Memo to:
Kasey Curtis, Puget Sound Energy
Jesse Durst, Puget Sound Energy
Copied to:
Jon Taffel, DNV
Geoff Barker, DNV
Ken Agnew, DNV

From: DNV – Energy
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Prep. By: Steven Chang, DNV

Subject: 2021 Home Energy Reports Evaluation – Electric and Gas Savings Final Results

Introduction

This memo provides a summary of Puget Sound Energy's (PSE's) Home Energy Report (HER) legacy and expansion program savings for 2021. The HER program delivers customized information on energy consumption to participating households and compares the households' energy consumption to that of similar neighboring homes. In addition, the report provides personalized tips on how to save energy based on the energy usage and housing profile of recipients. The HER program was designed to motivate households to reduce energy consumption through behavioral changes and participation in other PSE energy efficiency programs.

PSE first implemented the HER program in 2008. Each new cohort of the program is structured as a randomized controlled trial (RCT) where the eligible population is randomly assigned to treatment and control groups. The RCT design results in precise and unbiased estimates of savings per household since the only systematic difference between randomly assigned treatment and control households is the HER.

Since the launch of the program, the number of households and the composition of PSE HER cohorts have changed over time.

- The initial HER legacy cohort consisted of around 84,000 dual fuel, single family homes. Of these, 40,000 were randomly selected to receive the report while the remaining 44,000 homes were randomly assigned as the control group and did not receive the report. All households in the treatment group received the report either monthly or quarterly for two years.
- At the start of the third year, approximately 10,000 HER legacy treatment group households were randomly selected to stop receiving the reports. This created a second treatment group (suspended) designed to test the persistence of report-based savings after the termination of reports. The rest of the households in the treatment group (legacy current households) still receive the home energy reports either monthly or quarterly. By program year 2021, 15,652 of the original treatment population remain as current or suspended HER treatment participants. Program attrition is due to customer moveouts.
- In March 2014, PSE expanded the HER program to include 140,000 additional households. The HER expansion program targeted relative high users, non-urban, and electric only groups. Like the HER legacy program, the HER expansion effort followed an experimental design with 105,000 randomly selected treatment households and 35,000 randomly selected control group households. In 2021, about 50,000 treatment households remain in the program.

- In May 2015, PSE added a refill cohort numbering about 25,000 treatment households and 10,500 control households to replace households lost due to customer attrition since the start of the program. Of these, close to 57% of the treatment households remain in the program in 2021.
- In May 2019, PSE added two new electric only cohorts: a second refill cohort (65,000 treatment households and 25,000 control households) and manufactured home customers (37,977 treatment households and 9,494 control households). About 51,000 treatment households remain in the second refill cohort and 30,000 treatment households remain in the manufactured home cohort.
- In January 2020, PSE added another dual-fuel refill cohort (henceforth referred to as "refill 2020") numbering 90,000 treatment household and 30,000 control households. About 80,000 treatment households remain active.
- In March 2021, PSE added a refill cohort to the manufactured home cohort numbering 7,148 treatment households and 1,787 control households.
- In September 2021, PSE added a gas-only refill cohort numbering 100,000 treatment households and 30,000 control households.

1.1 Evaluation Objectives

The main goal of this impact evaluation is to estimate HER legacy and expansion program savings for 2021. Specifically, the research objectives are as follows:

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, including an increase in the number of participants and/or extent of participation in PSE rebate programs due to HER. Lighting savings were based on a survey which asked PSE customers about their 2021 lighting purchase history, while all other types of savings were based on the 2021 tracking data.
3. Provide an estimate of 2021 HER credited savings for legacy and expansion programs adjusted for joint savings resulting from participation in PSE.
4. Provide an estimate of electric and natural gas savings for an additional legacy treatment group that had been previously excluded from savings estimates due to lack of a randomly assigned control group (the unmatched treatment group).

This evaluation used historical consumption data to measure the difference in consumption between the treatment and control groups.[1] We measured savings estimates for the different treatment sub-groups, namely, the current and suspended cohorts for the HER legacy program and the numerous cohorts for the HER expansion program. To quantify joint savings, DNV used the PSE program tracking data for downstream programs and fielded a survey for upstream lighting purchases.

1.2 Findings – Measured Savings and Rebate Savings

DNV's primary goal for this evaluation is to develop the 2021 PSE HER program credited savings. The estimated credited savings have two components. The first is the HER program's measured savings, which reflects the program's impact on average household consumption. It is the average reduction in energy consumption of HER treated households. The second

[1] DNV used daily consumption data obtained from Oracle (the program administrator) to conduct the 2021 analysis.

component is the joint savings. To avoid double counting, DNV calculates credited savings by removing the downstream rebate joint savings and upstream lighting savings from the HER measured savings. The downstream rebate joint savings are calculated using PSE tracking data. The upstream lighting savings are calculated from a customer survey while also incorporating the savings from the previous four years (lighting savings are assumed to have a 5-year lifespan).

The credited savings DNV estimates include savings estimates for a group of legacy treatment households, mostly concentrated in the 98006-zip code, which were not assigned a random control group, but have received HER reports since the start of the program. Initially numbering close to 5,000, the current analysis is based on 2,234 unmatched households that have remained at the same premise since the start of the program. We estimated the unmatched group's 2021 HER savings by applying the percentage savings of the legacy current group to the baseline consumption of the unmatched group.

Table 1 and Table 2 provide the cohort-level and overall electric and gas savings estimates, respectively. The overall electric savings were estimated at 90/14 precision and the gas savings were estimated at 90/25 precision. Legacy suspended customers showed positive yet statistically insignificant electric savings in 2021. The electric-only refill cohort generated the most electric savings among all the treatment groups. Overall, PSE HER electric customers saved 46,246 MWh in 2021.

Table 1 Total credited electric savings for 2021 HER programs (kWh)

HER treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Claimed Savings	No. of Treatment customers	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - Current	126	5	121	10,463	1,262,654	420,980	2,104,327
Legacy - Suspended	62	0	62	5,189	319,870	-214,111	853,851
Legacy - Unmatched^			122	2,234	271,685	91,976	451,395
Expansion - Electric only	283	42	241	15,712	3,780,677	1,542,976	6,018,379
Expansion - High relative user	416	20	395	13,787	5,450,365	3,630,691	7,270,038
Expansion – Non-urban	141	30	112	20,915	2,334,889	417,329	4,252,450
Expansion - Refill	264	16	248	14,240	3,536,936	1,922,530	5,151,343
Expansion - Refill Electric only	406	22	384	51,198	19,679,001	16,133,660	23,224,341
Expansion - Manufactured Homes	196	10	185	30,725	5,693,391	3,096,665	8,290,117
Expansion - Refill 2020	61	13	48	79,749	3,841,471	1,058,115	6,624,827
Expansion Manufactured Homes Refill	15	5	11	6,876	74,938	-733,112	882,988
ALL			**184**	**251,088**	**46,245,877**	**39,662,553**	**52,829,201**

^Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (1.3%) by the average household consumption of the unmatched group (9,645 kWh).

On the gas side, the legacy current, expansion high user, expansion non-urban, and expansion refill cohorts generated statistically insignificant savings. Overall, PSE HER customers saved 1,220,951 therms in 2021.

Table 2 Total credited gas savings for 2021 HER programs (therms)

HER treatment group	Per Household				Total		
	Measured Savings	Joint Savings	Claimed Savings	No. of Treatment customers	Total savings	Lower limit 90% CI	Upper limit 90% CI
Legacy - Current	7	2	5	10,463	49,929	-6,471	106,329
Legacy - Suspended	10	0	10	5,189	53,942	18,267	89,617
Legacy - Unmatched^			6	2,234	14,259	2,217	26,302
Expansion - High relative user	10	2	8	13,787	105,858	-1,081	212,796
Expansion – Non-urban	4	0	4	20,915	76,671	-35,634	188,975
Expansion - Refill	5	1	5	14,240	68,764	-18,139	155,668
Expansion - Refill 2020	4	0	4	79,749	281,766	110,837	452,695
Expansion - Gas Only 2021	6	0	6	95,629	569,761	405,439	734,084
ALL			**5**	**242,206**	**1,220,951**	**916,948**	**1,524,953**

^Note that we calculated the unmatched per household savings by multiplying the legacy current per household savings as a percentage of consumption (0.7%) by the average household consumption of the unmatched group (872 therms).

The summary credited savings per household and joint savings results for legacy programs are presented in Table 3. The legacy current treatment group produced statistically significant credited electric savings of 120.7 kWh or 1.3% but no significant gas savings. The suspended treatment group produced statistically significant gas savings of 10.4 therms (1.6% savings per household), but no longer produces significant electric savings. Notably, this is the first year the suspended treatment group produced more gas savings than the current treatment group. These results, in combination are somewhat confounding. Ongoing gas savings from the suspended group may be due to installation of more efficient hardware, while electric savings may depend more on behavioral changes, such as turning off lights and unplugging discretionary load. Efficient gas hardware would remain after the program, while discretionary behaviors may attenuate. However, this does not explain why the suspended group appears to do better than the still current group with respect to gas savings. While the suspended group gas savings are more than double those of the current group, the difference is not statistically significant. As these groups' customer counts get smaller, all estimates of savings will become statistically insignificant because the population is too small to address the natural variability in the consumption data.

Table 3 Summary of credited savings per household for PSE HER Legacy, 2021

Treatment Groups	Consumption	HER measured savings	Downstream Joint savings	Upstream Joint savings	Credited savings	Percent credited savings
Electric (kWh)						
Current	9,571	125.6* (45.6, 205.6)	4.9 (-3.4, 13.2)	0.0 (0.0, 0.0)	120.7* (40.2, 201.1)	1.3%
Suspended		61.6 (-41.3, 164.6)	0.0 (0.0, 0.0)	0.0 (0.0, 0.0)	61.6 (-41.3, 164.6)	0.6%
Gas (therms)						
Current	652	6.8* (1.6, 12.1)	2.0* (0.9, 3.2)		4.8 (-0.6, 10.2)	0.7%
Suspended		10.4* (3.5, 17.3)	0.0 (0.0, 0.0)		10.4* (3.5, 17.3)	1.6%

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

Each expansion cohort except the manufactured home refill cohort generated statistically significant credited electric savings, while the only the refill 2020 and gas-only cohorts generated statistically significant gas savings (Table 4). Among the expansion cohorts, the high user cohort generated the largest credited electric and gas savings. The electric only cohort generated the largest joint electric savings, mostly because the HER program has a substantive impact on the uptake of upstream lighting measures for single fuel, electric only households. Although the 2021 survey indicated the control group purchased more energy-savings bulbs than the treatment group, savings are cumulative for the 5-year effective useful life of the rebated bulbs and thus leave a sizeable amount of upstream savings for this cohort. The same can be said about the non-urban group of customers. Prior year upstream savings that remain will continue to be deducted until the remaining useful life of rebated bulbs and fixtures expire.

Table 4 Summary of credited savings per household for PSE HER Expansion, 2021

Treatment Groups	Consumption	HER measured savings	Downstream Joint savings	Upstream Joint savings	Credited savings	Percent credited savings
Electric (kWh)						
Electric Only	14,158	282.5* (143.0, 422.1)	19.9 (-5.1, 44.9)	22.0* (8.5, 35.5)	240.6* (98.2, 383.0)	1.7%
High User	11,292	415.7* (284.7, 546.6)	18.5* (8.5, 28.6)	1.8 (-11.7, 15.3)	395.3* (263.3, 527.3)	3.5%
Non-urban	10,012	141.1* (50.3, 232.0)	12.8* (5.6, 20.1)	16.7* (6.7, 26.7)	111.6* (20.0, 203.3)	1.1%
Refill	12,197	264.5* (151.4, 377.5)	16.1* (8.0, 24.1)	0.0 (0.0, 0.0)	248.4* (135.0, 361.8)	2.0%
Refill Electric only	21,314	406.3* (339.7, 472.9)	13.5* (5.0, 22.0)	8.4 (-8.5, 25.3)	384.4* (315.1, 453.6)	1.8%
Manufactured Homes	14,551	195.6* (112.3, 278.9)	10.3 (-4.0, 24.6)	0.0 (0.0, 0.0)	185.3* (100.8, 269.8)	1.3%
Refill 2020	10,345	61.1* (29.4, 92.8)	0.5 (-1.2, 2.1)	12.5 (-2.0, 26.9)	48.2* (13.3, 83.1)	0.5%
Manufactured Homes Refill	11,033	15.5 (-101.7, 132.7)	4.6 (-4.3, 13.5)	0.0 (0.0, 0.0)	10.9 (-106.6, 128.4)	0.1%
Gas (therms)						
High User	683	10.0* (2.4, 17.7)	2.3* (1.1, 3.6)		7.7 (-0.1, 15.4)	1.1%
Non-urban	638	3.9 (-1.5, 9.2)	0.2 (-0.6, 1.0)		3.7 (-1.7, 9.0)	0.6%
Refill	723	5.5 (-0.6, 11.5)	0.6 (-0.2, 1.4)		4.8 (-1.3, 10.9)	0.7%
Refill 2020	609	3.6* (1.4, 5.7)	0.0 (-0.1, 0.2)		3.5* (1.4, 5.7)	0.6%
Gas Only 2021	213	6.0* (4.2, 7.7)	0.0 (0.0, 0.0)		6.0* (4.2, 7.7)	2.8%

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

Table 5 presents baseline electric and gas consumption and the average savings per household as a percent of consumption for the unmatched households. For each fuel, we select the legacy current cohort's percentage savings per household and multiply these by the unmatched group's baseline consumption to generate the credited savings per household for the group.

Table 5 Summary of credited savings for the unmatched group

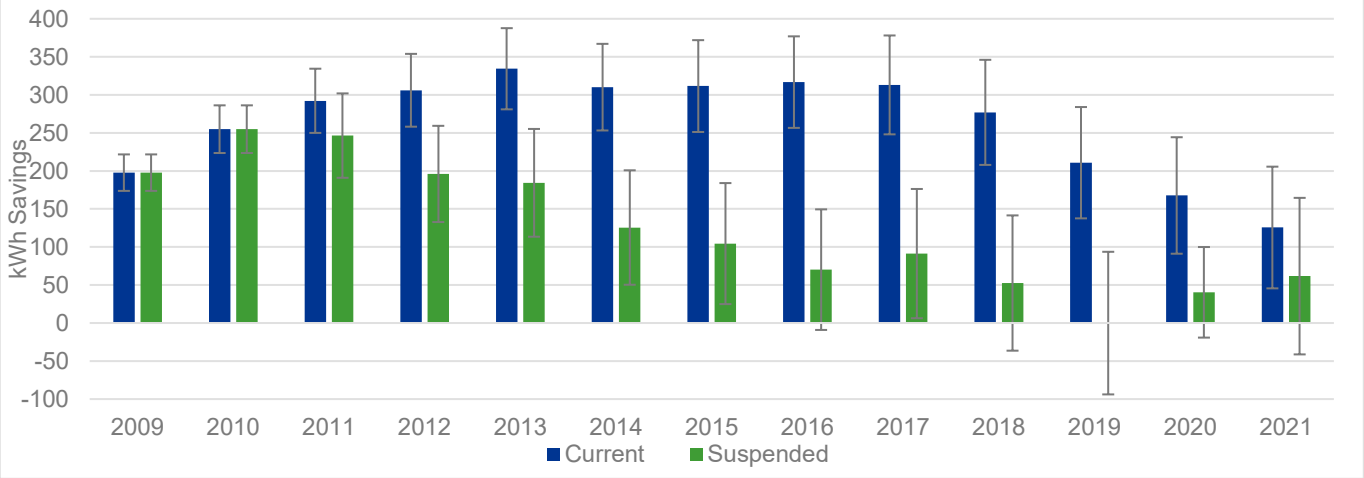
Electric (kWh)			Gas (therms)		
Consumption	**Savings**	**Percent**	**Consumption**	**Savings**	**Percent**
9,645	121.6* (41.2, 202.1)	1.3%	872	6.4* (1.0, 11.8)	0.7%

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

To put the 2021 findings in context, we provide measured electric and gas savings over time. Figure 1 provides measured electric savings and Figure 2 measured gas savings for the legacy program from 2009 to 2021. The current legacy cohort has continually registered electricity savings since the start of the HER program. While the savings for this cohort have persisted over the entire period, their upward trend has stalled since 2013 (the fifth year of the program) and decreased since 2017. The electric savings of the suspended cohort have generally been in decline since the group stopped receiving HERs in 2011, generating insignificant savings since 2018 onwards. Since 2015, the electric savings among the suspended households remained on the edge of statistical significance before dipping below zero in 2019 and back above zero in 2020.

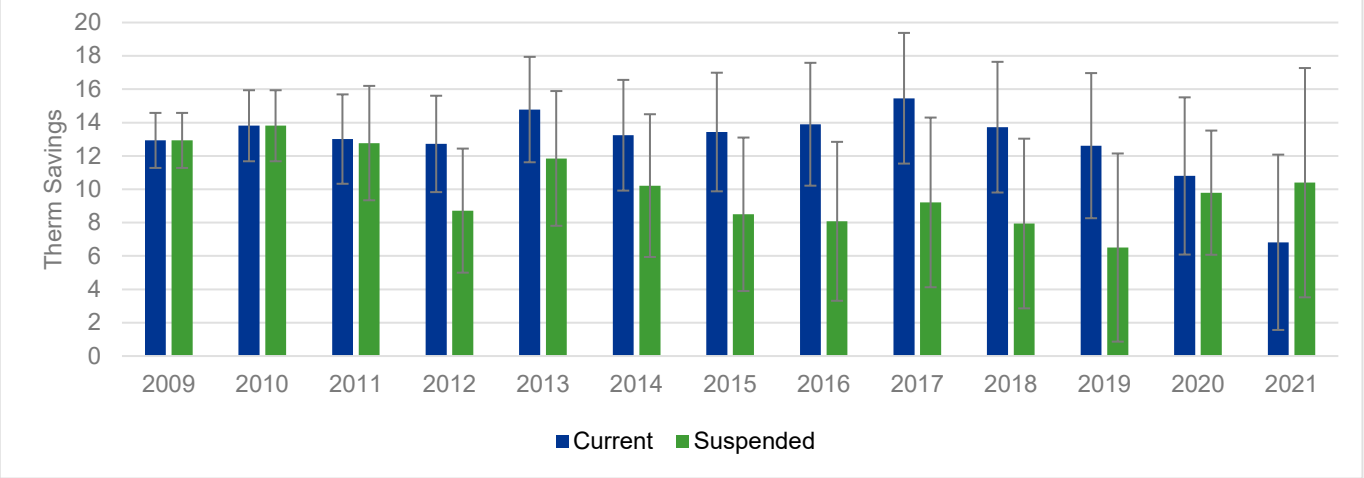
Gas savings also persist both for the current and suspended legacy cohorts. Gas savings do not have a marked trend and are not statistically different over the years. While legacy suspended gas savings have decreased since PSE discontinued HER messaging, 2021 measured savings of the suspended cohort are higher than the legacy current households' gas savings.

Figure 1. Measured HER electric savings per household for legacy, 2009-2021



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

Figure 2. Measured HER gas savings per household for legacy, 2009-2021

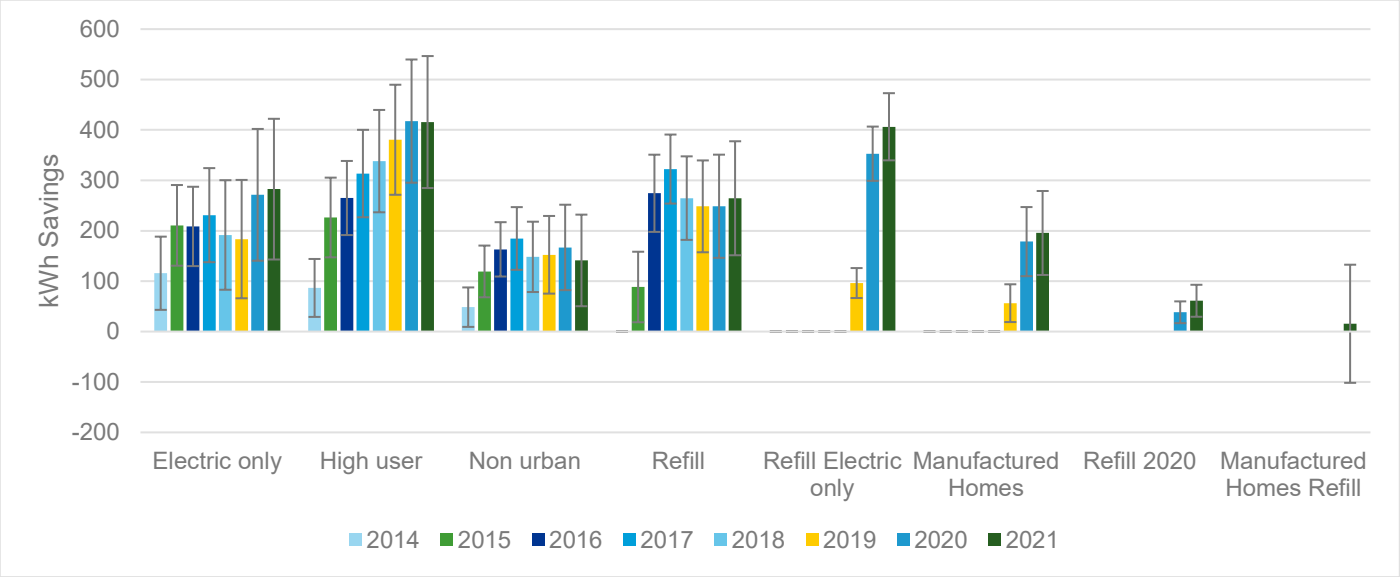


Note: The graph above shows the savings with upper and lower bounds at the 90% confidence level.

We provide electricity measured savings over time for the expansion cohorts in Figure 3 and gas measured savings over time in Figure 4. The savings for 2014 reflect partial year HER messaging as the program began in March 2014 for high

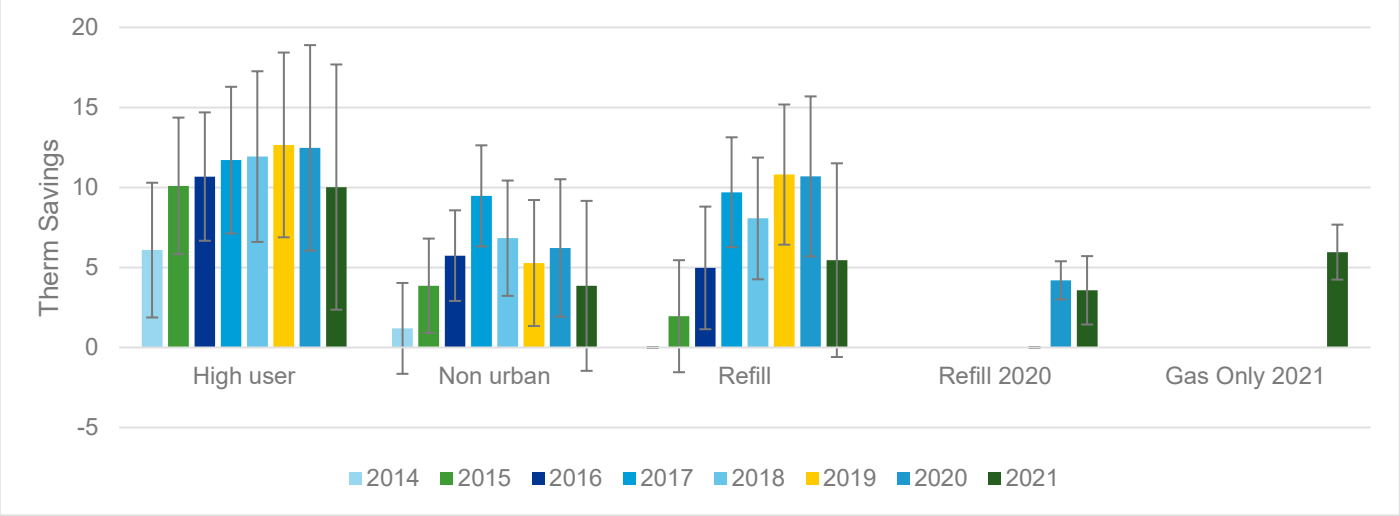
users, electric-only and non-urban households, all of which were in their seventh full year of the program in 2021. The refill group is in its sixth full year since the program for this group began in May 2015. Both the manufactured homes refill and gas-only refill began in March and September 2021, respectively, so their savings represent partial year HER messaging. Measured electric savings are around the same levels as 2020 for the earlier cohorts while the more recent cohorts are still exhibiting signs of ramp-up. The increasing trend in savings for both electricity and gas follow patterns exhibited by other HER cohorts in their early years. However, also note that the refill 2020 cohort showed a very small increase in electric savings in 2021 compared to 2020, which is much smaller than what previous cohorts exhibited.

Figure 3. Measured HER electric savings per household for expansion cohorts from 2014 to 2021



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

Figure 4. Measured HER gas savings per household for expansion cohorts from 2014 to 2021



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

Conclusions

We note the following general results:

- Total PSE HER 2021 electric savings are 46.2 million kWh and gas savings are 1,220,951 therms. The total electric savings are just slightly lower than what was achieved in 2020 due to attrition in the high-saving cohorts. While several cohorts produced insignificant per household gas savings, total gas savings were significant and increased in part due to the new gas-only cohort introduced in 2021.
- After averaging more than 300 kWh savings per household for six years, the legacy current cohort has been generating fewer and fewer electric savings since 2018. Its measured gas savings has also been declining for the past four years.
- The suspended legacy cohort's electric savings continue to be statistically insignificant while its gas savings is higher than the current legacy cohort's. This suggests that electric savings may have run out of persistence without HER while gas savings continue to maintain some level of persistence.
- The earlier expansion cohorts (electric only, non-urban, high user, refill) continue to save electricity and gas. Measured electric savings remained around the same levels as in 2020 but gas savings decreased.
- The two expansion cohorts from 2019, the electric only refill and the manufactured homes, show an increase in electric savings in 2021, following similar trajectories as the original expansion trio.
- The refill 2020 cohort showed an increase in electric savings that is much smaller than anticipated. This cohort was added at the beginning of the COVID-19 pandemic and received HER messaging that balanced an encouragement to save energy with an understanding that many residents would need to stay home and, at least temporarily, increase their energy consumption.

Recommendations

- Refill 2020 in-depth examination: As noted above, the refill 2020 cohort exhibited a smaller second-year electric savings increase than expected. We recommend tracking this cohort closely and possibly conducting a follow up study into the cohort to explore characteristics that would explain the small increase in electric savings. Two possible explanations for the low savings follow from the implementation and timing of this wave. First, the wave is mostly comprised of customers not previously chosen for participation when preferred characteristics (e.g., high consumption) were targeted. It should be expected that these customers will perform worse than the prior wave customers that were targeted. Second, as the wave was launched, the COVID-19 pandemic started. Not only did the pandemic make some of the HER savings harder to achieve, but PSE messaging acknowledged this challenge, potentially undermining the peer pressure aspect of the reports.

  A third possible reason for lower than expected savings may be due to the inclusion in the new wave of either prior HER recipients who moved within PSE territory or the homes of prior HER recipient now occupied by new owners. Previous HER recipients may now embody adopted behavioral changes suggested by the reports. The homes of previous HER customers could have received durable improvements to the premise prior to the HER recipient moving away, such as hot water pipe insulation, reduced hot water temperature or even the installation of new, more efficient appliances. Prior HER customers and homes would have been randomly assigned to the treatment and control groups as the RCT was created. The presence of these "transformed" customers and homes in the

control group represent an effective re-baselining which would lower the potential for savings from HERs relative to waves without these customers and homes. Exploring this dynamic would involve a historical analysis that tracks prior HER participation among refill 2020 cohort treatment and control customers and homes. In the same analysis, it would be possible to compare other characteristics such as average consumption and location across waves to quantify the difference in those characteristics between the refill 2020 cohort and prior cohorts. Given that HER messaging to this cohort began at the onset of the pandemic, it may be worth waiting until 2023 to see if the cohort's savings ramp up to higher levels in 2022 prior to conducting this research.

Appendix: Impact Evaluation Methods

We estimated monthly savings using a fixed-effects (FE) 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

λ_t = Monthly effects

μ_i = Account level fixed effect

ε_{it} = Regression residual

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

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

Where:

$\bar{S}_t$ = Average treatment related consumption reduction during month t

$\hat{\beta}_t$ = Estimated parameter measuring the treatment group difference in the post period month *t*

The model also includes site-specific and month/year fixed effects. The site-specific effects control for mean differences between the treatment and control groups that do not change over time. Baseline energy use is captured by estimates of λ_t in post-treatment period months. 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. During post-treatment months, the energy use of control households is estimated by $\widehat{\lambda_t}$ while those of the treatment households is estimated by $\widehat{\lambda_t}+\hat{\beta}_t$; the latter is a negative term that indicates reduction due to HER. 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.