because some respondents participated in more than one program.

3.4.4 Key survey findings

The majority of the respondents are satisfied with each aspect of the scoping study and optimization event, as well as the program overall. Satisfaction with other program features is also high, but somewhat lower for those items: assistance implementing measures, time to get final inspection, amount of paper work and monthly updates on energy savings.

A majority of respondents reported identifying low-cost savings opportunities and concerns about high bills as major reasons for their company's initial participation in the program. A smaller majority indicated accessing program rebates as a major reason. All listed reasons were a factor for the great majority of initial participants. A majority of respondents also identified learning from program staff and getting assistance making the changes as major reasons for getting the optimization event. Getting rebates was a major or minor reason for all participants.

The research team had hoped to get insight from the surveys regarding barriers to participating in the program. Because most respondents were participants, the majority indicated that they did not experience each of the challenges. The remaining responses were varied.

The program did influence participants to participate in other PSE programs. Approximately one-third of the participants participated in another PSE program after ISOP, and all said that ISOP was a minor or major influence on their decision.

The research team would not recommend online or telephone surveys with this type of population due to multiple characteristics:

- The study population is too small for quantitative analysis.
- Although the survey included many opportunities for open-ended responses, most respondents did not provide a single comment. This is unusual and may reflect the nature of the respondent population.
- The program is relatively new and the type of information valuable for the evaluation requires getting a better understanding of the different situations and circumstances that these industrial customers face.

4 BEST PRACTICES REVIEW

PSE identified three focus areas for the identification of best practices or recommendations for modifications. These areas were:

- Implementing and estimating savings from behavioral and O&M programs
- Reviewing the ISOP's M&V approach relative to best practices
- Reviewing PSE's rebate structure for recommended modifications, if applicable

The evaluation team completed a two-pronged approach to address these issues: secondary research and a comparison of PSE's ISOP to programs with similar offerings. The literature included published papers and reports addressing industrial programs and energy efficiency program best practices. Program comparisons relied on secondary sources such as evaluation reports and program online sites. In one case, the research team obtained additional information from a program lead.

4.1 Best practice literature review

In this section, the research team provides a list of best practices most applicable to ISOP and the evaluation objectives. The research team addresses best practices under four sub-headings: program design, program marketing; program delivery; and M&V and rebate levels. The research team identifies the best practice, the sources (in parentheses), provide explanation, if needed, and relate it to the program. The full references for the source materials are provided in Section 6.

4.1.1 Program design

- **Develop a sound program plan.** If possible, have a clearly articulated program theory (Quantum). PSE's program appears well planned. Program roles and responsibilities are established and documented; program processes are consistent and facilitated by report templates and other tools. The program meets its goals within budget.
- **Articulate a program theory or stated objectives beyond meeting savings goals.** (Quantum) The program was originally offered "to fill a gap in service offerings" to industrial customers. The program would benefit from identifying additional and more specific objectives that would help guide program enhancements and to establish priorities (e.g., program targeting and evaluation research).
- **Maintain program design flexibility to respond to changes** (multiple sources). The program demonstrated flexibility within the first two program cycles (e.g., adapting processes for smaller projects).
- **Design program tracking system to support program staff and evaluators** (Quantum). The program implementer maintains comprehensive and detailed documentation for each participant site. The implementation program manager uses Excel workbooks to track each project's status, costs, dates for key milestones and other valuable information. Evaluation team members agreed that the tracking was most comprehensive (i.e., what was addressed) and complete (i.e., there is almost no missing data).

4.1.2 Program marketing

- **Include the non-energy benefits of energy-efficiency in the value proposition,** State and Local Energy Efficiency Action Network (SEE Action) and others. "A key point in making the value proposition case to industrial company managers is to lay out in simple and concise terms the operating cost savings and other benefits—including profits—that are being left on the table by not addressing cost-effective energy efficiency improvement opportunities" (SEE Action, p.27). Non-energy benefits are mentioned in written program materials. It is unclear whether they are highlighted for potential participants.

- **Include a mix of technical (engineering) and non-technical staff in program delivery** (Research into Action). Non-technical staff are often more effective in sales-focused roles. They may also provide insight into specific customer or industry needs that need to be addressed to build customer confidence.
- **Provide case studies of successful projects to potential participants.** (SEE Action) The case studies should be for similar industries when possible.

4.1.3 Program delivery

- **Develop long-term relationships with industrial customers** (SEE Action). Long-term relationships are important in building up trust with the customer and with better understanding their needs and wants. PSE's Major Account Representatives and EME's have ongoing relationships with the customers and may serve this function. Cascade Energy also has long-term relationships with some of these customers, and is the face of the program. It is unclear if this program helps to build that relationship, given the limited involvement PSE staff.
- **Build synergies between program offerings**. (SEE Action) Synergies between programs provide customers' exposure to other offerings and opportunities to leverage them as needed. ISOP is marketed directly to targeted eligible customers (or recommended by an account representative). It is an opportunity for entry point into PSE's other energy efficiency programs, and a program that could get referrals from other programs for sites where O&M opportunities are identified. Program implementers identify some opportunities for capital projects that could get PSE incentives, but are not responsible for follow-up.
- **Avoid program overlap.** The current program appears to overlap with other program offerings. Participants have completed action items identified by ISOP using other PSE programs, likely to leverage larger rebates. Rather than being a synergy, this can result in double-counting of savings and incrementally increases the cost to PSE for these savings. The research team did find one site where this occurred and subtracted the capital project's savings from ISOP ex-ante savings. If the program were to grow larger, this could be problematic.
- **Keep program participation easy for customers.** (Quantum, SEE Action) This applies to all programs, and can be more challenging for programs with multiple requirements and steps. ISOP has many steps but it appears that much of the burden is on the program implementer. Participant requirements are clearly articulated in Agreement B and participants know what to expect.
- **Use well-qualified engineering staff** (Quantum, SEE Action, evaluation reports). This is especially important for industrial programs, which require industry-specific expertise (and credibility) to address the myriad industries within a service territory. The SEE Action report points out that when offering an industrial program "Access to specific subsector technical expertise for specific short-term assignment is almost always necessary." Evaluations of several programs point to this challenge as a limiting factor in what they can offer. Program implementation staff

have substantial experience with industrial "tune-up" programs, especially for refrigeration systems. It's unclear if their expertise is as deep for other industrial systems.

- **Automate routine functions as much as possible** (Quantum). The ISOP program is efficient in the preparation of reports and thorough in its documentation. Some of this is due to the templates and processes that they use for ISOP and other similar programs. Program implementation staff noted that they can easily work on an ISOP site and function efficiently.
- **Take steps to ensure that settings and behaviors are maintained** (Thompson, Hart, and Mustaq). These steps could include encouraging or requiring facilities to include action items in their standard operating procedures, training personnel within the facility, or identifying with placards systems that require on-going actions. PG&E's Industrial Retro-commissioning (IRCx) Program required participants to have or purchase a computerized maintenance-management system (CMMS) or have a multi-year preventative maintenance contract. Only one ISOP participant identified that they used CMMS.

4.1.4 M&V

Neither the best practices literature nor the evaluations addressed details regarding M&V. The evaluation team can provide some observations:

- **Ensure robust monitoring and verification** (Quantum). Measurement and verification are essential components of all energy programs and are especially important for industrial programs in general and for optimization programs in particular. Industrial programs because of their high potential savings and the unique characteristics of each site; optimization programs because of the uncertainty around savings estimates. The program requires and completes M&V for all completed sites based on baseline and post-program usage data, as well as on-site verification of action item completion.

- **Complete third-party program evaluations periodically** (Quantum, SEE Action). PSE contracts for third-party evaluations for all its programs. Most PSE programs are evaluated every few years, which is reasonable for programs that are achieving their goals and have high participant satisfaction.

The secondary literature and evaluation reports did not address the merits of alternative savings approaches for industrial optimization programs. The evaluation team did identify the following "best practices" based on evaluation reports, internal expertise and IPMVP guidelines:

- **Use a whole-facility regression modeling approach to estimate savings for ISOP, International Performance Measurement and Verification Protocol** (**IPMVP) Option C**. The multitude of action items with small savings (relative to baseline) are difficult to quantify individually, but total savings can be estimated using these techniques. Pre- and post-modeling are appropriate when the expected savings are large enough to be discernible over natural variation in the consumption. When the savings are too small to be detected, bottom-up approaches in conjunction with limited metering or spot measurements may be appropriate. The program implementer uses engineering based estimates when savings are too small for modeling.

- **For each facility use appropriate independent variables to account for typical variation in energy consumption** (IPMVP). Pre- and post-usage data are essential: pre-usage to establish a baseline and post for estimating savings. Also essential are pre and post data on drivers of site energy usage and variation (e.g., production levels). At least one year of pre-program data are needed to understand variations (especially for seasonal operations). ISOP used one to two years to establish the baseline. The length of time needed for post-optimization data is dependent on the type and complexity of the project and should be extended beyond the required 60 days when necessary.

- **Consider using performance tracking systems (PTS) for baseline and post-program data collection, which is a relatively new approach.** The inclusion of monitoring equipment has been shown to increase persistence and measure life in commercial retro-commissioning, and this is likely to be the case for industrial sites as well. (Hart) BPA's Track and Tune program uses PTS for pre and post data, as well as for on-going tracking and incentives for measure persistence. Strategic energy management programs often include PTS. Staff can assess their performance toward goals. Also, tracking systems may provide early detection of problems to facility staff who can adjust accordingly.

4.2 Program comparisons

The evaluation team selected four programs for comparison to ISOP:

- **BPA's Track and Tune (BPA T&T).** This program is part of the BPA Energy Smart Industrial (ESI) programs. The program is offered by a subset of BPA retailers including utilities and public utility districts. The program requires savings potential of 250,000 kWh per year and daily usage data. The customer served by utilities without daily metering capabilities must purchase a PTS to participate. ISOP was designed based on T&T and the program implementer is the same for both programs. A program evaluation report for this program pending.
- **Ameren Illinois' Retro Commissioning Program (Ameren RCx).** This industrial offering is part of the RCx program for commercial and industrial. The program addresses compressed air systems greater than 200 horsepower and industrial refrigeration greater than 500 horsepower. Most savings are from industrial refrigeration. The program requires payback of year or less for compressed air.
- **Com Edison's Industrial Systems Optimization Program (ComEd Optimization).** This program addresses compressed air and industrial refrigeration with the same size requirements as Ameren, as well as process cooling. The program addresses a combination of capital and low or no cost measures, which are combined into an Implementation Bundle.
- **Energy Trust of Oregon's Target 90 by 90 Industrial O&M (Energy Trust O&M).** The program is offered within the Energy Trust's Production Efficiency Program umbrella. The targeted program focuses on Boiler Tune-ups and HVAC retro-commissioning. The custom program 90 by 90 addresses a wider range of items. Both address only maintenance behavioral items by training facility staff.

All of these programs include a focus on low and no-cost improvements in industrial facilities. Tables identifying the characteristics of these programs are provided in Appendix G. The programs also share other commonalities that include:

- providing financial incentives (rebates)
- assisting in the identification of O&M opportunities
- verifying savings

They also have substantial differences from each other and from the ISOP. The research team discusses both the commonalities and the differences in the next section.

4.2.1 Rebates[15]

The ISOP provides rebates based on the lesser of $0.05 per kWh ex-ante savings or 70 percent of customer costs, including internal labor. The comparison programs offer the following:

- Ameren's RCx provides incentives for the initial study, which identifies cost effective savings recommendations. They provide 70 percent to 80 percent of the cost for refrigeration and compressed air reports, respectively. The studies are completed by program approved industry specific contractors, called retro-commissioning service providers (RSP).
- ComEd's Optimization covers the full cost of the study, completed by an RSP. The study addresses both capital and low-cost recommendations. Refrigeration and process cooling participants are required to complete $15,000 of improvements; compressed air sites must reduce leakage by 50 percent. The program provides an incentive to cover the costs of the equipment and installation of an Implementation Bundle of recommendations. Recommendations from the study are not eligible for any other Com Ed incentives. Measures not part of the Bundle may be eligible for $0.07 kWh incentive.
- BPA's T&T engages participants in a three or five-year contract. Incentives are $0.075 per kWh up to 70 percent of eligible costs, including technical resources. Additional incentives of $0.025 per kWh of sustained energy savings are paid annually. Participants who purchased a PTS are eligible for additional annual incentives calculated based on baseline use at $0.0015 for a 3-year contract, $0.0025 for a five-year contract, with a cap of $50,000.
- Energy Trust O&M rebates are based on facility implementation costs (including tools and instrumentation) and how quickly items are completed. Rebates cover 90 percent of implementation cost if completed within 90 days, 50 percent after 90 days.

ISOP rebates per kWh are lower than those of the other programs, with the exception of BPA's T&T. BPA T&T provides higher incentives per kWh, as well as requiring more from the participants. The program, however, provides all the services at no cost.

4.2.2 Implementation

With the exception of the Energy Trust, the comparison programs are delivered through a third-party implementation firm. The responsibilities of the program implementation firm vary by program.

- Ameren RCx and ComEd Optimization each use a program implementer to manage the program and paperwork. The utilities promote their programs through their online sites, communication to customers, and provide marketing collateral for RSPs to use. RSPs market the program, conduct the study to identify recommended actions and estimate ex-ante savings based on measures installed and actions taken. Participants implement the measures themselves or hire contractors.
- BPA T&T is promoted by BPA and by the participating utilities. Energy Smart Industrial Partners (ESIPs) or Technical Service Providers complete a scoping study that is followed up by an audit. TSPs or ESIPs identify action plans, which the facilities implement. The program implementer

[15] We use "rebates" to refer to all financial incentives.

conducts annual reviews throughout the agreement period to track annual savings and provide incentive payments.

4.2.3 M&V and savings estimation

All comparison programs rely on entities independent measure implementation to verify savings estimates. or confirm action items are completed.

- The Energy Trust O&M manages all program processes, which are handled by a network of approved trade allies and sub-contractors filling specific roles. The Energy Trust prepares a verification report. It's unclear if the Energy Trust verifies savings or just the changes made at the facility.
- Ameren and Com Edison use RSPs to identify recommended measures and to verify savings. Measures are implemented by the participant and their contractors.
- BPA T&T uses the program implementer to verify savings
- Comparison programs use a variety of methods and time frames to estimate ex-ante savings.
- BPA T&T uses whole facility regression models based on a minimum of 90 post- implementation days of daily data. On-going daily metering supports annual incentives for sustaining savings.
- Ameren and ComEd RSPs use a variety of bottom-up methods to estimate savings. Some RSPs use loggers or other measurements to support their estimates.

The ISOP program implementer estimates ex-ante savings using whole facility regression analysis for sites where savings are considered sufficient to be observed. The implementer performs individual measure calculations where savings are expected to be less than or equal to 2 percent or less of the facility's baseline consumption.

4.3 Best practices discussion

The program implementer delivers the program using best practices for many aspects of the program's implementation. Table 20 shows our assessment of ISOP compared with best practices. The highest rating, 3, indicates that ISOP is consistent with best practices. A rating of 2 indicates that ISOP somewhat consistent with best practices, and 1 means best practices are not used.

Table 20. ISOP Program Relative to Best Practices

Selected Best Practices	ISOP Rating	Discussion
Program planning		
Develop a sound program plan.	3	Well planned.
Articulate a program theory or objectives beyond savings goals	1	No written program theory or logic model. Only kWh goals.
Maintain program design flexibility to respond to changes	3	Program made changes to address challenges
Design program tracking system to support program staff and evaluators	3	Detailed tracking facilitates program delivery and evaluation.
Program marketing		
Include the non-energy benefits of energy-efficiency in the value proposition	1	Primarily focus is on savings and payback.

Selected Best Practices	ISOP Rating	Discussion
Include a mix of technical (engineering) and non-technical staff in program delivery	2	Non-technical staff for administrative tasks only.
Provide case studies of successful projects to potential participants	1	Not used.
Program delivery		
Develop long-term relationships with industrial customer	2	PSE staff's limited involvement may be a missed opportunity.
Build-synergies between program offerings	2	ISOP marketed to select customers, limiting opportunity for synergy. Some overlap between ISOP and other PSE incentive programs.
Avoid program overlap	2	
Keep program participation easy for customers.	3	ISOP, relative to similar programs, is easy for participants.
Use well-qualified engineering staff.	2	Program implementation staff well-qualified for refrigeration focused measures. Possible weaknesses for other systems
Automate routine functions as much as possible.	3	Program implementation staff rely on templates for project documents, and excel workbooks for refrigeration and compressed air recs and savings estimates.
Take steps to ensure that settings and behaviors are maintained.	1	Program has no requirements shown to increase persistence.
M&V		
Ensure robust monitoring and verification	3	Consistent with best practices, except not completed by independent third party. PSE does review all M&V plans and reports for approval.
Use a whole-facility regression modeling approach (IPMVP Option C) to estimate savings ISOP	3	Consistent with best practices.
Complete third-party program evaluations periodically	3	Consistent with best practices.
For each facility use appropriate independent variables to account for typical variation in energy consumptions.	2	Mostly consistent with best practices.

PSE's ISOP has one of the simplest delivery structures: one single entity ,the program implementer, is responsible for all aspects of the program. This makes the program easy for participants; they need to interact with fewer people. The simple delivery structure increases consistency within and across sites, likely increasing efficiency as well as keeping program costs down. Although the approach is efficient, it deviates from the best practice of independent measurement and verification. PSE's review and approval of key documents, as well as periodic independent evaluations may mitigate the risks associated with the lack of independent verification.

The literature review and comparisons point to some areas where PSE could enhance the program that include:

- Adding non-energy benefits to discussions with customers about participating in the program. Identify additional program objectives to guide program decisions
- Providing higher incentives for accelerated implementation of action items, if the time frame is problematic
- Leveraging natural synergies across industrial programs to increase industrial program participation

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Based on the findings presented in Section 3 and Section 4, the research team draws the following conclusions about the success of the program and the participant experience.

5.1.1 Program delivery

- **Energy savings at lower-cost:** PSE staff targeted delivering program energy savings at a maximum of $0.13 per annual kWh; however, ISOP performed better than the target with savings delivered at $0.10 per annual kWh.
- **Meets best practices:** Overall, the program meets and in some areas, exceed best practices for program delivery and measurement and verification;
    - **Well executed:** In terms of delivery, all parties clearly understand their roles and responsibilities They execute program processes consistently and project documentation and program tracking data are detailed and complete.
    - **Excellent documentation:** Project and program documentation are detailed and comprehensive. Project folders contained complete information on baseline usage estimates, recommended action items, estimated savings and the savings estimation approach. Program implementation tracking workbooks include substantial detail that facilitated a thorough evaluation.
- **Satisfied participants:** According to the survey, program participants are very satisfied with many aspects of the program and with the interactions with the program staff.
- **Program influence.** The program is generating increased participation in other PSE programs. Participants state (via the survey) that their experience with the ISOP program influenced their decision to try other PSE programs as they implement other capital projects.

5.1.2 Program impacts

Overall, the ISOP program appears quite successful and has achieved nearly 90% of ex ante savings. Key findings regarding program impacts follow:

- **Substantial savings**: The program achieved significant savings while focusing only on O&M activities. The evaluation verified 18.2 GWh of energy savings, representing an average of 8 percent reduction of electricity consumption from the baseline of ISOP participants. These savings were achieved with a realization rate of 89 percent compared to the ex-ante savings, as shown in Table 1.
-

Table 21. Verified electricity savings

Program measure group	Sample n	Population N	Total ex-ante Savings (kWh)	Total ex-post Savings (kWh)	Realization Rate	Relative Precision at 90% Confidence
Refrigeration	17	29	17,601,885	15,369,129	87%	5.0%
Pumps, Fans, Blowers	5	6	2,514,062	2,363,924	94%	3.6%
Compressed Air	2	5	313,765	370,807	118%	14.7%
Other (primarily HVAC)	1	1	80,600	80,600	100%	0.0%
Overall	**25**	**41**	**20,510,312**	**18,184,459**	**89%**	**4.2%**

- **Evidence of persistence** Almost all action items continue to persist across all categories, including behavior/maintenance, settings (set-point and schedule adjustments), and hardware (purchased items). The evaluation found that 97 percent of the action items completed at time of measurement and verification (M&V), were still in place at the time of the evaluation site visits. Although the evaluation occurred less than five years after the performance period (between 6 months and 30 months), 9 percent more action items were completed since the conclusion of the program M&V and payment of the incentive. These observations, as well as the literature review suggest that five years is a reasonable measure life.
- **Highest savings for refrigeration projects:** Refrigeration measures drive overall program results with 71 percent of projects and 85 percent of program savings. The success for this measure is due largely to targeting customers with large refrigeration loads with opportunities for substantial savings and to the program implementer's specific and deep expertise in this area.

5.2 Recommendations for adaptive management

While overall the program is meeting and exceeding targets, the team offers the following recommendations to improve savings calculation accuracy:

- **Reform calculation methods.** The team recommends the program select model variables and relationships that are consistent with the energy consumption of the operations and to avoid use of calculated variables unless there is a demonstrable reason why the variable drives energy consumption. While the overall realization rate was high, the team found that site-level realization rates varied considerably. This variability could be due to incorrectly estimating savings based on factors with a high correlation to usage for the performance period even though those factors were not drivers of energy consumption.

- **Extend the minimum performance period.** The current 60-day minimum is very brief and the evaluation team believes that this brevity reduces the accuracy of the savings estimates. The evaluation team recommends a period of 90 days for facilities with consistent plant loads with even longer periods for inconsistent or seasonal plant loads. The length of the periods sufficient to capture seasonality should be assessed on a case-by-case basis for facilities considering the site-specific seasonal loads. The goal of the longer periods is to capture a more representative of the annual range of conditions, thereby improving savings accuracy.

5.3 Suggestions for consideration

In addition to the above recommendations, the research team offers the following for PSE's consideration for prospective program delivery.

- **Expand the program to address a wider range of industries within PSE's service territory.** The program has addressed cold storage and food processing, but not many other sectors. The program can bring in deep expertise in a wider range of industrial systems to increase savings and provide ISOP services to a broader range of PSE industrial customers. PSE can achieve this by identifying and contracting with industry specific experts for specific sites.
- **Incorporate action items that facilitate ongoing maintenance practices to increase savings retention.** Maintaining maintenance practices and optimal settings can be challenging, especially when routines are not established or personnel change. The research team identified multiple approaches used by similar programs to address this risk, such as; training facility personnel, requiring new practices are added to the facility SOP or similar document, continuous monitoring, and delaying incentives.
- **Offer higher incentives for completing implementation steps within a specified timeframe.** Two of the comparison programs were successful in using financial incentives to accelerate project completion. The program could use this approach to accelerate the customer commitments to an optimization event and to accelerate implementation. Providing incentives for rapid commitment to an optimization event may also reduce the number of scoping studies needed to meet program goals.

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Appendix A. EVALUATION METHODS

This section provides a description of the methods used in the impact and process evaluations. Additional detail on the methods as well as the data collection forms are provided in the appendices.

Tracking data review

The goal of the tracking data review was to determine the accuracy and completeness of the available program data for developing savings and persistence results. Specifically, the research team reviewed the documentation to compare the program tracking (ex-ante) energy savings to the savings listed in the reports provided to program customers. The research team also reviewed the participant-site files to assess its usefulness in determining energy savings. For each project, PSE provided the following files: scoping report, action plan, M&V report, energy savings spreadsheet, incentive invoice, and incentive rebate check.

On-site data collection

The objectives of this task are to develop an understanding of the sampled projects, collect data to support gross savings evaluation estimates, and use that data to calculate individual site-level evaluated energy savings.

Sample disposition

We attempted to contact all of the participants with savings in the program using the project contact information provided in the M&V reports. Backup sites were contacted if a sampled site refused or was found to be non-responsive. The research team completed 28 site visits from the sampled and backup sites.

After the research team had made at least four attempts to contact by phone and email, five project contacts were characterized as non-responsive. One of these sites was no longer operational. Another project contact requested more information about PSE’s requirements, but after receiving it did not respond.

Four of the project contacts refused to participate in advance; three of these were represented by a single contact responsible for the three projects. One project was removed from the sample because they claimed they had no knowledge of the program and would not be able to do anything to support the evaluation. Table 22 shows the disposition of the sample.

Table 22. Site-visit sample disposition

Sample Disposition	Number of Projects
Site visit completed, savings estimated, action items verified	25
Site visit completed, action items verified, but savings not estimated	2
Site visit attempted, but project contact could provide no information*	1
Non-Responsive	6
Refused	5
No savings; no site visit attempted	2
Total projects	**41**

*One site the research team visited had almost no available information, as the facility lead was no longer at the plant and no one remaining was familiar with the program. At this site, the research team were unable to assess action items or the savings calculation.

It is important to note that 25 projects remain in the evaluated sample although 27 site visits were completed. Savings from two projects were considered indeterminate because the baseline period for the savings calculations was during a time of changing site conditions that affected energy consumption. At one of these sites, the facility underwent significant remodeling during the baseline period. At the other site, a fire occurred and the facility operated at a significantly reduced capacity for a portion of the baseline period. Action items were verified at these two sites, but savings were not estimated for these projects. Instead, the savings for the projects are based on the evaluated savings for other projects in the same program measure group.

Table 23 shows the relationship between the sample and the program population in regards to number of sites and ex-ante savings. The site visit sample represents 58 percent of the savings for both program cycles.

Table 23. Relationship of the sampled sites to the population savings

Program Measure Group	Projects		Ex-ante Savings		
	Population	Site Visit Sample	Population	Site Visit Sample	percent of Savings
Refrigeration	29	17	17,601,885	10,710,024	61%
Pumps, fans, and blowers	6	5	2,514,062	958,349	38%
Compressed Air	5	2	313,765	225,544	72%
Other*	1	1	80,600	80,600	100%
Total	**41**	**25**	**20,510,312**	**11,974,517**	**58%**

*The program identified one facility as other, without a dominant energy system addressed by the program. Action items completed were related to HVAC, lighting, refrigeration, and plug load items.

Impact evaluation data-collection planning

The objectives of the on-site data collection were to support the energy savings calculations and to support estimates measure persistence and measure life.

To estimate energy savings, the research team required sufficient information about the participant site operations to assess the validity of the ex-ante methods. To obtain this information, the research team asked program project contacts about operational schedules and equipment or processes driving energy consumption. Additionally, for projects where regression analysis was used, the research team collected data on factors that affect energy consumption that were included as variables in the regression model. The research team also asked project contacts about any capital projects that may have produced energy savings so that these changes could be incorporated into the calculations. Capital projects undertaken outside of the program were separated out to avoid double counting with other programs, as well as to focus on what the program rather than other efforts achieved. To assess whether the baseline model was still applicable, the research team inquired asked about any changes to the facility that would affect how energy is consumed.

To assess measure life and persistence, the research team asked a series of questions regarding maintenance and operational practices. These included the type of maintenance approach (proactive or reactive), whether energy management was ongoing, and how action items were incorporated into permanent maintenance practices. In particular, the research team sought out information that indicated which completed action items were more likely to stay in place. For example, the research team anticipated that adjustments to equipment set-points or process schedules are more likely to persist at facilities that incorporate action items into written industrial standard operating procedures. Similarly, the research team hypothesized that maintenance and behavior actions are more likely to continue where facilities are less reactive in their maintenance practices and have a designated energy team or energy manager.

The on-site data collection instrument for this evaluation is provided in Appendix D. The instrument guided the field team on the questions to ask to assess action item completeness and measure persistence.

Once the project contact agreed to a site visit, research team engineers reviewed the participant project files for each sampled project to develop an understanding of the activities undertaken during the program. They examined the documentation for the details of the action items and the calculation methodology. The baseline plan provided the information for the regression analysis. The action plan report and the M&V reports listed all of the identified action items. Research team engineers prepared a matrix for each site that listed all of the action items to be verified.

Site-visit verification and interviews

During each site visit, a research team engineer asked the project contact about each identified action item and confirmed implementation status and persistence. The engineer also collected data to support the calculation of savings, discussed any developments that may affect measure savings, such as load or schedule changes, and determined the availability of any data streams that may assist in the savings calculations. Availability of site trend data and production schedules were requested as needed. The research team also asked about their operating and maintenance practices to assess persistence as described in the previous section.

Site-visit sample design

The research team developed a site-visit sample design to support estimates of program gross savings. Since the program population is dominated by refrigeration projects, the non-refrigeration projects were given priority within the sample in order to ensure that all program measure groups get adequate representation in the evaluation. For each of the four program measure groups, the research team stratified the projects based on the magnitude of savings.

The program for 2012 through 2015 had 41 projects. Two projects had zero reported ex-ante energy savings.[16] All 39 projects with savings in the population were designated either as primary or back-up sample points, with 28 sites in the primary sample. The expected overall precision was 8 percent at the 90 percent confidence level. The sample design memorandum in Appendix A provides a detailed description of the sample design.

Impact analysis strategy

Verify and determine program savings estimates

The research team applied the following steps to assess program savings for each site in the completed sample:

1. Review program savings calculations for errors in assumptions or operating characteristics, and other errors.
2. Recalculate savings to adjust for any identified errors, as well as equipment and operational changes identified in site-visit.

[16] Although these site participants completed action items, their site-level energy consumption increased. One site was an ice arena and the other a beverage manufacturer and both were refrigeration ISOP sites that completed fewer than ten action items.

3. Calculate a site-specific realization rate.

The research team reviewed the ex-ante calculations for the five projects that used spreadsheet calculations for specific action items, and adjusted methods and inputs as needed.

For those sites where the implementer based the ex-ante savings on whole facility regression analysis, the research team developed a protocol for the review and revision of the regression analysis. The research team assessed the reasonableness of the regression analysis form and variables, based on both statistical parameters and whether the form appeared appropriate to model energy consumption in the performance period. The research team considered whether the savings were reasonable based on the action items performed. The research team checked the regression by reproducing it, looked for errors and approach to removing potential data outliers. Last, the research team revised the regression equation, if necessary, based on our review, and recalculated the savings.

As part of the reasonableness assessment, we reviewed the relevant variable selections to ascertain if they made intuitive sense as an indication of energy consumption. In addition to weather, the implementer developed regressions with a range of relevant variables specific to operation characteristics, such as production quantities, labor hours, ice "cuts" at ice arenas, days of the week, and influent flowrates at wastewater plants.

The research team also tested calculated variables and indicator variables. An indicator variable would have a value such as zero or one, reflecting that certain criteria were met. Examples of a calculated variable are square root of production and the maximum of average daily dry bulb temperature. Indicator variables included days of the week or the end of a production period (e.g., the variable equals one on the production days followed by non-production days), or other factors influencing energy consumption such as the height of the river next to the wastewater plant (e.g., if the river was low, pumping could be avoided).

The models attempt to include key variables that apparently determine consumption in the baseline period and extend these relationships to show the effect of the program. Other factors that are either not causing variation in the baseline period or are not included in the model may also effect energy consumption. Thus, changes in the operation of the facility that were not included in the model can cause the model to be less predictive of energy consumption after the baseline period. The short performance period to assess the ex-ante savings is another limitation, as the savings that are projected to annual savings may not reflect the range of conditions and seasonal variations experienced in the plant over time.

When data were available and the regression could be expanded to the evaluation period, we attempted to predict the savings based on current conditions. For the majority of sites, this included extending the facility regression model to the present using updated production, weather, and energy consumption data. We extended the regression model for 12 of the 22 sites where regression modeling was the calculation method. At eight sites, we were not able to expand the regression because data were not available or were not sufficiently granular for use in the regressions. For example, some project contacts provided monthly data when the regression interval was daily, or very rough estimates of production quantities.

Appendix E provides additional detail on the analysis methods for estimating ex-post savings.

Following the development of site-specific savings, we extrapolated the savings from the sample to the population using ratio estimation techniques, which are described in detail in Appendix F.

Assess measure life and persistence

PSE currently assumes a five-year measure life for ISOP. Measure life is typically defined as the number of years when 50 percent of the implemented measures cease to realize energy savings.[17] For this program, the action items were assessed at three points in time: at the time of the optimization event, following the program performance period and during the evaluation site visit. The research team calculated, for each site, the time between program completion and site visit to assess persistence. The site-visit data showed very little change in action items completed, which precluded quantitative analysis to identify patterns.

We assessed the reasonableness of the five-year measure life, based on the rate of completion of action items at the evaluation site visit compared to the program M&V report. The research team also looked at the types of action items, and the reasons why they failed or succeeded. Finally, the research team reviewed relevant literature and the results of the best practices analysis as a guide to measure life.

We used the questions asked about maintenance practices to assess persistence of the actions taken. Specifically, facilities provided information about whether they practiced predictive or preventative maintenance and what efforts they may have taken to assure the actions items persist.

Program staff interviews

An essential task for the process evaluation was conducting in-depth interviews (IDIs) with those responsible for program planning, administration, and implementation. These are the people who know how the program works in practice, may identify other evaluation needs, and are interested in the evaluation findings.

The research team completed interviews with PSE and program implementation staff in person or via telephone over the course of the project. Potential respondents were contacted by the interviewer to explain the purpose of the interview and to schedule a time for completion. Respondents were promised confidentiality, in that no responses would be tied to an individual. We developed a single interview guide for all respondents that is provided in Appendix D. The interview focused on areas that pertained to the respondent based on his or her program role. Interviews times ranged from 35 minutes to 1.5 hours.

Prior to the project kickoff meeting the research team completed three in-person IDIs; two with PSE staff members and one with the implementer’s program manager. The purpose of these IDIs was two-fold: to develop a greater understanding of the program to inform the final work plan, and to identify any issues they wanted addressed in the evaluation.

Subsequent to these interviews the research team completed telephone interviews with three program implementer field staff members who had worked on ISOP projects: two serving as project engineers

[17] This definition is provided on page 22 of the EPA EM&V Guidance for Demand Side Energy Efficiency, https://www.epa.gov/sites/production/files/2015-08/documents/cpp_emv_guidance_for_demand-side_ee_-_080315.pdf

and one as a technician. The research team selected these staff members from a list that of the program implementer staff who had worked on ISOP and the number of projects on which they worked.

The original place included interviews with additional PSE staff, such as Energy Marketing Engineers or Major Account Engineers associated with ISOP projects. When these staff members were contacted by the PSE evaluation staff, they reported that they had little involvement in the program. No interviews were completed with these individuals.

Program participant online survey

The overall purpose of the program participant survey was to assess customer satisfaction with the program as well as motivations and barriers to participation. Given the small size of the participant population, the research team expanded the sample population to include partial participants (sometimes referred to as drop-outs) to better understand the challenges to participation. The PSE Evaluation Manager, other PSE staff members, and the implementer program manager assisted in survey design to assure that the interview questions were relevant to the respondents. The survey included a mix of closed- and open-ended questions. Close-ended (categorical) questions were included to ensure that consistent information was provided from all respondents; open-ended to ensure that respondents had a chance to fully share their thoughts on the issues addressed.

Survey sampling, recruitment, and response rate

The survey sample population included participants and partial participants from the 2012-15 program years. Participants were identified as PSE customers who received rebates through the program. Partial participants were customers who received a program Scoping Study Report but did not continue further in the program.

Program records identified 36 contacts for the 41 completed projects. Because some companies completed multiple ISOP projects, there were fewer contacts than the total number of projects. If a company had different contacts for different project sites, the research team attempted to reach each of the contacts.

The research team used program tracking workbooks to identify 37 partial-participant projects. These projects had a current status of “scoping report approved” and a designation of “dead.” Scoping study reports, which included contact information, were found for 25 of the remaining projects (23 contacts for 25 partial-participant projects).

The research team recruited project contacts via email Oct. 18, 2016 through Nov. 9, 2016. The PSE Evaluation Manager initiated contact with an advance email informing participants of the survey and requesting their participation. Next, the research team sent an initial email with a link to the survey and two follow-up emails to non-respondents. The sample disposition is in Table 24.

Table 24. Participant survey sample disposition

Disposition	Participant		Partial Participant		Overall	
	Contacts	Response Rate	Contacts	Response Rate	Contacts	Response Rate
Complete[1]	15	**42%**	4	**17%**	19	**32%**
No response	14	39	12	52	26	44
Email bounced	5	14	6	26	11	19
Terminated[2]	2	6	1	4	3	5
Totals	**36**	100%	**23**	100%	**59**	100%

1 Four of the participant respondents represented two projects each.
2 Two contacts started work at the facility after program participation. A third was transferred to another facility and did not provide another contact person.

Survey data analysis

Analysis of survey responses was limited to frequencies, with discussion of the results within the context of the program and evaluation objectives. The small participant population and respondent sizes do not lend themselves to more sophisticated quantitative analyses or comparisons of subgroups.

Best practices research

PSE identified three focus areas for the identification of best practices or recommendations for modifications. These areas were:

- Implementing and estimating savings from behavioral and O&M programs
- Reviewing the ISOP's M&V approach relative to industry best practices
- Reviewing PSE's rebate structure for recommended modifications, if applicable

The research team proposed and completed a two-pronged approach to address these issues: secondary research and a comparison of PSE's ISOP to programs with similar offerings. We discuss each of these next.

Secondary research

The secondary research relied on publicly available information from four types of sources:

- **Government and non-profit sponsored reports.** The American Council for an Energy-Efficient Economy (ACEEE), the State and Local Energy Efficiency (SEE) Action Network, and various federal agencies have publications addressing industrial energy efficiency programs of all types, or O&M programs specifically (but not necessarily industrial). ACEEE identified and described exemplary industrial programs. SEE Action Network, in its Designing Effective State Programs for the Industrial Sector,[18] discussed successful approaches to promotion, design and implementation of industrial programs using existing programs as examples.

- **ACEEE and IEPEC conference proceedings.** The research team identified several papers in these conference proceedings that addressed industrial O&M or retro-commissioning programs. They provided marginal value in meeting evaluation objectives, so effort in this area was limited.
- **Utility and public benefit program administrator online sites.** The research team used these online sites to identify programs similar to ISOP, as well as to find information for the program comparisons.
- **Industrial program evaluation reports.** When available, we used evaluations of the comparison programs to learn more about the program offering, to identify potential issues and successes, and to determine, if possible, measure life used.

Program comparisons

The research team used program comparisons to identify how other programs handle measurement and verification, rebate structures, and program delivery in general. The first step was to identify industrial programs with similarities to ISOP on multiple attributes. A threshold requirement was that comparison programs must target industrial customers and include financial incentives for O&M measures. We identified ten potential comparison programs through secondary research, by asking informed colleagues, and by searching program administrator online sites. We selected four programs for comparison with the following factors in mind:

- Availability of evaluation reports and other program information (not always available)
- Location—to get at least one in the northwest and one in another region
- Subsectors or measures that overlap with ISOP
- Scoping study or some form of technical assistance
- Success (met objectives)[19]

Analysis

We developed program descriptions and comparison tables to compare program features and identify differences across the programs. From the secondary literature, we culled successful or recommended practices applicable to the program. We used this information to inform our recommendations for potential modifications to the program.

Describe program activity and evaluated patterns

We used multiple data sources to combine and synthesize the myriad data collected to better describe the program and savings, as well as to identify patterns to inform recommendations to improve program efficiency and efficacy.

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[18] See Section 6 for the full citation.

[19] The research team could not determine whether comparison programs had met their goals based on publicly available information.

These analytics combined information and data provided by PSE and the program implementer, as well as data collected, compiled, or calculated by the research team. These data included:

- PSE records of program expenditures
- Program implementer data:
    - Program expenditures by project and activity
    - Project timing by activity
    - Project files
- Evaluation data:
    - The evaluation team categorized action items by type (hardware, settings, and behaviour) and by subsystem based on information in the project documentation. (see Project/Action Item data set for more detail.)
    - The status of action items at the time of M&V was in the project documentation and compiled with the status identified during the evaluation site visit (complete, partial, cancelled, not done)
    - Ex-post savings and other energy usage characteristics
    - Responses to questions regarding business practices

The data were compiled into two comprehensive files for analysis: one at the project level, and one at the project/action-item level.

Project-level data set

The research team combined data from the on-site verifications, on-site surveys, savings analysis, project files, and program administrator tracking into a project level data set that included:

- **Project costs.** The costs were tracked by step within the program, from the scoping study through the program implementer's final M&V report. Steps tracked included the scoping study, optimization event, follow-up, M&V plan development, and incentives.
- **Project timing.** The program implementer also tracked the dates for each milestone in the program, from when the participant signed Agreement A (to have a scoping study) through approval of the program M&V report.
- **Energy information.** This included baseline usage, ex-ante and ex-post savings, and realization rates
- **The program implementer-designated program measure groups**:
    - Refrigeration
    - Pumps, fans, and blowers
    - Compressed air
    - Other
- **Summary information on the status of action items** in the program M&V report and observed during the evaluation site visit. Status designations were:
    - Complete

- Partially complete
- Cancelled
- Not completed

- **Characteristics provided by participants**, including operating hours, maintenance practices (i.e. preventive or predictive), and whether the action items had been incorporated into company standard operating procedures.

Project/action-item data set

The second data set was at the project/action item level. In other words, each case was associated with an action item that was recommended at a specific site. This data set included the 713 action items for the 27 projects that had a site visit. This data set allowed for a more detailed analysis of the types of action items that were implemented. This data set contained, for each action item at a site:

- **Sub system** (designated by research team)– Lighting, compressed air, refrigeration, HVAC, pumps-fans, doors (for refrigerated rooms), material handling, and other
- **Action item type** (designated by research team based on description in project file):
  - Behavior – Maintenance (e.g., repairs, cleaning, changing filters) and other on-going behavior practices (e.g., closing doors, turning off equipment)
  - Hardware – All action items that require purchasing equipment such as controls (e.g., occupancy sensors, control system upgrades) and other items for efficiency and measurement
  - Settings - Adjustments to schedules, cycling times, and other controls or valves (e.g., pressure and temperature), and equipment calibration. In some cases, the settings may be permanent, while others may require changes based on season, production levels, or other factors.
- **Action item status** at M&V and evaluation site visit
- **Program group and industry type.** The project designation by the program implementer and industry type as designated by the research team. We created industry types to explore potential patterns across industries, rather than by end-uses. This allowed for more differentiation among the participants. The industry types identified for the 27 projects are:
  - 10 cold storage
  - 8 food processing
  - 4 water/wastewater treatment plant
  - 5 "other" industry type

Analysis

The analysis provided descriptive statistics on program participation, action item adoption, and project timing and costs. It also included exploratory analysis to identify patterns in participation, action item adoption, and a savings to improve program efficiency and efficacy.

The research team had two sources of program costs. PSE provided budgets and monthly program costs for the two program cycles evaluated. The program implementer provided disaggregated project level costs, as well as amounts billed monthly to PSE. These costs were allocated to site related program activity (e.g., scoping report, optimization visit, and to overall costs (e.g. marketing). The program implementer’s tracking data provided a rare opportunity to analyse highly disaggregated costs and milestones to explore patterns.

Appendix B. SAMPLE DESIGN MEMORANDUM

Memo to:
Michael Noreika
Puget Sound Energy

From: Julia Vetromile, DNV GL

Date: May 25, 2016

Prepared by: Santosh Lamichhane

Subject:
Sample Design for the Industrial Systems Optimization Program Evaluation

Summary

This memorandum presents DNV GL's proposed sample design for the ISOP evaluation. The sample design method used ratio estimation to select 28 projects from the 39 projects with energy efficiency savings in the tracking data. The expected overall precision is 8 percent at the 90 percent confidence level. Achieving the precision will be dependent, in part, on recruiting the largest sites for the evaluation.

Background

The ISOP program for 2013 through 2015 developed 41 projects to save energy through operations and maintenance measures. The evaluation of this program begins by selecting a sample of program participants to represent the population. DNV GL plans to estimate the ISOP ex-post gross savings by evaluating a sample of projects and expanding the results of the sample to the program population.

The primary objective of the sample design is to support estimates of program gross savings, with the overall precision no worse than 10 percent at 90 percent confidence level (two-tailed). A second objective is to adequately represent all measures. Since the ISOP population emphasizes refrigeration projects, the sample was designed with stratification by dominant measure to make sure the non-refrigeration projects were represented. The research team used ratio estimation to optimize the measure and program level estimates.

Stratification

Stratification is an important and commonly used design feature in most evaluation efforts. Stratification refers to the process of partitioning the sample frame into distinct groups (called strata) and sampling is done independently within groups. Stratification is often used to (1) improve precision of the final estimates and (2) control the sample size by subgroups of interest during the analysis. Precision is improved if strata are formed so that the population is relatively homogeneous within each stratum and relatively heterogeneous between strata.

For this study, the sample will be selected independently within stratum defined by the following:

- Size: Strata were created by size by looking at the distribution of energy saving among all projects within the program measure group. The research team chose to stratify by size in order to ensure an adequate number of small, medium, and large sites in the sample.

- Program measure group: Each program measure group was sampled separately. For the non-refrigeration projects, the largest ones were selected to be in the sample at a minimum to ensure representation. For refrigeration measures, the ratio estimation technique resulted in the selection of the largest 13 projects. Additional projects were randomly selected from all measure groups, as available.

The sampling methodology consisted of the following distinct steps:

1. Stratify the measure level data based on magnitude of kWh savings.
2. Use ratio estimation sampling techniques to optimize and set the target number of samples in each stratum.
3. Specify primary sample and backup samples in each stratum. Primary samples have the highest priority to collect required data. In an event when data cannot be collected for primary sample, use the backup sample with next priority.

Measure data and sampling

The data the research team began with had 41 projects with four program measure groups. Two of the refrigeration projects had zero savings. These projects were removed from the sample.

Table 25 shows the distribution of savings and number of projects across each measure group.

Table 25. Counts and expected precision by program measure group

Program Measure Group	Sample Projects	Total Projects	Expected Relative Precision at 90% Confidence	Percent Program Savings (kWh)
Compressed air	2	5	57%	2%
Pumps, fans, and blowers	3	6	43%	12%
Refrigeration	22	27	7%	86%
Other	1	1	0%	0%
Total	**28**	**39**	**8%**	**100%**

Expected precision overall is +-8 percent and is +-7 percent for the refrigeration category at 90 percent confidence. As refrigeration group accounts for 86 percent of savings, overall precision is driven by this group. Since four of the largest projects account for 39 percent of the total sample, achieving the expected precision will be dependent on recruiting the largest sites.

Based on experience with similar industrial studies, the research team anticipates an error ratio of 0.8 or less. The error ratio is a summary statistic of variability between tracking savings and the ex-post savings. If the evaluation finds an error ratio of better (less) than 0.8, then the achieved relative precision will be better (smaller) than the expected values shown in Table 25.

Table 26 shows expected precisions for refrigeration and non-refrigeration categories.

Table 26. Counts and expected precision by measure category

Measure Category	Sample Projects	Total Projects	Expected Relative Precision at 90% Confidence	Percent Program Savings (kWh)
Refrigeration	22	27	7%	86%
Non-refrigeration	6	12	38%	14%
Total	**28**	**39**	**8%**	**100%**

The sampled projects reflect 91 percent of the total savings. All other projects are included as the backup sample.

Appendix C. TRACKING DATA MEMORANDUM

Memo to:
Michael Noreika
Puget Sound Energy

From: Julia Vetromile, DNV GL

Date: June 10, 2016

Prepared by: Ankita Goel

Subject:
Tracking data review for the Industrial Systems Optimization Program (ISOP) Evaluation.

Summary

This memorandum presents DNV GL's review of tracking data for the ISOP evaluation. The principal objectives for this task are to develop an understanding of the program's scope and reach, in terms of customers and measures, and to determine the completeness of the available data. DNV GL reviewed all the completed project files under this evaluation period. For each project PSE provided the following files: scoping report, action plan, M&V report, energy savings spreadsheet, incentive invoice, and incentive check. All the claimed savings in the M&V reports were found to exactly match with the values in the tracking database. DNV GL is pleased to report that the documentation provided was consistent and each project file was complete.

Background

The ISOP program for 2013 through 2015 developed 41 projects to save energy through operations and maintenance measures.

PSE provided the following list of files for each completed project:

- **Scoping Report:** This report identifies annual electrical energy cost savings for the facility. These savings were identified based upon a brief scoping walkthrough. The intent of this scoping phase is to identify the rough savings potential with sufficient accuracy to allow a facility to confidently commit to the next phases of participation.
- **Action Plan**: The intent of the action plan report is to identify energy efficiency opportunities that may have merit, and to provide preliminary estimates of economics.
- **M&V Report:** This report outlines the completed action Items, documents final implementation costs, and presents the energy savings and incentives resulting from the implementation of Puget Sound Energy.
- **Energy Savings Spreadsheet:** Each completed project file included spreadsheets for calculating energy savings, either using a facility energy regression model or measure specific calculations.
- **Incentive Invoice and check**: These two documents provide the final incentive invoice and check that was given to the facility after the completion of the ISOP measures.

Report review

All the reports were reviewed to check the savings estimation methodology. The scoping report documented the scope very well. The M&V report clearly states the reasons why certain identified action items were not implemented. Table 27 represents the summary of total and average number of action items identified and completed.

Table 27. Total and average number of action items completed and identified

Measure	Total Number of Action Items Identified	Total Number of Action Items 100% Completed	Average Number of Action Items Identified	Average Number of Action Items 100% Completed
Compressed Air ISOP	80	27	16	5
Other ISOP	24	18	24	18
Pumps, Fans, Blowers ISOP	104	53	17	9
Refrigeration ISOP	834	549	29	19

Savings estimation documentation

All the projects have either an engineering calculation spreadsheet and/or a regression model spreadsheet to estimate savings. The program implementer initially attempted to calculate energy savings by a facility regression model. In some cases, the savings were low as a percent of annual consumption, suggesting that a whole facility regression model might not be able to isolate the effect of the program. In those cases, end use calculations were performed.

Table 28 presents the savings calculation methodology used to calculate energy savings for the whole program by each program measure group.

Table 28. Savings calculation methodology used

Measure	Savings Calculation Methodology	Number of Projects Using Particular Savings Calculation Methodology
Compressed Air ISOP	End-Use	3
	Regression	2
Other ISOP	End-Use	1
Pumps, Fans, Blowers ISOP	End-Use	1
	Regression	5
Refrigeration ISOP	End-Use	3
	Regression	26

Regression analysis was the most common approach for estimating energy savings; it was used for 33 projects. The explanation about the variables used in the regression model or parameters used in end use technology savings calculations is documented in the M&V report. Energy savings for eight projects were estimated using engineering calculations by isolating end-use technology.

DNV GL also looked into the M&V reports to observe the total targeted energy savings and total energy savings achieved by the program. Table 3 represents the summary of savings targeted and achieved by program measure group.

Table 29. Total and average energy savings targeted and achieved

Measure	Total Targeted Energy Savings (kWh)	Total Energy Savings Achieved (kWh)	Average Targeted Energy Savings (kWh)	Average Energy Savings Achieved (kWh)
Compressed Air ISOP	1,021,000	313,765	204,200	62,753
Other ISOP	231,005	80,600	231,005	80,600
Pumps, Fans, Blowers ISOP	2,732,300	2,514,062	455,383	419,010
Refrigeration ISOP	17,028,500	17,601,885	587,190	606,962

DNV GL reviewed the M&V reports to see the percent reduction in annual energy consumption for each project. Table 4 provides the average of percent reduction in annual energy consumption. It was found that the sites with refrigerant measures have the most energy savings as a percent of reduction from their baseline consumption.

Table 30. Average percent reduction in annual energy consumption

Measure	Average % Reduction in Annual Energy Consumption
Compressed Air	2%
Other	1%
Pumps, fans, and blowers P	9%
Refrigeration	11%

Overall Findings

The overall findings of the tracking data review for the Industrial System Optimization program are as follows:

- The files for the ISOP completed projects are clear, consistent, and complete.
- Claimed energy savings from the tracking database were checked with the savings reported in the M&V report. All the savings were found to exactly match between the two documents.

- The reason for using a particular savings approach is well documented.

All the projects have energy savings spreadsheets.

Appendix D. DATA COLLECTION INSTRUMENTS

Site interview instrument

Plant Maintenance Practices Global Questions:

1. a What is the operational schedule for the facility?

Normal		Light Occupancy
M	_______________	_______________
T	_______________	_______________
W	_______________	_______________
Th	_______________	_______________
F	_______________	_______________
Sat	_______________	_______________
Sun	_______________	_______________

b Has the schedule changed since the ISOP project performance period? If yes, how so?

2. Approximately what percent of operating costs for this facility are for:

a Electricity ________%

b Natural gas _______%

3. Is there a person at this facility who is responsible for energy management?

Who is it?

4. Does your plant practice preventative or predictive maintenance?

Please describe your maintenance program.

What percentage of work orders are generated due to preventative or predictive maintenance vs responding to problems?

5. Have you incorporated any of these practices (from the action items) into your maintenance system?
    a. How?

6. Have you implemented additional energy efficiency actions beyond the ISOP action item list? (Goal is to determine if additional free drivership of savings is occurring)
    a. If yes ask: What were the measures and when were they implemented?

b. Was this measure implementation influenced or inspired by the ISOP project? (ask question of each measure)

7. Who has the primary responsibility for implementing the energy efficiency actions? Is it the energy team, maintenance team, production operators, or someone else

Plant Energy Usage Questions:

8. What are the drivers for energy consumption at your facility? (Discuss production, weather, types of products, seasonal variation, other)

9. Can you provide data for the drivers (outside of weather)? Specifically, can you provide the production data (same kind of data used by the implementer -list the independent variables used in the regression model)

10. Is there variation across your product line that causes changes in energy usage?
(In other words, are some of your products more energy intensive than others?)

    a. If yes, were there changes made the product mix either in the performance period (the time between when the ISOP project was initiated, and the final report) *(Indicate the performance period)* or after the performance period?

11. Have there been any changes in production levels or product types?

If yes, were these changes made the performance period (the time between when the ISOP project was initiated, and the final report) (*Indicate the performance period*) or after the performance period?

12. Have there been any capital projects that may have caused changes in the plant energy usage during the performance period or after? (additions, overhauls, major equipment changes, new product lines, etc). When were they implemented? Where they incentivized in a utility program? Which one? Is there documentation of the savings calculation?

Identify best person to provide information on-line (to support the process evaluation).

As part of the evaluation we will be collecting information about your company's experience participating in the program. The information is used to identify improvements to this program and other services that may be help to your business. The questions will address the program processes, reports, and challenges your company may have had.

13. Which of the following people would be the best one to send the survey to:
    a. Person A?
    b. Person B?
    c. Person C?
    d. Someone else?

What is this person's email address?

Program staff interview guide

This in-depth interview (IDI) guide is for the process evaluation of PSE's Industrial System Optimization Program (ISOP). Questions may not be read verbatim and additional probing or questions may be asked, as needed, to meet the interview objectives. All IDIs will be completed by one interviewer. Italicized content will not be read and is to inform any other readers of the guide.

Interview Objectives

- Identify the roles and responsibilities for the organizations and people delivering ISOP
- Discovery – learn what and how data are collected and tracked, and what documents are available to inform the evaluation
- Understand how the program is delivered
- Identify what is working well and what could improve, from the perspective of those involved in program planning and delivery

About the respondent and program goals

This puts the respondent at ease and establishes the context for responses.

- Background – education and job experience
- Length of time on ISOP
- Individual responsibilities in relation to the ISOP program?
- Percent of time devoted to ISOP
- Do you have the resources you need to do the job?
- What are the goals of the program?
- How well do you think the program goals are being met? (Why do you say that?)

Organizational responsibilities and communication

Identifies the roles of the organizations involved in marketing, program management, delivery, and QC. Also addresses whether there have been changes or any problems.

What are the responsibilities of _____ regarding the ISOP program?

- PSE
- Cascade
- Others (e.g. subcontractors, rebate processors)

Have there been any changes in responsibilities since the programs started? (If yes, what, when, why)

Program processes

This section addresses the program steps and processes. The focus of the discussion will vary based on the respondent's role in the program.

Let's talk about how the program works – from how a customer learns about the program, through the entire participation process. Start with how a customer might learn about the program.

Program steps for interview purposes are:
1) recruiting – sign agreement Part A.
2) scoping study and report.
3) sign Agreement Part B thru Incentive Payment.

For each step, probe regarding:

- Who is involved
- What paper work (e.g. application forms) is done, and by whom
- What is tracked, how it is tracked and where it is stored
- Role of participant/participant interaction
- What works
- What is problematic and why
- Follow-up
- Drop-out along the way – reasons, any common business characteristics (e.g., ownership or management structure)

Internal and external communication

Explores communication and information flow.

What types of ***formal*** communication (regarding ISOP) are there ***within*** your organization (e.g. regular meetings, reports, updates, other)? For each:

- Who
- Purpose
- Frequency
- Outcomes
- How well does this work?

What types of ***informal*** communication (regarding ISOP) are there ***within*** your organization?
What types of ***formal*** communication (regarding ISOP) do you have with CASCADE/PSE (e.g. regular meetings, reports, updates, other)?
What types of ***informal*** communication (regarding ISOP) do you have with CASCADE/PSE?

Customer characteristics and feedback

For respondents with participant contact.

What feedback, if any, do you hear from customers or participants about the ISOP program? For each:

- How common is this?
- With whom do you share this feedback?

- If an issue: follow-up to address the issue?

Closing

What are the greatest **strengths** of the ISOP program?

What are the greatest **weaknesses** of the ISOP program?

What suggestions, if any, do you have for **improving** the program?

Is there anything else you want to share with me about the program?

Thank you for sharing your thoughts and your time.

Participant online survey

Were you working at {{ invite.projname }} when the organization participated in the Industrial System Optimization Program (ISOP)?

○ Yes

○ No

Please provide the name and contact information for someone in your organization who is familiar with the ISOP program.

From which of the following sources did you hear about PSE's ISOP program? (check all that apply)

☐ Program representative

☐ PSE representative

☐ Someone within my company

☐ Colleague outside my organization

☐ Other, please specify... ________________________

☐ I don't remember

Please indicate whether each of the items below was a major, minor or not a reason for your company's initial participation in the Industrial Systems Optimization Program (getting a scoping study).

	Major reason	Minor reason	Not a reason	I don't know
Concerns about high energy bills	○	○	○	○
To assess current O&M practices	○	○	○	○
To identify low-cost savings opportunities	○	○	○	○
To identify capital improvements	○	○	○	○
To access program rebates	○	○	○	○

What other reasons, if any, played a role in the decision to participate in ISOP?

Please explain

Some organizations experience internal challenges to participating in programs like ISOP. Please indicate whether the items below were a major, minor or not a challenge to participating in ISOP.

	Major challenge	Minor challenge	Not a challenge	I don't know
Getting internal support.	○	○	○	○
Having enough time (mine or other staff).	○	○	○	○
Concerns regarding effect on production equipment.	○	○	○	○
Belief that savings would not justify costs.	○	○	○	○
Resistance to unknown persons modifying equipment settings.	○	○	○	○

What other challenges, if any, did you experience participating in ISOP?

Please describe.

Please rate your satisfaction with various aspects of the Scoping Study.

Satisfaction

	Very Dissatisfied	Somewhat Dissatisfied	Not Satisfied nor Dissatisfied	Somewhat Satisfied	Very Satisfied	I don't know
Length of scoping visit.	○	○	○	○	○	○
Staff conducting scoping study.	○	○	○	○	○	○
The scoping report.	○	○	○	○	○	○
Time it took to get scoping report	○	○	○	○	○	○
Scoping study overall.	○	○	○	○	○	○

Why were you less than satisfied?

Partial participants only.

ISOP records show that your organization did not participate in the program after the scoping study. For what reasons did your organization stop participating in the program?

If you don't know, please tell us that.

Partial participants were skipped to program participation questions starting on page 6 of the survey.

Please indicate whether each of the items below was a major, minor or not a reason for your organization having an Optimization Event.

	Major reason	Minor reason	Not a reason	Don't know
No cost for the optimization event.	○	○	○	○
To get assistance making the changes.	○	○	○	○
Opportunity to learn from program staff.	○	○	○	○
To get rebates for installing recommended measures.	○	○	○	○
To get rebates for a Performance Tracking System (PTS).	○	○	○	○
To better identify the costs and savings of optimization.	○	○	○	○

What other reasons, if any, played a role in your decision to have an ISOP Optimization Event?

Please explain

Please rate your satisfaction with aspects of the Optimization Process.

Satisfaction

	Very Dissatisfied	Somewhat Dissatisfied	Not Satisfied nor Dissatisfied	Somewhat Satisfied	Very Satisfied	Don't know
Length of optimization event.	○	○	○	○	○	○
Changes made during the optimization event.	○	○	○	○	○	○
Time it took to get optimization report.	○	○	○	○	○	○
The optimization report.	○	○	○	○	○	○
Information provided during the optimization event.	○	○	○	○	○	○
The staff conducting the optimization event.	○	○	○	○	○	○
The optimization event overall.	○	○	○	○	○	○

Why were you less than satisfied?

Please rate your satisfaction with the following aspects of ISOP.

Satisfaction

	Very Dissatisfied	Somewhat Dissatisfied	Not Dissatisfied nor Satisfied	Somewhat Satisfied	Very Satisfied	NA/Dk
Program assistance in implementing measures.	○	○	○	○	○	○
The time it took to get the final inspection.	○	○	○	○	○	○
The amount of paperwork involved.	○	○	○	○	○	○
The monthly updates on energy savings.	○	○	○	○	○	○

Why were you less than satisfied?

Partial participants skipped to here

Before participating in ISOP, had your organization participated in any PSE energy saving programs?

○ Yes

○ No

○ I don't know

Since participating in ISOP, has your organization participated in any other PSE energy saving programs?

○ Yes

○ No

○ I don't know

What PSE programs has your organization participated in since ISOP? (Check the box next to the program.) Was ISOP a major, minor, or not an influence on the decision to participate in the program? (Check the appropriate box in the next column.)

PSE Program	Participated in Program	Influence of ISOP on Program Participation
Business Lighting	☐	○ Major ○ Minor ○ Not an influence ○ Don't know
Custom grants for non-lighting projects	☐	○ Major ○ Minor ○ Not an influence ○ Don't know
Resource Conservation Manager	☐	○ Major ○ Minor ○ Not an influence ○ Don't know
Other PSE program	☐	○ Major ○ Minor ○ Not an influence ○ Don't know

Overall, how satisfied or dissatisfied are you with PSE's Industrial System Optimization Program?

○ Very dissatisfied

○ Somewhat dissatisfied

○ Neither satisfied nor dissatisfied

○ Somewhat satisfied

○ Very satisfied

Why do you say that?

Anything else you want to say? Any suggestions for improving ISOP?

Appendix E. SITE-SAVINGS MEMORANDUM

Memo to:
Michael Noreika
Puget Sound Energy

From: Julia Vetromile, DNV GL

Date: October 28, 2016

Prepared by: Julia Vetromile and Dale Tutaj, DNV GL

Subject:
Site savings for the Industrial Systems Optimization Program (ISOP) Evaluation.

Summary

This memorandum presents the results of the site-specific gross savings analysis for individual sampled sites from the ISOP program. The purpose of this memo at this time is to provide the results of the savings analysis to inform the process analysis. The findings focus on the verification of completed action items and the estimated savings for each site. DNV GL completed 28 site visits from a total of 41 participants. Of the 28 sites, there were three sites where data were insufficient to complete savings. This memo provides the evaluated savings for 25 sites.

Overall, DNV GL found that the retention of completed action items was very high. Table 31 shows the number of action items identified and completed as reported by the program (tracked) compared to the number verified as complete in the evaluation. The average number for each program measure group is also shown. The table shows that the retention of completed action items is high, and many sites completed additional items since the end of the program, continuing to work on the list of items identified during the program. The overall realization rate for completion of action items is 106%.

Table 31. Action item verification results of sampled sites

Measure	Sites in sample	Ex-ante Action Items		Ex-post Action Items		
		Total Number of Action Items Identified	Total Number of Action Items 100% Completed	Total No. of Action Items Identified	Total Number of Action Items 100% Completed	Realization Rate, Action Items 100% Complete
Compressed Air ISOP	2	32	13	32	15	115%
Pumps, Fans, Blowers ISOP	5	87	45	87	45	100%
Refrigeration ISOP	19	570	404	557	431	107%
Other ISOP	1	24	18	24	19	106%
Total	**27**	**713**	**480**	**700**	**510**	**106%**

DNV GL assessed the savings for each site, summarized by measure category as shown in Table 32. Although the overall results are close to the ex-ante savings results, considerable variation was observed from site to site for the sites evaluated using regression analysis. The most variation was observed in sites where the research team was able to include current data to update the regression analysis. Less variation was observed in sites using calculations or with sites where extending the regression was not feasible or not appropriate. Table 32 only shows the evaluation results of the sampled sites, and does not reflect the extrapolation of the realization rates to the population.

Table 32. Gross savings and realization rate of sampled sites

Measure category	Number of Sites	Ex-ante Savings	Ex-post Savings	
		Gross Electric Savings	Gross Electric Savings	Realization Rate
Compressed Air ISOP	2	225,544	243,903	108%
Pumps, Fans, Blowers ISOP	5	958,349	901,117	94%
Other ISOP	1	0,600	80,600	100%
Refrigeration ISOP	17	10,710,024	9,508,405	89%

Background

The ISOP program is designed to encourage low-cost operations and maintenance (O&M) improvements in industrial facilities. Incentives are provided based on savings achieved. Customers agree to monitoring and verification to assure persistence of savings. A total of 41 projects were completed in the evaluation period from 2011 through 2015.

The program encourages customers to complete action items to save energy, beginning with a scoping walkthrough. Following signing of an agreement with the customer, the implementer and customer participate in an "optimization event" to identify action items. The PSE implementation team documents the identified action items. Savings are estimated by modelling energy consumption in a baseline period prior to the program, and comparing baseline modelled energy usage predictions with actual energy consumed in a post-program period. Throughout the program period, the implementer tracks the customers' energy consumption and the relevant variables from the energy model. The program also compares the identified and completed action items at the end of the program, as the program requires customers to agree to continued monitoring and verification.

Although a wide range of action items may be identified at each site, the program identified each site by the dominant focus on a particular equipment area: refrigeration, air compressors, pump/fan/blowers and other.

For the evaluated projects, the ex-ante savings method was either an engineering calculation spreadsheet and/or a regression model spreadsheet to estimate savings. For each site, the program implementer attempted to calculate energy savings by a whole premise regression model. In some cases, the savings were low percentage of annual consumption, suggesting that a whole facility regression model might not be able to isolate the effect of the program. In those cases, end use calculations were performed.

Sample disposition

DNV GL developed a sample from the 39 projects that had ex-ante savings. Two participants had no savings, and were excluded from the sample frame. A total of 28 sites were included in the sample, with the remainder of the participants forming the backup sample (Table 33). DNV GL attempted to contact all participants in both the sample and the backup, and completed 28 site visits. Eleven participants were not amenable to a site visit. Four refused, five were declared non-responsive after multiple attempts to connect with someone knowledgeable about the program, and two were dropped after they expressed concerns about a site visit.

Table 33. Sample disposition

Sample Disposition	Number of Sites
Site visit complete	28
Non-Responsive	6
Refused	5
Total	39

One site the research team visited had almost no available information, as the facility lead was no longer at the plant and no one remaining was familiar with the program. DNV GL dropped this site from the evaluation sample subsequent to the site visit.

Evaluation methods

The gross savings evaluation included verification of action items and calculating energy savings.

Verification of action items and current practice

DNV GL asked the facility contact a series of questions about maintenance practices, operating schedule, and changes in energy consumption since the program. The research team asked participants about action items they completed and whether they are continuing actions implemented under the plan. DNV GL also asked about maintenance practices to assess the probability of participants sustaining their energy savings action items.

Prior to each site visit, DNV GL compiled all of the action items identified from the implementer's Action Item Report. During the site visit, the evaluation engineer discussed each action item with the facility contact, who verified whether the action item was completed and still in operation. Many of the action items involved activities with no cost, such as adjusting set points, timers, and schedules. Some involved installing or upgrading the existing control system. Others were maintenance actions such as changing filters, cleaning equipment components, and replacing faulty parts. A smaller number included installing or replacing parts. DNV GL verified completed measures that were observable, and recorded the status of the identified actions as complete, partially complete or cancelled.

Energy savings estimation

DNV GL developed ex-post site savings based on production activity data collected from the facility, weather data, and whole facility meter data acquired from PSE.

Action item calculations

Ex-ante savings for five sites were based on simple engineering calculations to estimate savings on a measure-level basis. The program implementer used this approach when the savings were low relative to the facility consumption or when energy consumption has a low correlation with the available independent variables. DNV GL verified the calculation methodology for reasonableness and also assessed the inputs to the calculations. In some cases, the operating hours or conditions changed. DNV GL changed the inputs using the project contacts input and supporting trend data when available.

Regression analysis

The research team assessed the reasonableness of the implementer regression, appropriateness of performance period savings, and extrapolation of the performance period savings to annualize savings. Additionally, in cases were new data were available, DNV GL expanded the performance period to determine current annual savings.

First, DNV GL reproduced the regression using the baseline period implementer data. This period is before any action items are completed. The research team checked the regression for errors, data cleaning approach, and appropriateness of independent variables. Further, the research team assessed the regression results by looking at the coefficient of determination, R value, and the p value[20] of independent variables. In general, the targeted R^2 and p values were 0.7 or greater and 0.1 or less, respectively. However, the research team considered projects on a case-by-case basis. In some instances, an independent variable might have had a p value greater than 0.1, but removing that variable pushed the R^2 below 0.7 if it was included. The independence of the variables and treatment of raw variables were considered. Ideally each variable would be independent to avoid inflating the effects of a particular factor in the regression model.

Next, DNV GL assessed whether the implementer cleaned the data in a reasonable way, and how missing data points (either dependent or independent variables) were removed. In some instances, the implementer removed data points when operating conditions were not representative of typical operations. DNV GL agreed these cases were justified because large pieces of equipment were temporarily offline or part of the plant shut down due to unplanned activity. However, if DNV GL found data points were removed to improve overall R^2 value without justification, we included these data points in the evaluated regression.

After developing the evaluation regression model, DNV GL ran the regression and determined the achieved savings in two ways. First, DNV GL used the energy consumption and variable data provided in the implementation documents to model the performance period energy savings.

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[20] Probability of obtaining the observed (or more extreme) result assuming the null hypothesis is true. The p-value of an estimated model coefficient provides guidance on whether the corresponding variable should be retained in the model.

DNV GL then calculated ex-post energy (kWh) savings using the following equation:

$$kWh\ Savings = (Baseline\ Year\ kWh)(\%\ Savings_{perf\ period})$$

$$\%\ Savings_{perf\ period} = \sum_{1}^{n} \frac{(Projected\ kWh_n) - (Actual\ kWh_n)}{(Projected\ kWh_n)}$$

where,

kWh Savings = annualized energy savings, kWh

Baseline Year kWh = annual baseline energy consumption, kWh

% Savings = the percent savings achieved during the performance period, %

n = number of intervals in the performance period (days or months)

Projected kWh = the kWh based on the regression model equation and the independent variables; the energy consumption that would have occurred without the program and thus represents the baseline consumption at performance period conditions, kWh

Actual kWh = the energy consumption during the performance period, typically based on the facilities meters and adjusted to account for capital projects that will change energy usage that were not completed as part of the ISOP, kWh

Second, the research team attempted to perform the evaluation regression model using current energy consumption and variable values to update the regression to conditions found during the evaluation. Generally, this involved extending the data from the performance period to July 2016. When extending the data through the evaluation period, DNV GL accounted for capital projects that impact energy consumption since the performance period. For example, if a capital project reduced energy consumption at the facility, DNV GL subtracted the capital project savings from the baseline kWh using the equation.

If current data were not available, the savings were based on the first analysis, using the energy consumption and variable values in the program performance period.

As an additional check, DNV GL assessed the baseline year energy consumption for reasonableness. This involved looking at how capital projects affecting energy consumption were treated. In some cases, the energy consumption from capital projects was removed from the regression, but not from the baseline year consumption. As the percent savings during the performance period is based on the post capital project energy consumption, the baseline year kWh should also be based on the post capital project energy consumption. DNV GL corrected these inconsistencies in the evaluation calculations.

Results

Verification of action items

During the site visits, DNV GL verified the completion and persistence of action items identified in the action plans. As shown in Table 34, participants developed an average of 26 action items overall. However, where the program focused on refrigeration, the implementer identified an average of 30 action items.

Table 34. Action items identified and completed

Measure	Sites in sample	Ex-ante Action Items				Ex-post Action Items				Realization Rate, Action Items 100% Complete
		Total Number of Action Items Identified	Total Number of Action Items 100% Completed	Average Number of Action Items Identified	Average Number of Action Items 100% Completed	Total Number of Action Items Identified	Total Number of Action Items 100% Completed	Average Number of Action Items Identified	Average Number of Action Items 100% Completed	
Compressed Air ISOP	2	32	13	16	7	32	15	16	8	115%
Pumps, Fans, Blowers ISOP	5	87	45	17	9	87	45	17	9	100%
Refrigeration ISOP	19	570	404	30	21	557	431	29	23	107%
Other ISOP	1	24	18	24	18	24	19	24	19	106%
Total	**27**	**713**	**480**	**26**	**18**	**700**	**510**	**26**	**19**	**106%**

The persistence of the action items was very good throughout the end of the program to the evaluation period. At some sites, the status of a few items changed, where new ones were completed but some items that previously were in place were no longer in effect. Overall, more action items were completed since the end of the program versus actions items that are no longer in effect.

Savings estimation

Table 35 shows the savings achieved for each sampled site, organized by program measure group. The table shows the savings calculation method, ex-ante and ex-post savings, realization rates and primary reason for the discrepancy. It also presents the baseline energy consumption and the savings as a percentage of baseline consumption.

Table 35. Evaluated site savings and realization rate

DNV GL ID	Program measure group	Savings Methodology	Gross Electric Savings	Gross Electric Savings	Realization Rate	Reason for Discrepancy	Baseline Energy Consumption	Savings as a Percent of Baseline Consumption[21]
CA113	Compressed Air ISOP	Calculations	24,571	38,672	157%	Operating hours	1,565,100	2%
CA211	Compressed Air ISOP	Regression	200,973	200,973	100%	None	14,390,557	1%
O111	Other ISOP	Calculations	80,600	80,600	100%	None	5,579,259	1%
PFB121	Pumps, Fans, Blowers ISOP	Calculations	10,711	10,711	100%	None	462,293	2%
PFB122	Pumps, Fans, Blowers ISOP	Regression	29,952	28,881	96%	None	1,083,916	3%
PFB123	Pumps, Fans, Blowers ISOP	Regression	119,704	72,160	60%	Operating hours	845,798	9%
PFB124	Pumps, Fans, Blowers ISOP	Regression	307,481	307,481	100%	none	1,946,332	16%
PFB125	Pumps, Fans, Blowers ISOP	Regression	490,501	481,884	98%	none	13,813,033	4%
RI151	Refrigeration ISOP	Regression	254,160	316,168	124%	Operating hours	2,789,879	11%
RI1510	Refrigeration ISOP	Regression	100,180	100,180	100%	none	1,199,127	8%
RI152	Refrigeration ISOP	Regression	77,419	(2,492)	-3%	Few action items	685,880	0%

[21] Savings are rounded to single digit.

DNV GL ID	Program measure group	Savings Methodology	Gross Electric Savings	Gross Electric Savings	Realization Rate	Reason for Discrepancy	Baseline Energy Consumption	Savings as a Percent of Baseline Consumption[21]
RI154	Refrigeration ISOP	Regression	184,300	47,823	26%	Short performance period	1,896,626	3%
RI156	Refrigeration ISOP	Calculations	6,687	6,687	100%	none	3,561,600	0%
RI157	Refrigeration ISOP	Regression	330,691	322,791	98%	none	6,929,938	5%
RI242	Refrigeration ISOP	Regression	473,315	778,564	164%	Seasonal variation	4,766,371	16%
RI243	Refrigeration ISOP	Calculations	495,809	495,809	100%	none	1,497,112	33%
RI244	Refrigeration ISOP	Regression	425,290	360,583	85%	Less action items completed	2,189,470	16%
RI245	Refrigeration ISOP	Regression	421,719	421,719	100%	none	7,526,018	6%
RI333	Refrigeration ISOP	Regression	568,933	440,844	77%	Short performance period	8,701,476	5%
RI441	Refrigeration ISOP	Regression	732,743	455,361	62%	Short performance period	4,528,954	10%
RI443	Refrigeration ISOP	Regression	682,732	682,732	100%	none	12,838,996	5%
RI444	Refrigeration ISOP	Regression	728,316	403,162	55%	Operating hours	5,916,553	7%
RI561	Refrigeration ISOP	Regression	898,197	898,197	100%	none	5,961,022	15%
RI562	Refrigeration ISOP	Regression	869,993	902,348	104%	none	3,940,053	23%

DNV GL ID	Program measure group	Savings Methodology	Gross Electric Savings	Gross Electric Savings	Realization Rate	Reason for Discrepancy	Baseline Energy Consumption	Savings as a Percent of Baseline Consumption[21]
RI566	Refrigeration ISOP	Regression	3,459,540	2,877,929	83%	Short performance period	9,197,402	31%

For four sites, DNV GL considered the engineering end use calculations used during the program implementation appropriate and used this approach in the evaluation for these sites. Only one of the sites showed much variation from the ex-ante savings. This was due to current operating conditions increasing the use of the energy consuming equipment. This was a compressed air measure site.

DNV GL evaluated the remaining sites using regression analysis. In most cases, the research team used the implementer regressions without modification and where appropriate, the research team extended them using current energy consumption and independent variable data as described in the methods section of this memo. Variation in the results was highest when extending the regression. This was due to the program implementation using short performance periods, often two to three months. The extended regressions resulted in seasonality issues and production variations, affecting the results, both positively and negatively. Similarly, changes in operating hours and other model variables since the time of the program calculation also affected the results.

In some cases, DNV GL was not able to extend the model because energy consumption or production data were not available. In these situations, the evaluated savings are based on the review of the tracking model. In others, the data were available but changes since the program called into question the current validity of the baseline model. For example, the completion of a large capital project or site remodel meant that the baseline model was outdated; estimated savings would reflect not only the effect of ISOP but also the capital project.

Another concern is the form and variable selection of the regression models. The whole facility regression approach is based on developing a baseline model with independent variables that drive energy consumption. If these variables fit the data well in the baseline period but are not really representative of what drives consumption, the model cannot be extended realistically. For example, one site model used non-overhead labor hours raised to the power of 0.75 as an independent variable. It’s not clear why labor really drives energy consumption, or why the power of 0.75 was appropriate, other than it gave the best fit to the baseline data. Although energy and labor hour data were available to extend the model, the modeled resulting savings were not reasonable, as they were a factor of 3 greater than the ex-ante savings. Further, there was no indication that a savings increase of this magnitude was justified, based on the site visit. The project contact confirmed not much had changed, and the completed action items were similar to the program performance period. In this case, DNV GL determined that while the model appeared to be valid in the short term, this model could not be updated. This may be a case where an attempt to get the best statistical fit results in curve fitting rather than an appropriate model of energy consumption.

The two sites considered indeterminate were found to have baseline models based on changing conditions. In one case, the facility underwent significant remodeling during the baseline period. In the other case, a fire occurred and the facility operated at a significantly reduced capacity. Since these sites participated in the program and completed action items, DNV GL chose to drop them from the sample rather than assume no savings. As such, DNV GL will assign savings based on the sample extrapolation to the full population.

Table 36 summarizes the savings achieved as a fraction of baseline consumption. The most significant savings are found in the refrigeration measure sites, with evaluated savings at 11%. This is consistent with the larger number of action items at these sites.

Table 36. Reduction in annual energy consumption

Measure	Baseline Consumption	Ex-ante Savings	Ex-post Savings	Average % Reduction in Annual Energy Consumption	
				Ex-ante Savings	Ex-post Savings
Compressed Air ISOP	15,955,657	225,544	243,903	1%	2%
Other ISOP	5,579,259	80,600	80,600	1%	1%
Pumps, Fans, Blowers ISOP	18,151,372	958,349	901,117	5%	5%
Refrigeration ISOP	84,126,477	10,710,024	9,508,405	13%	11%
Total of sampled sites	**123,812,765**	**11,974,517**	**10,734,025**	**10%**	**9%**

Table 37 lists reasons why the ex-ante and ex-post savings differ. Overall, changes in plant operations since the tracked savings were determined are the major factors that changed. This reflects the limitations of the whole facility regression model approach. The models attempt to include key variables that apparently determine consumption in the baseline period and extrapolate these to show the effect of the program. Other factors that are either not causing variation in the baseline period; or are not necessary for the model may also effect energy consumption. Thus, changes in the operation of the facility that were not included in the model can cause the model to be less predictive of energy consumption after the baseline period. The short performance period to assess the tracked savings is another limitation, as the savings that are projected to annual savings may not reflect the range of conditions experienced in the plant over time.

Table 37. Reasons for discrepancies between ex-ante and ex-post results

Reasons for Discrepancy	Number of Occurrences
Operating hours/ changes in operations	4
Few action items or less action items completed	2
Seasonal variation/short performance period	5
No difference (within 5%)	14
Total	**25**

Findings

The overall findings of the site gross savings estimation are as follows:

- The program documentation was very complete, and allowed a detailed assessment of each site. The Baseline Report provided an explanation of the variables included and the rationale for the selected relationships. The Action Plan provided a very good explanation of each action item identified, and the M&V Report documented which items were completed or partially completed.
- The program participants, with one exception, were able to provide information on whether action items were completed, or whether their status had changed. This allowed estimating realization rates for completed action items. The fact that the realization rates are more than 100% suggests a strong persistence of these items.
- High levels of variation of savings on a site basis occur with the updating of the regression analysis to current operations. This suggests care should be taken to avoid over-fitting the regression model to the baseline period. Some of the models used terms that may provide better statistical correlations, but may not be representative of the drivers of energy consumption. In these cases, high variability may occur when extending the model beyond the program period.
- The evaluation found ex-post program savings to be close to the ex-ante data for each program measure group.
- We could not assess savings at some sites since the baseline period was not representative for the performance period. For sites without a representative baseline, DNV GL recommends the implementer consider a different calculation approach.

In conclusion, the evaluation found that ex-post site savings could be determined and were overall similar to the ex-ante results.

Appendix F. EXTRAPOLATION OF THE SAMPLE RESULTS TO THE POPULATION

In order to expand the results of sample to the population DNV GL applied the case weights to each completed project measure group. The case weight is simply the number of projects in the population in each stratum divided by the number of projects in the final sample in the corresponding stratum.

Table 38. Case weights by project measure-group stratum

Stratum	Population	Sample	Case Weight
Compressed Air ISOP-Size-1	4	1	4.00
Compressed Air ISOP-Size-2	1	1	1.00
Other ISOP-Size-1	1	1	1.00
Pumps, Fans, Blowers ISOP-Size-1	6	5	1.20
Refrigeration ISOP-Size-1	9	6	1.50
Refrigeration ISOP-Size-2	5	4	1.25
Refrigeration ISOP-Size-3	3	1	3.00
Refrigeration ISOP-Size-4	4	3	1.33
Refrigeration ISOP-Size-5	6	3	2.00

Using these weights DNV GL calculated the gross realization rate.

$$Gross\ Realization\ Rate = \frac{\sum_{i=1}^{n} w_i y_i}{\sum_{i=1}^{n} w_i x_i}$$

Where,

w is weight for each project, y is the verified savings, and x is the tracked savings.

The standard error of gross realization rate is calculated using the formula below.

Standard Error of Gross Realization Rate = $\frac{\sum_{i=1}^{n} w_i (w_i - 1) e_i^2}{\sum_{i=1}^{n} w_i x_i}$

Where error for each project $e_i = y_i$ – (Gross Realization Rate * x_i)

Relative precision is calculated using the formula:

z*(standard error of gross realization rate/mean of y)

Where z is the measure of standard deviation based on the level of confidence required. It is 1.645 for 90% confidence using a two-tailed test.

An estimate of total gross savings from the program is then calculated using the gross realization rate. The estimated gross savings from the program is the multiplication of gross realization rate and the total gross savings from the tracking data. Estimating the realization rate and standard error for subset is done using the same formula, only the number of projects change based on the subset chosen.

Table 39. Program measure group extrapolation results

Program measure group	Sample n	Population N	Ex-ante Savings	Ex-post Savings	Realization Rate	Relative Precision at 90% Confidence	Error Bound at 90% Confidence	Error Ratio
Refrigeration	17	29	17,601,885	15,369,129	87%	5.0%	768,973	0.229
Pumps, Fans, Blowers	5	6	2,514,062	2,363,924	94%	3.6%	86,260	0.126
Compressed Air	2	5	313,765	370,807	118%	14.7%	54,573	0.209
Other	1	1	80,600	80,600	100%	0.0%	-	0.000
Overall	**25**	**41**	**20,510,312**	**18,184,459**	**89%**	**4.2%**	**775,718**	**0.214**

Appendix G. BEST PRACTICES REVIEW

Table 40. Program comparisons: program measures, eligibility, and incentives

	Ameren Illinois	Com Ed III	ETO O&M & 90 x 90	BPA	PSE ISOP
Industrial systems included	Compressed air Refrigeration[1] Process Cooling, year 4 only	Compressed Air –all years Refrigeration Process Cooling	**Targeted O&M** Boiler Tune-up HVAC RCx **Custom O&M**	Compressed Air Other Process systems	Refrigeration Compressed Air Pumps, Fans, Blowers Other
Eligible measures	≤ 1 yr payback	≤Le 1.5 yr payback	Behavior only Allow-costs for tools and instrumentation		Not specified
Program position	Combined C&I RCx separate industrial offerings	Combined C&I RCx separate industrial offerings	Within production efficiency offerings	Within industrial portfolio	Industrial - stand-alone
Customer eligibility	CA system > 200 hp Ref sys > ge 500 hp	CA system > 200 hp Ref sys > ge 500 hp Process coooling	Participation in other ETO program	Varies by participating retailer	250
Other eligibility requirements	Pre-approval	Pre-approval		Pre-approval	
Other requirements		Repair 50% of CA air leaks at own expense		Implement PTS Savings potential of ≥ 250,000kWh/yr	
Incentives	Refrigeration – up to 70% of study costs Compressed Air – 80% of study costs	$0.07/kWh	within 90 days: 90% of implementation costs 90+ days: 50% of costs	<75-hp varies ≥75-hp $0.25/kWh Co-funding of technical resources for tune-up and action item implementation	$0.05/kWh

	Ameren Illinois	Com Ed III	ETO O&M & 90 x 90	BPA	PSE ISOP
Incentive caps		50% of implementation costs and 100% of incremental costs	Max $0.08/kWh	70% of approved retrofit cost 100% of incremental for new equip	N/A
PTS incentives	no	no	no	$0.025 per kWH per year for sustained savings (3 or 5 years) $0.0015 or $0.0025 kWh of baseline use ($50K max) for 3 or 5 year performance period	Up to $10k first program cycle
Time limitations	?	120 days	90 days to get higher incentive		
Projects per year	14 Compressed Air in 2014	20-25 industrial optimization	***60-70***	unknown	

1 food processing and refrigerated warehouses

Table 41. Program comparisons: program delivery

	Ameren Illinois	Com Ed III	ETO 90 x 90	BPA	PSE ISOP
Program administrator	Ameren	Com Ed	Energy Trust	Utility	PSE
Program implementer	Third party	Third party	Multiple entities	Third party through BPA	Third party

	Ameren Illinois	Com Ed III	ETO 90 x 90	BPA	PSE ISOP
Marketing – who	Approved Retro-commissioning Service Providers (RSPs)	Account managers Approved RSPs Implementer	Energy Trust initiates Leads to Program Delivery Contractor (PDCs)	BPA and utility	Implementer
Marketing -how	Marketing materials Print ads Online site Key account reps	Fact sheets Case studies Co-branding flyers Utility newsletter	Online site Develop collateral PDCs use collator		Person to person marketing to targeted eligible customers
Scoping study/ID measures	System specific RSPs	System specific RSPs	Industrial system service provider (ITSP)	Participant staff Program engineers	Implementer
ID capital measures	Yes	Yes	Required to be in other program to participate in O&M		Yes
Other steps	NA			Tune-up Event participant staff and implementer engineers ID and implement action items	
Actions to promote persistence			Expect them to include in SOP Put placards on equipment Training		
Implementing measures/action items	DIY Participant contractors	DIY Participant contractors	ITSP trains participant staff on equipment tuning PDCs assist ITSP	Tune-up Event Participant staff and implementer engineers ID and implement action items	Optimization Event Participant staff and program implementer ID and implement action items Participant completes action items
Inspection	Program implementer	Program implementer	Energy Trust Verification report	Program Implementer	Program Implementer

	Ameren Illinois	Com Ed III	ETO 90 x 90	BPA	PSE ISOP
How verifies savings	Retro-commissioning Service Providers	PPS	PDC	Implementer engineers	Program Implementer
How verify savings		2 weeks pre and post metered usage, meter amperage, and estimated power factor for kW		PTS for baseline 90-day post PTS data PTS for 3-5 years post[1]	Minimum 60 days post usage
Program Changes		Early completion bonus to speed up installation (it worked) Added option to combine planning/investigation phases	Increased incentive for 90-day completion		Streamlining for smaller projects Identification of "Data Master"
Follow-up	None	none	PDC (account manager) responsible for regular follow-up after completion	none	none
Program evaluation	Every 1- 2 years (all industrial)	Every 1- 2 years (all industrial)	All industrial regularly	Pilot impact evaluation (2 sites) in 2013 Program evaluation report pending	Evaluation of first 2 program cycles (this report)

1 It is unclear if PTS required for all facilities.

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Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil and gas, and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our 16,000 professionals are dedicated to helping our customers make the world safer, smarter, and greener.

2014-2015 DIRECT-TO-CONSUMER IMPACT AND PROCESS EVALUATION

Appendices

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APPENDIX A IN-SCOPE PROGRAM SUMMARY

The table below provides a listing of the DtC programs that were considered in-scope for this evaluation. For each in-scope program and measure this table includes the source of the 2015 UES estimate (PSE or RTF Deemed), the RTF category and status, and the RTF sunset date. For the showerhead and lighting measures a majority of the UES estimates are based upon PSE specific adjustments to the RTF Deemed UES approaches.

TABLE A-1: DTC IN-SCOPE PROGRAM SUMMARY

Program	Measure	UES Source	RTF Category	RTF Status	RTF Sunset Date
Appliance Rebates	APS	RTF Deemed	Planning	Active	8/31/2018
	Clothes Washer	RTF Deemed	Proven	Active	12/31/2017
	Refrigerator - Tier 1	RTF Deemed	Proven	Active	10/31/2018
	Refrigerator - Tier 2	RTF Deemed	Proven	Active	10/31/2018
	Refrigerator - Tier 3	RTF Deemed	Proven	Active	10/31/2018
	Freezer	RTF Deemed	Proven	Active	10/31/2018
Appliance Decommissioning	Refrigerator	RTF Deemed	Proven	Active	9/30/2017
	Freezer	RTF Deemed	Proven	Active	9/30/2017
Appliance Replacement	Clothes Washer	PSE Deemed	n/a	n/a	n/a
	Refrigerator (years 1-14)	PSE Deemed	n/a	n/a	n/a
	Refrigerator (years 15-20)	PSE Deemed	n/a	n/a	n/a
Showerhead	Showerhead	PSE Deemed	Planning	Active	8/31/2019
	ShowerStart Adapter	PSE Deemed	Planning	Active	7/31/2018
	ShowerStart Showerhead	PSE Deemed	Planning	Active	7/31/2018
Lighting	Spiral CFLs	PSE Deemed	Proven	Active	1/31/2017
	Specialty CFL	PSE Deemed	Proven	Merged	1/31/2017
	LED A-lamp	PSE Deemed	Proven	Merged	1/31/2017
	LED Candelabra	PSE Deemed	Proven	Merged	1/31/2017
	LED Globe	PSE Deemed	Proven	Merged	1/31/2017
	LED MR-16	PSE Deemed	Proven	Merged	1/31/2017
	LED Reflector	PSE Deemed	Proven	Merged	1/31/2017
	LED Retrofit Kit	PSE Deemed	Proven	Merged	1/31/2017
	LED Indoor Fixture	PSE Deemed	Proven	Merged	1/31/2017
	LED Outdoor Fixture	PSE Deemed	Proven	Merged	1/31/2017
	Induction A-lamp	PSE Deemed	Proven	Merged	1/31/2017

Table A-2, below, provides the 2015 and 2016 electric (kWh) UES estimates for each of the in-scope DtC measures, the total 2015 ex-ante savings estimates for these measures, and the percent of the total 2015 in-scope savings each of these measures comprises. As this table shows, the majority of electric savings for the DtC programs come from the Lighting measures (88 percent). The total electric savings across all of the DtC programs makes up 63 percent of the total Residential Energy Management program electric savings in 2015.[1]

1 Based on Exhibit 01 from the 2015 Annual Report, the total electric savings across the Residential Energy Management programs was 135,765 MWh.

TABLE A-2: DTC IN-SCOPE PROGRAM SAVINGS SUMMARY (KWH)

Program	Measure	2015 UES	2016 UES	2015 Ex-Ante Savings	% of 2015 DtC Savings
Appliance Rebates	APS	300	216	820,200	1%
	Clothes Washer	126	65-82	1,451,021	2%
	Refrigerator - Tier 1	22	9	57,743	0.1%
	Refrigerator - Tier 2	47	42		
	Refrigerator - Tier 3	88	98		
	Freezer	40	23	2,960	0.0%
Appliance Decommissioning	Refrigerator	356	356	906,480	1%
	Freezer	570	570	480,760	1%
Appliance Replacement	Clothes Washer	764	848	1,418,748	2%
	Refrigerator (years 1-14)	580	503	1,410,298	2%
	Refrigerator (years 15-20)	86	9		
Showerhead	Showerhead	63 - 239	63 - 239	2,225,294	3%
	ShowerStart Adapter	222	131	129,442	0.2%
	ShowerStart Showerhead	390	190	152,670	0.2%
Lighting	Spiral CFLs	9.09	14.13	14,067,183	17%
	Specialty CFL	15.09	19.13	4,096,776	5%
	LED A-lamp	16.02	24.09	24,887,028	29%
	LED Candelabra	17.76	30.95	2,657,264	3%
	LED Globe	15.71	21.19	1,471,799	2%
	LED MR-16	25.42	28,77	280,578	0%
	LED Reflector	28.23	38.8	19,114,065	22%
	LED Retrofit Kit	19.71	33.73	3,835,612	5%
	LED Indoor Fixture	18.02	22.44	1,671,456	2%
	LED Outdoor Fixture	58.47	58.03	2,844,624	3%
	Induction A-lamp	10.53	20.52	0	0%
Kits	LEDs	16.02	24.09	102,178[2]	0.1%
	Showerheads	103 - 125	103 – 125	874,008	1%
Total				84,958,187	100%

[2] Includes 34 engagement LEDs that had been included in the lighting program savings

Similarly, Table A-3 below, provides the results for the gas savings (therms) for each of the DtC measures that claim therm savings. As this table shows, the majority of therm savings for the DtC programs come from the showerhead measures, however the total therm savings across all of these programs is relatively small as it made up only 10 percent of the total Residential Energy Management program therm savings in 2015.[3]

TABLE A-3: DTC IN-SCOPE PROGRAM SAVINGS SUMMARY (THERMS)

Program	Measure	2015 UES	2016 UES	2015 Savings	% of 2015 DtC Savings
Appliance Rebates	Clothes Washer	1.1 – 7.6	0.9 – 1.2	9,187	7%
Showerhead	Showerhead	2.6 - 10.2	2.6 - 10.2	71,194	53%
	ShowerStart Adapter	4.9 - 8.1	4.9 - 8.1	19,898	15%
	ShowerStart Showerhead	8.4 - 13.7	8.4 - 13.7	19,365	14%
Kits	Showerheads	5	5	15,680	12%
Total				135,324	100%

3 Based on Exhibit 01 from the 2015 Annual Report, the total gas savings across the Residential Energy Management programs was 1,283,247 therms.

APPENDIX B APPLIANCE REBATE SUPPLEMENTAL

B.1 APPLIANCE REBATE TRACKING DATA REVIEW

Table B-1 below compares PSE's Appliance Rebate ex-ante savings claims (units, kWh, and therms) to the tracking review verified estimates for 2014 and 2015. As this table shows, the tracking review verified unit and savings totals are very close, resulting in a tracking review realization rate of 99%-100%.

TABLE B-1: TRACKING REVIEW VERIFIED IMPACTS FOR APPLIANCE REBATE PROGRAM

Program Year	Measure	Savings Type	Ex-Ante	Tracking Review Verified*	Tracking Review Realization Rate
2014	Clothes Washer	Units	12,591	12,591	100%
		kWh	1,048,878	1,048,878	100%
		therms	7,468	7,468	100%
	Refrigerator	Units	2,894	2,894	100%
		kWh	177,234	177,234	100%
		therms	-	-	-
	Freezer	Units	676	676	100%
		kWh	27,340	27,340	100%
		therms	-	-	-
	APS	Units	1,306	1,306	100%
		kWh	391,800	391,800	100%
		therms	-	-	-
	Total	**Units**	**17,467**	**17,467**	**100%**
		kWh	**1,645,252**	**1,645,252**	**100%**
		therms	**7,468**	**7,468**	**100%**
2015	Clothes Washer	Units	10,444	10,444	100%
		kWh	1,451,021	1,451,021	100%
		therms	9,187	9,184	100%
	Refrigerator	Units	674	674	100%
		kWh	57,743	57,743	100%
		therms	-	-	-
	Freezer	Units	74	74	100%
		kWh	2,960	2,960	100%
		therms	-	-	-
	APS	Units	2,734	2,682[4]	98%
		kWh	820,200	804,600	98%
		therms	-	-	-
	Total	**Units**	**13,926**	**13,874**	**100%**
		kWh	**2,331,924**	**2,316,324**	**99%**
		therms	**9,187**	**9,184**	**100%**

Source: Evaluation Team Analysis

4 In 2015, 51 APS were distributed to non-qualified customers ("NQC") who resided outside of PSE service territory. Starting in March 2015 a zip code list was used by the program vendor to verify eligibility before the units were shipped.

B.2 CLOTHES WASHER REBATE UES REVIEW

As part of the 2015 UES review the evaluation team assessed the input parameters used within the Clothes Washer Rebate savings algorithm (included in Section 6.2.2 of the evaluation report) to ensure they were appropriate for PSE service territory, reflect current measure standards and the best available data (both program and market) at the time they were deemed. Table B-2 lists the input parameters applied in 2015 to estimate the UES for the Clothes Washer Rebate Program, along with the source of these parameter estimates and the evaluation team's recommendation for future program years where appropriate.

TABLE B-2: 2015 CLOTHES WASHER REBATE UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Estimate	Ex-Post Estimate	Ex-Ante Source	Ex-Post Source
UEC_{load}	0.2	0.2	CEC database - based on the existing stock of clothes washers	No change
AnnualLoads	257	256	RBSA 2012, 4.92 loads/week	Stage 2 Participant Survey
Gallonsyr	Varied	Varied	CEC database. Varies by measure type	Updated with CEC database including units as of 12/2014
HW_fraction	13%	13%	Unsourced	No change
WaterSH	0.002448 (kWh/G degF)	0.002448 (kWh/G degF)	Specific heat is property of water	No change
DeltaT	65 degrees	75 degrees	Northwest Council 6th Plan Conservation Supply Curve Files (2009)	DOE test procedure for residential clothes washers, NEEA HPWH study (prepared by Ecotope Consulting), and the new RTF calculator v5.3
ElecWHeff	98%	98%	DOE Test Procedure*	No change
%Moisture	Varied	Varied	CEC database. Varies by measure type	Updated with CEC database including units as of 12/2014
Slope / Constant	3.73 / -0.03	3.73 / -0.03	DOE Appliance Program linear regression[5]	No change
ES_CW_Sat[6]	54%	56%	D&R International 2013 retail sales data	Energy Star unit shipment data[7] from 2015 states 56% saturation.
CW_Capacity[8]	3.54 ft^3	4.44 ft^3	CEC database, average across existing stock of clothes washers	2015 PSE tracking data average

5 U.S. Department of Energy. Residential Clothes Washers Direct Final Rule Technical Support Documents: Chapter 7. Energy and Water Use Determination.

6 The Energy Star Clothes Washer Saturation is not used directly in the algorithms, but it is used to create the value for the final normalized kWh/year.

7 https://www.energystar.gov/ia/partners/downloads/unit_shipment_data/2015_USD_Summary_Report.pdf?1ccd-a8b5

8 Clothes Washer volume is not used directly in the calculations, but used to create a kWh/year which is normalized to the baseline volume for each of the clothes washers in the CEC database.

Parameter	Ex-Ante Estimate	Ex-Post Estimate	Ex-Ante Source	Ex-Post Source
GasWHeff	75%	75%	DOE Res Clothes Washer TSD: Energy and Water Use Determination.	No change
GasDryerFactor	1.12	1.12		No change
WW_savings	5.29 (kWh/ 1,000g)	3.68 (kWh/ 1,000g)	RTF Standard Information Workbook (SIW) v1.5	RTF Standard Information Workbook v2.6

Source: Evaluation Team Analysis

* Title 10 CFR 430 - Energy Conservation Program for Consumer Products Appendix E to Subpart B - Uniform Test Procedure for Measuring the Energy Conservation of Water Heaters, effective June 10, 1998

B.3 REFRIGERATOR/FREEZER REBATE UES REVIEW

To estimate the measure-level savings for the refrigerator and freezers sold through the Appliance Rebate Program, a series of input parameters were entered into the algorithms shown in section 6.5.2 of the main report. Table B-3 below provides the ex-ante and ex-post input parameters estimates for the refrigerator and freezer measures, and the ex-ante and ex-post source of the parameter estimates.

TABLE B-3: 2015 REFRIGERATOR REBATE UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Estimate	Ex-Post Estimate	Ex-Ante Source	Ex-Post Source
UEC_{base}	Table B-5	Table B-5	CEC Database as of 4/3/2013* and 2001 Federal Standards	Updated with a newer version of CEC database including units as of 12/31/2014
UEC_{effX}	Table B-5	Table B-5		
DoorConf%	Various	Various	Distribution of units in CEC database. Tier 1 (n = 98), Tier 2 (n=5), Tier 3 (n=11)	2015 participant tracking data
HVAC_IE	86%	90%	RTF Workbook, from Residential CFL Lighting	Stage 2 participant web surveys, 2014/2015 weather data, and 2010 RBSA results

* The CEC database contains a record for all refrigerators and freezers available. The baseline and efficient UEC estimates are calculated in the RTF workbook (ResRefrigerators_v3.xlsx).

TABLE B-4: 2015 FREEZER REBATE UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Estimate	Ex-Post Estimate	Source	Evaluation Assessment
UEC_{base}	Table B-6	Table B-6	CEC Database as of 4/3/2013* and 2001 Federal Standards	Updated with a newer version of CEC database including units as of 12/31/2014
UEC_{effX}	Table B-6	Table B-6		
UnitType%	Various	Various	2012 RBSA, Market share of chest freezers. CEC Database, Market share of auto-defrost upright units.	2015 participant tracking data
HVAC_IE	92.8%	98%	Undocumented	Stage 2 participant web surveys, 2014/2015 weather data, and 2010 RBSA results

* The CEC database contains a record for all refrigerators and freezers available. The baseline and efficient UEC estimates are calculated in the RTF workbook (ResRefrigerators_v3.xlsx).

Table B-5 and Table B-6 below provide the ex-ante and ex-post UEC estimates for the baseline and efficient cases (as well as the change in UEC, ΔUEC) for refrigerators (by door configuration) and freezers (by unit type). The ex-ante UEC parameter estimates in these tables (UEC_{base} and UEC_{eff}) are used within the 2015 RTF Deemed UES algorithms for rebated refrigerators and freezers.

TABLE B-5: BASELINE AND EFFICIENT REFRIGERATOR ENERGY CONSUMPTION BY DOOR CONFIGURATION

Refrigerator Door Configuration	Ex-Ante					Ex-Post				
	UEC base	CEE Tier 2		CEE Tier 3		UEC base	CEE Tier 2		CEE Tier 3	
		UEC_{eff}	ΔUEC	UEC_{eff}	ΔUEC		UEC_{eff}	ΔUEC	UEC_{eff}	ΔUEC
Bottom Freezer w/Ice thru door	560	526	33.6	526	33.6	554	526	478	526	478
Bottom Freezer w/o Ice thru door	479	421	57.4	421	57.4	488	421	397	421	397
Side-by-Side w/Ice thru door	580	511	68.1	511	68.1	631	532	499	532	499
Side-by-Side w/o Ice thru door	504	458	45.4	458	45.4	573	462	431	462	431
Top Freezer w/Ice thru door	408	354	54.1	354	54.1	430	357	330	357	330
Top Freezer w/o Ice thru door	417	351	65.7	351	65.7	434	351	316	351	316

Source: Source of Savings workbook

TABLE B-6: BASELINE AND EFFICIENT FREEZER ENERGY CONSUMPTION BY UNIT TYPE

Freezer Unit Type	Ex-Ante			Ex-Post		
	UEC_{base}	UEC_{eff}	ΔUEC	UEC_{base}	UEC_{eff}	ΔUEC
Chest, Any Defrost	382	352	30	386	359	27
Upright, Automatic Defrost	655	595	60	658	607	51
Upright, Manual Defrost	402	372	30	440	408	32

B.4 ADVANCED POWER STRIP REBATE UES REVIEW

To estimate the measure-level savings for Advanced Power Strips sold through the Appliance Rebate Program, a series of input parameters were entered into the algorithms shown in section 3.2.2 of the main report. Table B-7 below provides the ex-ante and ex-post input parameters estimates for the APS measures, and the ex-ante and ex-post source of the parameter estimates.

TABLE B-7: 2015 APS REBATE UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Estimate	Ex-Post Estimate	Source	Evaluation Assessment
kWh Savings	371 kWh	137 kWh	3 small field trials	Update based on literature review or metering study
HVAC Yield	86%	81%	Lighting in conditioned spaces	Evaluation Analysis based on Participant survey data
Installation Rate (ISR)	100%	66%	All assumed to be installed	

APPENDIX C APPLIANCE DECOMMISSIONING SUPPLEMENTAL

C.1 APPLIANCE DECOMMISSIONING TRACKING DATA REVIEW

Table C-1 below compares PSE's ex-ante savings claims (units sold, kWh, and therms) to the tracking review verified estimates for the 2014 and 2015 Appliance Decommissioning program. As this table shows, the 2014 and 2015 tracking review verified unit and savings totals match the ex-ante estimates exactly for the decommissioning measures, resulting in a 100% realization rate.

TABLE C-1: TRACKING REVIEW VERIFIED IMPACTS FOR APPLIANCE DECOMMISSIONING PROGRAM

Program Year	Measure	Savings Type	Ex-Ante	Tracking Review Verified	Tracking Review Realization Rate
2014	Refrigerator Decommissioning	Units	4,246	4,246	100%
		kWh	1,809,236	1,809,236	100%
		therms	-	-	-
	Freezer Decommissioning	Units	1,702	1,702	100%
		kWh	817,560	817,560	100%
		therms	-	-	-
	Total	**Units**	**5,948**	**5,948**	**100%**
		kWh	**2,626,796**	**2,626,796**	**100%**
		therms	**-**	**-**	**-**
2015	Refrigerator Decommissioning	Units	2,476	2,476	100%
		kWh	906,480	906,480	100%
		therms	-	-	-
	Freezer Decommissioning	Units	862	862	100%
		kWh	480,760	480,760	100%
		therms	-	-	-
	Total	**Units**	**3,338**	**3,338**	**100%**
		kWh	**1,387,240**	**1,387,240**	**100%**
		therms	**-**	**-**	**-**

Source: Evaluation Team Analysis

C.2 APPLIANCE DECOMMISSIONING UES REVIEW

To estimate the measure-level savings for the Appliance Decommissioning program, a series of input parameters were entered into the algorithm (separate input parameters were used for decommissioned refrigerators and freezers), and the resulting output was the deemed UES estimate. Table C-2 below lists the ex-ante input parameters that were applied through this process to estimate the 2015[9] RTF Deemed UES values for refrigerator and freezer decommissioning, the ex-post recommendations, and the sources of each of these input parameters.[10]

[9] There were no changes to the 2016 input parameters or algorithm and so these estimates are also reflective of the 2016 UES estimates. The UEC of the Old and Replacement units changed in the RTF in September of 2015, but it was after PSE had finalized the 2016 business case and so these changes, if applied, will not be effective until 2017. They result in a net decreased in UES for both refrigerator and freezer replacements (the updated RTF UES estimates are 289 kWh and 444 kWh, respectively).

[10] Currently this RTF measure has a Status of "Active" and a sunset date of 9/30/2017 which makes this evaluation research extremely relevant at this time as the RTF is likely currently reviewing the measure in anticipation of the upcoming sunset date.

TABLE C-2: 2015 REFRIGERATOR DECOMMISSIONING UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Value	Ex-Post Value	Ex-Ante Source	Ex-Post Source
LeftOnGrid$_{SD}$	55%	39%	Weighted average from 4 NW Refrigerator Studies[11]	Updated from participant web survey
LeftOnGrid$_{kept}$	7%	13%		
LeftOffGrid	38%	48%		
Replaced	75%	71%	No source provided	Updated from participant web survey
NonReplace	25%	29%		
Replace$_{ind}$	5.5%	12%	Average induced replacement from 2 NW Studies[12]	
Replace$_{NonInd}$	94.50%	88%		
PartUse	91%	90%	Weighted Part-Use Factor from 3 studies[13]	Updated from participant web survey
InsituAdj	81%	n/a	Residential Retrofit High Impact Measure Evaluation Report[14]	Parameter not required with UMP regression-based approach based on metered data
C-Factor	-1.90%	n/a	JACO data	
UEC$_{old}$	1,274 kWh	1,137 kWh	Average UEC of recycled units in 2012-2013, JACO data. Adjusted using C-Factor to account for increase in efficiency.	2013–2014 Pacific Power Washington "See ya later, refrigerator®" Program[15]
UEC_Replace	523 kWh	534 kWh	JACO data, RTF Residential Refrigerator Measure Workbook v3.0, and the RBSA refrigerator distribution	Energy Star website[16] based on door configuration, age, and capacity.
R1$_{new}$	79%	73%	% of R1 replacement units that are new, JACO data	Energy Star website[17] based on door configuration, age, and capacity; and participant web survey
R2$_{new}$	59%	27%	% of R2 replacement units that are new, ADM 2004-2005 CA Statewide survey	

11 Avista, 2010-2011, Cadmus report page 25; ETO, 2011, Fast track Feedback final report 2011; Rocky Mountain Power Idaho SYL, Refrigerator Program Evaluation Report 2011-2012; Pacific Power Washington SYL, Refrigerator Program Evaluation Report 2011-2012

12 Rocky Mountain Power Idaho SYL, Refrigerator Program Evaluation Report 2011-2012; Pacific Power Washington SYL, Refrigerator Program Evaluation Report 2011-2012

13 Avista, 2011; CADMUS, PacifiCorp ID, 2011-2012; CADMUS, PacifiCorp WA, 2011-2012

14 Cadmus Group, Residential Retrofit High Impact Measure Evaluation Report, 2/8/2010, Table 123, page 141

15 Source: https://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Demand_Side_Management/2016/SYLR_2013-2014_Washington_Final_Report.pdf

16 https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

17 https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

TABLE 3-3: 2015 FREEZER DECOMMISSIONING UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Value	Ex-Post Value	Ex-Ante Source	Ex-Post Source
LeftOnGrid$_{SD}$	53%	53%	Weighted average sold/donated unit from 4 NW Refrigerator Studies[18]	Updated from participant web survey
LeftOnGrid$_{kept}$	13%	8%	Weighted average kept unit from 4 NW Refrigerator Studies	
LeftOffGrid	34%	39%	1 - LeftOnGrid$_{SD}$ - LeftOnGrid$_{kept}$	
Replaced	75%	61%	No source provided	Updated from participant web survey
NonReplace	25%	39%	1 - Replace	
Replace$_{ind}$	6%	14%	Average induced replacement from 2 NW Studies[19]	
Replace$_{NonInd}$	95%	86%	1 - Replace$_{ind}$	
PartUse	91%	86%	Weighted Part-Use Factor from 3 studies[20]	Updated from participant web survey
InsituAdj	81%	n/a	Residential Retrofit High Impact Measure Evaluation Report[21]	Parameter not required with UMP regression-based approach based on metered data.
C-Factor	1.2%	n/a	JACO data	
UEC$_{old}$	1,509 kWh	941 kWh	Average UEC of recycled units in 2012-2013, JACO data. Adjusted using C-Factor to account for increase in efficiency.	2013–2014 Pacific Power Washington "See ya later, refrigerator®" Program[22]
UEC_Replace1	500 kWh	485 kWh	R1$_{new}$ * RTF_Baseline + (1- R1$_{new}$) * RBSA_Installed	Energy Star website[23] based on door configuration, age, and capacity; and participant web survey

18 Avista, 2010-2011, Cadmus report page 25; ETO, 2011, Fast track Feedback final report 2011; Rocky Mountain Power Idaho SYL, Refrigerator Program Evaluation Report 2011-2012; Pacific Power Washington SYL, Refrigerator Program Evaluation Report 2011-2012

19 Rocky Mountain Power Idaho SYL, Refrigerator Program Evaluation Report 2011-2012; Pacific Power Washington SYL, Refrigerator Program Evaluation Report 2011-2012

20 Avista, 2011; CADMUS, PacifiCorp ID, 2011-2012; CADMUS, PacifiCorp WA, 2011-2012

21 Cadmus Group, Residential Retrofit High Impact Measure Evaluation Report, 2/8/2010, Table 123, page 141

22 Source: https://www.pacificorp.com/content/dam/pacificorp/doc/Energy_Sources/Demand_Side_Management/2016/SYLR_2013-2014_Washington_Final_Report.pdf

23 https://www.energystar.gov/index.cfm?fuseaction=refrig.calculator

APPENDIX D APPLIANCE REPLACEMENT SUPPLEMENTAL

D.1 APPLIANCE REPLACEMENT PROGRAM TRACKING DATA REVIEW

Table D-1, below, compares PSE's 2014 and 2015 ex-ante savings claims (units, kWh, and therms) for the Appliance Replacement program to the tracking review verified savings estimates at the measure-level. As this table shows, the tracking review verified unit and savings totals match the ex-ante estimates with the following exception: the ex-ante refrigerator replacement units reported in the 2014 and 2015 EES PDFs do not reflect the quantity of measures distributed through the program. The unit totals reported by PSE include one unit for refrigerator replacement savings in years 1-14 (the RUL of the replaced unit) and another unit for the refrigerator replacement savings in years 15-20 (the remaining EUL of the new unit), resulting in a double counting the number of units.

TABLE D-1: TRACKING REVIEW VERIFIED IMPACTS FOR APPLIANCE REPLACEMENT PROGRAM

Program Year	Measure	Savings Type	Ex-Ante	Tracking Review Verified	Tracking Review Realization Rate
2014	Clothes Washer Replacement	Units	1,896	1,896	100%
		kWh	1,341,264	1,341,264	100%
		therms	-	-	-
	Refrigerator Replacement	Units	5,144	3,045	59%
		kWh	2,139,451	2,139,451	100%
		therms	-	-	-
	Total	**Units**	**7,040**	**4,941**	**70%**
		kWh	**3,480,715**	**3,480,715**	**100%**
		therms	**-**	**-**	**-**
2015	Clothes Washer Replacement	Units	1,857	1,857	100%
		kWh	1,418,748	1,418,748	100%
		therms	-	-	-
	Refrigerator Replacement	Units	4,760	2,380	50%
		kWh	1,410,298	1,410,298	100%
		therms	-	-	-
	Total	**Units**	**6,617**	**4,237**	**64%**
		kWh	**2,829,046**	**2,829,046**	**100%**
		therms	**-**	**-**	**-**

Source: Evaluation Team Analysis

D.2 REFRIGERATOR REPLACEMENT PROGRAM UES REVIEW

Because this program was discontinued at the end of 2016, the evaluation team conducted did not conducted any ex-post UES research.

D.3 CLOTHES WASHER REPLACEMENT PROGRAM UES REVIEW

To estimate the measure-level savings for the Clothes Washer Replacement program, a series of input parameters were entered into the algorithms presented in Section 5.2.2 of the main report. Table D-2 below provides the ex-ante and ex-post input parameters included in the Clothes Washer Replacement UES algorithm along with the source of the parameter values.

TABLE D-2: 2015 CLOTHES WASHER REPLACEMENT UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Estimate	Ex-Post Estimate	Ex-Ante Source	Ex-Post Source
%Savings_CW	20%	20%	ES Calculator Default	No change
%Savings_WH	80%	80%		
RatedUEC$_m$ (EnergyStar)	159	130	"EPA research on available models, 2011", no link to source provided	2015 PSE tracking data average
RatedUEC$_b$ (Conventional)	470	470	"Federal standard, Code of Federal Regulations, Title 10, Part 430, Subpart C", link broken	No change
AnnualLoads	256	226	2011 RBSA	Participant web survey
ReferenceLoads	392	392	DOE Federal Test Procedure, Code of Federal Regulations, Title 10, Part 430, Subpart B, Appendix J	No change
%LoadsDried (EnergyStar[24])	100%	94.17%	ES Calculator Default	Participant web surveys
%LoadsDried (Conventional)				
CW_Capacity	3.64	3.81	ES Calculator Default	2015 PSE tracking data average
MEF* (EnergyStar)	2.48	2.51	EnergyStar	2015 PSE tracking data average**
MEF* (Conventional)	0.817	0.817	DOE Minimum Federal Efficiency Standard for pre-1997 Clothes Washers	No change

Source: Evaluation Team Analysis

* In March 2015, Energy Star updated their energy performance metric for certified residential clothes washers to an Integrated Modified Energy Factor (IMEF).

** In 2016, the UES the MEF of Energy clothes washers was increased to 3.19 for front loaders and 2.8 for top loaders. This increased the UES estimates to 848 kWh for front loaders and 809 kWh for top loaders.

24 The evaluation team plans to investigate during the Stage 2 participant's surveys if the percentage of loads dried is reduced with the installation of an EnergyStar Clothes Washer.

APPENDIX E LIGHTING SUPPLEMENTAL

E.1 LIGHTING PROGRAM TRACKING DATA REVIEW

Table E-1 below compares PSE's 2014 and 2015 ex-ante savings claims (units and kWh) for the Residential Lighting program to the tracking review verified savings estimates at the measure-level. As this table shows, the tracking review verified unit and savings totals match the ex-ante estimates with a few exceptions. As shown, the evaluation team determined a 100% tracking review realization rate for 2014 ex-ante estimates of savings for all measures. For the 2015 participation data, differences were observed in the deemed savings values applied to specific measures. For standard CFLs, specialty CFLs, and reflector LEDs, the evaluation team found that the 2014 deemed savings values were applied in the initial invoicing periods of 2015. In these instances, a 100% tracking review realization rate was applied to these measures and no correction was applied during the tracking review stage. However, in the case of indoor LED fixtures and LED retrofit kits, where the 2014 deemed savings value was applied to records spanning most of 2015, the evaluation team applied the 2015 deemed savings value and adjusted for this discrepancy. As seen, LED retrofit kits have a tracking review realization rate of 99% and indoor LED fixtures have a realization rate of 90% in 2015. The overall Lighting Program tracking data review realization rate for 2015 was calculated at 100% (rounded up from 99.8%).

TABLE E-1: TRACKING REVIEW VERIFIED IMPACTS FOR RESIDENTIAL LIGHTING PROGRAM

Lighting Measure	Savings Type	2014			2015		
		Ex-Ante	Track Rvw Verified	Tracking Review RR	Ex-Ante	Track Rvw Verified[25]	Tracking Review RR
Standard CFLs	Bulbs	1,739,414	1,739,414	100%	1,309,297	1,309,297	100%
	kWh	27,830,626	27,830,626	100%	14,067,184	14,067,183	100%
A-Lamp LED	Bulbs	1,305,770	1,305,770	100%	1,616,884	1,616,884	100%
	kWh	18,399,654	18,399,654	100%	24,887,027	24,887,028	100%
Specialty CFL	Bulbs	645,422	645,422	100%	260,606	260,606	100%
	kWh	11,033,211	11,033,211	100%	4,096,776	4,096,776	100%
Reflector LED	Bulbs	441,184	441,184	100%	702,747	702,747	100%
	kWh	10,896,180	10,896,180	100%	19,114,065	19,114,065	100%
Candelabra LED	Bulbs	169,600	169,600	100%	149,682	149,682	100%
	kWh	3,012,090	3,012,090	100%	2,657,265	2,657,264	100%
Indoor LED Fixture	Units	72,375	72,375	100%	69,673	69,673	100%
	kWh	1,739,814	1,739,814	100%	1,671,456	1,553,924	90%
Retrofit Kit LED	Bulbs	86,408	86,408	100%	192,465	192,465	100%
	kWh	1,727,296	1,727,296	100%	3,835,612	3,787,168	99%
Outdoor LED Fixture	Units	29,482	29,482	100%	48,651	48,651	100%
	kWh	1,723,813	1,723,813	100%	2,844,624	2,844,624	100%
Globe LED	Bulbs	96,033	96,033	100%	93,714	93,714	100%
	kWh	1,508,682	1,508,682	100%	1,471,799	1,471,799	100%
CFL: Dir. Mail& Door-to-Door	Units	13,784	13,784	100%			
	kWh	206,760	206,760	100%			
Outdoor CFL Fixture	Units	1,571	1,571	100%			
	kWh	188,520	188,520	100%			
Indoor CFL Fixture	Units	4,087	4,087	100%			
	kWh	175,725	175,725	100%			
MR-16 LED	Bulbs	6,610	6,610	100%	11,043	11,043	100%
	kWh	167,782	167,782	100%	280,578	280,578	100%
Engagement Bulb LED	Bulbs	232	232	100%			
	kWh	3,127	3,127	100%			
Engagement Bulb	Bulbs	85	85	100%	34	34	100%
	kWh	1,700	1,700	100%	458	458	100%
Standard CFL - Door-to-Door/DM	Units	31	31	100%			
	kWh	465	465	100%			
Total	Units	4,612,088	4,612,088	100%	4,454,796	4,454,796	100%
	kWh	78,615,445	78,615,445	100%	74,926,844	74,760,867	100%

Source: Evaluation Team Analysis

** The ex-ante kWh savings totaled one kWh less than the EES database total savings for Standard CFLs and Candelabra LEDs. This was attributed to rounding issues and not corrected in the tracking data review process.

[25] Some of the quantities here include NQC records that were found in the tracking database.

E.2 LIGHTING PROGRAM UES REVIEW

To estimate the measure-level savings for the residential lighting program, a series of input parameters were entered into the algorithm shown above. Table E-2 through Table E-5 below provides the input parameters included in the Residential Lighting UES algorithm, the source of the parameter estimate, and the evaluation teams' Stage 1 assessment of this value.

TABLE E-2: 2015 RESIDENTIAL LIGHTING UES INPUT PARAMETER ASSESSMENT – BASELINE WATTAGE

Measure	Ex-Ante Value	Ex-Post Value	Ex-Ante Source	Ex-Post Source
A-Lamp LED	32.8	32.95	2011 RBSA, Average installed wattage across similar measures from PSE sample	UMP approved lumen mapping adjusted to account for percentage of lamps that are replacing CFLs and LEDs.
A-Lamp Induction		n/a		
Standard CFL		n/a		
Candelabra LED	37.4	36.15		
Globe LED	38.9	36.09		
Reflector LED	48.9	55.27		
Retrofit Kit LED	44.1	55.73		
Specialty CFL	41.3	32.78		
Indoor LED Fixture	57.4	70.13		
Outdoor LED Fixture	51.8	71.38		
MR16 LED	43.8	35.53	Sales Data (undocumented), Average wattage across 12 models	

TABLE E-3: 2015 RESIDENTIAL LIGHTING UES INPUT PARAMETER ASSESSMENT – MEASURE WATTAGE

Measure	Ex-Ante Value	Ex-Post Value	Ex-Ante Source	Ex-Post Source
A-Lamp LED	9.37	9.57	Average wattage by measure of lamps in PSE's sales data (primarily 2012 sales) from incentive processor.[26]	Wattage of program bulbs sold in 2015 based on file of 2015 program sales from C+C-
Reflector LED	12.82	12.49		
Retrofit Kit LED	13.07	17.37		
Indoor LED Fixture	15.36	21.33		
Outdoor LED Fixture	9.68	22.07		
Candelabra LED	3.65	4.90	Online survey (undocumented) of products at two program retailers	
Globe LED	5.31	7.88		
MR16 LED	6.31	7.09	Source not documented	
A-Lamp Induction	14.5	N/A		
Standard CFL	17	16.51	Weighted average of 2014 sales	
Specialty CFL	14.89	14.74		

TABLE E-4: 2015 RESIDENTIAL LIGHTING UES INPUT PARAMETER ASSESSMENT – DAILY HOU

Measure	Ex-Ante Value	Ex-Post Value	Ex-Ante Source	Ex-Post Source
A-Lamp LED	2.23	2.47	Same as below with NonRes HOU applied to 3.9% of LEDs (26% LEDs sold through BB/HW stores * 15% of sales to NonRes = 3.9%)	Methods similar to Ex-Ante but with updates to Res/NonRes Split based on 2015 lamp purchase study and 2017 deemed HOU values.
Retrofit Kit LED	2.10	3.06	Average NonRes HOU of 11.01 (average HOU across Retail, Office, Restaurant and Other)	
Candelabra LED	1.75	2.26	KEMA 2010 HOU results by room type (backfilled with DOE 2010, where missing). HOU assigned to PSE's RBSA inventory data by room type, average HOU calculated across all similar measures.	
Globe LED	1.58	1.80		
MR16 LED	2.20	2.98		
Reflector LED	2.54	2.98		
Indoor LED Fixture	1.71	2.57		
Outdoor LED Fixture	3.80	3.66		
A-Lamp Induction	1.88	N/A		
Standard CFL		2.47		
Specialty CFL	1.87	2.78		

26 According to SoS documentation, this included a full year of sales data (~4.6MM LED and CFL lamps), however the data included in the 2015 UES file (PSEDeemed_Residential Lighting_VActive.xlsx) that is used to estimate these measure wattages had significantly less data (~1.3MM LED lamps and ~340,000 CFL lamps.)

TABLE E-5: 2015 RESIDENTIAL LIGHTING UES INPUT PARAMETER ASSESSMENT – HVAC_IE

Measure	Ex-Ante Value	Ex-Post Value	Ex-Ante Source	Ex-Post Source
A-Lamp LED	-15.9%	-14%	HVAC_IE = %sockets_cond_space * Sum of (kWh and therm IE) %sockets_conditioned_space (2011 RBSA) kWh IE = -15.4%, Therm IE = -3.35% (RTF's 6th Power Plan load profile)	RTF's 7th Power Plan modified to account for lumen distribution of 2015 sales and home type and fuel adjustment
A-Lamp Induction		N/A		
Standard CFL		-14%		
Candelabra LED	-17.4%	-15%		
Globe LED	-18.8%	-16%		
MR16 LED	-15.7%	-14%		
Reflector LED		-14%		
Retrofit Kit LED	-16.9%	-16%		
Specialty CFL	-16.5%	-14%		
Indoor LED Fixture	-31.4%	-16%		
Outdoor LED Fixture	0.0%	0.0%	No HVAC IE for outdoor locations	

APPENDIX F SHOWERHEAD SUPPLEMENTAL

F.1 SHOWERHEAD PROGRAM TRACKING DATA REVIEW

Table F-1 below compares PSE's 2014 and 2015 ex-ante savings claims (units and kWh) for the Residential Showerhead program to the tracking review verified savings estimates at the measure-level. As this table shows, the 2014 tracking review verified unit and saving totals match the ex-ante estimates. In 2015, slight differences were found in the unit quantities of electric showerheads and electric ShowerStart adapters, however the electric energy savings matched between the two sources. These two measures where a discrepancy was found were both noted as "NQC", and no savings were claimed for these measures.

The main discrepancy found in the tracking data review for showerheads resulted from the fact that some measures in 2015 were assigned both gas and electric deemed savings. For these measures, the unit is counted twice in the unit totals, once for the gas savings and once for the electric savings. This is a frequent occurrence, so while the 2015 tracking data shows the total number of units with gas savings is 20,845 and the total number of units with electric savings is 23,570, the total number of units sold in 2015 is 27,948, meaning that nearly half of the measures are double counted with respect to units sold.

TABLE F-1: TRACKING REVIEW VERIFIED IMPACTS FOR RESIDENTIAL SHOWERHEAD PROGRAM

Program Year	Measure	Savings Type	Ex-Ante	Tracking Review Verified	Tracking Review Realization Rate
2014	Showerhead	Units	71,561	71,561	100%
		kWh	4,301,679	4,301,679	100%
		Therms	145,778	145,777	100%
	2014 Total	Units (E)	40,162	40,162	100%
		Units (G)	31,399	31,399	100%
		kWh	4,301,679	4,301,679	100%
		Therms	145,777	145,777	100%
2015	Showerhead	Units	39,014	37,982	97%
		kWh	2,225,294	2,225,294	100%
		Therms	71,194	71,193	100%
	ShowerStart Showerhead	Units	2,484	2,484	100%
		kWh	152,670	152,670	100%
		Therms	19,898	19,897	100%
	ShowerStart Adapter	Units	3,973	3,949	99%
		kWh	129,442	129,442	100%
		Therms	19,365	19,366	100%
	2015 Total	Units (E)	24,626	23,570	96%
		Units (G)	20,845	20,845	100%
		kWh	2,507,406	2,507,406	100%
		Therms	110,457	110,456	100%

Source: Evaluation Team Analysis

F.2 SHOWERHEAD ONLY MEASURE UES REVIEW

The evaluation team reviewed the input parameters used within the savings algorithm to ensure they are appropriate for PSE service territory, reflect current measure standards, and are based on the best available data (program and market) at the time they were deemed. Table F-2 lists the ex-ante and ex-post input parameters applied in 2015 to estimate the UES for showerhead only measures, along with the source of these parameter estimates. A number of the changes recommended in the table below were also recommended in the RTF Residential Showerheads UES Update in October 2015.[27] Some of the parameters shown below, such as the water heater saturations for electric and combined service territories and the showerhead installation rates, have been updated with PSE-specific values that are more representative of PSE territory than the values found in the RTF.

27 http://rtf.nwcouncil.org/meetings/2015/10/Residential%20Showerheads%20UES%20Measures%20v03.pptx

TABLE F-2: 2015 SHOWERHEAD UES INPUT PARAMETER ASSESSMENT

<table>
<tr><th>Parameter</th><th>Ex-Ante Value</th><th>Ex-Post Value</th><th colspan="2">Ex-Post Source & Explanation</th></tr>
<tr><td>PersonsHH</td><td>2.51 people</td><td>N/A</td><td>N/A</td><td rowspan="5">$\#ShowerHH_{ann}$ replaced with $\#ShowerSH_{ann}$ which is a per SH, not per HH, estimate. $\#ShowerSH_{ann}$ = $\# Persons_{SH}$ $Showers_{person}$</td></tr>
<tr><td>DailyShowers</td><td>0.46 showers</td><td>N/A</td><td>N/A</td></tr>
<tr><td>$Days_{ann}$</td><td>350 days</td><td>N/A</td><td>N/A</td></tr>
<tr><td>$\#Persons_{SH}$</td><td>N/A</td><td>1.52</td><td>Evaluation Analysis of Phone General Population Survey Data</td></tr>
<tr><td>$Showers_{person}$</td><td>N/A</td><td>250</td><td>Updated based on RTF Thermostatic Valve Calculation. Consistent with RUEWS (1999)** and EPA New Homes Study (2011)*</td></tr>
<tr><td>Length</td><td>7.84 minutes</td><td>Baseline: 8.2 min
2.0 GPM: 8.43 min
1.75 GPM: 8.7 min
1.5 GPM: 9.21</td><td colspan="2">2016 REUS. Used by RTF Showerheads v3.1.
Updated value consistent with RTF showerhead update.</td></tr>
<tr><td>$FlowRate_b$</td><td>2.2 GPM</td><td>2.3 GPM</td><td colspan="2">To average flowrate, 2.3 gpm, from median flowrate (skewed to lower GPM).
Updated value consistent with RTF Thermostatic Valves calculation.</td></tr>
<tr><td>$FlowRate_e$</td><td>1.8, 1.58, or 1.35 (for 2.0, 1.75, 1.5 GPM SH)</td><td>No change</td><td colspan="2">RTF Decision, based on data from 1994 metering study ***, 2007 showerhead impact eval****</td></tr>
<tr><td>HW_Mix_b</td><td>73.10%</td><td rowspan="2">71%</td><td colspan="2" rowspan="2">Ex-ante values were not supported by data.
Consistent with updated RTF Showerheads 3.1.</td></tr>
<tr><td>HW_Mix_e</td><td>75.5% to 78.2%</td></tr>
<tr><td>DeltaT</td><td>75 degrees</td><td>No change</td><td colspan="2">RTF Decision, based on data from 1994 metering Study***</td></tr>
<tr><td>WHeff</td><td>Elec: 98%
Gas: 75%</td><td>No change</td><td colspan="2">RTF Decision, based on data from 1994 metering study ***, 2007 showerhead impact eval****</td></tr>
<tr><td>WH_{energy}</td><td>0.00244 (kwh/g)
0.0000834 (therm/g)</td><td>No change</td><td colspan="2">Constant to account for the energy it takes to heat a gallon of water</td></tr>
<tr><td>IR</td><td>70-80%, by flowrate, Gas Only SH 90%</td><td>90.2%</td><td colspan="2">Evaluation Analysis of Phone Survey Data. Includes both an install rate and an in-service rate.</td></tr>
<tr><td>WH_{sat}</td><td>58.9% electric (EO)
48.7% electric (C)
49.7% gas (C)
52% gas (GO)</td><td>59.5% electric (EO)
63.5% electric (C)
33.8% gas (C)
59.7% gas (GO)</td><td colspan="2">Evaluation Analysis of Phone General Population Survey Data</td></tr>
<tr><td>WWsavings</td><td>5.4 - 10.0 kWh/ 1000 gallons</td><td>3.7 kWh per 1000 gallons</td><td colspan="2">Updated based on revised RTF estimates.</td></tr>
</table>

Source: Evaluation Team Analysis

* Analysis of Water Use in New Single Family Homes. Aquacraft. 2011.

** Residential End Uses of Water Study. Water Research Foundation. 1999.

***Energy Efficient Showerhead and Faucet Aerator Metering Study. PSE/BPA/SBW, 1994.

**** Single Family 2007 Showerhead Kit Impact Evaluation. Seattle City Light, October 2008.

F.3 SHOWERSTART MEASURE UES REVIEW

The evaluation team reviewed the input parameters for the ShowerStart measures in a manner consistent to what was done for the Showerhead only measures. Table F-3 lists the ex-ante and ex-post input parameters applied in 2015 to estimate the UES for ShowerStart measures, along with the source of these parameter estimates.

TABLE F-3: 2015 SHOWERSTART AND ADAPTER UES INPUT PARAMETER ASSESSMENT

<table>
<tr><th>Parameter</th><th>Ex-Ante Value</th><th>Ex-Post Value</th><th colspan="2">Ex-Post Source & Explanation</th></tr>
<tr><td>$Savings_{SH}$</td><td>307 kWh
13.00 Therms</td><td>292 kWh
13.02 Therms</td><td colspan="2">Updated based on Showerhead Only Measure Updates</td></tr>
<tr><td>$\#ShowerSH_{ann}$</td><td>644</td><td>N/A</td><td>N/A</td><td rowspan="3">$\#ShowerHH_{ann}$ replaced with $\#ShowerSH_{ann}$ which is a per SH, not per HH, estimate.
$\#ShowerSH_{ann}$ = $\#Persons_{SH}$ $Showers_{person}$</td></tr>
<tr><td>$\#Persons_{SH}$</td><td>N/A</td><td>1.518</td><td>Evaluation Analysis of Phone General Population Survey Data</td></tr>
<tr><td>$Showers_{person}$</td><td>N/A</td><td>250</td><td>Updated based on RTF Thermostatic Valve Calculation. Consistent with RUEWS (1999)** and EPA New Homes Study (2011)*</td></tr>
<tr><td>$Waste_{sec}$</td><td>80.8 seconds</td><td>66 seconds</td><td colspan="2">There is very little data surrounding this value. The ex-ante value is unsourced. The value of 66 seconds was sourced from the SD Whitepaper. The new RTF Thermostatic Valve Calculator statues 38 seconds, but is based on limited dataset.</td></tr>
<tr><td>$FlowRate_{b}$</td><td>2.2 GPM</td><td>2.3 GPM</td><td colspan="2">To average flowrate, 2.3 gpm, from median flowrate (skewed to lower GPM). Updated value consistent with RTF Thermostatic Valves calculation.</td></tr>
<tr><td>DeltaT</td><td>60.4 degrees</td><td>75 degrees</td><td colspan="2">RTF Decision, based on data from 1994 metering Study*** Updated for consistency with Showerhead Measure.</td></tr>
<tr><td>WHeff</td><td>Elec: 98%
Gas: 75%</td><td>No change</td><td colspan="2">RTF Decision, based on data from 1994 metering study ***, 2007 showerhead impact eval****</td></tr>
<tr><td>WH_{energy}</td><td>0.00244 (kwh/g)
0.0000834 (therm/g)</td><td>No change</td><td colspan="2">Constant, accounts for energy to heat 1 gallon of water</td></tr>
<tr><td>HW_Mix</td><td>N/A</td><td>71%</td><td colspan="2">Consistent with updated RTF Showerheads 3.1 and Showerhead-Only Measure.</td></tr>
<tr><td>IR_{RTF}</td><td>90%</td><td>N/A</td><td colspan="2">This variable is unnecessary in the evaluated savings algorithm.</td></tr>
<tr><td>IR_{PSE}</td><td>70%</td><td>90.2%</td><td colspan="2">Evaluation Analysis of Phone Survey Data. Includes both an install rate and an in-service rate.</td></tr>
<tr><td>WH_{Sat}</td><td>58.9% electric (EO)
48.7% electric (C)
49.7% gas (C)
81% gas (GO)</td><td>59.5% electric (EO)
63.5% electric (C)
33.8% gas (C)
59.7% gas (GO)</td><td colspan="2">Evaluation Analysis of Phone General Population Survey Data</td></tr>
<tr><td>$ShowerStart_{use}$</td><td>N/A</td><td>75%</td><td colspan="2">RTF Thermostatic Valve Calculations. This value is stated to come from an Evolve Technologies Survey. This also assumes that 100% of showers are initiated via ShowerStart, and only 60% of Tub/Shower combinations. There is some uncertainty surrounding this.[28]</td></tr>
<tr><td>WW_savings</td><td>N/A</td><td>3.7 kWh per 1000 gallons</td><td colspan="2">Updated based on revised RTF estimates.</td></tr>
</table>

Source: Evaluation Team Analysis

- Table notes provided here are the same as the Showerhead only table

[28] The General Population survey conducted by the evaluation team asked survey participants how often they leave the shower running unattended while the water is warming up. Forty-four percent of respondents

F.4 ENGAGEMENT AND LEAVE-BEHIND SHOWERHEAD MEASURES UES REVIEW

The evaluation team reviewed the input parameters used within the savings algorithm shown above to ensure they are appropriate for PSE service territory, reflect current measure standards, and are based on the best available data (program and market) at the time they were deemed. Table F-4 lists the input parameters applied in 2015 to estimate the UES for the showerhead kit measures, along with recommended updates made by the evaluation team to any parameters, and the source of those updates. Many of the adjusted input parameters are based off of evaluation findings from the Showerhead-only calculations, seen in Table F-1, above.

TABLE F-4: 2015 SHOWERHEAD UES INPUT PARAMETER ASSESSMENT

Parameter	Ex-Ante Value	Ex-Post Value	Ex-Post Source & Explanation
$\%PSECust_{Confirmed}$	94%	94%	PSE Value calculated by performing a separate analysis of PSE customers using average of both an exact match analysis and a zip code analysis. No updates made by evaluation team.
$Share_{Primary}$	86% (Gas) 78% (Elec)	N/A	It was not clear where these values were sourced from in the ex-ante calculations. It was not used by the evaluation team, as the evaluation team did not differentiate between primary and secondary showers for consistency with other Showerhead measures.
$Share_{Secondary}$	14% (Gas) 22% (Elec)		
$Saving_{SHPrimary}$	17 Therms (Gas) 408 kWh (Elec)	N/A	The evaluated savings values were calculated in the Showerhead-Only measures calculation, based on updated evaluation parameters.
$Saving_{SHSecondary}$	9 Therms (Gas) 209 kWh (Elec)		
$Savings_{SHEval}$	N/A	13 Therms (Gas) 292 kWh (Elec)	
IR	66% (Gas) 62% (Elec)	N/A	It is not clear where the ex-ante installation rates were sourced from. The evaluation team calculated an installation rate from the Appliance Survey they conducted. The $IR_{retailEval}$ value was included only so that it could be backed out of the $Savings_{SHEval}$ number.
IR_{eval}	N/A	56%	
$IR_{retailEval}$	N/A	90.2%	
WH_{sat}	58.9% electric (EO) 48.7% electric (C) 49.7% gas (C) 52% gas (GO)	59.5% electric (EO) 63.5% electric (C) 33.8% gas (C) 59.7% gas (GO)	Evaluation Analysis of Phone General Population Survey Data
WWsavings	N/A	3.7 kWh per 1000 gallons	Updated based on revised RTF estimates.

Source: Evaluation Team Analysis

stated that they never leave the shower unattended. This indicates that it is possible the 75% value is too high. However, it can also be argued that purchasers of ShowerStart technologies are more likely to leave the water running unattended. Therefore, the evaluation team did not make an update from the RTF estimate for this value.

APPENDIX G DATA COLLECTION INSTRUMENTS

G.1 CLOTHES WASHER SURVEY

G.1.1 Clothes Washer Web Survey Instrument

PSE_ClothesWasher_
Participant_Survey_In:

G.2 APPLIANCE REBATE SURVEY

G.2.1 Appliance Rebate Web Survey Instrument

PSE_Rebate_Participa
nt_Survey_Instrument

G.3 APPLIANCE DECOMMISSIONING SURVEY

G.3.1 Appliance Decommissioning Web Survey Instrument

PSE_Decom_Participa
nt_Survey_Instrument

G.4 GENERAL POPULATION SURVEY

G.4.1 General Population Web Survey Instrument

PSE_GenPop_Survey_
Instrument.docx

APPENDIX H OPTIMAL DATA FLOW MODEL

PSE updated their program tracking systems and processes in the 2016-2017 period. Specifically, they transitioned to a new internal program tracking system, DSMc. As part of this process, PG&E worked with vendors and staff to ensure that the appropriate variables are included in the new database. This process happened in parallel with Itron's evaluation effort. Along the way, the evaluation team shared information on what would be needed. This appendix documents the specific players, roles and data that should be collected for future evaluations. It is intended to help the program team confirm that all of the important data is being collected, and to aid future evaluators in their efforts to understand program processes and data sources.

PSE worked with the evaluation team to develop the data flow maps below. In these maps, we lay out the specific variables that should be collected for verification, as well as the additional data that is known to be collected—or that would be useful—for future evaluations of these programs.

We note that the current processes involve multiple data collection points and multiple databases. Going forward, PSE should explore whether this process could be further streamlined so that vendors are entering data directly into a vendor portal within the DSMc database (rather than maintaining their own databases, exporting to an Excel template from PSE, uploading to FTP site, having program managers upload to the DSMc).

H.1 DATA SOURCES FOR DTC CHANNELS

There are multiple data sources for the information needed to complete the evaluation effort. This includes:

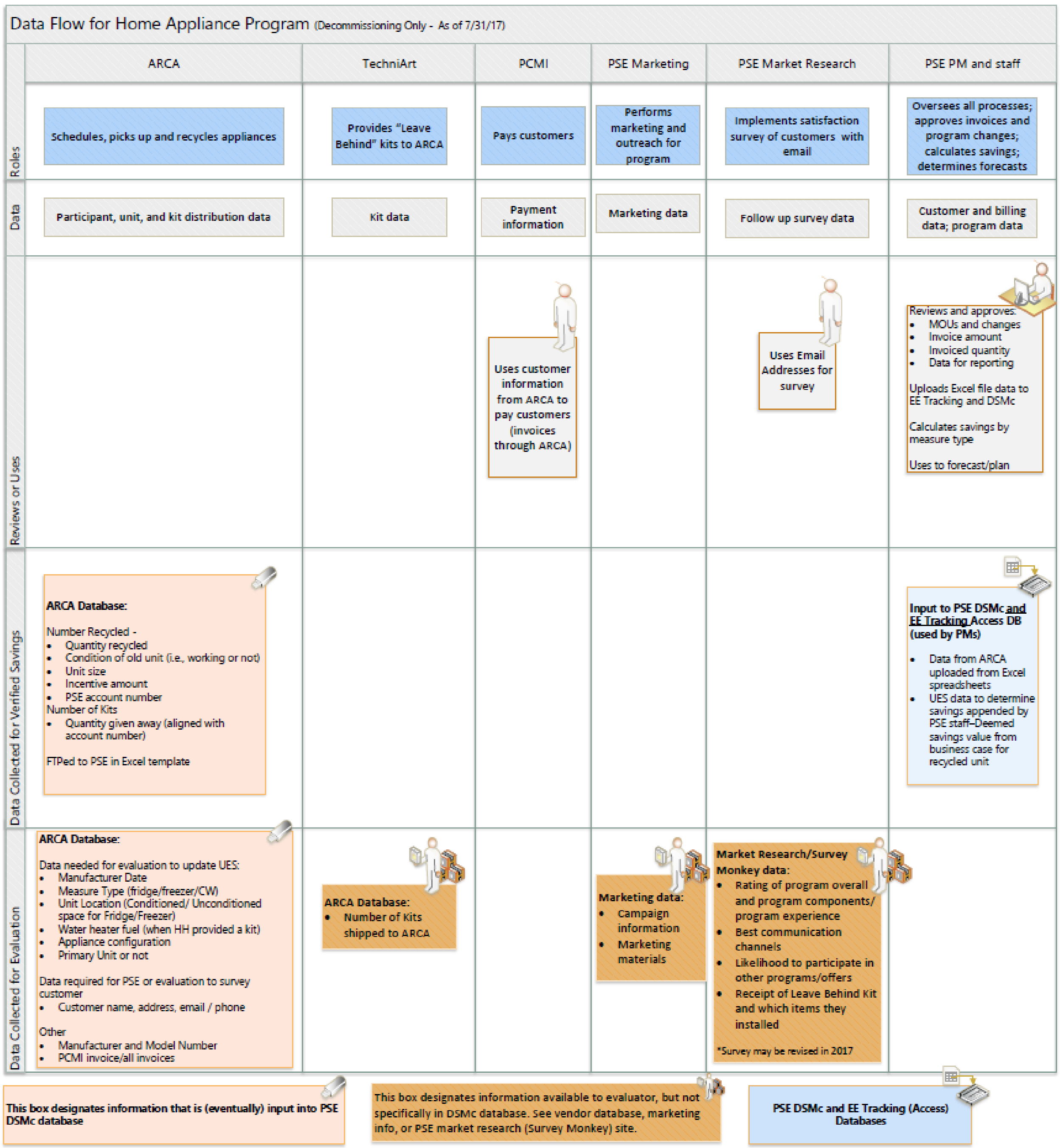
- **The Business Case**: This is a document formally filed with the PUC that lays out the measures, UES, EULs, and measure costs. These are considered the agreed-upon deemed savings estimates for qualifying products. This is updated at least annually and documents any program changes.
- **DSMc database, and EE Tracking Access database:** These serve as the internal program tracking databases. The DSMc database includes information from all programs, and is used to report on the DtC program. It is also capable of forecasting and other types of data analysis; however, this is a newer system and all of the features have not fully been adopted by the program staff. The program staff currently use the EE Tracking Access database for reviewing numbers and forecasting. These two databases generally include the same information.
- **CRM data:** This is PSE's customer data, and is available to provide customer information or billing data for programs with known participants.

- **PSE Marketing and Market Research Data:** PSE is responsible for all marketing of the DtC programs and the marketing department is the best source of marketing information. The market research group also conducts a rolling survey of participants with email addresses to collect information on satisfaction with the program. This is maintained as an online Survey Money database.
- **Vendor Databases:** There are several vendor-specific databases. These tend to include more information than is available through PSE's DSMc database.
- **Evaluation Data and Outside Research Efforts:** Past, present and future evaluation studies are also valuable sources of data for estimating savings, and understanding possible program improvements.

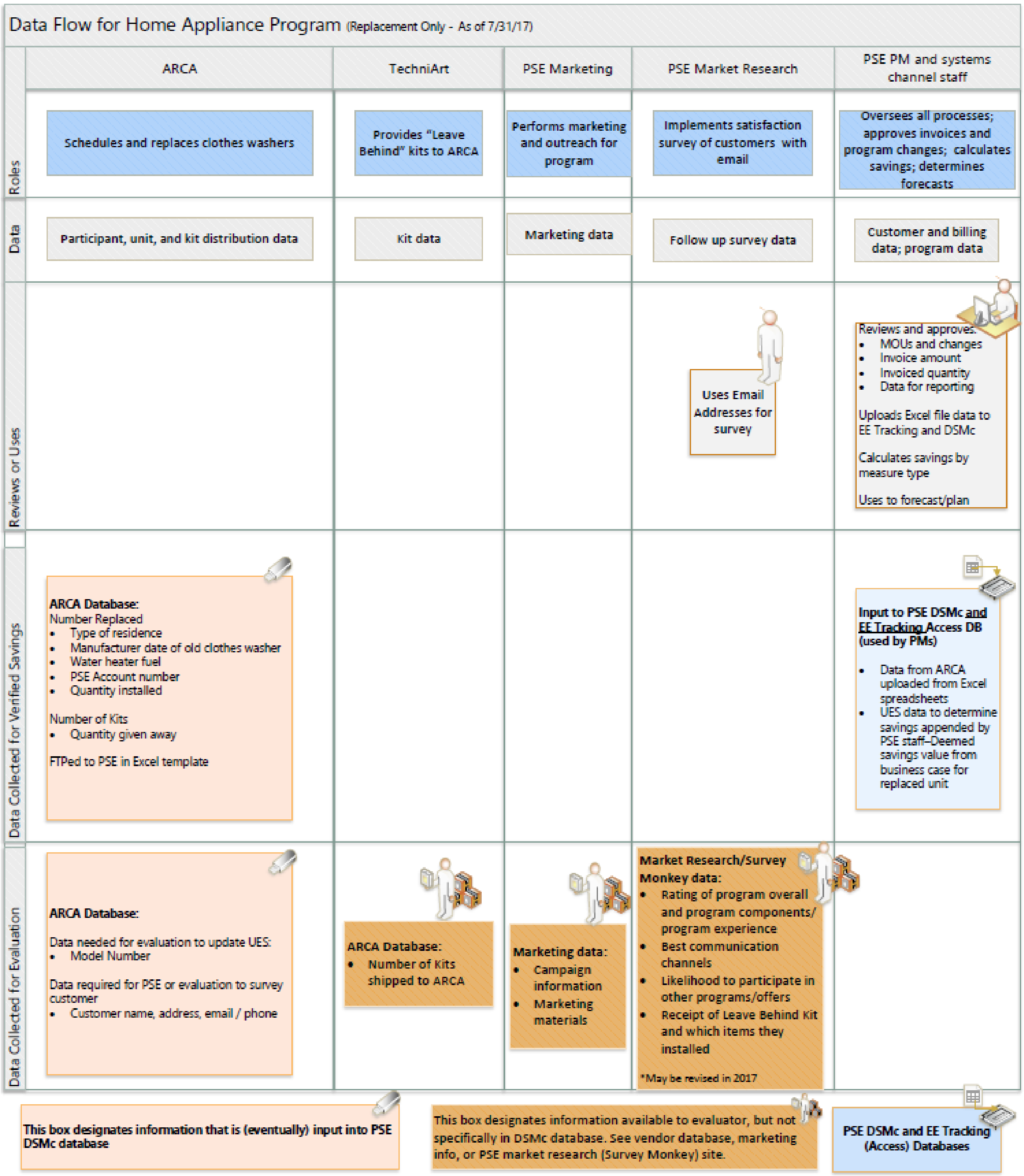
H.2 DATA MAPS BY PROGRAM

Below we provide data maps for four programs: Appliance Decommissioning, Appliance Replacement, Appliance Rebates and Lighting and Showerheads.

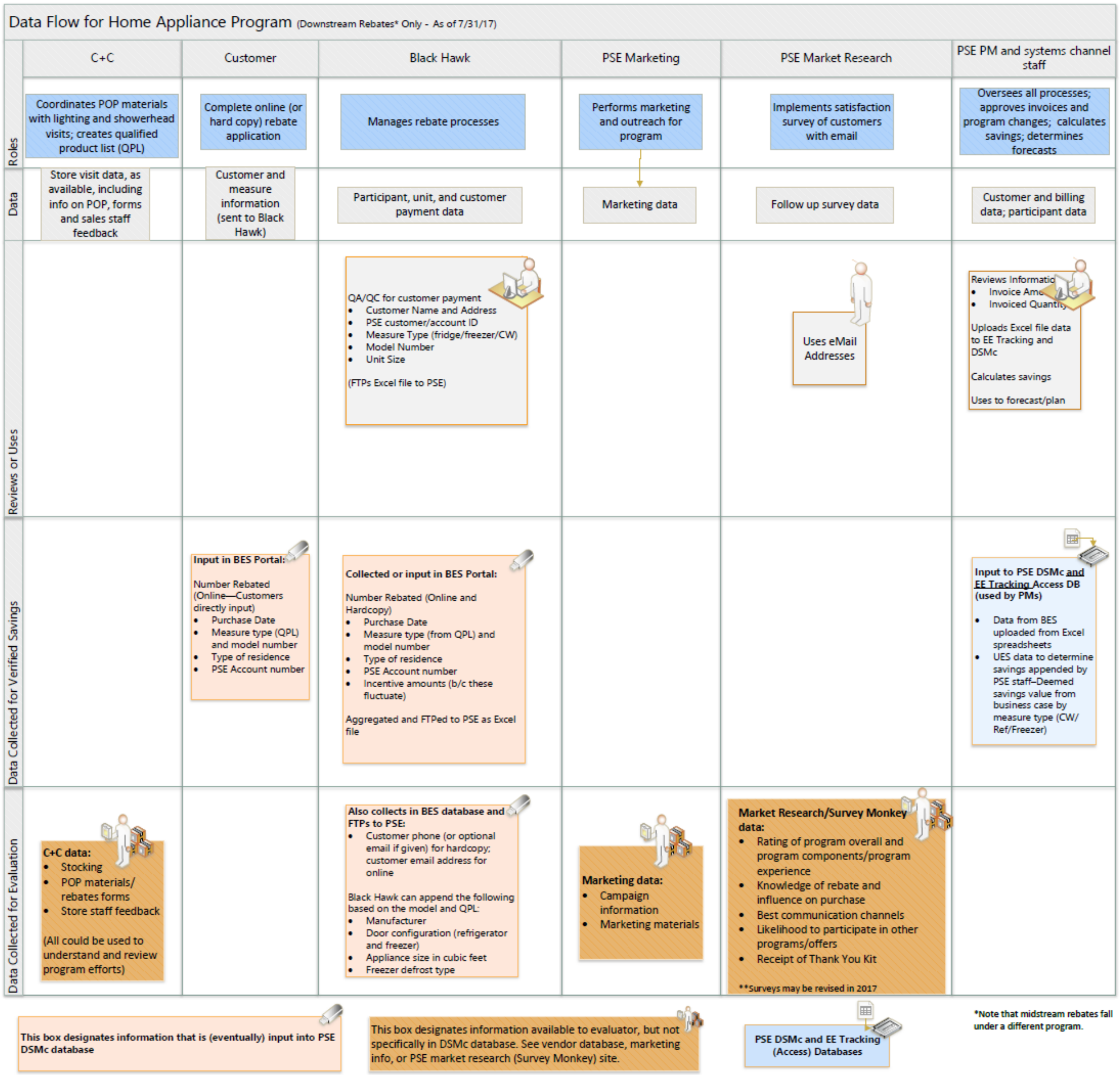
H.2.1 Appliance Decommissioning Program Data Map



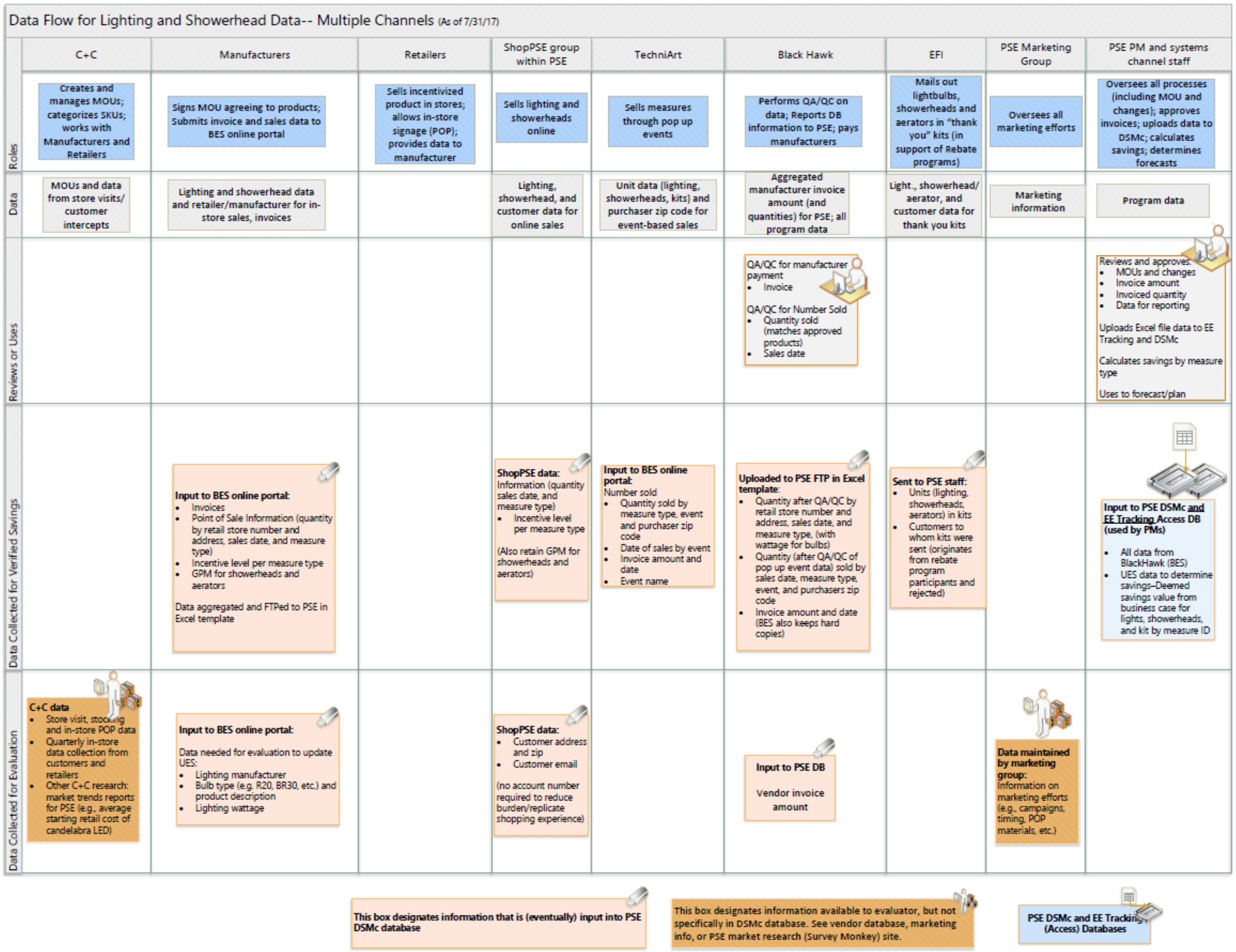
H.2.2 Appliance Replacement Program Data Map



H.2.3 Appliance Rebates Data Map



H.2.4 Lighting and Showerhead Programs Data Map



APPENDIX I MEASURE COST RESULTS SUMMARY

In order to identify measure cost estimates and/or assumptions that may be in need of updating, the evaluation team benchmarked PSE's full and incremental measure cost estimates of its residential deemed measures against the best available data in the public domain. To the maximum extent possible, the hedonic price models recently developed for the CPUC were leveraged to estimate average prices for the specific deemed residential measures being offered by PSE, and benchmarked those predicted prices against the measure cost estimates currently being used by PSE. Wherever possible, the evaluation team also benchmarked current PSE cost values against those recommended by the RTF, the USDOE, and other publicly-available data sets, including published retail prices in the greater Puget Sound region. The key findings from this benchmarking exercise are summarized by measure below.

Clothes Washers. The source data used by PSE (via the RTF) appear recent and comprehensive enough to enable robust estimates of full and incremental measure costs. The analysis methods used by PSE (via the RTF) also appear to be reasonably capable of producing defensible average price estimates. The only area of concern is the explicit assumption that the *25th percentile* prices are an appropriate way to "mitigate the effect of non-energy features on cost", since that approach risks systematically under-estimating full and incremental cost without empirical evidence to support the assumption. Indeed, PSE's (and the RTF's) and the CPUC estimates of full and incremental cost compare best when the *mean* values from RTF's price models are used, rather than the 25th percentile value. This finding reinforces the concern that the 25th percentile assumption may risk systematic under-estimation of full and incremental costs.

Perhaps more importantly, however, it is worth noting the dynamics associated with the way that PSE (via the RTF) defines the baseline for this measure, i.e. a "market average" unit that is essentially a blend of top- and front-loading units across all available efficiencies. When this "market average" baseline definition is used, the incremental cost of Tier 1 top-loaders is negative. However, if the baseline is defined as a code-minimum top-loading unit, the incremental costs of Tier 1 top-loaders becomes positive and those of Tier 1 front-loaders increases by roughly a factor of two. These dynamics are important to consider not just for cost-effectiveness testing but also for their associated impacts on program design.

Refrigerators. The source data used by PSE (via the RTF) are based on cost estimates developed by the USDOE as part of the last rulemaking proceeding for refrigerator standards (2008). Although the sample size behind the USDOE estimates is unknown, the RTF price analysis is clearly based on seven specific data points pulled from the USDOE Technical Support Documents. While the USDOE's price estimates are generally based on large input data sets, the fact that the RTF analysis is based on a very small set of the USDOE's outputs raises potentially significant concerns about the RTF's results. Additionally, the RTF makes a strong assumption in the modeling approach that three specific "product classes" of refrigerators are representative of the total refrigerator market in the Northwest, without providing any explicit empirical evidence.[29]

Relative to the baseline price estimates, the RTF and CPUC price estimates appear to be reasonably consistent across the three product classes defined by the RTF. Both sets of estimates also benchmark reasonably well against a small sample of advertised prices for similar products in the greater Puget Sound area. However, the incremental costs estimated by the RTF are generally 4-6 times higher than those estimated by the CPUC price models and 6-10 times higher than those estimated by the USDOE. The importance of these benchmarks is augmented by the fact that PSE's rebate levels for Tier 1, 2, and 3 refrigerators also exceeds the incremental costs estimated by the CPUC and the USDOE – often by a factor of 2 or more. As such, the evaluation team recommends that PSE reconsider its current use of the RTF incremental cost estimates for this measure and/or raise the key methodological issues identified with the RTF and its stakeholders for further discussion and vetting.

Lighting. The source data used by PSE appear recent and comprehensive enough to enable robust estimates of full and incremental measure costs. Similarly, the weighted average methods used by PSE to develop average full and incremental costs appear reasonably appropriate for these measures. While the evaluation team was not able to reasonably replicate (and therefore benchmark) the baseline prices – and therefore incremental costs – used by PSE or the RTF using data from the California Retail Lighting Shelf Survey (CA RLSS), PSE's estimates of full measure costs compare very well against CA RLSS-based estimates.

The most significant difference between the PSE and CA RLSS-based estimates is for CFL "specialty" bulbs – which is an aggregate of torpedoes, all reflector types (BR, R, PAR, MR), and globe lamps. Due to the aggregate nature of this measure definition, the evaluation team believes the comparison is likely being significantly impacted by inconsistent weighting and categorization between PSE and the CA RLSS and does not recommend lending much credence to this particular benchmark. PSE's estimates of full measure costs also compare well against the RTF estimates for the same measures – with the key exception that the RTF's price estimates for LED A-lamps and candelabra lamps are 30-50% lower. Due to the significant role that these particular products play in PSE's overall portfolio, the evaluation team recommends investigating these particular differences further, since the RTF estimate would imply that

29 For comparison, the USDOE defines 24 "product classes" for standard refrigerator-freezers.

PSE's current rebate levels for LED A-lamps and candelabras would be greater than 100% of the true incremental cost.[30]

Showerheads. Although the source data and estimation methods used by PSE (via the RTF) for this measure lack any level of documentation, PSE's estimates of incremental measure costs compare reasonably well to those developed by Itron for the CPUC. Additionally, PSE's estimates compare well to a small sample of advertised prices for similar products in the greater Puget Sound area.

[30] One distinct possibility is that the BPA/NEEA data used by the RTF include utility-discounted lamps – which the evaluation team was neither able to confirm or deny within the scope of this benchmarking exercise. The CA RLSS data contains an explicit flag that allows utility-discounted lamps to be filtered from any given query.

APPENDIX J BEST PRACTICES RESULTS SUMMARY

In Stage 1, the evaluation team conducted a comparison of select PSE programs to national energy efficiency program best practices that were developed in the National Energy Efficiency Best Practices Study.[31] The goal of this study was to develop and communicate national excellent practices, built off the experience and knowledge gained through 25 years of program implementation, in order to enhance the design, implementation, and evaluation of energy efficiency programs.

Six best-practice areas were explored as part of this analysis: (1) Program theory and design, (2) Program management, (3) Reporting and tracking, (4) Quality control, (5) Participation processes, and (6) Marketing and outreach. We drew on interviews with PSE staff and implementers,[32] as well as our review of program tracking data and secondary information about the program to answer an established set of questions found within the National Energy Efficiency Best Practices benchmarking tool. The objective of this effort was to understand PSE's programs and begin to identify strengths, areas of improvement, and strategies for improving them.

Based on our benchmarking review, the evaluation team found the following:

- **Program Theory and Design:** While not explicitly laid out in a program theory and logic model, the PSE programs are described in annual and biennial plans and reports. In addition, many of the changes are documented in the businesses cases as they are updated each year. In general, the programs are well-established and have an understood theory. Given the history of these programs in the market, the implementers and PSE have been able to update and adjust the program designs to ensure that they run well. Among the multiple DtC programs explored for this evaluation, (i.e., the residential lighting, appliances, and showerhead programs), there are a few areas that should be explored further since they are new or changing.
  - **Appliance Rebates:** Changing energy efficiency standards for appliances, the incentive amount relative to overall costs, and the number of retailers, have led implementers across the country to explore the option of a mid-stream appliance model (incentives are provided directly to the retailers who stock and sell the energy efficient appliances to consumers). PSE implementers are also working on pilot efforts to explore this option. As interest in mid-stream appliance programs grows, PSE should work with stakeholders to lay out the theory behind both the downstream and mid-stream components and how they interact in the market.

[31] http://www.eebestpractices.com/

[32] In total, we conducted eight interviews with program staff and five interviews with program implementers. See Appendix B for this list.

- **Advanced Power Strips:** Consumers are generally not aware of the benefits of advanced power strips and need some instruction or knowledge on where to use them and how to appropriately install and program the units. It is currently unclear how customers will learn about these units, be educated on how to properly install them, and ultimately increase their demand for this product. If PSE decides to scale this effort, the theory behind this component should be explored further.
- **Appliance Decommissioning:** Threats to stability of the decommissioning/recycling business model currently exist due to the decline in the price of scrap metal. This has caused some vendors to exit the market, as they can no longer afford to implement such programs under the existing terms. PSE should continue to closely monitor the situation via conversations with their program vendor and other market intelligence. In the future, PSE may be required to research alternative program designs to ensure they are able to find vendors who can make a business case that supports implementing these important energy saving programs.

- **Program Management:** The management of the DtC programs is well-defined and roles and responsibilities across the PSE staff and implementers are clear. PSE is satisfied with the performance of their implementers, and the implementers felt that the current communication channels work well and that they have the flexibility to pivot the programs as needed to ensure that they are successful. One area that could be explored further is whether the implementers of the appliance programs could assist with targeting for underperforming programs.
- **Reporting and Tracking:** In 2015, PSE began implementation of its new DSMc program management system that allows program staff to access online rebate application forms, provides real-time rebate processing status, and provides real-time reporting. These reporting and monitoring processes follow best practices in the industry. PSE's planning documents also lay out the data requirements for measuring program success. These are defined in the program development, and are documented as they change over time. All data needed for reporting appears to be collected and tracked by the program implementers, although some of the tracking systems need to be better coordinated between program implementers and PSE to make sure that all of the information needed for evaluation and customer follow-up is readily available. PSE has begun to make changes to include the missing variables identified by this evaluation. Improvements are also needed in ensuring that the tracking systems are well-documented with up-to-date user manuals and documented data flows from implementer to PSE. A first step in this is the Optimal Data Flow models presented in Appendix H of this document.
- **Quality Control:** There is no indication of significant problems with databases or invoices. According to program vendors, they QC all invoice and back up materials sent to PSE.
- **Participation Processes:** PSE uses a multi-channel approach to reaching customers. Where rebates are required (i.e., appliance rebates), the rebate form appears to be easy to use and

available to be submitted both online and in hard copy. PSE and implementers report few issues related to participation processes.

- **Marketing and Outreach:** In general, marketing and outreach has been a strong focus for PSE over the 2014-2015 period, as documented in PSE's planning and reporting. While there has been an emphasis on marketing, the appliance program fell short of its goals in 2014 and 2015 because of changing efficiency standards and lack of customer demand.[33] Showerheads also need additional support since this is a difficult market to penetrate, with little customer demand. PSE refined their materials in 2015 and is working on better target marketing. The evaluation team will discuss whether there are specific areas where our efforts could help inform future marketing for the measures and channels that fell short of goals in 2014 and 2015.

33 Based on PSE's *2015 Annual Report of Energy Conservation Accomplishments*, March 1, 2016.

APPENDIX K   PSE MARKET RESEARCH RESULTS SUMMARY

PSE follows best practices of gathering data from participants through follow up satisfaction surveys wherever possible; however, the DtC retailer efforts (where the majority of units are sold) are upstream programs that do not lend themselves to customer follow-up since the customers who purchase lighting or showerheads in the retail stores are not tracked in an upstream program model. PSE does have a built in an opportunity to collect some data from customers receiving lighting and showerheads through the Leave Behind and Thank You Kits, but they do not appear to ask questions about the lighting and showerheads given to these customers.

The evaluation team reviewed the market research survey instruments for these programs to identify areas where adjustments or changes to the PSE surveys (or methods) could lead to improved program knowledge. The tables below document the information collected at the time of this review and suggests small changes to the existing surveys.

TABLE K-1: APPLIANCE REPLACEMENT AND DECOMMISSIONING PROGRAMS

Current Surveying Effort	Available Email Contacts from Stage 1 Review*	Data Currently Collected	Notes and Potential Areas for Further Exploration
ARCA fields customer satisfaction survey by email each month	Email addresses for 61% of replacement participants and 41% of recycling participants	▪ Rating of program overall ▪ How they heard of program and best communication channels ▪ Whether experience helped to save energy ▪ Likelihood to participate in other programs/offers ▪ Zip and county (drop if available from tracking data?) ▪ How they received rebate from PSE, and preference for future [recycling only] ▪ Preference for method of appliance pickup/delivery scheduling ▪ Experience with call center ▪ Experience with workers ▪ Receipt of Leave Behind Kit and which items they installed (LED/Showerhead/Faucet aerators/none/none but intend to) ▪ Rating of program areas (e.g., clarity of requirements, speed of rebate, timeliness of installation, ease of applying, accuracy of rebate)	▪ Look at whether homes really are what they would predict (by age, size, consumption, etc.) based on RBSA and PSE's propensity scoring to help understand and revise targeting strategies ▪ Collect information on part-use factors, heating system type, average number of loads for participants, and alternative outcomes if there were no program to inform impact estimates ▪ **For replacement:** add questions to explore satisfaction with product since this is reportedly an issue for some customers ▪ **For recycling:** process issues would be best explored with participants in 2016 since implementer changed in 2015. ▪ **Other options:** Ride along observations to shadow ARCA and better understand customer feedback ▪ **For Leave Behind Kits:** Could ask about water fuel type for those where this information is not known

TABLE K-2: APPLIANCE REBATE PROGRAMS

Current Surveying Effort	Available Email Contacts from Stage 1 Review*	Data Currently Collected	Notes and Potential Areas for Further Exploration
PSE fields customer satisfaction survey	■ Email addresses for 0% of participants based on tracking data but emails collected by program implementers	■ Rating of program overall ■ How they heard of program and best communication channels ■ Whether experience helped to save energy ■ Likelihood to participate in other programs/offers ■ Zip and county (drop if available from tracking data?) ■ Knowledge that the appliance qualified for a PSE rebate before purchasing it ■ Rating of clarity of requirements, speed of rebate, ease of applying, accuracy of rebate ■ Influences on decision to purchase energy efficient appliance (Should the PSE rebate be on this list?) ■ Whether they were able to complete your rebate transaction entirely by web/mobile ■ How they submitted rebate forms or application to PSE and how they prefer to submit application forms ■ Retail store where they heard about PSE programs	■ Further explore satisfaction for this channel. PSE indicated that satisfaction is reportedly lower for this channel than for other PSE program channels. ■ Collect information on part-use factors, heating system type, average number of loads for participants, and alternative outcomes if there were no program to inform impact estimates. ■ **For Thank You Kit Measures:** Installation, storage, use and water fuel type

TABLE K-3: SHOPPSE SALES

Current Surveying Effort	Available Email Contacts from Stage 1 Review*	Data Currently Collected	Notes and Potential Areas for Further Exploration
PSE fields customer satisfaction survey	■ 100% email addresses	■ Rating of program overall ■ How they heard of program and best communication channels ■ Whether experience helped to save energy ■ Likelihood to participate in other programs/offers ■ Zip and county (drop if available from tracking data?) ■ How they heard about the website ■ Satisfaction overall ■ Satisfaction with: Selection of items, Price of items, Convenience of the site, Speed of delivery	■ APS purchasers from ShopPSE represent a good group for follow up on installation rates, use of the APS, connected load (i.e., what is plugged in), motivations for purchasing, satisfaction/concerns with product, persistence. ■ Lighting and water device purchasers can also provide insights on installation, use, motivations, and concerns to use as proxy where retail customer data is not available. ■ Ask about fuel type for water devices as this is not collected through ShopPSE.

Currently there are no surveying efforts for pop-up retail or upstream lighting or showerhead programs as there is no contact information available for these program participants. The evaluation team recommends PSE consider the following options for these programs:

- Pop-Up Retail Events
- In 2016, advanced power strips are also being sold through this method. This may be a good opportunity to collect data on this newer technology.
- In coordination with implementer, PSE could use a "drop your email in a fish bowl" approach to voluntarily collect names of those who purchased an APS (and/or other measures if needed). Would most likely offer $ back, or some incentive, if purchasers complete a follow up online survey.
- Observations and/or intercepts at pop-up retail events to better understand who is being reached.
- Lighting and Showerhead Programs
- In-store intercepts to estimate measure installation, storage, use, and to assess water fuel type of participants.

APPENDIX L ADVANCED POWER STRIP OPTIONS AND OPPORTUNITIES

As an add-on research effort, the evaluation team explored the benefits and drawbacks of possible program designs and delivery channels for Tier 2 Advanced Power Strips (APS) to help maximize the chances of a successful outcome within PSE's territory (e.g., savings). Past research has primarily focused on the unit energy savings of the device—and less so on customer barriers and acceptance of the technology. This research complements past (and future) studies by discussing the options available for getting these devices to customers. Note that our research looks only at audio visual (AV) devices within the residential market. This research did not explore delivery to business customers or the use of an APS for personal computers and related devices. We also briefly discuss APS's in the general context of plug load reduction.

L.1 APS PROGRAMS AND DELIVERY CHANNELS

Across the country, there are several energy efficiency programs that offer APS's to their customers. In general, these models use the following delivery channels:

- **Direct installation (DI):** The APS device is provided directly to the end-user. These include offerings through traditional multi-family (MF) and low-income (LI) direct install programs, as well as newer partnerships with cable and pay-tv providers.
- Note that not all DI programs are directly installing APS's. PSE's DI program is currently directly installing some measures, but they are opting to leave the APS with the occupant with instructions on how to install.
- **Giveaways**: The APS device is included in an energy savings kits or provided to customers for free.
- **Promotions**: Program administrators sometimes offer limited time promotions for customers, providing reduced-cost or free APS's.
- **Buydowns or instant rebates:** APS's are sold through retail channels, including online retail, pop-up event based retailers, and traditional brick and mortar retail stores.

Other important characteristics that vary across programs that provide APS's include unit cost, whether installation assistance is provided to the customer, the target audience, and the potential energy savings of the device.

Unit Cost. Some program administrators offer the APS units free to the end-user. The specific delivery channels used to provide free units include direct installation and giveaway based models. Other program administrators are significantly buying down or offering an instant rebate on the Tier 2 APS device (e.g., buying down to a cost of about $10 to the end-user). In addition, one area is currently considering an option of an initial buy-down, with a full refund once the installation of the Tier 2 APS device has been verified via Bluetooth connection to the Smartphone application.

Installation Assistance to Customers. Some off these channels include customer assistance during the sale or installation. Customers may be given information during the installation of the equipment in a customer's home (i.e., through a direct installation program) or through discussions at the time that the unit is sold or given to the customer. When there is no in-person interaction with the user, program administrators sometimes make videos available to the user. In addition, a newer version of the Tier 2 APS, specifically the one that connect via Bluetooth to an application on the customer's Smartphone, has "how to install" and "how to use" videos available through the app.

Target Audience. The programs and pilots that promote APS units as part of their offering are generally available to all audiences, but some programs, because they are direct installation programs, specifically target low-income homes or multi-family units. Others, because they are online efforts geared to proactive customers, target early adopters. There are also kit-based efforts that target youth (i.e., students) and their families. Note, however, that not all customers are good targets for this program. In a study in the Northwest, roughly 55% [of homes] had accessible entertainment centers that could benefit from a DI based program approach. An additional 5% of homes had entertainment centers that were not accessible.[34]

Potential Savings. There are several factors that can affect the savings of the APS device including, installation rate or removal, proper installation, connected load (declining TV consumption, power down features of TV), hours of use (HOU) by the user, and the type of controls on the APS (e.g., IR vs MS-IR). Large surveys in the Puget region yield installation/retention rates of 88% for the Embertec and 78-88% for the Tricklestar units.[35] [36] These rates can vary across the channel (with some having higher installation rates than others—and thus higher savings). Savings are also affected by removal rates (i.e., persistence of the measures). Key findings from past studies in this area that can affect savings show:

- DI installation rate – 88% (among about 55% of the DI homes

34 "Out of Control: Barriers to Smart Power Strip Implementation", prepared for Energy Trust of Oregon, ACEEE. O'Neil, N and M. Braman. 2010.

35 PSE deployed the Embertec as part of a large multifamily direct install program and surveyed participants 3 months after installation. Snohomish PUD and PSE both deployed the Tricklestar by soliciting previous program participants to purchase one online for $10 and surveyed participants after only 3-4 weeks.

36 Advanced Power Strips Metering Plan for ETO Pilot program, CLEAResult, 2015.

- Online installation rate – 78-88% when persuaded
- 28% removal rate (among those installed), with no differences in retention by channel (to date)

The various models used to distribute Tier 2 APS's are shown in Table L-1.

TABLE L-1: EXAMPLES OF APS TIER 2 PROGRAM MODELS

Delivery channel and targeted audience →	Direct Installation (DI)			DI through partnerships with cable or satellite providers	Giveaways through school-based programs or events	Promotion through web or catalog (mail-out)	Buydown or instant rebate		
	Low-Income	**MF**	**Existing homes**				**Pop-up retail events**	**Online stores**	**Traditional brick and mortar**
PSE offering	PSE offers APS measure as option, but CAPS do not install	PSE DI installers leave behind with occupant	None	None	None	None	PSE pop-up stores started selling APS's in 2016	ShopPSE.com offers to customers at $10 (after discount)	None (No traction to date with brick and mortar retailers in PSE territory or across the US)
Example programs	Seattle City and Light was going to start in 2017	Seattle City and Light	Maryland utilities offer through Quick Home Energy Checkup	SCE pilot; VEIC program; NJ Clean Energy for Tier 1	ComEd; Chicago	MassSave; PSE&G has catalog; NEEP 2015 also mentions; California Municipals exploring	MassSave [BPA sold through fairs?]; SMUD pilot (1,000 units at 15 events)	MassSave through EFI, multiple examples in RLW spreadsheet but mostly $10	
Cost	Free	Free	Unknown	Free	Free (or reduced cost with full rebate once installed)	Reduced Cost	Reduced Cost	Reduced Cost	Reduced Cost
Assistance (customized to household)	Yes	Yes	Yes	Yes	No	No	Yes, through discussion at event	No	No
Factors affecting savings from channel; see also discussion above about the factors that can affect savingsǂ	• Limited by #LI units that can be served by DI each year • PSE serves approx. 1,300 units per year	• Limited by #MF units that can be served by DI each year • PSE serves approx. 36K units per year	• Limited by #HH that can be served each year	• Limited by numbers served through various cable or pay-tv partners	• Limited by # of households with children in age group; and ability to serve schools		• Limited to reach of the pop up retail events each year • Numbers reached (and types of customers) are also limited by the locations selected	• Limited by # of early adopters (who also need to be exposed to offer) • PSE sold about 2,700 in 2015	• Most access/could reach most people, but barriers to getting to stores • Sales in retail stores (generally of Tier 1 devices) have been low in the past

Delivery channel and targeted audience ➔	Direct Installation (DI)			DI through partnerships with cable or satellite providers	Giveaways through school-based programs or events	Promotion through web or catalog (mail-out)	Buydown or instant rebate		
	Low-Income	**MF**	**Existing homes**				**Pop-up retail events**	**Online stores**	**Traditional brick and mortar**
Comments about the model's ability to meet goals related to savings									
	• Installed by technician • Installation done correctly and in appropriate locations; most likely will return higher savings • Ability to interact and talk to potential users to understand energy use and convey importance of equipment			• Installed by technician • Installation done correctly and in appropriate locations; most likely will return higher savings • Ability to interact and talk to potential users	• Not directly installed • May not get installed, or likely not installed to full potential. (Missouri:48% installation rate for kits.)	• Not directly installed • May not get installed, or if installed, likely to not be installed to full potential.	• Ability to interact, talk to, and explain installation • Not directly installed • Not all people will be the right targets for savings*	• Not directly installed	• Not directly installed
Opportunities for further education									
	• Ability to interact and talk to potential users to educate about energy savings and waste			• Energy efficiency is not core area for partner • Education not primary objective, but some ability to interact and talk to potential users to educate about energy savings and waste	• Children are educated. Families receive information through children (indirectly)	• Some opportunity for education depending on method of promotion	• Ability to interact and talk to potential users to educate about energy savings and waste	• Information on energy use and waste can be provided online, but may be less impactful than in-person	• No real ability to educate (although could do store events at a small scale)

ǂ Estimated 216 kWh/unit starting in 2017.Savings come from PSE's 2017 Annual Conservation Plan. Other notes on savings from the ETCC report (V&C, 2016): 29% of households surveyed had a power strip, 35% had two power strips, and 24% has three or more power strips; 12% had 0. In addition, 95% of power strips are standard power strips, and 5% are smart strips. *No data yet on how co-pay affects ISE.

L.2 PSE PROGRAMS AND DELIVERY CHANNELS

Currently, PSE provides access to Tier 2 APS's through the following programs:

- Direct-to-Consumer
- ShopPSE.com, PSE's online retail site
- Pop-up retail events by TechniArt
- Dealer Channel
- None
- Multifamily Direct Install
- Installers provide homeowners with device when they feel that it would work in the customer's home. Note that the APS unit is not directly installed (unless the occupant requests help) due to concerns around the moving furniture and working around expensive TV and audio-visual systems.
- Low-income (as an unutilized option)
- While community agency programs (CAPs) are given the option of installing APS's as a qualifying measure, to date, PSE indicated that the agencies generally do not choose to install this measure because they tend to focus on required measures.

L.3 KNOWN BARRIERS TO THE PURCHASE AND USE OF APS

While APS's offer energy savings, there are several known barriers to the purchase and use of these devices. Some of these barriers are specific to the technology (and thus cut across all program designs and delivery channels), while others can be overcome by the selection of the delivery channel. In the table below, we briefly describe the barriers, and program designs that can help overcome the barriers. Note that the program design can help overcome some barriers, while other barriers exist regardless of the channel.

TABLE L-2: BARRIERS

Barrier	Barrier Notes	How one can overcome barrier	Program design that can help overcome barrier
Lack of consumer awareness of wasted energy from standby power	Customers generally aren't aware of issues around standby power or wasted energy, and thus are not seeking out a solution to this problem. As such, there is no perceived need for this technology. Building customer demand for this measure would require extensive education about energy use and standby power.	Increase awareness of wasted stand-by energy	Education that occurs through: Direct Install Giveaways Promotions
Lack of awareness of APS devices	Customers generally do not know what an advanced power strip is. In PSE territory, about 70% or more of the population have never heard of the an advanced power strip (~28% awareness).ǂ Cadmus is also currently gathering data on the percentage of households in the Northwest that have an APS device installed through the current RBSA study.	Increase awareness of solution to wasted stand-by energy	Direct Install Giveaways Promotions Pop-up Retail
Complexity of marketplace and product diversity	For customers that are aware of energy savings power strips, there are multiple types of units. This complicates the market. NREL has a one-page handout to help customers understand which devices might best meet consumer needs, but customers are unlikely to have this information at their fingertips. The NREL one-pager lists the following options: timer power strip, activity monitor power strip, remote switch power strip, master controlled power strip, masterless power strip.	Provide consumers with simplified information on APS's	Direct Install Giveaways Promotions Pop-up Retail
High cost relative to savings	Tier 2 APS's have a high cost relative to standard power strips. "General MSRP to consumers in traditional retail is about $75-$100 [when tried in the past] and online pricing around $60-$90. (NEEP, 2015)" Tier 2 can be three times the cost of Tier 1 power strips; estimated savings vary, with Tier 2 currently getting 216 kWh in PSE territory, where Tier 1 from other areas garner about 75 kWh (up to 122 kWh/year depending on the configuration. (Van de Grift, 2014)	Reduce costs to consumer	All program designs help here
Low retail margins	The "low retail margins" make manufacturers not want to sell through retailers and/or not want to have a program that works with retailers. Manufacturers, however, have been open to direct sale to customer through online mechanisms.	Increase volume so that low margins are overshadowed by overall profit	None
Incorrect installation	Customers often install the wrong equipment or install in the wrong configurations. However, implementation of the A/V APS is feasible for the average homeowner as long as the A/V devices are not **too complex** or installed in **inaccessible configurations**.	Provide labor to install unit correctly	Direct Install (if installed, not left behind)

Barrier	Barrier Notes	How one can overcome barrier	Program design that can help overcome barrier
Inability to install	Certain installations require significant effort to install and may be prohibitive outside of a concerted M&V study. For instance, if the TV is mounted on the wall or if the DVD player is not located directly next to the TV, installation can become difficult or unattractive. (V&C 2015)" Interruptible load must be accessible.	No cost-effective way to overcome this barrier	None
Persistence	Based on a Silicon Valley Power survey, "user understanding and acceptance of this technology was mixed. (NEEP, 2015)" Respondents indicated that they had problems using their devices as they normally would. There may also be a perceived intrusiveness of the auto-shutdown feature that may lead some households to remove the device. As a result, users may remove the device. To date, the studies appear to show the same persistence regardless of the technology. (V&C 2016) Additionally, APS's sometimes interfere with AV devices use or have problems related to the technology. This may mean that the device is not able to be installed or does not work when installed (regardless of who installs).	Improve ability of APS to work with multiple pieces of equipment	None (will improve as technology improves)
Achieving energy savings	Energy savings are dependent on what A/V equipment is installed, how efficient the equipment is, and how the customer uses the equipment that is plugged in. Customers have various set ups. May require a minimum number of devices in order to get savings (e.g., at least four peripheral devices). (Rasmussen, 2015) "Even slight variability in device usage patterns within the same household presents a large challenge in determining the actual energy necessitating larger sample sizes and longer trial periods." And, "Should additional connected devices be switched into a lower power state or off after this point, this new power level and therefore reduced energy savings would not be calculated correctly and an overestimation of energy savings would occur." (CalPlug, 2014)	No way to overcome this barrier	None (although program may have some influence if installed correctly by the program)

ⱡ Data from survey conducted for this evaluation effort.

L.4 BENEFITS AND DRAWBACKS OF VARIOUS PROGRAM MODELS AND PSE OPPORTUNITIES

Most program administrators focus on direct install as the primary delivery approach for APS's. "Customer resistance has led customers to explore direct install and give away" programs.[37] Models that provide customers with assistance specific to their home are also perceived to be among the most effective. Below we describe the benefits and drawbacks associated with the various models, and explore opportunities for PSE. We note, however, that PSE is currently utilizing many of these channels, as described above and shown in Table L-1.

Direct Installation (for SF, MF, or LI). During a simple energy audit or a typical direct install program, the program representative qualifies the customer to see if they are interested in the device. If accepted the user is provided a brief explanation, and the Tier 2 APS is given to the user.

- **Benefits:** This method overcomes awareness, cost and potentially installation barriers (if the DI program installs or describes installation to the user). Leave behind educational materials can also be given to the user, and in-person education could occur on site. There are labor costs for installation, but this can be distributed as part of a larger LI DI effort, so there may be one small labor costs. Installation is estimated to take 10-20 minutes.[38]
- **Drawbacks:** When bundled with other measures, APS's may take a back seat and don't always get installed (Embertec interview). When APS's are not bundled with other DI measures, the cost is higher since the APS incurs the full labor cost. Some program administrators, including PSE, see the challenges of moving furniture and working around AV equipment as a risk, so the APS is left behind. If directly installed, whoever is charged with installing APS technology will need special training as they are not as simple to install as a surge protector. In addition, if the unit is left behind during the DI visit (rather than installed) there is a possibility that the customer will not install the unit since they are not financially invested and might not really want the APS unit.
- **Opportunities:** There may be opportunities through partnerships with Direct TV or other cable or pay-tv providers to install APS's when the cable provider is installing the cable box (i.e., set top box) but one would need to consider why PSE does not currently have a set top box program).

Giveaways. APS's are included in energy saving kits or given away through events.

- **Benefits:** Moves APS's into the market, and into homes, quickly.

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37 Tier 2 Advanced Power Strips in Residential and Commercial Applications. Prepared for San Diego Gas and Electric by Alternative Energy Systems Consulting. Valmiki and Corradini, 2015.

38 Consumer Electronics: Tapping into the Power of the Service Provider. Ecova, Rasmussen. R. 2015.

- **Drawbacks:** APS's don't always get installed, and even if installed, they may not be installed properly. Tier 2 APS's are expensive to give away if no savings occur and they do not get installed. Missouri saw 48% installation rate for kits.
- **Opportunities:** There may be opportunities for adding Tier 2 to leave behind kits, thank you kits, and school-based kits if PSE can find ways to ensure that these measures get installed. The Bluetooth application (with video) could help encourage and verify installation; however, installation rates without customized education are expected to be low. PSE would need to consider ways to increase installation from this channel, and look at costs versus savings.

Promotions. APS's are sold at reduced prices during limited time promotions either online, or through mailers or catalogs. According to one manufacturer, the ideal time for special retail promotion are in the Fall and the Spring as it applies to AV products and applications. The key to the online promotion is advertising. According to the same manufacturer, the best form is via email blast, which can result in an open rate of 40%, 20% click through and 40% conversion rate.[39]

- **Benefits:** Moves APS's into the market, and into homes, quickly.
- **Drawbacks:** APS's don't always get installed, and even if installed, they may not be installed properly. Tier 2 APS's are expensive to give away if no savings occur and they do not get installed.
- **Opportunities:** Some California-based municipals are considering a promotional model where the APS units are sold at some discount, but then are rebated fully (so that they are free to the household) once the unit has been installed. This is a new model being considered by municipal utilities in California. It does not appear to be in place yet. There may be some opportunity for PSE to distribute APS's through this model.

Pop up Retail. This option allows for sale of Tier 2 APS's at mobile education events where consumers may be purchasing other energy efficient products. PSE currently has a vendor conduct these events on their behalf at work "campuses", office buildings, universities, home shows, public festivals and other community events. This channel allows for a one-on-one direct interaction with customers. In this channel, the customer learns about the technology prior to purchase.

- **Benefits:** The customer is provided with one-on-one assistance and education about the unit and how to install the APS in their home's application.
- **Drawbacks:** Because of the nature of PSE's territory, pop-up retail events will serve both PSE customers and customers from surrounding utilities, which means that the energy savings cannot

39 Tier 1 Advanced Power Strip Program Proposal PPT. Illinois TRM Stakeholder Advisory Group, TrickleStar. 2015.

be counted for all of the APS devices sold. (PSE does have an estimate of the percentage that go to non- PSE customers.)

- **Opportunities:** Additional opportunities are limited since PSE already effectively uses this channel; however, PSE could consider additional education or displays at the pop-up retail site, or expanding the number of pop-up events within PSE's territory.

Online Stores. The online store provides a consistent location where Tier 2 APS can be purchased, which could also be coupled with "limited time" promotions (see above). This is a stable distribution channel, and can be used with digital and social media to target the residential customer base.

- **Benefits:** There are no direct installation labor costs or retailer overhead in this distribution channel; however, there will be some postage cost. APS's can be available to users without disruption. It is also likely that customers will want to install since they purchased the unit.
- **Drawbacks:** This delivery method may tend to attract early adopters of the technology rather than the full general population. PSE also needs to actively drive customers to the website.
- **Opportunities:** There are additional opportunities for PSE to couple the purchase of the technology with education through information and videos. There may also be an opportunity to ensure installation and better understand connected loads using APS's that are Bluetooth-enabled with a downloadable app.

Traditional Brick and Mortar Stores. This includes working with manufacturers and retailers (similar to lighting and showerhead efforts) to get stores to stock APS's at a cost that is bought down through the program.

- **Benefits:** APS's would be accessible to the general population. This would be an important step if the long-term objective is to have households purchase on their own outside of the program.
- **Drawbacks:** Sales of APS's without assistance have been proven to be low. Margins are also low. This method of delivery does not allow for education (unless coupled with a special event), nor does it ensure installation of the APS.
- **Opportunities:** The opportunities appear to be limited as PSE and the manufacturers of APS's have been exploring this option for several years.

L.5 PUTTING APS'S IN CONTEXT AND RESEARCH CONCLUSIONS

This research explores options for delivery of Tier 2 APS's; however, it is important to put this technology in the context of the "problem" that it is intended to solve. Much of the available APS research is *product-specific* (i.e. the APS) and not *problem-specific* (i.e., the reduction of plug load energy use). APS's are intended to reduce standby power (also referred to as vampire power). Tier 2 APS's go beyond just managing standby usage to also control some "wasted" active power from devices that are left on when not in use.[40] These Tier 2 APS's focus on a portion of wasted energy. And more specifically, this device is intended to be used where AV equipment is clustered (and therefore is not necessarily relevant to all AV equipment).

As part of understanding the problem, there is a need to better understand what portion of homes may include one or more APS's and what percentage of energy use that savings from this device might make up. PSE is currently part of a residential saturation study that is exploring some of these issues.

In addition, it's important to understand that while Tier 2 APS's lead to energy savings from residential AV equipment after installation, there are other, more direct methods for getting to the outcome of reducing waste (including standby power) from AV equipment. These efforts include efforts at the regional and national level—through NEEA and others—to directly reduce both active and standby energy use of plug load equipment. Through these programs, manufacturers are making changes in AV equipment directly to reduce use or build in shut-off type devices like APS's. While this approach could negate the use of an APS altogether in the future, an APS is an energy saving measure now.

In the future, PSE may also want to consider how APS fits into their full portfolio of DtC measures. For example, in the 2016-2017 PSE Business case, there are 54 different electric measures for which PSE provides an incentive. Among these, the APS unit ranks low in terms of the per-unit savings obtained for every incentive dollar (41st).

Given the current inclusion of APS within the portfolio, though, there are opportunities to expand the distribution of APS's that PSE may want to consider. As described earlier, these include the following:

- **Direct Installation (for SF, MF, or LI) Opportunities:** There may be opportunities through partnerships with Direct TV or other cable or pay-tv providers (but one would need to consider why PSE does not currently have a set top box program).
- **Giveaway Opportunities:** There may be opportunities for adding Tier 2 to leave behind kits, thank you kits, and school-based kits if PSE can find ways to ensure that these measures get installed. The Bluetooth application (with video) could help encourage and verify installation; however, installation rates without customized education are expected to be low. PSE would need to consider ways to increase installation from this channel, and look at costs versus savings.
- **Promotion Opportunities:** Some California-based municipals are considering a promotional model where the APS units are sold at some discount, but then are rebated fully (so that they are

40 AV equipment is estimated to make up about 60% of standby power draw after removing lighting and kitchen appliances. Footnote PG&E ETCC study and/or PG&E 2016 study.

free to the household) once the unit has been installed. This is a new model being considered by municipal utilities in California. It does not appear to be in place yet. There may be some opportunity for PSE to distribute APS's through this model.

- **Pop up Retail Opportunities:** Additional opportunities are limited since PSE already effectively uses this channel; however, PSE could consider additional education or displays at the pop-up retail site, or expanding the number of pop-up events within PSE's territory.
- **Online Store Opportunities:** There are additional opportunities for PSE to couple the purchase of the technology with education through information and videos. There may also be an opportunity to ensure installation and better understand connected loads using APS's that are Bluetooth-enabled with a downloadable app.

PSE should also think more holistically and consider including APS as one part of an integrated strategy to educate for the future (while saving now). Raising awareness of plug load energy use and "wasted power" can lead to behavioral changes or the desire for control devices (like an APS) to reduce their own power use. Increasing awareness of plug load energy use from customer- facing campaigns can also make manufacturers more inclined towards reducing stand-by power in electronics and equipment.

PSE currently has energy-efficient electronics brochures that introduce basic energy terms, power modes (i.e., active use, active and passive standby, off), and describe smart power strips; but PSE does not currently seem to focus on using the APS device as an educational tool. The current educational activities could be expanded and PSE could work more actively to couple the installation of Tier 2 APS's with education related to "smart homes", control technologies, and wasted energy. This would allow PSE's current Tier 2 APS efforts to have a longer-lasting outcome.

Overall, PSE may want to:

- Consider additional opportunities and delivery channels for Tier 2 APS's
- Figure out how to integrate with connected home platforms to form a part of larger energy management ecosystems
- Use Tier 2 APS to educate customers about smart homes, control technologies or wasted energy from plug loads (but realize that for some applications, there may be lower cost measures that educate equally as well)

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2016 Multifamily Air Sealing Savings Evaluation Update

Contents:

- Impact and Process Evaluation Report
- Evaluation Report Response

This document contains the 2016 Multifamily Air Sealing Savings Evaluation Update, and Puget Sound Energy's Evaluation Report Response (ERR). In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator[1]. Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC[2]. Evaluations are conducted using best-practice approaches and techniques including those outlined in the National Action Plan for Energy Efficiency (NAPEE) Program Impact Evaluation guide.[3]

PSE program managers prepare an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Please note that this is an evaluation of the program as run in the 2015-2016 time period and do not necessarily reflect the performance of the program as currently implemented, or of the measures currently deployed by the program.

This, and all PSE evaluations are posted to Conduit Northwest. Visit https://conduitnw.org/Pages/Welcome.aspx to view an electronic copy and to leave comments.

[1] **(6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for 2016-2017 PSE Electric Conservation.**

[2] **PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised August 6, 2015.**

[3] **Ibid.**

MULTIFAMILY AIR SEALING PROGRAM

2016 Savings Evaluation Update

Puget Sound Energy

Report No.: 1 Rev. 001
Document No.: 10033986
Date: February 20, 2017

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1 SAVINGS EVALUATION UPDATE

This is an update to the Multifamily Air Seal Pilot Program Evaluation. The Multifamily Air Seal Pilot Program provides incentives to participating contractors to test and seal electrically-heated multifamily buildings. This pilot is being conducted to 1) identify savings resulting from the PSE Puget Sound Energy Multifamily Air Sealing Pilot Program; and 2) determine whether energy savings data supports the use of a deemed savings value for multifamily air seal projects. The previous evaluation determined that the program was achieving 87% of the expected energy savings (87% realization rate), with a 97% realization rate for previously insulated buildings and 100% for 2-8 Unit buildings. https://conduitnw.org/Pages/File.aspx?rid=3051

A calculator developed as part of this pilot is being used to predict future energy savings. The predictive value of the calculator is increasing as data from newly completed projects is incorporated. However, based on analysis to date we recommend that a deemed savings of 612 kWh per tenant unit be applied, with sample based test-in and test-out to help ensure consistent savings. This savings value is likely to change as additional post-project data becomes available.

Overview of project and background:

- Evaluation protocols developed in 2012
- Evaluation of all pilot sites 2013 - 2014
- Calculator developed in 2015
- Began developing a deemed savings estimation approach - 2015
- Defined potential population of applicable buildings in PSE territory and estimated necessary sample to achieve 90/10 savings estimates to be used for deemed savings - 2015
- Further development of deemed savings estimation approach - 2016

1.1 Energy Savings Drivers

The previous report determined that normalizing measurements and savings by number of tenant units provided the best metrics as opposed to normalizing by square footage. Other than the measured factors, baseline leakage and leakage reduction, other factors were expected to either:

- Remain the same before and after the retrofit – ex: heating system
- Have variations that average out over a large population – ex: thermostat settings

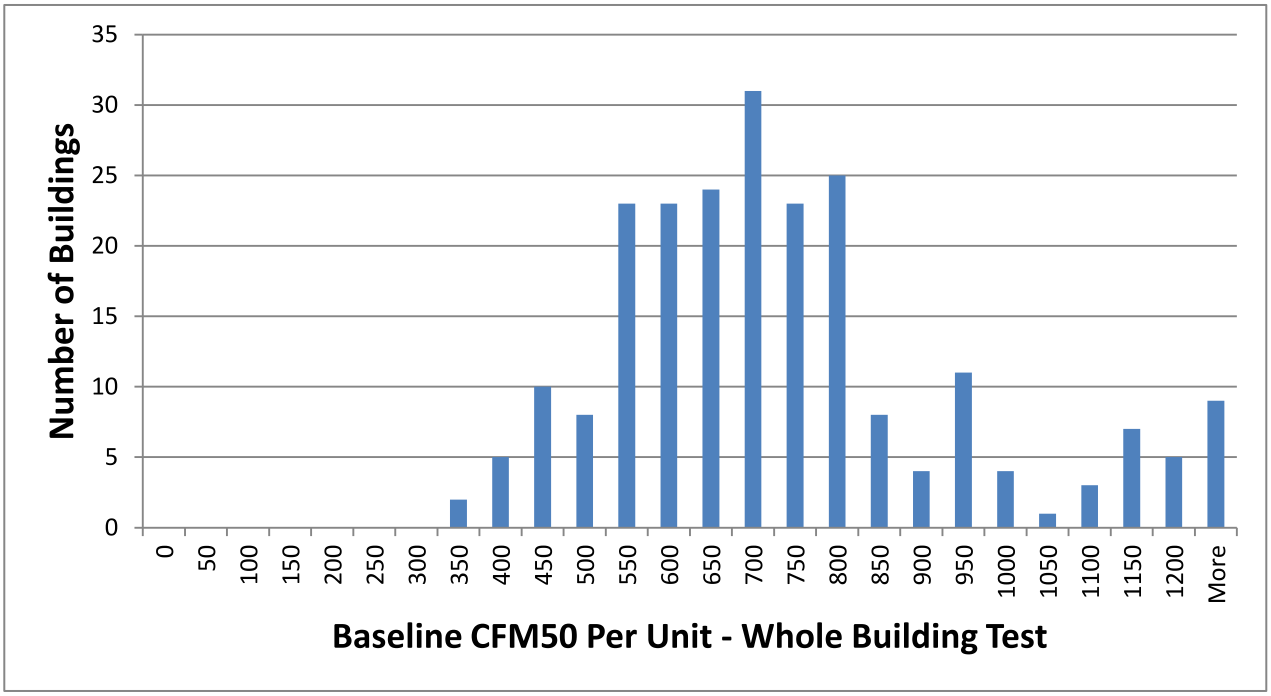
In developing the deemed savings estimates, the influence of two measured factors on energy savings were examined:

1. What is the Baseline leakage per tenant unit? What is the range and the variability in per unit leakage?

   The baseline leakage per tenant unit is 736 CFM_{50} +/- 5.8%. The coefficient of variation (CV) is 0.55, which indicates a normal distribution.

   Figure 1 shows the distribution of baseline leakage for 228 buildings with 20 or fewer tenant units that participated in the program and had pre-retrofit test data.

Figure 1: How Leaky? Average Baseline (Test-in) Leakage Per Tenant Unit



Source: PSE program tracking data

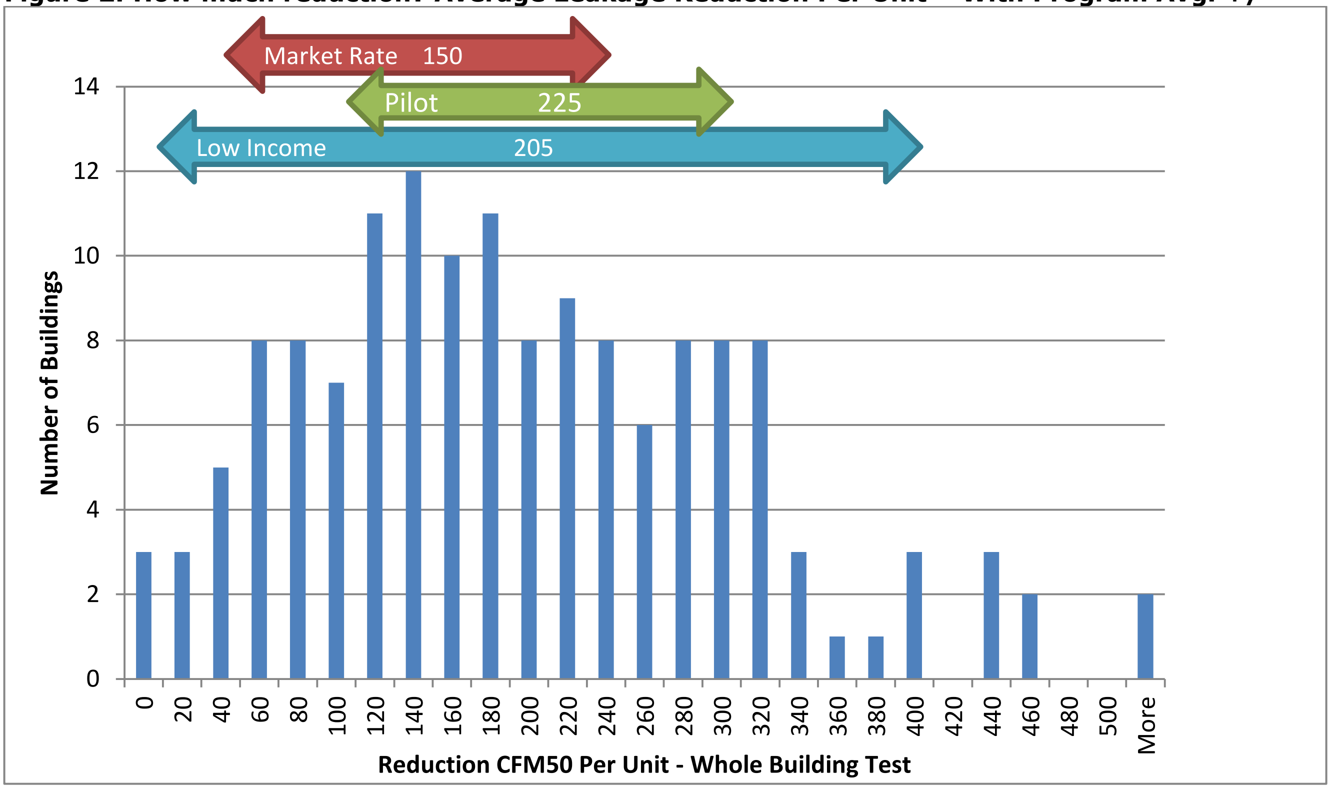
2. What is the Amount of Leakage Reduction per tenant unit?

- For a deemed measure, what is the average reduction?
- What is an acceptable range of leakage reduction? Do results indicate "tiers" based on building size, location, year built, or other variables?
- What is the relationship between leakage reduction and energy savings?

The program produced an average reduction per tenant unit of 151 CFM_{50} or 26%, +/- 9.3%. Low reductions usually lead to low savings, and large reductions usually lead to high savings. The CV is 0.77, indicating variability in baseline leakage per unit, and in contractor performance.

Figure 2 shows the distribution of leakage reduction for 148 small buildings with air sealing completed through the program. The Pilot group were projects completed in 2013-14 by a single contractor. Market Rate refers to the expanded program with multiple participating contractors in 2015-16 and Low Income Weatherization (LIW) were projects completed under that program which has similar technical requirements as MFAS.

Figure 2: How much reduction? Average Leakage Reduction Per Unit – With Program Avg. +/-



Source: PSE program tracking data

Energy Usage – Annual pre-air seal kWh per tenant unit is 9,223 +/- 8.7%. The CV for the energy usage across the population is 0.38, indicating relatively little variation in energy use despite the variation in pre-project air leakage.

1.2 2016 Savings Results

Overall energy savings in 2016 are 83% of the expected savings (realization rate). Table 1 compares 2016 savings with the realization rates from previous years. The deviations between the expected savings and evaluated savings can be explained by several factors:

- Wider range of leakage reductions as program opened to more contractors.
- Added sample from late 2015 and early 2016. (Pending addition of data from post-February 2016 projects may show improved project quality).
- Calculator showing some overestimation for extreme situations.
- In some cases, incorrect billing data led to overestimated savings.

Table 1: Results over time of evaluation (growing sample)

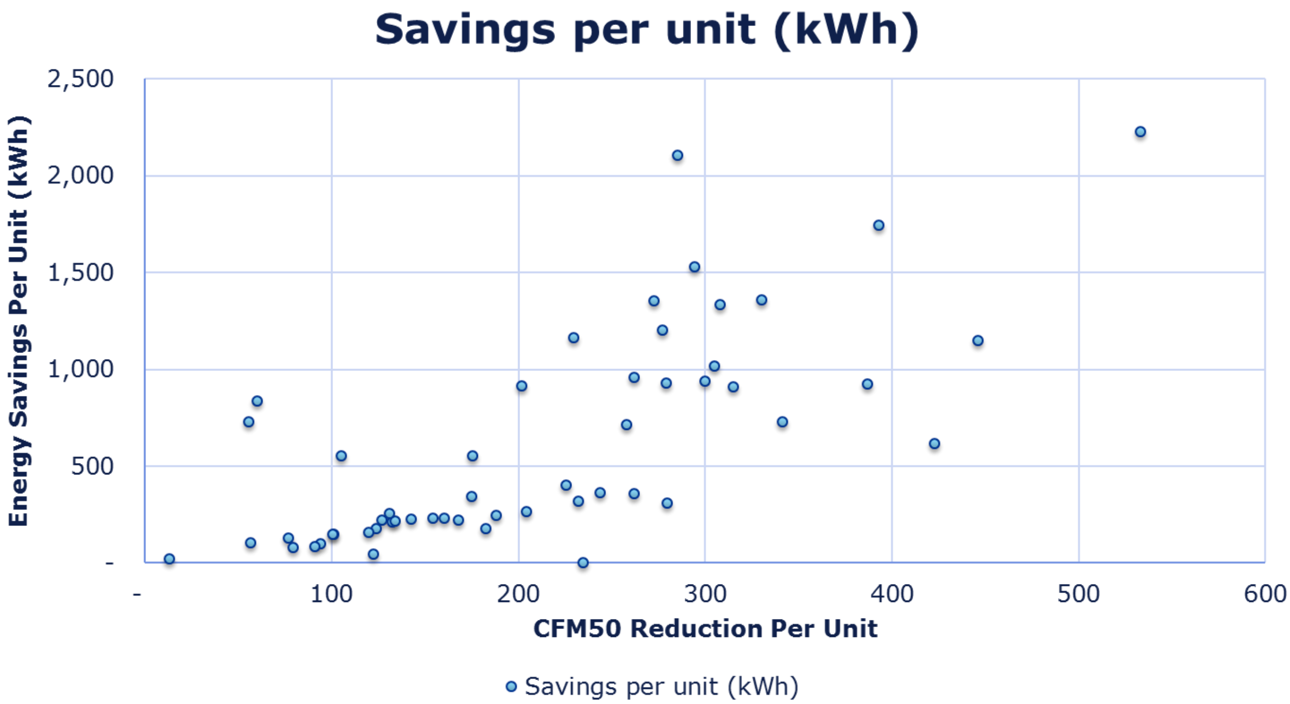
Evaluation Year	Sample	Realization	Precision
2013	17*	123%	NA
2014	26*	109%	NA
2015	36	87%	+/-27%
2016	54	83%	+/-20%

Source: DNV GL Analysis

An important finding was the average energy usage per building had the least variance when normalized by number of tenant units as opposed to conditioned square footage or bins of either metric. The average annual electric consumption per tenant unit was 9,223 kWh +/- 8.7% for the 54 evaluated projects. That is a coefficient of variation of 0.38 which means this is a tight distribution considering a much higher variation by building. In terms of the simulated models, the average heating load was roughly 37% of whole building energy use, with a tight distribution of this ratio consistent with the overall usage and extremes corresponding accordingly to colder or higher altitude locations.

The average annual energy savings of 612 kWh per tenant unit +/- 20% for the 54 evaluated projects was normalized by number of residential tenant units. This implies that a building with ten tenant units would on average save 6,120 kWh of heating energy. The coefficient of variation for savings is much higher at 0.89, so there remains a high degree of variability. Therefore, average savings are about 6-7% of whole building electric consumption and 20% of heating end use electric consumption with variation by leakage reduction and number of units in the building. Figure 3 shows the correlation between annual energy savings and building shell leakage reduction on a tenant-occupied apartment unit basis. It trends the way we expect, though the variability is significant.

Figure 3: Evaluated energy savings per residential tenant unit



Source: DNV GL Analysis and PSE program tracking data

The pilot (2013-14) achieved larger leakage reductions on average than post-pilot projects completed in 2015. Notably, the 2015 projects produced some results that were flagged by PSE based on the calculator outputs of low savings. PSE then did an extensive program re-training after discovering some protocols were not being fully implemented. Results from the pilot are higher than from the 2015 participants, both in CFM reductions and ultimate electric savings. The overall savings would be lower if we eliminate the units completed for the pilot, but we are including mostly pre-retraining sites completed after the pilot which may define the upper and lower bounds of the performance after the contractor re-training.

1.3 Recommendations

Based on project data, we built models for campuses and revisited some pilot sites that had anomalous results. The final sample of 54 excluded 12 sites with negative savings or impossibly high savings inconsistent with their low leakage reductions. (All of the excluded projects were completed in early pilot phases of the program.) Based on the results of this modeling and other analysis we recommend the following:

Deemed savings:

- Use deemed savings of 612 kWh / tenant unit and require sample based test-in and test-out. This deemed savings value is based on slightly below average test-in and slightly below average reduction values.
- Do not include additional evaluation sample from pre-February 2016 in additional analysis. Based on discussions with program implementers, they will likely not represent the current program well.
- Obtain post-billing data and campus building characteristics to model as many post February 2016 buildings as possible.
- Consider additional modeling quarterly to confirm program performance, as more completed buildings reach the point of providing a full year of post retrofit data. Almost all 2016 participants will have "post winter" retrofit data in Q2 2017.
- Develop a deemed savings estimate for large buildings based on modeling. Compare leakage reduction per unit to small building distribution prior to modeling, to determine if and how quickly a sampling approach for large building testing can be applied.

Using QA/QC data to inform EM&V and savings updates:

- Compare results periodically to the data from the initial pilot as a goal to achieve and track improvements above the 2015 projects that triggered re-training.
- Continue to scale savings based on total building usage. Data should be available for any participant regardless of blower door test requirements.
- Modify the calculator if QA/QC tests reveal very leaky buildings or large reductions.
- For buildings larger than 20 units, but less than four-stories, use TREAT modeling process consistent with the low-income weatherization (LIW) program and require testing for at least the first few buildings. Recommend not using the calculator for larger buildings (four-stories or greater) since per tenant unit average savings may change based on building features, especially common areas and elevators. Also recommend excluding mixed-use (commercial tenants on first floor) buildings and recommend using commercial modeling software (e.g. EnergyPlus).
- Begin sampling approach to test-in and test-out, focused on more frequent testing for new contractors as a QA/QC method.

- Reduce costs (proportionally) by moving from testing every unit to site-level sampling. Currently, every unit at every site undergoes a test-in, test-out procedure. We recommend 25% test-in, test-out for new contractors and 15% for more established contractors.
- Consider within campus sampling since the current MFAS participant population and PSE multifamily existing program population are primarily made up of campuses. Recommend requirement of 50% testing of buildings on a campus on a new contractor's first job. The criteria can then relax to 25% and 15% after proven performance. Added benefits include:
    - The evaluation can construct a model for each campus, and can utilize QA/QC data, billing data, and audit data.
    - Continuous expansion of savings data set to continuously improve precision and look for new trends as the sample of buildings grows.
- Continue to track where the QA/QC sample maps to the distribution of leakage reductions. The recommended QA/QC testing should lead to achieving 90/10 precision within the next evaluation year.
    - Explore whether leakage reduction values are below overall average and train contractors to correct as needed. Use pilot average leakages as another indicator of "good".
    - Examine best practices from leakage reduction values above average, especially at or above pilot averages.
    - Monitor and consider corrective actions (change in project targeting, re-training) for the lowest quartile of leakage reductions

We also provide a short list of audit and inspection data collection priorities for EM&V, listed in order of feasibility for implementation or inspection teams to collect cost-effectively.

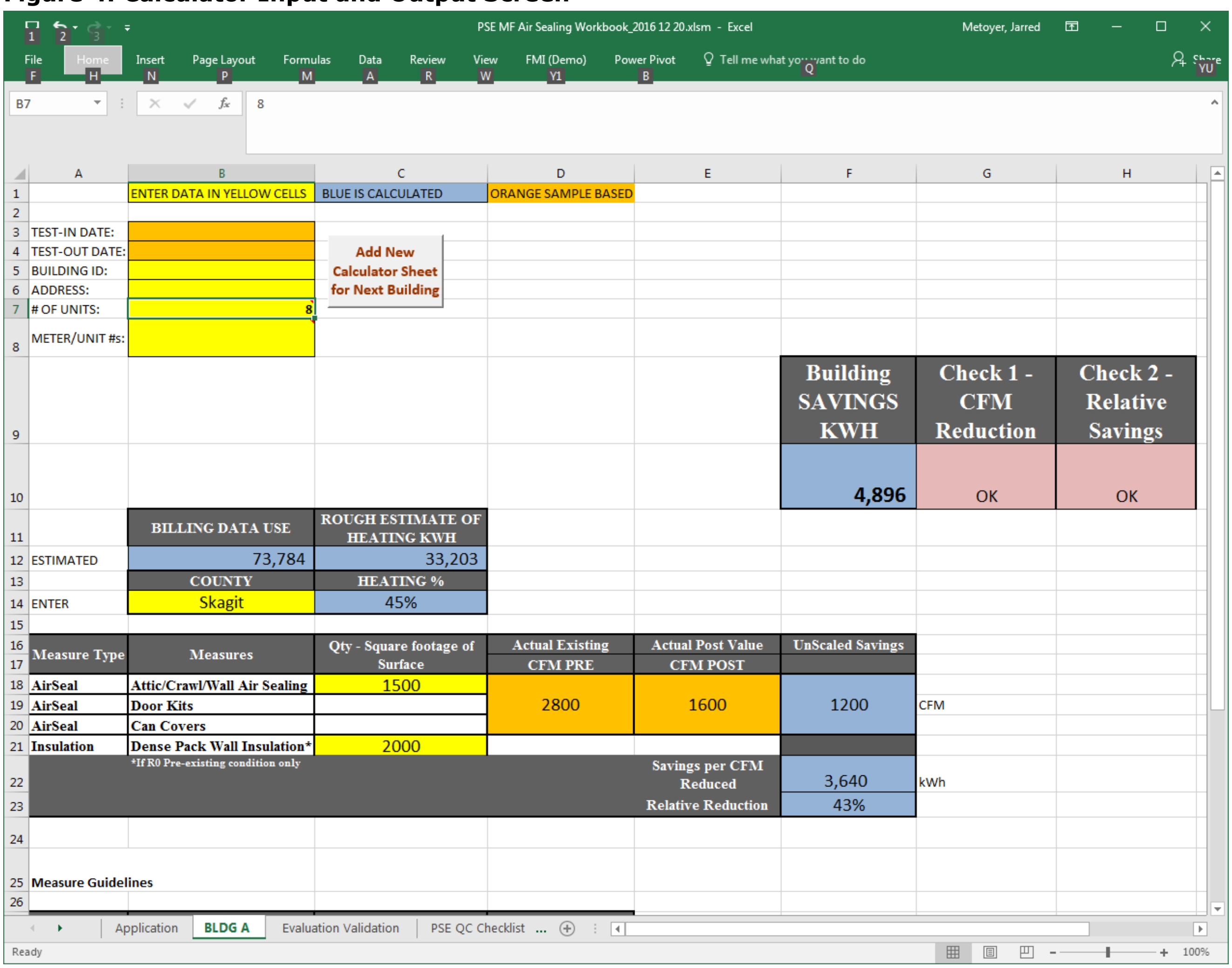
1. Front orientation of building (ordinal direction)
2. Heating systems capacity
3. Specific project descriptions. Audit spreadsheet had some unclear descriptions or was left blank; for instance, instead of providing a value for attic insulation, it says "already upgraded", which makes TREAT modeling difficult.
4. Exterior door information – orientation and number of doors
5. Thermostat set point and schedule information
6. Hot water heater nameplate information
7. Foundation and roof information
8. Number of windows and size in all directions

2 AIR SEALING SAVINGS CALCULATOR - ADDENDUM

2.1 Version 3

The air sealing calculator requires input of basic building information and uses past program and pilot data to estimate the average usage and electric energy savings based on previous whole-building blower door measurements and calibrated-simulation modelling. On a sample basis prescribed by PSE, the calculator also accepts whole building blower door measurements both before any measures are installed and after all measures are installed. The blower door entries can be any numeric value and savings are based on modelling sensitivity analysis and trued up using evaluation results from earlier implementation. The billing data is used to benchmark the savings on an average usage of 9,223 kWh annually. This aligns with the simulated average for the same set buildings with 20 units or less used to estimate the deemed savings of 612 kWh per tenant unit. The calculator spreadsheet, shown in Figure 4, is set up with checks to show flags if the QA/QC CFM reductions or savings are higher than expected based on evaluation results. The current calculator does not have a lower limit check.

Figure 4: Calculator Input and Output Screen



The calculator also provides the RTF approved savings estimates for wall insulation based on the wall surface area insulated. PSE claims other insulation savings for attics and floors at the program level and thus these calculations are not included in the calculator.

3 BACKGROUND – HOW THE CALCULATOR WORKS

3.1 Version 1 and 2

The basic approach to developing a spreadsheet calculator was to use early evaluation results in applying the sensitivity analysis from the first phase of the project which created evaluation guidelines[4] to develop a rough draft of the air sealing calculator for interim use to project program savings. The calculator was simple in terms of inputs and only required the measured CFM reduction, an input for county, and total building annual energy consumption. It was designed to enable comparison to some of the actual evaluated projects to aid in future development and refinement of the calculator. The calculator was designed for pilot program implementation with blower door testing and requires redesign for any future programs without those measurement requirements.

Looking forward beyond the pilot program, it is understood that projects will implement all measures for all surfaces. Looking only at the 17 projects from the first phase of the pilot evaluation led to a strong correlation between relative CFM_{50} reduction and savings per CFM_{50} reduced. This correlation begins to form the basis for future calculations; data from additional air sealing projects will improve calculator accuracy. The correlation shows that large relative reductions have lower savings per CFM reduced, so a fixed value used as a deemed ratio will overestimate the savings for large relative reductions. It is also true that lower relative reductions will have savings underestimated. The calculator places limits on the kWh savings per CFM_{50} on the high side. The first QC check is for relative CFM reduction and percentages over 50 are questioned.

The 2012 sensitivity analysis produced a result of about 3 kWh of heating savings per CFM_{50} leakage reduction. The total across the first 17 "all measures" evaluated projects in the pilot evaluation was 4.3 kWh of savings per CFM_{50}. The single measure sites are higher (7.9 kWh/CFM_{50}) than all measures (3.9 kWh/CFM_{50}), but all measure sites had more total savings and higher realization rates. The average for previously insulated and not previously insulated building categories were both 4.3 kWh/CFM_{50}.

The calculator also takes the input of total building energy use and scales the savings if they are higher or lower than the average from the sample of 82,500 annual kWh used to develop the savings calculation. The heating portion of the bills is roughly estimated based on county and the value is used to check the percentage of heating air sealing is saving. This is flagged in QC check number two.

[4] DNV GL for Puget Sound Energy. Guidelines for Evaluating the Impact of Air Sealing and Insulation in Multifamily Buildings January 4, 2013

About DNV GL

Driven by our purpose of safeguarding life, property and the environment, DNV GL enables organizations to advance the safety and sustainability of their business. We provide classification and technical assurance along with software and independent expert advisory services to the maritime, oil & gas and energy industries. We also provide certification services to customers across a wide range of industries. Operating in more than 100 countries, our professionals are dedicated to helping our customers make the world safer, smarter and greener.

Evaluation Report Response

Evaluation Report Response

Program:	Multifamily Retrofit
Program Manager:	Mac Snow
Study Report Name:	2016 Multifamily Air Sealing Savings Evaluation Update
Report Date:	December 29, 2016
Report Given to Program Staff:	January 27, 2017
Evaluation Analyst:	Jim Perich-Anderson
Date of ERR:	February 8, 2017

PSE Program Response to Evaluation Findings

PSE will follow the recommendation of this memo and apply a blower door testing requirement of 15% for more established contractors and 25% for new contractors (or 50% of buildings on a MF campus for first jobs). PSE may elect to increase the number of buildings to be tested as a QA/QC measure if a contractor is not effectively reducing the building's air infiltration.

By Q2 2017, PSE will pull the post-billing data and compile the campus building characteristics in order to model as many 2016 buildings as possible. This will help determine the impact of the revised QA/QC protocols put into place in January 2016 as well as inform a more representative prescriptive savings value. Further, we will pursue additional modelling on a quarterly basis to continue to acquire more buildings that have a full year of post retrofit data. With regard to buildings larger than 20 units, we will apply a TREAT modelling process similar to LIW and require full building depressurization testing. This will allow us to compare leakage reductions per unit for small buildings prior and determine if and how quickly a sampling approach for testing can be applied for large buildings.

The blower door test results will not be used to derive savings estimations, but rather will serve as a means to conduct impact evaluations and performance assessments. We will instead adopt the recommended prescriptive savings of 612 kWh per unit based on the results from this Savings Evaluation Update. Further, we will continue to conduct in-progress QA inspections and verify 20% of completed units, and we will also introduce mandatory pre-construction meetings with the contractors prior to beginning any new project. The recommended list of audit and inspection items will be gathered before work begins to help inform evaluation efforts at later point in time. Lastly, the air sealing calculator will continue to be utilized to calculate incentives and savings, albeit on a prescriptive basis. It will serve to document the sampled blower door results, the scope of measures installed, estimated project savings, eligible incentives, and the building characteristics.

PUGET SOUND ENERGY

Program(s):

- C&I New Construction
- Commercial Rebates

Program Year(s):

- 2016-2017

Contents:

- PSE Evaluation Report Responses
- Evaluation Report
- Evaluation Report Appendices

This document contains Puget Sound Energy's (PSE) Commercial and Industrial (C&I) New Construction and Commercial Rebates Programs Evaluation Report and Evaluation Report Response (ERR). In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

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[1] (6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for 2016-2017 PSE Electric Conservation.

[2] PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised August 6, 2015.

[3] Ibid.

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Evaluation Report Response

Program:	C&I New Construction
Program Manager(s):	Tom Anderson, Dave Montgomery, James Marker
Study Report Name:	Evaluation of PSE's PY2016/17 Commercial Rebate and New Construction Programs
Primary Author(s):	Navigant
Report Date:	December 2017
Evaluation Analyst(s):	Michael Noreika
Date of ERR:	January 2018

Evaluation Overview, Key Findings, Recommendations and Program Responses:

I. Abstract

PSE developed the New Construction (NCx) program to encourage the construction of buildings that are more energy efficient than the minimum required by Washington code. The program is designed to address customer barriers to efficient construction, such as owners/developers not considering energy efficiency early enough in the design process, market actor lack of understanding regarding building energy consumption, and developers not being able to recover the additional costs associated with energy-efficient design beyond code. As a part of the NCx program, PSE staff conduct marketing and outreach, engage market actors on specific projects, provide incentives, and verify that participating buildings or projects are built as designed.

II. Conclusions, Recommendations, and PSE Responses

A. Overall Performance

Table 2: 2016/17 New Construction Program - Realization Rate by Fuel Type

Fuel Type	Reported Savings*	Evaluated Savings	Realization Rate	Relative Precision
Electricity (MWh)	67,500	54,867,014	0.81	10%
Gas (therms)	345,583	375,624	1.09	10%

* The reported savings for 2017 are based on the 12/13/2017 data extract and should be revised when the 2017 Annual Report of Energy Conservation Accomplishments is released in March of 2018.
Source: Navigant analysis

B. Recommendations

Recommendations for the indoor horticulture program

- **Use the 1.8 baseline factor for both flowering and non-flowering spaces.** PSE's 3.3 baseline factor for non-flowering spaces assumes that these spaces require as much light as flowering spaces in the base case, which can be provided by much lower wattage efficient lamps than is possible for flowering rooms, resulting in a larger delta watts. The evaluation activities indicate that non-flowering rooms require whiter more "broad spectrum" lights, instead of the spectrally selective fixtures common in flowering rooms, and that the baseline fixture wattage for these spaces should be lower, closer to 600-800W per fixture. As such, the team recommends using the same baseline multiplier, 1.8, in both the non-flowering and flowering spaces.

PSE Response: PSE uses the 3.3 factor for non-flowering and vegetative spaces. Although the 1.8 baseline factor reflects what indoor horticulture operations *could* do, it is PSE's experience that more often than not the operations use the same lights in the flowering and non-flowering spaces for operation and maintenance reasons (i.e., they find it easier to stock one lamp type than multiple lamp types). As such, PSE will consider this recommendation in the future, but for now will continue to use the 3.3 factor in our calculations.

- **Limit the canopy lighting power density to 68.75W/sf.** Instead of assuming a 1:1 lamp replacement, the current industry standard assumes one 1,000W fixture per 4' x 4' square foot of canopy space. This cap helps correct for the excessively high lighting power densities that result from using baseline factors, and which program participants and industry experts confirm are unrealistic. Without limiting the baseline LPD, four of the 8 projects evaluated were calculated to have LPDs exceeding 70W per square feet, with the highest being 96.8.

PSE Response: PSE has implemented this recommendation for the 2018-19 program cycle.

- **Develop a uniform method for determining operating hours for indoor horticulture projects.**

  Option 1. Update project application to collect lighting operating hours and area by space type. The evaluation team recommends that PSE collect customer-reported lighting operating hour estimates by space type for three general space types; flowering, non-flowering (including all vegetative, mothering and cloning spaces) and all other spaces (including all non-grow spaces such as offices, corridors, restrooms, etc.) Collecting the respective floorspace and canopy space for each of these space types would also improve the certainty in lighting savings estimate allowing for a more informed baseline lamp quantity and wattage assumption.

  Option 2. Update ex-ante assumptions and/or model calculations to include lighting operating hours and floorspace by space type. In lieu of updating the application, the evaluation team recommends that PSE expand current program assumptions to include lighting operating hours for the same three space types defined in Option 1 (flowering, non-flowering, all other).

PSE Response: PSE already implements Option 1 for non-grow spaces. Those spaces are incentivized through the Commercial Lighting path of the New Construction program, not under the Indoor Horticulture path.

Recommendations to improve future evaluations

- **Develop a method to maintain and update business cases.** The biggest challenge during the evaluation of multifamily projects proved to be with PSE's documentation. PSE should consider creating a master tracker document that provides the file location, lead author, version number, and date of all business cases.

PSE Response: PSE is actively addressing our business case and archival processes.

PUGET SOUND ENERGY

Evaluation Report Response

Program:	Commercial Rebates
Program Manager(s):	Chrissy Crowell, Sarah Cann, Tianna Byrtus, Chris Boroughs
Study Report Name:	Evaluation of PSE's PY2016/17 Commercial Rebate and New Construction Programs
Primary Author(s):	Navigant
Report Date:	December 2017
Evaluation Analyst(s):	Michael Noreika
Date of ERR:	January 2018

Evaluation Overview, Key Findings, Recommendations and Program Responses:

III. Abstract

PSE's Commercial Rebate program consists of seven related but distinct sub-programs:

- Small Business Direct Install (SBDI)
- Lodging Direct Install (LDI)
- Agriculture Direct Install (ADI)
- Premium HVAC
- Commercial HVAC
- Hospitality Management
- Kitchens & Laundry

The SBDI, LDI and ADI sub-programs are designed to provide low and no-cost direct install measures to small business customers. The Premium HVAC sub-program provides incentives for maintenance and service of HVAC systems leading to energy efficiency savings, while the Commercial HVAC, Hospitality and Kitchens & Laundry sub-programs provide customers with rebates on qualifying efficient HVAC, kitchen and laundry equipment.

IV. Conclusions, Recommendations, and PSE Responses

A. Overall Performance

Table 7: Commercial Rebate Program - Electric Savings by Sub-Program

Program	Ex-Ante Savings	Ex-Post Savings	Realization Rate	Relative Precision
SBDI	15,101	11,785	0.78	7.7%
LDI	4,791	4,743	0.99	
Com. HVAC	1,501	1,501	1.00	
Com. Kitchen	953	936	0.98	
Other (Prem. HVAC and Hospitability)	1,428	1,456	1.02	
Overall	**23,775**	**20,421**	**0.86**	**7.1%**

Source: Navigant Analysis

Table 8: Commercial Rebate Program Results - Gas Savings by Sub-Program

Program	Ex-Ante Savings	Ex-Post Savings	Realization Rate	Relative Precision
SBDI	6,514	4,698	0.72	34.6%
LDI	18,342	7,735	0.42	
Prem. HVAC	51,977	48,312	0.93	
Com. Kitchen	166,202	157,660	0.95	
Other (Com. HVAC and Com. Laundry)	10,906	10,906	1.00	
Overall	**253,941**	**229,310**	**0.90**	**5.0%**

Source: Navigant Analysis

B. Recommendations

Recommendations for the general Commercial Rebate program

- **Make tracking data structure streamlined and consistent across sub-programs.** The data we received differed significantly between sub-programs within the Commercial Rebate program, both in terms of formatting and field names, as well as the completeness and quality of data captured. Many datasets we received were missing the majority of key fields such as contractor name, contractor email address and contractor phone. The evaluation team recommends PSE streamline the tracking data system for all programs, perhaps using the DI program tracking data as the model for all sub-programs.

PSE Response: PSE has recently migrated all project tracking to a new system (DSMc). The inconsistencies were likely a result of some projects in 2016 coming from the old system, and some projects in 2017 coming from the new system. PSE does not expect this to be a concern going forward now that the migration is completed.

- **Update annual HOU assumptions for exterior lights.** PSE's current deemed annual HOU estimate for exterior lighting photo cell projects is 4,200. The team estimated savings for these projects using 4,656 annual HOU, derived from astrological sunrise-sunset data for the PSE service territory.

PSE Response: PSE will consider changing the HOU for exterior lighting. Any change will need to be aligned with PSE's Commercial Lighting program.

- **Consider applying HVAC interactive effects for lighting projects**. Currently, PSE's business cases for lighting measures do not include the interactive effects of efficient lighting on HVAC energy consumption. We recommend PSE expand current lighting savings values to incorporate the interactive effects currently used in the RTF lighting unit energy savings assumptions.

PSE Response: PSE will consider this recommendation in the context of small to medium commercial and large commercial lighting projects. PSE currently uses an evidence-based methodology in large commercial lighting projects that differs from that of the RTF.

- **Monitor participant perception of PSE representative availability.** Insufficient PSE representative availability surfaced in the 2017 participant survey as the second most mentioned barrier to participation, but was not mentioned as a key barrier in 2016. PSE should conduct research during the next biennium to better understand the source of the issue. This research should include targeted participant survey questions throughout the next biennium to monitor the issue.

PSE Response: PSE will incorporate this recommendation into the 2018-19 evaluation cycle.

Recommendations for Lodging Direct Install

- For LDI projects, the evaluation team recommends that PSE double check the installed quantities reported in the tracking data against project documentation for a random sample of PY2018 projects to confirm the duplication in reporting issue has been resolved.

PSE Response: PSE believes this issue was related to the migration from the previous tracking system to the new DSMc tracking system. Migration occurred midway through the 2016-17 program cycle. PSE will monitor program tracking through DSMc during the 2018-19 program cycle.

Recommendations for Commercial Laundry

- **Revitalize the program.** As the equipment installed at the start of the program is nearing the end of its useful life, the program manager expects participation to ramp up in coming years. Our team suggests PSE research the installation year and effective useful life of equipment previously installed through the program, to proactively approach and engage past participants.

PSE Response: PSE will consider this recommendation in the 2018-19 program cycle and will determine if it is a feasible approach. PSE understands that previous program participants are more likely to participate in a program than customers who have not previously participated.

Recommendations for Commercial Kitchens

- **Encourage early replacement.** A key barrier to program participation is the tendency of restaurants to wait until equipment fails to replace it, rather than proactively adopting new energy efficient equipment. Our behavior optimization research yielded key suggestions for PSE to consider, including: (1) Focusing on the non-energy benefits, not just the financial case for early replacement, (2) acknowledging the customer's attachment to existing equipment because of "sunk costs", (3) framing benefits in terms of loss to leverage loss-aversion tendencies.

PSE Response: PSE will consider this recommendation in the 2018-19 program cycle.

- **Address vendor concerns.** During trade ally interviews, vendors in the Kitchen program had several complaints and suggestions for improvement which PSE should follow-up on and develop strategies to mitigate.

PSE Response: PSE strives to maintain mutually beneficial relationships with our trade allies. PSE will follow up on this recommendation and intends to monitor trade ally sentiment through the 2018-19 program cycle.

Recommendations for targeting remaining T12 commercial lighting stock

- **Allow T12s their natural decline.** Our lighting modeling analysis team's work demonstrated that the prevalence of T12 lighting is extremely low and on the decline. Because this type of lighting will be mostly absent from the commercial lighting stock as of 2020, it may not be cost-effective to take a targeted approach to lowering the T12 lighting stock.
  -OR-
- **Target hi-bay and low-bay lighting in Industrial buildings.** If PSE desires to hasten the decline of T12 commercial lighting stocks, the most advantageous and cost-effective approach, may be to target hi-bay and lo-bay T12 lighting in Industrial spaces

PSE Response: PSE does not specifically target T12 lighting retrofits, but addresses them when they are discovered in assessments. Existing T12 retrofit savings signal that, although there is an overall decline in the commercial sector, T12s in small businesses are still prevalent and reflect a slower decline in use. PSE will continue to replace T12 lighting if they are uncovered during project audits.

Recommendations to improve future evaluations

- **Develop a method to maintain business cases and have projects reference the correct version.** PSE should consider creating a master tracker document that provides the file location, lead author, version number, and date of all business cases. PSE should also define the date range across which each version should be used in reported savings, to eliminate projects referencing deemed values from outdated versions of a business case.

PSE Response: PSE has begun a project to comprehensively overhaul the business case process, including development, maintenance, and archiving. The overhaul is scheduled to be completed in Q2 2019.

- **Eliminating contractor misperceptions.** While analyzing data collected during trade ally interviews, we realized that a large portion of Commercial HVAC contractors were answering our questions with the Custom Grants program in mind. For future evaluations, we recommend (1) the program do more to educate contractors about the difference between programs so contractors are fully aware of which program they are participating in; (2) have the process evaluation team anticipate lack of a clear distinction between programs from the contractors' perspectives, and design questions to explicitly remind them to comment only on the prescriptive program.

PSE Response: PSE will consider this recommendation in the 2018-19 evaluation cycle.

- **Sub-Program Differentiation.** Our team learned that sub-programs vary tremendously in terms of design, intent, audience, incentive mechanism, marketing and outreach strategies, delivery and dependence on trade allies. Even in interviewing program managers, we were repeatedly asked why we were referring to their sub-program as a "sub-program" rather than a "program." This revealed that program managers view their sub-programs within the Commercial Rebate program as independent and only loosely linked to a larger program umbrella. In future evaluations, we encourage the process evaluation team to think about these programs in a more autonomous manner from the start of the evaluation and to define different key research questions and areas of inquiry for each sub-program. We suggest drawing parallels and commonalities between them at the end of the evaluation rather than at its start.

PSE Response: PSE has designed the 2018-19 evaluations to meet this recommendation.

Evaluation of PSE's PY2016/17 Commercial Rebate and New Construction Programs

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We would like to acknowledge the following people for their contributions to this report:

Christina Crowell
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Tianna Byrtus
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Dave Montgomery

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

This document provides the results, findings and recommendations from the impact and process evaluation of Puget Sound Energy's (PSE) PY2016/17 New Construction and Commercial Rebate programs. Four 1-page evaluation summaries take the place of a traditional executive summary. The appendices include all additional details (methodology, sample design, data collection, etc.) including all the milestone summary memos presented to PSE throughout the evaluation.

Evaluation Summary

COMMERCIAL
MULTIFAMILY
INDOOR HORTICULTURE

FY2016-2017 New Construction Program Impact Evaluation

The program is achieving reported savings, but we recommend a baseline change for Indoor Horticulture projects.

Findings:

Engineering Review

- Multifamily business cases were often missing
- Project files often did not include energy simulation models
- Baseline lighting assumptions were often based on 1:1 replacement or baseline multipliers. The team used lighting power densities and space types from Washington State Energy Code 2012 to evaluate savings.

Recommendations:

New Construction Program

- Track contact information
- Develop a method to maintain and update business cases

Indoor Horticulture Projects

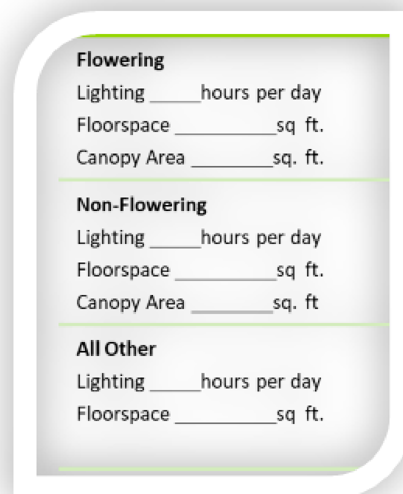
- Create an application which all Indoor Horticulture projects must use that collects the HVAC system type as well as lighting daily hour of use, floorspace and canopy areas for flowering, non-flowering and all other spaces.
- Use 1.8 as the baseline factor for flowering and non-flowering spaces in the savings estimation of efficient lighting in new construction indoor horticulture projects.
- Limit the canopy lighting power density to 68.75W/sf. Implement this cap to help correct for the excessively high lighting power densities that result from using baseline factors combined with a 1:1 fixture replacement assumption.

Realization Rate by Fuel Type

Fuel Type	Realization Rate	Relative Precision
Electricity (MWh)	0.81	9%
Gas (therms)	1.09	10%

Source: Navigant analysis

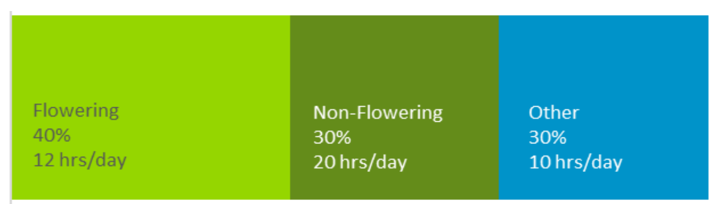
Create an Indoor Horticulture project form


Flowering
Lighting _____hours per day
Floorspace __________sq ft.
Canopy Area ________sq. ft.

Non-Flowering
Lighting _____hours per day
Floorspace __________sq ft.
Canopy Area ________sq. ft

All Other
Lighting _____hours per day
Floorspace __________sq ft.

Use updated floorspace and daily HOU assumptions by space type for Indoor Horticulture projects, if form data is unavailable



Adopt a HVAC IF of 1.3 for projects with VRF or unknown HVAC systems, and 1.4 for projects that are verified as using free-cooling.

VRF System	All Systems	Free-Cooling
1.3	1.3	1.4

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EVALUATION SUMMARY

COMMERCIAL
MULTIFAMILY
INDOOR
HORTICULTURE

FY2016-2017 New Construction Program Process Evaluation

The New Construction Program can increase early engagement with owners and design teams to continue to capture savings beyond code.

Strategies for Engagement

	When	Who	How
Findings	Best time to engage projects is early in the design process, before the design phase even begins.	Develop strategies to engage both owners (because they are the decision makers) and design teams (because they can heavily influence the owner).	Participants want to learn about program offerings via email, but direct connections to customers and design teams are important to actual program engagements.

Recommendations

Reach out to owners and design teams before or during the conceptual design stage.
- Work with account executives and sales representatives to bring in new projects.
- Work with existing participants, developers/large corporations, for additional projects.
- Market to owners via email ads and campaigns at local planning or permitting offices.
- Familiarize design teams with program offerings to recommend to their clients.

Capture Savings Beyond Code

	New Incentives	Upselling	Influence
Findings	Additional savings beyond code are created through new incentives, including innovative design incentives and pay-for-performance options.	Upselling customers on aspects of design projects can help push customers to achieve greater energy savings in their building designs.	Current incentives are helping to influence most participants (up to 79%) but will need to be monitored overtime.

Recommendations

1. Consider innovative design incentives and pay-for-performance options.
2. Incorporate incentives for more complex and innovative measures.
3. Continue to focus on energy-intensive customer segments (indoor horticultural).
4. Move projects to exceed code, train staff in upselling techniques.

Participant Experiences

	Program Experiences	Barriers	Motivations
Findings	Need for greater/more communication about the program—including more and/or better information on program processes, timelines, and online references.	Time and money are the largest barriers to program participation for owners/developers who do not always build beyond code.	Most reported motivations for including energy efficient equipment in new construction projects were operational savings (89%) and reduced environmental impact (42%).

Recommendations

1. Provide greater communication to potential participants online.
2. Improve communication to participants during their projects.
3. Consider need to hire more program staff.
4. Consider creating an express program for small customers/projects.

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Evaluation Summary

COMMERCIAL KITCHENS AND LAUNDRY
COMMERCIAL HVAC
PREMIUM HVAC SERVICE
SMALL BUSINESS DIRECT INSTALL
AGRICULTURE DIRECT INSTALL
HOSPITALITY AND LODGING DIRECT INSTALL

FY2016-2017 Commercial Rebate Program Impact Evaluation

Overall, the Commercial Rebate program is achieving reported savings, and SBDI HOU assumptions are representative.

Findings:

Tracking Data Review

- Three separate tracking data systems.
- Many projects were missing contact info (mostly email addresses).

Engineering Review

- Most business cases are up-to-date with no revisions required.
- Interior lighting algorithms do not include HVAC interactive effects
- A few discrepancies exist between reported savings in tracking data and deemed savings provided in business cases.

Installation Verification SIte Visits

- For majority of projects, verified quantities matched with reported quantities.
- Several sampled LDI projects reported duplicated quantities in tracking data.

Recommendations:

All Sub-Programs

- Streamline the tracking databases across all the sub-programs.
- Expand data fields provded in sub-programs to mirror current DI database.
- Include Regional Technical Forum's HVAC interactive effect assumptions for interior lighting measures
- Use astrological sunrise-sunset data for annual HOU for exterior lighting measures
- Develop a method to maintain and update business cases

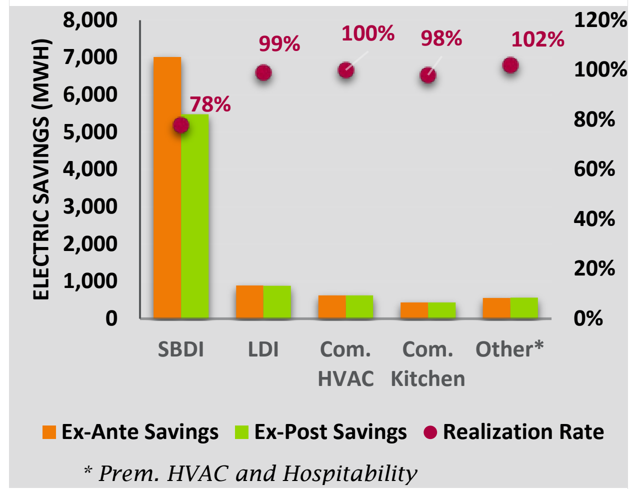
Premium HVAC

- Use more durable stickers and color coding to identify rebated units/implemented measures in the field.

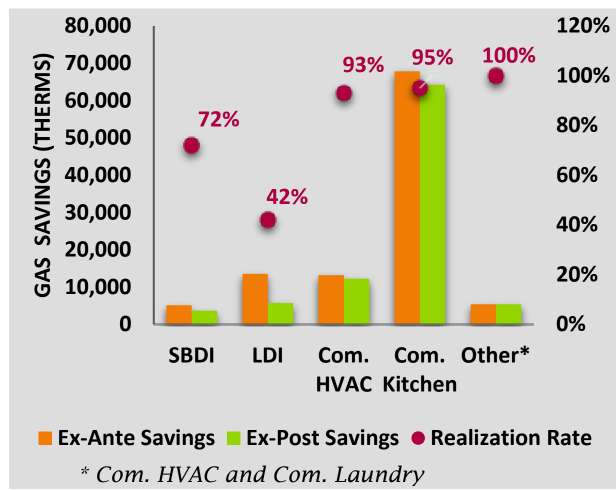
SBDI Lighting HOU Assumption

- Customer-reported HOUs collected during site visits averaged to be within 3% of PSE's current annual HOU estimate.
- PSE should continue using the current assumption and revisit it after the new CBSA data is released.

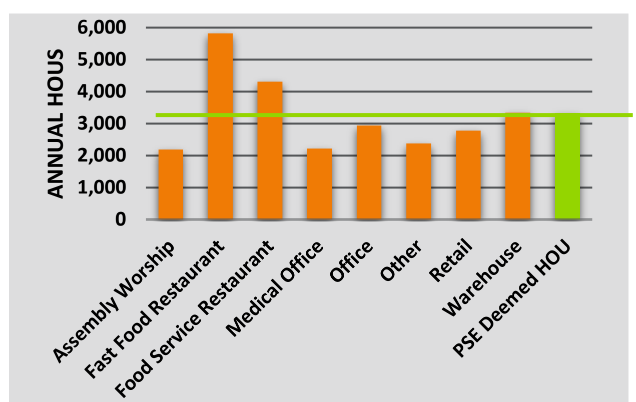
0.86 Realization Rate – Electric Savings



0.90 Realization Rate – Gas Savings



SBDI HOU Match Customer-Reported HOU



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Evaluation Summary

COMMERCIAL KITCHENS AND LAUNDRY
COMMERCIAL HVAC
PREMIUM HVAC SERVICE
SMALL BUSINESS DIRECT INSTALL
AGRICULTURE DIRECT INSTALL
HOSPITALITY AND LODGING DIRECT INSTALL

FY2016-2017 Commercial Rebate Program Process Evaluation

The Commercial Rebate Program is performing well, achieving expected savings levels and high customer satisfaction.

Customer Experience and Participation

Findings

- Both mean program satisfaction and the program's success at meeting expectations were rated a 9 out of 10
- Interactions with program staff and contractors were rated very highly—the median score, both for interaction with PSE staff and with contractors, was a 10 out of 10
- Saving Money (50%) and Benefiting the Environment (30%) were the top motivations cited for program participation
- Overall, participants were highly satisfied with the application process
- In 2017 participants reported PSE representative availability as a barrier to participation

Recommendations

- Investigate PSE representative availability as a key participation barrier
- Leverage sources of information participants reported as most useful but did not commonly encounter
- Proceed with plans to increase in-store use of signage and marketing for the Commercial Kitchens program

Program Efficiency, Cost-effectiveness and Quality

Findings

- The Community Blitz outreach approach was rated very highly by SBDI participants; It proved not as useful for new Agriculture and Lodging DI sub-programs, which experienced slow ramp-up periods
- The Commercial Kitchens program expanded participation through a new manufacturer-retailer cooperation effort to rebate select equipment
- SBDI participants who installed copaid equipment said this new program component heavily influenced their choice to participate
- While Commercial HVAC showed robust participation and performance, Premium HVAC Service sub-program experienced a slow ramp up after major program design and delivery changes

Recommendations

- Work closely with the Premium HVAC Service implementer to monitor program ramp-up and consider implementing implementer suggestions for program delivery improvement
- Investigate re-invigorating the Commercial Laundry program as currently installed equipment nears its End of Useful Life

Trade Ally and Implementer Relationships

Findings

- Most trade allies reported positive experiences in the program, though many had constructive suggestions for improvement
- PSE program managers all reported clear channels of communication and good relationships with their implementation contractors
- The new Premium Service HVAC implementer actively worked to re-engage trade allies and rebuild connections with the Contractor Alliance Network (CAN)
- External factors including a vibrant commercial new construction market pulled contractors' attention away from the Commercial Rebate program, sometimes limiting their engagement in HVAC and DI programs

Recommendations

- Consider Commercial HVAC contractors' and Commercial Kitchens vendors' program improvement suggestions
- Investigate a small number of cases where SBDI trade allies and customers reported concerns and negative program experiences

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2. NEW CONSTRUCTION

PSE developed the New Construction (NCx) program to encourage the construction of buildings that are more energy efficient than the minimum required by Washington code. The program is designed to address customer barriers to efficient construction, such as owners/developers not considering energy efficiency early enough in the design process, market actor lack of understanding regarding building energy consumption, and developers not being able to recover the additional costs associated with energy-efficient design beyond code. As a part of the NCx program, PSE staff conduct marketing and outreach, engage market actors on specific projects, provide incentives, and verify that participating buildings or projects are built as designed. Appendix D provides the complete description of PSE's NCx program structure and logic.

2.1 Impact Evaluation

This section presents the high-level results of the impact evaluation activities. As shown in Table 1, the impact analysis relied on an in-depth review of program tracking databases, project data, billing data, secondary data and select participant interviews. The methodology is detailed in Section 3.2.

Table 1: New Construction Program - CY2017 Impact Evaluation Activities

Strata	Tracking Database Review	Engineering Review	Billing Analysis	Participant Interview	Literature Review
Commercial	✓	✓	✓		
Multifamily	✓	✓	✓		
Indoor Horticulture	✓	✓	✓	✓	✓

Source: Navigant analysis

2.1.1 Results

As presented in Table 2, the evaluation team calculated a 0.81 and 1.09 realization rate for electricity and gas savings achieved through the PY2016/2017 New Construction program.[1]

Table 2: 2016/17 New Construction Program - Realization Rate by Fuel Type

Fuel Type	Reported Savings*	Evaluated Savings	Realization Rate	Relative Precision
Electricity (MWh)	67,500	54,867,014	0.81	10%
Gas (therms)	345,583	375,624	1.09	10%

* The reported savings for 2017 are based on the 12/13/2017 data extract and should be revised when the 2017 Annual Report of Energy Conservation Accomplishments is released in March of 2018.
Source: Navigant analysis

[1] Throughout this report, realization rate is calculated as evaluated (or ex-post) savings divided by reported (or ex-ante) savings.

To develop these program-level realization rates, the team calculated a project-level realization rate for each sampled project, then weighted each by project size to develop a stratum-level realization rate. From here, the team weighted the strata and sub-programs by 2016/17 reported savings to extrapolate out to the program population. Table 3 provides a detailed view of the evaluated savings by sub-program and sample strata.

Table 3: 2016/17 New Construction Program – Realization Rate by Sub-Program and Stratum

Sub-Program	Stratum	kWh Realization Rate	Relative Precision	Therm Realization Rate	Relative Precision
Commercial	Large	-	NA	1.00	5%†
	Medium	0.99	5%†	1.14	17%
	Small	1.34	15%	1.05**	50%
	Subtotal	**1.22**	**16%**	**1.14**	**15%**
Multifamily	Large	1.02	5%†	1.00	5%†
	Medium	0.75	25%	1.08	50%
	Small	1.33	50%	1.17	31%
	Subtotal	**1.12**	**27%**	**1.08**	**12%**
Indoor Horticulture	Large	0.47§	5%†	-	-
	Medium	0.86§	5%†	-	-
	Small	0.53§	24%	-	-
	Subtotal	**0.59§**	**12%†**	**-**	**-**

*The Commercial and Indoor Horticulture also included a "Tiny" sub-stratum that was not included in sampling efforts due to the size of each project. The "Small" stratum realization rates were applied to the "Tiny" stratum's claimed savings and the program wide savings results for the "Small" and "Tiny" strata were rolled together.

**Due to their small size, no commercial gas small projects were evaluated. The combined large and medium overall realization rate was applied to the small stratum.

§These indoor horticulture realization rates do not use the 2014/15 tracked savings for the sample projects. Instead, Navigant used a recalculated baseline to simulate the 2016/17 method used by PSE. This method is further discussed in Appendix 3.3A.6.

†A minimum relative precision of 5% is assigned to all sub-strata whose calculated relative precision is less to account for a minimum level of measurement error and unpredictable variations.

Source: Navigant analysis

2.1.1.1 Drivers

This section highlights the key drivers behind the evaluated savings and realization rates calculated by sub-program. Details are provided in Section 3.2.

Commercial New Construction

Missing energy simulation models

- The project team was unable to obtain the building energy simulation models for the sampled Commercial NCx projects. As an alternative approach, Navigant verified the savings using billing data analysis. Details are provded in Appendix A.4.

Incorrect operating hours for chillers

- For one commercial-electric project, the implementer applied a bin data analysis to calculate chiller savings using Typical Meteorological Year 3 (TMY3) data. Navigant updated the operating hours for each temperature bin, which slightly increased chiller savings.

Direct replacement assumptions for lighting measures

- For one commercial-electric project, the implementer used a "Direct Replacement" baseline methodology for savings calculations. This assumes that efficient fixtures replaced baseline fixtures on a one-for-one basis. Navigant evaluated savings by applying the building-area lighting power density method as defined by Washington State Energy Code 2012.

Multifamily New Construction

Missing or inconsistent business cases

- PSE was unable to provide complete business cases for all measures included in the sampled projects. Where business cases were lacking, Navigant either used a more recent business case or unit energy savings data from the Regional Techinical Forum. This resulted in realization rates varying from claimed savings for projects that used deemed values as a part of the ex-ante savings estimation.

Missing project documentation

- Navigant awarded no savings for one Multifamily project for which PSE could not provide documentation.
- PSE could not provide the building energy simulation model used for one whole-building design project. Instead Navigant verified savings using billing data analysis, which resulted in a 19% realization rate.

Not awarding therm savings for hot water projects using gas heat

- Some projects only claimed electric savings for hot water measures, despite project documenation indicating gas water heating. Navigant awarded the appropriate gas and electric savings to such projects.

Baseline multiplier assumptions for lighting measures

- Reported savings for corridor and garage lighting used a deemed value that awarded energy savings on a kWh per square feet times watt reduced basis. To evaluate savings, Navigant performed lighting power density calculations using the space area and fixture wattages reported in project data as defined by Washington State Energy Code 2012.

Indoor Horticulture

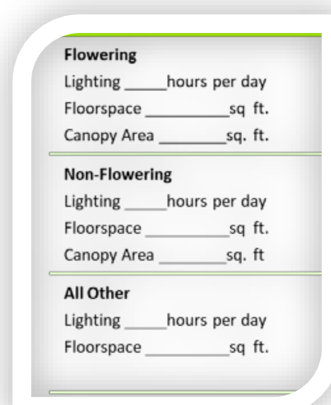
For the 2016/17 biennium, PSE created an energy savings calculation tool that uses baseline factors to estimate baseline wattage from installed wattage in flowering and non-flowering spaces.[2] PSE calculated these multipliers by taking a simple average of the fixture wattages across a small sample of industry fixtures, and calculating the baseline to efficient ratio using a 1:1 efficient to baseline fixture replacement assumption. This tool assumes a 1,100W high pressure sodium (HPS) or 1,000W metal halide (MH) baseline fixture for the flowering and non-flowering fixtures respectively, and results in a 1.8 baseline factor for flowering and 3.3 for non-flowering spaces.

To estimate savings, Navigant used PSE's savings calculation tool with the following two changes:

- **Used the 1.8 baseline factor for both flowering and non-flowering spaces.** PSE's 3.3 baseline factor for non-flowering spaces assumes that these spaces require as much light as flowering spaces in the base case, which can be provided by much lower wattage efficient lamps than is possible for flowering rooms, resulting in a larger delta watts. The evaluation activities indicate that non-flowering rooms require whiter more "broad spectrum" lights, instead of the spectrally selective fixtures common in flowering rooms, and that the baseline fixture wattage for these spaces should be lower, closer to 600-800W per fixture. As such, the team recommends using the same baseline multiplier, 1.8, in both the non-flowering and flowering spaces.
- **Limit baseline wattage to 68.75W per square feet**. Instead of assuming a 1:1 lamp replacement, the current industry standard assumes one 1,000W fixture per 4' x 4' square foot of canopy space. This cap helps correct for the excessively high lighting power densities that result from using baseline factors, and which program participants and industry experts confirm are unrealistic.[3]

2.1.2 Develop a Uniform Method for Determining Operating Hours for Indoor Horticulture Projects

Our team presents two options for PSE to consider in moving toward developing a uniform method for determining lighting operating hours for its indoor horticulture projects. These methods target improving certainty in savings estimates for efficient lighting by leveraging findings from our evaluation and research activities and balancing the burden additional data collection may place on PSE program staff and program participants. Details are provided in Section 3.2.


Flowering
Lighting _____hours per day
Floorspace __________sq ft.
Canopy Area ________sq. ft.

Non-Flowering
Lighting _____hours per day
Floorspace __________sq ft.
Canopy Area ________sq. ft

All Other
Lighting _____hours per day
Floorspace __________sq ft.

Option 1. Update project application to collect lighting operating hours and area by space type. The evaluation team recommends that PSE collect customer-reported lighting operating hour estimates by space type for three general space types; flowering, non-flowering (including all vegetative, mothering and cloning spaces) and all other spaces (including all non-grow spaces such as offices, corridors, restrooms, etc.) Collecting the respective floorspace and canopy space

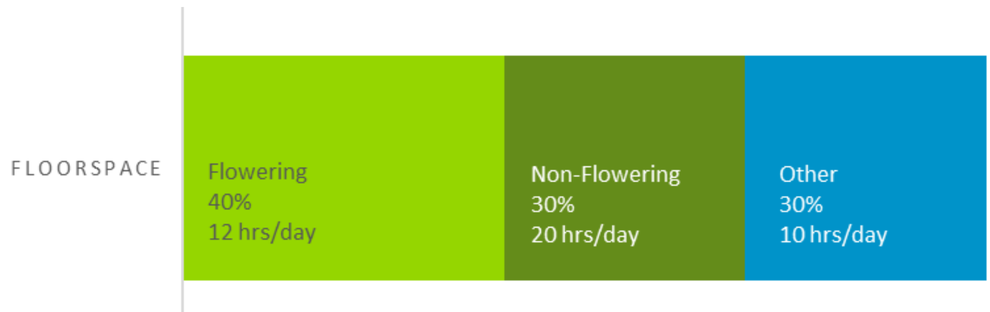
[2] *PSE Horticulture NC lgt Workbook (2017 4-25-17 REV01)*

[3] Without limiting the baseline LPD, four of the 8 projects evaluated were calculated to have LPDs exceeding 70W per square feet, with the highest being 96.8.

for each of these space types would also improve the certainty in lighting savings estimate allowing for a more informed baseline lamp quantity and wattage assumption.

Option 2. Update ex-ante assumptions and/or model calculations to include lighting operating hours and floorspace by space type. In lieu of updating the application, the evaluation team recommends that PSE expand current program assumptions to include lighting operating hours for the same three space types defined in Option 1 (flowering, non-flowering, all other). Additionally, the team recommends PSE assume the split of floorspace for each of these spaces as indicated in Figure 1.

Figure 1: Lighting Operating Hours and Floorspace by Space Type



Source: Navigant analysis

2.1.3 HVAC Interaction Factors (IF) for Indoor Horticulture Projects

Using participant project documentation and interview responses, the evaluation team identified the top two most prevalent HVAC system types in PSE's indoor horticulture participant population as variable refrigerant volume (VRF) systems and free-cooling.[4]

Our data analysts used fixture wattages, set points, schedules and other parameters culled from interview, project documentation and secondary data to build two complete energy simulation models. The team ran parametric runs across a representative set of lighting power density reductions to estimate the interactive effects of efficient lighting. Ultimately, the team recommends that PSE adopt a HVAC IF of 1.3 for projects with VRF or unknown HVAC systems, and 1.4 for projects that are verified as using free-cooling. The details analysis, including all model parameters, are provided in 3.2.8.

2.2 Process Evaluation

When compiling the evaluation team's findings for the process evaluation of the PSE NCx program, the evaluation team took into consideration the research priorities established in early discussions with

[4] Free cooling, in this context, refers to the process of allowing the building heating load to bypass mechanical cooling and to exchange heat with lower temperature outdoor air.

program staff and from analysis of program participation data. Research priorities for the process evaluation included:

- Identify strategies and program changes that could increase market penetration.
- Determine how to continue to capture saving opportunities in the context of increasingly stringent building codes.
- Characterize participant experiences with PSE's new construction program.

Overall, the evaluation team found that participants expressed satisfaction with the program, but opportunities exist to increase participation via outreach and collaboration with both design teams and customers with multiple facilities. For example, engaging more customers earlier in the design process could help capture more savings from each project.

Key findings for each of the research priorities are presented in the remainder of this section. Detailed findings are provided in Appendix D, including: peer utilities benchmarking results and best practice feedback, local market actor feedback on best practices and opportunities to optimize the program, and participant feedback on program experiences.

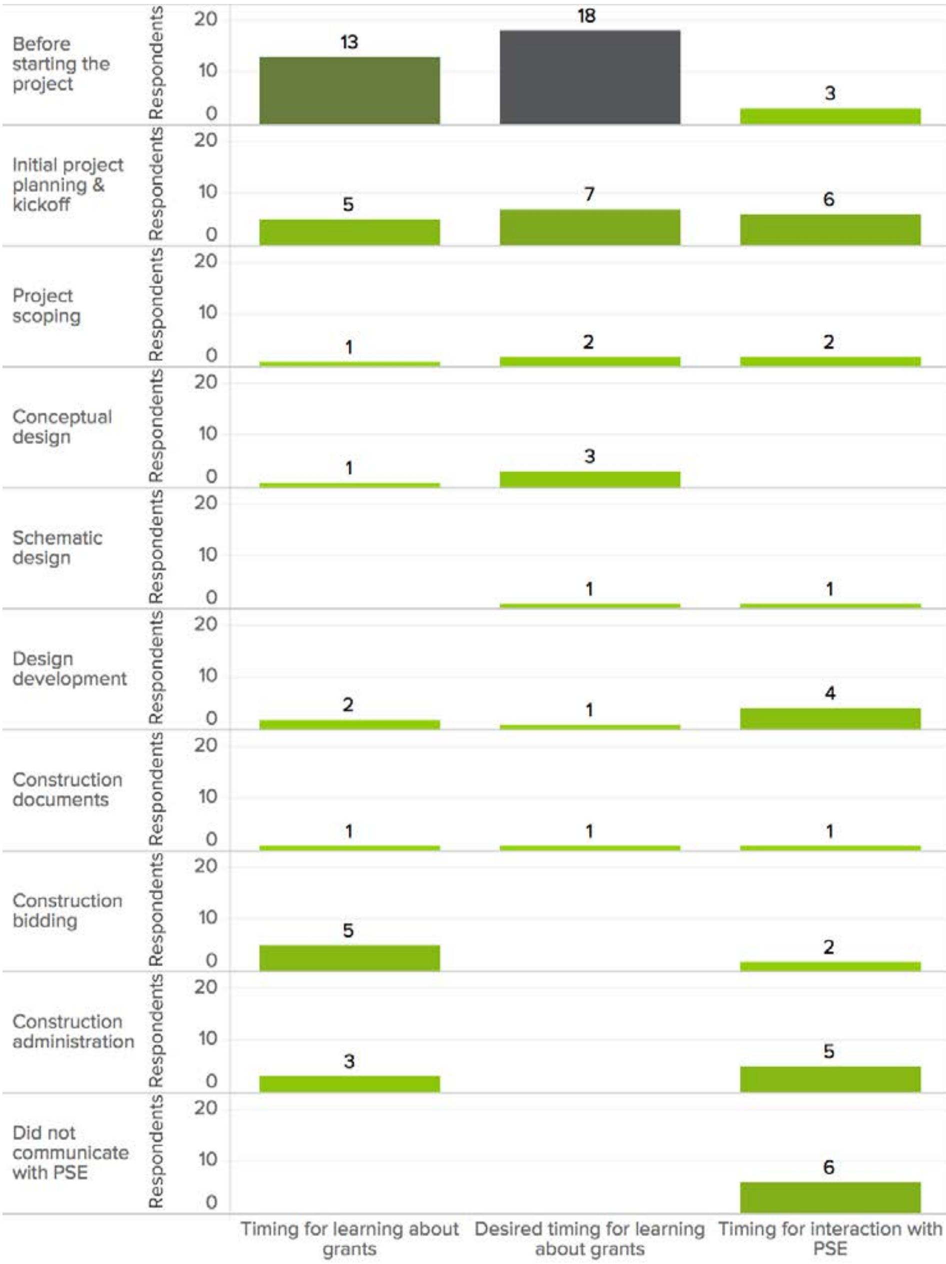
2.2.1 Strategies for Increasing Market Penetration

To understand how PSE can increase market saturation and penetration, the evaluation team collected information on ideal marketing and outreach strategies including *when* to engage market actors, *who* to target outreach efforts, and *how* best to engage with market actors. This section presents these findings in more detail. We identified the following three high-level findings:

- **When**: The best time to engage projects is early in the design process, before the design phases even begin.
- **Who**: PSE should develop strategies to engage both owners (because they are the decision makers) and design teams (because they can heavily influence the owner)
- **How**: Participants want to learn about program offerings via mass marketing tools, but direct connections to customers and design teams are important to actual program engagement.

The best time to engage projects is before a project even begins. As shown in Figure 2, participating customers reported the ideal time to learn about the program is before or during the conceptual design stage even begins. This is because design goals are set prior to developing any actual designs. This is confirmed by market actor findings that suggest best practices are to reach design teams and customers early in the process in order to impact the whole building, instead of specific equipment. Comparable program at two peer organizations provide design meeting incentives (monetary as well as non-monetary) to discuss program elements with potential participants early in the design process. They use this meeting to present program requirements, discuss project timeline, review the project details, and review qualified products and building systems. Their goal is to ensure that, once the design process is initiated, the design team will incorporate energy efficient measures into the building design. One of those programs provides a $2,500 incentive for the design assistance, while the other does not provide a monetary incentive.

Figure 2: Timing for Interaction with Program

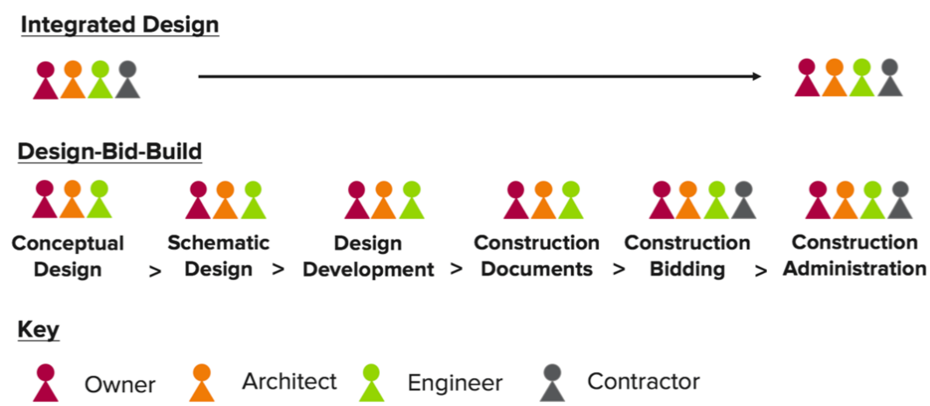


Source: EMI Consulting analysis

PSE should develop strategies to engage both owners and design teams. Figure 3 presents which market actors play a role at each stage in the design process (including both the "integrated design" approach, where the contractor is involved at the onset of a project; and the "design-bid-build" approach, where the contractor is only brought in during the construction stage of the project). As shown in Figure 3, the design team and the owner are important players at the beginning of a project, and therefore are both important actors to target outreach efforts. Contractors can also be an important player if owners are relying on an integrated design approach. While market actors and participants reported that it is the owner/developer's final decision to participate in a utility energy efficiency program, market actors can play a key role at influencing that decision. It is important to reach out to both owner and design teams because of the following reasons:

- **Owners –** the owners are the ultimate decision makers and will remain in the project no matter how the design team shifts over time. If an owner is committed to energy efficiency, they will be less likely to remove energy efficient designs during the final stages, when energy-efficient equipment and/or designs can be value-engineered out of the project for cost savings.
- **Design teams –** Design teams can be very influential in recommending energy efficiency opportunities to their customers. Because of this, one peer program makes its incentive structure and rebate forms easy for design teams to understand in order to influence more design teams to market the program to their customers.

Figure 3: New Construction Process



Source: EMI Consulting analysis

Participants want to learn about program offerings via mass marketing tools, but direct connections to customers and design teams are important to actual program engagement. Lastly, the evaluation team found that market actors and participants learned about the program through direct connections, however participants reported that they preferred to learn about program offerings via email (44%) or through local planning and/or permitting offices (18%). This suggests that PSE could use email marketing to inform customers of the program, but then also provide more direct outreach to customers and design teams to truly engage them in the program. Specific outreach methods mentioned by interviewees included:

- **Account Executives/ Sales Representatives –** Peer programs reported they effectively connect and build direct relationships with owners and developers through account executives and sales representatives. These staff typically know when a customer is considering a new construction project and can bring program staff into the conversation early in the design phase.
- **Design associations –** Market actors in PSE's territory and peer program managers recommended reaching out to design teams through existing NCx associations. The new construction associations most frequently included Architects Institute of America (24%), Master Builders Association (24%), Built Green (18%), Commercial Real Estate Development Association (18%) and Urban Land Institute (15%). Market actors recommended using these channels for offering trainings or lunch 'n' learns focused on building program awareness.
- **Prior participants –** Market actors also recommended PSE build long-term relationships with design teams and/or customers that previously participated in the program. One market actor

recommended PSE staff follow up and check in on projects two and five years after they are completed to increase future participation, since many commercial customers build multiple buildings (either because they are developers, they have a campus with multiple buildings, or they are a chain of stores). In addition, two market actors recommended PSE continue to share program updates to contacts with design teams. These relationships are already established, and PSE may uncover opportunities to foster repeat participation.

2.2.2 Opportunities to Capture Additional Savings Beyond New Codes

The evaluation team collected information on PSE's current energy savings and opportunities to increase energy savings above new codes. The following sections discuss these findings in more detail. We identified the following three high-level findings:

- PSE can create additional savings beyond code through new incentives, including innovative design incentives and pay-for-performance options.
- Upselling customers on aspects of design projects can help push customers to achieve greater energy savings in their building designs.
- Current incentives are helping to influence most participants (up to 79%) but will need to be monitored overtime.

Create additional savings through new incentives. The research uncovered a variety of ideas for how to best encourage increased savings in the future, including (1) providing incentives for measures not now covered by the NCx program, (2) utilizing innovative incentives to influence project design, and (3) incorporating pay-for-performance approach in the program's incentive structure. A promising measure to emphasize in the energy-intensive horticultural segment is high efficiency HVAC. Horticulture participants indicated they are considering adding HVAC to their facilities and would welcome incentives for high efficiency equipment. Market actors recommended that PSE incorporate incentives for more innovative and complex technologies; specific examples mentioned were district heating, waste heat recovery, and thermal storage.

Peer utilities tended to highlight pay-for-performance incentives as a useful tool for moving new construction projects above code. They viewed pay-for-performance incentives as a way to make it easier for customers to build above code. They were also useful for allowing highly-customized designs, such as those in industrial facilities, to participate in utility programs.

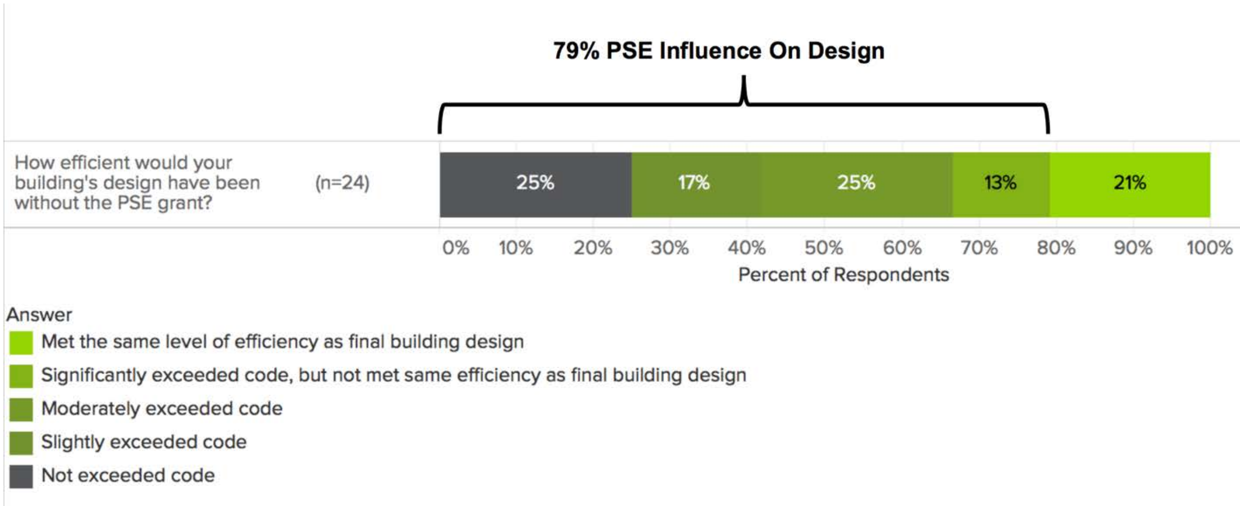
An approach used by two peer utilities involved offering incentives to design teams and their clients to meet with utility program staff to review project design, high efficiency options, and utility program details. One utility offers $2,500 for these face-to-face meetings.

PSE may also want to consider the approach of some peer companies, in which customers with large projects are offered building design incentives able to accommodate large, more complex projects, while customers with smaller projects are offered an incentive through an express program option.

Upselling customers can capture additional savings on participating projects. Two peer utilities reported success in achieving higher energy savings from projects by meeting with participants to inform them of additional site-appropriate efficiency measures (i.e. upselling) that they can take. Staff review project plans, identify additional savings opportunities, and approach the facility owner, or design team, about their options and the associated benefits. Because some portions of the new construction market are constrained by time and money limitations, the upselling actions can help spur greater adoption where customers on their own would not invest the time to identify the incremental efficiency opportunities.

Current incentives are effective but effectiveness will need to be monitored over time and outreach may need to be amended if codes change. Participant data indicated that up to 79% of respondents' projects included higher efficiency than would otherwise have been the case.

Figure 4: Efficiency of Design without PSE Incentive



Source: EMI Consulting analysis

The program incentives were sufficiently attractive to draw in customers who would have otherwise built at code. While some participants would have taken steps to build above code absent the program, a full 32% would have deemed the payback periods too long for any above-code investments. Market actors indicated they are uncertain how they will continue to work with clients to exceed code and participate in the NCx program in the future if codes become more stringent.

Program communications emphasizing the benefits of lowered operating costs for qualifying equipment and designs may help the program continue to be effective in moving the market, even in the face of more stringent future codes. Customers reported that operating costs were a top motivation for adopting higher efficiency project elements, and market actors requested that program materials include more information on this topic and the positive return on investment that may be anticipated. Environmental benefits are also a key motivator, and these themes may assume increasing importance in the future. However, given the uncertainty expressed by market actors, it is likely that program staff will need to put in extra effort to meet with the design community to identify what measures qualify and what incentives can be expected.

2.2.3 Characterization of Participant Experiences

A final research priority was to characterize participant experiences with the program. We identified the following three high-level findings:

- Participants and market actors reported positive experiences with the program overall; however, some participants expressed a need for greater/more communication about the program—including more and/or better information on program processes, timelines, and online references.

- Time and money are the largest barriers to program participation for owners/developers who do not always build beyond code.
- Participants were motivated to participate in the program for both monetary and non-monetary reasons.

Participants and markets actors reported positive experiences with the program; however, the opportunity for some implementation improvements exist. Market actors familiar with the program all reported positive experiences. Three out of four market actors who had participated in the program had very positive impressions of the PSE staff.[5] For all three, having a contact within the PSE staff to whom they could ask direct questions made the process much easier. One interviewee shared that the staff was easy to talk to. Another interviewee explained their experience with PSE staff when their project was transferred to a different PSE employee and some papers were lost in the process:

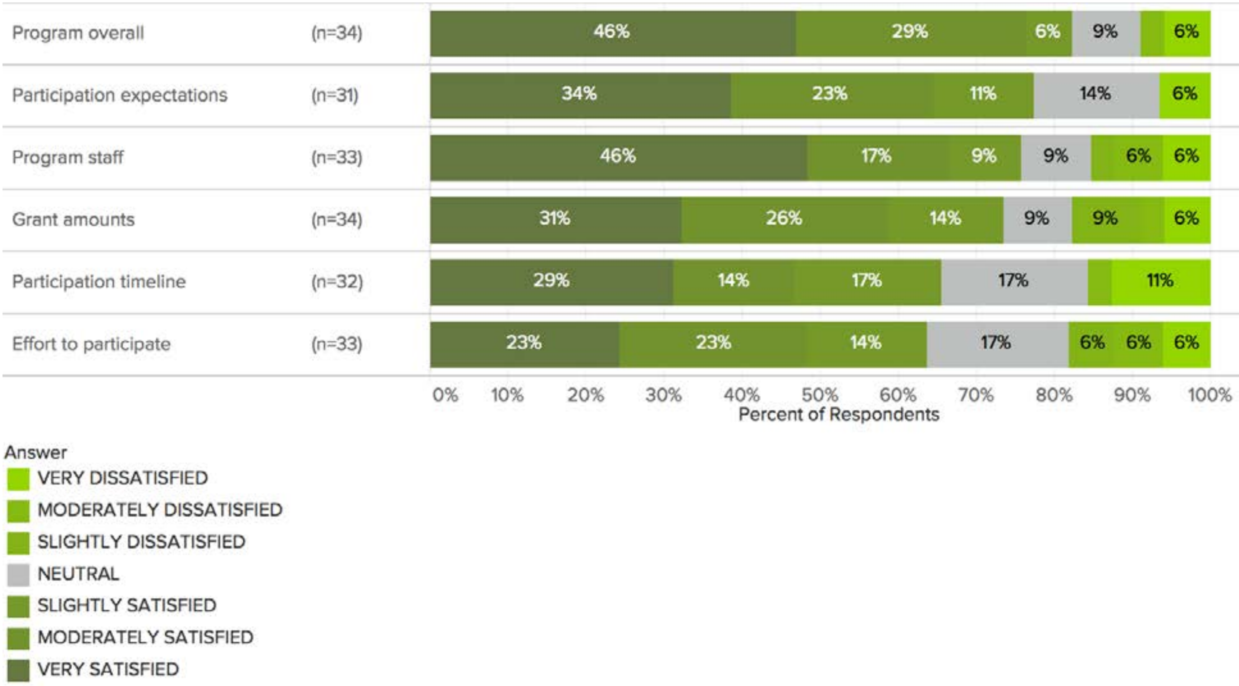
> *People retire, people move on, you lose information, but how PSE handled it was really admirable. They could have easily said, sorry, we don't have document right here. And so, you're out of luck. But they didn't, they worked for this and [we] got our payment… I think the process is more straightforward in PSE than it is in other jurisdictions.*

This quote highlights how the PSE NCx staff's efforts to provide consistent program support are a strong program asset. The respondents expressed that their satisfaction with the program is partially due to PSE staff's responsiveness and collaboration.

Participants also expressed satisfaction and indicated they would recommend the program to others. As illustrated in Figure 5, 81% of participants were satisfied with the program overall.

[5] The fourth market actor who participated in the program did not provide feedback on their experiences.

Figure 5: Participant Satisfaction with NCx Program



Source: EMI Consulting analysis

Almost half of the participants reported no challenges to participating in the NCx program (47%). For those who did, the main participation challenges reported were poor PSE communication (21%), cumbersome paperwork (15%), long program timeline (15%) and difficult energy analysis requirements (12%). Table 4 presents specific participation challenges reported by participants.

Table 4: Participation Challenges Reported by Participants

Theme	Results
Timeline	• Timeline too long (n=2) • Checks came a year after a building was closed out (n=1) • PSE staff shortages contributed to extended timelines (n=1)
Communication	• Poor communication from PSE staff (n=2) • Getting everyone (customer service and program staff) on the same page (n=1)
Paperwork/ Energy Analysis	• Too much paperwork (n=2) • Difficult calculations and energy analysis (n=2) • Paperwork difficult to understand (n=1) • Limited time and resources to do a study before the project (n=1) • Too much effort to participate (n=1)
Monetary	• Minimal monetary amounts (n=2) • Actual incentives smaller than estimates (n=2)

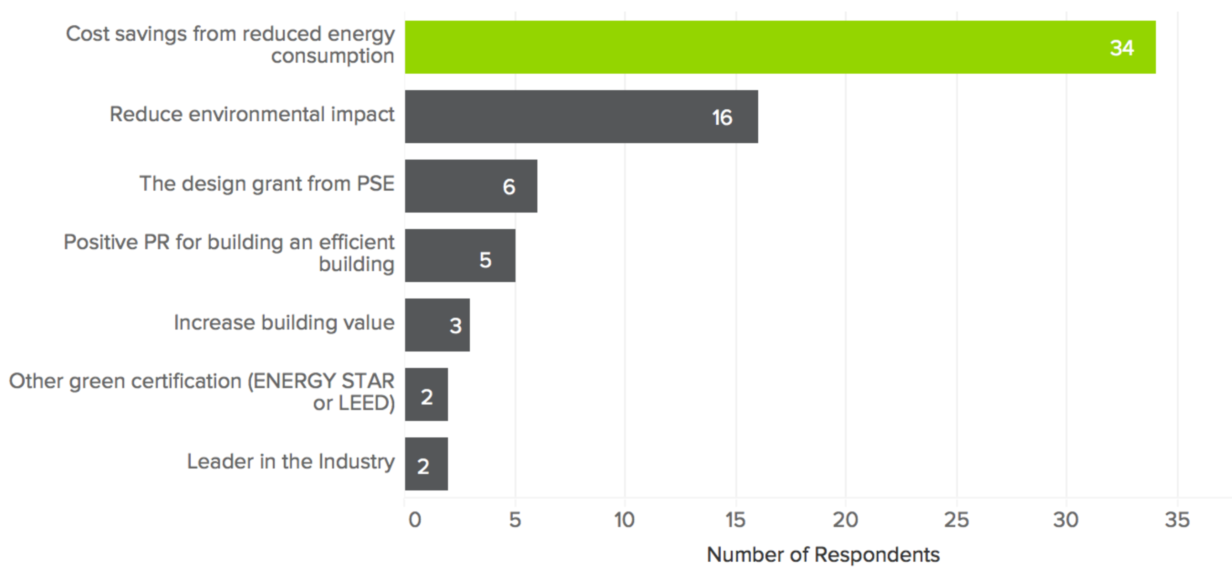
Source: EMI Consulting analysis

Participants and market actors both reported that time and money are the largest barriers to program participation. With regards to time, participants reported that they did not pursue some new construction projects because they were uncertain that the project would be eligible. Rather than prioritizing time to investigate whether the project was eligible, these participants would pursue the projects without an incentive from PSE.

One market actor shared that time and money are barriers to market actors as well. This market reported that average builders who are simply working to meet code and not go beyond are focused on completing their work as quickly as possible and any extra steps that add to a project timeline ends up costing them money. Increased project costs due to schedule delays were not the only cost barriers faced by participants. High first costs also remained a barrier to participation. Market actors reported that customers are not interested in pursuing incentives when they believe that the incentive will not be worth the effort or money to pay the design team to research options or do the work to participate. This is supported by the participant research: when participants don't submit eligible projects to the program, they reported it was because the incentive was too small, in addition to not having time to research whether their project would qualify.

Participants were motivated to participate in the program for both monetary and non-monetary reasons. The evaluation team asked respondents to identify their reasons for participating in the NCx program. As shown in Figure 6, most participants reported operational savings as the primary motivation for including energy efficient equipment in new construction projects (89%) over any other factor. The second-most reported motivation, reduced environmental impact, was reported less than half as frequently (42%), and other factors were far less influential. These findings are supported by educational recommendations from respondents in the market actor research and suggest that ongoing benefits are the most influential considerations for many participants. PSE may want to include marketing material that emphasizes information about operational savings and environmental benefits to attract like-minded customers in the future.

Figure 6: Motivations and Influences for Pursuing Energy Efficient Design



Source: EMI Consulting analysis.

The data also clearly document that PSE's incentive did allow some participants to afford more expensive energy efficiency equipment that otherwise would not have been installed. Below are examples of how PSE's incentive helped some participants:

> *The credits allowed us to install more expensive components that would not have been affordable without the credits.*

> *The funds from PSE [were key], without them the upgrade would not have happened...we did not have [sufficient] funds without this program.*

These quotes demonstrate that for some customers, the upfront cost without the PSE incentive would have been prohibitive to pursuing more efficient equipment. To reach similar customers in the future, PSE may also want to prominently emphasize the available incentives in its program marketing materials.

In addition to monetary motivations, five participants reported 'Positive PR (public relations) for building an efficient building' as a motivation for pursuing energy efficient equipment. The evaluation team included this motivation as an option in the survey in response to input from a program manager at one of the peer programs, who shared that, for some owners, the incentive is negligible compared to project costs, but that this non-monetary motivation does have an impact on their decision-making in the design process. One interviewee explained how they intended to use the positive PR:

> *We wanted to have a high efficiency building to market to tenants, that it is energy efficient to reduce their costs and add value to the building and to be environmentally conscious as a company goal.*

This quote demonstrates that some building owners will consider pursuing energy efficient upgrades if doing so is seen as making their buildings more appealing to potential tenants.

The evaluation team also found that two horticulture respondents were specifically motivated to include LED lighting in their facilities after touring another horticulture facility with LEDs and seeing the healthy growth achieved under LED lights. The respondents were originally unsure about participating in the program because they worried that their product quality might be poorer with LED lighting. During the tour, one participant did a side-by-side test and saw better production results with LED lights. PSE may want to communicate results like these to the horticulture segment and their design influencers to increase LED adoption within this portion of the business community.

2.3 Recommendations & Best Practice Considerations

The evaluation team presents the following recommendations and best practice considerations for PSE NCx program and future areas of evaluation and research.

Recommendations for the indoor horticulture program

- **Create an indoor horticulture-specific project form.** The evaluation team received three different application forms for sampled indoor horticulture projects. Creating a single form would streamline program administration and evaluation efforts. This form should collect the HVAC system type as well as lighting daily hour of use, floorspace and canopy areas for flowering, non-flowering and all other spaces.
- **Update baseline factors.** PSE should use 1.8 as the baseline factor for flowering and non-flowering spaces in the savings estimation of efficient lighting in new construction indoor horticulture projects.
- **Limit the canopy lighting power density to 68.75W/sf.**[6] PSE should implement this cap to help correct for the excessively high lighting power densities that result from using baseline factors combined with a 1:1 fixture replacement assumption.

Best practice considerations to increase market penetration

- **Reach out to owners earlier; before or during the conceptual design stage.** PSE staff should work with account executives and sales representatives to connect NCx staff to their customers as soon as they become aware of a new construction project. PSE program staff can also work with existing participants, particularly developers or large corporations, who might have additional new construction projects. Lastly, PSE program staff could market to customers earlier in the design phase via email advertising and campaigns at local planning or permitting offices.
- **Reach out to design teams earlier; before or during the conceptual design stage.** PSE program staff should reach out to design teams so they are familiar with the program offerings and are willing and able to recommend the program to their clients. Staff should also follow up with design teams to remind them of the program and keep them up-to-date on incentives.

Best practice considerations to capture savings beyond new codes

- **Consider innovative design incentives and pay-for-performance options.** Focusing on whole building design and pay for performance incentives could take the program away from a measure by measure incentive design, providing flexibility and making it easier for customers to build above code. PSE should investigate the specific incentive levels and features used by the peer utilities that recommend moving in this direction (detailed peer program incentives can be found in Appendix D).
- **Incorporate incentives for more complex and innovative measures**. Market actors that are already active in NCx are requesting incentives for the following more complex measures: district heating, waste heat recovery, and thermal storage. This creates a nice opportunity for PSE to

[6] During an interview with PSE staff in November 2017, PSE indicated that the LPD for indoor horticulture projects was currently limited to the industry standard of "near 70 W/sf". However, the tool the evaluation team reviewed did not limit the LPD.

broaden the program's scope. PSE may also want to consider making case studies of projects that include these advanced technologies.

- **Continue to focus on energy-intensive customer segments, such as indoor horticultural customers.** Indoor horticultural customers are energy intensive and offer a large amount of energy savings. PSE should consider expanding the offering to include energy efficient HVAC equipment.
- **Move projects to exceed code, train staff in upselling techniques**. This technique is useful when program staff are interacting with customers and/or the design team after some design elements have been selected. Being able to identify additional options, applicable incentives, and impact on the owner's investments are important tools in the program outreach toolbox.

Best practice considerations to improve participant experiences

- **Provide greater communication to potential participants online.** PSE should focus communication on (1) information that can overcome time-related barriers, (2) current incentive levels, (3) and non-monetary benefits, such as positive public relations and environmental benefits.
- **Improve communication to participants during their projects.** PSE staff should provide support to participants and market actors throughout their project and provide updates on project timelines.
- **Consider need to hire more program staff.** If PSE were to increase marketing and outreach efforts, it should consider whether it needs additional staff to account for this work while maintaining strong support to current participants.
- **Consider creating an express program for small customers/projects**. The primary goal of adding an express program would be to lower barriers to program participation among this customer segment, some of whom struggle with the calculations and paperwork requirements. Such an offering could provide more customers, market actors, and/or trade associations experience with the program, and thereby serve as a tool to engage more customers and market actors in energy efficiency building design and construction.

Recommendations to improve future evaluations

- **Develop a method to maintain and update business cases.** The biggest challenge during the evaluation of multifamily projects proved to be with PSE's documentation. PSE should consider creating a master tracker document that provides the file location, lead author, version number, and date of all business cases.

Best practice considerations to improve future evaluations

- **Improve contact information.** The primary challenge to conducting the NCx process evaluation was accessing accurate contact information from the program database. Improving contact data in the database can also support program staff in conducting follow-up outreach to customers and market actors after project completion.
    - o **Track project contact email address.** Program managers should collect email addresses for the participant contact, not just for a billing department at a company. Full contact information for participants would allow for easier follow-up communications from program staff and evaluators.

- **Use separate fields to document owners/developers versus members of the design team.** Separate fields can clearly indicate who is the participant and who is the primary design team lead. This granular information could not only support future evaluation recruiting efforts, but it could allow program staff to more easily follow-up with past participants.
- **Track specific lead market actor contact information.** Program managers should collect the name of the lead market actor facilitating a project with a customer. Knowing the market actor’s name could help evaluators with recruiting efforts because they would have a specific person to contact. It could also be a valuable resource to program staff, who would then have an easier time reaching out to participating market actors for support in identifying future projects.

3. COMMERICAL REBATE

PSE's Commercial Rebate program consists of seven related but distinct sub-programs:

- Small Business Direct Install (SBDI)
- Lodging Direct Install (LDI)
- Agriculture Direct Install (ADI)
- Premium HVAC
- Commercial HVAC
- Hospitality Management
- Kitchens & Laundry

The SBDI, LDI and ADI sub-programs are designed to provide low and no-cost direct install measures to small business customers. The Premium HVAC sub-program provides incentives for maintenance and service of HVAC systems leading to energy efficiency savings, while the Commercial HVAC, Hospitality and Kitchens & Laundry sub-programs provide customers with rebates on qualifying efficient HVAC, kitchen and laundry equipment.

3.1 Impact Evaluation

This section presents the high-level results of the impact evaluation activities. As shown in Table 5, the impact analysis relied on an in-depth review of program tracking databases, project data, site visits, secondary data and select participant interviews. The methodology is detailed in Section 3.2.

Table 5: Commercial Rebate Program - CY2017 Impact Evaluation Activities

Sub-Program	Tracking Database Review	Engineering Review	Installation and Operational Verification	Customer Interview	Literature Review
Small Business Direct Install (SBDI)	✓	✓	✓	✓	✓
Lodging Direct Install (LDI)	✓	✓	✓		
Commercial HVAC	✓	✓	✓		
Kitchen & Laundry - Commercial Cooking Equipment	✓	✓	✓		
Hospitality Rebates	✓	✓	-		
Kitchen & Laundry - Commercial Laundry Rebate	✓	✓	✓		
Premium HVAC	✓	✓	✓		
Agriculture Direct Install (ADI)	✓	-	-		

Source: Navigant analysis

3.1.1 Results

As presented in Table 6, the evaluation team calculated a 0.86 and 0.90 realization rate for electricity and gas savings achieved through the PY2016/2017 Commercial Rebate program.

Table 6: 2016/17 Commercial Rebate Program - Realization Rate by Fuel Type

Fuel Type	Reported Savings*	Evaluated Savings	Realization Rate	Relative Precision
Electricity (MWh)	23,775	20,421	0.86	7.1%
Gas (therms)	253,941	229,310	0.90	5.0%

** The reported savings for 2017 are based on the 12/13/2017 data extract and should be revised when the 2017 Annual Report of Energy Conservation Accomplishments is released in March of 2018.*
Source: Navigant analysis

The team used the evaluation activities described in this section to derive an evaluated estimate of savings for each unique sampled project. We then weighted these realization rates by project size and within each stratum to develop a stratum-level realization rate. Table 7 and Table 8 provide the details.

Table 7: Commercial Rebate Program - Electric Savings by Sub-Program

Program	Ex-Ante Savings	Ex-Post Savings	Realization Rate	Relative Precision
SBDI	15,101	11,785	0.78	7.7%
LDI	4,791	4,743	0.99	
Com. HVAC	1,501	1,501	1.00	
Com. Kitchen	953	936	0.98	
Other (Prem. HVAC and Hospitability)	1,428	1,456	1.02	
Overall	**23,775**	**20,421**	**0.86**	**7.1%**

Source: Navigant Analysis

Table 8: Commercial Rebate Program Results - Gas Savings by Sub-Program

Program	Ex-Ante Savings	Ex-Post Savings	Realization Rate	Relative Precision
SBDI	6,514	4,698	0.72	34.6%
LDI	18,342	7,735	0.42	
Prem. HVAC	51,977	48,312	0.93	
Com. Kitchen	166,202	157,660	0.95	
Other (Com. HVAC and Com. Laundry)	10,906	10,906	1.00	
Overall	**253,941**	**229,310**	**0.90**	**5.0%**

Source: Navigant Analysis

3.1.1.1 Drivers

This section highlights the key drivers behind the evaluated savings and realization rates calculated by sub-program. Details are provided in3.2.

Small Business Direct Install

Exterior lighting hours of use (HOU) assumptions

- PSE's current deemed annual HOU estimate for exterior lighting photo cell projects is 4,200. The team estimated savings for these projects using 4,656 annual HOU, derived from astrological sunrise-sunset data for the PSE service territory.

Discrepancy in installed quantities

- The team awarded no savings for three sites at which the reported measures were not installed.
- The project with the largest gas savings in the sample (and PY2016 population) had removed the installed showerheads due to customer dissatisfaction with the low flow rate. The evaluation team did not award savings for this measure.

Projects claiming deemed values from previous biennium

- One aerator project from the electric sample reported savings using the 712 kWh per year estimate from the previous biennium. The team revised the savings to reflect the current deemed savings estimate of 151.6 kWh per year.

Lodging Direct Install

Project duplicaiton in tracking data

- Four out of the five sampled gas sites and one of the four sampled electric sites reported duplicate project quantities in the tracking data. One project reported quantities in triplicate.

Lighting hours of use (HOU) assumptions

- The team updated the annual HOU values using operating schedules collected during the site visits for two projects, which resulted in slightly higher realization rates.

Commercial Kitchen

Projects claiming deemed values from previous biennium

- Two electric and two gas projects reported deemed savings using values from the 2014/15 biennium. The team verified that the measures were installed and awarded evaluated savings equal to the deemed values from the current business cases for these measures.

Discrepancy in measure quantities and/or specifications

- For one sampled project, the team found only one of two reported fryers.
- For three projects, field technicians found a different fryer installed than the type reported.
- At a different site, the team found a single-tank low temperature dishwasher installed where a double-tank low temperature unit was reported.

HOSPITALITY AND PREMIUM HVAC

Projects claiming deemed values from previous biennium

- The single sampled hospitability project reported savings using the deemed savings value included in a PY2014/15 business case. The team verified that the measure was installed and awarded an evaluated savings using the current savings value included in the most current business case.

Discrepancy in installed quantities

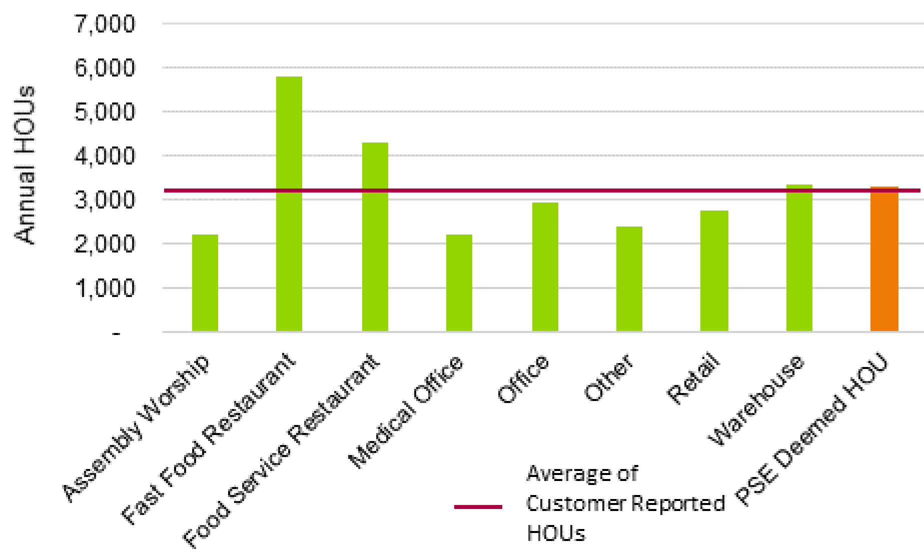
- For one Premium HVAC project, the therm savings reported in the tracking data did not match the deemed savings referenced in the project file.

3.1.2 Evaluate Business Operating Hours Currently in Use by SBDI Program

To evaluate PSE’s current annual lighting hours of use (HOU) assumption for the SBDI program, the evaluation team interviewed 54 SBDI site contacts to derive customer-reported HOU estimates. Our team found that PSE’s estimate of 3,317 annual HOU for the SBDI program is reasonable and within 3% of the average unweighted customer-reported value of 3,248. Figure 7 shows how PSE’s deemed value compares to the customer-reported HOU by building type and on average.

The evaluation team recommends PSE continue using the current deemed estimate and consider updating it after the next round of CBSA data is available. Appendix A.9 provides additional details.

Figure 7: Average of Customer-Reported HOU Tracks Close to PSE’s Deemed HOU for SBDI Participants



Based on customer-reported values for 54 participating PY2016 SBDI sites.
Source: Navigant analysis

3.1.3 Review Measure Life

The evaluation team used secondary data to evaluate the measure life assumptions PSE currently uses for the Commercial Rebate program. Overall, the team found PSE's assumptions reasonable, with only the few minor considerations:

SBDI & LDI:

- **Retrofit to T8.** PSE currently assumes a 12-year measure life for these measures. If the average T8 bulb lifetime is 15-20,000 hours and PSE assumes 3,317 annual HOU, this estimate may be too high. Many technical reference manuals have measure life estimate of ~ 5 years for T8 measures.
- **Integral LED lamp.** PSE's measure life estimate ranges from 3 to 5 years for integral LED lamp measures. Many data sources use a 7 to 15 year measure life, based on a common 25-30,000 hour lifetime assumption for LED bulbs.

Com. Kitchen & Laundry:

- **Ovens and fryers**. The RTF measure life for these measures is half (6 years) of the PSE estimate (12 years).
- **Dishwashers.** The current PSE measures life is 20 years, which is high compared to 10-13 year estimate from the RTF.

3.2 Process Evaluation

This section provides our findings for each of the research priorities established for this evaluation based on early discussions with program staff and analysis of program documentation. We have excerpted and summarized the key findings and actionable insights stemming from these activities in this section. Complete findings and methodology for each process activity are summarized in the memos presented to PSE throughout this evaluation and included in full in Appendix E.

3.2.1 Customer Experience and Participation

Through participant surveys and in-depth interviews with program managers and implementers, best practices and behavior optimization research, and review of program documentation, the evaluation team explored several key research objectives relevant to the customer experience and program participation. The remainder of this section is organized to answer each of these research objectives in turn:

- Satisfaction and reasons for participating
- Participation barriers and opportunities to enhance customer engagement
- Recruitment, marketing and outreach
- Application process experience
- Demand for new products and measures
- Trends in engagement and external factors

3.2.1.1 Satisfaction and Reasons for Participating

Overall, customers reported high levels of satisfaction both with the Commercial Rebate program overall, and its individual components and sub-programs. Figure 8 summarizes key findings, followed by more in-depth analysis.

Figure 8: Customer Satisfaction, Expectations and Motivations Summary

Customer Satisfaction — Commercial Rebate customers are highly satisfied

- Mean overall program satisfaction --8.9 out of 10
- Mean satisfaction with PSE staff interactions--9.3 out of 10
- Median satisfaction with contractors and the direct install experience--10 out of 10
- Enthusiastic and engaged staff positively influence satisfaction

Program Expectations — Most customers felt the program met their expectations

- Mean satisfaction with how well the program met expectations--8.8 out of 10
- Saving money (50%) and environmental benefits (30%) were the most mentioned program expectations
- Free equipment, better lighting and equipment upgrades were also common program expectations

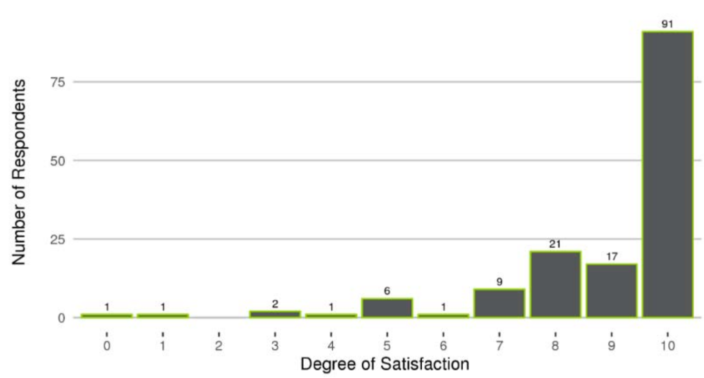
Motivation for Participating — Reasons for participating aligned well with program expectations

- Reduced-cost equipment upgrades, higher technology performance and sustainability were top motivations for participating
- SBDI participants that installed co-paid equipment rated this program component as very important in their decision to participate

Source: Navigant analysis

PSE's Commercial Rebate Program in general has robust participation levels and highly satisfied customers. Asked to rate their overall satisfaction with the program on a zero to ten scale, surveyed program participants' mean satisfaction score was an 8.9 and their median a ten. Despite the overwhelmingly positive response, the cluster of respondents around a score of eight suggests some relatively minor improvements in customer satisfaction might nudge these customers up to a nine or ten.

Figure 9: Satisfaction with Program Overall—Commercial Rebate Program Overall (n=150)



Source: Navigant analysis

The participant survey probed for more granular satisfaction details by asking respondents about their satisfaction with the application process, rebate processing time, and contractor, vendor and program staff interactions. In every case, participants, on average, reported high levels of satisfaction. Of these program components, communication and interactions with PSE program staff were rated most highly, with mean and median satisfaction scores of 9.3 and 10, respectively. During the program manager in-depth interviews, the Small Business Direct Install (SBDI) Program Manager indicated contractor/customer communication as an area she was actively working to improve. Her efforts appear to have paid off, as program participants, on average, rated both the direct install experience and their communication with contractors very highly.

Figure 10: Satisfaction with Communication and Interaction with PSE Staff—Commercial Rebate Program Overall (n=142)

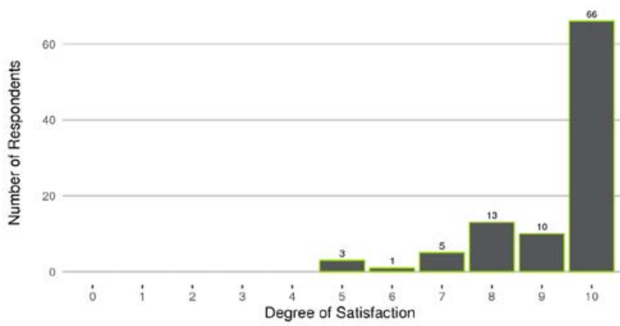


Figure 11: Satisfaction with the Direct Install Process (n=111)

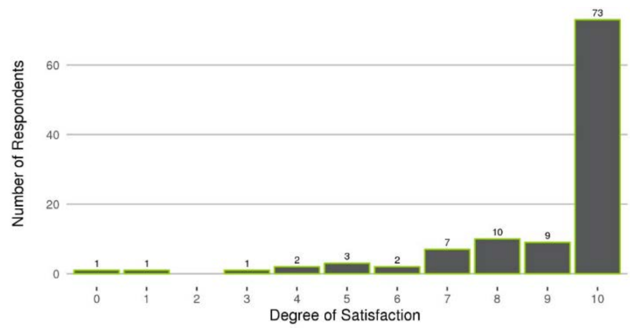
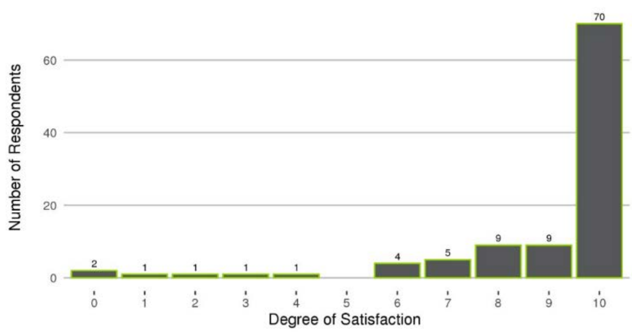


Figure 12: Satisfaction with Contractor Communication (n=123)



Source: Navigant analysis

Such positive participant satisfaction results are not surprising, given PSE's program managers' enthusiasm for their programs and the degree of concern they displayed for their customers during in-depth interviews. The Commercial Kitchens Program Manager stated, "I'm always on the lookout for what other equipment there is in the back (of kitchens) that we can cover, which means our portfolio of measures just keeps growing and growing. It means more opportunity for our customers when they ask, 'what about this?' and I can say 'yes' instead of 'no.'" The program manager for the SBDI program described Community Blitz events where PSE and the implementer spend several days in a town engaging with the small business community as being "a lot of fun" and a rewarding experience, as it's an opportunity to make personal connections with her customers.

"I'm always on the lookout for what other equipment there is... It means more opportunity for our customers when they ask, 'what about this?' and I can say 'yes' instead of 'no.'"

Participation varied widely by sub-program, and Program Manager in-depth interviews revealed the observed variation is expected due to program changes and market factors. Most participation in the Commercial Rebate program occurred through the SBDI, Commercial HVAC and Commercial Kitchens sub-programs, all of which have been operating for years and have not undergone significant changes this biennium. By contrast, the Commercial Laundry program had low participation, but the program manager anticipated this due to normal business cycles. Because most commercial laundry facilities installed new equipment through the program when the program began operation, and that equipment has not come to the end of its effective useful life (EUL), she does not expect participation in this sub-program to rebound for another biennium. Low participation in the Premium HVAC Service sub-program was also anticipated by its program manager. He felt that due to the transition to a new implementer and the associated ramp-up period, participation levels would be low in 2016, and slowly increasing in 2017.

> *While participation varied widely by sub-program, Program Manager in-depth interviews revealed the observed variation is expected due to program changes and market factors.*

Participant surveys asked respondents to identify their main expectations of the Commercial Rebate program and how well it met those expectations. Top expectations were for the program to provide cost savings and upgrades at a reduced cost, improve the performance of their technology, and improve sustainability. Respondents rated the program favorably in terms of having met their expectations, with a mean of 8.8 and a median score of ten on a zero to ten scale. The survey also asked participants their motivation for participating in the program. The most common reasons cited were to save money and benefit the environment, because it was free, because of the rebates, and to obtain better quality equipment and lighting.

Figure 13: Program Expectations—Commercial Rebate Program Overall (n=119)

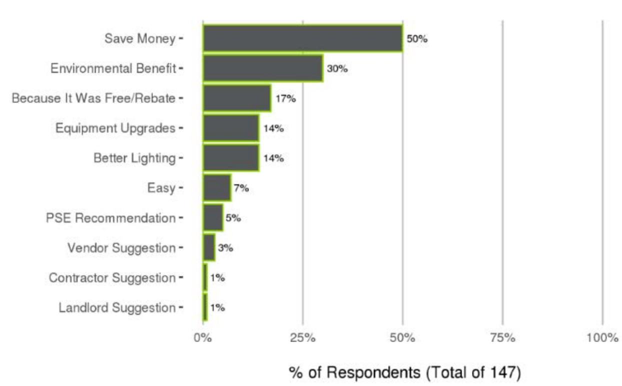
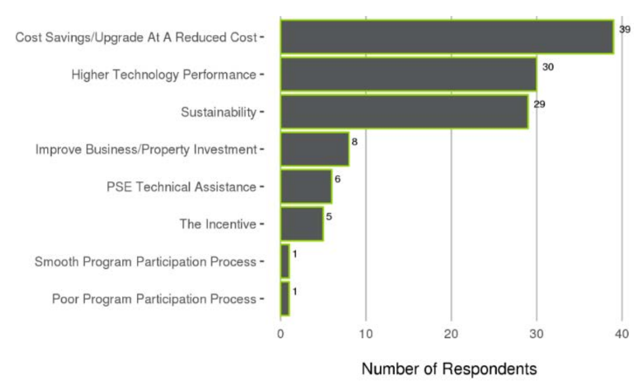


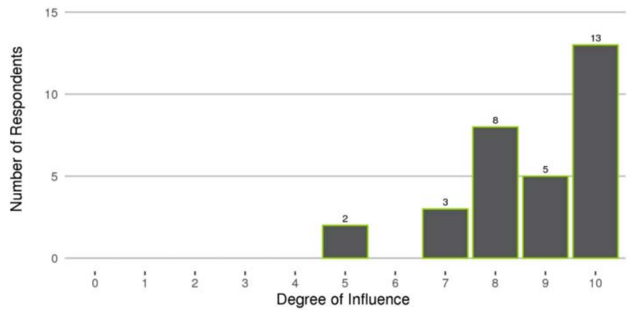
Figure 14: Main Reason for Program Participation—Commercial Rebate Program Overall (n=147)



Source: Navigant analysis

During program manager interviews, the SBDI PM expressed the hope that expanding that program beyond just free direct install to include some co-paid equipment upgrades would better serve the needs of the small business community and increase participation. To help answer this question, we asked survey participants from the SBDI program about their experience with the new co-pays. Customers that made use of this new program offering reported the availability of the co-paid equipment was important in their decision to participate in the program.

Figure 15: Importance of Low-Cost Co-Paid Equipment in Direct Install Participation Decision



Source: Navigant analysis

3.2.1.2 Participation Barriers and Opportunities to Enhance Customer Engagement

Common barriers to participation identified during program manager and implementation contractor interviews include customer lack of awareness or understanding of potential energy efficiency improvements and program offerings, a lack of time to deal with energy efficiency upgrades, and limited budget for capital investments and upgrades. Participant survey respondents identified these same barriers, with lack of awareness by far the largest barrier. This suggests effective communication and outreach to customers is essential. We asked participants for their suggestions on how to overcome the barriers they identified, and the most common suggestions were to increase in-person direct contact and to improve program advertising through multiple channels.

Figure 16: Most Significant Barrier Keeping Businesses Like Yours from Participating—Commercial Rebate Program Overall (n=109)

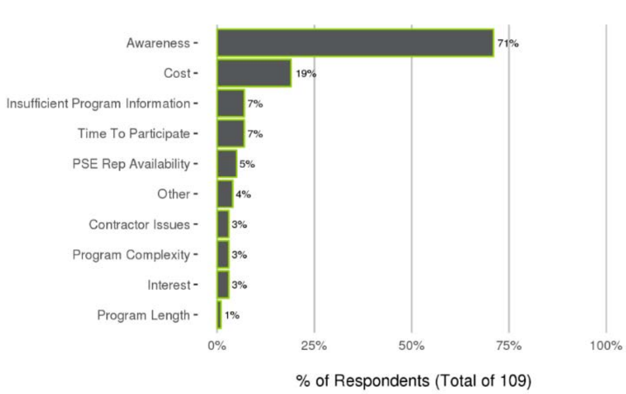
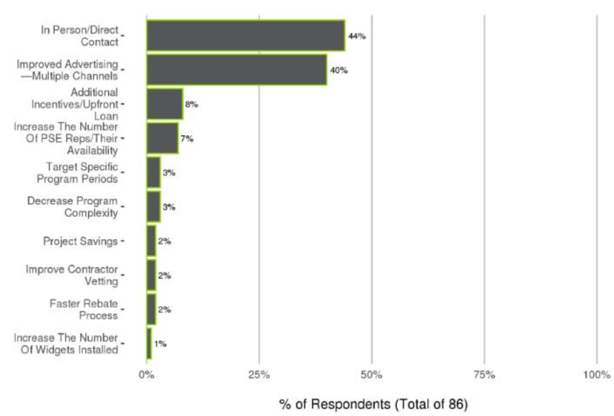


Figure 17: Suggestions to Overcome Barriers to Participation, Commercial Rebate Program Overall (n=86)



Source: Navigant analysis

Participant responses on key barriers to participation showed interesting variation between 2016 and 2017. Respondents perceived awareness as less of an issue in 2017 relative to 2016, perhaps signaling improved marketing or outreach. Also notable was a change in perception of PSE representative availability during this period. PSE representative availability was not mentioned as a barrier by 2016 participants, but it became the third most common barrier cited by respondents in 2017[7]. We will actively monitor any changes in responses to this question throughout the remainder of 2017, but this signals an area for further investigation in the next biennium, and an area of concern program managers may want to address in the near-term.

Figure 18: Most Significant Barrier Keeping Businesses Like Yours from Participating—2016 Only—Commercial Rebate Program Overall (n=73)

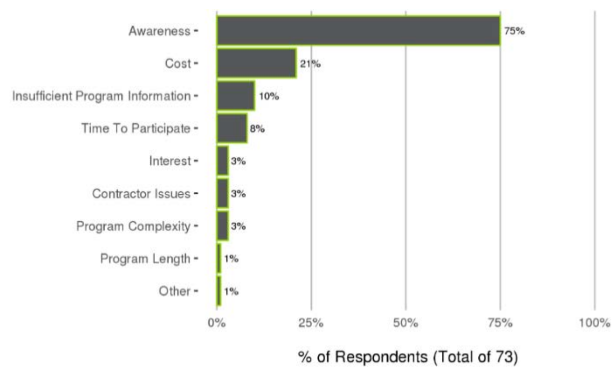
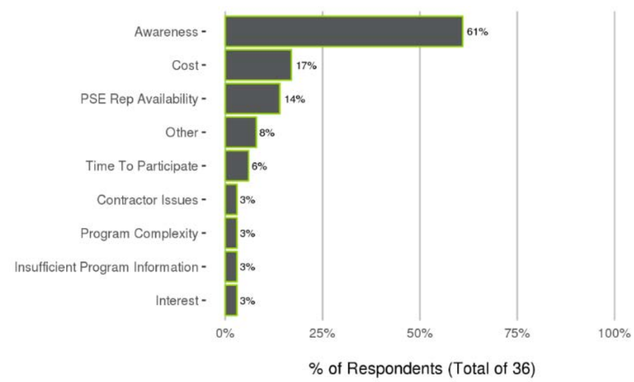


Figure 19: Most Significant Barrier Keeping Businesses Like Yours from Participating—2017 Only (through Q2)—Commercial Rebate Program Overall (n=36)



Source: Navigant analysis

To investigate whether the enrollment process or recruitment issues posed a barrier to participation for different sub-programs, we surveyed trade allies. Most Commercial Kitchens vendors felt that getting customers to participate in the program was easy—rating the ease of enrolling participants a ten on a zero to ten scale—though a few found enrolling participants more difficult. Commercial HVAC program contractors generally felt it was not difficult to get customers to participate in the program, rating the ease of enrolling customers an eight. Similarly, SBDI contractors tended to rate the ease of enrollment between and eight and a nine. By contrast, the Premium HVAC Service contractor surveyed found enrolling customers difficult. Trade allies had varied suggestions for how to make the enrollment process easier:

[7] Note that this finding is based on survey responses from Q1 and Q2 2017 participants; at the time of writing this report, Q3 and Q4 participants have not yet been surveyed. This information will be incorporated, and findings adjusted accordingly as final survey results become available.

"How could PSE make enrolling customers easier for your firm?"	**Commercial Kitchens**
	"They should go back to a system where everything is automated. [Then] enrolling customers is easy.”
	“We now direct the customers to the website and have the customers deal with PSE directly. Generally, we let the customers do all the paperwork now.”
	“The paperwork is very easy to do.”
	Commercial HVAC
	“I think the biggest issue is like a lot of big corporations, you can access them through email, but it’s very difficult to get a person on the phone and sometimes things are complicated—sometimes they respond quickly, sometimes not.”
	“Nothing much—It could be a little more clear, the information on program guidelines, what customer qualifies, etc.—for instance, what rate category and size category, etc.”
	SBDI
	“One area where we do see some issues is in converting people over from standard fluorescent tubes to LED T8s—you have to replace the driver, ballast, lamp etc. and it is a really fine line to make money on these—it is a very low participation measure.”
	“It’s not too difficult to enroll customers—if they’re in the geographic area, we know who to offer the program to.”
	Premium HVAC Service
	“They want to know the benefits and it is a fantastic program, but we can’t provide an estimate a lot of the time. If we are going after a new customer and this is our initial approach, it looks pretty bad. It’s a great program, but it needs to get off the ground.”

Source: Navigant analysis

Commercial Rebate sub-programs vary considerably in terms of outreach and marketing, available measures, implementation strategy, target audience and incentive structures. As a result, each sub-program faces a separate set of challenges in terms of barriers to participation. We address some of the most significant challenges below.

Sub-programs with non-free measures face the barrier of customers’ ability and willingness to allocate money for the upfront investment in efficient upgrades. Particularly for the Commercial Kitchens and HVAC sub-programs, one of the largest barriers to participation is convincing customers to replace functioning but inefficient equipment proactively, rather than waiting for equipment to fail. During our in-depth interview, the Commercial Kitchens program manager identified this as a top barrier to program participation by restaurants. To address this barrier, the program manager has developed relationships with equipment manufacturers to offer special, deep rebates on specific pieces of equipment, to encourage

Particularly for the Commercial Kitchens and HVAC sub-programs, one of the most significant barriers to participation is convincing customers to replace functioning but inefficient equipment proactively, rather than waiting for the equipment to fail.

restaurant customers to upgrade proactively rather than replace on burnout (ROB). This year she worked collaboratively with manufacturers and retailers to offer customers an economy model EnergyStar commercial fryer that typically costs over $1500 for under $400, notifying restaurants through mailers. The program manager commented, "We saw commercial fryers bursting through as a result. I can say in this case mailers were successful, but it was really the price point of the customer paying less than $500 which made the difference."

Because this barrier to participation is common to multiple sub-programs, we undertook behavior optimization research on how to motivate business owners to make proactive, energy efficient upgrades, rather than waiting to replace on burnout. We identified key insights from the behavior optimization research which may help program managers overcome these barriers and increase participation.[8]

Figure 20: Behavior Optimization Insights—Encouraging Early Equipment Replacement

Focus on making the investment decision easy instead of changing individual attitudes or awareness

- Focus on framing as investment--changing energy efficiency awareness is not as effective for these customers
- Be aware in marketing approaches that just the fact of owning equipment makes it painful for these customers to give it up--show understanding of their sensitivity to sunk costs

Don't just focus on energy savings; address non-energy benefits that may be equally important to customers

- Just focusing on financial benefits can cause business customers not to purchase efficient equipment when their main motivations are the non-energy benefits
- Emphasize non-energy benefits such as noise-reduction, comfort, better lighting, reduced maintenance costs, etc.

Maximize personal and in-person communication strategies, and trusted information sources.

- HVAC equipment and associated savings feel abstract and not tangible for many business customers
- More face-to-face interaction, testimonials, case studies and community engagement can help overcome this barrier

Source: Navigant analysis

> *"The most significant barrier is the fact that the program drives most of participation through the contractors. Our biggest recommended change would be to drive program recognition directly through the customers more."*

Interviews with the Premium HVAC Service program manager and implementation contractor suggest a key barrier to participation is the limitation of having HVAC contractors as the main outreach channel. According to the implementer, "The most significant barrier is the fact that the program drives most of participation through the contractors. Our biggest recommended change would be to drive program recognition directly through the customers more—have the customers go to PSE and ask for a contractor. That by itself would drive a significant improvement both in customer knowledge of EE and CAN (Contractor Alliance Network) participation."

[8] These findings are explained in greater detail in the Appendix with full citations.

3.2.1.3 Recruitment, Marketing and Outreach

The diversity of sub-programs within the Commercial Rebate program requires a variety of different outreach and marketing strategies. We surveyed participants separately by sub-program how they became aware of program offerings[9]. Community blitzes and contractors visiting businesses in person were the most common ways customers about the SBDI program. Contractors and vendors/retailers were the most common sources of program awareness for the Commercial HVAC and Kitchens programs.

Figure 21: Source of Program Awareness—Commercial HVAC (n=9)

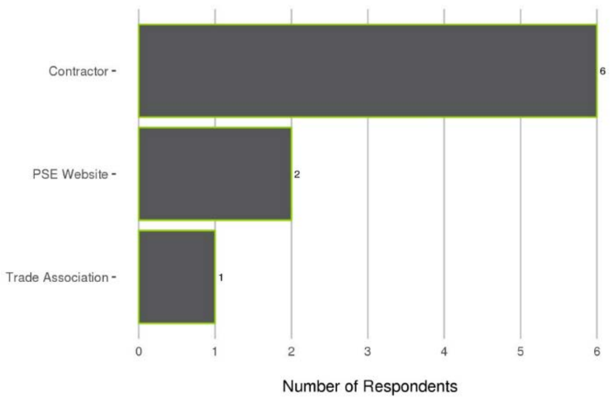


Figure 22: Source of Awareness—Commercial Kitchens (n=8)

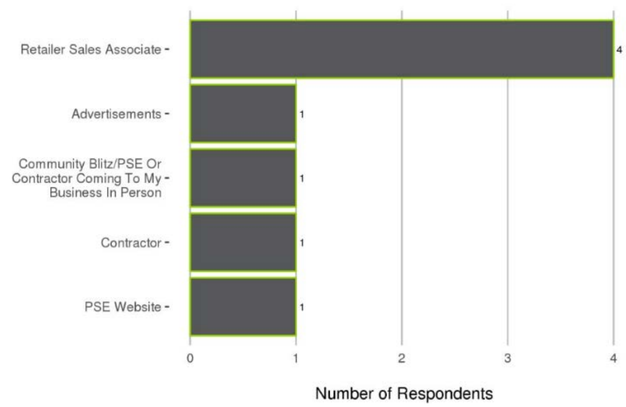
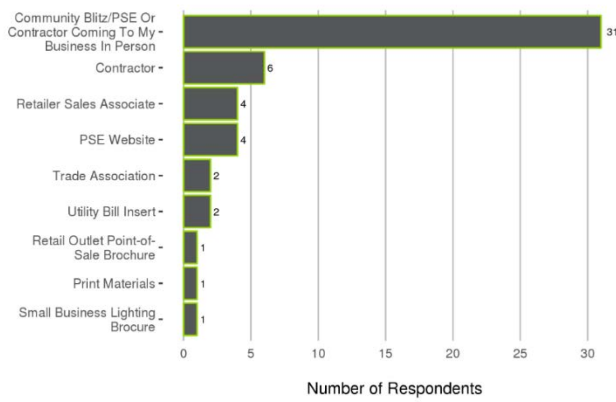


Figure 23: Source of Program Awareness—SBDI (n=52)



Source: Navigant analysis

Perceptions of the usefulness of different sources of information also showed large variability. The sources of information participants found most useful were often not the ones they most commonly encountered. While SBDI participants were most likely to hear about the program through a Community Blitz event or contractor visit, they found retail sales associates to be the most useful source of information. Similarly, though the PSE Website and Trade Associations were perceived by SBDI

[9] Many survey respondents chose "don't know" in answer to the awareness question, leading the number of responses by sub-program to be considerably smaller than the total number of participants surveyed for each sub-program.

participants to be as informative as blitzes or contractor visits, they were much less frequently cited. This suggests an opportunity to expand awareness through these channels.

Figure 24: Percent of Respondents Citing each Source versus Perceived Usefulness of Information—SBDI (n=53)

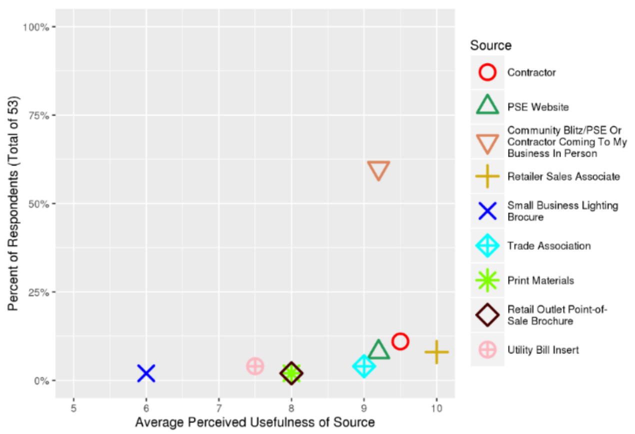


Figure 25: Percent of Respondents Citing each Source versus Perceived Usefulness of Information—Commercial Kitchens (n=7)

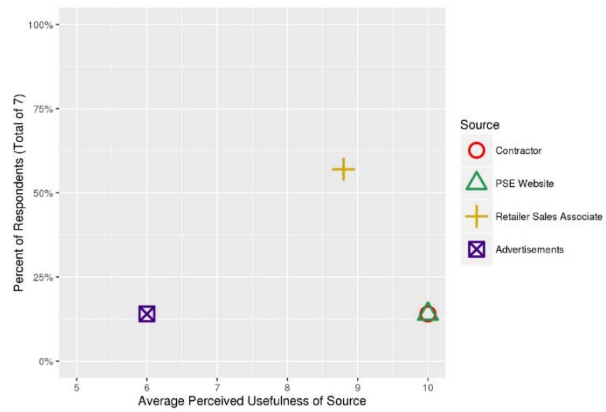
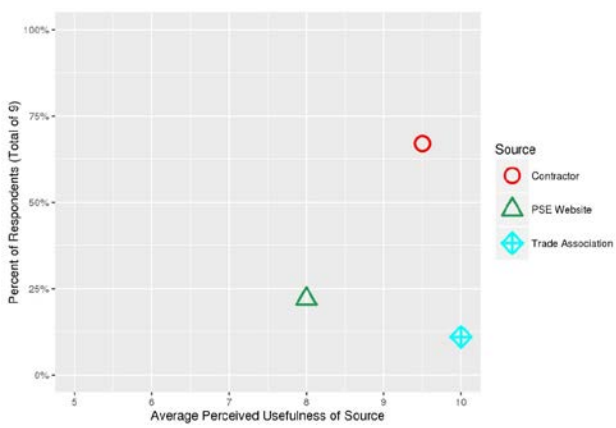


Figure 26: Percent of Respondents Citing each Source versus Perceived Usefulness of Information—Commercial HVAC (n=9)



Source: Navigant analysis

Nearly equal numbers of participants felt marketing materials were extremely influential (a ten out of ten) in their decision to participate versus not influential at all (a zero out of ten). This finding suggests a potential growth opportunity in refining and updating marketing materials for the program. One particular form of outreach that participants rated very highly was the community blitz. Those that experienced a community blitz generally rated it as extremely influential on their decision to participate in the program.

Figure 27: Influence of Marketing Materials on Participation Decision—Commercial Rebate Program Overall (n=103)

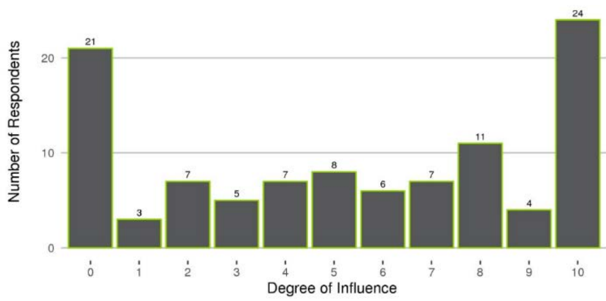
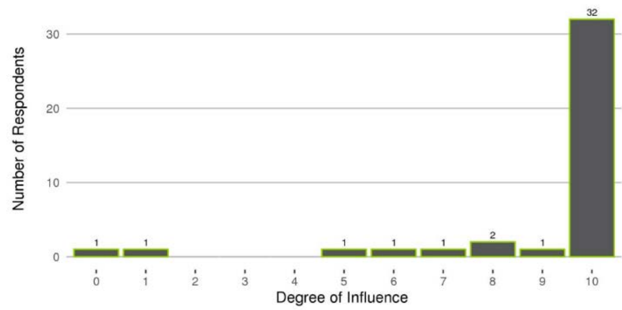


Figure 28: Community Blitz Degree of Influence on Participation Decision (n=40)



Source: Navigant analysis

When asked the best way to reach more businesses like theirs, participants from the SBDI program were most likely to suggest direct, in-person contact, followed by direct mail or postcards. Commercial HVAC participants most frequently suggested inserts in their power bill, followed by direct contact. By contrast, the largest number of Commercial Kitchen respondents suggested email as the best way to reach businesses like theirs. In addition to direct contact, mail or postcards, Kitchen program participants were equally likely to suggest retailers and social media as the best ways to reach them.

Interviews with program managers, implementers and trade allies revealed interesting challenges and questions regarding marketing and outreach for several sub-programs, including Commercial Kitchens, Agriculture Direct Install, and Small Business Direct Install. We present findings on these issues below.

During our in-depth program manager interview, the Commercial Kitchens manager indicated that one goal she had for the upcoming biennium was to refresh and enhance her approach to in-store and Point of Purchase (POP) signage. To provide actionable suggestions, we chose this as one behavior optimization research focus area, which provided the following key insights.[10]

[10] These findings are explained in greater detail in the Appendix with full citations.

Figure 29: Behavior Optimization Insights—Optimizing In-store Signage and Advertising

Provide information on technologies from trusted sources unaffiliated with products

- Customers are often skeptical of brand-affiliated ads
- Trusted and unbiased information sources will have more influence

Curate choices to avoid choice overload for the customer

- Too many choices overwhelm customers and demotivate them
- Limit choices to make decisions easier for the customer
- Use customer input to determine which choices to offer and adjust flexibly in response to customer input and response

Optimize in-store signage and positioning of products

- Locate energy efficient options towards the front of the store and in high-traffic areas
- People respond more strongly to loss than gain--so frame the investment decision in terms of what they stand to lose by not upgrading to an efficient choice

Source: Navigant analysis

PSE's Agriculture Direct Install faces a unique marketing challenge, as its target customers are physically distant from one-another and potentially less influenced by the types of marketing effective in urban environments and communities. For this program, we leveraged social sciences research findings to better understand how to optimize outreach efforts and program marketing approaches in rural areas with less dense social networks relative to cities, particularly with respect to engaging small farmers.[11]

Figure 30: Best Practices Insights—Engaging Rural Communities and Customers

Use interpersonal communications strategies, trusted sources and appropriate media outlets

- Interpersonal communication and trusted information sources are important to small farmers
- They are time constrained and respond well to testimonials and messaging from "people like them"
- Leverage farming community resources and stakeholders such as Agriculture Extension offices, equipment manufacturers and dealers, and local farming associations

Make it social, using community status, social accountability, and community challenges to influence small farmers.

- Rural communities are more reliant on social networks; hence they place high value on their status and perception in the community
- Challenges, commitments and competitions that stand to benefit the whole community are particularly effective in rural areas

Leverage public commitments and farmers' self-perception of consistency

- Commiting to an action taps into a customer's self-perception, and following through activates their sense of self-consistency
- Commitment making can be leveraged to encourage energy efficient behavior and decision making, and is most effective when made public

Source: Navigant analysis

[11] These findings are explained in greater detail in the Appendix with full citations.

Small businesses are considered hard-to-reach customers for several reasons. Owners may have little time to devote to researching energy efficient options and limited budget to invest in upgrades. Additionally, many small business owners work long hours and are not likely to pay attention to direct mail or be available to answer marketing phone calls. In-person outreach has been shown effective with small business customers, and PSE's SBDI program has demonstrated mastery of this approach through its highly successful Community Blitz program. Both program manager and implementer in-depth interviews suggest the Community Blitz approach increases program participation and generates goodwill and a sense of partnership between PSE and communities. PSE staff and the implementer work collaboratively to identify communities with high potential, then schedule blitz events in different communities throughout the year. During these events program and implementer staff are directly engaged with the small business community of a city, visiting small businesses in person, and networking within the community to increase program participation. SBDI participants interviewed through the participant survey rated the experience very highly, indicating it was very influential in their decision to participate in the program.

Some of the most effective options for marketing to small businesses are shown to be direct and in-person outreach, and PSE's SBDI program has demonstrated mastery of this concept through execution of a highly successful Community Blitz program.

The Commercial Kitchens program manager often participates in these Community Blitzes in order to directly contact the restaurant community. She says "I go door-to-door to the restaurants in that area telling them about the SBDI and Kitchen programs. I will look at the equipment they have in the kitchens and tell them that if they replace it with an EnergyStar unit they can get a thousand-dollar rebate and will likely save $X per month. The outreach is important because this customer is not necessarily going to go out and find rebates on their own."

3.2.1.4 Application Process Experience

Despite suggestions by the program managers and implementers that updates to the customer application process were not fully in effect yet, customers reported high levels of satisfaction with the application process and experience. While satisfaction may improve farther during the next biennium with the new system fully implemented, the process is already resulting in high customer satisfaction.

Roughly half of respondents for whom applications were required reported filling out the application themselves, and those who filled out their own application rated the process highly, with a mean satisfaction score of 8.1 and a median of 9 on a scale of zero to ten. The majority of participants expressed that the length of time to process their application was "About Right." Only three out of 52 respondents reported their wait time to be "Too Long" or "Far Too Long." The typical program duration was two months, with less than 10% of respondents reporting program participation durations of four months or longer. Only 9% of respondents reported encountering any problems with their application process, with those that did encounter problems mentioning communication issues, applications not well suited to the project, or insufficient assistance completing forms.

The vast majority of participants expressed that the length of time to prcess their application was "About Right." Only three out of 52 respondents reported their wait time to be "Too Long" or "Far Too Long."

Figure 31: Satisfaction with Application Process—Commercial Rebate Program Overall (n=49)

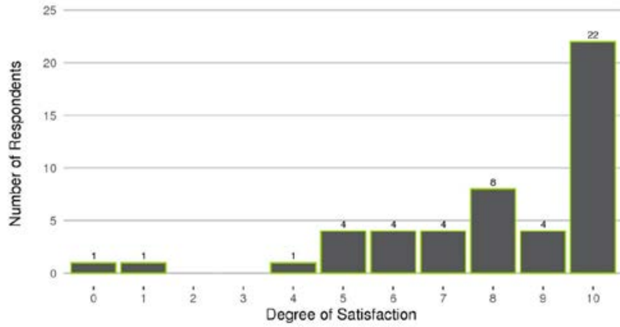


Figure 32: Satisfaction with Length of Time to Process Application, Commercial Rebate Program Overall (n=52)

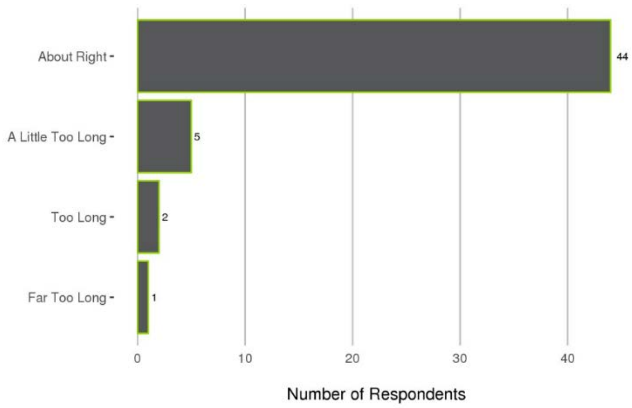
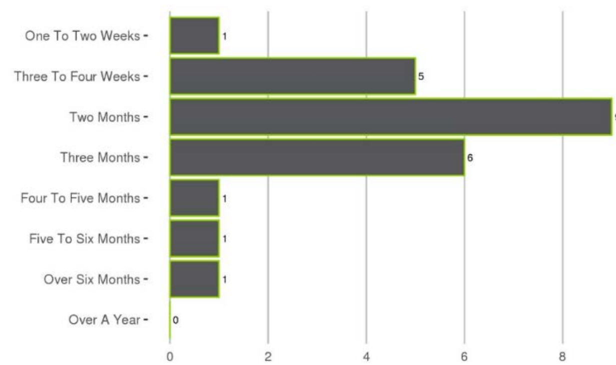


Figure 33: Program Participation Duration, for All Those Receiving Rebates (n=24)



Source: Navigant analysis

3.2.1.5 Demand for New Products and Measures

PSE program managers and implementers work collaboratively eliciting input from customers and trade allies to gauge trends and demand for new products, and to expand program offerings to better meet customer needs. Figure 34 highlights new and proposed measures by sub-program, and more detailed information is provided below.

Figure 34: New and Proposed Measures

DI Programs

- **New Measures**
  - TLEDs
  - Strip Curtains
  - Night Covers
  - Refrigeration Gaskets
  - Large-scale Hotel Lighting (through investment-grade ASHRAE energy audit)

Commercial Kitchens & Laundry

- **New Measures**
  - Griddles
  - New Fryer Sizes
  - Holding Cabinets
  - New Nugget-shape Ice Makers
  - Deck Ovens
  - Coin-operated Laundry Machines in MF and Hotels
- **Proposed Measures**
  - Demand Control Kitchen Ventilator
  - Char-broilers
  - Kitchen Wells
  - Reach-In-Refrigeration

HVAC Programs

- **New Measures**
  - Service for Small HVAC Units (< 5 Ton)
  - Service for Split Systems
  - Service for Heat Pumps
- **Proposed Measures**
  - Ductless Heat Pump Variable Refrigerant Flow Systems

Source: Navigant analysis

The Commercial Kitchens program manager indicated that she adds new measures to the portfolio as often as possible. She said during the current biennium the program had added new fryer sizes, holding cabinets, nugget-shaped ice machines and a deck oven to better serve customer needs. She sees a large demand for griddles, and is working with distributors, manufacturers and retailers to engineer a targeted deep discount on new energy efficient griddles in 2017, similar to that offered for efficient fryers in 2016. Demand control kitchen ventilators are a measure she is working to establish for the next biennium, in addition to efficient char-broilers and kitchen wells. Because the federal EnergyStar refrigeration standards are changing, she also hopes to leverage the code change to add reach-in-refrigeration measures to the portfolio. For the Commercial Laundry sub-program, rebates were extended this biennium to coin-operated laundry machines in hotels and multifamily residences to better serve the needs of these customers and expand participation.

The SBDI program manager noted several trends in the small business community that drove changes in program offerings and design this biennium. Customers expressed significant interest in replacing T12 and T8 linear fluorescent lighting with TLEDs. Because TLEDs are not cost-effective enough yet to offer as a free direct install, the program innovated by including these and some other measures this biennium along with copays to cover part of the expense. In this manner, the customer can access the new measures and have them installed directly through the program, while maintaining program cost-effectiveness. The program is also expanding its offerings to meet small grocery customer needs for refrigeration measures such as strip curtains, night covers and gaskets. They've engaged a new contractor specializing in gaskets in order to meet customer demand for these specialized measures. The program manger noted, "There wasn't a lot of uptake with gaskets because the current IC doesn't have expertise in gasket replacements. I'm expecting a bigger uptake with the new gasket contractor this year."

"There wasn't a lot of uptake with gaskets because the current IC doesn't have expertise in gasket replacements. I'm expecting a bigger uptake with the new gasket contractor this year."

The program manager for Lodging DI feels there is a significant, largely untapped potential to increase program participation by offering large-scale lighting measures to large hotels. In order to reach this market and make lighting available to these large hotels through the LDI program, the program has piloted a channel which performs and pays half the cost of an investment-grade ASHREA Level 2 energy audit, then allows the customer to install large-scale lighting improvements through the LDI program. While this channel is recent, the program manager feels it holds great potential and hopes to market it more broadly with large hotels in the future. She said, "This is totally new. We are hopping the fence from deemed to custom. Once we have this project under our belt, we'll be able to take that to some of the larger hotels that we know are interested in these investment upgrades."

The Commercial HVAC program manager feels the program offers a good range of products, though he is always looking for new opportunities. A potential new measure he is considering rebates for is a ductless heat pump variable refrigerant flow system, which trade allies indicate customers have a large demand for and could generate significant savings. The program manager also sees an increasing demand for Premium HVAC Service on smaller HVAC units for schools and small businesses. The implementation contractor for the Premium HVAC Service sub-program agreed and indicated that the program had expanded its service offerings to include service for small (under five ton) systems, split systems, and ductless heat pumps in response to the need by schools and small business customers.

The Premium HVAC Service sub-program … expanded its service offerings to include service for small systems, split systems and ductless heat pumps in response to the need by schools and small business customers.

3.2.1.6 Trends in Engagement and External Factors

Commercial Rebates sub-programs differ considerably in how much they are impacted by external factors like economic performance because each has a different incentive structure and serves customer segments with unique needs. While the SBDI program reported seeing little to no change or trending behavior in recent years, other sub-programs have seen shifts in participation and interest.

The SBDI program manager … has not witnessed any notable changes or trends in customer behavior and engagement, …noting that "Everyone is excited about 'free', regardless of what the economy is doing."

The SBDI program manager commented that she has not witnessed any notable changes or trends in customer behavior or engagement during this biennium compared with others, noting that "Everyone is excited about 'free' regardless of what the economy is doing." By contrast, most sub-programs are heavily influenced by economic factors, as restaurants, hotels and small businesses may choose not to participate in Kitchens, HVAC or other programs, despite rebates, during times of economic stress. Many of these small businesses have small profit margins and cannot make energy efficiency upgrade investments, even with the help of rebates, when the economy is doing poorly. Most program managers reported that economic conditions are fairly positive in the region this biennium, and are having a limited impact on participation.

The Commercial Kitchens program sees large changes in customer interest and engagement due to a variety of factors. Customer engagement is largely driven by sales efforts by retailers, and changes in their business operations can significantly impact program participation. The program manager explained, "At any given time at least half of program participation is driven by equipment distributors. We saw participation go down in 2015 because one of our very busy distributors stopped participating in the point-of-purchase portion. It was a father-son operation in Seattle, and the father passed. Since he was the one who handled the rebate paperwork, now one else wanted to figure it out, so we lost a lot of opportunity there." While this suggests external factors due to retailers may affect the program unpredictably, it also implies the need to maintain strong relationships with retailers in order to drive participation.

Participation and customer engagement in the Kitchens sub-program is also heavily influenced by codes and standards changes. The program manager explained that a new Seattle city energy code went into effect in 2016 which is more stringent than Washington state energy code— "That means the rebates customers can qualify for are different outside Seattle. Inside the city code requires ENERGY STAR for certain measures, so they couldn't get a rebate on these. That reduces the number of participants." She expressed her concern that while the code may be higher in Seattle relative to the rest of the state, that does not mean that all restaurants comply. Hence, there may be a justification for continuing to offer rebates on code-compliant ENERGY STAR measures inside Seattle if the baseline is not yet in line with code.

> *"Rebates customers can quality for are different outside Seattle. Inside the city code requires ENERGY STAR for certain measures, so (customers) couldn't get a rebate on these. That reduces the number of participants."*

3.2.2 Program Efficiency, Cost-Effectiveness, and Quality

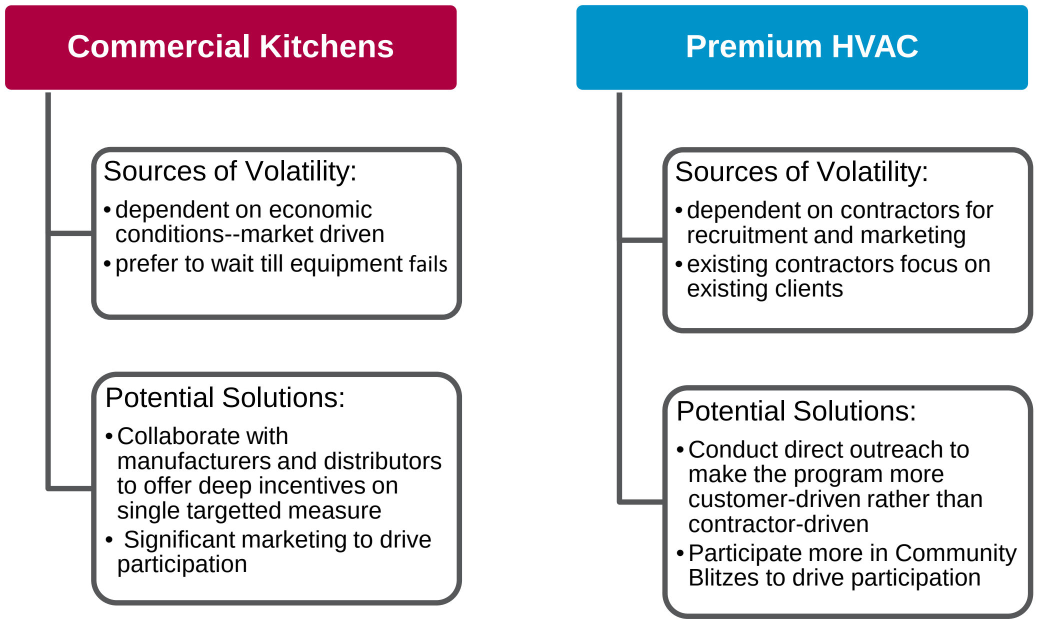
Through in-depth interviews with program managers and implementers, trade ally interviews, review of program tracking data and materials and program theory and logic models, we've explored several key research objectives relevant to program efficiency, cost-effectiveness and quality. The remainder of this section is organized to answer each of these research objectives in turn:

- Participation predictability issues
- Program changes and impacts on performance
- Quality control and assurance
- Program cost-effectiveness

3.2.2.1 Participation Predictability Issues

Most participation in the Commercial Rebate program occurs through the SBDI sub-program, and participation within that sub-program is stable and fairly predictable. As discussed earlier, while participation in the Commercial Laundry program is low this biennium, regular business cycles and the useful-life of equipment largely explain participation in this program, making it predictably low this biennium. By contrast, the Commercial Kitchens and Premium HVAC Service sub-programs both demonstrate considerable volatility. Program managers and implementers expressed interest in better understanding and addressing participation volatility within these sub-programs. Key sources of sub-program volatility and solutions are summarized in Figure 35 and explained in greater detail below.

Figure 35: Sub-program Forecasting Volatility and Potential Solutions



Source: Navigant analysis

The Commercial Rebate program manager suggested that of all the sub-programs, forecasting participation accurately for the Commercial Kitchens program tends to be the most difficult. "It's a very unpredictable program. Sometimes we will be surprised with a bunch of different measures if restaurants are doing well and they have a lot of money to spend." The Commercial Kitchens program manager had great insights into the variable performance of the program, the key observation being that this program is "very market dependent." Restaurants are very reactive and highly dependent on economic conditions in their decision making, which leads to participation volatility. Moreover, they often have tight profit margins and will wait for equipment to fail rather than upgrading to new, more efficient equipment proactively.

Restaurants are very reactive and highly dependent on economic conditions in their decision making, which leads to participation volatility. …they often have tight profit margins and will wait for equipment to fail rather than upgrading to new, more efficient equipment proactively.

In order to curb this volatility and motivate restaurant owners to be more proactive in replacing inefficient equipment, the program initiated a new approach this biennium that is showing positive results. The program manager negotiated cooperative agreements between equipment manufacturers, distributors and vendors to offer one particular economy model ENERGY STAR fryer at a significant discount, so that paired with program rebate incentives and targeted mailings and outreach, the program might motivate a large number of restaurants to invest in the equipment during 2016. The efforts paid off, as the program sales of these fryers surged. The program manager is undertaking a similar effort with griddles in 2017. By purposefully targeting a high-demand item that is usually cost-prohibitive, and making it affordable enough for restaurants not to be able to pass up the opportunity, the program manager has developed a way to make program participation more predictable, and afford the program greater control over the timing and volume of participation.

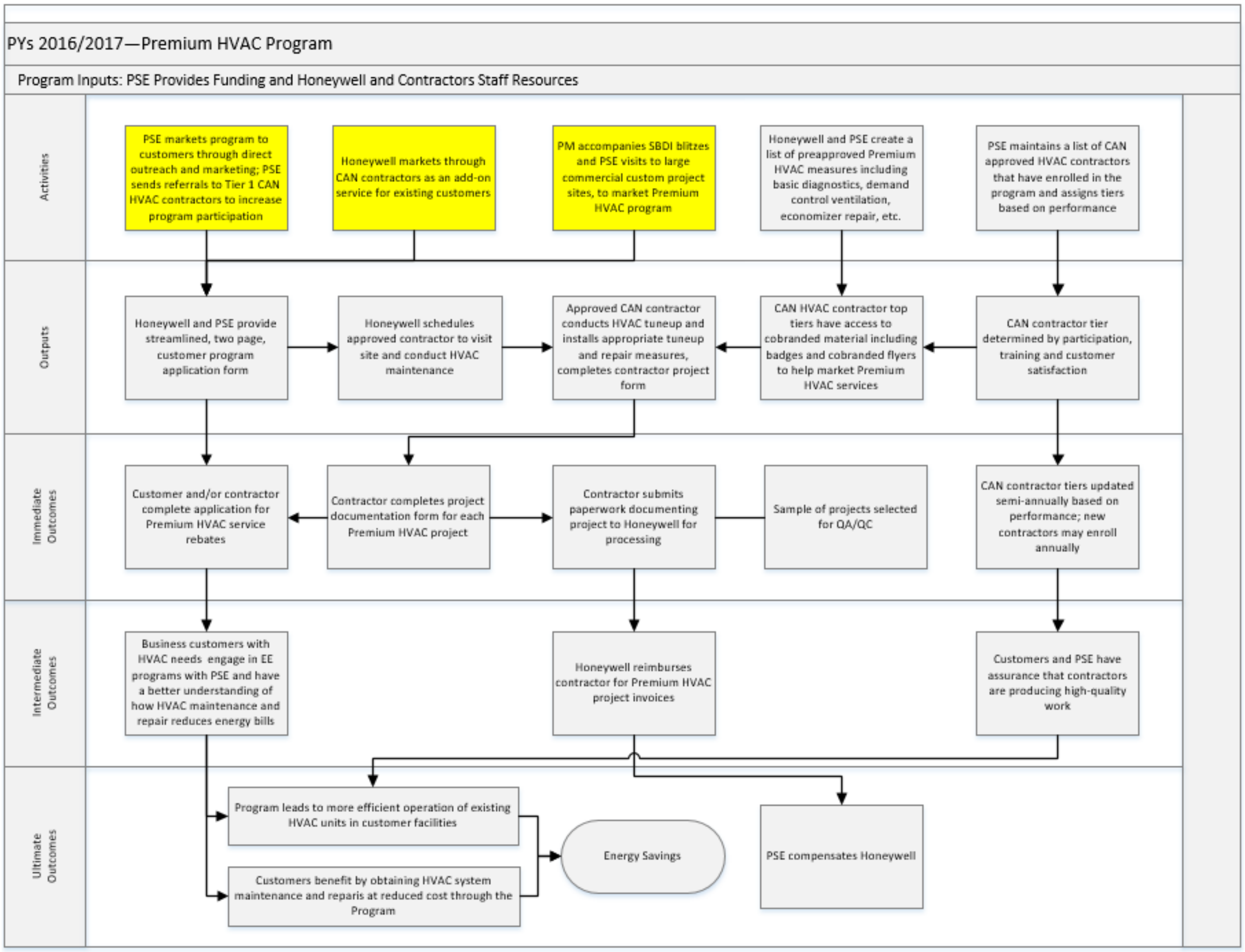
The program manager and implementer for the Premium HVAC Service sub-program indicated that forecasting participation in this program is particularly challenging. The implementer identified several contributing factors, the first being that as with the Kitchens program, this program faces the challenge of HVAC customers often preferring to wait for equipment to fail rather than investing in maintenance and service to make it operate more efficiently. The fact that the program is contractor driven also contributes to unpredictability, as contractors face external economic forces that may divert their attention from the program for a period of time unpredictably. For example, he cited the recent tech boom of Amazon, Facebook and Google moving operations to the Seattle area as having drawn contractors' focus away from HVAC service to more lucrative contracts facilitating new construction needs. Finally, communication and scheduling lags between contractors and customers also contribute to unpredictability of participation timing.

The fact that the program is contractor driven…contributes to unpredictability, as contractors face external economic forces that may divert their attention from the program unpredictably.

The implementation contractor had constructive suggestions for how to improve forecast accuracy and reduce participation volatility. "The biggest recommended change would be to drive program recognition directly through the customers more (rather than through contractors). Have the customers go directly to PSE and ask to have a contractor service their system. …If you drove the program more through customers, they'd go to PSE and say, 'Hey, I'd like to get a contractor that can do this for me,' and that would drive very legitimate referrals to the contractors and make the program better all around." By focusing on direct recruitment and outreach for the program, rather than relying on contractors to drive enrollment, the program could better predict and influence participation.

In the Logic Model below, three modes for recruiting participants are highlighted, however, in practice, the program currently relies almost exclusively on the second mode, contractors referring existing clients for service. By strengthening the outreach modes to the left and right, as suggested by the implementer, the program would exert more control over participation, be better able to forecast participation, and improve program performance in the process.

Figure 36: Program Theory and Logic Model—Premium HVAC Service

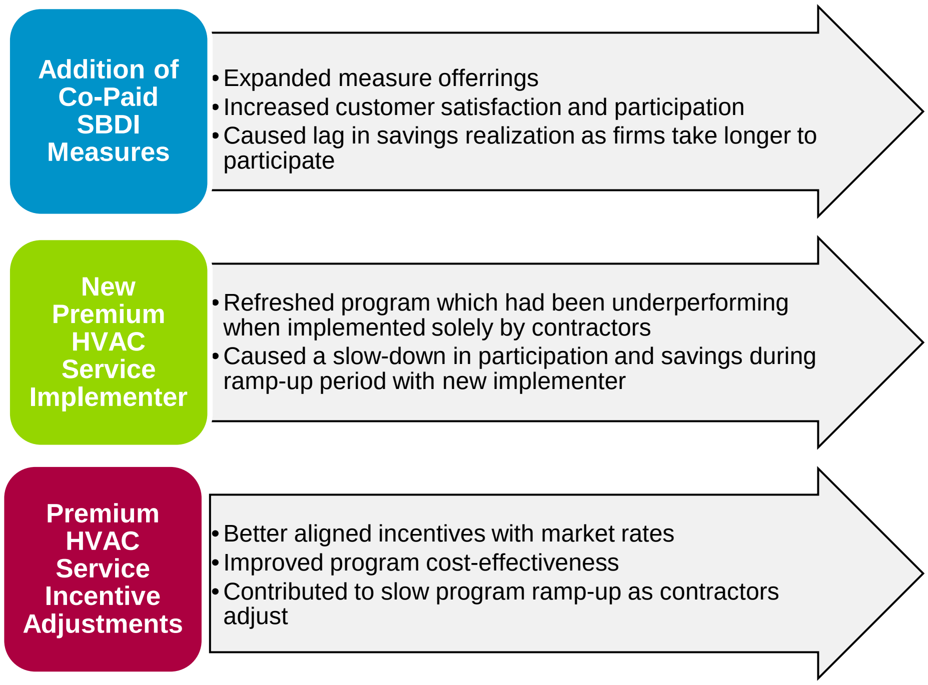


Source: Navigant analysis

3.2.2.2 Program Changes and Impacts on Performance

Changes in program implementation and incentive designs have impacted the performance of certain sub-programs during the 2016/2017 biennium. These changes are summarized in Figure 37 and explained in greater detail below.

Figure 37: Major Program Changes, Motivations and Effects

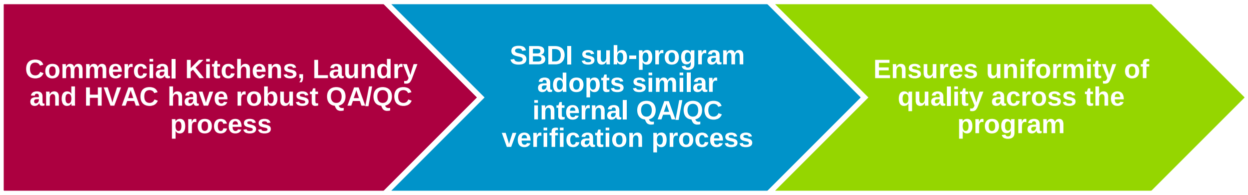


Source: Navigant analysis

The SBDI program saw a major incentive structure change during this biennium, which caused some slow-down in 2016. The program began offering co-paid measures in addition to existing free direct install measures, in order to expand to higher-end products and increase program participation. While the change has had positive effects on customer satisfaction and participation, it has slowed down the participation process leading to lags compared with forecast participation levels. The program manager observed that previously, when all direct install measures were free, it was a very quick-turnaround process. However, now that co-pays are involved, more decision makers are involved, and they often take more time to deliberate and consider their options. This leads to a queue of projects in different stages of approval, lengthens the participation process, and leads to a lag in realized savings versus anticipated savings.

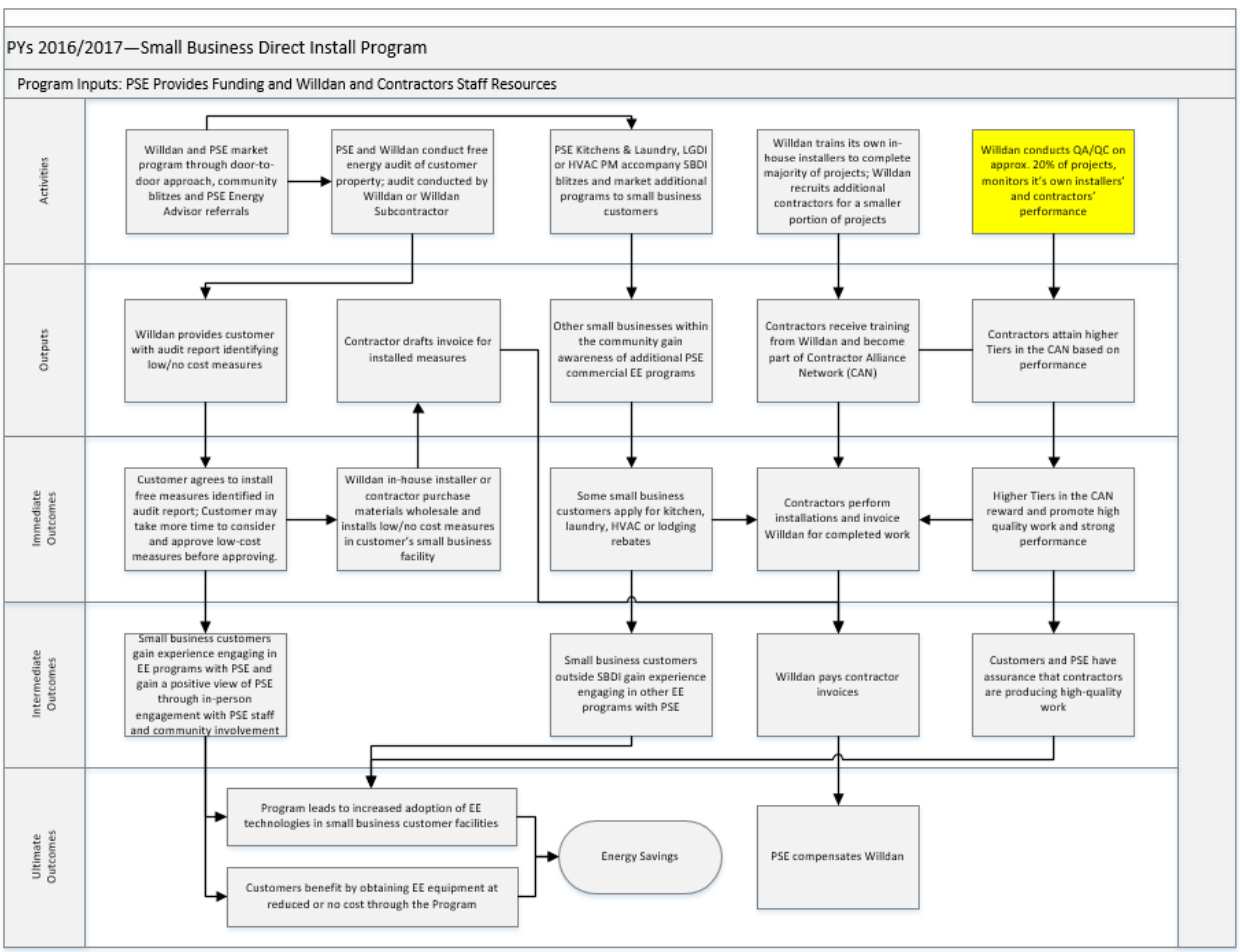
The Premium HVAC program underwent a significant implementation change this biennium, moving from a strictly contractor-implemented program to being run through an implementation contractor. Both the implementer and program manager noted that participation was low in 2016 due to the “ramp up” period associated with a new implementer, but expected it to increase during 2017 as the implementer gains a foothold. The implementer provided more detail, suggesting that lower levels of contractor engagement also contributed to the lag in participation. In order to overcome this barrier, the implementer is actively working to recruit and engage more contractors in the program through the Contractor Alliance Network (CAN), and hopes a refresh of contractor engagement will help to revitalize the program. The new Premium HVAC Service implementer also made constructive changes to the incentive structure, which made the program more cost-effective, but likely also contributed to the slow participation ramp-up in 2016.

3.2.2.3 Quality Control and Assurance



The Commercial Rebates program manager explained that robust QA/QC procedures are in place across the program. She indicated that while the Commercial Kitchens, Laundry and HVAC programs had always had a robust QA/QC process in place, the program recently implemented a similar process for its DI programs. The SBDI program manager verified that completed project lists are sent to the verification team led by the implementer monthly. The verification team randomly samples from the total population of projects, and performs onsite verification for approximately 20% of sites to ensure proper installation which matches reporting. This improvement to the SBDI program is highlighted in the SBDI Logic Model in Figure 38.

Figure 38: SBDI Logic Model



Source: Navigant analysis

3.2.2.4 Program Cost-Effectiveness

Overall, the Commercial Rebates program is cost-effective, and the diversity of sub-programs and incentive structures within it allow flexibility in maintaining that cost-effectiveness. Less cost-effective sub-programs can be balanced by more cost-effective ones. Moreover, the program staff are continually refining incentive structures and program designs to maximize cost-effectiveness.

PSE's DI programs improve cost-effectiveness through geographically targeted marketing and outreach approaches. These programs incur costs by having to visit customer sites to direct-install measures. As a result, the more they can consolidate trips and reach more customers in a given area, minimizing follow-up visits, the more cost-effective the programs are. Both the Community Blitz and contractor door-to-door marketing in targeted geographic areas aid with cost-effectiveness. Similarly, outreach through local Conservation Districts and coordinating site visits to multiple small farms in close proximity in a single day maximizes cost-effectiveness for the ADI program.

Both the Community Blitz and contractor door-to-door marketing in targeted geographic areas aid with [SBDI] cost-effectiveness.

Because geographic targeting plays a critical factor in determining the cost-effectiveness of DI programs, we undertook best practices research on geotargeting approaches. We found that geospatial analysis of participation trends and new participation potential is becoming an increasingly valuable tool for engaging hard-to-reach populations cost-effectively. This best practice research identified several key best practice findings on how to use geospatial analysis such as Geographic Information Systems (GIS) effectively.

Figure 39: Best Practices Insights—GIS Applications for DI Outreach

GIS mapping best practices

- Leverage relevant data sources from potential studies
- Analyze historical participation trends
- Compare high and low participation potential areas with actual participation
- Develop targeted outreach strategies for untapped areas with high potential

Multiple data sources to inform customer segmentation

- Include past program participation tracking data, evaluation results, utility customer data, Census data, commercially available business data and other sources
- Develop thorough understanding of each customer segment's savings potential, barriers and best communication channels

Tools that implementers can use in real time in the field

- DI and programs using door-to-door outreach or canvassing can benefit from web-based GIS mapping solutions they can use in the field
- These tools can help target high-potential areas and lower costs of outreach

Source: Navigant analysis

The Premium HVAC program's new implementation contractor found opportunities to better align incentives with market prices and improve cost-effectiveness in the program this biennium. The previous contractor-implemented program offered packages of measures for the customer to choose from—but the new implementer found these packages were not the most cost-effective incentive mechanism. Instead, the implementer changed the structure to be a menu of options the customer chooses individually, rather than choosing between just a limited number of packages. This allows the customer to better customize to their needs, and allows more flexible pricing of incentives. While some customers experienced an incentive decrease due to this adjustment, others experienced an incentive increase, so the effect was neutral. However, from PSE's perspective the change made the sub-program as a whole more cost-effective.

The implementer changed the structure to be a menu of options the customer chooses individually, rather than choosing between just a limited number of packages. This allows the customer to better customize to their needs and allows more flexible pricing of incentives.

Commercial Kitchens and Commercial HVAC have traditionally had no difficulty remaining cost-effective. The Kitchens program manager explained that "overall the portfolio of kitchen measures is very cost-effective." Recognizing that many measures in the sub-program are very expensive, and up-front costs, despite incentives, limit program participation, she strives to provide the largest incentives possible up to incremental cost. Because of high overall measure-level cost-effectiveness, the program manager was able to cost-effectively increase rebates on a large number of measures this biennium.

3.2.3 Trade Ally and Implementer Relationships

Through in-depth interviews with program managers and implementers, trade ally interviews, review of program tracking data and materials and program theory and logic models, and best practices and behavior optimization research, we've explored several key research objectives relevant to trade ally and implementer relationships. The remainder of this section is organized to answer each of these research objectives in turn:

- Implementer relationships, communication and performance
- Trade ally satisfaction and motivation to participate
- Barrier to trade ally participation and external factors
- Opportunities to strengthen trade ally ties and increase engagement

3.2.3.1 Implementer Relationships, Communication, and Performance

Within the Commercial Rebate program, the DI sub-programs (SBDI, ADI and LDI) and the Premium HVAC Service sub-program are delivered through implementation contractors. A single implementation contractor delivers all the DI sub-programs, while a separate implementer delivers the Premium HVAC Service program.

The overall Commercial Rebate program manager and individual sub-program managers all reported excellent channels of communication with these implementers. While the overall program manager meets with the implementation contractors on a quarterly basis, the sub-program managers hold weekly meetings with the implementers. The SBDI program manager described an interactive and collaborative communication process with the implementer and reported that "they are so quick to reply (to emails) that it is almost like an ongoing conversation one day to the next. We have a really good relationship." The Premium HVAC Service program manager had similarly positive observations on his relationship with the implementer. "As far as the implementation contractor manager, he's been absolutely great. He has been a wealth of knowledge and has tons of HVAC experience. As far as their internal staff, they do a great job of following up with me on questions, etc. Overall it has been a good experience." During in-depth interviews, both implementers reported open, clear channels of communication with PSE staff, echoing their positive statements.

"They are so quick to reply [to emails] that it is almost like an ongoing conversation one day to the next. We have a really good relationship."

The implementation contractor for the SBDI sub-program has been in place for many years, and has developed a successful working relationship with PSE program staff. Implementer staff accompany PSE staff during Community Blitzes, and work closely in the field with PSE staff meeting small business owners, conducting door-to-door outreach, and implementing measures. The SBDI program manager described this relationship as highly productive and positive. As of this biennium, the DI implementer has also taken on implementation of the ADI and LDI sub-programs, which were initiated in 2016 to better serve the needs of farmers and hotel operators. While both new sub-programs have been slow to ramp-up participation, the program managers feel this is not a reflection on the implementer. Rather, they emphasized that both new sub-programs have been a learning experience, and that PSE staff are actively working with the implementer to hone and improve these programs and increase participation.

By contrast, the Premium Service HVAC sub-program was contractor-implemented prior to this biennium, so a new relationship is forming between the PSE staff and this program implementer. While the program reported some initial difficulties obtaining reliable program savings forecasts with the implementer, he felt this process had improved by 2017. Overall, he had a positive impression of the implementer's handling of the program, and felt changes to the incentive structure, and other changes put in place by the new program implementer had improved the program. According to the program manager, under delivery by contractors, the program "had just gotten to the point where it was stagnating and we were getting less and less participation through the contractors, so we were looking for some new ideas and some new blood to revamp the program and get it working again."

"[The program] had just gotten to the point where it was stagnating and we were getting less and less participation through the contractors, so we were looking for some new ideas and some new blood to revamp the program and get it working again."

While program participation has ramped up more slowly than expected, the program manager feels this is due to external market factors affecting the contractor market, and not a reflection on the implementer's performance. He expressed optimism that the program would gain traction throughout 2017. The implementer agreed that low engagement by contractors was a key factor explaining lower-than expected performance, but felt that positive changes to the program's incentive structure, and their recruitment efforts with new contractors they would be able to overcome this obstacle to increase participation throughout 2017. "Over the next few months, we will be focusing on not only new units, but instead rebuilding the Contractor Alliance Network (CAN). …If we show steady growth based on the restructured incentives and the changes to how we approach contractors, then I think PSE will be interested in continuing the program."

3.2.3.2 Trade Ally Satisfaction and Motivation to Participate

Overall trade allies expressed satisfaction with their participation experience and expressed sufficient motivation to continue participating in the Commercial Rebate program. We conducted brief telephone surveys of three different groups of trade allies:

- Contractors—Commercial HVAC and Premium HVAC Service Programs
- Retail outlet vendors—Commercial Kitchens Program
- Contractors—SBDI Program

Commercial HVAC and Premium HVAC Service Contractors

Commercial HVAC contractors generally expressed satisfaction with their experience, though the Premium HVAC Service contractor expressed more concerns. Asked about how easy it was for their firm to participate in the Commercial HVAC program overall on a zero to ten scale, the contractors responded positively, with scores between 6 and 9. Asked what PSE could do to make the program participation experience easier for them, they had the following suggestions:

"How could PSE make the program participation experience easier for you?"	"PSE could have more automation on submission of rebate forms to make it easier. Cascade does a much better job with this than PSE."
	"It is very hard to meet the requirements every six months. Maybe over a year would be better. If you're kicked out of the program after six months for not participating, this is hard for small companies to do."
	"Requirements are pretty straightforward, but it's a bit of a hassle getting and finding and uploading the required documents and paperwork—they could make this easier."

By contrast, the Premium HVAC Service contractor expressed more concern over the difficulty of participation:

> *"We've tried to get a couple of locations started and haven't gotten anyone to participate in the PSE process yet. The "premium" part we don't have a problem [with]. It is more the rebate service. Our technicians know exactly what the premium service is. The issue is getting ahold of people for getting rebates and getting the proper information, calculating the rebate. A couple of times the rebate has been inaccurate or out of date. It's hard to estimate what the rebate will be when pitching [the program] to customers. I think the calculation spreadsheets are coming directly from PSE. Who I was talking to at PSE changed halfway through. Getting ahold of the PSE rep is difficult. When [the implementer] came out and explained everything to my manager and I, it was very helpful. After that, it has been hit or miss getting ahold of them. I've had several spreadsheet calculation errors as well."*

We asked contractors about how they felt about the amount of time it takes their firm to manage their participation in the program overall. Firms rated this component of satisfaction between a five and a nine on a zero to ten scale, indicating overall satisfaction with some room for improvement. Firms had the following observations to share:

"How could PSE make you more satisfied with the amount of time it takes to process rebates, and the time it takes your firm to participate in the program?"	"Once you've done it, it goes pretty smoothly."
	"Making the process more automated. I believe the training hours are stupid. It takes time to train someone, and you don't always have the time at that moment."
	"PSE could send the rebates sooner so customers don't call him asking about where their checks are"
	"They should have a place on their website where customers and contractors can go to track their rebate by their account number. A graph showing the location in the timeline. That would help us save time."
	"They [should] stick with the new rebate application process."

Asked to rate their satisfaction with the Commercial HVAC program overall, all firms rated their satisfaction an eight on a zero to ten scale. They offered these observations:

"How could PSE improve your satisfaction overall with participating in the program?"	"We have no reason for dissatisfaction."
	"Can't say too much here except it's a pain to renew every six months. A six-month window is bad."
	"Requirements are pretty straightforward, but it's a bit of a hassle getting and finding and uploading the required documents and paperwork—they could make this easier."
	"Paperwork historically has been a lot but they are quick to attend to our questions."

Retail Outlet Vendors

Commercial Kitchens program retail vendors expressed overall satisfaction with their experience participating in the program, though they offered some actionable insights on areas for improvement.

While most high-frequency vendors rated ease of participation an eight on a zero to ten scale, some low-frequency vendors found participation more challenging, rating ease of participation a five or six. Vendors provided suggestions for improving ease of participation in the program:

"How could PSE make the program participation process easier for you?"	"There are too many rebates out there now; You need to offer only two rebates."
	"Training entry level employees is a problem and there is a lot of confusion."
	"Rebates change, they are a moving target. We have lost some money due to this process."
	"You have to go through PSE staff for everything, and they are spread too thin and don't always get right back to you. We need a quicker turnaround."

Commercial Kitchen program vendors reported problems and rated the program less highly in terms of the time it takes PSE to process program paperwork, and the time it takes them to manage their firm's participation in the program. Respondents tended to rate satisfaction with these elements in the five to seven range on a zero to ten scale. Open ended responses provided insights into the challenges they perceived:

"What would make you more satisfied with how much time it takes to process rebates, and the time it takes your firm to participate in the program?"	"(Processing time) varies. It is very inconsistent. Sometimes it happens very quickly. Other times you are still waiting six months later."
	"The paperwork is easy, however I do not like some of the questions that are asked. Some questions I never ask the customer, they are irrelevant."
	"It's nothing they can change. For us it is based on how we are internally paid…we've shared this with (PSE)."

Despite some areas for improvement mentioned above, most vendors rated their satisfaction with the program overall very highly—an eight to ten on a zero to ten scale. Respondents provided the following context:

"How could PSE improve your satisfaction overall with participating in the program?"	"There's a lack of consistency and too much confusion, especially for an entry-level employee. The program needs to be simplified."
	"I love the program and I support the program and would like to see it continued."
	"Items listed as rebate items still need rebate verification. Our PSE contact is one person, and when that person is gone, we start the waiting game. Everything is very time consuming."

SBDI Contractors

Overall, contractors working with PSE in the SBDI program were very satisfied with the experience. Asked about how easy it was for their firm to participate in the program on a zero to ten scale, the SBDI contractors responded positively, with scores between seven and ten. Asked what PSE could do to make the program participation experience easier for them, most were satisfied and had no suggestions to offer, but one firm volunteered a suggestion:

> "They could get us marketing materials. There are marketing materials we asked for and still have not received. We were given badges recently, but we needed them earlier—that would have been helpful."

We asked SBDI contractors first to rate their satisfaction, using a zero to ten scale, with the amount of processing time involved in the program paperwork, and then to rate their satisfaction with how much time it takes their firm to participate in the program. Most rated their satisfaction with processing time between seven and nine, while they rated their satisfaction with the overall time commitment for their firm between seven and ten. These firms shared the following observations:

"What would make you more satisfied with how much time it takes to process rebates, and the time it takes your firm to participate in the program?"	"Participation for our firm is neither difficult or easy---that one is neutral. Not really sure if anything can be done to change that—PSE needs to get their info and we need to do our part to provide it—it's necessary, I understand, so I don't have a good suggestion for how to make it less time-intensive for the contractor."
	"There's gotta be a glitch in the program—we're offered an online entry system, but it seems they never got it up and running—this would be an improvement because for now we have to do it all manually.

One SBDI contractor scored their satisfaction with processing time very poorly—a two out of ten—and expressed dissatisfaction with the amount of time it takes their firm to participate, rating their satisfaction a five. Asked for clarification this firm reported issues with the implementation contractor:

> *"The issue is with logistics between us and [the implementer]—it's been several months and we haven't gotten paid yet—a big lag in payment—we've installed measures with 25-30 clients and still haven't received a single dollar of payment from [the implementer]."*

SBDI contractors rated their satisfaction with the program overall highly, between a seven and a nine out of 10. Asked to provide more information on their level of program satisfaction, they mentioned the following:

"How could PSE improve your satisfaction overall with participating in the program?"	"SBDI really is a good program—it allows us to reach out to these customers that don't qualify for the large commercial program—small mom and pop shops that don't have the finances for big investments in conservation—for them, this program is a good option. For me the biggest thing that makes me satisfied with participating in the program is helping people and seeing their response when their places are brighter and better looking—this is satisfying."
	"There have been some funding level changes that need to be communicated better in advance—for instance, the customer is given a proposal, they don't act on it right away, but then the funding changes by the time they want to participate. It would be better if once a customer is given a proposal, you don't change the proposal at a later date, etc."
	"I like the fact that the number of contractors who get to participate in this program is small—it keeps us motivated. If there are too many contractors participating in the program, it muddies the waters."

The single contractor who identified issues with a payment lag involving the implementer said their satisfaction overall was dependent on whether or not the payment issue was resolved. Assuming resolution to the payment issue, they would rate overall program satisfaction a seven. For further context, they provided the following:

> "If we'd already been paid we would be pretty satisfied, but if it takes another couple months, we're going to be pretty upset—our satisfaction is a 5, neutral, as a result—the issue is payment. It is hard to give you a numeric answer on this because we'll be pretty satisfied with the program overall if we get paid pretty soon, maybe a seven, but otherwise not."

3.2.3.3 External Barriers to Trade Ally Participation

Through in-depth program manager and implementation contractor interviews, we learned that contractor driven sub-programs such as the Commercial HVAC, Premium HVAC Service and SBDI programs may face challenges engaging contractors due to external economic forces. According to program managers, a recent "tech boom" in the region has brought many large firms to the area, leading to massive new construction efforts. As a result, PSE's programs must complete with new construction projects for contractor attention, leading to a shortage of contractors, and overall contractor disengagement.

In order to gain direct insights into this issue, we asked contractors to comment on whether or not they felt this was an issue for their firm, and if so, how PSE might help overcome this barrier to contractor engagement and participation.

"Do booms in new construction ever hinder your ability to participate in the program, and if so, how could the program overcome this barrier?"	"Yes, depending on the different programs. The HVAC service program which is pretty good but there isn't a lot of money in it."
	"With new construction, there are a lot more high-value projects going on right now."
	"They could simplify the paperwork and integrate with the contractors' processes so there is no extra paperwork."

Contractor responses implied that increased incentives and reduced paperwork burden might help make PSE HVAC program projects more attractive in the booming new construction climate.

3.2.3.4 Opportunities to Strengthen Trade Ally Ties and Increase Engagement

Most of PSE's Commercial Rebate subprograms depend critically on trade allies for performing installations, marketing program equipment as part of their sales process, and managing outreach and marketing for programs. As discussed above, these trade allies include both contractors, critical to HVAC-related and DI programs, and retail vendors, essential to the Commercial Kitchens program. During our in-depth program manager and implementation contractor interviews, a goal voiced by the staff for many programs was to investigate opportunities to strengthen trade ally relationships and increase engagement. To provide actionable suggestions, we chose this as one best practices research focus area, which provided the following key insights.[12]

[12] These findings are explained in greater detail in the Appendix with full citations.

Figure 40: Best Practices Insights—Strengthening Trade Ally Relationships

Be creative when developing a trade ally network

- Don't limit trade ally networks to just the utility and contractors--look to include industry associations, manufacturers, distributors or trade coops to bring greater benefit to trade allies

Understand barriers faced by your trade allies

- Understand the challenges your trade allies face; annual trade ally surveys are invaluable
- Trade ally surveys on a regular basis will allow you to engage trade allies better by understanding how to appeal to them, motivate them and help them overcome barriers to participation

Give trade allies customer touchpoint opportunities and the skillset to capitalize on them

- New pilot programs, special offers, new technology announcements, or any program novelty gives trade allies a reason to reach out to customers
- Trainngs by the utility on new products, etc. can make those customer touchpoints even more valuable
- Ask trade allies what assistance they need to integrate the program into their regular sales process and be sure to provide that assistance

Engage trade allies in mutually beneficial activities

- Trade ally networks shouldn't be a one-way communication channels from the utility to the trade allies
- Experiences that benefit both the utility and the trade ally are key to developing strong, lasting trade ally relationships
- Mutually beneficial activities
  - Joint sales calls that give trade allies the opportunity to learn how to effectively promote the program
  - Collaborating on end-use customer market research
  - Providing trade allies with educational and marketing materials.

3.2.4 Lighting Market Modeling Analysis

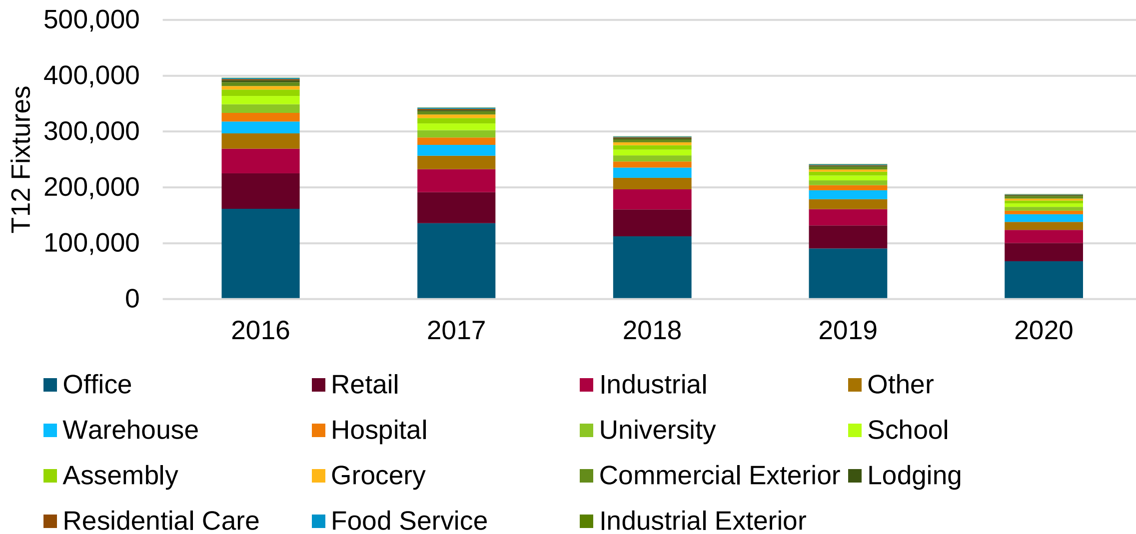
Our team analyzed detailed lighting data from the PSE 2013 CBSA oversample along with regional technology trends to estimate the remaining stock of T12 lamps and fixtures in commercial and industrial buildings in PSE's service territory and to forecast changes in the T-12 lighting stock through 2020. This analysis leveraged the regional lighting market model Navigant developed with the Bonneville Power Administration[13].

We estimate that T12 fixture saturation will drop from just over 3% in 2017 to less than 2% of total PSE fixtures by 2020. This implies that fewer than 200,000 T12 fixtures will remain in PSE's territory by 2020. As shown in Figure 41, T12 saturation varies significantly by application and building type, but it appears targeting industrial high and low bay fixtures is the best remaining option to accelerate the decline in T12

[13] https://rtf.nwcouncil.org/subcommittee/market-analysis

saturation. That said, T12 saturation is low enough that targeting remaining fixtures with programs may not be cost-effective. Details are provided in Appendix B.7.

Figure 41: Forecast of T12 Fixtures in PSE C&I Service Territory



Note: The highest number of remaining T-12 fixtures are in office and retail, but that is mainly because those are the largest building types. The saturation of T12s is highest in industry hi/lo bay fixtures.
Source: Navigant analysis of PSE 2013 CBSA oversample and regional lighting market model

3.3 Recommendations & Best Practice Considerations

The evaluation team presents the following recommendations and best practice considerations for the PSE Commercial Rebate program and future areas of evaluation and research.

Recommendations for the Commercial Rebate program

- **Make tracking data structure streamlined and consistent across sup-programs.** The data we received differed significantly between sub-programs within the Commercial Rebate program, both in terms of formatting and field names, as well as the completeness and quality of data captured. Many datasets we received were missing the majority of key fields such as contractor name, contractor email address and contractor phone. The evaluation team recommends PSE streamline the tracking data system for all programs, perhaps using the DI program tracking data as the model for all sub-programs.
- **Update annual HOU assumptions for exterior lights.** The team recommends PSE adopt the 4,656 annual HOU derived using sunrise-sunset data for the PSE service territory.
- **Consider applying HVAC interactive effects for lighting projects**. Currently, PSE's business cases for lighting measures do not include the interactive effects of efficient lighting on HVAC energy consumption. We recommend PSE expand current lighting savings values to incorporate the interactive effects currently used in the RTF lighting unit energy savings assumptions.
- **Monitor participant perception of PSE representative availability.** Insufficient PSE representative availability surfaced in the 2017 participant survey as the second most mentioned barrier to participation, but was not mentioned as a key barrier in 2016. PSE should conduct research during the next biennium to better understand the source of the issue. This research should include targeted participant survey questions throughout the next biennium to monitor the issue.

Best practice considerations for the Commercial Rebate program

- **Improve program awareness.** PY2016/17 participants cited lack of program awareness as the top barrier to participation. Though the participant survey suggested some improvement in this metric between the two years, we recommend PSE assess areas for improvement in its marketing and outreach by subprogram and implement these changes during the next biennium.
- **Leverage other information sources.** Participant survey results revealed that the sources of program information participants found most useful often were not the sources of information most commonly used to learn about the program. We recommend PSE research options to better leverage the sources of information customers found most useful, and improve the usefulness of sources of information customers most commonly used to learn about the program.

Best practice considerations for SBDI

- **Expand co-paid offerings.** PSE added categories of copaid equipment to the program during this biennium to expand program offerings and increase the one-stop-shop appeal of the program. Our team recommends continuing and perhaps expanding this trend, as participant survey response were very positive about this program component, citing it as a key reason for their decision to participate.
- **Address trade ally and customer concerns.** Trade Ally interviews revealed some potential areas for improvement. While most contractors were very satisfied, a minority expressed negative

feelings about the program and recounted very negative program experiences. PSE should follow up to better understand the context for their concerns and see that they're addressed. Our team suggest that trade ally surveys be used to target these areas of concern to monitor progress and resolution of these issues during the coming biennium.

- **Consider using GIS tools to improve cost-effectiveness.** Because locating and recruiting new customers is one of the key drivers of cost in the direct install programs, our team undertook best practice research which suggests that many similar programs successfully utilize GIS mapping tools to target new communities and business sectors to target cost-effectively.

Best practice considerations for Commercial HVAC

- **Investigate contractor issues and suggestions.** During the trade ally interviews, commercial HVAC contractors had several complaints and suggestions for improvement which PSE should take into consideration. PSE should consider the merits of these suggestions, adjust as appropriate, and follow up with a trade ally survey next biennium to assess whether these issues persist or have been remedied.

Recommendations for Lodging Direct Install

- For LDI projects, the evaluation team recommends that PSE double check the installed quantities reported in the tracking data against project documentation for a random sample of PY2018 projects to confirm the duplication in reporting issue has been resolved.

Recommendations for Commercial Laundry

- **Revitalize the program.** As the equipment installed at the start of the program is nearing the end of its useful life, the program manager expects participation to ramp up in coming years. Our team suggests PSE research the installation year and effective useful life of equipment previously installed through the program, to proactively approach and engage past participants.

Recommendations for Commercial Kitchens

- **Encourage early replacement.** A key barrier to program participation is the tendency of restaurants to wait until equipment fails to replace it, rather than proactively adopting new energy efficient equipment. Our behavior optimization research yielded key suggestions for PSE to consider, including: (1) Focusing on the non-energy benefits, not just the financial case for early replacement, (2) acknowledging the customer's attachment to existing equipment because of "sunk costs", (3) framing benefits in terms of loss to leverage loss-aversion tendencies.
- **Address vendor concerns.** During trade ally Interviews, vendors in the Kitchen program had several complaints and suggestions for improvement which PSE should follow-up on and develop strategies to mitigate.

Best practice considerations for Commercial Kitchens

- **Improve in-store signage and marketing.** The program manager suggested improved and expanded in-store signage and marketing as key areas for growth in the next biennium. Our behavior optimization research on the subject yielded several key recommendations for PSE to consider, including: (1) limiting choices to avoid "choice overload", (2) employing trusted sources and non-product-affiliated recommendations, (3) strategically choosing optimal positioning of products in the store.

Recommendations for targeting remaining T12 commercial lighting stock

- **Allow T12s their natural decline.** Our lighting modeling analysis team's work demonstrated that the prevalence of T12 lighting is extremely low and on the decline. Because this type of lighting will be mostly absent from the commercial lighting stock as of 2020, it may not be cost-effective to take a targeted approach to lowering the T12 lighting stock.

  -OR-

- **Target hi-bay and low-bay lighting in Industrial buildings.** If PSE desires to hasten the decline of T12 commercial lighting stocks, the most advantageous and cost-effective approach, may be to target hi-bay and lo-bay T12 lighting in Industrial spaces

Recommendations to improve future evaluations

- **Develop a method to maintain business cases and have projects reference the correct version.** PSE should consider creating a master tracker document that provides the file location, lead author, version number, and date of all business cases. PSE should also define the date range across which each version should be used in reported savings, to eliminate projects referencing deemed values from outdated versions of a business case.
- **Eliminating contractor misperceptions.** While analyzing data collected during trade ally interviews, we realized that a large portion of Commercial HVAC contractors were answering our questions with the Custom Grants program in mind. For future evaluations, we recommend (1) the program do more to educate contractors about the difference between programs so contractors are fully aware of which program they are participating in; (2) have the process evaluation team anticipate lack of a clear distinction between programs from the contractors' perspectives, and design questions to explicitly remind them to comment only on the prescriptive program.
- **Sub-Program Differentiation.** Our team learned that sub-programs vary tremendously in terms of design, intent, audience, incentive mechanism, marketing and outreach strategies, delivery and dependence on trade allies. Even in interviewing program managers, we were repeatedly asked why we were referring to their sub-program as a "sub-program" rather than a "program." This revealed that program managers view their sub-programs within the Commercial Rebate program as independent and only loosely linked to a larger program umbrella. In future evaluations, we encourage the process evaluation team to think about these programs in a more autonomous manner from the start of the evaluation and to define different key research questions and areas of inquiry for each sub-program. We suggest drawing parallels and commonalities between them at the end of the evaluation rather than at its start.

Best practice considerations to improve future evaluations

- **Expand parameters included in tracking data.** The evaluation team recommends PSE collect the same level of information for each sub-program as it currently collects for the DI sub-programs. Tracking data at minimum should include, site contact details (Name, Phone and Email), measure location, and unit details.
- **Improve contact information.** The primary challenge to conducting the process evaluation was accessing accurate contact information from the program database. Improving contact data in the database can also support program staff in conducting follow-up outreach to customers and market actors after project completion.

- **Track project contact email address.** Program managers should collect email addresses for the participant contact. Full contact information for participants would allow for easier follow-up communications from program staff and evaluators.

Evaluation of PSE's PY2016/17 Commercial Rebate and New Construction Programs – Appendices

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APPENDIX A. IMPACT EVALUATION APPROACH & ANALYSIS

Our team used the approaches summarized in Table 1 and Table 2 to assess the impacts achieved through PSE's New Construction and Commercial Rebates program respectively. The remainder of this appendix describes these approaches in detail.

Table 1: NCx Program - Summary of Impact Evaluation Approach

Strata	Tracking Database Review	Engineering Review	Billing Analysis	Participant Interview	Literature Review
Commercial	✓	✓	✓		
Multifamily	✓	✓	✓		
Indoor Horticulture	✓	✓	✓	✓	✓

Source: Navigant

Table 2: Commercial Rebate Program - Summary of Impact Evaluation Approach

Sub-Program	Tracking Database Review	Engineering Review	Installation and Operational Verification	Customer Interview	Literature Review
SBDI	✓	✓	✓	✓	✓
Lodging Direct Install (LDI)	✓	✓	✓		
Commercial HVAC	✓	✓	✓		
Kitchen & Laundry - Commercial Cooking Equipment	✓	✓	✓		
Hospitality Rebates	✓	✓	✓ (e)		
Kitchen & Laundry - Commercial Laundry Rebate	✓	✓	✓		
Premium HVAC	✓	✓	✓		
Agriculture Direct Install (ADI)*	✓	-	-		

Notes: (e) Indicates electric measures only

* ADI program had a very low participation in 2016-17 biennium. This program is slated to be incorporated in the SBDI program for next biennium. Thus, team did not include ADI in the Engineering Review as well as Installation and Operational Verification task.

Source: Navigant

A.1 Tracking System and Database Review

Our evaluation team reviewed PSE's databases and any additional data required for the tracking and reporting of ex ante savings. The team performed quality control checks on the tracking system and database to ensure that savings are being tracked correctly (e.g. no data entry errors, no duplicate line items). The team then created and shared summary tables and charts with PSE staff to confirm reported savings by program, sub-program, fuel type and program year.

For the New Construction program, discrepancies identified at this stage included differences between program-level summaries derived using tracked savings and those presented in summary tables included in the RFP.

For the Commercial Rebate program, other issues were encountered, which we summarize here.

There are three separate tracking system types which PSE uses across the Commercial Rebate sub-programs:

- All Direct Install Programs (SBDI, LDI & ADI),
- All Non- DI programs: Com. HVAC, Kitchen and Laundry, Hospitability Rebates, and;
- Premium HVAC Program.

These three tracking data systems have different sets of data field. Most sub-programs have significant overlap in the fields they capture, (e.g. contact details, Measure Name, Savings, Project Details, etc.), but Premium HVAC is significantly different and captures the least amount of data.

The following figure shows our findings from the review of these tracking databases.

Figure 1: Findings from Tracking Data Review of Commercial Rebate Program

DI Programs

- Out of total 930* customers for SBDI, LDI and ADI combined, ~700 are missing email addresses.

Non-DI Programs

- All projects are missing contact emails for tenant and owner.
- This tracking system contains too many contact details (Tenant, Owner, Payee, Vendor) compared to similar DI programs offered by other utilities.
- Installation location for the installed measures is not provided

Prem. HVAC

- This data has least amount of information, only include project details, site address, brief measure names and savings.
- Site contact names and details are missing.
- Installation/measure location are not provided.
- HVAC units details such as tonnage, make and model are not provided.**

** PY2016 tracking data.*

*** These details are available in the individual project files that PSE provided.*

Source: Navigant analysis

A.2 Engineering Review

As a part of our engineering review, our team conducted a thorough assessment of all deemed savings, models and calculation assumptions[1] used to estimate impacts across a representative sample of

[1] This included a review of all critical input files and supporting documents, including application materials, simulation files, schematic designs, and utility data.

projects. Our team then re-created the ex-ante savings estimates for this sample. Finally, our engineers reviewed the ex-ante methodologies against industry standards and accepted engineering practices.

Ultimately, our engineers uncovered several discrepancies and other issues within the business case files. The comprehensive list of discrepancies and issues detailed in this section were brought to and ultimately resolved with PSE through discussion and the collection of additional data or project documentation, when needed. For the select business cases that were never provided, the evaluation team used the unit energy savings workbooks provided by the Regional Technical Forum (RTF).[2]

New Construction Program

Multifamily NCx projects often referenced deemed measures for which PSE could not provide business cases, including those listed in Table 3.

Table 3: Multifamily Measures Missing 2014/15 Deemed Savings

Measure Name
Energy Star hard-wired CFL fixture - TCt 69
Clothes Washer 2.4+ MEF CEE TIER3
Clothes Washer MEF 2.46+ WF 4- EWH/Edryer 92kWh
Stairwell bi-level >3

Source: Navigant analysis

Commercial Rebate Program

The team found that some projects within the SBDI, Commercial Kitchen and Hospitability sub-programs, reported savings from old business cases (which were retired prior to 2016-17 biennium). The team evaluated these measures using updated savings from current business cases relevant to the 2016/17 biennium. The following figure shows the team's additional findings from the engineering review.

Figure 2: Engineering Review – Overall Findings

Up-to-Date Savings	SBDI Refrigeration Measures	Waste Heat Factors	Exterior Lighting HOU
• Most of the business cases are up to date with the industry standard and require low or no revision.	• All refrigeration measures (except LED lighting) are coded out by IECC 2015. PSE may consider removing these measures starting next biennium.	• All interior lighting business cases do not include an HVAC interactive effect for the interior spaces.	• For exterior lighting measures, PSE's business case uses 4200 annual HOUs. The team used astrological sunrise-sunset hours for the PSE's territory to calculate the HOUs (4,656) for the exterior lighting.

Source: Navigant analysis

[2] https://rtf.nwcouncil.org/work-products

The team also mapped tracked savings by measure to the current business case savings. The majority mapped directly, however, there are few discrepancies which are highlighted in the figure below:

Figure 3: Engineering Review – Mapping Tracking Data to Business Cases

SBDI	LDI	Non-DI Programs
• For exterior LED wall pack measures, savings are coming from older business case dated 1/2014 as opposed to the current LED Wall Pack business case. • Significant number of measures still use savings from older business cases.	• PSE tracking data claims 937 kWh/unit for "LGDI: Fixture - LED - Wall Pack - Photocell - 60w" whereas the business case lists 970 kWh/unit. Navigant and PSE reviewed this measure but were not able to reconcile the 937 value.	• For Hospitability, the tracking data is using the 222 kWh/hr PY2015 value and not the current 260 kWh/unit. • For Com. HVAC, current savings for 2016 projects are calculated using 2014 business case.* • For Com. Kitchen, 12 measures (out of 33) are using older savings which were retired in 2015.

** New update for 2017 is included in the business cases but it was not applicable for the 2016 projects.*
Source: Navigant analysis

A.3 Billing Analysis

Navigant performed billing analysis for the four Commercial NCx projects for which simulation models were not available. Our engineers used the following methodology.

- Processed the energy consumption data and historical weather data of relevant site location on a monthly-basis to ensure that data represents a valid post-occupancy period
- Regressed the monthly energy consumption data against the monthly historical weather data to create a reasonable regression relationship using the following equation:

$$E_i = a * HDD_i + b * CDD_i + c$$

where,

E_i	=	Monthly energy consumption
HDD_i	=	Monthly heating degree days
CDD_i	=	Monthly cooling degree days
a, b, c	=	Coefficients obtained from regression
i	=	Month serial number, 1,2,3…

- Predicted the monthly energy consumption of the post-occupancy period using the Typical Meteorological Year 3 (TMY3) data
- Calculated the annual energy consumption of the post-occupancy period
- Estimated the project savings using best available data for baseline assumptions

- The assumptions align with PSE's assumptions or calculations and are summarized in the table below.

Table 4: Billing Data Analysis for Four Sampled Commercial NCx Projects

Project Number	Sub Program	Realization Rate	PSE or Implementer Methodology	Findings
880720	Commercial Gas	109%	An eQUEST building energy simulation was provided to PSE for this project. But PSE recognized that utilizing billing data of actual similar buildings should be more reliable than the building energy model. PSE used the energy use intensity (EUI) and bill histories for multiple buildings with similar end uses as this facility's.	Navigant calculated post-occupancy energy consumption for domestic hot water (DHW) and space heating using PSE's gas consumption assumptions of 41% DHW, 41% ventilation and 18% space heating. Using the post-occupancy end use data, Navigant backed out the baseline energy use and calculated savings as the difference.
770967	Commercial Gas	180%	This is a whole building design project. The implementer used an eQUEST building energy simulation. However, the implementer only modeled 40,000 square feet of total conditioned space (52,426 square feet) and converted simulation results to the whole building energy use by multiplying a ratio of 52,426 and 40,000.	The billing data analysis indicates that the building energy simulation approach claims much lower savings. Navigant believes this discrepancy is reasonable due to the nature of the multiplier in the ex-ante savings calculation.
994907	Commercial Electric	96%	The implementer used an eQUEST building energy simulation.	The eQUEST building energy models were not provided for this project.
868056	Commercial Electric	123%	Two measures were implemented for this project, one for the design plus construction phase and one for the post-construction phase. Simulated results were used for both construction phase and post-occupancy phase savings but the savings from the construction phase were adjusted by using the billing history of this building. Savings of post-occupancy phase savings were still simulated savings.	Navigant calculated the savings for commissioning phase and post-occupancy phase using PSE's assumption that this facility has estimated 3% savings for commissioning in the construction phase and 5% savings for commissioning in the post-occupancy phase.

Source: Navigant analysis

A.4 Phone Interviews

After reviewing all available project documentation, including billing data, for each sampled indoor horticulture project, the team conducted phone interviews with a sample of participants. The team worked directly with PSE to scope, design and finalize the interview questions, as well as to include select process evaluation questions to enhance PSE's understanding of this expanding customer segment.

A.5 Literature Review

Our team drew upon our comprehensive collection of secondary data to review and vet all relevant measure-life assumptions and claims. The sources for this literature review included all pertinent sources tracked by the RTF, as well as related studies or past evaluations and technical reference material.

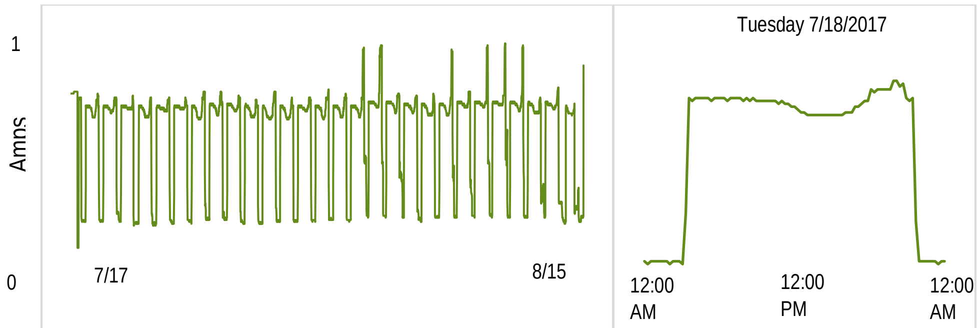
A.6 Develop a Uniform Method for Determining Operating Hours for Lights in Indoor Horticulture Projects

Our team used a three-part approach to determine lighting operating hours for indoor horticulture projects.

1. **Phone surveys**: Our team conducted phone interviews with key contacts at indoor horticulture sites to ascertain typical lighting operating hours, HVAC system types, operating schedules and setpoints. We recognize that, in typical commercial evaluations, self-reported estimates can be very uncertain. However, in the indoor horticulture industry, we found that facility operators are very knowledgeable about the specific operating characteristics of their facilities, and particularly precise when estimating lighting operating hours (as verified by our billing data analysis).
2. **Literature review and expert interviews:** Our team performed a literature review as well as select interviews with expert contacts in the industry, where possible, to further determine standard operating hours. The team began with an in-depth interview of an industry expert to understand the context of the industry, baseline issues, perception of LEDs in the industry, lighting power density and photosynthetic active radiation (PAR). Members of our team interviewed additional industry experts at the EUCI Cannabis Industry Energy Challenge in San Francisco and the Cannabis Sustainability Symposium in Denver in October of 2017.
3. **Billing analysis**: Our team requested metered data at hourly intervals for all sites in our indoor horticulture sample. We analyzed these data to determine hours of operation trends, and corroborate information gathered through phone interviews, literature review, and expert interviews. As lighting is one of the primary energy end uses for these facilities, the lighting hours of operation were evident in many sites without complex end-use disaggregation. Certain sites had corrupt data or trends that were indiscernible, often due to staggered lighting schedules. Of the 33 sites in the sample, 14 sites had corrupt or inappropriate data, and of the remaining sites, the team could reliably discern lighting operating hour trends from 7 sites.

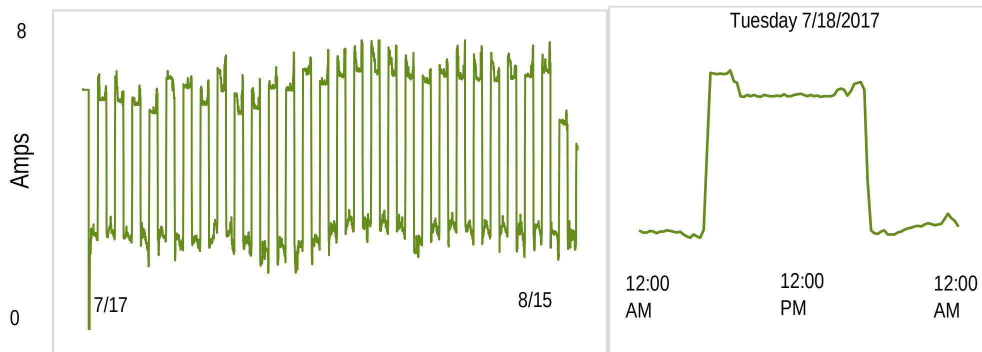
   The billing data that was decipherable indicated usage intervals of 12, 18, 20, and 24 or 12/12 hours per day. (12/12 indicates 12 hours on and 12 hours off, but alternated between two rooms which would reflect as 24 hours per day in billing data.)

Figure 4: Billing Analysis Data Showing a 24-hour Base-Load and an 18-hour per day Additional Load



Source; Navigant analysis

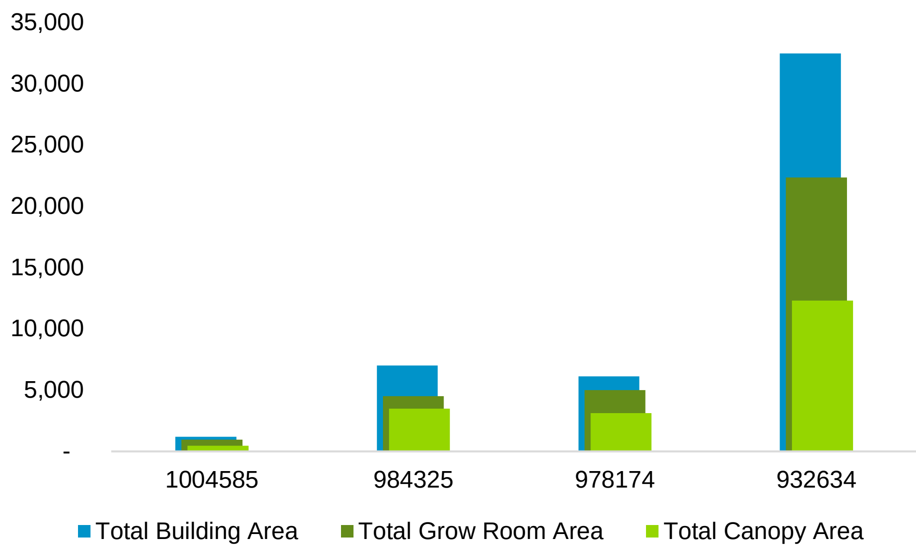
Figure 5: Billing Analysis Data Showing a 24-hour Baseload and a 12-hour per day Additional Load



Source; Navigant analysis

Our interviews and analysis also revealed that grow room floorspace can range from 69-82% of building area, and that, for single level structures, canopy area can range from 49-78% of grow room area and 38-51% of total building floorspace.

Figure 6: Building, Grow Room, and Canopy Area of Interviewed Sites



**Project 1009762 was excluded here as they utilize multi-level rack systems, resulting in canopy areas exceeding both grow room and building areas.*
Source; Navigant analysis

Note: The evaluation team sampled indoor horticulture projects from the 2014/15 biennium, as the team originally intended to use post-consumption billing data to help evaluate the savings achieved by these projects. Because of this and the methodological change PSE program staff implemented in the savings estimation of 2016/17 indoor horticulture projects, the evaluation team recalculated the reported savings for the sampled 2014/15 projects using PSE's 16/17 methodology. This allowed the evaluation team to extrapolate the realization rates of the sampled projects to the 16/17 population and provide a more meaningful realization rate for program staff. The following table presents the reported savings across these biennia.

Table 5: Comparison of Saving Using

Biennium Savings Calculation Method	Reported Savings	Verified Savings	Realization Rate
14/15	9,777,359	5,725,195	59%
16/17	11,293,011*	5,725,195	51%

Source: Navigant analysis and PSE tracking data
**Recalculated*

The reduction in realization rates across the biennia for these projects is the result of PSE's implementation of the 3.3 baseline factor for non-flowering spaces in the 16/17 biennium. The evaluation activities do not support this high ratio of efficient wattage to baseline wattage in these spaces, and instead the evaluation team uses PSE's 1.8 baseline factor for all grow spaces in the sampled projects. Additional discussion is provided in Section 2.1.1.1.

A.7 HVAC Interaction Factor Modeling for Indoor Horticulture Projects

Our team used project documentation and participant interviews to identify the top two most common HVAC system types found in the PSE program participant population, specifically a variable refrigerant volume (VRF) system and free-cooling.

Our data analysts used the following methodology to derive a set of representative HVAC interactive factors for indoor horticulture projects:

- Create two models; one using a VRF system and the other using free-cooling
- Use the hourly lighting profiles developed as a part of this evaluation
- Simulate two versions of the building, one with baseline lighting and one with efficient lighting (e.g. code minimum LPD from high pressure sodium bulbs compared to LED bulb LPD achieved through the NCx program)
- Compare HVAC and lighting loads from both versions to establish the interaction factor (e.g. X% reduction in LPD yields Y% decrease in HVAC energy consumption)
- Develop a recommended interaction factor by HVAC system type

Table 6 summarizes the EnergyPlus model inputs used.

Table 6: EnergyPlus Model Inputs for the VRF system

Model Inputs	Data	Data Source
EnergyPlus Version	Version 8.6[3]	Navigant Study; 8,760 hours of simulation
Building Type	Indoor Horticulture Faculty	PSE NC Program
Site Location	Seattle, WA, USA	PSE NC Program
Weather Data	USA_WA_Seattle-Tacoma.Intl.AP.727930_TMY3.epw	Weather data in EnergyPlus weather format[4]
Total Building Area	11,303 Square Feet	Navigant's phone surveys
Space types	• Small Office; 538 square feet • Storage (storage, restrooms, mechanical, electrical, et al); 2,692 square feet • Grow room (flowering and non-flowering room); 8,074 square feet	Navigant's phone surveys
Lighting Power Density	• 42 Watts per Square feet for baseline model • 0.6 Watts per Square feet for office and storage spaces	Navigant's evaluations

[3] EnergyPlus Software Version 8.6. https://energyplus.net/downloads

[4] Weather Data in EnergyPlus Weather Format. https://energyplus.net/weather

Model Inputs	Data	Data Source
Lighting Operating Hours	• 15 hours for grow room (5:00am – 8:00 pm) • 8 hours for office and storage spaces (9:00am – 5:00pm); same as building operation schedule	Navigant's phone surveys
Building Operation Schedule	9:00am – 5:00pm	Navigant's phone surveys
HVAC Operation Schedule	• 24 hours for grow room • 8 hours for office and storage spaces (9:00am – 5:00pm)	Navigant's phone surveys
HVAC System Types	Multi-splits Variable Refrigerant Flow with Heat Recovery and Fluid Temperature Control	Navigant's phone surveys
Space Thermostats	• 70 F for Grow Room heating • 70 F for Grow Room cooling	Navigant's research
Fan Types	Variable Volume Fans	Navigant's research
Fan Operation Schedule	24/7	Navigant's phone surveys

Source: Navigant's Phone Surveys and Evaluations

The only difference between the energy model with the VRF system and the model used to estimate a free-cooling site is the HVAC system.

The team used parametric model runs to develop an HVAC interaction factor by bulb, independent of the number of bulbs installed. To do this, we iteratively reduced lighting power densities (LPDs) of the model. Our team calculated the decrease of HVAC energy consumption for each iterative case and compared the HVAC energy consumption decrease with the lighting energy consumption decrease. For each scenario, the interaction factor was calculated using the following equation.

$$HVAC\ Interaction\ Factor = 1 + \frac{Decrease\ in\ HVAC\ Energy\ Consumption}{Decrease\ in\ Lighting\ Energy\ Consumption}$$

The following table provides the results of this modeling.

LPD Percent Reduction	Derived HVAC Interactive Effect VRF System	Derived HVAC Interactive Effect Free-Cooling
40%	1.30	N/A*
50%	1.31	N/A*
60%	1.32	1.47
70%	1.32	1.40
80%	1.31	1.35

Source: Navigant analysis
**The team only calculated HVAC IFs for large LPD reductions, to acknowledge the fact that the opportunity to reduce or eliminate mechanical cooling in these facilities only exists where heat gain from lights is very low.*

The team recommends that PSE adopt a HVAC interactive factor of 1.3 for projects with VRF or unknown HVAC systems, and 1.4 for projects that are verified as using free-cooling.

A.8 Installation and Operation Verification of Commercial Rebate Projects

The evaluation team visited 102 sites between July-August 2017. The following table shows the breakdown of completed site visits by each program.

Table 7: Commercial Rebate Program Installation Verification Site Visits – Achieved Sample

Program	Sample Size*
SBDI	70
LDI	8
Com. Kitchen & Laundry	17
Com. HVAC	3
Prem. HVAC	3
Hospitability	1
Overall	**102**

** Combined sample for Gas and Electric. There are many projects across these programs that were selected for electric as well as gas savings to optimize the sample and reduce customer burden.*

Source: Navigant

For each sampled site, our field technicians:

- Confirmed the total number of installed incented measures
- Quantified measures that were installed but later removed
- Identified measures that were improperly installed or are no longer operating
- Recognized measures that did not match those identified in the tracking database

The following figure shows the installation verification findings from these visits.

Figure 7: Commercial Rebate Program Installation Verification Site Visit Findings

SBDI

- Overall, installed quantities matched tracking data with only a few minor discrepancies. For a DI program, a few discrepancies are common as project scope and other conditions can change during the project implementation.
- At four SBDI sites, field staff found out that no measures were installed.
- One site removed installed showerheads due to customer dissatisfaction.

LDI

- Five out of eight sites reported duplicated quantites in the tracking data. With PSE's help, Navigant understood that this duplication occurred in the tracking system and not during the project implementation.

Non-DI Programs

- The team found that the verified quantities from the fieldwork match tracking data (except one project in the Commercial Kitchen program).
- For four Commerical Kitchen projects, the team found installed measure is slightly different than reported measure.

Source: Navigant analysis

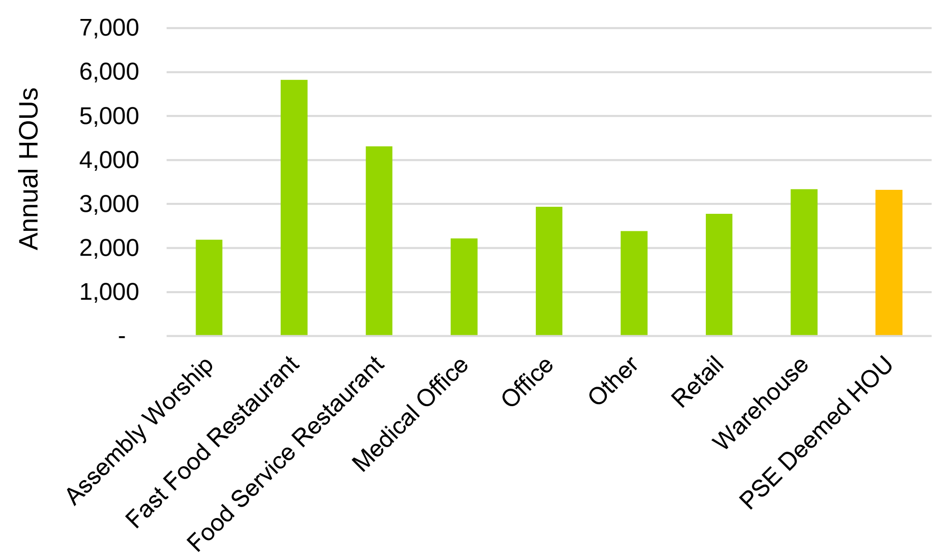
In addition to visual verification and inspection, our team conducted brief interviews with key site contacts to better understand lighting schedules and business operating hours.

A.9 Evaluate the SBDI Program's Current Business Operating Hours Estimates

During the on-site visits, our team interviewed site contacts to derive a customer-reported estimate of operating hours. Our team compared the customer-reported values with the program's operating hour assumptions for each sampled SBDI project. Our engineers then compared the current operating hour assumptions across SBDI with values available from a relevant metering study.

The following figure shows the comparison of PSE's HOU estimate to the customer-reported HOUs by building type for 54 sites.

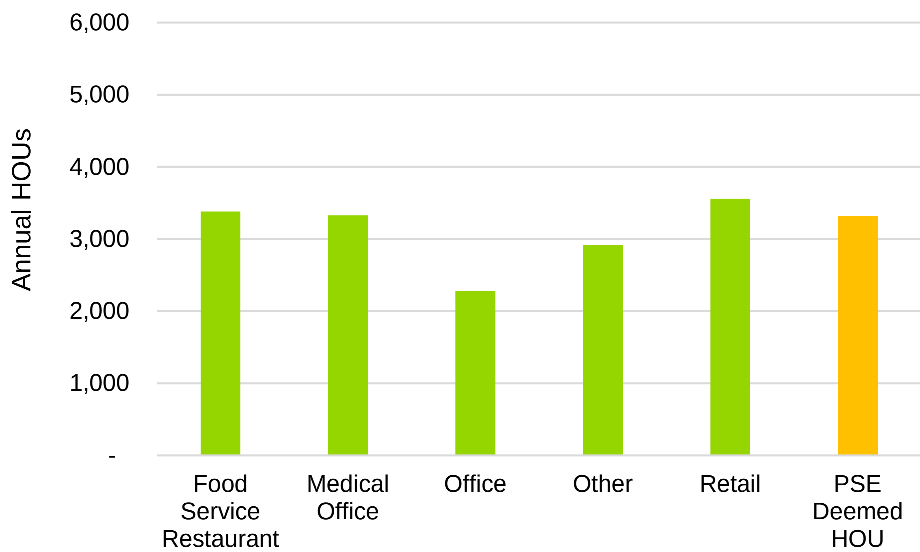
Figure 8: SBDI - Customer Reported HOUs and Deemed HOU Comparison (n = 54)



Source: Navigant analysis

During the on-site visits for SBDI sample, site visit engineer asked the site contacts about the operating hours of the facility. With the data collected from onsite visits, our team derived a customer-reported estimate of operating hours. There were fourteen sites (out of 68 total) where our site visit engineer was not able to interview the site contact. For these sites, we used online research to look-up the hours of use for the sites. The following figure shows the comparison of PSE's HOU estimate to HOUs by building type for the 14 sites where the team could confirm business operating schedules using online research.

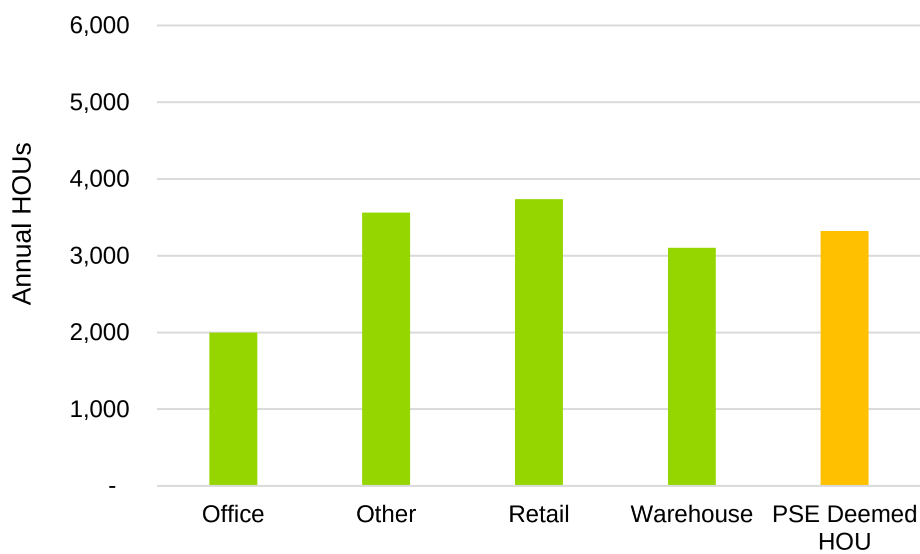
Figure 9: SBDI - Researched HOUs and Deemed HOU Comparison (n = 14)



Source: Navigant analysis

The team also sourced actual metered data from Navigant's evaluation of a similar SBDI program. The following figure shows the comparison of PSE's HOU estimate to metered HOUs for the 24 sites included in that study.

Figure 10: Comparison of PSE Deemed HOU and Metered data from an impact evaluation of another utility



Source: Navigant analysis

Our team found that PSE's estimate of 3,317 annual HOU for the SBDI program is reasonable and within 3% of the average unweighted customer-reported value of 3,248. The evaluation team recommends PSE continue using the current deemed estimate and consider updating it after the next round of CBSA data is available.

APPENDIX B. PROCESSS EVALUATION APPROACH

Our team used the approaches summarized in Table 8 and Table 9 to form the process evaluation of PSE's New Construction and Commercial Rebates programs respectively. The remainder of this appendix describes these approaches in detail.

Table 8: NCx Program - Summary of Process Evaluation Approach

Activity	Objective
Program Theory and Logic Model Review	Document program goals, activities and desired outcomes.
Program Materials, Document and Tracking Data Review	Form an understanding of the program design and implementation based on documentation and participation data.
Program Manager Interviews	Understand the program implementation experience and any evaluation priorities.
Participant Survey	Characterize the participant experience.
Best Practices and Behavior Optimization	Gather data on peer and best practice implementation strategies.

Source: EMI

Table 9: Commercial Rebate Program - Summary of Process Evaluation Approach

Activity	Objective
Program Theory and Logic Model Review	Document program goals, activities and desired outcomes.
Program Materials, Document and Tracking Data Review	Form an understanding of the program design and implementation based on documentation and participation data.
Program Manager and Implementation Contractor Interviews	Understand the program implementation experience and any evaluation priorities.
Trade Ally Interviews	Gain insights into the trade ally experience and motivation for participation.
Participant Survey	Characterize the participant experience.
Lighting Market Modeling	Understand the extent of T-12 linear fluorescent lighting still in use in commercial buildings in PSE's service territory
Best Practices and Behavior Optimization	Gather data on peer and best practice implementation strategies.

Source: Navigant

B.1 Program Theory and Logic Model Development

The first task of the process evaluation was to develop a logic model for each sub-program. Our team used program data and staff interviews to develop models, and ultimately provided them in draft and final memos to PSE. These memos also provided a discussion of the program theory, and the explanation of why the program design will lead to intended outcomes. The full memos can be found in Appendix D and E.

The program theory and logic models were used to help determine key research questions and guide the subsequent process evaluation activities described below.

B.2 Program Materials, Documents, and Tracking System

To help develop evaluation plan and sampling, the evaluation team collected and reviewed program application documentation materials and participation data from program managers. The evaluation reviewed the following sources:

1. Program Participation Data 2012-2017
2. Program Application Materials

The team collected any issues found between these reviews and those conducted for the impact analysis. These issues were ultimately brought to and resolved with PSE during this evaluation.

B.3 Program Manager In-Depth Interviews

To evaluate current program processes, the evaluation team conducted in-depth interviews with program managers across the evaluated programs. Specific research questions for program managers targeted:

1. Gathering data on program activities, program logic, and program staff roles and responsibilities.
2. Identifying available program documentation and a process for obtaining the data.
3. Identifying challenges staff face in implementing the program and opportunities for improvement.
    a. Guide evaluation efforts.
    b. Identify research topics that could be addressed through the participant survey and peer utility interviews
    c. Identify possible peer utilities and topics for inclusion in the best practices secondary research
    d. Identify areas of concern or curiosity with respect to savings estimates, to establish priorities for the impact evaluation.

B.4 Participant Surveys

To evaluate current participant experiences, the evaluation team distributed an online survey to previous program participants. Specific research questions for participant interviews included:

1. What are sources of awareness for the program?
2. What are motivations and influencers for program participation?
3. What are barriers to program participation?
4. How satisfied are customers with the program?

The target and achieved samples for the participant surveys are provided in Appendix C.

B.5 Trade Ally In-Depth Interviews

The evaluation team conducted interviews with a sample of trade allies to gather insights into their experience, motivation for participation, and trends and issues they observe during the day-to-day operation in the program. In addition, we gathered information on trade allies' motivations for participation, positive and negative experiences with the program, suggestions for program improvement, and ideas for increasing customer participation. We presented our findings from this activity in draft and final memos presented to PSE and included in Appendix D and E.

B.6 Best Practices and Behavior Optimization

As part of the best practices and behavior optimization activity, the evaluation team completed three tasks: peer program interviews, market actor interviews, and a literature review. This section outlines the methodology for each.

B.6.1 In-Depth Peer Program Interview Methodology

To evaluate key performance metrics, the evaluation team conducted in-depth interviews with staff from peer programs. The purpose of these interviews was to benchmark PSE's programs against other similar programs and to gather best practices employed by peer programs. Specific research questions included:

1. **Total Annual Energy Savings –** what were the annual savings from 2016 captured by each program?
2. **Total Participation –** what were the total number of projects processed through the PSE program and through the peer programs in 2016
3. **Program Penetration –** what were the total number of annual projects paid through the program in 2016 compared to the number of new construction starts in the same year?
4. **Cost of Acquisition –** what were the total program costs including grants, staffing, and other overhead costs divided by the total energy savings?
5. **Direct Benefit to Customers –** what were the proportion of customer benefits (design grants, for NCx) relative to total program budget
6. **Outreach Activity and Targets –** what marketing & outreach activities do peer programs conduct for their NCx programs?
7. **Point of Entry-** at what point in the new construction process are participants recruited and/or enrolled in the programs?
8. **Market Actor Participation –** what is the program participation by market actor?
9. **Incentive Basis –** what are peer NCx program incentive structures?
10. **Best Practices –** what are best practices employed by peer programs to overcome stringent code, reach market actors early in design, and increase program participation?

B.6.2 In-Depth Market Actor Interview Methodology

To evaluate best practices, the evaluation team conducted in-depth interviews with market actors. Specific research questions for the market actor interviews included:

1. What are current design and building practices based on current codes and opportunities to move the market beyond code?
2. What are strategies for increasing participation/program penetration?
3. What are strategies for communicating to and engaging trade allies & other market actors?
4. What is the ideal population for targeted outreach (building owners, trade allies, etc.)?

B.6.3 Literature Review (New Construction Program only)

As a part of the NCs program evaluation, the team analyzed literature on best practices for incorporating energy efficient designs in new construction projects. The evaluation reviewed the following sources:

1. Andrejko et al. (2012). An Architect's guide to Integrating Energy Modeling in the Design Process. The American Institute of Architects. Retrieved from http://aiad8.prod.acquia-sites.com/sites/default/files/2016-04/Energy-Modeling-Design-Process-Guide.pdf
2. Strecker, C. (2014). The Good, Better and Best Ways to Overcome Barriers in the Small Commercial Market. ACEEE Summer Study on Energy Efficiency in Buildings. Retrieved from http://aceee.org/files/proceedings/2014/data/papers/4-1146.pd
3. Bueren, E. & Priemus, H. (2001). Institutional barriers to sustainable construction. Environment and Planning B: Planning and Design. 2002, volume 29, pages 75-86.
4. Hoffman, A. J. & Henn, R. (2008). Overcoming the Social and Psychological Barriers to Green Building. Organization & Environment. Volume 21, pages 390-419.

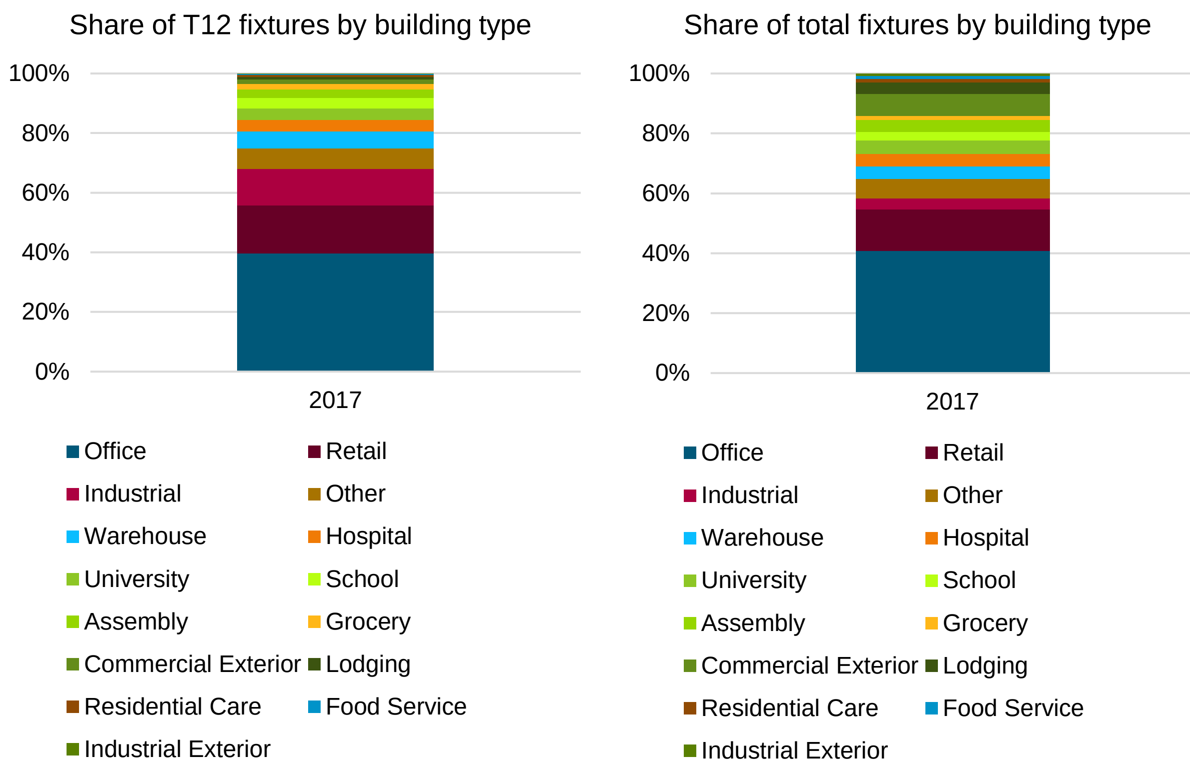
B.7 Lighting Market Modeling Analysis

Our team analyzed detailed lighting data from the PSE 2013 CBSA oversample along with regional technology trends to estimate the remaining stock of T12 lamps and fixtures in commercial and industrial buildings in PSE's service territory and to forecast changes in the T-12 lighting stock through 2020. This analysis leveraged the regional lighting market model Navigant developed with the Bonneville Power Administration[5].

High numbers of T12s generally correlate with the largest building types. This can be seen by comparing the share of T12 fixtures by building type and the share of total fixture by building type for 2017 in Figure 11. The exceptions are Industrial and Warehouse, where the share of T12s is disproportionately high, and exterior lighting, where it is disproportionately low.

[5] https://rtf.nwcouncil.org/subcommittee/market-analysis

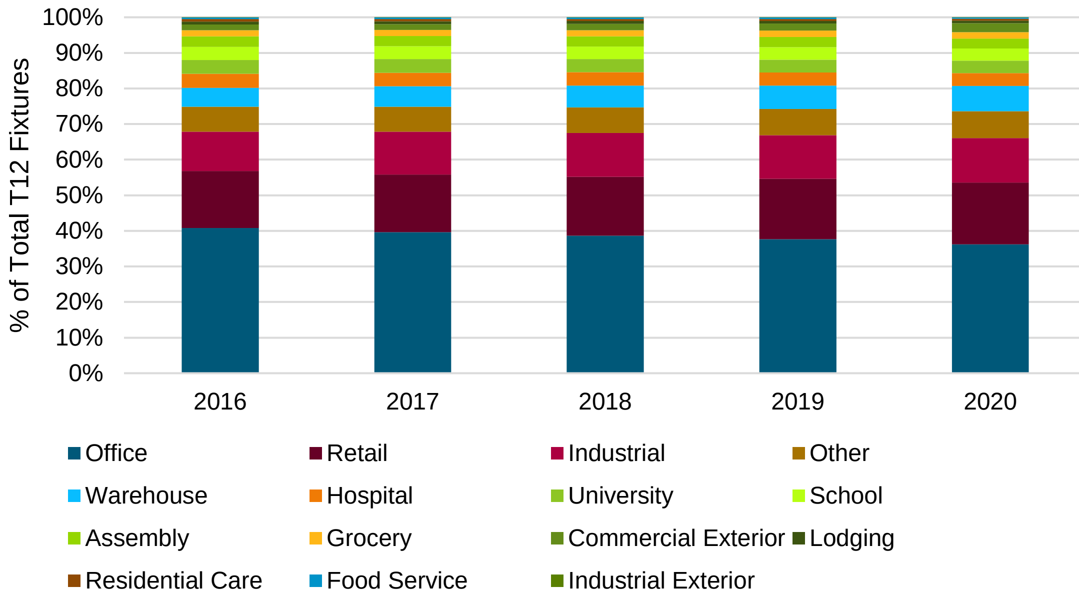
Figure 11: Comparison of T12 Fixtures and Total Fixtures by Building Type—2017



Source: Navigant analysis of PSE 2013 CBSA and regional lighting market model

Over time, the share of T12s in the Office building type is expected to decline faster than in the Industrial building type, as can be seen in Figure 12. The presence of high/low bay lighting is the primary driver in this case. The T12 density remains higher over time in building types where the high/low bay application is more common. These building types include Industrial, Warehouse, Other, and Retail. This change in share is based solely on where the different applications occur and how much of each building type is made up by each application.

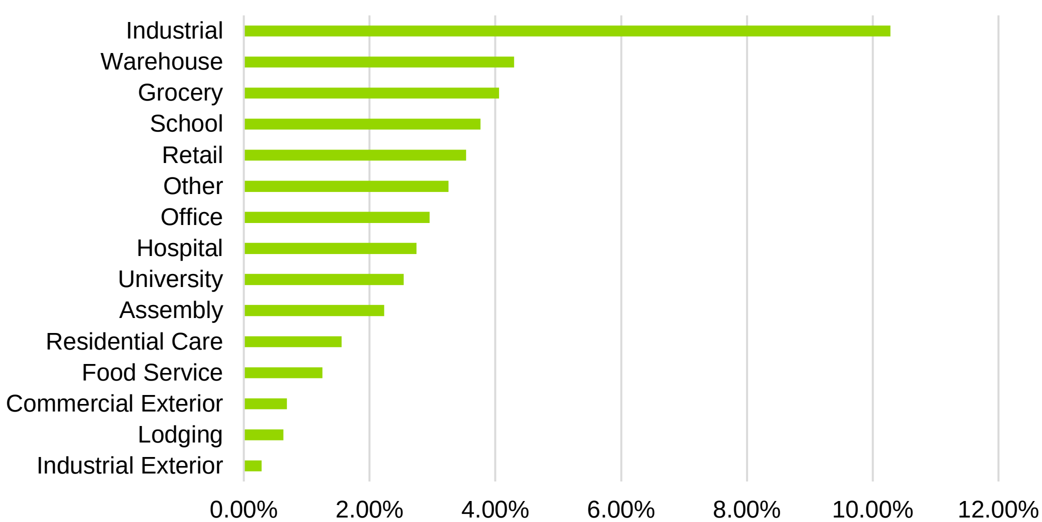
Figure 12: Forecast of T12 Fixture Distribution Across Building Types by Year



Source: Navigant analysis of PSE 2013 CBSA and regional lighting market model

Figure 13 shows the estimated T12 fixture saturation by building type, indicating where T12s are most likely to be found. While most of the T12 fixtures might be in office buildings, only about 3% of fixtures in offices are T12 compared to over 10% in industrial buildings. It is worth noting that the industrial saturation is based on IFSA data which included many fewer sites than the CBSA data, but given the magnitude of the difference between commercial and industrial buildings this difference is likely significant.

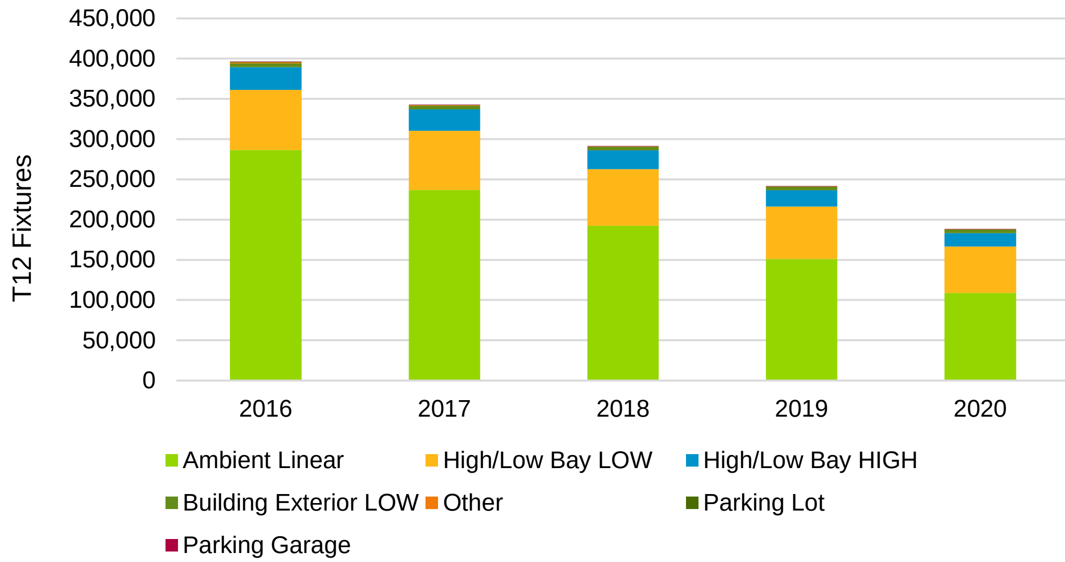
Figure 13: Estimated T12 Fixture Saturation by Building Type—2017



Source: Navigant analysis of PSE 2013 CBSA and regional lighting market model

Figure 14 show the estimated number of T12 fixtures by lighting application, accounting for what spaces within a building are most likely to have T12s. Figure 14 shows the forecasted T12 fixtures by lighting application across all commercial and industrial buildings. The Ambient Linear application has the highest number of T12 fixtures because it is the largest application in the C&I sector.

Figure 14: Forecast of T12 Fixtures by Lighting Application by Year[6]

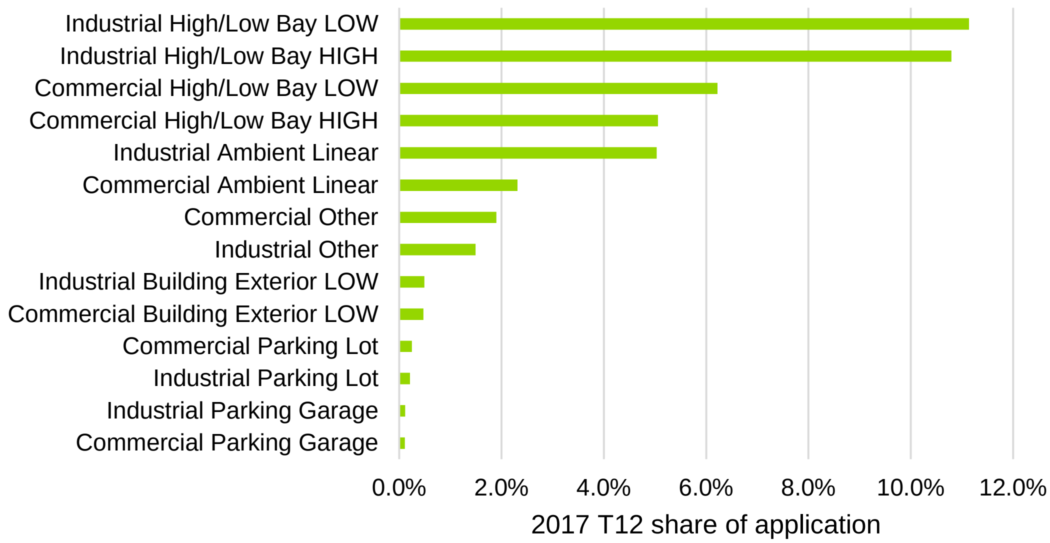


Source: Navigant analysis of PSE 2013 CBSA and regional lighting market model

While Ambient Linear has the most T12 fixtures and most of those are in the commercial sector, the share of T12s within the commercial Ambient Linear application is just 2.3% as shown in Figure 15.

[6] The LOW and HIGH after the application name refers to different lumen output categories in the same lighting application. The High/Low Bay application is split by 15,000 lumens, a 250W metal halide equivalent fixture, with 15,000 lumens and above in HIGH. The Building Exterior application is split by 7,000 lumens, a 70W high pressure sodium equivalent fixture, with 7,000 lumens and above in HIGH.

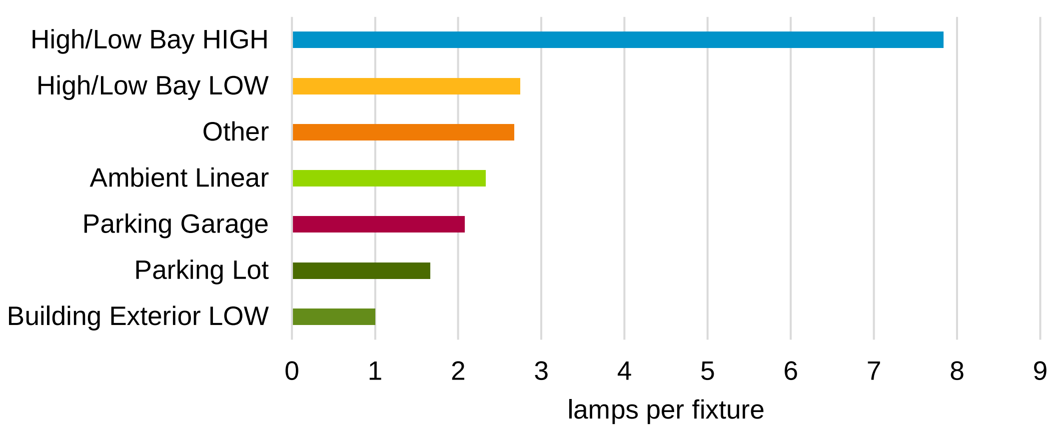
Figure 15: T12 Fixture Saturation by Application and Sector—2017



Source: Navigant analysis of PSE 2013 CBSA and regional lighting market model

Another factor to consider is the number of lamps per fixture. Figure 15 display results on a fixture basis, aligning with how most spaces are retrofitted. However, not only do the high/low bay applications have higher T12 fixture saturation, they also have more lamps per fixture which typically increases potential savings from retrofitting T12 fixtures. Navigant analyzed the CBSA data to estimate the number of lamps per fixture for T12 fixtures by application, as shown in Figure 16. This revealed that the High/Low Bay HIGH application has almost four times the number of lamp per fixture as the Ambient Linear application.

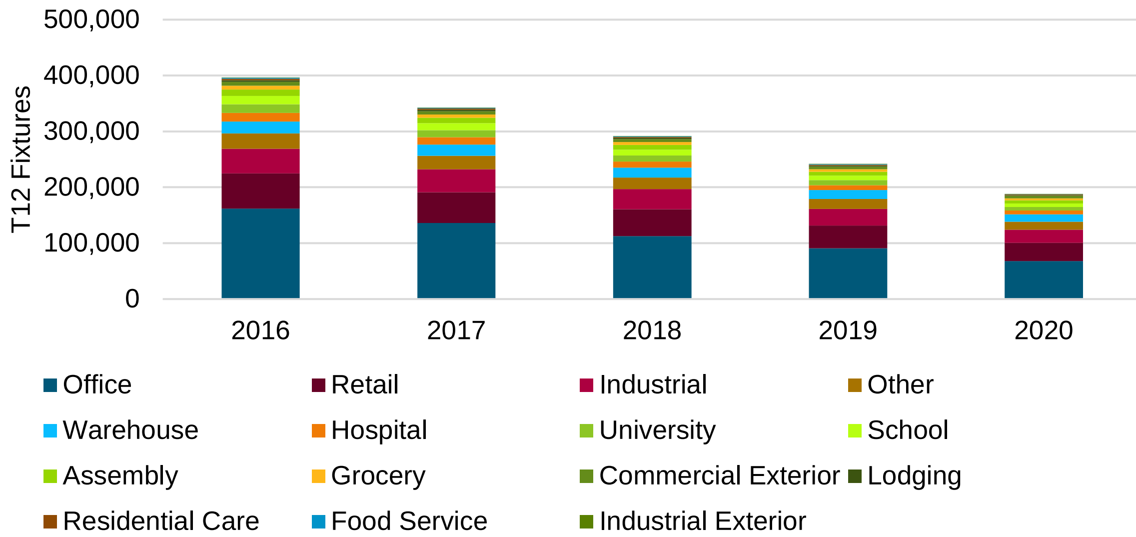
Figure 16: Approximate T12 Lamps per Fixture by Application



Source: Navigant analysis of PSE 2013 CBSA and regional lighting market model

Ultimately, we estimate that T12 fixture saturation will drop from just over 3% in 2017 to less than 2% of total PSE fixtures by 2020. This implies that fewer than 200,000 T12 fixtures will remain in PSE's territory by 2020. As shown in Figure 17, T12 saturation varies significantly by application and building type, but it appears targeting industrial high and low bay fixtures is the best remaining option to accelerate the decline in T12 saturation. That said, T12 saturation is low enough that targeting remaining fixtures with programs may not be cost-effective.

Figure 17: Forecast of T12 Fixtures in PSE C&I Service Territory



Source: Navigant analysis of PSE 2013 CBSA oversample and regional lighting market model

APPENDIX C. SAMPLE DESIGN

C.1 New Construction

C.1.1 Impact Evaluation

We developed our impact evaluation sample to target a 90 percent confidence interval with 10 percent relative precision on realization rates by fuel type (electric and gas) at the sub-program level (Commercial and Multifamily), as well as across horticulture projects. To achieve this design, we excluded the smallest premises based on contribution to savings (~5% of total), leaving a population that represents 95% of the total savings within each sub-program. Next, we sampled from the horticulture project population to target precision within that population only. Then, taking that sample, we added in savings from the Commercial sub-program and drew remaining sites from non-horticulture Commercial projects to achieve precision targets at the overall Commercial sub-program level.

A crucial step in this design was the accurate aggregation of projects to the unique premise level, as program tracking data includes certain premises with multiple measures. For our impact evaluation, a premise-level sample design allowed for the most accurate comparison of evaluated savings to claimed savings, as well as the highest chance to accurately assess measure interactions, where they may exist.

Of the PY2014/15 projects, there are 249 individual measures, located at 140 unique sites. Of these 140 sites, 24 have both electric and gas savings, and are included in both the electric and gas sampling strata. Table 10 shows the target and achieved sample by fuel type and sub-program.

Table 10. Sample Design for the Impact Evaluation of PSE NCx Program

Sub-Program	Target Number of Premises		Actual Number of Premises	
	Electric	Gas	Electric	Gas
Commercial Only	*4*	*4*	*4*	*4*
Horticulture	*8*	*N/A*	*8*	*0*
Commercial	12	4	12	4
Multifamily	10	7	10	7
Total Premises	**22**	**11**	**22**	**11**

Source: Navigant analysis of PSE New Construction program tracking data using February 2017 extract.

C.1.2 Process Evaluation

Given the relatively small number of projects, typical survey response rates and the fact that PSE did not have email contact information for all participants[7], the evaluation team planned to contact the census of PY2014 through May 2017 program participants to attempt to achieve our targets for the participant survey.

The evaluation team set a target number of responses by program subset and year for the participant survey. Setting targets by two independent criteria provides greater flexibility in reaching targets when populations are small, while allowing our team to effectively collect data from a diverse group of participants. Participants (as defined by unique email addresses) were defined by combinations of the following three variables:

- **Sub-Program:** Projects will be categorized within Commercial (including Energy Smart Grocer) or Multifamily.
- **Project Size:** Per the program design, projects receiving grants of $20,000 or more require site visits. These projects were categorized as “large” projects to reflect this difference in program processes. All other projects were categorized as “small”.
- **Whole Building (“WB,” Large projects only):** Whole building projects require an energy model, and were categorized separately from custom and prescriptive large projects to reflect this difference in program processes.

Participants who fell into multiple categories were classified by the least common project type. Participants involved in WB projects, for example, were included in the WB strata, regardless of their participation in non-WB projects. Likewise, large projects took precedence over small projects, and multifamily projects took precedence over commercial projects.

Based on the population size and assumed variation, the team targeted 34 completes to allow our team to achieve a greater than 90/15 confidence and precision level on survey results. Table 11 shows the total number of unique projects in each subset, along with the target and actual number of completes.

[7] As of March 2017, PSE has estimated email addresses will be available for approximately 70% of New Construction program participants.

Table 11: New Construction Participant Survey Targets by Program Subset

Sub-Program	Project Size	Whole Building	Population of Unique Emails	Target Number of Completes	Actual Completes
Commercial	Large (≥$20,000)	Yes	7	1	1
		No	24	6	6
	Small	No	79	19	19
Multifamily	Large (≥$20,000)	Yes	3	1	1
		No	16	2	2
	Small	No	40	5	5
Grand Total			**169**	34	**34**

Source: EMI Consulting

The evaluation team also set targets according to program year. We anticipated it would be more difficult to reach participants from earlier program years and that feedback from more recent participants will be more insightful and relevant to the program in its current state, so we adopted graduated targets, ~15% of PY2014 projects, ~20% of PY2015 projects and ~25% of PY2016 and 2017 projects.[8] Table 12 shows the total number of unique participants (as defined by email address) by program year of most recent project, along with the of target and actual number of survey completes.

Table 12: New Construction Participant Survey Targets by Program Year

Most Recent Program Year	Population of Emails	Target Number of Completes	Actual Completes
2014	43	6	8
2015	35	6	6
2016-2017	87	22	19
Grand Total	**165**	**34**	**34**

Source: EMI Consulting

Given the relatively small number of projects, the evaluation team contacted the census of PY16-17 biennium program participants (to date) to attempt to achieve our targets for the participant survey.

C.2 Commercial Rebates

C.2.1 Impact Evaluation

Our team designed the impact evaluation sample leveraging stratified ratio estimation to efficiently target a 90 percent confidence interval with 10 percent relative precision on program and fuel-level realization rates, as well as across the SBDI sub-program directly. Using this approach, we divided the PY2016 program data into subgroups (i.e. strata) and selected target sample sizes based on savings contribution, estimated uncertainty and established priority assignment. This strategy ensures that we will have

[8] 2017 data only includes participants from January-April.

evaluated the largest contributors to program performance, while also investigating a sufficient number of smaller projects that, in aggregate, could represent a substantial percentage of ex ante savings and/or uncertainty within the program. In order to make our results statistically significant for the PY16-17 biennium, our sample design was based on ex-ante savings equal to double the PY2016 Commercial Rebate reported savings, within each sub-program.[9]

Our team assigned each sub-program a coefficient of variation (CV), based on previous evaluation experience and statistical analysis of program data. Most sub-programs were assumed to have a CV equal to 0.3, a conservative assumption based on our most recent impact evaluation of PSE's Commercial Rebate program. We assumed a CV of 0.5 for the SBDI sub-program's electric projects, due to the higher expected variability of the evaluation findings. We assumed a lower CV of 0.3 for SBDI gas projects as they have a small contribution (~5%) at the program level. For LDI measures, we assume a CV of 0.5, as these programs offers measures similar to the SBDI program.

To draw the sample, our team randomly selected participating sites from the program tracking databases to meet each stratum's quota. We analyzed the resulting selections to ensure the sampled project distribution was representative of the population. Finally, to reduce customer burden, we sampled projects that contributed to our gas and electric targets simultaneously, whenever possible. Table 13 and Table 14 show the overall population, target and actual sample by sub-program and fuel-type.

Table 13: Sample Design for the Impact Evaluation of PSE Commercial Rebate Program - Electric

Sub-Program and Stratum	Population*	Ex-Ante Savings (kWh)	Target Sample	Actual Sample
SBDI Measures	889	7,013,408	68	68
Lodging Direct Install (LDI)	25	892,984	4	4
Commercial HVAC	73	621,546	3	3
Kitchen & Laundry - Commercial Cooking Equipment	58	439,733	3	3
Other (Hospitability Rebates and Premium HVAC)	23	527,410	2	2
Kitchen & Laundry - Commercial Laundry**	1	750	NA	NA
Agriculture Direct Install (ADI)**	3	31,280	NA	NA

* Number of unique customers (for DI measures) or number. of unique premises (for other sub-programs).
** Excluded from the sample due to very small contribution.
Source: Navigant analysis of PSE Commercial Rebate program tracking data using February 2017 extract.

Table 14: Sample Design for the Impact Evaluation of PSE Commercial Rebate Program - Gas

Sub-Program and Stratum	Population*	Ex-Ante Savings (Therms)	Target Sample	Actual Sample

[9] A key assumption in this sample design is that PY2017 program population will be similar to that of PY2016.

SBDI Measures	36	5,138	20	20
Kitchen & Laundry - Commercial Cooking Equipment	94	67,846	15	15
Lodging Direct Install (LDI)	12	13,531	6	6
Premium HVAC	5	13,186	3	3
Kitchen & Laundry - Commercial Laundry	1	597	1	1
Commercial HVAC**	17	82	NA	NA

* Number of unique customers (for DI measures) or number of unique premises (for other sub-programs).
** Excluded from the sample due to very small contribution.
Source: Navigant analysis of PSE Commercial Rebate program tracking data using February 2017 extract.

Our team used the evaluation activities described in Appendix A to derive both an evaluated estimate of savings as well as a realization ratio of evaluated savings to ex-ante savings for each unique sampled project. We then weighted these realization rates by project size and within each stratum to develop a stratum-level realization rate. These stratum-level level realization rates were then rolled up to the entire 2016/17 participant population to calculate the evaluated impacts.

C.2.2 Process Evaluation

Our team used the sample design summarized in Table 15 to conduct the process evaluation activities.

Table 15: Sample Design for the Process Evaluation of PSE Commercial Rebate Program

Activity	Approach	Target Sample Size	Actual Sample Size
Participant Surveys	Random Sample	100 PY2016 Participants 100 PY2017 Participants	100 PY2016 Participants 50 PY2017 Participants*
Trade Ally Interviews	Census	10 Contractors 4 Vendors	9 Contractors 5 Vendors
PM and IC Interviews	Census	4 PSE Program Staff 3 Implementer Staff	4 PSE Program Staff 3 Implementer Staff

Source: Navigant
**In December 2017, PSE staff decided not to field Q3 and Q4 participant surveys.*

Our team intended to survey 200 program participants in total. Of those, 100 were retrospective surveys of PY2016 participants, and the remaining 50 targeted current PY2017 participants, fielded on a quarterly basis throughout 2017.

To account for the fact that multiple customers must be contacted to yield a single response, our team created a large sample frame. Within that sample frame, participants were randomized so that each has an equal chance of being contacted. While we did not stratify the sample by measure or sub-program in advance, our team continually monitored results to ensure we attained a response pool representative of overall program participation.

APPENDIX D. PROCESS EVALUATION INTERIM MEMOS – NEW CONSTRUCTION PROGRAM

D.1 Commercial Rebate Process Evaluation – Program Theory & Logic Model Memo

To: Michael Noreika, Jim Perich-Anderson, Christina Crowell

From: Navigant

Date: June 12, 2017

Re: Commercial Rebate Process Evaluation - Program Theory & Logic Model Memo

The objective of this memorandum is to document and assess the strength of the Puget Sound Energy (PSE) Commercial Rebate program's theory and logic. The evaluation team will use this information to help frame process evaluation activities for the Commercial Rebate program. This memorandum begins by first defining program theory and logic models. It then presents the program theory with a logic model for each of PSE's Commercial Rebate program's subprogram and concludes by assessing the viability of the program theory and logic.

Introduction to Program Theory and Logic Models

Program designs are based on theoretical assumptions that certain program activities will result in specific desired outcomes. A program logic model depicts the baseline program theory of what the program intends to accomplish. They achieve this by providing a visual depiction of the interrelated activities that combine to produce a variety of outputs, which in turn lead to desired outcomes, such as energy savings or increased customer satisfaction. Logic models are "living" documents and need to be revisited periodically to ensure they continue to represent the program.

Understanding the program theory is essential to ensuring program implementers and program evaluators have a common understanding of the program design and its intended outcomes. Evaluators can use logic models to guide evaluation research and develop key performance indicators. Program implementers can use logic models to better understand the relationship between program activities and their intended outcomes. In the case that program goals are not met; stakeholders can use logic models to help explore reasons why activities and outputs did not lead to desired outcomes.

The evaluation team began the logic modeling process by drafting a rough logic model based on the program descriptions given during the program manager interviews for each subprogram. The evaluation team reviewed this initial draft with each program manager, and made edits to reflect feedback given during these discussions. The logic models and program theory are presented in the remainder of this memo. Arrows between items indicate a theoretical causal relationship between them. Dashed arrows indicate indirect desired outcomes from the program. These outcomes are not necessarily explicit goals, or tracked to measure program success.

Commercial Rebate Program Theory and Logic

PSE's Commercial Rebate program encourages businesses in PSE's service territory to adopt energy efficient equipment. The program serves many distinct business sectors and needs through its different subprogram channels, but in all cases the program's intent is to encourage business owners to install equipment which is more energy efficient than what they would have installed in the absence of the program. This section identifies barriers addressed by the program, provides logic models and discussion specific to each subprogram, outlines the program theory, and concludes with a discussion of external factors affecting program success.

Barriers Addressed by the Commercial Rebate Program

While subprograms within the Commercial Rebate program address barriers in a variety of ways, they all address the following common set of barriers to commercial customer adoption of energy efficient equipment:

- Upfront costs to investment in energy efficient equipment may deter businesses from adoption, even if it makes economic sense in the long run
- Businesses may lack time or resources to investigate and plan purchases of energy efficient equipment; the time cost required to investigate rebate incentives and programs may even be a deterrent
- Many businesses do not proactively plan to upgrade the energy efficiency of their equipment; their approach may be "reactive," simply replacing equipment as quickly and inexpensively as possible when equipment fails
- Commercial customers may have incomplete information on energy efficient equipment; without full and accurate information, they are unable to effectively incorporate equipment efficiency upgrades into their purchasing and planning

Theory and Logic Models by Subprogram

Because the different subprograms vary widely in terms of program intent, design and delivery mechanism, an overarching Commercial Rebate program-level Program Theory and Logic Model (PTLM) would be overly general and provide little insight. Instead, Navigant created a PTLM for each of the following key subprograms, for which PSE program staff indicated interest:

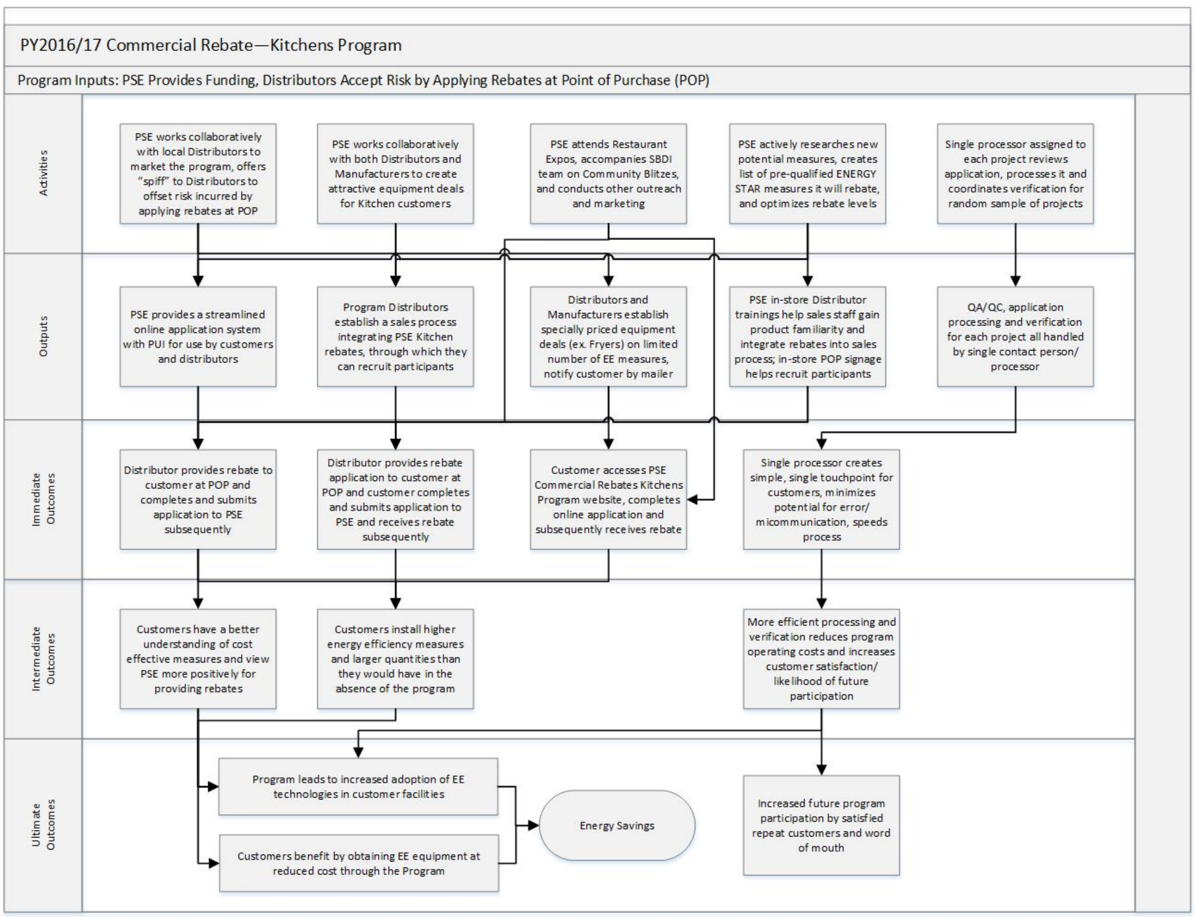
- Kitchens Program
- Laundry Program
- Commercial HVAC
- Premium HVAC Service
- Small Business Direct Install
- Agriculture Direct Install
- Lodging Direct Install

Creation of the PTLM for each of these subprograms demonstrated that all are well-designed and have the potential for success, but that these subprograms vary widely in terms of maturity. Thus, some of these subprograms, such as Agriculture Direct Install or Lodging Direct Install, still have incomplete or underdeveloped activity and input nodes, and non-functional or incomplete linkages. This does not indicate an issue with program design, rather, it reflects the stage of program maturity and opportunities for growth as these newer channels continue to develop and grow.

Other subprograms such as Laundry are well-developed and mature, but in a dormant period, and as such, their PTLMs reflect inactivity and weak or inactive linkages. Finally, the PTLMs for many well-established and long-running program components such as Commercial HVAC, Kitchens, and Small Business Direct Install, reflect the archetypal Theory and Logic Model Diagram, with complete and substantial input and activity nodes, and strong, well-developed, functional linkages reflected in successful outcomes and achievement of desired goals.

Kitchens Program

Figure 1. Kitchens Program Logic Model



The logic diagram for the Commercial Rebate Kitchens program presented in Figure 1 depicts a well-designed and implemented program with multiple key nodes at each level, connected by strong and functional linkages.

Multiple channels for customer recruitment and participation are represented by various nodes in the Activities level. PSE markets the program through partnerships with local retailers and distributors to channel customers in-store to program qualifying measures, offering these key trade allies spiffs to increase participation and offset the risk they incur by offering PSE incentives at Point of Purchase

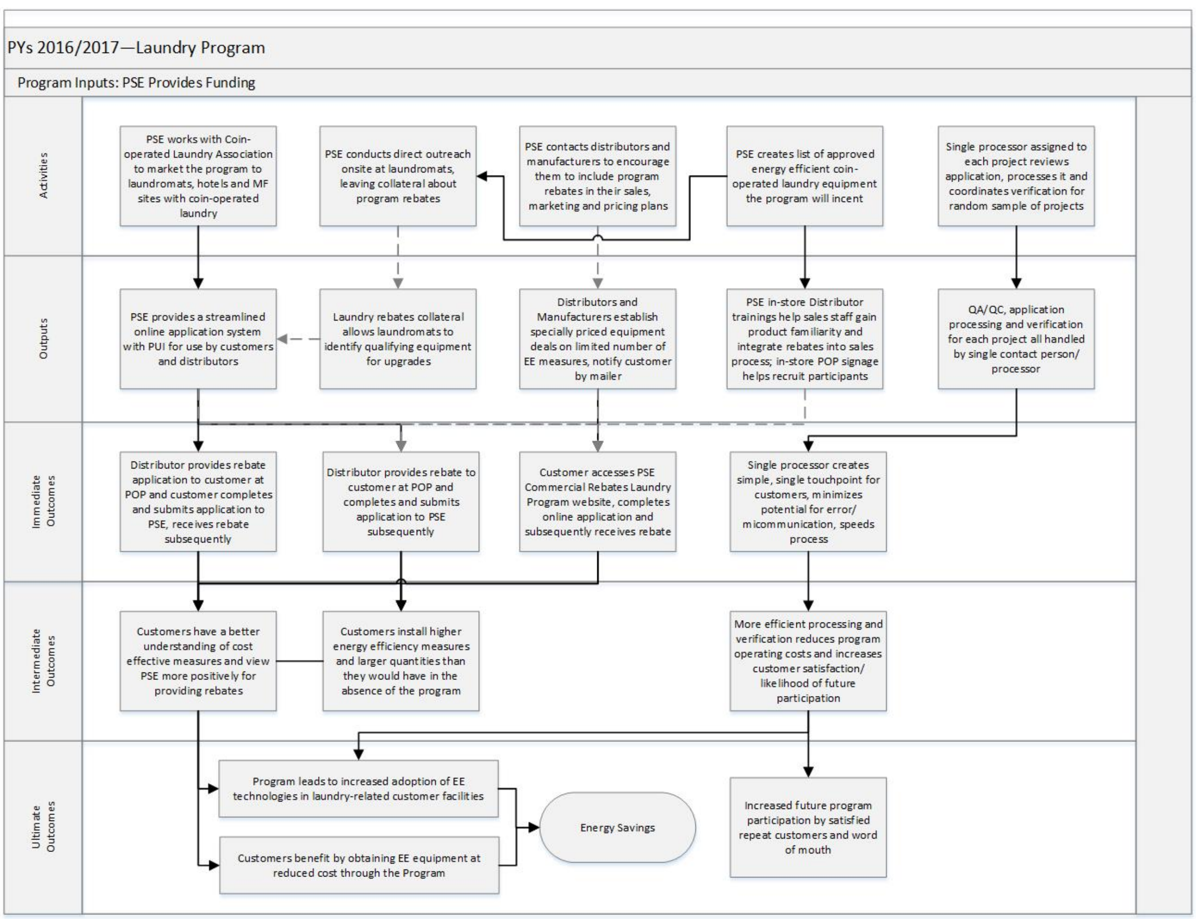
(POP). PSE also works collaboratively with both retailers and manufacturers to offer special deals on specific high-demand kitchen items, where the energy efficient option would usually be too expensive to bring the purchase cost down significantly, driving participation. Finally, PSE also actively engages in direct outreach through participation in Community Blitzes and attendance at trade shows and kitchen expos.

On the Outputs level, a key node is the "streamlined online application system." PSE has worked to create a streamlined application and rebate processing system, which came online during 2017. This system will provide a Public User Interface (PUI), allowing trade allies to access the system directly and monitor application progress. This improvement to the application process will positively impact customer and trade ally satisfaction and experience with the program. Another key node at this level is the node indicating that "QA/QC, application processing and verification" are all handled by a single contact person who processes each project and moves it through the system. This process improvement over past years is also likely to improve customer satisfaction, reduce the potential for error, and streamline processing.

Overall, this program has strong key nodes and linkages, allowing inputs and activities to result in the desired outputs and outcomes – the increased program participation and adoption of energy efficiency kitchen equipment and overall satisfaction with the program and PSE.

Laundry Program

Figure 2. Laundry Program Logic Model



While the Commercial Rebate Laundry program has a strong design and multiple potential channels for recruitment and marketing depicted in the Activities level of the logic diagram in Figure 2, the program is largely dormant and hence many key nodes and linkages are currently inactive (indicated by grey dashed connectors).

The main reason for the program's dormant status is that when the Laundry Program launched over ten years ago, the program blanketed all laundromat facilities in the area so that a large proportion of facilities upgraded their coin-operated laundry equipment at that time. The useful life of most of these pieces of equipment is between ten and fifteen years, meaning that soon these machines will need repair or replacement, but not largely during the current biennium. As such, the program has had little success increasing program participation through laundromats and outreach to collaborate with distributors and manufacturers. This blockage is indicated by the grey dashed arrow from the "PSE contacts distributors and manufacturers" node on the Activity level. A secondary blockage is represented by the grey dashed arrow from the "direct outreach onsite at laundromats" node. While the program attempted a direct outreach effort with laundromats in 2015, leaving behind program collateral, it found that laundromat owners are rarely onsite, and distributed collateral was not impactful, as it did not reach the intended audience.

The program did have success reaching potential participants through collaboration with the Coin-operated Laundry Association, especially by including non-laundromat facilities, such as multifamily and lodging facilities with coin-operated laundry units, in the program this year. By allowing these other facilities to participate in the program, the program manager has found a successful avenue to begin increasing program participation this year and reinvigorating the program.

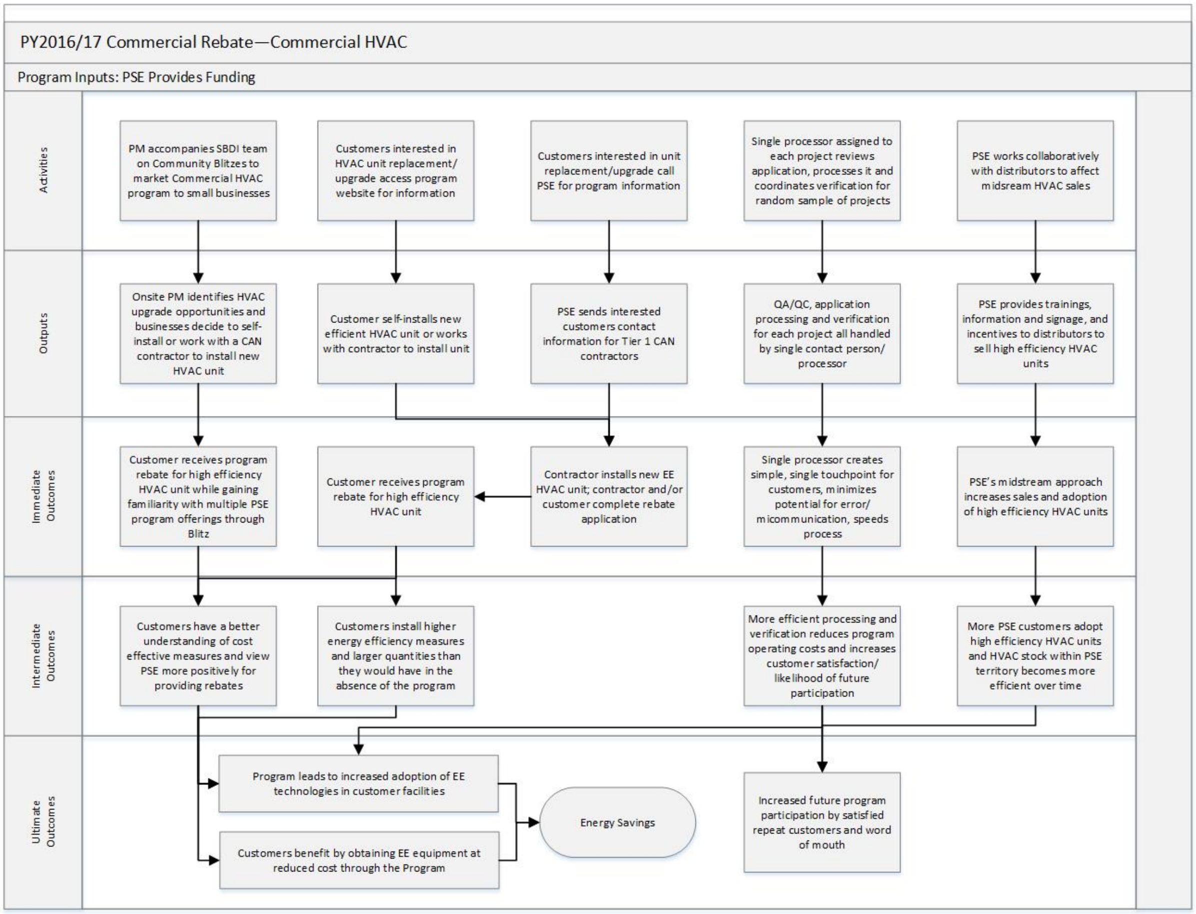
As the current fleet of coin-operated laundry equipment approaches replacement age over the next few years, the program will once again have the opportunity to enter an active stage and expand and strengthen some of the key nodes and linkages in this model.

Commercial HVAC

The Commercial HVAC retrofit rebates program is well designed and functioning, however it appears based on the Logic Diagram in Figure 3 that the program has less-dense nodes representing different opportunities for outreach and recruitment relative to other subprograms within Commercial Rebates. While current nodes and linkages in this subprogram are functional, there may be opportunities to expand and strengthen them.

Nodes in the Activity level indicate that there are two channels through which customers become engaged with the Commercial HVAC program: (1) the PSE program manager accompanies SBDI Community Blitz teams and Commercial Custom program outreach teams to perform direct outreach to commercial customers, or (2) customers interested in HVAC system replacements and upgrades may utilize PSE's website or call PSE directly for information on rebates. The PM channels referrals from interested customers to qualified Tier 1 Contractor Alliance Network (CAN) contractors, who can bid on the work.

Figure 3. Commercial HVAC Logic Model



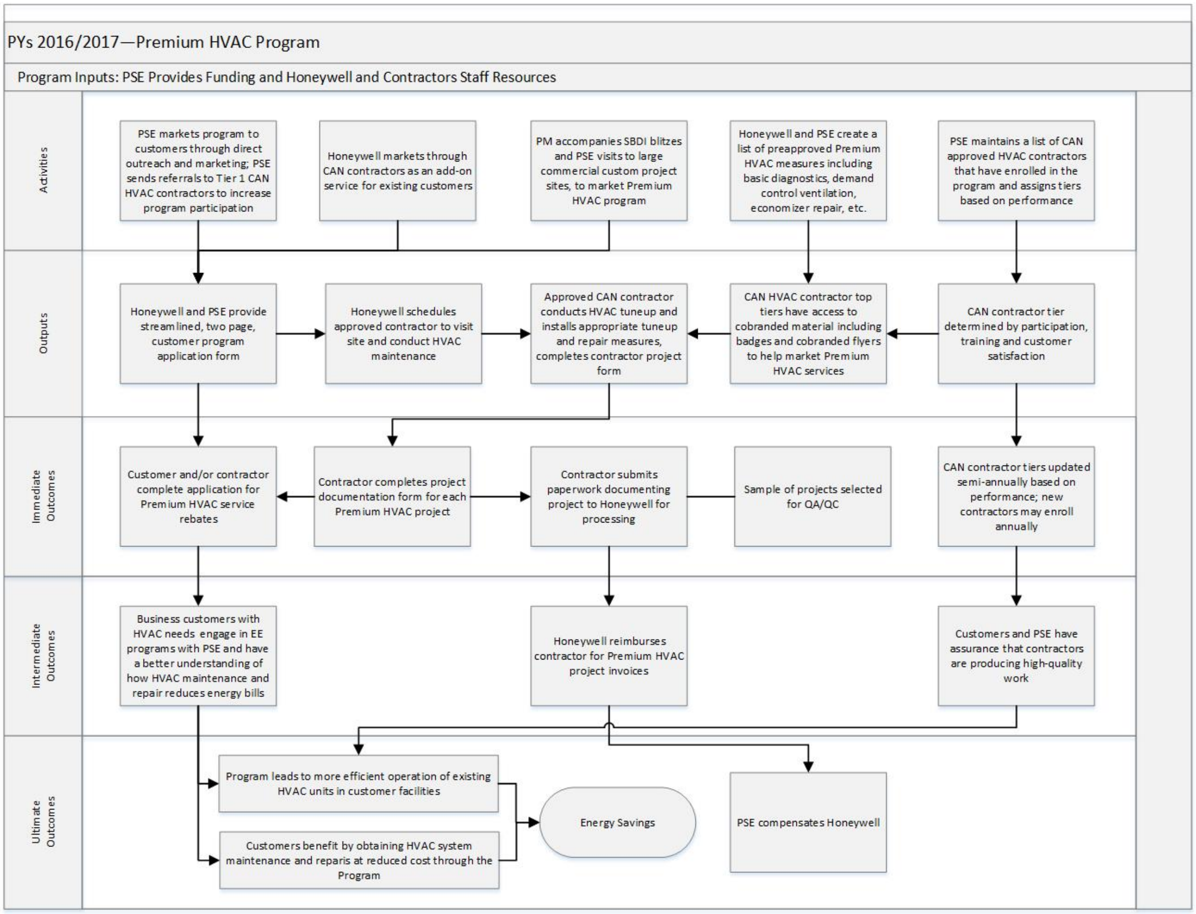
By contrast to other Commercial Rebate subprograms such as the Kitchens program, vendors and retailers do not currently play an active role in the program, and the program staff are not actively engaged in trade shows, expos or other direct outreach events. Comparison of this logic diagram with other subprogram diagrams suggests that there may be opportunities to improve/strengthen the outreach and recruitment aspects of this subprogram. Current linkages may not be sufficient to exert control over the ramp up and ramp down of program participation to the desired degree.

Figure 3 also depicts a program channel and linkages which are not yet active, but which the PM has expressed interest in examining. This program channel would increase program participation using a midstream process through which the PM engages with retail outlets and distributors to provide training, signage, information and incentives for retail outlets to sell higher volumes and wider varieties of program-qualified high efficiency HVAC systems.

The Commercial Rebate program has launched a new, streamlined online application system during 2017. Per the PM, the user interface is not yet available to his program for this system. Once that system becomes available, fields and linkages should be added to this diagram to represent the streamlining of application processes, and resulting increases in customer satisfaction.

Premium HVAC Service

Figure 4. Premium HVAC Logic Model



The Premium HVAC program is a well-designed and active program, as indicated in the Logic Diagram in Figure 4 by strong linkages and multiple key nodes at different levels. The program has a new implementation contractor this biennium and has transitioned to an implementer-led program rather than a vendor-led program, and this transition appears to be well underway and successful.

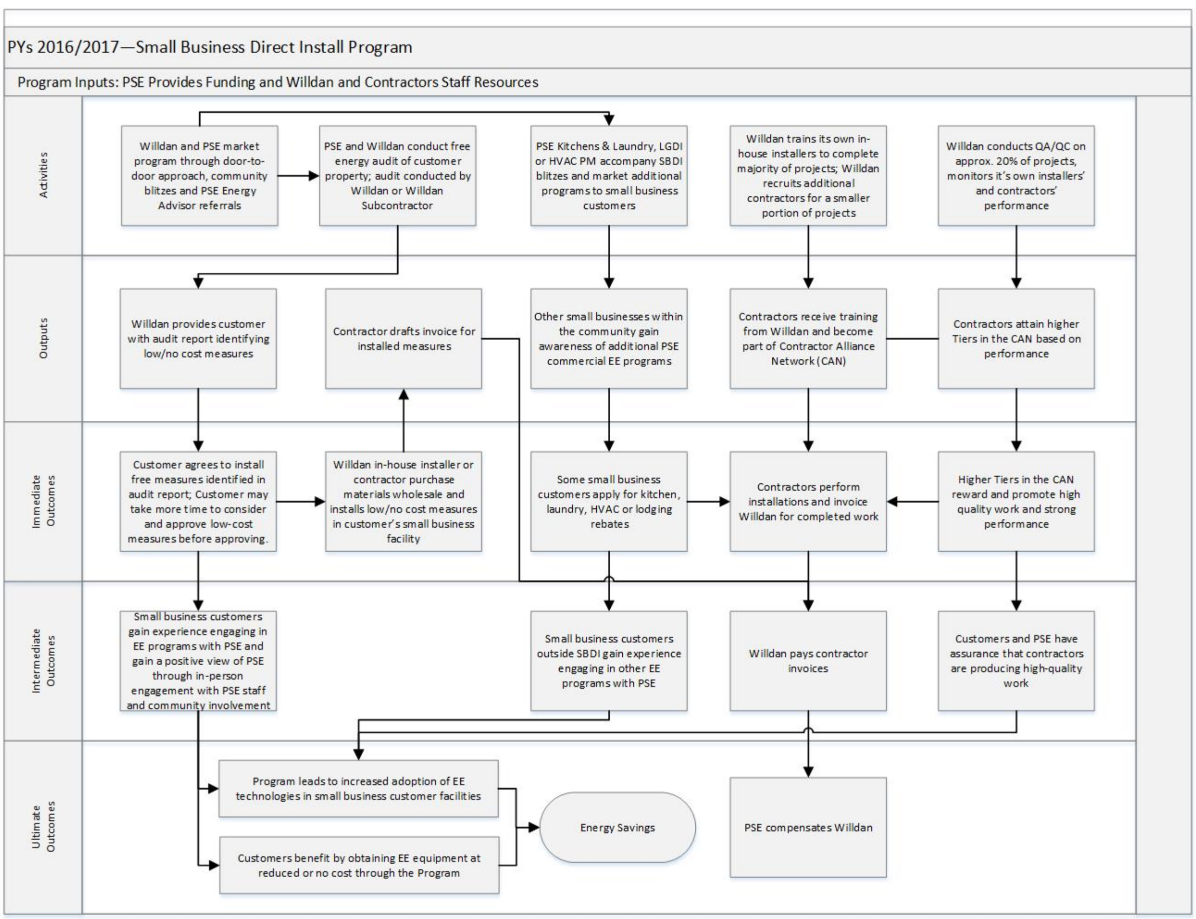
Nodes in the Activities row in Figure 4 demonstrate that there are a variety of means by which customers may become familiar with and participate in the Premium HVAC program. PSE, Honeywell and program contractors are all active in recruiting potential participants. PSE markets the program to customers through direct outreach and participation in Community Blitzes hosted by the SBDI program. Additionally, when PSE receives notification of interest from customers, it provides referrals to top performing Tier 1 CAN contractors so that they may recruit these customers. The PM also accompanies PSE or contractor staff on site visits to custom projects to market HVAC unit replacement and upgrades to larger commercial customers. Program CAN contractors also play a significant role in marketing the program. Tier 1 and 2 CAN contractors receive cobranded promotional materials and badges from PSE to help their recruitment strategies. More generally, Honeywell, the implementer, markets the Premium HVAC program through CAN contractors as an add-on service for existing customers.

Feedback and performance monitoring are also featured prominently in this logic diagram, as PSE and Honeywell maintain a well-organized and systematic approach to managing program contractors. This program component is represented by the series of nodes connected to the far right in the diagram. Contractors must be enrolled in the CAN network to participate in the program, and can move up in status to higher tiers based on performance, which takes into account volume of sales, customer satisfaction and other key metrics. With strong linkages and well-defined nodes, this component of the program appears to function well.

The PM indicated that soon the new online application system may include a user interface accessible by contractors. This would be represented by a new field in the logic diagram with linkages to incentive and application processing, and customer rebate receipt. Addition of this feature to the program would likely streamline performance and increase customer satisfaction by reducing wait time for rebate processing.

Small Business Direct Install

Figure 5. SBDI Logic Model



PSE's Commercial Rebate Small Business Direct Install (SBDI) subprogram is a very well established, designed and implemented program as evidenced by the strong nodes and linkages in the logic model diagram in Figure 5. The door-to-door approach used by the Willdan, (the implementation contractor,) PSE's Energy Advisor referrals and Community Blitzes generate the majority of participation. While

Community Blitzes generate only a quarter of program participation, they are highly visible and generate program awareness and foster positive interactions with communities in PSE territory.

A key element of this program depicted in the logic diagram, is the manner in which this program serves to channel participation into other Commercial Rebate subprograms. Through the Community Blitz outreach mechanism, other subprograms are able to find new potential participants and increase participation. As depicted in the Intermediate Outcomes level of the diagram, the in-person community engagement aspect of this program's outreach strategy has a positive impact on community and business perceptions of PSE.

A developing program strength highlighted in the logic diagram is the process for contractor engagement in the program. This engagement process involves contractors voluntarily enrolling in the program through participation in the CAN and attaining higher Tiers based on performance as they increase volume and quality of work through the CAN. Willdan manages and provides feedback to the program contractors. Positive reinforcement of high-quality work and increasing program participation by contractors in the CAN through the Tier system contributes to PSE and customer confidence in high-quality work by contractors through the program.

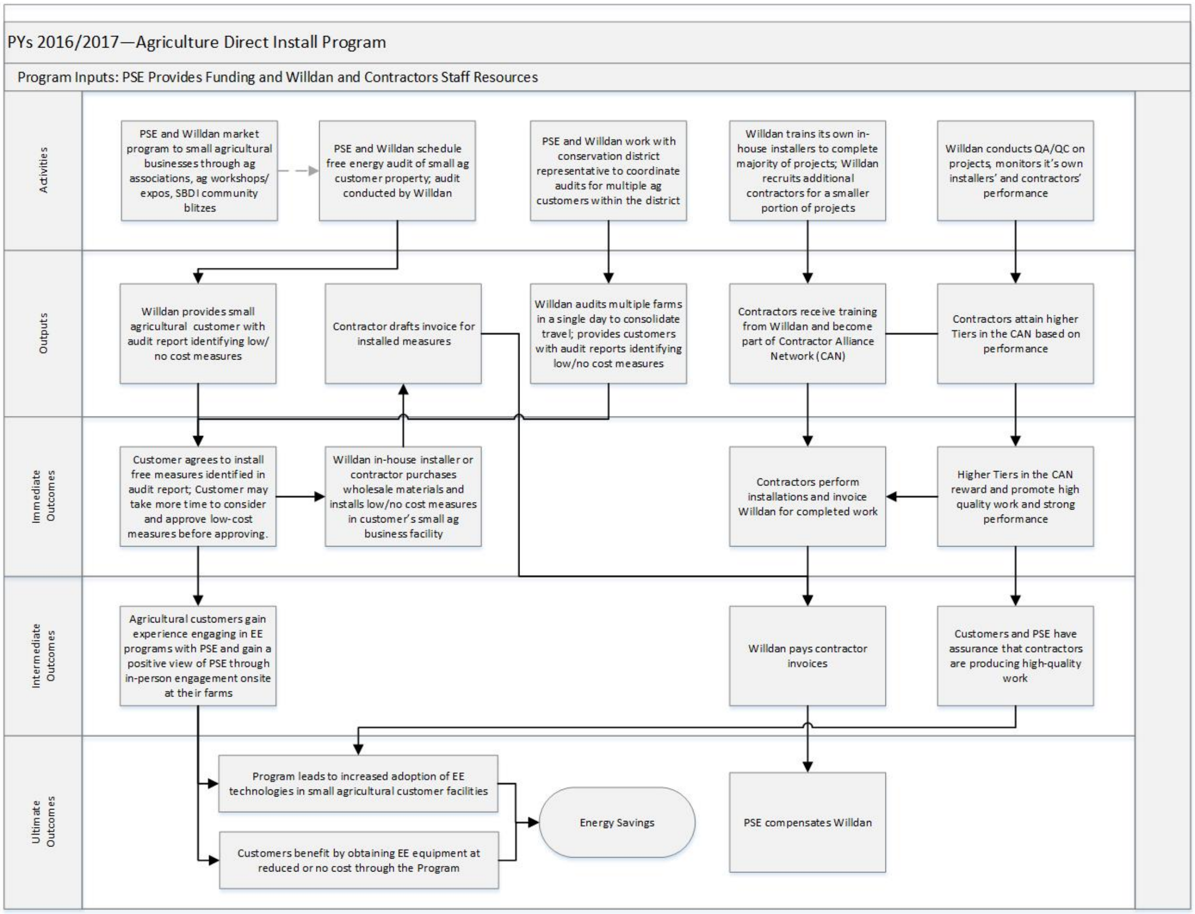
Agriculture Direct Install

The Agriculture Direct Install program is new to the 2016/17 biennium, and so it is still developing some of the key nodes and linkages that will define the program. However, less than year into its operation, the program is well scoped-out and examination of the logic model diagram in Figure 6 shows many effective linkages and nodes.

The main area for growth in this program is to expand the approaches to customer recruitment and refine those currently in place. In the Activities level, the light grey arrow representing the linkage between traditional DI marketing approaches and successful recruitment of participants shows that these traditional outreach and marketing strategies used by SBDI are not as relevant or successful in the Agriculture DI space. To the right on this level, the node representing collaboration with local conservation districts is connected to participation with a black arrow, indicating a successful linkage. This has proven to be the most successful outreach and recruitment strategy to date. Also, this approach is innovative and efficient because it facilitates visits to multiple farms in a single day, minimizing travel time and mileage, improving program cost-effectiveness. In the coming program years, PSE staff will work to expand the range of marketing strategies for this program and nodes and linkages will be revised accordingly.

A final node worthy of notice at the Intermediate Outcomes level is the node indicating that agricultural customers will gain a more positive view of PSE through the in-person interaction on their farms. Farming customers are often in remote locations and have little interaction with the utility, so this positive in-person interaction on the farm has the potential to significantly increase their overall satisfaction and positive view of PSE.

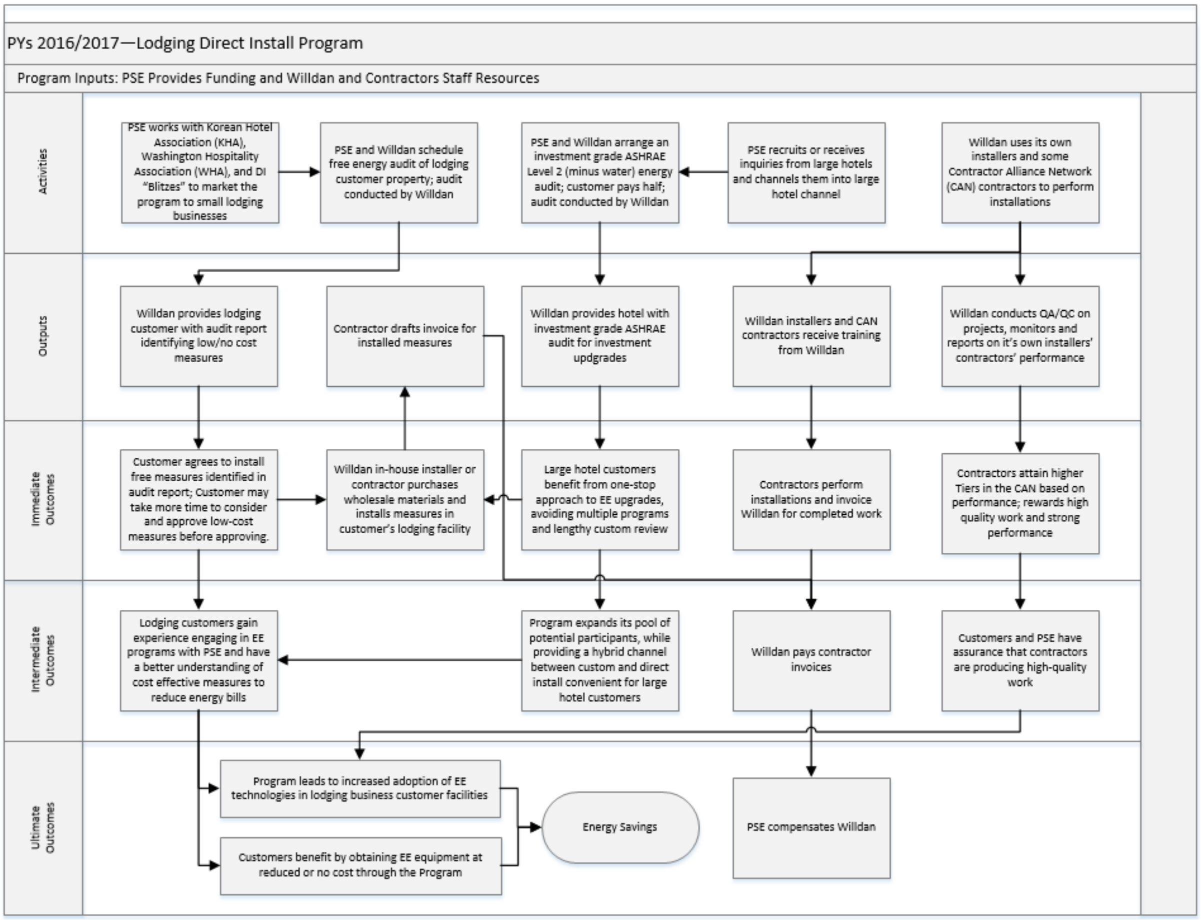
Figure 6. ADI Logic Model



Lodging Direct Install

The Lodging Direct Install program is relatively new, however it has already established strong nodes and linkages, indicative of successful program design and implementation, as evidenced by Figure 7. The logic diagram for this program shows that the program has already developed some specialized approaches to recruiting participants into the program, shown in the top left node on the Activities level. By working collaboratively with the Korean Hotel Association and the Washington Hospitality Association, the program will be able to focus recruitment efforts on high-likelihood potential customers. While Community Blitz participation is included in this node, the program manager has noted that this outreach channel is less successful for the Lodging component of the program relative to other Direct Install subprograms.

Figure 7. LDI Logic Model



Another Activities level node highlights a new and innovative approach the program manager has piloted to expand participation and program reach. In order to bring large hotels into the program, the program has begun offering ASHRAE Level 2 investment-grade energy audits to large hotels, as an enticement to make energy efficiency upgrades through the Lodging DI subprogram. The node below it on the Intermediate Outcomes level highlights the fact that this approach facilitates participation by large hotels who would otherwise have to apply for various rebates through multiple programs and invest in outside investment-grade audits. The alternative the program now offers is an integrated channel through which large hotels can receive an investment-grade audit, obtain rebates on large volumes of lighting and other energy efficiency measures common to large hotel customers, and utilize the Lodging DI subprogram as a "one-stop" turnkey approach to energy efficiency upgrades. If successful, this program enhancement has the potential to dramatically increase participation, savings and scope of this program.

External Factors Influencing Program Success

The theory described above for each Commercial Rebate subprogram assumes continuation and consistency of a range of external factors. However, we recognize that these factors may change, and that changes in external factors may cause the program theory not to function as designed. In that case, adjustments will need to be made in order to react flexibly and efficiently to these external factors. We discuss some of the key external factors which could influence the success of the Commercial Rebate program below:

- **Economic conditions:** Many subprograms within the Commercial Rebate program, but particularly the Kitchens program, are strongly tied to economic conditions. Small businesses, particularly restaurants, will have program participation rates strongly tied to economic performance. Economic downturns may negatively influence program participation by making the decision to invest in energy efficient equipment that much more difficult. Small businesses in the Direct Install subprograms will also be affected by economic downturns, but more so through decreased willingness to invest in measures that are not zero-cost and require a copay.
- **Technology equivalence:** Certain customer subsets served by the Commercial Rebate program are part of heavily customer-centric industries such as restaurants and lodging. These customers may hesitate to participate in the Commercial Rebate program due to the issue of technology equivalence. Technology equivalence refers to concerns around the efficient technology not having the same "creature comfort" characteristics as less efficient technologies, that may lead to customer dissatisfaction if adopted. For instance, hotels may resist installing low-flow showerheads due to their perception that this will create a less positive customer experience. Similarly, hotels or restaurants may choose lighting based on dimmability and light quality, and ultimately choose a less efficient product for customer satisfaction-based reasons. Technology equivalence issues may negatively affect participation in the kitchens and lodging subprograms.
- **Renter vs. landlord dynamic:** A common issue faced by many of the Commercial Rebate subprograms is the difficulty in convincing renters to make capital investments and upgrades to rental properties. A shift towards a larger percentage of businesses renting spaces rather than owning would negatively affect program participation, particularly through the Commercial HVAC, Premium HVAC Service, Kitchens and Laundry channels.
- **Energy code changes:** Energy codes are changing for many categories of equipment, including but not limited to HVAC, cooking and lighting equipment. Increases in the stringency of codes negatively impact program savings, as the delta between efficient and baseline equipment becomes smaller, making programs less cost-effective. Moreover, codes are not identical across PSE territory, and these differences have the potential to affect program success. For instance, the Kitchens program faces different codes with which restaurants within Seattle must comply, compared with restaurants in other parts of Washington outside Seattle. This poses a challenge for the program where vendors have different motivations and abilities to incent the same equipment between restaurants in different parts of PSE's service territory.
- **Decreasing efficient equipment costs**: Particularly in lighting, rapid decreases in the costs of LEDs and other efficient equipment pose a problem for program cost-effectiveness. Decreasing efficient equipment costs make it increasingly difficult to cost-effectively provide a substantial enough incentive to affect customer purchasing behavior.

Assessment of Program Theory and Logic

The majority of PSE's Commercial Rebate subprograms, including Kitchens, Commercial HVAC, Premium HVAC Service and SBDI, present strong and comprehensive program theories demonstrated through dense networks of effective activity nodes and strong and functional linkages. While several of the newer or dormant programs, including ADI, LGDI and Laundry, have strong and effective program theories, some of the linkages or activities are not yet functional. However, this is not indicative of any underlying issue with the program theory and logic, rather, this reflects the process through which these programs are evolving and maturing to reach their full potential. Overall, the Commercial Rebate program is effectively addressing the barriers it is intended to overcome, and encouraging market actors to install more energy efficient equipment.

Upcoming Process Evaluation Research

Our development of PTLMs revealed several key areas where our process evaluation research can provide actionable information for PSE. The following list is not exhaustive, but illustrative of some of the ways our PTLM work contributes to the overall process evaluation effort.

- The Kitchens theory and logic model explains that a key program improvement implemented during 2017 has been the launch of a streamlined online application process and user interface. PSE program staff anticipate this streamlined process will improve both vendor and customer satisfaction. Through interviews with vendors and surveys of program participants, we will investigate satisfaction with this new system.
- The Premium HVAC Service theory and logic model describes the program's transition during this biennium from a vendor-based program to an implementer-based program. The intent of this change was to reinvigorate program participation. Participant surveys and contractor interviews will help us understand if this change has positively impacted the program participation experience for these parties.
- The Commercial HVAC theory and logic model demonstrates the potential to improve program participation by increasing the marketing and outreach effort. This program has less outreach and marketing efforts relative to many of the subprograms, and may benefit from a more diverse approach. The participant survey will include questions aimed at identifying the best channels and approaches to reach potential Commercial HVAC participants.
- For the SBDI subprogram, one method of outreach is the community blitz. The theory and logic model for this program suggests this marketing channel may serve as an important cross-program promotion tool. Our participant survey will include questions to help determine the effectiveness of this channel in increasing participation in other subprograms such as Commercial HVAC or Kitchens.

D.2 Lighting Market Modeling Analysis Memo

To: Michael Noreika, Jim Perich-Anderson, Christina Crowell

From: Navigant

Date: October 30, 2017

Re: Lighting Market Modeling Analysis

Navigant analyzed detailed lighting data from the PSE 2013 CBSA oversample along with regional technology trends to estimate the remaining stock of T12 lamps and fixtures in commercial and industrial buildings in PSE's service territory. This analysis leveraged the regional lighting market model Navigant developed with the Bonneville Power Administration[10]. This memorandum describes the methodology used and results from this analysis, which focused on estimating the remaining T12 fixtures in PSE service territory between 2017 and 2020.

Methodology

We performed three steps to generate a PSE T12 forecast from 2017 through to 2020, shown in Figure 1. First, the team compared the saturation of T12s in the PSE CBSA lighting data to the same data for Pacific Northwest region overall. Next, the team scaled the regional lighting market model results to better represent the stock in the commercial and industrial spaces in the PSE electric service territory. Finally, the team applied T12 saturation trends from the regional model forecast to the PSE stock to estimate the change in total T12 fixtures from 2017 to 2020.

Figure 1. Methodology to generate PSE T12 forecast to 2020

Step 1: Comparison of regional and PSE lighting data

To understand the differences between the lighting installed in the PSE territory and the region, Navigant compared the 2013 PSE CBSA oversample lighting data to the regional 2013 CBSA data. The team

[10] https://rtf.nwcouncil.org/subcommittee/market-analysis

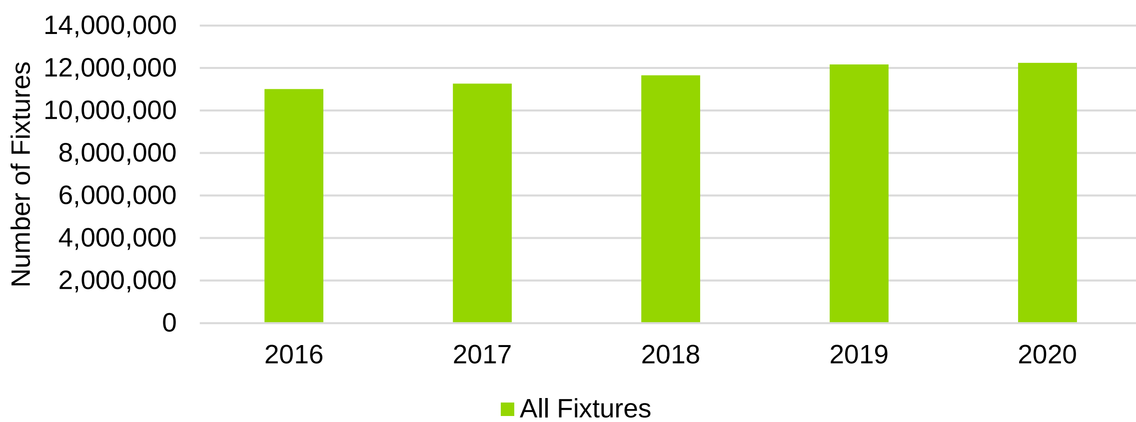
found that PSE had a lower T12 density than the regional average in 2013 in many of the lighting applications. For this reason, the team adjusted the starting T12 fixture share by application to align with the PSE CBSA data. Since the industrial data is from the IFSA, which did not include utility oversamples, the team assumed that the industrial spaces in the PSE service territory have the same ratio of PSE to regional T12 saturation as the commercial spaces by lighting application.

Step 2: Scaling regional lighting stock to PSE lighting stock

To scale the regional lighting stock to the PSE lighting stock, Navigant first estimated the total square feet in commercial and industrial PSE electric customer buildings. For commercial buildings, the team used the commercial square footage estimates developed for the PSE potential study. To estimate PSE industrial square footage, the team compared the forecasted ratio of PSE industrial electric sales and total C&I electric sales with the forecasted regional ratio of industrial lighting consumption to total C&I lighting consumption. The forecasted industrial to total C&I sales ratio in PSE is only 66% of the regional lighting ratio, indicating that there are fewer industrial sites in the PSE service territory on average. The team assumed that the industrial to total C&I square footage ratio in PSE is also 66% of the regional ratio of industrial to total C&I square footage. Based on this assumption, the team estimated that PSE's industrial square footage is about 9% of the total C&I square footage, resulting in a total of 70,000 square feet of industrial space in the PSE electric service territory.

Next, Navigant estimated the total PSE fixtures by multiplying the building square footage of each building type by the assumed fixture density for each building type. The fixture density for each building type is based on analysis of the regional 2013 CBSA data. Overall, the team estimated that there are slightly over 11.25 million fixtures in the PSE C&I service territory in 2017. This is across indoor and outdoor C&I and all applications including high bay and small task lighting. The team estimated that the total number of fixtures will rise to over 12 million by 2020 due to forecasted new construction. Figure 2 shows the estimated number of fixtures from 2016 to 2020 in the PSE C&I service territory.

Figure 2. Estimated fixtures in PSE C&I service territory



Navigant also estimated the number of fixtures in each lighting application by building type. Due to the small sample sizes for some building types in the PSE CBSA data, Navigant applied the lighting application shares—i.e. the percentage of fixtures within a certain building type that fall within the Ambient Linear fixture application—by building type developed from analysis of the regional CBSA data.

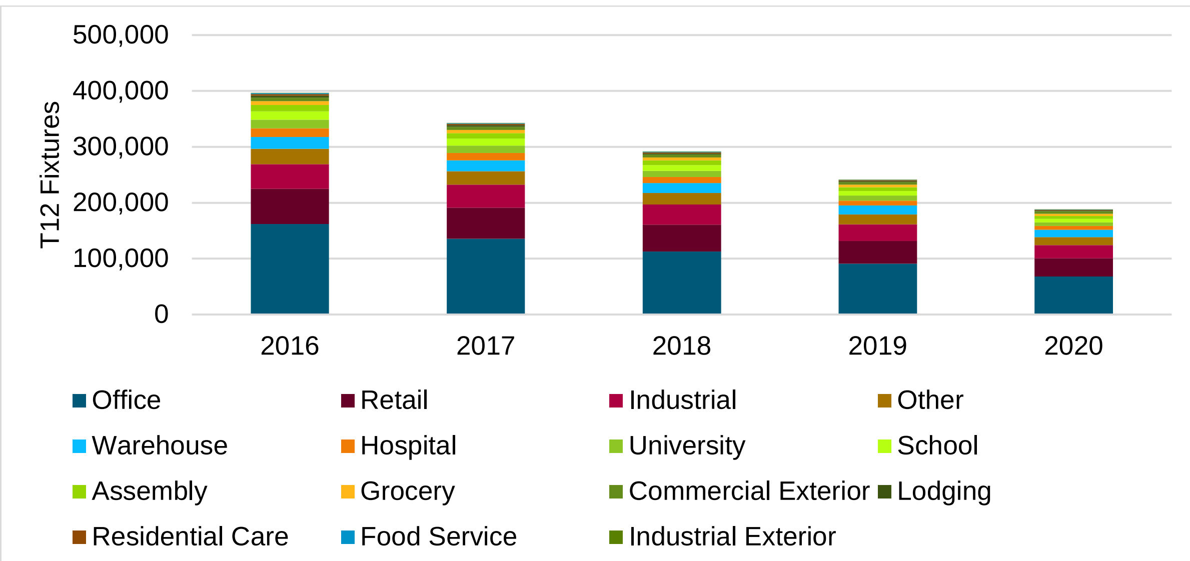
Step 3: Applying regional forecast trends

For the final step, Navigant determined the year over year forecasted change in T12 stock from the regional forecast model by application and sector from 2013 through to 2020. Starting with the 2013 T12 fixture saturation by application and sector, the result of the first step, Navigant applied the year over year change to generate a PSE T12 fixture saturation forecast through to 2020 for all lighting applications and building types. The team multiplied the number of fixtures in each lighting application by building type from 2016 through to 2020, the result of the second step, by the forecasted fixture saturation for 2016 to 2020 to estimate the total number of T12 fixtures in PSE's C&I service territory by application and building type.

Results

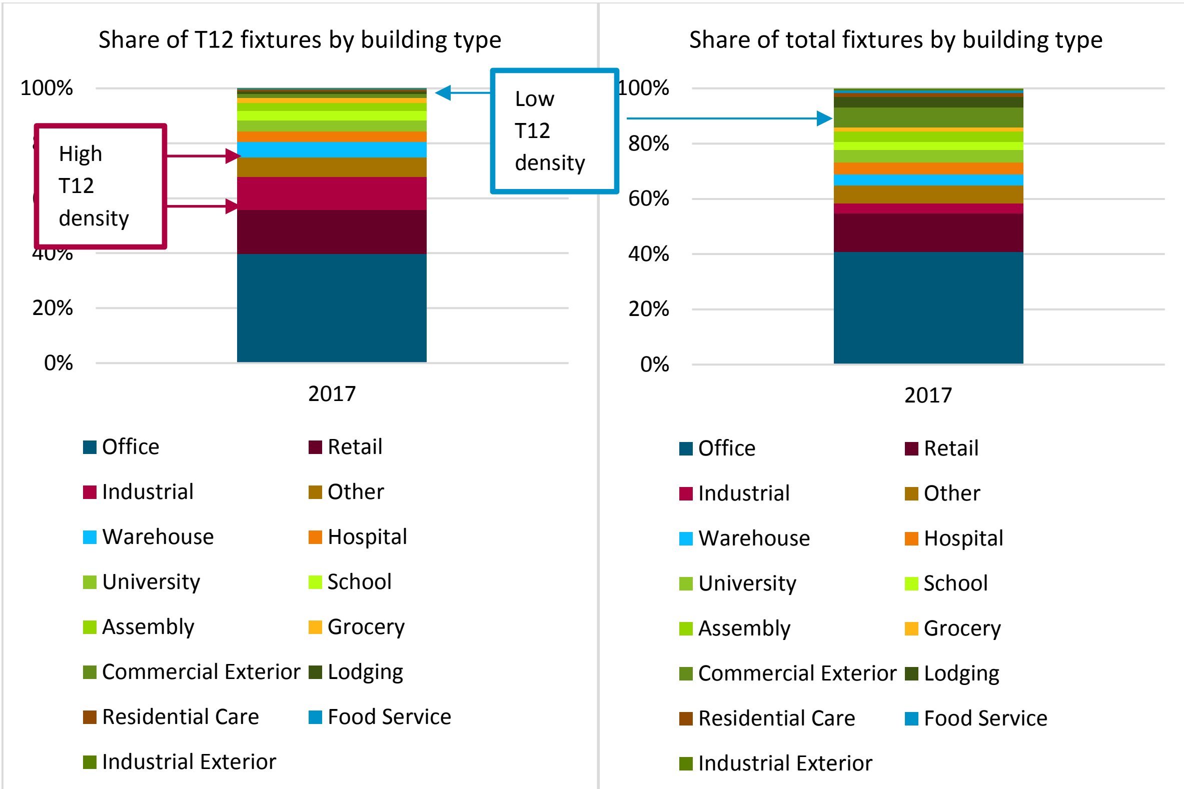
Overall, T12 fixtures are declining in all building types even though the total number of fixtures is increasing due to new construction. Navigant estimates that fewer than 200,000 T12 fixtures will remain in PSE's territory by 2020. Figure 3 shows the T12 fixtures remaining by building type.

Figure 3. Forecast of T12 fixtures in PSE C&I service territory



For the most part, high numbers of T12s correlate with the largest building types. This can be seen by comparing the share of T12 fixtures by building type and the share of total fixture by building type for 2017 (Figure 4). The exceptions are Industrial and Warehouse, where the share of T12s is disproportionately high, and exterior lighting, where it is disproportionately low.

Figure 4. Comparison of T12 fixtures and total fixtures by building type for 2017



Over time, the share of T12s in the Office building type is expected to decline faster than in the Industrial building type, as can be seen in Figure 5. The presence of high/low bay lighting is the primary driver in this case. The T12 density remains higher over time in building types where the high/low bay application is more common. These building types include Industrial, Warehouse, Other, and Retail. This change in share is based solely on where the different applications occur and how much of each building type is made up by each application. The regional model does not account for differences in decision making between building types.

Figure 5. Forecast of T12 fixture distribution across building types

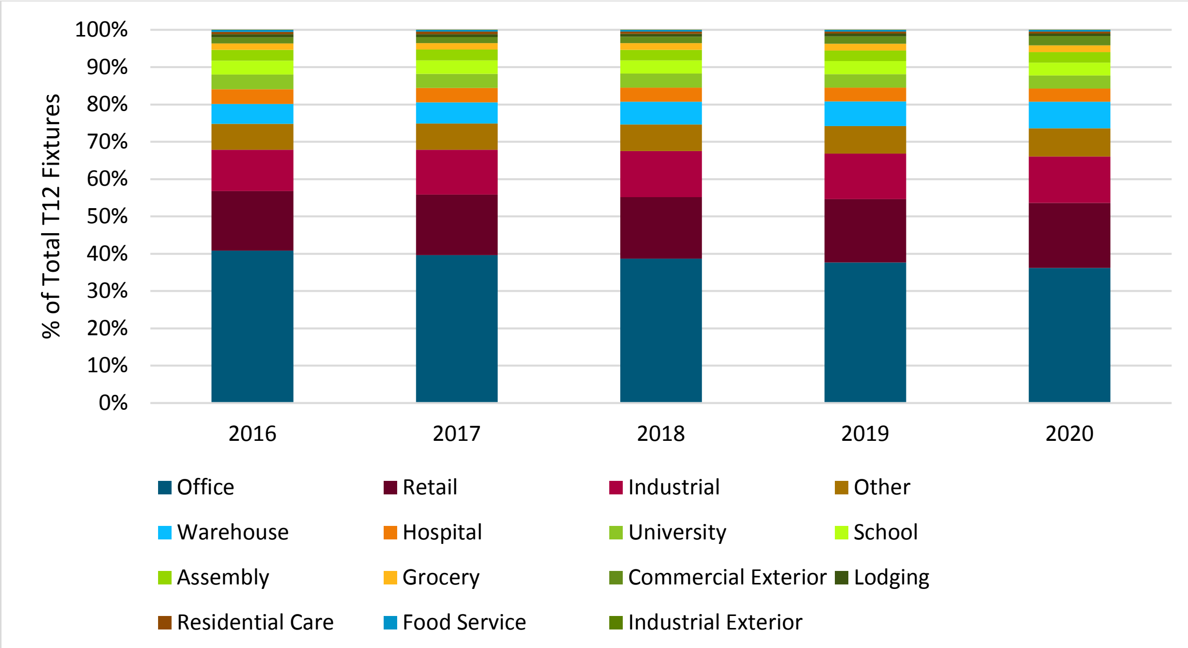


Figure 6 shows the estimated T12 fixture saturation by building type, indicating where T12s are most likely to be found. While most of the T12 fixtures might be in office buildings, only about 3% of fixtures in offices are T12 compared to over 10% in industrial buildings. It is worth noting that the industrial saturation is based on IFSA data which included many fewer sites than the CBSA data, but given the magnitude of the difference between commercial and industrial buildings this difference is likely significant.

Figure 6. 2017 Estimated T12 fixture saturation by building type

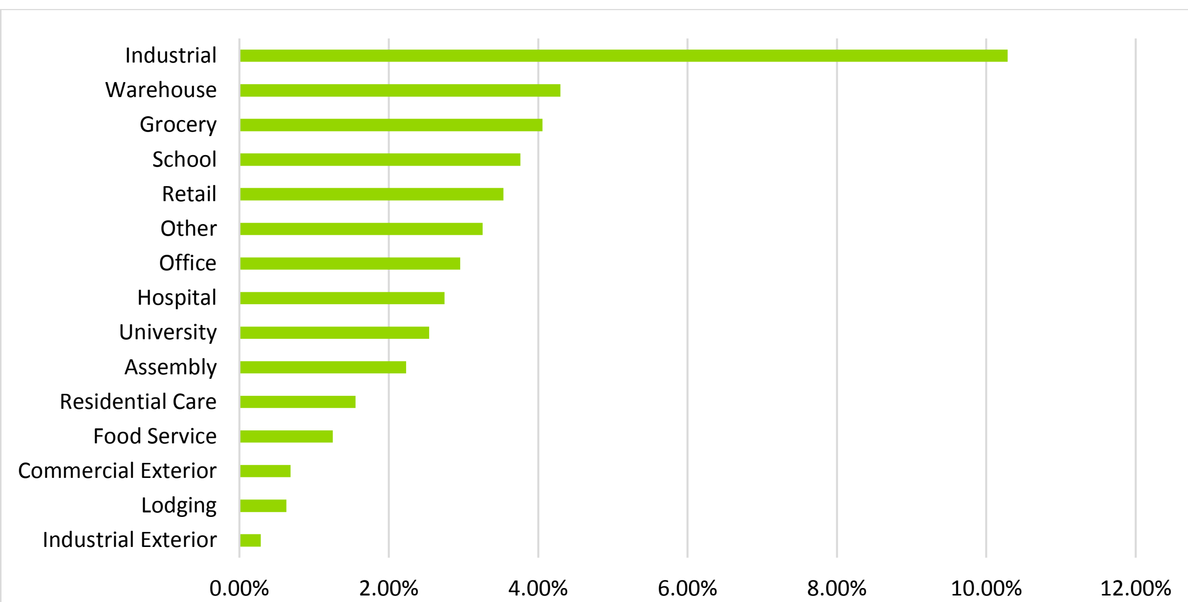
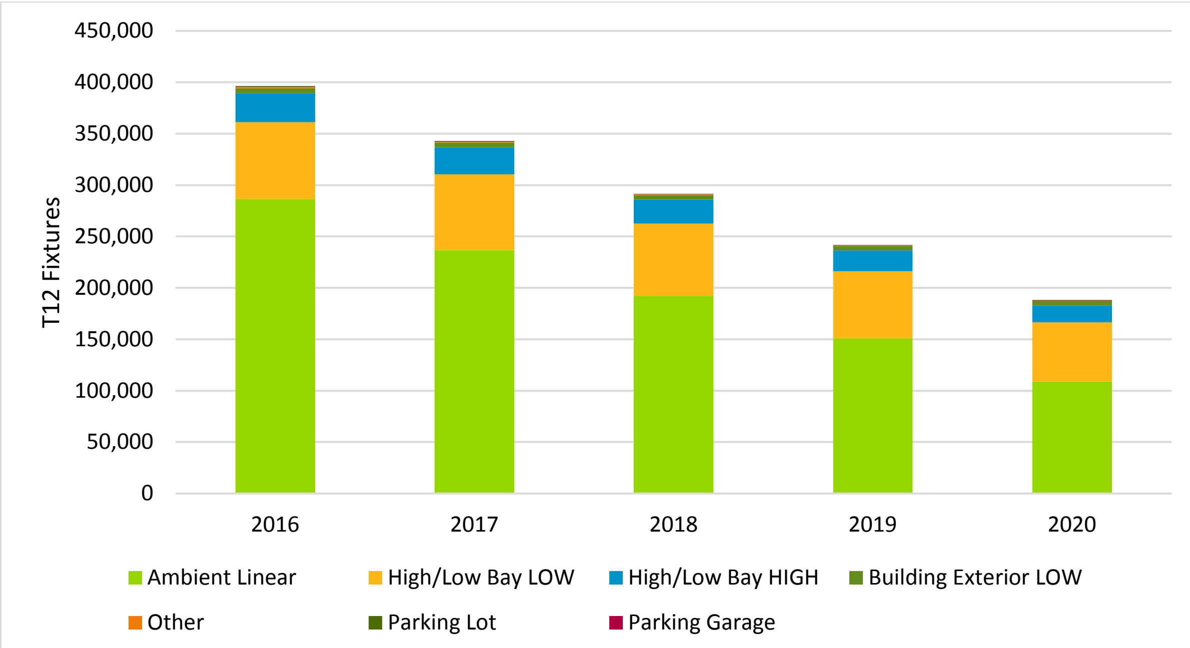


Figure 7 through Figure 9 show the estimated T12 fixtures by lighting application. This considers what spaces within a building are most likely to have T12s. Figure 7 shows the forecasted T12 fixtures by lighting application across all commercial and industrial buildings. The Ambient Linear application has the highest number of T12 fixtures because it is the largest application in the C&I sector.

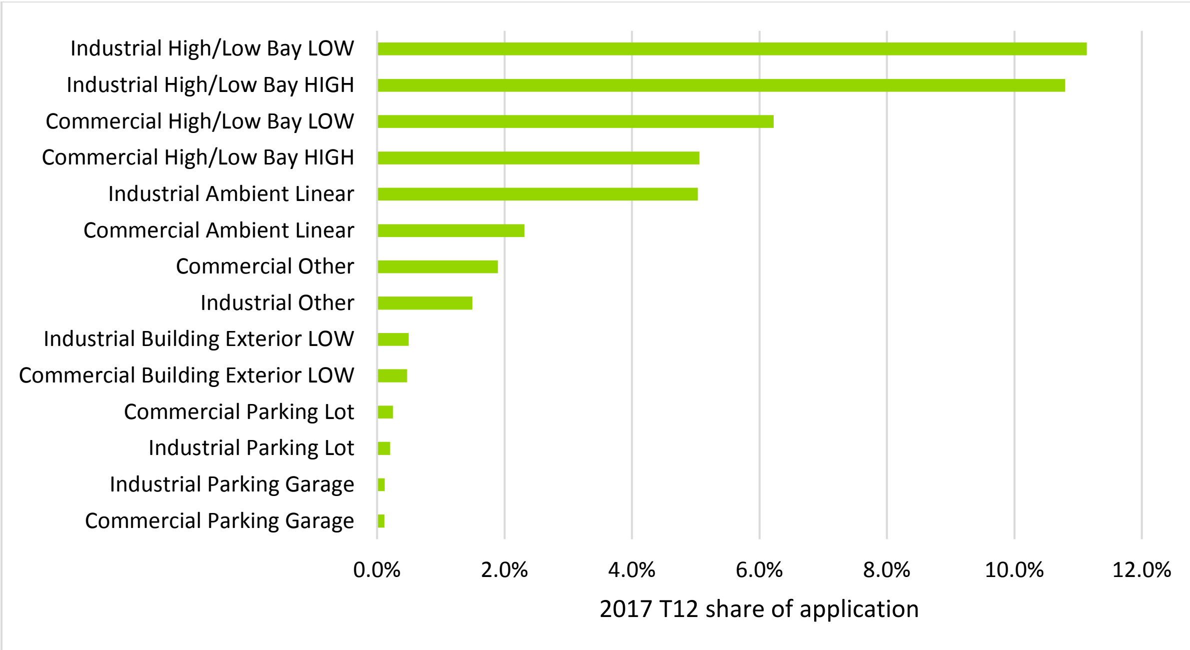
Figure 7. Forecast of T12 fixtures by lighting application[11]



While Ambient Linear has the most T12 fixtures and most of those are in the commercial sector, the share of T12s within the commercial Ambient Linear application is just 2.3% as shown in Figure 8.

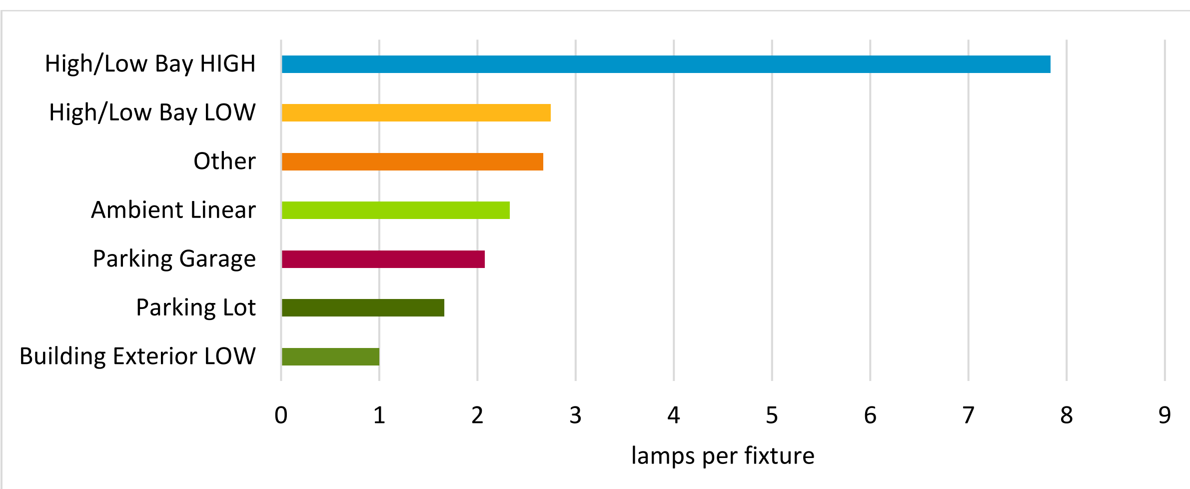
[11] The LOW and HIGH after the application name refers to different lumen output categories in the same lighting application. The High/Low Bay application is split by 15,000 lumens, a 250W metal halide equivalent fixture, with 15,000 lumens and above in HIGH. The Building Exterior application is split by 7,000 lumens, a 70W high pressure sodium equivalent fixture, with 7,000 lumens and above in HIGH.

Figure 8. 2017 T12 fixture saturation by application and sector



Another factor to consider is the number of lamps per fixture. Figure 3 through Figure 8 display results on a fixture basis, aligning with how most spaces are retrofitted. However, not only do the high/low bay applications have higher T12 fixture saturation, they also have more lamps per fixture which typically increases potential savings from retrofitting T12 fixtures. Navigant analyzed the CBSA data to estimate the number of lamps per fixture for T12 fixtures by application, as shown in Figure 9. This revealed that the High/Low Bay HIGH application has almost four times the number of lamp per fixture as the Ambient Linear application.

Figure 9. Approximate T12 lamps per fixture by application



Conclusions

Overall T12 fixture stock in PSE commercial and industrial buildings will continue to decline due to the growing sales of more efficient technologies, namely T8 linear fluorescent lamps and LED products. Navigant estimates T12 fixture saturation will drop from just over 3% in 2017 to less than 2% of total PSE fixtures by 2020. T12 saturation is low enough that targeting remaining fixtures with programs may not be cost-effective. However, T12 saturation varies significantly by application and building type and targeting industrial high and low bay fixtures is the best remaining option to accelerate the decline in T12 saturation.

D.3 Commercial Rebate Process Evaluation—Participant Survey Highlights Memo

To: Michael Noreika, Jim Perich-Anderson, Christina Crowell

From: Navigant

Date: November 7, 2017

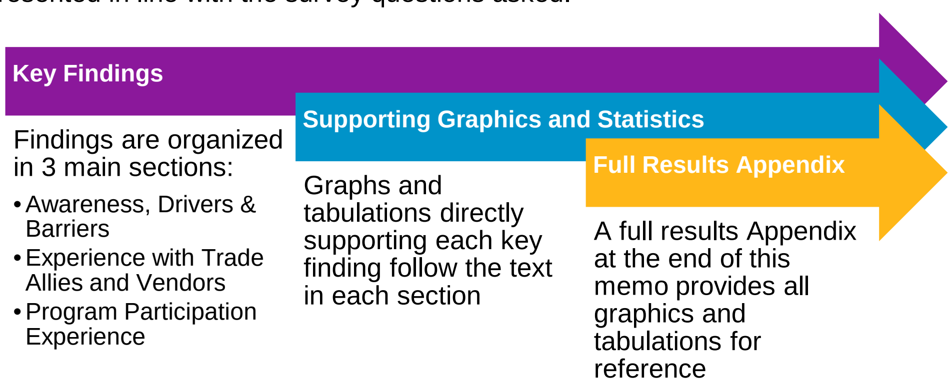
Re: Commercial Rebate Process Evaluation—Participant Survey Highlights Memo

This memorandum highlights key findings from the Puget Sound Energy (PSE) program participant survey based on results through Q2 of 2017. The evaluation team has distilled key findings to enable staff to make mid-course program corrections, as needed, and to help planning for the coming year.

This memo includes a detailed Appendix, with complete graphics and tabulations for all survey questions posed to respondents, along with breakouts by key subprogram and year, in addition to sample size, mean and median for all quantitative questions.

Overview

Each section of this memo begins by presenting key findings which are followed by supporting graphics and tabulations presented in line with the survey questions asked.



Awareness, Drivers, and Barriers

Sources of program awareness varied substantially by subprogram within the Commercial Rebate program. Small Business Direct Install (SBDI) participants most commonly learned about the program through a Community Blitz event or a contractor coming in person to their business. By contrast, Commercial HVAC and Commercial Kitchens participants were more likely to learn about the program through contractors or vendors.

Correlating how frequently respondents cited different information sources with the usefulness of the information revealed the most useful information sources often were not the most commonly encountered. While SBDI participants were most likely to hear about the program through a Community Blitz event or contractor coming to their premises, they found retail sales associates to be the most useful sources of information. Even though the PSE Website and Trade Associations were perceived by SBDI participants to be as informative as blitzes or in-person contractor visits, they were much less frequently cited, suggesting an opportunity to expand awareness through these channels. Commercial Kitchen participants found the PSE website to be the most useful source of information, yet were much more likely to learn about the program through a vendor sales associate. Commercial HVAC customers were most likely to learn about the program from contractors, yet they found the trade associations provided more useful information.

> "Even though the **PSE Website and Trade Associations** were perceived by SBDI participants to be **as informative** as blitzes or in-person contractor visits, they were **much less frequently cited**, suggesting an opportunity to expand awareness."

Overall, the most commonly suggested means of reaching "other businesses like yours" was direct, in-person contact. SBDI, Commercial HVAC and Commercial Kitchen participants suggested direct in-person contact, bill inserts and emails, respectively, as the best means of outreach to other businesses like theirs.

The main reasons people cited for participating in the Commercial Rebate program overall, were to save money and to benefit the environment, though equipment upgrades and improved lighting were also key motivators. Interestingly, while Small Business Direct Install (SBDI) and Commercial HVAC closely mirrored the overall Commercial Rebate program findings, after "Saving Money," Commercial Kitchens respondents rated "Vendor Suggestion" as the second most common reason for participation, with "Environmental Benefit" ranked much lower at fifth. 53% of participants *had considered* installing the energy efficient equipment before they heard of the program, suggesting possible room for improvement in promoting program awareness.

> "After 'Saving Money,' Commercial Kitchens respondents rated '**Vendor Suggestion**' as the second most common reason for participation, with 'Environmental Benefit' ranked much lower."

The recent program change to include co-payed higher-end equipment through the Direct Install (DI) programs appears justified—participants that installed these measures through the program ranked their availability as very important in their decision to participate in the program. Most of these participants felt the co-pay amounts, and the duration of the application process, were "about right."

For non-DI programs, rebates played an important role in customers' decisions to install energy efficient equipment or to service HVAC systems, with the mean rebate influence on participation rated an eight on a zero to ten scale. It is notable though that nearly equal numbers of customers rated the influence of rebates between a five and a seven, or a ten, indicating two different viewpoints.

Commercial Rebate program participants were nearly equally split between feeling marketing materials were extremely influential in their decision to participate versus not influential at all. Roughly the same number of participants rated the program's marketing materials a zero versus a ten on a zero to ten influence scale. Those that experienced a "Community Blitz" overwhelmingly reported this activity being extremely influential on their decision to participate in the program.

Most respondents felt the largest obstacle to getting other firms "like themselves" to participate was lack of awareness. Because a large portion of participants rated the marketing as ineffective, this might be an area of focus to increase overall participation. Other barriers expressed by Kitchens program participants included the high cost of equipment and whether customers have natural gas as a fuel source. SBDI and Commercial HVAC customers also mentioned cost as a barrier, and noted that the blitz approach is not effective if the firm doesn't have a clear decision-maker. Leading suggestions for how to overcome these obstacles to participation were more direct/in-person contact, and improved marketing and advertising through multiple channels.

> "Most respondents felt the largest obstacle to getting other firms 'like themselves' to participate was **lack of awaraeness**. Because a large portion of participants rated the marketing as ineffective, this might be an area of focus."

A1. How did you learn about the program?

Figure 1. Source of Program Awareness—SBDI (n=52)

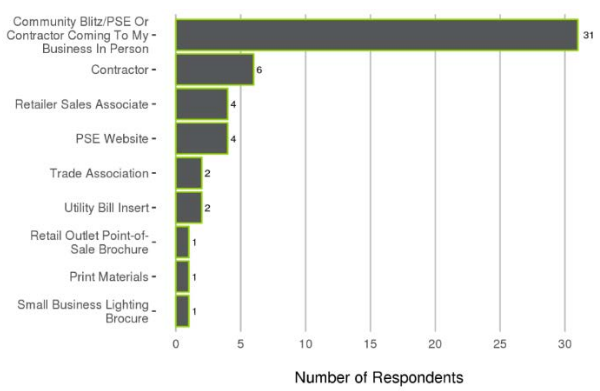


Figure 2. Source of Program Awareness—Commercial HVAC (n=9)

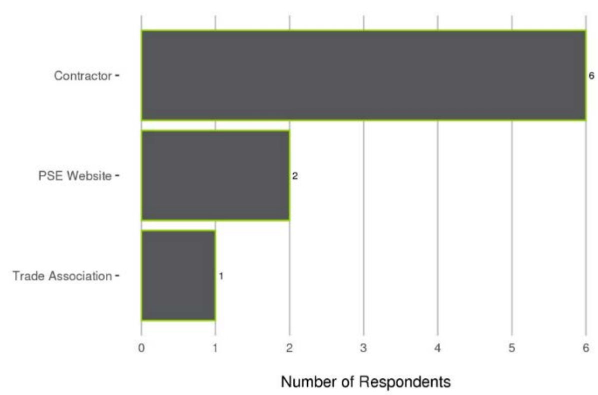
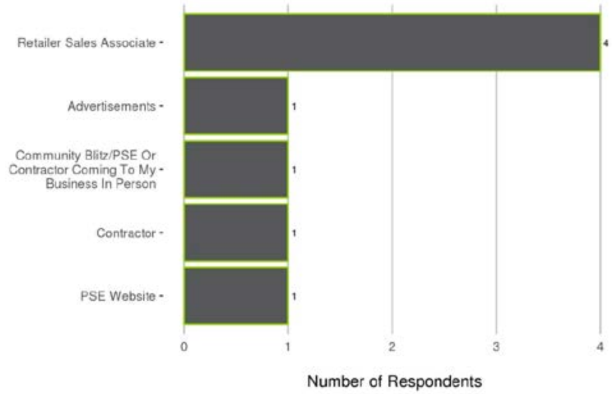


Figure 3. Source of Program Awareness—Commercial Kitchens (n=8)



Other Subprograms:

Commercial Laundry

- PSE Website (n=2)

Premium HVAC

- Retail Sales Associate (n=1)
- Contractor (n=1)

Agriculture DI

- Conservation District Representative/Meeting (n=1)

Hospitality

- Korean Hotel Association (n=1)

A2. On a scale of 0 to 10, where zero is not at all useful and ten is very useful, how useful was the source information in helping you participate in the program?

Figure 4. Percent of Respondents Citing each Source versus Perceived Usefulness of Information—SBDI (n=53)

Figure 5. Percent of Respondents Citing each Source versus Perceived Usefulness of Information—Commercial Kitchens (n=7)

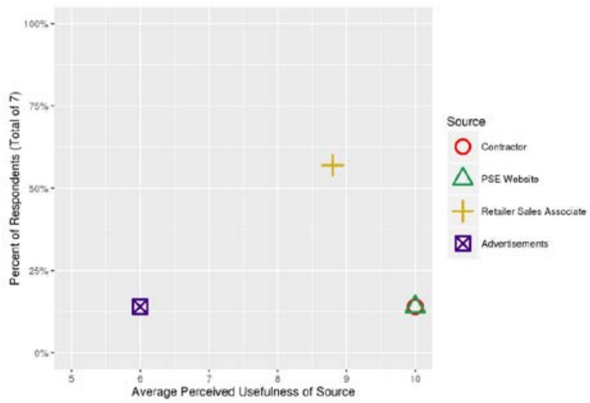
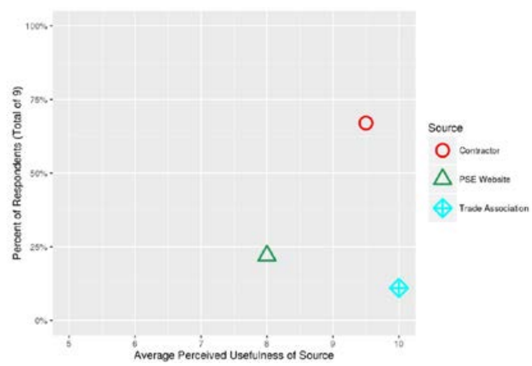


Figure 6. Percent of Respondents Citing each Source versus Perceived Usefulness of Information—Commercial HVAC (n=9)



A3. What do you think would be the best way to reach other businesses like yours to participate in the program?

Figure 7. Best Way to Reach More Businesses Like Mine, SBDI (n=122)

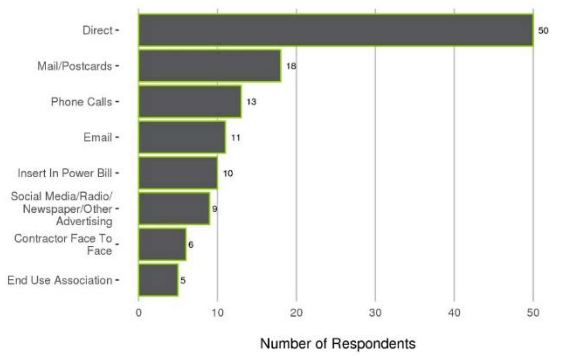


Figure 8. Best Way to Reach More Businesses Like Mine, Commercial HVAC (n=9)

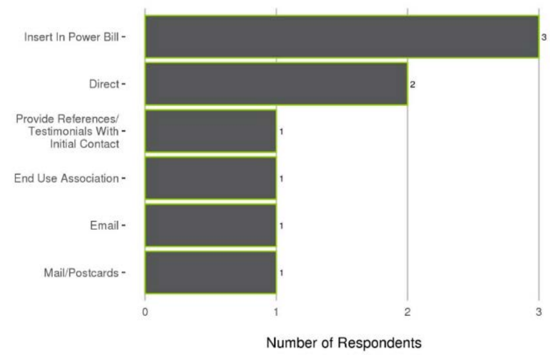
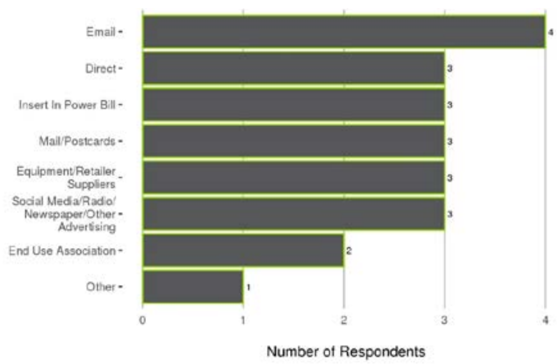


Figure 9. Best Way to Reach More Businesses Like Mine, Commercial Kitchens (n=22)



D1. Why did you participate in the program? (n=147)

Figure 10. Main Reason for Program Participation—Commercial Rebate Program Overall (n=147)

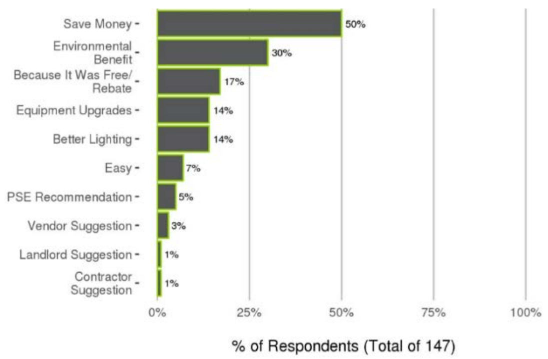
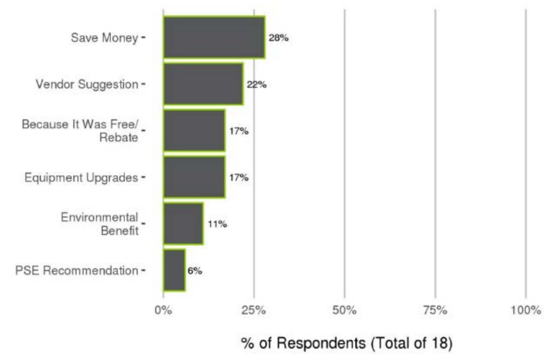


Figure 11. Main Reason for Program Participation—Commercial Kitchens (n=18)



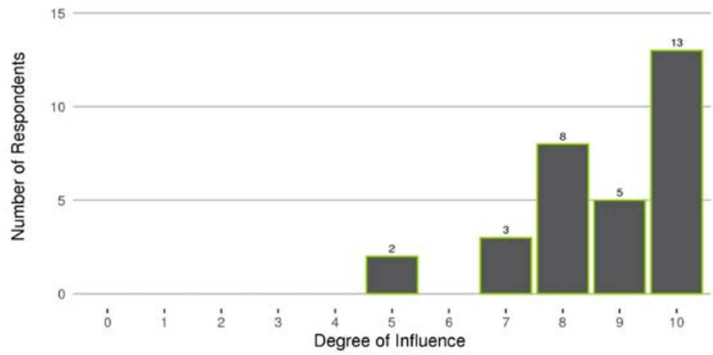
D2. Did you consider installing the energy efficient equipment before you heard about the program? (n=151)

Yes	**53%**
No	**47%**

D3. For DI customers who paid at least part of the cost of equipment (i.e.-they installed some not completely free DI measures), on a scale of 0-10, with zero being not at all influential and ten being very influential, how influential was the availability of the low-cost equipment in your decision to participate? (n=31)

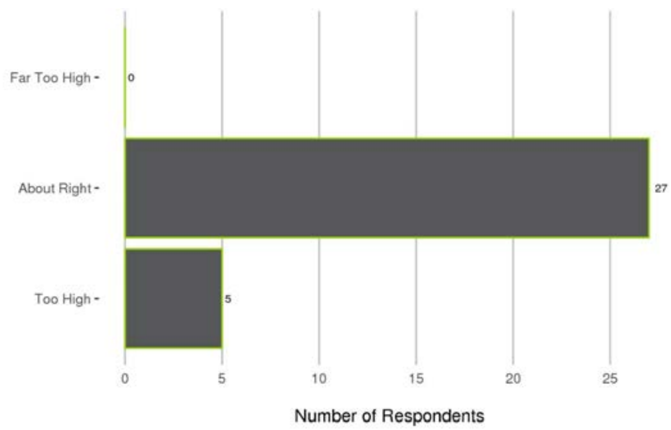
Mean	**8.7**
Median	**9**

Figure 12. Importance of Low-Cost Co-Paid Equipment in Direct Install Participation Decision (n=31)



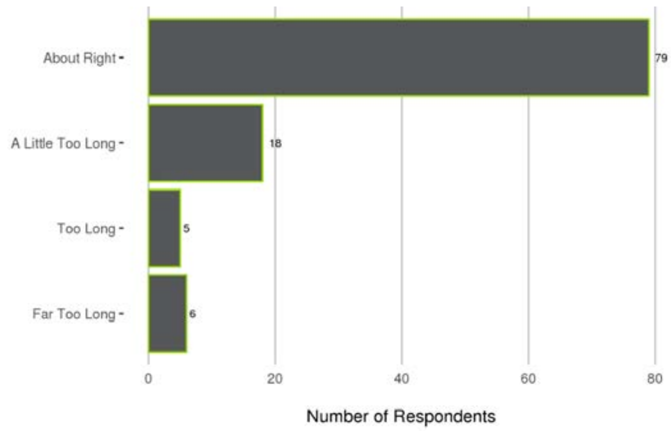
D4. How would you rate the amount of the co-pays you had to pay for the equipment through the program? About right, too high or far too high? (n=32)

Figure 13. Perceived Appropriateness of Co-pay Level for Non-Free DI Measures (n=32)



D5. For DI participants, from the time of the energy audit on your premises to final installation of the last energy efficient equipment through the program, how would you rate how long it took you to complete the program participation process? About right, a little too long, too long, or far too long? (n=107)

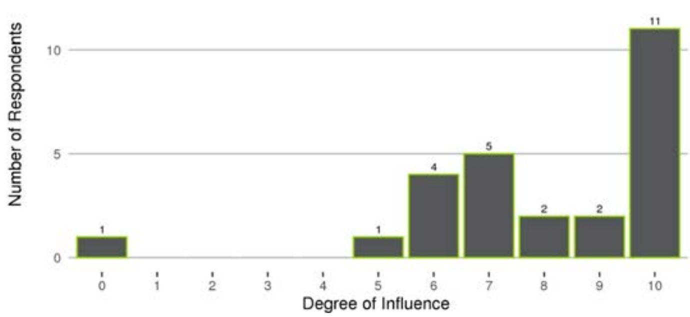
Figure 14. Perceived Appropriateness of Length of Time to Complete Participation in DI Programs (n=107)



D6. [Excluding DI participants, including all other subprograms] On a scale of 0-10, with zero being not at all influential and ten being very influential, how influential was the financial incentive on your decision to install the equipment/perform the HVAC service? (n=26)

Mean	**8.5**
Median	**9**

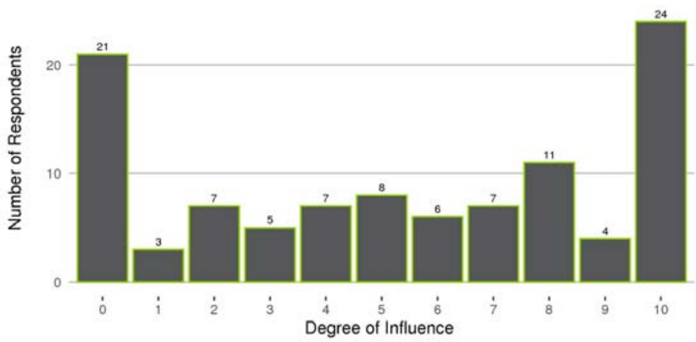
Figure 15. Influence of Incentive on Decision to Install Equipment/Service Existing HVAC Equipment (n=26)



D7. On a scale of 0-10, with zero being not at all influential and ten being very influential, how influential were the program's marketing materials on your decision to participate? (n=103)

Mean	**5.3**
Median	**6**

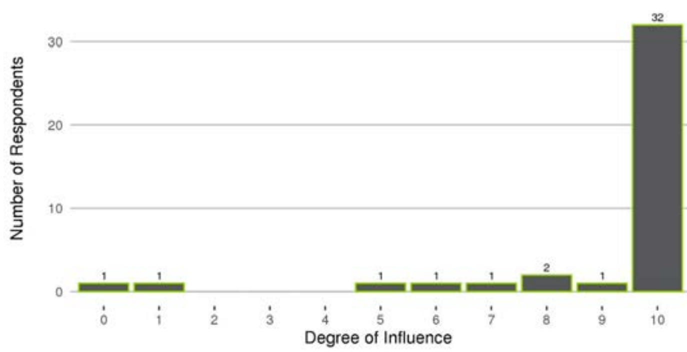
Figure 16. Influence of Marketing Materials on Participation Decision—Commercial Rebate Program Overall (n=103)



D8. Of those for whom the Community Blitz was a part of their program participation experience, on a scale of 0 to 10, with zero being not at all influential and ten being very influential, how influential was the PSE Community Blitz in your decision to participate in the program? (n=40)

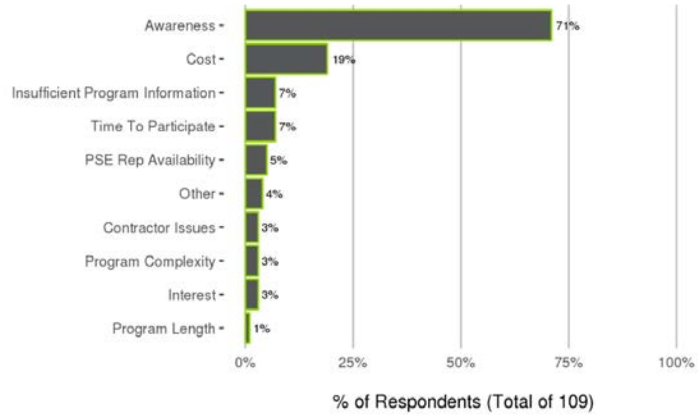
Mean	**9.1**
Median	**10**

Figure 17. Community Blitz Degree of Influence on Participation Decision (n=40)



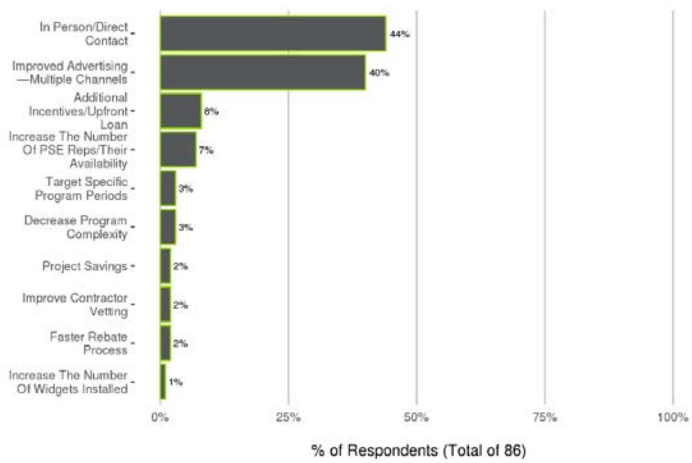
D9. What do you see as the most significant barrier keeping other businesses like yours from participating in the program? (n=109)

Figure 18. Most Significant Barrier Keeping Businesses Like Yours from Participating—Commercial Rebate Program Overall (n=109)



D9a. What suggestions do you have for how the program could overcome this barrier to make participation easier for businesses like yours? (n=86)

Figure 19. Suggestions to Overcome Barriers to Participation, Commercial Rebate Program Overall (n=86)



Experience with Trade Allies and Vendors

Most respondents either identified the contractor they used via a web search, had an existing relationship with a contractor, or chose a contractor who reached out directly to them. Participants who interacted with the Contractor Alliance Network (CAN) found it very helpful in selecting a contractor, with a mean usefulness score of 9.2 on a zero to ten scale.

Most respondents that used a contractor felt the contractor was highly influential on their decision to participate in the program, with a median influence score of 9 on a zero to ten scale. Interestingly, the mean score, 7.3 out of ten, reflects the fact that 14 percent of respondents rated contractor influence a zero out of ten, bringing the average down, and indicating a second distinct perspective. While the vast majority of participants were very satisfied with the contractor's work, providing a mean satisfaction score of 9.1 and median score of ten out of ten, a small, highly dissatisfied minority reported poor workmanship, poor communication, and contractors not finishing work.

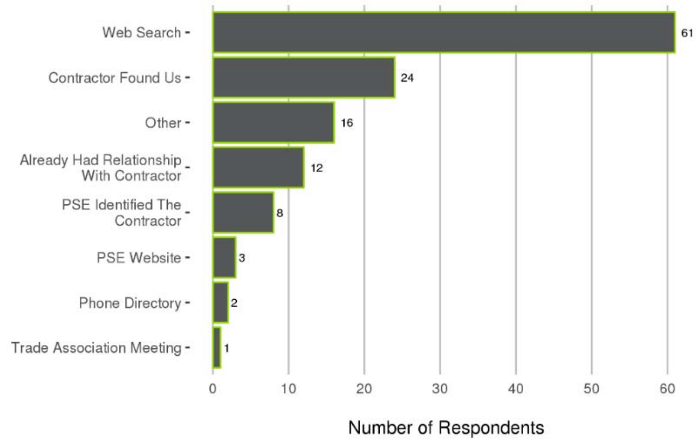
"While the **vast majority of participants were very satisfied** with the contractor's work, providing a mean satisfaction score of 9.1…, a small, highly dissatisfied minority reported poor workmanship, poor communication and contractors not finishing work."

All Commercial Kitchens participants we interviewed reported having purchased their program qualifying equipment through a retail outlet. None of the participants surveyed knew of any kitchen equipment vendors not currently in the program that they would like to see added. This likely indicates the program has developed a comprehensive relationship with local vendors and has good coverage throughout PSE's territory. However, there could also be underserved regions where additional vendors need to be engaged, but these might not appear in the survey results due to low representation in the participant sample. In most cases the vendor mentioned the PSE rebate before the customer purchased the equipment, rather than subsequently. This is a very positive finding, indicating vendors are using the program rebates as a marketing tool, and lowering the potential for free-ridership. Roughly half of participants reported that the vendor also mentioned available rebates on additional equipment, again signaling proactive marketing efforts. Most participants reported being highly satisfied with their interactions with Commercial Kitchen program vendor. The mean satisfaction score was 8.5 on a zero to ten scale, and the median was a nine.

"Roughly half of participants reported that the vendor also mentioned available **rebates on additional equipment**, …signaling proactive marketing efforts."

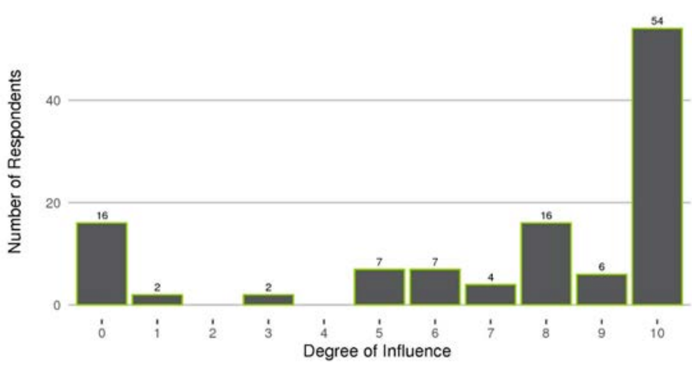
T2. How did you find the contractor who completed the installation? (n=125)

Figure 20. How did you Find a Contractor? (n=125)



T3. On a scale of 0-10, with zero being not at all influential and ten being very influential, how influential was the contractor in your decision to participate in the program? (n=114)

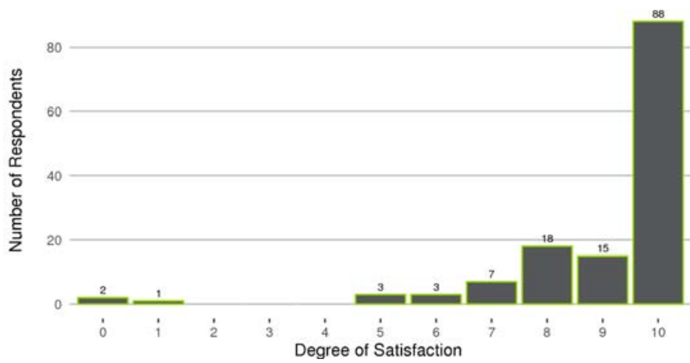
Figure 21. Influence of Contractor on Participation Decision—Commercial Rebate Program Overall (n=114)



T4. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction with the contractor's work? (n=137)

Mean	**9.1**
Median	**10**

Figure 22. Satisfaction with Contractor's Work—Commercial Rebate Program Overall (n=137)



T4a. For those with satisfaction less than 6, what was the reason for your dissatisfaction? (n=4)

Note: Not all those that rated satisfaction below 6 provided a reason**.**

- "Total fraud, replaced very few lights."
- "Communication, took too long getting back."
- "Contractor did inside work, but not outside."
- "Poor workmanship"

V3. Did the retail outlet/vendor mention the PSE rebate available on the equipment prior to your purchasing the equipment? (n=11)

Yes	**82%**
No	**9%**
Other	**9%**

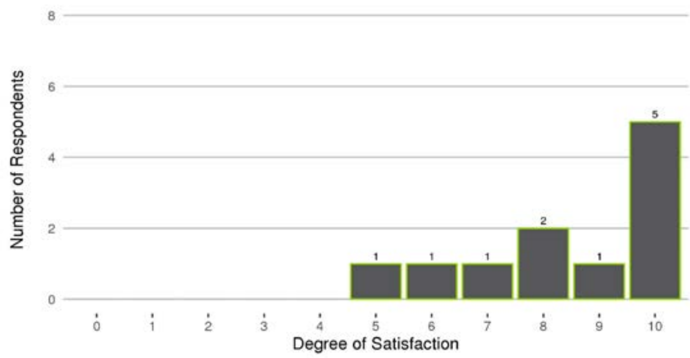
"Other" response (n=1)

"No, they mentioned some other company."

V4. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction with your interaction with this vendor?

Mean	**8.5**
Median	**9**

Figure 23. Satisfaction with Vendor Interaction (n=11)



V5. Did the vendor provide any information on PSE rebates available for energy efficient kitchen equipment other than the equipment you purchased? (n=11)

Yes	**45%**
No	**55%**

V6. Are there any vendors you typically purchase equipment from that are not part of the Kitchens program that you wish were involved in the program? (n=8)

Yes	**13%**
No	**87%**

"Yes" response (n=1):
"Don't recall"

Program Participation Experience

People's expectations for the program aligned with their reported main reason for participation, with monetary incentives and sustainability mentioned most often. The clear majority of program participants rated the program very highly in terms of its meeting their expectations, with a median score of ten out of ten. When asked how the program could have better met expectations, the small number of dissatisfied respondents mentioned lower-than-expected savings, lengthy process and low incentives.

"The clear majority of program participants **rated the program very highly** in terms of its meeting their expectations, with a median score of **ten out of ten**."

Roughly half of respondents reported filling out the application themselves, and those who filled out their own application rated the process highly, with a mean score of 8.1 and a median of 9 on a scale of zero to ten. The vast majority of participants expressed that the length of time to process their application was "About Right." Only three out of 52 respondents reported their wait time to be "Too Long" or "Far Too Long." Figure indicates that the typical program duration was two months, with less than 10% of respondents reporting program participation durations of four months or longer. Only 9% of respondents reported encountering any problems with their application process, with those that did encounter problems mentioning communication issues, applications not well suited to the project, or insufficient assistance completing forms.

Participants rated their satisfaction with participation in the DI programs very highly, with a mean and median score of 9.0 and 10, respectively. The small number of dissatisfied DI participants cited unfinished work, communication issues with contractors, and poor work quality. Only two Premium HVAC participants were reached by the survey, but both rated their program experience highly. Overall, respondents suggested they were likely to participate in programs again in the future. 72% of respondents indicated they would participate in the Commercial Rebate program again in the future. Interestingly, of the subprograms with sufficient response rates, Commercial Kitchens generated the largest percent likely to repeat participation (90%), followed by SBDI (73%) and Commercial HVAC (67%).

"**72%** of respondents indicated they **would participate** in the Commercial Rebate program **again in the future**."

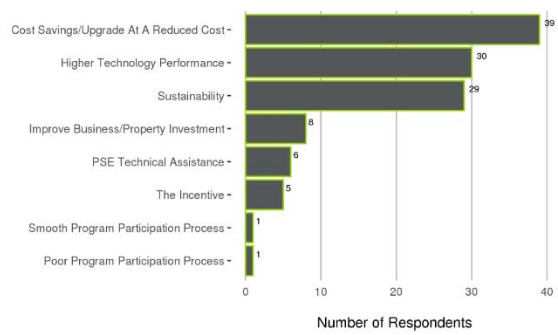
Overall, participants rated their communication and experiences with contractors, vendors and PSE staff highly. Respondents rated their satisfaction with contractor communication and interactions very favorably, with a mean score of 9.0 and a median score of ten on a zero to ten scale. Using the same scale, respondents rated their communications and interactions with PSE staff even more highly. Though based on a much smaller sample size, satisfaction with vendor communication and interactions through the Commercial Kitchen and Laundry subprograms was rated less highly, earning a mean and median score of 7.8 and eight, respectively.

Participants expressed very high levels of satisfaction with the Commercial Rebate program overall, with the variety of energy efficiency programs offered by PSE, and with PSE as a utility. Mean and median satisfaction scores for these ranged between 8.8 and ten. Interestingly, the distribution of each of these scores showed a small increase at eight, suggesting there are a large number of very satisfied customers whose experience, nonetheless, could be improved to nudge their satisfaction ratings to nine or ten.

E1. What were your expectations of the program? (n=119)

Mean	**8.8**
Median	**10**

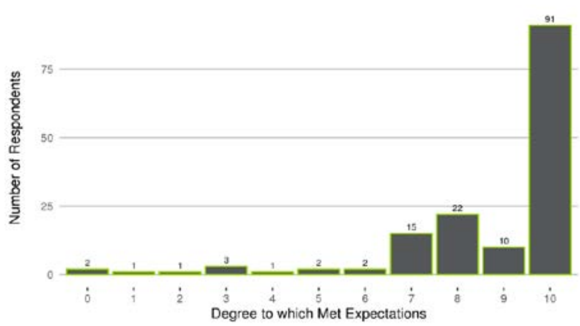
Figure 24. Program Expectations—Commercial Rebate Program Overall (n=119)



E2. On a scale of 0-10, where zero means not at all well, and ten means very well, how well did the program meet your expectations? (n=150)

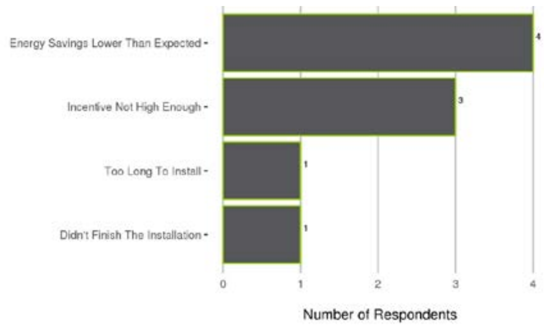
Mean	**8.8**
Median	**10**

Figure 25. Degree to which Program Met Expectations—Commercial Rebate Program Overall (n=150)



E2a. For those who rated degree to which the program met their expectations less than a 6. What could have been done differently to ensure the program met or exceeded your expectations? (n=9)

Figure 26. Areas for Improvement for those with Satisfaction Less than 6—Commercial Rebate Program Overall—(n=9)



*Note: Not all respondents with satisfaction lower than 6 provided a response to this question.

E3. Did you fill out the program application yourself? (n=119)

Yes	**45%**
No	**55%**

E3a. For those who completed their own application, on a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction with the program application? (n=49)

Mean	**8.1**
Median	**9**

Figure 27. Satisfaction with Application Process—Commercial Rebate Program Overall (n=49)

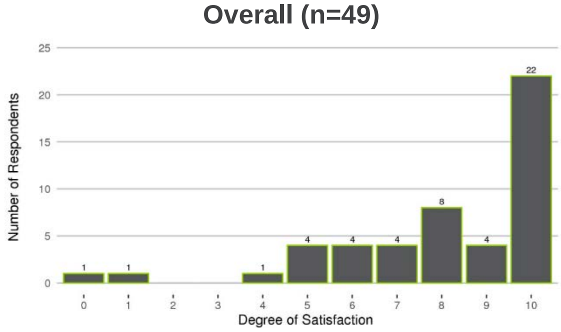
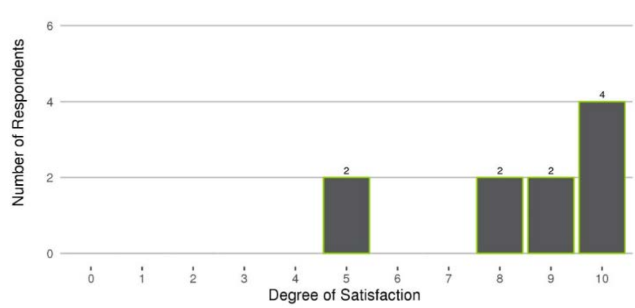
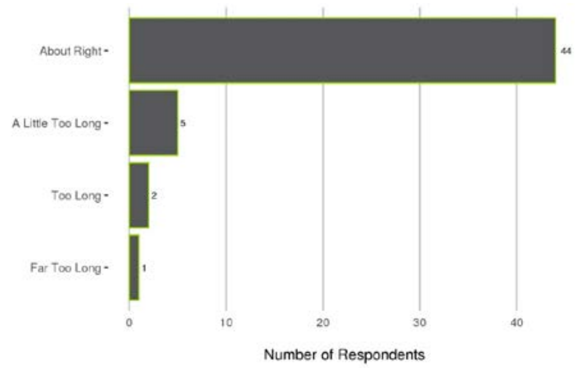


Figure 28. Satisfaction with Application Process—Commercial Ki tchens (n=10)



E5. For those that completed the application themselves, how would you rate the length of time it took to process the application? About right, a little too long, too long, or far too long? (n=52)

Figure 29. Satisfaction with Length of Time to Process Application, Commercial Rebate Program Overall (n=52)



E6. For those that completed the application themselves, were there any problems with your application? (n=54)

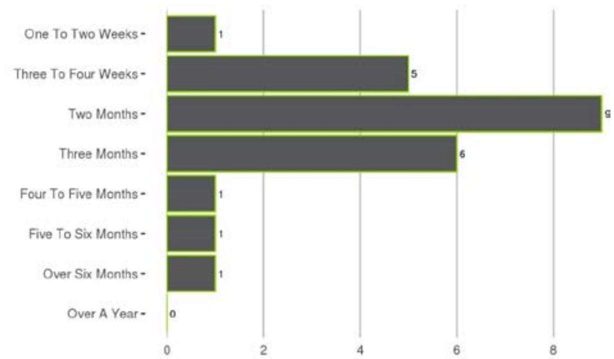
Yes	**9%**
No	**91%**

E6a. For those that experienced problems, what problems were there with your application? (n=4)

- "Needed more help in the beginning filling it out"
- "Application didn't fit my situation"
- "I didn't get to complete one question"
- "Contact person was fired, so I could not get feedback"

E7a. Regardless of whether they filled the application out themselves, how long did it take to complete the program process, from application submission to rebate check receipt? (n=24)

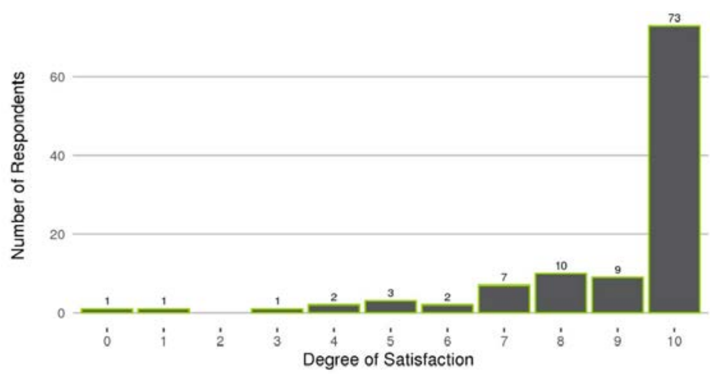
Figure 30. Program Participation Duration, for All Those Receiving Rebates (n=24)



E8. On a scale of 0-10, with zero being very dissatisfied and 10 being very satisfied, how satisfied were you with the direct install experience? (n=111)

Mean	**9.0**
Median	**10**

Figure 31. Satisfaction with the Direct Install Process (n=111)



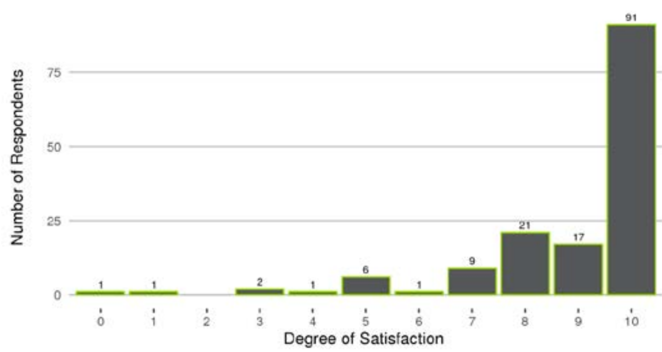
E8a. For those who reported being dissatisfied, what would have made you more satisfied with the direct install experience? (n=5)

- "Not having the mix-up about when to come and install bulbs."
- "They could come and finish the job on the outside lighting and return my calls."
- "Have my calls returned in a timely manner, having the contractor be fully aware of the scope of the project, have the original project outline completed properly, have the contractor be properly equipped to complete the project, contractor should be sure all equipment is returned on time. Reduce the time between the energy audit and the actual install."
- "Very few lights were replaced as promised."
- "Complete the work. They did not complete the work."

E10. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction overall with the program? (n=150)

Mean	**8.9**
Median	**10**

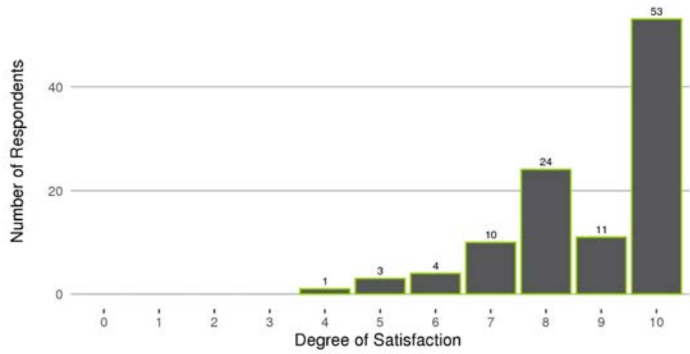
Figure 32. Satisfaction with Program Overall—Commercial Rebate Program Overall (n=150)



E11. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate PSE on the variety of energy efficiency programs offered? (n=106)

Mean	**8.8**
Median	**10**

Figure 33. Satisfaction with the Variety of Energy Efficiency Programs PSE Offers—Commercial Rebate Program Overall (n=106)



E12. Would you to participate in this program or another PSE program in the future? (n=145)

Commercial Rebate Program Overall (n=145)

Yes	**72%**
No	**28%**

SBDI (n=96)

Yes	**73%**
No	**27%**

Commercial HVAC (n=12)

Yes	**67%**
No	**33%**

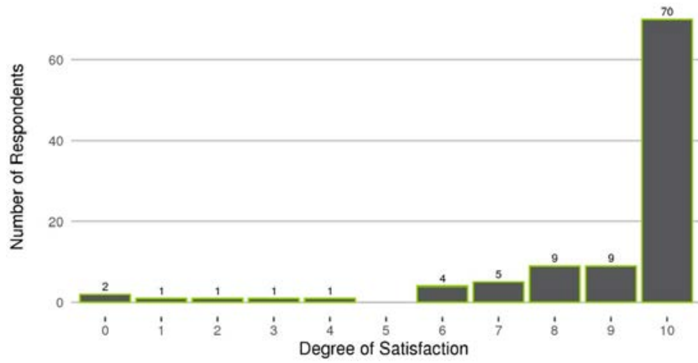
Commercial Kitchens (n=19)

Yes	**90%**
No	**10%**

E13. On a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with any communications or interactions you might have had with the contractor? (n=123)

Mean	**9.0**
Median	**10**

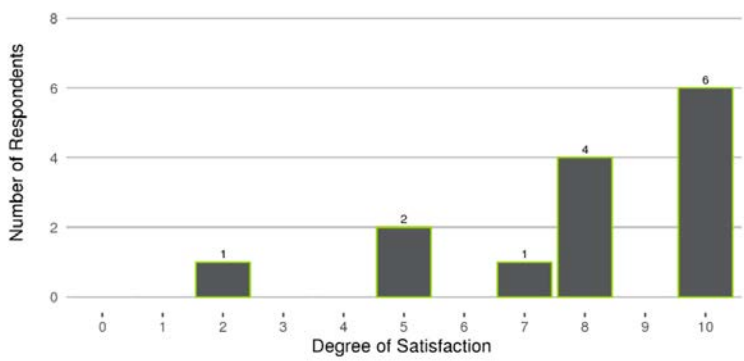
Figure 34. Satisfaction with Contractor Communication (n=123)



E14. For Kitchens Program participants, on a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with any communications or interactions you might have had with the vendor? (n=14)

Mean	**7.9**
Median	**8**

Figure 35. Satisfaction with Vendor Communication and Interactions, Commercial Kitchens (n=14)

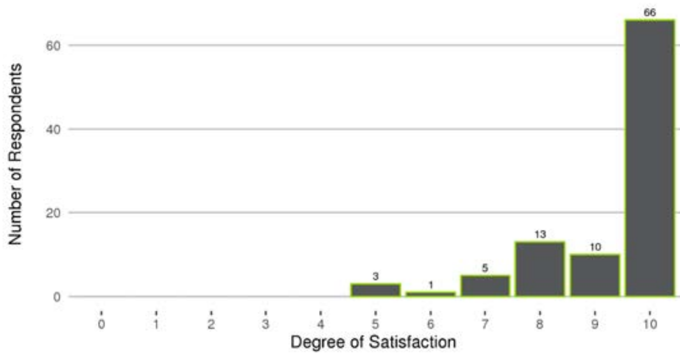


E15. On a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with any communications or interactions you might have had with PSE staff? (n=98)

Note: There were many "Don't Know" or "Not Applicable" responses; without these removed, the total number of respondents was 142.

Mean	**9.3**
Median	**10**

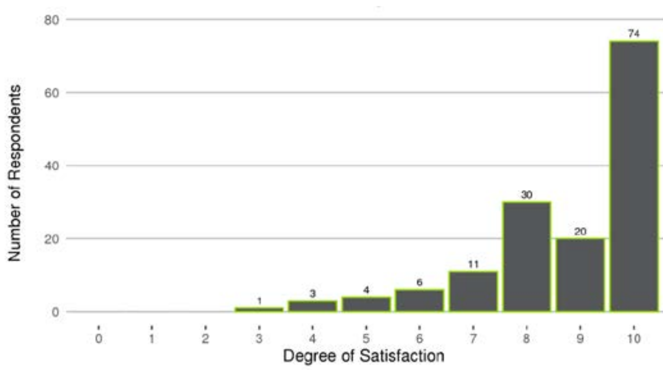
Figure 36. Satisfaction with Communication and Interaction with PSE Staff—Commercial Rebate Program Overall (n=142)



E16. On a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with Puget Sound Energy overall? (n=149)

Mean	**8.8**
Median	**9**

Figure 37. Satisfaction with Puget Sound Energy Overall—Commercial Rebate Program Overall (n=149)



Appendix

Awareness

A1. How did you learn about the program?

Figure 38. Source of Program Awareness—SBDI (n=52)

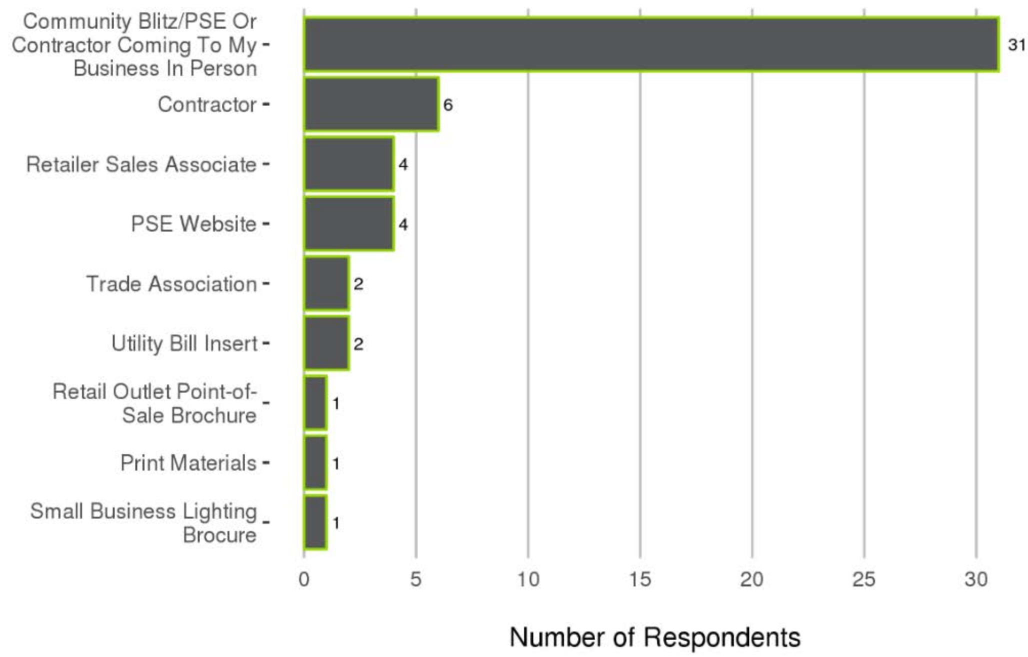


Figure 39. Source of Program Awareness—Commercial HVAC (n=9)

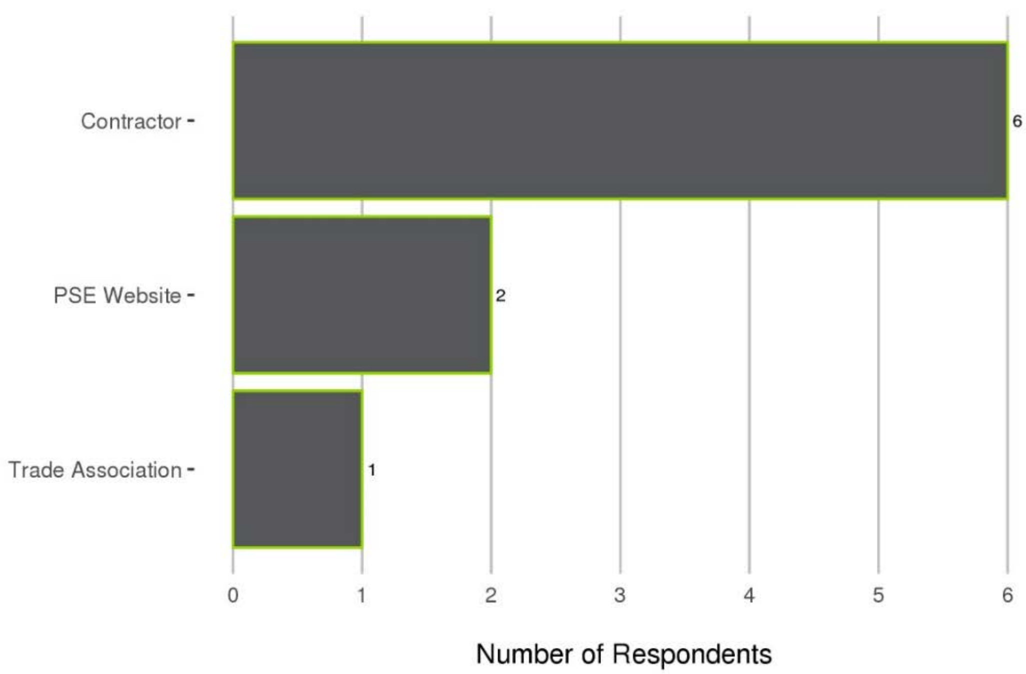
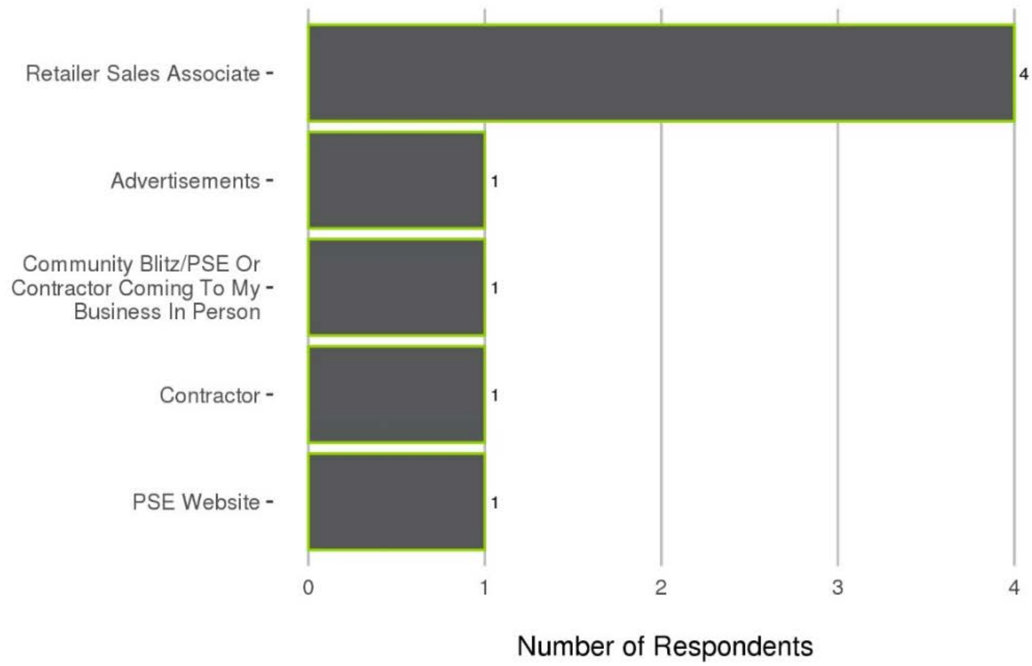


Figure 40. Source of Program Awareness—Commercial Kitchens (n=8)



Other Subprograms:

Commercial Laundry
- PSE Website (n=2)

Premium HVAC
- Retail Sales Associate (n=1)
- Contractor (n=1)

Agriculture DI
- Conservation District Representative/Meeting (n=1)

Hospitality
- Korean Hotel Association (n=1)

A2. On a scale of 0 to 10, where zero is not at all useful and ten is very useful, how useful was the source information in helping you participate in the program?

Figure 41. Percent of Respondents Citing each Source versus Perceived Usefulness of Information—SBDI (n=53)

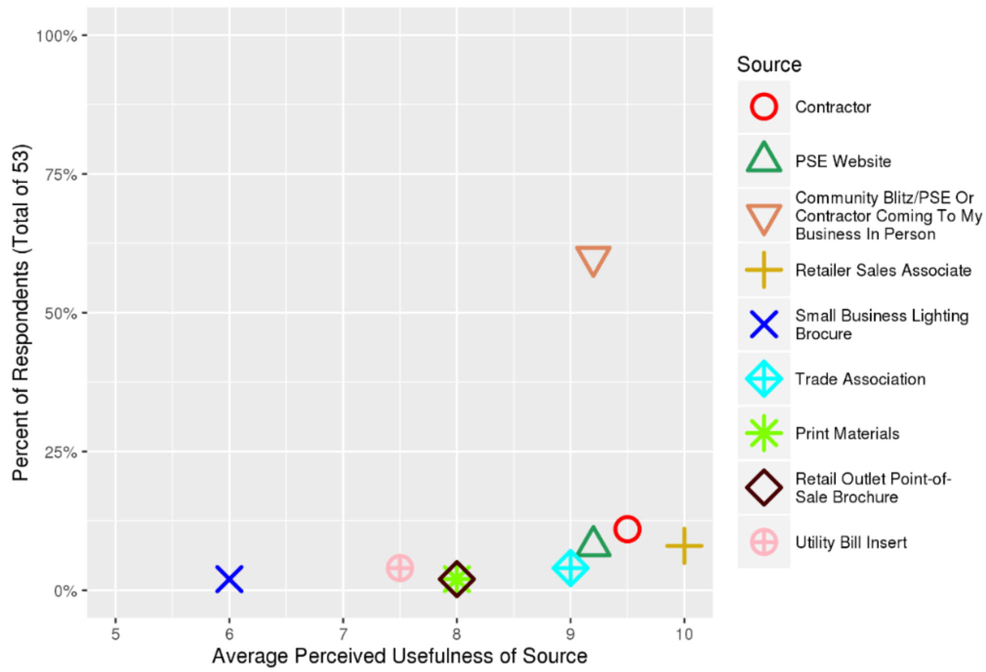


Figure 42. Percent of Respondents Citing each Source versus Perceived Usefulness of Information—Commercial Kitchens (n=7)

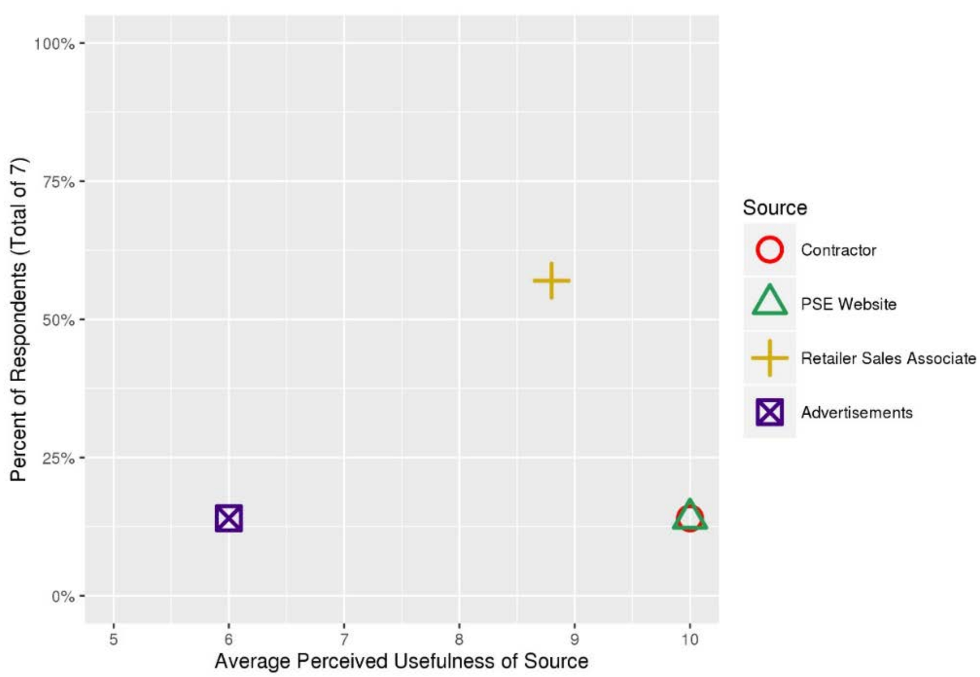
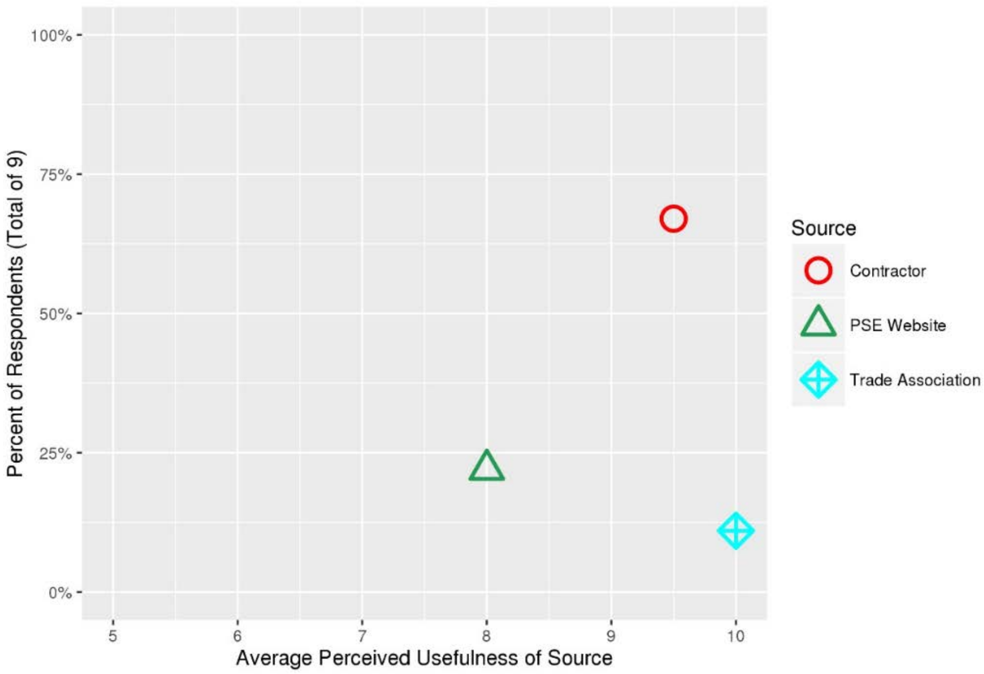


Figure 43. Percent of Respondents Citing each Source versus Perceived Usefulness of Information—Commercial HVAC (n=9)



A3. What do you think would be the best way to reach other businesses like yours to participate in the program?

Note: Some respondents provided more than one suggestion; as a result, the number of responses (169) exceeds the number of respondents (150).

Figure 44. Best Way to Reach More Businesses Like Mine, Commercial Rebates Overall (n=169)

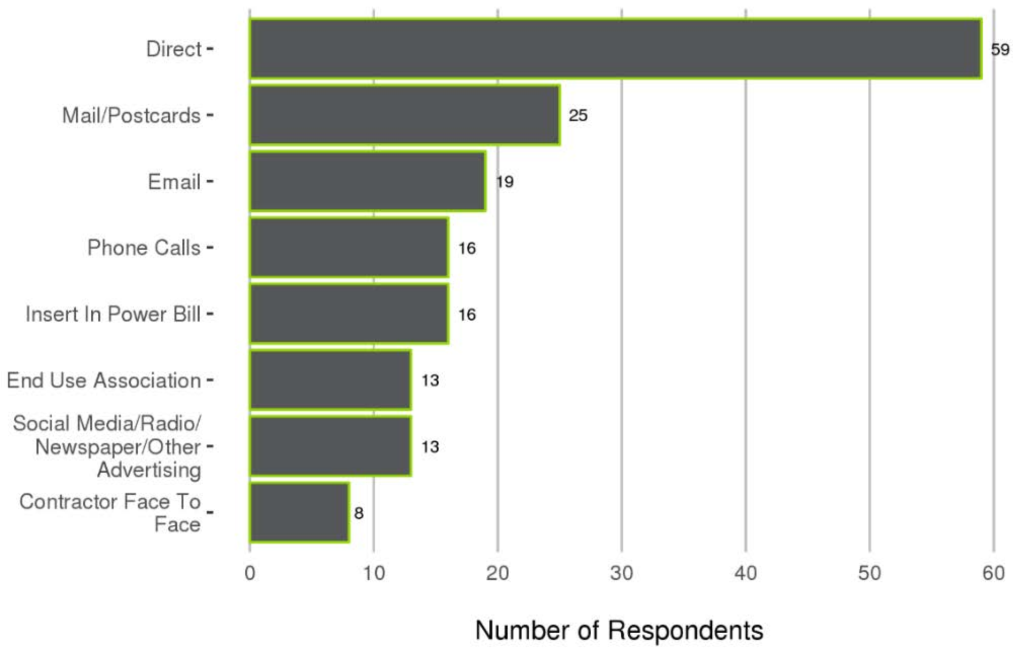


Figure 45. Best Way to Reach More Businesses Like Mine, SBDI (n=122)

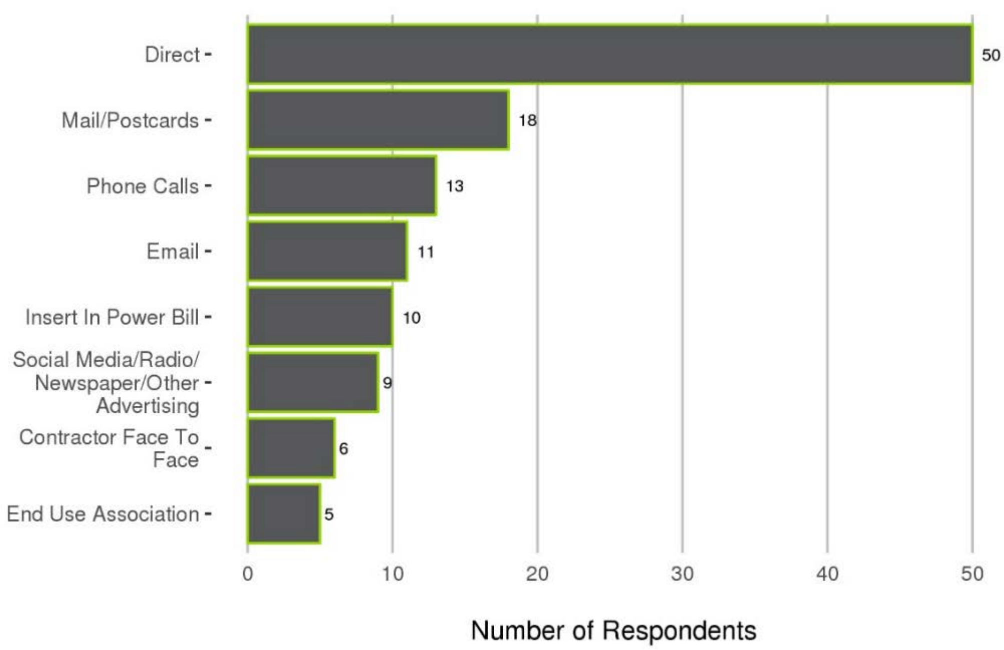


Figure 46. Best Way to Reach More Businesses Like Mine, Commercial HVAC (n=9)

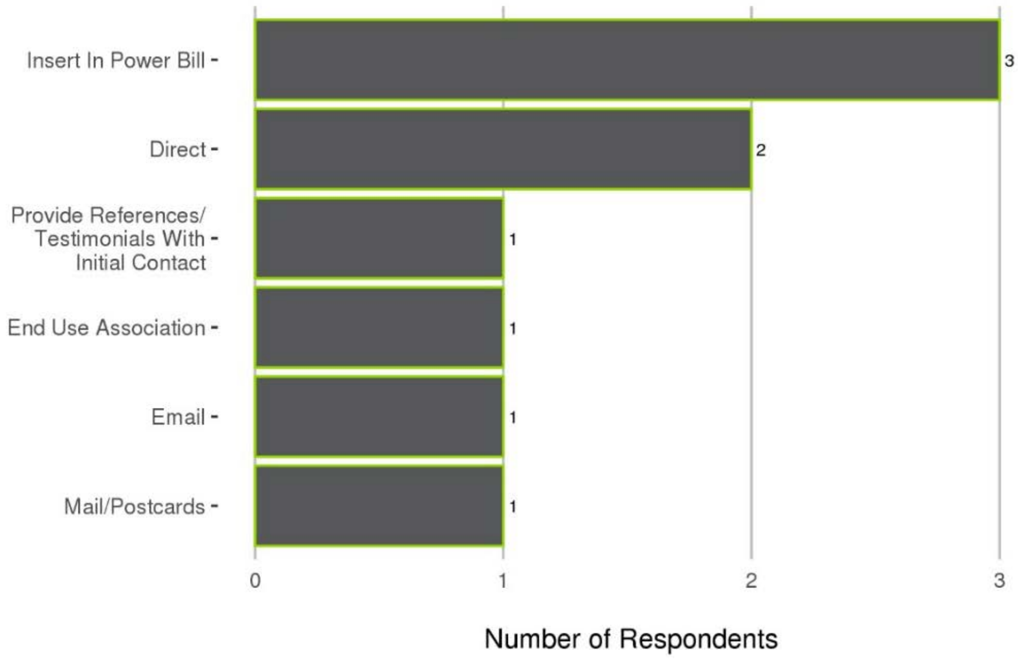
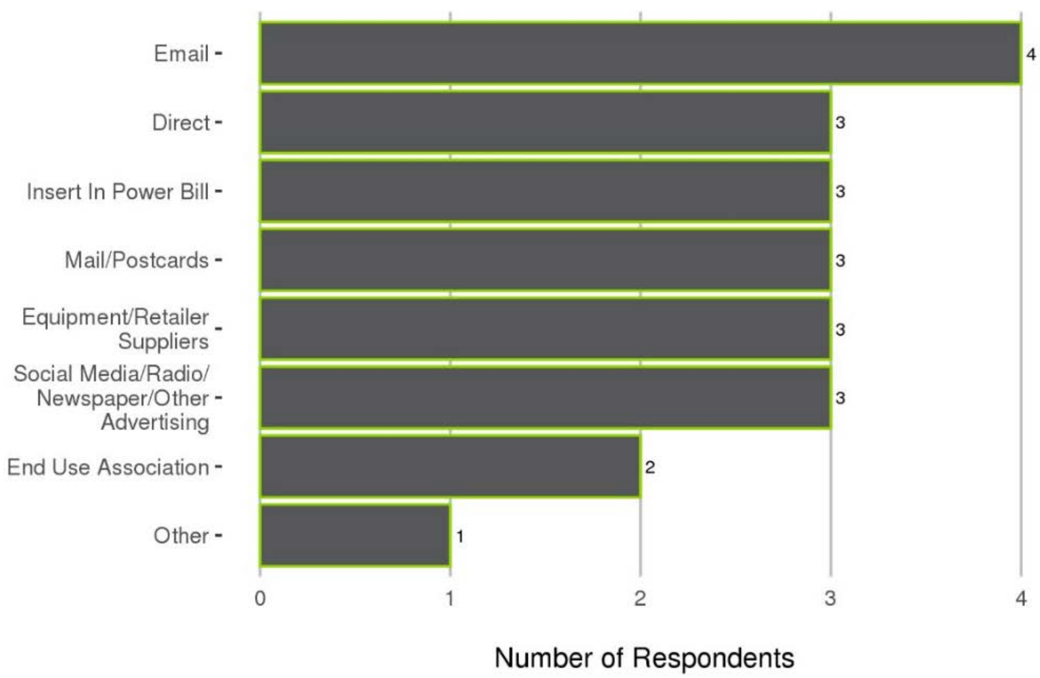


Figure 47. Best Way to Reach More Businesses Like Mine, Commercial Kitchens (n=22)



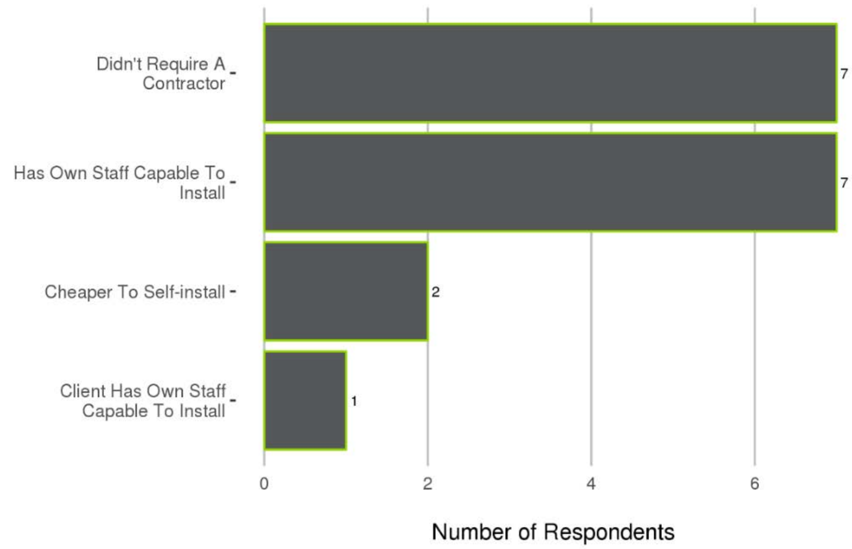
Trade Ally Involvement

T1. Did you self-install the equipment, or did you have a contractor complete the work? (n=151)

Self-install	**11%**
Contractor-install	**89%**

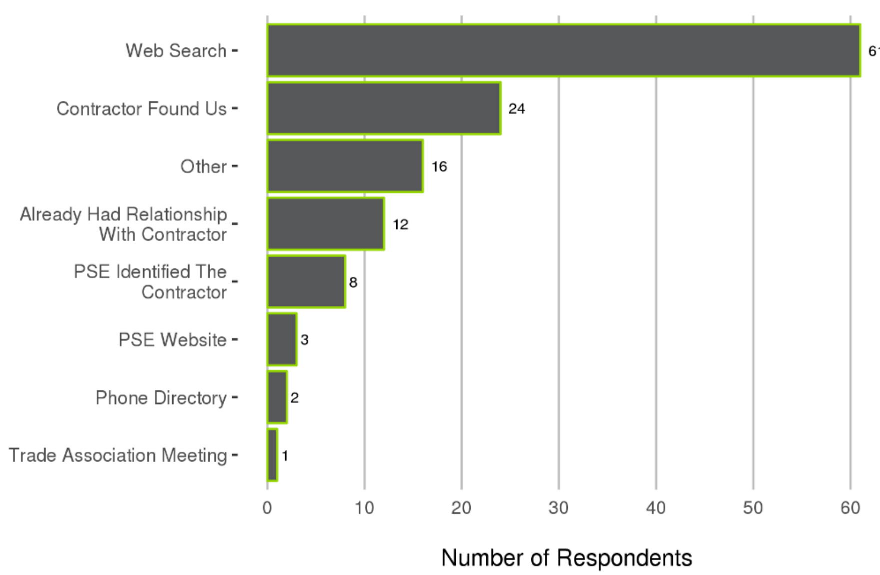
T1a. Why did you decide to self-install and not have a contractor complete the work? (n=17)

Figure 48. Reasons for Self-Install (n=17)



T2. How did you find the contractor who completed the installation? (n=125)

Figure 49. How did you Find a Contractor? (n=125)



T2a. On a scale of 0-10, with zero being not at all helpful and ten being very helpful, how helpful was the PSE Contractor Alliance Network (CAN) in your search for a contractor? (n=27)

Mean	**9.2**
Median	**10**

T3. On a scale of 0-10, with zero being not at all influential and ten being very influential, how influential was the contractor on your decision to participate in the program? (n=114)

Mean	**7.3**
Median	**9**

Figure 50. Influence of Contractor on Participation Decision—Commercial Rebate Program Overall (n=114)

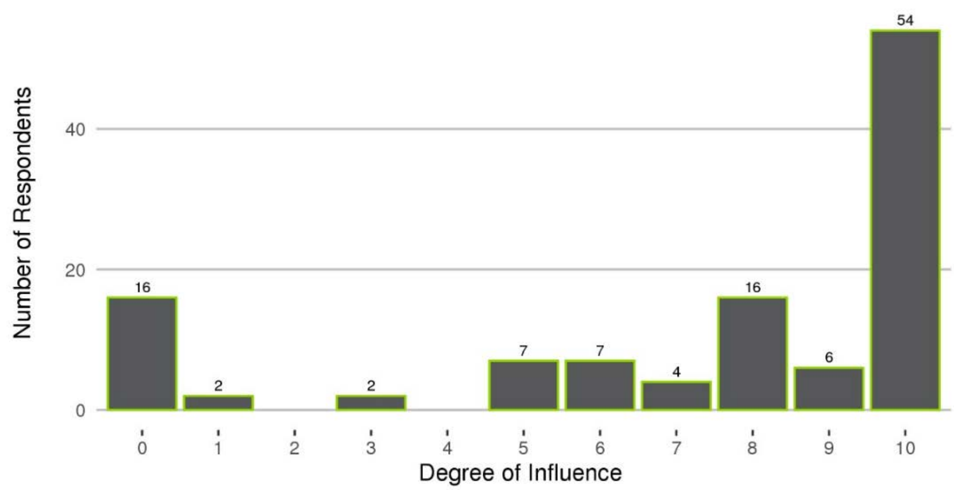


Figure 51. Influence of Contractor on Participation Decision—2016 Only—Commercial Rebate Program Overall (n=76)

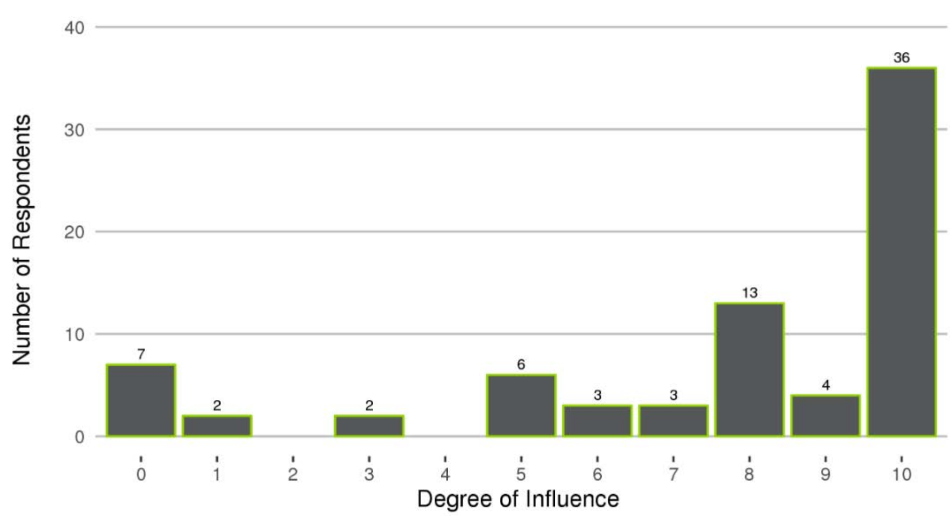


Figure 52. Influence of Contractor on Participation Decision—2017 Only (through Q2)—Commercial Rebate Program Overall (n=38)

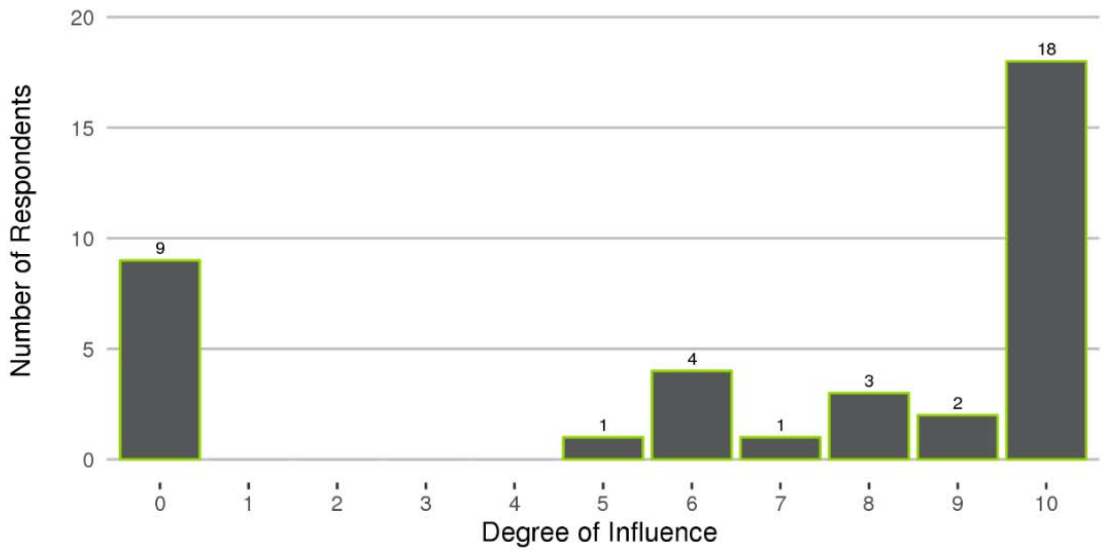


Figure 53. Influence of Contractor on Participation Decision--SBDI (n=78)

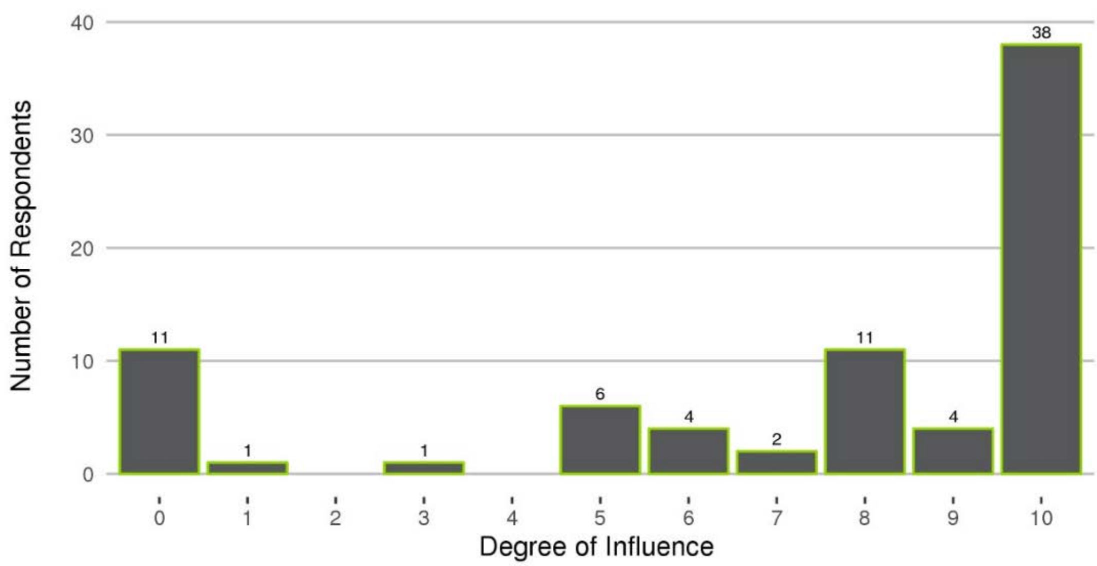


Figure 54. Influence of Contractor on Participation Decision—Commercial HVAC (n=10)

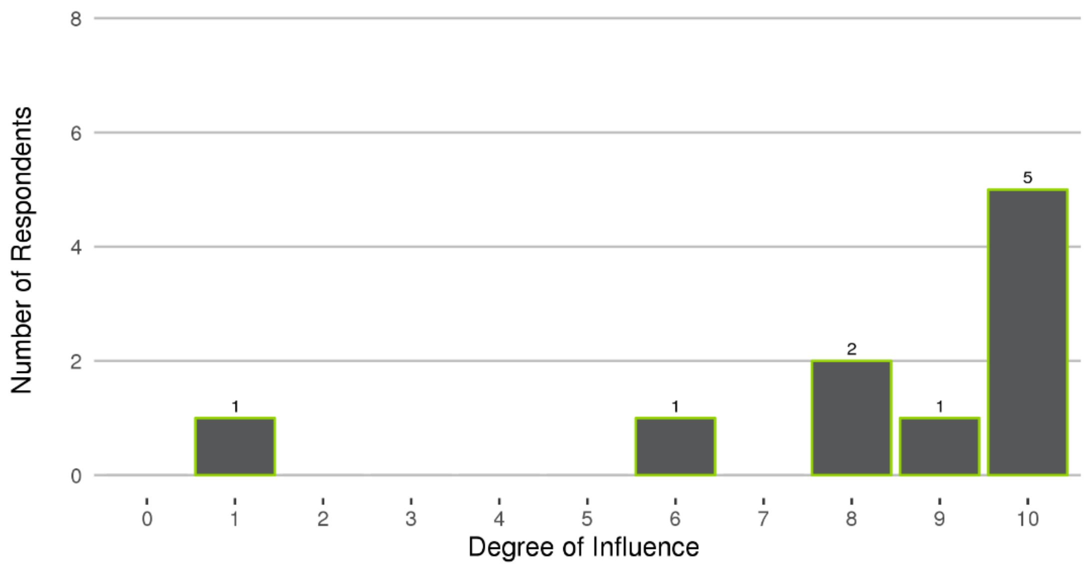


Figure 55. Influence of Contractor on Participation Decision--Kitchens (n=13)

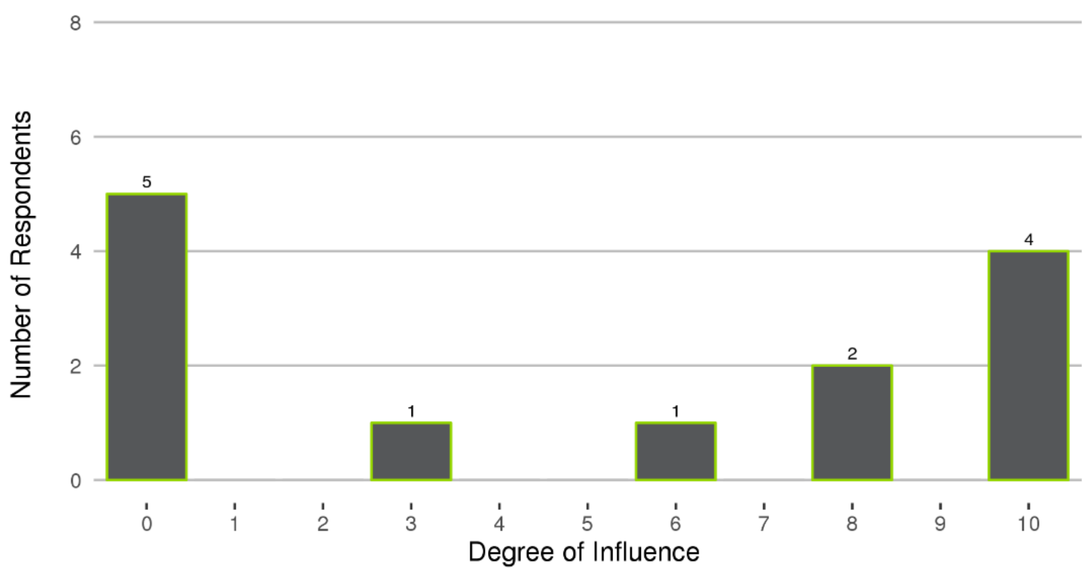
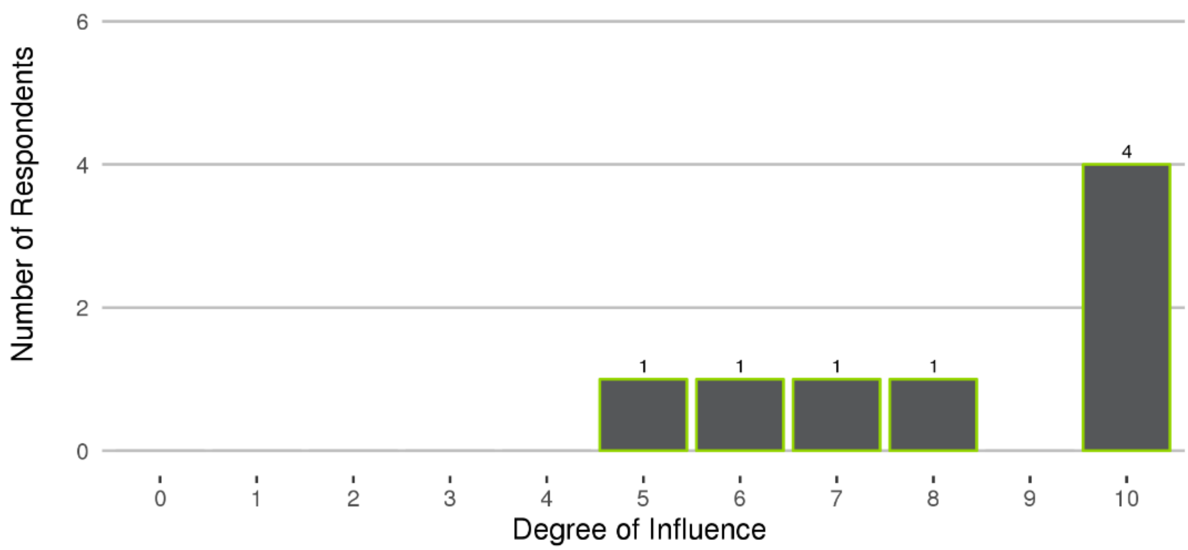


Figure 56. Influence of Contractor on Participation Decision--LDI (n=8)



T4. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction with the contractor's work? (n=137)

Mean	**9.1**
Median	**10**

Figure 57. Satisfaction with Contractor's Work—Commercial Rebate Program Overall (n=137)

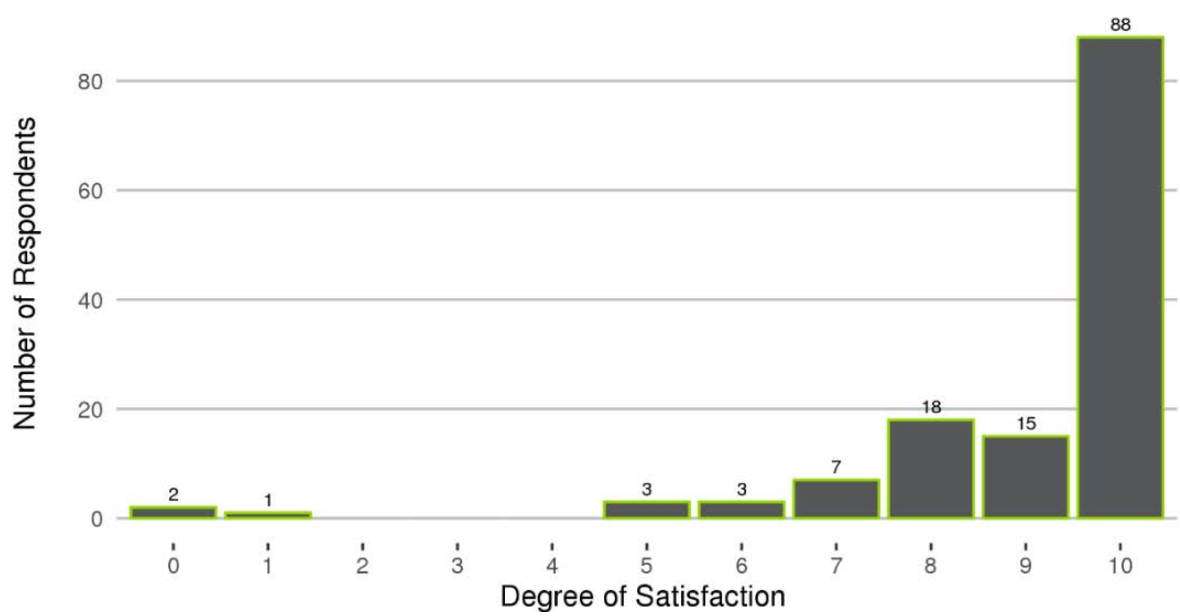


Figure 58. Satisfaction with Contractor's Work--SBDI (n=97)

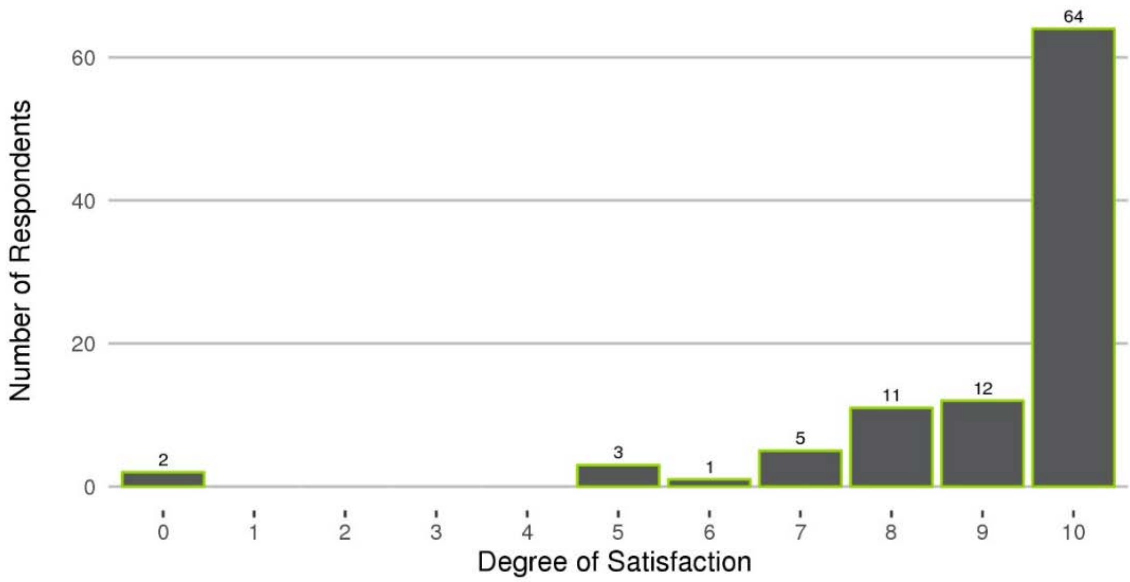


Figure 59. Satisfaction with Contractor's Work--Commercial HVAC (n=11)

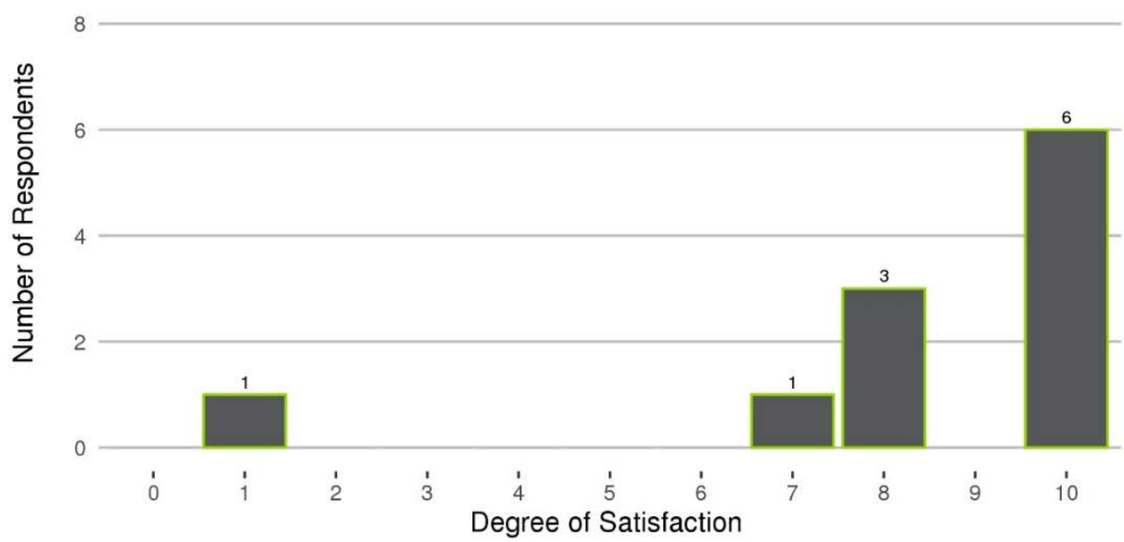
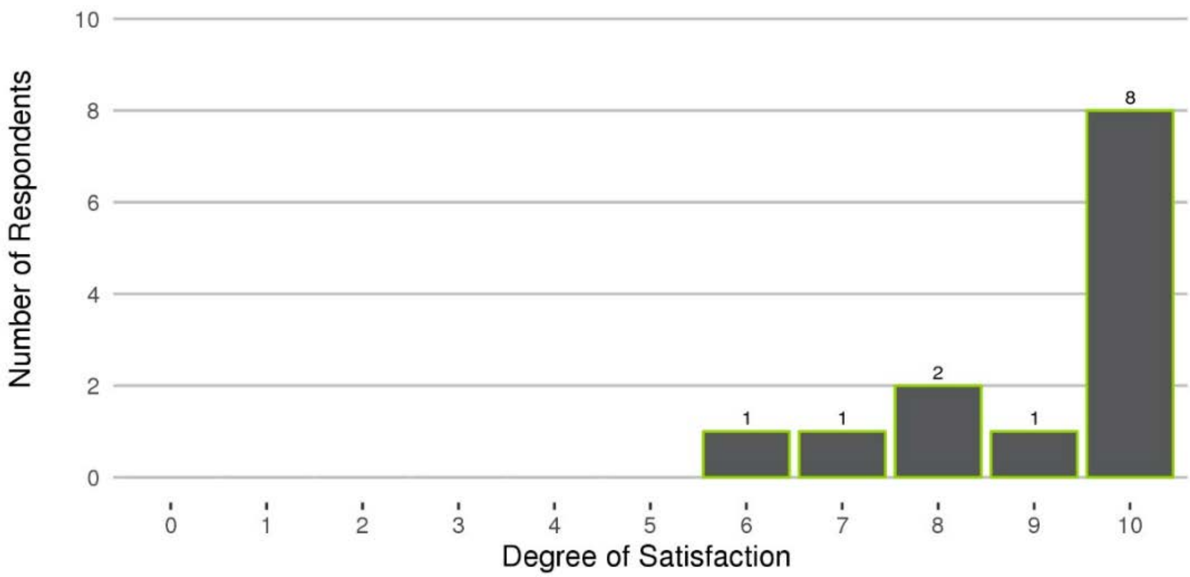


Figure 60. Satisfaction with Contractor's Work--Kitchens (n=13)



T4a. For those with satisfaction less than 6, what was the reason for your dissatisfaction? (n=4)

Note: not all those that rated satisfaction 5 or less provided a reason.

- "Total fraud, replaced very few lights."
- "Communication, took too long getting back."
- "Contractor did inside work, but not outside."
- "Poor workmanship"

Vendor Involvement (Kitchens Program)

V1, V2. Did you purchase your equipment from a retail outlet/vendor? If not, where did you purchase the equipment? (n=11) If so, what was the name of the retail outlet/vendor where you purchased the equipment?

Yes	**100%**
No	**0%**

V3. Did the retail outlet/vendor mention the PSE rebate available on the equipment prior to your purchasing the equipment? (n=11)

Yes	**82%**
No	**9%**
Other	**9%**

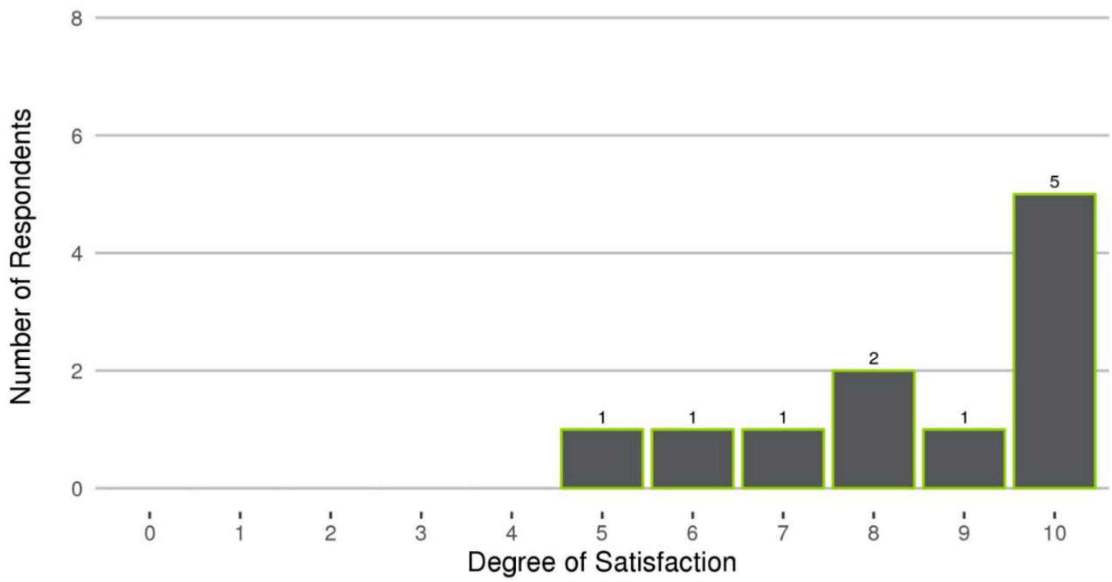
"Other" response (n=1)

"No, they mentioned some other company."

V4. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction with your interaction with this vendor?

Mean	8.5
Median	9

Figure 61. Satisfaction with Vendor Interaction (n=11)



V5. Did the vendor provide any information on PSE rebates available for energy efficient kitchen equipment other than the equipment you purchased? (n=11)

Yes	45%
No	55%

V6. Are there any vendors you typically purchase equipment from that are not part of the Kitchens program that you wish were involved in the program? (n=8)

Yes	13%
No	87%

"Yes" response (n=1):
"Don't recall"

Drivers and Barriers

D1. Why did you participate in the program? (n=147)

Figure 62. Main Reason for Program Participation—Commercial Rebate Program Overall (n=147)

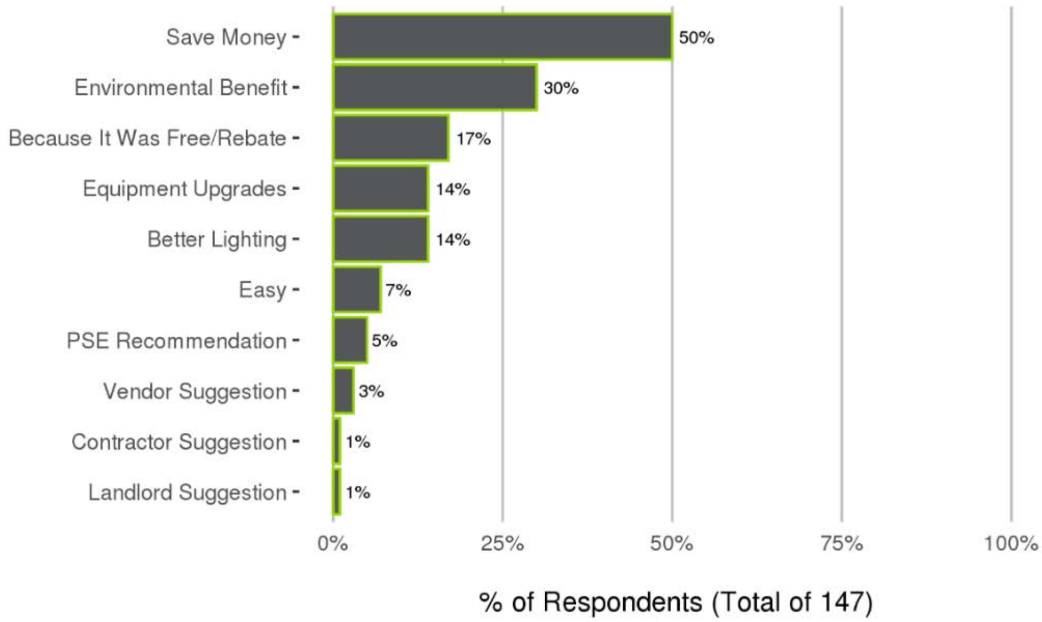


Figure 63. Main Reason for Program Participation—SBDI (n=102)

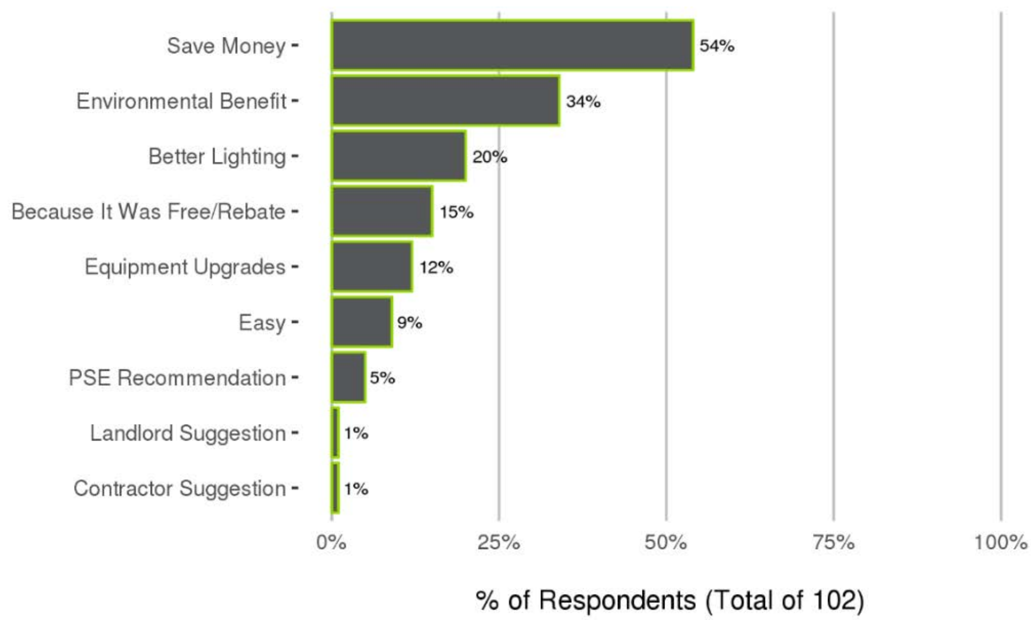
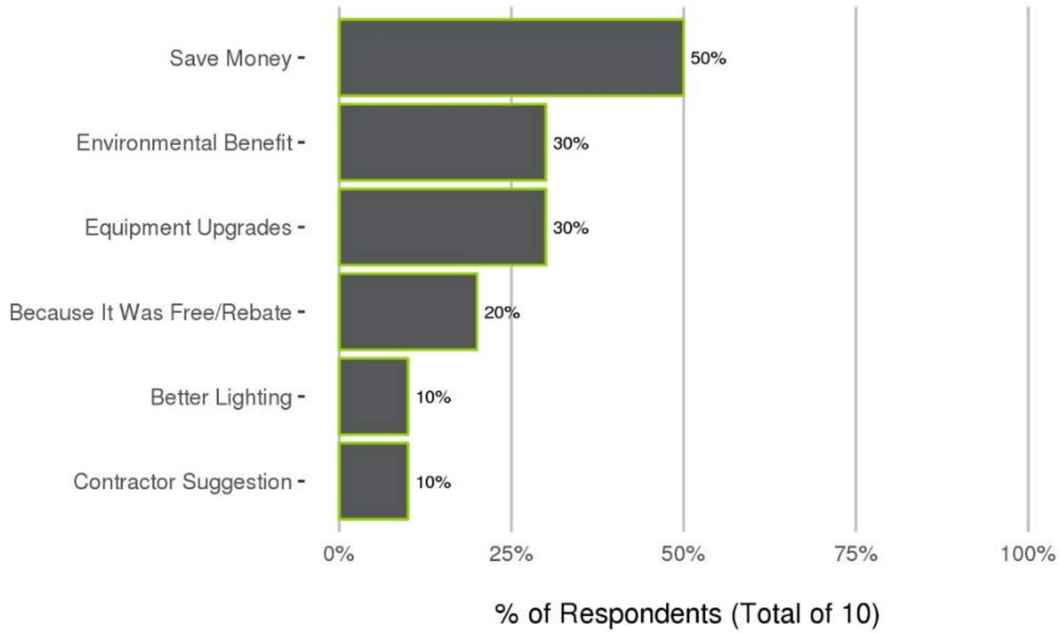


Figure 64. Main Reason for Program Participation—Commercial HVAC (n=10)



Note: "Better Lighting" response may indicate this customer participated in more than one program, and answered generally rather than specifically to the Commercial HVAC portion of the Commercial Rebate program.

Figure 65. Main Reason for Program Participation—Commercial Kitchens (n=18)

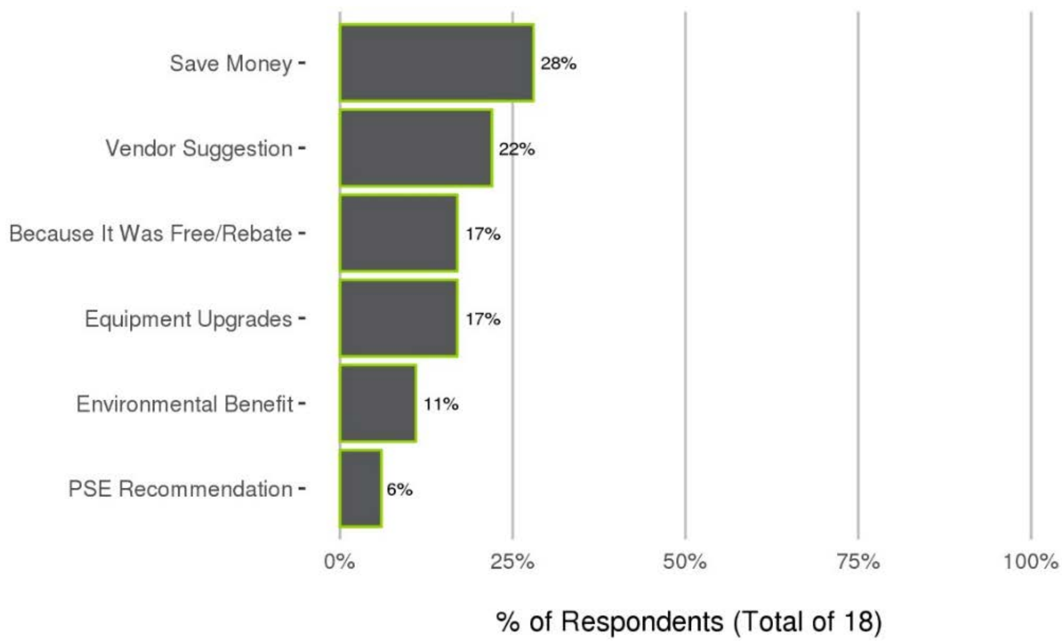


Figure 66. Main Reason for Program Participation—2016 Only—Commercial Rebate Program Overall (n=98)

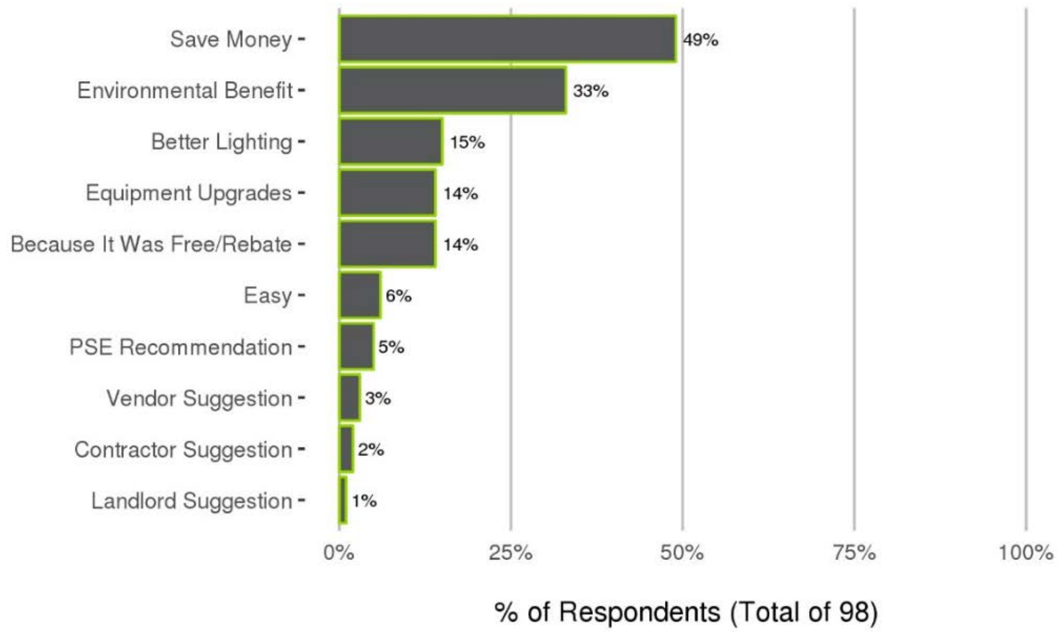
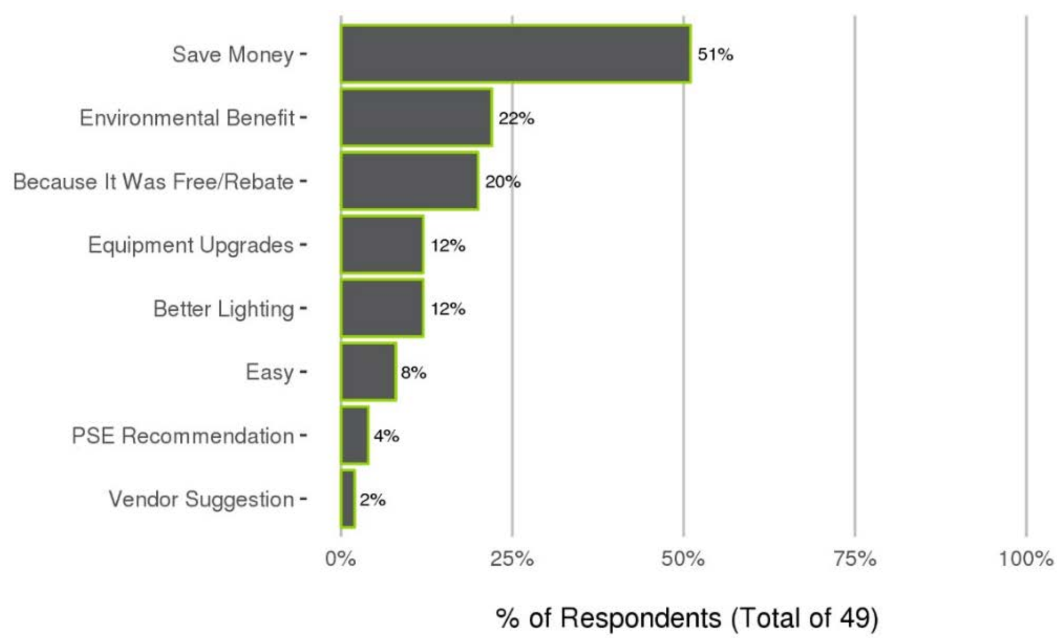


Figure 67. Main Reason for Program Participation—2017 Only (through Q2)—Commercial Rebate Program Overall (n=49)



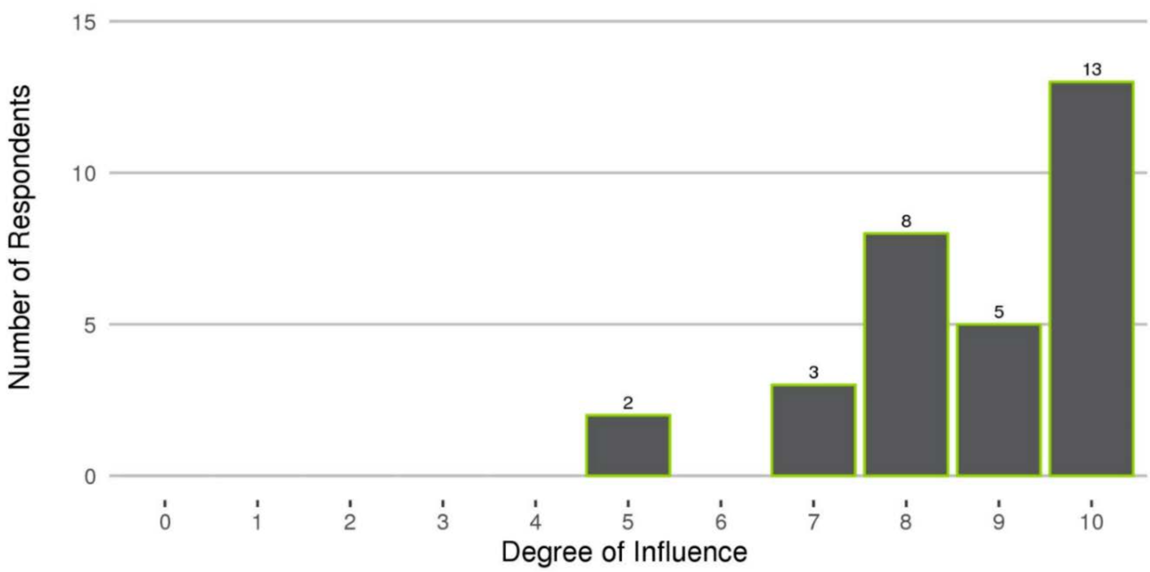
D2. Did you consider installing the energy efficient equipment before you heard about the program? (n=151)

Yes	53%
No	47%

D3. For DI customers who paid at least part of the cost of equipment (i.e.-they installed some not completely free DI measures), on a scale of 0-10, with zero being not at all influential and ten being very influential, how influential was the availability of the low-cost equipment in your decision to participate in the program? (n=31)

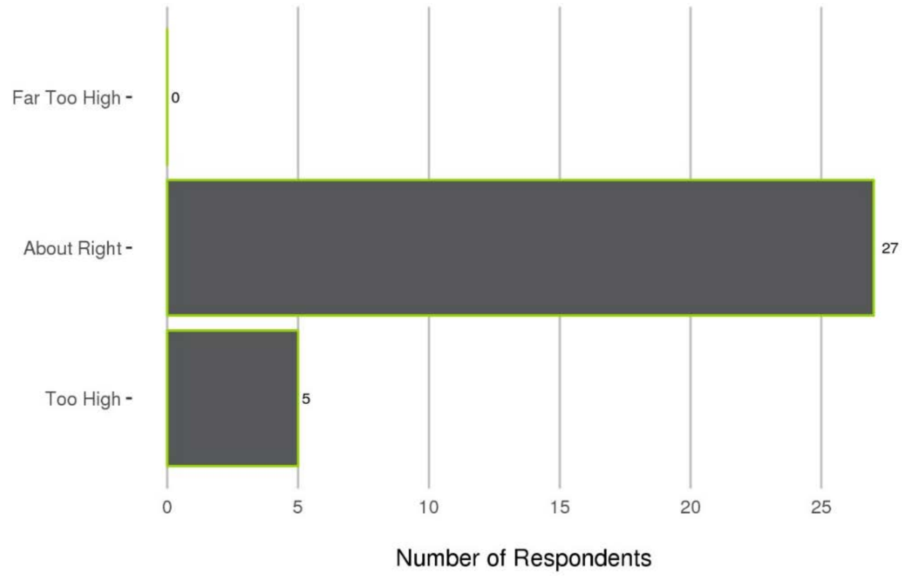
Mean	8.7
Median	9

Figure 68. Importance of Low-Cost Co-Paid Equipment in Direct Install Participation Decision



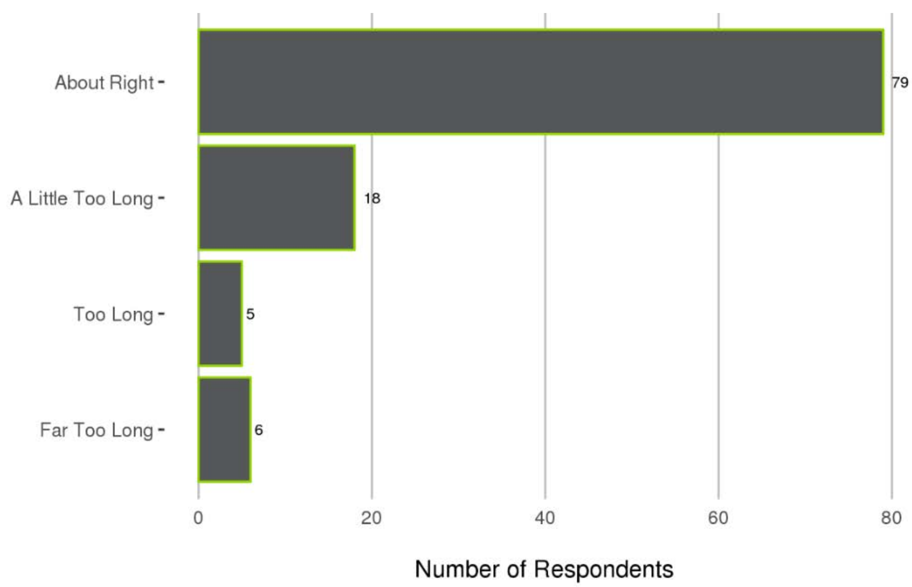
D4. How would you rate the amount of the co-pays you had to pay for the equipment through the program? About right, too high or far too high? (n=32)

Figure 69. Perceived Appropriateness of Co-pay Level for Non-Free DI Measures (n=32)



D5. For DI participants, from the time of the energy audit on your premises to final installation of the last energy efficient equipment through the program, how would you rate how long it took you to complete the program participation process?—About right, a little too long, too long, or far too long? (n=107)

Figure 70. Perceived Appropriateness of Length of Time to Complete Participation in DI Programs (n=107)



D6. [Excluding DI participants, including all other subprograms] On a scale of 0-10, with zero being not at all influential and ten being very influential, how influential was the financial incentive on your decision to install the equipment/perform the HVAC service? (n=26)

Mean	**8.5**
Median	**9**

Figure 71. Influence of Incentive on Decision to Install Equipment/Service Existing HVAC Equipment (n=26)

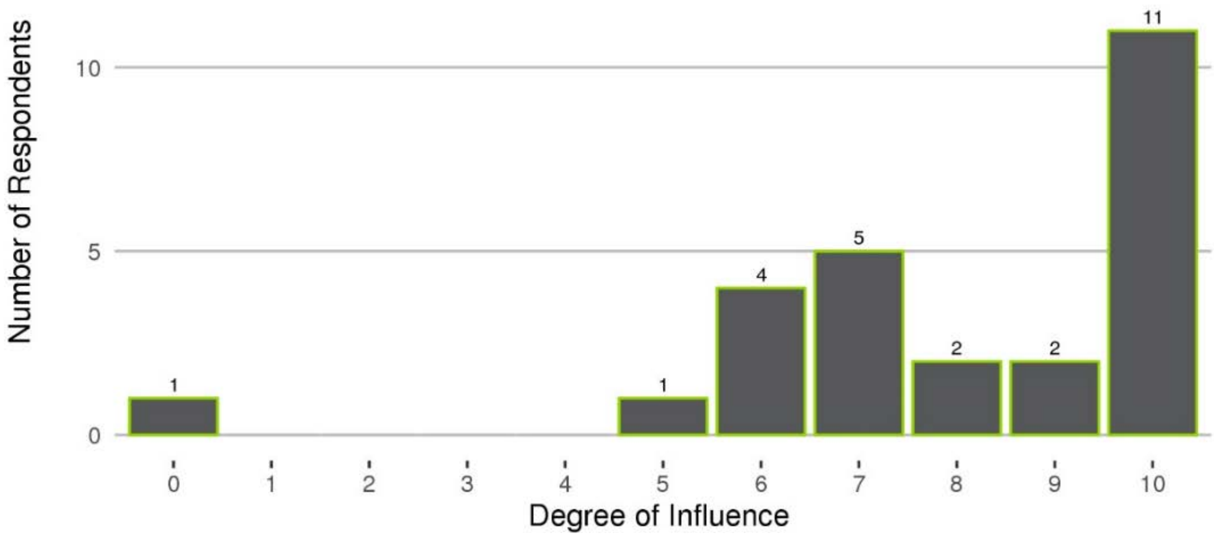


Figure 72. Influence of Incentive on Decision to Install Equipment—Commercial HVAC (n=10)

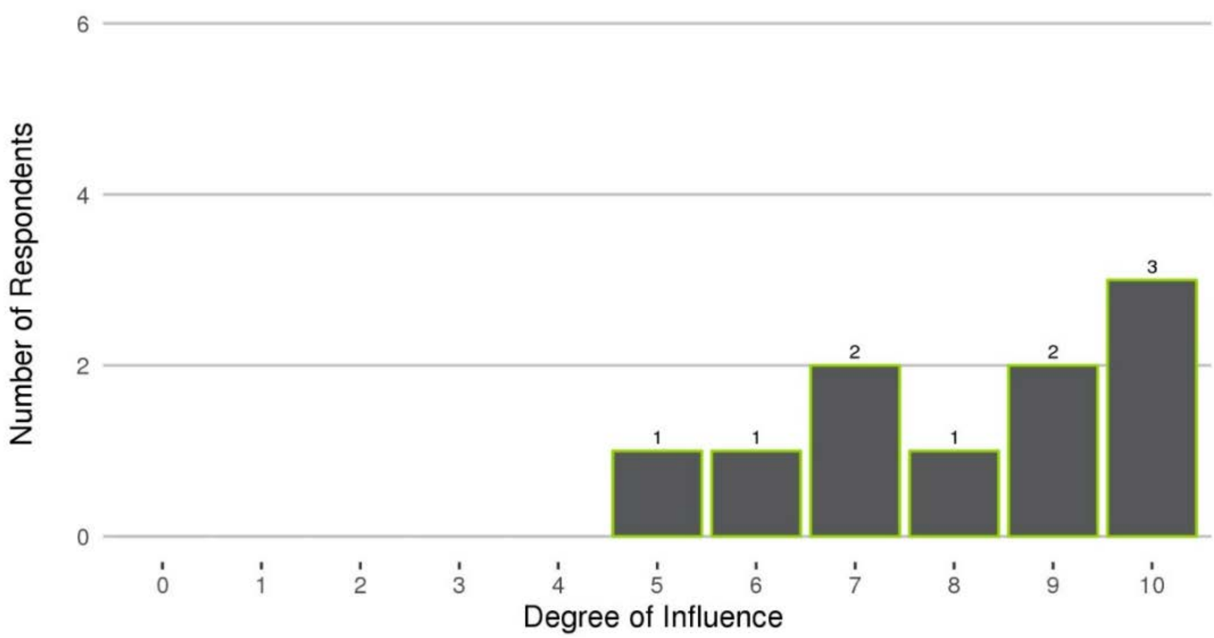
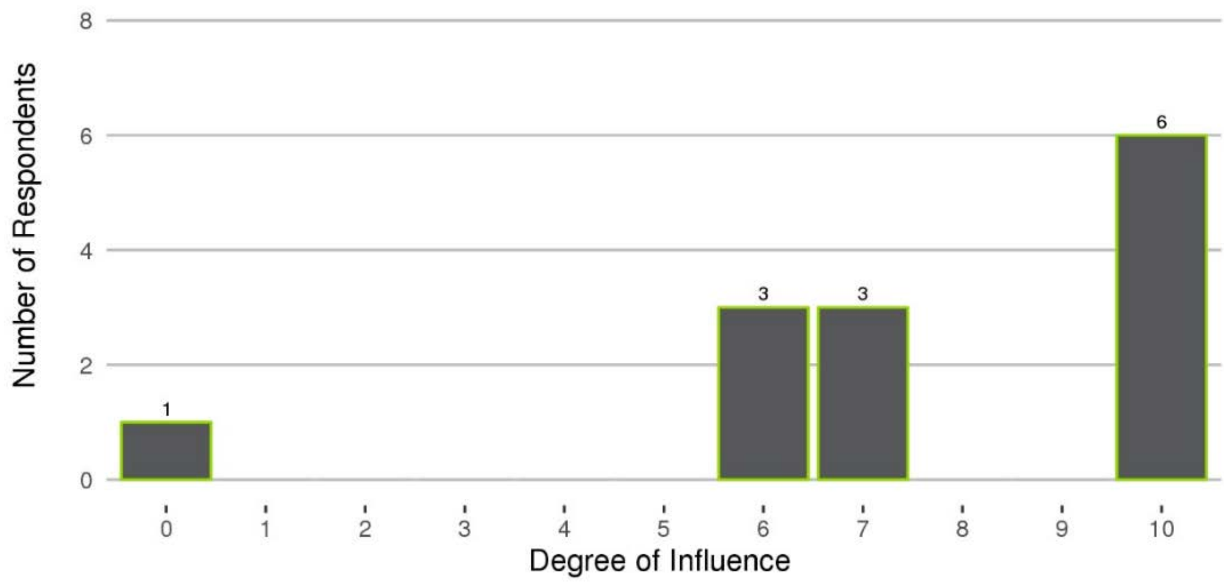


Figure 73. Influence of Incentive on Decision to Install Equipment—Commercial Kitchens (n=13)



D7. On a scale of 0-10, with zero being not at all influential and ten being very influential, how influential were the program's marketing materials on your decision to participate? (n=103)

Mean	**5.3**
Median	**6**

Figure 74. Influence of Marketing Materials on Participation Decision—Commercial Rebate Program Overall (n=103)

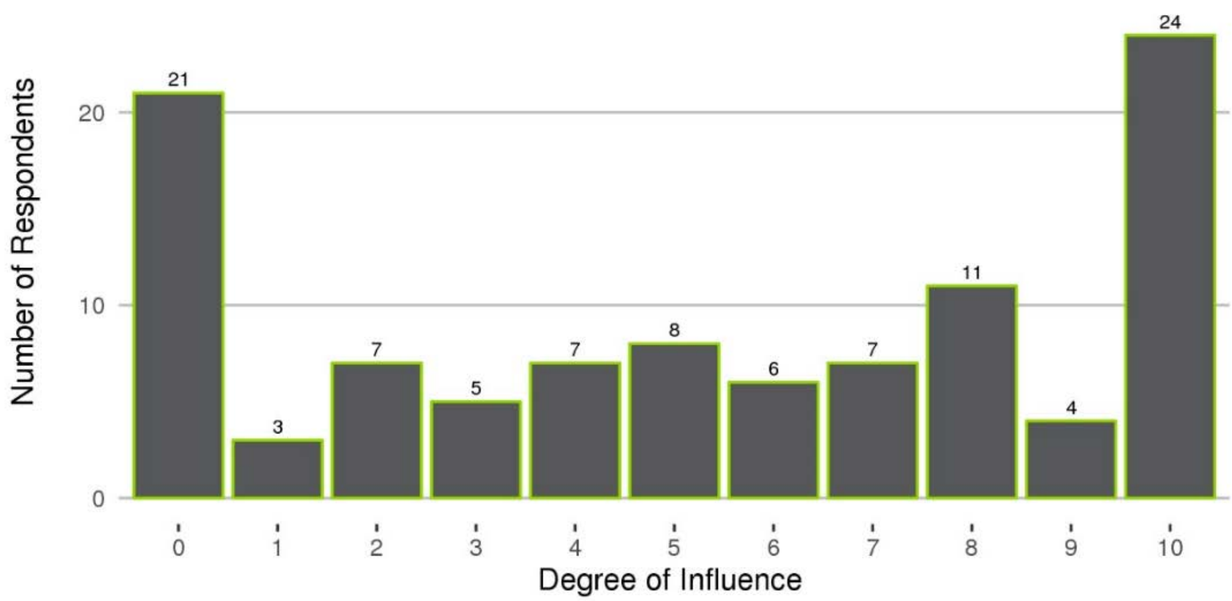


Figure 75. Influence of Marketing Materials on Participation Decision—SBDI (n=64)

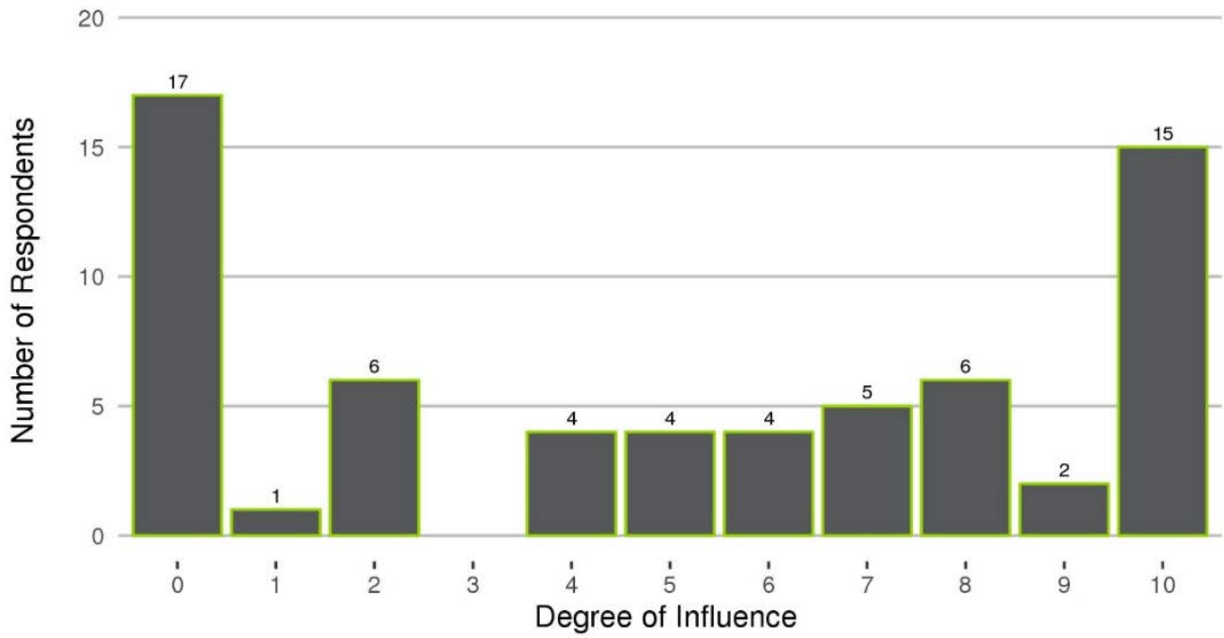
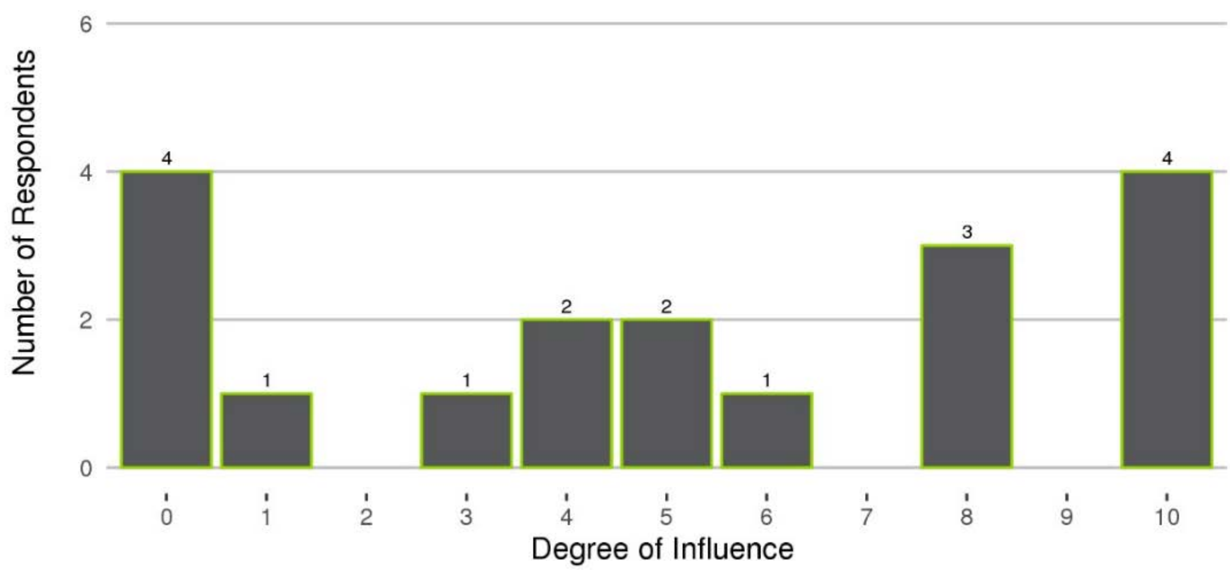


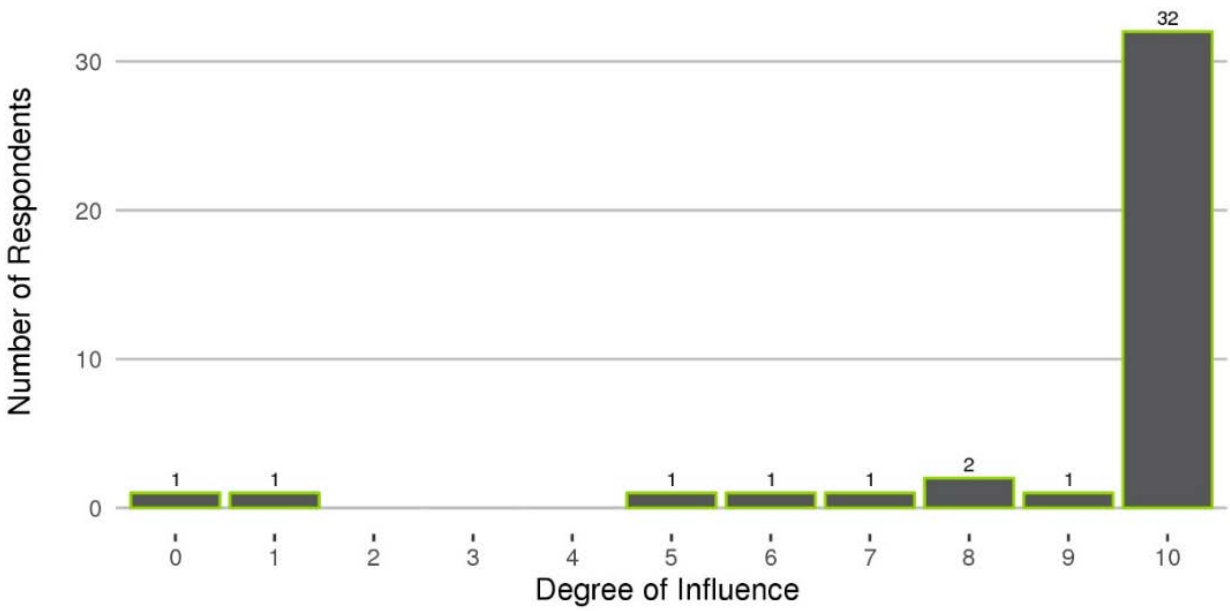
Figure 76. Influence of Marketing Materials on Participation Decision—Commercial Kitchens (n=18)



D8. Of those for whom the Community Blitz was a part of their program participation experience, on a scale of 0 to 10, with zero being not at all influential and ten being very influential, how influential was the PSE Community Blitz in your decision to participate in the program? (n=40)

Mean	**9.1**
Median	**10**

Figure 77. Community Blitz Degree of Influence on Participation Decision (n=40)



D8b. Do you have any suggestions that would improve the effectiveness of the Community Blitz approach at recruiting small businesses to participate in the program? (n=14)

- "Have the vendors tell us about the Community Blitzes and offer discount prices."
- "Just have the contractors come in person."
- "Pay attention to businesses' hours of operation."
- "Keep coming to the businesses."
- "Involve the Chamber of Commerce"
- "More coordination between the Health Department and PSE"
- "More interaction with us when they came in to do the work; we lost some bulbs we needed."
- "Make the program free"
- "No, just coming in person"
- "They should respond to the owners' concerns"
- "The Chamber of Commerce should let us know"
- "There's a breakdown in communication between the folks that contact us and the people who do the work."
- "Doing it more"
- "More awareness of the blitz"

D9. What do you see as the most significant barrier keeping other businesses like yours from participating in the program? (n=109)

Figure 78. Most Significant Barrier Keeping Businesses Like Yours from Participating—Commercial Rebate Program Overall (n=109)

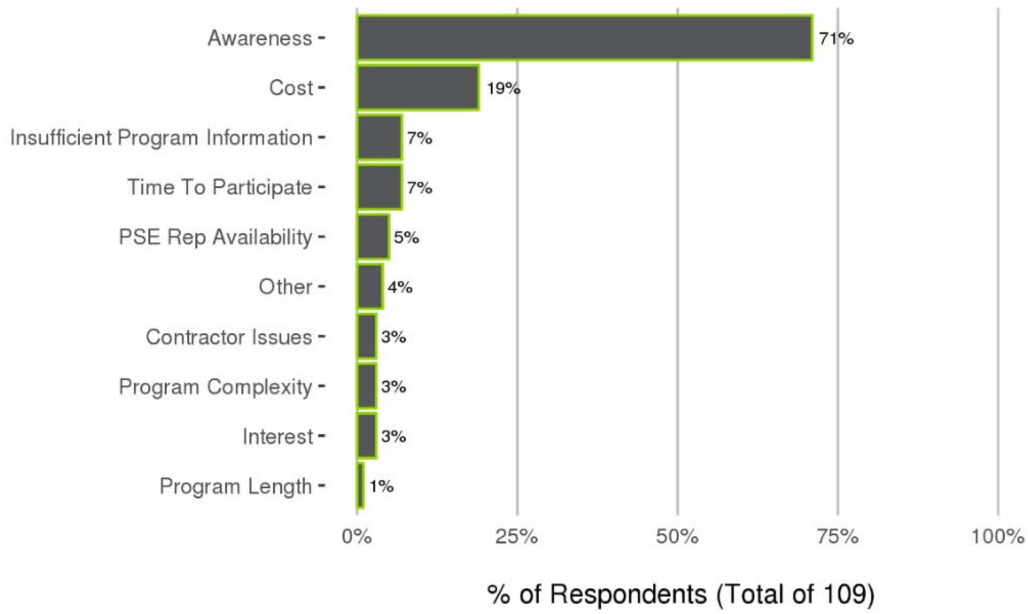
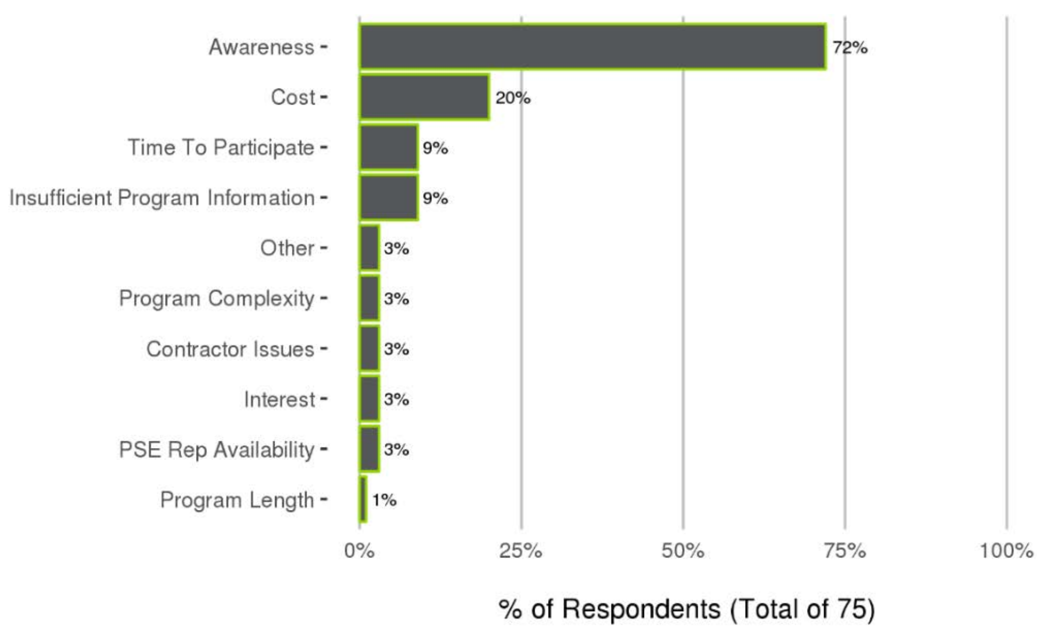


Figure 79. Most Significant Barrier Keeping Businesses Like Yours from Participating—SBDI (n=75)



"Other" response (n=2):

- "If no decision maker, location blitz isn't effective"
- "Finding a decision maker"

Figure 80. Most Significant Barrier Keeping Businesses Like Yours from Participating—Commercial HVAC (n=8)

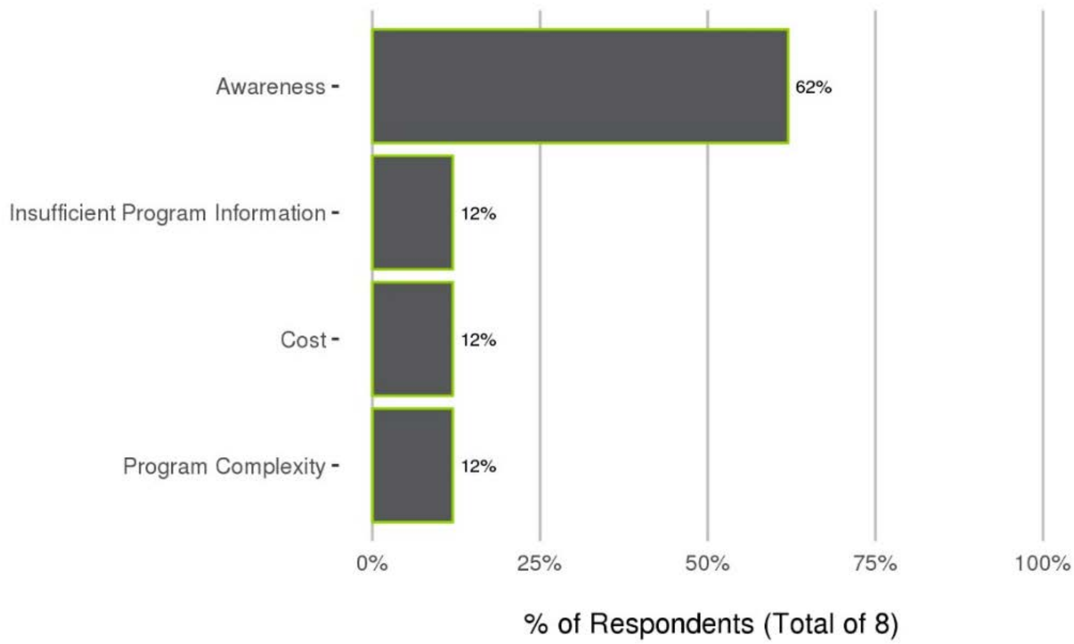
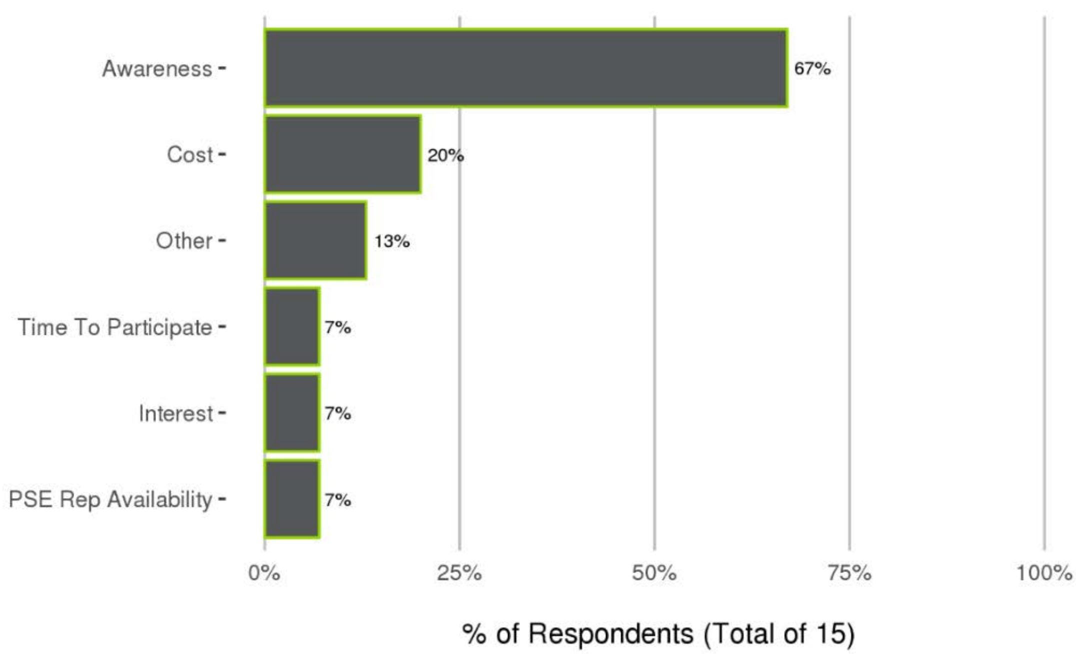


Figure 81. Most Significant Barrier Keeping Businesses Like Yours from Participating—Commercial Kitchens (n=15)



"Other" response (n=2):

- "Depends if they have natural gas or not"
- "Cost of getting new equipment"

Figure 82. Most Significant Barrier Keeping Businesses Like Yours from Participating—2016 Only—Commercial Rebate Program Overall (n=73))

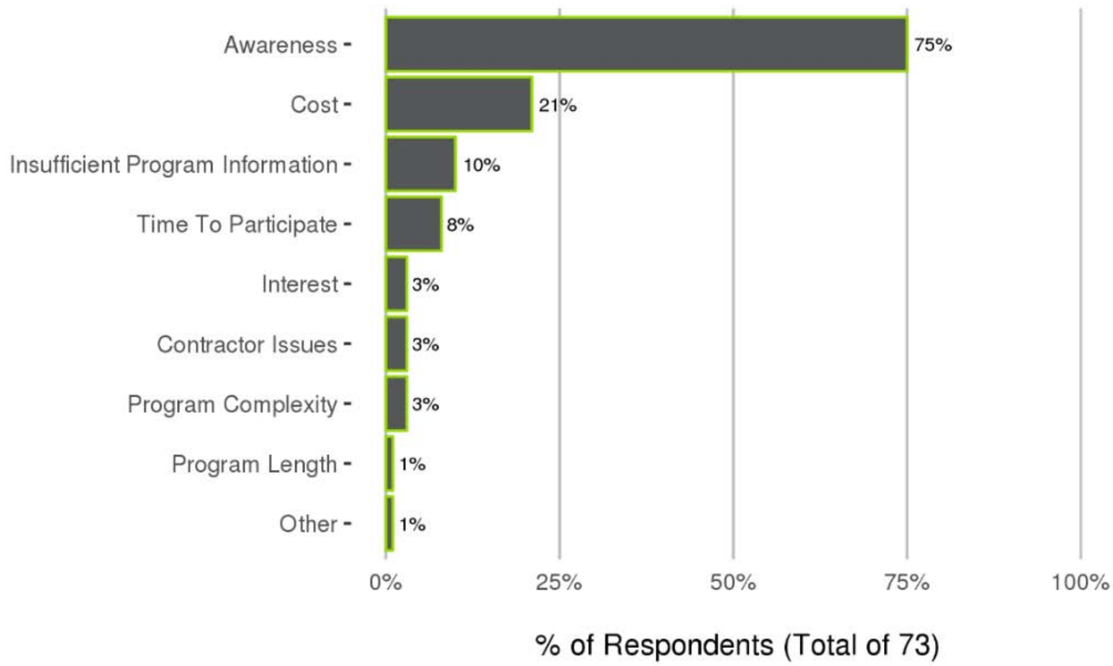
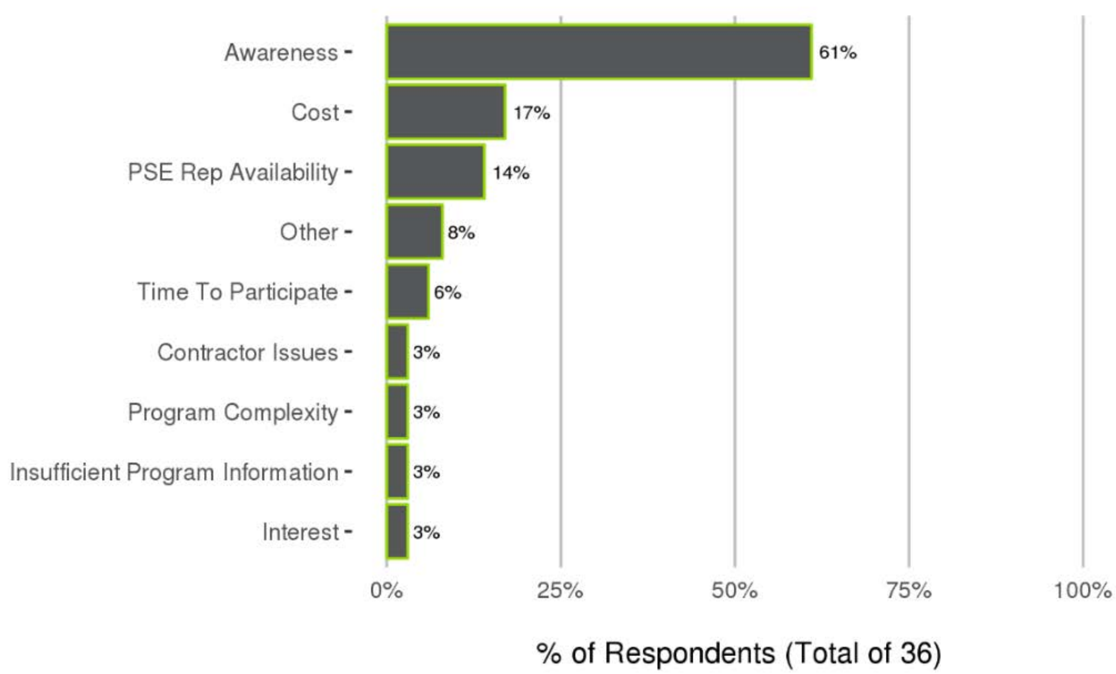


Figure 83. Most Significant Barrier Keeping Businesses Like Yours from Participating—2017 Only (through Q2)—Commercial Rebate Program Overall (n=36)



D9a. What suggestions do you have for how the program could overcome this barrier to make participation easier for businesses like yours? (n=86)

Figure 84. Suggestions to Overcome Barriers to Participation, Commercial Rebate Program Overall (n=86)

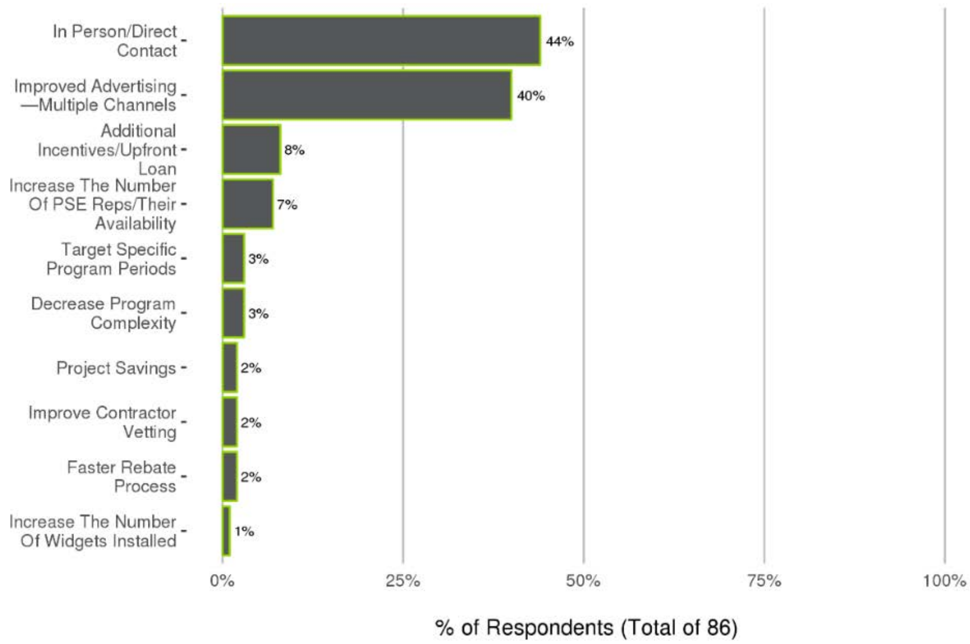


Figure 85. Suggestions to Overcome Barriers to Participation, SBDI (n=59)

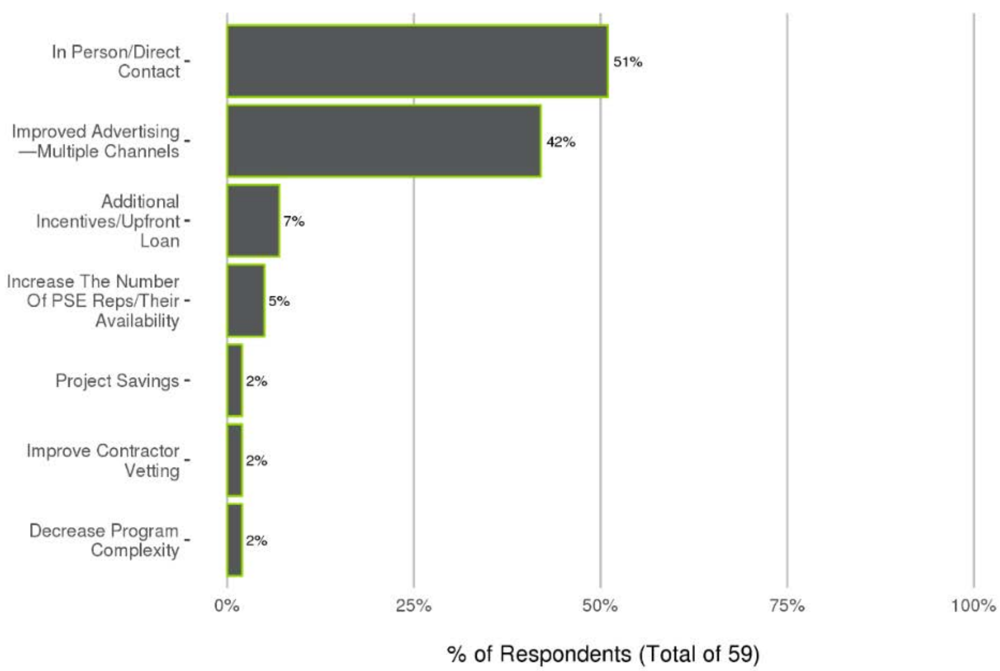


Figure 86. Suggestions to Overcome Barriers to Participation, Commercial HVAC (n=7)

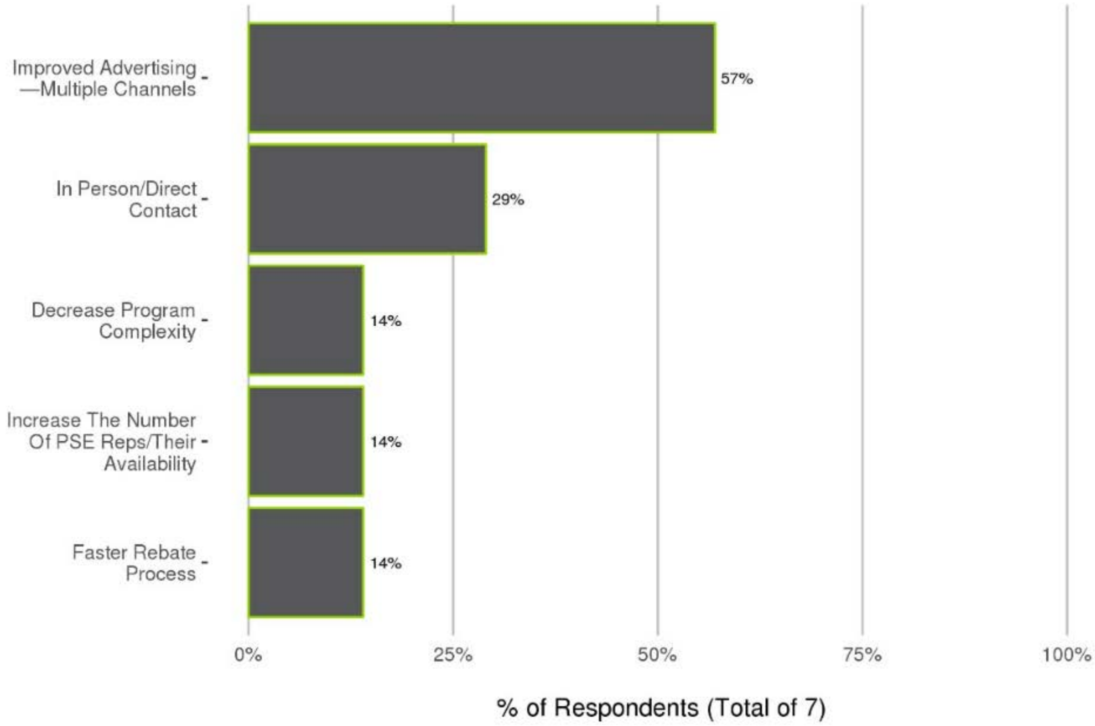
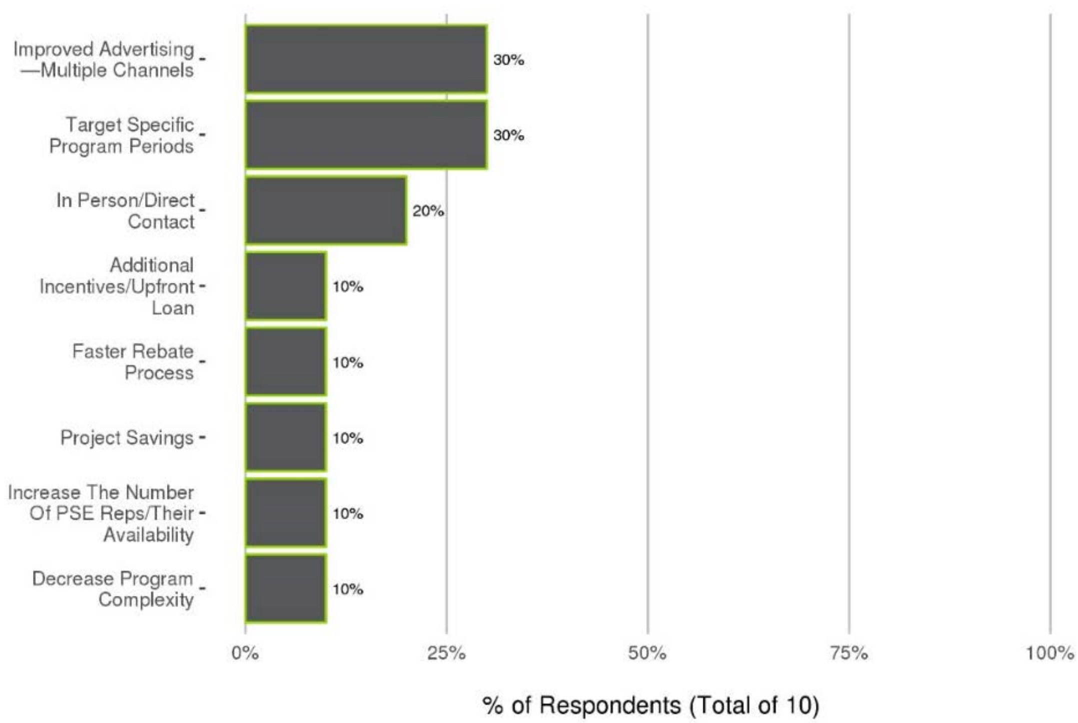


Figure 87. Suggestions to Overcome Barriers to Participation, Commercial Kitchens (n=10)

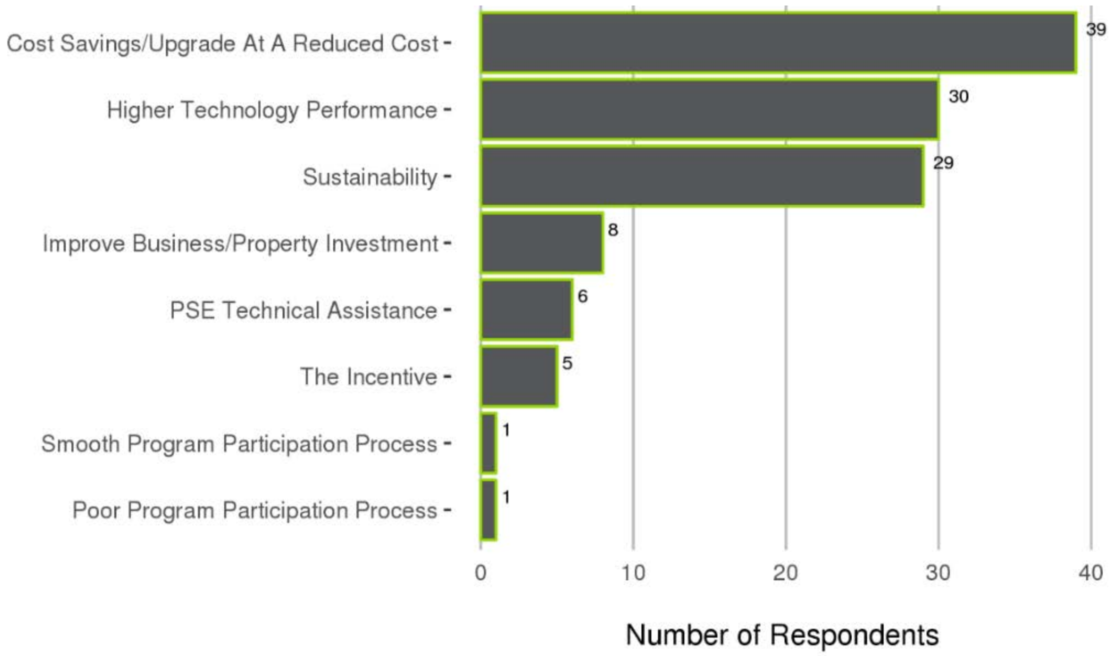


Customer Experience with Program

E1. What were your expectations of the program? (n=119)

Mean	**8.8**
Median	**10**

Figure 88. Program Expectations—Commercial Rebate Program Overall (n=119)



E2. On a scale of 0-10, where zero means not at all well, and ten means very well, how well did the program meet your expectations? (n=150)

Mean	**8.8**
Median	**10**

Figure 89. Degree to which Program Met Expectations—Commercial Rebate Program Overall (n=150)

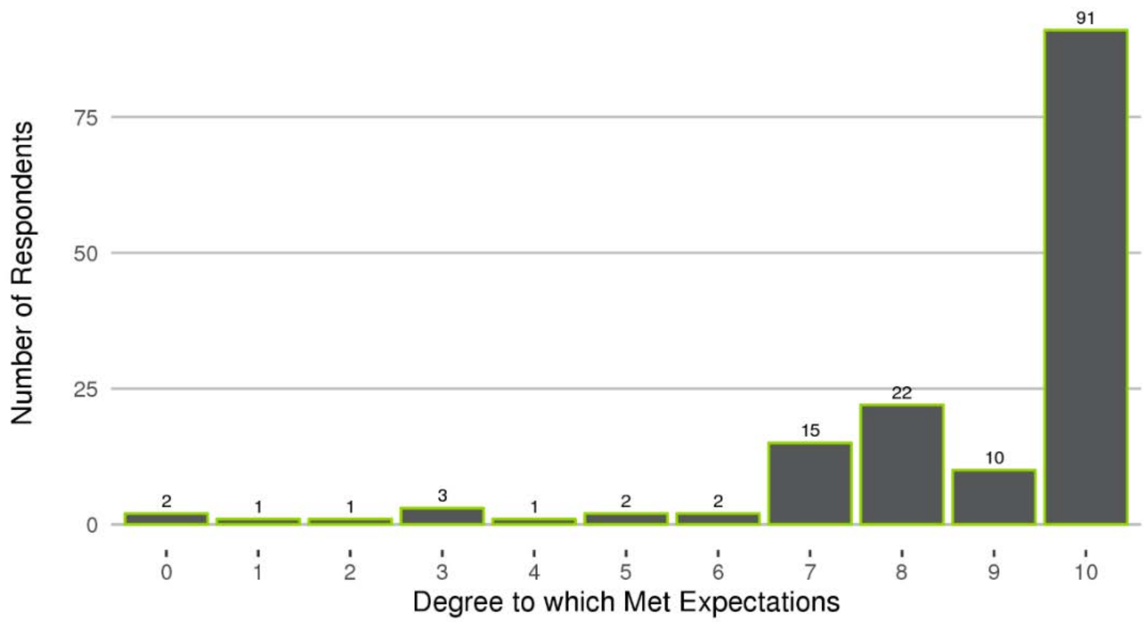


Figure 90. Degree to which Program Met Expectations—SBDI (n=102)

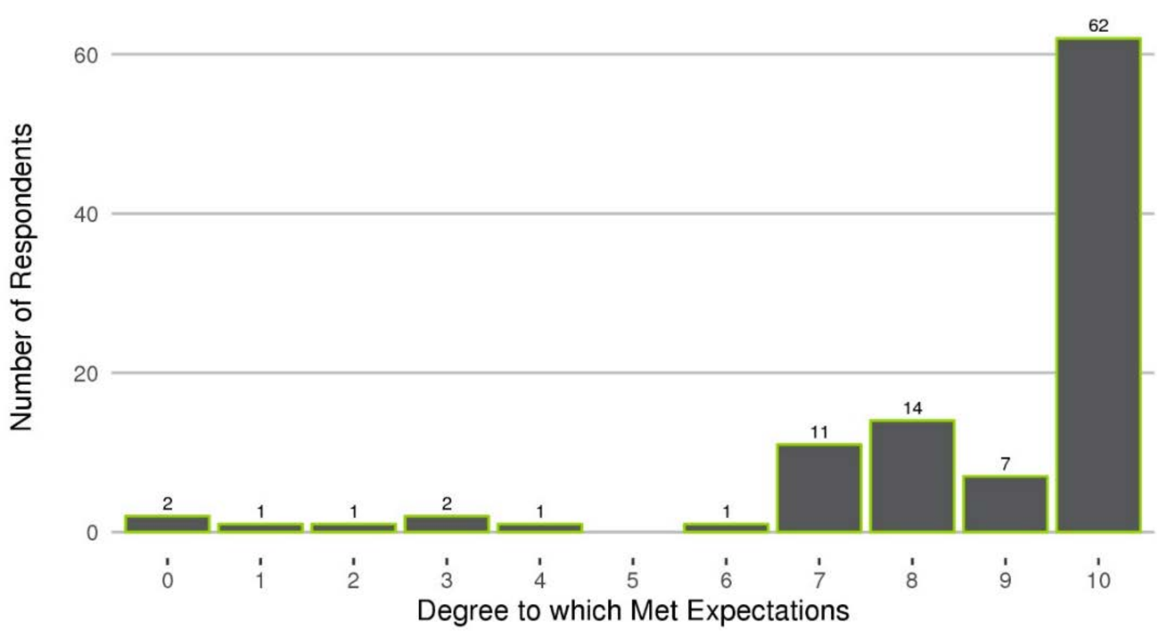


Figure 91. Degree to which Program Met Expectations—Commercial Kitchens (n=19)

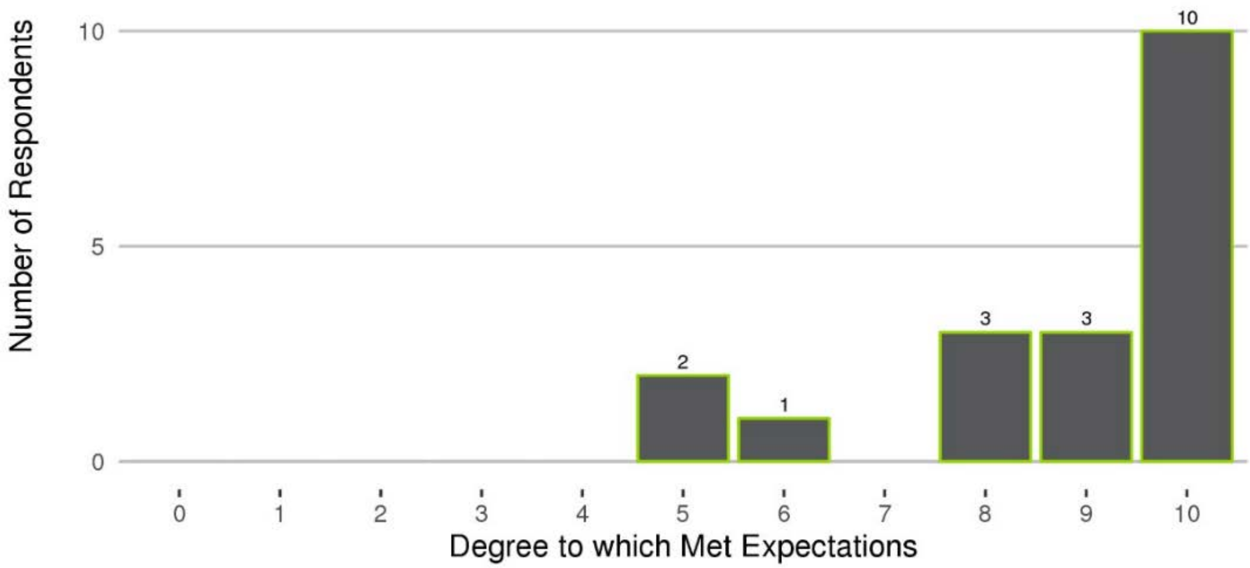
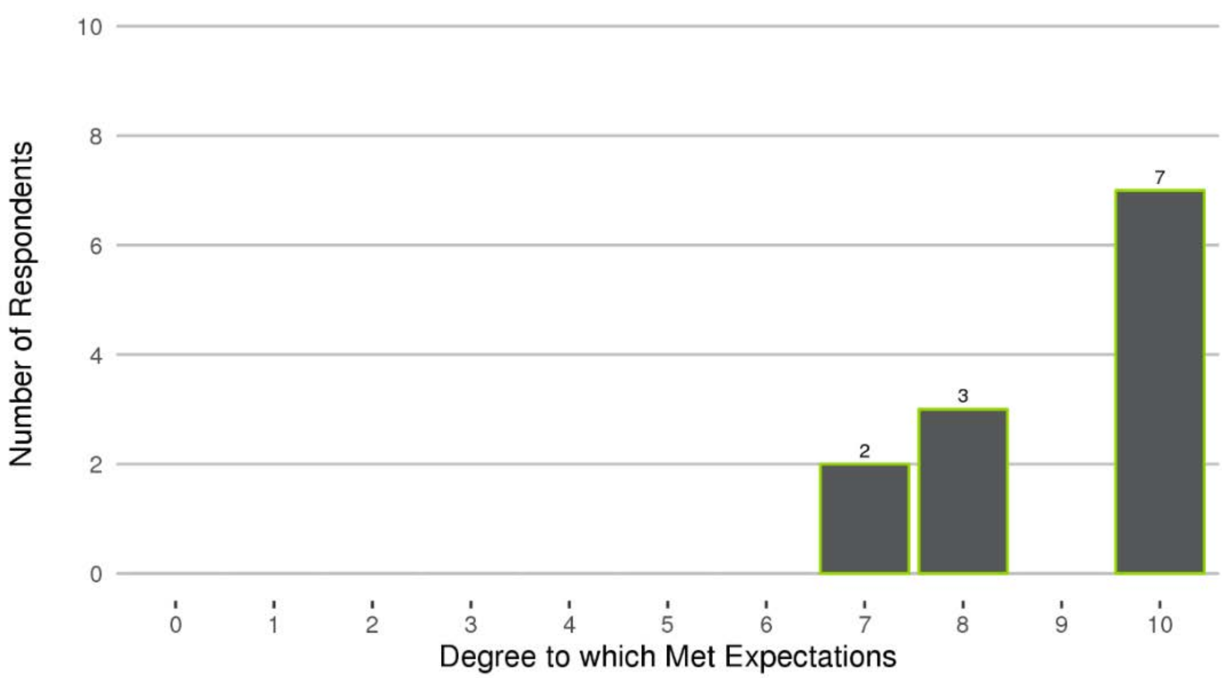
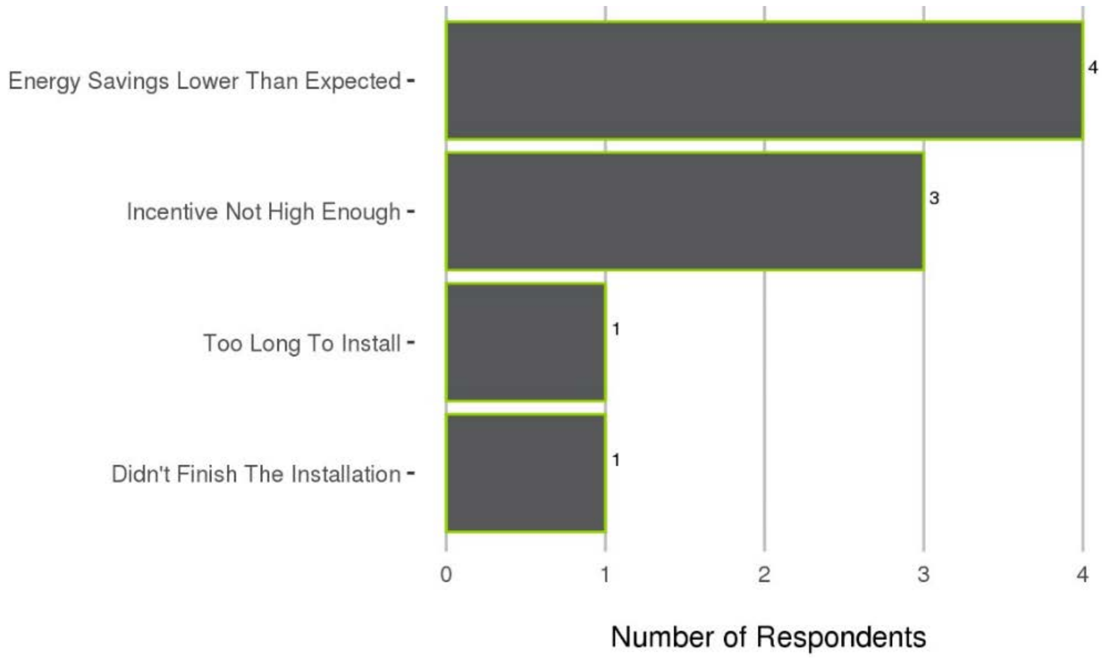


Figure 92. Degree to which Program Met Expectations—Commercial HVAC (n=12)



E2a. What could have been done differently to ensure the program met or exceeded your expectations? (n=9)

Figure 93. Areas for Improvement for those with Satisfaction Less than 6—Commercial Rebate Program Overall—(n=9)



Note: Not all respondents with satisfaction lower than 6 provided a response to this question.

E3. Did you fill out the program application yourself? (n=119)

Yes	**45%**
No	**55%**

E3a. For those who completed their own application, on a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction with the program application? (n=49)

Mean	8.1
Median	9

Figure 94. Satisfaction with Application Process—Commercial Rebate Program Overall (n=49)

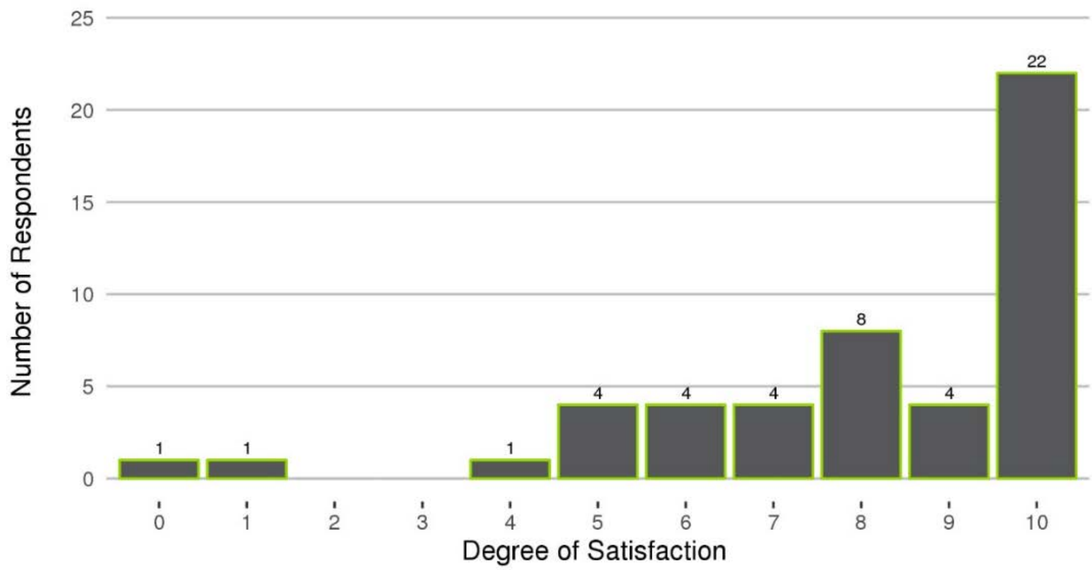


Figure 95. Satisfaction with Application Process—SBDI (n=26)

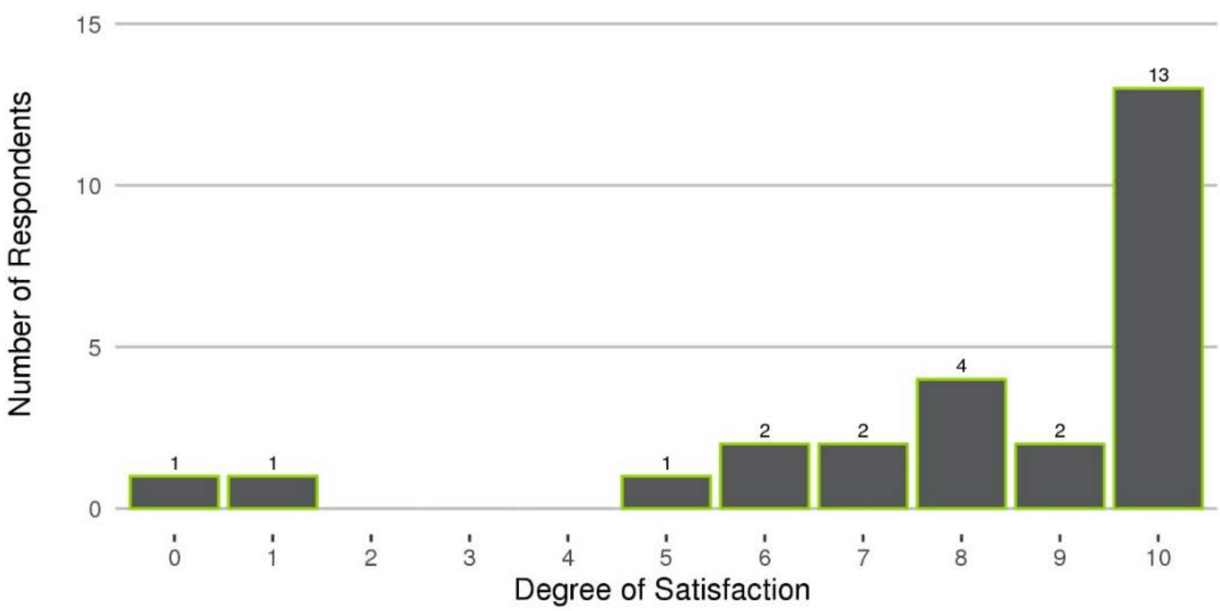
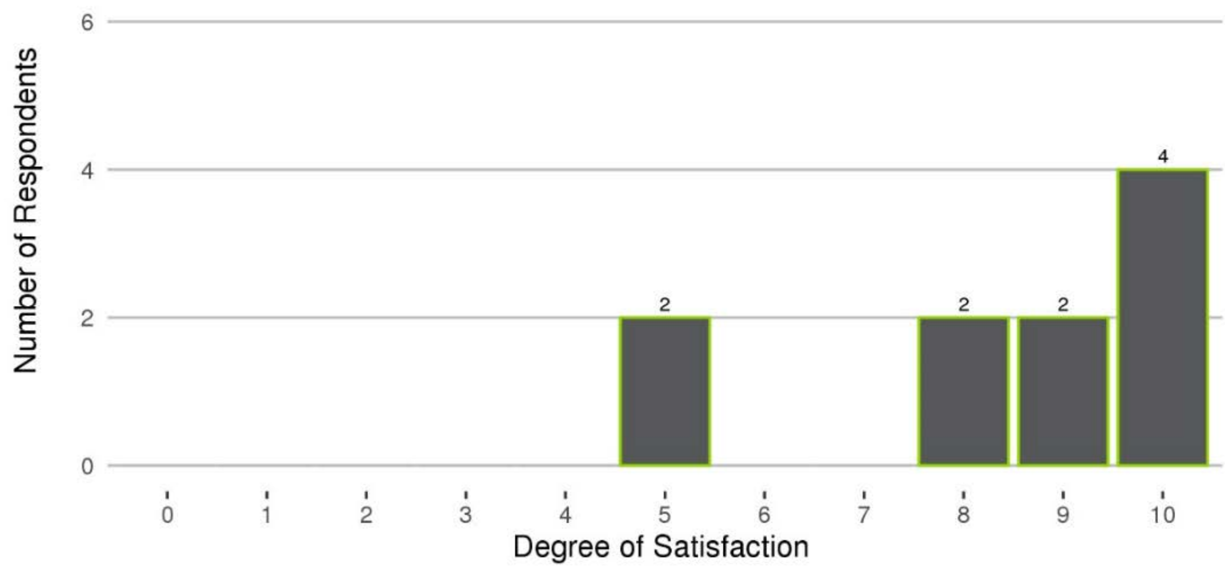
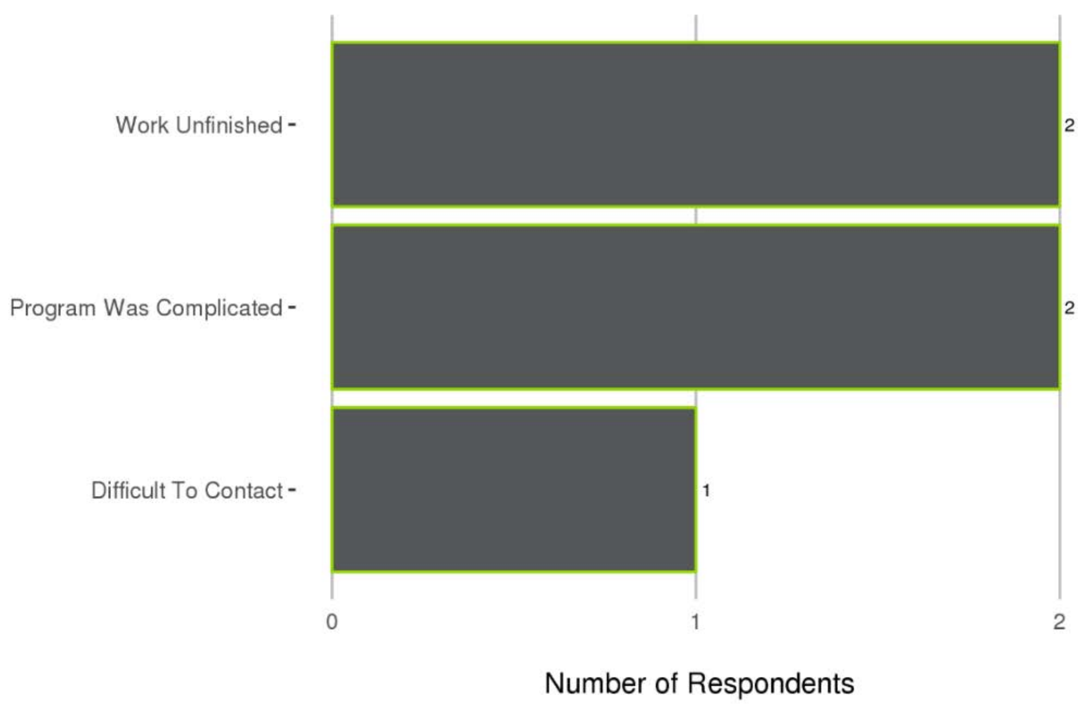


Figure 96. Satisfaction with Application Process—Commercial Kitchens (n=10)



E3b. What was the reason for your dissatisfaction with the application process? (n=5)

Figure 97. Reason for Dissatisfaction with Application Process, Respondents with Satisfaction Lower than 6, Commercial Rebate Program Overall (n=5)



E4. Did you complete the application online or submit a paper application? (n=40)

Online	**23%**
Paper	**75%**
Other	**3%**

"Other" response (n=1):
"both"

E5. For those that completed the application themselves, how would you rate the length of time it took to process the application?—About right, a little too long, too long, or far too long? (n=52)

Figure 98. Satisfaction with Length of Time to Process Application, Commercial Rebate Program Overall (n=52)

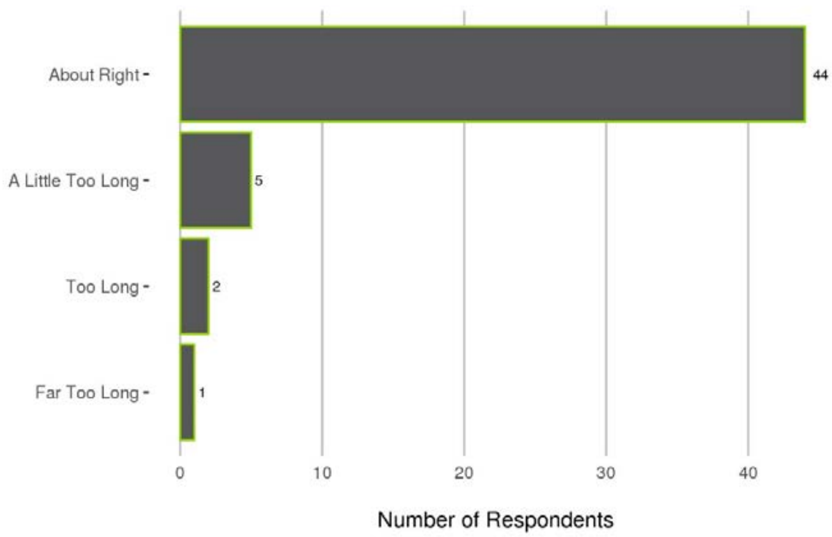


Figure 99. Satisfaction with Length of Time to Process Application, SBDI (n=27)

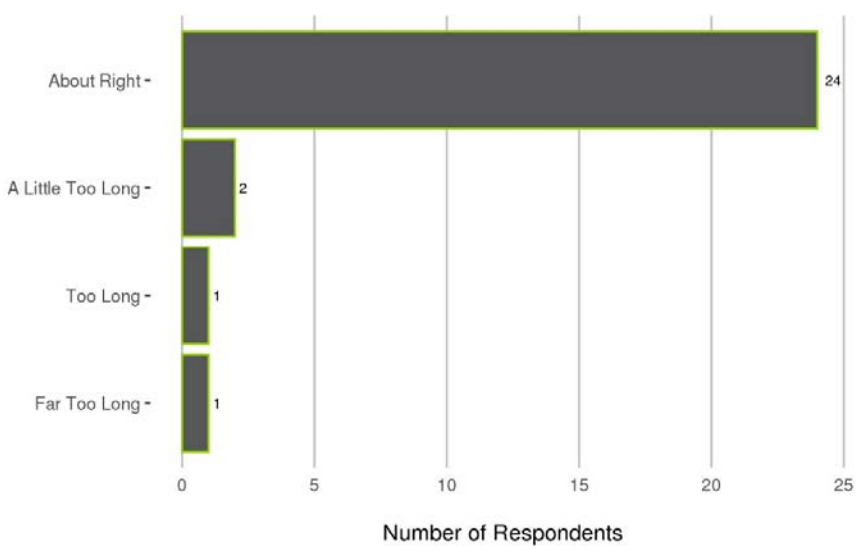


Figure 100. Satisfaction with Length of Time to Process Application, Commercial HVAC (n=6)

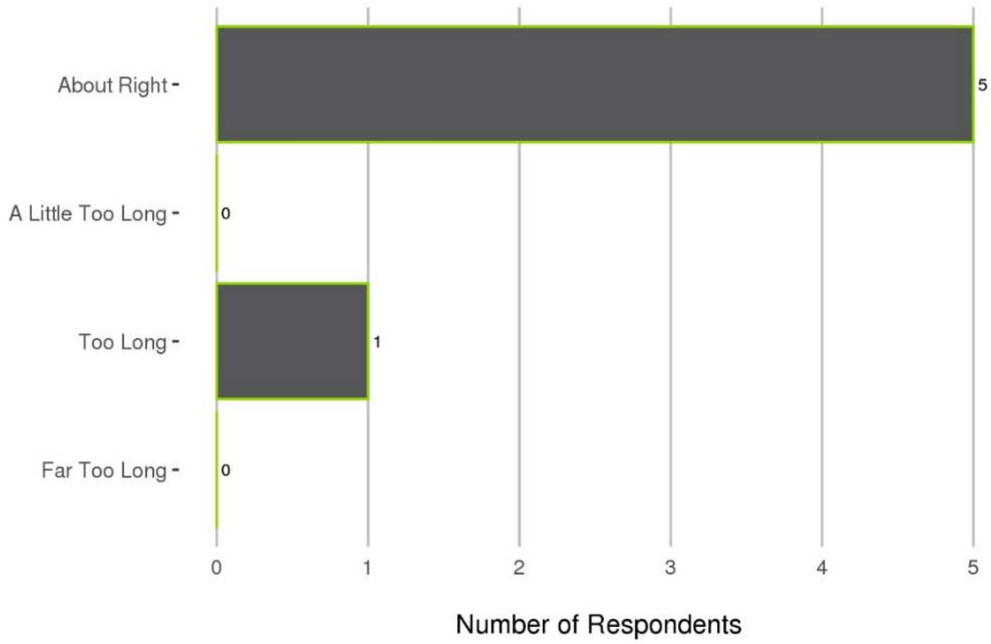
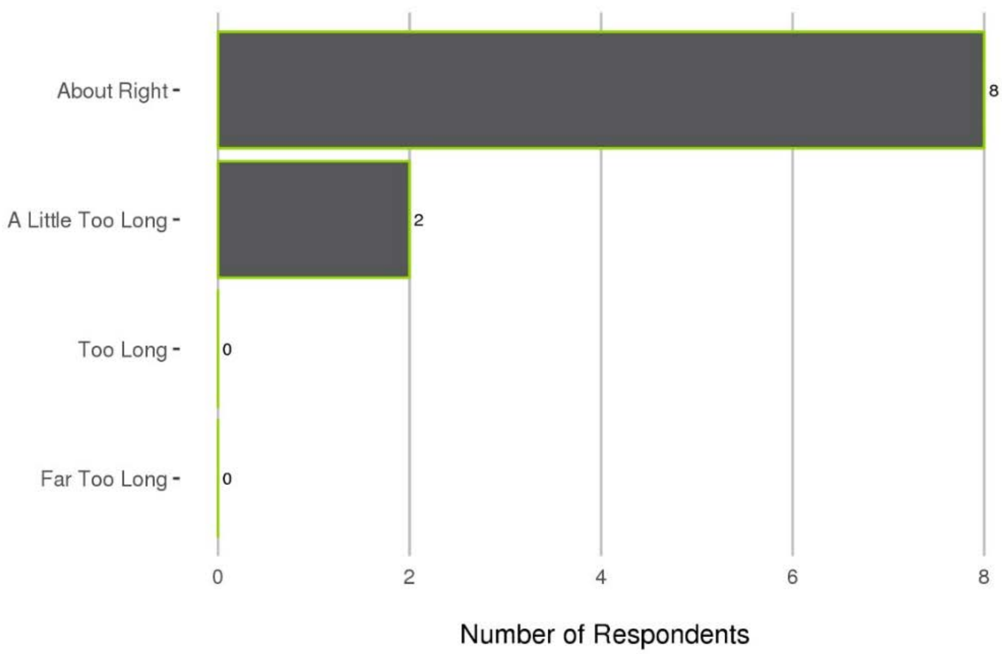


Figure 101. Satisfaction with Length of Time to Process Application, Commercial HVAC (n=10)



E6. For those that completed the application themselves, were there any problems with your application? (n=54)

Yes	9%
No	91%

E6a. For those that experienced problems, what problems were there with your application? (n=3)

- "Needed more help in the beginning filling it out"
- "Application didn't fit my situation"
- "I didn't get to complete one question"
- "Contact person was fired, so I could not get feedback"

E7a. Regardless of whether they filled the application out themselves, how long did it take to complete the program process, from application submission to rebate check receipt? (n=24)

Figure 102. Program Participation Duration, for All Those Receiving Rebates (n=24)

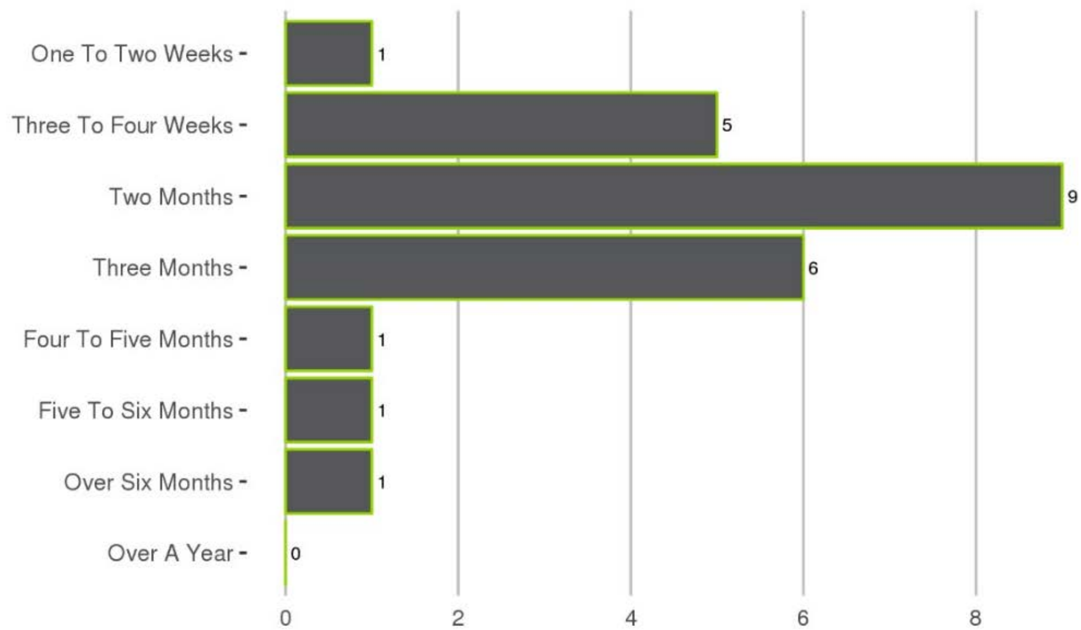


Figure 103. Program Participation Duration, for Those Receiving Rebates through Commercial HVAC (n=7)

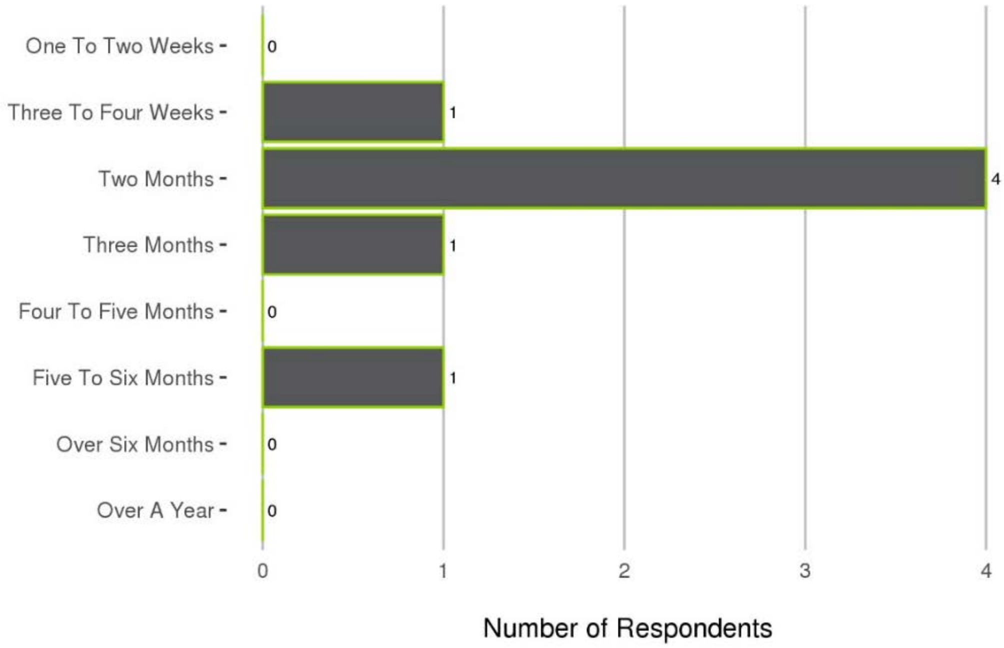
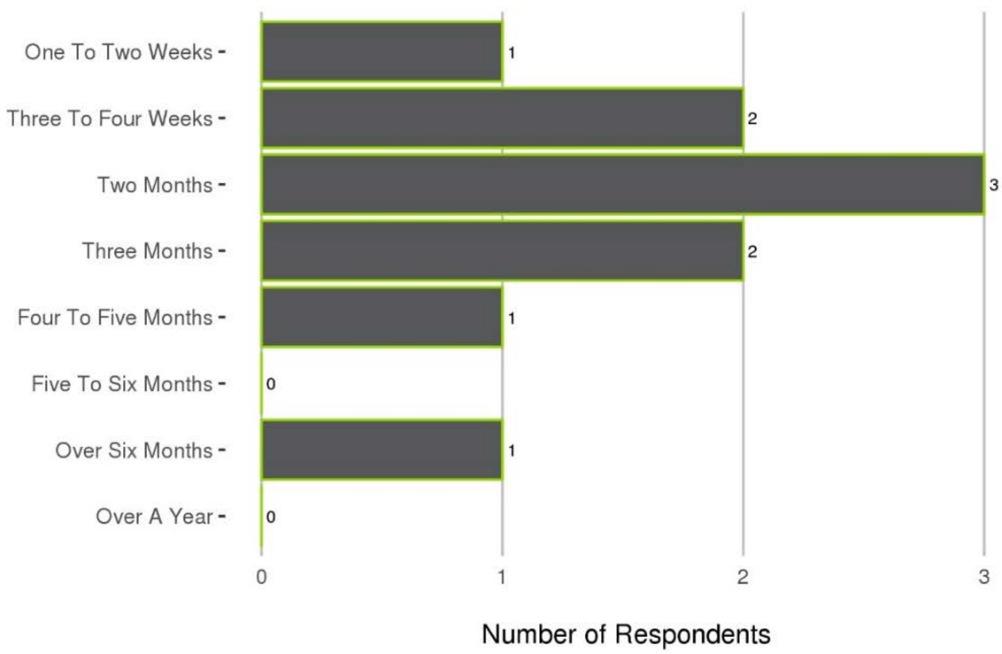


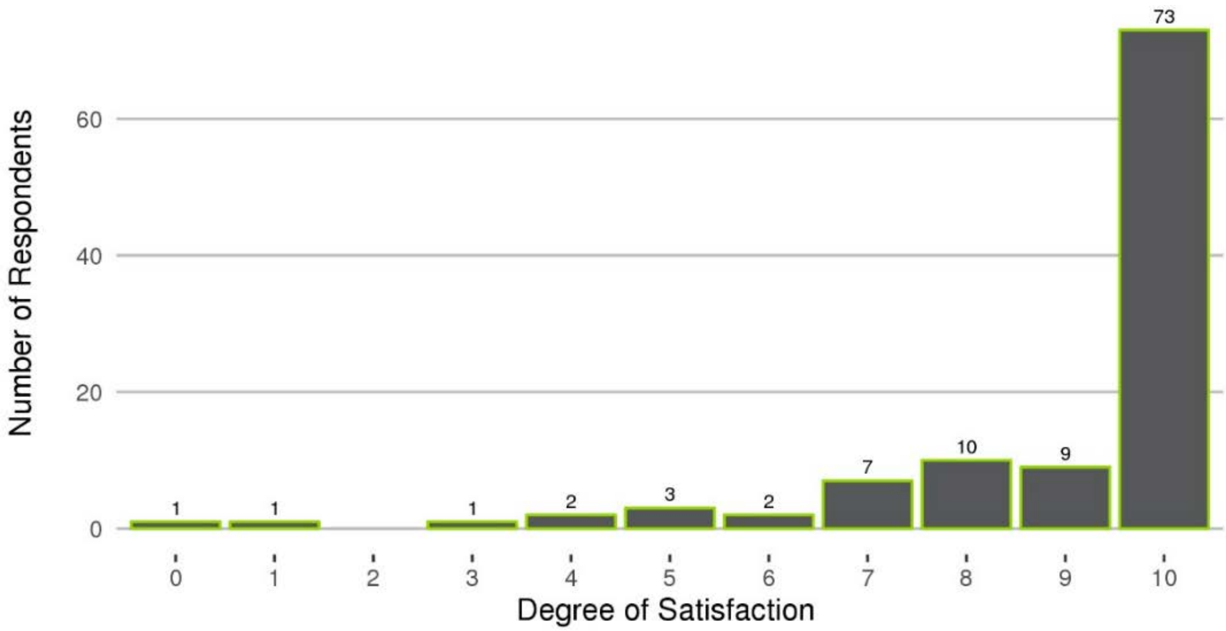
Figure 104. Program Participation Duration, for Those Receiving Rebates through Commercial Kitchens (n=10)



E8. On a scale of 0-10, with zero being very dissatisfied and 10 being very satisfied, how satisfied were you with the direct install experience? (n=111)

Mean	**9.0**
Median	**10**

Figure 105. Satisfaction with the Direct Install Process



E8a. For those who reported being dissatisfied, what would have made you more satisfied with the direct install experience? (n=5)

- "Not having the mix-up about when to come and install bulbs."
- "They could come and finish the job on the outside lighting and return my calls."
- "Have my calls returned in a timely manner, having the contractor be fully aware of the scope of the project, have the original project outline completed properly, have the contractor be properly equipped to complete the project, contractor should be sure all equipment is returned on time. Reduce the time between the energy audit and the actual install."
- "Very few lights were replaced as promised."
- "Complete the work. They did not complete the work."

E9. For Premium HVAC participants, on a scale of 0-10, with zero being very dissatisfied and 10 being very satisfied, how satisfied were you with the service you received on your HVAC system? (n=2)

Mean	**9.0**
Median	**9**

E10. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate your satisfaction overall with the program? (n=150)

Mean	**8.9**
Median	**10**

Figure 106. Satisfaction with Program Overall—Commercial Rebate Program Overall (n=150)

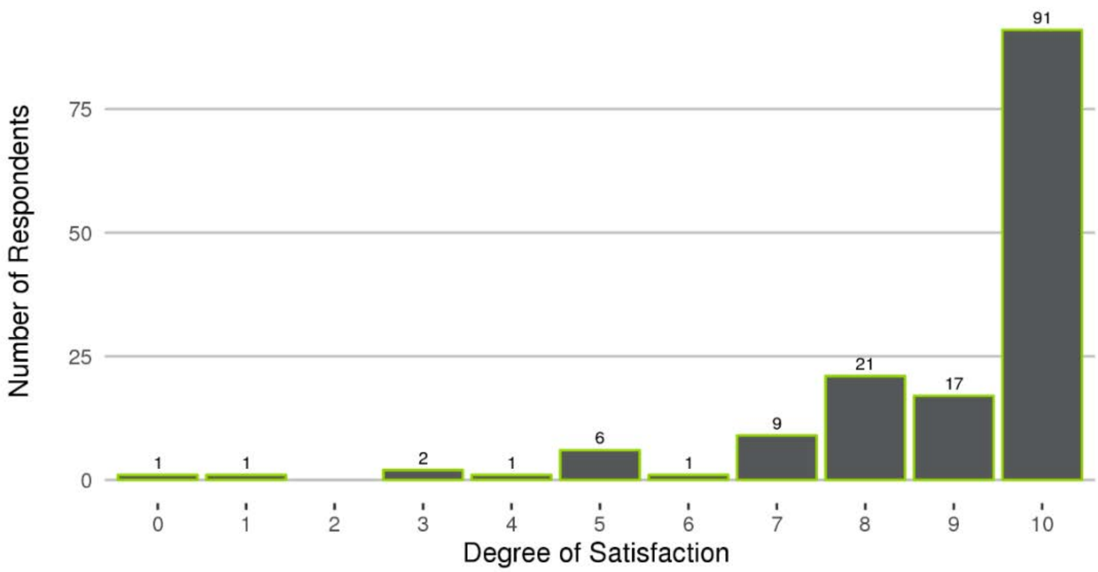


Figure 107. Satisfaction with Program Overall—Commercial Kitchens (n=19)

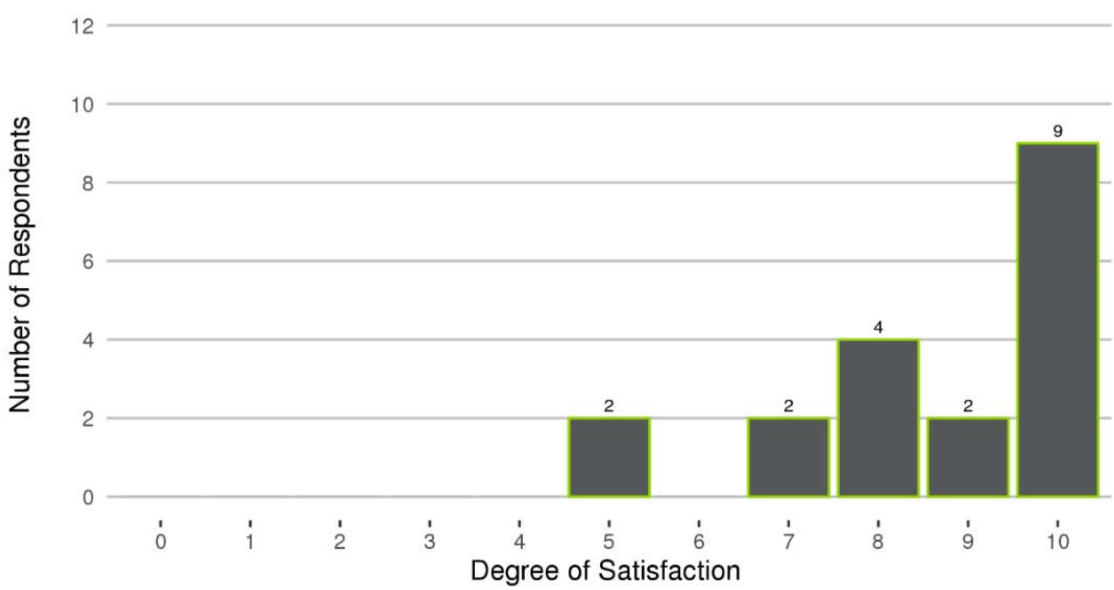
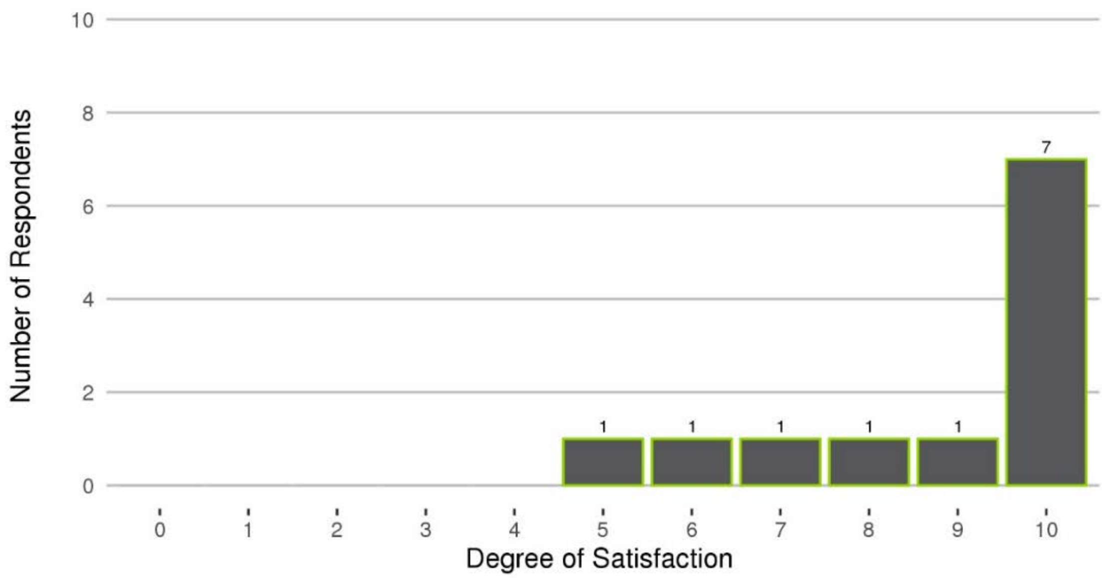


Figure 108. Satisfaction with Program Overall—Commercial HVAC (n=12)



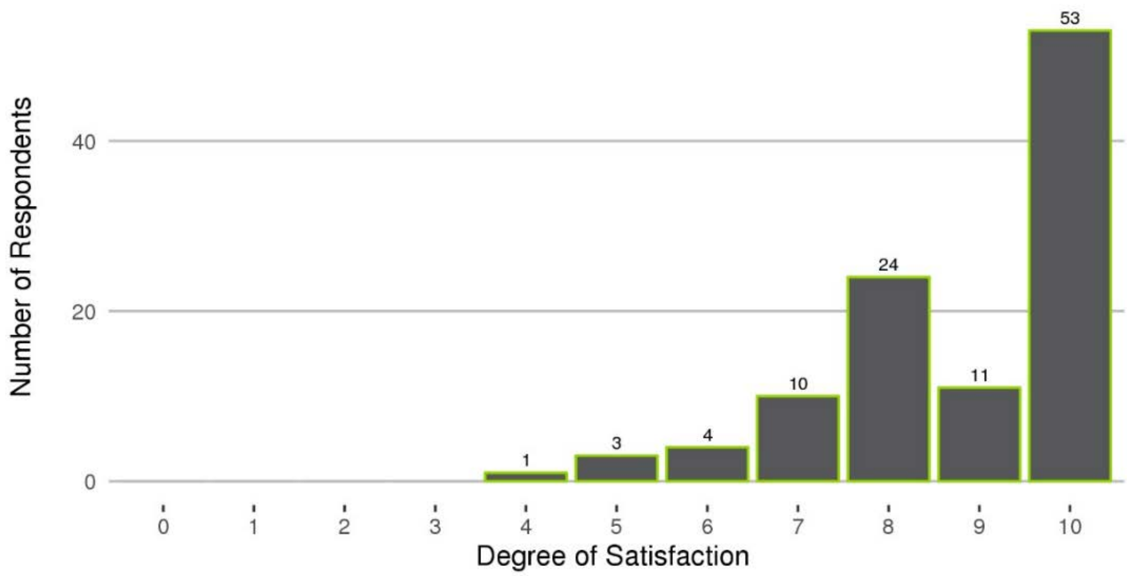
E10a. For those dissatisfied with their program participation experience, what was the reason for your dissatisfaction? (n=6)

- "They made a mess when they installed new lightbulbs. Clean up after yourself."
- "Total fraud. Lights were not replaced as promised, LED bulbs strobe when fatigued."
- "They did not finish the job on the outside lights yet, and I have been waiting a long time for them to do it."
- "My bill didn't go down."
- "They never came back to finish doing all the work."
- "The contractor was supposed to come back and he never did."

E11. On a scale of 0-10, with zero being very dissatisfied and ten being very satisfied, how would you rate PSE on the variety of energy efficiency programs offered? (n=106)

Mean	**8.8**
Median	**10**

Figure 109. Satisfaction with the Variety of Energy Efficiency Programs PSE Offers—Commercial Rebate Program Overall (n=106)



E12. Would you to participate in this program or another PSE program in the future? (n=145)

Commercial Rebate Program Overall (n=145)

Yes	**72%**
No	**28%**

SBDI (n=96)

Yes	**73%**
No	**27%**

Commercial HVAC (n=12)

Yes	**67%**
No	**33%**

Commercial Kitchens (n=19)

Yes	**90%**
No	**10%**

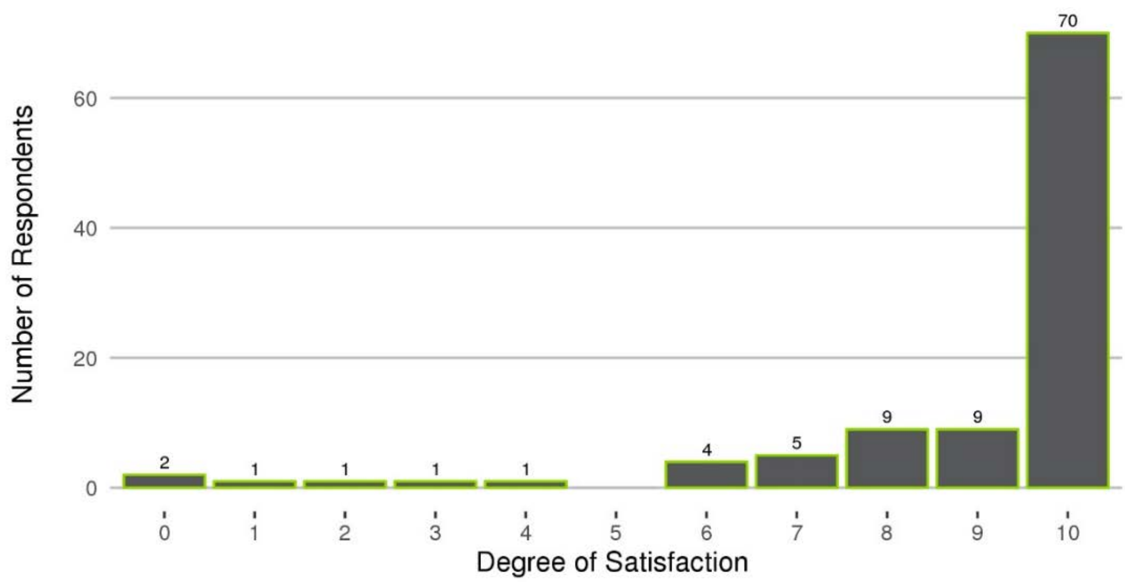
E12a. Reasons participants gave for not participating in the future (n=2)

- "Waste of time; I can replace three small light bulbs myself—wanted large barn lights replaced."
- "We tried another program, but they never responded about the cost."

E13. On a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with any communications or interactions you might have had with the contractor? (n=123)

Mean	**9.0**
Median	**10**

Figure 110. Satisfaction with Contractor Communication



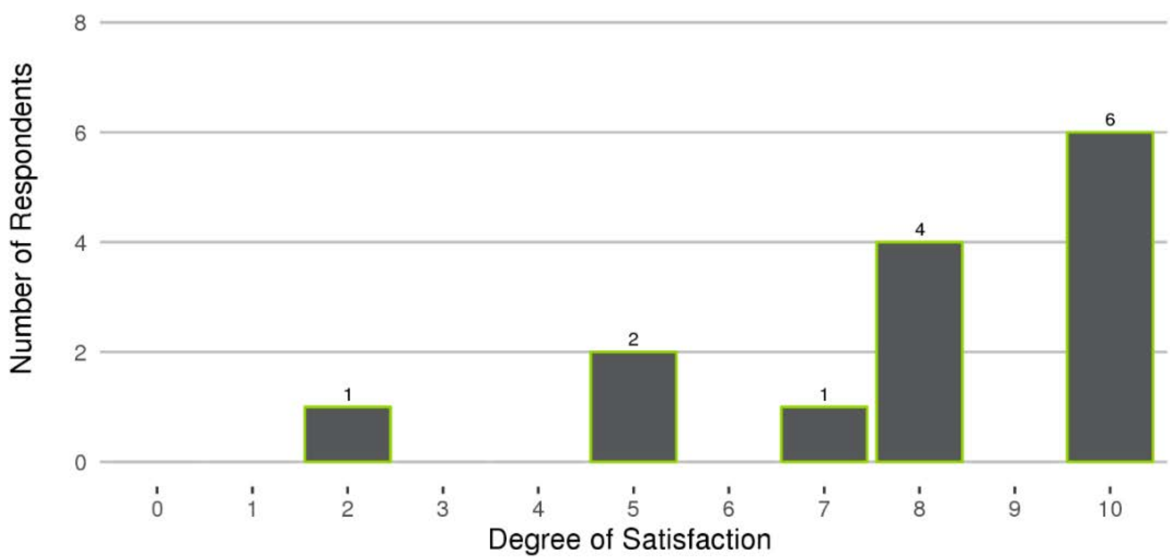
E13a. For those dissatisfied with their communication or interactions with the contractor, what was the reason for your dissatisfaction? (n=7)

- "Miscommunication, and he took too long to get back to me. Plus, he left a mess."
- "He never finished the work on the outside lights."
- "His communication skills were lacking, and he took too long to get back to me."
- "Lack of communication."
- "It took too long to get the rebate."
- "No return calls without having PSE program manager intervention and prodding. No scheduling updates at all."
- "We were told the LED bulbs did not strobe when they failed. That was a lie."

E14. For Kitchens Program participants, on a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with any communications or interactions you might have had with the vendor? (n=14)

Mean	**7.9**
Median	**8**

Figure 111. Satisfaction with Vendor Communication and Interactions, Commercial Kitchens (n=14)

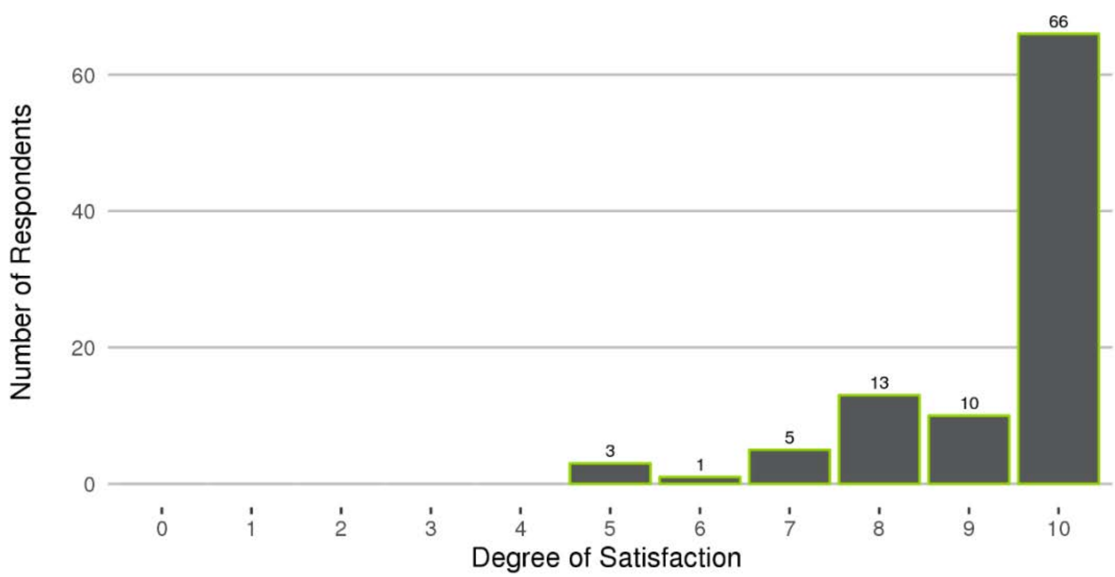


E15. On a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with any communications or interactions you might have had with PSE staff? (n=98)

*Note: There were many "Don't Know" or "Not Applicable" responses; without these removed, the total number of respondents was 142.

Mean	**9.3**
Median	**10**

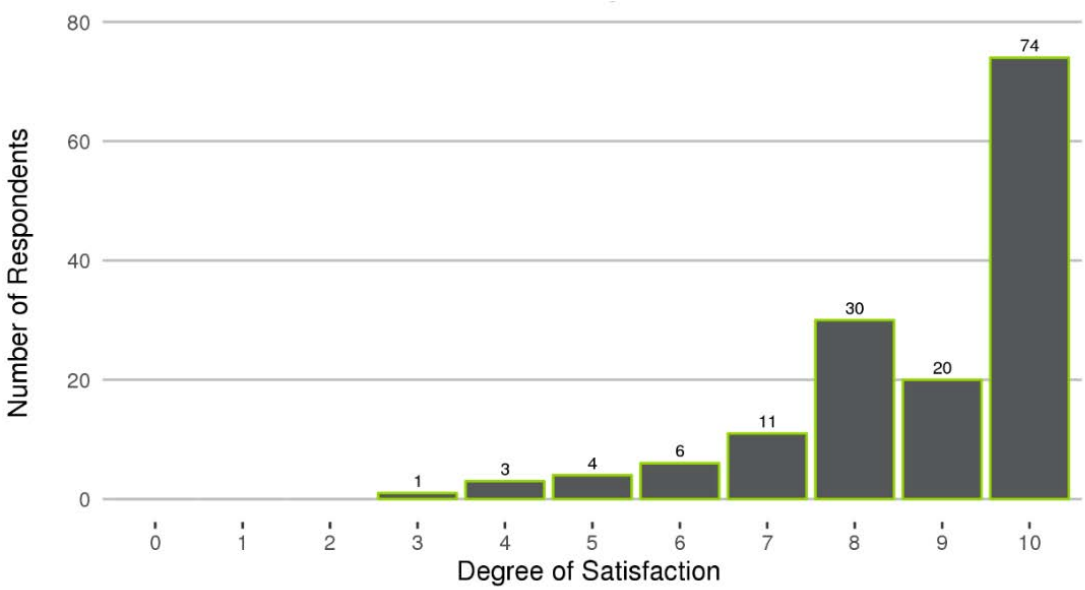
Figure 112. Satisfaction with Communication and Interaction with PSE Staff—Commercial Rebate Program Overall (n=142)



E16. On a scale of 0 to 10, with zero being very dissatisfied and ten being very satisfied, how satisfied are you with Puget Sound Energy overall? (n=149)

Mean	**8.8**
Median	**9**

Figure 113. Satisfaction with Puget Sound Energy Overall—Commercial Rebate Program Overall (n=149)



D.4 Commercial Rebate Process Evaluation—Participant Survey Highlights Memo

To: Michael Noreika, Jim Perich-Anderson, Christina Crowell

From: Navigant

Date: November 13, 2017

Re: Trade Ally Interview Results Memo

Navigant conducted phone interviews with retail sales vendors participating in the Commercial Kitchens program, and contractors active in the Small Business Direct Install (SBDI), Commercial HVAC and Premium HVAC sub-programs between spring and summer of 2017. We interviewed these trade allies on their experience in the program, drivers and barriers influencing trade ally participation, as well as program information channels. In total, we interviewed and collected responses from twelve trade allies active in the program. This memorandum summarizes the methodology and results of this process evaluation activity.

Methodology

During Spring, 2017 we contacted trade allies identified in program participation tracking data from 2016 and the first quarter of 2017. While the Commercial HVAC program had dozens of participating trade allies, the Premium HVAC Service, SBDI and Commercial Kitchens subprograms each had fewer than ten actively participating trade allies. The tracking data we received did not contain any contact information for a large portion of trade allies, necessitating a combination of outreach to program managers and online research to supplement contact information.

Due to the small number of participating trade allies and barriers to obtaining usable contact information, we chose to contact a census of all contractors and vendors for which we had obtained contact information. Our final sample included both low-frequency and high-frequency trade allies for all subprograms with substantial participation. We made multiple attempts by phone, and when possible through email, to invite every trade ally in our final sample to participate in a brief, 10 to 15-minute phone interview. In every case, we interviewed the person at each firm most directly knowledgeable about participation in PSE's Commercial Rebate program.

As a result of these outreach efforts we interviewed the following trade allies:

- 5 Commercial Kitchens vendors
    - 2 high-frequency, 3 low-frequency
- 3 SBDI contractors
    - 1 high-frequency, 2 low-frequency
- 5 Commercial HVAC contractors
    - 2 high-frequency, 3 low-frequency
- 1 Premium HVAC Service contractor
    - Low frequency

The titles of interviewees included:

- Principal
- President

- Vice President
- Director of Utility Relations
- General Manger
- Owner
- Sales Manager.

Results

Commercial Kitchens Program Vendors

We conducted phone surveys with two high-frequency and three low-frequency vendors active in the Commercial Kitchens program. These retail outlets accounted for a large proportion of overall program sales, and therefore provided a balanced view of the vendor program experience.

Program Experience

Most high-frequency vendors found participation in the program easy, rating the ease of participation an eight on a zero to ten scale, through some low-frequency vendors found participation more difficult, rating it a five or six. Vendors had some suggestions for how participation could be made easier for them:

"How could PSE make the program participation process easier for you?"	"There are too many rebates out there now; You need to offer only two rebates."
	"Training entry level employees is a problem and there is a lot of confusion."
	"Rebates change, they are a moving target. We have lost some money due to this process."

Most vendors rated the ease of enrolling customers in the program a ten on a zero to ten scale. Despite this high level of satisfaction, vendors provided some suggestions for improvement in addition to comments reflecting approval of the process:

"How could PSE make it easier for you to enroll customers in the program?"	"They should go back to a system where everything is automated. [Then] enrolling customers is easy."
	"We now direct the customers to the website and have the customers deal with PSE directly. Generally, we let the customers do all the paperwork now."
	"The paperwork is very easy to do."

Vendors reported some problems and rated the program less highly in terms of the time it takes PSE to process program paperwork, and the time it takes them to manage their firm's participation in the program. Respondents tended to rate satisfaction with these elements in the 5 to 7 out of 10 range. Open ended responses provided insights into the challenges they encountered:

"How could PSE improve your satisfaction with processing time or the time it takes your firm to participate?"	"(Processing time) varies. It is very inconsistent. Sometimes it happens very quickly. Other times you are still waiting six months later."
	"The paperwork is easy, however I do not like some of the questions that are asked. Some questions I never ask the customer, they are irrelevant."
	"It's nothing they can change. For us it is based on how we are internally paid…we've shared this with (PSE)."

Despite some areas for improvement listed above, most vendors rated their satisfaction with the Kitchens sub-program overall very highly (8 to 10 out of 10). Some relevant quotes below provide suggestions for how PSE might still improve the program overall, while others suggest no room for improvement:

"How could PSE improve your satisfaction with participation in the program overall?"	"There's a lack of consistency and too much confusion, especially for an entry-level employee. The program needs to be simplified."
	"I love the program and I support the program and would like to see it continued."
	"Items listed as rebate items still need rebate verification. Our PSE contact is one person, and when that person is gone, we start the waiting game. Everything is very time consuming."

Participation Drivers and Barriers

Most vendors reported promoting the program to customers nearly all, if not all the time, particularly because it is in the customer's best interest. A few vendors reported offering the program less frequently, largely due to differences in staff ability to promote the program, familiarity with program offerings, and trust of the firm's internal process to ensure they receive payment. These vendors cited frequent turnover of their staff and the need for ongoing training as issues contributing to their recommending the program less often. Vendors commented:

"How often do you recommend the program to your customers?"	"We recommend it 100% of the time; I am very much vested in this program."
	"This is an education piece and it depends on who is educated. Lack of training/education is an issue. Some of our staff also don't trust the internal process to get the permissions paid to them; it's the perception that it might impact their commissions (negatively). The paperwork/process that we have internally isn't always easy to understand. We get a lot of turnover in our business with sales people, and not everyone is as educated as the next—they won't ask if they don't know."
	"We recommend it to all. It is not a decision we have to make. This company will do whatever they can for the customers."
	"Generally, it's on our staff to decide to file paperwork on their own behalf or to take that off their invoices. Sometimes these are wrapped into bigger projects, so it is not always easy to do this."

Asked what motivates them to recommend the program to their customers, vendors had varied responses, but mainly focused on energy costs and the ability to help their customers, though some mentioned the incentives they receive and the competitive advantage it offers them over retail outlets.

"What motivates you to recommend the program to your customers?"	"I am driven by energy costs. As we know energy cost are going through the roof. When we can help someone save some money, we will do it."
	"We're motivated by the incentive to a small degree. We want to be better than our competition in presenting an option (to the customer). I use it as a way to broker a deal with the customer. We get a lot of competitors from outside the area who wouldn't know these programs too well."

Vendors suggested several different channels through which they promote the program, including internet marketing, signage on appliances, direct mail and trainings/informational sessions between PSE and their staff.

"How do you promote the program to your customers?"	"We promote the program through internet, website and have signage on ALL appliances. We also do push mail."
	"PSE has provided us signage in the past. Those folks have been out here in the past and talked some of our personnel. They come in and have regular meetings. That is important since it helps people understand how it works. Generally speaking, that is how we go to market with that information."

They also suggested that promoting the program as part of their regular sales process was critical. Vendors had comments on how they integrate PSE's rebate program as part of their regular sales process, as well as suggestions for how to help them better integrate it into their sales process.

"Do you incorporate PSE Commercial Kitchen rebates into part of your regular sales process, and how could PSE help with this?"	"Yes, it is a regular part of our sales process. We always want to outbeat our competition."
	"I think it does have an effect, I think it helps garner that competition, especially when our customers use the internet to compare."
	"They could help with repeated instruction and awareness. For example, manufacturers often know about the programs and help educate our staff so if PSE were to reach out to some of those vendors and us directly, then we will have a better conduit of information."

Asked what they believe motivates their customers to participate in PSE's Kitchens program, and what keeps them from participating, the vendors had great insights:

"What do you feel keeps customers from participating in the program?"	"Saving money motivates customers to participate. Everyone wants to save."
	"Beyond money, you have to educate them about operational costs/savings beyond the initial purchase discount. It isn't always the best decision, but we need to at least educate them. A quarter of the time, people coming to us know about the program, so they are hearing about it somewhere."
	"If they don't qualify they get mad. If we advertise a rebate, they expect the rebate. Everyone wants to participate. (Those that don't qualify), they see it as free money and they can't have it."
	"Lack of understanding on their own part with the paperwork. Often times we ask them to sign the rebate over to us and they don't often want to give that information. Paperwork process is the only thing I see (as a barrier to participation). They want to save money and they want us to take it."

We asked vendors how often they gave customers the PSE rebate at the Point of Purchase (POP) rather than having the customers complete paperwork on their own, and what changes PSE could make that would encourage them to give more POP rebates. Vendors were very evenly split between those that give rebates at POP nearly all the time, versus those that almost never do and have the customer handle the rebate themselves. Asked how PSE could make it easier and encourage them to give more rebates at POP, they had the following to say:

"How often do you give rebates at the POP, and what would encourage you to do so more of the time?"	"It would be nice to have a couple of categories. They should look at inductions. This is a big opportunity for energy savings. They should also have a grill category."
	"When the program started, we were more proactive about making sure that we were doing our part. (What would help is) for PSE to reach out to our individual store managers and help them put on stickers promoting savings opportunities and providing our contact information."

Most vendors reported having PSE promotional signage in place in their stores, and found these materials useful. They also had some suggestions for improvement of signage/promotional materials:

"Do you have PSE program-specific promotional materials in your store, and do you find these useful?"	"Yes, we have PSE signage in place, it helps with participation."
	"Yes, we do. I think it can help on two angles. It helps customers who walk in to remember these guys can help us beyond what they see in the store. It also reminds our staff of the existence of these programs/incentives. Both help with education."
	"We put signage on all of our appliances about the PSE rebate."

Asked for any additional suggestions for PSE on the program, vendors felt most important topics had been covered. One supplied the following:

> *"They are great. They are always part of the equation."*

Small Business Direct Install (SBDI) Program Contractors

We spoke with three SBDI contractors, one with very high program sales volume, and two lower-frequency trade allies. These contractors accounted for a large proportion of all work through the SBDI program, so were able to offer well-rounded insights into program performance.

Program Experience

Asked about how easy it was for their firm to participate in the SBDI program overall on a zero to ten scale, the contractors responded positively, with scores between 7 and 10. We asked what PSE could do to make the program participation experience easier for them, most were satisfied and had no suggestions to offer, but one firm volunteered a suggestion:

> *"They could get us marketing materials. There are marketing materials we asked for and still have not received. We were given badges recently, but we needed them earlier—that would have been helpful."*

SBDI contractors generally felt it was not difficult to get customers to participate in the program, rating ease of enrollment between an eight and a ten on a zero to ten scale. Asked what could be done to make it easier for them to get customers to participate, they had several suggestions, including measure-specific recommendations:

"How could PSE make it easier for you to enroll customers in the program?"

"One area where we do see some issues is in converting people over from standard fluorescent tubes to LED T8s—you have to replace the driver, ballast, lamp etc. and it is a really fine line to make money on these—it is a very low participation measure."

"It's not too difficult to enroll customers—if they're in the geographic area, we know who to offer the program to."

We asked SBDI contractors first to rate their satisfaction, using a zero to ten scale, with the amount of processing time involved in the program paperwork, and then to rate their satisfaction with how much time it takes their firm to participate in the program. Most rated their satisfaction with processing time between seven and nine, while they rated their satisfaction with the overall time commitment for their firm between seven and ten. One contractor scored their satisfaction with processing time very poorly—a two out of ten—and also expressed dissatisfaction with the amount of time it takes their firm to participate, rating their satisfaction a five. Asked for clarification this firm reported issues with the implementation contractor:

> *"The issue is with logistics between us and [the Implementer]—it's been several months and we haven't gotten paid yet—a big lag in payment—we've installed measures with 25-30 clients and still haven't received a single dollar of payment from [the Implementer]."*

Other responses from contractors on how to potentially improve their satisfaction with these components of the program experience included the following:

"How could PSE improve your satisfaction with processing time or the time it takes your firm to participate?"	"Participation for our firm is neither difficult or easy---that one is neutral. Not really sure if anything can be done to change that—PSE needs to get their info and we need to do our part to provide it—it's necessary, he understands, so I don't have a good suggestion for how to make it less time-intensive for the contractor."
	"There's gotta be a glitch in the program—we're offered an online entry system, but it seems they never got it up and running—this would be an improvement because for now we have to do it all manually."

SBDI contractors rated their satisfaction with the program overall highly, between a seven and a nine out of 10. Asked to provide more information on their level of program satisfaction, they mentioned the following:

"How could PSE improve your satisfaction with participation in the program overall?"	"SBDI really is a good program—it allows us to reach out to these customers that don't qualify for the large commercial program—small mom and pop shops that don't have the finances for big investments in conservation—for them, this program is a good option. For me the biggest thing that makes me satisfied with participating in the program is helping people and seeing their response when their places are brighter and better looking—this is satisfying."
	"There have been some funding level changes that need to be communicated better in advance—for instance, the customer is given a proposal, they don't act on it right away, but then the funding changes by the time they want to participate. It would be better if once a customer is given a proposal, you don't change the proposal at a later date, etc."
	"I like the fact that the number of contractors who get to participate in this program is small—it keeps us motivated. If there are too many contractors participating in the program, it muddies the waters."

The single contractor who identified issues with a payment lag involving the implementer said their satisfaction overall was dependent on whether or not the payment issue was resolved. Assuming resolution to the payment issue, they would rate overall program satisfaction a seven. For further context they provided the following:

> *"If we'd already been paid we would be pretty satisfied, but if it takes another couple months, we're going to be pretty upset—our satisfaction is a 5, neutral, as a result—the issue is payment. It is hard to give you a numeric answer on this because we'll be pretty satisfied with the program overall if we get paid pretty soon, maybe a seven, but otherwise not."*

Participation Drivers and Barriers

We asked SBDI contractors about how frequently they recommended the program to customers, and what motivations and barriers they faced in promoting the program to customers. While most report promoting the program to customers 100% of the time, the contractor with the late payment issue from the implementer reported promoting the program less so now due to concerns over payment. Some contractors further elaborated on the relationship between the SBDI program and PSE's "standard" lighting program, giving insight into their decision process to engage a customer in the SBDI program, rather than another PSE program. Some contractor observations are offered below:

"How often do you recommend the program to your customers?"

"The funding in some categories is better than the standard program, faster turnaround than standard, and measures are more diverse—there are some items excluded from standard program that are in SBDI—more variety."

"How we approach whether to recommend the SBDI program is we definitely go out and look at a couple factors: is this a large project, etc. We get all the paperwork into PSE, it undergoes the pre-inspection, etc. Now if there's a time crunch, or if the customer then says they don't have the money to do it through the regular commercial channel program—then we offer the SBDI program, but first we try to use the standard program. There are definitely no reservations or things that make us hesitate to recommend the program—we recommend the SBDI program wherever it makes sense based the process I described (ie.—trying standard commercial program first for many that might qualify there)."

"We always recommend if available to them—we even put a note in the contact information saying they qualify and to remind us to offer it to them."

"The financial incentives—if that wasn't there there's no way we'd participate in the program—so that is the primary motivation. But the secondary motivation is it really helps our customers. On the gaskets for the walk-ins and coolers, it is sure easier for us not to have to go through the paperwork, have the customer submit to us partial payment, get the rest of the payment from PSE, etc. But even though it is more work for us, we also do it for the customer because it really helps the customer."

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We asked for their insights into what factors keep customers from participating. These firms offered several interesting insights, including potential issues with contractors not following through with their promises to customers and issues with specific measures:

"What do you feel keeps customers from participating in the program?"

"There are no issues with the problem that keep customers from wanting to participate. But one thing—when we have multiple contractors hitting the same territory, some go out and say "we're going to go process your paperwork" and they disappear, and then the customer never hear back from them. This creates problems. (Interviewer asks if these are other PSE contractors, or unrelated): I don't know but I can tell you that we have heard from customers that "PSE has been out here, other contractors have been out here, and they were going to submit the paperwork and nothing has happened." (This indicates that there may be a problem with other PSE contractors not following through.)

"Suspicion, not having materials to show them, them not trusting the program, that its too good to be true and there must be some catch, etc. Let me give you an example too that shows another barrier to the program participation—Refrigeration strip curtains are a great example—with the PSE incentives, these are a great measure—we can practically offer these for free—BUT there is a lot of push-back from the chefs because they hate the strip curtains—they save energy for sure, but they get in the way of the kitchen crew—and so the kitchen staff don't like them—there's one example (before we started participating in PSE's program) where we installed them, and the chef hated them so much he called up his district manager and got permission to cut them off because they were just too cumbersome. When the clients are owner-operators, they've got skin in the game, they're paying the energy bills, so they're a lot more likely to put up with the inconvenience—versus those that are not."

Information Channels

When asked about the Contractor Alliance Network (CAN) and its usefulness to the contractors, most did not comment, but one of the contractors suggested an area for growth:

> *"We have applied, but we haven't ever heard back from PSE and it's been 2 months. It would definitely benefit us when we're going out and talking with people, they can look us up on the PSE website and it gives us more legitimacy, plus we can download brochures, etc."*

Commercial HVAC and Premium HVAC Service Program Contractors

We interviewed two high-volume and four low-volume contractors active in the HVAC components of the Commercial Rebates program. While only one of these interviews was specific to participation in the Premium HVAC Service subprogram, participation so far in that program is very low and just ramping up. Statistics presented on satisfaction with various elements of program participation are based solely on Commercial HVAC subprogram contractors.[12] We treat the Premium Service Contractor's responses as qualitative in nature, and present verbal responses which provide useful insights into this sub-program's ramp-up experience.

Program Experience

We asked about how easy it was for their firm to participate in the Commercial HVAC program overall on a zero to ten scale. The contractors responded positively, with scores between 6 and 9. We asked what PSE could do to make the program participation experience easier for them. They had the following suggestions:

"How could PSE make the program participation process easier for you?"	"PSE could have more automation on submission of rebate forms to make it easier. Cascade does a much better job with this than PSE."
	"It is very hard to meet the requirements every six months. Maybe over a year would be better. If you're kicked out of the program after six months for not participating, this is hard for small companies to do."
	"Requirements are pretty straightforward, but it's a bit of a hassle getting and finding and uploading the required documents and paperwork—they could make this easier."

By contrast, the Premium HVAC Service contractor had this to say:

> *"We've tried to get a couple of locations started and haven't gotten anyone to participate in the PSE process yet. The "premium" part we don't have a problem [with]. It is more the rebate*

[12] For the reporting HVAC contractor responses in this section, one contractor's responses were largely excluded. Analysis of this contractor's responses (particularly satisfaction questions) revealed they were responding mainly to the Custom Grants program, not specifically the prescriptive Commercial HVAC sub-program, and this contractor did not respond to requests for a follow-up interview. As a result, for our results to provide a true reflection of participation in the Commercial HVAC and Premium HVAC subprograms, we excluded these responses. We did include a few verbal responses that were clearly relevant to the Commercial HVAC prescriptive program barriers or information channels.

service. Our technicians know exactly what the premium service is. The issue is getting ahold of people for getting rebates and getting the proper information, calculating the rebate. A couple of times the rebate has been inaccurate or out of date. It's hard to estimate what the rebate will be when pitching [the program] to customers. I think the calculation spreadsheets are coming directly from PSE. Who I was talking to at PSE changed halfway through. Getting ahold of the PSE rep is difficult. When [the implementer] came out and explained everything to my manager and I, it was very helpful. After that, it has been hit or miss getting ahold of them. I've had several spreadsheet calculation errors as well."

Commercial HVAC program contractors generally felt it is not difficult to get customers to participate in the program, rating this ability an 8 to a 10 out of 10 for ease. Asked what could be done to make it easier for them to get customers to participate, they had the following comments:

"How could PSE make it easier for you to enroll customers in the program?"	"I think the biggest issue is like a lot of big corporations, you can access them through email, but it's very difficult to get a person on the phone and sometimes things are complicated—sometimes they respond quickly, sometimes not."
	"Don't know, no complaints here!"
	"Nothing much—It could be a little more clear, the information on program guidelines, what customer qualifies, etc.—for instance, what rate category and size category, etc."

By contrast, the Premium HVAC Service contractor had the following to share regarding the difficulty of getting customers to participate in the program:

"They want to know the benefits and it is a fantastic program, but we can't provide an estimate a lot of the time. If we are going after a new customer and this is our initial approach, it looks pretty bad. It's a great program, but it needs to get off the ground."

We asked Commercial HVAC program contractors first to rate their satisfaction (on a zero to 10 scale) with the amount of processing time involved in the program paperwork, and then to rate their satisfaction with how much time it takes their firm to participate in the program overall. Ratings of the processing time fell between a 5 and an 8, while they ratings of the overall time commitment for their firm ranged between 5 and 9, indicating some room for improvement but overall satisfaction. Contractors had no meaningful comments on the amount of time it takes PSE to process applications, but had the following observations on the time it takes their firm to participate in the program:

"How could PSE improve your satisfaction with processing time or the time it takes your firm to participate?"	"Once you've done it, it goes pretty smoothly."
	"Making the process more automated. I believe the training hours are stupid. It takes time to train someone, and you don't always have the time at that moment."
	"PSE could (1) send the rebates sooner so customers don't call him asking about where their checks are, and (2) have a place on their website where customers and contractors can go to track their rebate by their account number. A graph showing the location in the timeline. That would help us save time."
	"They [should] stick with the new rebate application process."

Commercial HVAC program contractors rated their satisfaction with the program overall highly, between a 7 and an 8.5 out of 10. Asked to provide more information on their level of program satisfaction, they mentioned the following:

"How could PSE improve your satisfaction with participation in the program overall?"	"We have no reason for dissatisfaction."
	"Can't say too much here except it's a pain to renew every six months. A six-month window is bad."
	"Requirements are pretty straightforward, but it's a bit of a hassle getting and finding and uploading the required documents and paperwork—they could make this easier."
	"Paperwork historically has been a lot but they are quick to attend to our questions"

Participation Drivers and Barriers

We asked Commercial HVAC program contractors about how frequently they recommended the program to customers, and what motivations and barriers they faced in promoting the program to customers. Interviewed contractors report promoting the program to customers 100% of the time. By contrast, the Premium HVAC Service contractor responded that he "had not had much luck with it yet."

Asked about what motivates them to participate in the program and why customers want to participate, Commercial HVAC program contractors had the following to say:

"What motivates you to recommend the program to your customers, and what do you feel motivates customers to participate in this program?"	"Our firm actively seeks retrofit work. The program sweetens the pot, lends third party credibility, helps the customer reach earlier payback."
	"The Northwest is a great market for the product. The rebates are one of the best and simplest in the whole U.S. The physical environment (weather) makes it a great payback."
	"In the commercial sector it's all financial. It's a business case."

Asked for their insights into what factors keep customers from participating and how to increase customer participation, they offered several insights:

"What keeps customers from participating in this program?"	"They are usually very good about working with us very quickly so we never direct a customer away from this market if their equipment meets the basic requirements."
	"Better marketing of the rebates to their customers, especially to the higher up decision makers. The account reps are often swamped."

During the Program Manager and Implementer in-depth interviews, we encountered many references to issues with contractors not having time or bandwidth to participate in the program because of competing projects in a booming construction economy. We asked contractors directly about their experiences in this respect and what the program could do to help overcome this barrier to contractor participation. They offered some valuable insights:

"Do you ever feel economic conditions make it difficult for you to participate in this program due to competing projects? How could PSE help overcome this barrier?"	"Yes, depending on the different programs. There is the HVAC service program which is pretty good but there isn't a lot of money in it."
	"With new construction, there are a lot more high-value projects going on right now."
	"They could simplify the paperwork and integrate with the contractors' processes so there is no extra paperwork."

Information Channels

We asked contractors how they typically marketed the program to customers, and they had several responses:

"How do you promote the program to your customers?"	"We promote it to them as a little to no cost opportunity for the customer"
	"We use it to upsell. Even in a competitive bid situation we include little measures the customer can do, then they suggest deeper retrofits and say, 'if you do this, you can get this grant.'"

When asked for more information on the kind of marketing materials PSE provides, whether they are useful, or how they could be improved, Commercial HVAC program contractors had the following comments:

"Do you have marketing materials from PSE, and do you find these useful?"	"They provide vague and unnecessary ones."
	"The customer wants to know what the bottom line is, not a glossy brochure. So more detail or transparency on the payout and process."
	"It's the Trade Allies that provide the marketing materials." (presumably HVAC manufacturers or distributors)

Asked the same question, the Premium HVAC Service contractor provided this response:

> *"I haven't asked. [The implementer] has given us some internal pamphlets to use. The only thing I asked for was stickers to put on the units and they couldn't provide that."*

Finally, we asked Commercial HVAC program contractors about whether they participated in the CAN, its usefulness and suggestions for improvement. They had several interesting observations to share:

“Do you participate in the CAN, and if so, how could it be improved to leverage it better for the program or make it more useful?”	“No. Like we did with the Premium HVAC Service program, we declined to participate. For either (or both) it would require a dedicated FTE at our firm, and that didn’t pencil out. Why spend 15k to save a customer 10k?”
	“At the basic level, yes. We didn’t see a huge value in going to the Tier 1 status to get the referrals. I know smaller firms are the ones who typically go after those referrals.”
	“I emailed [the implementer] at Premium Service and said it is too top-heavy and too hard too work through. He said they might streamline. They need to engage with the contractors better. Do a roundtable, a workshop, find out what they want. Sometimes it seems like they dream up these programs in a vacuum. However, I’ve participated at roundtables in the past and I’m skeptical my input would create real change. Seems like they do it to show contractors they care, but then do whatever … they wanted to do anyway.”
	“Might be good to mandate that only CAN contractors can participate- but only if it is easy. Offer more marketing materials/other events to introduce them to customers (e.g. focused energy audits with strip malls in the area).”

D.5 Commercial Rebate Process Evaluation—Behavior Optimization and Best Practices Memo

To: Michael Noreika, Jim Perich-Anderson, Christina Crowell

From: Navigant

Date: November 21, 2017

Re: Commercial Rebate Process Evaluation—Behavior Optimization and Best Practices Memo

This memo presents the findings and recommendations from our team's Behavior Optimization and Best Practices process evaluation research of Puget Sound Energy's (PSE) Commercial Rebate program.

Overview

Our team optimized the behavior optimization and best practices research to generate actionable findings by focusing the research on answering the key process-oriented questions identified through program manager and implementer in-depth interviews. In each case, we selected the issues where best practices and behavior optimization research were most likely to yield actionable findings and suggestions.

Behavior Optimization

Methodology and Goals

In the past ten years, efforts to maximize energy efficiency have begun to realize the valuable contributions of social science insights for improving customer engagement, enhancing the adoption of energy efficient technologies, and for enhancing savings through programs designed to shift customer behaviors. This shift represents a noteworthy departure from the longstanding approaches used by traditional utility programs and some of the basic assumptions on which such programs were built. Of note are traditional assumptions that imagine customers as consistently acting in rational ways, that rely on information and economic incentives as the sole means of motivating customers to choose energy efficient products, and that envision energy efficiency solutions exclusively in terms of widgets while ignoring the complexities of social and behavioral factors that shape the actions and decisions of utility customers.

The goal of this research is to provide insights and recommendations for improving program intervention strategies and for modifying consumer behavior. The following describes key research questions and areas of inquiry considered through our Behavior Optimization research:

Behavior Optimization Key Areas of Inquiry	Leveraging insights from behavioral economics to help improve point of purchase (POP) signage and materials, and to understand how and where these can be most effective, particularly for kitchens vendors.
	Utilizing findings from behavioral sciences research to improve sales strategies and contractor/vendor incorporation of PSE's program as a core part of their sales process, particularly for kitchens and commercial HVAC equipment.
	Applying behavioral science insights on the perspectives of small businesses and effective approaches to developing ongoing customer relationships and customer engagement.
	Leveraging social sciences research findings to better understand how to optimize outreach efforts and program marketing approaches in rural areas with less dense social networks relative to cities, particularly with respect to engaging small farmers.

A five-step method was used to gather the insights presented in this memo. The steps include:

Identify Areas of Inquiry

- Identifying key areas of inquiry informed by program manager and implementation contractor interviews, trade ally interviews, previous best practices research findings for the program and issues raised in program theory and logic development

Review Secondary Literature

- Conducting secondary literature research focused on findings most relevant to key areas of inquiry, utilizing utility publications, new articles, academic literature, conference proceedings and presentation materials, energy and utility-related journal articles and other relevant materials

Conduct Interviews

- Conducting a select set of interviews with thought leaders and utility peers deemed likely to have valuable insights into key areas of inquiry

Develop Research Findings Matrix[1]

- Developing a research findings matrix that maps out the relevance of insights for each of the areas of inquiry

Describe Most Actionable Insights for each Area of Inquiry

- Identifying and describing three to four of the most salient and actionable insights for each area of inquiry

We gathered data from a variety of sources including existing reports, papers, conference proceedings, and interviews. The following list represents some of the resources that were reviewed to gather the insights that are presented here.

- Proceedings of the ACEEE Summer Study on Energy Efficiency in Buildings
- Presentations of the Behavior, Energy and Climate Change Conference
- AESP Conference Proceedings
- Behavioral Economics Guides
- Journal of Energy Efficiency
- Google Scholar searches
- Interviews with subject matter experts

Key Findings

Table 1 summarizes behavior optimization and social science insights researched through this study and their applicability across multiple Commercial Rebate program channels. We highlighted in yellow cells the most salient findings, and these are included in the sections that follow.

Table 1. Summary of Select Social Science Insights

	Behavior Science Strategy	Commercial Kitchen and Laundry	Commercial HVAC	Small Business	Agriculture and Rural Populations
1	Maximize interpersonal communication strategies and trusted information sources	x	x	x	x
2	Tap into community status			x	x
3	Get a commitment			x	x
4	Establish a lottery approach to engagement				x
5	Set a personal/community goal, challenge, or competition	x	x	x	x
6	Avoid crowding out / recognize non-energy benefits		x		x
7	Leverage reciprocity, prompts, and loss aversion in messaging			x	x
8	Use reference dependence in messaging	x			
9	Curate choices	x	x	x	x
10	Overcome the Endowment Effect	x	x		

[13] The embedded matrix provided on page 17 presents 20 behavioral economics and social science insights pulled from research relevant to one or more of the commercial program areas covered in this memo. The matrix presents the key finding, a description of its application to commercial customers, and indicates which of the social science insights has relevance for each of the program areas.

	Behavior Science Strategy	Commercial Kitchen and Laundry	Commercial HVAC	Small Business	Agriculture and Rural Populations
11	Be aware of seasonality of work			x	x
12	Be targeted in audience & action	x	x	x	x
13	Use appropriate media outlets				x
14	Be conscientious of regional and cultural concerns, business culture				x
15	Focus on the investment decision, not the person	x	x		
16	Provide information on technologies from sources unaffiliated with products	x	x		
17	Optimize in-store signage and positioning	x			
18	Personalize communications and target message			x	
19	Recognize variation across business segments; offer competitions within segments			x	
20	Provide continuous feedback on energy use to ALL staff			x	

In the following section, we describe the top three to four behavioral science techniques and recommendations for each area of inquiry.

Commercial Kitchens and Laundry Programs

Program Challenge: How can we leverage insights from behavioral economics to help improve point of purchase (POP) signage and materials, and to understand how and where these can be most effective?

Context: Purchasing large specialized commercial equipment for kitchens and laundry facilities can be large expenses at the outset of a new business, when a piece of equipment fails, or when a business owner is looking to upgrade or remodel. The decision may be overwhelming, and energy efficiency is not often the top priority. Program managers can work with the equipment retailers to steer the business owner toward efficient choices using the following behavioral science strategies.

1. Information from Sources Unaffiliated with Products

Customers may be skeptical of brand-affiliated information sources, causing them to discount or mistrust the content (Hanus 2017). Providing unbiased information to educate customers to make the efficient choice overcomes this skepticism. Effective materials should come from sources that the customer trusts, providing useful information about the economic decision at hand, and information about the non-energy benefits of the selected equipment.

2. Curate Choices

Too many choices can be overwhelming for customers and de-motivating (Sullivan 2017; Sullivan et al. 2012). Commercial kitchen and laundry equipment retailers can overcome this obstacle by presenting customers with a limited number models that are program-eligible, to constrain the variety of options. Curated lists of equipment could focus on the most popular energy efficient models or identify the most popular energy efficient models for each type of commercial kitchen (i.e. fast food or upscale restaurant for example) or some other means of classification that resonates with customers. An ideal first step would be to test a few approaches to see what resonates with customers themselves.

3. Optimize In-store Signage and Positioning
Program managers should work with retailers to locate efficient products in prime locations near the front of the store, and create eye-catching signage to draw in customers to the target products. This technique has been proven to be successful in LED lighting retail (Sullivan 2017), and can be extrapolated to other energy efficient products sold in retail settings, including kitchen and laundry equipment. Signage can be improved using numerous behavioral economics insights. For example, given that research has shown that people tend to be more focused on losses than gains, energy information should be framed as preventing a loss rather than incurring a gain. In the case of kitchen equipment, signage and materials might compare each appliance to the best-in-class appliance (Houde and Todd 2010). The materials for a given appliance could say "This appliance is 5 times *less* efficient that the best in class." Or "If your oven hood is more than 5 years old, you're probably losing $xx each year by delaying its replacement." Other strategies might include the strategic use of social norms in signage or testimonials from respected individuals or organizations associated with the field of business. (Houde and Todd 2010)

Commercial HVAC and Kitchens Programs

Program Challenge: How can we leverage findings from behavioral sciences research to improve sales strategies and contractor/vendor incorporation of PSE's program as a core part of their sales process, particularly for kitchens and commercial HVAC equipment?

Context: Business customers seldom seek to replace existing HVAC equipment with new equipment except in those instances when a piece of equipment fails, or when a business owner is remodeling the commercial space. Traditional energy efficiency programs have tried to overcome this pattern of behavior primarily through efforts to increase customer education and information about the benefits of more efficient equipment. However, a variety of different insights from the social sciences suggest that information and education-based approaches may not be the most effective method. Program managers are likely to find value in the following behavioral science strategies that have proven more effective in changing behavior and driving investments.

1. Focus on Making the Investment Decision Easy, not Changing Attitudes

It is important to acknowledge that while customer attitudes and awareness are important when addressing those behaviors that are relatively easy to take (like turning up a thermostat), they tend to be less important for investment-related decisions. Notably, efforts to shape investment behaviors tend to benefit more from changing the investment context. This insight comes from Sullivan et. al. (2012) who explain that humans consistently underestimate the power of the environment and the situation in explaining behavior, attributing behavior instead to individuals and their personalities. This "fundamental attribution error" is part of the reason why traditional utility programs frequently focus on raising customer awareness or on changing customers' attitudes about energy efficiency when trying to change investment decisions.

Strategies for developing more effective approaches should focus on making programs less complex and more "usable". One way to do so is to acknowledge that the mere fact of ownership often makes it painful for customers to part with items that they've already paid for, even if that item is inefficient and it makes financial sense to replace it with something better. This phenomenon is known as the "endowment effect". One way of overcoming this psychological disadvantage is to acknowledge the old device in program marketing and state that even including sunk costs, a customer is losing money by not upgrading to the efficient option. A related alternative is to develop a "cash for clunkers" type of program incentive approach that acknowledges the value of existing equipment and uses that toward the purchase of new equipment. This type of approach could be further complemented through the application of the scarcity principle by making it a limited time offer or a limited number of program participants.

2. Avoid "Crowding Out" (Recognize Non-Energy Benefits)

Another important insight for efficiency investments is that purchase decisions are often based on a wide range of perceived benefits including a variety of non-energy benefits that are often of equal or greater value to customers than the financial benefit. Importantly, research has shown that an exclusive focus on monetary benefits often leads people to decide against a purchase even when they would have otherwise made the purchase due to their interest in the non-energy benefits the product has to offer. This phenomenon, known as "crowding out", occurs because the focus on monetary benefits diminishes the relevance of non-monetary benefits in customers' minds.

To address this phenomenon, program staff should take the time to identify all the non-energy benefits that customers associate with various products and be sure that program materials highlight these equally with the energy and cost benefits of the program. Highlighting the non-energy benefits of participation can validate the importance of the other benefits in customers' minds. Given that energy savings alone may not be enough to motivate customers to choose energy efficient technology, a good strategy would be sure to also highlight Improvements in comfort and, air quality, reduced noise, or avoided costs from emergency repairs or replacements may be key in swaying decision-making (Emerging Products 2015).

3. Maximize Interpersonal Communication Strategies and Trusted Information Sources
HVAC technology is complex and distant from daily operations in a commercial setting, often literally situated in a hard to access location – the roof. While the output delivered from these units – heating and cooling – is tangible, the energy savings are not (Emerging Products 2015). It is hard to "see" savings, and this obstacle can be difficult to overcome for energy efficiency skeptics. To overcome this transparency problem, contractors can provide an informal source of information in that they can share the experience of one customer with another. Businesses can also share their results with one another, to help quantify actual savings results (Emerging Products 2015).

Face-to-face, interpersonal interactions with people like friends, block leaders, or representatives of community-based organizations tend to be very effective in increasing uptake in commercial energy efficiency programs. One such example, as described in Sullivan et. al. (2012), is the Hood River weatherization project, led by NRDC and the Pacific Northwest's electricity suppliers. Initial enrollment in the program was 20%, but when the program switched to using residents to conduct outreach and speak to their own experiences with the program, enrollment increased to 85% in two years and 95% by the end of the project.

Small Business Direct Install Program

Program Challenge: How can we apply behavioral science insights relating to the perspectives of small businesses and effective approaches to developing ongoing customer relationships, in order to maximize small business customer engagement in programs?

Context: Small business decision makers are often considered difficult to reach. While they value their role in the community and often are motivated to save energy, their primary concern is often focused on the financial return (generally associated with reduced operating costs) given the tight margins faced by most small businesses. It is essential to reach this community on their terms, respecting the lack of specialized knowledge concerning energy, competing demands for their time, and the limited attention they have for energy-related issues. Social science and industry research both suggest that personalized and targeted strategies are essential for engaging with small businesses. Small businesses are also generally very rooted in the communities within which they operate. These strong ties to community highlight the importance of face-to-face communications strategies, the necessary reliance on trusted messengers, and the value of strategies that draw on social accountability. These ideas are explored below.

1. Personalize Communications and Target Messaging

Small business owners and decision makers have numerous competing demands on their time and attention. From a small business perspective, generic materials are seen as having little relevance for the specialized business environments within which small businesses operate and are unlikely to hold their attention (Dethman et al. 2016). Conversely, small business decision makers are far more likely to spend time reviewing targeted or customized reports or materials that recognize the specific set of constraints and challenges associated with narrowly defined business types or that are customized to a particular business (Cornish 2015). Using both personalized and targeted messaging enhances the perceived relevance of materials from the perspective of small business owners. Market segmentation plays an important role in effectively determining relevant business segments and their characteristics, concerns, and challenges and using that information to develop targeted outreach and engagement strategies. Segmentation research may include vertical segmentation research, geographic and demographic segmentation, and micro-targeting (Van de Grift, Dougherty, and Marquis 2014).

2. Rely on Reciprocity, Prompts and Loss Aversion Strategies

Social and behavior science offers numerous insights for successfully engaging with commercial customers by enhancing customers' willingness to participate, helping them remember when and how to take action, and motivating action. For example, efforts to enhance customer engagement and participation have been shown to benefit from the implementation of strategies that address the reciprocity principle. Simply stated, reciprocity triggers customers' motivation to return a favor by providing an upfront gift or favor. In a recent study, customers were provided with Business Energy Reports as a free gift and later asked to sign up for a program. Those who were offered the reports were twice as likely to participate in the program. Prompts have also been shown to be effective.

Prompts can take many forms, but these reminders have been shown to be an effective means of encouraging behavior change over time (Neff and Fry 2009). A recent study comparing the savings and satisfaction of energy reports to a prominent display communicating current usage information to all staff found that the display generated more satisfaction, engagement and savings. The display offered a constant awareness of energy use that engaged all staff, as opposed to a report that may go to one person and be viewed only upon receipt. (Ashby et al, 2015) Recent research indicated that businesses who received reminders were twice as likely to sign up (Dethman et al. 2016).

Finally, people tend to be much more motivated to avoid loses than they are by the possibility of a similar gain (Kahneman 2011). When given a choice between surgery and radiation therapy, describing surgical outcome statistics as a 90% survival rate led more people to choose surgeries than when the survival rate was described as a 10% mortality rate (McNeil et al. 1982). Rather than focusing on potential savings, this principle suggests that programs carefully frame their messaging to highlight lost opportunities. For example, messaging for an LED program might say "are you wasting hundreds of dollars a year on lighting – this bulb could cut your losses by 75%... rather than "These new bulbs will save you $20 per month."

3. **Integrate Interpersonal Interventions, Sweepstakes, and Communal Feedback**

Interpersonal interventions that use face-to-face contact are particularly important when working with small businesses. Through the use of face-to-face contact small business owners can feel confident that their particular concerns and constraints are being taken into account, creating the sense that the program is catering to their specific needs. These types of interactions also provide an important direct learning experience (Sullivan et al. 2012). In fact, in one recent study, researchers found that "SMBs that were visited or called were 17 times more likely to sign up for the program than those in a control group (Dethman et al. 2016).

Engagement with small businesses may also benefit from the use of sweepstakes or lotteries that encourage some form of enrollment or participation in exchange for entry into a lottery or sweepstakes with an enticing prize. Sweepstakes have been shown to be a highly effective source of motivation because people tend to overestimate their odds of winning. The implication is that while providing a small rebate or promise of some energy savings might be enough to get a small fraction of customers to take action, programs that offer sweepstakes typically garner higher levels of participation because they are able to tap into the *possibility effect…* the opportunity to win a large prize (Kahneman 2011).

Finally, programs that are focused on changing the energy conservation efforts of businesses and their employees have been shown to benefit from communal feedback. There is an extensive literature on the importance of providing behavioral feedback in successfully changing behaviors. In their book *Nudge*, Thaler and Sunstein point to experience, good information, and prompt feedback as key factors that enable people to make good decisions (Samson 2014). Efforts to reduce energy consumption have experimented with a variety of feedback mechanisms including Opower's monthly energy reports as well as in-home displays and online sources of feedback.

One program that successfully combined the use of energy feedback technologies with social science insights is the PG&E Han pilot. This pilot provided customers with either the Bidgely gateway or an Aztech in-home display; two different forms of energy use feedback. Importantly, the Bidgely approach pushes relevant use and cost data to the customer's phone, tablet or computer via an app or web portal. The Aztech device displays customers' electricity usage and related costs on the display itself. Notably, while most Bidgely users indicated looking at the information about once per week, nearly half of the Aztech users reported looking at it more than *once per day*. Aztech users also reported having taken more electricity reducing actions (Ashby et al. 2015). These results suggest that allowing ready access to energy-related feedback across workers and in a place where it is readily viewable, may play an important role in turning real-time energy feedback into an effective engagement strategy and one that results in savings.

4. **Make it Social: Social Accountability, Challenges and Competitions**

Small businesses have a prominent role in their communities, and they greatly value recognition within that community. In general, small businesses have a heightened sense of place and acknowledge that their connection to the community is important to the success of their business. Programs can tap into this sense of social accountability that is strongly held by businesses through the use challenges and competitions that bring recognition to participating businesses. Such strategies are particularly effective when the choice to participate and the level of participation result in benefits for the entire community (not just the business) because community rewards tend to increase the effort of participants (Fehr and Falk 2002). Moreover, by shifting the focus away from individual monetary gains and tapping into other benefits (such as social esteem), programs avoid an undue (and even sometimes exclusive) focus on individual monetary gain that has been shown to "crowd out" a consideration of non-monetary reasons to participate. In other words, programs that tend to focus exclusively on individual monetary benefits generally fail to engage a broad set of would-be participants and may discourage participation among some.

Challenges and competitions can be particularly effective in driving participation and energy efficient actions, particularly when the competition is backed with personal engagement strategies to educate and assist the businesses. A wide range of behavior change strategies can be integrated into competitions including many of those discussed elsewhere in this paper such as the use of comparative feedback (to gauge success), prompts, commitments, goal setting, scarcity, reciprocity, loss aversion, etc. According to Vine and Jones (2015), intra-community competitions are often more effective if competitors are natural rivals.

Agriculture Direct Install Program

Program Challenge: Leveraging social sciences research findings to better understand how to optimize outreach efforts and program marketing approaches in rural areas with less dense social networks relative to cities, particularly with respect to engaging small farmers.

Context: Engaging with rural households and small farmers can present a variety of unique challenges. Approaches that are successful in urban communities may not work in rural communities. (That said, it is also important to recognize that rural communities are not homogeneous.) Tapping into existing networks, forming partnerships, and establishing trust are particularly important in rural communities. Working together is a way of life in most rural areas and doing so is seen in favorable terms. In that sense, partnering with known entities is both practical and culturally appropriate. While trusted sources play a big role in engaging with rural communities, a variety of other strategies have also been recognized for their effectiveness. These include: maximizing inter-personal communications strategies and appropriate media outlets, tapping into community status and social accountability, getting commitments, and curating choices.

1. Use Interpersonal Communications Strategies, Trusted Sources & Appropriate Media Outlets

Small farmers have many similarities to small business owners and many of the same recommendations apply to both. Primary among these is the importance of interpersonal communications strategies, the need to actively reach out to engage with small farmers, and the importance of trusted sources of information (Metz 2015). Like small businesses, small farmers don't have the luxury of taking the time to develop a deep understanding of energy efficiency. Instead, these actors rely on the insights of trusted messengers and the experiences of other people who they consider to be like them. In terms of small farmers, key stakeholder groups often include equipment manufacturers, equipment dealers, and the extended agricultural community such as agricultural extension offices, and federal agricultural programs (Metz 2015). Several marketing and outreach approaches have been shown to be effective, particularly phone calls or site-visits and advertisements or programs local radio stations (Metz 2017), but also direct mail and leveraged opportunities through the extended agricultural community (including participation in agricultural events and farm shows, and advertisements in the agricultural press) (Metz 2017). Testimonials from respected community members or farm owners of similar farm types are also of great value.

2. Make it Social: Community Status, Social Accountability, and Community Challenges

Given that rural communities are often more reliant on local social networks than their urban counterparts, it isn't surprising that rural families are generally more concerned with their status within their local community and perhaps more motivated by opportunities to enhance their local status. Programs can tap into this sense of social accountability using challenges and competitions that result in rewards or benefits for the community as a whole. Such strategies are particularly effective when the choice to participate and the level of participation result in benefits for the entire community because community rewards tend to increase the effort of participants (Fehr and Falk 2002). In general, "competitions "build on the growing evidence of the power of social influence… in promoting cooperative behavior" (Vine and Jones 2015:3). Importantly, competitions are "typically conducted in a social, publicly visible setting where group dynamics are important and where goals are set, commitments are made, information and feedback are provided, and prompts are used to keep participants informed and to make it easy for them to participate." (Vine and Jones 2015:3).

3. Consistency and Public Commitment

Asking participants to take a small action or make a commitment to take an action taps into their self-perception and is the most important factor in determining why commitments work. In short, when people make a commitment to do something, they are altering the way they perceive themselves (Burger 1999) and creating a sense of obligation to others. Once a commitment has been made, people are more likely to follow through with an action, especially when making a public commitment (McKenzie-Mohr 2011). Programs that use public pledges are effective in activating social norms because people want to live up to others' expectations and follow through on their commitments (Fuller et al. 2010). This is particularly effective in tight-knit communities.

Commitments can take a variety of forms and range from asking people to take a pledge or to take a small action. Asking people to make a commitment to take an action in the (near) future provides a mechanism for helping them overcome procrastination (Houde 2010) and people are generally more willing to make a commitment to a future activity because present events are weighted more heavily than future ones (Sampson 2014). This strategy could be integrated into a rural community program by asking people to sign up for more information or an energy audit while at an agricultural event. A commitment can also take the form of having people engage in one simple action like putting a sticker in their window or a sign in their yard and then acknowledging some of the other energy efficiency behaviors that they are already engaging in. Doing so activates people's sense of themselves as being concerned with efficiency.

4. Curate Choices and Avoid Crowding Out

Program participation can often be enhanced by limiting the number of options presented to would-be participants and by acknowledging (and sometimes highlighting) the nonenergy benefits of participation. As noted earlier, providing people with too many choices often results in paralysis and a lack of action. One customer research study showed that shoppers bought much more jam when presented with only 6 jam varieties as opposed to 24 jam varieties (Iyengar and Lepper 2000). Faced with similar decisions concerning energy efficiency products or actions, having too many decisions means would-be program participants must spend considerable amounts of time evaluating options. Program managers can overcome this problem by curating a limited set of efficiency choices.

Emphasizing the non-energy benefits of participation plays an important role in acknowledging the diverse interests that motivate people to take action. Sometimes the economic benefits alone don't provide sufficient motivation because the payback period may be too long or the upfront costs too high. However, when the benefits include a reduction in work load, more control over work, better product performance, greater reliability or performance, or making an investment for the community or future generations, people are often more willing to move forward with an action that may not otherwise be a priority. In addition, highlighting quality-of-life benefits and social benefits allows people to feel good about their decision and the benefits that it will afford for themselves and others. Research has shown that an exclusive focus on economic benefits often "crowds out" peoples' tendency to focus on the other benefits that are equally if not more important in their decision-making process. In other words, an exclusive focus on economic benefits could result in lower participation rates.

Best Practices

Methodology and Goals

PSE invested in best practices research as a key component of its process evaluation during the PY2014-2015 biennium. Taking this into account, our team structured the approach to this research so as not to cover the same ground, and to, instead, identify and leverage new and novel findings in the best practices research directly applicable to key problems and challenges identified during program manager and implementer in-depth interviews.

The goal of this research is to provide actionable recommendations for improving program delivery based on the experiences of peer utilities and other industry actors. The following describes key research questions and areas of inquiry considered through our Best Practices research:

Best Practices Key Areas of Inquiry	Effective ways to strengthen existing trade ally relationships and networks, and how to leverage these networks most effectively.
	Effective practices to reach, engage, and build trust with agricultural communities and their trade ally networks to increase agricultural energy efficiency program participation.
	Methods for leveraging geospatial data analytics such as GIS (geographic information systems) mapping and customer segmentation research to engage "hard to reach" populations and increase participation by small businesses and laundry, kitchen, and lodging facilities.

These topics are narrow, and—in the case of the geospatial analysis topic—existing on the very cutting edge of the energy efficiency world, so the available literature is relatively limited. The research team focused on identifying publicly available papers and evaluation reports on programs which are like those implemented by PSE, with an emphasis on publications from within the past two years. Subsequently, we reviewed trade ally survey results and interview notes from a variety of recent internal projects conducted for clients in other jurisdictions. We then extended our research to include conversations and interviews with internal and external sources and subject matter experts.

- ACEEE Summer Study on Energy Efficiency in Buildings
- Behavior, Energy, and Climate Change Conference (BECC)
- International Energy Program Evaluation Conference (IEPEC)
- Navigant reports and projects for clients in other jurisdictions
- Agricultural market research studies
- Interviews with subject matter experts
    - BPA trade ally network manger
    - GIS experts and practitioners

Premium HVAC Service Program

<u>Program Challenge:</u> How can we strengthen existing trade ally relationships and networks, and how can we leverage these networks most effectively?

Context: Many of PSE's Commercial Rebate sub-programs, such as Commercial HVAC, Commercial Kitchens and Premium HVAC Service, are largely driven by trade allies such as vendors and contractors. Program performance, in terms of participation and other KPIs, improves when trade allies are engaged and active in the program. There are many reasons why trade ally networks, or individual trade allies, may become disengaged over time. Through in-depth interviews with the program managers and implementation contractors, we found this has been a barrier to ramping up participation in the Premium HVAC Service program this biennium, and to a lesser extent, the Commercial HVAC program. Interviews with trade allies also indicated some felt the CAN was not optimally helpful as a resource and not optimized to connect trade allies with customers and with the programs. Navigant reviewed the literature on trade ally networks and barriers faced by trade allies and interviewed several commercial energy efficiency program managers on how they interact with trade allies. These findings are discussed below.

1. Develop Trade Ally Networks Creatively

Missed opportunities arise when narrowly defining a trade ally network (TAN) as just the utility and its participating contractors. Look to partner with other organizations, such as industry associations, manufacturers, distributors, or trade cooperatives, and leverage or co-sponsor their trainings, content, and events to bring greater value to the utility's trade allies and expands the utility's reach to trade allies they may not have yet engaged in their programs. Bonneville Power Administration's Air Northwest Network takes this approach by publicizing and/or co-sponsoring events sponsored by many different organizations, as well as cross-promoting events and workshops sponsored by their sister TAN (the Northwest Lighting Network).[14]

2. Understand Trade Ally Barriers

Trade allies—particularly smaller trade allies—can experience many challenges in their work, including trouble getting in front of the financial decisionmaker, project seasonality, and inexperience with energy efficiency projects. [15] Conducting an annual trade ally survey will help the utility understand the unique challenges its trade allies face and will guide the development of collateral marketing materials, program logistics, and trade ally trainings. For example, trade allies who serve a variety of small business types have a need for segment-specific marketing materials, not generalized program collateral; this type of collateral may feature multiple programs which could all serve a specific market segment. Those trade allies whose sale cycles don't align with the program year can better overcome this challenge when given more advanced notice of changes in program offerings. Also, trade ally service territories frequently don't align with utility service territory lines, which can be confusing; trade allies working near the boundaries of a utility service territory may benefit from a cheat sheet with a map of where the utility service territory ends (and possibly information on neighboring utilities' energy efficiency rebates as well).

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[14] A quick review of their events calendar shows the variety of organizations sponsoring events: https://www.airnorthwesthvac.com/training-and-events.html. The importance of engaging a wide variety of stakeholders and industry players is also emphasized in this excellent summary of the Northwest Lighting Network: http://evergreen-efficiency.com/wp-content/uploads/2017/03/ACEEE-Leveraging-a-Regional-Trade-Ally-Network.....pdf.

[15] DNV-GL is conducting an annual, national survey of trade allies working with utility energy efficiency programs. A helpful summary of their 2017 research is available here: https://www.iowaenergy.org/documents/resources/SkinnerASession1Coburn_24D39D6F9FA37.pdf. A summary of results specific to small trade allies from the 2016 survey is available here: https://beccconference.org/wp-content/uploads/2016/10/Maoz_presentation.pdf.

3. Provide Trade Allies Customer Touchpoints and the Skillsets to Capitalize on them

New pilot programs, special offers, new technology announcements, or any sort of program novelty give trade allies a reason to reach out to customers and have that touchpoint to engage them in a discussion about energy efficiency. Those touchpoints are even more valuable if trade allies are offered trainings on enhanced sales and customer service skills as well as technical education on the more complex energy efficiency measures; a 2017 DNV-GL survey reveals that trade allies are actively looking to their utilities to provide that type of education. Trade allies can enhance their businesses and customer relationships by learning how to sell solutions rather than widgets and get their customers thinking in terms of lifecycle costs. In particular, trade allies could greatly benefit from learning how to tailor their energy efficiency pitches to the specific needs of different types of small businesses. Energy Upgrade California developed an excellent small business decision-maker segmentation study with suggested messaging that would resonate with each segment, which could form the basis of a marketing training for trade allies.[16]

4. Mutually Beneficial Activities

A trade ally network shouldn't be a one-way communication channel from the utility to the trade allies. Experiences that benefit both the utility and the trade ally are key to developing strong, lasting trade ally relationships. Examples of these types of activities include:

- Participating in joint sales calls that give trade allies the opportunity to learn how to effectively promote the program and enable the utility to observe customers' reactions to the program and better understand barriers faced by customers. These joint sales calls can involve utility account managers (for bigger customers) as well as program staff.
- Collaborating on end-use customer market research that gives trade allies better insight into their customers' needs while allowing the utility to leverage trade allies' boots-on-the-ground insight. For instance, trade allies may greatly benefit from a webinar summarizing the results of the participant surveys often conducted as part of program evaluations, or from being invited to observe a focus group with potential customers. Creating a feedback loop in which trade allies can then share how that utility-sponsored research resonated with their experiences in the market could open up a mutually beneficial dialogue on how to move the program forward.
- Providing trade allies with educational and marketing materials that simultaneously help trade allies sell energy efficiency to their clients while increasing the trade allies' ability to complete projects through the program. The BPA trade ally networks both have comprehensive, polished trade ally "field guides" that include both technical information that the trade ally can show to customers as well as practical information on the utility program's requirements and processes.[17]

Agriculture Direct Install

<u>Program Challenge:</u> What are effective practices to reach, engage, and build trust with agricultural communities and their trade ally networks to increase agricultural energy efficiency program participation?

<u>Context:</u> Agricultural customers can be challenging to recruit to energy efficiency programs as they are often difficult to locate, have limited time, have varied and unique needs, and may not prioritize energy efficiency. Customers range from produce growers to dairy farmers to greenhouse operations, and each

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[16] The segmentation study is located here: http://beccconference.org/wp-content/uploads/2015/10/presentation_wellner.pdf.

[17] See the HVAC guide here: https://www.airnorthwesthvac.com/AN_Field-Guide_2017.compressed.pdf and the lighting guide here: https://nwlightingnetwork.com/app/uploads/2017/03/2017-Trade-Ally-Field-Guide_sm.pdf.

presents their own opportunities and challenges. However, programs can be designed to cater to these characteristics by implementing best practices. Peer utilities and similar programs in regions where agriculture is prevalent face similar challenges and have developed many best practices around reaching and engaging rural communities and small farming business customers. Some of these findings are explored below.

1. Tap into the Existing Agricultural Community to Educate, Build Awareness, and Gain Trust[18]

One of the main reasons utilities see slow uptake of energy efficiency programs in agricultural communities is that the utility is often perceived as an outside entity that is not to be trusted. Therefore, it is imperative that the utility treats farmers as *farmers*, and not as just another utility customer. The agricultural community is typically tightly-knit and relies on personal relationships and word of mouth to spread new ideas and opportunities, and that has several implications for outreach and marketing of an agricultural direct install program. First, utilities should leverage the reputation and influence of existing community actors, such as the local Farm Bureau chapter, trade organizations, and university ag programs and demonstration farms to build awareness through newsletters[19], outreach events, technology classes, or pilot programs. Second, there should be a focus on local resources—staffing local program offices and relying on the local trade allies who have already developed a good reputation within the community will see much greater success than program staff or TAs based out of a large, central headquarters.

2. "Streamlined Approach" to Program-level Structural Organization[20]

A common pitfall in small direct install programs is that they rely too much on customers investing their valuable time navigating the program. This barrier can be overcome by creating a team of energy advisors that will serve as a single point of contact for the customer as they move through the program. Key to this approach is an organizational structure that is flat, highly responsive, and can engage with customers and vendors, as well as provide engineering, EM&V, and administrative support. Simplifying the process in the eyes of the customer and minimizing the number of hoops a customer must jump through should be the focus of the program and thus the energy advisors should be equipped to handle all parts of the process, from the initial energy audit, to project QA/QC, and even assistance with financing opportunities.

3. Appropriate On-site Energy Audits

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[18] ACEEE 2015 National Symposium on Market Transformation: *Agricultural Energy Efficiency* http://aceee.org/sites/default/files/pdf/conferences/mt/2015/C3-Metz.pdf

[19] The Utah Office of Energy Development has a slide deck summarizing the various partnership-based outreach strategies they employ to promote agricultural energy efficiency: http://energy.utah.gov/download/Agricultural%20Energy%20Efficiency%20Publications%20(2)/Agricultural%20Energy%20Efficiency%20Publications%20/Draft%20EE%20Con%20Plan%20AgEE%20UDAF%20Advisory%20Board.pptx. Slide 16 has a good example of a concise, attention-grabbing piece of marketing collateral that makes it easy for customers to understand whether they can benefit from a program and how to take the first step toward participation.

[20] *A Streamlined Solution for Hard to Reach Small Industrial and Agricultural Markets* http://aceee.org/files/proceedings/2017/data/polopoly_fs/1.3687913.1501159091!/fileserver/file/790282/filename/0036_0053_000020.pdf

Testimonial of the streamlined process can be found in an interview with the Colorado Ag Today program manager: http://www.aginfo.net/index.cfm/report/id/Search-31553.

Several studies tout the benefits of low-cost, standardized energy audits as a way to identify energy efficiency opportunities for small and medium-sized agricultural businesses. However, there are several best practices to keep in mind to ensure the audit is both high quality and time efficient. First, the auditor should come prepared with up-to-date knowledge of typical agricultural efficiency best practices as different types and sizes of agricultural businesses present different efficiency opportunities.[21] Second, the customer and appropriate staff should be met on-site to collect all the relevant data during the initial walkthrough and reduce the need for a second visit or follow-up. Third, the auditor should be equipped with the tools, knowledge, and preparation to share preliminary results while on-site and offer comparisons, present interactive reports, and allow time for questions and answers with the customer. These audit best practices are keeping in line with the streamlined approach and strive to maximize the value to the customer while minimizing their time commitment.

Laundry, Agriculture and SBDI Programs

Program Challenge: What are effective practices to leverage geospatial data analytics such as GIS (geographic information systems) mapping and customer segmentation research to engage "hard to reach" populations?

Context: The use of advanced analytics in energy efficiency is by definition an emerging practice, and our research revealed that some of the most innovative projects in the industry are using proprietary techniques which are not presented in public forums. The amount of publicly available information is limited, but suggests that geospatial analysis and other advanced analytic techniques can be used to enhance program staff's understanding of participation drivers, improve marketing cost-effectiveness, empower trade allies, and improve program planning. That said, these recommendations may be better classified as "leading edge practices" than "best practices" at this point in time. Navigant reviewed the secondary literature and interviewed internal experts in geospatial data analytics to investigate this area of inquiry. The most salient findings are presented below.

1. Collaboration Between Geospatial Researchers and Program Staff

Geospatial analysis to increase program participation exists somewhere in the space between program evaluation and potential studies. Many of the analytical approaches used will be familiar to evaluators, but make use of datasets more commonly used in potential studies (e.g., Census data). Most of the examples of GIS analytics identified in this literature review began with an analysis of program participation to date (involving elements of typical impact and process evaluations), moved into a comparison of areas of high participation to remaining areas of untapped potential (potential studies), and ended with the development of targeted outreach strategies for those underperforming areas (involving elements of process evaluation or program redesign).[22] Facilitating greater interaction between those performing program evaluation and those performing potential studies could avoid redundant analyses and leverage datasets that benefit both types of analyses. Process evaluations can greatly enhance the actionability of their recommendations for program marketing and outreach strategies by placing them in the context of where the program's greatest remaining potential lies. Potential studies can benefit significantly from the type of customer survey data collected by process evaluators; similarly, incorporating process evaluators'

[21] A holistic guide to agricultural energy efficiency best practices: https://www.focusonenergy.com/sites/default/files/Agriculture-Best-Practices_2016_web.pdf

[22] Navigant presented at Distributech 2017 on a project conducted for Duquesne Light which describes a typical geotargeting project following this pattern. The presentation is not available online but Navigant will provide it to PSE in PDF format.

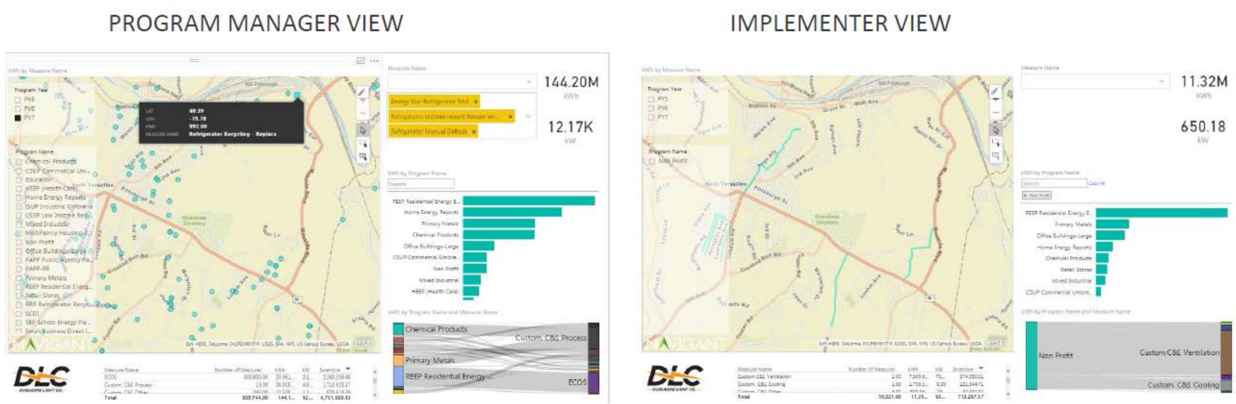
understanding of customer segmentation and propensity to participate in programs into potential study estimates of achievable potential will improve the accuracy of those estimates.

2. Multiple Data Sources to Develop Meaningful Customer Segmentation Schemes

The most useful customer segmentation schemes consider past program participation data, evaluation results, utility customer data, and secondary sources such as the Census and Dunn and Bradstreet business data to develop a thorough understanding of the composition of each segment, their energy savings potential, the barriers they face, and how to reach them.[23]

3.Tools that Implementers and Trade Allies can use in Real Time, in the Field

Direct install programs could greatly benefit from web-based GIS mapping solutions that allow their contractors to make decisions about where to target their direct outreach, including the ability to adapt their plans based on unexpected traffic problems or delays. Navigant developed such a tool for a direct install low income residential program based on information known about past participants' income (based on the assumption that low income customers tend to have low income neighbors). The following screenshot shows the program manager view of the map tool (with dots for individual past participants) and the implementer view (in which the location of past participants is obscured for privacy, but streets that are deemed to have a high potential for additional savings are highlighted).



Locations for Illustration only

Similarly, trade allies could benefit from a web-based tool that provides segment-specific insights on effective messaging—as well as technical information—to help them sell efficiency to some of the specialized small business segments that face unique barriers.

[23] Opinion Dynamics conducted a comprehensive small business segmentation study in Long Island, using both advanced statistical techniques and GIS mapping: http://aceee.org/files/proceedings/2016/data/papers/4_727.pdf

Table 2. Behavior Optimization Research Findings Matrix

	Behavior Science Strategy	Description	Strategy Mechanism	Commercial Kitchen and Laundry	Commercial HVAC	Small Business	Agriculture and Rural Populations	References
1	Maximize interpersonal communication strategies and trusted information sources	Small business customers and people from small towns are more likely to rely on established networks to gather reliable information. Efforts to reach out to these groups should tap into existing networks and trusted messengers. In rural communities, educating trade allies has proven valuable and helps ensure that would-be-participants are getting the message from multiple, trusted sources. Similarly, word-of-mouth contacts among participants and nonparticipants should be encouraged. Marketing materials should include endorsements and recommendations by these trusted messengers.	Messenger	x	x	x	x	Sullivan, Dylan; Armel, Carrie; and Annika Todd. 2012. "When "Not Losing" is Better than Winning:" Using Behavioral Science to Drive Customer Investment in Energy Efficiency." ACEEE Summer Study on Energy Efficiency in Buildings. Emerging Products, Customer Service, Southern California Edison. 2015. Market Barriers to Widespread Diffusion of Climate-Appropriate HVAC Retrofit Technologies. Achilles, Stephen. 2014. "Building Trust in the Marketplace: How the Northwest's Most Successful Commercial Program Succeeded." ACEEE Summer Study for Energy Efficiency in Buildings.
2	Tap into community status	Community image and status matter more in small communities where people know each other. Use social accountability principles to encourage participation. Create a community benefit for participation. Small business also often feels part of the neighborhood or community within which the business is located.	Message Framing			x	x	Fehr and Falk Vine, Edward and Jones, Christopher, Univ. of California, Berkeley, May 2015. A Review of Energy Reduction Competitions. What Have We Learned?
3	Get a commitment	Ask people to take a small action that shows support for the program and then increase from there. Or ask for a future commitment since people tend to discount the future investments of time and/or money. Conversely, encourage the most impactful measures on a business' savings to bring customers on board.	Motivation/ Program Design/ Message			x	x	McKenzie-Mohr, Doug, and William Smith. 2011. "Fostering Sustainable Behavior: An Introduction to Community-based Social Marketing."
4	Establish a lottery approach to engagement	Because people tend to overestimate small chances of winning, lotteries and sweepstakes are well suited to encourage	Motivation/ Program			x	x	Sullivan, Dylan; Armel, Carrie; and Annika Todd. 2012. "When "Not Losing" is Better than Winning:" Using Behavioral Science

	Behavior Science Strategy	Description	Strategy Mechanism	Commercial Kitchen and Laundry	Commercial HVAC	Small Business	Agriculture and Rural Populations	References
		people to engage in a particular program. Prospect theory tells us that people believe their chance of winning is higher than it actually is.	Design/ Message					to Drive Customer Investment in Energy Efficiency." ACEEE Summer Study on Energy Efficiency in Buildings
5	Set a personal/community goal, challenge, or competition	Help customers set a goal (potentially rooted in some type of social norm or benchmark) and then provide people with targeted and limited choices that provide a holistic approach/solution. Or establish a community goal as part of a community challenge with a deadline to avoid procrastination.	Motivation/ Program Design/ Message	x	x	x	x	Vine, Edward and Jones, Christopher, Univ. of California, Berkeley, May 2015. A Review of Energy Reduction Competitions. What Have We Learned?
6	Avoid crowding out / recognize non-energy benefits	Highlight secondary benefits of participation so the focus isn't strictly on the cost savings. (In the case of small farmers, other benefits may include making farmers lives simpler, improving crop yield, reducing need for labor, etc.) Related program materials need to be targeted to particular business or farm types and particular technologies. Energy savings alone may not be enough to motivate customers to choose energy efficient technology. Marketing additional benefits, such as increased comfort, improved air quality, reduced noise, or avoided costs from emergency repairs or replacements may be key in swaying decision-making.	Message Framing		x		x	Sullivan, Dylan; Armel, Carrie; and Annika Todd. 2012. "When "Not Losing" is Better than Winning:" Using Behavioral Science to Drive Customer Investment in Energy Efficiency." ACEEE Summer Study on Energy Efficiency in Buildings. Emerging Products, Customer Service, Southern California Edison. 2015. Market Barriers to Widespread Diffusion of Climate-Appropriate HVAC Retrofit Technologies.
7	Leverage reciprocity, prompts, and loss aversion in messaging	Framing problems or opportunities in slightly different ways has been shown to change decisions and actions in significant ways. People tend to discount the future and focus on losses much more than gains. Customers may be much more willing to engage in a program if it will help them stem loses and if they have a continual reminder of their energy use.	Message Framing			x	x	Ashby, Kira, Conley, Kimberly, Jimenez, Lupe, and Steves, Amber. IEPEC, June 2015. Getting Energy Use Down to a (Social) Science: Combining Behavior Insights and Connected Technologies. Houde, Sebastien and Annika Todd. 2010. "List of Behavioral Economics Principles that can Inform Energy Policy." (unpublished) Precourt Energy Efficiency Center.

	Behavior Science Strategy	Description	Strategy Mechanism	Commercial Kitchen and Laundry	Commercial HVAC	Small Business	Agriculture and Rural Populations	References
8	Use reference dependence in messaging	Reference dependence means that people judge their well-being relative to some reference point, which could be what they expect, what they have habitually experienced, or what other people are doing (Kahneman 1979). With energy use, the reference point to which a customer's energy use is compared should thus be to his "efficient neighbors," or a 10% reduction from last year's consumption. People can be primed to accept different numbers as reference points. Retailer-based programs could train sales staff to always show the efficient option first within a product category, and then present the option that costs less but uses more energy.	Message Framing	x				Sullivan, Dylan; Armel, Carrie; and Annika Todd. 2012. "When "Not Losing" is Better than Winning:" Using Behavioral Science to Drive Customer Investment in Energy Efficiency." ACEEE Summer Study on Energy Efficiency in Buildings
9	Curate choices	Too much choice can be de-motivating. Program managers can address this by presenting a limited set of packages rather than a menu of options that can be easily understood in the limited amount of time business owners have for non-essential activities.	Message Framing	x	x	x	x	Sullivan, Dylan; Armel, Carrie; and Annika Todd. 2012. "When "Not Losing" is Better than Winning:" Using Behavioral Science to Drive Customer Investment in Energy Efficiency." ACEEE Summer Study on Energy Efficiency in Buildings.
10	Overcome the Endowment Effect	take advantage of the endowment effect by targeting program efforts at points in time when the endowment effect is suspended, like just after a home is sold, or when a customer is in the market for a new device or create a "cash for clunkers" type of program; also renovation of space or new tenant of leased space.	Program Design/ Message Framing	x	x			Sullivan, Dylan; Armel, Carrie; and Annika Todd. 2012. "When "Not Losing" is Better than Winning:" Using Behavioral Science to Drive Customer Investment in Energy Efficiency." ACEEE Summer Study on Energy Efficiency in Buildings. Houde, Sebastien and Annika Todd. 2010. "List of Behavioral Economics Principles that can Inform Energy Policy." (unpublished) Precourt Energy Efficiency Center.
11	Be aware of seasonality of work	The work and schedules of small farmers and small businesses tend to have seasonal trends with periods of high intensity followed by relative lulls. These	Timing			x	x	Metz, Craig. 2015. "Agricultural Energy Efficiency." Presentation at the National Symposium on Market Transformation.

	Behavior Science Strategy	Description	Strategy Mechanism	Commercial Kitchen and Laundry	Commercial HVAC	Small Business	Agriculture and Rural Populations	References
		seasonal trends mean that customers are likely to be more or less receptive to engagement efforts at particular times of the year. In order to enhance engagement, it is important to be sensitive to the best timing/opportunities to initiate contact.						
12	Be targeted in audience and action	Understanding your audience and important sources of variation in perspectives, knowledge, motivation, barriers, and resources across segments is key to providing information that people can use and are likely to act on. Similarly, encouraging people to save energy is generally too broad of a message to be meaningful. Instead, programs should target particular audiences with a specific "ask" and make it as easy as possible for people to follow through.	Targeting	x	x	x	x	Van de Grift, Sara C.; Dougherty, Anne; and Danielle Marquis. 2014. "Know before you Go: How Up-Front Investments in Market Research and Segmentation Can Improve Outcomes in Small Business Direct Install." ACEEE Summer Study on Energy Efficiency in Buildings.
13	Use appropriate media outlets	Use local radio, phone calls and /or outreach reps, direct mail and (for ag families) leverage opportunities through extended agricultural community, best practices guides, agricultural events and farms shows, coordinate with federal programs, advertise in agricultural press, use testimonials of respected local people in similar farm type	Media				x	Metz, Craig. 2015. "Agricultural Energy Efficiency." Presentation at the National Symposium on Market Transformation.
14	Be conscientious of regional culture and concerns, business culture, etc.	For example, when working with agricultural communities, be aware of different farm types, number of farms, types of technologies that matter or resources used. Being aware of the diversity increases customer confidence that the solution being proposed is salient for their lives/businesses.	Message Framing and Content				x	Metz, Craig. 2015. "Agricultural Energy Efficiency." Presentation at the National Symposium on Market Transformation.
15	Focus on the investment decision, not the person	Context of the purchasing decisions is what matters, more than the person and their individual biases	Message Framing	x	x			Armel, Sullivan, Todd. 2013. When "Not Losing" is Better Than "Winning." ACEEE Summer Study.

	Behavior Science Strategy	Description	Strategy Mechanism	Commercial Kitchen and Laundry	Commercial HVAC	Small Business	Agriculture and Rural Populations	References
16	Provide information on technologies from sources unaffiliated with products	Customers may be skeptical of brand-affiliated information sources, causing them to discount or mistrust the content. Providing unbiased information to educate customers to make the efficient choice overcomes this skepticism.	Message Framing	x	x			Hanus. 2017. Applying decision science methods to identify non-economic factors to energy efficiency investments in the commercial sector. Emerging Technologies Summit.
17	Optimize in-store signage and positioning	Work with retailers to locate efficient products in prime locations, and create eye-catching signage to draw in customers to the target products	Targeting	x				Moore. 2015. Top Ten Best Practices to Engage and Educate Shoppers in Retail. BECC Presentation.
18	Personalize communications and target message	Generic messages addressed to the business will not rise above competing demands on the decision maker's time. SB owners are more likely to review material when it is addressed to them and specific to their business and business type.	Message Framing			x		Cornish, Laura, Eneroc, October 2015. What do businesses really think of energy reports?
19	Recognize variation across business segments; offer competitions within business segment	Competitions within business segments can be beneficial, offering multiple metrics and various "winners." A leader board should be offered, though businesses should be able to keep their data private. The competition should be backed with personal engagement. Business tenants may also join together, competing between office buildings with a reputable organization, such as the Building Owners and Managers Association (BOMA), recruiting participants.	Motivation/ Program Design/ Message			x		Vine, Edward and Jones, Christopher, Univ. of California, Berkeley, May 2015. A Review of Energy Reduction Competitions. What Have We Learned?
20	Providing continuous feedback on energy use that is available to all staff is more impactful	Use of an in-business display that monitors energy use raises the consciousness of all staff and encourages daily behavior changes to improve efficiency	Motivation/ Program Design/ Message			x		Ashby, Kira, Conley, Kimberly, Jimenez, Lupe, and Steves, Amber. IEPEC, June 2015. Getting Energy Use Down to a (Social) Science: Combining Behavior Insights and Connected Technologies

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APPENDIX E. PROCESS EVALUATION INTERIM MEMOS – COMMERCIAL REBATE PROGRAM

E.1 New Construction Process Evaluation - Program Theory & Logic Model Memo

To: Michael Noreika, Jim Perich-Anderson, Thomas Anderson, James Marker, PSE

From: Kerry Meade, Hannah Justus, EMI Consulting

CC: Jes Rivas, Jon Strahl, Navigant

Date: April 19, 2017

Re: New Construction Process Evaluation - Program Theory & Logic Model Memo

The objective of this memorandum is to document and assess the strength of the Puget Sound Energy (PSE) New Construction (NCx) program's theory and logic. The evaluation team will use this information to help frame process evaluation activities for the NCx program. This memorandum begins by first defining program theory and logic models. It then presents the program theory with logic model for PSE's NCx program and concludes by assessing the viability of the program theory and logic.

Introduction to Program Theory and Logic Models

Program designs are based on theoretical assumptions that certain program activities will result in specific desired outcomes. A program logic model depicts the baseline program theory of what the program intends to accomplish. They achieve this by providing a visual depiction of the interrelated activities that combine to produce a variety of outputs, which in turn lead to desired outcomes, such as energy savings or increased customer satisfaction. Logic models are "living" documents and need to be revisited periodically to ensure they continue to represent the program.

Understanding the program theory is essential to ensuring program implementers and program evaluators have a common understanding of the program design and its intended outcomes. Evaluators can use logic models to guide evaluation research and develop key performance indicators. Program implementers can use logic models to better understand the relationship between program activities and their intended outcomes. In the case that program goals are not met, stakeholders can use logic models to help explore reasons why activities and outputs did not lead to desired outcomes.

The evaluation team began the logic modeling process by drafting a rough logic model based on the program descriptions given during the program manager interviews. The evaluation team reviewed this initial draft with the program managers, and made edits to reflect feedback given during this discussion. Following these discussions, the evaluation team defined the program theory represented in the logic model. Both the logic model and program theory are presented in the remainder of this memo. Arrows between items indicate a theoretical causal relationship between them. Dashed arrows indicate indirect desired outcomes from the program. These outcomes are not necessarily explicit goals, or tracked to measure program success.

New Construction Program Theory and Logic

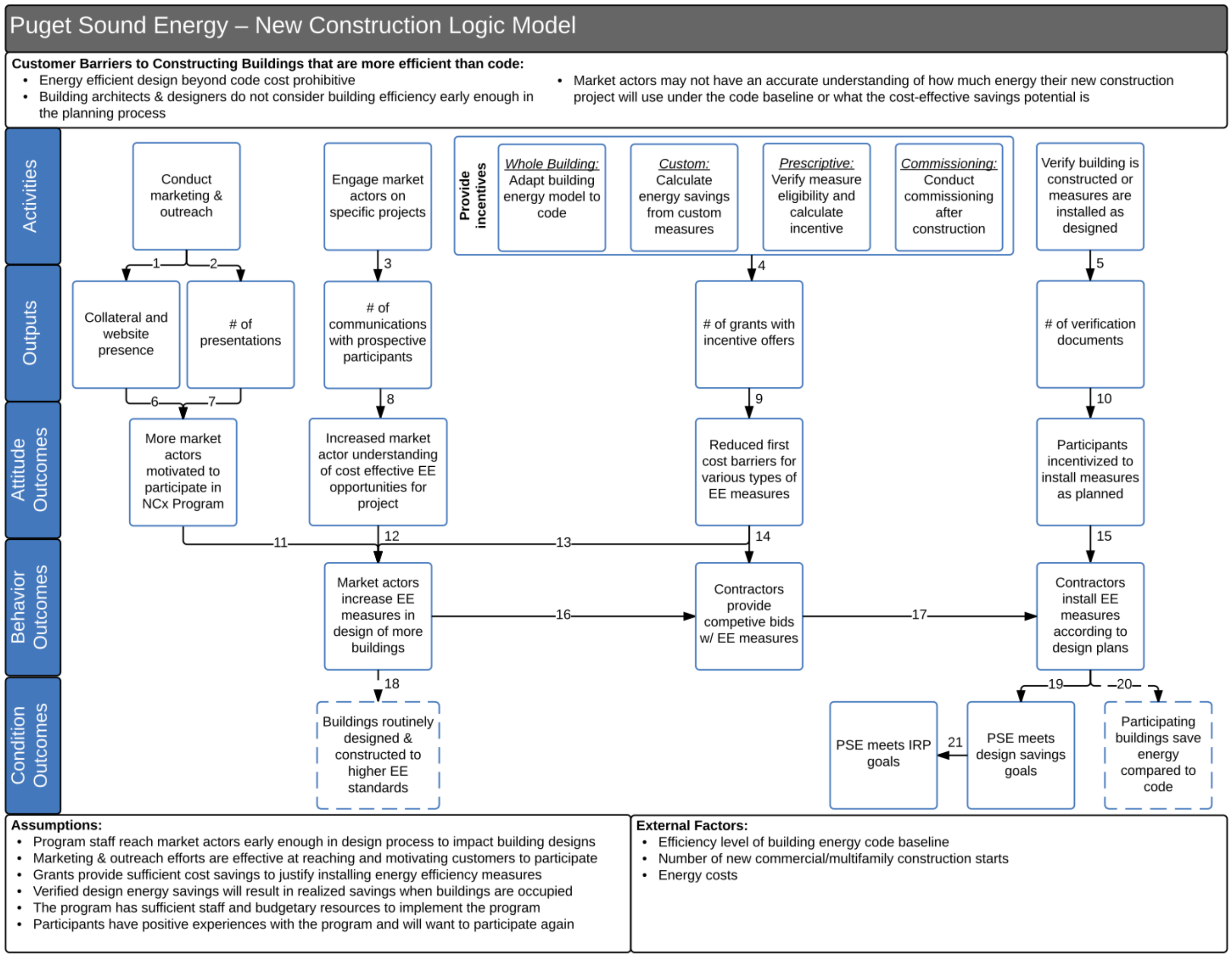
PSE developed the New Construction program to encourage the construction of buildings that are more energy efficient than the minimum required by Washington code. The program is designed to address customer barriers to exceeding the energy consumption baseline of buildings built to code. This section identifies the barriers the program is designed to address, describes the program theory, and concludes by identifying external factors that could influence program success. Figure 1, on the following page, summarizes this information by showing the program logic and specific linkages between program activities, outputs, and outcomes.

Barriers Addressed by the New Construction Program

To support real estate owners and developers in constructing energy-efficient new buildings, PSE developed the program to address the following barriers to constructing energy efficient facilities:

- Developers and owners do not adequately include energy efficiency in project criteria, so building architects do not consider building efficiency early enough in the design process.
- Market actors (developers, landowners, architects, engineers, and contractors) may not have an accurate understanding of how much energy their new construction project will use and how it compares to baseline energy consumption.
- Energy-efficient design beyond code may be relatively more expensive, and developers may not recoup the additional costs.

Figure 1. New Construction Program Logic Model



Program Theory

The New Construction program is comprised of four major activities. Each of these activities generates specific outputs and outcomes. This section documents the underlying theory shown in the logic model by describing each activity and associated outputs and outcomes. Throughout this section, the evaluation team refers to the numbered links shown next to the arrows included in the logic model in Figure 1. To facilitate the explanation, the evaluation team presents a section for each of the four activities:

- Conduct marketing and outreach
- Engage market actors on specific projects
- Provide incentives
- Verify building is constructed or measures are installed as designed

Conduct Marketing & Outreach

The first activity is intended to spread awareness about and generate interest in the NCx program. General marketing materials include physical collateral such as program pamphlets and a program page on the PSE website (Link 1).

Program staff also conduct several targeted outreach activities. These activities include presentations to local Master Builders' Associations and municipal Business Services Departments, both of which are organizations that interact with developers and owners early on in a construction project (Link 2). Staff use these presentations to familiarize the organizations with the program so that they can refer potential customers during the initial planning phase of the project, when developers and owners make key design decisions.

Providing information, both through general marketing and targeted outreach, results in an increase of awareness of the program for market actors (developers, landowners, architects, engineers, and contractors) who may play a role in future new construction projects, as well as motivation to participate due to awareness of the availability of design grants. The intended result of both these outputs is to increase the number of market actors aware of and motivated to participate in the program (Links 6 & 7).

Marketing and outreach is designed to increase the pool of potential participants by increasing awareness of the program, thereby increasing the number of market actors who include (energy efficient) EE designs and/or equipment ("measures") in building designs, the proportion of buildings with EE measures, and/or the extent to which building designs exceed the energy code baseline (Link 11). This behavior outcome is produced in conjunction with increased understanding of energy efficiency opportunities (Link 12, see "Engage Market Actors on Specific Projects" below) and reduced cost barriers (Link 13, see "Provide Incentives" below).

Additionally, program staff indicated that by making developers and market actors more aware of the possibilities for exceeding code-mandated energy efficiency standards, they might more routinely include cost-effective energy efficiency measures in building criteria and designs outside of the program (Link 18, indirect). Such an effect would constitute market transformation. However, the program is not specifically designed to create market transformation.

Contractors, in turn, provide bids incorporating measures selected in the initial building design (Link 16). This behavior outcome is also supported directly by reduced cost barriers (Link 14, see "Provide

Incentives" below). Next, contractors construct new buildings to the project specification (Link 17). This behavior outcome is also supported by verification procedures that reduce the incentive to build to a lower-efficiency standard (Link 15, see "Project Verification" below).

Ultimately, PSE claims savings from new buildings being built as specified, so completed projects contribute to meeting the program's design savings goal (Link 19) as well as their overall integrated resource plan (IRP) energy savings goals (Link 21).

Implicit in this program design is the assumption that participating buildings will consume less energy than they would have in absence of the program, regardless of building usage, occupancy, or other factors (Link 20, indirect).[24] The realized energy savings achieved may be different from the tracked and measured design savings; however, realized energy savings are not measured or tracked through the program.

Engage Market Actors on Specific Projects

Program managers identify potential projects in two ways: they respond to requests for information from interested customers, and proactively reach out to project leads obtained through PSE's subscription to a service called "New Construction Leads" that collects and provides data on new construction projects within the PSE service territory. Outputs from these activities include various communications, such as phone calls, email correspondence, and in-person presentations to individual customers (Link 3). These communications include general information about the program and potential project, such as the various program tracks, possible energy efficiency measures, and grant levels. Typically, NCx program staff will make an informal and/or verbal agreement of the expected grant amount (see "Provide Incentives" below). In some cases, NCx staff provide a grant estimate via email. These communications result in an increased market actor understanding of the opportunities for EE upgrades beyond code that are cost-effective with the inclusion of design grants offered through the program (Link 8).

Increasing market actor understanding of specific energy efficiency opportunities for buildings under development helps alleviate knowledge barriers. That is, NCx program staff help identify potential cost-effective EE measures that market actors may not otherwise reserve budget to explore in the design phase. Because of this awareness, market actors opt to include more energy efficiency measures or measures of higher efficiency in building design (Link 12). This behavior outcome builds off general program awareness (Link 11, see "Conduct Marketing & Outreach" above) and leverages the grants that reduce first cost barriers (Link 13, see "Provide Incentives" below).

The remainder of the program logic is described in additional detail under "Conduct Marketing & Outreach" above.

Provide Incentives

PSE offers financial incentives in the form of design grants to developers that construct new buildings to be more efficient than the code baseline. Four types of grants are given through the program: whole building, custom, prescriptive, and post-occupancy commissioning. Whole-building and custom grants lower the first costs of both design and construction, while prescriptive grants lower the first costs of EE measures. Commissioning grants reduce the first costs of conducting the study, which is especially

[24] Note that indirect objectives are depicted in the logic model by dotted lines.

important when the developer is not the future occupant and does not have any further incentive to reduce future energy consumption.

These grant tracks are described as follows:

- **Whole Building:** Participants must provide a whole-building energy model to NCx program staff to participate in this track. Program staff adapt the building's energy model to meet, but not exceed, code, and estimate designed energy savings as the difference between the energy consumption of the code-adapted and actual model. This method allows the program to best estimate the energy savings achieved while capturing the impacts of measure interaction, such as upgrading HVAC system components and the building envelope.
- **Custom:** NCx program staff calculate savings from individual measures, such as lighting or domestic hot water, relative to the minimum efficiency required by code. This track allows the program to account for measure savings in cases where a whole-building energy model is not necessary, allowing buildings without one to participate.
- **Prescriptive:** For prescriptive measures such as showerheads and clothes washers, NCx program staff apply deemed savings and incentive levels to determine the total grant. This track reduces the burden of participation when installing common measures with lower uncertainty in per-unit savings estimates, such as low-flow showerheads and clothes washers.
- **Post-occupancy Commissioning:** Commissioning incentives are offered to ensure new buildings are operating as efficiently as possible. Post-occupancy commissioning for new buildings is managed under the PSE's Comprehensive Building Tune-Up (CBTU) commissioning program, separate from the rest of the NCx program. However, NCx commissioning is categorized and budgeted under the NCx program (and savings are attributed to NCx) because it is an offering for new buildings.

After calculating incentives, NCx program staff provide formal grant offers to potential participants (Link 4). The purpose of offering these grants is to reduce high first costs associated with designing higher-efficiency buildings and/or installing higher-efficiency equipment, which the incentive offer formalizes (Link 9). In turn, committing grant funds reduces the first costs of energy efficiency measures for market actors, so market actors include more or higher energy efficiency measures in new building designs. This behavior outcome builds off increased awareness of the program, including the general availability of these grants (Link 11, see "Conduct Marketing & Outreach" above) and increased opportunity of project-specific energy efficiency opportunities (Link 12, see "Engage Market Actors on Specific Projects" above).

In design-bid-build projects, reducing first cost barriers also has a direct impact on contractors to include energy efficiency measures in the initial design bid to construct the actual building (Link 14). In some cases, contractors developing bids for construction work will remove energy efficiency measures that add to project cost through value engineering analysis. Design grants reduce the first costs of these added expenditures, making the measures more likely to be cost-effective and included in a competitive bid. Note that there is little distinction between including energy efficiency measures in the initial design and the final construction bid in design-build projects; Links 13 and 14 are the same in these cases.

The remainder of the program logic is described in additional detail under "Conduct Marketing & Outreach" above.

Project Verification

When a project is completed, program staff verify the built design to ensure the building is constructed as designed and/or measures are installed as planned. All projects require some form of verification, but the process varies by grant amount. For larger prescriptive projects (grants of $20,000 or more), NCx staff will conduct a site visit. These visits include visual inspection of a minimum of 10% of installed measures. For smaller projects (grants under $20,000, typically prescriptive-only projects), the program requires participants to submit invoices and photos of the installed equipment. Program staff create verification documents of the installed measures, including documentation provided by participants (Link 5). Although verification does not measure energy savings, requiring verification provides an incentive to participants to ensure that measures are installed as planned (Link 10). As a result, contractors install measures as planned (Link 15).

The remainder of the program logic is described in additional detail under "Conduct Marketing & Outreach" above.

Theoretical Assumptions Impacting Program Success

There are several theoretical assumptions underpinning the overall program logic. If these assumptions are inaccurate, program success could be affected. Some key assumptions include:

- Program staff are able to reach market actors early enough in the design process to impact building designs.
- Marketing and outreach efforts utilized by program staff are an effective means to motivate customers to participate in the program.
- Grants provide sufficient cost savings to justify installing the energy efficient measures as planned and to keep energy efficient measures in place if market actors need to reduce costs during the construction bidding and building phases.
- Verified designed energy savings will result in realized energy savings once the buildings are occupied.
- There is sufficient program staff and resources to implement the program as planned.
- Participants have positive experiences with the program and want to participate again when they complete a NCx project.

External Factors Influencing Program Success

The theory described above assumes the status quo with regards to a variety of external factors. These external factors are beyond the control of program implementers; however, these factors can influence program success. If these external factors change, it is possible that the program's logic might not function as planned. The bullets below highlight some examples of external factors that could influence program success.

- **Building energy codes:** Washington state has one of the most stringent energy efficiency codes in the country, which may increase with future iterations of building code. More stringent codes typically entail the next-most cost-effective energy efficiency measures, both increasing the marginal cost of remaining measures and reducing the marginal savings the program can claim. Reducing the cost-effectiveness of energy efficient design and measures that go beyond code may prevent the program from overcome the associated cost barriers. (Links 13 and 14).
- **Number of new commercial and multifamily construction starts:** New construction in PSE service territory has been rising in recent years due to economic growth in Western Washington. A slowdown in economic growth and new construction could reduce the number of viable

participants they are able to recruit through marketing, outreach, and engagement (Links 11 and 12).

- **Energy costs:** Participants will need to justify the costs of energy-efficient equipment in relation to their return on investment. If energy rates decrease, then the customer's cost effectiveness to complete these projects may decrease.

Assessment of Program Theory and Logic

The overall program theory and logic are well defined and can be used to inform evaluation priorities. Program activities, outputs, and outcomes address energy efficient new construction barriers, so it is, therefore, reasonable to assume that by addressing these barriers, the NCx Program will encourage market actors to participate. In terms of the evaluation effort, the evaluation team identified three areas where research can support program optimization or clarity:

- **Influencing Design:** Historically, the program has faced challenges in reaching out to market actors early enough in the design process to encourage including energy efficient designs at a whole building level. Because this activity is important to achieving whole building savings, the evaluation will pay particular attention to how the program interacts with market actors to identify ways to work with market actors earlier in the design phase.
- **Realized Energy Savings:** Because the program is focused on achieving designed energy savings, the extent to which energy savings are realized once the buildings are occupied is unclear; therefore, the current impact evaluation will focus on determining the actual energy consumption and how that might compare to the original building designs to understand the energy savings impact of the program.
- **Repeat Participation:** Ideally, as market actors, such as general contractors and architecture firms, become aware of the program, they will continue to encourage their clients to increase the energy efficiency of their buildings through participation. Therefore, the evaluation can assess whether trade ally participants are repeating year to year, and, if not, explore ways to increase repeat trade ally participation.

E.2 New Construction Process Evaluation: Best Practices and Behavior Optimization Review, Market Actor Findings Memo

To: Michael Noreika, PSE

From: Hannah Justus, Joan Effinger, Julie Scrivner, EMI Consulting

CC: Jes Rivas, Jon Strahl, Navigant

Date: October 17, 2017

Re: New Construction Process Evaluation: Best Practices and Behavior Optimization Review, Market Actor Findings

Introduction

The evaluation team researched best practices and behavior optimization opportunities as a part of the process evaluation of the Puget Sound Energy (PSE) New Construction (NCx) program. To conduct this research, the evaluation team conducted two separate research tasks: peer NCx program research and market actor research. This memo presents results from the market actor research.

The objective of this research was to understand how PSE can better engage market actors in the NCx program. The evaluation team researched how the PSE program fits into the new construction market by asking interviewees about their awareness of the PSE program, impacts of the energy code on building design, typical design processes, and which market actors are considered key players in the design stages of a new construction project. In addition, the evaluation team researched current participant experiences with the PSE program to gain insight into effective program outreach and communication, motivations to participate, barriers to participate, and specific participation experiences. Finally, the evaluation team gathered feedback from participants on communication tactics, education outreach methods, program improvements, and surpassing energy code.

To conduct this research, the evaluation team interviewed eight market actors involved in new construction in the Puget Sound area during the summer of 2017. The following memo presents key findings, an overview of the respondents, and detailed in-depth interview discoveries. Detailed findings for how to better engage market actors in the new construction market are organized into sections covering program awareness and design practices, program experiences, and recommendations from interviewees. The evaluation team will synthesize the results along with other evaluation tasks and present overall program recommendations in the final evaluation report.

Key Findings from Market Actor Interviews

The evaluation team conducted interviews with eight market actors. The following sections present key findings from these market actor interviews organized by the following three themes: energy code, design processes and programmatic experiences.

Energy Code

- **Changes in energy code may impact a market actor's ability to exceed code in new construction projects –** Interviewees expressed some uncertainty around the feasibility of building beyond future code requirements. With an increasingly stringent energy code, market actors may have a harder time qualifying for incentives unless they explore newer or different technologies that achieve efficiencies beyond code. The evaluation team found that market actors with customers who are new to Seattle or not based in Seattle must spend time educating their customers on the energy code requirements. This need presents an opportunity for PSE to provide trainings and educational material to market actors who need to educate their customers on the energy code.

Design Processes

- **Market actors confirmed that energy efficiency goals are established during the conceptual design stage –** New construction processes can vary by firm and depending on the project, different actors are involved at different stages. Interviewees reported that discussions about utility incentives primarily happen at the beginning of a project through the schematic design stage when the owner/developer and the design team are involved. These findings suggest that the start of the project during the conceptual design stage is potentially the best timing for initial engagement from PSE, and that continued engagement throughout a project is important as market actors change.
- **Both the owner/developer and their design team make key decisions in new construction –** Interviewees reported that it is the owner/developer's final decision to participate in a utility energy efficiency program. However, five of the interviewees reported that the design team (architects/engineers) and contractors actually submit the application on behalf of the owner/developer. The developers interviewed reported they apply for their own projects. Interviewees—including architects, engineers and contractors—reported they are paid by customers to research and apply for incentive programs. If the design team perceives the process as too burdensome, they may not recommend the program to their customers. On the other hand, in some design processes the energy efficiency upgrades risk being 'value engineered out' if the owner/developer is not committed to participating in the program once contractors start bidding on the project. As a result, both the owner/developer and the design team are the key decision makers in new construction. This suggests there is value in engaging both the owner/developer and the design team in program outreach.

Programmatic Experiences

- **Market actors had positive program experiences –** Interviewees reported high satisfaction with the PSE NCx program and PSE staff's responsiveness and collaboration before and during the project process. The evaluation team found that interviewees did not find the process burdensome. These findings suggest supportive and responsive staff increase program retention.
- **Market actors learn about utility NCx programs[25] through direct connections, however opportunities exist to conduct outreach through existing trade networks –** Interviewees consistently recommended that PSE staff conduct program outreach through established

[25] This insight is not specific to the PSE NCx program.

networking channels, such as new construction associations. All of the interviewees who were aware of their participation in the PSE NCx program initially learned about it by specifically looking for incentives from the utility or through personal connections or trainings/classes. These findings suggest the most effective outreach methods involve established channels such as new construction associations or personal connections.

- **Time and money are the largest barriers to program participation for market actors and customers –** Interviewees reported that customers are not interested in pursuing incentives when customers perceive the process as burdensome or believe that the incentive will not be worth the effort or money to pay the design team to research options or do the work to participate. In addition, one interviewee shared that average builders who are simply working to meet code and not go beyond are focused on completing their work as quickly as possible and any extra steps that add to a project timeline ends up costing them money. This reluctance suggests design teams and contractors may need to be further incentivized by utilities to spend time researching and applying for a program, especially if the customer is not initially inclined to do so.

Respondents

The evaluation team targeted conducting eight in-depth interviews with a mix of participating and non-participating market actors. PSE provided the evaluation team with five market actor contacts who participated in the program, three of which were interviewed by the evaluation team. The evaluation team identified the next four interviewees by cold-calling companies listed on the NCx participant lists from 2012-2017, provided by PSE. The final interviewee was a contact from the new construction market. The evaluation team spoke with individuals at two development firms, two architecture firms, two engineering firms, and two contractors. The final interview demographics are outlined in Table 1.

Table 1: Interview Demographics

Actor	Previous Participation by Firm	Interviewee Awareness of PSE NCx
Developer	Yes	Yes
Developer	Yes	Yes
Architect	Yes	No
Architect	Yes	No
Engineer	Yes	Yes
Engineer	NA[26]	Yes
Contractor	Yes	Yes
Contractor	Yes	No

Source: EMI Consulting analysis.

As shown in Table 1, all but one interviewee worked at a firm that participated in the PSE NCx program (the last interviewee was not sure if his/her firm had participated).

[26] One interviewee did not know if his/her firm had participated in the PSE NCx program or any other utility NCx incentive programs. As a result, the evaluation team did not ask the interviewee questions about their involvement with the program or utility incentives.

Three of the eight interviewees were not aware of the program despite their firm's participation in the program. These findings are explored further in the next section covering program awareness.

Program Awareness and Design Practices

The evaluation team asked interviewees a series of questions about the overall new construction market and the PSE NCx program specifically to better understand the impact of their program and how they can most effectively engage potential participants with targeted outreach. We found the following four high-level findings:

- Five out of the eight interviewees were aware of the PSE program.
- Interviewees expressed some uncertainty around the feasibility of building beyond future code requirements.
- Interviewees reported they discuss utility incentives with their customers at the beginning of the design process for both integrated design and design-bid-build processes.
- Both owners/developers and design teams serve as the main decision-makers in new construction projects.

This section presents these findings in more detail. It is followed by program-specific findings, and then interviewee recommendations.

Program Awareness

The evaluation team spoke with three market actors recommended by PSE staff, one contact from the NCx market, and we recruited the remaining interviewees from the general program participation list provided by PSE. As shown in Table 2, although seven of the firms have participated in the NCx program, three of the interviewees were unware of the program, despite their firms' previous participation. This may indicate that the individuals within the firms who had previously participated are not recommending the program to their staff, and/or the firms only participate in the program when it aligns with their customer's interests.

Table 2: Levels of PSE NCx Program Awareness and Participation

Awareness Level	Description	Number of Interviewees
High	Submit all eligible projects to the PSE NCx program	3
Medium	Submitted one project to the NCx program	1
Low	Aware of PSE NCx program, but not sure if firm participated	1
Low	Aware of their participation in a PSE program, but did not know if it was with the NCx program	1
Low	Not aware of the NCx program or their participation	2

Source: EMI Consulting analysis.

The three interviewees unaware of the program included the two architecture firms and one contractor. They attributed their lack of awareness to various reasons:

- One participant knew that PSE offered incentives, but was not aware of the specific incentives or programs.
- One participant knew PSE offered many incentives, but was not aware of the NCx program.
- One participant knew that their firm had applied for PSE's incentives for high-performing buildings, but was not sure if that was through the NCx program.

These findings suggest that it may be beneficial to follow-up with participating market actors to sustain their firm's engagement over time.

Design Practices Based on Energy Code

As PSE considers making updates or changes to the program, changes in energy code and the ability of market actors to exceed code should be taken into consideration, because these factors may heavily impact program participation. In our interviews with market actors, responses varied regarding the impact of the current energy code on their design process. Interviewees expressed some uncertainty around the feasibility of building beyond future code requirements. With an increasingly stringent energy code, market actors may have a harder time qualifying for incentives unless they explore newer or different technologies that achieve efficiencies beyond code. In addition, we found that market actors with customers who are new to Seattle or not based in Seattle must spend time educating their customers on the energy code requirements. Specific interviewee responses to how their design practices are impacted by code are outlined below:

- Both developers and one contractor build their projects beyond code or have very experienced consultants, so hitting the energy code is not an issue for them.
- The two architects shared that the high-energy code requires them to invest time in customer education because their customers are not aware of the requirements.
- One interviewee said meeting code was not an issue in the past but was unsure how the new energy code released on July 1st would affect their processes.
- One interviewee shared that the recent energy code changes caused some market confusion over what the code applies to and what it does not.
- One interviewee expressed frustration about getting fewer rebates for installing efficient measures because the code changed. The direct quote is below:

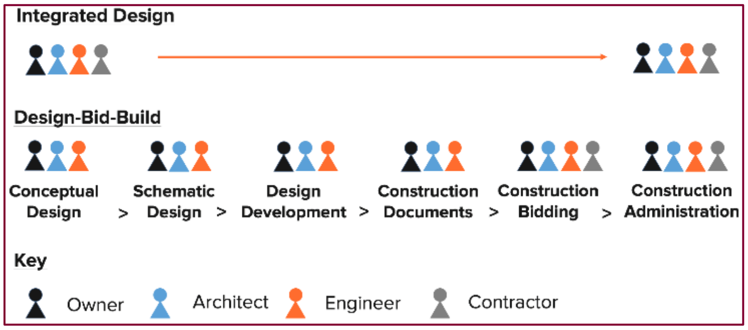
  It's brutal. It's very brutal. We used to be able to qualify, obviously, for a lot more. And now with everything mandated—there's still a lot you can do, especially on the control frequencies. But you don't get money for it unless you can really model the building.

These findings suggest that trainings and educational material on the new energy code and how to exceed it might provide value to architects, engineers and contractors to educate their customers.

New Construction Design Process

Information about the different new construction design processes and when utility incentives are typically discussed with owners/developers can help PSE inform the ideal timing for effective program outreach. The evaluation team found that the interviewees participate in two types of new construction design processes: integrated design and design-bid-build. As shown in Figure 1, all major actors collaborate from the beginning of the project in an integrated design process, including the owner/developer, architect, and contractor. In a design-bid-build process, the owner/developer and design team are involved from the start, while the contractor is brought on after the construction design phase.

Figure 1: New Construction Process



Source: EMI Consulting analysis.

Four interviewees primarily participate in an integrated design process:

> *Yeah, ideally…they're all in the room at the start…we call that integrated design and that can happen as early as…a developer with a piece of property bringing one of their primary investors into the room and a trusted contractor and an architect with…that ethos. And just say, 'Okay, let's imagine what we can do here.'*

The remaining interviewees primarily participate in a design-bid-build process, which is architecturally led. The below quote explains the design-bid-build process.

> *A lot of new construction projects, are still what we call bid plan and spec where the customer goes to the architect and designs a building and drawings get made and then they send them on and say, "hey contractors, bid this work."…They select a winning contractor and then you go build what's in the plans and specifications.*

While interviewees participate in different new construction processes, seven out of eight of the interviewees reported to discuss utility NCx incentives[27] with their customers as early as possible in the process: five interviewees said right from the beginning; two said during the schematic design phase before getting into design development.[28] Note that these discussions happen between the design team and their customers, and may not include PSE staff until the design team and/or owner is ready to bring PSE staff into the discussion.

Discussing incentives early in the design process is supported by energy efficiency NCx best practices literature. Decisions made by market actors early in the design process determine the amount of sustainable construction that can be possible. Along the same lines, if a project is too late in the design process, it is often too expensive or time-consuming for actors to incorporate energy efficient measures.[29] These findings emphasize the importance of discussing the program early in the design process, and

[27] These discussions are not specific to PSE NCx incentives, but utility incentives in general.

[28] One interview did not know if their firm discussed utility incentives with customers and therefore was not asked this question.

[29] (Strecker, 2014)

suggest that the start of the project during the conceptual design stage is potentially the best timing for initial engagement, and that continued engagement throughout a project is important as market actors change.

New Construction Market Actors

To help PSE better engage market actors, the evaluation team asked interviewees about the roles each market actor plays within the design process to identify an ideal market actor population for outreach. Although some market actors change throughout a new construction project, the evaluation team found that owners/developers participate at each stage, and that the design team is paid by the owners/developers to apply for the grants on their behalf. This section describes these findings in more detail. First, it describes the market actors involved at each stage, then describes each of their responsibilities in incentive programs.

As shown in Figure 1, interviewees reported that the actors involved at each stage of the new construction process vary by project and design process. After talking with all of the interviewees, the evaluation team found that whether the owner/developer is using an integrated design process or a design-bid-build process, the design team, which includes an architect, is almost always involved from the start. Additionally, owners/developers are always involved at the start of a new construction project.

All of the architects, engineers and contractors who pursue utility incentives, apply for incentives on behalf of their customers. Developers, on the other hand, apply for their own incentives. Of the architects, engineers, and contractors asked, all said they are paid by customers to research and apply for incentive programs (n=3). To see if the financial support from PSE would justify the effort to participate in the program, one interviewee was paid an additional $5,000 by their customer to go through the program's preliminary design stages to assess the grant amount.

While the interviewed architects, engineers, and contractors are responsible for researching and applying for incentives, ultimately all of the interviewees reported it is the owner/developer's final decision to participate in a utility energy efficiency program (n=7). This is a barrier to customer participation—although it is the owner/developer's final decision to participate in the program, the architects, engineers and contractors do the work to apply for the program. If these market actors do not recoup their costs for their time, they may not recommend program participation to the owners/developers. In addition, the evaluation team found that these market actors charge a fee for the work the team does to participate in the program, adding to an owner/developer's cost for program participation. We discuss this concept further in the next section of this memo, which describes the drivers of program participation.

These findings suggest that the key actors for PSE to engage with are both the owner/developer and the design team, especially the architect. This is also supported by peer program findings, along with energy efficiency in NCx best practices literature. According to The American Institute of Architects, "regardless of the size of firm in which architects practice, [architects] must take ownership of the energy modeling process. Because [architects] hold unique expertise in the integration of programmatic goals, spatial organization, and building systems, [architects] are the most appropriate team members to assume a leadership role in the process."[30]

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[30] (Andrejko et al., 2012)

Program Experiences

Once the evaluation team developed an understanding of how the interviewees viewed the new construction market and the key players in that market, we asked interviewees questions about their experiences with the PSE program to better understand how to improve program outreach and processes by highlighting effective aspects and removing barriers to participation. We found the following three high-level findings:

- Interviewees learned about the program by specifically looking for incentives from the utility or through personal connections or trainings/classes
- Financial incentives are the main motivation for participating in utility programs
- Lack of time and money are the biggest barriers to program participation; and the majority of participants had positive program experiences.

This section presents these findings in more detail.

Program Outreach

PSE can use information about effective current program outreach methods to identify what communication tactics should be used to engage more potential participants. The market actor interviews highlighted the following impacts of current outreach efforts. All of the interviewees who were aware of their participation in the program, initially learned about the program by specifically looking for incentives from the utility or through personal connections or trainings/classes. None of the interviewees learned about the PSE program through online marketing channels (email, ads). The specific channels through which the interviewees learned about the program are outlined below:

- Two originally sought out PSE incentives through online research and established connections to PSE staff members.
- Two attended a PSE community or training event.
- One learned from a colleague.

One of the interviewees, who was not aware of the PSE NCx program, but was aware of other PSE programs, found out about them through PSE incentive classes. These findings suggest the most effective outreach methods involve personal connections with market actors.

Program Participation Motivations

PSE can leverage information about motivations for current program participation in marketing language in order to increase program participation. The evaluation team found that the six interviewees (or their clients) who have consistently participated in utility programs, do so because of the financial incentives. Three interviewees shared that owners/developers care about getting money for pursuing more energy efficient designs. One interviewee reported their customers make energy efficient decisions based on the return on investment in energy efficient designs. These findings suggest that the main driver for owners/developers when it comes to energy efficiency decisions in new construction is the cost to pursue efficient measures.

Program Participation Barriers

The evaluation team asked interviewees about program participation barriers to see how PSE can minimize these restrictions in future program planning to increase participation. Despite incentives offered by PSE, interviewees reported costs as a barrier to program participation. They also reported time to be a barrier. Specific interviewee responses are outlined below:

- One interviewee shared that some customers are not interested because they don't think there is enough value derived from utility incentive programs to spend the time and money to look for them.
- One interviewee had a customer who was not interested in pursuing a very efficient design incentive from another utility program because the extra upfront cost to purchase the energy efficient equipment was more than they had expected to spend.
- One interviewee believed that participating was going to be a burdensome process that would end up costing the design team money. The direct quote is below.

  Yea, so the perception was that there was going to be a burdensome level of paperwork that we weren't going to be compensated for and that was the reason not to even bring it to the table. The grant amount wasn't even going to incentivize the customer to pay us to do anything about it and we wouldn't want to do it for free because it would be too much work.

These perspectives help illuminate how lack of time and money are large barriers to participating in utility energy efficiency programs. It also emphasizes how a perceived cumbersome process can be a barrier as well: if the design team or contractor does not think the process is worth the effort, they may not tell the owner about the program.[31] These findings suggest that the design team and contractors need to be incentivized by utilities to spend time researching and applying for a program. In addition, the cost of pursuing an energy efficient new construction design must not be prohibitive to owners/developers.

Another barrier for projects following the design-bid-build process in Figure 1 is that energy efficiency is often value engineered out at the bidding stage when contractors are brought into a project. Even when decisions are made by owners/developers and the design team to increase the amount of sustainable construction opportunities, later actors may not take advantage of them.[32] One interviewee shared that average contractors who are simply working to meet code and not go beyond are focused on completing their work as quickly as possible because time is money. As a result, these contractors may not include energy efficiency aspects in their proposals to owners/developers during the bidding stage. These findings suggest that a strong relationship with owners/developers, who are present throughout the entire project and are the final decision makers, is particularly important as other actors change throughout a project. Ensuring owners/developers are adequately educated and engaged as proponents for energy efficiency projects may lead to increased participation.

Participation Experiences

PSE can use information about participation experiences to better understand how they can effectively support participants and increase program retention. The evaluation team found that interviewees had positive program experiences.

[31] See more on decision-making in new construction in the 'Actor for Engagement' Section.

[32] (Bueren & Priemus, 2001)

As demonstrated in the quote in the 'Program Participation Barriers' section, the evaluators found that one market actor initially perceived program participation as burdensome, but those who did participate in the PSE program reported it was not a burdensome process. This may suggest that some potential participants may incorrectly perceive participation to be prohibitively time-consuming with insufficient payoff.

In addition, three out of four recent interviewees had very positive impressions of the PSE staff. For all three, having a contact within the PSE staff to whom they could ask direct questions made the process much easier. One interviewee shared that the staff was easy to talk to. Another interviewee explained their experience with the staff when their project was transferred to a different PSE employee and some papers were lost in the process:

> *People retire, people move on, you lose information, but how PSE handled it was really admirable. They could have easily said, sorry, we don't have document right here. And so, you're out of luck. But they didn't, they worked for this and [we] got our payment… I think the process is more straightforward in PSE than it is in other jurisdictions.*

This quote highlights how the PSE NCx staff are a strong program asset. The interviewees expressed that their satisfaction with the program is partially due to PSE's responsiveness and collaboration.

Recommendations from Interviewees

The evaluation team gathered feedback from interviewees on what PSE could do to more effectively communicate to decision makers in the new construction market. These included recommendations for communication tactics, education outreach methods, program improvements, and surpassing energy code. The high-level recommendations are:

- Network through established channels such as NCx associations.
- Provide case studies and information on operational savings.
- Increase transparency around deliverables, deadlines, and PSE staff commitments to improve program processes.
- Incentive options and promoting certification programs to push projects beyond code.

This section presents these recommendations in more detail. The evaluation team will synthesize these findings and present overall program recommendations in our final report.

Communication Tactics

Interviewees consistently recommended that PSE do outreach through established networking channels in the new construction market and follow up on completed project. Interview responses also suggest that personal connections are an effective strategy for PSE to utilize to communicate with trade allies and other market actors. Market actors are already connected to a variety of new construction channels and those who have participated in the PSE program already have connections with PSE staff, minimizing barriers to communication. Specific recommendations are outlined below:

- **Network through established channels:** Four interviewees recommended networking through established new construction channels such as Architects Institute of America, Built Green, Northwest Ecobuilding Guild, Passive House, Urban Land Institute (2), NAOP, WAMOA. Many of the interviewees already get information from these channels about opportunities and updates in the new construction sector.

- **Follow-up PSE Contact:** One interviewee recommended PSE staff follow-up and check-in on projects after they are completed 2 and 5 years later to increase future participation. In addition, two interviewees recommended PSE continue to share program updates to contacts at businesses. These relationships are already established, and PSE may have an opportunity to take advantage of the direct connections to increase repeat participation.
- **Provide Online Resource:** An architect and a contractor reported that having an online resource to use during conversations with customers would be useful to increase program understanding. PSE already provides program information on their website, but may benefit from making navigation to the website easier or having a one pager to share.
- **Lunch ‘n Learns:** One interviewee recommended using Lunch ‘n Learns to network with and educate market actors. These sit-down discussions would allow PSE to establish direct connections with market actors.
- **Sustainability or Business Development Arm of Company:** One interviewee recommended reaching out to the sustainability or Business Development arm at companies to educate them about program opportunities. These departments are already focused on strategies to build business and sustainability options and may appreciate insight into the PSE program.

Educational Outreach Materials

Through these communication channels, PSE staff are interested in identifying strategies for engaging trade allies and other market actors. The interviewees consistently reported that PSE could help equip design teams with information about the program that the design team can then pass on to their customers to educate them about program options and benefits. This educational support would allow design teams to more effectively engage owners and developers in a conversation around utility incentives. What information should be included in this educational outreach is highlighted below:

- **Provide Up-to-Date Case Studies:** Three interviewees reported that case studies would help increase program participation such as installation savings achieved by buildings with similar location and functions and success stories of integrated designs that saved energy and received a rebate. PSE already provides case studies, and may benefit from releasing updated case studies that apply to the new energy code. One interviewee expressed how important it is to adjust the savings potential advertised in case studies as there are changes in code. This interviewee expressed their frustration over a case study that advertised higher savings potential based on the old code compared to the new code:

  [PSE] came out with previous [building type] savings and said, "Hey, the [building type] got all this money, they did such a great job." Of course I asked everybody, "Great, so we should expect that much for our project." And we got so much less [than the amount advertised in the case study] that the customers were pretty pissed and said, "Why are we getting 30,000 when all of you got 300,000." [PSE] said, of course, "Well, that was under the old energy code. Under the new energy code, you're not going to get this much.

- **Provide Information on Operational Savings:** Three interviewees recommended providing an overview of operational savings and benefits from program participation in addition to an explanation of total cost ownership. This information would help explain long-term benefits of program participation through lower operational costs.

- **Provide Information on Energy Efficiency:** One interview recommended educating owners/developers about energy efficiency. This may increase excitement around options to save and encourage customers to push traditional building boundaries.
- **Provide More Comprehensive Rebate Matrix:** One interviewee reported a need for a matrix of average rebate values by building type to allow owners/developers to more easily understand if the incentive allows them to achieve an acceptable ROI. PSE already provides this matrix on their website. However, if customers are not aware this resource exists, PSE may benefit from reducing the number of clicks it takes to get to the program landing page.

Program Improvements

Once potential participants are engaged, PSE staff are interested in recommendations for increasing participation and program penetration. Interviewees reported increased transparency and communication would allow more projects to participate in the program. New construction projects have many moving pieces and adding more work to the project planning process by participating in an incentive program may seem daunting to potential participants. Minimizing and making program requirements explicitly clear may reduce apprehension around participation. Specific recommendations are outlined below:

- **Provide Project Roadmap with Deadlines:** Two interviewees reported that a flowchart of every stage in the new construction process with clear deadlines for each program requirement/decision would help them understand better participant commitments. In addition, one interviewee requested that PSE commit and hold themselves accountable to a stated timeline for their own responses to deliverables to increase program process transparency. Reduced uncertainty around expected timelines for participation may increase participation from projects with tighter deadlines.
- **Provide Project Portal:** Two interviewees reported that a singular location for uploading project files would minimize confusion over program paperwork submissions. These interviewees reported previous issues with lost documents within inboxes, confusion over submitted documents when PSE staff changed, or files being too large to send over email.
- **PSE Communication:** Two interviewees requested PSE proactively communicate when PSE commitment timelines slip or when more documentation is needed from participants. Interviewees reported this would minimize surprises by keeping all parties in the loop on project updates.
- **Shorter Timeline Approval:** One interviewee reported decreasing the time for PSE staff to approve projects would speed up the overall project timeline and allow projects with tighter timelines to participate.

Surpassing Energy Code

In addition to increasing program participation, PSE staff would like to explore opportunities to move the market beyond the current energy code and achieve higher savings through projects. Interviewees reported that offering more incentives and promoting certification programs would help push projects beyond energy code. As the energy code continues to become more stringent, more creative design incentives may also spur additional energy savings. Specific recommendations are outlined below:

- **Increase Incentive Options:** Three interviewees reported more and larger incentive options would help motivate customers to save money and push projects beyond code.

- **Provide Innovative Design Incentives:** One interviewee reported incentives supporting innovative technologies such as district energy systems, waste heat recovery, and thermal storage tanks would increase opportunities to save. This interviewee pointed to a district energy system example in South Lake Union where one building is selling its heat waste to another building to use as heating energy. PSE may want to explore incentives that support these innovative ideas as code continues to become more stringent.
- **Promote Certification Programs:** Two interviewees reported certification programs, such as Passive House and LEED, increase knowledge of how to move projects beyond code. Promoting these programs may decrease perceived barriers to energy efficient building design.

E.3 New Construction Process Evaluation: Peer NCx Program Benchmarking and Best Practices Memo

To: Michael Noreika, PSE

From: Hannah Justus, Julie Scrivner, Joan Effinger, EMI Consulting

CC: Jes Rivas, Jon Strahl, Navigant

Date: November 3, 2017

Re: New Construction Process Evaluation: Peer NCx Program Benchmarking and Best Practices Memo

Introduction

The evaluation team researched best practices and behavior optimization opportunities as a part of the process evaluation of the Puget Sound Energy (PSE) New Construction (NCx) program. To conduct this research, the evaluation team conducted two separate research tasks: peer program research and market actor research. This memo presents results from peer program research.

The research objective was to compare key indicators related to PSE's program performance and design to four peer programs. A secondary objective was to collect best practices from peer programs that could help PSE better engage market actors earlier in the design process and address challenges relating to increasingly stringent building codes.

To conduct the peer program research, the evaluation team collaborated with PSE to identify a set of key performance indicators (KPIs) and a cohort of four peer programs. As shown in Table 1, the KPIs were broken down between primary KPIs and supporting KPIs. The evaluation team then interviewed program managers from each of the four peer programs using an interview guide to systematically collect data across the four programs. The evaluation team also collected secondary data from industry and academic journals to identify additional best practices from prior NCx research.

Table 1. Key Performance Indicators

Key Performance Indicator	Type of Indicator
Total Annual Energy Savings	Primary
Total Participation	Primary
Program Penetration	Primary
Cost of Acquisition	Primary
Incentives-to-Program Costs Ratio	Primary
Outreach Activity and Targets	Supporting
Point of Entry	Supporting
Market Actor Participation	Supporting
Incentive Levels	Supporting

Source: Navigant Best Practices Evaluation Plan.

The remainder of this memo presents key findings from the peer program research, an overview of the four peer programs, primary KPI findings, supporting KPI findings, and concludes by presenting interviewee feedback on best practices. The evaluation team will synthesize these results along with other evaluation results to present overall program recommendations in the final evaluation report.

Key Findings from Peer Program Interviews

Based on the peer program interviews, the evaluation team found PSE is operating relatively similar to its peers; however, some differences in program energy savings, cost of acquisition, incentive structure and outreach efforts highlight opportunities for program changes. The following bullets present key findings organized by the primary KPIs, supporting KPIs, and best practices.

- **PSE energy savings and participation are relatively high, despite low program penetration–** The PSE program reported the second highest levels of savings and participation in 2016. This is likely because the PSE service territory is relatively large compared to many of the peer programs included in the research. The high number of indoor horticultural facilities built in the PSE territory during this period also helped to boost these numbers. Despite relatively high energy savings and participation, the evaluation team calculated program penetration in 2016 to be 14.4%, which indicates that PSE has an opportunity to reach a greater share of the new construction market.
- **PSE's cost of acquisition is low compared to peer programs –** KPI results show that PSE has a low cost of acquisition compared to the peer programs for kWh savings. While results do not explicitly define why these costs are lower, it may be because the PSE program appears to perform less outreach to market actors compared to the peers.
- **PSE's incentive structure is similar to peer programs but there is an opportunity to include a design incentive** – The PSE NCx program, along with the peer programs, offer incentives for whole building design and prescriptive measures; however, some utilities include specific incentives (monetary as well as non-monetary) to engage potential participants earlier in the design process.
- **Peers reported a best practice of engaging owners, developers, and design teams** – All interviewees reported experiencing greater success when they engaged and built direct relationships with key market actors. Interviewees provided the following engagement methods:

- Conduct trainings, presentations, and design assistance meetings
- Perform outreach through existing NCx associations
- Build relationships with owners and developers through existing utility networks such as account executives and sales representatives

- **One Peer reported a best practice of allowing their programs to meet varied customer needs** – A common best practice across all energy efficiency programs is to provide different program offerings for small businesses. One program provides variable rebate levels based on the level of savings the project will generate. This approach not only encourages market partners to pursue more energy saving options, but it also supports market partners who have fewer resources to invest in energy efficient equipment.

Overview of Peer Programs

The evaluation team spoke with program managers from four peer programs. Two programs operated in Washington state, one program operated in an area with stringent code, and one program was considered best in its class by its peers. Table 2 provides general information about each program to help place results in context.

Table 2. Peer Program Context

NCx Program	Sector Focus[33]	Number of commercial customers 2016 [34]	2016 NCx Budget
Puget Sound Energy	*C&I, MF*	*129,346*	*$5,153,329*
Program 1	C&I, MF	41,180	$16,045,262
Program 2	C&I, MF	16,384	$2,285,000
Program 3	C&I	526,484	$10,237,119
Program 4	C&I	Not available	$17,857,019

Source: EIA data; data provided by peer programs.

Primary Key Performance Indicators

PSE can use primary indicators to better understand how their NCx program is currently performing and set a baseline against which future goals can be measured. In addition, they can see how their NCx program differs from other programs on annual energy savings, total participation, and cost of acquisition. The evaluation team collaborated with PSE to identify the following five primary KPIs:

- **Total Annual Energy Savings –** The first KPI tracks the annual savings from 2016 captured by each program. PSE can use this KPI to track progress against their current energy savings goal.

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[33] The evaluation team was only able to collect data for both the commercial and industrial (C&I) and multifamily (MF) NCx programs for PSE and Program 1. Program 2 does not have a dedicated MF NCx program although savings from MF NCx projects are included in their C&I NCx program. Programs 3 and 4 have separate MF NCx programs that are not represented in this memo as they are managed by separate groups.

[34] Annual number of customers from EIA data published November 2016. This data was not available for Program 4.

- **Total Participation –** This KPI tracks the total number of projects processed through the PSE program and through the peer programs in 2016 to understand how PSE participation levels compare. PSE can also use this information to better understand whether their goal of increasing participation by 10% in 2017 is realistic.
- **Program Penetration –** This KPI will track the total number of annual projects paid through the program against the number of new construction starts in the same year. This KPI is designed as an internal indicator to help PSE measure whether it is increasing program penetration overtime. The evaluation team did not compare program penetration across peer programs.
- **Cost of Acquisition –** The calculation will include the total program costs including grants, staffing, and other overhead costs divided by the total energy savings. This KPI is a common industry metric that provides insight into the cost effectiveness of efforts implemented by peers; and secondly, it's helpful in gauging program costs over time and can provide insight into a number of things, such as the increasing cost of efficiency measures given code changes.
- **Incentives-to-Program Costs Ratio –** This is the proportion of customer benefits (design grants, for NCx) relative to total program budget. PSE staff indicated this is a metric of interest to PSE. Like program penetration, the evaluation team did not compare this KPI across peer programs.

The remainder of this section presents results for each KPI based on findings from peer NCx program interviews and secondary data collection.

Total Annual Energy Savings

PSE has a bi-annual energy savings goal with annual targets for the NCx program. The Total Annual Energy Savings KPI tracks the total energy savings captured by the program relative to code in 2016, and allows PSE to see their progress towards attaining the biennial energy savings goal. In addition, PSE can use it to compare their program energy savings to those of the peer programs.

PSE's gross electric savings from 2016 were 18,557,839 kWh and gross gas savings were 34,552 therms. As shown in Table 3, PSE's annual designed electric C&I energy savings were the second highest among the five NCx programs. This makes sense given that the PSE territory is also the second largest amongst the peers. PSE's annual designed C&I gas energy savings are the lowest out of the NCx programs.[35] The concentration of electric savings, rather than gas savings, may be due to the relatively high number of indoor horticultural facilities built in the PSE territory, which rely heavily on lighting measures.

Table 3 presents the energy savings for each peer NCx program. As shown, the peer programs define energy savings slightly differently, depending on variables such as energy type and market sector. Like PSE, all of the peer programs track project-level energy savings based on annual designed energy savings for a building.[36] Some of the programs also only track savings for certain fuel types or program types.

[35] The evaluation team was unable to compare PSE's MF gas energy savings to peer programs as this metric is not tracked at peer programs.

[36] Designed energy savings are the energy savings a building is designed to achieve based on energy models, not the actual measured savings.

Table 3. Total Annual NCx Gross Energy Savings in 2016 (sorted by decreasing NCx C&I kWh)

Program	Gross Electric Saving (kWh)			Gross Gas Savings (Therms)		
	C&I	MF	Total[37]	C&I	MF	Total[38]
Program 4	50,808,000			597,714		
PSE	***18,557,839***	***1,441,098***	***19,998,937***	***34,552***	***123,122***	***157,674***
Program 3	13,247,268			505,270		
Program 1	5,335,876	5,554,713	10,890,589	NA	NA	NA
Program 2			1,994,927[39]	NA	NA	NA

Source: Data provided by peer programs.

Total Participation

PSE program managers are interested in PSE's total program participation in 2016 to better understand whether their goal of increasing participation by 10% in 2017 is realistic. PSE can also use this data to understand how their participation levels compare to peer programs.

PSE processed 92 projects in 2016. As shown in the final column of Table 4, PSE is performing second highest compared to its peers for total number of projects. This may be a result of the higher number of customers in PSE's territory.

Table 4 presents the number of participants in the NCx MF and C&I peer programs, defined as the number of projects processed through programs in 2016. Note that some peer programs do not separate savings by sector or only focus on one sector.

Table 4. Total C&I and MF NCx Participation 2016 (organized by total projects)

Program	Number of commercial customers[40]	2016 Participation		
		MF	C&I	Total

[37] The evaluation team only summed savings when it collected both C&I and MF savings for the program.

[38] The evaluation team only summed savings when it collected both C&I and MF savings for the program.

[39] While Program 2 does not have a MF NCx program, savings from MF NCx projects are included in the C&I NCx program.

[40] EIA data

Program 4	NA[41]	NA	NA	426
PSE	***129,346***	***22***	***70***	***92***
Program 1	41,180	66	21	87
Program 3	526,484	NA	50	NA
Program 2	16,384	NA	NA	20[42]

Source: Participation data provided by peer programs.

Program Penetration

The program penetration KPI allows PSE to understand how much of the new construction market their program has touched by tracking the total number of annual projects paid through the program in 2016 against the number of NCx starts in the same year. PSE program managers are interested in increasing the program penetration. While there is no formal program goal, current program penetration data will establish a baseline against which a future goal could be measured. As shown in Table 5, the evaluation team calculated program penetration in 2016 to be 14.4%.

To calculate program penetration, the evaluation team reviewed permits filed for new C&I and MF buildings from primary cities within the PSE service territory in 2016 as a proxy for NCx starts.[43] In addition, the evaluation team conducted data cleaning to exclude irrelevant projects, such as retrofits to existing buildings and permits for new single-family residences and townhomes.[44] Table 5 shows the total number of issued permits and paid projects in 2016.

Table 5. PSE NCx Program Penetration in 2016

PSE NCx Program Metrics	2016 Value
Issued Permits in PSE Territory	*636*
Annual Paid Projects (C&I and MF)	92[45]
Program Penetration	14.4%

Source: Data provided by PSE.

[41] The evaluation team was not able to access this information.

[42] Program 2's total project number includes both C&I and MF NCx projects.

[43] The projects paid in 2016 may not exactly correlate to the projects that received permits in 2016 as projects may be paid for in a later year than when the building originally received a permit. See full list of collected permit data in the Appendix.

[44] The evaluation team removed retrofits from the data because data did not easily identify the extent of the retrofits. Because major retrofits can qualify for NCx rebates, it is important to recognize that the reported program penetration may be inflated.

[45] This number does not include any projects labeled as 'Phase 2'

The evaluation team did not formally compare this KPI to peer programs, although they did ask the peer programs how they track this metric. Program 4 reported they track this metric by assessing program participation by the square footage coming through the program compared to the square footage of all NCx projects according to Dodge Data. For tracking purposes, Program 4 reported that Dodge Data is flawed due to incomplete data, unclear definitions, and inconsistencies with the program's calculations. Program 4 plans on looking at new metrics to measure program penetration as the energy code continues to become more progressive. Some of the metrics they are considering include measure saturation, number of measures, and resulting energy intensity.

Cost of Acquisition

This KPI measures the total program costs including grants, staffing, and other overhead costs divided by the total design energy savings above code.[46] Although program staff did not identify a formal or informal goal relating to the cost of acquisition, the evaluation team believes this is a useful metric to track for two reasons: first, it is a common industry metric that provides insight into the cost effectiveness of efficiency programs; and secondly, it's helpful in tracking program costs over time. It can also provide insight into key issues such as the increasing cost of obtaining efficiency savings with more stringent code requirements.

As shown in Table 6, PSE's cost of acquisition for kWh savings is lower than all of the other NCx programs. This may be due to PSE's limited marketing and outreach. PSE's cost of acquisition for therm savings is highest out of three NCx programs. This may be due to PSE having fewer gas projects than other peer programs.

Table 6. Total C&I and MF Cost of Acquisition in 2016 (sorted by $/kWh)

Program	Qualifiers	2016 $/kWh	2016 $/Therms
PSE	***C&I, MF***	***$0.26***	***$32.68***
Program 4	C&I	$0.35	$29.9
Program 3	C&I	$0.77	$20.26
Program 2	C&I, MF[47]	$1.15	NA
Program 1	C&I, MF	$1.47	NA

Source: Program budget and energy savings data provided by peer programs.

Incentives-to-Program Costs Ratio

The incentives-to-program costs ratio KPI will allow PSE to see what portion of money spent on the program goes to benefit customers. It measures the proportion of customer benefits (defined as the total cost of design grants distributed to customers) relative to total program budget. PSE's overall ratio was

[46] Not all peer programs tracked budgets for electric and gas projects separately. As a result, the evaluation team calculated the cost of acquisition for electric and gas savings separately using the overall budget for each.

[47] Program 2's kWh savings include savings from C&I and MF projects.

98.1% in 2016. PSE can use this information to help decide where to direct their funds in future program years. For example, PSE may be interested in spending more money on staff activities, such as program outreach, to increase program participation.

Because overhead costs for the C&I and MF NCx programs overlap, this metric is estimated both separately for each program, and in aggregate for both programs. This KPI was designed to be unique to PSE, so the evaluation team did not gather comparison data from the peer programs.

Table 7. PSE NCx Incentives-to-Program Costs Ratio in 2016

Program	Paid Grants	Budget	Ratio
C&I	$4,106,056.76	$4,031,134	106%
MF	$796,792.94	$1,122,195	71%
Total	**$5,052,830.26**	**$5,153,329**	**98.1%**

Source: Data provided by PSE program staff.

Supporting Indicators

PSE can use supporting indicators to better understand how their NCx program differs from other programs from a more qualitative perspective. These insights can be used to help explain differences in the primary KPIs and identify how implementation strategies compare between the peer programs. The evaluation team asked peer program managers about the following supporting indicators:

- **Outreach Activity and Targets –** The evaluation team asked peer programs about the marketing & outreach activities they conduct for their NCx programs. This is intended to provide PSE with information on what channels peer programs use to engage the key actors within the NCx process.
- **Point of Entry –** The evaluation team asked peer programs about the point in the new construction process at which participants are recruited and/or enrolled in the programs. The timing can determine the program's ability to influence project decision-makers to install energy efficient equipment as well as what measures a program can offer.
- **Market Actor Participation –** The evaluation team asked peer programs about program participation by market actor. The evaluation team intended these data to help PSE identify how other NCx programs utilize market actors to drive program participation. NCx market actors include develops/owners, architects, engineers, and contractors.
- **Incentive Basis –** The evaluation team researched peer NCx program incentive structures to gain an understanding of what type of incentives other NCx programs offer customers.

The remainder of this section presents supporting indicator results based on findings from the peer program interviews.

Outreach Activity and Targets

The evaluation team gathered information from peers on the channels used to engage the key actors within the NCx process. PSE can use this information to help shape future program marketing and outreach activities. The evaluation team found that all peer programs focus outreach activities on engaging owners/developers in NCx projects. Three of the peer programs also focus outreach efforts on design teams. Only one of the peers reported focusing efforts on contractors. The specific outreach activities the evaluation team heard about from peer programs are outlined in Table 8 and are grouped by the target market actor: owners/developer, design team (architects and engineers), and contractors. The remainder of this section discusses the main marketing techniques used by peer programs, effective marketing channels used by peer programs, and the program actors involved in outreach activities.

The peer programs employ different marketing techniques for different market actors. All of the programs engage design teams through educational opportunities, such as conducting trainings and presentations. This educational approach is supported by NCx best practices literature. An effective way to promote energy efficiency design in NCx is to educate new construction firms, contractors and customers about the benefits of energy efficient buildings and address misconceptions through new and existing training programs.[48]

In addition, three of the peer programs utilize networking through city development or permitting departments to develop relationships with owners/developers. Program 4 emphasized the importance of building these relationships:

> *It comes down to working with the business managers that are going to part of developing a program, … developing a bond … and looking to collaborate with as many people as they can to get as many additional dollars as they can. So it comes down to like I said, this is an investment. We're investing in developing relationships and developing that market delivery structure that we know we can get in future years.*

Overall, offering educational opportunities including trainings and presentations, along with direct outreach were found to be marketing best practices.

The evaluation team found that specific marketing channels are used to promote these educational and relationship building opportunities. Multiple peers reported a best practice of networking through established channels for each market actor, such as American Institute of Architects (AIA) for architects, Integral Design for engineers, and Master Builders Association for developers. Program 3 mentioned one particularly successful outreach effort in which they partnered with AIA and provided language about the NCx program for architecture teams to include in their responses to RFPs. This blurb was along the lines of "'We will do your project. This is our proposal and we'll also participate in [NCx Program], which could grant you incentives and add energy efficiency design elements to your projects.'" Program 3 found driving participation from the RFP level and engaging with a well-known NCx association to be key engagement points.

In order to drive these outreach activities, peer programs utilize a variety of staff and incentives. Program staff across all peer programs are involved in outreach activities through the market channels listed above. Two of the peer programs also use account executives, sales representatives and field engineers to drive program participation. One of the programs assigns savings goals to program staff including account representatives and field engineers to drive outreach efforts.

PSE does not do outreach for the C&I program. PSE's MF NCx program outreach methods are consistent with other programs, but on a more limited scale as PSE's outreach is conducted by one program staff member. In contrast, two of the peer programs also use account executives and sales representatives to

[48] Hoffman & Henn (2008)

drive program participation. PSE's MF outreach efforts target developers and design teams, which is consistent with the peer programs. Outreach for the MF program also includes networking through city and NCx associations, subscribing to a company that provides leads, along with giving presentations at engineering firms—all methods consistent with efforts undertaken by peer utilities.

Table 8. Outreach Activities

Program	Owner/Developer	Design Team(s)	Contractors
PSE	*MF:* • *Subscribe to company that provides leads* • *Meet with cities and municipalities Business Services Department* • *Meet with Master Builders Association*	*MF:* • *Reach out and engage engineering firms with presentations*	
Program 1	• Build relationships with developers that want to repeat process • Reach out to buildings applying for permits on a monthly basis	• Will conduct outreach to MEPs in the future • Sponsored training series by UW's Integrated Design Lab	• Partner with SDCI to host code trainings to increase market "readiness" for current and future code cycles and promote programs
Program 2	• Account Executives conduct outreach to accounts with new development work • Contacts at City Economic Development Group and City Arts Program conduct outreach to new customers about program	• Not a focus because limited repeat design teams	• Send email updates to trade allies about any changes in program
Program 3	• Sales representative advertise program when new service is requested • Account representatives advertise program to accounts • Field engineers research new projects (University system posts about projects 10 years out) and cold-call about program; (field engineers are assigned by customer segment including office buildings, schools, groceries)	• Partnered with AIA and provided RFP language to firms so that they could respond to requests for proposals with information on program • Conduct outreach at Green Build Conference and other conferences • Partner with workforce education and training • Conduct outreach to Mechanical Engineers through Integral Group	

Program	Owner/Developer	Design Team(s)	Contractors
Program 4	• Conduct outreach by market segment • Develop business relationships with customers through networking • Established relationships with state and government entities, school districts, and the metro	• Design team training education effort called Allies for Efficiency (multiple trainings per year); goal is to build a community around integrating energy efficiency into buildings • Network with different associations (provide sponsorship or half-day trainings); increases brand awareness and credibility	

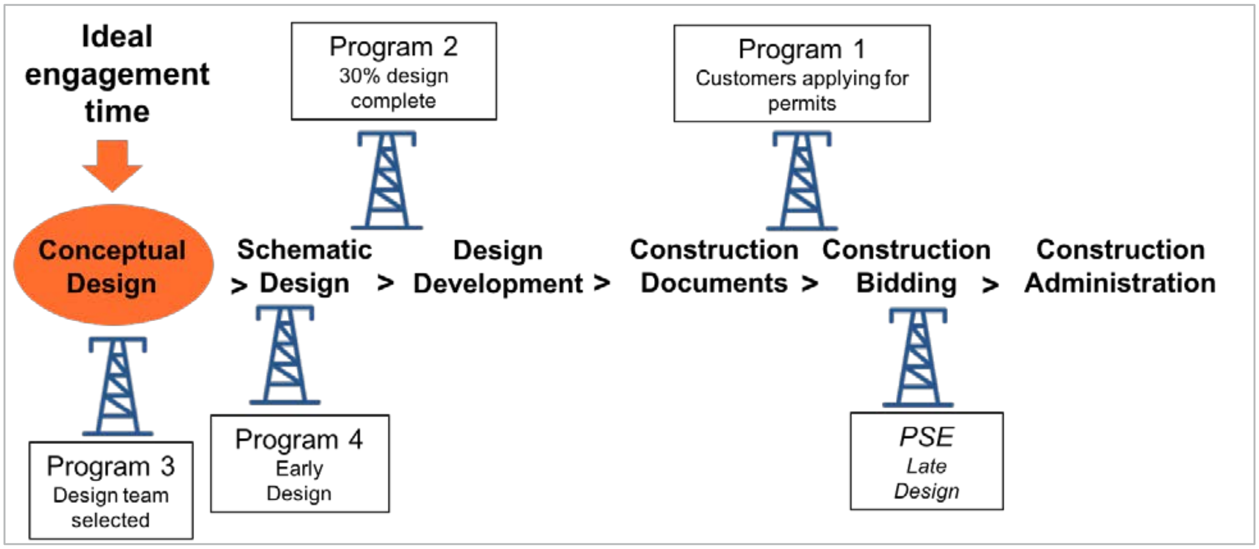
Source: EMI Consulting Analysis

Point of Entry

PSE program managers were interested in knowing the point in the new construction process at which participants are recruited and/or enrolled in the programs. The timing can determine the program's ability to influence project decision-makers to install energy efficient equipment as well as what measures a program can offer. PSE can use this information to help shape outreach timing for C&I NCx program offers. The evaluation team found that the peer programs all have different points of entry, although all peers reported that the ideal time period for engaging the market is early in the design phase, during conceptual design. The remainder of this section presents the main point of entry for each peer program, and then discusses the benefits of early engagement in more detail.

Figure 1 presents a typical design process and shows the typical point of entry for each program. Program 3 and Program 4 both focus on early engagement, when the design team is selected or soon afterwards, to drive participation. Program 2 attempts to engage from the start of the NCx process but usually engages with projects a little later, when 30% of the design is complete. Program 1 engages when customers are applying for permits. PSE's point of entry is most commonly later than all of the other programs.

Figure 1. Point of Entry



Source: EMI Consulting analysis.

Peers reported the earlier they engage with customers, the greater their ability to influence design decisions. Later on in the design process, owners/developers may still be flexible around lighting options, but the bigger design decisions are already set and, therefore, there is less opportunity to influence project decision-makers to install more efficient equipment. By engaging earlier in the design process, Program 1 shared they can "help both the contractor and the owner or operator think about how to optimize the amount of money they can receive from [the program] by making certain design decisions early on."

This perspective is supported by NCx best practices literature. Decisions made by the design team during the conceptual and schematic design stages determine the amount of energy efficient measure opportunities in the construction stages.[49] If a project is too late in the design process, it is often too expensive or time-consuming for the design team and contractors to incorporate energy efficient measures. Even when decisions are made that increase the amount of energy efficient measure opportunities, contractors may not take advantage of them or they may get value engineered out during the construction bidding stage.[50]

Market Actor Participation

The evaluation team asked peer programs about program participation by market actor[51] to see how PSE can utilize market actors to drive program participation. The peers reported that they primarily work with

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[49] (Strecker, 2014)
[50] (Bueren & Priemus, 2001)
[51] In this section, the evaluation team refers to NCx market actors, which include developers/owners, architects, engineers, and contractors.

developers and design teams, which include architects and engineers. The remainder of this section discusses the importance of the design team and the engagement levels among market actors. Multiple peers emphasized the importance of the design team in increasing program participation. Program 3 reported that architects and engineers play pivotal roles in the NCx program. Their direct quote is below:

> *Architects [play a pivotal role in NCx programs] from an overall building design and measurements, and the mechanical engineers play a pivotal role in energy modeling.*

Program 3 reported that architects usually act as the representative on program applications, which may be because architects provide the majority of the necessary data for the process. Program 2 reported that stakeholders emphasized that "MEPs should be [the program's] primary ally in NCx because they understand how the systems operate, what the options are to link multiple approaches." These quotes demonstrate how both architects and engineers in the design team play critical roles in helping projects meet program participation requirements. The evaluation team was not able to collect consistent quantitative data on engagement levels among market actors, but collected the following qualitative feedback:

- Program 1 developed relationships with key developers that provide multiple NCx participation opportunities.
- Program 2 developed relationships with three to four key developers within the MF sector. They focused less on relationships with design teams because their service territory is small and they found design teams did not typically have repeat participation in their territory.
- Program 3 developed relationships with roughly 20 design team professionals, who provide multiple NCx participation opportunities.
- Program 4 developed relationships with roughly 100 design team professionals, who provide multiple NCx participation opportunities.

The evaluation team also looked at whether program participation is driven by the same market actors (repeat participation) or by many different market actors. At Programs 1 and 2, there is some repeat participation from several developers in the service area. At Programs 3 and 4, there is a high level of repeat participation from design teams in the service area. The evaluation team found that the peer programs with more commercial customers had more repeat participation by market actors. In contrast, Program 2 has a small service territory, which limits repeat participation opportunities for NCx. Program 2 reported that market actors are not compelled to build a close relationship with the program because they aren't sure when they will have another project in the service territory.

Incentive Levels

The evaluation team researched peer NCx program incentive structures to gain an understanding of what type of incentives other NCx programs offer customers. PSE can use the Incentive Levels KPI to help identify future program offers to increase participation. When comparing peer NCx program incentive levels to PSE incentive levels, the evaluation team found that PSE offers fewer options and less flexibility in terms of types of offers and support than two of the peer programs. The PSE NCx program offers a whole building design incentive along with prescriptive incentives for specific measures. In contrast, Programs 3 and 4 provide those incentives and also offer design assistance meetings and express programs for small business customers.

As shown in Table 9, the peer programs provide a range of incentive options. These include whole building incentives based on percentage built beyond code, design assistance, and prescriptive measures. The remainder of this section presents more detail for each of the three incentive types.

Table 9. Incentive Structure

Program	Are incentives based on design or performance?	Design Support Incentive	Whole Building Incentive	Measure-Based Incentives
PSE	*Design*	*No*	*$0.30 / saved kWh, $5.00/ saved therm*	*See Appendix*
Program 1	Design, moving towards pay-for-performance	No	$0.23/ saved kWh	See Appendix
Program 2	Design	No	$.20/ saved kWh	
Program 3	Design, moving towards pay-for-performance	Meeting	$.10-$0.40 /saved kWh, $1.00/ saved therm, + $150.00/ peak kW	See Appendix
Program 4	Design	$2,500 for meeting	$0.15-$0.40/saved kWh; $0.80-$1.80/ saved therm	See Appendix

Source: Peer program websites and EMI Consulting analysis.

Design Support Incentive

Two of the programs (Program 3 and 4) focus on having a meeting with the design team at the beginning of the project. This meeting is used to present program requirements, discuss project timeline, review the project details, and review qualified products and building systems. The goal of providing design assistance for this type of meeting is to ensure that once the design team starts the design process, they will incorporate energy efficient measures into the building design. Program 4 provides a $2,500 incentive for the design assistance, while Program 3 does not provide a monetary incentive.

This approach to encouraging energy efficient design is supported by NCx best practices literature, which recommends changing new construction design and building processes to include all parties in initial design planning.[52] These parties may include owners, contractors, engineers, architects, and sometimes

[52] (Hoffman & Henn, 2008)

local community members. Increasing communication between new construction players from the start of a project can enable collaborative decision-making around energy efficient design.[53]

Whole Building Incentive

As called out in Table 9 in the 'Are incentives based on design or performance' column, all the peer programs reported they base their whole building incentives on designed-per kWh savings. The electric incentive varies from $0.15-$0.40/ kWh depending on the percentage built beyond code. The whole building gas incentive for applicable programs varies from $0.80-$5.00/therm depending on percentage built beyond code.

Two programs (Program 1 and Program 3) are moving towards pay-for-performance options to ensure that the building is performing to the design's intent, to simplify the incentive structure and to move away from a measure-by-measure approach for large NCx facilities, and to allow customers to more easily move beyond the energy code.

Program 3 reported that incentives may be less important for the owners/developers, but make a big difference for design firms. As a result, Program 3 gives 1/3 of the whole building incentive to the design team. In addition, the design team is paid half of the incentive upfront once the design is set and permits are being pulled, and then the other half at completion. The owner is paid 100% at completion.

Measure-Based Incentives

Three of the peer programs offer measure-based incentives within the NCx program.[54] Program 4 offers a good, better, best prescriptive measure package for small buildings. In addition to the package, Program 4 offers elective measures depending on a project teams' desire for savings. This approach is supported by NCx best practices literature, which recommends designing packages to have cost-effective robust savings while exceeding energy code.[55] Best Practice Findings and Recommendations from Interviewees

In addition to the primary and supporting KPIs, the evaluation team asked interviewees about whether they found any program strategies to have been particularly successful for overcoming a stringent code, reaching out to market actors early in design, and increasing program participation. The evaluation team presents their responses in this section.

The majority of these findings come from the two out-of-state peer programs because they were either known to be a leader and/or have been operating in a state with a strict building code. The two Washington state peer programs did not provide much feedback on best practices, but the evaluation team included all relevant input from them in these findings as well. In our final report, the evaluation team will synthesize and present these best practices along with findings and recommendations.

Best practices to overcome stringent code

[53] (Bueren & Priemus, 2001)

[54] See specific incentive levels are presented in the appendix.

[55] (Strecker, 2014)

Given the increasingly stringent state building codes, program staff are interested in determining how the program can continue to capture savings and/or help customers identify cost-effective and worthwhile new construction efficiency opportunities. PSE can use the peer program best practices for overcoming a stringent energy code to help achieve this goal. The peers reported three opportunities to helping customers capture more savings: upselling customers during design review, promoting certain technologies, and moving towards pay-for-performance measures. The following bullets provide more information on these three opportunities.

- Two programs, Program 3 and Program 4, heavily emphasized the importance of **upselling their customers with additional energy-saving opportunities** when reviewing a project plan. During the design review process, they talk to customers about what they can do to meet code as well as what they can do to go above and beyond. For example, if customers don't include lighting, the programs mention lighting; if customers include lighting, they mention controls. Below is an example of a conversation Program 4 might have with customers whose projects are not meeting code:

  > *"Hey, you're not meeting [the energy code]. Here's how you can meet it, and by the way, if you exceed [the energy] code by ten percent, we can give you incentives for lighting."'*

- This upselling process allows peer programs to consistently provide support and value to their customers by helping them achieve more energy savings. PSE can incorporate this methodology into their current project review process to help promote additional energy savings and build stronger relationships with program participants.
- In addition to upselling customers during the project review process, two peer programs (Program 2 and Program 3) mentioned **several end-uses that are successful in driving savings beyond code**. Program 2 reported that although code has become more stringent in the NW, promoting lighting measures is still the greatest opportunity for easy savings, although Program 2 did not identify any specific lighting technologies. In California, Program 3 reported they focus on controls, windows, and envelopes to help push customers beyond code. They also reported focusing on energy intensive industries such as data centers and horticulture projects that have a higher potential for energy savings. Program 2 mentioned that there is a high potential for savings through HVAC measures in indoor horticulture projects, but that owners are sensitive about what lighting they use for growing operations, as they are handling 'biological organisms.' This insight confirms PSE's efforts to target these customers and work in a very focused way to educate them about savings opportunities within their sector.
- Finally, Program 1 shared that they are moving towards a **pay-for-performance option** to help push more projects beyond code. Program 1 reported that stakeholders have been interested in a pay-for-performance option for their NCx program to simplify documentation requirements and program procedures. Program 1 believes that a performance-based approach will make the program process easier and more transparent, ultimately allowing more buildings to move beyond code. This approach is an option PSE may want to explore for future incentive offers.

Best practices to reach out to market actors early in design

The evaluation team gathered best practices on how to effectively reach out to market actors early in design. Reaching market actors before design decisions are solidified increases the opportunities for NCx programs to influence design in more impactful ways. The peers reported that hiring team members with NCx expertise, making incentives easier to understand, and ensuring the program team owns the project pipeline are several best practices to reach out to market actors early in design. The following bullets present these findings in more detail.

- Two programs (Program 3 and Program 4) **said it is important to have team members with NCx expertise**. This expertise includes having a strong background in construction, design, or green buildings. Both programs recommended having mechanical engineers on staff as well. One program said it is important to be able to perform in-house quality control on energy models to maintain consistent program requirements and maintain progress on the timeline for projects. In addition, these staff members have "a business skill set where they can influence… the design community" because they have already worked in the community and understand what drives design decision-making. PSE may want to consider this perspective when hiring new staff for the NCx program.
- In addition, Program 2 reported that through their stakeholder outreach they were told they need to focus their attention on **making their program options for incentives easier to understand for MEPs (Mechanical, Electrical, and Plumbing Engineers)** if they want to engage projects earlier in the design process. As discussed in the 'Market Actor Participation' section, MEPs play a critical role in the building design process, which is a critical part of program participation. Program 2 has not yet designed an outreach method to specifically target MEPs, however, NCx programs may have the opportunity to build stronger relationships with design teams in the area by making the incentives easier to understand for MEPs. This insight confirms PSE's MF efforts to conduct outreach to engineering teams to increase program participation.
- Peers also recommended specific outreach techniques to engage different market actors early in the design process. They reported that they experience success in reaching out to design teams through existing NCx associations. Through these outreach efforts, multiple peers engage design teams by conducting trainings, presentations and design assistance meetings with them. In addition, peers reported they effectively connect and build direct relationships with owners and developers through existing utility networks such as account executives and sales representatives. PSE may want to consider what existing NCx channels can be used for outreach activities to both owners/developers and design teams.
- The final recommendation to help engage projects earlier in the design process is to **ensure the NCx program team owns the project pipeline**. Program 4 reported that a consistent NCx team that owns the project pipeline and follow-through on projects, even when staff turnover happens, is integral to a successful program. This staff should be accountable to not letting project slip through the cracks. This recommendation is particularly important when PSE is considering methods to increase repeat participation.

Best practices to increase program participation

PSE Program staff currently estimate they are capturing 5-10% of the market, and are interested in understanding whether there are strategies others have employed to increase saturation and/or whether there are changes the program could make to increase penetration. PSE can use peer program recommendations when considering updates to program outreach and requirements. The peers reported that providing simplified program options for small buildings, simplifying energy modeling requirements, and advertising program participation benefits beyond incentives are several best practices to increase program participation. The remaining bullets provide more detail on these findings.

- Three peer programs successfully **engaged more small building projects by setting up new programs or processes with fewer participation requirements**. One program simplified the project contract, another provided good, better, best prescriptive measure options, and a third provided an express rebate program. All of these tactics allowed customers to participate with less risk and effort and also reduced the amount of review time needed by the program staff for each project. PSE may want to consider how some of their prescriptive measures could be modified to accommodate smaller projects with shorter timelines.

- In addition, Program 3 **made many of the energy model requirements for participating in the program the same as the ones required by code**. This way, the project team would only need to create one energy model, and show they are exceeding code to participate in Program 3's program. These findings suggest that PSE should continue to make energy modeling requirements in their program comply with those required by the energy code to allow customers to more easily participate.
- Finally, Program 3 recommended that PSE **advertise program participation benefits beyond incentives**. Program 3 found that owners may be incentivized to participate for two reasons other than the monetary support: one is positive public relations for the company for marketing purposes, and the second is having a trusted third-party review of their energy modeling to confirm their building design is actually energy efficient. PSE may want to include these participation benefits in future conversations with potential participants.

Appendix A: NCx Program Incentive Levels

Tables 10-14 detail the incentive levels offered by PSE and each peer NCx program. These incentives include whole building, prescriptive and design incentives.

Table 10. PSE Incentives

Type	Grant applies to	Incentive
Whole Building	Equipment and Installation	$0.30/kWh; $5.00/therm
Lighting power density reduction	All lighting	$.20/kWh above WSEC lighting compliance
Custom approach	Energy-efficient equipment that saves energy above WSEC	$0.30/kWh; $5.00/therm
MF Prescriptive	Clothes Washer	$100
MF Prescriptive	Showerhead	$15-$25

Source: Peer program websites and EMI Consulting analysis.

Table 11. Program 1 Incentives

Type	Grant applies to	Incentive
Whole Building		$0.23/kWh
Lighting	Card Key Room Control	$0.23/kWh
Lighting	Central Lighting Controls	$0.23/kWh
Lighting	Daylighting Controls	$0.23/kWh
Lighting	Occupancy Sensors (Wall/Ceiling Mount)	$0.30/$0.90/kWh
Lighting	Fixture-mounted Occupancy Sensor Retrofits	$0.23/kWh
Lighting	Fixture Removals	$0.11/kWh
Lighting	Fluorescent Lighting, Hard Wired	$0.23/kWh
Lighting	High Intensity Discharge (HID) Hard Wired	$0.23/kWh
Lighting	LED Lamp-Only Upgrades	$0.17/kWh
Lighting	T8 or T5 Lamp Removals	$0.20/kWh
Lighting	T8 or T5 Low-Watt Removals	$0.07/kWh
HVAC	HVAC Controls	$0.23/kWh
HVAC	Chillers – Water Cooled	$0.27/$0.34/kWh
HVAC	Chillers – Air Cooled	$0.20/kWh
HVAC	Cooling Towers	$0.27/kWh
HVAC	Air-to-Air Heat Pumps	$0.23/kWh
HVAC	Hydronic Heat Pumps	$0.27/kWh
HVAC	Packaged Terminal Air Conditioners (PTAC)	$0.23/kWh
HVAC	Packaged Terminal Heat Pumps (PTHP)	$0.23/kWh
HVAC	Variable Refrigerant Flow Heat Pumps	$0.24/kWh
HVAC	Economizers (Water-Side or Air-Side)	$0.23/kWh
HVAC	Air Conditioners	$0.23/kWh

HVAC	Advanced Rooftop Unit Controls	$225/ton
Data Center	Efficient Uninterruptible Power Supply (UPS) Systems	$0.12/kWh for firmware upgrade; $0.23/kWh per new UPS
Data Center	Network PC Power Management	#3/Mobile Workstation; $8/PC
Data Center	Server Virtualization	$150/server removed; Max 100
Data Center	Thin Client Conversion	$25/PC converted to thin client
Data Center	Custom IT Equipment/Software-Plug Loads	$0.07/kWh
Data Center	Air Flow Management	$0.06-$0.20/kWh
Data Center	CRAC Unit Fan Variable Speed Drives and Controls	$0.20-$0.23/kWh
Data Center	Economizers and Direct Evaporative Cooling	$0.23/kWh
MISC	Air Compressors	$0.27/kWh
MISC	Efficient Transformers	$0.27/kWh
MISC	Process Loads for Industrial Customers	$0.27/kWh
MISC	Variable Frequency Drives (VFD/VSD)	$0.27/kWh
Commercial Kitchen	Dealer Handling Rebate	$30/unit
Commercial Kitchen	Electric Convection Oven	$300/unit
Commercial Kitchen	Electric Combination Oven	$1,000/unit
Commercial Kitchen	Ice Machine – 100-500lbs. of Ice per Day	$100/unit
Commercial Kitchen	Ice Machine – Over 500lbs. of Ice per Day	$300/unit
MF Weatherization	Replace single-pane window with double-pane window	$5/square foot
MF Weatherization	Replace aluminum frame, double-pane window with double-pane window	$3/square foot
MF Weatherization	Upgrade existing wall, attic, or floor insulation	50% of the cost, up to $1/square foot
MF Appliances	Clothes Dryers, ENERGYSTAR	$50/unit

MF Appliances	Clothes Dryers, Heat Pump	$200/unit
MF Appliances	Clothes Dryers, Heat Pump Hybrid	$100/unit
MF Appliances	Clothes Washers, ENERGYSTAR	$50/unit
MF Appliances	Shower Heads	$20/unit
MF Appliances	Advanced Power Strips	$40/unit
MF Mechanical	Whole House Fans	$30/unit
MF Mechanical	Whole House Fans Flows	$10/unit
MF Mechanical	In-Unit Heat Pumps (Space Heat)	$250/ton
MF Mechanical	In-Unit Heat Pumps, CEE Tier 2	$400/ton
MF Mechanical	Hot Water Heat Pumps	$200/unit
MF Mechanical	Hot Water Heat Pumps, High COP	$350/unit
MF Lighting	In-Unit Lighting	$0.15/square foot, fixture by fixture; $0.20/square foot comprehensive

Table 12. Program 2 Incentives

Source: Peer program websites and EMI Consulting analysis.

Type	Grant applies to	Incentive
Whole Building	All systems	$0.20/kWh

Source: Peer program websites and EMI Consulting analysis.

Table 13. Program 3 Incentives

Type	Grant applies to	Incentive
Whole Building	Owners (10%); max $150,000	$0.10-$0.40/kWh, $1.00/therm + $150.00/peak kW
Whole Building	Design Team; max $50,000	1/3 of owner incentive
Lighting	Lighting Systems	$0.08/kWh $150.00/peak kW
HVAC	HVAC Systems	$0.15/kWh
Refrigeration		$0.15/kWh $1.00/therm $150.00/peak kW
Envelope Measures		$1.00/therm
Service Hot Water Systems		$1.00 / therm
Other Systems and Processes		$0.08/kWh $1.00/therm $150.00/peak kW

Source: Peer program websites and EMI Consulting analysis.

Table 14. Program 4 Incentives

Type	Grant applies to	Incentive
Design Support	Whole Building Efficiency Projects	$2,500
Design Support	Net Zero projects <20,000 sq ft	$5,000
Design Support	Net Zero >20,000 sq ft	$10,000
Design Support	Energy Studies; max $50,000	75% of cost
Whole Building	Energy Modeling Assistance; max $25,000	Minimum of 50% of approved costs for energy analysis
Solar	Solar Feasibility; max $1,700	Determine solar potential of project
Solar	Solar Ready Design; max $15,000	Build to program solar standards
Solar	Solar Installation; max $150,000	To install a solar electric system
Prescriptive	Equipment Installations	Varies based on business type

Source: Peer program websites and EMI Consulting analysis.

Appendix B: NCx Permits 2016 in PSE Service Territory

Table 15 details the new commercial and MF permits issued in 2016 by primary cities in PSE's service territory.

Table 15. Permits issued in 2016 in PSE Service Territory

City[56]	New Commercial and Multi-Family Permits issued in 2016
SEATTLE	146
TACOMA	71
BELLEVUE	48
EVERETT	20
KENT	17
RENTON	65
BELLINGHAM	46
MARYSVILLE	25
REDMOND	13
OLYMPIA	38
EDMONDS	4
BREMERTON	23
PUYALLUP	9
ANACORTES	10
AUBURN	4
BAINBRIDGE ISLAND	5
BLACK DIAMOND	2
CENTRALIA	14
CHEHALIS	5
CLE ELUM	0
DUVALL	15
ELLENSBURG	4

[56] Primary cities were identified in PSE's service territory online map: https://pse.com/aboutpse/PseNewsroom/MediaKit/1213_ServiceAreaMap_web.pdf

ENUMCLAW	0
GIG HARBOR	11
INDEX	0
KITTITAS	24
LANGLEY	0
MONROE	3
MOUNT VERNON	10
NORTH BEND	0
SHELTON	4
SEATTLE	146
TACOMA	71
BELLEVUE	48
EVERETT	20
KENT	17
RENTON	65
BELLINGHAM	46
MARYSVILLE	25
REDMOND	13
OLYMPIA	38
Total	**636**

Source: EMI Consulting analysis.

Appendix C: NCx Energy Savings Goals

Table 16 details the peer program energy savings goals for 2016 and 2017.

Table 16. NCx Annual Energy Savings Goals

Program	Sectors (C&I, MF)	Gross Electric Saving Goals (kWh)		Gross Gas Savings (Therms)	
		2016	2017	2016	2017
Program 4	C&I	C&I: 50,808,000	C&I: 55,188,000	C&I: 597,714	C&I: 946,372
Program 3	C&I	C&I: 15,893,018[57]	C&I: 11,433,425	C&I: 537,229[58]	C&I: 276,548
PSE	***C&I, MF***	***C&I: 10,108,435*** ***MF: 2,000,000***	***C&I: 6,981,030*** ***MF: 2,000,000***	***C&I: 157,500*** ***MF: 52,630***	***C&I: 165,375*** ***MF: 52,630***
Program 1	C&I, MF	C&I: 5,472,063 MF: 9,253,500	C&I: 5,472,063 MF: 9,253,500	NA	NA
Program 2	C&I, MF	C&I and MF: 3,504,000	C&I and MF: 3,504,000	NA	NA

Source: Data provided by peer programs.

[57] Projected Energy Savings

[58] Projected Energy Savings

E.4 New Construction Participant Survey Memo

To: Michael Noreika, PSE

From: Hannah Justus, Julie Scrivner, EMI Consulting

CC: Jes Rivas, Jon Strahl, Navigant

Date: November 6, 2017

Re: New Construction Participant Survey

Introduction

The evaluation team researched current program participation experiences as a part of the process evaluation of the Puget Sound Energy (PSE) New Construction (NCx) program. This memo presents results from the participant online survey.

The objective of this research was to understand which program processes are working and which ones could be improved. To conduct this research, the evaluation team collected feedback on sources of program awareness, motivations and influences for program participation, barriers to program participation and participant satisfaction. We fielded an online survey with 34 program participants in the Fall of 2017. In addition, the evaluation team conducted in-depth interviews with four horticulture-related participants with a number of the same questions.

This memo presents the key findings of the research, an overview of the respondents, and detailed in-depth interview discoveries. Detailed findings about program processes are organized into sections covering program awareness, motivations and influences, barriers, and satisfaction.

Key Findings from Participant Survey

Key findings summarized in this section are organized by program awareness, motivations and influences, barriers, and satisfaction.

The ideal timing for learning about the program is no later than the conceptual design stage of a project (preferred by 88% of respondents). For the participants who became aware of the program at a later juncture, a strong majority (83%) would have liked to have learned about it earlier. Across half of the projects, PSE was engaged later in the conversation, after the schematic design stage (53%). Finding the means for building earlier awareness should become an important priority for NCx.

Professional networks and email are likely to be effective outreach channels. More participants (29%) learned about the program through established connections than through other channels; these established connections included their employer, a project team member, and word of mouth. However, participants indicated a preference for email for information on energy efficiency design incentives. Considering the importance of direct connections within the NCx sector, PSE may want to create a multi-pronged marketing approach – pairing email outreach with direct contact from program staff.

Many participants already planned on building beyond code, but not to the degree that they did with the PSE incentives. The evaluation team found that for 32% of respondents, nothing would have kept them from pursuing an energy efficient design. In addition, 75% of respondents claimed they would have exceeded code, even without the PSE incentive. Nonetheless, the program influenced most (79%) to construct more efficient projects than they would have otherwise.[59] This suggests that the program's potential to move the new construction market is significant, when the awareness barrier is removed.

The large majority of participants (90%) installed high efficiency equipment because of operational savings. The second-most reported motivation was reduced environmental impact (42% of respondents). Only six respondents marked PSE's incentive as one of the primary motivations for including energy efficiency equipment in the design. PSE may want to include marketing material that emphasizes information about operational savings and environmental benefits to attract like-minded customers in the future. These findings are supported by educational recommendations from respondents in the market actor research.

For participants who don't always build beyond code, money is the largest barrier. For 32% participants, investment in energy efficient designs without the PSE incentive would not have been cost-effective or the payback period would have been too long. In addition, when participants don't submit their other eligible projects to the program, it is because the incentive is too small or because they are unsure if the project qualifies. This finding further suggests that information about operational savings should be included in marketing material to explain long-term financial benefits. In addition, if outreach focus is moved earlier, it may help address this barrier as well, as there will be a greater opportunity to impact whole building design, rather than individual elements. If cost is still a barrier when PSE intervenes early in the design process, PSE may want to consider varied incentive structures, such as offering a higher incentive for certain markets depending on customer size or the opportunity for repeat participation if it is the customer's first project with PSE.

Horticulture participants are motivated to pursue energy efficient designs when they see other facilities successfully doing so as well. The evaluation team found that two horticulture respondents were specifically motivated to include LED lighting in their facilities by touring another horticulture facility with LEDs and seeing the healthy growth achieved under LED lights. The respondents were originally unsure about participating in the program because they worried that their product quality might be poorer with LED lighting. One participant did a side-by-side test during the tour and saw better production results with LED lights. To increase LED adoption within the horticulture segment, PSE may want to communicate results like these to these businesses and their design teams.

Respondents

The evaluation team targeted getting feedback from 38 previous participants, including 4 horticulture-focused projects. We fielded an online survey for 34 participants, and conducted in-depth phone interviews with the 4 horticulture projects. The evaluation team emailed previous participants to complete the online survey and received 11 responses. In order to reach the targeted 34 non-horticulture participants, the evaluation team also used a survey house to call previous participants and have them complete the same survey via the phone.

[59] These percentages are based on the number of participants (24) who knew the level of efficiency their building would have achieved without the PSE incentive.

Contact Lists

The evaluation team received general customer contact information from PSE along with a list of previous participants.

Online Survey

To build the email list for the online survey, the evaluation team first combined the customer contact information with the program participation data. The evaluation team then removed duplicate email records. Finally, the evaluation team pulled out all records associated with a horticulture project. The unique email addresses for non-horticulture participants were emailed once with the survey and then reminded four times to complete the survey. Eleven previous participants completed the online survey.

Survey House

To build the calling list for the Navigant survey, the evaluation team first pulled out all the participants associated with a horticulture project. The team then removed participants with bad telephone numbers, and combined participant records with duplicate phone numbers. The evaluation team removed all participants that completed the online survey or with whom the evaluation team had communicated via email. The evaluation team finally removed all participants who had participated in the market actor interviews.[60] The survey house filled out the online survey for 23 previous participants.

Horticulture In-depth Interviews

The evaluation team conducted interviews with horticultural participants to meet specific impact-related research objectives. As a part of that process, horticulture-related respondents were also asked a number of questions from the participant survey. Because the interviews were focused on impact, the evaluation team highlighted only key questions from the participant survey.

[60] The evaluation team provided a memo to Puget Sound Energy on market actor interview results on October 17, 2017.

NCx Project Role

As shown in Table 1, the majority of the 38 respondents consisted of property owners/owner's representatives (22) and project managers (7).

Table 1. Respondents' Role on NCx Projects

Role on NCx project	Number of Respondents
Property owner/Owner's representative	22
Project Manager	7
Engineer	2
Facilities Manager	1
Sustainability Manager	1
Developer	1
Contractor	1
Tenant	1
Accountant	1
I don't know/Not Sure	1
Total	**38**

Source: EMI Consulting analysis.

Detailed Findings

The following sections outline the detailed findings from the participant survey and summarize data on sources of awareness, motivations and influences, barriers, and satisfaction.

Sources of Awareness

The evaluation team asked the participants a series of questions about their program awareness and preferred outreach methods to help inform PSE on how it can most effectively utilize marketing channels for targeted outreach. We found the following three high-level findings:

- The highest reported source of awareness for the program was through established connections (11), which includes their employer, a project team member, and word of mouth.
- The most preferred outreach channels were email (15) and local planning/permitting offices (6).
- Participants reported the ideal time to discuss energy efficiency with customers is before starting the project through the conceptual design stage (30).

This section presents these findings in more detail and summarizes data on program awareness, preferred outreach channels, and timing for program engagement.

Program Awareness

The highest reported source of awareness for the program was through established connections (11) such as an employer, a project team member, or word of mouth. This finding supports the finding in the market actor research that relationships and direct connections within the NCx community help drive program participation. PSE may want to focus future outreach efforts on these influential channels and find ways to expand these contacts. In addition, PSE can use the other sources of awareness outlined in Table 2 as opportunities to build new connections.

Table 2. Sources of Awareness

Source of Awareness[61]	Number of Respondents
Established Connections (Employer, project team member, word of mouth)	11
A Puget Sound Energy representative or event	5
Conservation-related group	5
Online	4
Puget Sound Energy advertisement	3
A construction-related trade group, organization, or company	3
A municipal permitting agency or Business services department	2

Source: EMI Consulting analysis.

Preferred Outreach Channels

Considering the importance of direct connections within the NCx sector, PSE may want to consider combining an email outreach with direct follow-ups from program staff. While email was the most preferred outreach channel for information on energy efficiency design incentives (cited by 15 respondents), participants also reported local planning/permitting offices, NCx associations, and contractors as their preferred outreach channels. Specific organizations through which participants learned about the program were Sustainable Connections, King Conservation District and Community Green Build Workshop. With respect to the new construction associations, respondents most often the following organizations: Architects Institute of America (24%), Master Builders Association (24%), Built Green (18%), Commercial Real Estate Development Association (18%) and Urban Land Institute (15%). PSE should explore opportunities to have these associations include NCx program information in their own email communications as well as other association-sponsored outreach. Participants also mentioned the PSE website, PSE newsletters, and bill inserts as useful marketing channels which can be helpful in program communications.

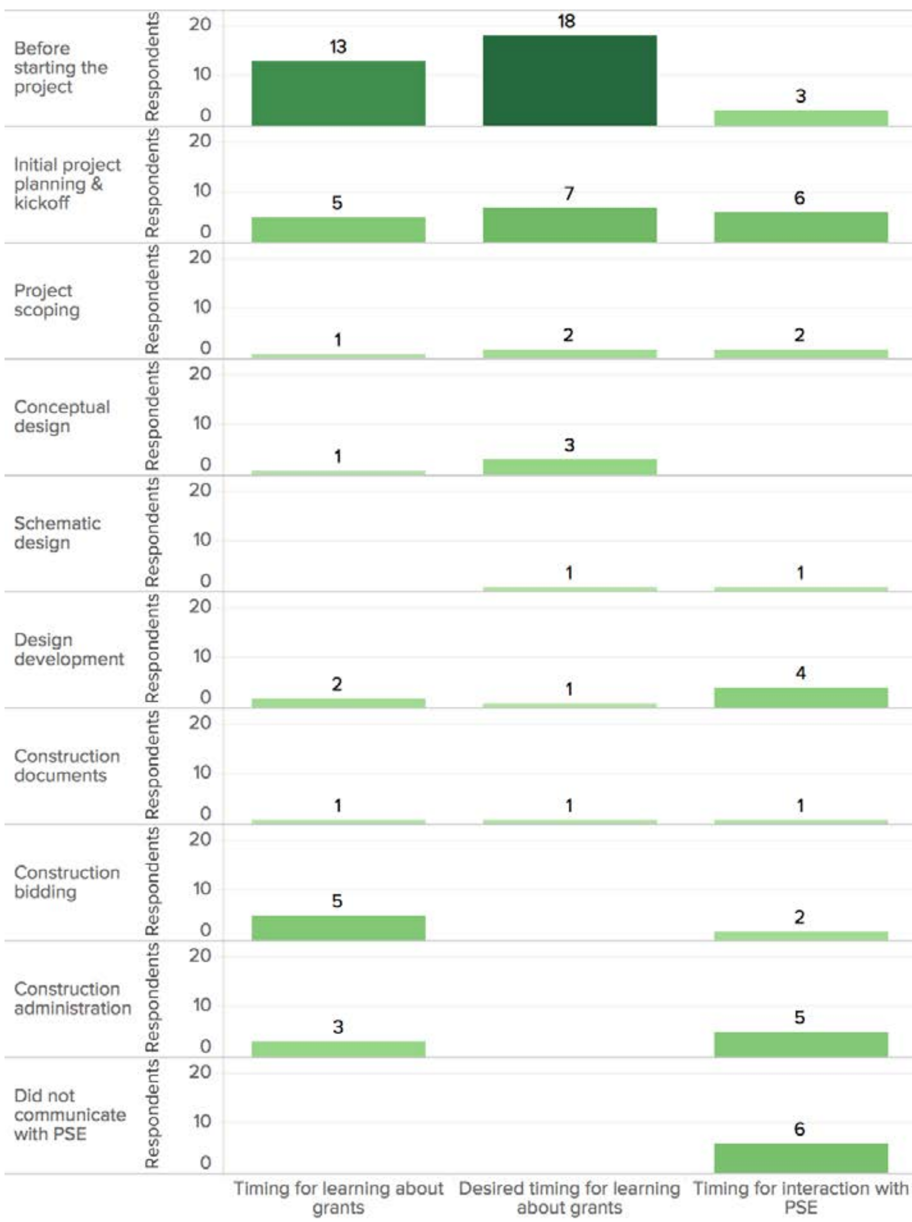
Timing for Program Engagement

According to most respondents (88%), the ideal time to learn about incentives is before starting the project through the first desingn stage, conceptual design. This supports the findings in the market actor research and peer program research that the ideal timing for engagement is early in the design process. As shown in Figure 1, not all participants learned about the program or interacted with PSE early in the

[61] Four respondents were not sure where they learned about the PSE NCx program.

design process, suggesting there may be an opportunity for greater impact by interacting with customers earlier in the process.

Figure 1. Timing for Program Interactions



Source: EMI Consulting analysis.

As shown in Figure 1, thirteen of the respondents (38%) knew about the incentives before starting the project and five participants learned about the incentives during the initial project planning and kickoff stage (only the non-horticulture participants were asked this question). This demonstrates that PSE already reached more than half of the respondents during the ideal engagement time. However, 35% participants learned about the program after the conceptual design stage and 38% of these participants would have preferred to learn about the program before the conceptual design stage. This challenge reinforces the importance of creating robust communications channels through permitting offices, contractors, and trade associations, where there is a greater possibility of the information reaching the project decision-makers early on.

Motivations and Influences

The evaluation team asked participants about what motivated them to pursue energy efficient designs to inform future marketing material. We found the following three high-level findings:

- More than half of respondents reported the property owner/owner's representative as both the most influential person on the project team for pursuing incentives (53%) and also the person who ultimately decided to pursue incentives (63%).
- Operational savings was the most reported motivation for pursuing energy efficient designs (89%).
- Two horticulture projects toured a facility and saw that product quality was not impacted by LED lighting.

This section presents these findings in more detail and summarizes data on influencers in NCx and participation motivations.

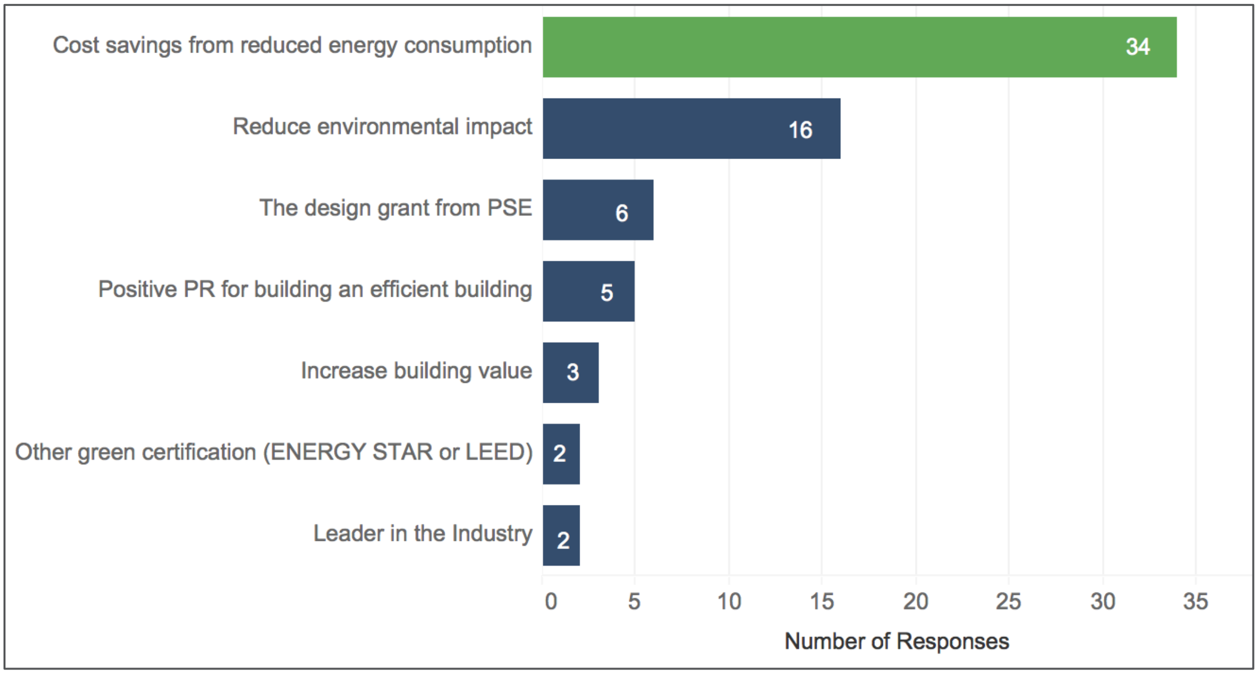
Influencers in NCx

More than half of respondents reported the property owner/owner's representative as both the most influential person on the project team for pursuing incentives (53%) and also the person who ultimately decided to pursue incentives (63%). Both the participant interviews and the market actor research found that, for most projects, the owners make the final decision to pursue design incentives. However, in the market actor interviews, the evaluation team found that the design team, which includes architects and engineers, also influences property owners in their decisions to pursue design incentives. In the program participant interviews, only one respondent reported the engineer as influencing the project team to pursue incentives and no respondents reported the architect. This suggests there is an opportunity for PSE to conduct direct outreach to design teams to help influence owners that are not already involved in the program (this market approach is discussed more in the Program Awareness section).

Participation Motivations

The evaluation team asked respondents to identify their reasons for participating in the NCx program. As shown in Figure 2, more participants reported operational savings as the primary motivation for including energy efficient equipment in new construction projects (89%) over any other factor. The second most reported motivation, reduced environmental impact, was reported less than half as frequently (42%), and other factors were far less influential. These findings are supported by educational recommendations from respondents in the market actor research and suggest that ongoing benefits are the most influential considerations for many participants. PSE may want to include marketing material that emphasizes information about operational savings and environmental benefits to attract like-minded customers in the future. Below, we present additional motivations across all participants, followed by unique findings related to horticulture participants.

Figure 2. Motivations and Influences for Pursuing Energy Efficient Design



Source: EMI Consulting analysis.

The data also clearly document that the PSE incentive did allow some participants to afford more expensive energy efficiency equipment that otherwise would not have been installed. Feedback on how the incentive helped some participants follows below:

- *"The credits allowed us to install more expensive components that would not have been affordable without the credits."*
- *"The funds from PSE [were key]; without them, the upgrade would not have happened...we did not have [sufficient] funds without this program."*

These quotes demonstrate that, for some customers, without the PSE incentive the upfront cost would have been prohibitive to pursuing more efficient equipment. To reach similar customers in the future, PSE may also want to prominently emphasize the available incentives in its program marketing materials.
In addition to monetary motivations, five participants reported 'Positive PR for building an efficient building' as a motivation for pursuing energy efficient equipment. The evaluation team included this motivation as an option in the survey in response to input from one of the peer programs who shared that, for some owners, while the incentive is negligible compared to project costs, this non--incentive motivation does have an impact on their decision-making in the design process. One interviewee explained how they intended to use the positive PR:

- *"We wanted to have a high efficiency building to market to tenants that it is energy efficient – to reduce their costs, add value to the building…and being environmentally conscious is a company goal."*

This quote demonstrates that some building owners would consider pursuing energy efficient upgrades if doing so would increase the appeal of the building to potential tenants.

The evaluation team also found that two horticulture respondents were specifically motivated to include LED lighting in their facilities after touring another horticulture facility with LEDs and seeing the healthy growth achieved under LED lights. The respondents were originally unsure about participating in the program because they worried that their product quality might be poorer with LED lighting. During the tour, however, one participant did a side-by-side test and saw better production results with LED lights. This suggests PSE could increase LED adoption within the horticulture segment by communicating similar results to these businesses and their design team.

Barriers

The evaluation team asked the participants a series of questions about potential barriers to pursuing energy efficient designs without the PSE incentive to better understand PSE's current impact and how the utility could foster greater adoption of energy efficient designs. We found the following high-level findings:

- The program influenced most participants (79%) to construct more efficient projects than they would have otherwise; 21% would have done nothing differently with respect to efficiency.
- More than a third of participants (37.5%) would have still moderately or significantly exceeded code without the program, but not to the degree undertaken under the program.
- Almost a third of participants (32%) always pursue energy efficient designs, however, for another 32% of respondents, investment in energy efficiency beyond code would not have been cost-effective without the PSE incentives or the timeline for payback would have taken too long.
- When participants don't submit eligible projects to the program, it is because the incentive is too small or because they are unsure if the project qualifies.

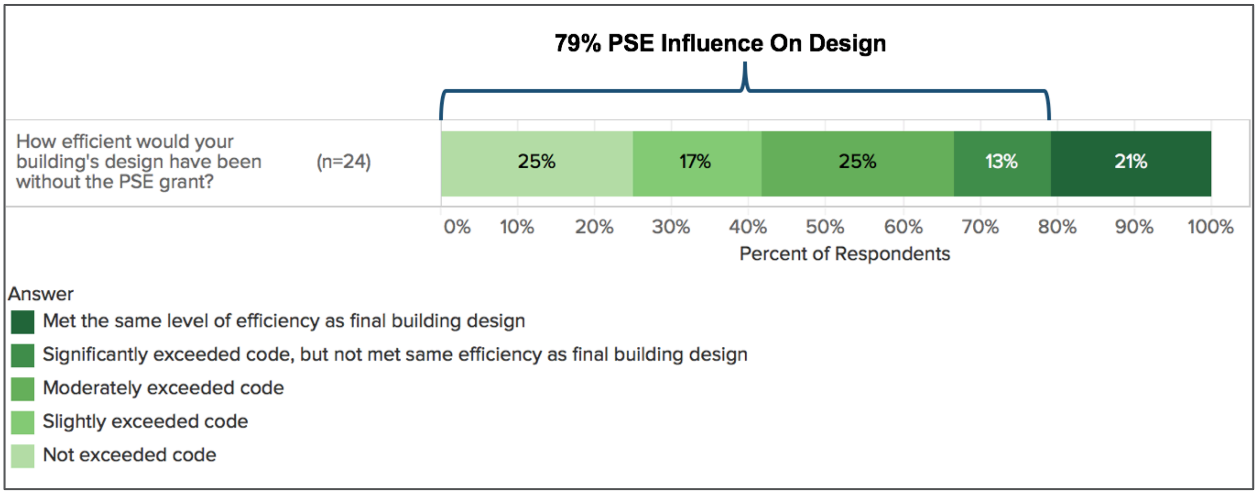
This section presents these findings in more detail and summarizes data on efficiency of design without incentive, barriers without PSE incentive, and barriers for other projects.

Efficiency of Design without incentive

The incentives from PSE influenced most participants (79%) to construct higher efficiency projects. That being said, of the participants who knew, 54% would have still exceeded code by some extent without the program. On top of that, 21% participants would have met the same level of efficiency as the final building design.[62] This finding suggests that the PSE program offers incentives that allow programs to exceed energy code and will allow customers to continue to exceed the energy code as code becomes more stringent. In addition, this suggests there is an opportunity to focus PSE resources on identifying and marketing to potential participants that are not already planning on exceeding code.

[62] These percentages are based on the number of participants (24) who knew the level of efficiency their building would have achieved without the PSE incentive.

Figure 3. Efficiency of Design without PSE Incentive

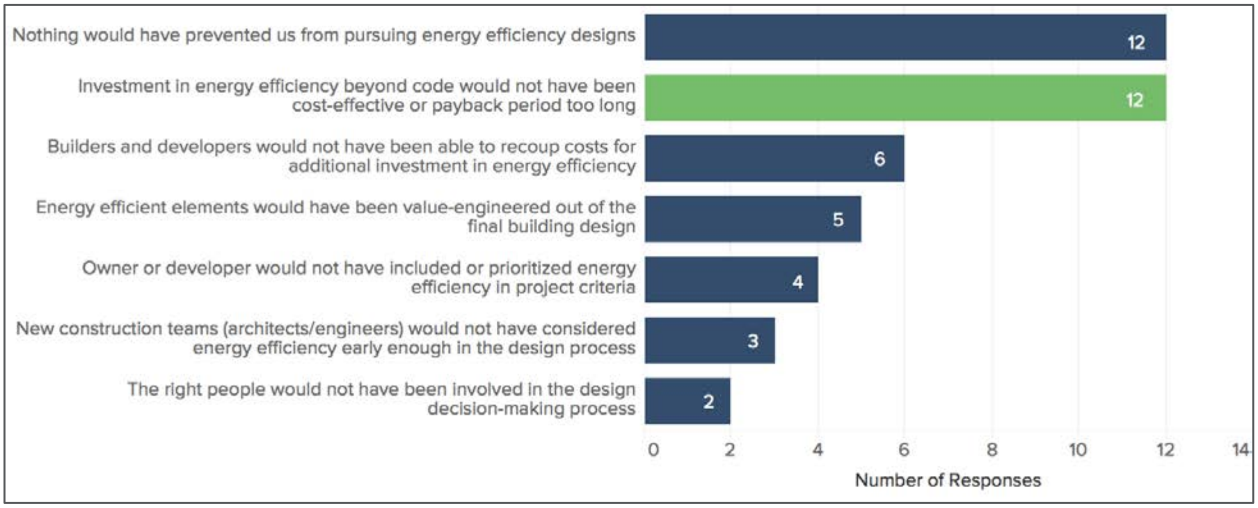


Source: EMI Consulting analysis.

Barriers without PSE incentive

The evaluation team found the PSE incentive had a wide range of impact on a participant's ability to pursue energy efficient designs. This section first discusses the data on monetary barriers in more detail and then discusses non-monetary barriers.

Figure 4. Barriers to Energy Efficient Design without PSE Program



Source: EMI Consulting analysis.

As shown in Figure, for 32% of participants the investment would not have been cost-effective or the payback period would have taken too long, for 13% of participants the energy efficient elements would have been value-engineered out to save money, and for 10% of participants the builders and developers would not have been able to recoup costs for the additional investment in energy efficiency. These findings emphasize the importance of cost-effectiveness when making decisions around energy efficient equipment and designs.

Participants also reported several non-monetary barriers: 11% of participants would not have included or prioritized energy efficiency in project criteria, 8% of new construction teams would not have considered energy efficiency early enough in the design process, and for 5% of participants the right people would not have been involved in the discussion. These findings emphasize the importance of the PSE program for driving conversations around energy efficiency design with the right people early enough in the design process to make an impact on design.

Barriers for Other Eligible Projects

The evaluation team gathered information relating to barriers from respondents who did not enroll some or all of their projects in the NCx program. Respondents reported varied reasons for not participating in the PSE program on other eligible projects. Of the respondents who have been involved in other eligible new construction projects, more than half reported that all of their eligible projects have received design incentives from PSE. When participants don't submit their eligible projects to the program, it is either because the incentive is too small or because they are unsure if the project qualifies. These findings reinforce the findings in the market actor research that money is a barrier to program participation. However, they also indicate that lack of familiarity with program details is suppressing participation levels.

Satisfaction

The evaluation team asked respondents about their satisfaction and experience with the program to gain a better understand of current participant experiences. We found the following three high-level findings:

- The majority of customers reported they were satisfied with each program element, however there are opportunities to increase satisfaction across all program elements.
- Almost half of the participants did not experience any challenges (47%). For those who did, respondents reported the following challenges: poor communication from PSE (21%), cumbersome paperwork (15%), long program timeline (15%), and difficult energy analysis requirements (12%).
- Participants reported PSE could improve program processes by using better calculation formulas, increasing PSE staff numbers, communication, and support—all of which would help decrease the project timeline.
- When asked what else PSE could do to improve their program, six respondents recommended an increase in effective marketing.

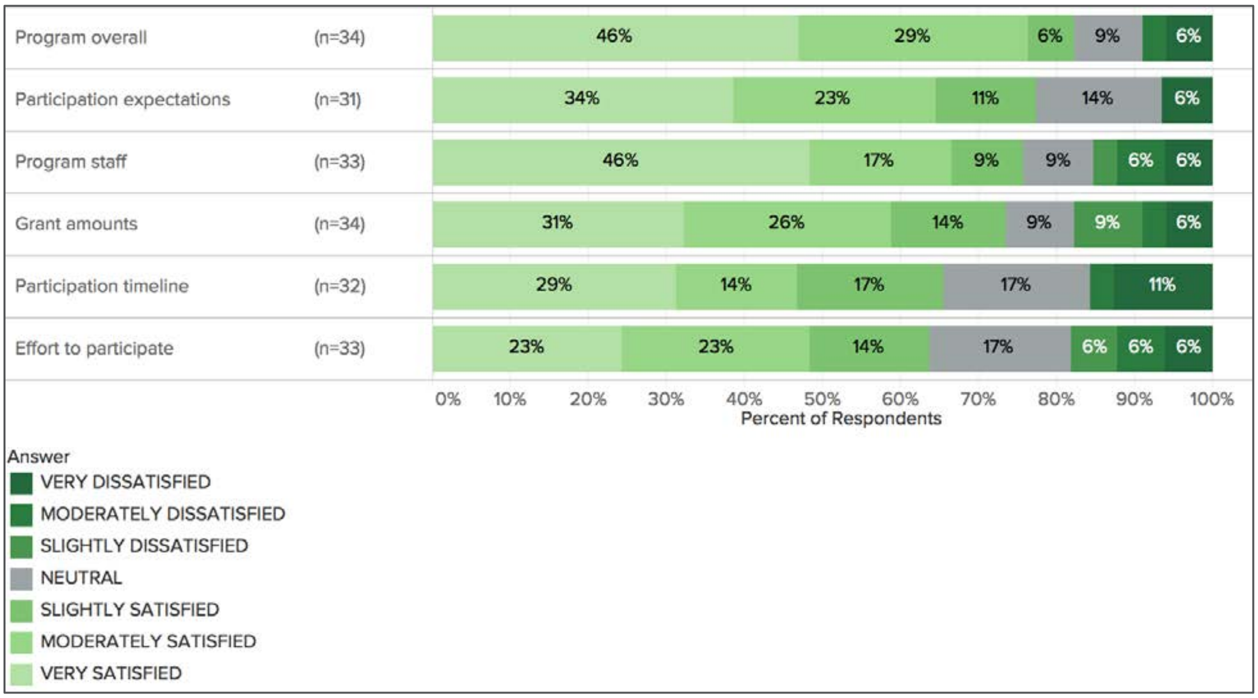
This section presents these findings in more detail and summarizes data on program satisfaction rankings, program participation challenges, and recommendations from respondents.

Program Satisfaction Rankings

Customer satisfaction ratings were positive on all investigated program elements and on the program experience overall. In addition, 83% of respondents have already or are likely to recommend the program to others. However, there are opportunities to increase satisfaction across all program elements. PSE can use information on dissatisfaction with program elements to inform future program changes to help increase both satisfaction and the number of people who recommend the program to other market actors. This section presents satisfaction rankings, followed by a recommendation to provide program rankings. As shown in Figure 5, although most participants were satisfied with their experiences, more than 10% of participants reported dissatisfaction with the level of effort required to participate (18%), the participation timeline (15%), and incentive amounts (18%). One disgruntled participant noted extreme dissatisfaction with all program elements and stated:

- *"No I think I have said enough, I would be open to a face to face talk with PSE ...as a contractor I have seen so many other contractors who just walk away from this program ...I have been doing this for 35 years and I could give them a lot of feedback if they wanted."*

Figure 5. Satisfaction with Program Elements



Source: EMI Consulting analysis.

The evaluation team also asked participants how likely they are to recommend the program. The majority are inclined to do so: 24% respondents have already recommended the program and 59% respondents are extremely, very, or slightly likely to recommend the program. As discussed in the Program Awareness section, established connections—including word of mouth—were the highest reported sources of information about the program, making this willingness to recommend the program important to building future awareness and, potentially, participation.

Program Participation Challenges

Almost half of the participants reported no challenges to participating in the NCx program (47%). For those who did, respondents reported the following participation challenges: poor PSE communication (21%), cumbersome paperwork (15%), long program timeline (15%), and difficult energy analysis requirements (12%). PSE can use this information to inform program improvements to increase satisfaction. This section discusses these findings in more detail.

- **Timeline:** Participants expressed that the timeline was too long (2), the incentive process was unclear (1), the checks came a year after a building was closed out (1). These insights suggest that the timing for program stages is unclear and PSE staff shortages (1) may increase project timelines.
- **Communication:** Participants expressed that there was poor communication from PSE staff (2), one PSE representative was very busy (1), one participant had to go through customer service first to talk with PSE, and it was a challenge getting everyone on the same page (1). These insights suggest the communication process and communication expectations between PSE staff and participants are undefined.
- **Paperwork/Energy Analysis:** Participants felt there was too much paperwork (2) and that the paperwork was difficult to understand (1), it was a challenge to have the time and resources to do a study before the project (1), and it was too much effort to participate (1). In regard to the energy analysis, participants expressed the calculations and energy analysis were difficult (2). These findings imply that some participants may not be set up for success for filling out participant paperwork. In fact, one interviewee shared they would not have been able to do the paperwork without the PSE staff's support. Their insight is below:
    - *"Too much paperwork but [programs staff] was so helpful. We would never have accomplished it without his help with the paperwork"*
- As discussed with the communication and timeline challenges, some participants found that the PSE staff were very busy or even understaffed. If the paperwork is too difficult to fill out without the PSE staff and there is a shortage of PSE staff support, timelines will most likely stretch out, making participation in the program more challenging.
- **Monetary:** Two participants also felt they had received minimal monetary amounts. These findings suggest that these participants perhaps did not fully understand their potential for incentives from the beginning of the project. On the other hand, two other participants' actual incentives were much smaller than their estimated incentives. This emphasizes the importance of accurate expectation setting and savings calculations when making incentive estimates.

Recommendations from Respondents

Participants reported PSE could improve program processes by using better calculation formulas, increasing PSE staff numbers, communication, and support, all of which would help decrease the project timeline. Participants also recommended more and larger incentives. Finally, participants recommended PSE market the NCx program more. This section discusses these findings in more detail. The evaluation team will assess these recommendations when compiling the final report and evaluation recommendations.

- **Communication:** Participants recommended PSE increase staff communication (2) and improve PSE coordination with contractors (2).
    - **Increase Staff Communication:** Participants recommended PSE improve communication and follow-up, and hire more staff (2). Increasing staff communication may improve participant satisfaction with other program elements if participants are able to speak directly with PSE staff, better understand how the program process works, and how to complete program requirements. This finding is supported by the market actor

research, in which market actors reported they appreciated the opportunity to speak directly with PSE staff.

- **Improve PSE Coordination with Contractors:** In addition, two participants recommended PSE increase its coordination with recommended contractors. One participant could not find the contractor's direct phone number on the PSE website. They found it inconvenient to have to call another number on the PSE website in order to get the contractor's number. This insight emphasizes the importance of making it easy for participants to quickly get information about the program.

- **Paperwork/Energy Analysis:** Participants recommended PSE implement better calculations (2) and involve staff with more expertise (2).
    - **Use Better Calculations:** Participants (2) recommended PSE improve calculations and make them easier to complete. One participant shared that the savings calculations offered by COSTCO are much easier to understand than the ones offered by PSE. Another participant reported that PSE must develop accepted formulas for comparison of systems to better recognize changes in systems from one system to the next. For example, provide customers the ability to easily calculate the difference between 1969 electric equipment to any type of modern system by square feet. These findings suggest that the savings calculations offered by PSE could potentially be more transparent and straightforward.
    - **Involve staff with more expertise:** Two respondents expressed that once they got above the 'normal' PSE staff, their experience improved. This finding is supported by the peer research which recommended having individuals on staff with specific NCx expertise.
- **Project Timeline:** Participants requested a faster timeline (2), payout (2), and a project timeline tracker (2).
    - **Faster timeline/Payout:** Four participants specifically recommended a faster timeline and payout. Improving staff communication and making the energy analysis easier to complete may lead to a shorter timeline.
    - **Provide Project Timeline Tracker**: One participant recommended PSE provide a project timeline tracker. This recommendation was also provided in the market actor research. Increased visibility into expected project timeline deadlines and schedules may allow participants to anticipate any barriers that arise and overcome them easier.
- **Incentives:** Participants recommended PSE provide better savings information (1), more money/incentives (4) and specifically an HVAC incentive for horticulture projects (3).
    - **Provide Better Savings Information:** Two participants received smaller incentives than they had initially expected. One participant recommended providing better upfront information about savings opportunities. Setting expectations correctly from the start will allow customers to better decide whether to participate or not. This finding is supported by the market actor research, which recommended providing more online tools for savings estimates.
    - **Provide More Money/Incentives:** 4 participants recommended providing more money and incentives. This finding is also supported by the market actor research. PSE may want to consider what types of incentives would allow more customers to more easily participate by overcoming the initial monetary barrier.

    - **Provide HVAC Incentive for Horticulture projects:** Three horticulture companies expressed they would like to see PSE incentivize efficient cooling (HVAC) equipment. One horticulture participant currently does not use HVAC because it costs too much in their facility.

- **Increase Marketing:** When asked what else PSE could do to improve their program, six respondents recommended an increase in effective marketing. This question was focused on general program improvements, and these participants expressed it was important for customers to know this opportunity is available.

PSE PUGET SOUND ENERGY

Program(s):

- Conservation Voltage Reduction

Program Year(s):

- 2016

Contents:

- Evaluation Report
- PSE Evaluation Report Response

This document contains Puget Sound Energy's (PSE) Commercial and Industrial (C&I) New Construction Program Evaluation Report and Evaluation Report Response (ERR). In accordance with WUTC conditions, all PSE energy efficiency programs are evaluated by an independent, third party evaluator.[1] Evaluations are planned, conducted and reported in a transparent manner, affording opportunities for Commission and stakeholder review through the Conservation Resource Advisory Group (CRAG) and reported to the UTC.[2] Evaluations are conducted using best-practice approaches and techniques.[3]

PSE program managers and evaluation staff prepare an ERR upon completion of an evaluation of their program. The ERR addresses and documents pertinent adjustments in program metrics or processes subsequent to the evaluation.

Please note that this is an evaluation of the program as it operated during the 2016-2017 program years, and does not necessarily reflect the program as currently implemented, or measures currently deployed by the program.

This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx**

[1] (6)(c.) Approved Strategies for Selecting and Evaluating Energy Conservation Savings, Proposed Conditions for 2016-2017 PSE Electric Conservation.

[2] PSE 2016-2017 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised August 6, 2015.

[3] Ibid.

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Evaluation Report Response

Program:	Conservation Voltage Reduction
Program Manager(s):	Lionel Metchop
Study Report Name:	Evaluation of the Energy Savings Impacts of PSE's Conservation Voltage Reduction Program
Primary Author(s):	Michael Noreika (Puget Sound Energy)
Report Date:	December 2017
Evaluation Analyst(s):	Michael Noreika
Date of ERR:	January 2018

Evaluation Overview, Key Findings, Recommendations and Program Responses:

I. Context

Puget Sound Energy's (PSE) Conservation Voltage Reduction (CVR) program demonstrates pro-active compliance with I-937 obligations. I-937 is an initiative requiring utilities in Washington to achieve an energy portfolio of 15% renewable energy and to "undertake cost-effective energy conservation." Although CVR energy savings are reported in PSE's Biennial Conservation Plans, PSE does not allocate a Conservation Rider budget for the program.

CVR is a program where the distribution line voltage at a substation is set at a more efficient level while staying within the required customer voltage limit defined by the ANSI Standard range of 114V to 126V. Historically, the practice has been to set the voltage on the higher end of the range in order to safeguard the end-of-line (EOL) voltage. However, advancements in voltage optimization allows utilities to lower the voltage and remain securely within the range.

This report includes an evaluation of the 2016 energy savings reported by the CVR program.

II. Conclusions, Recommendations, and PSE Responses

A. Overall Performance

For the 2016 program period, the PSE CVR program achieved 93.5% of the reported energy savings as shown in Table 1. PSE used the best available data at the time of the reported energy savings calculation. However, since the time the savings were reported, more recent data concerning residential customer load characteristics became available. The updated load characteristics led to a change in one of the energy savings parameters, which ultimately reduced the evaluated energy savings compared to the reported.

Table 1. Reported vs. evaluated savings for 2016 CVR projects.

Project (Substation Name)	Reported Energy Savings (MWh)	Evaluated Energy Savings (MWh)	Realization Rate†
Hazelwood	1,352.1	1,259.4	93.1%
Panther Lake	804.3	750.7	93.3%
Pine Lakes	1,163.2	1,095.4	94.2%
Total	3,319.6	3,105.5	93.5%

† Realization rate is the evaluated energy savings divided by the reported energy savings.

B. Recommendations and PSE Responses

- **Recommendation:** PSE should continue to use the RTF protocol, but PSE should update the energy savings calculation methodology for future CVR projects to incorporate the most recent residential load characteristics data completed in 2017. Specifically, PSE should change:
    - Percentage of existing residential class consumers that have electric heat from 28.0% to 35.7%
    - Percentage of existing residential class consumers that have any type of electric air conditioning from 25.0% to 27.3%

  PSE Response: PSE will update the analysis calculation methodology to incorporate the new data.

Evaluation of the Energy Savings Impacts of PSE's Conservation Voltage Reduction Program

December 15, 2017

Analysis and Report by:

Michael Noreika

PSE PUGET SOUND ENERGY

Table of Contents

I. Executive Summary

A. Evaluation Context

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Recommendation: PSE should continue to use the RTF protocol, but PSE should update the energy savings calculation methodology for future CVR projects to incorporate the most recent residential load characteristics data completed in 2017. Specifically, PSE should change:

- Percentage of existing residential class consumers that have electric heat from 28.0% to 35.7%
- Percentage of existing residential class consumers that have any type of electric air conditioning from 25.0% to 27.3%

II. Introduction

A. Program Description

PSE first researched the relationship between CVR also known as Voltage Optimization (VO), and energy savings in 1983. In 2006, PSE and 13 other Pacific Northwest utilities participated in the Distribution Efficiency Initiative (DEI) managed by Northwest Energy Efficiency Alliance (NEEA). The DEI study was intended to quantify the effects of power consumption in relation to the applied voltage or CVR. The results of the 2007 NEEA study conclusively showed that operating a utility distribution system within the lower half of the acceptable voltage range (120-114 volts) saves energy, reduces demand, and reduces reactive power requirements without negatively impacting the customer. The results of energy savings are within expected values of one to three percent total energy reduction, two to four percent reduction in kW demand, and four to ten percent reduction in kilovolt amperes-reactive (kvar) demand. Computer model simulations showed that by performing selected system improvements, between 10 and 40 percent of the total energy savings occurs on the utility side of the meter.

PSE CVR projects are implemented at selected electric substations. These projects are completed without the assistance of conservation funding, and thus the projects are completed on the timeline of the transmission and distribution (T&D) department of PSE. The energy management engineers are engaged in a reactive manner and determine energy savings for completed projects.

a) Reported Program Achievements (2016)

As shown in Table 2, PSE reported energy savings for three CVR projects in 2016. The projects were implemented in the summer of 2015

Table 2. Summary of CVR program achievements as reported, 2016.

Project (Substation Name)	Reported Energy Savings (MWh)	Project Cost	Implementation Period
Hazelwood	1,352.1	$14,241	Aug-2015
Panther Lake	804.3	$15,573	Aug-2015
Pine Lakes	1,163.2	$9,397	Sept-2015
Total	3,319.5	$39,211	

Source: Analysis of completed CVR projects provided by program staff.

III. Impact Evaluation Findings

A. Reported Savings Methodology

The program relies on the Simplified VO M&V Protocol published by the Regional Technical Forum (RTF).[1] The protocol was approved for use in 2010 and deactivated in 2015. The measure was deactivated as a result of the RTF subcommittee decision that the value of the protocol did not sufficiently justify the necessary resources for proving and maintaining the protocol. However, the RTF agrees that the protocol as published remains a practical method for determining energy savings associated with CVR. Through its review of the calculations, PSE evaluation staff confirmed the correct use of the RTF protocol.

Equation 1 shows the algorithm used in the RTF protocol for each feeder.

Equation 1. Energy savings algorithm used for reported savings calculation.

$$Energy\ Savings_{substation} = \sum_{feeder} \left\{ E_{annual} \times VOf \times \frac{V_{oc} - V_{cvr}}{V_{oc}} \right\}$$

E_{annual} = Annual energy load
VOf = Voltage optimization factor provided in protocol tables
Voc = Average substation voltage before CVR implementation
Vcvr = Average substation voltage after CVR implementation

a) Substation and Feeder Annual Energy Load

Energy consumption data were obtained for the feeders associated with each substation. The data were aggregated by rate category and categorized as Residential, Small Commercial, Large Commercial, and Mix (Residential and Agriculture). Table 3 shows the feeders associated with each substation. The RTF protocol is valid only for feeders that have a majority of residential and small commercial loads. Therefore, PIN-17 was excluded from the reported savings and evaluated savings.

[1] https://rtf.nwcouncil.org/subcommittee/automated-conservation-voltage-regulation-cvr-and-voltage-optimization

Table 3. Substation and feeder energy consumption data and load class (July 2014-June 2015).

Substation	Feeder	Energy Consumption (MWh)	% Residential Load	WECC Load Class†	Included in Energy Savings?
Hazelwood	HAZ-12	30,993	54.9%	MIX	TRUE
Hazelwood	HAZ-13	12,658	86.7%	RES	TRUE
Hazelwood	HAZ-15	21,637	64.4%	MIX	TRUE
Hazelwood	HAZ-16	28,301	89.5%	RES	TRUE
Panther Lake	PAN-12	6,021	90.9%	RES	TRUE
Panther Lake	PAN-13	10,927	87.2%	RES	TRUE
Panther Lake	PAN-14	13,721	85.0%	RES	TRUE
Panther Lake	PAN-15	19,591	85.4%	RES	TRUE
Panther Lake	PAN-16	13,208	82.9%	RES	TRUE
Pine Lakes	PIN-17	7,019	35.9%	MIX	FALSE
Pine Lakes	PIN-23	20,746	75.2%	RES	TRUE
Pine Lakes	PIN-25	20,664	83.7%	RES	TRUE
Pine Lakes	PIN-26	22,654	91.9%	RES	TRUE
Pine Lakes	PIN-27	18,734	65.9%	RES	TRUE

† Load class is defined in the Western Electricity Coordinating Council (WECC) "Composite Load Model for Dynamic Simulations" report dated June 12, 2012.

b) Voltage Reduction Determination

The reduction in substation voltage was observed upon implementation of the projects using 15-minute interval energy usage data at each substation. Average voltage readings were analyzed for one month prior to implementation and one month after implementation. Table 4 shows the voltage readings and percent average voltage reduction for each substation included in the evaluation.

Table 4. Substation voltage reduction after CVR implementation.

Project (Substation Name)	Avg. Pre-Implementation Voltage	Avg. Post-Implementation Voltage	Avg. Voltage Change	% Avg Voltage Reduction
Hazelwood	122.44	118.97	3.47	2.83%
Panther Lake	122.48	119.43	3.05	2.49%
Pine Lakes	122.08	118.68	3.40	2.79%

c) Voltage Optimization Factor Determination

The RTF protocol relies on data obtained through the DEI project and estimates VO factors based on the following parameters:

- "Heating and cooling climate zone classification for each substation area
- Percentage of existing residential class consumers that have electric heat
- Percentage of existing residential class consumers that have any type of electric air conditioning"[2]

The PSE 2010 Residential Characteristics Study (RCS) reported the percentage of residential customers with electric heat as 28.0% and the percentage of residential customers with electric air conditioning as 25.0%. By applying those values to the RTF protocol, the applicable VO factor is 0.510.

See Appendix A for the full matrix of VO factors.

B. Evaluated Savings

The evaluation methodology followed the RTF protocol. Energy consumption data for the three substations were accessed for the same period used in the reported savings (July 2014-June 2015) and July 2015-May 2016. The July 2015-May 2016 period was analyzed to ensure that no significant changes to the customer class had occurred since the implementation of the CVR projects. No significant changes to feeder load characteristics were identified.

Since the implementation of these CVR projects, PSE completed an updated residential characteristics study. As such, the evaluated savings calculation replaced the 2010 RCS data with the 2017 RCS data for a more accurate representation of load characteristics at the time of the CVR implementation. Table 5 shows both the 2010 and 2017 data relevant to the RTF protocol. Since 2010, both the percentage of residential consumers with electric heat as well as the percentage of residential consumers that have electric air conditioning have increased. By applying the new values to the RTF protocol, the applicable VO factor is 0.475. As such, this evaluation recommends PSE continue to report savings using the RTF protocol, but PSE should incorporate the updated RCS data and change the VO factor used in the energy savings calculation.

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[2] Regional Technical Forum. "Simplified voltage optimization (VO) measurement and verification protocol." (Portland, OR: 2010). Accessed December 2017. https://rtf.nwcouncil.org/subcommittee/automated-conservation-voltage-regulation-cvr-and-voltage-optimization

Table 5. Load characteristics data available from PSE Residential Characteristics Studies (RCS).

Parameter	2010 RCS	2017 RCS
Percentage of existing residential class consumers that have electric heat	28.0%	35.7%
Percentage of existing residential class consumers that have any type of electric air conditioning	25.0%	27.3%

Source: Energy savings analysis files; 2017 RCS

IV. Appendix A: Savings Review Details

Figure 1. Measured voltage data for each substation

Hazelwood

AVERAGE VOLTAGE AT SUBSTATION BEFORE	122.44
AVERAGE VOLTAGE DROP AT EOL BEFORE	121.24
AVERAGE VOLTAGE AT SUBSTATION AFTER	118.97
AVERAGE VOLTAGE DROP AT EOL AFTER	117.95
Delta Voltage	3.47
% V reduction	0.0283

Panther Lake

AVERAGE VOLTAGE AT SUBSTATION BEFORE	122.48
AVERAGE VOLTAGE DROP AT EOL BEFORE	121.53
AVERAGE VOLTAGE AT SUBSTATION AFTER	119.43
AVERAGE VOLTAGE DROP AT EOL AFTER	117.35
Delta Voltage	3.05
% V reduction	0.0249

Pine Lakes

AVERAGE VOLTAGE AT SUBSTATION BEFORE	122.08
AVERAGE VOLTAGE DROP AT EOL BEFORE	121.86
AVERAGE VOLTAGE AT SUBSTATION AFTER	118.68
AVERAGE VOLTAGE DROP AT EOL AFTER	118.32
Delta Voltage	3.40
% V reduction	0.0279

Table 6. End-use voltage optimization factors from RTF protocol for Climate Zone 1 and Heating Zone 1.

	% of Customers with Non Electric heat and Heat Pumps (e.g. gas, oil, or wood heat)										
%AC	0%	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
20%	0.270	0.300	0.330	0.360	0.390	0.430	0.470	0.510	0.570	0.630	0.700
25%	0.280	0.305	0.335	0.365	0.395	0.435	0.475	0.515	0.570	0.630	0.695
30%	0.290	0.310	0.340	0.370	0.400	0.440	0.480	0.520	0.570	0.630	0.690
35%	0.290	0.315	0.345	0.375	0.405	0.445	0.485	0.525	0.575	0.630	0.690
40%	0.290	0.320	0.350	0.380	0.410	0.450	0.490	0.530	0.580	0.630	0.690
45%	0.295	0.325	0.355	0.385	0.415	0.450	0.490	0.535	0.580	0.630	0.690
50%	0.300	0.330	0.360	0.390	0.420	0.450	0.490	0.540	0.580	0.630	0.690

Note: The gray shaded rows are linearly interpolated.

Table 7. Western Electricity Coordinating Council (WECC) classification of load types.

Load Type	Load Mix	Res	Com	Ind	Agr	Data	Service
Residential	RES	75%	23%	0%	0%	0%	2%
Commercial	COM	20%	73%	0%	0%	5%	2%
Mixed	MIX	45%	48%	0%	0%	5%	2%
Rural/Agricultural	RAG	40%	20%	15%	25%	0%	0%

Table 8. Evaluated savings analysis table.

Feeder	Usage (kWh) 07/2014 thru 06/2015	Summary of Percent Customer Type					Load Class	RTF protocol applicable?	% Electric Heat:	VO Factor	%V reduction (Voc-Vcvr)/Voc	ΔE (kWh)	Period of Implementation
		Residential	Small Com.	Large. Com	Mix (Res + Ag)	Total % (CHECK)							
HAZ-12	30,992,712	54.9%	12.5%	30.2%	2.5%	100.0%	MIX	Yes	35.7%	0.475	2.83%	417,067	From: 8/24/2015
HAZ-13	12,657,970	86.7%	4.5%	8.2%	0.6%	100.0%	RES	Yes	35.7%	0.475	2.83%	170,337	@ 11:30:00 AM
HAZ-15	21,636,572	64.4%	10.0%	24.1%	1.5%	100.0%	MIX	Yes	35.7%	0.475	2.83%	291,162	To: 8/27/2015 @
HAZ-16	28,301,224	89.5%	3.9%	3.4%	3.3%	100.0%	RES	Yes	35.7%	0.475	2.83%	380,848	11:30 AM
PAN-12	6,020,575	90.9%	0.7%	8.4%	0.1%	100.0%	RES	Yes	35.7%	0.475	2.49%	71,214	From: 8/24/2015
PAN-13	10,927,475	87.2%	0.3%	12.4%	0.2%	100.0%	RES	Yes	35.7%	0.475	2.49%	129,255	@ 10:15:00 AM
PAN-14	13,721,456	85.0%	1.2%	13.6%	0.2%	100.0%	RES	Yes	35.7%	0.475	2.49%	162,304	
PAN-15	19,590,758	85.4%	9.4%	4.4%	0.8%	100.0%	RES	Yes	35.7%	0.475	2.49%	231,729	To: 8/30/2015 @
PAN-16	13,207,775	82.9%	8.1%	6.1%	2.9%	100.0%	RES	Yes	35.7%	0.475	2.49%	156,228	10:15:00 AM
PIN-17	7,019,475	35.9%	9.8%	54.0%	0.3%	100.0%	MIX	No	35.7%	0.475	2.79%	0	From: 09/14/2015
PIN-23	20,746,032	75.2%	6.0%	10.0%	8.9%	100.0%	RES	Yes	35.7%	0.475	2.79%	274,450	@ 11:00 AM
PIN-25	20,663,814	83.7%	5.5%	9.2%	1.5%	100.0%	RES	Yes	35.7%	0.475	2.79%	273,362	To: 09/20/2015 @
PIN-26	22,654,406	91.9%	3.7%	3.6%	0.8%	100.0%	RES	Yes	35.7%	0.475	2.79%	299,696	11:00 AM
PIN-27	18,734,721	65.9%	11.3%	22.3%	0.5%	100.0%	RES	Yes	35.7%	0.475	2.79%	247,842	
											Total	3,105,493	