SMART THERMOSTAT PROGRAM

Final Report
2022-2023 Impact and Process Evaluation

Puget Sound Energy

Date: February 15, 2024

Table of Contents

List of Figures

List of Tables

Primary Contact
David Avenick, Senior Consultant, Markets and Risk
DNV Energy
David.Avenick@dnv.com

Project Sponsor
Geoff Barker, Senior Consultant, Markets and Risk
DNV Energy
Geoff.Barker@dnv.com

PSE Contract Manager
Jesse Durst, Senior Market Analyst, Energy Efficiency Services
Puget Sound Energy
Jesse.Durst@pse.com

1 EXECUTIVE SUMMARY

This report summarizes the results of the impact and process evaluations of Puget Sound Energy's (PSE) 2021 and 2022 Smart Thermostat program.

1.1 Program Description

PSE's Smart Thermostat program provides incentives to encourage all electric, gas, or combined fuel customers to install ENERGY STAR® certified thermostats or PSE qualified line voltage connected thermostats (LVCT). Wi-Fi enabled smart thermostats work with existing heating systems to help customer monitor and control the temperature of their homes from anywhere via a mobile app. Rebates are offered either post-purchase with an online application or through instant rebates via PSE's online Marketplace platform. For the 2022 program, instant rebates were also offered through contractors. The program is available to all PSE residential electric and gas customer segments, including Named Community members such as customers with low incomes.

1.2 Research Objectives

In this section, we provide a summary of research activities and which primary impact and process research objectives they help address. Research objectives for the impact evaluation include an assessment of energy savings, installation verification, building changes, and behavioral/occupancy changes. DNV conducted a billing analysis to determine energy savings. For measure verification and to identify building and behavioral/occupancy changes, DNV conducted participant surveys.

Research objectives for the process evaluation included participant satisfaction, program awareness, perceived barriers to program participation, and program delivery. To address these objectives, DNV conducted participant surveys and program manager interviews.

1.3 Impact Evaluation Results

DNV conducted an impact evaluation to quantify the achieved savings of the program. We used a billing analysis approach with a matched comparison group to estimate the amount of per-premise savings that occurred because of installing a smart thermostat device. These per-premise values were then scaled up to the total number of participants in the program to arrive at the evaluated savings totals for this program. Our impact evaluation indicates a 0% realization rate for electric savings and a 28% realization rate for gas savings for this program. Table 1-1 shows electric and gas savings in more detail along with the realization rate by fuel type. In this report, results are presented for both thermostat types combined[1].

Table 1-1. Impact evaluation results and realization rates

Fuel Type	Evaluated Savings per Premise	90% CI Low	90% CI High	Number of Claims	Total Evaluated Savings	Total Reported Savings	Realization Rate
Electric (kWh)	-21.7	-128.2	89.7	9,131	0	4,236,212	0%
Gas (therms)	9.2	4.9	13.5	23,734	217,061	787,173	28%

1.4 Process Evaluation Results

We conducted a process evaluation for the purpose of identifying program successes and opportunities for program improvement. Key research questions for the process evaluation focused on recent and planned program changes, sources

[1] The Web Enabled Thermostats program included Smart Thermostats and Line Voltage Connected Thermostats. Tracking data indicated differing deemed savings for each measure, but our analysis showed no statistically significant difference in savings between the two thermostat types.

of program awareness among participating customers, levels of satisfaction among customers, and barriers to program participation.

The research activities that helped inform the process evaluation included the following research activities:

- Program staff interview
- Online survey with program participants

We asked customers who participated in the program how they learned about the program in the online survey. Respondents reported learning about the program most commonly through a PSE email (45%) and on the PSE website (28%). Very few (2%) found out about the program through a contractor.

Respondents to the online survey were asked about their satisfaction with various aspects of the program using a 5-point scale, where 5 means “very satisfied” and 1 means “very dissatisfied.” Eleven distinct aspects were covered with the intent of capturing key steps of the rebate and installation process, from eligibility requirements to energy savings since installing the thermostat. Respondents were also asked about their satisfaction of the program overall. All categories yielded moderate to high average satisfaction scores, ranging from 3.9 to 4.6. Only one aspect (energy savings since installing the thermostat) received an average satisfaction rating less than 4, while the other ten aspects had high average satisfaction ratings from 4.0 to 4.6. This suggests that participants are generally satisfied with most aspects of the program.

DNV asked respondents what they think the primary barrier is to purchasing and installing a smart thermostat. While 21% of respondents said there are no significant barriers, nearly half (49%) said cost was a primary barrier, and 26% said installing the thermostat is the primary barrier. We then asked participants about any secondary barriers to the purchase and installation of smart thermostats. Over half (54%) said installing the thermostat was an additional barrier, 36% said cost, and 17% said finding an installation contractor.

Participants were asked the primary reason they chose to purchase the program-rebated thermostat. Close to half of the respondents (46%) said they had interest in smart thermostats and smart home technology. Reducing their energy bill (14%), increased convenience (14%) and getting an incentive from PSE (13%) were all mentioned as primary reasons for participation.

1.5 Key Findings and Recommendations

Key findings from the Smart Thermostat program impact and process evaluation are as follows:

FINDINGS	The Smart Thermostats program achieved no statistically significant electric savings impact evaluation and realized only 28% of claimed gas savings. These results are consistent with the previous evaluation of PSE's program year 2017-2018 Web-Enabled Thermostats program, which showed no electric savings and lower than expected gas savings.
	The online survey results show that one in five smart thermostats were not yet installed at the time of the survey. Installation rates were slightly higher for line voltage connected thermostats at 89%. This finding is a contributor to lower than expected savings.
	Results from the participant online survey suggest customers who received a rebate through the Smart Thermostat program are generally satisfied with the program. Ninety percent of respondents are at least somewhat likely to recommend the program to someone they know, and satisfaction with the program overall was rated 4.2 on a 5-point scale. However, participants rated their satisfaction with energy savings since installing the thermostat at 3.9 on a 5-point scale, which suggests that the program is falling short of its primary objective.
	A vast majority of survey respondents (81%) reported that they override their thermostat setpoints at least once a month. In theory, smart thermostats are designed in a way to learn the preferences of customers soon after they are installed and to optimize setpoints after learning these preferences. In practice, customers are overriding setpoints on their thermostats long after this post-installation learning period. This is likely another contributor to lower than expected savings.
	Nearly half of the survey respondents said cost was a primary barrier to purchasing and installing a smart thermostat.
	Over half of the survey respondents said installing the thermostat was a primary or secondary barrier to using a smart thermostat.

Based on these key findings, DNV has the following recommendations:

RECOMMENDATIONS
Savings assumptions for smart thermostats in single family homes in the Regional Technical Forum's (RTF) workbooks are too high. Evaluations in different regions across the country have shown lower than expected savings for smart thermostats over the past decade. PSE should work with staff responsible for overseeing the RTF smart thermostat savings assumptions and encourage a deeper review in subsequent RTF workbook revisions.
PSE should re-evaluate whether to continue providing incentives for smart thermostats for the purposes of energy efficiency and reducing energy consumption given that evaluations have consistently shown lower than expected savings. However, smart thermostats have proven effective in the context of demand response programs. PSE should continue to assess the peak demand impacts associated with incentivizing smart thermostats for energy curtailment during demand response events through PSE's Flex programs.
Dissatisfaction with energy savings since installing the thermostat could be attributed to recent rate increases for kWh and Therms in PSE service territory, as well as the fact that thermostats are not achieving as much energy savings as expected. This provides PSE with an opportunity to integrate non-energy benefits more explicitly into marketing materials. PSE could emphasize the convenience of setting the thermostat while away from the home, while also explaining that increasing setpoints to improve comfort could lead to higher energy bills.
Since so many participants are facing the barrier of installing the thermostat themselves, PSE may consider following up with customers at some interval after they purchase the smart thermostats (e.g., 4 to 6 weeks after) and asking customers if they have installed the thermostat yet. If not, PSE can provide a list or link to qualified contractors to assist with installation.

2 INTRODUCTION

In this section, we provide an overview of Puget Sound Energy's (PSE) 2021 and 2022 Smart Thermostat program, research objectives, impact evaluation methods, and process evaluation methods.

2.1 Program Overview

PSE's Smart Thermostat program provides incentives to encourage all electric, gas, or combined fuel customers to install ENERGY STAR® certified thermostats or PSE qualified Line Voltage Connected Thermostats. Wi-Fi enabled smart thermostats work with existing heating systems to help customer monitor and control the temperature of their homes from anywhere via a mobile app. Rebates are offered either post-purchase with an online application, mail-in application, or through instant rebates via PSE's online Marketplace platform.[2] For the 2022 program, instant rebates were also offered through contractors. The program is available to all PSE residential electric and gas customer segments, including Named Community members such as customers with low incomes.

2.2 Research Objectives

In this section, we provide a summary of research activities and which primary impact and process research objectives they help address. Research objectives for the impact evaluation of the 2021 and 2022 Smart Thermostat program include an assessment of energy savings, installation verification, building changes, and behavioral/occupancy changes. Research objectives for the process evaluation included participant satisfaction, program awareness, perceived barriers to program participation, and program delivery. In Table 2-1 below, we have provided an overview of research objectives and activities for both the impact and process evaluations.

Table 2-1. Research activities and primary research objectives for the Smart Thermostat program

	Objective	Billing Analysis	Participant Survey	Program Manager Interviews
Impact	Energy Savings	■		
	Measure Verification		■	
	Building Changes		■	
	Behavioral/Occupancy Changes		■	
Process	Participant Satisfaction		■	
	Program Awareness		■	
	Perceived Barriers		■	■
	Program Delivery		■	■

2.3 Impact Evaluation Overview

The impact evaluation quantified the actual savings that occurred because of the program. DNV performed the impact evaluation using a billing analysis approach with a matched comparison group. This approach has two primary steps:

1. Create a matched comparison group for program participants
2. Estimate per-premise savings using weather normalized energy use in a difference-in-difference model

[2] Puget Sound Energy. Smart Thermostat: Program Guide.

The combination of these two steps allowed us to estimate the impact of the program's intervention after controlling for the effect of weather and non-program related changes on energy use. We controlled for the effect of weather to put energy consumption on the same weather basis before and after the program's intervention. We controlled for the effect of non-program or exogenous changes, such as changes in the composition of the household and addition of conditioned space through home renovation, by including data from a matched comparison group. The matched comparison group serves the same purpose that a control group does in a randomized controlled trial.

To create the matched comparison group, we identified customers with similar annual energy use levels and seasonal energy use patterns to the participant group. The difference-in-difference model used the matched comparison group to control for year-to-year changes that happen in the population absent program influence, so that change in participant consumption can be evaluated against an accurate counterfactual. In cases where the year-over-year change in the matched comparison group does not adequately control for such change among participants, we also made additional adjustments based on the trend in baseload, or portion of customer load that is not weather sensitive and not expected to be affected by the program's intervention.

2.4 Process Evaluation Overview

The process evaluation is designed to provide information on how the Smart Thermostat program creates savings and how it might increase those savings. This year's evaluation included two components:

1. An interview of PSE Smart Thermostat program staff
2. A large-scale online survey of Smart Thermostat program participants to understand their behaviors and attitudes

The program staff interview was designed to understand program challenges and opportunities from the perspective of PSE's program manager. This interview generated suggestions for program process improvements, a description of any recent program changes, a discussion of whether those changes impacted the program positively, and a discussion of aspects of the program that are working well.

The online survey was sent to a large sample of program participants to better understand customer behaviors that affect energy use, their attitudes toward the thermostats, and how these might vary between different types of customers. We focused, specifically, on questions to determine participation and decision factors, outcomes and satisfaction with the program, and how behaviors and sentiments might differ between smart thermostat participants and line voltage connected thermostat participants.

2.5 Report Overview

We have organized the remainder of this report as follows:

- **Section 3 Data Sources** describes the evaluation's data sources.
- **Section 4 Impact Evaluation Results** details the results of the impact evaluation.
- **Section 5 Process Evaluation Results** provides the results of the process evaluation.
- **Section 6 Findings and Recommendations** includes the evaluation's key findings and recommendations.
- **Appendix A: Impact Methodology** provides additional details on the impact evaluation methods.
- **Appendix B: Additional Online Survey Results** provides additional results from the participant online surveys.
- **Appendix C: Data Collection Instruments** provides the data collection instruments used for the participant online surveys.

3 DATA SOURCES

This section provides the data sources used to evaluate PSE's Smart Thermostat program. These data sources include tracking data, deemed savings documentation, energy consumption data, weather data, virtual verification, program staff interviews, and online surveys with participants. We discuss each source in the sections below.

3.1 Program Tracking Data

PSE provided DNV with the 2021 and 2022 rebate program tracking data. The tracking data included participant information, account numbers, program name, measures installed, installation dates, and claimed savings. Table 3-1 shows the claimed electric savings for program years 2021 and 2022 along with the number of sites with program savings. The vast majority of electric installations were for smart thermostats. In both 2021 and 2022, line voltage connected thermostats (LVCT) made up 7% and 14% of the total electric thermostat savings, respectively. Comparing 2021 and 2022, line voltage connected thermostats saw an increase in the number of sites while smart thermostats saw a decrease. On a per-premise basis, savings remained roughly the same between the two years.

Table 3-1. Summary of expected electric (kWh) savings for installed thermostats

Measure Group	2021			2022		
	Total kWh Savings	No. of Sites	Savings per Site	Total kWh Savings	No. of Sites	Savings per Site
LVCT Thermostats	176,019	861	204	249,021	1,190	209
Smart Thermostats	2,245,372	4,086	550	1,571,244	3,085	509

Table 3-2 shows the claimed gas savings for program years 2021 and 2022 along with the number of sites that received them. Line voltage connected thermostats had zero claimed gas savings. Smart thermostats had a 19% decrease in both total therm savings and number of sites from 2021 to 2022, but the per-premise savings remained the same.

Table 3-2. Summary of expected gas (therm) savings for installed thermostats

Measure Group	2021			2022		
	Total Therm Savings	No. of Sites	Savings per Site	Total Therm Savings	No. of Sites	Savings per Site
LVCT Thermostats	-	-		-	-	
Smart Thermostats	435,888	13,129	33	351,648	10,630	33

3.2 Deemed Savings Documentation

DNV reviewed the Regional Technical Forum's (RTF) measure case documentation to understand the inputs, assumptions, and calculations that informed the RTF deemed savings. A DNV engineer reviewed the smart thermostat measure cases as part of this exercise. We summarize the findings of this review below.

The analysis included two types of thermostats — electronic line voltage thermostats and line voltage communicating thermostats. Both types featured a 7-day programmable scheduling, Wi-Fi or bridge connectivity for remote access, and used outdoor air temperature sensors or internet weather data. The energy savings for these thermostats were estimated based on the average zonal electric energy use from the Residential Building Stock Assessment (RBSA) I and RBSA II household studies and calculated as a percentage of electric heating energy saved, with electronic line voltage thermostats at around 5% and line voltage communicating thermostats at approximately 6%. The RTF cites a paper published in 1999 by the Northeast Utilities and CDH Energy Corporation, which provides a savings estimate of 4.7% for non-connected

electronic line voltage thermostats at multi-family sites.[3] A 2018 study published by Hydro Quebec that shows kWh savings of 5.8% for line voltage communicating thermostats.[4] The study consisted of a test pilot run of 300 line voltage connected thermostats installed in 30 houses (10 per home) during the heating season. The RTF claim that LVCTs save an additional 1% over non-connected ELVTs is derived from the difference in reported savings between these two studies. Based on DNV's review of the RTF workbooks, these assumptions were still being used as of the April 2019 RTF meeting.

3.3 Consumption and Weather Data

DNV used advanced metering infrastructure (AMI) consumption data and daily temperature data to complete the impact evaluation. We received AMI data from Oracle via PSE staff. The data included daily electric and gas AMI consumption data for PSE's entire residential service population at the meter level for all available premises. DNV analysts used the AMI data for the analysis, which included the creation of a matched comparison group to control for exogenous change.

DNV obtained local weather data to perform weather normalization before estimating savings. Analysts retrieved this data using a DNV internal tool called WeatherHub. WeatherHub is an application programming interface that provides both historical hourly climate data sourced from the National Oceanic and Atmospheric Administration (NOAA) and typical meteorological year (TMY3) hourly climate data for weather stations around the country. We aggregated hourly temperature data to daily mean temperature before use in the weather normalization process. Weather normalization involves estimating heating and cooling setpoints and occupant sensitivity to outside temperature for every premise in the study population using premise-specific regression models. The resulting regression models are then used to shift daily consumption totals for each site to the same reference weather (in this case TMY3 weather). This process allows us to control for the effects of variable weather on daily consumption so we can compare consumption between the two periods in a meaningful way.

3.4 Virtual Verification

As part of the online survey, DNV asked participants to verify that they had installed the program-rebated smart thermostat or line voltage connected thermostat. While installation rates did not factor into the evaluated savings results, they provide additional context for the results. For further details on the virtual verification effort and installation rates, please see Section 5.4 below.

3.5 Program Staff Interview

The program staff interview took place in October of 2023 and included the Smart Thermostat program manager as well as one additional PSE staff member. The primary goals of the program staff interview were to understand any recent and planned program changes, marketing and outreach efforts, and barriers preventing customers from participating. Evaluators also asked PSE program staff to characterize the quality control processes they use with respect to the installation of thermostats. For further details on insights gained from this interview, please see Section 5.2.

3.6 Participant Online Surveys

PSE provided DNV with the 2021 and 2022 population of Smart Thermostat program participants. Prior to launching the survey, evaluators cleaned the participant tracking data. Following this, DNV wrote and programmed the online participant survey. For the process evaluation DNV aimed to find out reasons for participation, satisfaction with program delivery, barriers to participation, and energy use behaviors.

[3] Johnson, R., D. Bhagani, and S. Carlson. Measured Impact of Mechanical Thermostat Replacement. Residential Buildings: Technologies, Design, and Performance Analysis. 1.137. 1999.

[4] Fournier, M. et al. Making the Connection: Testing Line-Voltage Communicating Thermostats for Baseboard Heaters in DR and EE Experiments. Institut de Recherche d'Hydro-Québec. 2018.

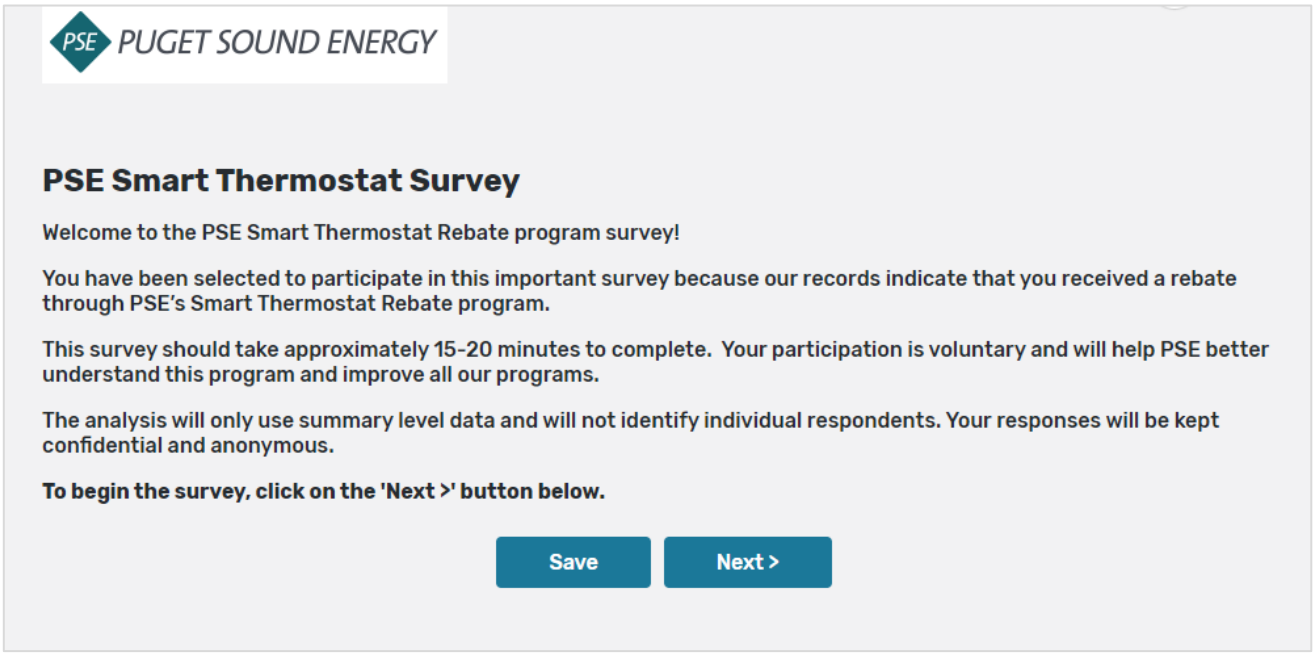
The survey invitation was delivered to participants via email and included the following features:

- A research bulletin alerting customers of the upcoming survey
- A landing page with PSE's logo on landing
- A lottery with a chance to win an e-gift card

To motivate respondents to participate in the online survey, we held a lottery that offered two e-gift cards incentives of $300 and $200. Respondents who completed the survey were eligible to win one of the prizes, and therefore included in the gift card lottery. All respondents were provided the option to opt-out of the survey and opt-out of the incentive.

Figure 3-1 shows the landing page participants view upon accessing the survey.

Figure 3-1. Participant survey landing page



The survey was launched on September 1, 2023 and remained open until October 4, 2023. Non-respondents received up to three reminder emails to complete the survey. Table 3-3 shows the number of completed and partially completed surveys and response rate. The overall reponse rate was 16%. DNV included all viable responses in the analysis, including the respondents who only partially completed the survey.

Table 3-3. Participant surveys completed and response rate

Online Survey Results	Overall
Total Sent*	28,244
Not Started	23,727
Partial Complete	471
Completed	4,046
Response Rate	**16%**

* When preparing the online survey sample, DNV removed participants from the Smart Thermostat survey population who either: a.) opted out of receiving emails or b.) did not have valid email addresses.

4 IMPACT EVALUATION RESULTS

In this section, we provide the results of our impact evaluation of the 2021 and 2022 Smart Thermostat program, including an overview of our results and methodology, verification of installed measures, and evaluated savings results by fuel type.

4.1 Results Overview

Our analysis showed no statistically significant electric savings attributable to the Smart Thermostat program and evaluated gas savings were 28% of claimed savings. These realization rates are based on estimates of -22 kWh and 9.2 therms savings per premise for homes with electric and gas heating, respectively.

Fuel Type	Evaluated Savings	Reported Savings	Number of Premises in Tracking Data	Realization Rate
Electric	0	4,236,212	9,131	0%
Gas	217,061	787,173	23,734	28%

Table 4-1 provides the estimated savings per premise with associated confidence intervals and Table 4-2 provides the program total evaluated savings and realization rates. The estimated electric negative savings is not statistically different from 0, which is the basis of the reported realization rate. In this table, number of premises refers to the number of unique participants with claims in the program tracking data and not the number of tracking claims. We calculated total realization rates by multiplying the savings per premise by the total number of participating premises to get the total evaluated savings, which we divided by the total reported savings for each fuel type. In this report, results are presented for both thermostat types combined[5]. See Appendix A: Impact Methodology for details on the number of premises that informed the final analysis.

Table 4-1. Program per-premise savings estimates.

Fuel Type	Evaluated Savings	90% CI Low	90% CI High	Savings as Percent of Consumption	Number of Premises in Analysis
Electric	-21.7	-128.1	84.8	-0.19%	2,791
Gas	9.2	4.9	13.5	1.63%	7,916

Table 4-2. Program total evaluated savings and realization rates.

Fuel Type	Evaluated Savings	Reported Savings	Number of Premises in Tracking Data	Realization Rate
Electric	0	4,236,212	9,131	0%
Gas	217,061	787,173	23,734	28%

4.2 Methods Overview

The impact evaluation used a billing analysis approach with a matched comparison group to estimate per-premise savings for each fuel type. We selected a matched comparison group to control for the effect of non-program-related changes. Comparison groups are needed to determine program impacts because many changes affecting energy use patterns unrelated to the program can occur within customer premises.

In a difference-in-difference framework, the matched comparison group controls for trends in consumption that occur year-to-year that are not a result of program influence, such as changes in home composition or the addition of new conditioned space in a home, giving us a more accurate counterfactual or baseline consumption to compare the participant group's

[5] The Web Enabled Thermostats program included Smart Thermostats and Line Voltage Connected Thermostats. Tracking data indicated differing deemed savings for each measure, but our analysis showed no statistically significant difference in savings between the two thermostat types.

energy consumption. We used load markers that reflected the total magnitude of household usage and seasonal usage patterns as well as account tenure (time spent at the current address) to match participants and non-participants.

After selecting the matched comparison group, we weather normalized the energy consumption data for both groups. Weather normalization is the process in which heating and cooling setpoints and occupant sensitivity to outside temperature are modelled for every premise in the study population using premise-specific regression models. The resulting regression models are then used to shift daily consumption totals for each site to the same reference weather (in this case TMY3 weather), giving normalized annual consumption (NAC) for each premise. This process allows us to control for the effects of variable weather on daily energy consumption between the pre-installation and post-installation time periods so that pre-installation and post-installation consumption can be compared in a meaningful way. The regression models created as part of the weather normalization process also enable us to decompose household consumption into baseload, heating load, and cooling load. These load components can then be used to quantify heating load and cooling load savings.

Finally, to estimate per-premise savings, we used a difference-in-difference regression model. This approach compares the pre-to-post difference in consumption of the participant group against that of the matched comparison group. The difference between these two differences (difference-in-difference) is the quantification of savings, showing how much more or less the participant group reduced consumption relative to the matched comparison group. Using a regression model for this step provides both the estimates of savings and the precision of these estimates. In cases where the matched comparison group did not adequately control for the year-over-year change observed among participants, we adjusted our results based on the trend in baseload, or the portion of customer load that is not weather sensitive and is not expected to be affected by the installation of a thermostat measure. This adjustment is discussed in more detail in Section 4.3 below.

4.3 Evaluated Savings Results

Because smart thermostats affect the operation of the HVAC system and associated cooling and heating load, we do not expect them to affect baseload or weather independent load. In this evaluation of the 2021 and 2022 Smart Thermostat program, we observed a statistically significant increase in electric baseload consumption of the participant group relative to the comparison group. The increase in baseload indicates selection bias may be present in the estimated impact of smart thermostats.

To address this potential bias, we adjusted estimated savings to control for the difference in year-to-year trend between participants and the matched comparison group (Figure 4-1). The adjustment proportionally scales comparison group consumption upward to remove the effect of the increase in participant baseload while also adjusting comparison group heating and cooling load consumption upwards by the same proportional amount. This adjustment addresses the trend differential evident in increased participant baseload consumption. Note that although this adjustment effectively sets any baseload savings to 0, Table 4-3 shows that the resulting baseload savings estimates is -1.5 kWh. While small and close to 0, the final estimate is not exactly equal to 0 because we stratified the analysis by dwelling type and applied the adjustment to strata that exhibited a significant increase in baseload.

Figure 4-1. Electric savings with and without baseload adjustment

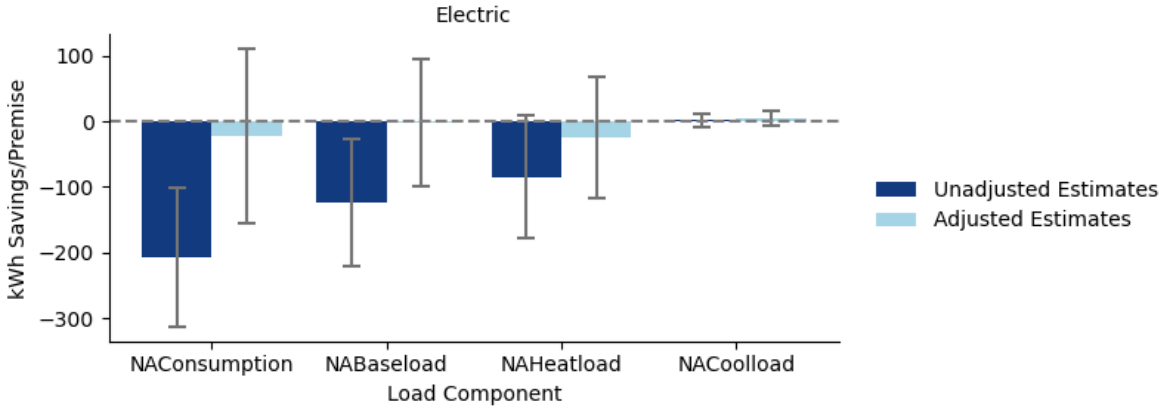


Figure 4-2 provides the breakdown of the evaluated electric and gas savings estimates per premise by load type, while Table 4-3 provides the specific values. The 90% confidence intervals include 0 for all electric savings estimates, making all components of electric load savings not statistically significantly different from 0. As indicated above, the estimated electric impact per premise is an increase in consumption of 22 kWh, which is 0.2% of annual electric consumption. The estimated savings of 9 therms per premise is approximately 2% of annual gas consumption.

Figure 4-2. Load-specific per-premise savings estimates

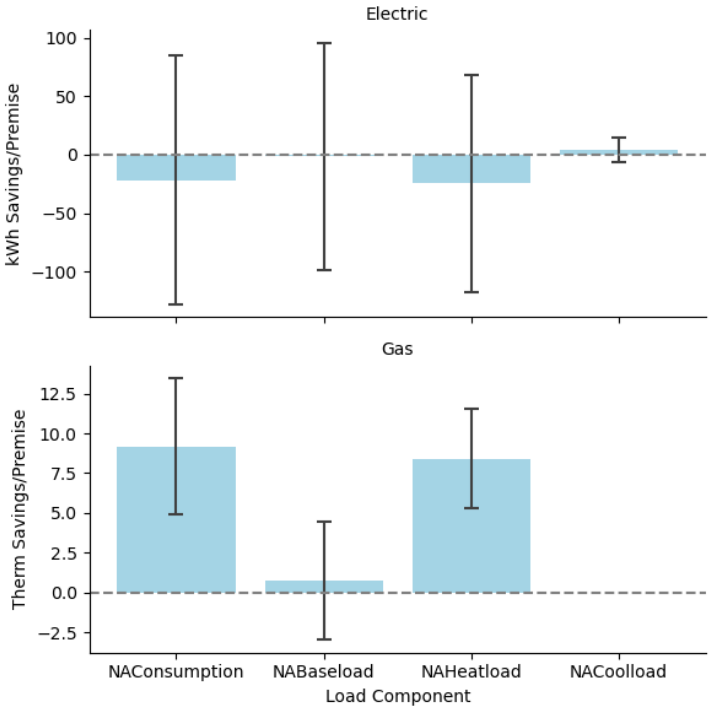


Table 4-3. Load-specific per-premise savings estimates

Fuel Type	Load Type	Evaluated Savings	90% CI Low	90% CI High
Electric	Normalized Annual Consumption	-21.7	-128.2	84.8
Electric	Normalized Annual Baseload	-1.5	-98.7	95.7
Electric	Normalized Annual Heating Load	-24.6	-117.6	68.4
Electric	Normalized Annual Cooling Load	4.5	-6.2	15.2
Gas	Normalized Annual Consumption	9.2	4.9	13.5
Gas	Normalized Annual Baseload	0.8	-2.9	4.5
Gas	Normalized Annual Heating Load	8.4	5.3	11.5

4.4 Discussion

The results presented above are consistent with other smart thermostat evaluations performed for PSE by both DNV[6] and other evaluators,[7] as well as with smart thermostat evaluations performed by DNV in other regions, such as California.[8] Multiple studies indicate that smart thermostats are not effective at delivering annual electric savings and deliver gas savings that are far lower than expected.[9] We should note that the 2015 study by DNV was an evaluation of a smart thermostat pilot program that had a randomized controlled trial program design. This study also showed electric and gas savings that were far lower than expected.

As this current evaluation indicates, smart thermostats are not delivering any electric savings and may result in modest gas savings. While smart thermostats offer features that are capable of lowering consumption, those features need to be activated for energy savings to be realized at the meter. Smart thermostats need to be able determine heating and cooling reductions that will be accepted by the customer, and those savings need to be greater than any other increases in consumption that may be motivated by the thermostat features such as geo-fencing, remote access, and other features. In other words, smart thermostats are a behavioral measure that is dependent on the customer to be an effective tool for saving energy. These results indicate that smart thermostats are not successful in assisting customers save energy in aggregate.

The evidence from this evaluation and others suggests that the RTF overestimates savings from smart thermostats. The process portion of this evaluation, discussed in the next section, determined that up to 20% of rebate recipients did not install their smart thermostat for various reasons. Therefore, any modest expected gas savings for this measure should incorporate the fact that one in five participants may not install the smart thermostat device within a year of purchase.

[6] DNV GL, Impact Evaluation of PSE Web-Enabled Thermostat Program. August 2015.

[7] Opinion Dynamics, Puget Sound Energy 2017-2018 Web-Enabled Thermostats Program Impact and Process Evaluation Report. November 20, 2019.

[8] DNV, Impact Evaluation of Smart Thermostats – Residential Sector – Program Year 2019. Jun 16, 2021. 2019 Smart Thermostat Evaluation (calmac.org)

[9] A. Brandon et al. The Human Peris of Scaling Smart Technologies: Evidence from Field Experiments. National Bureau of Economic Research. September 2022. https://www.nber.org/system/files/working_papers/w30482/w30482.pdf

5 PROCESS EVALUATION RESULTS

This section summarizes the findings for the Smart Thermostat process evaluation and includes findings from the participant surveys and program manager interviews.

5.1 Overview

The main objectives of this Smart Thermostat program process evaluation are as follows:

1. Gain an understanding of participant awareness of the program and household characteristics before participation.
2. Understand the program experience from the participant perspective.
3. Identify reasons for participating in the program.
4. Quantify the level of satisfaction with the program among participants.
5. Uncover perceived barriers to program participation.

We present results related to these research objectives in the sections that follow.

5.2 Insights from Program Staff Interview

The program staff interview included the program manager for PSE's Smart Thermostat rebate program. We provide details below on various aspects of the program, including recent and planned program changes, marketing and outreach efforts, quality control processes, participation barriers, and identification of any missed savings opportunities.

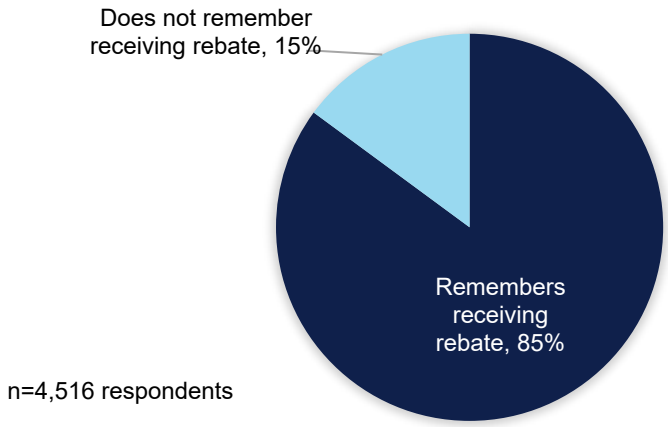
1. **Program Changes:** Beginning in 2022, contractors have been able to apply for the rebates as well as customers. Additionally, PSE added Efficiency Boost for low-to-moderate income customers, increasing the rebate from $75 to $175 for these applicants. For low-to-moderate income customers with line voltage connected systems, the rebate increased from $75 to $130 for up to five units. Before 2023, customers could not call PSE for a contractor recommendation because there were not enough contractors interested in installing thermostats. PSE has now recruited enough contractors that customers can call or reference the PSE Marketplace website to get a list of recommended contractors.[10] Currently, to apply for a rebate for a thermostat and a furnace or heat pump, contractors need to fill out two different applications. In 2024, PSE will allow contractors to apply for a rebate using the same application as the one used for furnace rebates. Additionally, in 2024, PSE will allow customers to enroll in PSE's demand response program, PSE Flex, when they purchase a thermostat through the Marketplace. A benefit of this new feature of the program is that customers can receive an additional rebate on top of the thermostat rebate, further lowering the cost of the equipment.
2. **Marketing and Outreach Efforts:** To market the program, PSE relies heavily on targeted emails. PSE also conducts high impact events where they set up a table at a retail store and educate potential customers about the program. Signage in stores and rebate forms are available in English and Spanish. Additionally, PSE has an outreach team at community events with a table that has samples with thermostats for customers to look at and learn about from the team.
3. **Quality Control:** PSE's verification team verifies the installation of 3% of smart thermostat purchases via phone calls on a monthly basis.
4. **Barriers to Participation:** According to PSE's program manager, the biggest barrier to having more customers participate in the Smart Thermostat program is the cost of the thermostats. The program manager noticed a dip in participation in 2023 and believes that has to do with customers having less surplus income. Another barrier is the thermostat being incompatible with customers' systems and/or needing a contractor for installation. The program manager also noted that customers may not see the benefits of a thermostat and may not see the need to upgrade.

[10] https://pse-marketplace.com/

5.3 Program Awareness

This section summarizes results related to the level and source of awareness among Smart Thermostat program participants. We evaluated program participant awareness by first asking respondents if they remember receiving a rebate from PSE for a smart thermostat or line voltage connected thermostat purchase. As shown in Figure 5-1, the vast majority (85%) reported that they remembered participating in the program.

Figure 5-1. Respondent recall of program participation



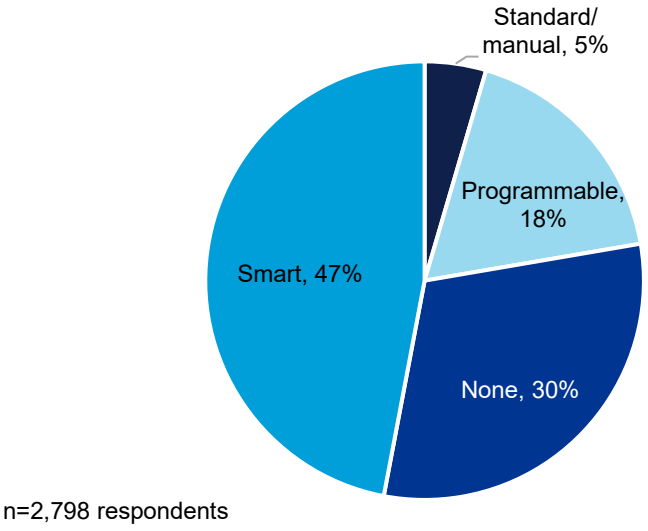
We also asked participants how they first found out about the Smart Thermostat Rebate program. Most customers (45%) found out about the program through a PSE email, and 28% discovered the program on the PSE website. Very few heard about the program through a contractor (2%). Figure 5-2 shows the various ways in which participants heard about the program.

Figure 5-2. Source of program awareness

We asked participants what type of thermostat they replaced with their program-rebated thermostat. A little over half (54%) replaced a programmable thermostat, about a third (34%) replaced a standard or manual thermostat, 11% replaced an existing smart thermostat, and one percent had no prior thermostat. Customers who replaced an existing smart thermostat are likely one of the contributing reasons for lower than expected energy savings from the program.

DNV asked participants what type of thermostat they would have purchased without the program rebate (see Figure 5-3). Around a third (31%) said they would not have bought a thermostat at all. However, almost half (47%) said they would have purchased a smart thermostat with or without a rebate. This indicates a relatively high free-ridership among program participants. Although high levels of free-ridership may not be desirable, it does not negatively affect gross realization rates or claimed savings. As noted in the Evaluation Framework, "Consistent with condition (8) (a) of UTC Order 1 approving PSE's 2022-2023 Biennial Conservation Plan, PSE does not estimate net savings for a program or portfolio since the Net-to-Gross ratio is set at 1.0 for cost effectiveness analysis. However, the Company will examine program spillover and free-ridership when it is feasible to do so for program design purposes."[11]

Figure 5-3. What type of thermostat participants would have purchased without the program rebate



n=2,798 respondents

Additionally, without the program rebate, 29% of participants said they would have installed a thermostat at the same time as when they purchased the program-rebated thermostat, which is also indicative of free-ridership. Per the Evaluation Framework, the free-ridership does not negatively affect realization rates or claimed savings.

5.4 Installation Rates

To understand installation rates, we asked participants if their program-rebated thermostat is currently installed in their home. The majority of respondents (81%) said that the thermostat is currently installed in their home. There was a difference in installation rates between customers who purchased line voltage connected and smart thermostats. While 89% of line voltage connected participants reported that their thermostat was installed, 80% of smart thermostat participants said that the thermostat was currently installed. Figure 5-4 and Figure 5-5 show installation rates for the two thermostat types.

[11] Puget Sound Energy. Evaluation, Measurement, and Verification Framework: Exhibit 6, Supplement 1. November 1, 2023. https://apiproxy.utc.wa.gov/cases/GetDocument?docID=9&year=2023&docketNumber=230893

Figure 5-4. Percent of line voltage connected thermostats currently installed

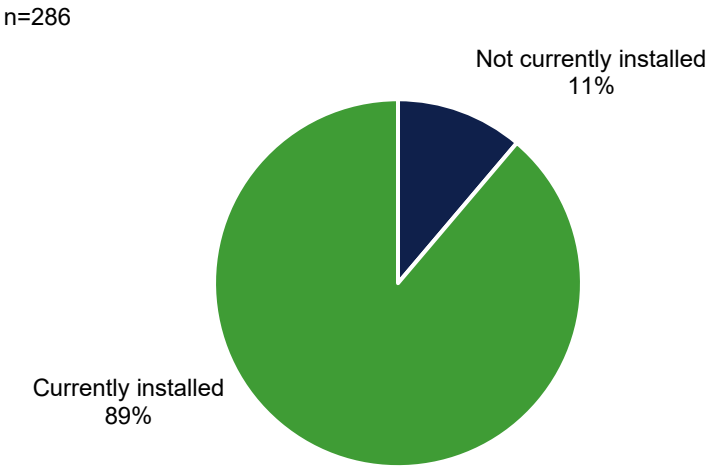
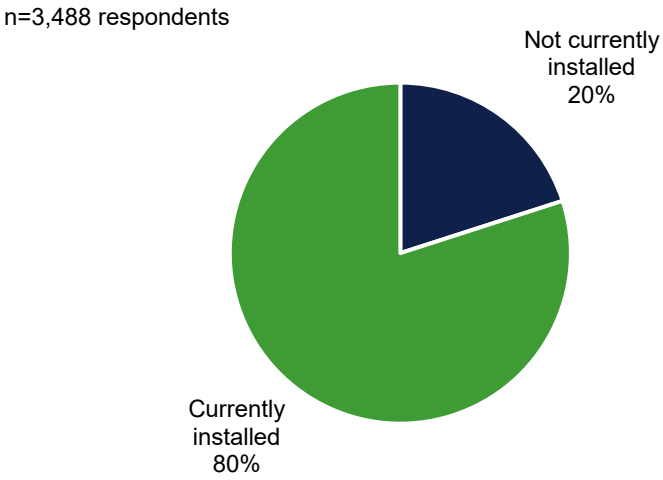


Figure 5-5. Percent of smart thermostats currently installed



We then asked participants why their thermostat is not currently installed (Table 5-1). Compatibility issues with the HVAC system and dealing with challenging installations were the most often reported reasons that the program-rebated thermostat was not installed. Difficulty with installation was a common theme reported by respondents, which points to an opportunity for PSE to engage their trade ally network further in this program to ensure equipment is installed and working correctly for participants.

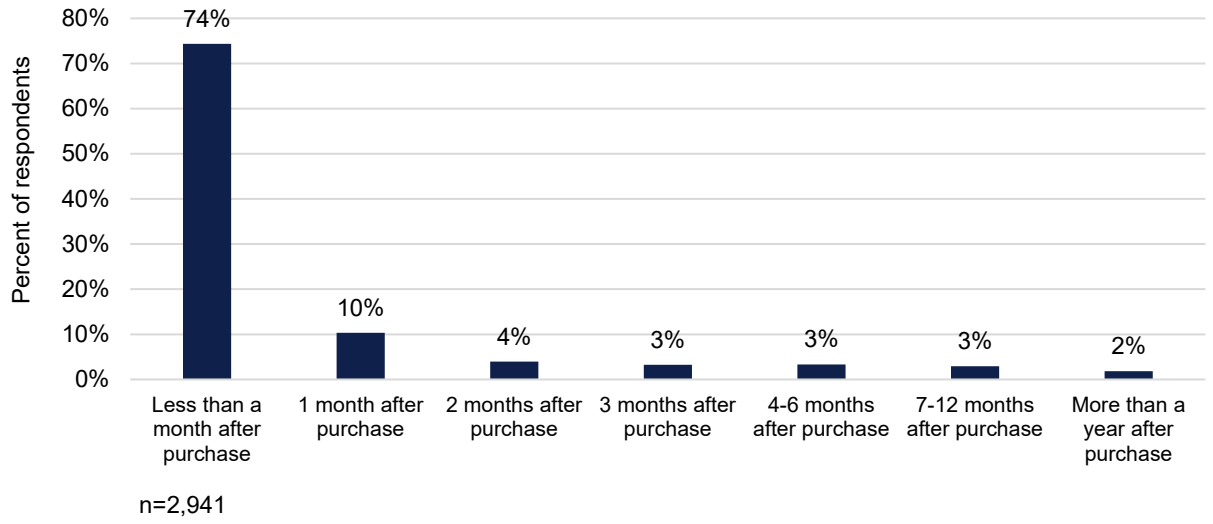
Table 5-1. Respondent-reported reasons that program rebated thermostat is not currently installed

Reason	Smart Thermostat (n=639)	LVCT (n=26)
Compatibility issues with HVAC system or wiring	35%	30%
Challenging installation - need professional to install	27%	35%
Have not had time to install, but plan to	10%	11%
Thermostat is faulty	9%	12%

Reason	Smart Thermostat (n=639)	LVCT (n=26)
New HVAC system with new thermostat	7%	8%
Moved to new home – left thermostat behind	4%	0%
Using a different smart thermostat	4%	0%
Decided to continue using old thermostat	2%	0%
Do not trust "smart" technology	1%	0%
Do not own their home	1%	4%
Total	**100%**	**100%**

Participants who installed their thermostats were asked how long they waited to install the thermostat after purchase (see Figure 5-6). Most (74%) installed their thermostat less than one month after purchase, and 2% installed their thermostat more than a year after purchase.

Figure 5-6. When participants installed their program-rebated thermostat



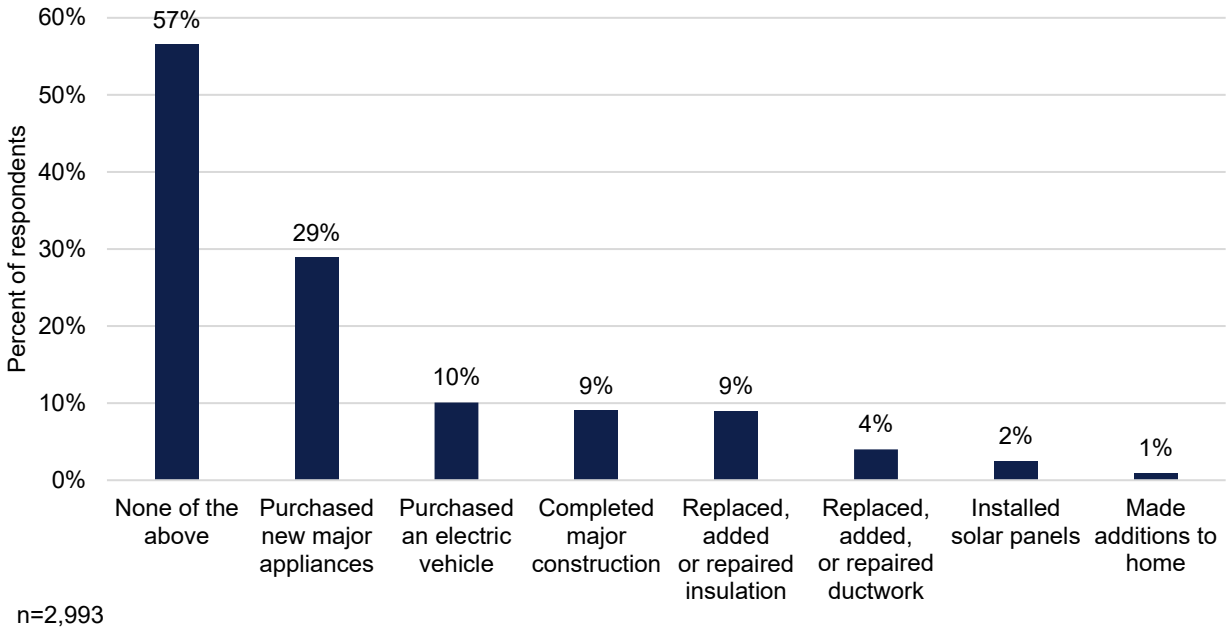
5.5 Energy Use Behavior

DNV asked survey respondents about their current heating and cooling systems, any changes they have made since installing the thermostat, and heating setpoints with their previous and current thermostats.

Almost three quarters (72%) of respondents reported that they have a gas forced air furnace as their primary heat source. The next most frequently reported heat source are air source heat pumps (8%) and electric forced air furnaces (8%). Approximately a third (31%) reported they do not have a primary cooling system, while another 31% have central air conditioning as their primary cooling system. The next most frequently reported cooling system was portable air conditioners (15%).

The survey asked about any changes to the home at the same time or after they installed the thermostat (see Figure 5-7). A little more than half (57%) did not make any major household changes. Respondents that made changes reported purchasing a new appliance (29%), followed by purchasing an EV (10%), doing major construction (9%), and adding insulation (9%).

Figure 5-7. Household changes since purchasing the thermostat



n=2,993

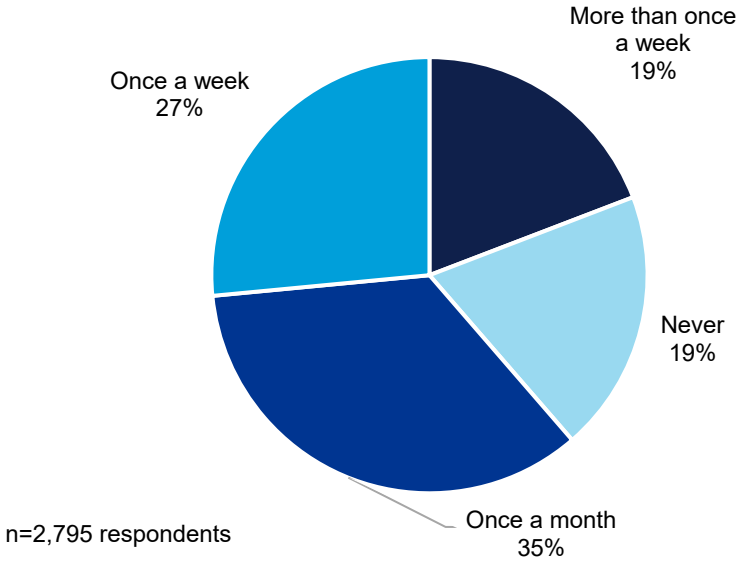
We then asked respondents what heating setpoint they typically used on their old thermostat during the week and weekends. With their old thermostat, participants on average had their setback/night setpoint at 65 degrees. We then asked customers if their heating setpoints have changed with the new thermostat. Most (78%) of customers did not change their heating setpoints. The average setback/night heating setpoint for customers who changed their setpoints was 64 degrees. At most, participants changed their setpoints by one degree at various times of day with the new thermostat. Table 5-2 shows heating setpoints during the week and weekend with participants' old and new thermostats.

Table 5-2. Respondent-reported heating setpoints with old and new thermostat

Day and Time	Setpoint with Old Thermostat (n=2,625)	Setpoint with Program-rebated Thermostat (n=565)
Weekday morning	68°	67°
Weekday day	67°	66°
Weekday evening	68°	68°
Weekday night/setback	65°	64°
Weekend morning	68°	68°
Weekend day	68°	67°
Weekend evening	68°	68°
Weekend night/setback	65°	64°

DNV asked participants how often they manually override their thermostat settings (see Figure 5-8). About a third (35%) override their thermostat once a month on average, 27% override the settings once a week, and the remaining respondents were evenly split between overriding it more than once a week and never manually overriding (19%). In other words, about four in five participants reported that they manually override their smart thermostat at least once per month.

Figure 5-8. How often, on average, participants manually override their thermostat settings



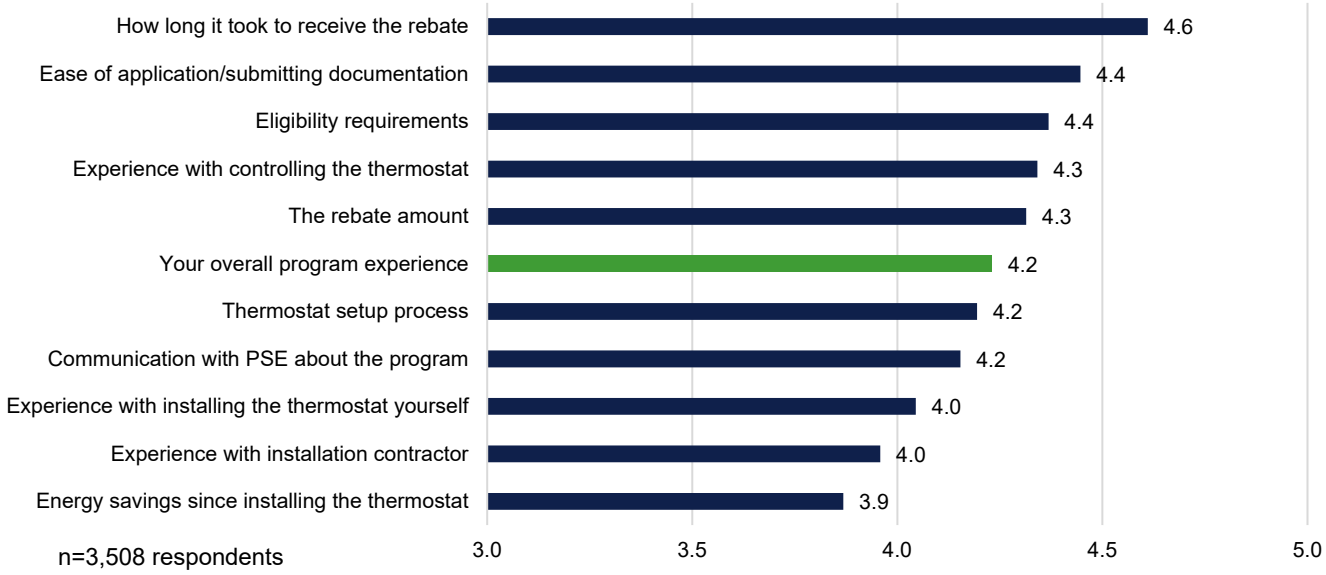
Participants were asked if they override the settings more, less, or about the same as with their old thermostat. Most respondents (57%) override the settings less frequently, and only 15% saying they override the settings more often with the new equipment. The remaining 28% override the settings at about the same frequency as with their old thermostat.

5.6 Satisfaction

DNV asked participants about their satisfaction with various aspects of the program using a 5-point scale, where "5" means "very satisfied" and "1" means "very dissatisfied." Eleven distinct aspects were covered with the intention of capturing key steps of the rebate and installation process, from eligibility requirements to energy savings since receiving upgrades. Respondents were also asked about their satisfaction with the program overall.

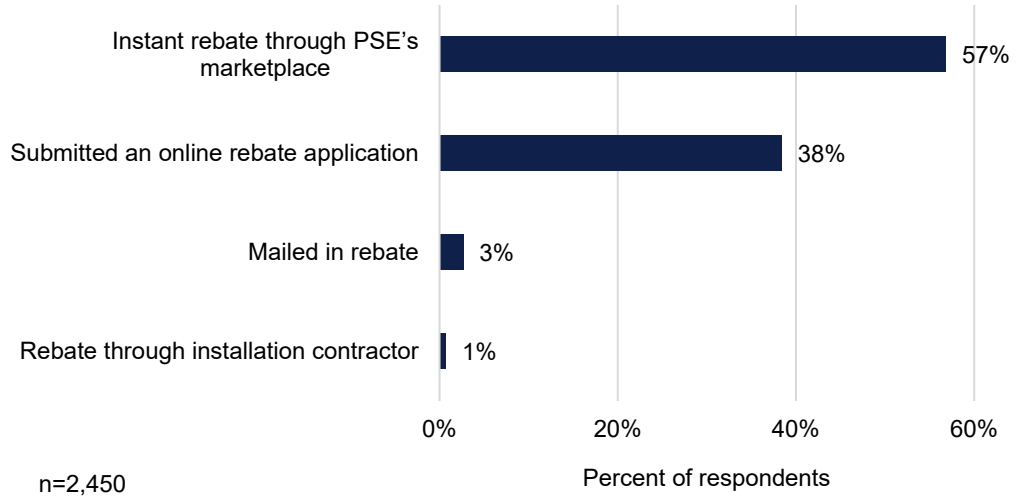
Figure 5-9 presents satisfaction with the various aspects of the program as well as satisfaction with the overall program experience (see green bar for overall satisfaction). All categories yielded moderate to high average satisfaction scores, ranging from 3.9 to 4.6. The highest-rated aspect of the program was how long it took to receive the rebate after purchase (4.6). Only one aspect (energy savings since installing the thermostat) received less than 4.0 average satisfaction rating while the other 10 aspects had higher average satisfaction ratings. This suggests that participants are generally satisfied with most aspects of the program. The lower average satisfaction rating (3.9) of energy savings since receiving upgrades may be due to participants expecting to see higher bill savings as a result of the new thermostat than what they experienced on their bills. Furthermore, it is likely that most customers experienced an increase in the electric and gas rates that they pay since they purchased their smart thermostats, which would further erode potential bill savings.

Figure 5-9. Participant satisfaction with various program aspects



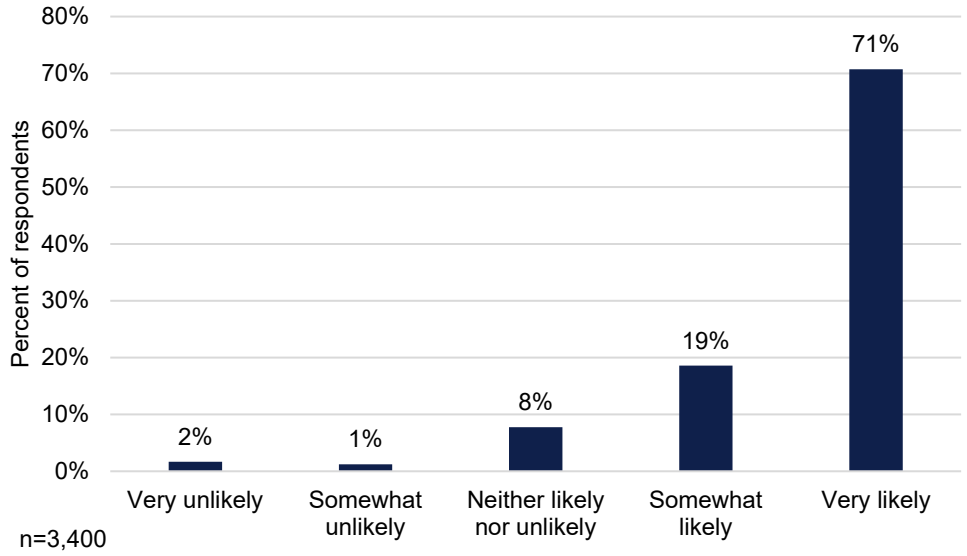
As shown in Figure 5-10, most participants (57%) received their rebate instantly after purchasing the thermostat through PSE's online marketplace. Thirty-eight percent submitted an online rebate application after purchasing the thermostat. The remaining participants mailed in their rebate application or received the rebate through the installation contractor.

Figure 5-10. How participants received the program rebate



Finally, participants were asked how likely they are to recommend PSE's Smart Thermostat Rebate program to someone they know (see Figure 5-11). Most respondents (88%) said they are at least somewhat likely to recommend the program. Very few (3%) said they were somewhat or very unlikely to recommend the program.

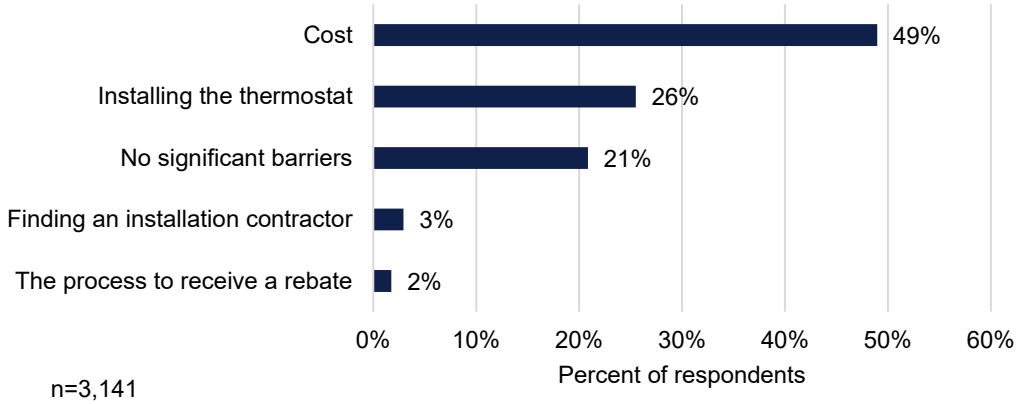
Figure 5-11. Participant likelihood to recommend the program to someone they know



5.7 Barriers to Program Participation

DNV asked respondents what they think the primary barrier is to purchasing and installing a smart thermostat (see Figure 5-12). While 21% of respondents said there are no significant barriers, nearly half (49%) said cost was a primary barrier, and 26% said installing the thermostat is the primary barrier. This aligns with previous survey responses indicating customer difficulty in installing the thermostat themselves (see Table 5-1 above).

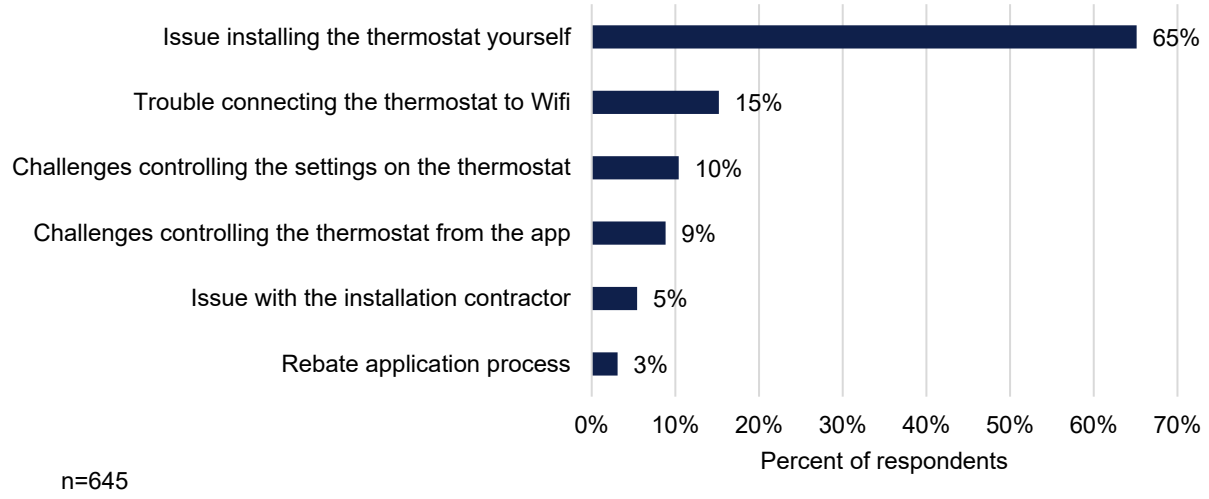
Figure 5-12. Primary barriers to purchasing and installing a smart thermostat.



We then asked participants about any secondary barriers to the purchase and installation of smart thermostats. Over half (54%) said installing the thermostat was an additional barrier, 36% said cost, and 17% said finding an installation contractor.

Participants were asked if they experienced any issues that led them to seek help (see Figure 5-13). Most (81%) did not, but the remaining 19% of respondents said they did seek help for an issue. Issues installing the thermostat was the most frequently reported issue.

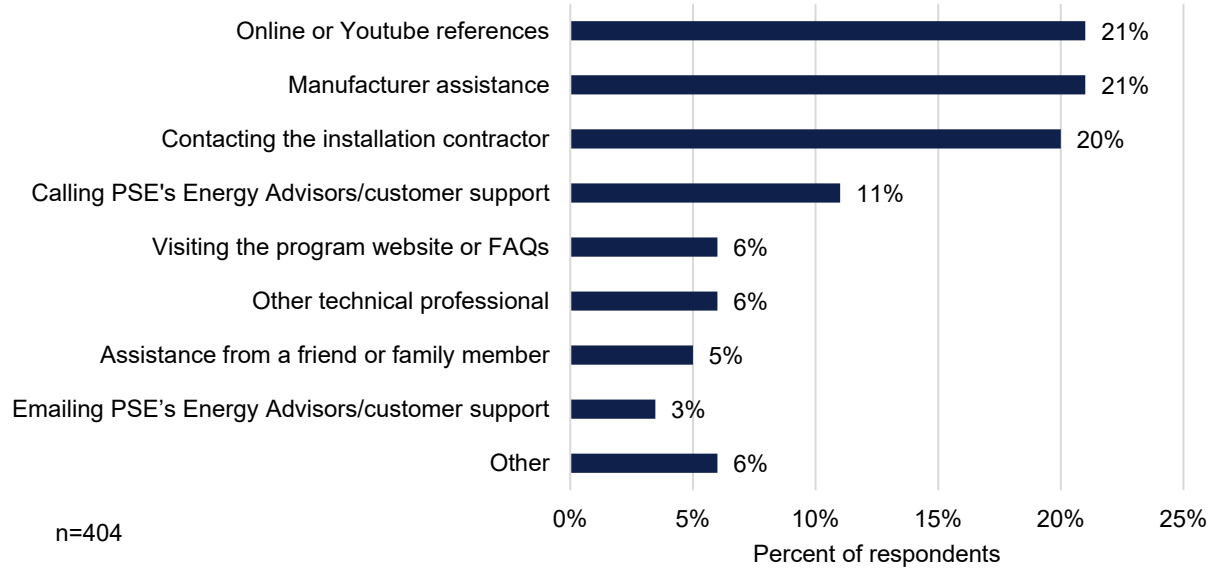
Figure 5-13. Issues for which participants sought help



While 64% of respondents said their issue was resolved, the remaining 36% of customers who experienced issues were not able to resolve them. These issues largely were related to equipment installation. PSE may consider following up with customers at some interval after they purchase the smart thermostats (e.g., 4 to 6 weeks after) and asking customers if they have installed the thermostat yet. If not, PSE can provide a list or link to qualified contractors to assist with installation.

Participants who said their issues were resolved were then asked which resource proved to be the most helpful in resolving the issue (see Figure 5-14). The most common ways in which participants resolved their issues were through online sources or YouTube videos (21%) and manufacturer assistance (21%), and 20% of respondents said they resolved their issue after contacting the installation contractor.

Figure 5-14. Resources that resolved customer issues

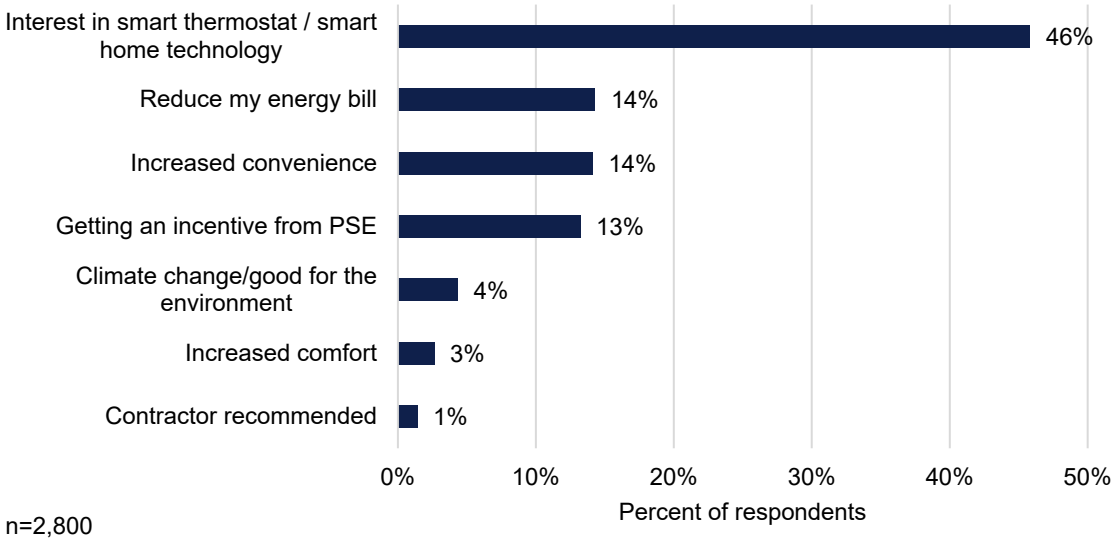


5.8 Reasons for Program Participation

Participants were asked the primary reason they chose to purchase the program-rebated thermostat (see Figure 5-15. Close to half of the respondents (46%) said they had interest in smart thermostats and smart home technology. Reducing their energy bill (14%), increased convenience (14%), and getting an incentive from PSE (13%) were all mentioned as primary reasons for participation. Only 1% of respondents said that a contractor recommended the program. No respondents who purchased a line voltage connected thermostat reported that their purchase was due to a contractor recommendation.

Of the respondents who said that the primary reason for participation was to reduce their energy bill, most (68%) said they were either somewhat or very satisfied with the energy savings they've experienced since installing the program-rebated thermostat. The remaining participants were somewhat or very dissatisfied (14%) or neither satisfied nor dissatisfied with the energy savings since installing the thermostat (18%).

Figure 5-15. Primary reasons for purchasing thermostat through program



n=2,800

6 FINDINGS AND RECOMMENDATIONS

In this section, we summarize overall findings from the evaluation and recommendations based on these findings.

6.1 Findings

Key findings from the Smart Thermostat program impact and process evaluation are as follows:

FINDINGS	The Smart Thermostats program achieved no statistically significant electric savings impact evaluation and realized only 28% of claimed gas savings. These results are consistent with the previous evaluation of PSE's program year 2017-2018 Web-Enabled Thermostats program, which showed no electric savings and lower than expected gas savings.
	The online survey results show that one in five smart thermostats were not yet installed at the time of the survey. Installation rates were slightly higher for line voltage connected thermostats at 89%. This finding is a contributor to lower than expected savings.
	Results from the participant online survey suggest customers who received a rebate through the Smart Thermostat program are generally satisfied with the program. Ninety percent of respondents are at least somewhat likely to recommend the program to someone they know, and satisfaction with the program overall was rated 4.2 on a 5-point scale. However, participants rated their satisfaction with energy savings since installing the thermostat at 3.9 on a 5-point scale, which suggests that the program is falling short of its primary objective.
	A vast majority of survey respondents (81%) reported that they override their thermostat setpoints at least once a month. In theory, smart thermostats are designed in a way to learn the preferences of customers soon after they are installed and to optimize setpoints after learning these preferences. In practice, customers are overriding setpoints on their thermostats long after this post-installation learning period. This is likely another contributor to lower than expected savings.
	Nearly half of the survey respondents said cost was a primary barrier to purchasing and installing a smart thermostat.
	Over half of the survey respondents said installing the thermostat was a primary or secondary barrier to using a smart thermostat.

6.2 Recommendations

Based on these key findings, DNV has the following recommendations:

RECOMMENDATIONS

Savings assumptions for smart thermostats in single family homes in the Regional Technical Forum's (RTF) workbooks are too high. Evaluations in different regions across the country have shown lower than expected savings for smart thermostats over the past decade. PSE should work with staff responsible for overseeing the RTF smart thermostat savings assumptions and encourage a deeper review in subsequent RTF workbook revisions.

PSE should re-evaluate whether to continue providing incentives for smart thermostats for the purposes of energy efficiency and reducing energy consumption given that evaluations have consistently shown lower than expected savings. However, smart thermostats have proven effective in the context of demand response programs. PSE should continue to assess the peak demand impacts associated with incentivizing smart thermostats for energy curtailment during demand response events through PSE's Flex programs.

Dissatisfaction with energy savings since installing the thermostat could be attributed to recent rate increases for kWh and therms in PSE service territory, as well as the fact that thermostats are not achieving as much energy savings as expected. This provides PSE with an opportunity to integrate non-energy benefits more explicitly into marketing materials. PSE could emphasize the convenience of setting the thermostat while away from the home, while also explaining that increasing setpoints to improve comfort could lead to higher energy bills.

Since so many participants are facing the barrier of installing the thermostat themselves, PSE may consider following up with customers at some interval after they purchase the smart thermostats (e.g., 4 to 6 weeks after) and asking customers if they have installed the thermostat yet. If not, PSE can provide a list or link to qualified contractors to assist with installation.

7 APPENDICES

7.1 Appendix A: Impact Methodology

7.1.1 Data Cleaning

DNV performed rigorous data cleaning on customer advanced metering infrastructure (AMI) data before performing the impact analysis. These cleaning steps were taken to ensure that final results were representative and unbiased. Cleaning steps included checking for data completeness, screening customers who had participated in other PSE energy efficiency programs within a certain timeframe, limiting analysis to sites with applicable home heating fuel, and removing sites with negative loads. Table 7-1 below shows the starting participant count across the 2021 and 2022 program years, the number of participants remaining after each cleaning step, and the final count of customers present in our analysis.

Table 7-1. Participant data cleaning

Data Cleaning Step	Electric Participants	Gas Participants
Starting participant count from tracking data	9,163	23,718
Device installed before 6/1/2022	6,341	16,668
Sufficient pre/post data	3,404	9,410
No program participation in prior year	3,189	8,784
No other program participation in same year	2,939	8,231
Obtainable weather data	2,839	7,950
Clean data (no negative reads)	2,838	7,929
Final count	**2,838**	**7,929**

As part of the difference-in-difference model estimation, a small number of premises were removed from analysis as high-leverage outliers. This small handful of outliers contributed to large variation in impact evaluation results and were also otherwise unrepresentative of the relationships that were present for the general analysis group. Table 7-2 below shows the final count of participant premises included in the analysis before and after removing outliers.

Table 7-2. Removal of high leverage outliers

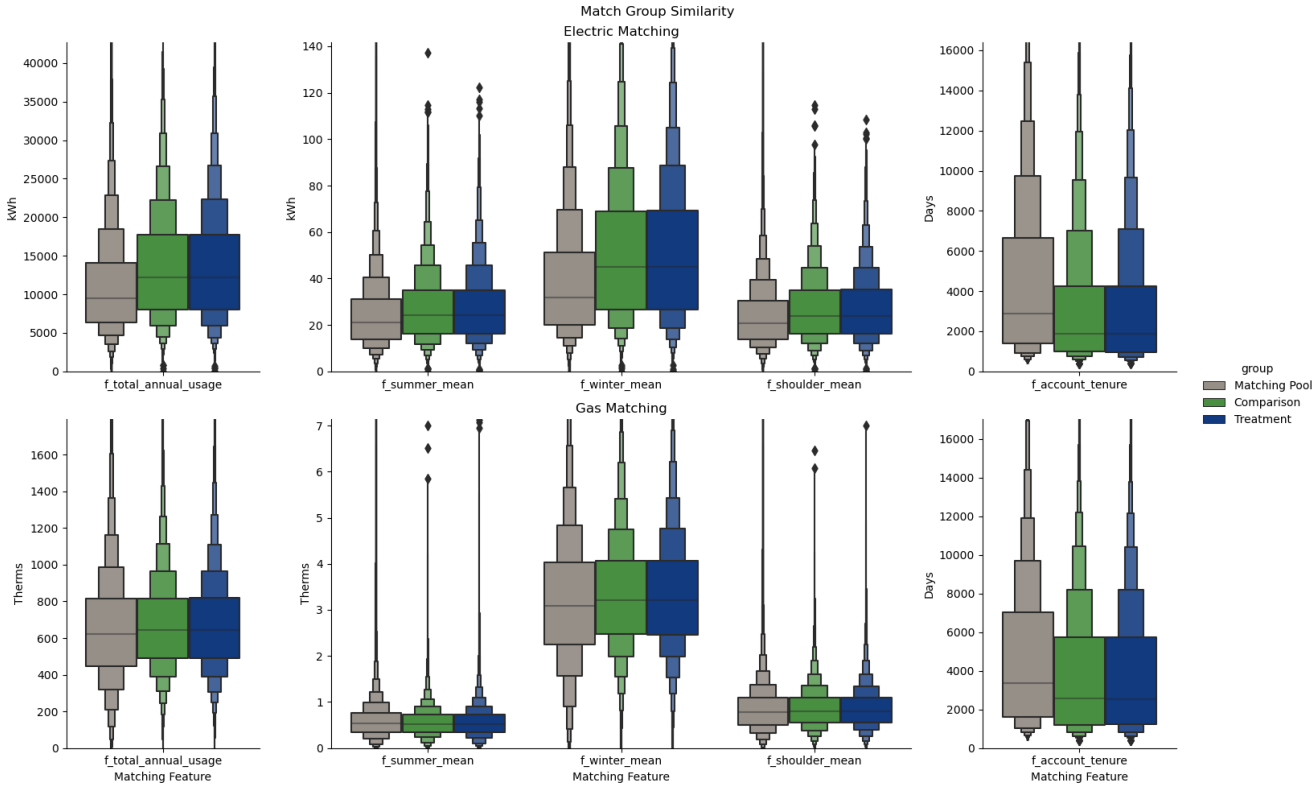
Data Cleaning Step	Electric Participants	Gas Participants
Starting count	2,838	7,929
Removed as high leverage outliers	47	13
Final count	**2,791**	**7,916**

7.1.2 Matching

DNV created the matched comparison group using a Nearest Neighbors algorithm based on Mahalanobis distance. To get a representative comparison group, we found the nearest neighbor to each participant based on total annual usage, average load for summer, winter, and shoulder seasons, and account tenure (time spent inhabiting current address). These features were chosen to find matches that had similar home size, exhibited similar seasonal usage patterns, and were in similar stages of settling into a home. Figure 7-1 shows the distributions of each of these variables for the general PSE service area population, the treatment group, and the comparison group. Notice that for the electric analysis, program participants had higher than average annual usage and higher than average seasonal usage, particularly in the winter, as well as relatively little time spent at their current address, and that the matched comparison group closely mirrors these characteristics. For

the gas analysis, program participants exhibited a slightly larger and more compressed distribution of these variables compared to the general population, and once again the matched comparison group closely resembles the participant group along these dimensions.

Figure 7-1. Similarity between treatment and matched comparison group



7.2 Appendix B: Additional Online Survey Results

We provide additional demographic results from the online participant survey below.

Figure 7-2. Program participant housing type

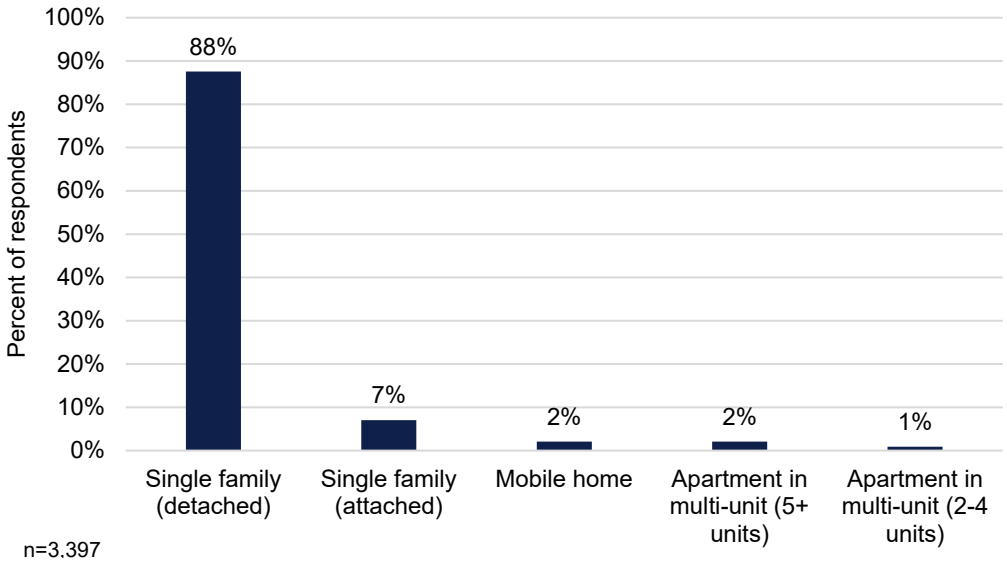


Figure 7-3. Primary household language

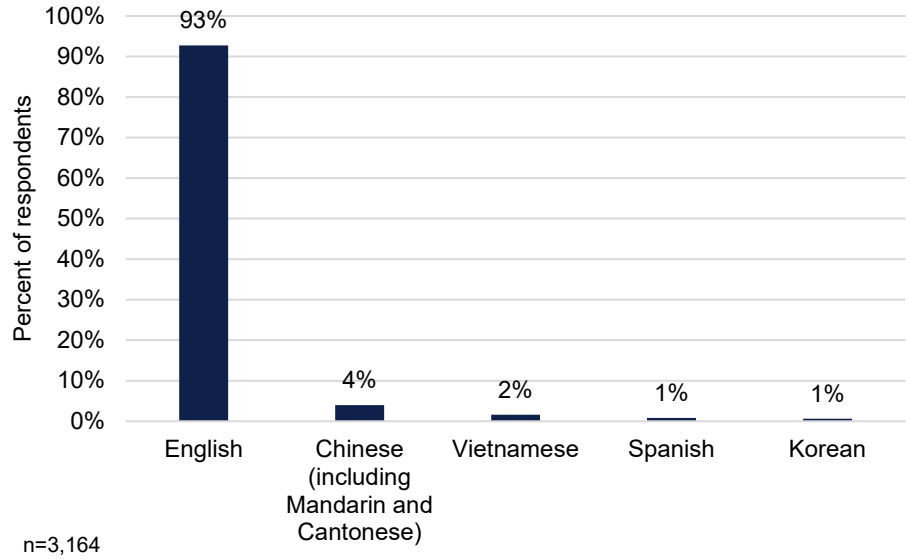


Figure 7-4. Annual 2022 household income

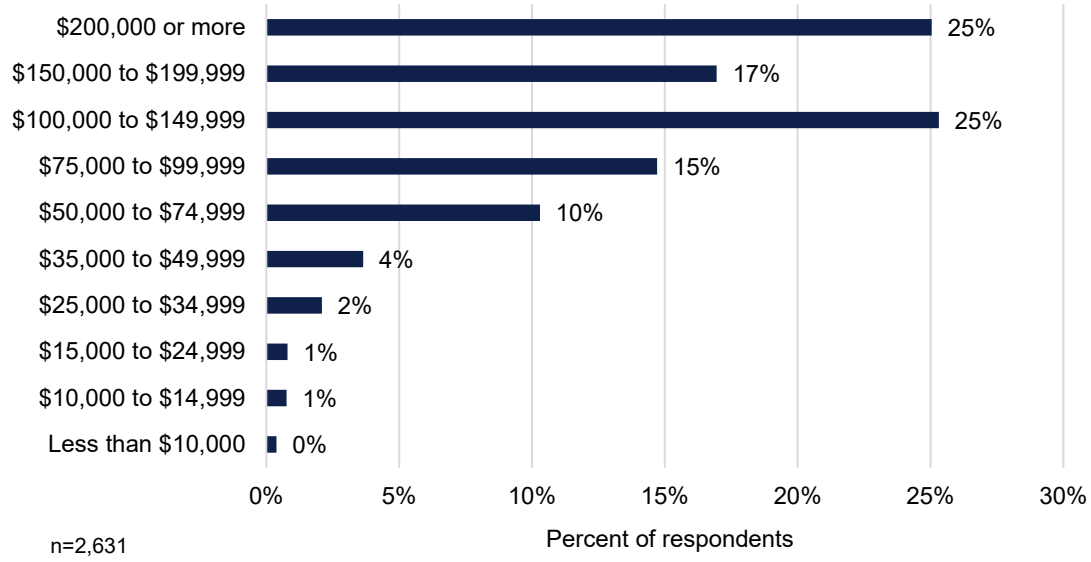
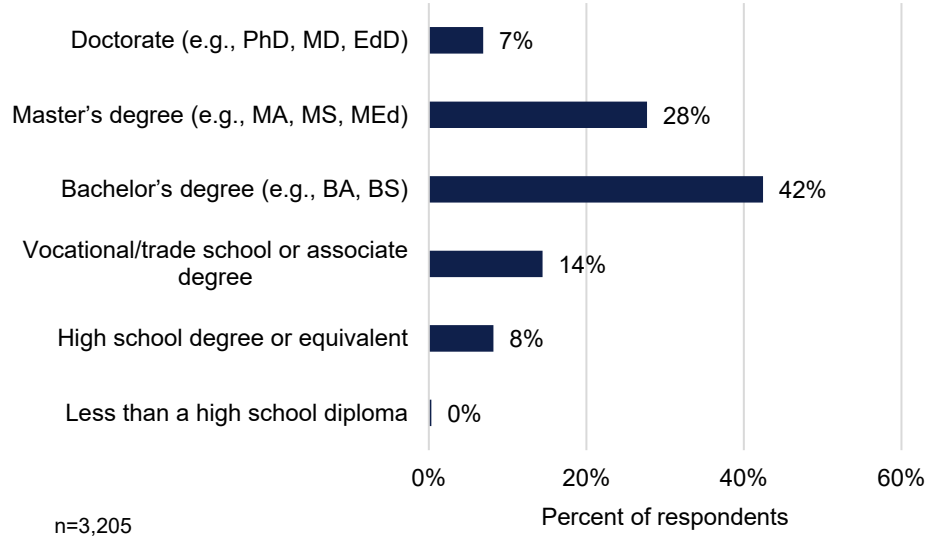


Figure 7-5. Highest degree completed



7.3 Appendix C: Data Collection Instruments

To: Jesse Durst, Puget Sound Energy

From: Katie Ryder, David Avenick, Geoff Barker, DNV

Date: August 10, 2023

PSE: SMART THERMOSTAT REBATE PROGRAM PARTICIPANTS WEB SURVEY GUIDE

1 INTERVIEW GUIDE OVERVIEW

Objective: The Evaluation Team will conduct web surveys with PSE Thermostat Rebate program participants assess installation rates, program awareness, satisfaction, and other program-specific topics.

Anticipated timing (survey length): Approximately 15 minutes

Method of data collection: Web Survey

Table 1: Research Objectives Mapped to Questions in this Instrument

Question	Instrument Goal
Q1 - Q2	Screening
Q3 - Q14	Background
Q15 - 0	Participation/Decision Factors
Q23 – Q34	Outcomes/Satisfaction
Q35 – Q40	Household Characteristics
Q41 – Q43	Closing

2 SURVEY GUIDE

Table 2: Overview of Data Collection Approach

Data Collection	Description
Population Description	PSE Smart Thermostat Rebate program participants
Sampling Method	Census
Instrument Type	Web Survey
Survey/Interview Length	Approximately 15 minutes
Description of Contact Sought	Those who received rebates as part of the PSE program.

Email Invitation Template

[FROM] Puget Sound Energy

[SUBJECT]: PSE Smart Thermostat Rebate Program Survey

Hello **[PIPE IN FROM DATA: Name]**,

You are invited to participate in Puget Sound Energy's Smart Thermostat Rebate program survey!

At Puget Sound Energy, we're committed to providing the best products and services for customers like you. As part of this effort, we are conducting an evaluation of the Smart Thermostat Rebate program. As a participant in PSE's program, your opinions are important. PSE would like your input and perspectives to understand how to best structure this program in the future for customers like you.

As a token of our appreciation for completing the survey, you'll have a chance to enter a raffle for an e-gift card of up to $300.**To get started, click on this link:** [INSERT LINK]

It will take approximately 15 minutes to answer our questions. Participation in this survey effort is voluntary and your individual responses will be kept confidential and anonymous. Any analyses will not identify individuals.

Thank you for your participation.

If you have any questions about this research effort, please contact the PSE Evaluation and Research team at EESEvaluations@PSE.com.

Thank you for participating in PSE's program evaluation. We really appreciate your input!

Puget Sound Energy
355 110th Ave NE
Bellevue, WA 98004

PUGET SOUND ENERGY

- This email was sent by DNV on behalf of Puget Sound Energy. DNV is an authorized agent of Puget Sound Energy. If you have questions about the survey or would like to be removed from future surveys, please contact the study coordinator at: survey.pse@impact.dnv.com.
- To unsubscribe from future energy efficiency promotional emails, contact eesevaluations@pse.com.
- Link to PSE's Privacy Policy: https://www.pse.com/pages/privacy

2.1 Introduction

Welcome to the PSE Smart Thermostat Rebate program survey!

You have been selected to participate in this important survey because our records indicate that you received a rebate through PSE's Smart Thermostat Rebate program.

This survey should take approximately 15 minutes to complete. Your participation is voluntary and will help PSE better understand this program and improve all our programs.

The analysis will only use summary level data and will not identify individual respondents. Your responses will be kept confidential and anonymous.

To begin the survey, click on the arrow below.

2.2 Screening

Q1. According to our records, you received a rebate from PSE for a smart thermostat or line voltage thermostat purchase. Most customers received $75 off the purchase price of the thermostat, while other income qualified customers may have received up to $175 off the purchase price. Do you recall receiving this rebate on your thermostat purchase?
[FORCE RESPONSE]

1. Yes **[Skip to Q3]**
2. No

Q2. You may have received an instant rebate at the time of purchase or you could have received a rebate through working with a contractor. Do you recall receiving a rebate for your thermostat?

1. Yes
2. No **[Termination Script 1]**

[PASSED SCREENING]: Great! You are eligible to take our survey. Let's get started.

[TERMINATION SCRIPT 1]: Thank you for answering our questions. However, we are looking for respondents who received a rebate through the program. Your response has been recorded. Have a great day.

2.3 Background

Q3. Did you purchase a {thermostat type} on {Purchase Date}? **[SHOW THERMOSTAT TYPE BASED ON PROGRAM DATA]**

1. Smart thermostat **–** program-rebated smart thermostats connect to your centralized home heating/cooling system and allow you to program desired settings and connect to Wi-Fi for more advanced features. Program-qualified smart thermostats are required to be ENERGY STAR certified.
2. Line voltage connected thermostat - program-rebated line voltage connected thermostats is used to regulate heating systems that work on direct electricity, such as baseboard, wall, or ceiling radiant heaters. These program-rebated thermostats have 7-day programming schedules and utilize Wi-Fi connectivity.

Q4. Is the new thermostat currently installed in your home?

1. Yes
2. No

Q5. **[ASK IF Q4 = 2]** Why is the thermostat not installed? **[OPEN ENDED] [Skip to Q23]**

Q6. **[ASK IF Q4 = 1]** Approximately when was the thermostat installed?

1. Drop down options (1 month, 2 months, 3 months, 4-6 months, 7-12 months, more than a year after purchase)
2. Never
98. Don't know

Q7. When you installed your new thermostat, what type of thermostat did you replace?

1. Standard/manual **[Hover text: Manual thermostats require homeowners to manually adjust their system to manage their home's temperature]**
2. Programmable **[Hover text: Programmable thermostats can store and repeat multiple daily settings that you can manually override without affecting the rest of the daily or weekly program]**
3. Smart **[Hover text: Smart thermostats are Wi-Fi enabled devices that automatically adjusts heating and cooling temperature settings in your home]**
4. No prior thermostat
97. Other (please specify)

Q8. What is the primary source of heat in your home?
[SINGLE RESPONSE]

1. Gas forced air furnace
2. Air source heat pump
3. Electric forced air furnace
4. Ducted mini-split heat pump
5. Gas fireplace insert(s)
6. Wood-burning fireplace
7. Wood-burning stove
8. Plug-in portable space heater
9. Floor or wall heater
10. Hot water radiator
11. Electric baseboard
12. Ductless mini-split heat pump
97. Other home heating equipment, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**
99. None of the above
98. Don't know

Q9. What is the primary cooling system in your home?
[SINGLE RESPONSE]

1. Central air conditioner
2. Heat pump
3. Window air conditioner
4. Portable air condition
5. Other home cooling equipment, please specify:_____**[INSERT OPEN-ENDED RESPONSE]**
99. None
98. Don't know

Q10. Have you made any of the following changes to your home at the same time or after you installed the thermostat? Please select all that apply.
[MULTIPLE RESPONSE]

1. Purchased new major appliances (refrigerators, freezers, washer/dryer, dishwasher)
2. Replaced, added, or repaired insulation in your home
3. Purchased an electric vehicle
4. Completed major construction on your home's building shell, such as replacing the roof, the flooring, or walls
5. Replaced, added, or repaired ductwork in your home
6. Installed solar panels
7. Made additions to your home that increased the overall square footage
99. None of the above

Q11. Approximately how many hours a day is your house occupied during a typical weekday and weekend?

Typical Weekday	
Typical Weekend	

Q12. During winter season with your **old thermostat**, what heating set point did you typically use on your thermostat during the week and weekends? Please specify if you have different settings for different days or times during the week (i.e., what do you set the temperature to?).

Time of day	Temperature setpoint (in Fahrenheit)
Weekday morning	
Weekday day	
Weekday evening	
Weekday night	
Weekend morning	
Weekend day	
Weekend evening	
Weekend night	

Q13. Have your heating set points changed with your new thermostat?

1. Yes
2. No
98. Don't know

Q14. **[ASK IF Q13 = 1]** What are the new heating set points?

Time of day	Temperature setpoint (in Fahrenheit)
Weekday morning	
Weekday day	
Weekday evening	
Weekday night	
Weekend morning	
Weekend day	
Weekend evening	
Weekend night	

2.4 Participation/Decision Factors

Q15. Thinking back, how did you find out about the Smart Thermostat Rebate program?
[SINGLE RESPONSE, RANDOMIZE 1-10]

1. Contractor
2. PSE Energy Advisor
3. PSE website
4. PSE email
5. PSE's online marketplace
6. PSE press release
7. Signage at retail store
8. Social media
9. Local community event
10. Neighbors, family, friends, or colleagues
98. Don't recall
97. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**

Q16. How did you receive the rebate for your thermostat purchase?

1. Submitted an online rebate application after purchasing the thermostat
2. Mailed in a rebate form after purchasing the thermostat
3. Received an instant rebate after purchasing the thermostat through PSE's online marketplace
4. Received rebate through the installation contractor
98. Don't recall
97. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**

Q17. What is the primary reason you chose to purchase the thermostat?

[SINGLE REPONSE, RANDOMIZE 1-7]

1. Interest in smart thermostat and/or smart home technology
2. Increased comfort
3. Increased convenience
4. Getting an incentive from PSE
5. Helping fight global warming/climate change/good for the environment
6. Reduce my energy bill
7. A contractor recommended a smart thermostat
97. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**
98. Don't know

Q18. Are there any other reasons you chose to purchase the thermostat? Please select all that apply.
[MULTIPLE RESPONSE, RANDOMIZE 1-7]

1. Interest in smart thermostat and/or smart home technology
2. Increased comfort
3. Increased convenience
4. Getting an incentive from PSE
5. Helping fight global warming/climate change/good for the environment
6. Reduce my energy bill
7. A contractor recommended a smart thermostat
97. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**
98. Don't know

Q19. Without the program rebate, what type of thermostat would you have purchased?

1. Standard/manual **[Hover text: Manual thermostats require homeowners to manually adjust their system to manage their home's temperature]**
2. Programmable **[Hover text: Programmable thermostats can store and repeat multiple daily settings that you can manually override without affecting the rest of the daily or weekly program]**
3. Smart **[Hover text: Smart thermostats are Wi-Fi enabled devices that automatically adjusts heating and cooling temperature settings in your home]**
99. None
97. Other, please specify: _____ **[INSERT OPEN-ENDED RESPOSE]**

Q20. Without the program rebate, when would you have considered installing a new thermostat?

1. Same time
2. 1 year later
3. 2 years later
4. More than 2 years later
5. Never
97. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**
98. Don't know

Q21. On average, how often do you manually override the thermostat settings?

1. Never
2. Once a month
3. Once a week
4. More than once a week

Q22. Do you override the settings more, less, or about the same frequency as with your old thermostat?

1. I override the thermostat settings more frequently with the new thermostat
2. I override the thermostat settings less frequently with the new thermostat
3. I override the settings at about the same frequency with the new thermostat

2.5 Outcomes/Satisfaction

[DISPLAY]: The next section will ask you questions about your experiences with PSE's Smart Thermostat Rebate program.

Q23. Please indicate how strongly you agree or disagree with the following statements about PSE's Thermostat Rebate program.
[INSERT "STRONGLY AGREE", "SOMEWHAT AGREE", "NEITHER AGREE NOR DISAGREE", "SOMEWHAT DISAGREE", "STRONGLY DISAGREE", AND "DON'T KNOW" CHOICES FOR ALL OPTIONS, RANDOMIZE STATEMENTS]

1. The benefits of this program (energy savings/environmental benefits) are important to me
2. The eligibility requirements for this program were clear
3. Submitting the rebate application is easy
4. Customer support for the program was readily available

Q24. Using a scale of 1 to 5 where 1 means very dissatisfied, 2 is somewhat dissatisfied, 3 is neither satisfied nor dissatisfied, 4 is somewhat satisfied, and 5 is very satisfied, please indicate your level of satisfaction with the following aspects of the program: **[RANDOMIZE 1-8, INCLUDE 'Not Applicable' AS RESPONSE OPTION]**

1. Eligibility requirements
2. Ease of application/submitting documentation
3. The rebate amount
4. Communication with PSE about the program
5. Experience with installation contractor
6. Experience with installing the thermostat yourself
7. Experience with controlling the thermostat
8. Thermostat setup process
9. **[HIDE IF 0 = 3]** How long it took to receive the rebate after submitting the application
10. Energy savings since installing the thermostat
11. Your overall program experience

Q25. **[ASK FOR ANY ITEMS IN Q24 WITH SOMEWHAT OR VERY DISSATISFIED RESPONSE]** Do you have any suggestions for how we can improve the following program element(s) for which you indicated dissatisfaction?
[INSERT OPEN-ENDED RESPONSE]

Q26. What do you think the primary barrier is to purchasing and installing a {thermostat type}?

1. Cost
2. The process to receive a rebate
3. Installing the thermostat
4. Finding an installation contractor
5. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**
6. No significant barriers
7. Don't know

Q27. **[SKIP IF Q26 = 6 or 7]** Are there any other barriers to purchasing and installing a {thermostat type}? Select all that apply.

1. Cost
2. The process to receive a rebate
3. Installing the thermostat
4. Finding an installation contractor
5. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**

Q28. Did you experience any issues that led you to seek help?

1. Yes
2. No

Q29. **[ASK IF Q28 = Yes]** What issue did you experience?

1. Rebate application process
2. Trouble connecting the thermostat to Wifi

3. Issue with the installation contractor
4. Issue installing the thermostat yourself
5. Challenges controlling the thermostat from the app
6. Challenges controlling the settings on the thermostat
7. Other, please specify

Q30. **[ASK IF Q28 = 1]** Was the issue(s) successfully resolved?
1. Yes
2. No

Q31. **[ASK IF Q30 = 1]** Which resource proved to be the most helpful for resolving your issue?
[SINGLE RESPONSE]
1. Visiting the program website or FAQs
2. Emailing PSE's Energy Advisors/customer support
3. Calling PSE's Energy Advisors/customer support
4. Contacting the installation contractor
97. Other, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**

Q32. **[ASK IF Q30 = 2]** We are sorry you experienced an issue(s) that was not successfully resolved. Do you have any feedback you want to provide on the issue(s) and how it could have been resolved?
1. Yes, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**
2. No

Q33. Is there anything you would change about PSE's Smart Thermostat Rebate program?
1. Yes, please specify: _____ **[INSERT OPEN-ENDED RESPONSE]**
2. No

Q34. How likely are you to recommend PSE's Smart Thermostat Rebate program to someone you know?
1. Very likely
2. Somewhat likely
3. Neither likely nor unlikely
4. Somewhat unlikely
5. Very unlikely

2.6 Household Characteristics

[DISPLAY]: Please answer the next set of questions so we can better understand who participates and make sure we have reached a variety of households. Your responses will remain anonymous.

Q35. About when was the building you live in first built? Your best guess is fine.
1. 2020 or later
2. 2010 to 2019
3. 2000 to 2009
4. 1990 to 1999
5. 1980 to 1989
6. 1970 to 1979
7. 1960 to 1969
8. 1950 to 1959
9. 1940 to 1949
10. 1939 or earlier
98. Don't know
99. Prefer not to answer

Q36. Which of the following best describes the type of home you live in?
1. Single family, detached (e.g., freestanding house)
2. Single family, attached (e.g., townhouse or row house)
3. Apartment in multi-unit structure of 2-4 units
4. Apartment in multi-unit structure of 5 or more units

5. Mobile home
98. Don't know
99. Prefer not to answer

Q37. What is the total square footage of your home? Your best guess is fine.

1. Less than 500
2. 500 to 749
3. 750 to 999
4. 1,000 to 1,499
5. 1,500 to 1,999
6. 2,000 to 2,499
7. 2,500 to 2,999
8. 3,000 to 3,999
9. 4,000 or more
98. Don't know
99. Prefer not to answer

Q38. What is the highest degree or level of school you have completed? If you're currently enrolled in school, please indicate the highest degree you have received.

1. Less than a high school diploma
2. High school degree or equivalent
3. Vocational/trade school or associate degree
4. Bachelor's degree (e.g., BA, BS)
5. Master's degree (e.g., MA, MS, MEd)
6. Doctorate (e.g., PhD, MD, EdD)
97. Other (please specify)
99. Prefer not to answer

Q39. What is the primary household language?

1. English
2. Spanish
3. Chinese (including Mandarin and Cantonese)
4. Tagalog
5. Vietnamese
6. Korean
97. Other (please specify)
99. Prefer not to answer

Q40. Please select the range that best describes your household's annual 2022 income before taxes:

1. Less than $10,000
2. $10,000 to $14,999
3. $15,000 to $24,999
4. $25,000 to $34,999
5. $35,000 to $49,999
6. $50,000 to $74,999
7. $75,000 to $99,999
8. $100,000 to $149,999
9. $150,000 to $199,999
10. $200,000 or more
98. Don't know
99. Prefer not to answer

2.7 Closing

Q41. Is there anything else you want to tell us about your experience with PSE's Smart Thermostat Rebate program?

1. Yes. Please share your comments: _____ **[INSERT OPEN-ENDED RESPONSE]**
2. No

Q42. To thank you for your participation in this research, we may enter you into a drawing for an Amazon e-gift card of up to $300. If selected for the e-gift card, you will be notified by email (please check your spam filter). Would you like to be included in the incentive drawing? **[SINGLE REPONSE]**

1. Yes
2. No

Q43. **[ASK IF Q42 = 1]** Please provide your preferred contact information for the drawing:

1. First name: _____ **[INSERT OPEN-ENDED RESPONSE]**
2. Last name: _____ **[INSERT OPEN-ENDED RESPONSE]**
3. Email address: _____ **[INSERT OPEN-ENDED RESPONSE]**

[DISPLAY FOR ALL RESPONDENTS]: You have completed the survey and your responses have been submitted. Your contribution to this survey helps Puget Sound Energy to evaluate and improve its program offerings. Thank you for your participation and time.

About DNV

DNV is a global quality assurance and risk management company. Driven by our purpose of safeguarding life, property and the environment, we enable our customers to advance the safety and sustainability of their business. We provide classification, technical assurance, software and independent expert advisory services to the maritime, oil & gas, power and renewables industries. We also provide certification, supply chain and data management services to customers across a wide range of industries. Operating in more than 100 countries, our experts are dedicated to helping customers make the world safer, smarter and greener.

Evaluation Report Response

Program: Smart Thermostats

Program Manager: Holly Mulvenon

Study Report Name: Smart Thermostat Program 2022-2023 Impact and Process Evaluation Final Report

Draft Report Date: December 15, 2023

Evaluation Analyst: Jesse Durst

Date of Final Report Provided to Program Manager: February 1, 2024

Date of Program Manager Response: February 29, 2024

Overview

PSE's Smart Thermostat program provides incentives for residential electric, gas, or combined fuel customers to purchase and install ENERGY STAR® certified thermostats or PSE qualified line voltage connected thermostats (LVCT). Wi-Fi enabled smart thermostats work with existing heating systems to help customers monitor and control the temperature of their homes from anywhere via a mobile app.

The Smart Thermostat program began as a web-enabled pilot program within Q3 and Q4 of 2013 for residential customers that heat primarily with natural gas. The pilot included roughly 1,000 test and 1,000 control homes. PSE launched a wider-scale rebate offering for Smart Thermostats in 2016 and in 2020 added Line Voltage Connected Thermostats to the program.

PSE rebates are offered either post-purchase with an online application or through instant rebates via PSE's online Marketplace platform. Beginning in 2022, instant rebates were also offered through contractors. The program is available to all PSE residential electric and gas customer segments, including Named Community members such as customers with low to moderate incomes.

Evaluation

The Smart Thermostat program evaluation research objectives consisted of impact and process elements. Research objectives for the impact evaluation included an assessment of energy savings, installation verification, building changes, and behavioral/occupancy changes. The process evaluation objectives included measuring participant satisfaction, program awareness, perceived barriers to program participation, and program delivery.

The activities undertaken to fulfill these research objectives included a billing analysis, participant survey and program manager interview:

- **Billing Analysis:** The methodology for determining energy savings consisted of a difference-in-difference billing analysis with a matched comparison group. This approach estimates the impact of the program intervention after controlling for the effects of weather and non-program related changes in energy use.
- **Online Participant Survey:** To verify measure installation and identify building, behavioral and occupancy changes, the evaluation contractor conducted an online survey with a large sample of program participants. The survey also fulfilled process evaluation objectives by focusing on customer participation and decision factors, outcomes and satisfaction with the program, and how behaviors and sentiments might differ between smart thermostat participants and line voltage connected thermostat participants.
- **Program Manager Interview:** Evaluators conducted a program staff interview to identify challenges and opportunities from the perspective of a program administrator. This interview explored recent program changes and future opportunities for program process improvements.

Key Findings

Key findings from the impact and process evaluations include:

- The Smart Thermostats program achieved no statistically significant electric savings impact evaluation and realized only 28% of claimed gas savings. These results are consistent with the previous evaluation of PSE's program year 2017-2018 Web-Enabled Thermostats program, which showed no electric savings and lower than expected gas savings.
- The online survey results show that one in five smart thermostats were not yet installed at the time of the survey. Installation rates were slightly higher for line voltage connected thermostats at 89%. This finding is a contributor to lower than expected savings.
- Results from the participant online survey suggest customers who received a rebate through the Smart Thermostat program are generally satisfied with the program. Ninety percent of respondents are at least somewhat likely to recommend the program to someone they know, and satisfaction with the program overall was rated 4.2 on a 5 point scale. However, participants rated their satisfaction with energy savings since installing the thermostat at 3.9 on a 5-point scale, which suggests that the program is falling short of its primary objective.
- A vast majority of survey respondents (81%) reported that they override their thermostat setpoints at least once a month. In theory, smart thermostats are designed in a way to learn the preferences of customers soon after they are installed and to optimize setpoints after learning these preferences. In practice, customers are overriding setpoints on their thermostats long after this post-installation learning period. This is likely another contributor to lower than expected savings.
- Nearly half of the survey respondents said cost was a primary barrier to purchasing and installing a smart thermostat.

- Over half of the survey respondents said installing the thermostat was a primary or secondary barrier to using a smart thermostat.

Recommendations

Recommendation

Savings assumptions for smart thermostats in single family homes in the Regional Technical Forum's (RTF) workbooks are too high. Evaluations in different regions across the country have shown lower than expected savings for smart thermostats over the past decade. PSE should work with staff responsible for overseeing the RTF smart thermostat savings assumptions and encourage a deeper review in subsequent RTF workbook revisions.

PSE Response

PSE will submit the results of the Smart Thermostat Program 2022-2023 Impact and Process Evaluation to the RTF and encourage them to review the Connected Thermostats and Residential Line Voltage Thermostats workbooks.

Recommendation

PSE should re-evaluate whether to continue providing incentives for smart thermostats for the purposes of energy efficiency and reducing energy consumption given that evaluations have consistently shown lower than expected savings. However, smart thermostats have proven effective in the context of demand response programs. PSE should continue to assess the peak demand impacts associated with incentivizing smart thermostats for energy curtailment during demand response events through PSE's Flex programs.

PSE Response

As long as the RTF continues to offer unit energy savings (UES) measures for smart thermostats and they remain cost effective, PSE will offer a Smart Thermostat rebate program through our residential energy efficiency programs. PSE recently launched a demand response program and uses cross marketing to promote the DR program to smart thermostat rebate recipients. Should the RTF no longer support smart thermostats as an effective energy conservation measure, PSE will transition the program to be solely a Demand Response program offering.

Recommendation

Dissatisfaction with energy savings since installing the thermostat could be attributed to recent rate increases for kWh and therms in PSE service territory, as well as the fact that thermostats are not achieving as much energy savings as expected. This provides PSE with an opportunity to integrate non-energy benefits more explicitly into marketing materials. PSE could emphasize the convenience of setting the thermostat while away from the home, while also explaining that increasing setpoints to improve comfort could lead to higher energy bills.

PSE Response

PSE implemented a similar evaluator recommendation from its previous program evaluation. PSE sends follow up emails quarterly to all thermostat rebate recipients, promoting the non-energy benefits of smart thermostats, including comfort and convenience features. The emails also list best practices for higher savings with thermostats and advise customers about the energy benefits of lower set points. PSE is open to future suggestions about how to improve messaging.

Recommendation

Since so many participants are facing the barrier of installing the thermostat themselves, PSE may consider following up with customers at some interval after they purchase the smart thermostats (e.g., 4 to 6 weeks after) and asking customers if they have installed the thermostat yet. If not, PSE can provide a list or link to qualified contractors to assist with installation.

PSE Response

PSE will take DNV's recommendation into consideration. PSE sends follow up emails quarterly to all thermostat rebate recipients, listing best practices for higher savings with their thermostat. PSE will consider improvements, which may include adding PSE Trade Ally Network contractor information and referral links into the emails as an additional follow-up.