Program:

- Web-Enabled Thermostats Program

Program Years:

- 2017-2018

Contents:

- Evaluation Report
- PSE Evaluation Report Response

This document contains Opinion Dynamics' Puget Sound Energy 2017-18 Web-Enabled Thermostats Program Impact and Process Evaluation Report and Puget Sound Energy's Evaluation Report Response (ERR).

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

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

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

This and all PSE evaluations are posted to Conduit Northwest. To view an electronic copy and to leave comments, visit **https://conduitnw.org/Pages/Welcome.aspx,** search words '2017-2018 Web-Enabled Thermostats Program Impact and Process Evaluation Report''.

---

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

[2] PSE 2018-2019 Biennial Plan, Exhibit 8: Evaluation, Measurement & Verification (EM&V) Framework, revised November 1, 2017.

[3] Ibid.

Opinion Dynamics

San Francisco Bay

510 444 5050 tel
510 444 5222 fax
800 966 1254 toll free

1999 Harrison Street
Suite 1420
Oakland, CA 94612

Puget Sound Energy

2017-2018 Web-Enabled Thermostats Program Impact and Process Evaluation Report

November 20, 2019

Opinion Dynamics

Table of Contents

Opinion Dynamics

Table of Tables

Opinion Dynamics

Table of Figures

Table of Equations

1. Overall Conclusions and Recommendations

This report provides the results from an evaluation of the Puget Sound Energy (PSE) 2017-2018 Web-Enabled Thermostat (WET) Program. As part of PSE's direct-to-consumer (DTC) offerings, this program provides a $75 rebate to customers that install ENERGY STAR-certified smart thermostats. The program began as a randomized control trial pilot with 2,000 participants in 2013 and has since evolved into a bring your own thermostat program with over 20,000 participants to date.

This evaluation explored both impact and process topics, but these aspects of the evaluation included different subsets of customers based on the timing of evaluation, participation, and the availability of sufficient post-installation consumption data to quantify energy savings. The process evaluation targets 2017 - 2018 program operations and design via secondary reviews of program materials and depth interviews with program staff, while the impact evaluation explores savings amongst 2017 participants by comparing participant's full year of 2018 energy consumption to pre-installation consumption. Finally, the evaluation included a survey of participants to contextualize consumption analysis results and provide insights into smart thermostat engagement behavior.

Table 1 summarizes the key performance indicators (KPIs) used to assess overall program performance. As shown in the "overall program health" column, the evaluation results determined that the program is well-designed to capture significant participation and is implemented in a fashion that satisfies PSE's customers. However, consumption analysis of the annual energy savings fell below PSE's planned savings expectations.

- Our analysis found statistically significant gas savings of 21 therms, or 2.9% of annual household energy consumption, and the average therm savings per participant was a little more than half of what PSE expected. While savings are lower than anticipated, the savings are substantive and consistent with gas savings found in the Pacific Northwest or other similar climates from smart thermostats.
- For electric savings, the consumption analysis did not detect significant annual savings. PSE should continue to explore the electric savings potential from smart thermostats; more research is needed to move beyond exploring the average savings and dig deeper into the savings at the individual household level. As a result, we suggest gaining a better understanding of which customers are realizing electric savings and what is driving those savings to help PSE design targeting and incentive strategies that garner electric savings from smart thermostats.

Table 1. WET Program Performance Summary

KPI	Definition	KPI Status	Overall Program Health	KPI Data Source
Gas savings	Therm savings per participant with gas heating	Annual gas savings per participant were 2.9%, or 21 therms, which aligns with what the evaluation team has observed across multiple smart thermostat studies. This estimate was 58% of the PSE's deemed savings assumption.		Consumption analysis
Electric savings	kWh savings per participant with electric heating	The evaluation team did not detect statistically significant annual electric savings.		Consumption analysis

KPI	Definition	KPI Status	Overall Program Health	KPI Data Source
Participation	Number of thermostats rebated through the program	The WET program rebated 23,995 smart thermostats in 2017 and 2018. The program attracted enough participation to scale from a pilot to a full program.		Program tracking data
Customer Satisfaction	Average score on a 1 to 5 scale	4.7 out of 5 average satisfaction amongst 2017-2018 participants (n=665).		Participant survey

1.1 Energy Savings Conclusions and Recommendations

The evaluation team estimated the average gas and electric savings per participant using a pooled consumption analysis of pre and post usage with a matched comparison group. Some WET participants also installed other energy efficiency measures via other PSE program incentives in the pre and post time period. Therefore, the evaluation conducted an additional channeling analysis to further isolate smart thermostat savings from these other measures. The results of these two analyses are summarized below.

1.1.1 Gas Savings

Table 2 provides the results of four models that the evaluation team used to quantify gas savings amongst participants who use gas for heating. The first model shows that participants, on average, saved 21 therms, or approximately 2.9% of average annual gas consumption. To help isolate WET program savings, the final model uses a comparison group and excludes any participants or comparison group customers who participated in another PSE program after WET.

We ran three additional exploratory models. Juxtaposing the final model (with a comparison group) to the model without the comparison group helps see how changes in exogenous factors (i.e., not related to the program, such as the macroeconomic changes), aspects of weather not captured by the model (e.g., humidity), and market forces (e.g., the natural rate of smart thermostat or EE technology uptake in the market) impact the energy usage baseline. In the case of gas savings, savings did not change substantially by adding a comparison group to the model. The evaluation team also explored heating season savings and customers saved slightly more gas in the heating season (3.2%) than annually (2.9%) when including the matched comparison group. Further, there does not appear to be much overlap in gas savings between smart thermostats and other program measures; after removing cross-program participation, savings dropped slightly from 3.0% to 2.9%. The 0.1% of savings captured in other programs is largely from 8% of participants who installed showerheads in addition to a smart thermostat.

Table 2. WET Program Gas Savings Per Participant – Summary

Model Type	Participants in Model	Average Daily Therm Savings	Average Total Therm Savings	Average Percent Savings	Statistically Significant at 90% Confidence Level
Annual with Comparison Group (Final Model)	4,255	0.06	21	2.9%	Yes

Model Type	Participants in Model	Average Daily Therm Savings	Average Total Therm Savings	Average Percent Savings	Statistically Significant at 90% Confidence Level
Annual without Comparison Group (Exploratory Model)	4,255	0.06	21	2.8%	Yes
Heating Season with Comparison Group (Exploratory Model)	4, 255	0.11	16	3.2%	Yes
Annual with Comparison Group, before Removing Other Program Participants (Exploratory Model)	6, 765	0.06	22	3.0%	Yes

This level of gas savings is convergent with WET's prior pilot evaluation results and is within the range of what similar offerings have achieved in the Pacific Northwest or similar climate zones. Table 3 provides a comparison of the average therm savings achieved by several gas heating thermostat programs. We drew these comparisons from literature reviews sponsored by the Regional Technical Forum (RTF)[4] and Bonneville Power Authority (BPA)[5]. Overall, these results show that the range of gas savings is extremely wide, and that PSE's program is well within expectations for the region.

Table 3. Comparison of Evaluation Results with Similar Gas Heat Thermostat Programs

Sponsor	Thermostat(s)	Average Therms per Participant	Source
Energy Trust of Oregon	Honeywell Lyrics	*negative* 29 therms (increased usage)	RTF Study
Pacific Gas and Electric	Unspecified	0 - 17 therms depending on vendor	BPA Study
PSE (WET pilot)	Honeywell	17 therms	Previous evaluation
PSE	Honeywell Vision Pro 8000	17 therms	RTF Study
PSE (WET program)	Any ENERGY STAR-certified	21 therms	This evaluation
Energy Trust of Oregon	Nest	34 therms	RTF Study

However, the evaluated savings are approximately 58% of PSE's updated[6] deemed savings value of 36 therms per participant. PSE's deemed values and the evaluation team's models both assumed similar baselines of annual gas consumption. However, PSE's percentage savings were based on an Energy Trust of Oregon study that calculated percent savings of heating load consumption, while the evaluated savings are a percent savings of household consumption. A heating load savings percentage is typically greater than a household savings percentage because it does not account for other household factors that may impact thermostat savings.

[4] Ryan Firestone. September 2016. *Connected Thermostats Devices (and Services?)*. Prepared for the RTF.
[5] Research into Action. October 2018. *Smart Thermostat Market Characterization to Inform Market Modeling*. Prepared for BPA.
[6] PSE updated their 2017-2018 gas deemed saving value during the 2017-2018 biennium. The original per participant gas savings value was 17 therms, based on the evaluation of the initial pilot.

- We recommend that **PSE update the deemed savings assumption for gas heating customers** to 21 therms per participant.

Notably, PSE tracks savings per thermostat in program tracking data. The vast majority of participants in 2017 – 2018 installed only one thermostat. However, almost 2% of participants installed more than one, to likely accommodate separate heating and cooling zones.

- We recommend that PSE **apply the 21 therms savings estimate to each thermostat** in the tracking data.

1.1.2 Electric Savings

This is the first time that PSE is evaluating electric savings for the program, as the last evaluation was of the initial gas heating pilot. Table 4 provides the results of four models that explore the electric savings from participants that use electricity for heating. The evaluation team detected 0.3% (or 30 kWh) in annual electric savings, but it was not statistically significant at the 90% confidence level. However, we did find a statistically significant electric savings (0.8%, or 48 kWh) in the heating season. Therefore, when looking at the average savings across participants, customers are saving a bit in the heating system with the smart thermostat but that savings is eclipsed by their electric usage throughout a full year, suggesting that cooling equipment or other electric appliances are offsetting the seasonal savings.

Interestingly, the electric model without a comparison group detected more savings than the model with a comparison group, while the gas model in contrast did not change much after adding a comparison group. One of the key drivers of this difference is the number of participants in the electric model, about 700 in the electric model versus over 4,000 in the gas model, driven by the fact that the program evolved from a gas heating pilot and has mostly served gas heating customers as a program. Just over one-in-seven participants (or 16%) had electric heat in 2017 according to program tracking data. Models with fewer participants tend to have larger measurement error and as such benefit more from adding a comparison group. Further, there are a wide variety of electric end uses outside of heating systems (while gas has fewer in comparison) and electric usage tends to be more variable over time. Considering these factors, adding a comparison group not only controlled for exogenous factors, but helped correct for measurement error due to small sample size and controlled for the natural variation in electric usage.

In contrast to the gas savings analysis, there does appear to be substantial overlap in electric savings between smart thermostats and other program measures; after removing cross-program participation, savings dropped from 1.4% to 0.3%. The savings captured in other programs is largely from 20% of participants who installed energy efficient lighting in addition to smart thermostats.

Table 4. WET Program Electric Savings Per Participant - Summary

Model Type	Participants in Model	Average Daily kWh Savings	Average Total kWh Savings	Average Percent Savings	Statistically Significant at 90% Confidence Level
Annual with Comparison Group (Final Model)	734	0.08	30	0.3%	No

Model Type	Participants in Model	Average Daily kWh Savings	Average Total kWh Savings	Average Percent Savings	Statistically Significant at 90% Confidence Level
Annual without Comparison Group (Exploratory Model)	734	0.30	109	0.9%	Yes
Heating Season with Comparison Group (Exploratory Model)	734	0.32	48	0.8%	Yes
Annual with Comparison Group, before Removing Other Program Participants (Exploratory Model)	1,111	0.46	167	1.4%	Yes

PSE expected to achieve on average 899 kWh per participant, and more research is needed to understand whether or not PSE can achieve that level of savings, and what types of customers are likely to provide it. Further, while the consumption analysis detected no annual savings *on average*, it is likely that individual savings varies widely amongst participants, based on their household characteristics, location, baseline electric usage, behavior, and more. Below are several factors we explored that could potentially explain the electric savings results.

- **Type of thermostat replaced.** Survey results suggest that most 2017 electric heating participants (69%, n=32) replaced programmable thermostats, as opposed to manual thermostats. This suggests there is likely less potential for savings by upgrading to "smart" technology. Notably, compared to the recent Pacific Northwest Residential Building Stock Assessment[7], there is a much higher incidence of WET participants that owned programmable thermostats than we would expect compared to the broader Washington market. According to the Stock Assessment, the market consists of 47% of consumers who have programmable thermostats (46% have manual thermostats and 7% have smart thermostats).
- **Heating equipment type.** Nearly half of electric heating survey respondents (44%) used heat pumps for cooling, and about a third (34%) used it for heating. Very few (6%) of respondents made changes to their heating or cooling system post-WET, so we can infer that heat pumps were common in the baseline. Heat pumps are a very efficient technology, meaning that HVAC energy usage for these customers was already low before installing a smart thermostat, limiting the potential for savings.
- **Cooling equipment type.** Nearly a quarter (22%) of electric heating survey respondents used no cooling equipment or electric fans. This is another possible source of low annual baseline electric usage, and partially explains why there is savings in the heating season but not the cooling season.
- **Engagement behavior.** The way participants use their smart thermostat can impact energy savings. For instance, tinkering with settings or installing additional sensors could have an impact on savings potential. We were able to explore which self-reported behaviors were correlated with energy savings for

[7] Northwest Energy Efficiency Alliance. 2017. *Residential Building Stock Assessment II. Single-Family Homes Report 2016-2017.*

gas heating participants who responded to the survey, but the limited number of electric heating customers in the model *and* the survey prevented a similar analysis for electric heating.

- **Other Changes in the Home.** The survey also uncovered evidence of several conflating factors that may impact energy savings estimates, including electric vehicles and renewables purchases. Over a quarter (27%) of electric-heating respondents experienced occupancy changes. After participating in WET, 13% purchased new major appliances like refrigerators, freezers or washer/dryers, 6% purchasing electric vehicles, 6% changed their heating and cooling system, and 3% installed solar. The evaluation team took standard steps to limit the impact of these additional actions on savings estimates. Specifically, the use of a comparison group and the removal of any participants with records of participating in other programs post-WET installation helped to isolate WET savings.
- **Renting.** About one in five (19%) of electric heating survey respondents did not live (or no longer live) at the property where they installed the thermostat. Most of these respondents still owned the home and rent it out. Split incentives in rental situations are a well-documented issue in the energy efficiency industry. For instance, renters may pay a flat fee for utilities, so they have no incentive to lower their landlord's energy bill. Further, it could be that the renters moved in after the thermostat was installed and don't know the thermostat is "smart".
- **Climate**. PSE being a winter-peaking utility may also be a factor that limits electric savings potential from smart thermostats. From this evaluation specifically, we saw that there are heating season savings for electric heat customers, which can shave winter peak demand, but the electric usage in other seasons for lighting or cooling is offsetting the electric heating season savings.
- **Thermostat Technology and Program Design.** In the Pacific Northwest market, the programs that have achieved savings in line with PSE's expectations were designed differently than the WET program's BYOT model. They specifically targeted air source heat pumps and the thermostats offered advanced heat pump controls.[8]
- **Thermostat vendor.** It is also possible that savings vary depending on the device (i.e., Nest, Ecobee, and Honeywell thermostats may have different savings potential), but there were not enough non-Nest thermostats in the current program to quantify statistically significant savings by device.

The evaluation team concluded that more analysis and research is needed to better understand the electric savings potential for smart thermostats in PSE's region and the characteristics associated with savings so PSE can target the program to yield greater electric savings.

- We recommend that **PSE continue to use the latest approved RTF electric deemed savings values** until further research can better explore the level of savings from PSE's program specifically.
- We recommend that PSE **conduct additional research with an expanded participant pool and consumption data** to understand the range of savings and types of electric heating customers who benefit the most from installing thermostats. Options include:

[8] Ryan Firestone. September 2016. *Connected Thermostats Devices (and Services?)*. Prepared for the RTF.

- **Expand energy savings analysis efforts to include 2018 participants, and ideally some early 2019 participants**. The evaluation team was unable to include these participant groups given the timing of the evaluation. By spring 2020, PSE should have access to one year of post-participation consumption data for all 2018 participants, and potentially some of the early 2019 participants.

- **Use multi-level modeling to generate pooled *and* individual savings estimates and correlate savings with existing customer data sources**. This will allow PSE to group participants by savings level (i.e., very positive, positive, neutral, negative, very negative) and run a variety of descriptive statistics based on PSE data fields and secondary data sources such as Census or Experian (e.g., program year, device type, housing type) to identify trends associated with savings levels.

- **Correlate savings further with data collected via survey efforts.** The amount of 2017 electric heating customers and survey responses in this evaluation were too small to draw meaningful conclusions on the range of savings at the household level and correlate that variation with survey data. While the evaluation team conducted a preliminary correlation analysis with gas model participants (see the next section), this was limited to 2017 gas heating participants due to sample constraints. As such, PSE should **consider fielding the survey to more 2018 electric heating customers** to allow for correlation with electric savings at the household level.

Finally, while these recommendations are in reaction to the electric savings findings, we recommend that PSE conduct the same research for gas customers as well, to better understand how to maximize the potential for gas savings.

1.2 Thermostat Engagement Conclusions and Recommendations

Smart thermostats do not necessarily have static savings in the same way that a new high efficiency appliance does. Savings can vary significantly based upon when and how customers engage with the thermostat. As such, the savings from this evaluation reflect savings with the time period of analysis. Savings could vary depending on various program messaging, targeting and incentive strategies. To begin to understand how PSE can better engage with their customers on thermostat usage, the evaluation team conducted a participant survey to understand how participants' have been engaging their smart thermostats so far.

The survey results show that customers have been highly engaged with some features of their smart thermostat: 97% say they have used the smart phone app, 82% have viewed energy usage reports on a monthly basis or more often and 81% have made settings adjustments to see Nest's "green leaf" indicator of energy conservation. However, two out of every three (65%) participants reported that they manually override the smart thermostat setting several times a month. Those who manually override do so primarily for comfort reasons, not energy efficiency reasons, which can potentially reduce energy savings.

There were enough gas heating participants in the analysis to develop savings at the household level and correlate them with self-reported thermostat engagement behaviors from the survey. The analysis showed the following statistically significant correlations with savings (90% confidence level):

- Customers that "set and forget" the WET device, and allow it to be "smart", save more energy. Customers that manually override the thermostat settings often save less than those that rarely or never override settings.
- How frequently customers manually override settings also impacts savings, those who override on a weekly basis or more frequently save less than those who override monthly or less frequently.
- Customers who install occupancy sensors in addition to the on-board device sensor save more energy.
- Customers who are more engaged with their device's energy usage reports save more energy.

Based on this preliminary research, we recommend the following to encourage customers to adopt engagement behaviors that are correlated with higher gas heat savings:

- We recommend using marketing collateral or other educational resources (e.g., webinars) to **educate customers on the benefits of "setting and forgetting" smart thermostats**. The participant survey specifically found that 93% of respondents adjusted thermostat settings manually for comfort, while 61% considered energy usage. Providing education on how smart thermostats use pre-cooling/pre-heating and other features to manage comfort while optimizing energy efficiency may be helpful in avoiding unnecessary manual overrides.
- We recommend delivering this information via **short videos or links to online resources on the PSE website**. According to the participant survey, almost half of the participants (40%) reported interest in more information. These customers **typically preferred to receive information from the PSE website**, rather than in-person coaching or a phone call.

1.3 Design and Implementation Conclusions and Recommendations

The evaluation team reviewed program implementation plans and interviewed program staff to explore program design and implementation and key performance metrics. From the staff's perspective, implementation is running smoothly. To date, the program successfully transitioned from a pilot and achieved high participation, reaching approximately 24,000 participants by 2018. Further, PSE tracks all the necessary data to assess program performance according to the current set of KPIs (see Table 1).

We do not recommend a program design change at this time. However, in the next biennium as PSE waits for additional analysis into savings they should continue to shift away from seeing smart thermostats as a "plug and play" measure that can save energy for all customers. As discussed above, it is possible that the lack of electric savings found so far is due to a combination of factors such as customer behavior, household characteristics, heating and cooling system characteristics, baseline usage, or the smart thermostat technology itself. The "bring your own thermostat" model currently employed by the program does not easily allow PSE to target certain participant types, beyond potentially offering tiers of incentives or using targeted marketing strategies. More research is needed to determine the right strategies and types of participants to target, and if a change in design is necessary to support a cost-effective program.

2. Evaluation Methodology

This section summarizes the research objectives as well as the data sources and methodologies used to conduct this evaluation of the WET program.

2.1 Research Questions

PSE is required by the Washington Utilities and Transportation Commission to evaluate their energy efficiency programs periodically from an impact and process perspective. The goals of this evaluation were to evaluate the program's design, implementation and performance. Taking PSE's regulatory requirements into consideration, as well as PSE's interest in better understanding smart thermostat usage amongst their customers, the core research questions of this evaluation were:

Energy Savings

- What are the gross electric and gas impacts associated with these devices?
- Are the deemed savings values appropriate or do they require updates?
- Is there any uncertainty surrounding the deemed savings values?
- Did any changes occur during or after the smart thermostat installation (to contextualize program savings)?

Thermostat Engagement

- How and how often do participants engage with their smart thermostat?
- How satisfied are participants with their smart thermostat?
- How interested are participants in additional PSE offerings to support optimal smart thermostat use for their home?

Program Design and Implementation

- How is the program currently implemented? What changes have occurred in 2018? When did those changes happen? What changes is program staff planning for 2019 onward?
- What were the program's marketing efforts?
- What are the KPIs? What improvements can be made, if any, to the KPIs?
- What success and challenges, if any, has program staff encountered so far in 2018?
- Is PSE tracking all necessary data needed to assess impacts?

2.2 Methods and Data Sources Summary

To evaluate the WET program, the evaluation team used a combination of secondary data review (e.g., program documentation), interviews with program staff, participant surveys, and a consumption analysis. Table 5 below maps data sources to specific evaluation activities. More information on consumption analysis and participant survey methods follow the table.

Table 5. Data Sources and Evaluation Activities

Data Source	Evaluation Activity				
	Design and Implementation Review	KPI Review	Tracking Database Review	Consumption Analysis	Participant Survey
WET program tracking data collected by program staff	X	X	X	X	X
2018-2019 Biennial Conservation Plan and other program design documentation	X	X			
Interviews with program staff	X	X			
Primary data from surveyed participants on household characteristics and changes, device engagements, and program satisfaction	X	X		X	
Daily billing data for all customers who participated in one of their residential programs from January 2014 to May 2018.			X	X	
Weather data from the National Oceanic and Atmospheric Administration's National Climactic Data Center				X	
Tracking data encompassing participation in all PSE programs in 2017 and 2018				X	

2.3 Consumption Analysis Methods

The evaluation team conducted a consumption analysis to estimate first year and heating season savings for 2017 WET participants. First year savings are defined as the savings generated for a full year following the installation of these devices, whereas calendar year savings are the savings generated by the devices the calendar year following the installation date. The evaluation team split the energy savings results by the two fuel types PSE provides to their residential customers (i.e., electric and gas).

The following sections describe the data sources for the evaluation and the consumption analysis methods. Additional detail on these topics is available in Appendix A.

2.3.1 Data Sources

This evaluation used information collected from consumption data, weather data, and program tracking data from January 2016 to May 2018. Opinion Dynamics reviewed all datasets for accuracy and completeness. The description of each data source is below.

- **Program Tracking Data**: PSE provided Opinion Dynamics with a participant tracking file that included all 2017 WET program participants. This file contained descriptive information for each participant, including unique customer identifiers, contact information, thermostat purchase date, thermostat manufacturer, and home heating fuel type. In the tracking file, there were a total of 12,912 observations, with 12,806 unique 2017 participants. Less than 1% of these participants installed more than one thermostat in their homes.

- **Cross-Program Tracking Data**: PSE supplied Opinion Dynamics with a program participation tracking database that included each measure installed through each residential program from 2014 through March 2018. The database included basic participant information (e.g., name, account number) and deemed electric and gas savings per measure. The evaluation team flagged the participants and matched comparison group customers that participated in a different residential program during the analysis period and removed these customers from the models.

- **Customer Billing Data**: PSE provided daily billing data for all customers who participated in one of their residential programs from January 2014 to May 2018. The daily billing data included the Opower customer id, date, fuel type, usage value, and read type. PSE also provided a mapping file to allow the evaluation team to map customers across the billing data and the WET program participant file. For this evaluation, the analysis period covered January 2016 to May 2018.

- **Weather Data:** Opinion Dynamics gathered weather data from the National Oceanic and Atmospheric Administration's National Climactic Data Center, which houses the Integrated Surface Database of hourly weather measurements from thousands of locations across the country. The team used customer addresses to geocode the locations of all customers within the models and found that the weather station closest to each customer with sufficient weather data.

2.3.2 Modeling Approach

Opinion Dynamics used a linear fixed-effects regression (LFER) analysis to estimate first year and heating season savings for both electric and gas. First year savings are defined as the savings generated for a full year following the installation of these devices, whereas calendar year savings are the savings generated by the devices the calendar year following the installation date. The team determined the heating season to be from November 2017 through March 2018 by analyzing the average energy usage and outside and temperatures across the participants and non-participants throughout the analysis period.

The "fixed-effects" modeling approach controls the "time-invariant" household-level factors affecting energy use (i.e., factors that do not change over the evaluation period, such as type of home or square footage) without

measuring those factors explicitly in the models. The evaluation team conducted LFER analyses of daily electric and gas data to assess changes in energy consumption attributable to the WET program.

The evaluation team tested a range of models with different covariates and interactions, and selected the best fit according to standard econometric and evaluation practices. Models were split by savings estimate (i.e., first year and heating season) and fuel type (i.e., electric and gas). Equation 1 shows the final model for the first year savings while Equation 2 shows the final model for the heating season savings.

Equation 1. First Year Savings Model

$$ADC_{it} = \alpha + \alpha_i + \beta_{post} Post_{it} + \beta_{treat\,post} Treatment_i \cdot Post_{it} + \beta_{HDD} HDD_{it} + \beta_{CDD} CDD_{it} + \\ + \beta_{day\ of\ week} Day\ of\ Week_t + \beta_{month} Month_t + \varepsilon_{it}$$

Where:
ADC_{it}= Average daily consumption (therms of kWh) for household *i* at time *t*
α= Overall intercept
α_i= Household-specific intercept (absorbed)
$Post_{it}$= Indicator for post-period (where a proxy post-period is assigned to comparison group customers based on the installation data of their respective matched participants)

$Treatment_i$= Indicator variable for inclusion in the treatment group
HDD_{it}= Heating degree days for household *i* at time *t*
CDD_{it}= Cooling degree days for household *i* at time *t*
$Day\ of\ Week_t$= Indicator variable for day of the week
$Month_t$= Indicator variable for month
β_x= Model coefficients
ε_{it} = Error term

Equation 2. Heating Season Savings Model

$$ADC_{it} = \alpha + \alpha_i + \beta_{post} Post_{it} + \beta_{treat\,post} Treatment_i \cdot Post_{it} + \beta_{HDD} HDD_{it} + \beta_{month} Month_t + \varepsilon_{it}$$

Where:
ADC_{it}= Average daily consumption (therms of kWh) for household *i* at time *t*
α= Overall intercept
α_i= Household-specific intercept (absorbed)
$Post_{it}$= Indicator for post-period (where a proxy post-period is assigned to comparison group customers based on the installation data of their respective matched participants)
$Treatment_i$= Indicator variable for inclusion in the treatment group
HDD_{it}= Heating degree days for household *i* at time *t*
$Day\ of\ Week_t$= Indicator variable for day of the week
$Month_t$= Indicator variable for month
β_x= Model coefficients
ε_{it} = Error term

2.3.3 Selecting Comparison Group

The evaluation team built the matched comparison groups based on energy consumption prior to installing the smart thermostats (i.e., pre-period), specifically average daily use during each pre-period month. The matching process included replacement, that is, one participant matched to one or multiple comparison group customers. Each energy fuel type (i.e., electric and gas) and analysis period (i.e., first year and heating season) had a separate matched comparison group.

The evaluation team explored the use of several matching methods and ultimately selected the normalized Euclidean distance method for electric comparison group matching and propensity score matching for gas comparison group matching. Both methods are standard industry approaches. The normalized Euclidean distance approach selects pairs by finding pairs with the smallest distance between the customers' characteristics (i.e., monthly usages) while normalizing the distances based on the standard error of each characteristic. Propensity score matching first builds a logistic regression model to estimate each unit's probability of being treated based on characteristics of interest, and then matches participants to the comparison group with similar propensity scores.

The evaluation team verified the equivalency of the participant and matched comparison groups by conducting equivalency checks based on their pre-period energy usage. Appendix A provides greater details for these equivalency checks.

2.3.4 Accounting for Savings from Other PSE Programs

The evaluation team found high levels of participants and matched comparison group customers that participated in other PSE residential programs. To account for savings from other PSE programs, the evaluation team removed customers that participated in a different program during the analysis period. This was done through the program participation tracking database provided by PSE. This database included each measure installed through each residential program form 2014 through March 2018. The evaluation team flagged participants and matched comparison group customers that participated in a different residential program during the analysis period and removed these customers from the models. This allowed for the models to isolate WET devices and estimate savings strictly from these devices.

2.4 Participant Survey Methods

Opinion Dynamics conducted a web survey to gather information for program participants to help inform energy savings found through the consumption analysis. The survey request was sent to customers who received a rebate for purchasing a smart thermostat through the Web-Enabled Thermostat program in 2017 or 2018. The survey collected information about participant households helped to contextualize the consumption analysis results, specifically, occupancy changes, previous thermostat type, heating and cooling system configurations, and additional retrofits participants completed during or after installing a new thermostat. The survey also explored how participants engaged with their smart thermostat. This information was used to be a helpful tool for PSE to understand how they might craft future information or offerings to encourage optimal thermostat configurations and use.

2.4.1 Sampling and Outreach Approach

The evaluation team selected a random sample of 5,000 participants, split evenly between 2017 and 2018. The composition of the sample closely matched the 2017-2018 participant population in terms of thermostat type, primary heating fuel, primary heating system type, and housing type.

PSE initially sent out an e-mail to the selected sample to confirm the validity of the survey and to encourage customers to respond. PSE also provide an EM&V staff contact (EESEvaluations@PSE.com) for the customers who had any questions or concerns. Opinion Dynamics then sent e-mail invitations to all selected sample points followed by three reminder e-mails after the invitation at one-week intervals.

As shown below in Table 6, Opinion Dynamics used a census approach (contacting all sample points) for this program. The survey was fielded from April 3rd through April 19th, 2019 and completed 665 surveys. The final response rate was 13%[9].

Table 6. Survey Sample and Target Completes

Population	Sample Available	Sampling Approach	Completes
23,573	4,986	Random Sample	665

It is important to note that the significant respondent characteristics mirror that of the population closely. As can be seen in Table 7, the distribution of respondents by the program thermostat brand for each project year was similar to the distribution across all program participants. This allowed for the evaluation team to make meaningful comparisons that could be extrapolated to the population.

Table 7. WET Survey Completes by Thermometer Brand and Year

Brand	2017-2018 Population	Respondents by Year (n)		Respondents Total
		2017	2018	
Nest	20,214 84%	220 82.4%	311 78.1%	531 79.9%
Ecobee	3,137 13%	41 15.4%	54 13.6%	95 14.3%
Other	644 3%	6 2.3%	33 8.3%	39 5.9%
Total	**23,995**	**267**	**398**	**665**

[9] American Association for Public Opinion Research (AAPOR) Response Rate 3

Similarly, Table 8 shows the distribution of respondents by the heating fuel type used in the home compared to that of the population of WET participants. The proportions were again similar enough to allow meaningful comparisons to be made and to supplement the consumption analysis.

Table 8. WET Survey Completes by Home Heating Fuel Type and Year

Home Heating Fuel Type	2017-2018 Population	Respondents by Year (n)		Respondents Total
		2017	2018	
Natural Gas	20,530 86%	235 88.0%	351 88.2%	586 88.1%
Electricity	3,459 14%	32 12.0%	47 11.8%	79 11.9%
Other	6 <1%	0 0%	0 0%	0 0%
Total	**23,995**	**267**	**398**	**665**

2.4.2 Survey Objectives and Structure

This survey was a follow-up to a consumption analysis of savings amongst 2017 participants and aimed to answer the following research questions:

- Did any changes occur during or after the smart thermostat installation that might help contextualize program savings?
- How do respondents engage with their smart thermostat, and how often? How do these behaviors align with best practices?
- How satisfied are customers with their smart thermostat?
- How interested are participants in additional PSE offerings to support optimal smart thermostat use for their home?

3. Detailed Evaluation Findings

The following section details findings concerning the evaluation's key focus areas: Energy Savings, Thermostat Engagement, Program Design, Program Implementation, and Program Participation & Marketing,

3.1 Energy Savings

3.1.1 Annual Savings Results

Table 9 shows the annual electric savings for 2017 participants with electric home heating and gas savings for 2017 participants with gas home heating. On average, gas home heating participants saved 2.9% of their annual gas usage, amounting to 21 therms per year per participant. The model detected a small amount of electric savings (0.3%, or 30 kWh per year) but cannot infer that electric savings are statistically different from zero at the 90% confidence level.

Table 9. Average Daily and Annual Savings (with Comparison Group)

Energy Savings	Unit	Participants in Model	Modeled Baseline Daily Usage	Per Participant Regression Estimated Treatment Effect			Standard Error[1]	90% CI Daily Savings	
				Daily Savings	Annual Savings	% Savings		Lower	Upper
Gas	Therms	4,255	2.02	0.06	21	2.9%	0.002	0.055	0.060
Electric	kWh	734	31.54	0.08	30	0.3%	0.050	-0.0001	0.165

[1]Standard Errors pertain to the average daily savings.

In addition, the evaluation team ran the same models in Table 9 without including the comparison group. As shown in Table 10, the electric savings are much higher than the model with a comparison group, suggesting that there are many exogenous factors (i.e., external influence not related to the program, for instance economic trends) that participant households experienced that led to a reduction in their electric energy use. Using a comparison group accounts for these factors and helps to isolate WET program savings. The gas savings, on the other hand, was hardly impacted at all by using a comparison group, lending added confidence to the results.

Table 10. Average Daily and Annual Savings (without Comparison Group)

Energy Savings	Unit	Participants in Model	Modeled Baseline Daily Usage	Per Participant Regression Estimated Treatment Effect			Standard Error[1]	90% CI Daily Savings	
				Daily Savings	Annual Savings	% Savings		Lower	Upper
Gas	Therms	4,255	2.02	0.06	21	2.8%	0.001	0.056	0.059
Electric	kWh	734	31.75	0.30	109	0.9%	0.037	0.238	0.360

[1]Standard Errors pertain to the average daily savings.

3.1.2 Heating Season Savings Results

The heating season savings focused on specific months of the evaluation period (i.e., November 2017 through March 2018) and participants with the specified heating fuel type. The evaluation team determined these months as part of the heating season by analyzing the average energy usage and outside and temperatures across the participants and non-participants throughout the analysis period. As shown in Table 11, both the electric and gas results are positive during the heating season. In addition, the per-participant daily savings were, on average, higher than the savings from the annual savings results. On average, participants reduced their electric usage by 48 kWh and 16 therms during the heating season.

Table 11. Heating Season Savings

Energy Savings	Unit	Participants in Model	Modeled Baseline Daily Usage	Per Participant Regression Estimated Treatment Effect			Standard Error[1]	90% CI Daily Savings	
				Daily Savings	Heating Season Savings	% Savings		Lower	Upper
Gas	Therms	4,255	3.37	0.11	16	3.2%	0.003	0.103	0.113
Electric	kWh	734	39.19	0.32	48	0.8%	0.085	0.178	0.458

[1]Standard Errors pertain to the average daily savings.

3.1.3 Impacts of Other Program Participation

A key step in isolating WET device savings was ensuring that the estimates were not capturing savings from other actions customers took to save energy after participating in WET. While there are some factors that cannot be controlled for by modeling (i.e., actions that are not captured in program tracking data), the evaluation team did remove all participants and comparison group customers who participated in another PSE program after WET. The result, as shown in the table below, suggest that other program participation was significantly conflating savings in the electric model, but not the gas model.

Table 12. Annual Savings Before and After Accounting for Other Program Participation

Heating Fuel Type	Savings Definition	Participants in Model	Average Annual Savings
Electric	WET Measures + Other Program Measures (Original model)	1,111	167 kWh
	WET Measures Only (Final model)	734	30 kWh
Gas	WET Measures + Other Program Measures (Original model)	6,765	22 therms
	WET Measures Only (Final model)	4,255	21 therms

The team explored the reason behind this difference by examining the other programs that the excluded customers had participated in. Through this analysis, it became clear that most of the other programs that customers participated delivered electric savings, rather than gas savings. For instance, 20% of customers in the

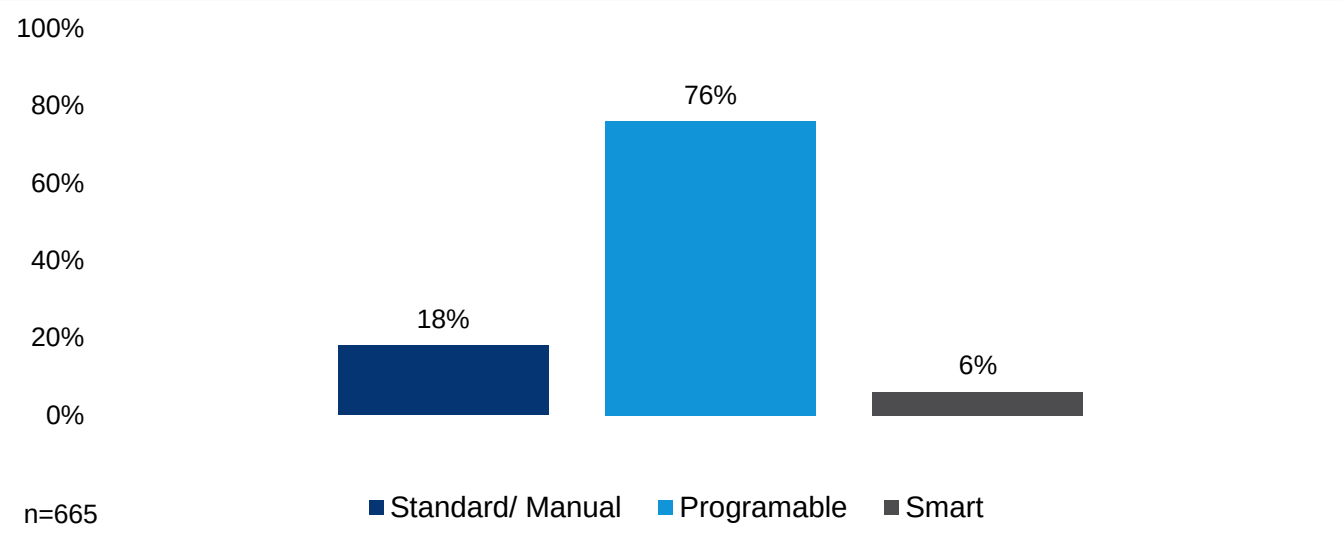
original electric model also participated in Retail Lighting. Gas savings program participation was much less pronounced (but still present) amongst the original gas model participants. Retail Showerheads was the most common (8% of participants in the gas model).

3.1.4 Survey Insights About Participant Households

Thermostat program savings are highly dependent on the types of thermostats replaced. It is quite common for thermostat programs to have additional upward or downward pressure on savings based on other actions or changes to households that participants undertake during or after installing a new thermostat.

Based on the survey responses, most participants (76%) replaced programmable thermostats for the program's smart thermostat instead of manual thermostats (18%) or another smart thermostat (6%; Figure 1). This finding is consistent with other studies on smart thermostats that have found between 70% and 75% of participants replacing programmable thermostats for the smart thermostat in these smart thermostat programs. However, replacing mostly programmable thermostats rather than manual ones can have a significant, negative effect on energy savings potential.

Figure 1. Survey Respondents by Type of Replaced Thermostat



Notably, however, compared to the recent Pacific Northwest (PNW) Residential Building Stock Assessment, there is a much higher incidence of WET participants that owned programmable thermostats than we would expect compared to the broader Washington market. According to the Stock Assessment, the PNW market consists of 47% of consumers who have programmable thermostats (46% have manual thermostats and 7% have smart thermostats).

The survey also uncovered evidence of several conflating factors that may impact energy savings estimates. Several participants experienced occupancy changes (13%, n=665), and over a third (39%) made energy efficient changes or purchases to their home at the same time or since installing the thermostat. These included making changes to the heating and cooling system (15%), purchasing new major appliances like refrigerators, freezers or

washer/dryers (18%), purchasing electric vehicles (6%), and installing solar (1%). The evaluation team took standard steps to limit the impact of these additional actions on savings estimates. Specifically, the use of a comparison group and the removal of any participants with records of participating in other programs post-WET installation helped to isolate WET savings.

3.2 Thermostat Engagement

The evaluation team designed several sections of participant survey to explore how customers interact with their thermostats. For instance, we explored how often they adjusted settings, how satisfied they are with their thermostat, and whether they want more information about them. We also conducted a follow-up analysis using individual pre/post gas savings estimates to investigate the relationship between the individual savings estimates and self-reported thermostat engagement behaviors in the survey.

3.2.1 Thermostat Usage Behaviors

Overall, survey results show that WET participants are highly engaged with the smart thermostats, adjusting their thermostats' schedules and setpoints often. The majority (72%) of participants do not make adjustments to their thermostat's programmed *schedule* more than a few times over the course of a season (Figure 2). However, nearly two-thirds (65%) of participants were manually overriding the thermostat's *setpoint* (i.e., turning it on when it is scheduled to be off or changing the current temperature setting) several times per month or more (Figure 3). This "tinkering" behavior tends to have negative impacts on the energy efficiency of smart thermostats, as participants are typically increasing HVAC load to increase comfort (e.g., making the home cooler in the summer and warmer in the winter).

Figure 2. How Often Participants Adjust the Programmed Schedule

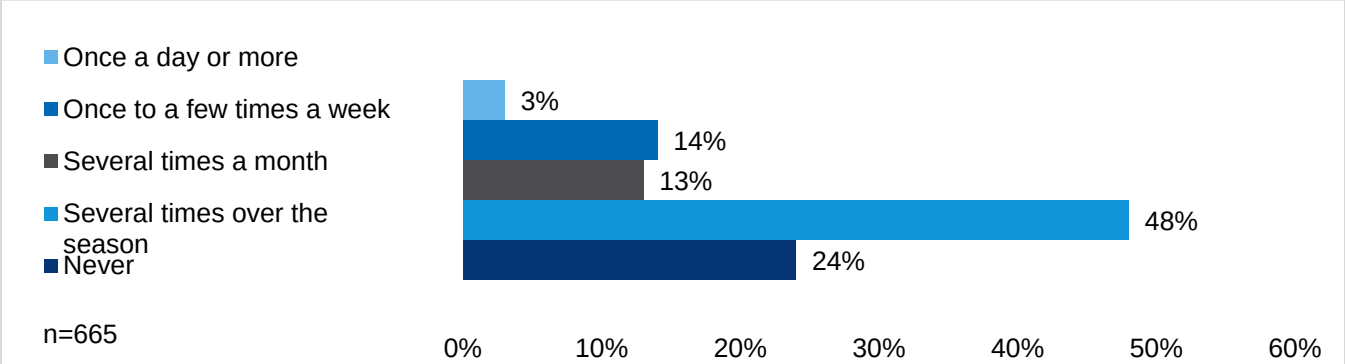
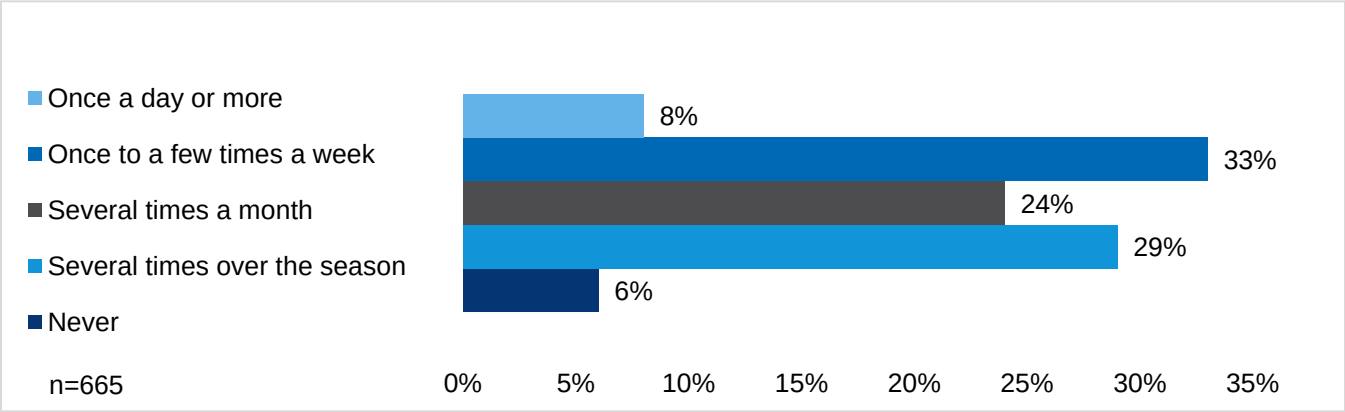


Figure 3. How Often Participants Manually Override Settings



The survey also identified several positive types of engagement with smart thermostats. WET participants reported being highly engaged with the features of their smart thermostat that encourage more energy efficient behavior. These features included having downloaded the smart phone app (97%, n=665), viewing the energy usage reports (81% view it at least several times per season), and responding to the Nest's "green leaf" recommendations (81%). The majority of participants additionally reported using the "away" or "vacation" setting on the thermostat when away for multi-day absences (59%) and enabling the geofencing capabilities when possible (51%).

Though participants were engaged with the features that come with the thermostat, the use of ancillary devices was less common. Less than half of the participants installed additional temperature sensors (24%), additional occupancy sensors (19%) or smart speakers (37%). However, when considering temperature sensors or occupancy sensors there is a significant vendor difference that arises. Of the participants who installed an Ecobee thermostat, 81% of participants installed temperature sensors. This is significantly higher than the amount of Nest users that installed the extra temperature sensors (14%). A similar trend occurred for occupancy sensors where 72% of Ecobee users adopted the sensors compared to only 10% of Nest users.

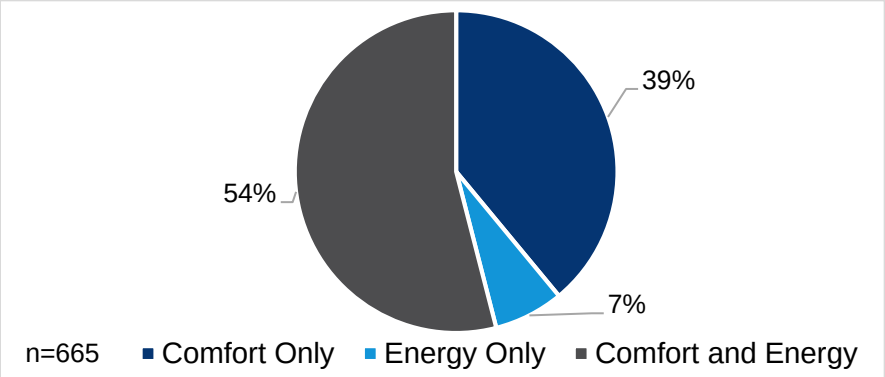
3.2.2 Behaviors That Potentially Energy Savings

The evaluation team calculated individual pre/post gas savings estimates, using the same model specifications as the consumption analysis. The team also investigated the relationship between the individual usage estimates and several survey responses regarding thermostat behavior. This analysis included 2017 participants who were in the in the gas model above and who also responded to the survey (n=135).

The evaluation team identified several strong correlations between participant behavior and individual savings that were significant at the 90/10 confidence level (based on p-value). The first significant finding suggested that customers that "set and forget" their WET device (i.e., allowed it to be "smart"), experienced higher savings. Customers that manually overrode the thermostat settings often, or those that used the device more like a manual thermostat than a smart thermostat, saved less than those who rarely or never overrode settings.

This is an important finding because there were a considerable number of customers in the survey that reported manually overriding the settings often. Specifically, 33% of participants overrode settings monthly and 24% overrode setting on a weekly basis. Respondents reported that their motivation to override settings was predominately "comfort", with 93% of all participants stating the importance of the factor whilst making thermostat decisions (Figure 4).

Figure 4. Motivations for Manually Adjusting Thermostat Settings

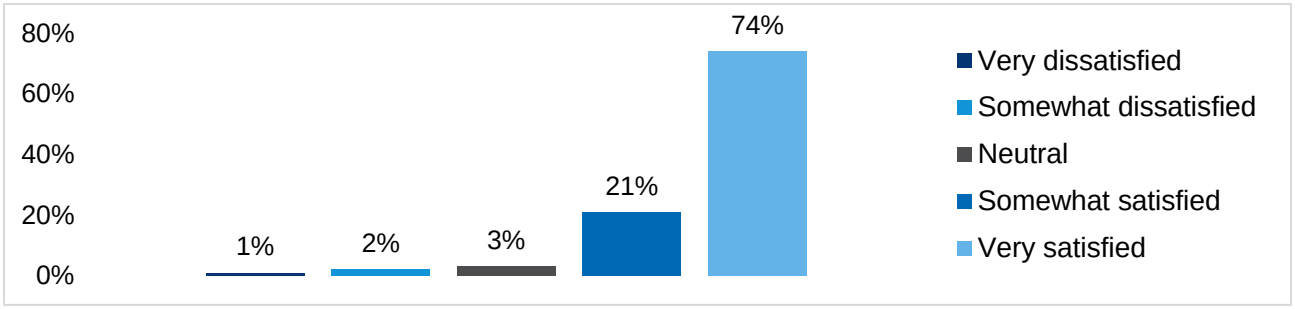


The analysis also found that customers who installed additional occupancy sensors (19% of survey respondents did so) tended to save more than those who did not. Lastly, customers that read the device's energy usage reports more often tended to save more energy. Customers that viewed reports monthly, saved significantly more than customers that viewed it only a few times a season or less.

3.2.3 Participant Satisfaction with the Smart Thermostat

Participants were highly satisfied with their thermostats. Participants rated the satisfaction an average of 4.7 out of 5 where 74% of participants were "very satisfied" (Figure 5).

Figure 5. Participant Satisfaction



3.2.4 Participant Interest in Additional Thermostat Support

The evaluation team asked participants if there was interest in receiving more information or support from PSE about the smart thermostat. Almost half of the participants (40%) reported interest in more information. The evaluation team then used a ranking tool in the survey that asked participants to consider four different ways

PSE could offer mote support. The options included: a phone call from a thermostat coach at PSE, a free Home Energy Assessments that included a discussion about optimal thermostat settings, an online video training for the smart thermostat, and a website with tips and information about the thermostat. The overarching finding here was that participants would prefer online resources over direct engagement with PSE staff or vendors (Figure 7).

3.3 Design and Implementation

This section presents the results of the evaluation team's review of program design and implementation, KPIs, data tracking, and marketing. The sources of these analyses are interviews program implementation staff and review of program documentation and data.

3.3.1 Staff Perspective on Program Performance

Through conversations with program staff, the evaluation team developed an understanding of the program's key successes and challenges. To date, the program has successfully transitioned from a pilot and achieved high participation, reaching nearly 20,000 participants by Q1 2018. In 2017, PSE faced challenges working with thermostat manufacturers to ensure all thermostats are registered, resulting in delays in rebate processing. As a result, PSE did not require registration verification in 2018. In 2018, the program was working to add the instant rebate option for other manufacturers beyond Nest.

Table 13 summarizes the results of the program staff interviews.

Table 13. WET Program Staff Interview Findings

2017-2018 Key Successes	2017-2018 Key Challenges	2017-2018 Key Implementation Changes	2018-2019 Planned Implementation Changes
▪ Program participation, achieving more than 20,000 participants by Q1 2018.	▪ Difficulty confirming registration of thermostats, slowing down applications and rebate processing, specifically: (1) Customers do not know how to find the serial number when filling out applications; and (2) Thermostat manufacturers are unable to provide the serial numbers of connected thermostats.	▪ Added WET to Pop-Up Retail. ▪ In April 2018, PSE switched vendors for validating and processing rebates. ▪ No longer required registration verification in 2018 due to manufacturer data sharing challenges ▪	▪ Plan to expand instant rebate technology to additional smart thermostat manufacturers and retail partners.

3.3.2 Marketing Efforts

PSE includes the WET program in its general DTC program marketing efforts, including traditional tactics (e.g., advertising on TV, online ads, e-mails, and promotions through PSE-owned channels) as well as more innovative promotional efforts. These include social media campaigns and retail "blitz" events. During retail blitz events,

PSE's marketing team sets up a booth and signage and distributes co-branded "Golden Tickets" to give away free LEDs, appliances, and other prizes. They also conduct store visits to place POP signage to promote program-discounted products and in-store events to educate retail employees about the programs and incentivized products. PSE promotes the DTC programs through pop-up retail events at farmers markets, festivals, and community events. PSE also used e-mail marketing to promote Black Friday sales on the online store, after which they noted an uptick in WET participation.

3.3.3 Review of KPIs

The primary goal of this program is to achieve energy savings though the installation and programming of thermostats. As such, the program's primary KPIs are the number of purchased and registered thermostats, energy savings, and expenditure. Aside from these KPIs, program staff consider customer satisfaction and how customers engage with the device to be important measures of successful program operations. However, the program currently does not collect telemetry data from thermostat manufacturers (see Table 14).

Table 14. WET Program Current and Recommended KPIs

Metric	Definition	Currently Collected by Program(Y/N)	Collection Method
Electric savings	Amount of MWh savings biennially	Y	Program tracking data
Gas savings	Amount of therm savings biennially	Y	Program tracking data
Participation	Number of participants biennially	Y	Program tracking data
Expenditure	Amount of dollars spent biennially	Y	Program tracking data
Customer Satisfaction	Average score on a scale from 0 to 10	Y	Customer Insights Survey

3.3.4 Data Tracking Review

The evaluation team requested data in multiple iterations from program staff through the evaluation contract and reviewed the data for quality and completeness. PSE provided all the data needed for the evaluation and the evaluation team only encountered minor issues in one case, when the team attempted to connect participant data with daily usage data, because the premise IDs connecting these databases did not have the same formats. The evaluation team resolved this issue, in consultation with PSE, by removing leading 7's and 0's from the participant database's premise IDs. Table 15 summarizes data review findings.

Table 15. WET Summary of Data Received

Data Category	Required Data Points	Received (Y/N)	Data Issues	Action Required
Customer identification	Unique customer identifier (e.g., premise id, customer account number, billing	Y	Premise ID has inconsistent	Ensure consistent format in the future

Data Category	Required Data Points	Received (Y/N)	Data Issues	Action Required
	account number), name, contact phone and/or e-mail		formats across datasets	
Customer Location	Zip code	Y	None	None
Customer status	e.g., active, inactive, moved out	Y	None	None
Customer Participation Date	Date of participation	Y	None	None
Energy Consumption Data	Daily consumption data for 2016 through 2018	Y	None	None
Thermostat Information	Thermostat brand, Savings associated with thermostat, Number of thermostats	Y	None	None

Appendix A. Detailed Consumption Analysis Methods and Results

The following appendix provides additional detail on the methods and results of the consumption analysis,

Data Cleaning Before Matching

Before any analysis was performed, the evaluation team checked the data and removed accounts with insufficient data to support the analysis. Insufficient accounts were those that do not have enough data to be included in the analysis. This resulted in the removal of about 44% of treatment customers and about 8% of control customers. Table 16 below summarizes dropped accounts and reasons for removal when cleaning the data for matching.

Table 16. Participant and Comparison Group Pool Before Matching

Drop Reason	Participants		Comparison Group Pool	
	N Removed	% Remaining	N Removed	% Remaining
Total Customers	**12,806**	**100%**	**200,457**	**100%**
Not in raw billing data	*-808*	*93.7%*	*-289*	*99.9%*
No data during analysis period	*-27*	*93.5%*	*-30*	*99.8%*
Usage data equaling zero for entire analysis period	*-6*	*93.4%*	*-463*	*99.6%*
On average, usage greater than three standard deviations away from mean customer usage	*-17*	*93.3%*	*-3,474*	*97.9%*
Usage greater than three standard deviations away from mean usage per day	*0*	*93.3%*	*-21*	*97.9%*
Less than 75% of data during 2016 (first year matching period)	*-3,257*	*67.9%*	*-9,759*	*93.0%*
Less than 75% of data during heating seasons (Nov 2016 – Mar 2017 and Nov 2017 – Mar 2018)	*-182*	*66.4%*	*-1,297*	*92.4%*
Kept Customers	**8,509**	**66.4%**	**173,024**	**92.4%**

Comparison Group Matching Approach

The evaluation team built the matched comparison groups based on energy consumption prior to installing the smart thermostats (i.e., pre-period), specifically average daily use during each pre-period month. The matching process included replacement, that is, one participant matched to one or multiple comparison group customers. Each energy fuel type (i.e., electric and gas) and analysis period (i.e., first year and heating season) had a separate matched comparison group.

The evaluation team explored the use of several matching methods and ultimately selected the normalized Euclidean distance method for electric comparison group matching and propensity score matching for gas

comparison group matching. Both methods are standard industry approaches. The normalized Euclidean distance approach selects pairs by finding pairs with the smallest distance between the customers' characteristics (i.e., monthly usages) while normalizing the distances based on the standard error of each characteristic. Propensity score matching first builds a logistic regression model to estimate each unit's probability of being treated based on characteristics of interest, and then matches participants to the comparison group with similar propensity scores.

The evaluation team verified the equivalency of the participant and matched comparison groups by conducting equivalency checks based on their pre-period energy usage. The sections below provide greater details for these equivalency checks.

Electric Usage Comparison Group Matching Results

For electric usage, participants matched to a comparison group customer based on their pre-period average monthly electric usage. In addition, each analysis period (i.e., first year and heating season) had a separate matched comparison group. The evaluation team verified matching based on monthly usage. Electric participants for the first year and heating season analysis periods have similar pre-period electric usage compared to their matched comparison group, as shown in Figure 6, 7, Table 17, and Table 18. Figure 6 and 7 compare the average monthly pre-period energy usage graphically while Table 17 and Table 18 quantify the differences. The differences between treatment and comparison groups, for both the first year and heating season analysis periods, were close to 0 for all months during the pre-period.

Figure 6. Normalized Euclidean Distance, Electric Usage for First Year Analysis Period

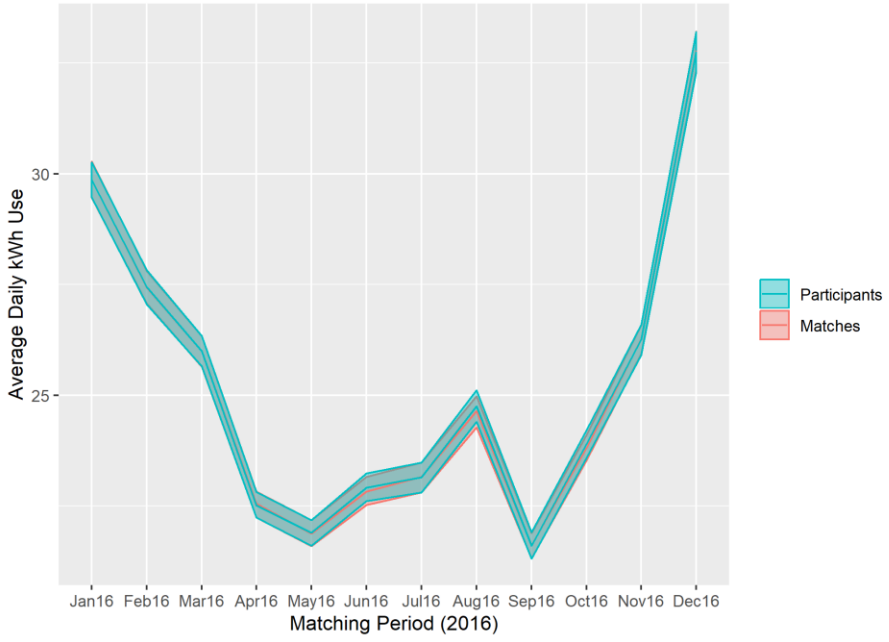


Table 17. Normalized Euclidean Distance for Electric Usage in First Year Analysis Period, Covariate Balance for Matched Pre-Period Months

Month	Participant Count	Comparison Count	Average Daily Consumption		
			Participants	Comparison Group	Difference
1	5,413	5,234	30.79	30.73	0.06
2			28.18	28.19	-0.02
3			26.70	26.69	0.01
4			23.06	23.10	-0.04
5			22.42	22.43	-0.01
6			23.52	23.43	0.09
7			23.71	23.72	-0.01
8			25.39	25.30	0.09
9			22.14	22.15	-0.01
10			24.51	24.46	0.05
11			27.00	26.99	0.01
12			33.92	34.00	-0.08

Figure 7. Normalized Euclidean Distance, Electric Usage for Heating Season Analysis Period

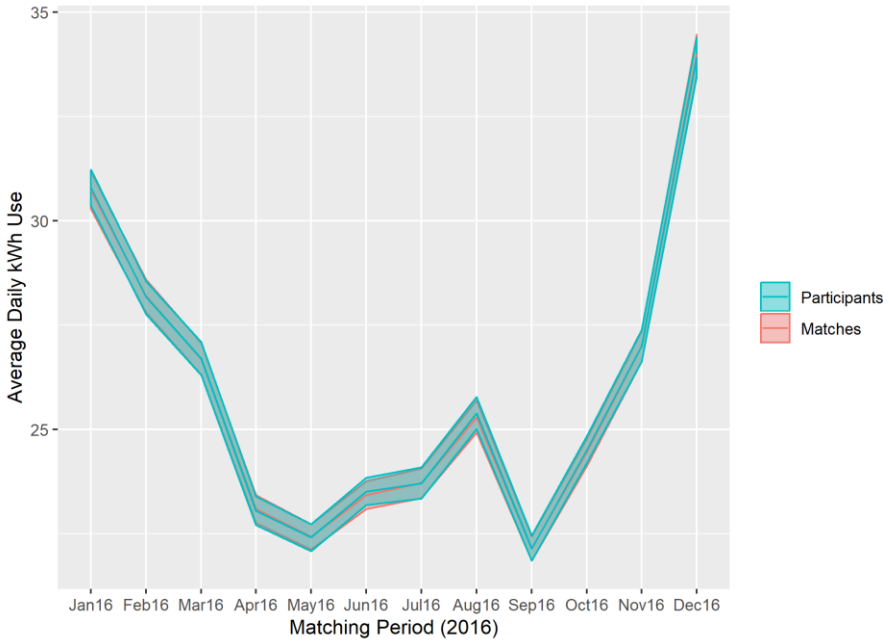


Table 18. Normalized Euclidean Distance for Electric Usage in Heating Season Analysis Period, Covariate Balance for Matched Pre-Period Months

Month	Participant Count	Comparison Count	Average Daily Consumption		
			Participants	Comparison Group	Difference
1	1,111	1,105	40.18	39.67	0.50
2			36.16	35.81	0.35
3			33.87	33.41	0.46
4			26.44	26.30	0.13
5			24.49	24.43	0.06
6			24.79	24.66	0.13
7			24.83	24.78	0.05
8			26.15	26.08	0.07
9			23.86	23.76	0.11
10			28.49	28.32	0.17
11			32.86	32.54	0.32
12			45.55	44.76	0.79

Gas Usage Comparison Group Matching Results

For gas usage, participants were matched to a comparison group customer based on their pre-period average monthly gas usage. In addition, each analysis period (i.e., first year and heating season) had a separate matched comparison group. Participants had very similar pre-period gas usage compared to the matched comparison group after matching, as shown in Figure 8, Figure 9, Table 19, and Table 20. Figure 8 and Figure 9 compare the average monthly pre-period gas usage graphically while Table 19 and Table 20 quantify the differences and show them close to 0 for all pre-period months.

Figure 8. Propensity Score, Gas Usage for First Year Analysis Period

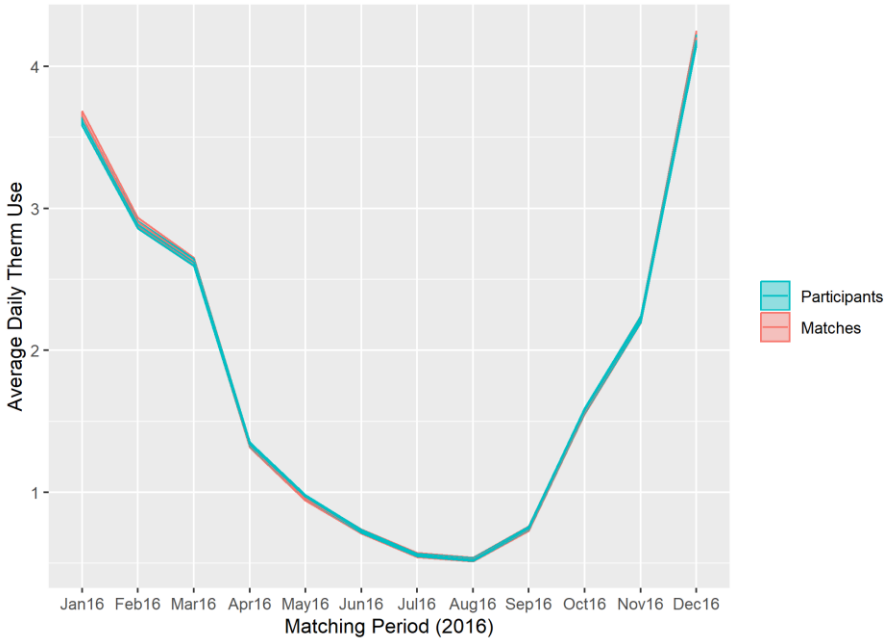


Table 19. Propensity Score for Gas Usage in First Year Analysis Period, Covariate Balance for Matched Pre-Period Months

Month	Participant Count	Comparison Count	Average Daily Consumption		
			Participants	Comparison Group	Difference
1	7,440	7,083	3.61	3.65	-0.03
2			2.88	2.90	-0.02
3			2.62	2.63	-0.01
4			1.34	1.33	0.01
5			0.97	0.96	0.01
6			0.73	0.72	0.00
7			0.56	0.56	0.00
8			0.53	0.53	0.00
9			0.75	0.74	0.00
10			1.58	1.57	0.01
11			2.22	2.22	0.00
12			4.18	4.20	-0.02

Figure 9. Propensity Score, Gas Usage for Heating Season Analysis Period

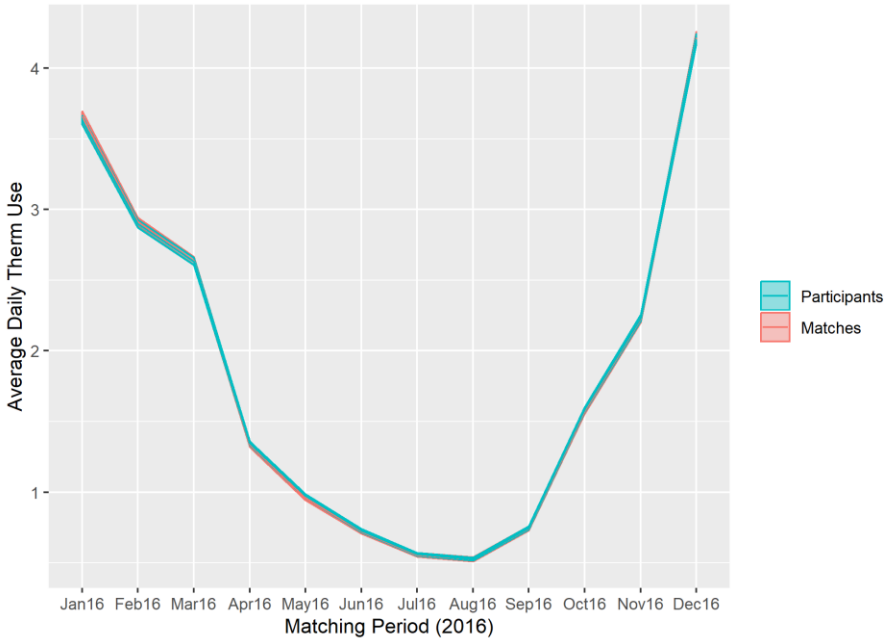


Table 20. Propensity Score for Gas Usage in Heating Season Analysis Period, Covariate Balance for Matched Pre-Period Months

Month	Participant Count	Comparison Count	Average Daily Consumption		
			Participants	Comparison Group	Difference
1	6,765	6,475	3.630	3.660	-0.029
2			2.900	2.914	-0.015
3			2.633	2.637	-0.004
4			1.345	1.336	0.009
5			0.973	0.959	0.014
6			0.728	0.722	0.006
7			0.561	0.557	0.004
8			0.526	0.525	0.002
9			0.748	0.744	0.004
10			1.585	1.575	0.010
11			2.233	2.225	0.008
12			4.206	4.215	-0.009

Data Cleaning After Matching

A few more data cleaning steps were conducted after matching. First, the evaluation team removed participants that did not have billing data for the fuel type similar for their home heating fuel type. For example, we removed participants that only had electric daily billing data but have gas heating in their home. PSE was interested in estimating annual savings for each fuel type based on the participant's home heating fuel type given that PSE is a winter-peaking utility. In addition, the evaluation team found that there were a fair amount of participants and matched comparison group customers that participated in other residential energy efficiency programs. Because PSE was interested in producing energy savings results that isolated WET device savings, the evaluation team removed participants and matched comparison customers that participated in a different residential program throughout the analysis period.

Table 21. Participant and Comparison Group Pool after Matching

Drop Reason	Participants		Comparison Group Pool	
	N Removed	% Remaining	N Removed	% Remaining
Total Customers After Matching	**8,509**	**66.4%**	**12,100**	**6.0%**
Heating fuel type different than daily billing data fuel type	*-183*	*61.5%*	*-4,556*	*3.8%*
Cross Participation	*-2,151*	*44.7%*	*-2,702*	*2.4%*
Kept Customers	**5,725**	**44.7%**	**4,842**	**2.4%**

Energy Saving Estimation Approach and Detailed Results

The evaluation team used an LFER analysis to estimate first year and heating season savings for both electric and gas. First year savings are defined as the savings generated for a full year following the installation of these devices, whereas calendar year savings are the savings generated by the devices the calendar year following the installation date. The team determined the heating season to be from November 2017 through March 2018. These months were determined as part of the heating season by analyzing the average energy usage and outside and temperatures across the participants and non-participants throughout the analysis period.

The "fixed-effects" modeling approach allows us to control for the "time-invariant" household-level factors affecting energy use (i.e., factors that do not change over the evaluation period, such as type of home or square footage) without measuring those factors explicitly in the models. The evaluation team conducted LFER analyses of daily electric and gas data to assess changes in energy consumption attributable to the WET program.

The team tested a range of models with different covariates and interactions and selected the best fit according to standard econometric and evaluation practices. Models were split by savings estimate (first year and heating season) and fuel type (i.e., electric and gas). Equation 3 shows the final model for the first year savings while Equation 4 shows the final model for the heating season savings.

Equation 3. First Year Savings Model

$$ADC_{it} = \alpha + \alpha_i + \beta_{post} Post_{it} + \beta_{treat\,post} Treatment_i \cdot Post_{it} + \beta_{HDD} HDD_{it} + \beta_{CDD} CDD_{it} + \\ + \beta_{day\ of\ week} Day\ of\ Week_t + \beta_{month} Month_t + \varepsilon_{it}$$

Where:

ADC_{it}= Average daily consumption (therms of kWh) for household *i* at time *t*
α= Overall intercept
α_i= Household-specific intercept (absorbed)
$Post_{it}$= Indicator for post-period (where a proxy post-period is assigned to comparison group customers based on the installation data of their respective matched participants)
$Treatment_i$= Indicator variable for inclusion in the treatment group
HDD_{it}= Heating degree days for household *i* at time *t*
CDD_{it}= Cooling degree days for household *i* at time *t*
$Day\ of\ Week_t$= Indicator variable for day of the week
$Month_t$= Indicator variable for month
β_x= Model coefficients
ε_{it} = Error term

Equation 4. Heating Season Savings Model

$$ADC_{it} = \alpha + \alpha_i + \beta_{post}Post_{it} + \beta_{treat\ post}Treatment_i \cdot Post_{it} + \beta_{HDD}HDD_{it} + \beta_{month}Month_t + \varepsilon_{it}$$

Where:
ADC_{it}= Average daily consumption (therms of kWh) for household *i* at time *t*
α= Overall intercept
α_i= Household-specific intercept (absorbed)
$Post_{it}$= Indicator for post-period (where a proxy post-period is assigned to comparison group customers based on the installation data of their respective matched participants)
$Treatment_i$= Indicator variable for inclusion in the treatment group
HDD_{it}= Heating degree days for household *i* at time *t*
$Day\ of\ Week_t$= Indicator variable for day of the week
$Month_t$= Indicator variable for month
β_x= Model coefficients
ε_{it} = Error term

Adjustments for Other PSE Program Savings

The evaluation team used PSE's program participation tracking database to remove participants and matched comparison customers that participated in a different residential energy efficiency program. Although the residential program tracking database was valuable in conducting the channeling analysis, there was a limitation when using this file. This analysis captures energy savings after installing a web-enabled thermostat in 2017. While this analysis was limited to 2017 HEA participants, it is possible that participants in late 2017 have not yet participated in a different program though they plan to do so (note: the analysis found that, across all programs, it took several months on average for customers to participate in a different program).

Appendix B. Participant Survey Topline

Below are the detailed survey responses. Please note that some questions are "multiple response" and do not sum to 100%. In some cases, the percentages do not sum to 100% due to rounding.

Household Changes and Characteristics

P1. When you installed your new thermostat, what type of thermostat did you replace?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Programmable	504 75.8%	72 75.8%	405 76.3%	27 69.2%	198 74.2%	306 76.9%
Standard/ Manual	119 17.9%	15 15.8%	93 17.5%	11 [A] 28.2%	52 19.5%	67 16.8%
Smart	38 5.7%	6 6.3%	31 5.8%	1 2.6%	15 5.6%	23 5.8%
Other	2 0.3%	2 [A] 2.1%	0 0%	0 0%	1 0.4%	1 0.3%
No Prior Thermostat	2 0.3%	0 0%	2 0.4%	0 0%	1 0.4%	1 0.3%
Total	**665**	**95**	**531**	**39**	**267**	**398**

[A] Results are statistically significant at the 90% level for Brand Type.

P2. Which of the following is the MOST important reason why you decided to purchase a smart thermostat?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
I was interested in smart thermostat and/or smart home technology	333 50.0%	45 47.4%	274 [A] 51.6%	14 35.9%	135 50.6%	198 49.7%
I wanted to reduce my energy bill	190 28.6%	30 31.6%	145 27.3%	15 38.5%	77 28.8%	113 28.4%
I wanted to be "green" or reduce my carbon footprint	83 12.5%	12 12.6%	69 13.0%	2 5.1%	37 13.9%	46 11.6%
A friend or neighbor recommended a smart thermostat to me	23 3.5%	0 [A] 0%	21 4.0%	2 5.1%	9 3.4%	14 3.5%
A contractor recommended a smart thermostat to me	13 2.0%	2 2.1%	5 0.9%	6 [A] 15.4%	1 0.4%	12 [B] 3.0%

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Other	23 3.5%	6 6.3%	17 3.2%	0 0%	8 3.0%	15 3.8%
Total	**665**	**95**	**531**	**39**	**267**	**398**

[A] Results are statistically significant at the 90% level for Brand Type.
[B] Results are statistically significant at the 90% level for Participation Year.

P3. Do you have more than one thermostat in your home?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	44 6.6%	1 1.1%	42 [A] 7.9%	1 2.6%	20 7.5%	24 6.0%
No	619 93.1%	93 97.9%	488 [A] 91.9%	38 97.4%	245 91.7%	374 94.0%
Unsure	2 0.3%	1 1.1%	1 0.2%	0 0%	2 0.7%	0 0%
Total	**665**	**95**	**531**	**39**	**267**	**398**

[A] Results are statistically significant at the 90% level for Brand Type.

H1. Do you live at the property where you installed the thermostat?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	633 95.2%	93 97.9%	502 94.5%	38 97.4%	247 92.5%	386 [B] 97.0%
No	32 4.8%	2 2.1%	29 5.5%	1 2.6%	20 [B] 7.5%	12 3.0%
Total	**665**	**95**	**531**	**39**	**267**	**398**

[B] Results are statistically significant at the 90% level for Participation Year.

[If participants responded "no", ask H2]

H2. Which of the following best applies to you?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
You sold the home	17 53.2%	1 50.0%	16 55.2%	0 0%	10 50.0%	7 58.3%

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
You own the property and currently rent it to someone else	7 21.8%	0 0%	7 24.1%	0 0%	4 20.0%	3 25.0%
You were a renter and have since moved	5 15.6%	1 50.0%	4 13.8%	0 0%	5 25.0%	0 0%
This home is not your primary residence, but no one else lives there (a vacation home or second home)	3 9.4%	0 0%	2 6.9%	1 100%	1 5.0%	2 16.7%
Total	**32**	**2**	**29**	**1**	**20**	**12**

Note: This question was only asked of respondents who do not live at the property where the thermostat was installed in H1.

[If participants said they sold the home or that they were only renting the home, ask H3 and H4]

H3. Did you take the thermostat with you when you moved or sold the home?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	11 50.0%	0 0%	11 55.0%	0 0%	9 60.0%	2 28.6%
No	11 50.0%	2 100%	9 45.0%	0 0%	6 40.0%	5 71.4%
Total	**22**	**2**	**20**	**0**	**15**	**7**

Note: This question was only asked of respondents who were renting and moved or who sold the home where the thermostat was installed in H2.

H4. When did you move or sell the home?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Before 2019	18 81.8%	2 100%	16 80.0%	0 0%	12 80.0%	6 85.7%
2019	4 18.1%	0 0%	4 20.0%	0 0%	3 20.0%	1 14.3%
Total	**22**	**2**	**20**	**0**	**15**	**7**

Note: This question was only asked of respondents who were renting and moved or who sold the home where the thermostat was installed in H2.

[If participants reported not moving from the home where the thermostat was installed, ask H5]

H5. Is the thermostat currently installed in the property?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	628 97.7%	93 [A] 100%	499 97.7%	36 [A] 92.3%	244 96.8%	384 98.2%
No	14 2.2%	0 [A] 0%	12 2.3%	2 [A] 5.1%	8 3.2%	6 1.5%
Don't Know	1 0.2%	0 0%	0 0%	1 2.5%	0 0%	1 0.3%
Total	**643**	**93**	**511**	**39**	**252**	**391**

[A] Results are statistically significant at the 90% level for Brand Type.
Note: This question was only asked of respondents who did not move or sell the home in H1 and H2.

[If participants reported that the thermostat is no longer installed, ask H5a]

H5a. Did you re-install your old thermostat or install a different thermostat?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
I installed a new thermostat	10 71.4%	0 0%	8 66.7%	2 100%	4 50.0%	6 [B] 100%
I installed my old thermostat	4 28.6%	0 0%	4 33.3%	0 0%	4 [B] 50.0%	0 0%
I do not have a replacement thermostat installed	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Total	**14**	**0**	**12**	**2**	**8**	**6**

[B] Results are statistically significant at the 90% level for Participation Year.
Note: This question was only asked of respondents who did not move or sell the home that had the thermostat installed but who report that the thermostat is not currently installed in H2 and H5.

[If participants reported that they replaced the program thermostat with a new thermostat, ask H5b]

H5b. What brand of thermostat did you install?

Response	All Respondents	Brand (old)			Year	
		ECOBEE	NEST	Other	2017	2018
HONEYWELL (New)	6 60.0%	0 0%	5 62.5%	1 50.0%%	3 75.0%	3 50.0%
Nest (New)	0	0	0	0	0	0

Response	All Respondents	Brand (old)			Year	
		ECOBEE	NEST	Other	2017	2018
	0%	0%	0%	0%	0%	0%
Ecobee (New)	1 10.0%	0 0%	1 12.5%	0 0%	0 0%	1 16.7%
LUX (New)	1 10.0%	0 0%	1 12.5%	0 0%	0 0%	1 16.7%
LENNOX (New)	1 10.0%	0 0%	0 0%	1 50.0%	1 25.0%	0 0%
AMERICAN STANDARD (New)	1 10.0%	0 0%	1 12.5%	0 0%	0 0%	1 16.7%
Total	**10**	**0**	**8**	**2**	**4**	**6**

Note: This question was only asked of respondents who did not move or sell the home that had the thermostat installed and who report that they installed a new thermostat instead of the program's thermostat in H2 and H5a.

[If participants reported that they replaced the program thermostat with a thermostat other than NEST and ECOBEE, ask H5c]

H5c. What type of thermostat did you install?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Smart	5 55.6%	0 0%	4 57.1%	1 50.0%	4 [B] 100%	1 20.0%
Programmable	3 33.3%	0 0%	3 [A] 42.9%	0 0%	0 0%	3 [B] 60.0%
Other	1 11.1%	0 0%	0 0%	1 50.0%	0 0%	1 20.0%
Standard/ Manual	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Total	**9**	**0**	**7**	**2**	**4**	**4**

[A] Results are statistically significant at the 90% level for Brand Type.
[B] Results are statistically significant at the 90% level for Participation Year.
Note: This question was only asked of respondents who report that they installed a new thermostat other than a NEST or ECOBEE brand in H5b.

[If participants reported that the program thermostat is currently installed, ask H6 and H7]

H6. Is the thermostat currently connected to the internet?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	615 97.9%	92 98.9%	490 98.2%	33 [A] 91.7%	239 98.0%	376 97.9%
No	13 2.1%	1 1.1%	9 1.8%	3 [A] 8.3%	5 2.0%	8 2.1%
Total	**628**	**93**	**499**	**36**	**244**	**384**

[A] Results are statistically significant at the 90% level for Brand Type.
Note: This question was only asked of respondents who report that the program thermostat is currently installed in the home in H5.

H7. Since installing the smart thermostat, has there been a change in the number of people who live in your household on a full-time basis? (For example: If someone moved in to the home and stayed for some time, we would consider this an increase in household occupancy, even if the person moved out again in the same year.)

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes, an increase in occupancy	65 10.4%	7 7.5%	55 11.1%	3 7.9%	28 11.5%	37 9.6%
Yes, a decrease in occupancy	22 3.5%	5 5.4%	16 3.2%	1 2.6%	11 4.5%	11 2.9%
No Change	541 86.2%	81 87.1%	426 85.7%	34 89.5%	205 84.0%	336 87.5%
Total	**628**	**93**	**497**	**38**	**244**	**384**

Note: This question was only asked of respondents who report that the program thermostat is currently installed in the home in H5.

H8. What type of cooling equipment do you have in your home? Please select all that apply if more than one. **[Multiple Response]**

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Electric fan	202 30.4%	34 [A] 35.8%	161 30.3%	7 17.9%	83 31.1%	119 29.9%
Central air conditioner (Provides cooling only – heating is provided by separate equipment)	196 29.5%	32 33.7%	148 27.9%	16 [A] 41.0%	73 27.3%	123 30.9%
No cooling equipment	167 25.1%	23 24.2%	134 25.2%	10 25.6%	66 24.7%	101 25.4%

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Window air conditioner (Placed inside a window frame)	104 15.6%	12 12.6%	87 16.4%	5 12.8%	48 18.0%	56 14.1%
Heat pump (A central unit that can provide cooling and heating)	83 12.5%	11 11.6%	65 12.2%	7 17.9%	34 12.7%	49 12.3%
Mini-split, ductless heat pump (Heats and cools specific rooms, typically wall mounted)	11 1.7%	1 1.1%	9 1.7%	1 2.6%	4 1.5%	7 1.8%
Don't Know	3 0.5%	0 0%	2 0.4%	1 [A] 2.6%	1 0.4%	2 0.5%
Total	**766** **115.3%**	**79** **119.0%**	**606** **114.1%**	**47** **120.4%**	**309** **115.7%**	**457** **114.9%**

[A] Results are statistically significant at the 90% level for Brand Type.
Note: This is a multiple response question so the number of responses may exceed the number of respondents and the percentage total may be greater than 100%.

H9. What type of heating equipment do you have in your home? Please select all that apply if more than one. **[Multiple Response]**

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Furnace (Provides heating only – cooling is provided by separate equipment)	597 89.8%	90 94.7%	476 89.6%	31 [A] 79.5%	242 90.6%	355 89.2%
Gas fireplace	182 27.4%	32 [A] 33.7%	144 27.1%	6 15.4%	73 27.3%	109 27.4%
Heat pump (A central unit that can provide cooling and heating)	72 10.8%	9 9.5%	55 10.4%	8 [A] 20.5%	28 10.5%	44 11.1%
Portable electric heater	72 10.8%	9 9.5%	56 10.5%	7 17.9%	25 9.4%	47 11.8%
Baseboard heating	24 3.6%	2 2.1%	20 3.8%	2 5.1%	10 3.7%	14 3.5%
Wood fire stove	31 4.7%	2 2.1%	29 5.5%	0 0%	11 4.1%	20 5.0%
Other	19 2.9%	3 3.1%	15 2.8%	1 2.6%	10 3.7%	9 2.3%

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Mini-split, ductless heat pump (Heats and cools specific rooms, typically wall mounted)	8 1.2%	1 1.1%	6 1.1%	1 2.5%	3 1.1%	5 1.3%
Don't Know	1 0.2%	0 0%	1 0.2%	0 0%	0 0%	1 0.3%
No heating equipment	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Total	**1006** **151.4%**	**116** **155.8%**	**802** **151.0%**	**146** **143.5%**	**402** **150.4%**	**604** **151.9%**

[A] Results are statistically significant at the 90% level for Brand Type.
Note: This is a multiple response question so the number of responses may exceed the number of respondents and the percentage total may be greater than 100%.

H10. Have you made any of the following changes to your home at the same time or after you installed the smart thermostat? Please select all that apply. **[Multiple Response]**

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
None of the above	404 60.8%	51 53.7%	333 [A] 62.7%	20 51.3%	159 59.6%	245 61.6%
Purchased new major appliances (for example refrigerators, freezers, washer/dryer, dishwashers)	119 17.9%	15 15.8%	101 [A] 19.0%	3 7.7%	54 20.2%	65 16.3%
Made changes to your heating or cooling system, such as your air conditioner, heat pump, or furnace	102 15.3%	22 23.2%	65 [A] 12.2%	15 [A] 38.5%	46 17.2%	56 14.1%
Replaced, added, or repaired insulation in your home	52 7.8%	6 6.3%	41 7.7%	5 12.8%	18 6.7%	34 8.5%
Purchased an electric vehicle	42 6.3%	8 8.4%	33 6.2%	1 2.6%	21 7.9%	21 5.3%
Completed major construction on your home's building shell, such as replacing the roof, the flooring, or walls	26 3.9%	3 3.2%	21 4.0%	2 5.1%	11 4.1%	15 3.8%
Replaced, added, or repaired ductwork in your home	24 3.6%	3 3.2%	18 3.4%	3 7.7%	8 3.0%	16 4.0%

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Installed solar panels	7 1.1%	1 1.1%	6 1.1%	0 0%	4 1.5%	3 0.8%
Made additions to your home that increased the overall square footage	4 0.6%	0 0%	3 0.6%	1 2.6%	3 1.1%	1 0.3%
Total	**780** **117.3%**	**109** **114.9%**	**621** **116.9%**	**50** **128.3%**	**324** **121.3%**	**456** **114.7%**

[A] Results are statistically significant at the 90% level for Brand Type.
Note: This is a multiple response question so the number of responses may exceed the number of respondents and the percentage total may be greater than 100%.

[If participants reported making changes to their heating or cooling system, ask H11]

H11. Which of the following changes did you make to your heating or cooling system? Please select all that apply. **[Multiple Response]**

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Installed a new heating system	63 61.8%	12 54.5%	42 64.6%	9 60.0%	30 65.2%	33 58.9%
Installed a new cooling system	60 58.8%	15 68.2%	34 52.3%	11 73.3%	24 52.2%	36 64.3%
None of the above	9 8.8%	2 9.1%	7 10.8%	0 0%	4 8.7%	5 8.9%
Removed heating system, but did not replace it	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Removed cooling system, but did not replace it	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Total	**132** **129.4%**	**29** **131.8%**	**83** **127.7%**	**20** **133.3%**	**58** **126.1%**	**74** **132.1%**

Note: This question was only asked of respondents who report that they made changes to their heating of cooling system in H10.
Note: This is a multiple response question so the number of responses may exceed the number of respondents and the percentage total may be greater than 100%.

[If participants reported installing a new heating system, ask H12]

H12. When you installed your new heating system, what did you replace? If nothing, select "I did not have a heating system before".

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Furnace (Provides heating only – cooling is provided by separate equipment)	57 90.5%	11 91.6%	40 [A] 95.2%	6 66.7%	29 96.7%	28 84.8%
Heat pump (A central unit that can provide cooling and heating)	3 4.8%	0 0%	0 0%	3 [A] 33.3%	0 0%	3 [B] 9.1%
I did not have a heating system before.	2 3.2%	1 8.3%	1 2.4%	0 0%	1 3.3%	1 3.0%
Wood fire stove	1 1.6%	0 0%	1 2.4%	0 0%	0 0%	1 3.0%
Mini-split, ductless heat pump (Heats and cools specific rooms, typically wall mounted)	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Portable electric space heater	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Baseboard heating (Heats specific rooms, installed in the baseboard or lower part of the wall)	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Gas fireplace	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Purchased new major appliances (for example refrigerators, freezers, washer/dryer, dishwashers)	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Total	**63**	**12**	**42**	**9**	**30**	**33**

[A] Results are statistically significant at the 90% level for Brand Type.
[B] Results are statistically significant at the 90% level for Participation Year.
Note: This question was only asked of respondents who said they installed a new heating system in H11.

[If participants reported installing a new cooling system, ask H13]

H13. When you installed your new cooling system, what did you replace? If nothing, select "I did not have a cooling system before".

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
I did not have a cooling system before.	38 63.3%	9 60.0%	20 58.8%	9 81.8%	15 62.5%	23 63.9%
Central air conditioner (Provides cooling only – heating is provided by separate equipment such as a furnace, boiler, or other space heaters.)	15 25.0%	5 33.3%	9 26.5%	1 9.1%	6 25.0%	9 25.0%
Heat pump (A central unit that can provide cooling and heating)	5 8.3%	1 6.7%	3 8.8%	1 9.2%	1 4.2%	4 11.1%
Mini-split, ductless heat pump (Heats and cools specific rooms, typically wall mounted)	1 1.7%	0 0%	1 2.9%	0 0%	1 4.2%	0 0%
Window air conditioner (Placed inside a window frame)	1 1.7%	0 0%	1 2.8%	0 0%	1 4.2%	0 0%
Electric fan	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Total	**60**	**15**	**34**	**11**	**24**	**36**

Note: This question was only asked of respondents who said they installed a new cooling system in H11.

Device Engagement and Satisfaction

Note: This survey questions in this section skipped 44 respondents who removed their smart thermostat or no longer live at the property where the thermostat was installed. The total number of respondents for these questions was 621 unless otherwise noted.

P13a. First, think about your usage in the cold season, excluding vacations or other multi-day absences. How did you use your heating system during this winter?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Turned the system on when it got cold outside and kept the system turned on throughout the winter, adjusting the temperature as needed	414 66.7%	60 64.5%	334 67.9%	20 55.6%	156 64.7%	258 67.9%
Turned the system on and off depending on the weather and/or occupancy	207 33.3%	33 35.5%	158 32.1%	16 44.4%	85 35.3%	122 32.1%
Total	**621**	**93**	**492**	**36**	**241**	**380**

E1. Thinking about the cold season, how often do you do the following things with the thermostat? Please select the answer that best fits your usual behavior.

a. Adjust the thermostat's programmed schedule

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Once a day or more	21 3.4%	3 3.2%	16 3.3%	2 5.6%	6 2.5%	15 3.9%
Once to a few times a week	84 13.5%	8 8.6%	70 14.2%	6 16.7%	23 9.5%	61 16.1%
Several times a month	73 11.8%	12 12.9%	58 11.8%	3 8.3%	27 11.2%	46 12.1%
Several times over the course of the season	295 47.5%	45 48.4%	235 47.8%	15 41.7%	118 49.0%	177 46.6%
Never	148 23.8%	25 26.9%	113 23.0%	10 27.8%	67 [B] 27.8%	81 21.3%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[B] Results are statistically significant at the 90% level for Participation Year.

b. Manually override temperature setting

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Once a day or more	51 8.2%	6 6.5%	43 8.7%	2 5.6%	18 7.5%	33 8.7%
Once to a few times a week	202 32.5%	25 [A] 26.9%	161 32.7%	16 44.4%	76 31.5%	126 33.2%
Several times a month	150 24.2%	23 24.7%	118 24.0%	9 25.0%	57 23.7%	93 24.5%
Several times over the course of the season	180 29.0%	30 32.3%	143 29.1%	7 19.4%	72 29.9%	108 28.4%
Never	38 6.1%	9 9.7%	27 5.5%	2 5.6%	18 7.5%	20 5.3%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

c. View the thermostat's settings remotely via web portal or mobile app

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Once a day or more	86	8	75 [A]	3	28	58

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
	13.9%	8.6%	15.2%	8.3%	11.6%	15.3%
Once to a few times a week	188 30.3%	27 29.0%	148 30.1%	13 36.1%	76 31.5%	112 29.5%
Several times a month	131 21.1%	24 25.8%	101 20.5%	6 16.7%	54 22.4%	77 20.3%
Several times over the course of the season	163 26.3%	29 31.2%	128 26.0%	6 [A] 16.7%	60 24.9%	103 27.1%
Never	53 8.5%	5 5.4%	40 8.1%	8 [A] 22.2%	23 9.5%	30 7.9%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

d. View energy usage reports

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Once a day or more	12 1.9%	4 [A] 4.3%	8 1.6%	0 0%	5 2.1%	7 1.8%
Once to a few times a week	63 10.1%	6 6.5%	55 11.2%	2 5.6%	23 9.5%	40 10.5%
Several times a month	127 20.5%	11 11.8%	112 [A] 22.8%	4 11.1%	43 17.8%	84 22.1%
Several times over the course of the season	302 48.6%	37 39.8%	253 [A] 51.4%	12 33.3%	128 53.1%	174 45.8%
Never	108 17.4%	30 32.3%	63 [A] 12.8%	15 41.7%	40 16.6%	68 17.9%
My thermostat doesn't have this option	9 1.5%	5 5.4%	1 [A] 0.2%	3 8.3%	2 0.8%	7 1.8%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

[If participants reported receiving a NEST thermostat that is still reportedly installed, ask E1e]

e. Adjust temperature settings to see the green Leaf. (Nest users)

Response	All Respondents	Brand	Year	
		NEST	2017	2018
Once a day or more	54 11.0%	54 11.0%	24 12.2%	30 10.2%
Once to a few times a week	120 24.4%	120 24.4%	39 19.8%	81 27.5%
Several times a month	93 18.9%	93 18.9%	34 17.3%	59 20%
Several times over the course of the season	132 26.8%	132 26.8%	53 26.9%	79 26.8%
Never	91 18.5%	91 18.5%	45 [B] 22.8%	46 15.6%
My thermostat doesn't have this option	2 0.4%	2 0.4%	2 [B] 1.0%	0 0%
Total	**492**	**492**	**197**	**295**

[B] Results are statistically significant at the 90% level for Participation Year.
Note: This question was only asked of NEST recipients who report that the program thermostat is currently installed and those who currently live in the home in H1 and H5.

[If participants reported adjusting the programmed schedule or manually overriding setting at least once a day, ask E2]

E2. When making daily adjustments to your cooling system, what factors influence these changes? **[Multiple Response]**

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Adults or children home during the day	47 81.0%	6 85.7%	39 81.3%	2 66.7%	17 85.0%	30 78.9%
Pets home during the day	6 10.3%	0 0%	6 12.5%	0 0%	2 10.0%	4 10.5%
Total	**53 91.3%**	**6 85.7%**	**45 93.8%**	**2 66.7%**	**19 95.0%**	**34 89.4%**

Note: This question was only asked of respondents who report that they adjust the thermostat's programmed schedule or manually override temperature setting once a day in E1a or E1b.
Note: This is a multiple response question so the number of responses may be different from the number of respondents and the percentage total may be greater than or less than 100%.

P17. And in general, when selecting temperature settings on your thermostat, what did you mainly base your decisions on?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Both comfort and energy use equally	337 54.3%	49 52.7%	268 54.5%	20 55.6%	129 53.5%	208 54.7%
Comfort	239 38.5%	40 43.0%	188 38.2%	11 30.6%	97 40.2%	142 37.4%
Energy use	43 6.9%	4 4.3%	35 7.1%	4 11.1%	15 6.2%	28 7.4%
Not Sure	1 0.2%	0 0%	0 0%	1 [A] 2.8%	0 0%	1 0.3%
Other	1 0.2%	0 0%	1 0.2%	0 0%	0 0%	1 0.3%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

P13b. What did you do with your thermostat when you were away for vacations or multi-day absences?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
I set the thermostat to "away" or "vacation" mode	367 59.1%	59 63.4%	300 61.0%	8 [A] 22.2%	150 62.2%	217 57.1%
I set the thermostat to a higher/lower temperature depending on the season so it wouldn't run as much	136 21.9%	21 22.6%	95 19.3%	20 [A] 55.6%	49 20.3%	87 22.9%
I turned off the air conditioning system	41 6.6%	5 5.4%	31 6.3%	5 [A] 13.9%	15 6.2%	26 6.8%
I left the thermostat on its usual settings	39 6.28%	6 6.5%	31 6.3%	2 5.6%	16 6.6%	23 6.1%
Not Applicable	33 5.3%	2 2.2%	30 6.1%	1 2.8%	7 2.9%	26 [B] 6.8%
Not Sure	5 0.8%	0 0%	5 1.0%	0 0%	4 [B] 1.7%	1 0.3%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.
[B] Results are statistically significant at the 90% level for Participation Year.

E3a. Have you downloaded the smart phone app for the thermostat?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	601 96.8%	92 98.9%	479 97.4%	30 [A] 83.3%	235 97.5%	366 96.3%
No	20 3.2%	1 1.1%	13 2.6%	6 [A] 16.7%	6 2.5%	14 3.7%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

[If participants reported downloading the smartphone app, ask E3b]

E3b. Does the smart phone app give you the option to allow the thermostat to track your location so it can detect when you are away? This is called "geofencing".

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	437 72.7%	59 64.1%	366 [A] 76.4%	12 [A] 40.0%	173 73.6%	264 72.1%
No	72 12.0%	19 20.7%	44 [A] 9.2%	9 [A] 30.0%	29 12.3%	43 11.7%
Unsure	92 15.3%	14 15.2%	69 14.4%	9 30.0%	33 14.0%	59 16.1%
Total	**601**	**92**	**479**	**30**	**235**	**366**

[A] Results are statistically significant at the 90% level for Brand Type.
Note: This question was only asked of respondents who report downloading the smart phone app in E3a.

[If participants reported having the option of geofencing, ask E3c]

E3c. Is the geofencing feature enabled? This allows the thermostat to track your location so it can detect when you are away.

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	307 70.2%	28 47.5%	273 [A] 74.6%	6 50.0%	118 68.2%	189 71.6%
No	130 29.8%	31 52.5%	93 [A] 25.4%	6 50.0%	55 31.8%	75 28.4%
Total	**437**	**59**	**366**	**12**	**173**	**264**

[A] Results are statistically significant at the 90% level for Brand Type.
Note: This question was only asked of respondents who report that the app gives the option of "geofencing" in E3b.

E4. Have you installed any temperature sensors that connect to the thermostat? These read the temperature in specific rooms.

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	148 23.8%	75 [A] 80.6%	71 14.4%	2 5.6%	55 22.8%	93 24.5%
No	473 76.2%	18 [A] 19.4%	421 85.6%	34 94.4%	186 77.2%	287 75.5%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

E5. Have you installed any occupancy sensors that connect to the thermostat? These are motion sensors that detect pets or people in your home.

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	116 18.7%	67 [A] 72.0%	47 9.6%	2 5.6%	49 20.3%	67 17.6%
No	505 81.3%	26 [A] 28.0%	445 90.4%	34 94.4%	192 79.7%	313 82.4%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

E7a. Have you connected any "smart speakers" to the thermostat? For example, an Amazon Echo or Google Home Mini?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	231 37.2%	38 [A] 40.9%	184 37.4%	9 25.0%	92 38.2%	139 36.6%
No	390 62.8%	55 59.1%	308 62.6%	27 [A] 75.0%	149 61.8%	241 63.4%
Total	**621**	**93**	**492**	**36**	**241**	**380**

[A] Results are statistically significant at the 90% level for Brand Type.

[If participants reported that the thermostat is connected to smart speakers, ask E7b]

E7b. How often do you use voice commands to control the thermostat through your smart speaker?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Every day (1)	16 6.9%	2 5.3%	13 7.1%	1 11.1%	3 3.3%	13 [B] 9.4%
Often (a few times a week) (2)	29 12.5%	2 5.3%	26 14.1%	1 11.1%	14 15.2%	15 10.8%
Sometimes (a few times a month (3)	63 27.3%	8 21.1%	52 28.3%	3 33.3%	22 23.9%	41 29.5%
Rarely (a few times a year or once per year) (4)	94 40.7%	20 52.6%	71 38.6%	3 33.3%	42 45.7%	52 37.4%
Never (5)	29 12.6%	6 15.8%	22 12.0%	1 11.1%	11 12.0%	18 12.9%
Total/Weighted Mean	**231**	**3.68**	**3.34**	**3.22**	**3.50**	**3.22**

[B] Results are statistically significant at the 90% level for Participation Year.
Note: This question was only asked of respondents who report that they connected smart speakers to the thermostat in E7a.

E8. How satisfied are you with your smart thermostat overall?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Very satisfied (1)	457 73.6%	64 68.8%	368 74.8%	25 69.4%	173 71.8%	284 74.7%
Somewhat satisfied (2)	132 21.3%	27 [A] 29.0%	96 19.5%	9 25.0%	55 22.8%	77 20.3%
Neutral (3)	17 2.7%	1 1.1%	16 3.3%	0 0%	3 1.2%	14 [B] 3.7%
Somewhat dissatisfied (4)	11 1.8%	1 1.1%	8 1.6%	2 [A] 5.6%	7 [B] 2.9%	4 1.1%
Very dissatisfied (5)	4 0.6%	0 0%	4 0.8%	0 0%	3 1.2%	1 0.3%
Total/Weighted Mean	**621**	**1.34**	**1.34**	**1.42**	**1.39**	**1.33**

[A] Results are statistically significant at the 90% level for Brand Type.
[B] Results are statistically significant at the 90% level for Participation Year.

Interest in PSE Offerings

F1. Would you be interested in more information or support from PSE about using your smart thermostat?

Response	All Respondents	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
Yes	264 39.7%	44 46.3%	206 38.8%	14 35.9%	100 37.5%	164 41.2%
No	401 60.3%	51 53.7%	325 61.2%	25 64.1%	167 62.5%	234 58.8%
Total	**665**	**95**	**531**	**39**	**267**	**398**

[If participants reported being interested in more information, ask F2]

F2. PSE is considering a few different ways it could provide customers like you with more information on smart thermostats. Please rank the following options from greatest interest to lowest interest. You may also select "none of these options interest me" at the bottom.

Response	Total	Brand			Year	
		ECOBEE	NEST	Other	2017	2018
a. A website with tips for using smart thermostats	3.37	3.34	3.37	3.45	3.42	3.35
b. A short online video training with a coach who would discuss the optimal thermostat settings for your needs	2.92	2.82	2.95	2.82	2.92	2.93
c. A free in-person Home Energy Assessment that includes a discussion of the optimal thermostat settings for your needs	1.96	1.95	1.95	2.18	2.02	1.92
d. A free phone call with a coach who would discuss the optimal thermostat settings for your needs	1.74	1.89	1.72	1.55	1.64	1.80
e. None of these options interest me	38 14.4%	6 13.6%	29 14.1%	3 21.4%	16 16.0%	22 13.4%

* Values are the weighted means of ranked order except for row e (which is count and percentage). Values are [1,4] with 1 being ranked of least interest to 4 being of most interest.
Note: This question was only asked of respondents who report that they would be interested in more information or support from PSE in F1.

For more information, please contact:

Alan Elliott
Principal Consultant

510-444-5050 tel
510-444-5222 Fax
aelliott@optiondynamics.com

1 Kaiser Plaza, Suite 445
Oakland, CA 94612

Evaluation Report Response

Program: Web-Enabled Thermostats Program

Program Manager: Holly Mulvenon

Study Report Name: Puget Sound Energy 2017-18 Web-Enabled Thermostats Program Impact and Process Evaluation Report

Report Date: November 2019

Evaluation Analyst: Jim Perich-Anderson

Date Final Report provided to Program Manager: 11/27/2019

Date of Program Manager Response: 12/12/2019

Overview:

This report provides the results from an evaluation of the Puget Sound Energy (PSE) 2017-2018 Web-Enabled Thermostat (WET) Program. As part of PSE's direct-to-consumer (DTC) offerings, this program provides a $75 rebate to customers that install ENERGY STAR-certified smart thermostats. The program began as a randomized control trial pilot with 2,000 participants in 2013 and has since evolved into a bring your own thermostat program with over 20,000 participants to date.

This evaluation explored both impact and process topics, but these aspects of the evaluation included different subsets of customers based on the timing of evaluation, participation, and the availability of sufficient post-installation consumption data to quantify energy savings. The process evaluation targets 2017 - 2018 program operations and design via secondary reviews of program materials and depth interviews with program staff, while the impact evaluation explores savings amongst 2017 participants by comparing participant's full year of 2018 energy consumption to pre-installation consumption. Finally, the evaluation included a survey of participants to contextualize consumption analysis results and provide insights into smart thermostat engagement behavior.

Table 1 summarizes the key performance indicators (KPIs) used to assess overall program performance. As shown in the "overall program health" column, the evaluation results determined that the program is well-designed to capture significant participation and is implemented in a fashion that satisfies PSE's customers. However, consumption analysis of the annual energy savings fell below PSE's planned savings expectations.

- Our analysis found statistically significant gas savings of 21 therms, or 2.9% of annual household energy consumption, and the average therm savings per participant was a little more than half of what PSE expected. While savings are lower than anticipated, the savings are substantive and consistent with gas savings found in the Pacific Northwest or other similar climates from smart thermostats.
- For electric savings, the consumption analysis did not detect significant annual savings. PSE should continue to explore the electric savings potential from smart thermostats; more research is needed to move beyond exploring the average savings and dig deeper into the savings at the individual household level. As a result, we suggest gaining a better understanding of which customers are realizing electric savings and what is driving those savings to help PSE design targeting and incentive strategies that garner electric savings from smart thermostats.

Table 22. WET Program Performance Summary

KPI	Definition	KPI Status	Overall Program Health	KPI Data Source
Gas savings	Therm savings per participant with gas heating	Annual gas savings per participant were 2.9%, or 21 therms, which aligns with what the evaluation team has observed across multiple smart thermostat studies. This estimate was 58% of the PSE's deemed savings assumption.		Consumption analysis
Electric savings	kWh savings per participant with electric heating	The evaluation team did not detect statistically significant annual electric savings.		Consumption analysis
Participation	Number of thermostats rebated through the program	The WET program rebated 23,995 smart thermostats in 2017 and 2018. The program attracted enough participation to scale from a pilot to a full program.		Program tracking data
Customer Satisfaction	Average score on a 1 to 5 scale	4.7 out of 5 average satisfaction amongst 2017-2018 participants (n=665).		Participant survey

3.4 Energy Savings Conclusions and Recommendations

The evaluation team estimated the average gas and electric savings per participant using a pooled consumption analysis of pre and post usage with a matched comparison group. Some WET participants also installed other energy efficiency measures via other PSE program incentives in the pre and post time period. Therefore, the evaluation conducted an additional channeling analysis to further isolate smart thermostat savings from these other measures. The results of these two analyses are summarized below.

3.4.1 Gas Savings

Table 2 provides the results of four models that the evaluation team used to quantify gas savings amongst participants who use gas for heating. The first model shows that participants, on average, saved 21 therms, or approximately 2.9% of average annual gas consumption. To help isolate WET program savings, the final model

uses a comparison group and excludes any participants or comparison group customers who participated in another PSE program after WET.

We ran three additional exploratory models. Juxtaposing the final model (with a comparison group) to the model without the comparison group helps see how changes in exogenous factors (i.e., not related to the program, such as the macroeconomic changes), aspects of weather not captured by the model (e.g., humidity), and market forces (e.g., the natural rate of smart thermostat or EE technology uptake in the market) impact the energy usage baseline. In the case of gas savings, savings did not change substantially by adding a comparison group to the model. The evaluation team also explored heating season savings and customers saved slightly more gas in the heating season (3.2%) than annually (2.9%) when including the matched comparison group. Further, there does not appear to be much overlap in gas savings between smart thermostats and other program measures; after removing cross-program participation, savings dropped slightly from 3.0% to 2.9%. The 0.1% of savings captured in other programs is largely from 8% of participants who installed showerheads in addition to a smart thermostat.

Table 23. WET Program Gas Savings Per Participant – Summary

Model Type	Participants in Model	Average Daily Therm Savings	Average Total Therm Savings	Average Percent Savings	Statistically Significant at 90% Confidence Level
Annual with Comparison Group (Final Model)	4,255	0.06	21	2.9%	Yes
Annual without Comparison Group (Exploratory Model)	4,255	0.06	21	2.8%	Yes
Heating Season with Comparison Group (Exploratory Model)	4, 255	0.11	16	3.2%	Yes
Annual with Comparison Group, before Removing Other Program Participants (Exploratory Model)	6, 765	0.06	22	3.0%	Yes

This level of gas savings is convergent with WET's prior pilot evaluation results and is within the range of what similar offerings have achieved in the Pacific Northwest or similar climate zones. Table 3 provides a comparison of the average therm savings achieved by several gas heating thermostat programs. We drew these comparisons from literature reviews sponsored by the Regional Technical Forum (RTF)[10] and Bonneville Power Authority (BPA)[11]. Overall, these results show that the range of gas savings is extremely wide, and that PSE's program is well within expectations for the region.

Table 24. Comparison of Evaluation Results with Similar Gas Heat Thermostat Programs

Sponsor	Thermostat(s)	Average Therms per Participant	Source

[10] Ryan Firestone. September 2016. *Connected Thermostats Devices (and Services?)*. Prepared for the RTF.
[11] Research into Action. October 2018. *Smart Thermostat Market Characterization to Inform Market Modeling*. Prepared for BPA.

Energy Trust of Oregon	Honeywell Lyrics	*negative* 29 therms (increased usage)	RTF Study
Pacific Gas and Electric	Unspecified	0 - 17 therms depending on vendor	BPA Study
PSE (WET pilot)	Honeywell	17 therms	Previous evaluation
PSE	Honeywell Vision Pro 8000	17 therms	RTF Study
PSE (WET program)	Any ENERGY STAR-certified	21 therms	This evaluation
Energy Trust of Oregon	Nest	34 therms	RTF Study

However, the evaluated savings are approximately 58% of PSE's updated[12] deemed savings value of 36 therms per participant. PSE's deemed values and the evaluation team's models both assumed similar baselines of annual gas consumption. However, PSE's percentage savings were based on an Energy Trust of Oregon study that calculated percent savings of heating load consumption, while the evaluated savings are a percent savings of household consumption. A heating load savings percentage is typically greater than a household savings percentage because it does not account for other household factors that may impact thermostat savings.

3.4.2 Electric Savings

This is the first time that PSE is evaluating electric savings for the program, as the last evaluation was of the initial gas heating pilot. Table 4 provides the results of four models that explore the electric savings from participants that use electricity for heating. The evaluation team detected 0.3% (or 30 kWh) in annual electric savings, but it was not statistically significant at the 90% confidence level. However, we did find a statistically significant electric savings (0.8%, or 48 kWh) in the heating season. Therefore, when looking at the average savings across participants, customers are saving a bit in the heating system with the smart thermostat but that savings is eclipsed by their electric usage throughout a full year, suggesting that cooling equipment or other electric appliances are offsetting the seasonal savings.

Interestingly, the electric model without a comparison group detected more savings than the model with a comparison group, while the gas model in contrast did not change much after adding a comparison group. One of the key drivers of this difference is the number of participants in the electric model, about 700 in the electric model versus over 4,000 in the gas model, driven by the fact that the program evolved from a gas heating pilot and has mostly served gas heating customers as a program. Just over one-in-seven participants (or 16%) had electric heat in 2017 according to program tracking data. Models with fewer participants tend to have larger measurement error and as such benefit more from adding a comparison group. Further, there are a wide variety of electric end uses outside of heating systems (while gas has fewer in comparison) and electric usage tends to be more variable over time. Considering these factors, adding a comparison group not only controlled for exogenous factors, but helped correct for measurement error due to small sample size and controlled for the natural variation in electric usage.

In contrast to the gas savings analysis, there does appear to be substantial overlap in electric savings between smart thermostats and other program measures; after removing cross-program participation, savings dropped

[12] PSE updated their 2017-2018 gas deemed saving value during the 2017-2018 biennium. The original per participant gas savings value was 17 therms, based on the evaluation of the initial pilot.

from 1.4% to 0.3%. The savings captured in other programs is largely from 20% of participants who installed energy efficient lighting in addition to smart thermostats.

Table 25. WET Program Electric Savings Per Participant - Summary

Model Type	Participants in Model	Average Daily kWh Savings	Average Total kWh Savings	Average Percent Savings	Statistically Significant at 90% Confidence Level
Annual with Comparison Group (Final Model)	734	0.08	30	0.3%	No
Annual without Comparison Group (Exploratory Model)	734	0.30	109	0.9%	Yes
Heating Season with Comparison Group (Exploratory Model)	734	0.32	48	0.8%	Yes
Annual with Comparison Group, before Removing Other Program Participants (Exploratory Model)	1,111	0.46	167	1.4%	Yes

PSE expected to achieve on average 899 kWh per participant, and more research is needed to understand whether or not PSE can achieve that level of savings, and what types of customers are likely to provide it. Further, while the consumption analysis detected no annual savings *on average*, it is likely that individual savings varies widely amongst participants, based on their household characteristics, location, baseline electric usage, behavior, and more. Below are several factors we explored that could potentially explain the electric savings results.

- **Type of thermostat replaced.** Survey results suggest that most 2017 electric heating participants (69%, n=32) replaced programmable thermostats, as opposed to manual thermostats. This suggests there is likely less potential for savings by upgrading to "smart" technology. Notably, compared to the recent Pacific Northwest Residential Building Stock Assessment[13], there is a much higher incidence of WET participants that owned programmable thermostats than we would expect compared to the broader Washington market. According to the Stock Assessment, the market consists of 47% of consumers who have programmable thermostats (46% have manual thermostats and 7% have smart thermostats).
- **Heating equipment type.** Nearly half of electric heating survey respondents (44%) used heat pumps for cooling, and about a third (34%) used it for heating. Very few (6%) of respondents made changes to their heating or cooling system post-WET, so we can infer that heat pumps were common in the baseline. Heat pumps are a very efficient technology, meaning that HVAC energy usage for these customers was already low before installing a smart thermostat, limiting the potential for savings.

[13] Northwest Energy Efficiency Alliance. 2017. *Residential Building Stock Assessment II. Single-Family Homes Report 2016-2017.*

- **Cooling equipment type.** Nearly a quarter (22%) of electric heating survey respondents used no cooling equipment or electric fans. This is another possible source of low annual baseline electric usage, and partially explains why there is savings in the heating season but not the cooling season.
- **Engagement behavior.** The way participants use their smart thermostat can impact energy savings. For instance, tinkering with settings or installing additional sensors could have an impact on savings potential. We were able to explore which self-reported behaviors were correlated with energy savings for gas heating participants who responded to the survey, but the limited number of electric heating customers in the model *and* the survey prevented a similar analysis for electric heating.
- **Other Changes in the Home.** The survey also uncovered evidence of several conflating factors that may impact energy savings estimates, including electric vehicles and renewables purchases. Over a quarter (27%) of electric-heating respondents experienced occupancy changes. After participating in WET, 13% purchased new major appliances like refrigerators, freezers or washer/dryers, 6% purchasing electric vehicles, 6% changed their heating and cooling system, and 3% installed solar. The evaluation team took standard steps to limit the impact of these additional actions on savings estimates. Specifically, the use of a comparison group and the removal of any participants with records of participating in other programs post-WET installation helped to isolate WET savings.
- **Renting.** About one in five (19%) of electric heating survey respondents did not live (or no longer live) at the property where they installed the thermostat. Most of these respondents still owned the home and rent it out. Split incentives in rental situations are a well-documented issue in the energy efficiency industry. For instance, renters may pay a flat fee for utilities, so they have no incentive to lower their landlord's energy bill. Further, it could be that the renters moved in after the thermostat was installed and don't know the thermostat is "smart".
- **Climate**. PSE being a winter-peaking utility may also be a factor that limits electric savings potential from smart thermostats. From this evaluation specifically, we saw that there are heating season savings for electric heat customers, which can shave winter peak demand, but the electric usage in other seasons for lighting or cooling is offsetting the electric heating season savings.
- **Thermostat Technology and Program Design.** In the Pacific Northwest market, the programs that have achieved savings in line with PSE's expectations were designed differently than the WET program's BYOT model. They specifically targeted air source heat pumps and the thermostats offered advanced heat pump controls.[14]
- **Thermostat vendor.** It is also possible that savings vary depending on the device (i.e., Nest, Ecobee, and Honeywell thermostats may have different savings potential), but there were not enough non-Nest thermostats in the current program to quantify statistically significant savings by device.

The evaluation team concluded that more analysis and research is needed to better understand the electric savings potential for smart thermostats in PSE's region and the characteristics associated with savings so PSE can target the program to yield greater electric savings.

[14] Ryan Firestone. September 2016. *Connected Thermostats Devices (and Services?)*. Prepared for the RTF.


PSE
PUGET SOUND ENERGY

PUGET SOUND ENERGY

Evaluation Recommendations and Program Responses

Gas Savings

Recommendation:

- We recommend that **PSE update the deemed savings assumption for gas heating customers** to 21 therms per participant.

WET Program Response:

- PSE will take ODC's findings and suggestions into account when determining measure savings values for 2020. PSE received the evaluation after their internal September 1 cut date for updating measures.

Recommendation:

- We recommend that PSE **apply the 21 therms savings estimate to each thermostat** in the tracking data.

WET Program Response:

- PSE does not retroactively adjust savings values for measures.

Electric Savings

Recommendation:

- We recommend that **PSE continue to use the latest approved RTF electric deemed savings values** until further research can better explore the level of savings from PSE's program specifically.

WET Program Response:

- PSE agrees. The latest RTF workbook were used to calculate electric savings for the measure in 2019.

Recommendation:

- We recommend that PSE **conduct additional research with an expanded participant pool and consumption data** to understand the range of savings and types of electric heating customers who benefit the most from installing thermostats. Options include:

- **Expand energy savings analysis efforts to include 2018 participants, and ideally some early 2019 participants**. The evaluation team was unable to include these participant groups given the timing of the evaluation. By spring 2020, PSE should have access to one year of post-participation consumption data for all 2018 participants, and potentially some of the early 2019 participants.

- **Use multi-level modeling to generate pooled *and* individual savings estimates and correlate savings with existing customer data sources**. This will allow PSE to group participants by savings level (i.e., very positive, positive, neutral, negative, very negative) and run a variety of descriptive statistics based on PSE data fields and secondary data sources such as Census or Experian (e.g., program year, device type, housing type) to identify trends associated with savings levels.

- **Correlate savings further with data collected via survey efforts.** The amount of 2017 electric heating customers and survey responses in this evaluation were too small to draw meaningful conclusions on the range of savings at the household level and correlate that variation with survey data. While the evaluation team conducted a preliminary correlation analysis with gas model participants (see the next section), this was limited to 2017 gas heating participants due to sample constraints. As such, PSE should **consider fielding the survey to more 2018 electric heating customers** to allow for correlation with electric savings at the household level.

WET Program Response:

- PSE is open to providing an evaluator with 2018 and 2019 program rebate data to further analyze savings for the program, as well as different modeling strategies for comparisons and sending the original program evaluation survey to 2018 and 2019 customers to gather more behavioral data.

Recommendation:

- We recommend that PSE conduct the same research for gas customers as well, to better understand how to maximize the potential for gas savings.

WET Program Response:

- PSE is open to using the recommended evaluation approach for gas saving analysis as well.

Recommendation – Thermostat Engagement:

- We recommend using marketing collateral or other educational resources (e.g., webinars) to **educate customers on the benefits of "setting and forgetting" smart thermostats**. The participant survey specifically found that 93% of respondents adjusted thermostat settings manually for comfort, while 61% considered energy usage. Providing education on how smart thermostats use pre-cooling/pre-heating and other features to manage comfort while optimizing energy efficiency may be helpful in avoiding unnecessary manual overrides.

WET Program Response:

- PSE plans to incorporate "set it and forget it" themed messaging into their 2020 program marketing.

PUGET SOUND ENERGY

Recommendation – Thermostat Engagement:

- We recommend delivering this information via **short videos or links to online resources on the PSE website**. According to the participant survey, almost half of the participants (40%) reported interest in more information. These customers **typically preferred to receive information from the PSE website,** rather than in-person coaching or a phone call.

WET Program Response:

- PSE will take ODC's suggestions into consideration when delivering engaging materials and other marketing tools to help educate customers about their smart thermostats.

Recommendation – Design and Implementation:

- We do not recommend a program design change at this time. However, in the next biennium as PSE waits for additional analysis into savings they should continue to shift away from seeing smart thermostats as a "plug and play" measure that can save energy for all customers. As discussed above, it is possible that the lack of electric savings found so far is due to a combination of factors such as customer behavior, household characteristics, heating and cooling system characteristics, baseline usage, or the smart thermostat technology itself. The "bring your own thermostat" model currently employed by the program does not easily allow PSE to target certain participant types, beyond potentially offering tiers of incentives or using targeted marketing strategies. More research is needed to determine the right strategies and types of participants to target, and if a change in design is necessary to support a cost-effective program.

WET Program Response:

- PSE is in the process of testing different strategies to effectively market smart thermostats to customers. In addition to retail, there is an active pilot for a manufactured homes assisted install program, and plans to expand to direct installation.

<END>