

PSE HOME ENERGY REPORTS PROGRAM

# 2017 Impact Evaluation – Final Report

Puget Sound Energy

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# 1 EXECUTIVE SUMMARY

## 1.1 Background

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

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

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

- The legacy group (November 2008): the treatment group of nearly 40,000 dual fuel, single family homes received a Home Energy Report; the control group of 44,000 dual fuel, single family homes did not. By program year 2017, about 20,000 (50%) of the original treatment population remain; of these 13,526 continued to receive HERs in 2017. Program attrition is due to customer move-outs.
- The suspended group (January 2011): approximately 10,000 treatment group households stopped receiving the HER in January 2011, allowing PSE to test the persistence of savings after the cessation of reports. By program year 2017, 6,776 customers from the suspended treatment group remain.
- The expansion groups (March 2014): the program added approximately 140,000 households. This was a pilot effort to determine whether adding 1) households with high energy usage relative to the size of their home (high relative user), 2) electric-only households, and/or 3) non-urban households made a difference in per-participant energy savings and/or customer satisfaction. Like the PSE HER legacy program, the expansion program followed an experimental design with 105,000 randomly selected treatment households and 35,000 randomly selected control group households. In 2017, close to two-thirds of the original expansion treatment households remain in the program.

- The refill group (May 2015): PSE added approximately 25,000 treatment households and 10,500 control households from the remaining population of the HER expansion pool to replace households lost due to customer attrition since the start of the program.<sup>1</sup> Of these, close to 80% of the treatment households remain in the program in 2017.

## 1.2 Evaluation Goals and Objectives

The main goal of the impact evaluation is to estimate HER program savings for the year 2017. Specifically, the objectives are to:

1. **Calculate Measured Savings:** measure the reduction in electric and natural gas consumption for the HER treatment groups.
2. **Calculate Joint Savings:** quantify savings from HER participants' increased participation in other PSE energy efficiency programs, including:
  - 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's upstream lighting program.
3. **Calculate Credited Savings:** provide a final estimate of 2017 HER savings for all legacy and expansion programs, removing joint savings.
4. **Expand Study to Unmatched Group:** Provide an estimate of electric and natural gas savings for an additional treatment group that had been previously excluded from savings estimates due to the lack of a randomly assigned control group (the unmatched treatment group).

## 1.3 Key Findings

In this evaluation, key findings include:

1. **All randomized treatment groups who received HERs in 2017 achieved credited savings that are statistically significant.** The legacy current group achieved the largest significant credited savings as a percent of consumption (3.1% electric and 1.6% gas savings per household), while expansion groups, still within their ramp-up period, achieved significant credited savings for all groups (between 1.3% and 2.7% electric and 1.1% and 1.3% gas savings per household).
2. **HER-related savings persist after customers stop receiving the report, though savings decline over time.** The legacy suspended group saves a significant amount of both electric and gas. Its gas savings were two-thirds of the legacy current treatment group's gas savings while its electric savings were a third of that of the legacy current treatment group's savings.

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<sup>1</sup>Oracle selected the refill group from customers expected to have relatively high savings based on their energy use history; customers in the highest usage groups typically have higher savings potential.

3. **The expansion groups have lower credited savings percentages, though savings are increasing over time.** The expansion groups continue to show increasing trends in electric savings, matching the savings trends of the legacy current group. If these groups continue to mirror the program ramp-up trend of the legacy group, we will see additional years of growth in electric savings among the expansion groups. In addition, they also have gas savings that have been trending upwards since the start of the program.
4. **Over time, treatment households achieve deeper electric savings from participating in additional PSE programs than control households.** All electric groups except the legacy suspended and the expansion electric only households experienced joint electric rebate savings that were statistically significant in 2017. Similarly, all groups except the legacy suspended and the refill group had statistically significant joint gas savings. While treatment households, in general, had higher savings from participating in other PSE rebate programs, they participated at the same rate as control households in 2017. These results suggest that the increased uptake in other PSE rebate programs seen in past years has reached equilibrium. The treatment groups, however, continue to achieve deeper savings from other PSE energy efficiency programs which may be due to the installation of higher impact measures and/or year-on-year savings of previously-installed measures.

Table 1-1 and Table 1-2 summarize the group-level and overall electric and gas savings estimates, respectively. The overall electric savings were estimated at 90/13 precision and the gas savings were estimated at 90/15 precision. The table includes the unmatched treatment group per household savings. Total program savings for electric and gas are statistically significant at the group-level and overall.

**Table 1-1. Total credited electric savings for the 2017 HER program (kWh)**

Treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Credited Savings	No. in group	Total savings	Lower limit 90% CI	Upper limit 90% CI
<b>Legacy - Current</b>	313.1	8.1	305.0	13,526	4,125,073	3,242,057	5,008,090
<b>Legacy - Suspended</b>	91.3	0.0	91.3	6,776	618,370	42,539	1,194,201
<b>Unmatched Group<sup>1</sup></b>			335.9	3,628	1,218,578	957,765	1,479,601
<b>Expansion - Electric only</b>	231.0	49.5	181.5	20,782	3,771,407	1,785,578	5,757,235
<b>Expansion - High relative user</b>	313.5	18.4	295.1	19,001	5,608,085	3,934,119	7,282,050
<b>Expansion - Non-urban</b>	184.7	38.0	146.7	27,607	4,050,558	3,756,540	4,344,577
<b>Expansion - Refill</b>	322.4	10.6	311.7	19,638	6,121,810	4,775,018	7,468,602
<b>ALL</b>			229.9	110,958	25,513,880	21,805,444	29,222,317

<sup>1</sup>Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (3.1%) by the average household consumption of the unmatched group (10,967 kWh).



All the different treatment groups produced statistically significant electric savings. Overall, the PSE HER electric customers saved 25.5 GWh.

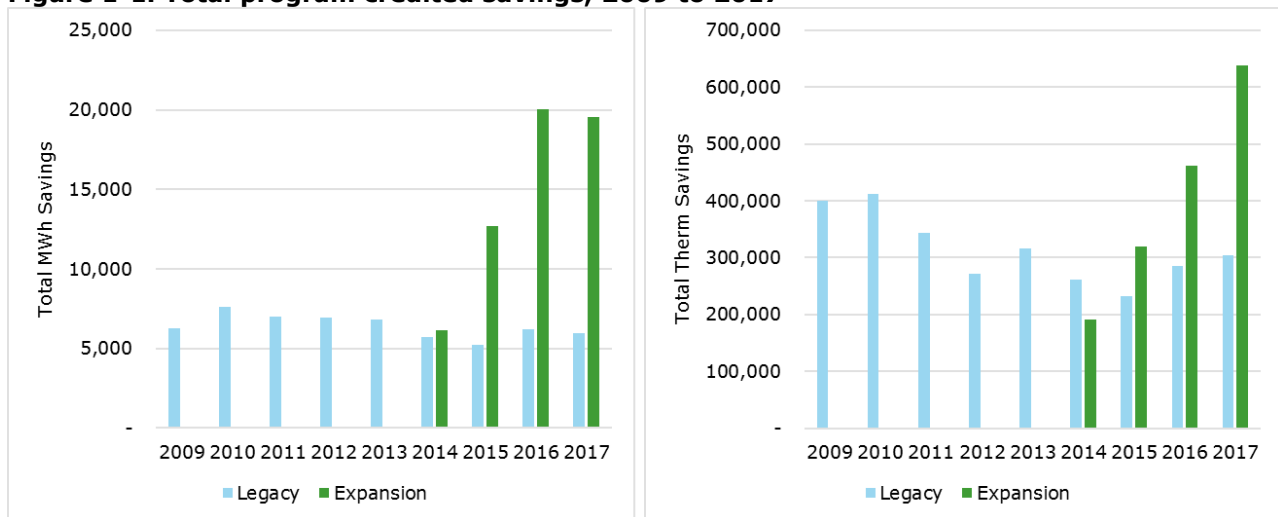
**Table 1-2 Total credited gas savings for the 2017 HER program (therms)**

HER treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Credited Savings	No. in group	Total savings	Lower limit 90% CI	Upper limit 90% CI
<b>Legacy - Current</b>	15.5	1.9	13.5	13,526	182,877	128,474	237,281
<b>Legacy - Suspended</b>	9.2	0.1	9.1	6,776	61,862	26,610	97,115
<b>Unmatched Group<sup>1</sup></b>			16.4	3,628	59,581	41,864	77,118
<b>Expansion - High relative user</b>	11.7	1.4	10.3	19,001	195,540	107,376	283,704
<b>Expansion - Non-urban</b>	9.5	0.1	9.4	27,607	260,072	171,934	348,210
<b>Expansion - Refill</b>	9.7	0.4	9.3	19,638	181,889	114,205	249,572
<b>ALL</b>			10.4	90,176	941,822	773,051	1,110,593

<sup>1</sup>Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (1.6%) by the average household consumption of the unmatched group (1,032 therms).


Like the electric savings, most of the PSE HER groups generated statistically significant gas savings with the unmatched group being the only exception. Overall, PSE HER customers generated 941,822 therms.

**Figure 1-1. Total program credited savings, 2009 to 2017**



Note that 2016 and 2017 legacy totals include the unmatched group's total savings.

The two charts above track historical savings starting with outcomes from the first HER program in 2009. The legacy group generated its highest electric savings in 2010 before beginning to decrease, when the legacy suspended group stopped receiving HERs and as attrition increased. Legacy gas savings have been experiencing peaks and valleys but overall have been decreasing as well. The legacy group's 2016 and 2017



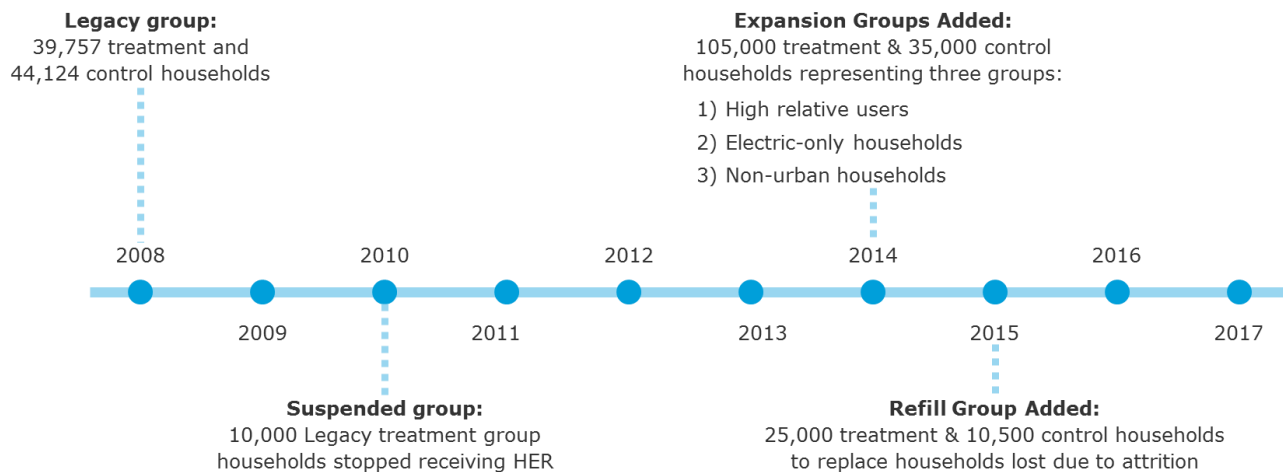
totals include the total savings estimates for the unmatched group. For the expansion group, savings for both electric and gas have been increasing. The increase in total savings over time for the expansion group includes results from the newly introduced refill group in 2015.

## 2 INTRODUCTION

### 2.1 Program Description

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 uses social normative techniques to encourage responsible energy behavior and choices. Oracle, formerly Opower, administers the program, providing comparative energy usage reports with feedback to households on their energy use compared to the energy usage of neighboring homes. The program applies the concept of behavioral “nudges” to motivate customers to achieve energy savings. In addition, the reports provide tips for reducing energy consumption through behavioral changes and participation in other PSE energy efficiency programs. The program is 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. Below we outline key milestones in the program’s history.

**Figure 2-1. PSE HER key milestones**



### 2.2 Experimental Design Overview

Table 2-1 describes the selection criteria for each HER group. They share many of the same characteristics such as single family households, no solar PV system installed, address in county parcel data, sufficient billing history, and sufficient number of similar neighbors. The requirement that households must have 100 similarly sized homes nearby to be included in the HER program ensures that comparisons are based on houses with similar energy needs and, hence, are valid. All groups, excluding the expansion electric only, consist of dual-fuel homes. Below we discuss the history and goals of the HER programs.

**Table 2-1. HER program selection criteria**

Criteria	Legacy	Relative high user	Non-urban	Electric only	Refill
<b>Starting year</b>	2008	2014	2014	2014	2015
<b>Single family</b>	√	√	√	√	√
<b>No solar PV system</b>	√	√	√	√	√
<b>Address in county parcel data</b>	√	√	√	√	√
<b>Billing history</b>	On or before Jan. 1, 2007	On or before Jan. 1, 2013	On or before Jan. 1, 2013	On or before Jan. 1, 2013	On or before Jan. 1, 2014
<b>Daily meter reads</b>	√	√	√	√	√
<b>100 similar sized homes nearby</b>	√	√	√	√	√
<b>&gt; 80 Mbtu of energy/year</b>	√				
<b>High consumption relative to size</b>		√			
<b>Non-urban zip code</b>			√		
<b>Electric space &amp; water heating</b>				√	
<b>PSE fuel type</b>	Dual	Dual	Dual	Electric Only	Dual

**Legacy program**

In 2008, PSE established the legacy HER program. PSE selected 83,881 single family homes located in PSE’s combined gas and electric service territory based on the selection criteria in the table above. After selecting participating households, PSE randomly assigned 39,757 homes to the treatment group with the remaining homes acting 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. This allowed PSE and Oracle to test if the frequency of reports affected energy savings.

This setup ran from November 2008 through December 2010. Starting in November 2010, PSE discontinued sending reports to 9,674 treatment homes. This treatment group became the “legacy suspended” group, while households that continued to receive reports became the “legacy current” group.

**Expansion program**

In 2014, PSE added a new population to the HER program to include a total of 140,000 single family households assigned to the high relative user, non-urban, and electric only groups. Both the high relative user and electric only groups consisted of 31,500 homes in the treatment group and 10,500 homes in the

control group. The non-urban group consisted of 42,000 homes in the treatment group and 14,000 homes in the control group.

**Refill program**

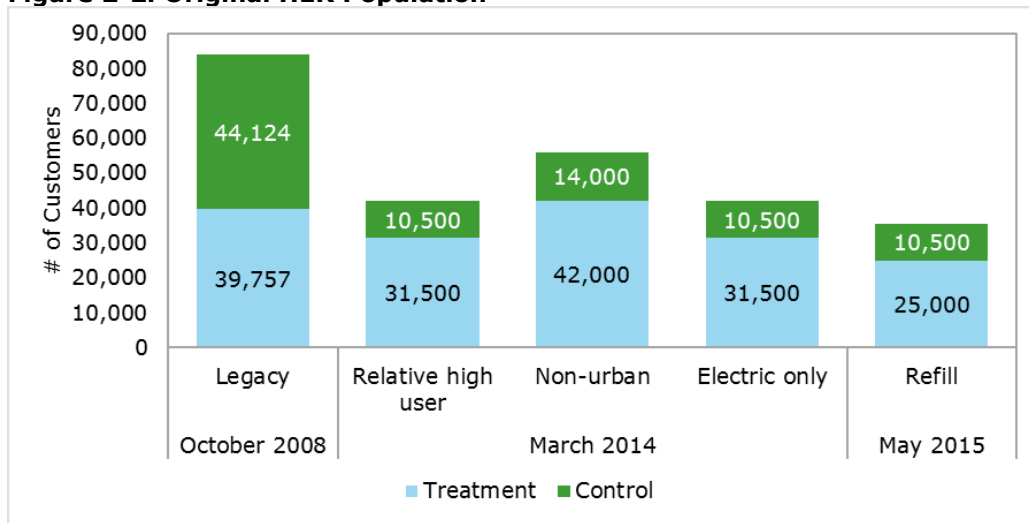
In May 2015, PSE added a refill group that consisted of households from the remaining population of the HER expansion pool. The refill group included 25,000 treatment households and 10,500 control households that were randomly selected to replace households lost due to customer attrition.

**Unmatched treatment customers**

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

Figure 2-2 shows the original number of customers in each of the HER groups excluding the unmatched customers.

**Figure 2-2. Original HER Population**



## 2.3 2017 Evaluation Objectives

This evaluation focused on energy savings due to the PSE HER program for calendar year 2017. The specific objectives are to:

1. Measure the reduction in electric and natural gas consumption for the HER treatment groups.
2. Quantify joint savings from HER-related increased uptake of other PSE energy efficiency programs which may be present in the measured consumption reduction:
  - o An increase in the number of participants and/or extent of participation in PSE rebate programs due to the HER
  - o A HER-related increase in the number of purchased upstream CFL or LED bulbs supported by PSE.
3. Provide a final estimate of 2017 HER savings for legacy and expansion programs, adjusted for double counted savings resulting from increased participation in PSE rebate and upstream lighting programs by treatment customers.
4. Provide an estimate of electric and natural gas savings for an additional treatment group that had been previously excluded from savings estimates due to lack of a randomly assigned control group (the unmatched treatment group).

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

## 3 DATA SOURCES AND PREPARATION

Like past evaluations, the 2017 PSE HER impact evaluation is based on consumption, program tracking, and customer information data. DNV GL reviewed all datasets for accuracy and completeness. Data sources and preparation activities are described in the following subsections.

### 3.1 Data sources

We describe sources of data used in the study in this section.

#### **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 original 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

DNV GL received daily consumption data for 2017 from Oracle to facilitate the impact analysis. This dataset included premise numbers, customer account numbers, meter numbers, daily consumption reads, read dates, and the type of reading (actual or estimated).

### Monthly consumption data

PSE also provided 2017 monthly consumption data for the HER legacy and expansion participants. The dataset included monthly consumption from January to December 2017, participant IDs, site location, treatment assignment, customers who opted out of the program, and consumption read dates. We used these read dates to identify participants that moved out during the analysis period.

### Rebate program tracking data


PSE provided the 2017 rebate program tracking data, which we used to calculate rebate program joint savings. The tracking data included participant information, account numbers, program name, measures installed, installation dates, and claimed savings. PSE also provided us with end-use load shapes when we first began evaluating the HER program, which we used to determine when savings occurred during the year for each measure installed.

## 3.2 Data Preparation

As part of the data preparation, we checked and cleaned the data and identified program participants from the initial HER rosters who should be included or excluded from the current year's evaluation. This section presents the methods used to prepare the data as well as the attrition which occurred during each step. We focus on the daily consumption data, as it was the primary data used to determine the impacts of the HER legacy and expansion programs. We examined the consumption data for completeness and potential data issues such as duplicates, extreme values, missing observations, and other inconsistencies.

Consumption data preparation steps addressed the following issues:

- **Duplicate reads.** DNV GL identified and removed duplicates using the following criteria:
  - When meters produced two or more identical reads in one day, we included only one read in the analysis.
  - When a meter produced two or more different reads in a day, we excluded all reads from the analysis.
- **Negative reads.** DNV GL excluded all negative reads.
- **Extreme reads.** We excluded extreme values, defined as a daily read greater than 150 kWh per day or 11 therms per day.
- **Missing reads.** DNV GL investigated missing reads and identified two causes:
  - *Missing daily observations, caused by missed daily reads.* These were generally followed by a single read that covered the multiple missing days. We employed data imputation to distribute energy consumption across the days with missing reads. DNV GL only imputed



consumption 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.
- **Move-outs.** While evaluations before 2016 removed move-outs from the entire analysis, the fixed-effects methodology used beginning in the 2016 evaluation allowed us to include households that moved out partway through the current evaluation year for the months where they were active customers.
- **Opt-outs.** One percent or less of the households in the legacy and expansion treatment groups opted to not receive the reports at some point during the treatment period, but remained designated as members of the treatment group. Removing opt-out households would undermine the similarity between the two groups established by the program’s experimental design and so we did not remove them. This is referred to as testing the “intent to treat” and is necessary to produce an unbiased estimate of the reports’ effect.<sup>2</sup>

Table 3-1 shows the disposition for the legacy group. The table summarizes the original program population, counts of households removed from the analysis, and the final sample used in the 2017 billing analysis for the legacy program. The majority of customers that we lose over time are due to move-outs (attrition). While we did not remove customers who moved out during the 2017 evaluation period, we did lose customers who moved out in prior years and are no longer active. We also lost a handful of customers due to data quality issues. By program year 2017, about 50% of the original treatment and control population from 2008 remain in the program.

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<sup>2</sup>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 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. Households with customer attrition that is not correlated with the treatment (in this case, the reports) can be removed from the analysis without undermining savings. For instance, occupants who leave the address where they received the reports are dropped from the analysis. We do not see evidence that the home energy reports have affected the moving rate among households. In fact, moving rates are similar across treatment and control groups. Households that opted out of the program report doing so because they disliked the treatment. Removing opt-outs would change the make-up of the treatment group and would undermine the RCT. Households that opted out of the program remain in the treatment group and will affect the results much the same way as people who ignore the reports (passively opt out). Savings estimates are the average savings across all treatment group households, including opt-outs. Opt-outs are also included in the treatment group counts with which total savings are calculated.



**Table 3-1. Legacy Disposition**

<b>Population</b>	<b>Control</b>	<b>Treatment</b>	<b>Total</b>
<b>Original population</b>	<b>44,124</b>	<b>39,757</b>	<b>83,881</b>
<b>Final analysis sample in 2016</b>	<b>27,420</b>	<b>21,737</b>	<b>49,157</b>
<b>Monthly - Current</b>		10,365	
<b>Monthly - Suspended</b>		5,196	
<b>Quarterly - Current</b>		4,134	
<b>Quarterly - Suspended</b>		2,042	
<b>Records removed in 2017</b>	<b>1,782</b>	<b>1,435</b>	<b>3,217</b>
<b>Move-outs (2016)</b>	1,752	1,404	
<b>Missing/negative/extreme consumption data (2017)</b>	30	31	
<b>Final analysis sample in 2017</b>	<b>25,638</b>	<b>20,302</b>	<b>45,940</b>
<b>Monthly - Current</b>		9,658	
<b>Monthly - Suspended</b>		4,866	
<b>Quarterly - Current</b>		3,868	
<b>Quarterly - Suspended</b>		1,910	

Table 3-2 shows the disposition for the expansion groups. Like the legacy groups, most expansion group customers we lose over time are those who move away, though we do drop some customers due to data quality issues. In 2017, the electric only, relative high user, and non-urban groups had all dropped to about 60-70% of their original population numbers, while the refill dropped to 80% of their original population.

**Table 3-2. Expansion Disposition**

Population	Control	Treatment	Total
<b>Original population</b>	<b>45,500</b>	<b>130,000</b>	<b>175,500</b>
<b>Electric only</b>	10,500	31,500	
<b>High User</b>	10,500	31,500	
<b>Non-Urban</b>	14,000	42,000	
<b>Refill</b>	10,500	25,000	
<b>Final analysis sample in 2016</b>	<b>35,153</b>	<b>99,516</b>	<b>134,669</b>
<b>Electric only</b>	7,646	23,050	
<b>High User</b>	7,098	21,558	
<b>Non-Urban</b>	10,263	30,758	
<b>Refill</b>	10,146	24,150	
<b>Records removed in 2017</b>	<b>4,428</b>	<b>12,488</b>	<b>16,916</b>
<b>Move-outs (2016)</b>	4,322	12,196	
<b>Missing/negative/extreme consumption data (2017)</b>	106	292	
<b>Final analysis sample in 2017</b>	<b>30,725</b>	<b>87,028</b>	<b>117,753</b>
<b>Electric only</b>	6,903	20,782	
<b>High User</b>	6,310	19,001	
<b>Non-Urban</b>	9,215	27,607	
<b>Refill</b>	8,297	19,638	

Overall, any data issues identified impacted less than 1% of observations, and should not bias the results as they were equally shared between the treatment and control groups. Appendix 7.4 presents the test of randomization using the final samples for legacy and expansion programs.

Table 3-3 shows the disposition for the unmatched legacy population. The treatment group has dropped to about 75% of its original population size in 2017.

**Table 3-3. Unmatched Population Disposition**

Population	Comparison	Treatment	Total
<b>Original population</b>	<b>44,124</b>	<b>4,864</b>	<b>48,988</b>
<b>Move-outs (2009-2016)</b>	20,130	1,152	
<b>Missing/negative/extreme consumption data</b>	674	84	
<b>Final analysis sample in 2017</b>	<b>23,320</b>	<b>3,628</b>	<b>26,948</b>

## 4 METHODOLOGY

In this section, we present the methods used to estimate measured savings, joint savings, credited savings, and total program savings. Measured savings are estimated reductions in consumption per household due to HER treatment for legacy (current, suspended and unmatched) and expansion (electric only, high relative user, non-urban and refill) treatment households. These savings can include a reduction in consumption due to a higher uptake in other PSE energy efficiency programs prompted by HER, called joint savings. Credited savings per household are the reduction in savings that are net of joint savings and are used to compute total HER savings. Finally, we discuss how we account for the effect of HER treatment on consumption.

### 4.1 Measured Savings

This evaluation used daily household energy consumption data summarized to monthly levels to estimate the reduction in energy consumption resulting from HER. This consumption reduction is the full measure of savings caused by receipt of home energy reports and is referred to here as measured savings. While in prior evaluations we estimated savings using a difference-in-difference methodology based on annual consumption data, starting in program year 2016 we began estimating program savings using a pooled fixed-effects model.

Relative to the difference-in-difference method, the fixed-effects methodology is a more flexible characterization of the effect of the treatment on household consumption. It allows us to estimate the effect of the treatment over time while controlling for household and time-specific characteristics, which results in more precise estimates. Further, it allows us to estimate savings from partial-year treatment participants.

The fixed effects model specification estimates program savings by comparing consumption of the treatment group and the control group before and after program implementation. The change that occurs in the treatment group is adjusted to reflect any change that occurred in the control group to isolate changes attributable to the program. While 2017 evaluated savings are based on results from the pooled fixed-effects model, for comparison to past evaluations we provide results from the difference-in-difference methodology in Appendix 7.2.

We estimated measured savings for the following groups:

#### **Legacy group**

- Current treatment group
- Suspended treatment group
- Unmatched treatment group

#### **Expansion group**

- High relative user treatment group
- Non-urban treatment group
- Electric only treatment group

- Refill treatment group

## 4.2 Joint Savings

The HER program has a secondary objective of promoting other PSE energy efficiency programs. If HER is successful in achieving this objective, 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.

Joint savings can occur when recipients:

- Install rebate program measures in greater numbers,
- Install rebate program measures generating greater savings, and/or
- Install any rebate program measures earlier than control households, regardless of the level of savings.

Since the rebate programs that facilitated the participation already claimed the savings, we deducted these joint savings from the HER measured savings to avoid double counting. The measured savings with joint savings removed are referred to as “credited savings” in this report. The following two sections go into further detail about how we calculated the downstream rebate and upstream lighting joint savings.

### 4.2.1 Downstream Rebate

We used PSE tracking and end-use load shape data to quantify energy savings for HER participants through PSE rebate programs. HERs generate a flow of savings throughout a program year that increases or decreases as the consumption of the treatment group changes compared to the control group. On the other hand, rebated savings are generally reported on an annual basis and do not account for when measures were installed, how long they last or when during the year savings from such measures happen.

To account for rebate program savings in a way that is consistent with the measured HER program savings, we took into consideration:

- When savings started (installation dates for downstream; rebate year for upstream),
- When during the year savings occurred (load shape of yearly savings), and
- How long the savings will last (persistence of savings or measure life).

Savings for all measures start on the day of installation (or rebate date) and are projected forward from that day based on daily load shapes and measure life. At present, the measure lives for all installed measures are greater than the nine years the HER program has been in place.

We calculated the stream of savings from PSE rebate programs for HER treatment and control group households by summing the savings achieved in 2017, including measures installed in prior years that are expected to be still in use. The rebate portion of joint savings is the difference between the treatment and control groups’ savings. We removed this difference from the HER measured savings.

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## 4.2.2 Upstream Lighting

DNV GL used a similar process to estimate joint savings associated with the upstream CFL/LED lighting programs. However, in place of the rebate program tracking data the estimates for upstream program savings are based on 2015 survey 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 survey data to calculate the number of purchased CFLs and LEDs associated with the upstream program for both the HER treatment and control groups. We subtracted the difference in reported upstream lighting savings from the HER measured savings.

Please refer to the 2016 evaluation report for more details on the 2015 upstream lighting survey.

## 4.3 Legacy Unmatched Savings Estimates

The legacy treatment group includes a small subset of households, mostly concentrated in the 98006 zip code, that have received HER reports since the start of the program, but were not assigned a random control group. Savings from this group were not included in program savings totals until the 2016 program year. In 2016, DNV GL explored the possibility of capturing savings from this customer group by creating a post hoc matching group and using fixed-effects to estimate HER program impact. We undertook a similar approach to measure savings from this subset for program year 2017.

Matching aims to replicate the RCT design by identifying comparison subjects whose characteristics closely match those of the treated group. We used pre-program consumption, and housing value and age to select a matched comparison group<sup>3</sup> for the legacy unmatched group from the legacy control group. While the matches were well balanced, we continued to recommend the conservative approach of using the legacy current savings percentage to calculate savings for the legacy unmatched group as the legacy unmatched estimated electric savings were substantially higher.

## 5 IMPACT EVALUATION RESULTS

The measured, joint, and credited savings results in this section can be used to support PSE savings claims for the 2017 HER program. Section 5.1 provides the measured savings per household achieved in calendar year 2017 for the different treatment groups in the legacy and expansion programs. Section 5.2 provides estimates of joint rebate (downstream) and upstream savings. We used the measured savings per household net of the joint savings per household to derive credited savings per household, which are reported in Section 5.3. We provide savings estimates for the legacy unmatched group in Section 5.4. Appendix 7.1 presents additional results details and comparisons.

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<sup>3</sup> We refer to the legacy treatment group that was not assigned a control group as the unmatched legacy treatment group. As this group does not have a control group, we use the term comparison group when referring to the group matched with the unmatched legacy treatment group.

## 5.1 Measured Savings

Table 5-1 presents the measured annual savings per household for 2017. All the groups generated statistically significant savings at a 90% confidence level. Electric savings ranged from approximately 1% to 3% percent of baseline consumption while gas savings ranged from 1% to 2% percent. All expansion groups had lower per household savings as a percentage of baseline than the more mature legacy current group indicating that they may still be in a ramp-up period.

Since baseline consumption for the expansion groups (except for the non-urban group, particularly for gas) is on par or higher than the legacy current group's, the percent saved per household for these groups is expected to reach those achieved by the legacy current group. The expansion electric-only group had the highest baseline electric consumption while the non-urban group had the lowest. The refill group had the highest and the non-urban group had the lowest baseline gas consumption.

**Table 5-1. Summary of measured annual per household savings for PSE HER, 2017**

Treatment group	Electric (kWh)			Gas (therms)		
	Consumption	Savings	Percent	Consumption	Savings	Percent
<b>Legacy program</b>						
<b>Current</b>	9,957	313.1* (248.1, 378.1)	3.1%	850	15.5* (11.5, 19.4)	1.8%
<b>Suspended</b>		91.3* (6.3, 176.2)	0.9%		9.2* (4.1, 14.3)	1.1%
<b>Expansion program</b>						
<b>Electric only</b>	14,228	231.0* (137.6, 324.3)	1.6%	N/A	N/A	N/A
<b>High relative user</b>	11,005	313.5* (226.8, 400.2)	2.8%	821	11.7* (7.1, 16.3)	1.4%
<b>Non-urban</b>	9,890	184.7* (122.5, 246.9)	1.9%	740	9.5* (6.3, 12.6)	1.3%
<b>Refill<sup>4</sup></b>	12,082	322.4* (253.9, 390.8)	2.7%	871	9.7* (6.3, 13.1)	1.1%

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


## 5.2 Joint Savings

The following sections present the results of the downstream rebate and upstream lighting (joint) savings analysis.

### 5.2.1 Downstream Rebate

In this section, we first investigated whether HER resulted in greater rebate program participation among HER recipients relative to control households. We then examined the difference in joint savings among HER recipients and control households. It is important to note that while participation rates only represent rebate

<sup>4</sup> Oracle selected the refill group from customers expected to have relatively high savings based on their energy use history; customers in the highest usage groups typically have higher savings potential.



program involvement for the current evaluation year, the joint savings include savings for measures installed in prior years that are expected to continue saving energy based on their estimated useful life.

### **Joint participation in rebate programs**

2017 participation in electric rebate programs was slightly higher than in previous years for both treatment and control groups, with participation ranging from 4.3% to 5.4% (Table 5-2); participation levels in 2016 were 2.7% to 3.6%. Unlike program year 2016, the difference in participation between treatment and control groups, however, was not statistically significant for any of the legacy or expansion groups. In program year 2016, participation rates were statistically identical for legacy treatment and control groups, but were higher for expansion treatment groups relative to expansion control groups. In addition, this difference as a percent of the control group's participation was low for all groups (not exceeding 9%) indicating that electric treatment groups were no more likely to have participated in other PSE energy efficiency programs than their control counterparts. In program year 2016, the difference as a percent of the control group's participation averaged about 20% for the expansion groups.

For gas, participation levels were also slightly higher than past years for both treatment and control, ranging from 4.8% to 5.7% in 2017, versus 2.8% to 3.6% in 2016. Like electric programs, the difference in participation between treatment and control groups were not statistically significant for any of the legacy or expansion groups. The difference as a percent of control group participation was also low for all groups further indicating that treatment groups were no more likely to have participated in PSE gas rebate programs than control group households. In program year 2016, expansion treatment group participation levels were statistically higher than expansion control groups' participation.

The statistically identical participation rates for all electric and gas expansion groups in 2017, unlike 2016, indicates that the increased uptake in PSE rebate programs that HER encourages in the early years of the program wane over time as participation among control households reaches levels achieved by treatment participants.

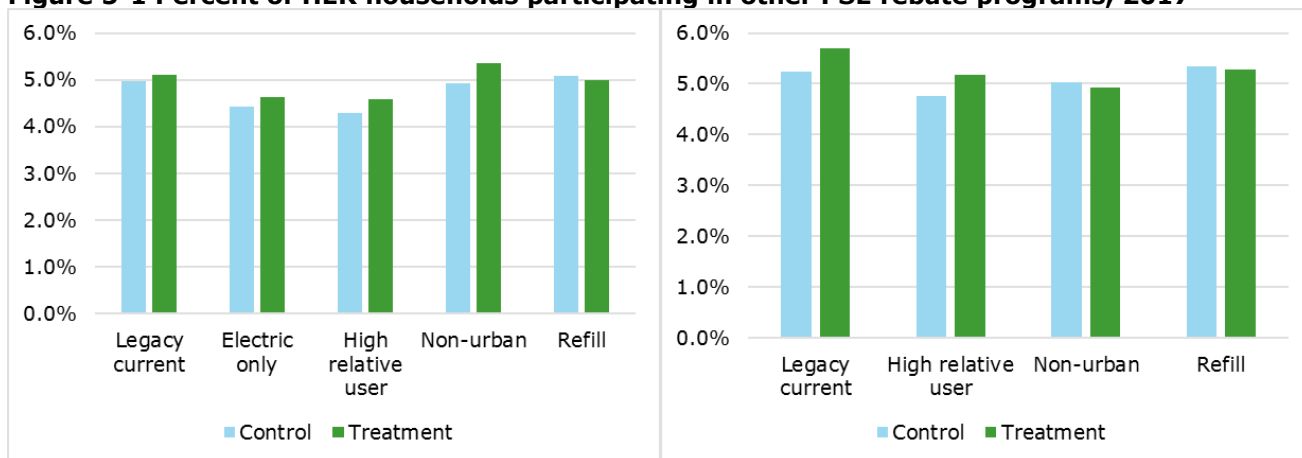
**Table 5-2. Treatment and control participation in 2017 PSE downstream rebate programs**

Treatment group	% Participation		Difference (treatment - control)	Difference as percent of control participation	Lower limit at 90% CI	Upper limit at 90% CI	Tstat	Pvalue
	Control	Treatment						
<b>2017 Electric rebate participation</b>								
Legacy-current	5.0%	5.1%	0.1%	2.6%	-0.3%	0.6%	0.6	0.6
Electric only	4.4%	4.6%	0.2%	4.9%	-0.4%	0.8%	0.7	0.5
High relative User	4.3%	4.6%	0.3%	6.6%	-0.3%	0.9%	0.9	0.3
Non-urban	4.9%	5.4%	0.4%	8.6%	-0.1%	0.9%	1.6	0.1
Refill	5.1%	5.0%	-0.1%	-1.5%	-0.6%	0.5%	-0.3	0.8
<b>2017 Gas rebate participation</b>								
Legacy-current	5.2%	5.7%	0.5%	8.8%	-0.9%	0.0%	1.9	0.1
High relative user	4.8%	5.2%	0.4%	9.0%	-0.2%	1.1%	1.3	0.2
Non-urban	5.0%	4.9%	-0.1%	-1.8%	-0.6%	0.4%	-0.3	0.7
Refill	5.4%	5.3%	-0.1%	-1.2%	-0.6%	0.5%	-0.2	0.8

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

Figure 5-1 shows the percent of HER treatment and control households participating in other PSE rebate programs in 2017. Treatment and control group participation in rebate programs is similar.

**Figure 5-1 Percent of HER households participating in other PSE rebate programs, 2017**



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

### Joint savings

While participation in PSE rebate programs for the treatment and control groups were statistically identical, as Table 5-3 indicates, both electric and gas joint savings for most legacy and expansion group treatment households were statistically significantly higher than for the control group in 2017. This suggests that through the installation of higher-impact measures, and/or the cumulative year-on-year savings of previously-installed program measures, legacy treatment households have achieved deeper savings than control households, despite similar rates of participation in 2017.



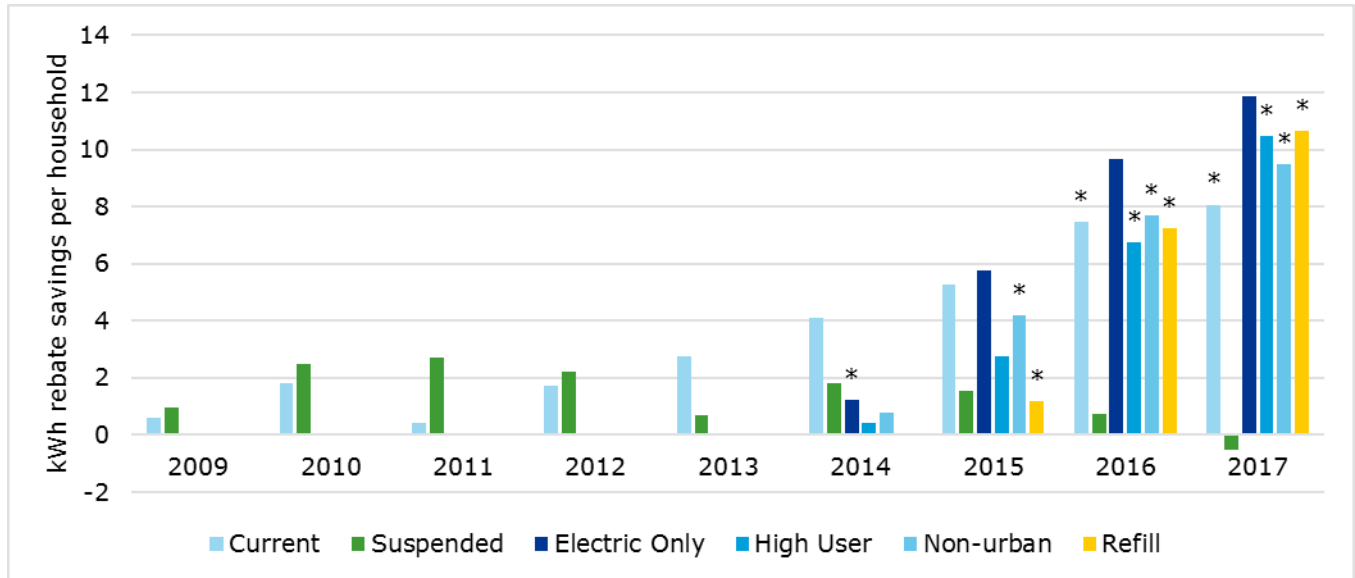
**Table 5-3. 2017 PSE rebate program joint savings**

Treatment Group	HER Groups		Joint Rebate Savings per household	Lower limit at 90% CI	Upper limit at 90% CI
	Control	Treatment			
<b>2017 Electric rebate savings (kWh)</b>					
<b>Legacy-current</b>	94.8	102.9	8.1*	2.0	14.1
<b>Legacy-suspended</b>		94.3	-0.5	-8.1	7.1
<b>Electric only</b>	163.3	175.2	11.9	-3.9	27.6
<b>High relative User</b>	51.7	62.2	10.5*	3.8	17.1
<b>Non-urban</b>	50.4	59.9	9.5*	5.3	13.7
<b>Refill</b>	28.6	39.3	10.6*	6.7	14.6
<b>2017 Gas rebate savings (therms)</b>					
<b>Legacy-current</b>	17.7	19.6	1.9*	1.0	2.8
<b>Legacy-suspended</b>		17.8	0.1	-1.0	1.2
<b>High relative user</b>	6.6	8.0	1.4*	0.7	2.1
<b>Non-urban</b>	5.1	5.2	0.1	-0.4	0.5
<b>Refill</b>	2.0	2.4	0.4*	0.1	0.8

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

Figure 5-2 and Figure 5-3 show annual electric and gas rebate savings per household starting from 2009 to 2017. On the electric side, the groups that still receive reports have increasing trends in joint savings over the years. The legacy suspended group, which has been experiencing a general decline in joint savings since 2011, did not generate any savings in 2017. While the legacy current group did not have statistically significant electric joint savings for the first seven years of the program, all expansion groups achieved statistically significant electric joint savings within the first three years of program participation. The electric only group achieved statistically significant joint savings in its first year, but has not since. The high relative user, non-urban, refill, and legacy current groups achieved statistically significant joint savings in both 2016 and 2017. Additionally, in 2017 all expansion groups have joint savings greater than the legacy current group. This suggests that expansion treatment groups are achieving deeper savings than the legacy group by installing measures generating greater savings and/or installing rebate program measures earlier than control households.

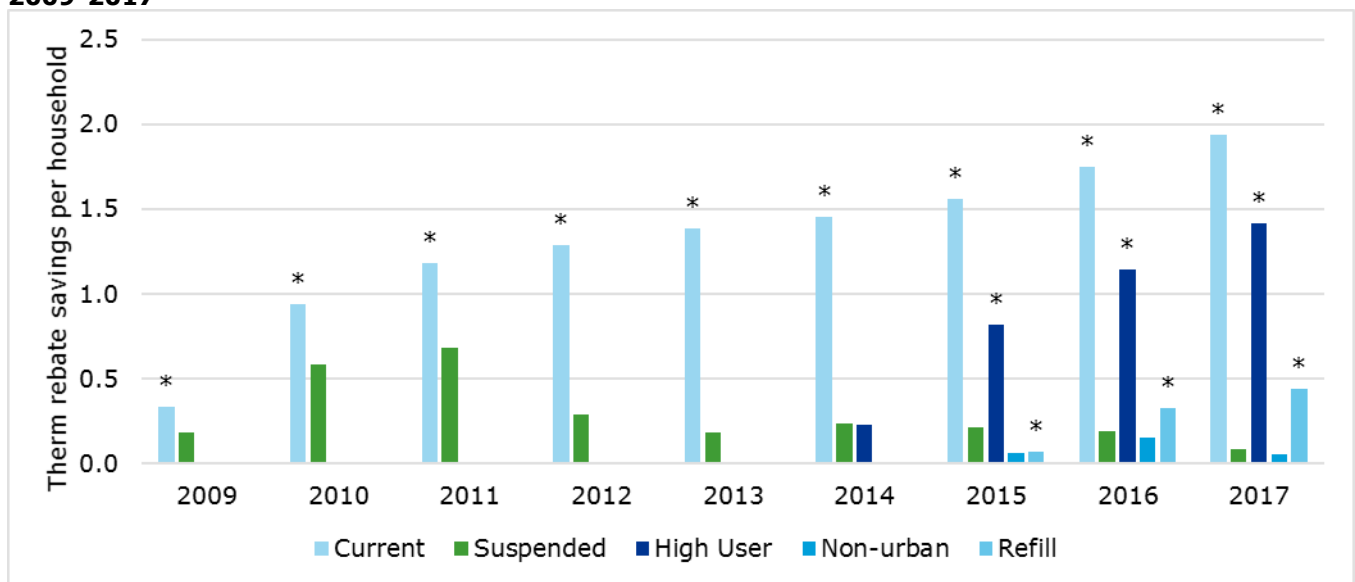
**Figure 5-2. Annual electric joint rebate savings per household for legacy and expansion groups, 2009-2017**



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

On the gas side, all groups except the legacy suspended and the non-urban groups had statistically significant gas joint savings starting in their first full year of program participation. The legacy current group has achieved statistically significant joint savings since the program began. Additionally, the high relative user and the refill groups also have achieved statistically significant joint savings for the last three years. The non-urban group has never achieved statistically significant joint savings and its joint savings decreased in 2017 compared with 2016.

**Figure 5-3. Annual gas joint rebate savings per household for legacy and expansion groups, 2009-2017**



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

## 5.2.2 Upstream Lighting

Results to quantify upstream savings are based on a 2015 web survey of PSE-sponsored CFL/LED lighting purchases. Table 5-4 provides the joint rebate counts and Table 5-5 presents the savings per household for the legacy current and legacy suspended treatment groups. Joint rebate counts per household measured the increased uptake in upstream lighting due to HER, calculated as the difference in CFL and LED purchases between the treatment group and control group. To estimate upstream savings, the joint rebate counts per household for each lighting measure were multiplied by the corresponding average bulb deemed savings. The average bulb deemed savings are weighted averages of the different specific bulb types that were rebated in 2014. These values will need to be updated if a survey is conducted for program year 2018 to get a current account of upstream joint savings.

The small and negative joint savings indicate that the program was no longer increasing uptake of the upstream program offerings with any kind of discernible pattern at the time of the survey. A negative savings result means that, during this period, treatment households installed fewer bulbs than the control group. This is consistent with HER programs initially causing an acceleration of such installations in early 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. Both the lamp type and the overall joint savings results were not statistically significant.

**Table 5-4. Bulbs per household from annual CFL and LED purchases, HER Legacy**

Upstream lighting measures	Difference in number of bulbs (T-C)	
	Current	Suspended
<b>CFLs</b>	-0.2 (-0.6,0.3)	-0.7 (-1.3,-0.2)
<b>LEDs</b>	0.1 (-0.7,1.0)	-0.3 (-1.3,0.8)

**Table 5-5. Savings per household from annual CFL and LED purchases, HER Legacy**

Upstream lighting measures	Average deemed savings (kWh per unit)	Upstream savings (kWh)	
		Current	Suspended
<b>CFLs</b>	16.3	-2.5 (-10.4,5.4)	-12.1 (-20.8,-3.5)
<b>LEDs</b>	17	2.5 (-12.6,17.5)	-4.4 (-22.8,14.1)
<b>Total upstream lighting savings</b>		-0.04	-16.5

*Note that the results in the table above are not statistically significant.*

Table 5-6 provides the joint rebate counts per household and Table 5-7 presents the savings per household for the different expansion groups. We applied the upstream lighting joint savings of the legacy current group to the refill group, as the refill group did not exist at the time of the survey and these customers replaced legacy customers due to attrition. Overall, results showed that the total upstream lighting savings were positive and can be attributed to the increase in LED purchases among the expansion treatment groups.

**Table 5-6. Bulbs per household from annual CFL and LED purchases, HER Expansion**

Upstream lighting measures	Difference in number of bulbs (T-C)			
	Electric only	High relative user	Non-urban	Refill
<b>CFLs</b>	-0.3 (-1.0,0.3)	-0.5 (-1.5,0.4)	-0.5 (-1.1,0.2)	-0.2 (-0.6,0.3)
<b>LEDs</b>	0.9 (-0.2,2.0)	0.9 (-0.1,1.9)	0.7 (-0.1,1.6)	0.1 (-0.7,1.0)

**Table 5-7. Savings per household from annual CFL and LED purchases, HER Expansion**

Upstream lighting measures	Average deemed savings (kWh per unit)	Upstream savings (kWh)			
		Electric only	High relative user	Non-urban	Refill
<b>CFLs</b>	16.3	-5.7 (-16.4,5.1)	-8.4 (-23.7,6.8)	-7.4 (-18.1,3.3)	-2.5 (-10.4,5.4)
<b>LEDs</b>	17	15.2 (-3.6,33.9)	15.3 (-2.1,32.7)	12.7 (-1.2,26.6)	2.5 (-12.6,17.5)
<b>Total upstream lighting savings</b>		9.5	6.9	5.3	-0.04

Note that the results in the table above are not statistically significant.

Table 5-8 provides the cumulative joint savings estimates from CFLs and LEDs credited per year for the legacy households. As CFL and LED savings continue across the lifetime of the bulb, joint savings are additive across their estimated lifetimes. As an example, a CFL credited in 2009 was included in the joint savings calculations through 2014 which was the end of its 5-year expected useful life.

**Table 5-8. Annual joint upstream savings per household for Legacy Current and Suspended treatment groups**

Program year	Lighting measures	Treatment group	
		Current	Suspended
<b>2009</b>	CFL	0.9	
<b>2010</b>	CFL	1.6	
<b>2011</b>	CFL	2.3	15.3
<b>2012</b>	CFL	5.5	10.5
<b>2013</b>	CFL and LED	7.3	18.0
<b>2014</b>	CFL and LED	-3.3	8.1
<b>2015</b>	CFL and LED	-4.5	-8.5
<b>2016</b>	CFL and LED	-6.9	-40.2
<b>2017</b>	CFL and LED	-12.4	-67.2

Note: Upstream survey only started in 2011 for PSE HER. The upstream values from 2009 and 2010 were extrapolated values using results for the legacy current treatment group in 2011. 2009 also includes November and December of 2008.

Table 5-9 provides the cumulative estimates of the expansion groups' upstream joint savings. Per household joint savings between the HER program and upstream programs amounted to 37.6 kWh for electric only, 7.9 kWh for high relative users, and 28.5 kWh for non-urban groups. Because the refill group's upstream savings were negative in 2017, only measured savings for the electric-only, high relative user, and non-urban groups were adjusted with upstream savings to avoid double counting.

**Table 5-9. Annual joint upstream savings per household for HER Expansion treatment groups**

Program year	Treatment group			
	Electric only	High relative user	Non-urban	Refill
2014	9.1	-12.8	12.6	N/A
2015	18.6	-5.9	17.9	0.0
2016	28.1	1.0	23.2	-0.1
2017	37.6	7.9	28.5	-0.1

### 5.3 Credited Savings

Our primary aim in this evaluation was to determine savings that can be attributed to the HER program (credited savings), which required that we deduct joint rebate (downstream) and upstream savings from measured HER program savings. Such an adjustment eliminates the potential of double counting savings that are already accounted for in other efficiency programs.

As we noted in the previous section, there are both upstream and downstream joint savings for the various legacy and expansion HER groups under evaluation. Table 5-10 and Table 5-11 present measured, joint, and credited savings estimates per household as well as the savings as a percent of consumption. Like in the past, PSE HER programs generate more electric savings as a percent of consumption than gas savings. Although research has not indicated the sources of HER program end-use savings, we hypothesize that the more discretionary aspect of many electric uses (such as lighting and electronics) make greater electric savings more possible.<sup>5,6</sup>

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<sup>5</sup> Puget Sound Energy, 2012. Puget Sound Energy's Home Energy Reports Program: Three Year Impact, Behavioral and Process Evaluation. April 2012. <https://conduitnw.org/Pages/File.aspx?rid=849>

<sup>6</sup> The RCT design allows for a highly precise estimate of the small overall savings estimate, but getting definitive estimates of the varied sources of savings within those overall savings has not been possible.

**Table 5-10. Summary of credited savings per household for PSE HER Legacy, 2017**

Treatment Groups	Consumption	HER measured savings	Joint savings	Credited savings	Percent credited savings
<b>Electric (kWh)</b>					
<b>Current</b>	9,957	313.1* (248.1, 378.1)	8.1* (2.1, 14.1)	305.0* (239.7, 370.3)	3.1%
<b>Suspended</b>		91.3* (6.3, 176.2)	0	91.3* (6.3, 176.2)	0.9%
<b>Gas (therms)</b>					
<b>Current</b>	850	15.5* (11.5, 19.4)	1.9* (1.0, 2.8)	13.5* (9.5, 17.5)	1.6%
<b>Suspended</b>		9.2* (4.1, 14.3)	0.1 (-1.0, 1.2)	9.1* (3.9, 14.3)	1.1%

*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.*

The legacy current group’s percent credited savings continues to be the highest for both electric and gas. The legacy suspended group’s electric reductions are about 30% of the legacy current group’s savings while its gas savings are about 70% of the legacy current group’s savings. This difference may indicate that electric savings are due more to behavior changes that can attenuate once households no longer get HER messaging. Stated in a different way, the larger persistence in gas savings may indicate installations of measures whose energy savings effects are longer-lived.

The expansion groups continue to experience a ramp up in savings and the cumulative joint savings will continue to rise as the length of time the expansion groups run nears the length of the joint savings measure lives. Among the expansion groups, the refill group achieved the highest credited electric savings and the credited savings per household exceeded even that of the legacy current group’s savings. As a percent of baseline savings, the high relative user group achieved the highest electric and gas savings among the expansion groups. Overall though, expansion group savings as a percent of consumption are still lower than the legacy current group’s savings.

**Table 5-11. Summary of credited savings per household for PSE HER Expansion, 2017**

Treatment Groups	Consumption	HER measured savings	Joints savings	Credited savings	Percent credited savings
<b>Electric (kWh)</b>					
<b>Electric Only</b>	14,228	231.0* (137.6, 324.3)	49.5* (28.9, 70.0)	181.5* (85.9, 277.0)	1.3%
<b>High User</b>	11,005	313.5* (226.8, 400.2)	18.4* (2.8, 33.9)	295.1* (207.0, 383.2)	2.7%
<b>Non-urban</b>	9,890	184.7* (122.5, 246.9)	38.0* (26.5, 49.4)	146.7* (83.5, 210.0)	1.5%
<b>Refill</b>	12,082	322.4* (253.9, 390.8)	10.6* (6.7, 14.6)	311.7* (243.2, 380.3)	2.6%
<b>Gas (therms)</b>					
<b>High User</b>	821	11.7* (7.1, 16.3)	1.4* (0.7, 2.1)	10.3* (5.7, 14.9)	1.3%
<b>Non-urban</b>	740	9.5* (6.3, 12.6)	0.1 (-0.4, 0.5)	9.4* (6.2, 12.6)	1.3%
<b>Refill</b>	871	9.7* (6.3, 13.1)	0.4 (0.1, 0.8)	9.3* (5.8, 12.7)	1.1%

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 to the gas savings calculation.

## 5.4 Unmatched Group

In this section, we present the 2017 estimates of HER savings for the unmatched legacy treatment group based on data from this group and the matched comparison group. Table 5-12 provides a summary of measured savings per household.

**Table 5-12. 2017 measured annual savings for the unmatched legacy treatment group**

Treatment Group	Electric (kWh)			Gas (therms)		
	Consumption	Savings	Percent	Consumption	Savings	Percent
<b>Legacy unmatched</b>	10,967	835.0* (653.0, 1,017.1)	7.6%	1,032	12.6 (-0.9, 26.1)	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.

The unmatched group produced measured electric and gas savings of 7.6% and 1.2%, respectively. These savings indicate average savings per household of 835.0 kWh and 12.6 therms for 2017. The kWh savings are more than double those saved by the legacy current treatment group while the therm savings are in line with those saved by the legacy current group. These estimates are comparable to program year 2016 savings estimates based on the same approach.

These savings reflect the effect of HER treatment relative to the matched comparison group. While the test of balance indicated a well-balanced sample using pre-treatment consumption, and housing value and age as a basis for matching, it is possible that there are other factors (such as weather, income and location-

specific factors) that are unaccounted for in the matching process that could confound the effect of treatment.

It would have been ideal to find a matched comparison group located in the same zip code to control partly for some of these factors. We explored this possibility, but found that the number of dual fuel PSE customers participating in the HER program exceeded those not participating in HER in this location.<sup>7</sup> Thus, we did not have a sufficient population to serve as a comparison group pool for matching.

Nevertheless, this exercise demonstrates that the savings among legacy current households can serve as a conservative estimate of savings for the unmatched households. We thus base our final estimates of savings for the unmatched group on the legacy current group’s savings. We apply the percent credited savings of the legacy current group to the average per household consumption of the unmatched group to obtain these final estimates. Table 5-13 provides the credited savings estimates per household for the legacy unmatched group using this approach.

**Table 5-13. Legacy unmatched credited savings**

Treatment group	Electric (kWh)			Gas (therms)		
	Consumption	Savings	Percent	Consumption	Savings	Percent
<b>Legacy unmatched</b>	10,967	336.0* (264.0, 407.8)	3.1%	1,032	16.4* (11.5, 21.3)	1.6%

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

## 5.5 Savings Trends

To put the 2017 evaluated savings in historical context, we examined trends in savings since the start of the HER program for both legacy and expansion groups. Figure 5-4 and Figure 5-5 show the historical results of the measured savings along with 90% confidence intervals for the legacy and expansion groups.

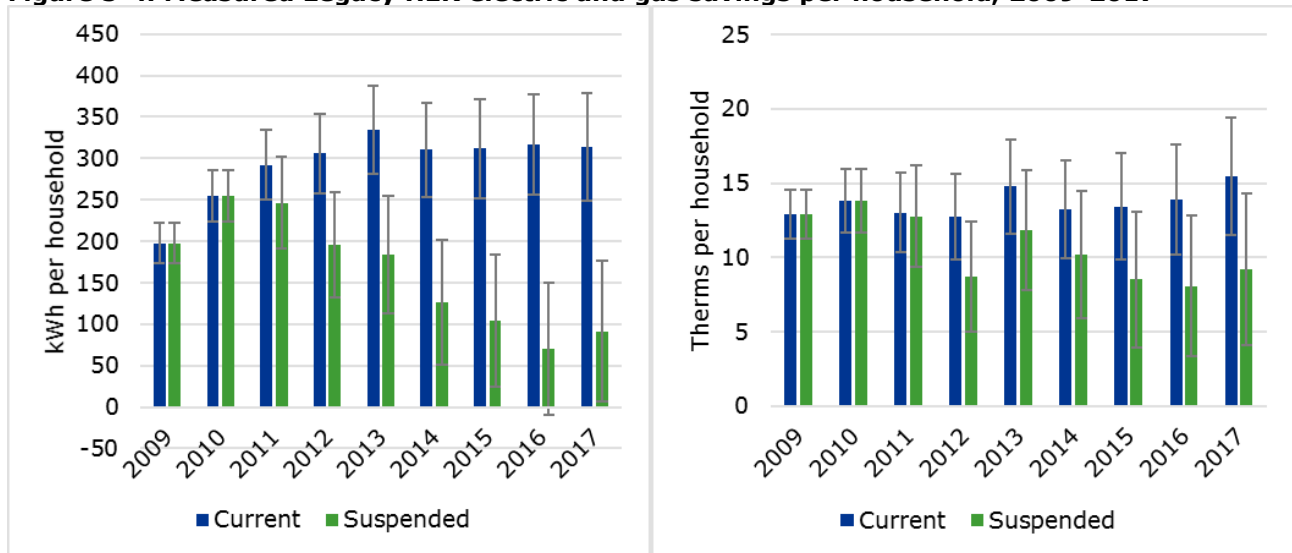
The current legacy group has continually achieved savings since the start of the HER program; however, the upward trend in savings has stalled since 2013 (the fifth year of the program). The electric savings of the legacy suspended group have generally been in decline since the group stopped receiving HERs in 2011 and are about 30% of the legacy current group’s savings in 2017. Since 2015, the electric savings among the suspended households remain on the edge of statistical significance. While the confidence bound of the estimated savings in 2016 suggested that the suspended group could no longer claim significant savings, this year’s results indicate that these households do continue to demonstrate small and statistically significant electric savings.

<sup>7</sup> In an RCT, the number of households assigned to the control group can be substantially lower than those in the treatment group as long as the assignments are random and the groups balanced. When matching, on the other hand, we select households that match the characteristics of those in the treatment group, which requires that we have a sufficient pool of comparison candidates among which to choose. Even in undertakings where we select one matched household for each treatment participant, we need at least two potential comparison candidates. In practice, the higher the number of potential comparison candidates the better.



Gas savings also persist both for the current and suspended legacy groups. The legacy current gas savings do not have a marked trend and are not statistically different over the years. While legacy suspended gas savings have decreased since PSE discontinued HER messaging, 2017 measured savings of the suspended group were about 60% of those of the legacy current households' savings.

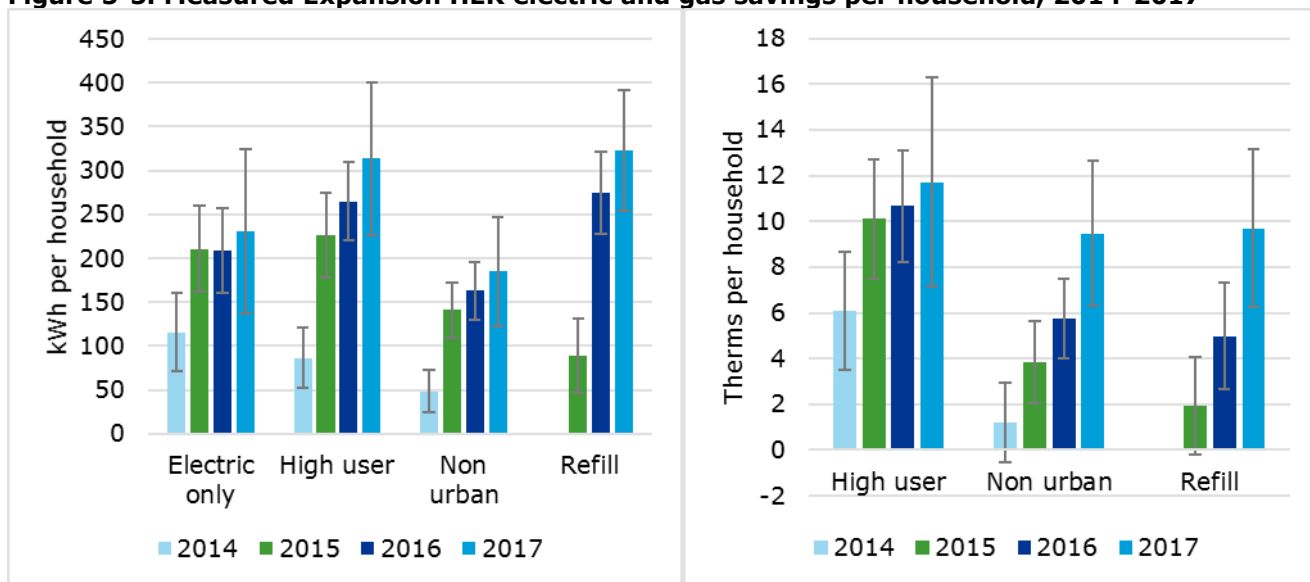
**Figure 5-4. Measured Legacy HER electric and gas savings per household, 2009-2017**



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

For the expansion groups, savings have been ramping up over the years for both fuels. The savings for 2014 reflect partial year HER messaging as the program began in March 2014 for high users, electric-only and non-urban households, all of which were in their third full-year of the program in 2017. The refill group's 2015 savings also reflect partial year activity since the program for this group began in May 2015. Measured electric and gas savings generally indicate an increasing trend for all expansion groups over time. The increasing trend in savings for both electricity and gas follow patterns experienced by the legacy HER program in its early years.

**Figure 5-5. Measured Expansion HER electric and gas savings per household, 2014-2017**



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

## 5.6 Overall

Table 5-14 and Table 5-15 recap the electric and gas savings generated by the HER groups in 2017. The overall electric savings were estimated at 90/13 precision and the gas savings were estimated at 90/15 precision. Total program savings for electric and gas are statistically significant at the group-level and overall.

When combined, the expansion groups achieved higher total electric and gas savings than the legacy groups. This is largely due to the greater number of expansion HER participants. The expansion groups have more HER participants than the legacy groups because they started with more households and they have lower total attrition since they are newer additions. The expansion refill group generated the highest electric savings. While the refill group did not have the highest number of participants, it did have the highest credited savings per household across all groups. The non-urban group generated the most total gas savings. It was the largest group and its average household gas savings fell in the middle of the other groups.

Overall, the HER program generated approximately 25.5 GWh of savings with a lower bound of 21.8 GWh and upper bound of 29.2 GWh. The program also generated 941,822 total therm savings with a lower bound of 773,051 and upper bound of 1,110,593 therms.

**Table 5-14. Total electric savings for HER, 2017**

Treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Credited Savings	No. in group	Total savings	Lower limit 90% CI	Upper limit 90% CI
<b>Legacy - Current</b>	313.1	8.1	305.0	13,526	4,125,073	3,242,057	5,008,090
<b>Legacy - Suspended</b>	91.3	0.0	91.3	6,776	618,370	42,539	1,194,201
<b>Unmatched Group<sup>1</sup></b>			335.9	3,628	1,218,578	957,765	1,479,601
<b>Expansion - Electric only</b>	231.0	49.5	181.5	20,782	3,771,407	1,785,578	5,757,235
<b>Expansion - High relative user</b>	313.5	18.4	295.1	19,001	5,608,085	3,934,119	7,282,050
<b>Expansion - Non-urban</b>	184.7	38.0	146.7	27,607	4,050,558	3,756,540	4,344,577
<b>Expansion - Refill</b>	322.4	10.6	311.7	19,638	6,121,810	4,775,018	7,468,602
<b>ALL</b>			229.9	110,958	25,513,880	21,805,444	29,222,317

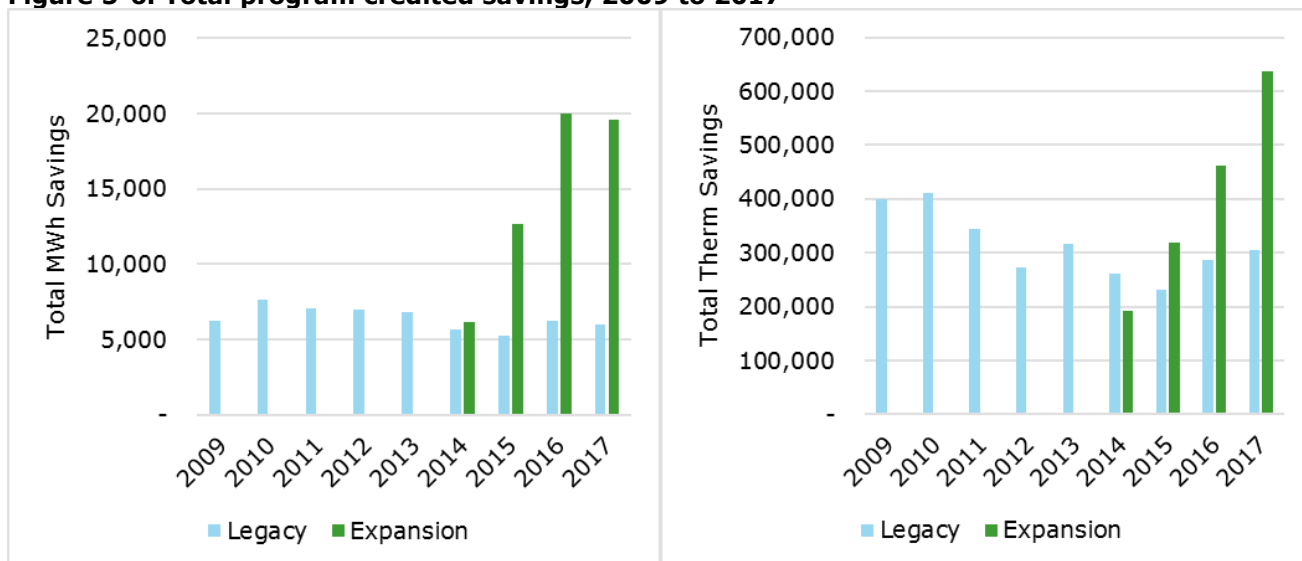
<sup>1</sup>Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (3.1%) by the average household consumption of the unmatched group (10,967 kWh).

**Table 5-15. Total gas savings for HER, 2017**

Treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Credited Savings	No. in group	Total savings	Lower limit 90% CI	Upper limit 90% CI
<b>Legacy - Current</b>	15.5	1.9	13.5	13,526	182,877	128,474	237,281
<b>Legacy - Suspended</b>	9.2	0.1	9.1	6,776	61,862	26,610	97,115
<b>Unmatched Group<sup>1</sup></b>			16.4	3,628	59,581	41,864	77,118
<b>Expansion - High relative user</b>	11.7	1.4	10.3	19,001	195,540	107,376	283,704
<b>Expansion - Non-urban</b>	9.5	0.1	9.4	27,607	260,072	171,934	348,210
<b>Expansion - Refill</b>	9.7	0.4	9.3	19,638	181,889	114,205	249,572
<b>ALL</b>			10.4	90,176	941,822	773,051	1,110,593

<sup>1</sup>Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (1.6%) by the average household consumption of the unmatched group (1,032 therms).

**Figure 5-6. Total program credited savings, 2009 to 2017**



*Note that 2016 and 2017 legacy totals include the unmatched group's total savings.*

The two charts above track historical savings starting with outcomes from the first HER program in 2009. The legacy group generated peak electric savings in 2010 before beginning to decrease, when the legacy suspended group stopped receiving HERs and as attrition increased. Legacy gas savings have been experiencing peaks and valleys but overall have been decreasing as well. The legacy group's 2016 and 2017 totals include the total savings estimates for the unmatched group. For the expansion group, savings for both electric and gas have been increasing. The increase in total savings over time for the expansion group includes results from the refill group beginning in 2015.

## 6 CONCLUSION

The 2017 evaluation marks the 9<sup>th</sup> year of PSE's HER program, providing behavioral incentives to different participant groups over time. Although it is hard to discern what actions drive savings for HER programs, the 2017 results once again prove that relatively small per-household savings that range from 1% to 3% of baseline consumption add up to sizeable savings of 25.5 GWhs and 941,822 therms across all groups.

### **Legacy - current group**

The legacy current group continued to achieve savings similar to the levels it achieved in previous years. Participant measured savings remained steady compared to the previous year, at 3.1% of annual electric and 1.8% of annual gas consumption.

The treatment group continued to demonstrate higher joint savings than its control counterpart, though between the two groups the difference in rebate program participation was not statistically significant. This suggests that through the installation of higher-impact measures, and/or the cumulative year-on-year savings of previously-installed program measures, legacy treatment households have achieved deeper savings than control households, despite similar rates of participation.

Although HER average credited savings remain steady, total credited savings for this group continue to decline as it continues to lose participants due to move-outs. We recommend that future evaluations continue to track the effect of HERs on credited savings and participation in other PSE energy efficiency programs, and consider ways of sustaining total credited savings from the program.

We also recommend updating the upstream lighting survey to ensure that participation and savings from this program reflect current trends.

### **Legacy – suspended group**


The legacy suspended group stopped receiving HER reports after two years of being in the program, but it continues to use less electricity and gas than its control counterpart over the years. Seven years after the suspension of HERs for these customers, the legacy suspended treatment group still achieved statistically significant electric and gas savings. Its electric savings, however, were about 30% of the legacy current's savings while its gas savings were 60% of the current group's savings in program year 2017.

We recommend that future evaluations continue to track savings from this group to learn about the persistence of the effect of HER messaging.

### **Expansion groups**

The expansion groups' electric and gas savings trends continue their upward trajectory, like the trend for the legacy group in its early years. Assuming this trend continues, per-household savings among the expansion groups will increase in the coming year.

As with the previous year, electric downstream rebate joint savings were statistically significant for all groups except the electric only group. Gas downstream rebate joint savings were significant for all groups except the non-urban group. Rebate program participation, while higher than the previous program year (at about 5% vs 3% in 2016), is statistically the same for treatment and comparison groups in 2017. Like for



the legacy group, HER increased uptake in other rebate programs seems to have ended, although deeper savings for expansion treatment groups endure.

We recommend that future evaluations continue to understand trends in savings associated with participation in HER programs and investigate how HERs change customer participation in other PSE efficiency programs.

### **Unmatched group**

Consistent with our findings from last year, the unmatched electric savings per household were twice as high as the legacy current group's electric savings while its gas savings per household were in line with those of the legacy current group. As we estimated savings using a matched comparison group rather than a randomized control group, we used a conservative ceiling for crediting savings for these households that is based on the legacy current group's savings estimates.

We recommend pursuing further matching exercises for this group in the next program year to ascertain the trend in savings and to determine reasonable consumption reduction that can be attributed to HERs for this group.

## 7 APPENDIX

We provide additional details on 2017 savings estimates in this appendix. First, we examine the results at additional levels of detail in section 7.1. In section 7.2, we provide the method used to generate a matched comparison group and the model used to estimate savings for the legacy unmatched treatment group using the matched data. Then we compare the fixed effects results presented in the main body of the report with the difference-in-difference results in section 7.3. Finally, we present the results of our sample randomization tests in section 7.4.

### 7.1 Deep Dives

This section covers some additional analyses that take deeper dives into the HER results including the effect of HER frequency and level of consumption on savings. The key findings include:

1. **The frequency of HER messaging does not affect savings.** Electric and gas savings of legacy treatment households that received HERs monthly are not statistically significantly different than those that received the report quarterly. It appears that in program year 2017, more frequent HER messaging was unimportant for the legacy program.
2. **In program year 2017, we do not find a clear relationship between consumption levels and savings rates.** Legacy electric savings rates for the highest (2.6%) and lowest (2.2%) consumption quartiles and gas savings rates for the bottom three consumption quartiles (1.3% to 1.4%) are similar. In addition, there is no clear relationship between baseline consumption and electric savings rates among all HER groups while the outcome for gas is mixed; the refill group with the highest gas baseline consumption has the lowest savings rate, but the higher the baseline consumption the higher the gas savings rates are for the remaining three groups.

#### 7.1.1 Frequency of HER Reports

In this section, we test the hypothesis that households that receive HER more frequently save more by comparing the savings per household for legacy households who receive HERs monthly and quarterly. This relationship may change over time; however, we compare results from the 2017 program year here. As we indicate below, we find that the frequency of HER messaging does not affect savings.

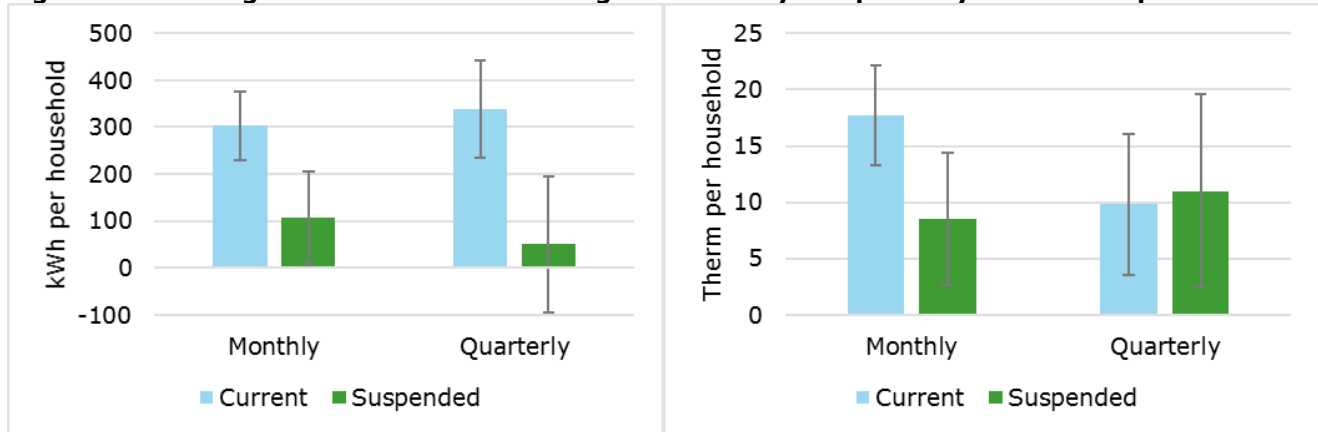
Figure 7-1 compares the performances of the legacy monthly and quarterly recipients. For monthly recipients, both the current and suspended customers generated statistically significant electric and gas savings. Quarterly legacy current customers achieved statistically significant electric and gas savings. The suspended quarterly HER recipients achieved statistically significant electric, but not gas savings.

For electricity, legacy current households that receive monthly HER save 36 kWh per household less than those that receive quarterly reports while the monthly legacy suspended households save about 60 kWh more per household than their quarterly counterpart. These differences, however, are not statistically significant, which suggest that the frequency of HER messaging does not affect savings.

For gas, legacy current households that receive monthly reports save more than those that receive quarterly reports. Legacy suspended households, on the other hand, save more on gas use than legacy current households. Like the electric case, the differences in gas savings between monthly and quarterly HER

recipients are not statistically significantly different. It appears that in program year 2017, more frequent HER messaging is unimportant for the legacy program.

**Figure 7-1. Average annual measured savings for monthly vs. quarterly current recipients**



### 7.1.2 Level of Consumption

In this section, we test the hypothesis that households with higher consumption will have higher savings rates. We do this by first looking at average savings by consumption quartile and then by comparing average baseline consumption with the savings rate of each HER group. As we indicate below, we do not find a clear relationship between consumption levels and savings rates.

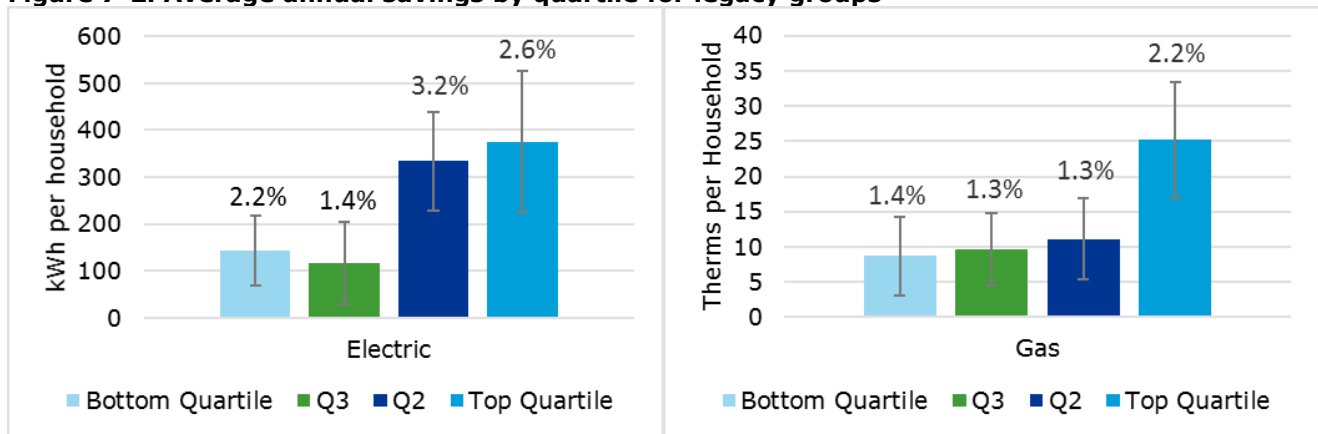
#### Consumption Quartiles

Figure 7-2 compares the performances of the legacy treatment customers by consumption quartiles. The bars represent the average annual savings and the percentages show the ratio of savings relative to consumption for each quartile. Average baseline consumption levels for each quartile are provided in Table 7-1. Although the top electric quartile generated the highest kWh savings per household, it produced the second highest percent savings after the second quartile. The bottom quartile (the quartile with the lowest consumption) achieved higher average and percent savings than the third quartile. For gas, both the savings per household and the percent saved followed the quartile distribution, with the top quartile having the highest savings per household and the greatest percent savings.



We expected higher consumption to be associated with higher savings. Savings levels are higher for higher consumption groups, but savings rates do not follow a clear-cut pattern. For electric, the highest consumption quartile saves 2.6% of baseline consumption while the next highest consumption quartile saves 3.2% of baseline use. Further, top quartile households consume 40% more than the bottom quartile, but save only 18% more relative to the bottom quartile. For gas, the highest consumption quartile saves the most, but the next three quartiles have similar percent savings.

**Figure 7-2. Average annual savings by quartile for legacy groups**



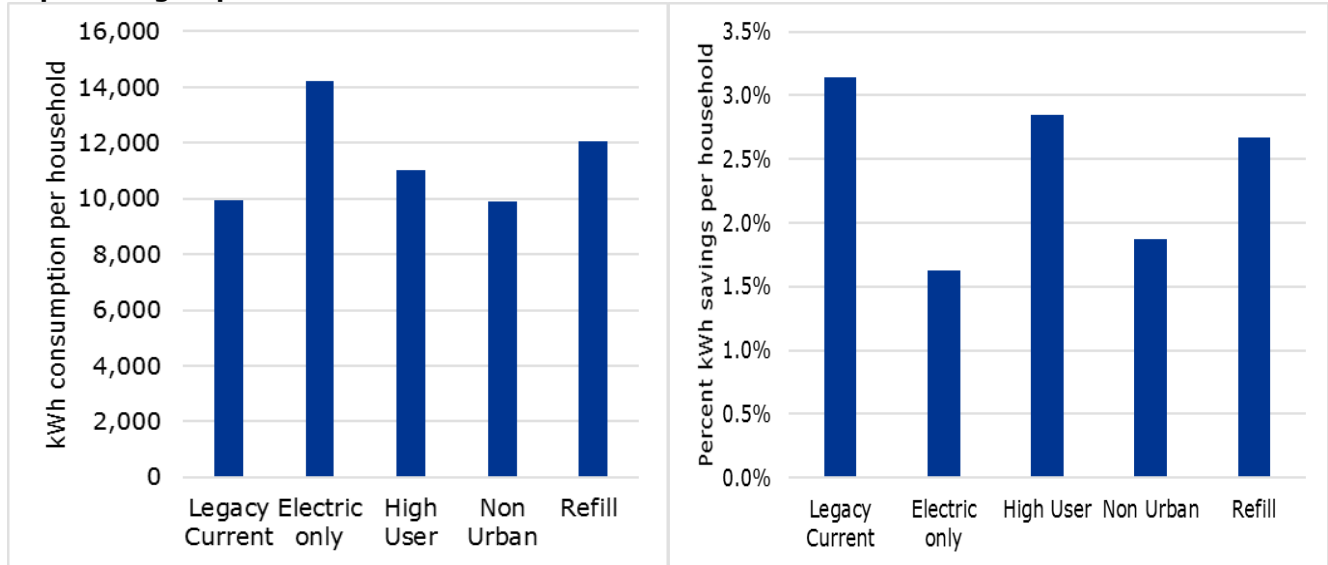
**Table 7-1 Average consumption by quartile for legacy groups**

Quartile	Electric quartile mean (kWh)	Gas quartile mean (therms)
Top	14,547	1,151
Q2	10,350	888
Q3	8,373	756
Bottom	6,550	605

**Baseline Consumption and Measured Savings Rates**

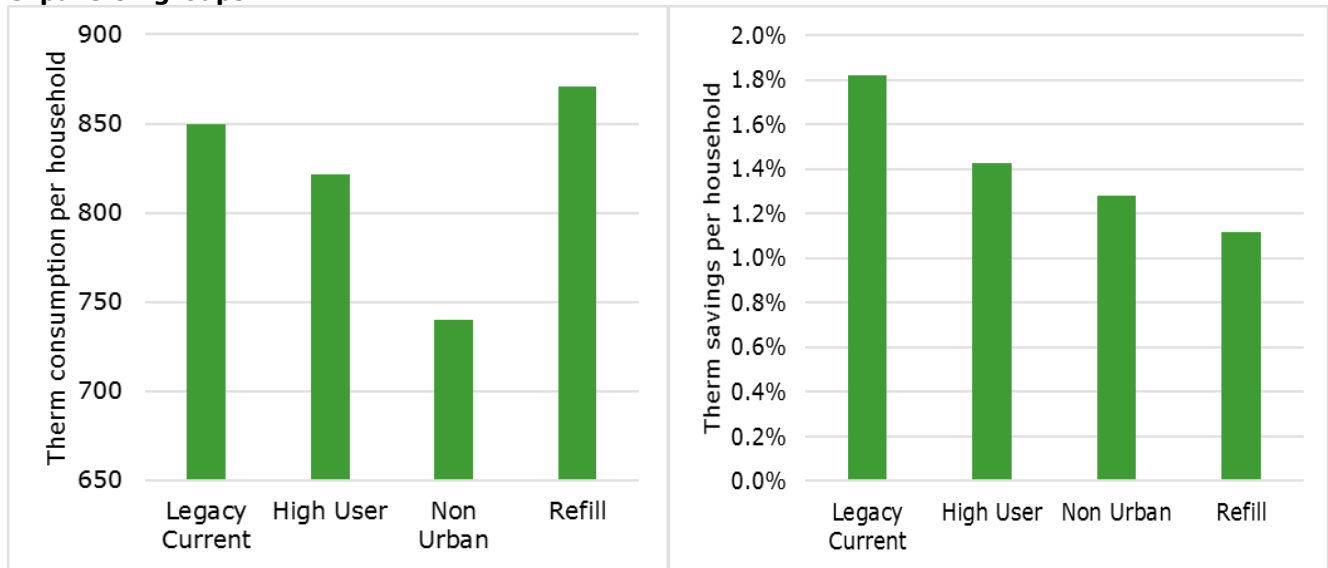
Figure 7-3 compares the electric baseline consumption and savings rates for the legacy current and expansion groups. This figure corroborates the findings above. Savings rates do not have a clear association with consumption levels in program year 2017. While electric only households had the highest level of baseline consumption, they registered the lowest level of savings. The legacy current group had the highest savings rate, but baseline use that is less than all expansion groups except the non-urban. Even among expansion groups, which are still in their ramp-up period, there is no discernible relationship between baseline use and savings.

**Figure 7-3. Baseline electric consumption and measured savings rates for legacy current and expansion groups**



The gas results are presented in Figure 7-4. The refill group had the highest baseline use in program year 2017, but the lowest savings rates among all groups. If we exclude the refill group, however, gas savings rate followed a predictable pattern where the legacy current group, with the highest baseline consumption, achieved the highest gas savings rate while the non-urban group, with the lowest baseline consumption, had the lowest gas savings rate.

**Figure 7-4. Baseline gas consumption and measured savings rates for legacy current and expansion groups**



## 7.2 Legacy Unmatched Methodology

In this section, we describe the matching procedure used to generate a matched comparison group for the legacy unmatched treatment households in section 7.2.1. We also discuss the test used to determine the quality of matches in section 7.2.2 and the results from the matching outcome in section 1.1.1. We provide the model used to estimate savings estimates for the legacy unmatched households using matched data in section 7.2.3.

### 7.2.1 Matching Procedure

Matching aims to replicate the RCT design by identifying comparison subjects whose characteristics closely match those of the treated group. There are various matching techniques that attempt to mimic the RCT design. In this study, as in the 2016 study, we use propensity score matching (PSM) to match treated households to a comparison group based on observable characteristics, which are likely to affect treatment assignment, but are not correlated with treatment outcome.

In the current study, we considered pre-program consumption and several household characteristics which were collected prior to the start of the HER program. We matched using the three combinations of variables provided in Table 7-2. We selected matches based on pre-period monthly consumption data, housing value, and age because the remaining characteristics were highly correlated with consumption and did not improve the matches.<sup>8</sup>

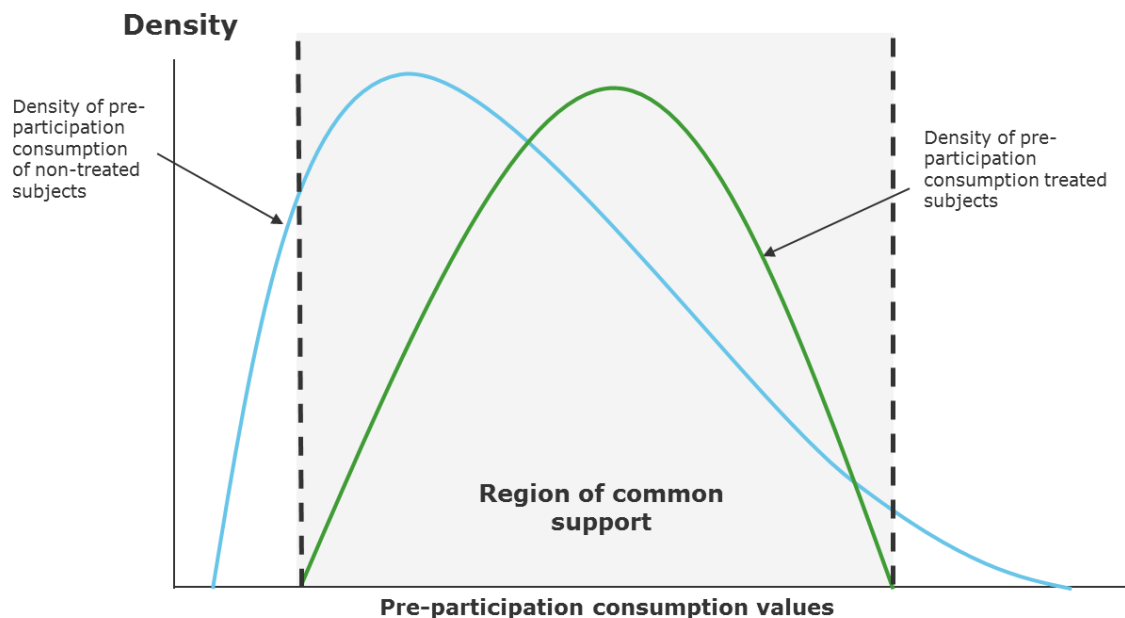
**Table 7-2 Sets of Matching Variables**

Variable	Matching Variables		
	Option 1	Option 2	Option 3
<b>House age</b>		√	√
<b>Bathrooms</b>		√	
<b>Number of bedrooms</b>		√	
<b>Fireplace indicator</b>		√	
<b>House value</b>		√	√
<b>Square Feet</b>		√	
<b>Electric consumption November 2007 - October 2008</b>	√	√	√
<b>Gas consumption November 2007 - October 2008</b>	√	√	√

As part of the matching process, we used the concept of common support to remove records from the potential comparison group that were outside of the range of the treatment group and would therefore be poor matches. Figure 7-5 presents an example of common support, which is the overlapping range of treatment and potential comparison group values, indicated by the region between the two vertical dashed lines. We applied common support to the data by trimming potential comparison group records that had pre-consumption values outside of the 1<sup>st</sup> and 99<sup>th</sup> percentiles.

<sup>8</sup> In program year 2016, we only considered and matched on pre-period monthly consumption data.

**Figure 7-5. Region of common support for matching**



Next, we fit a logistic regression model to the data to generate propensity scores which indicated the probability of receiving treatment given the level of pre-participation monthly consumption, housing value, and home age. We used the estimated propensity scores from this model to establish a second-round of common support by trimming values of the comparison group whose scores were above the maximum and below the minimum of those of the treated subjects.

Finally, we used the propensity scores to find matches for each treated subject based on one-to-one matches. We use the nearest neighbor matching (NN) algorithm for this purpose and selected 1 match without replacement for each treatment household. Selection is in random order and does not affect the condition of balance.

### 7.2.2 Test of Balance

After matching treatment with comparison group households, we checked the balance of the matches by comparing the distributions of the matching variables for the comparison and treatment households.

We evaluated the quality of the matches using the standardized difference and the ratio the variances of the propensity scores. A standardized difference is the difference in the mean values of the scores for the treatment and comparison groups relative to the standard error of the difference. A standardized difference that exceeds the value of 0.2 shows imbalance. However, the lower this difference, the better the balance. The ratio of propensity score variances is the treatment propensity score variance divided by the comparison group propensity score variance. A value that is close to 1 indicates balance whereas values that are close to 1/2 or 2 indicate extreme imbalance. Table 7-3 presents the standardized difference and the ratio of variance tests of balance, which indicate the distributions of the unmatched populations are different, but those of the matched are well balanced.

**Table 7-3. Propensity score diagnostics**

Status	Standardized Difference	Ratio of Variance
Unmatched	0.83	2.18
Matched	0.00	1.00

### 7.2.3 Post-treatment energy use model

Using the matched data, we evaluated the effect of the HER treatment on energy consumption by estimating a post-treatment energy consumption model with a difference-in-difference structure. This model is different than the model used for estimating measured savings for the households included in the RCT in that pre-period consumption data was included as an explanatory variable. This model specification allowed us to estimate the HER treatment effect based on a panel of data, where monthly observations for each treated and comparison household are stacked.

The model is given by:

$$C_{jt} = \alpha_0 + \beta_{0jt}Month_{jt} + \beta_{1jt}Month_{jt} * lagC_{jt} + \beta_2I_j + \varepsilon_{jt}$$

$C_{jt}$  = average daily consumption during interval  $t$  for household  $j$

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

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

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

$\varepsilon_{jt}$  = error term of the model

The parameter  $\beta_2$  captures the effect of HER treatment. It reflects the change in average daily consumption due to receiving HER messaging.

## 7.3 Difference-in-Difference vs Fixed Effects

In this section, we compare the current fixed effects (FE) results to results generated using our previous methodology, difference-in-difference (DID). Up until the 2015 evaluation, DNV GL used the DID method to calculate annual savings. In 2015, DNV GL continued to use the DID method but also estimated savings using the FE method as a comparison. Starting in 2016, DNV GL switched to the FE method as the main method to calculate savings to account for the savings of households that are partially present in a program year. Unlike the difference-in-difference method, the FE method permits us to estimate the savings of households that move out at any time during a program year.

### 7.3.1 Methodology

#### Fixed effects model

For this evaluation, we estimated monthly savings using a fixed-effects regression model that is standard for evaluating behavioral programs like HER. The FE model 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, to isolate changes attributable to the program.

The fixed effects equation is:

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

Where:

- $E_{it}$  = Average daily energy consumption for account  $i$  during month  $t$
- $P_{it}$  = Binary variable: one for households in the treatment group in the post period month  $t$ , zero otherwise
- $\lambda_t$  = Monthly effects
- $\mu_i$  = Account level fixed effect
- $\varepsilon_{it}$  = 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.

### Difference-in-Difference

The difference-in-differences approach is a direct and simple way of leveraging the experimental design of the HER program. The approach compares the difference in the average consumption of the treatment group between the pre- and post-report period with the same difference for the control group. The treatment group pre-post difference captures all changes between the two periods including those related to receiving the reports. The control group captures all changes except for 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 changes not related to receiving the HER which are experienced by both the treatment and control group between the pre-and post-report periods. Removing the non-HER 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:

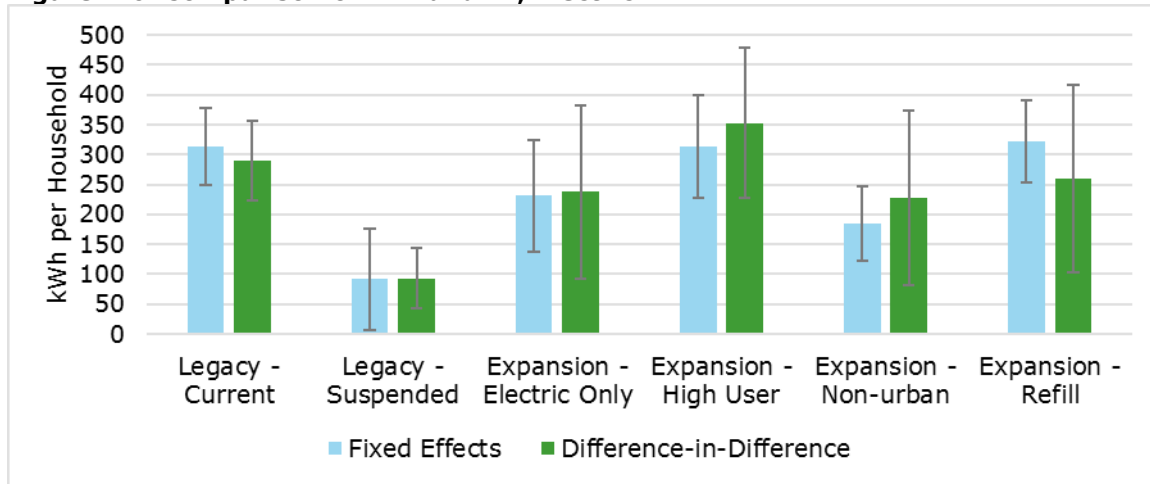
$\Delta C_i$	=	Pre-post difference in annual consumption for household $i$
$\alpha$	=	Intercept
$T$	=	Treatment indicator (value of 1 if treatment and 0 otherwise)
$\beta$	=	Treatment effect or savings estimate
$\varepsilon$	=	error term

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.

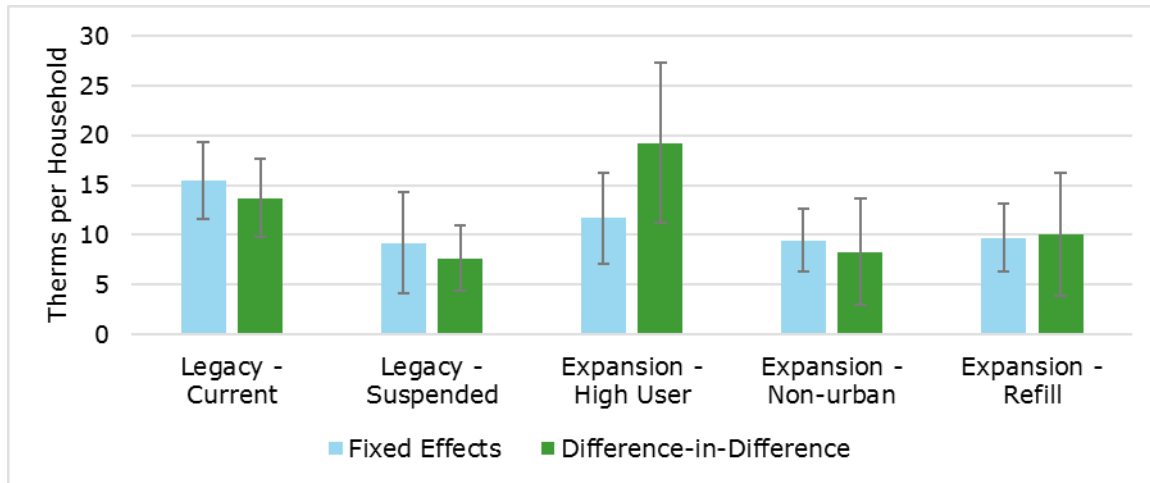
### 7.3.2 Difference-in-Difference Results

Figure 7-6 and Figure 7-7 compare the DID and FE measured savings. In all groups, the two results are statistically similar. Although some of the DID savings are higher than the FE savings, the DID savings tend to have wider confidence error bounds. In other words, the FE savings appear to be more precise than the DID savings.

**Figure 7-6. Comparison of DID and FE, Electric**



**Figure 7-7. Comparison of DID and FE, Gas**



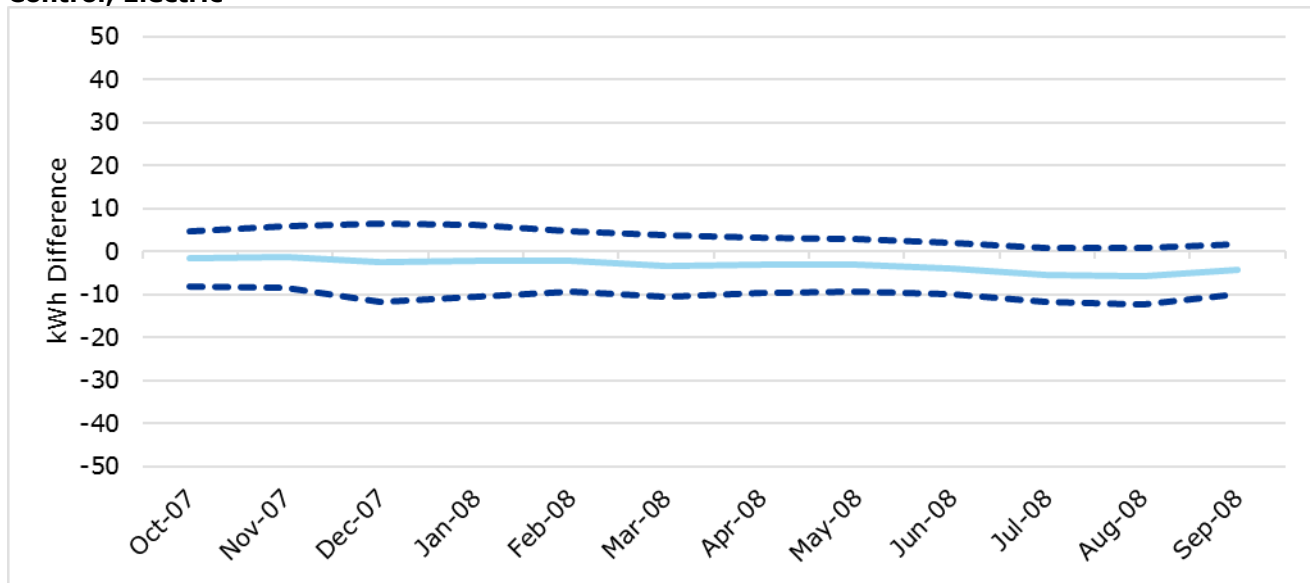
## 7.4 Randomization Tests

The following set of figures and table display how balanced the random allocation of treatment and control groups are in the pre-period after applying statistical t-tests. The figures show monthly balance with the two dotted lines as 90% confidence bounds: if both dotted lines are on opposite sides of zero then the difference is statistically insignificant. Legacy has an additional table that compares household characteristics such as

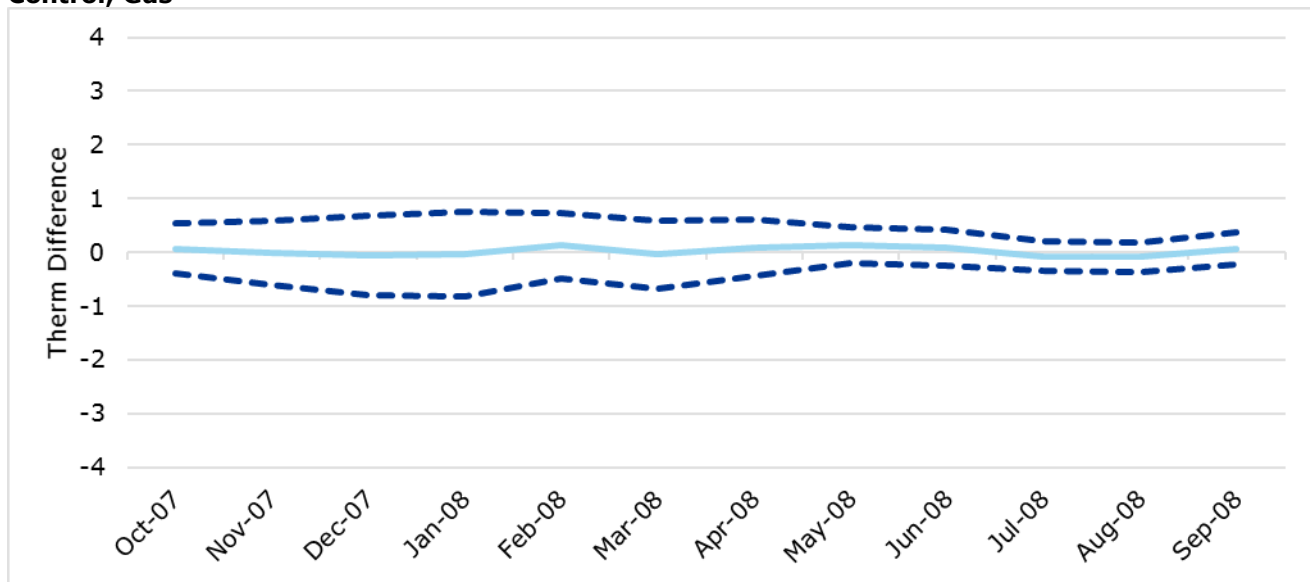


house size and age/vintage. Overall, all HER groups are balanced (with only a handful of months where some groups exhibit imbalance) indicating successful randomization of households into treatment and control groups.

**Figure 7-8. Test of Differences in Pre-Period Consumption Between Legacy Treatment and Control, Electric**



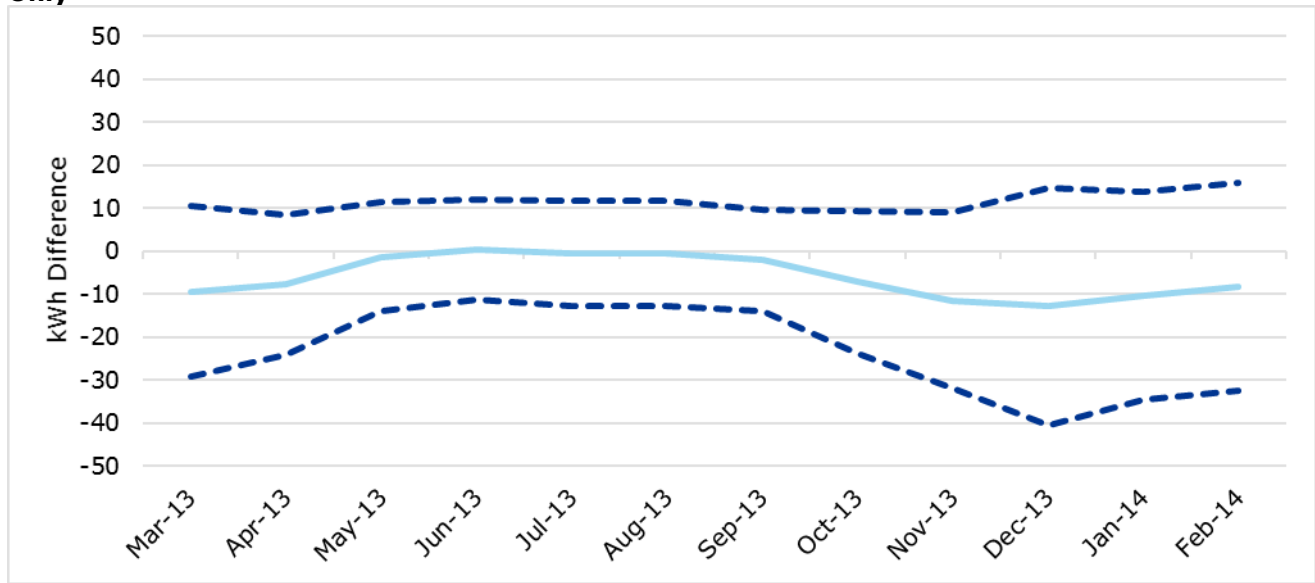
**Figure 7-9. Test of Differences in Pre-Period Consumption Between Legacy Treatment and Control, Gas**



**Table 7-4. Test of Differences in Household Characteristics Between Legacy Treatment and Control**

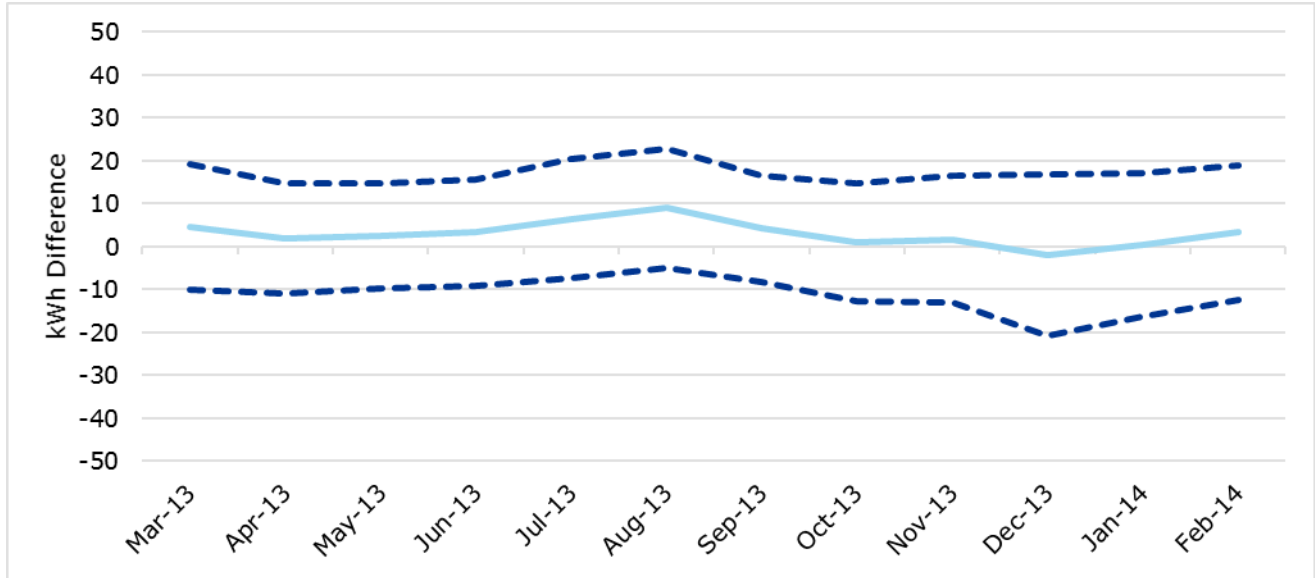
Characteristics	Treatment			Control			Control - Treatment	
	Count	Mean	Std Err	Count	Mean	Std Err	Diff	Probt
Age	20,302	30.8	0.108	25,638	30.7	0.097	-0.081	0.576
Number of bathrooms	20,302	2.3	0.004	25,638	2.3	0.004	0.004	0.449
Number of bedrooms	20,280	3.6	0.005	25,591	3.6	0.004	-0.011	0.111
House value (\$)	20,301	347,435	1,200	25,637	347,878	1,056	444	0.781
Number of occupancy	17,884	2.3	0.008	22,495	2.3	0.007	0.005	0.611
House size (sqft)	20,302	2,165.3	4.401	25,638	2,164.4	3.942	-0.854	0.885

**Figure 7-10. Test of Electric Consumption between Treatment and Control, Expansion Electric Only**

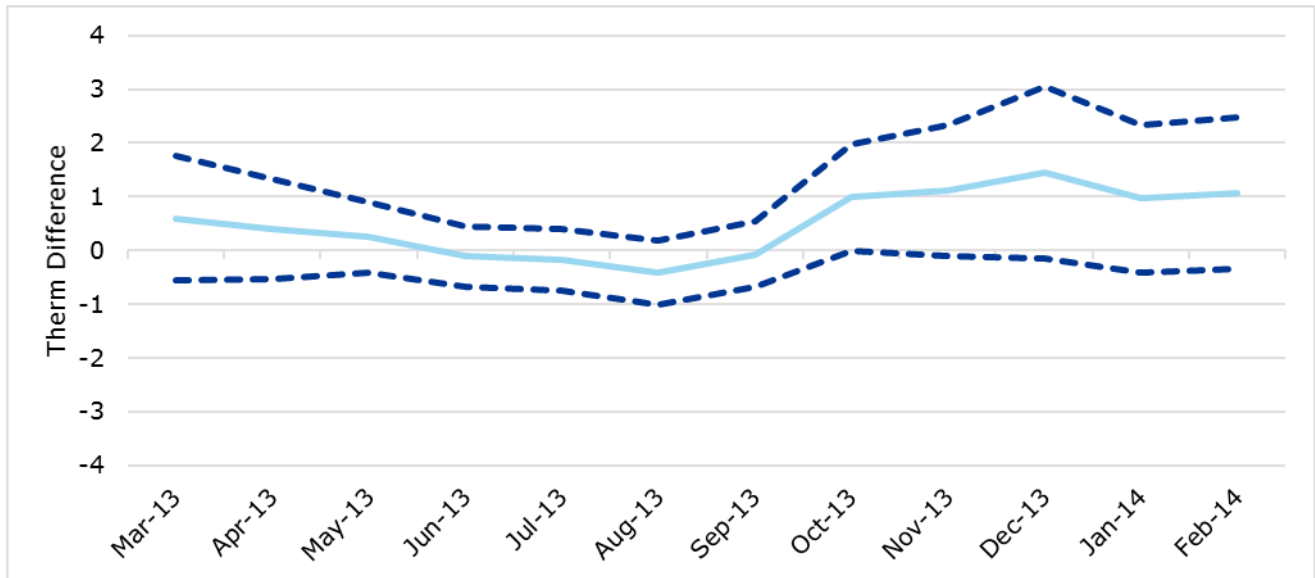




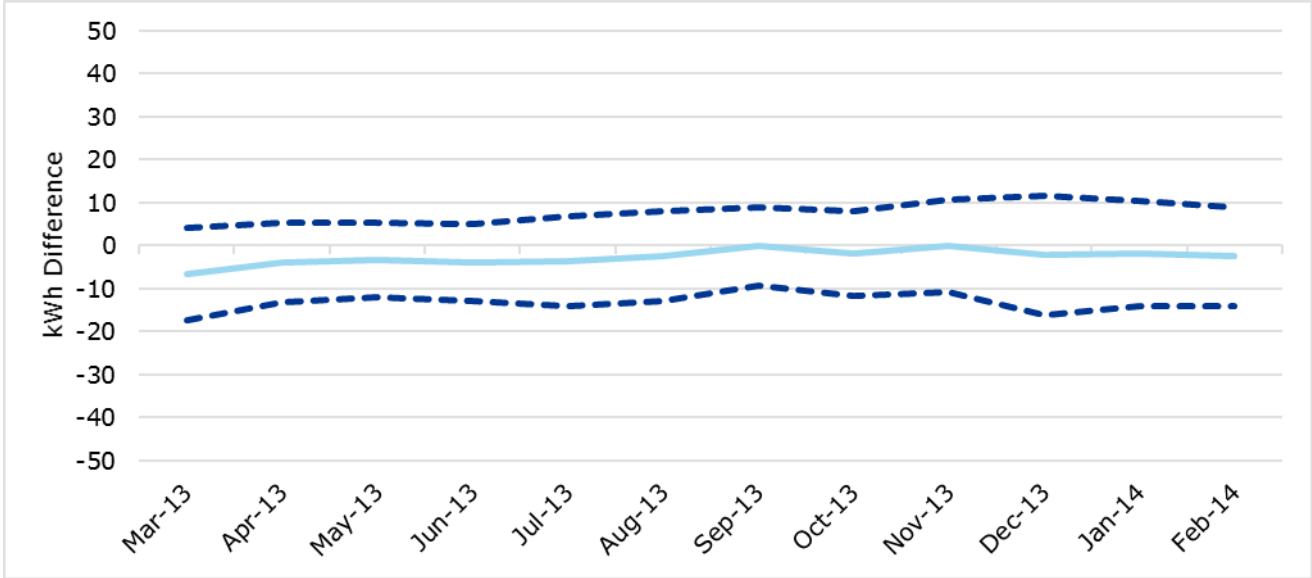
**Figure 7-11. Test of Electric Consumption between Treatment and Control, Expansion High Relative User**



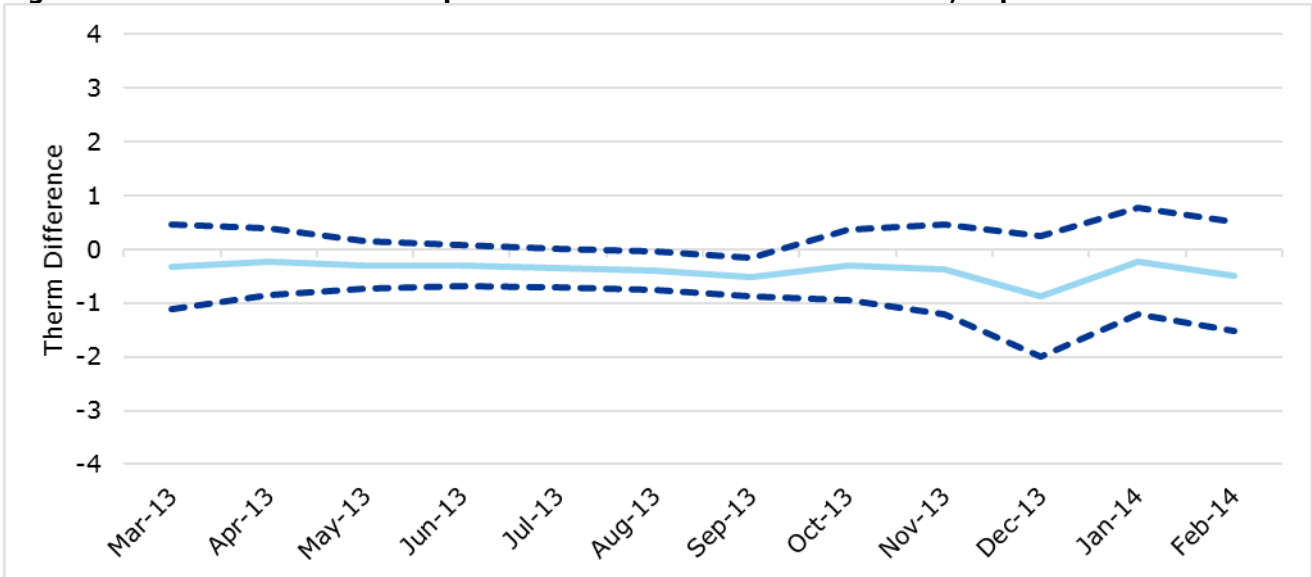
**Figure 7-12. Test of Gas Consumption between Treatment and Control, Expansion High Relative User**



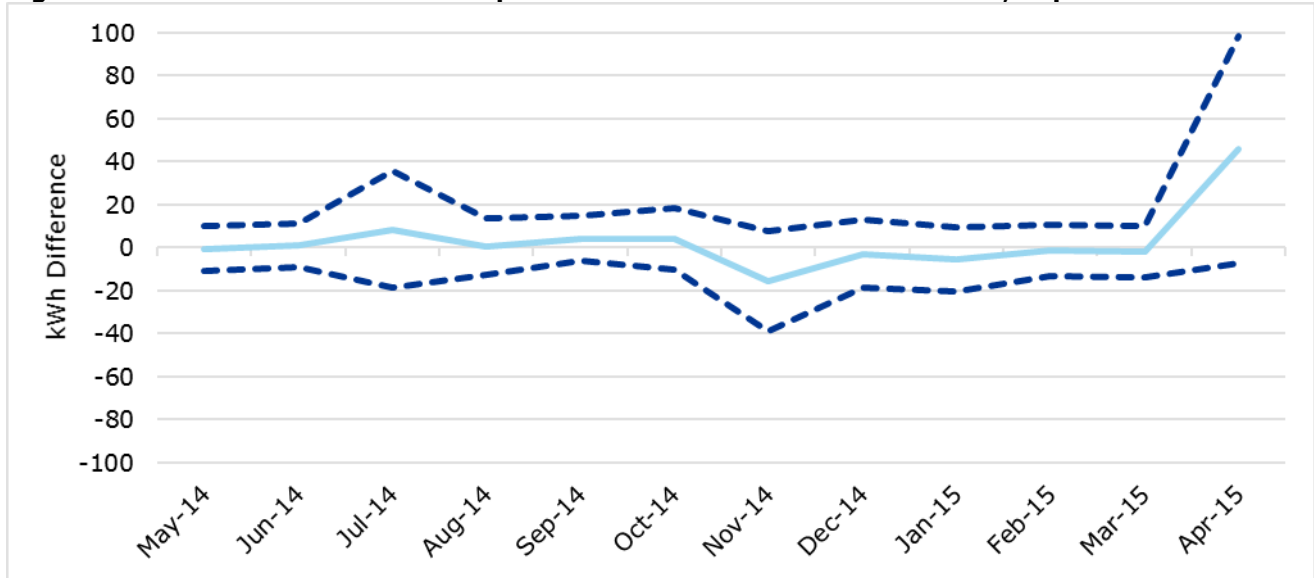
**Figure 7-13. Test of Electric Consumption between Treatment and Control, Expansion Non Urban**



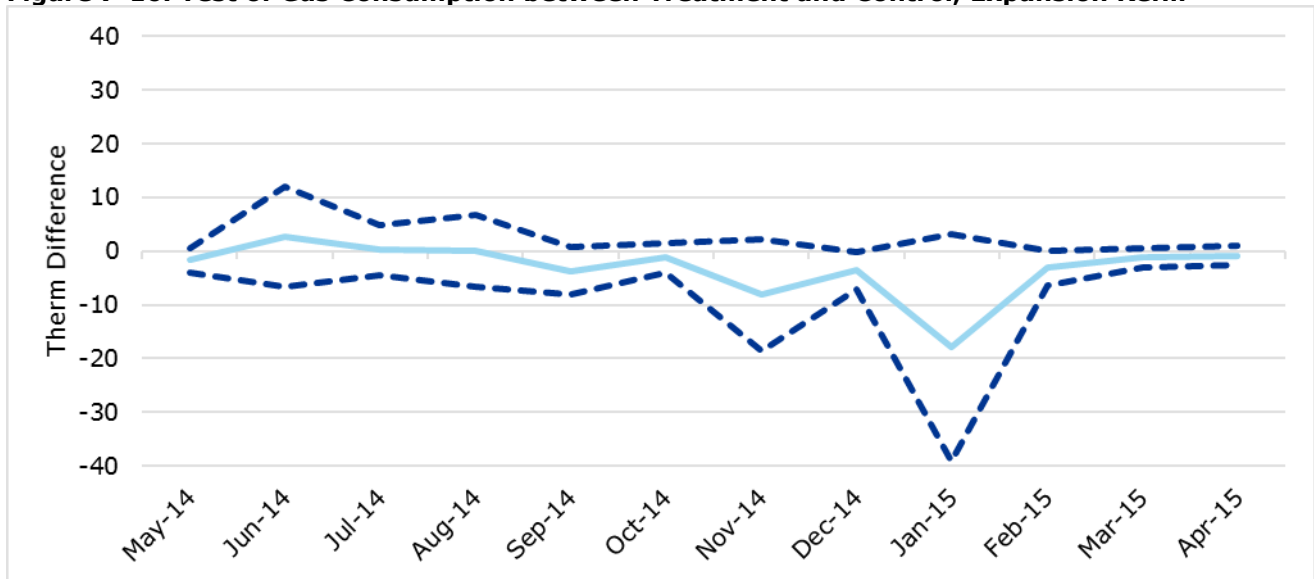
**Figure 7-14. Test of Gas Consumption between Treatment and Control, Expansion Non Urban**



**Figure 7-15. Test of Electric Consumption between Treatment and Control, Expansion Refill**



**Figure 7-16. Test of Gas Consumption between Treatment and Control, Expansion Refill**





## About DNV GL

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