2015 Home Energy Reports Impact Evaluation

Contents:

This document contains both the final Home Energy Reports Program Impact Evaluation and the Puget Sound Energy Evaluation Report Response (ERR). 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.

DNV·GL

PSE HOME ENERGY REPORTS PROGRAM

2015 Impact Evaluation – Final Report

Puget Sound Energy

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1 EXECUTIVE SUMMARY

Puget Sound Energy (PSE) implemented the Home Energy Reports (HER) legacy program in 2008. The HER program delivered customized information on energy consumption to participating households and compared the household's energy consumption to that of similar neighboring homes. In addition, the reports provided 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) wherein the eligible population was randomly assigned to treatment and control groups. The RCT included nearly 40,000 dual fuel, single family homes in the treatment group and 44,000 dual fuel, single family homes in the control group. Households in the treatment group received the report either monthly or quarterly for two years; the control group population did not receive a report. Beginning in the third year of the HER program, PSE discontinued sending the report to approximately 10,000 treatment group households. The termination of the reports created a second treatment group, called suspended group, which allowed PSE to test the persistence of report-based savings after the cessation of reports. The remaining households in the treatment group continued to receive the home energy reports either monthly or quarterly.

In March 2014, PSE expanded the HER program to include 140,000 additional households. The expansion program was a pilot effort to determine whether adding households with high usage relative to the size of their home (high relative user), electric only households and non-urban households made a difference in per-participant energy savings and/or customer satisfaction. Similar to the HER legacy program, the HER expansion program follows the experimental design format with randomly assigned treatment and control households of 105,000 and 35,000 respectively. In May 2015, PSE added a refill group from the remaining population of the HER expansion pool to replace households lost due to customer attrition. The refill group included approximately 25,000 treatment households and 10,500 control households; also randomly assigned.

1.1 Evaluation objectives

The main goal of the impact evaluation is to estimate HER legacy and expansion program savings for year 2015.[1] Specifically, the main objectives are:

1. Measure the reduction in electric and natural gas consumption between the control groups and the HER treatment groups.
2. Quantify joint savings from HER-related increased uptake of other PSE energy efficiency programs that may be present in the measured consumption reduction:
    - 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 NEEA upstream lighting programs.

[1] Program savings from the refill group were not included in the 2015 HER evaluation. The refill group was launched not until May 2015 and was in the field for only seven months in 2015. The refill group will be included in the next PSE HER evaluation when it has been in the field for at least one year.

3. Provide a final estimate of 2015 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.

This evaluation used historical consumption data to measure the difference in consumption between the treatment and control groups. Savings estimates were also measured for the different treatment sub-groups, such as the monthly and quarterly HER recipient groups, the current and suspended groups for the HER legacy program, and high relative users, non-urban, and electric-only groups for the HER expansion program.

This evaluation also quantified the potential for double counting energy savings due to participation in other PSE downstream and upstream rebate programs. We used the PSE program tracking data to quantify joint savings due to participation in other downstream PSE rebate programs. For the upstream programs where there was no tracking data, we used a web-based participant survey to quantify joint savings.

1.2 Key findings

The primary goal of this evaluation was to develop the 2015 PSE HER program credited savings estimates free of joint savings due to the participation in other PSE energy efficiency programs. Table 1-1 and Table 1-2 provide the wave-level and overall electric and gas savings estimates, respectively.[2] The overall electric savings were estimated at 90/18 precision and the gas savings were estimated at 90/59 precision.

Table 1-1. Total credited electric savings for 2015 HER programs

HER treatment group	Electric (kWh)				
	Per household	No. of treatment	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - Current	305.4	14,629	4,467,083	3,583,981	5,350,184
Legacy - Suspended	103.3	7,300	753,795	172,996	1,334,593
Expansion - Electric only	180.9	22,291	4,033,099	2,249,369	5,816,828
Expansion - High relative user	224.3	21,924	4,917,213	3,183,842	6,650,584
Expansion – Non-urban	119.3	31,241	3,725,527	2,122,766	5,328,288
ALL	183.8	97,385	17,896,717	14,603,328	21,190,106

[2] For planning purposes, PSE requested DNV GL to provide an overall electric and gas savings estimate in May 2016. We estimated a total credited savings of 17,591,513 kWh and 549,646 therms. The total credited savings value reported here is 1.7% higher for electric and 0.4% higher for gas. The differences in the two sets of savings estimates provided to PSE are not statistically significant at the 90% confidence interval.

Table 1-2. Total credited gas savings for 2015 HER programs

HER treatment group	Gas (therms)				
	Per household	No. of treatment	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - Current	11.7	14,629	170,736	118,707	222,766
Legacy - Suspended	8.4	7,300	61,275	27,677	94,873
Expansion - High relative user	9.3	21,924	202,813	109,231	296,395
Expansion – Non-urban	3.7	31,241	116,838	24,833	208,842
ALL	7.3	75,094	551,662	395,964	874,480

There were three components to estimate credited savings. The first component was the HER measured savings, which refers to the impact of HER on average household consumption. The second and third components were the rebate program and upstream retail lighting joint savings. These two joint savings components represented report-induced savings from the increased uptake of PSE-tracked rebate programs and increased purchases of CFL and LED bulbs through the PSE-supported upstream lighting program. To avoid double counting, credited savings were calculated by removing the rebate and upstream joint savings from the HER measured savings.

The summaries of results for legacy and expansion programs are presented in Table 1-3 and Table 1-4, respectively. All treatment groups produced statistically significant electric and gas savings in 2015.

Table 1-3. Summary of annual savings for PSE HER legacy 2015

Treatment groups	HER measured savings (per household)	Joint savings (per household)	Credited savings (per household)
Electric (kWh)			
Current	311.5*	6.2*	305.4*
	(251.2,371.9)	(0.7,11.7)	(244.7,366.0)
Suspended	104.4*	1.2	103.3*
	(24.9,184.0)	(-6.3,8.7)	(23.3,183.2)
Gas (therms)			
Current	13.4*	1.8*	11.7*
	(9.9,17.0)	(0.9,2.6)	(8.0,15.3)
Suspended	8.5*	0.1	8.4*
	(3.9,13.1)	(-1.1,1.3)	(3.6,13.1)

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

Table 1-4. Summary of annual savings for PSE HER expansion 2015

Treatment groups	HER measured savings (per household)	Joint savings (per household)	Credited savings (per household)
Electric (kWh)			
Electric only	210.7*	29.8*	180.9*
	(130.7,290.7)	(5.4,54.1)	(97.3,264.6)
High relative user	226.3*	2.0	224.23*
	(147.3,305.4)	(-21.5,25.6)	(141.8,306.8)
Non-urban	140.9*	21.6*	119.2*
	(89.6,192.2)	(3.9,39.3)	(65.0,173.5)
Gas (therms)			
High relative user	10.1*	0.8*	9.3*
	(5.8,14.4)	(0.4,1.3)	(5.0,13.5)
Non-urban	3.9*	0.1	3.7*
	(0.9,6.8)	(-0.2,0.4)	(0.8,6.7)

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

Table 1-5 summarizes the HER program results with respect to average consumption. The current treatment group produced credited savings of 3.0% and 1.6% for electric and gas, respectively. Even after five years of not receiving the report, the suspended treatment group still produced statistically significant electric savings, but those savings were only a third of the savings of the current treatment group. This difference in electric savings between the current and suspended groups was statistically significant at the 90% confidence level while the difference in gas savings between the current and suspended groups was not statistically significant.

Table 1-5. Credited savings per household as a percent of consumption

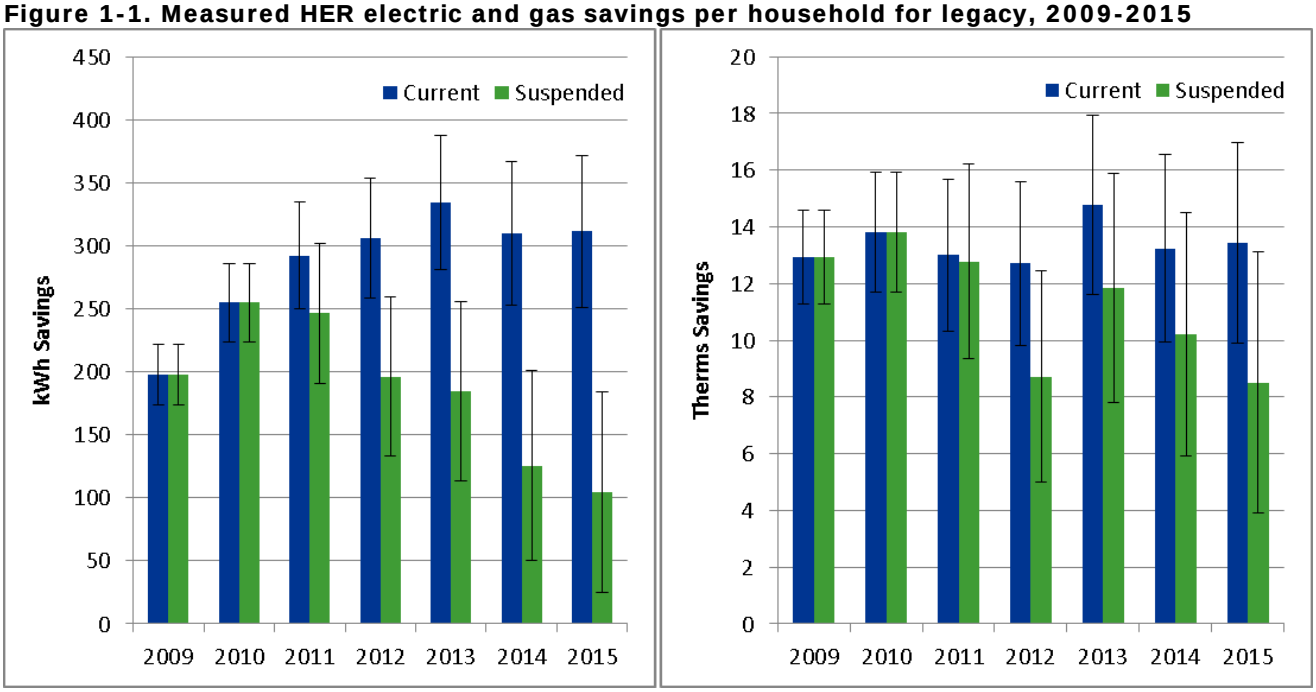
HER treatment group	Electric (kWh)			Gas (therms)		
	Consumption	Savings	Percent	Consumption	Savings	Percent
Legacy program						
Current	10,103	305.4*	3.0%	731	11.7*	1.6%
		(244.7,366.0)			(8.0,15.3)	
Suspended		103.3	1.0%		8.4*	1.1%
		(23.3,183.2)			(3.6,13.1)	
Expansion program						
Electric only	13,420	180.9*	1.3%	NA	NA	NA
		(97.3,264.6)				
High relative user	11,118	224.3*	2.0%	727	9.3*	1.3%
		(141.8,306.8)			(5.0,13.5)	
Non-urban	9,824	119.3*	1.2%	642	3.7*	0.6%
		(65.0,173.5)			(0.8,6.7)	

** 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 2015.*

The three HER expansion groups started receiving the reports in March 2014. Percent savings fell 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 2.0% electric and 1.3% gas while the non-urban group produced the lowest electric (1.2%) and gas (0.6%) savings.

Figure 1-1 provides measured electric and gas savings for the legacy program from 2009 to 2015. The electric savings for the active legacy HER group (current) increased through the fifth year (2013) of the program. The current group savings appeared to flatten or diminish since then, but this apparent trend was not statistically significant as of program year 2015. In addition, it should be noted that HER savings were not weather-normalized, so trends may reflect natural variation in local weather. Compared to electric savings, current group gas savings remained relatively flat and ranged from 13 to 15 therms per household in the last seven years. Evaluation results showed that both electric and gas savings for legacy households still receiving the reports remained at a level similar to the previous year.

Figure 1-1. Measured HER electric and gas savings per household for legacy, 2009-2015



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

The HER program exhibited two different kinds of persistence. Households in the current group that continued to receive reports through the seventh year generated savings at or above levels established in the first two years of the program. Households in the suspended group that were in the fifth year of not receiving reports still generated statistically significant savings of at least half of the first year savings of the current treatment group. Interestingly, measured electric savings of the suspended group continued to drop to almost one-third of the current treatment group savings, while measured gas savings of the suspended group were still over half of the measured savings of the current treatment group.

The HER program also continued to promote other energy efficiency programs. In this evaluation we observed the following:

- The uptake of gas rebate programs continued to increase for the current legacy treatment group while the discontinuation of the report caused a decreased joint savings from gas rebate programs.
- Joint savings from electric rebate programs were statistically significant for the first time for the current legacy 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.
- Joint savings analysis for the expansion groups indicate higher participation levels in electric rebate programs relative to the second year results of the legacy group.
- Consistent with the trends observed in the legacy group, the increase in program savings for the expansion groups was accompanied by an increase in HER-related rebate activities from Year 1 to Year 2.

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. In October 2008, PSE launched the HER legacy program with 83,881 households randomly assigned to the treatment and control groups. In 2010, a subset (approximately 10,000) of the HER legacy treatment group was randomly selected to stop receiving the reports. This created a second treatment group designed to test the persistence of program-induced savings after the termination of reports. PSE has continuously estimated savings for this group separately since the 2011 program year.

In March 2014, PSE launched the HER expansion program targeting three different groups: high relative users, non-urban, and electric-only households. The expansion program was a pilot effort to determine whether adding these groups made a difference in per-participant energy savings and/or customer satisfaction. The high relative user group was composed of single family homes with high energy consumption relative to the size of their homes. Households in the high relative user group received the reports four times per year. The non-urban group was composed of dual fuel households outside of PSE's major metropolitan core, and the electric-only group targeted customers using electric space and water heaters. The HER expansion program also followed an experimental design and included approximately 140,000 households randomly assigned to the treatment and control groups. 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 approximately 25,000 treatment households and 10,500 control households that were randomly selected to replace households lost due to customer attrition.

This evaluation focused on energy savings due to the PSE HER program for calendar year 2015. 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 NEEA upstream lighting programs.

3. Provide a final estimate of 2015 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 survey results. 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.

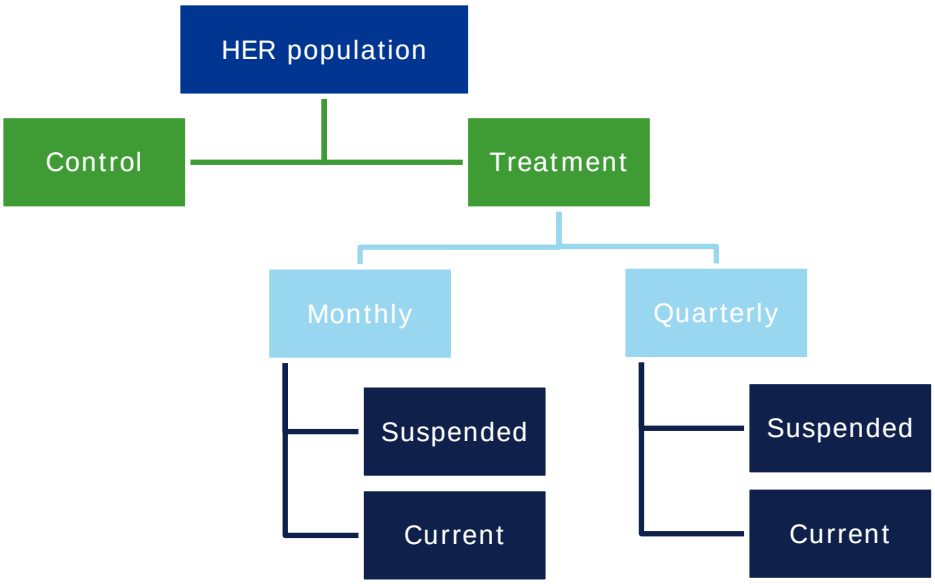
Figure 3-1. Selection criteria for legacy program

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 "suspended" treatment group; households that continued receiving reports are referred to as the "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 pilot study 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 composed 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	Non-urban	Electric only
• 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	• 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	• 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

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 2015 to facilitate the daily, pre-period, and post-period analyses. 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 2015, 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 2015, 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.

Consistent with previous HER legacy evaluations, 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 400 kWh per day or 40 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.
- Exclusion of households with less than 122 days of data during the pre- or post-treatment period.
- Removal of customers that moved out during the analysis period.

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. Households with occupancy status changes during the analysis period were removed from the analysis HER sample. Roughly 6% of the active households in 2014 moved out during 2015 and an additional 1% were removed from billing analysis due to other data issues.

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		4,864	
Other Opower program	111		
Move outs (2007 – 2014)	13,792	11,565	
Inconsistent zip codes	72	70	
Other data issues (low number of data due to missing meter reads, inconsistent reads and outliers)	538	487	
Final sample for 2014	**29,576**	**23,444**	**53,020**
Move outs in 2015	1,833	1,420	
Other data issues	282	274	
Final analysis sample for 2015	**27,461**	**21,750**	**49,211**
Monthly – Current		10,360	
Monthly – Suspended		5,205	
Quarterly – Current		4,140	
Quarterly – Suspended		2,045	

Note: Some sites may have multiple issues.

Consistent with previous PSE HER evaluations, the evaluators excluded households without an assigned control group in the analysis and their savings were not included in the total savings presented in this report. These non-random households comprise roughly 12% of the original treatment group and were located in zip codes that did not have an assigned control group. These non-random households were similar to the legacy group treatment households in the duration and start point of the HER reports they received. It is unknown whether these households had similar characteristics as the treatment group, thus savings for these households cannot be directly estimated because there is no control group matching the exact characteristics. In the absence of such an estimate, the legacy group's savings estimate would be the best proxy of savings for this non-random sample group.

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. Around 13.6% of the total population moved out during the analysis period and 4% of the remaining sample were dropped due to other data issues.

Table 3-2. HER expansion data disposition

Population	Control	Treatment	Total
Original population	**35,000**	**105,000**	**140,000**
Electric only	10,500	31,500	
High relative user	10,500	31,500	
Non-urban	14,000	42,000	
Missing consumption data	96	306	
Move outs	4,941	14,925	
Other data issues (low number of data due to missing meter reads, inconsistent reads and outliers, multiple accounts in same premise, no/wrong meter units)	1,065	3,078	
Final sample in 2014	**28,897**	**86,685**	**115,582**
Missing consumption data	299	881	
Move outs	3,653	10,436	
Other data issues (low number of data due to missing meter reads, inconsistent reads and outliers, multiple accounts in same premise, no/wrong meter units)	998	2,922	
Final analysis sample in 2015	**23,947**	**72,446**	**96,393**
Electric only	7,148	21,660	
High relative user	7,205	21,908	
Non-urban	9,594	28,878	

Note: Some sites may have multiple issues.

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. Unlike attrition due to move-outs, households that opted out of the program remained in 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 in order to produce an unbiased estimate of the reports' effect.[3]

[3] 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. It is hypothesized that the home energy reports were unlikely to have affected the moving rate among households. In fact, moving rates are similar across treatment and control groups. Households who opted out of the program suggest that they do not want the report and is, by definition, correlated with 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.

Overall, any data issues identified were minimal and should not bias the results. Data issues were equally shared between the treatment and control groups and the proportion of sites excluded in the analysis was approximately equal between the treatment and control groups of the legacy and expansion programs.

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

3.2.3 Participant survey data collection

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. Email-solicited online surveys have a number of desirable characteristics. An online survey is faster than individual telephone calls, less expensive to administer, and may make it easier for a customer to provide high quality responses because they control the time and pace of their response.

Online surveys have some potential drawbacks and biases, as will any data collection method. Response rates can be low and customers with valid email addressed on file at PSE may not be representative of the full HER legacy and expansion program populations. In fact, survey selection is a major challenge for all forms of surveys including both telephone and online. For telephone and online approaches, there were two processes at work: locating the subset of customers who have either telephone numbers or emails that are current, and then among that subset, identifying who is willing to complete the survey either on the phone or online. There is no reason to believe that respondents on the current online survey were any less representative of the HER population than were previous phone respondents.

The online survey was open from June 22 to July 25, 2016. The survey 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. The majority 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 this year was lower than last year's online survey response rate (7% compared to 12%) but the total number completed was very similar (4,228 in 2015 versus 4,239 in 2014). 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.

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. We used program savings to estimate a difference-in-differences approach. We also calculated savings using a fixed effect model specification that is commonly used in HER evaluations. 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

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 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 2015 savings estimate to avoid double counting. The measured savings with joint savings removed is referred to as "credited savings" in this report.[4]

4.1 Difference-in-differences

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

[4] 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.

of the control group difference (systemic effects only) from the treatment group difference (program effects and systemic effects).

The methods used in this year's evaluation were chosen to remain consistent with prior year evaluations. This explains the use of the difference-in-difference approach rather than pooled approaches that are more commonly used now. Similarly, only households that were still active at the end of the calendar year were included in the difference-in-difference calculation. This approach does not count partial year savings for households that move out during the program year. For comparison with other HER evaluations, the team also estimated savings from the pooled approach for the PSE HER legacy and expansion program. These results are summarized in Appendix 0.

A full discussion of the difference-in-differences and fixed effect models can be found 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 of the rebated measures at the household level so it is possible to directly calculate the number installed and savings claimed for all of the treatment and control groups. The goal of the joint savings[5] 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 two treatment 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 2015 data to the compiled data on all rebated installations, for both treatment and control groups. Savings were assigned on a daily basis starting with the installation date and carrying forward to the measure life.[6] Savings were apportioned 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 difference-in-differences calculations. For the 2015 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. The difference was the effect of HER on rebate program activity. We will remove this difference from the overall measured consumption reduction since the savings are already claimed by the rebate programs that facilitated the participation.

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

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

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 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 CFL bulbs 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 amount of additional savings associated with CFLs and LEDs purchased in 2015 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.

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

Bulb type	Weighted average claimed savings (kWh/unit)
CFL bulb	16.3
LED bulb	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. The 2011 upstream purchase data is used as a proxy for purchases prior to 2011 before an upstream survey was conducted. We assume that the bulbs stay in place for the full five year measure life. The upstream joint savings were cumulative through the seventh year.

Appendix 8.5 provides the web survey instrument used to gather CFL and LED purchase and installation data for the HER program in 2015.

5 IMPACT EVALUATION RESULTS

These results can be used to support PSE savings claims for the 2015 HER program. Section 5.1 provides the overall actual savings achieved in calendar year 2015. 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 2015 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 difference-in-differences 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 (current and 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 (current and suspended) and the control group.

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

Table 5-1. HER savings per household based on actual consumption in 2015

Treatment groups	HER measured savings	Joint savings (per household)		Credited savings
	(per household)	PSE rebate program	Upstream program	(per household)
Electric (kWh)				
Current	311.5*	6.2*	0.0	305.4*
	(251.2,371.9)	(0.7,11.7)		(244.7,366.0)
Suspended	104.4	1.2	0.0	103.3*
	(23.3,183.2)	(-6.3,8.7)		(23.3,183.2)
Gas (therms)				
Current	13.4*	1.8*	Not applicable	11.7*
	(9.9,17.0)	(0.9,2.6)		(8.0,15.3)
Suspended	8.5*	0.1	Not applicable	8.4*
	(3.9,13.1)	(-1.1,1.3)		(3.6,13.1)

*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 current treatment group produced credited savings at 3.0% and 1.6% for electric and gas, respectively. The suspended treatment group generated only a third as much electric savings when compared to the current treatment group. This difference was statistically significant at the 90% confidence level. For gas, the suspension of treatment has maintained just under three-quarters of the gas savings of the current group, and the difference in savings between the current and suspended groups was not statistically significant. 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 it is hypothesized that the greater number of electric end uses and the more discretionary aspect of many electric end uses (lighting, electronics) makes savings more feasible.[7]

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

HER treatment group	Electric (kWh)			Gas (therms)		
	Consumption per household	Savings per household	Percent	Consumption per household	Savings per household	Percent
Current	10,103.0	305.4	3.0%	730.6	11.7*	1.6%
		(244.7,366.0)			(8.0,15.3)	
Suspended		103.3*	1.0%		8.4*	1.1%
		(23.3,183.2)			(3.6,13.1)	

** 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.*

[7] DNV GL's report 'Puget Sound Energy's Home Energy Reports Program: Three Year Impact, Behavioral and Process Evaluation' 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.

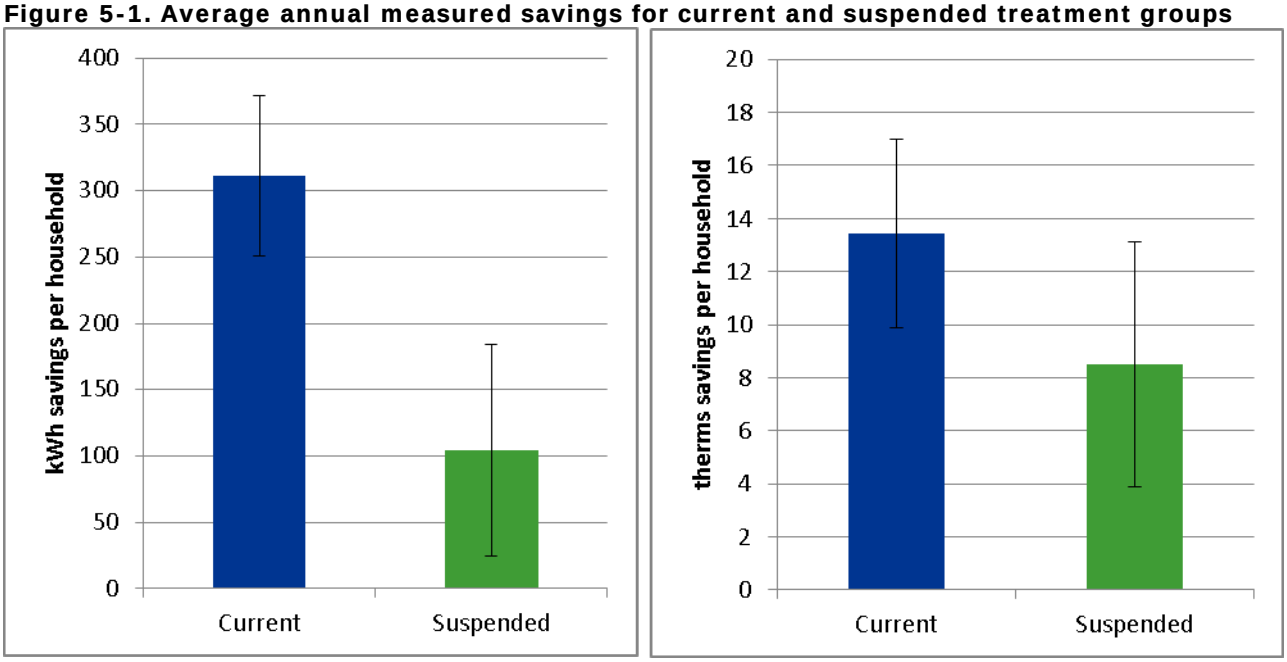
5.1.2 Measured program savings

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

Current vs. suspended treatment groups

Figure 5-1 summarizes the calendar year 2015 measured savings for the current and suspended treatment groups. Savings for both current and suspended report groups were significantly different from zero based on a 90% confidence interval, two-tailed test.

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



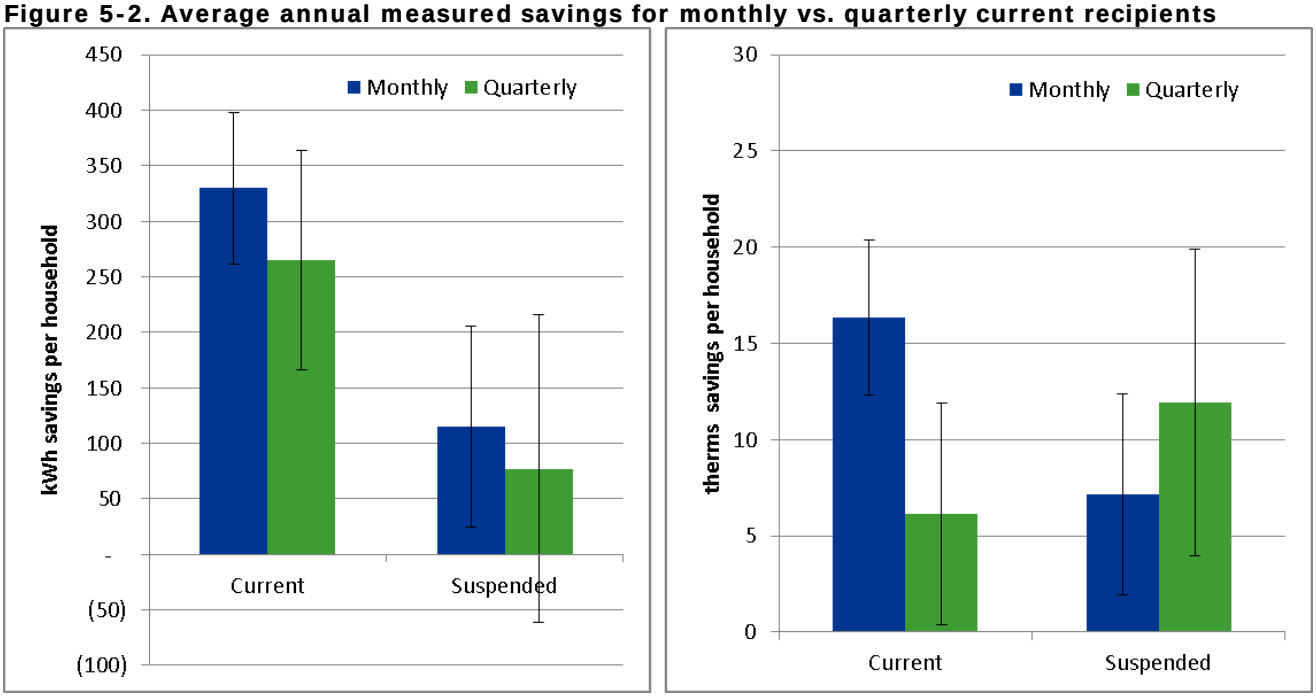
Note: The graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

The difference in electric savings between the two groups was statistically significant at the 90% confidence level while the difference in gas savings between the suspended and current treatment groups was not statistically significant. These findings are consistent with results from earlier PSE HER impact evaluation.

Monthly vs. quarterly treatment groups

Figure 5-2 provides the 2015 program savings for the monthly and quarterly recipients. The measured electric savings results for the current and suspended treatment groups for monthly and quarterly recipients generally conform to the expectation that monthly recipients should generate more savings than quarterly recipients. However, the difference was small and not statistically significant. The difference may point to the additional reports as being unnecessary.

Figure 5-2. Average annual measured savings for monthly vs. quarterly current recipients



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

Similar to last year, the gas savings results were harder to interpret. For the current treatment group receiving the reports quarterly, results showed a statistically significant reduction in gas savings when compared to monthly recipients. At first glance, a possible theory could be that in contrast to electric savings, the monthly reports were more important for maintaining a higher level of gas savings. However, the gas results from the suspended treatment group did not support this theory and were inconclusive.

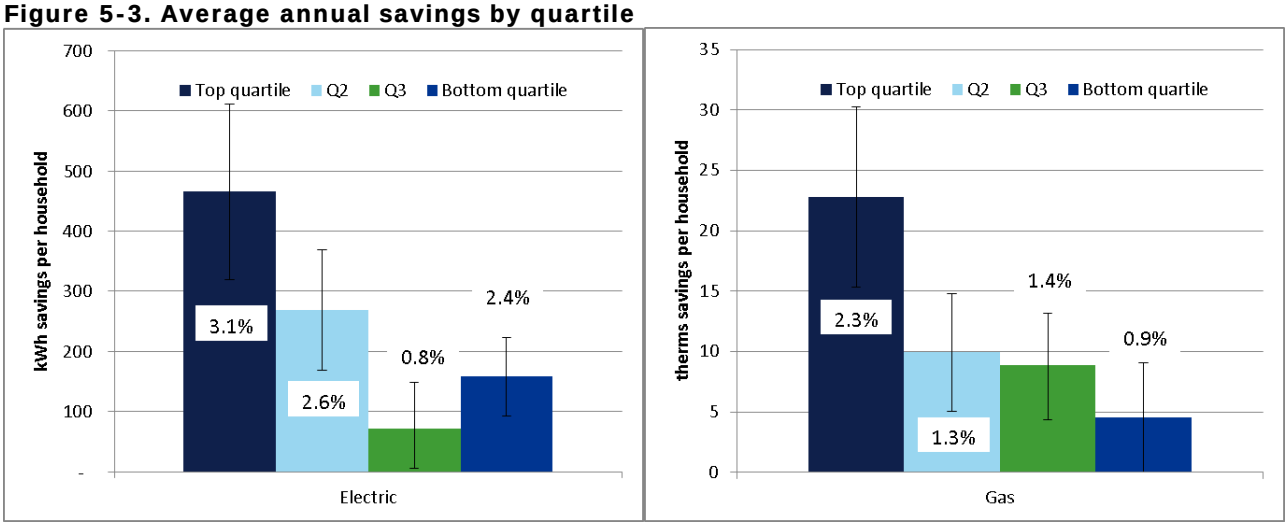
Annual savings by consumption quartile

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 5-3 shows the savings in energy consumption (kWh and therms) versus energy consumption for the same consumption quartiles from the control group. The top consumption quartile households saved electricity at a rate of 3.1%, very similar to the overall savings rate of 3%.[8] For gas, top quartile households saved at a rate of 2.3%, compared to 1.6% rate overall.

[8] These overall percentages are based on measured savings of the current treatment group before removing any double counted savings.

Figure 5-3. Average annual savings by quartile



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

In general, customers in the highest quartile generated the most savings. Similar to last year's findings, we noted a trend where electric savings in the third quartile were less than the electric savings generated by the bottom quartile. While not statistically significant, this apparent trend was in contrast to earlier evaluations indicating that savings generally decreased from top to bottom quartile.

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 savings by quartile - average consumption and percentiles

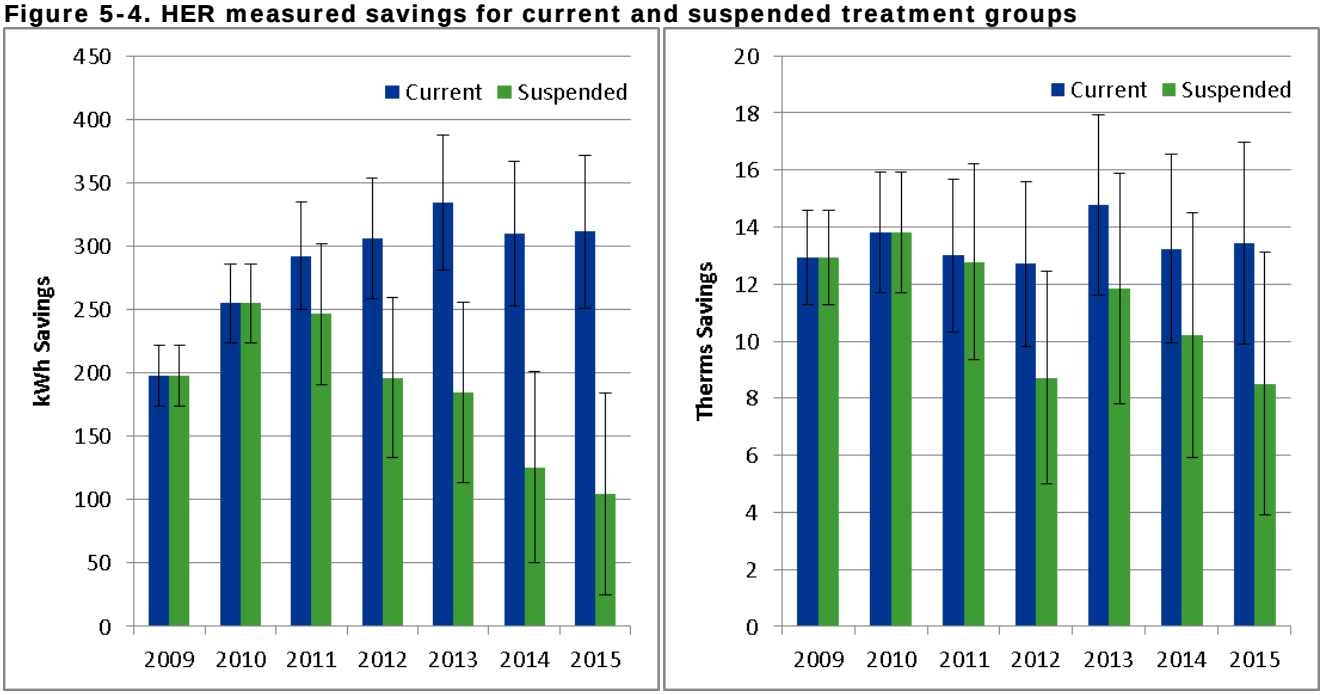
Quartile	Percentile	Electric		Gas	
		Lower bound (kWh)	Quartile mean	Lower bound (Therms)	Quartile mean
Top	**75th percentile**	13,311	15,007	1,171	1,010
Q2	**Median**	10,049	10,504	958	765
Q3	**25th percentile**	7,738	8,406	787	645
Bottom		0	6,501	0	503

HER measured savings from 2009 to 2015

The HER program generated statistically significant electric and gas savings from 2009 to 2015.

Figure 5-4 provides the historical measured savings for the HER legacy program since the first year of inception.

Figure 5-4. HER measured savings for current and suspended treatment groups



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

The HER program also continued to generate savings from the suspended treatment group but at a reduced rate. Electric and gas savings from the suspended group decreased by 17% from 2014 to 2015. In addition, per household electric savings (104 kWh per household) from the suspended group were 66% less than electric savings of the current treatment group in 2015 and per household gas savings (18.5 therms) were 37% less than gas savings from the continued treatment group in 2015.

Appendix 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 pilot study PSE launched in March 2014 that targeted three different groups: electric-only, high relative user, and non-urban households. The periods covered by this analysis are March 2013 to February 2014 (pre-treatment period) and January 2015 to December 2015 (post-treatment period). This section presents billing analysis results for the HER expansion program.

5.2.1 2015 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 of 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 2015

Treatment groups	HER measured savings (per household)	Joint savings (per household)		Credited savings (per household)
		PSE rebate programs	Upstream programs	
Electric (kWh)				
Electric only	210.7*	11.2	18.6	180.9*
	(130.7,290.7)	(-0.1,22.4)	(-3.0,40.2)	(97.3,264.6)
High relative user	226.3*	2.0	0.0	224.3*
	(147.3,305.4)	(-2.5,6.5)		(141.8,306.8)
Non-urban	140.9*	3.7*	17.9	119.3*
	(89.6,192.2)	(1.1,6.3)	(0.3,35.4)	(65.0,173.5)
Gas (therms)				
High relative user	10.1*	0.8*	NA	9.3*
	(5.8,14.4)	(0.4,1.3)		(5.0,13.5)
Non-urban	3.9*	0.1	NA	3.7*
	(0.9,6.8)	(-0.2,0.4)		(0.8,6.7)

** 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 per household	Savings per household	Percent	Consumption per household	Savings per household	Percent
Electric only	13,419.9	180.9*	1.3%	N/A	N/A	N/A
		(97.3,264.6)				
High relative user	11,118.1	224.3*	2.0%	727.1	9.3*	1.3%
		(141.8,306.8)			(5.0,13.5)	
Non-urban	9,823.9	119.3*	1.2%	642.0	3.7*	0.6%
		(65.0,173.5)			(0.8,6.7)	

** 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

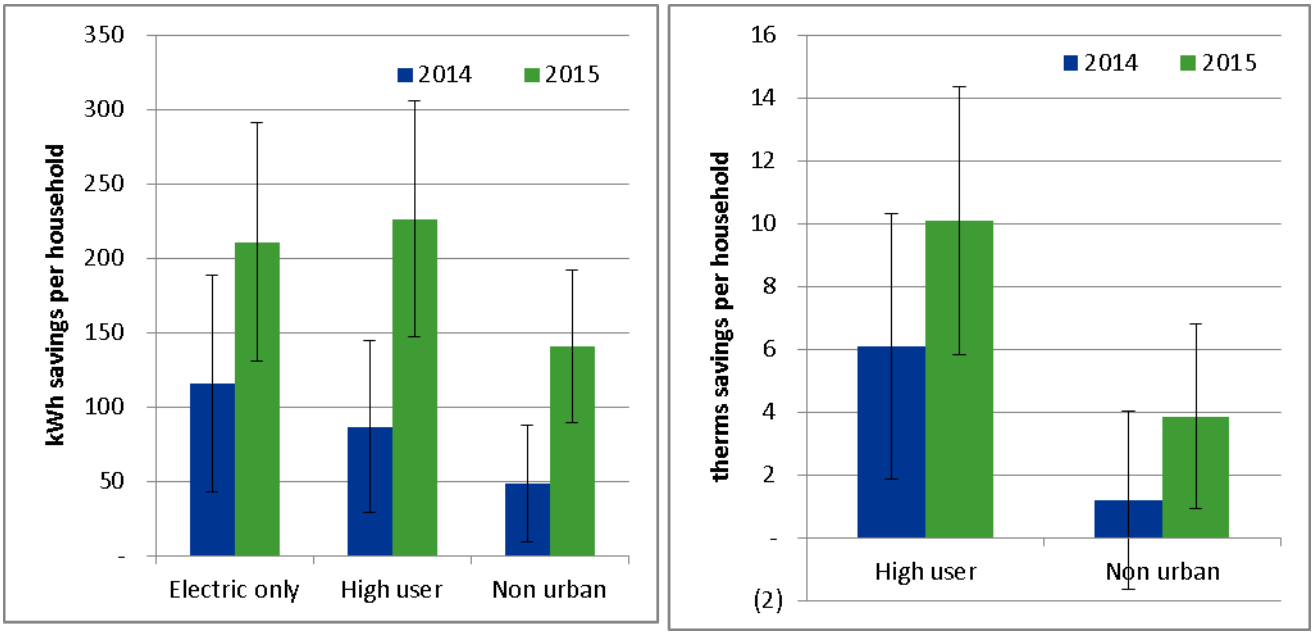
This section provides historical program savings for the expansion group and comparison of program savings per household between the expansion groups and legacy program.

Measured electric and gas savings from 2014 to 2015

Figure 5-5 provides the measured savings for the HER expansion program in 2014 and 2015. The expansion group started receiving the reports in March 2014, thus the 2014 savings reflected savings from March to

December. The 2015 savings were for the full calendar year. 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. The expansion program followed this pattern as electric and gas savings increased substantially from 2014 to 2015.

Figure 5-5. Measured electric and gas savings per household for expansion groups from 2014 to 2015



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

5.3 Comparison of legacy and expansion groups

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

5.3.1 Baseline consumption and savings – legacy vs. expansion groups

Figure 5-6 provides a comparison of the average 2015 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 high relative user group has the highest electric baseline consumption level; followed by the legacy and the non-urban groups. Gas consumption between legacy and high relative user groups were similar.

Figure 5-6. 2015 Baseline consumption for legacy and expansion groups

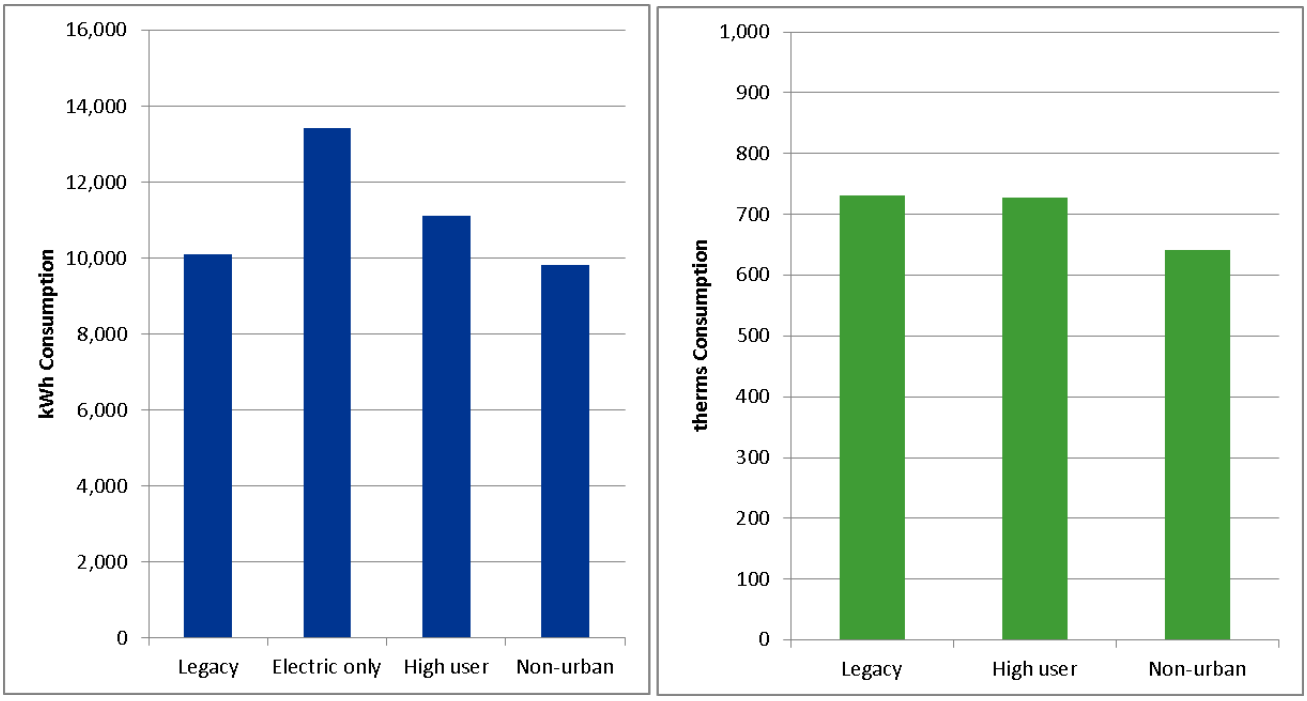
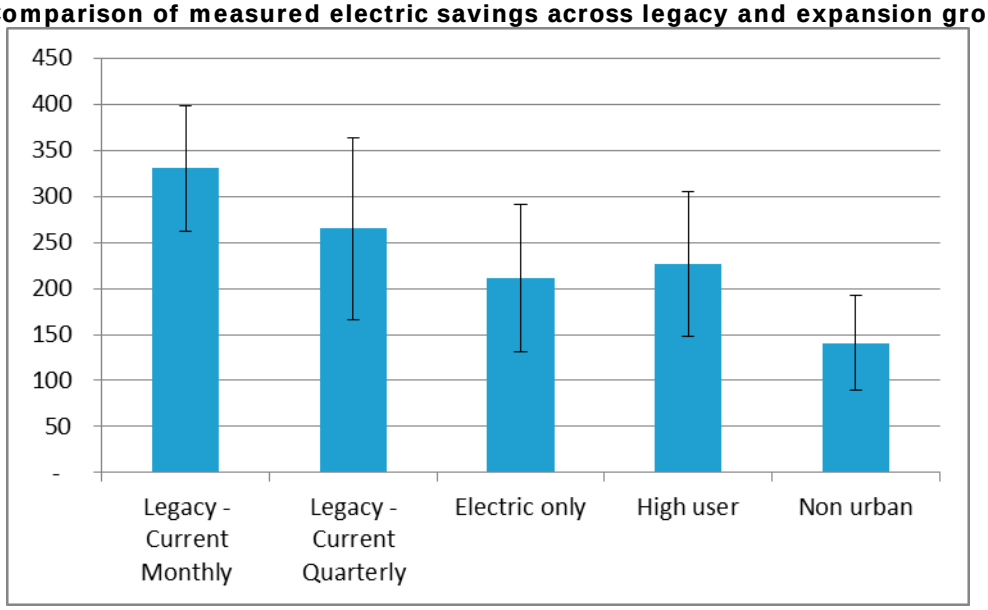


Figure 5-7 presents a comparison of measured electric savings of the three different expansion groups and the monthly and quarterly recipients from the legacy group that still receive reports. For this analysis, we provided savings separately for monthly and quarterly recipients in the legacy group for a better comparison with the high relative user group that also received the reports quarterly. From a percentage perspective, the measured electric savings for the monthly and quarterly recipients in the legacy group were 3.3% and 2.6% of consumption, respectively. For the expansion group, the percent savings for the electric only, high relative users, and non-urban groups were 1.6%, 2.0%, and 1.4%, respectively. Electric savings were highest for the legacy group receiving the reports monthly and lowest for the non-urban group.

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



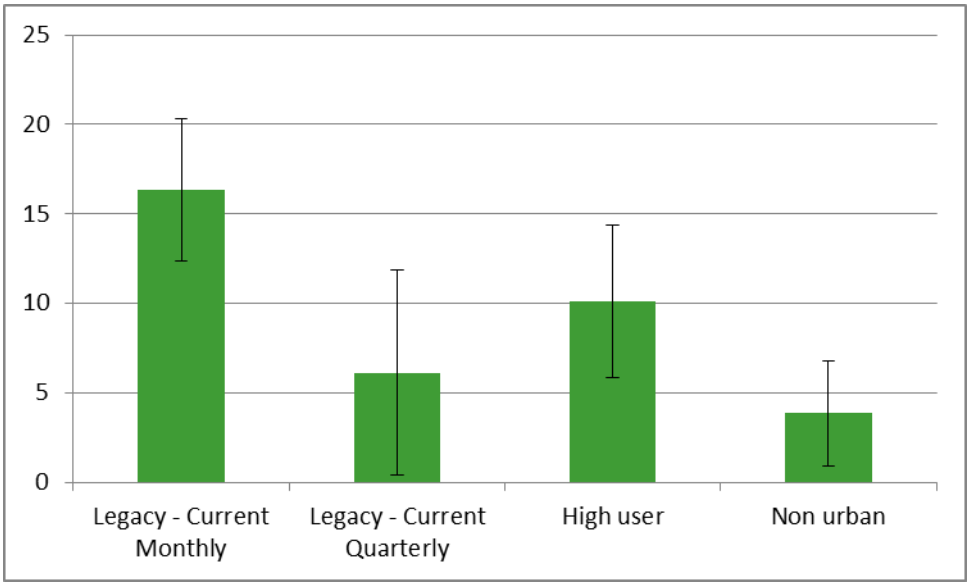
Note: The graph above shows the savings with upper and lower bounds at the 90% confidence intervals.

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 group were in their seventh year of receiving the reports while the expansion groups represented households that were relatively new to the program. The average savings from the legacy group represented a full year of savings for a mature program while savings from the expansion groups were likely just beginning to ramp up.

Both legacy 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 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 was not statistically significant at the 90% confidence interval. Despite being in the field for less than two years, the high relative user group produced savings similar to the mature legacy group.

Figure 5-8 presents a comparison of gas savings of the two expansion groups relative to the legacy savings. From a percentage perspective, the measured electric savings for the monthly and quarterly recipients in the legacy group were 2.2% and 0.8% of consumption, respectively. For the expansion group, the percent gas savings were 1.4% and 0.2% for the high relative users and non-urban groups, respectively. Similar to the findings for electric savings, the legacy 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 not statistically different from the savings produced by the legacy quarterly group. In fact, the high relative user group produced more than half of the savings from legacy quarterly group despite being in the field for less than two years.

Figure 5-8. 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.

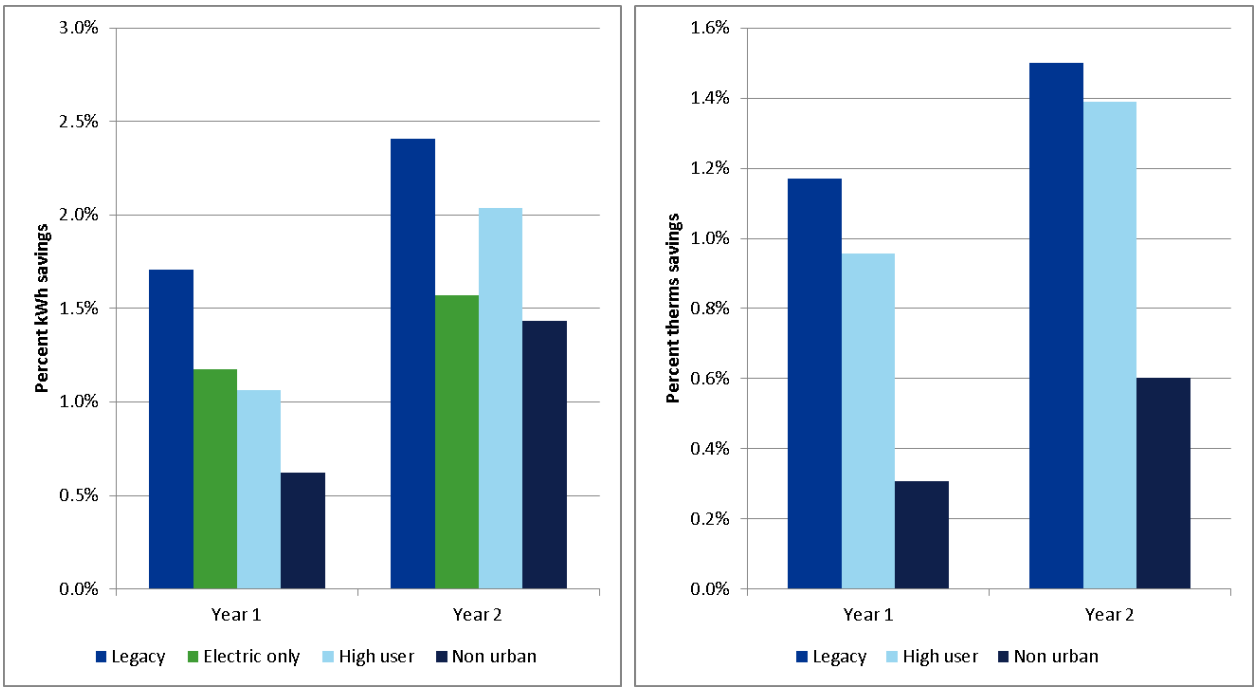
5.3.2 Comparison of early stage savings – legacy vs. expansion groups

DNV GL compared percent electric and gas savings between the legacy and expansion groups during the first and second year of the HER program. The HER program was offered at different times and the periods covered during the first and second years of the HER program were different for the legacy and expansion groups. For this comparison, Year 1 covered the first 12 months of receiving the reports while Year 2 covered calendar years 2010 and 2015 for the legacy and expansion groups, respectively.

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 (Appendix 8.3).

Figure 5-9 provides the percent electric and gas savings between Year 1 to Year 2 of the legacy and expansion programs. Both HER legacy and expansion groups showed an increase in savings from Year 1 to Year 2. 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 were comparable.

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

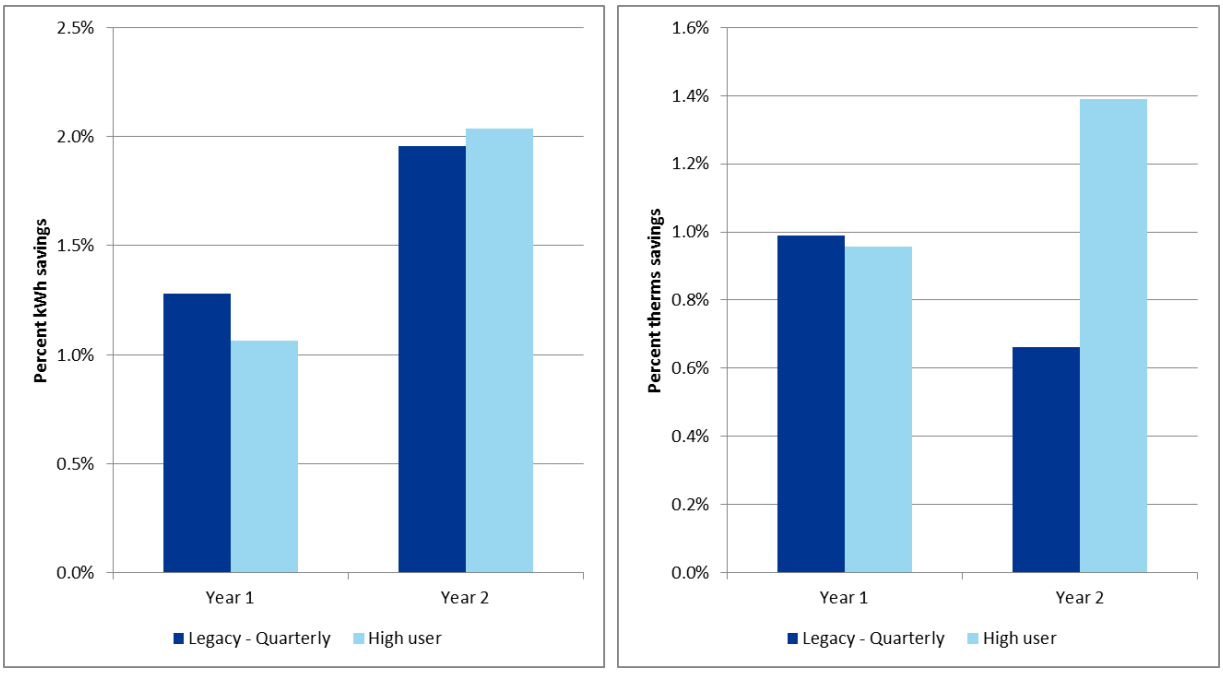


Among the expansion groups, the high relative user group had the highest measured electric and gas savings in terms of quantity and percentage while the non-urban group had the lowest savings. These findings were consistent with the results in quartile analysis in Section 5.1.2 where savings percentages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

The high relative user group produced relatively lower savings in Years 1 and 2 when compared to all treated households in the legacy group. However, percent savings of the high relative user group during the first 12 months were similar to the quarterly recipients of the legacy group. In Year 2, percent savings of the high relative user group were slightly above the savings of the legacy quarterly group for electric and more than double for gas.

Figure 5-10 shows a comparison of early stage savings from the high relative user group and the legacy group receiving the reports quarterly.

Figure 5-10. Percent measured electric savings for legacy – quarterly and high relative user groups



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.

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.

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

Figure 5-11 shows the percent of HER households participating in other PSE rebate programs in 2015. About 4% to 5% of the households in the treatment group participated in electric rebate programs while 2% to 3% of the treatment households participated in gas rebate programs. Overall, the results suggest that participation levels of the treatment groups were slightly higher than the control group.

Figure 5-11. Percent of HER households participating in other PSE rebate programs in 2015

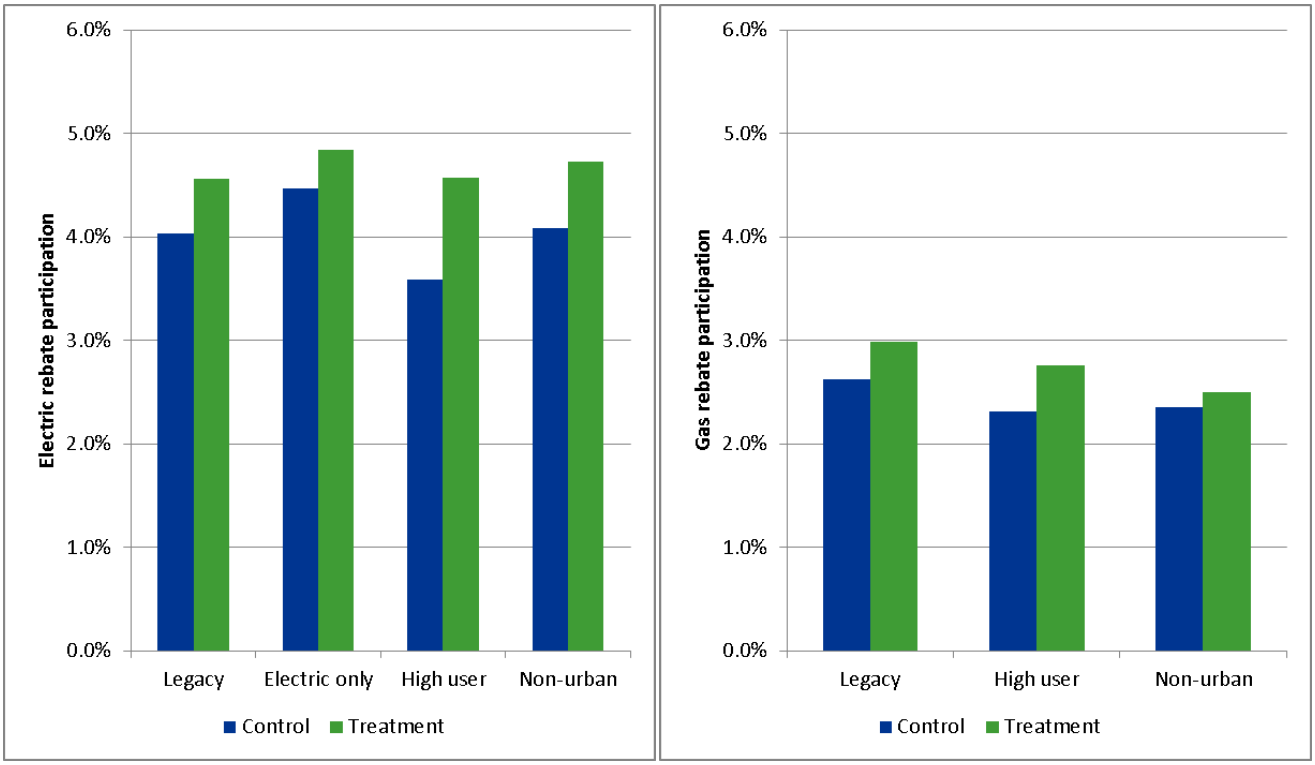


Table 5-6 shows a tabular representation of the illustrations above with the difference in percent participation between the treatment and control groups. The HER program encouraged participation in electric rebate programs for all of the groups except the electric-only group and encouraged gas rebate participation for all groups except the non-urban group.

Table 5-6. Treatment and control participation in 2015 PSE rebate programs

Electric	% Participation		Difference (treatment - control)	Lower limit at 90% CI	Upper limit at 90% CI	Tstat	Pvalue
	Control	Treatment					
2015 Electric rebate participation							
Legacy-current	4.0%	4.6%	0.5%*	0.1%	0.9%	2.57	0.01
Electric only	4.5%	4.8%	0.4%	-0.2%	0.9%	1.29	0.20
High relative user	3.6%	4.6%	1.0%*	0.4%	1.5%	3.53	0.00
Non-urban	4.1%	4.7%	0.6%*	0.2%	1.1%	2.73	0.01
2015 Gas rebate participation							
Legacy-current	2.6%	3.0%	0.4%*	0.0%	0.7%	2.19	0.03
High relative user	2.3%	2.8%	0.4%*	0.0%	0.9%	2.01	0.04
Non-urban	2.4%	2.5%	0.1%	-0.2%	0.5%	0.78	0.43

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

Table 5-7 presents the PSE rebate program joint savings analysis for current and suspended treatment groups across all HER post-treatment years for the HER legacy program. Joint savings estimates were cumulative and lasted for the life of the measure. Only measures with remaining useful life should be considered when calculating joint savings. The 2015 electric and gas joint savings were significant at the 90% level for the current group but not for the suspended group.

Table 5-7. Annual joint rebate savings per household for electric and gas, current and suspended groups, HER legacy

Fuel	Year	HER groups			Joint rebate savings per household			
		Control	Current	Suspended	Current	+/-	Suspended	+/-
Electric (kWh)	2009	3.7	4.1	4.5	0.3 (-0.7,1.3)	1.0	0.8 (-0.7,2.3)	1.5
	2010	13.8	15.1	15.7	1.3 (-1.5,4.2)	2.8	1.9 (-2.3,6.1)	4.2
	2011	25.6	25.6	27.4	0.0 (-3.4,3.4)	3.4	1.8 (-3.3,6.9)	5.1
	2012	40.6	41.6	41.8	1.0 (-3.1,5.0)	4.1	1.1 (-4.7,7.0)	5.8
	2013	53.1	54.7	52.5	1.6 (-2.9,6.1)	4.5	-0.6 (-6.8,5.6)	6.2
	2014	68.5	73.0	70.1	4.5 (-0.7,9.6)	5.2	1.6 (-5.4,8.6)	7.0
	2015	82.0	88.2	83.2	6.2* (0.7,11.7)	5.5	1.2 (-6.3,8.7)	7.5
Gas (Therms)	2009	1.2	1.6	1.5	0.3* (0.1,0.5)	0.2	0.2* (0.0,0.5)	0.3
	2010	4.9	5.7	5.6	0.9* (0.4,1.3)	0.4	0.7* (0.1,1.4)	0.7
	2011	8.1	9.2	9.0	1.1* (0.5,1.7)	0.6	0.9* (0.0,1.8)	0.9
	2012	10.2	11.5	10.8	1.2* (0.5,1.9)	0.7	0.6 (-0.4,1.5)	1.0
	2013	11.7	13.0	12.1	1.3* (0.6,2.0)	0.7	0.4 (-0.6,1.4)	1.0
	2014	13.8	15.4	14.1	1.5* (0.7,2.3)	0.8	0.3 (-0.8,1.4)	1.1
	2015	16.1	17.8	16.2	1.8* (0.9,2.6)	0.9	0.1 (-1.1,1.3)	1.2

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

Table 5-8 presents the PSE rebate program joint savings analysis for the different HER expansion groups in 2014 and 2015. Similar to joint savings calculation for the legacy program, these joint savings were cumulative and lasted the life of the measure. Electric joint savings were only statistically significant for the non-urban group, and gas savings were only statistically significant for the high relative user group.

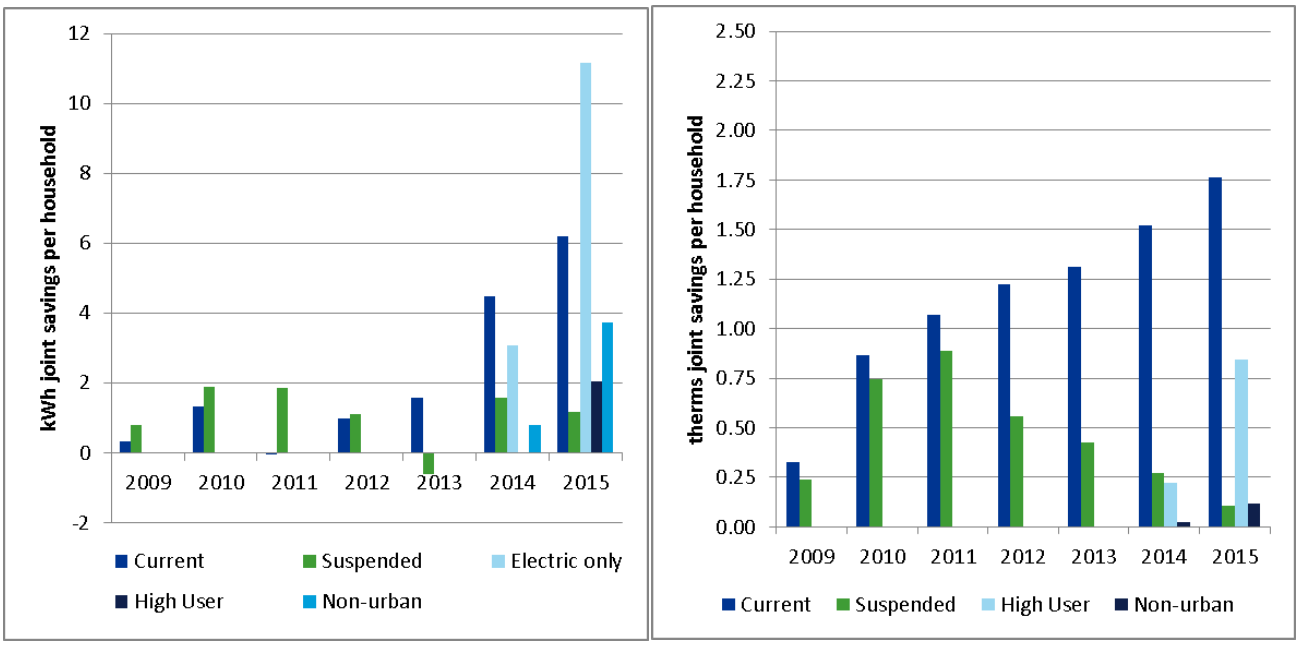
Table 5-8. Annual joint rebate savings per household for electric and gas, HER expansion

Fuel	Year	Group	HER groups		Joint rebate savings per household	
			Control	Treatment	Savings	+ / -
Electric (kWh)	2014	Electric only	24.8	27.9	3.1	4.5
					(-1.4,7.5)	
		High relative user	7.1	7.1	0.0	1.8
					(-1.7,1.8)	
		Non-urban	5.6	6.4	0.8	1.0
					(-0.2,1.8)	
	2015	Electric only	83.6	94.8	11.2	11.2
					(-0.1,22.4)	
		High relative user	25.6	27.6	2.0	4.5
					(-2.5,6.5)	
		Non-urban	22.2	26.0	3.7*	2.6
					(1.1,6.3)	
Gas (Therms)	2014	High relative user	0.8	1.0	0.2*	0.2
					(0.0,0.4)	
		Non-urban	0.6	0.6	0.0	0.1
					(-0.1,0.1)	
	2015	High relative user	2.7	3.5	0.8*	0.5
					(0.4,1.3)	
		Non-urban	2.0	2.1	0.1	0.3
					(-0.2,0.4)	

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

Figure 5-12 provides a historical rebate joint savings per household for legacy and expansion groups. Electric joint savings have always been relatively small and not statistically significant for the legacy group. In comparing joint savings between the legacy and expansion groups, results showed that expansion groups already had some different characteristics and may prove to be quite different over time. The electric-only households from both treatment and control groups participated in rebate programs at a relatively high level. The first year joint savings for the electric-only group, though not statistically significant, were bigger than the legacy joint savings estimates through 2013. In the second year, joint savings for the electric-only group surpassed all the other treatment groups.

Figure 5-12. Annual joint rebate savings per household for legacy and expansion groups, 2009-2015



Consistent with what we found last year, electric joint savings for the non-urban group were statistically significant. This was the first statistically significant electric joint savings ever measured in the PSE HER program. The mean treatment and control savings estimates, and the joint rebate savings per household for non-urban were all smaller than the electric-only joint savings, but the joint savings estimate from non-urban was statistically significant. This finding indicates wider adoption of smaller savings measures across the non-urban treatment and control groups.

5.4.2 Upstream program joint savings

The upstream joint savings measured the effect of the HER program on reduced-price retail sales of CFL and LED bulbs. LED bulbs were included in the estimated upstream joint savings for the first time in the 2013 evaluation.[9] Table 5-9 provides the number of CFL and LED bulbs purchased for the control, current treatment, and suspended treatment groups in 2015 HER legacy program.

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

Table 5-9. Count of CFL and LED bulbs purchased per household in 2015

Upstream lighting measures	HER groups		
	Control	Current	Suspended
CFL bulbs	2.08	1.93	1.34
LED bulbs	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, LED purchases were more than double the CFL levels in 2015.

Table 5-10 provides the joint rebate counts per household for the current and 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. Consistent with the finding in the 2014 evaluation, there was almost no difference in the purchase of upstream program-supported CFLs or LEDs due to the HER program. For CFLs, results showed that total upstream purchases of the control group were higher than the treatment groups.

Table 5-10. Savings from CFL and LED bulbs purchased per household in 2015

Upstream lighting measures	Joint rebate counts per household[1]		Weighted average deemed savings (kWh per unit)	Current group upstream savings	Suspended group upstream savings
	Current	Suspended			
CFL bulbs	-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)
LED bulbs	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	-16.50

** 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 in 2015. 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 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 5-11 provides the annual joint savings estimates from CFL and LED bulbs 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 savings also were removed along with the first year savings.

Table 5-11. Annual joint upstream savings per household for current and 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

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 current treatment group in Year 3. Year 1 also includes last November and December of 2008.

Both current and 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 being non-statistically significant, as they provided some evidence of possible double counting. Now that cumulative upstream joint savings for the 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 current treatment group shared around 6.2 kWh and 1.8 therms savings per household between HER and other PSE programs. For the suspended group, HER and other PSE programs share 1.2 kWh and 0.1 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 2015 had these joint program savings netted out.

We also calculated upstream joint savings for the three groups in the HER expansion program. Table 5-12 presents the number of CFL and LED bulbs purchased for the expansion control and treatment groups in 2015. Similar to legacy findings, LED purchases were above the CFL levels for all expansion groups. Also, the total number of LEDs purchased by the treatment groups was higher than the total number of LEDs purchased by the control groups.

Table 5-12. Count of CFL and LED bulbs purchased per household in 2015, HER expansion

Upstream lighting measures	Electric only		High relative user		Non-urban	
	Control	Treatment	Control	Treatment	Control	Treatment
CFL bulbs	2.57	2.23	2.64	2.13	2.61	2.16
LED bulbs	3.32	4.21	3.06	3.96	3.48	4.23

Table 5-13 provides the joint rebate counts per household for the different expansion groups. Overall, results showed that the total upstream lighting savings in 2015 were positive and can be attributed to the increase in LED purchases among the expansion treatment groups.

Table 5-13. Savings per household from CFL and LED purchases in 2015, HER expansion

Upstream lighting measures	Joint rebate counts per household[1]			Bulb type savings[2]	Upstream savings		
	Electric only	High relative user	Non-urban		Electric only	High relative user	Non- urban
CFL bulbs	-0.3 (-1.0,0.3)	-0.5 (-1.5,0.4)	-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)
LED bulbs	0.9 (-0.2,2.0)	0.9 (-0.1,1.9)	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)
Total upstream lighting savings					9.5	6.9	5.3

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

Table 5-14 provides the cumulative estimates of the annual joint savings from CFL and LED bulbs purchased in Year 1 and savings in 2015 as reported under total upstream lighting savings in Table 5-13. Per household joint savings between HER program and upstream programs amounted to 19 kWh, -6 kWh, and 18 kWh for electric only, high relative user, and non-urban groups, respectively. Because high relative user upstream savings were negative, only measured savings for the electric-only and non-urban groups were adjusted with upstream savings to avoid double counting. Measured savings were adjusted with joint savings despite statistical significance to provide the most conservative savings estimates that are free of potentially double counted savings.

Table 5-14. Annual joint upstream kWh savings per household for HER expansion

Program year	Treatment group		
	Electric only	High relative user	Non-urban
Year 1	9.09	-12.76	12.61
Year 2	18.59	-5.86	17.87

5.5 2015 total program savings

Table 5-15 and Table 5-16 provide the wave-level and overall electric and gas credited savings estimates, respectively. The overall electric savings were estimated at 90/18 precision and the gas savings were estimated at 9/59 precision. In total, the legacy program current and suspended groups together generated around 5.2 GWh and 232 thousand therms while the expansion program generated around 6.1 GWh and 191 thousand therms. Overall, PSE HER program produced savings of 12.7 GWh and 320 thousand therms in 2015.

Table 5-15. Total credited electric savings for 2015 HER programs

HER treatment group	Electric (kWh)				
	Per household	# households with reports	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - current	305.4	14,629	4,467,083*	3,583,981	5,350,184
Legacy - suspended	103.3	7,300	753,795*	172,996	1,334,593
Expansion - electric only	180.9	22,291	4,033,099*	2,249,369	5,816,828
Expansion - high relative user	224.3	21,924	4,917,213*	3,183,842	6,650,584
Expansion – non-urban	119.3	31,241	3,725,527*	2,122,766	5,328,288
ALL	183.8	97,385	17,896,717*	14,603,328	21,190,106

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

Table 5-16. Total credited gas savings for 2015 HER programs

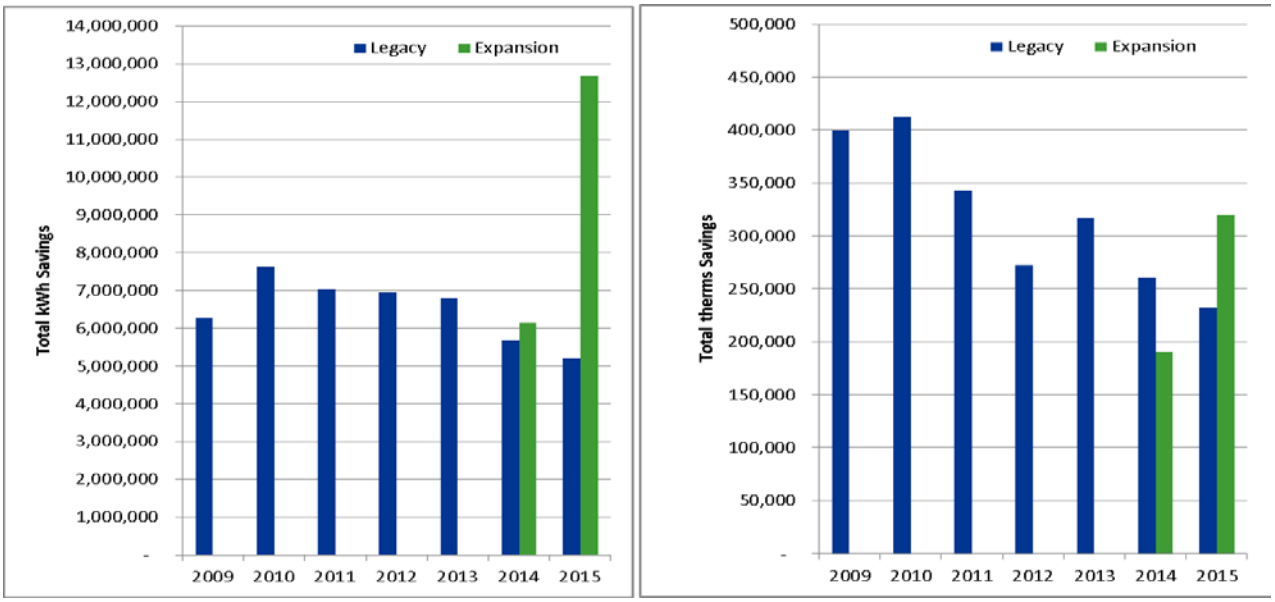
HER treatment group	Gas (therms)				
	Per household	# households with reports	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - current	11.7	14,629	170,736*	118,707	222,766
Legacy - suspended	8.4	7,300	61,275*	27,677	94,873
Expansion - high relative user	9.3	21,924	202,813*	109,231	296,395
Expansion – non-urban	3.7	31,241	116,838*	24,833	208,842
ALL	7.3	75,094	551,662*	395,964	874,480

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

Figure 5-13 provides the total credited program savings for the HER legacy and expansion programs from 2009 to 2015. 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 2015, total program electric savings from legacy were 17% below first year savings while gas savings were 42% below first year savings. The expansion groups total program savings doubled for electric and increased by more than 60% for gas. As savings from the expansion group start ramping up, the three HER expansion groups will compensate for the diminishing savings from the HER legacy program.

Figure 5-13. Total program credited savings from 2011 to 2015



6 SURVEY RESULTS

This section presents results from the online survey that included six questions on awareness, experience, and satisfaction with PSE programs. These questions are similar to the questions asked in last year's survey and meet PSE's request to collect additional information to compare with other data collection initiatives.

The survey analysis leveraged the program's RCT design by comparing the responses of the treatment group to that of the control group and attributing the differences in the responses to the program. The control group represented the background response level where any statistically significant deviation from the control group is caused by the home energy report. All statistically significant survey results are at the 90% confidence level.[10]

The background response levels may be of interest to PSE and are therefore included in the following analysis. These generally differed across the four HER program groups. The defining characteristics of each group, such as high relative user or non-urban, mean that inter-group comparisons included different demographic characteristics (unlike intragroup comparisons between treatment and control subsets in the same group where demographic differences are non-significant because of RCT) and in turn may have quite different responses to survey questions. For this analysis, we can note where these inter-group background differences are statistically significant. These results are unrelated to the report and the implications of these differences across groups, though useful for PSE, are primarily outside of the scope of this analysis.

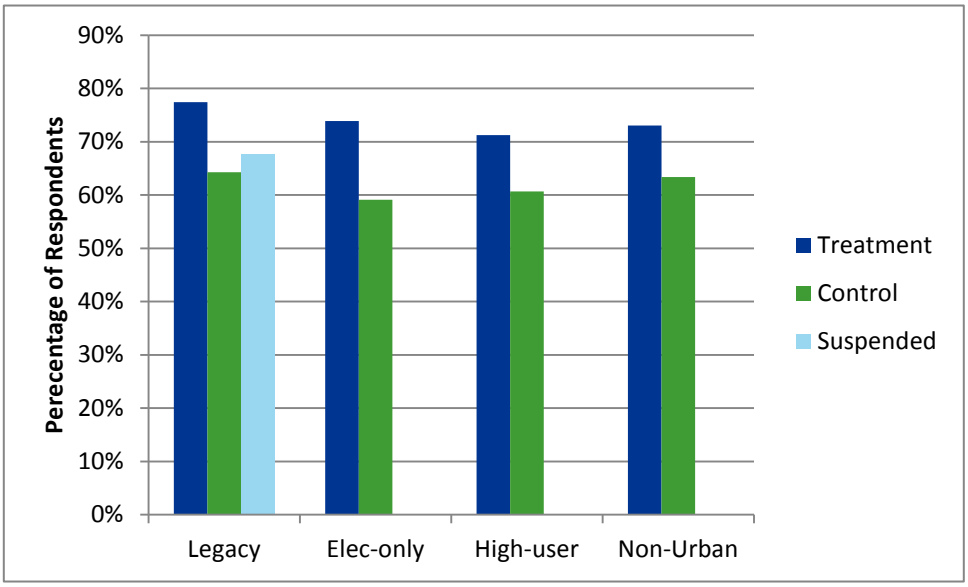
A final perspective compared report-related effects across the different groups. This goes beyond the first question "Is there a convincing effect from the reports?" and asks "Is the report effect different for different groups?" This question is particularly interesting when comparing the legacy group to the expansion group. The legacy group is in its seventh year, while the expansion group has been receiving reports for less than two years. When looking at the consumption impacts, we looked at the level achieved as well as the persistence of those savings, with and without reports. We took a similar perspective with the survey results. These results were related to the interaction of the report and the unique demographic characteristics of the groups. The implications of these differences are important for understanding how the different groups respond to different kinds of program or treatment. As is the case with HER program consumption results, RCT results have high degree of validity but provide no additional insight into what drives the results.

6.1 Familiarity with PSE efficiency programs

The survey asked respondents to rate how familiar they were with energy efficiency or conservation programs from Puget Sound Energy (on a scale of 1 -"Not at all familiar" to 4 - "Very familiar"). The questions were asked of both treatment and control groups for all HER waves. Figure 6-1 provides a bar graph of the combined "Somewhat" and "Very" familiar responses for all waves.

[10] Generally, an estimate has an associated confidence interval that indicates that we are, for instance, 90% confident the true answer is within that interval. When we say an estimate is not statistically significant (or more specifically not statistically significantly different than zero) we are saying that the confidence interval includes zero. This indicates that we cannot be 90% confident that the estimate is not zero. We used the same approach for measuring whether the difference between two values should be considered real or just a possible random outcome. Two estimates may appear to be different, or the difference is greater than zero, but given the underlying variation in the data, we may not be able to say with 90% confidence that the true underlying difference is not zero.

Figure 6-1. Somewhat or very familiar with Puget Sound Energy efficiency programs, all waves



Online survey question: 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?

The control group results provided the baseline level of familiarity with other PSE energy efficiency programs within the different HER waves. The level of familiarity varied among waves; with 59% very familiar for the electric-only wave to 64% for the legacy wave. These differences were solely due to the make-up of the populations in each of these waves. For instance, legacy wave customers have been in their present location since late 2007. Their average time in PSE service territory was probably higher than any of the newer groups, which include customers who have only been in the territory for just two years.

Similar to last year, all four waves showed an increase in familiarity with PSE energy efficiency programs due to the home energy reports. The report-related increases for the treatment groups relative to the control groups ranged from 9.7% to 14.8%. All differences were statistically significantly different from their respective control groups at the 90% confidence level. These results strongly support the hypothesis that HER reports increase familiarity with PSE energy efficiency programs. Additionally, the familiarity of PSE programs increased across all treatment groups compared to 2014.

The results for the suspended group indicated that this increased familiarity does not last after HER reports are suspended. For the second year in a row, the suspended group percentage was not statistically significantly different from the legacy control group.

Given that there was evidence that the reports increased familiarity with PSE energy efficiency programs, it is interesting to compare that increase across the four groups. In 2014, the legacy treatment group's increase in familiarity with PSE programs was smaller than either the high relative user or the non-urban groups' increases despite the substantial number of years the legacy group had been receiving the reports. We hypothesized that additional reports do not necessarily continue to increase awareness in a group. However, in 2015, the legacy treatment group had the largest increase in familiarity with PSE programs compared to the treatment group of any of the four waves. As previously mentioned, the familiarity of PSE

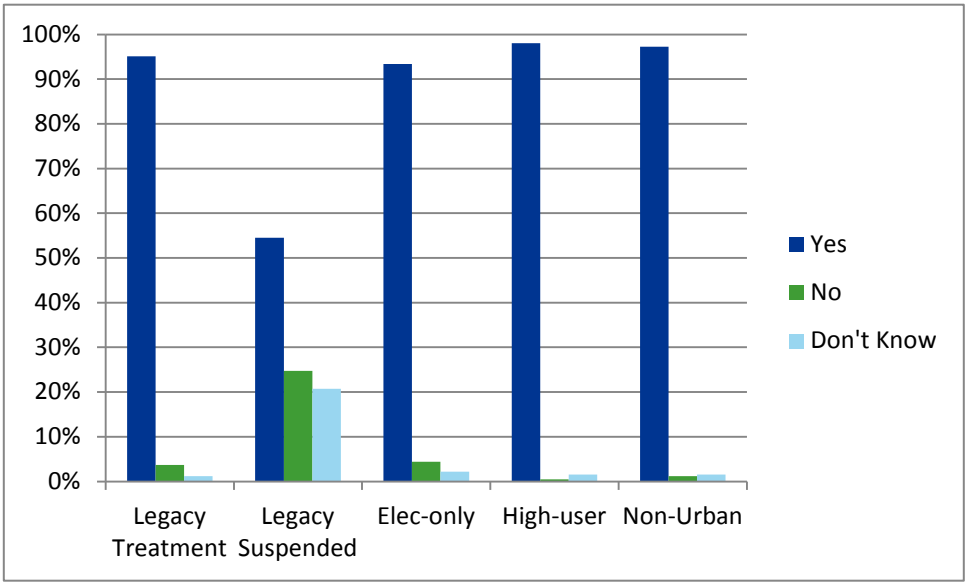
programs increased across all treatment groups compared to 2014. This may suggest that treatment group awareness does continue to increase over time. On the other hand, for the second consecutive year, the legacy suspended group result appeared to indicate that without ongoing reports, awareness will revert to background levels.

6.2 Receiving the home energy report

All respondents from both treatment and control groups were asked whether their household received a home energy report. As expected, the majority of treatment respondents stated that they did receive it. A small but not insignificant proportion of the control groups (12% - 21% across programs) responded that they did receive the home energy report. This is a useful check to show the variability in respondents' memory.

Figure 6-2 provides awareness of the home energy report by different treatment groups. At least 93% of the households in the current treatment groups said that they had received a report. The high user treatment group had the highest level of awareness (98% said "yes"), followed by the current legacy treatment group (95%). For the suspended legacy treatment group, the five-year break from reports substantially reduced the number of households that remember receiving reports (only 55% answered "yes"). This confusion is echoed in the high level of "Don't know" answers for this group.

Figure 6-2. Treatment group awareness of the home energy report

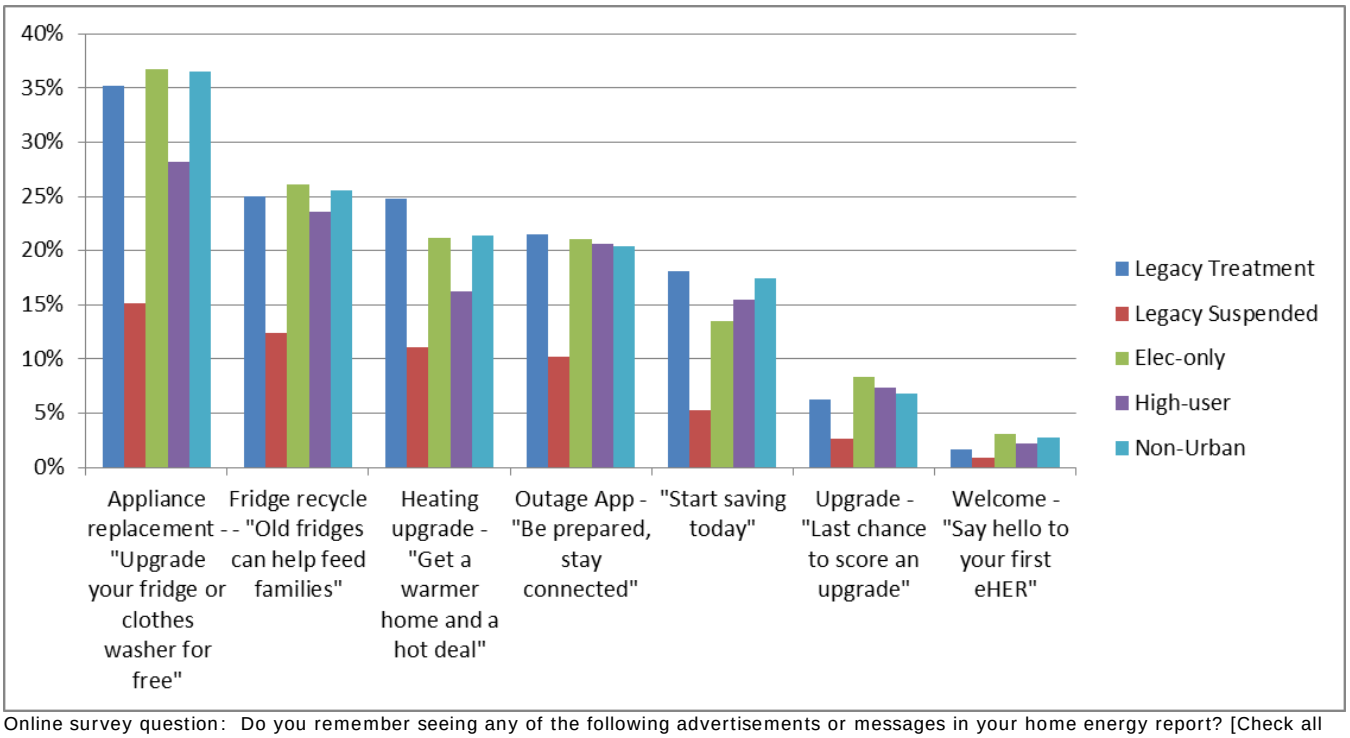


Online survey question: Has your household received a home energy report listing your home's energy use and comparing it with similar homes in the area?

6.3 Recognizing specific messages

PSE staff expressed interest in understanding if specific advertising messages were remembered by those customers receiving home energy reports. The direct way to assess this awareness was to look at customers who both said they received reports and actually did receive reports. Figure 6-3 provides the percentage of message-aware customers out of these report-aware recipients. The results show some differentiation across the five messages. Appliance replacement was clearly the most remembered program across all treatment groups, while the marketing around electronic HERs was at the opposite end of the spectrum. The recentness and frequency of these messages may be one of the drivers of the differentiation. In addition, while the question was specifically seeking memory of these programs as they appeared in the home energy reports, it was difficult to disentangle this memory from general awareness. In fact, general awareness is likely to be an important factor in reported memory of the specific instances of the messaging in the reports.

Figure 6-3. Message awareness across groups



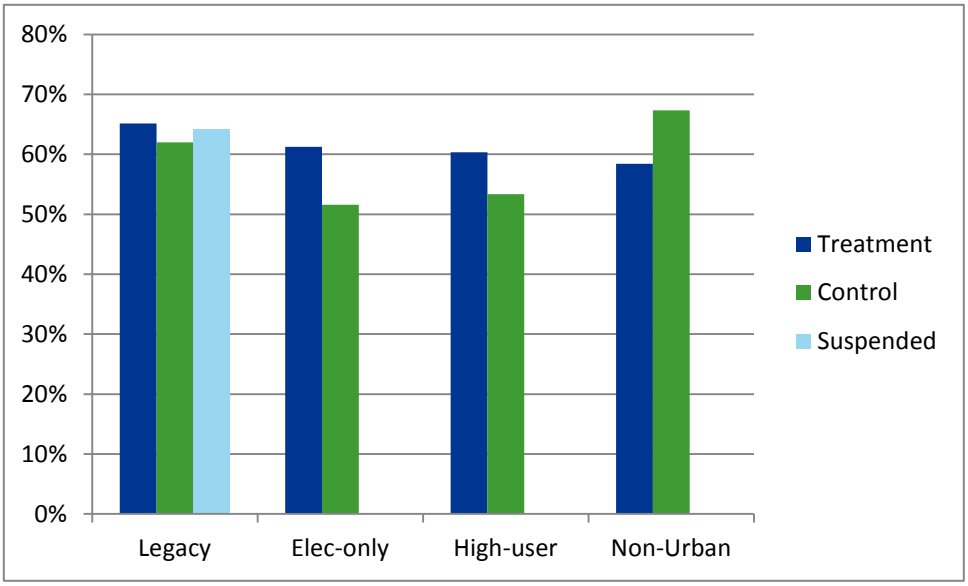
Online survey question: Do you remember seeing any of the following advertisements or messages in your home energy report? [Check all that apply]
a. Appliance replacement - "Upgrade your fridge or clothes washer for free"
b. Fridge recycle - "Old fridges can help feed families"
c. Heating upgrade - "Get a warmer home and a hot deal"
d. Outage App - "Be prepared, stay connected"
e. "Start saving today"
f. Upgrade - "Last chance to score an upgrade"
g. Welcome - "Say hello to your first HER"

It is difficult to draw any meaningful conclusions about the different levels of awareness within each message across the different HER groups. Overall, awareness of individual messages was low amongst all of the HER groups. The majority of messages were remembered by less than a quarter of report recipients across all of HER groups. As expected, the suspended legacy group had the lowest level of awareness of each message. This is likely due to the fact that PSE marketing messages have changed since the suspended group stopped receiving reports.

6.4 Awareness of lighting discounts

All respondents were asked whether they were aware that PSE offers discounts on energy-efficient lighting in retail stores. The non-urban control group had the highest percentage of respondents (67%) saying that they were aware of lighting discounts. While the difference between the non-urban treatment and control group was statistically significant, it's difficult to draw conclusions as to why the control group had a higher level of awareness of lighting discounts. In addition, the non-urban control group was the only control group with a higher level of awareness than the treatment group. Amongst treatment groups, the only statistically significant difference was between the current legacy group and the non-urban groups.

Figure 6-4. Awareness of Puget Sound Energy lighting discounts

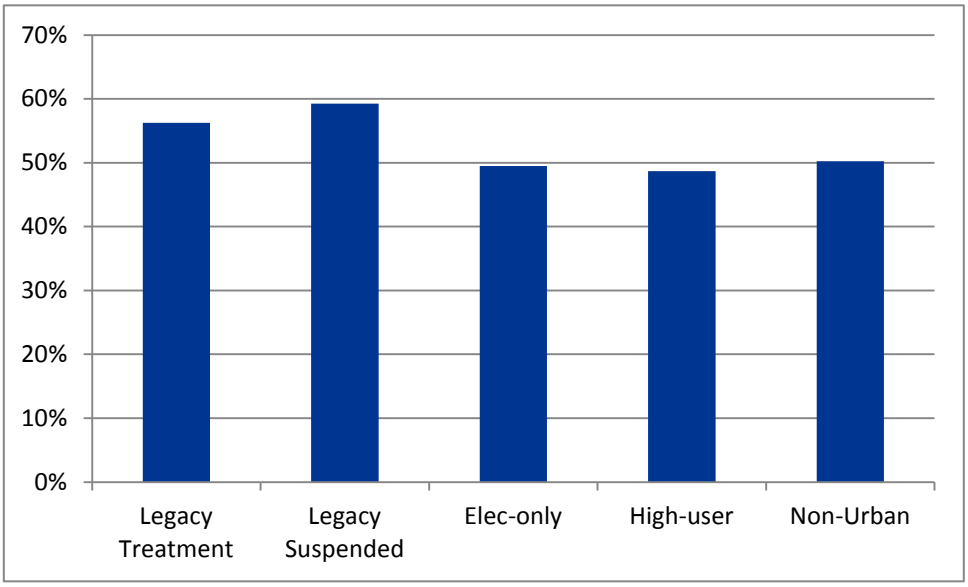


Online survey question: Are you aware of Puget Sound Energy offering discounts on energy efficient lighting in retail stores?

6.5 Satisfaction with home energy report

The online survey asked respondents to rate their overall experience with the HERs on a five point scale, where 1 is Very Unsatisfied and 5 is Very Satisfied. Overall, slightly more than half (51%) of HER recipients (i.e., all HER treatment groups) rated themselves as satisfied (rating of 4 or 5) with their overall experience; 10% of report recipients were very unsatisfied (rating of 1) with the program. Of the treatment groups, the suspended legacy group had the highest level of satisfaction (59%), while the high relative user group had the lowest level of satisfaction (49%). It is unclear if the suspended legacy group's high level of satisfaction is based on their prior experience with the HER program or their perception that they are still participating in the program and receiving reports.

Figure 6-5. Satisfaction with HER experience overall (rating of 4 or 5)



Online survey question: Taking into consideration all aspects, please rate home energy reports overall

6.6 Additional feedback

The final question of the online survey was open ended and asked respondents for suggestions to improve the HER program or other PSE energy efficiency programs. Table 6-1 provides a summary of responses to this question (N=1,238). Over 30% of respondents who answered expressed some type of unhappiness with the content of the report. Many of those respondents questioned the accuracy and/or fairness of the household comparisons included in the reports. In addition, 17% of respondents used the open ended question to raise concerns about something unrelated to the HER program. The three most common concerns were related to issues with PSE billing rates, frequency of power outages, and unhappiness with energy efficient light bulbs (CFLs or LEDs). On the positive side, 6% of respondents expressed positive sentiments about PSE and/or the HER program in general.

Table 6-1. Summary of open ended responses

Comment	Number of respondents	Percent of open-ended responses
Unhappy with HER content	378	31%
Wish to opt out of HER program	49	4%
Change HER delivery - email only	84	7%
Change HER delivery - regular mail only	14	1%
Customer question about HER or other PSE program	66	5%
HER content suggestions	132	11%
HER delivery suggestions	45	4%
Other suggestions	156	13%
Customer complaints	212	17%
Happy with HER or PSE in general	80	6%
Other	22	2%

Online survey question: Do you have any suggestions to improve the delivery of PSE's Home Energy Report Program or any other energy efficiency program?

At the conclusion of the online survey, we provided PSE with a list of customers who wished to opt out of the HER program or wanted to change how their report was delivered. It is our understanding that PSE removed these customers from the HER program or changed their delivery preference, as appropriate. We also followed up with customers who had questions about the HER program or other PSE programs.

7 CONCLUSIONS

The PSE HER program consisted of two pilot studies, the legacy group that began receiving the reports in late 2008 and the three new expansion groups that started receiving the reports in spring 2014. PSE HER legacy group was one of the first programs of its kind implemented in the US. This program has a long track record of savings results and has been one of the programs that served as a proof of concept for this kind of behavioral program as they become widespread in the industry. Because the legacy program is unique in its long tenure, it provided evidence of the persistence of HER program savings both with and without reports.

The PSE expansion program represents an extension of the HER concept into three new populations of PSE customers: high relative user customers, electric-only customers and non-urban customers. The 2015 results for these groups reflect a new implementation that only started in March 2014 when savings starting to ramp up.

The primary focus of this report was an impact evaluation of the PSE HER program. As 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. In particular, it is extremely difficult to establish, with any confidence, what actions are being pursued that produce savings that impact evaluations consistently identify. 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.

In 2012, we conducted a retrospective review of HER performance for the prior three years for a better understanding of what drives the HER program.[11] The conclusions, however, were mixed. The number and range of potential savings activities were large with a combined savings effect of just a couple of percentages. Even with substantial sample sizes in both the treatment and control groups, only a handful of results were statistically significant and informative. For this year's evaluation, the upstream joint savings survey made it possible to ask some customer response and satisfaction questions, but these do not replace a complete process evaluation. A more comprehensive study of the drivers of savings was outside of the scope for this impact evaluation.

Legacy group with reports

Results confirmed that savings for legacy households still receiving reports remained at a level similar to previous years. The HER program savings have been assigned a measure life of one year because this kind of year over year persistence, with ongoing reports, was unknown. The results in this evaluation indicated that savings for the households continuing to receive the reports have remained at a high level for a fifth year.

Consistent with previous evaluations, rebate program joint savings showed strong evidence that the legacy HER program motivated additional activity in gas energy efficiency programs for the group continuing to receive reports. The cumulative gas rebate program joint savings have increased gradually each year to 1.8 therms for 2015 and have been statistically significant every year. As of 2015, about 13.5% of the gas savings that we measured were actually due to the increased activity among the gas rebate programs. In addition, we observed some evidence of increased uptake in electric rebate programs after the seventh year of receiving the reports. In 2015, about 2% of the electric savings were made in conjunction with other

[11] Puget Sound Energy's Home Energy Reports Program: Three Year Impact, Behavioral and Process Evaluation. April 20th, 2012.

rebate programs. As these savings were already claimed by the rebate programs, they were removed for the final credited savings estimates.

Past survey results from a sample of treatment and control households in the legacy group suggested that the HER reports increased the purchase of reduced-price retail lighting for the treatment group continuing to receive reports relative to the control group. That effect was no longer present in 2014 and 2015 for the legacy program that has been in the field for seven years now. On the other hand, the survey results for the expansion group were consistent with the past survey results for the legacy group that suggested a HER-related increase in purchases of rebated efficient lamps. The increased lighting purchases for the expansion groups were mostly LEDs.

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.

Legacy group - suspended reports

The PSE HER program suspended reports to a randomly assigned portion of the legacy group as a test of savings persistence after report cessation. This evaluation was during the fifth year since the suspended treatment group stopped receiving the reports. Similar to 2014 results, measured electric savings of the suspended group maintained a third of what the continuing treatment group was saving. Measured gas savings, on the other hand, remained at about 60% of continuing group savings levels.

The gas rebate program annual joint savings for the suspended group showed a consistent reduction since the reports were discontinued, while the electric rebate program annual joint savings have been small and inconsistent for the suspended group over the last five years. Similarly, the upstream program joint savings have been inconclusive. In previous years, the suspended group annual upstream joint savings outpaced the continued group's levels ever since the reports were suspended, until 2015 when upstream joint savings for the suspended group were negative and relatively smaller than the households in the treatment group receiving the reports. We have no reasonable hypothesis of what could cause the suspended group to have higher upstream joint savings than the current group as observed in the past evaluations other than random variation in the data.

The total credited savings for the suspended group are falling rapidly through the combined effects of customer attrition through move-outs and the falling household-level savings. The household-level savings appear to be falling at a faster rate than the natural move-out related attrition.

Expansion groups

The three HER program expansion groups were only into the second year of the program and generated statistically significant electric and gas savings. Savings were consistent with the typical ramp up these programs experience. Even during the first year of the expansion groups when savings were relatively low, the three expansion groups already produced combined electric savings that exceeded the combined savings from the two legacy treatment groups. In 2015, the overall expansion group electric savings were more than twice the legacy group electric savings. In 2015, expansion group gas savings were also greater than legacy group gas savings, though not as dramatic.

In 2015, electric rebate joint savings from the non-urban group and gas rebate joint savings from the high relative user group were statistically significant while the rest were not. Consistent with the trends in rebate activity observed in the legacy program, all three expansion groups showed an increase in magnitude of rebate savings from 2014 to 2015, with the electric-only group producing the highest electric rebate savings and the non-urban group producing the lowest.

For the upstream joint savings, results indicated that electric-only and non-urban households were taking greater advantage of the upstream program due to the HER program. These findings were consistent with the results found in 2014. Similar to the findings in the rebate analysis, the HER-related uptake in upstream lighting programs increased from Year 1 to Year 2.

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)	7-Oct	21,750	916	2.86	27,461	916	2.55	-0.54	0.89
	7-Nov	21,750	996	3.17	27,461	995	2.77	-1.36	0.75
	7-Dec	21,750	1,217	4.05	27,461	1,216	3.53	-0.41	0.94
	8-Jan	21,750	1,101	3.68	27,461	1,099	3.21	-1.84	0.71
	8-Feb	21,750	941	3.09	27,461	941	2.73	-0.41	0.92
	8-Mar	21,750	974	3.18	27,461	976	2.81	1.37	0.75
	8-Apr	21,750	873	2.83	27,461	874	2.51	0.70	0.85
	8-May	21,750	836	2.66	27,461	837	2.37	0.78	0.83
	8-Jun	21,750	808	2.60	27,461	810	2.34	1.96	0.58
	8-Jul	21,750	810	2.74	27,461	814	2.48	3.32	0.37
	8-Aug	21,750	845	2.80	27,461	848	2.54	3.84	0.31
	8-Sep	21,750	794	2.53	27,461	795	2.31	1.71	0.62
Gas Consumption (therms)	7-Oct	21,750	79	0.20	27,461	79	0.18	-0.17	0.54
	7-Nov	21,750	114	0.26	27,461	114	0.23	-0.16	0.64
	7-Dec	21,750	148	0.32	27,461	147	0.29	-0.16	0.71
	8-Jan	21,750	162	0.35	27,461	162	0.31	-0.22	0.63
	8-Feb	21,750	119	0.26	27,461	119	0.23	-0.29	0.42
	8-Mar	21,750	122	0.28	27,461	122	0.25	-0.14	0.71
	8-Apr	21,750	95	0.23	27,461	94	0.20	-0.25	0.40
	8-May	21,750	51	0.15	27,461	51	0.13	-0.19	0.34
	8-Jun	21,750	42	0.14	27,461	42	0.13	-0.10	0.62
	8-Jul	21,750	21	0.12	27,461	21	0.11	0.08	0.62
	8-Aug	21,750	21	0.11	27,461	21	0.11	0.10	0.54
	8-Sep	21,750	29	0.13	27,461	29	0.12	-0.07	0.67

**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	21,750	30.9	0.105	27,461	30.8	0.094	-0.097	0.492
Number of bathrooms	21,750	2.3	0.004	27,461	2.3	0.003	0.003	0.594
Number of bedrooms	21,726	3.6	0.005	27,407	3.6	0.004	-0.009	0.165
House value ($)	21,749	347,595	1,161	27,461	347,706	1,030	111	0.943
Number of occupancy	19,179	2.3	0.008	24,098	2.3	0.007	0.001	0.948
House size (sqft)	21,750	2,164	4.268	27,461	2,162	3.814	-2.468	0.666

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, and Table 8-5, 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	13-Mar	21,781	992	4.11	7,158	988	7.07	-3.69	0.65
	13-Apr	21,793	887	3.62	7,163	886	6.26	-1.76	0.81
	13-May	21,802	827	3.46	7,165	826	6.01	-1.11	0.87
	13-Jun	21,819	800	3.50	7,173	797	6.02	-3.24	0.64
	13-Jul	21,808	864	3.93	7,170	857	6.77	-6.71	0.39
	13-Aug	21,821	869	3.93	7,169	860	6.83	-8.83	0.26
	13-Sep	21,850	835	3.52	7,182	832	6.24	-3.32	0.64
	13-Oct	21,858	940	3.89	7,190	940	6.83	-0.29	0.97
	13-Nov	21,882	1015	4.19	7,195	1015	7.37	-0.62	0.94
	13-Dec	21,911	1238	5.25	7,199	1240	9.28	2.23	0.83
	14-Jan	21,898	1108	4.72	7,197	1108	8.26	-0.28	0.98
	14-Feb	21,899	1025	4.43	7,187	1022	7.73	-3.53	0.69
Gas	13-Mar	21,221	98	0.33	6,961	98	0.57	-0.14	0.83
	13-Apr	21,291	74	0.26	6,980	74	0.45	-0.10	0.85
	13-May	21,410	40	0.19	7,033	40	0.31	-0.12	0.76
	13-Jun	21,456	24	0.16	7,052	25	0.28	0.10	0.76
	13-Jul	21,513	20	0.16	7,061	20	0.28	0.18	0.57
	13-Aug	21,604	19	0.16	7,097	19	0.31	0.39	0.24
	13-Sep	21,690	29	0.18	7,132	29	0.28	0.12	0.72
	13-Oct	21,788	76	0.28	7,161	75	0.47	-0.68	0.23
	13-Nov	21,808	105	0.35	7,170	104	0.59	-0.76	0.28
	13-Dec	21,820	147	0.45	7,175	146	0.78	-0.97	0.28
	14-Jan	21,880	124	0.39	7,189	123	0.67	-0.47	0.55
	14-Feb	21,887	130	0.40	7,194	130	0.68	-0.59	0.46

**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	13-Mar	28,690	836	3.11	9,531	844	5.67	7.57	0.23
	13-Apr	28,734	749	2.73	9,551	753	4.97	3.81	0.49
	13-May	28,779	709	2.60	9,555	714	4.68	4.80	0.36
	13-Jun	28,777	702	2.64	9,553	707	4.81	4.89	0.36
	13-Jul	28,777	780	3.04	9,559	786	5.51	6.03	0.33
	13-Aug	28,797	787	3.05	9,568	792	5.54	5.26	0.39
	13-Sep	28,816	740	2.68	9,575	742	4.86	2.41	0.66
	13-Oct	28,820	809	2.88	9,575	812	5.24	3.15	0.59
	13-Nov	28,848	880	3.18	9,583	880	5.73	0.43	0.95
	13-Dec	28,863	1084	4.09	9,599	1086	7.34	2.18	0.79
	14-Jan	28,851	959	3.62	9,597	959	6.44	-0.04	1.00
	14-Feb	28,866	886	3.41	9,602	888	6.09	1.60	0.82
Gas	13-Mar	28,333	83	0.24	9,417	84	0.42	0.54	0.25
	13-Apr	28,403	62	0.19	9,442	63	0.33	0.50	0.19
	13-May	28,522	35	0.13	9,491	35	0.23	0.47	0.07
	13-Jun	28,548	22	0.11	9,508	23	0.20	0.35	0.11
	13-Jul	28,594	19	0.10	9,516	19	0.19	0.36	0.08
	13-Aug	28,695	18	0.10	9,543	19	0.19	0.40	0.05
	13-Sep	28,751	26	0.10	9,566	26	0.21	0.61	0.00
	13-Oct	28,791	65	0.20	9,575	65	0.35	0.44	0.27
	13-Nov	28,818	90	0.25	9,575	91	0.44	0.45	0.37
	13-Dec	28,812	129	0.34	9,575	130	0.59	0.93	0.17
	14-Jan	28,831	108	0.29	9,578	108	0.52	0.34	0.57
	14-Feb	28,863	113	0.30	9,593	114	0.53	0.52	0.39

**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	13-Mar	21,468	1353	5.87	7,103	1361	10.19	8.36	0.48
	13-Apr	21,490	1129	4.82	7,104	1135	8.34	5.98	0.54
	13-May	21,500	907	3.78	7,102	908	6.52	0.55	0.94
	13-Jun	21,511	800	3.41	7,098	798	5.93	-1.55	0.82
	13-Jul	21,509	826	3.64	7,100	824	6.30	-1.71	0.81
	13-Aug	21,519	825	3.61	7,105	822	6.13	-2.27	0.75
	13-Sep	21,545	848	3.49	7,120	846	5.90	-1.53	0.83
	13-Oct	21,578	1165	4.93	7,119	1169	8.49	4.04	0.68
	13-Nov	21,586	1411	6.05	7,125	1420	10.52	9.07	0.45
	13-Dec	21,640	1867	8.18	7,144	1879	14.23	11.74	0.47
	14-Jan	21,630	1629	7.17	7,143	1639	12.47	9.31	0.52
	14-Feb	21,639	1611	7.21	7,146	1618	12.49	6.55	0.65

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 2015

Table 8-6. HER legacy measured savings based on actual consumption from 2009 to 2015

Year and group	Electric (kWh)	+ / -	Gas (therms)	+ / -
2009	197.7* (173.7,221.7)	23.99	12.9* (11.3,14.6)	1.65
2010	254.9* (223.5,286.2)	31.34	13.8* (11.7,15.9)	2.13
2011- current	292.2* (250.0,334.4)	42.20	13.0* (10.3,15.7)	2.68
2012 - current	306.0* (258.1,353.9)	47.87	12.7* (9.8,15.6)	2.89
2013 - current	334.3* (280.9,387.7)	53.37	14.8* (11.6,17.9)	3.16
2014 - current	310.1* (253.2,367.1)	56.95	13.2* (9.9,16.6)	3.32
2015 - current	311.5* (251.2,371.9)	60.37	13.4* (9.9,17.0)	3.56
2011- suspended	246.4* (190.9,301.9)	55.48	12.8* (9.3,16.2)	3.43
2012- suspended	196.0* (132.8,259.3)	63.26	8.7* (5.0,12.4)	3.72
2013- suspended	184.3* (113.5,255.2)	70.85	11.9* (7.8,15.9)	4.04
2014 -suspended	125.5* (50.3,200.8)	75.23	10.2* (5.9,14.5)	4.28
2015 - suspended	104.4 (24.9,184.0)	79.56	8.5 (3.9,13.1)	4.60

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

Table 8-7. HER expansion measured savings based on actual consumption from 2009 to 2015

Year and group	Electric (kWh)	+/-	Gas (therms)	+/-
2014 - Electric only	115.7	72.6	NA	NA
	(43.1, 188.3)		NA	
2014 - High relative user	86.6	57.5	6.1	4.5
	(29.1, 144.0)		(1.9, 10.3)	
2014 - Non-urban	48.4	39.1	1.2	2.8
	(9.3, 87.6)		(-1.6, 4.0)	
2015 - Electric only	210.7	80.02	NA	NA
	(130.7,290.7)		NA	
2015 - High relative user	226.3	79.06	10.1	4.27
	(147.3,305.4)		(5.8,14.4)	
2015 - Non-urban	140.9	51.30	3.9	2.94
	(89.6,192.2)		(0.9,6.8)	

8.3 HER results from the fixed effects model

This section provides monthly savings estimates from a pooled fixed effects model that is commonly used in HER evaluations. Unlike the differences-in-differences approach, this analysis accounts for partial year savings in 2015 by calculating savings for each post month using all active HER participants in each month in 2015. The average savings for each of the months in 2015 represent savings from the households still eligible for the program in that month.

Figure 8-1 and Figure 8-2 show monthly electric and gas savings for the legacy treatment groups. Electric savings for the two treatment groups are different in magnitude but follow a similar pattern. The savings trends were somewhat flat with the current group's monthly savings ranging from 20 kWh to 30 kWh and 0 kWh to 10 kWh for the suspended group. For all months in 2015, the current group showed savings that were statistically significant while the suspended group did not show any evidence of savings for almost half of the year in 2015. On the other hand, the suspended group showed slower decay in gas savings and maintained at least 60% of the gas savings of the households in the seventh year of receiving the report.

Figure 8-1. Monthly electric savings estimates for legacy group, 2015

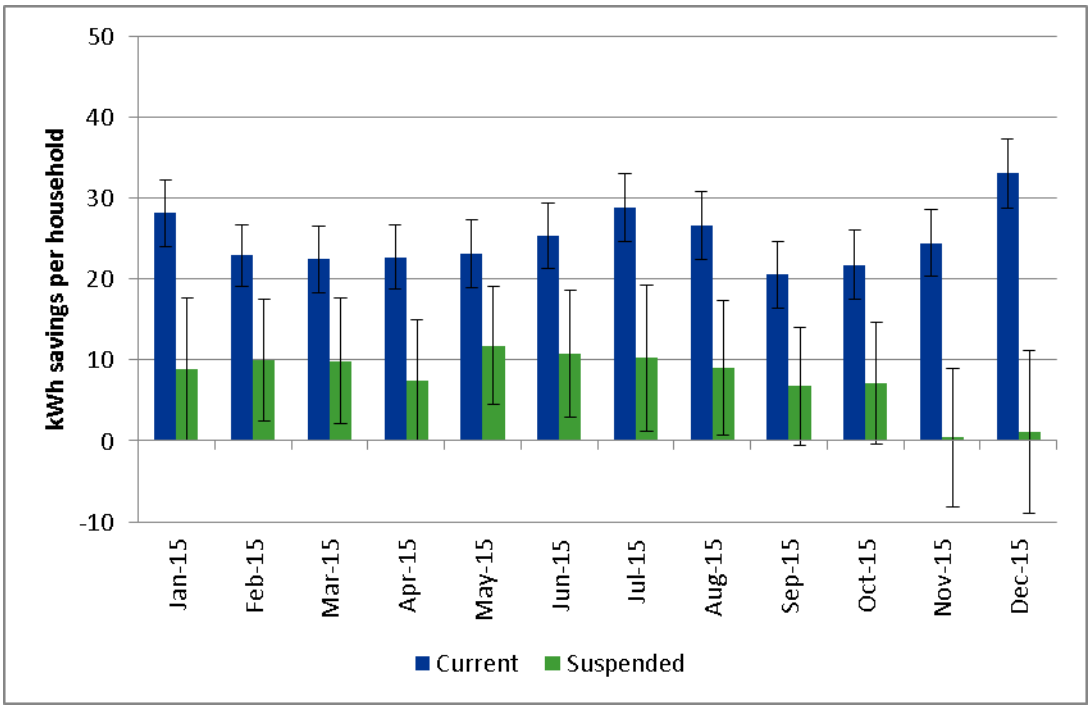


Figure 8-2. Monthly gas savings estimates for legacy group, 2015

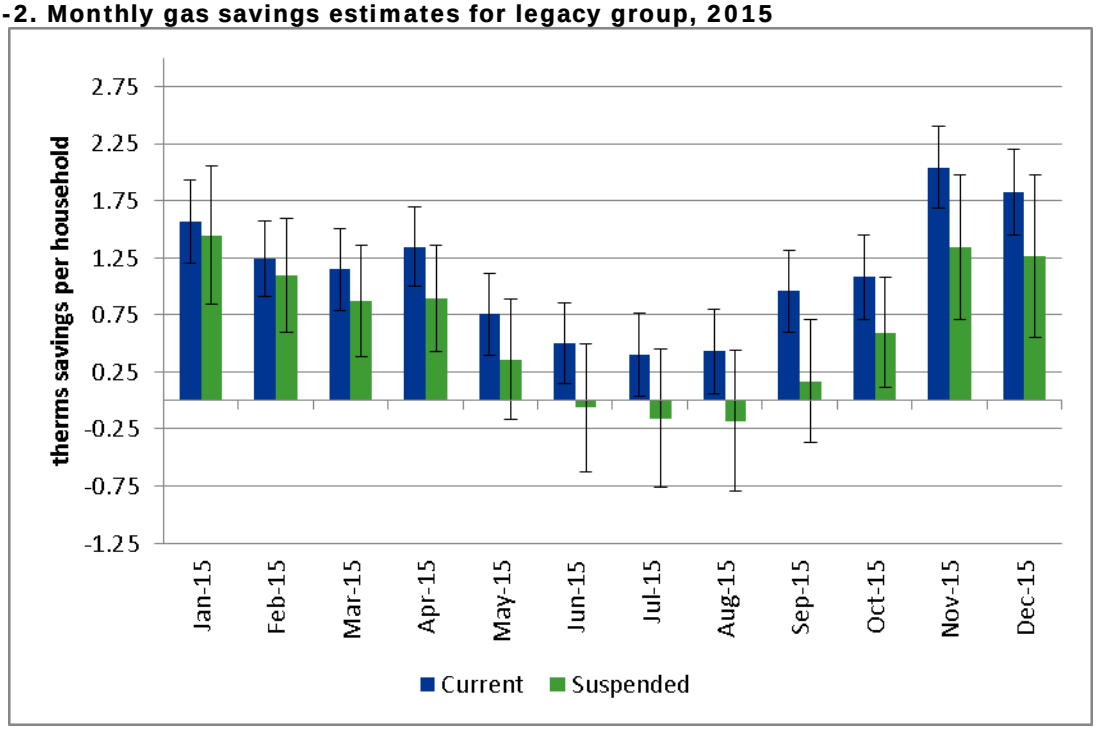


Figure 8-3 to Figure 8-5 show monthly electric savings for the three expansion groups. Monthly savings trends showed different patterns reflecting the inherent characteristics of the three expansion groups. The electric-only group produced the highest savings during the cooler months while electric savings produced by the high relative user groups were relatively flatter and statistically different from zero for all months in 2015. The non-urban group produced the smallest magnitude of savings among the three groups; savings were highest during the summer months and in December.

Figure 8-3. Monthly electric savings estimates for electric only group, 2015

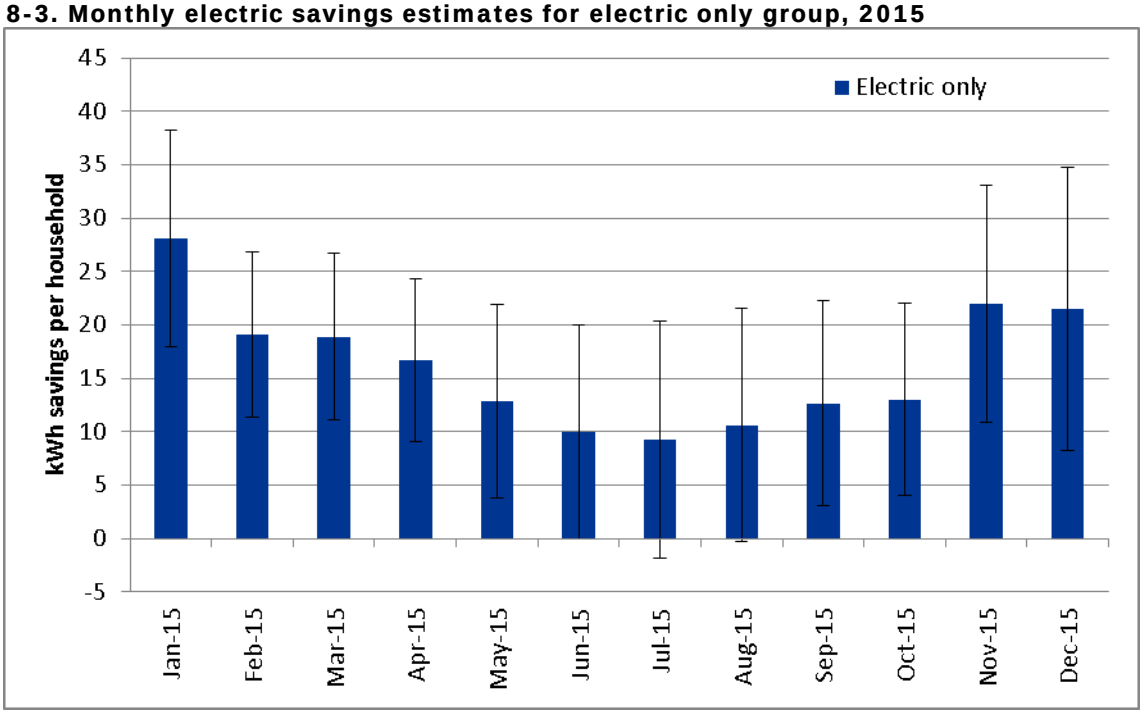


Figure 8-4. Monthly electric savings estimates for high relative user group, 2015

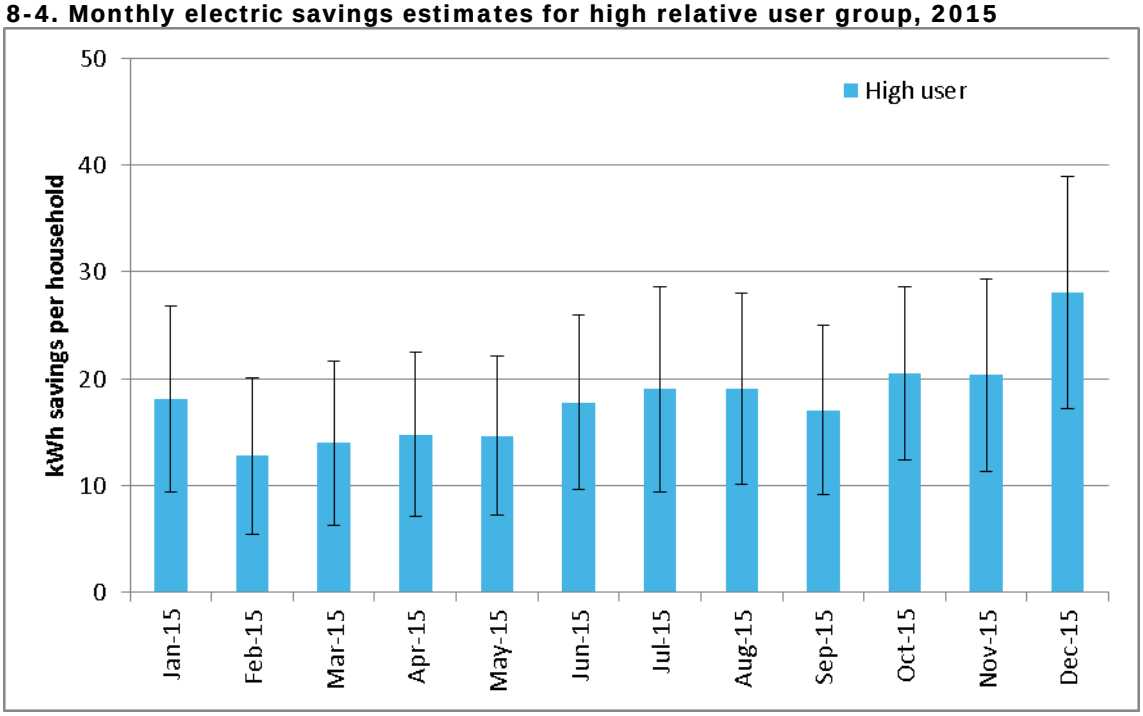


Figure 8-5. Monthly electric savings estimates for non-urban group, 2015

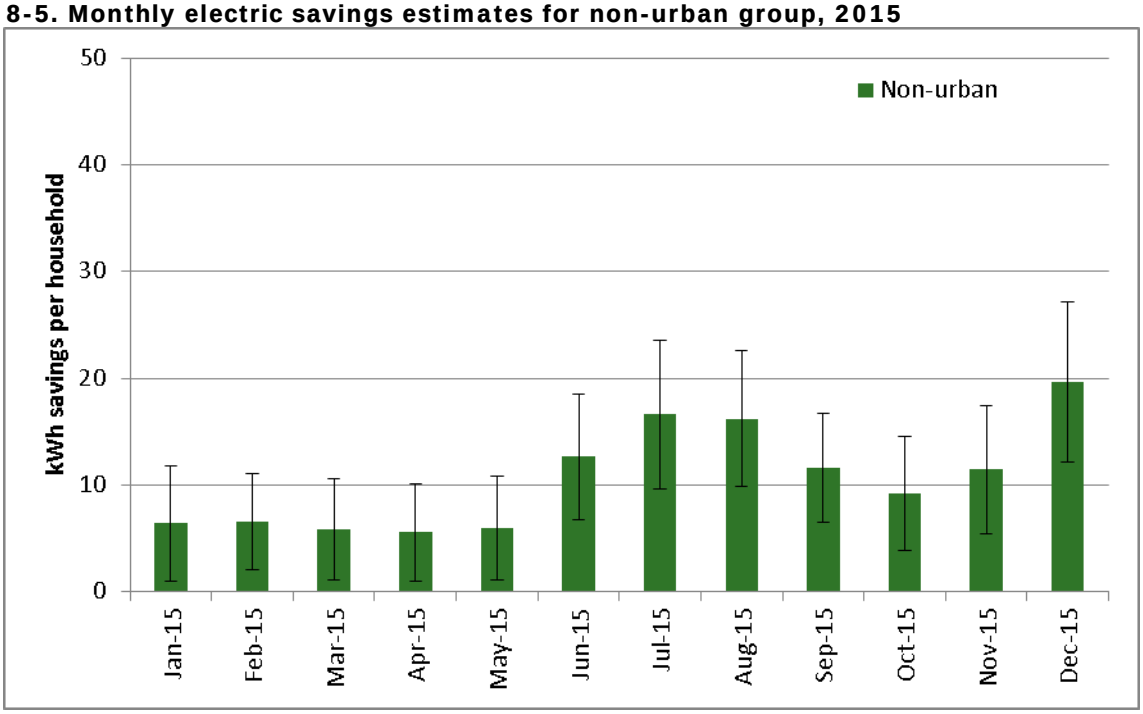


Figure 8-6 and Figure 8-7 show monthly gas savings for the high relative user group and non-urban group. The two expansion groups followed a similar trend in gas savings. Gas savings were statistically significant for most of the winter months and results also showed evidence of gas savings from February to May for both groups.

Figure 8-6. Monthly gas savings estimates for high relative user group, 2015

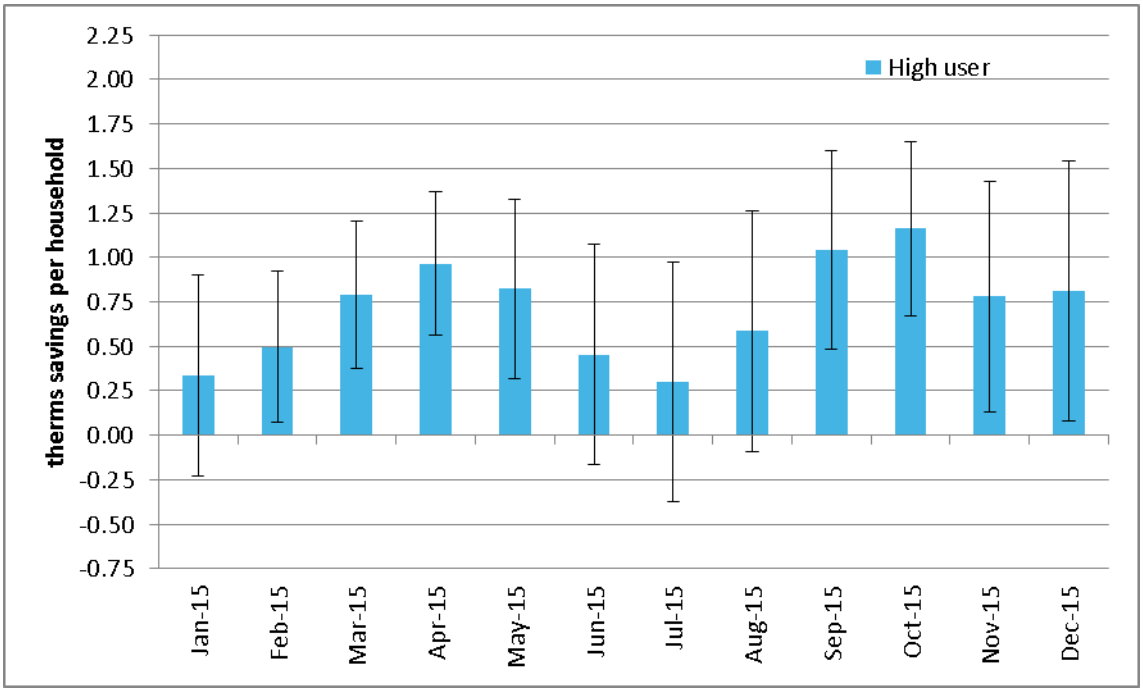
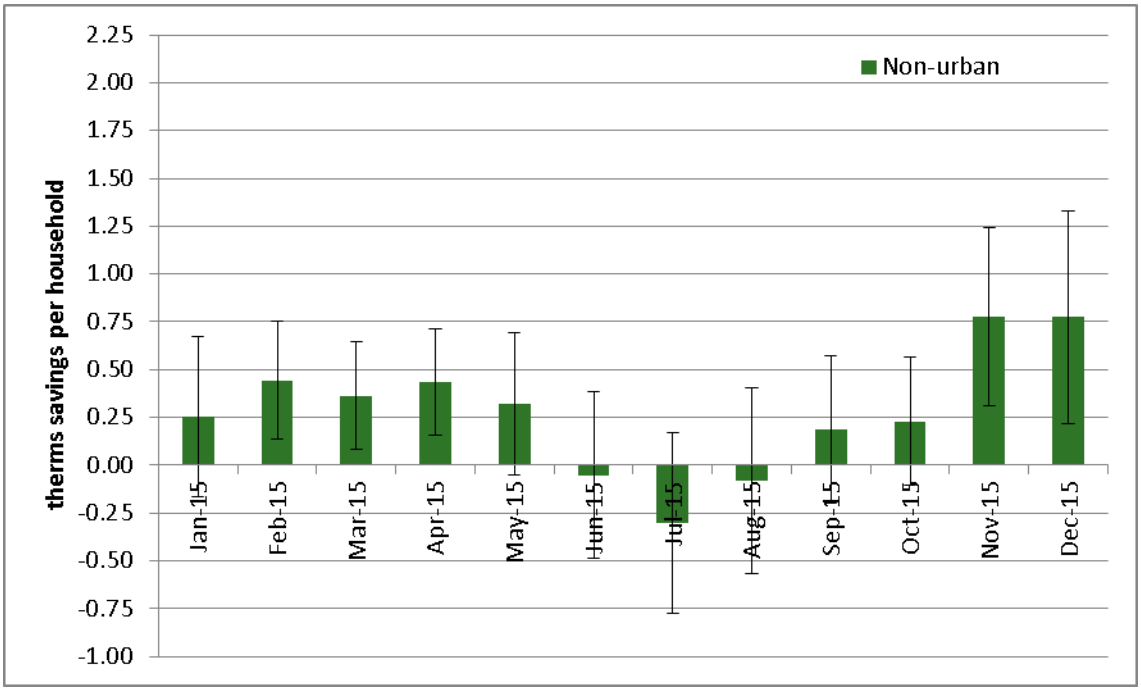


Figure 8-7. Monthly gas savings estimates for non-urban group, 2015



8.4 Impact methodology

Difference-in-differences

The difference-in-differences approach is the most 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

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.[12]

Fixed effects model

For this evaluation, we also 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:

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

[12] 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.

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]

[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.

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:

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: Dane Tomalin
Study Report Name: Puget Sound Energy's Home Energy Reports: 2015 Impact Evaluation
Report Date: October, 2016
Evaluation Analyst: Jim Perich-Anderson
Date ERR Provided to Program Manager: 11/11/2016

Date of Program Manager Response: 11/11/2016
Please describe in detail, action plans to address the evaluation study's key findings and recommendations.

Overview: Home Energy Report evaluation shows "joint savings" for both electric and gas fuels in households that continue to receive reports and households that had the report service discontinued. The evaluation also includes PSE's Expansion Group results.

Action Plan: Based on the results in the evaluation report, Program Management will adopt the key findings as savings for the program. Program Management will continue to review the savings performance of the households that had report service discontinued in order to evaluate the persistence of this measure.

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 will be used for our ex-post savings claim for 2015. This evaluation and the methodologies within should be used for future HER evaluations.