Portland General Electric Company
121 SW Salmon Street • 1WTC0306 • Portland, OR 97204
portlandgeneral.com

September 11, 2020

Via Electronic Filing

Public Utility Commission of Oregon
Attention: Filing Center
P.O. Box 1088
Salem, OR 97308-1088

Re: UM 1708: Cadmus' Evaluations of PGE's Residential Smart Thermostat program Winter 2018/2019 and Summer 2019 for the BYOT and Direct Installation Channels

Dear Filing Center:

Enclosed are evaluations of Portland General Electric Company's (PGE's) Direct Load Control Thermostat Pilot (DLCT) for the Winter 2018-2019 and Summer 2019 seasons. PGE contracted with a third-party evaluator, Cadmus, to evaluate the load impacts and customer satisfaction associated with the DLCT Pilot and identify areas for improvement. Cadmus evaluated and submitted reports for both the Bring-Your-Own-Thermostat (BYOT) and the Direct Install (DI) channels of the DLCT Pilot. These offerings are tariffed in PGE's Schedule 5.

Key load impact findings:
Cadmus's evaluation found that by the end of the Summer 2019 season, PGE had acquired approximately 3.7 MW of winter and 15.2 MW of summer demand response capacity from the combined DI and BYOT channels.

Both channels provided approximately the same demand response capacity per participant in the summer. For the winter season, Cadmus identified that 700 non-electric heat customers had been mistakenly enrolled via the BYOT channel. As a result, the demand capacity per participant for winter season BYOT was less than DI. Prior to the Winter 2019-2020 season, the non-electric heat customers Cadmus identified were correctly enrolled in summer season or unenrolled from the program.

Some key recommendations from the Cadmus evaluations

- Improve screening and validation of customers' HVAC system to prevent future participants without electric-heating systems from participating in winter.
    - **Update:** After the winter 2018/2019 season, PGE shifted to summer season or unenrolled customers Cadmus identified as not having electric-heating systems. PGE no longer relies on heating and cooling data provided to the DRMS provider via the thermostat manufacturer and now uses multiple sources of heating and cooling data to determine each customer's eligibility.

- Conduct a propensity assessment or load disaggregation study to identify customer heating fuel (or more broadly HVAC configuration, including cooling).
    - **Update:** In partnership with the Smart Grid Test Bed Pilot, the DLCT Pilot is evaluating internal and external partners to perform this work.
- Work with the demand response service providers to implement Intelligent Demand Response (IDR) strategies that may be able to reduce savings degradation across event hours.
    - **Update:** As of summer 2020, all thermostat brands in the Pilot incorporate IDR strategies into the thermostat settings the customer selects.

Key customer experience findings: PGE's DLCT Pilot customer satisfaction ratings were high in both seasons and across both BYOT and DI channels. Overall average ratings were 8 or greater on a 10-point scale.

Some key recommendations from the Cadmus evaluations:

- Conduct research on the relationship between customer comfort during events and event overrides.
    - **Update:** In January 2020, PGE interviewed DI customers that did not participate in events. Based on these results, PGE has increased education for customers on how to successfully participate and maintain comfort. Examples include seasonal emails, website information, and enhanced installation "leave behind" materials.
- Provide BYOT customers with their event participation history.
    - **Update:** PGE is evaluating the information technology changes required to access their event participation history.

PGE is continuing to work with Cadmus to further refine the evaluation methodology for assessing impact. Areas of focus are inclusivity of hour by hour analysis (vs. averaging) for load impact and refinement of weather correlation.

If you have any questions or require further information, please call Santiago Laborde at (503) 464-7902. Please direct all formal correspondence or requests to the following e-mail address pge.opuc.filings@pgn.com.

Sincerely,

/s/ Robert Macfarlane
Manager, Pricing and Tariffs

RM/np
Enclosure
Cc: UM 1708 Service list
Kacia Brockman, OPUC

Bring-Your-Own Smart Thermostat Demand Response Pilot Program

DRAFT EVALUATION REPORT

September 9, 2020

Prepared for:

Portland General Electric

121 SW Salmon Street

Portland, OR 97204

CADMUS

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Acronyms, Terms, and Definitions

Acronym/Term	Definition
AMI	Advanced metering infrastructure
BYOT	Bring-your-own thermostat
Control Group	Control group refers to BYOT participants randomly assigned *not* to receive the thermostat control signals during demand response events. The electricity demand of the control group provided a baseline for measuring the demand response event impacts. Program participants were randomly assigned to the evaluation test or control groups at the beginning of each season.
HVAC	Heating, ventilation, and air conditioning
IDR	Intelligent Demand Response
ITT	Intent to treat treatment effect – the average impact per home (or other relevant unit of analysis) for homes that the program intends to treat
kW	Kilowatt
kWh	Kilowatt-hour
MW	Megawatt
MWa	Average Megawatt
NOAA	National Oceanic and Atmospheric Administration
OLS	Ordinary least squares
OEM	Original equipment manufacturer
PGE	Portland General Electric
RCT	Randomized controlled trial
Test Group	Test group refers to participants who were randomly assigned to receive the thermostat control signals during demand response events. Program participants were randomly assigned to the evaluation test or control groups at the beginning of each season.
TOT	Treatment effect on the treated – the average impact per treated home

Executive Summary

The 2019 Integrated Resource Plan calls for PGE to engage its customers with new technologies and programs, decarbonize its energy supply, and maintain system reliability.[1] Smart thermostat demand response can help PGE achieve these goals by providing an unobtrusive means for the utility to engage customers in managing their electricity demand, to support the planned integration of 150 MWa of renewable resources by 2023, and to provide new flexible loads and reliability services.[2]

PGE's Smart Thermostat Demand Response pilot program enables the direct management of residential customer summer and winter peak electricity demand. Through demand response service providers (also known as aggregators), PGE can control the cooling and heating loads of thousands of participating customers by remotely adjusting the setpoints of their smart thermostats.

Customers who own a smart thermostat can participate in the pilot program through the Bring-Your-Own Thermostat (BYOT) track.[3] Participating customers receive a check after the heating and cooling seasons. In 2015, PGE launched the BYOT track of the Smart Thermostat Demand Response pilot program with Nest's Rush Hour Rewards program service. PGE then expanded the BYOT track in 2017 to include ecobee and Honeywell smart thermostats with Resideo's Connected Savings program service.[4]

At the end of summer 2019 event season, PGE had enrolled approximately 13,777 summer-eligible and 2,516 winter-eligible participants in the BYOT track, including 2,287 participants eligible for both heating and cooling seasons.[5] Using this evaluation's estimates of per participant demand savings for summer and winter, PGE possesses approximately 0.9 MW of winter demand response capacity and 12.3 MW of summer demand response capacity from BYOT.[6]

This evaluation focuses on the BYOT track, comparing the Rush Hour Rewards and Connected Savings program services. PGE initiated six load control events in winter 2018/2019 and six in summer 2019. Through meter data analysis, interviews with program staff, customer surveys, and a logic model review,

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1 Portland General Electric. July 19, 2019. *2019 Integrated Resource Plan*. Available at: https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning

2 According to the IRP, PGE plans to add 211 MW of demand response capacity in summer and 141 MW in winter by 2025.

3 Customers who do not have or cannot afford a smart thermostat can participate through the Direct Install track.

4 Whisker Labs previously operated Connected Savings. Resideo acquired Whisker Labs in May 2019.

5 Total participant count is less than the sum of summer and winter eligible participants because some participants are eligible for both seasons.

6 For this calculation, Cadmus used the average demand savings per enrolled thermostat across all event hours for each season (0.36 kW in 2018/2019 winter and 0.89 kW in 2019 summer).

the evaluation assessed the load impacts, program implementation, and customer experience. The evaluation covered these objectives:

- Estimate the average kilowatt impact per participant before, during, and after the load control events
- Assess the impact of events on customer comfort
- Assess the impacts of participation on customer satisfaction with the program and PGE
- Compare load impacts, customer comfort, and satisfaction between Rush Hour Rewards Nest thermostat impacts and to Connected Savings thermostat brands
- Identify opportunities for improving program marketing, customer recruitment, program performance, cost-effectiveness, and customer satisfaction

Key Findings

Table 1 presents the event demand savings and customer satisfaction findings from the evaluation for winter 2018/2019 and summer 2019. In winter, the average savings per participant ranged between 0.34 kW and 0.46 kW depending on the program and time of day for the event, and customer satisfaction ranged between 85% and 92%, depending on the program. In summer, the average savings per participant ranged between 0.80 kW and 0.89 kW and customer satisfaction ranged between 88% and 94% depending on the program.

In addition, Table 1 shows the average demand savings per participant for demand response events with weather conditions similar to those when PGE might need to dispatch residential smart thermostats as a demand response resource to meet future peak demand. These “peak events” had average event hour temperatures greater than or equal to 96°F in summer or less than or equal to 34°F in winter. In winter, the peak event demand savings ranged between 0.31 kW and 0.50 kW per participant. In summer, the peak event demand savings ranged between 0.88 kW and 1.01 kW per participant.

The bottom half of Table 1 shows estimates of participant savings and satisfaction by the brand of thermostat. Since the Rush Hour Rewards program only enrolled Nest thermostats, the Rush Hour Rewards results in the top half of Table 1 and Nest results are identical.

Table 1. Key Findings from BYOT Smart Thermostat Demand Response Pilot Program Evaluation

	Winter 2018/2019						Summer 2019				
	kW Savings*				Satisfaction**		kW Savings*			Satisfaction**	
	Planning	Evaluation			Satisfied (6-10)	Delighted (9-10)	Planning	Evaluation		Satisfied (6-10)	Delighted (9-10)
		Morning	Afternoon	Peak Event kW***				Afternoon	Peak Event kW***		
By Program											
Rush Hour Rewards	1	**0.34**	**0.37**	**0.31**	92%	64%	0.8	**0.89**	**0.88**	94%	62%
Connected Savings	1	**0.37**	**0.46**	**0.50**	85%	58%	0.8	**0.80**	**1.01**	88%	56%
By Thermostat Brand											
Nest	1	**0.34**	**0.37**	**0.31**	92%	64%	0.8	**0.89**	**0.88**	94%	62%
ecobee	1	**0.95**	**0.77**	**0.83**	85%	58%	0.8	**1.15^**	**1.18**	91%	58%
Honeywell	1	**0.15**	**0.34**	**0.37**	84%	58%	0.8	**0.74**	**0.79**	86%	55%

*Savings values reflect the average kW demand reduction per participant during events; **blue** font indicates significance at the 5% level for these estimates.

** Satisfaction values reflect the percentage of survey respondents who rated their program satisfaction on a 0 to 10 rating scale.

*** Peak event savings were the average kW for events with average temperatures greater than or equal to 96°F in summer (n=2) or less than or equal 34°F in winter (n=3).

^ Includes dispatch failure during event 3, reducing savings. Excluding this event, ecobee thermostats saved 1.12 kW.

Conclusions and Recommendations

Based on the evaluation findings, Cadmus came to the following conclusions and recommendations.

Load Impacts

The BYOT track of the pilot program reduced peak electricity demand from residential space heating in winter and air conditioning in summer.

In winter 2018/2019, Rush Hour Rewards achieved average demand savings per participant of 0.34 kW (20% of baseline demand) for morning events and 0.37 kW (14%) for afternoon events.[7] Connected Savings achieved average savings per participant of 0.37 kW (17%) during morning events and 0.46 kW (17%) during afternoon events.

[7] Baseline demand refers to the energy demand that would have occurred in absence of the event. Baseline demand is measured at the whole house level using the demand of customers from the randomized control group. These are customers who did not experience load control event, and thus provide a baseline for what energy demand would have been.

In summer 2019, Rush Hour Rewards achieved average demand savings per participant of 0.89 kW (36%) during events. Connected Savings achieved average demand savings per participant of 0.80 kW (28%).

BYOT met PGE's planning value for demand savings for summer but not for winter.

PGE has a winter demand response planned savings value of 1.0 kW per participant for Rush Hour Rewards and Connected Savings. The winter 2018/2019 demand savings of both program services fell below this value. PGE also has a summer demand response planning value of 0.8 kW per participant. Rush Hour Rewards (0.89 kW) and Connected Savings (0.80 kW) exceeded or met this planning goal.

Rush Hour Rewards' demand savings were less in winter 2018/2019 than previous winters because electricity was not the primary heating fuel for many Rush Hour Rewards participants.

In winter 2017/2018, Rush Hour Rewards achieved average demand savings per participant of 0.6 kW for afternoon events. For winter 2018/2019, Rush Hour Rewards afternoon events averaged 0.37 kW because the program's change in enrollment screening resulted in an increase of participants who did not have electric heating, as Cadmus' analysis strongly suggests. Non-electric heating participants provided close to zero demand savings and reduced the average demand savings for the program. Cadmus did not identify a similar problem of enrolling non-electric heat customers for Connected Savings during this period; however, enrollment of non-electric heating customers was an issue identified in the initial season of piloting (Winter 2017/2018), which PGE and its implementer have worked to address. Winter 2018/2019 was the first evaluated season for Connected Savings.

Savings degraded significantly across event hours for Rush Hour Rewards and Connected Savings.

In general, demand savings reached a maximum in the first event hour and a minimum in the last event hour. For example, in winter 2018/2019, Rush Hour Rewards average demand savings per participant decreased by 28% between the first and third hours of afternoon events. In summer 2019, Connected Savings demand savings decreased by 56% between the first and third hours of events. PGE operations and planning managers relying on demand response resources should be aware of this degradation and that the average event savings understate the available capacity during the first event hour and overstate capacity during the last event hour. There may be opportunities for PGE to work with its demand response service providers to optimize event dispatch and control algorithms to better meet its capacity needs.

Demand increased before and after events, but this increase did not cause overall energy consumption to go up on event days.

Pre-conditioning of participant homes before events and post-event snapback increased participant demand for electricity above normal levels before and after events.[8] In winter 2018/2019, Rush Hour Rewards participant loads increased by an average of 0.28 to 0.36 kW (14% to 18%) before events and 0.29 kW to 0.41 kW (12% to 26%) after events. Connected Savings participant loads increased by an average of 0.02 kW to 0.52 kW (1% to 22%) before events and 0.40-0.43 kW (16% to 21%) after events.

In summer 2019, Rush Hour Rewards participant loads increased by an average of 0.37 kW to 0.54 kW (16% to 27%) before events and 0.19 kW to 0.44 kW (8% to 17%) after events. Connected Savings participant loads increased by an average of 0.15 kW to 0.30 kW (6% to 14%) before events and 0.15 kW to 0.23 kW (5% to 8%) after events.

PGE operations and planning managers should be aware of this increase in demand before and after events. However, pre-conditioning and snapback did not lead to a statistically significant increase in energy consumption on event days. The increase in energy consumption from pre-conditioning and snapback was offset by the decrease in energy consumption during events.

Demand savings varied between events and were more strongly correlated with outdoor temperature in summer.

For the five afternoon events in winter 2018/2019, first hour savings ranged from 0.29 kW to 0.52 kW per participant for Rush Hour Rewards and 0.34 and 0.74 per participants for Connected Savings. The range of event hour temperatures was narrow, and the savings were not strongly correlated with outdoor temperature. The temperature-savings relationship may have been muted by the inclusion of non-electric heat customers in Rush Hour Rewards. In summer, the savings exhibited less variability across events. For the summer events, first hour savings ranged narrowly from 0.94 kW to 1.12 kW per participant for Rush Hour Rewards and slightly more widely from 0.73 kW to 1.38 kW per participant for Connected Savings.[9] The coefficient of variation of first-hour savings (the ratio of the standard deviation to the mean) was 0.06 for Rush Hour Rewards and 0.22 for Connected Savings. Summer savings were more strongly correlated with outdoor temperature.

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[8] Pre-conditioning refers to the increase in heating or cooling that is scheduled for thermostats prior to a load control event. The amount of pre-conditioning varied by thermostat brand, including a variable 1°F to 3°F increase for Nest devices, a flat 2°F increase for Honeywell devices, and no pre-conditioning for ecobee devices.

[9] These estimates exclude impacts from event 3, when a dispatch failure affecting ecobee thermostats occurred.

In summer, PGE can expect the same demand savings per participant from Rush Hour Rewards and Connected Savings participants.

There were no statistically significant differences in savings between Rush Hour Rewards (0.89 kW per participant) and Connected Savings (0.80 kW). In winter, there were also no statistically significant differences in savings per participant between Rush Hour Rewards and Connected Savings, but the comparison is complicated by the inclusion in Rush Hour Rewards of customers who did not heat with electricity.

Ecobee thermostats delivered the highest demand savings.

In winter, Connected Savings participants with ecobee thermostats averaged demand savings per participant of 0.81 kW. These savings were approximately 0.5 kW greater than those from participants with Nest and Honeywell thermostats, though the inclusion of non-electric heat customers in the Rush Hour Rewards program complicates the comparison and should be kept in mind.

In summer, Connected Savings participants with ecobee thermostats averaged demand savings per participant of 1.1 kW, when excluding event 3, in which ecobee thermostats failed to dispatch due to a server interruption. These savings were between 0.2 kW to 0.35 kW greater than those of the other brands, and this difference was statistically significant. Though ecobee thermostats had the highest demand savings, it is unclear if this difference indicates that ecobee thermostats provided superior demand response performance or if customers who selected ecobee thermostats had homes with greater demand response capacity.

The BYOT pilot program moved PGE closer to reaching its demand response capacity targets from residential smart thermostats by 2021.

At the end of the summer 2019 event season, PGE had enrolled approximately 13,377 summer-eligible and 2,516 winter-eligible participants in the BYOT track, including 2,287 participants eligible for both heating and cooling seasons.. Using this evaluation's estimates of per participant demand savings for summer and winter, PGE possesses approximately 0.9 MW of winter demand response capacity and 12.3 MW of summer demand response capacity from BYOT.[10]

[10] For this calculation, Cadmus used the average demand savings per enrolled thermostat across all event hours for each season (0.36 kW in 2018/2019 winter and 0.89 kW in 2019 summer). Though we used this straightforward average, Cadmus recognizes that demand response resources have many attributes and can be used in different ways. Demand response capacity can be calculated for events that are triggered for specific outside temperatures, PGE system load, or market condition thresholds, for subpopulations, or at different durations and dispatch times. PGE's demand response capacity would depend on it plans to use this capacity.

Load Impact Recommendations

- Improve screening and validation of customers' HVAC system, especially for winter participation, to prevent future participants without electric-heating systems from participating in winter.
- Conduct a propensity assessment or load disaggregation study to identify customer heating fuel (or more broadly HVAC configuration, including cooling). This will serve to identify customers with non-electric heat whom PGE can screen out of the program and support future direct marketing efforts to increase summer and winter enrollments (for those customers with complementary heating and cooling systems).
- Work with the demand response service providers to implement Intelligent Demand Response (IDR) strategies that may be able to reduce the savings degradation across event hours.
- Conduct research to determine if the higher demand savings of ecobee thermostats are due to customer attributes such as home size, HVAC system type, customer behaviors, such as overriding events, or superior demand response service performance.

Customer Experience

Assessment of the customer experience was undertaken primarily through analysis of survey responses.[11]

The BYOT track of the pilot program achieved high levels of customer satisfaction and positive customer experience.

As shown in Table 1 above, 92% (n=188) of test group survey respondents in winter and 94% (n=229) of test group survey respondents in summer said they were satisfied with Rush Hour Rewards. For Connected Savings, 85% (n=64) of respondents in winter and 88% (n=180) of respondents in summer were satisfied with the program. Customer satisfaction with the incentive, smart thermostat, and PGE were consistently high across both programs and seasons. Rush Hour Rewards' customer satisfaction ranged from 86% (n=227) in winter to 87% (n=186) in summer for the incentive, from 97% (n=226) in winter to 99% (n=185) in summer for the smart thermostat, and from 92% (n=188) in winter to 94% (n=229) in summer for PGE. Connected Savings' customer satisfaction ranged from 87% (n=64) in winter to 89% (n=176) in summer for the incentive, from 91% (n=63) in winter to 95% (n=181) summer for the smart thermostat, and from 85% (n=64) in winter to 88% (n=180) in summer for PGE. Test group respondents in both programs and both seasons said in their open-end comments that the program

[11] Sample sizes ranged from 100 to 400 completes per survey, with response rates between 23% and 32%. Additional detail regarding survey design and sample sizes can be found in the *Evaluation Findings* and *Customer Surveys* sections of this report.

works well, it helps the environment/community save energy, and respondents like receiving the incentives.

Most customers reported noticing demand response events but remembered fewer than PGE called.

Most Rush Hour Rewards (70%, n=193, in winter and 68%, n=231, in summer) and Connected Savings (61%, n=64, in winter and 63%, n=186, in summer) respondents reported noticing one or more events. Customers reported noticing fewer events than PGE called (six events). During winter, Rush Hour Rewards respondents perceived, on average, more events (5.4, n=136) on average than Connected Savings respondents (4.3 events, n=39), likely due to Nest sending out pre-event notifications. Likewise, during summer, Rush Hour Rewards respondents perceived, on average, more events (4.2, n=156) than Connected Saving's respondents (4.0 events, n=118); however, this difference was not statistically significant. For Nest customers, high awareness indicates that the notifications were having their intended effect and that customers were engaged. For Connected Savings customers, who did not receive notifications, high awareness may indicate high engagement with the program or that some customers noticed temperature drift in their homes.

Customers perceived a change in comfort during the events, and many overrode at least one event. More research on the relationship between customer comfort and event overrides is needed to understand their implications for demand savings.

During winter, 33% of Rush Hour Rewards test group respondents (n=189) and 48% of Connected Savings test group respondents (n=63) reported that they overrode at least one of the events. During summer, 33% of Rush Hour Rewards test group respondents (n=224) and 41% of Connected Savings test group respondents (n=180) reported that they overrode at least one of the events. Rush Hour Rewards respondents who reported overriding the events most frequently cited thermal discomfort as their reason in winter (83%, n=60) and summer (74%, n=74). Similarly, Connected Savings respondents who reported overriding the events most frequently cited thermal discomfort as their reason in the winter (87%, n=31) and summer (75%, n=48). The evaluation did not have thermostat telemetry data to further assess customers' override behavior in relation to their reported comfort.

When recalling their comfort before the winter events, 94% of Rush Hour Rewards (n=162) and 94% of Connected Savings respondents (n=51) said their home's interior temperature was comfortable. When recalling their comfort level during the winter events, 86% of Rush Hour Rewards (n=179) and 80% of Connected Savings respondents (n=55) said they were comfortable; these were statistically significant decreases of 8 and 14 points compared to the comfort level before events. In the summer, 90% of Rush Hour Rewards (n=182) and 92% of Connected Savings respondents (n=145) said their home's interior temperature was comfortable before the events. When recalling their comfort level during the summer events, 74% of Rush Hour Rewards (n=210) and 67% of Connected Savings respondents (n=159) said they were comfortable; these were statistically significant decreases of 16 and 25 points compared to the comfort level before events.

Some BYOT customers want a way to check their event participation history.

In open-end comments, survey respondents asked for a way to check their event participation history. Connected Savings experience survey test group respondents mentioned this suggestion 16 times (three in winter and 13 in summer) and Rush Hour Rewards' test group respondents mentioned it 17 times (nine in winter and eight in summer). Though these mentions may seem few, it should be noted PGE does not currently provide customers a way to check their event participation history to determine if they are on track to earn their incentive check; PGE is considering this for the future. In contrast, PGE offers an event participation history to customers in the Peak Time Rebates program. Should participants in the Peak Time Rebates enroll in the Smart Thermostat program, PGE could consider extending this approach and providing all customers with feedback about their event participation.

Customer Experience Recommendations

- Conduct research on the relationship between customer comfort during events and event overrides. Understanding customers' event override behaviors will be critical in understanding the stability and predictability of demand savings from smart thermostats.
- Provide customers their event participation history. For example, PGE could offer an event participation history webpage similar to the one for Peak Time Rebates where customers can check their history at any time and track their progress toward the $25 incentive.

Implementation

Although PGE improved its ability to target program marketing by customer HVAC system type, some customers with non-electric heating were mistakenly enrolled and participated in the winter season.

In previous years, PGE had little to no data on customers' HVAC system to use for BYOT targeted marketing. Now, PGE has several sources of data to identify and target eligible customers. These sources include data from Energy Trust of Oregon, purchased data from a third-party, and data from heat pump contractors. During the device registration or enrollment process, Nest and Resideo required customers to answer questions about their HVAC system and Resideo also checked run-time data to gauge the accuracy of customer self-reports of their HVAC system. Despite the availability of better HVAC data and HVAC confirmation questions, Cadmus' analysis strongly suggests that some non-electric heating customers got in and, as a result, reduced the average winter demand savings for the program.

PGE encountered event implementation issues during the summer season, which adversely impacted customer comfort.

Rush Hour Rewards did not run into any event-related issues during summer 2019. On the other hand, Connected Savings ran into two issues. First was an online service disruption on July 26 (event 3), which prevented PGE from dispatching ecobee thermostats and reduced the realized demand savings. Second was a software glitch with the temperature setback where some ecobee thermostats received a setback greater than three degrees. These ecobee issues reduced demand savings during Event 3 and may have adversely impacted customer comfort during the summer events as a statistically significant difference

in the proportion of ecobee respondents (62%) than Nest (74%) and Honeywell (74%) respondents reported feeling lower comfort during the events.

PGE's enrollment in residential smart thermostat programs equals 87% of enrollment goal for the pilot program.

PGE fell short of its combined BYOT and Direct Install 24,000 thermostat enrollment goal by the end of 2019. The BYOT pilot program and the Direct Install pilot program enrolled a total of 20,805 thermostats, 16,005 of which were from BYOT. PGE is expected to receive a BYOT Connected Savings enrollment boost in 2020 when ecobee roll-outs its new platform, which will make it easier for customers with an ecobee to discover their utilities' demand response and energy efficiency programs. Through this new platform launch, PGE expects to enroll an additional 3,000 customers in BYOT Connected Savings, which will bring PGE very close to meeting its overall pilot program enrollment goal.

Implementation Recommendations

- Improve screening and validation of customers' HVAC system, especially for winter participation.
- Review with program service providers the protocols for when operational issues occur so PGE can handle potential ramifications and make any course corrections.
- In addition to current program promotion through Energy Trust of Oregon's residential programs, consider partnering with local retailers and installation contractors to promote the program to customers. These partnerships may not only increase program enrollment but also help customers confirm whether their HVAC system meets the program eligibility requirements.

Future of Smart Thermostats as a Demand Response Resource

PGE has piloted smart thermostat demand response programs since 2015 and has recently been considering how to fully operationalize these programs as a peak capacity and other grid services resource. To operationalize thermostats as a resource, PGE power operators must have knowledge about the resource characteristics (e.g., ramping rate, capacity by 15 minute or hour intervals) and confidence that the resource will perform when called upon.

This evaluation cannot fully address questions regarding operational readiness because of several factors, including: the relatively small number of summer 2019 events (6) and winter 2019/2020 events (6); the limited number of event days with extreme temperatures; the analysis of one hour interval data instead of 15 minute interval data; and limitations in knowledge about how customers are interacting with the thermostats during events (such as the frequency with and conditions under which participants were overriding events).

Future Research to Support Use

- In the future, PGE should conduct additional research to advance the goal of operationalizing smart thermostats as demand response resources. Specifically, this research should:
    - Analyze 15-minute interval consumption data to better understand ramping of savings during the first even hour, degradation of savings across event hours, and snapback after the event ends
    - Analyze thermostat telemetry data to determine the frequency of and impacts on demand savings from participants overriding the thermostat settings during demand response events.
    - Estimate hourly demand response impacts as a function of outside temperature using data from multiple seasons to characterize definitively the demand savings that PGE can expect when it needs to dispatch residential smart thermostat demand response as a resource to meet peak demand.

Introduction

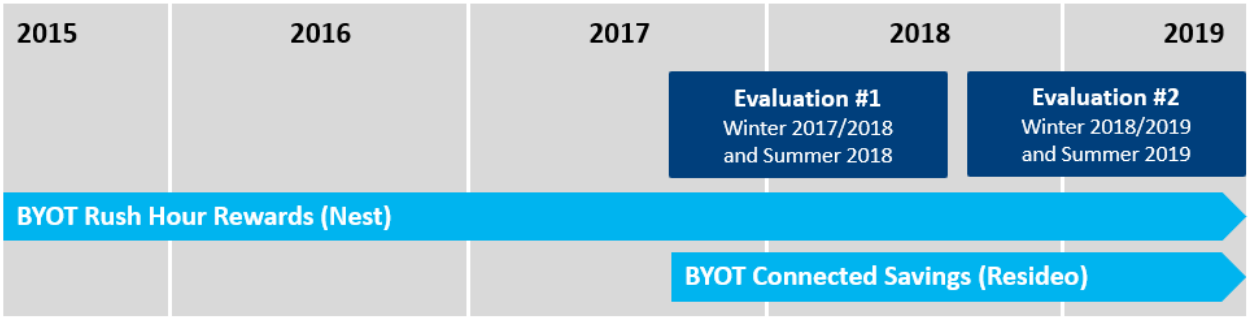
The 2019 Integrated Resource Plan calls for PGE to engage its customers with new technologies and programs, decarbonize its energy supply, and maintain system reliability.[12] Smart thermostat demand response can help PGE achieve these goals by providing an unobtrusive means for the utility to engage customers in managing their electricity demand, to support the planned integration of 150 MWa of renewable resources by 2023, and to provide new system capacity and reliability services.[13]

PGE's Smart Thermostat Demand Response pilot program enables the direct management of residential customer summer and winter peak electricity demand. Through demand response service providers (also known as aggregators), PGE can control the cooling and heating loads of thousands of participating customers by remotely adjusting the setpoints of their smart thermostats.

In 2015, PGE partnered with Nest and began enrolling customers in its Rush Hour Rewards program, enrolling customers who already owned a Nest smart thermostat. Then in 2017, PGE expanded the Bring-Your-Own Thermostat (BYOT) track by partnering with Whisker Labs (now Resideo) and began enrolling customers in its Connected Savings program, enrolling customers who already owned an ecobee or Honeywell smart thermostat.[14]

During the implementation of the two BYOT pilot programs, Rush Hour Rewards and Connected Savings, Cadmus conducted two evaluations of each program for the winter and summer seasons (Figure 1).

Figure 1. Timeline of BYOT Pilot Programs and Evaluations



First, Cadmus evaluated the two BYOT pilot programs for the winter 2017/2018 and summer 2018 event seasons. Through meter data analysis, interviews with PGE and implementation program managers, and online customer surveys, the evaluation team assessed the load impacts, program implementation, and

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[12] Portland General Electric. July 19, 2019. *2019 Integrated Resource Plan*. Available at: https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning

[13] According to the IRP, PGE plans to add 211 MW of demand response capacity in summer and 141 MW in winter by 2025.

[14] Resideo acquired Whisker Labs in May 2019.

customer experience. Table 2 and Table 3 summarize the conclusions and recommendations from this first BYOT evaluation.

Table 2. Conclusions and Recommendations from First BYOT Evaluation: Rush Hour Rewards Winter 2017/2018 and Summer 2018

Conclusions	Recommendations
Load Impacts	
Rush Hour Rewards reduced peak electricity demand from residential air conditioning and space heating.	• Continue recruiting customers for BYOT Rush Hour Rewards, provided it represents a cost-effective resource. • Continue to test IDR control algorithms to maintain a constant level of demand savings and to avoid degradation of savings across event hours. • Coordinate internally to ensure well-defined objectives, design, and key metrics of event dispatch that align goals of program delivery and capacity planning teams. ***STATUS UPDATE**: PGE continued recruitment, and increased IDR event testing.*
Demand savings degraded across event hours.	
Rush Hour Rewards load control events increased customer loads before and after events but did not result in a negative conservation effect.	
Rush Hour Rewards moved PGE closer to reaching its demand response capacity targets from residential smart thermostats by 2021. In summer, PGE can expect the same demand savings per customer from Connected Savings and Rush Hour Rewards participants.	
Customer Experience	
Rush Hour Rewards delivered a positive customer experience and achieved high customer satisfaction.	• Work with Nest to send Rush Hour Rewards participants reminders about the ability to adjust the event notification settings. PGE can send out the reminder via email, and Nest can send the reminder through the smartphone app. ***STATUS UPDATE**: Nest and PGE did not send out reminders to participants about the event notification settings.*
The load control events did not adversely affect comfort for the majority of customers.	
Sending a pre-event notification makes the events more noticeable for customers.	
A wider-range temperature setback instead of a one-size-fits-all temperature setback may make for a more comfortable event experience.	
PGE incurs a small decrement to customer satisfaction when smart thermostats are controlled.	
Implementation	
The program's maturity has minimized implementation challenges.	• Consider having Nest take the lead on marketing the program to customers, using its large market reach and frequent, targeted marketing approach. Having Nest take the lead on Rush Hour Rewards' marketing would allow PGE to take the lead on marketing Connected Savings. ***STATUS UPDATE**: Nest continued to lead the marketing for Rush Hour Rewards and PGE continued to do marketing to increase enrollment.*
Nest's strong market presence and more frequent marketing likely enabled Rush Hour Rewards to increase enrollments.	
Targeted marketing was possible for Rush Hour Rewards because the smart thermostat manufacturer and the demand response service provider were the same party.	

Table 3. Conclusions and Recommendations from First BYOT Evaluation: Connected Savings Winter 2017/2018 and Summer 2018

Conclusions	Recommendations
Load Impacts	

Conclusions	Recommendations
Connected Savings achieved the expected summer capacity savings of 0.8 kW per participant. [15]	• Continue recruiting customers for BYOT Connects Savings, provided it represents a cost-effective resource. • Continue to test IDR control algorithms to maintain a constant level of demand savings and to avoid degradation of savings across event hours. • Coordinate internally to ensure well-defined objectives, design, and key metrics of event dispatch that align goals of program delivery and capacity planning teams. • Work with the program implementer to improve the approach to validating customer heating system type and HVAC configuration. ***STATUS UPDATE***: *PGE continued recruitment, and increased IDR event testing. Resideo continues to run checks on customers' self-reported HVAC system (i.e., a non-electric heating home reported having an electric heating system).*
Degradation of savings occurred across event hours.	
Connected Savings load control events increased customer loads before and after events but did not result in a negative conservation effect.	
Connected Savings moved PGE closer to reaching its demand response capacity targets from residential smart thermostats by 2021. In summer, PGE can expect the same demand savings per customer from Connected Savings and Rush Hour Rewards participants.	
Customer Experience	
Connected Savings delivered a positive customer experience and achieved high customer satisfaction.	• Consider giving Connected Savings participants the option to receive pre-event notifications. Giving customers this option may further enhance customer satisfaction and would be responsive to the feedback of some customers. However, PGE should also weigh the costs of providing advance notifications, which could include lowered event participation, smaller savings, and reduced customer satisfaction. ***STATUS UPDATE***: *PGE did not provide pre-event notifications to Connected Savings participants.*
The load control events did not adversely affect comfort for the majority of customers.	
Not sending a pre-event notification makes the events less noticeable for customers.	
A wider-range temperature setback instead of a one-size-fits-all temperature setback may make for a more comfortable event experience.	
PGE incurs a small decrement to customer satisfaction when smart thermostats are controlled.	
Implementation	
The lack of existing data on customers' smart thermostats and HVAC systems resulted in program marketing and recruitment challenges.	• Consider taking on a greater lead role on mass marketing Connected Savings to customers via email and direct mail, rather than relying on the manufacturers. • Increase marketing efforts specifically at the point of sale or point of installation such as partnering with local retailers and installation contractors, and offering an online marketplace.
The average delay between when a customer installs a smart thermostat and when the customer enrolls in the program suggests an opportunity to accelerate enrollment.	
PGE's own marketing efforts engaged customers more than marketing efforts from the smart thermostat manufacturers.	
Customer education is needed about the connection of demand response to smart thermostats.	

[15] Cadmus did not evaluate the load impacts for Connected Savings in winter 2017/2018. Several issues prevented the impact analysis for this season. One issue was that control group customers experienced load control events. Another issue was that a large number of customers who did not have electric heat were included in the winter 2017/2018 season, and these customers could not be reliably identified after an event.

Conclusions	Recommendations
	• Develop educational content that emphasizes the smart thermostat's connection to demand response. Rather than using words to explain, consider presenting engaging visuals such as an infographic flowchart or a short video that clearly illustrates the relationship. ***STATUS UPDATE**: PGE increased its BYOT marketing efforts (Rush Hour Rewards and Connected Savings) to increase enrollment as part of the Test Bed Pilot. PGE's Test Bed Pilot marketing team collaborated with PGE's Smart Thermostat marketing team on ways to accelerate enrollment by utilizing a customer value proposition messaging approach.*

For this second BYOT program evaluation, Cadmus assessed the program's design and delivery, load impacts, and customer experiences for winter 2018/2019 and summer 2019. Cadmus tested smart thermostat demand response impacts using a randomized controlled trial (RCT) design, which provided highly credible evidence about the program impacts. The following evaluation provides PGE with valuable information about the program's performance and presents insights that can be used to optimize PGE's future demand response program offerings.

Evaluation Objectives and Approach

PGE specified these five objectives for the BYOT evaluation:

1. Estimate the average kilowatt impact per participant before, during, and after the load control events
2. Assess the impact of events on customer comfort
3. Assess the impacts of participation on customer satisfaction with the program and PGE
4. Compare load impacts, customer comfort, and satisfaction between Rush Hour Rewards Nest thermostat impacts and to Connected Savings thermostat brands
5. Identify opportunities for improving program marketing, customer recruitment, program performance, cost-effectiveness, and customer satisfaction

Table 4 lists the evaluation activities and how each addresses the evaluation objectives. The evaluation presented in this report covers winter 2018/2019 and summer 2019 event seasons for BYOT Rush Hour Rewards and Connected Savings. *Appendix A. Evaluation Methodology* presents a more detailed description of the randomized controlled trial (RCT) design and the evaluation activities, including the impact analysis and customer surveys.

Table 4. Evaluation Activities

Activity	Description	Corresponding Evaluation Objective(s)	Outcome
Research Design	RCT: pre-season random assignment of participants into test or control group	1, 2, 3, 4	Accurate and precise estimates of impacts
Data Collection and Preparation	Collect and prepare analysis of individual customer advanced metering infrastructure (AMI) meter interval consumption data	1, 2, 3, 4	Final analysis sample for estimation of load impacts
Load Impact Analysis	Regression analysis of individual customer AMI meter interval consumption data	1, 2	Estimates of event savings
Staff Interviews	Interviews with PGE and implementation program staff to understand program implementation processes, successes, and challenges	5	Thorough understanding and documentation of the program design and implementation
Customer Surveys	Seasonal experience surveys with participants	3, 4, 5	Findings on customer engagement, event awareness, comfort, and satisfaction
Logic Model Review	An assessment of whether the program operated as expected and produced results as theorized	5	Documentation of what is and what is not producing the theorized results

Pilot Program Description

PGE designed the Smart Thermostat Demand Response pilot program to manage residential summer and winter loads during hours of peak electricity demand. Through the program, PGE can control cooling and heating loads of participating customers.

PGE established several goals and objectives for the Smart Thermostat Demand Response pilot program:

- Implement the program over winter and summer seasons by calling up to 10 peak demand events per season
- Enroll 24,000 thermostats by the end of 2019[16]
- Obtain customer participation in at least 50% of event hours per season
- Achieve positive customer experiences and high customer satisfaction

The pilot program is delivered through two customer participation tracks: Bring-Your-Own Thermostat (BYOT) for customers who already own a smart thermostat and Direct Install for customers who do not own one.

PGE launched the BYOT track of the pilot program in 2015, recruiting Nest thermostat customers to enroll in Nest's Rush Hour Rewards program service. PGE launched with Rush Hour Rewards first because of Nest's dominant share of the smart thermostat market.

In 2017, PGE expanded the BYOT track and began recruiting customers with ecobee, Honeywell Lyric, and other Honeywell Wi-Fi-enabled thermostats to enroll in Connected Savings, which is operated by the demand response service provider Resideo. Connected Savings aimed to increase PGE's demand response capacity further by taking advantage of the growing number of customers with a non-Nest thermostat.

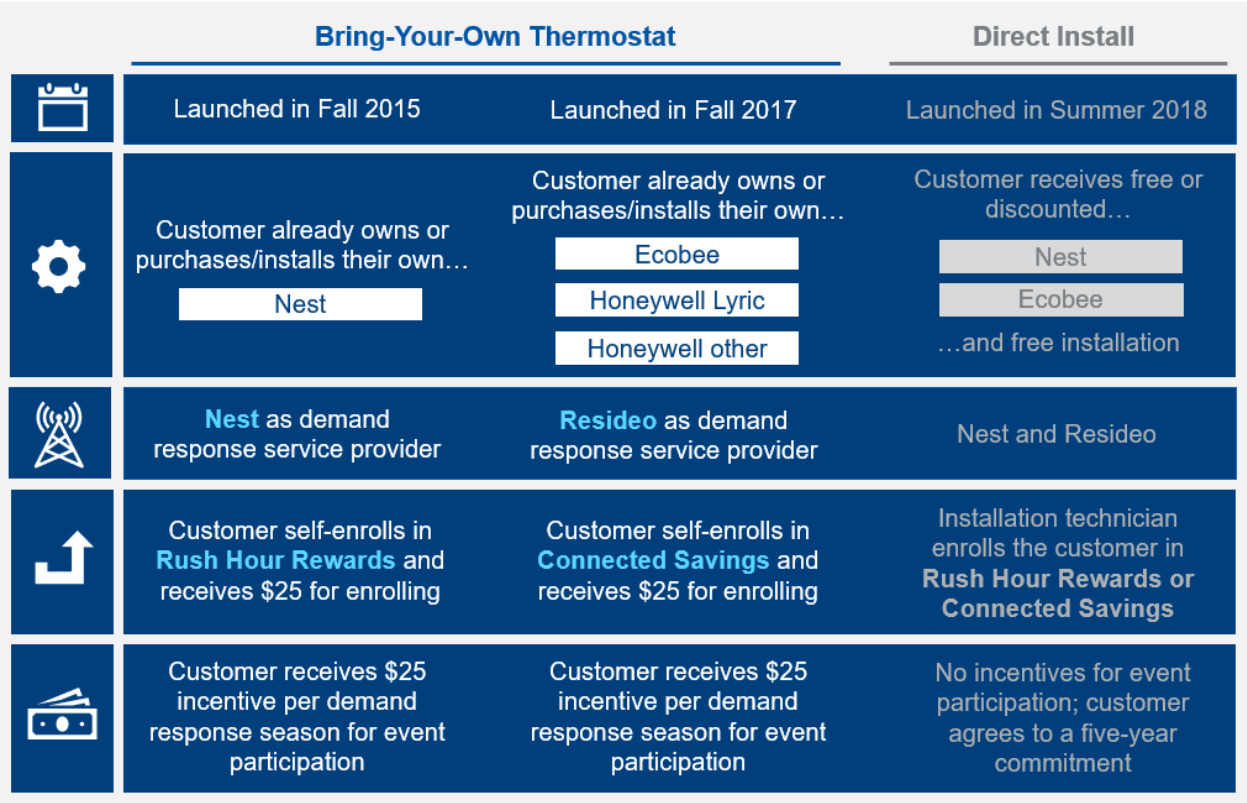
Figure 2 illustrates the Smart Thermostat Demand Response pilot program design, showing the distinctions between the BYOT and Direct Install tracks and between Rush Hour Rewards (Nest) and Connected Savings (Resideo) program implementation service providers.

BYOT Rush Hour Rewards and BYOT Connected Savings operate similarly in which customers to target (customers with the device), how customers enroll (self-enrolls), and incentives ($25 per event season participation). However, Nest and Resideo differ in how they carry out demand response events on their respective devices.

Event implementation details are described in detail in the subsequent sections.

[16] PGE staff indicated in the interviews that it did not establish separate enrollment goals for the BYOT and Direct Install tracks.

Figure 2. BYOT Smart Thermostat Demand Response Pilot Program Design



BYOT Implementation

The following section describes the implementation of the BYOT track of the pilot program.

Marketing and Recruitment

PGE and Nest have been marketing Rush Hour Rewards to customers since fall 2015. The marketing channels and strategies differ based on the target audience:

- **Customers who already have a Nest smart thermostat.** Nest sends out Rush Hour Rewards promotions via email and app notifications twice a year to PGE customers who purchase or install a Nest thermostat. Nest works with PGE to cobrand the program promotions. PGE also helps recruit more participants by promoting Rush Hour Rewards on its website and sending out promotional emails and direct mail.
- **Customers who have yet to purchase a Nest smart thermostat.** Nest employs search engine marketing and targeted social media ads to drive the sales of its thermostats. PGE promotes Nest and Rush Hour Rewards on its website and sends sales promotions via email. These sales promotions describe Rush Hour Rewards and incentive offers. Marketing is ramped up during holiday periods such as Black Friday and Father's Day. PGE also collaborates with the Energy

Trust of Oregon and promotes the $50 discount coupon the Energy Trust offers toward the purchase of a Nest Learning Thermostat or Nest Thermostat E. [17]

PGE and the smart thermostat manufacturers, ecobee and Honeywell, have been marketing Connected Savings to customers since fall 2017. The marketing channels and strategies differ based on the target audience:

- **Customers who already have a qualifying smart thermostat.** Manufacturers send out Connected Savings promotions via email and app notifications once a year to PGE customers who purchase or install a qualifying smart thermostat. Because the manufacturers' privacy policies prohibit sharing customer information, PGE could not market Connected Savings directly to customers who had a qualifying smart thermostat.
- **Customers who have yet to purchase a qualifying smart thermostat.** To encourage customers to purchase a smart thermostat, PGE promotes ecobee and Honeywell smart thermostats on its website and sends sales promotions via email that describe Connected Savings and incentive offers. Marketing is ramped up during holiday periods such as Black Friday and Father's Day. PGE also collaborates with the Energy Trust of Oregon and promotes the $50 discount coupon the Energy Trust offers toward the purchase of an ecobee smart thermostat.[18] PGE also markets the sales of smart thermostats and Connected Savings promotions on its social media channels and paid online ads.

To encourage customers to enroll in Rush Hours Rewards or Connected Savings, PGE offers a one-time $25 enrollment incentive. Customers receive a $25 check in the mail after PGE verifies the customer's program eligibility.

Program Eligibility Requirements

To be eligible for BYOT Rush Hour Rewards or Connected Savings, customers must meet these requirements:

- Be a PGE residential customer with an active account
- Have a central air conditioner, ducted heat pump, or electric forced-air furnace (with or without air conditioning) HVAC system
- Have a qualifying Nest Learning Thermostat, Nest Thermostat E, ecobee smart thermostat, Honeywell Lyric smart thermostat, or Honeywell Wi-Fi thermostat that controls the HVAC system in the home
- Have a Wi-Fi network in the home

[17] Energy Trust of Oregon increased the amount of the discount coupon to $100 on June 1, 2019.

[18] Ibid.

Enrollment Process

The promotion emails, direct mail, and web content direct customers to their Nest online accounts to enroll in Rush Hour Rewards. The Rush Hour Rewards page provides program details. To enroll, customers log in to their Nest account and enter their utility account information. Customers do not have to answer questions about their HVAC system on the Rush Hour Rewards enrollment page as customers already provide this information when they register their device online.

For Connected Savings, the promotion emails, direct mail, and web content direct customers to the Connected Savings enrollment web portal hosted by Resideo. The portal's main page provides information on how the program works. To enroll, customers login with their smart thermostat account credentials, enter their utility account information, and answer questions about their HVAC system. To check if customers had misreported their HVAC system (i.e., a non-electric heat home reported having an electric heating system), Resideo reviews the HVAC system's run-time data as captured in the smart thermostat and uses the data's load shape to assess customers' self-report accuracy.

Nest and Resideo give PGE the list of enrollees. PGE reviews the list, to confirm program eligibility, and approves the enrollees then mails the $25 enrollment incentive check a few weeks later.

Event Management

PGE contracted with Nest and Resideo to provide the demand response management system and aggregation services. When ready to call an event, PGE used Nest's and Resideo's online management platform to schedule the event one day ahead. After receiving the event dispatch, Nest and Resideo sent out Wi-Fi signals to adjust the smart thermostat settings on the event day. Table 5 shows the schedule of load control events (six in winter and six in summer) that PGE initiated.

Table 5. Rush Hour Rewards and Connected Savings Load Control Events

Season	Event	Date	Avg. Outdoor Temp.*	Start Time	Duration (hours)
Winter 2018/2019	1	2/4/2019	33°F	5:00 p.m.	3
	2	2/5/2019	34°F	5:00 p.m.	3
	3	2/12/2019	39°F	5:00 p.m.	3
	4	2/15/2019	40°F	7:00 a.m.	3
	5 ❄	2/20/2019	38°F	5:00 p.m.	3
	6 ❄	2/25/2019	33°F	5:00 p.m.	3
Summer 2019	1	6/12/2019	97°F	5:00 p.m.	2
	2	7/22/2019	84°F	5:00 p.m.	2
	3**	7/26/2019	89°F	4:00 p.m.	3
	4	08/05/2019	88°F	4:00 p.m.	3
	5	08/06/2019	84°F	5:00 p.m.	1
	6	08/28/2019	96°F	4:00 p.m.	3

* Outdoor temperature is the average temperature during event hours.
**Event failed to dispatch on ecobee thermostats due to widespread ecobee online service connection issue.
❄ = snow day

Events lasted one to three consecutive hours and occurred on weekday (non-holiday) afternoons or mornings, typically when electricity demand for space conditioning was greatest (that is, on cold days during winter and hot days during summer). The winter 2018/2019 event season ran from December 1, 2018, through February 28, 2019. The summer 2019 event season ran from June 1, 2019, through September 30, 2019.

Resideo tested Intelligent Demand Response (IDR) on a small number of ecobee devices. IDR customizes the thermostat setback for individual customers based on historical heating or cooling demand and the thermal properties of a home to achieve more consistent and lasting load reductions across event hours. IDR also includes regulating the dispatch of load control signals to avoid big changes in aggregate loads due to simultaneous pre-conditioning before the event, the event initiation, or snapback after an event.

Nest did not test IDR. Table 6 shows the event details for Rush Hour Rewards and Connected Savings by thermostat brand.

Table 6. Rush Hour Rewards and Connected Savings Event Implementation Details

Brand	Pre-Event Notification	Event In-Progress Notification	Pre-Conditioning before Event	Temperature Setback during Event
Rush Hour Rewards				
Nest	Displayed on thermostat screen and app (with push notifications)	Displayed on thermostat screen and app	1°F to 3°F pre-heating in winter; 1°F to 3°F pre-cooling in summer	1°F to 3°F lower in winter; 1°F to 3°F higher in summer
Connected Savings				
ecobee	Displayed on thermostat screen and app (no push notifications)	Displayed on thermostat screen and app	None	Up to 3°F lower in winter; Up to 3°F higher in summer
Honeywell Lyric	Displayed on thermostat screen and app (no push notifications)	Displayed on thermostat screen and app	2°F pre-heating in winter; 2°F pre-cooling in summer	Up to 3°F lower in winter; Up to 3°F higher in summer
Honeywell Other	Displayed on thermostat screen and app (no push notifications)	Displayed on thermostat screen and app	2°F pre-heating in winter; 2°F pre-cooling in summer	Up to 3°F lower in winter; Up to 3°F higher in summer

Test group participants' thermostats were controlled during the events while the control group was not. Test group participants in Rush Hour Rewards and Connected Savings could override the load control during events by adjusting the thermostat settings or hitting the event cancel button. Program implementors (Nest and Resideo) provided PGE customer- and event-level data indicating the degrees of pre-cooling and setback and whether the customer overrode the event. If customers participated in at least 50% of event hours during a season, they received a $25 incentive check. Control group participants also received a $25 incentive check per event season even though their thermostats were not controlled.

Only customers with a heat pump could participate in both winter and summer seasons.

PGE reviewed the participant data to determine who receives the seasonal incentives and mailed out incentive checks to participants six to eight weeks after the end of the season.

Logic Model

A logic model outlines how a program should be expected to succeed, given its design, by graphically presenting the relationships between program activities, outputs, and expected outcomes. The logic model serves as a useful tool for program staff, implementers, and evaluators to determine whether the program's activities and outputs are producing the outcomes as theorized.

In 2018, Cadmus developed the logic model for the BYOT Smart Thermostat Demand Response pilot program using program materials and information obtained from the staff interviews. Figure 3 shows the BYOT logic model. As part of the logic model, Cadmus identified and documented BYOT's implementation barriers, challenges and risks to program success. Figure 4 shows the mapping of these barriers, challenges, and risks, as well as solutions PGE and its partners will use to manage and overcome them. The colors used to denote the challenges, risks, and solutions correspond to the activities, outputs, and impacts in the logic model (Figure 3).

Figure 3. Logic Model of BYOT Smart Thermostat Demand Response Pilot Program

PROGRAM THEORY

PGE's Integrated Resource Plan (2016) calls for the use of demand response (DR) to help manage system peak loads. By offering residential customers financial incentives, PGE's Smart Thermostat Program will enroll customers and realize the goals of **24,000 enrolled smart thermostats by 2019**. Through collaboration with top-market original equipment manufacturers (OEMs) and DR service providers, and seasonal marketing campaigns, PGE will attract customers with a smart thermostat to enroll into the program. Giving customers control to opt out of DR events will ensure customer satisfaction and retain participants.

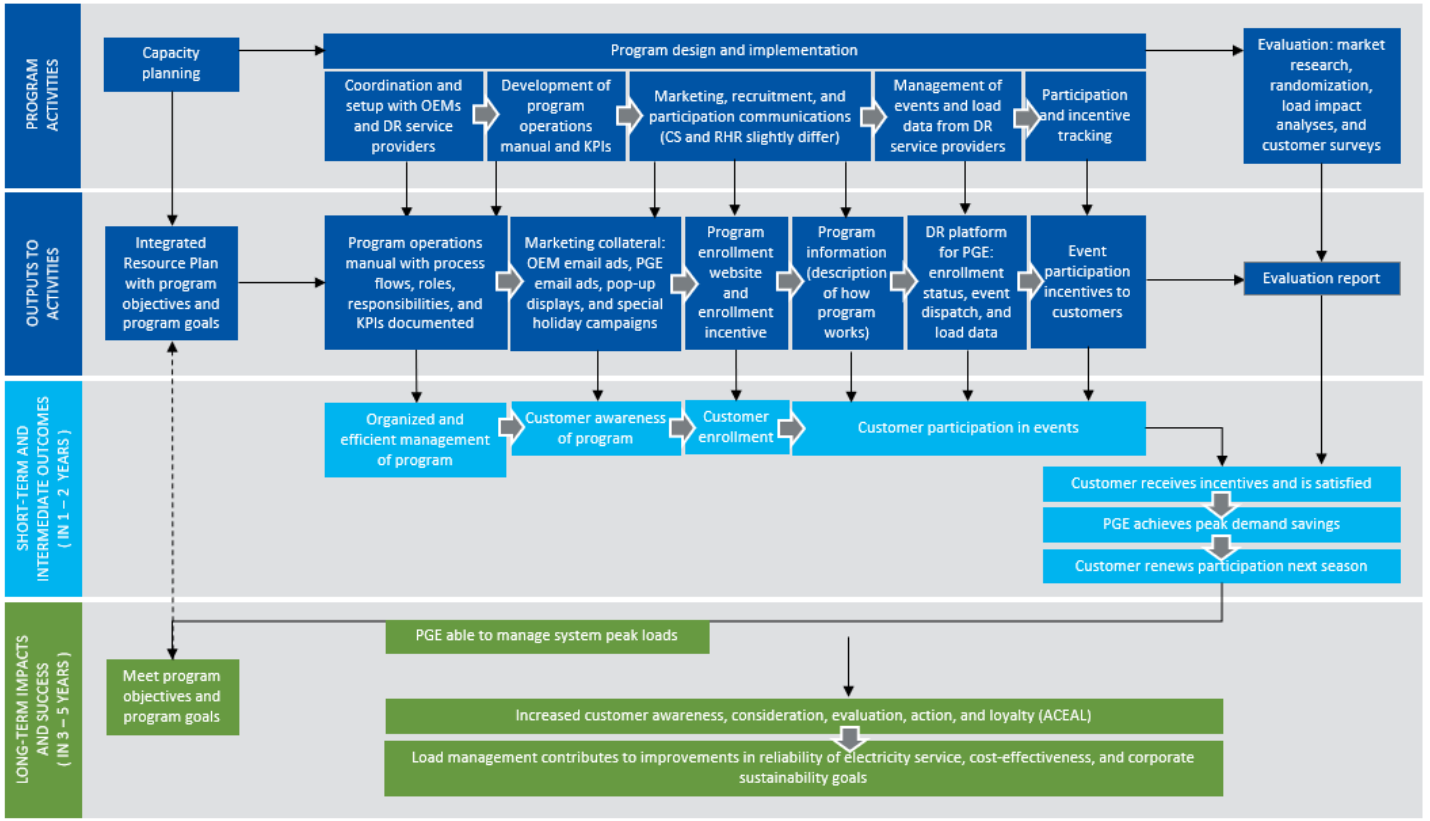
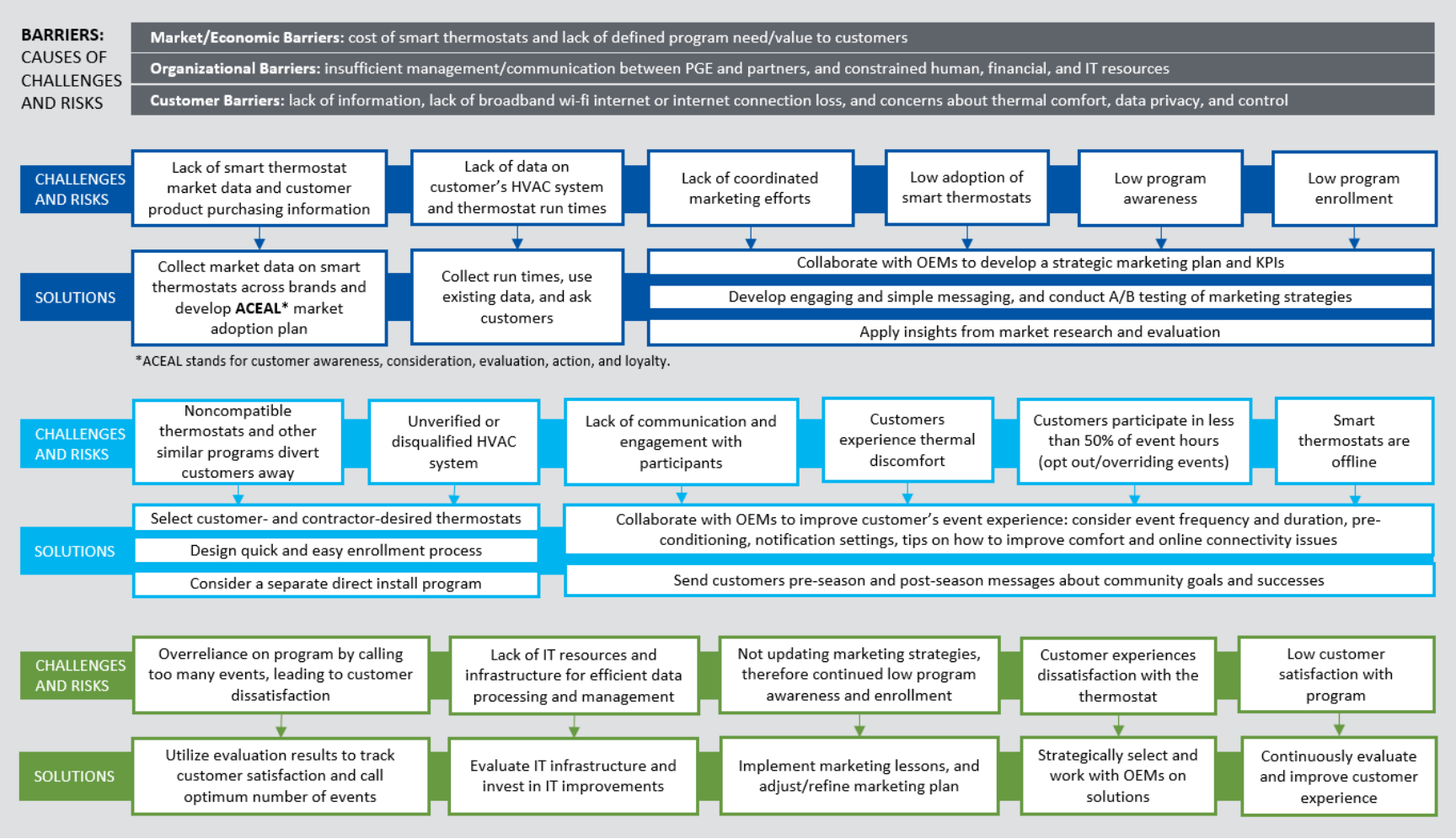


Figure 4. Map of BYOT Implementation Barriers, Challenges, Risks, and Solutions



Evaluation Findings

This section provides the evaluation findings on the BYOT track of the pilot program and is organized by season and the two program services: Rush Hour Rewards and Connected Savings. The findings capture the implementation successes and challenges, demand savings, customer experience, and logic model review. The end of the section includes a comparison between Rush Hour Rewards and Connected Savings.

Implementation Successes and Challenges

PGE's service territory called six events during winter season in 2018/2019 and six during summer season in 2019. The weather in both seasons was mild. During these event seasons, PGE encountered temporary challenges with Nest marketing and software glitches on ecobees. This section describes the program successes, challenges, and lessons learned.

Marketing and Recruitment

PGE made improvements to its customer marketing and recruitment efforts. In previous years, PGE had little to no data on customer's HVAC system for use in BYOT targeted marketing. Now, PGE has several sources of data to identify and target appropriate customers. These sources are Energy Trust of Oregon's smart thermostat rebate data, Energy Trust of Oregon's load data, purchased data from a third party, and heat pump contractor data.

From 2015 to 2018, Nest operated as an independent business from Google. In 2019, Google merged Nest into a home devices business called Google Nest. In spring 2019, during this business transition, PGE reported that Nest's normal marketing activities for Rush Hour Rewards had stopped. The affected marketing activities included in-app recruitment notifications and pre-season notifications. Marketing activities for Rush Hour Rewards resumed in summer 2019. This temporary halt on marketing activities did not affect program enrollment as Nest enrolled a record number of approximately 1,200 customers in Rush Hour Rewards during August 2019. Around the same time, in spring 2019, Resideo acquired Whisker Labs. None of Connected Savings' marketing activities were disrupted during this transition.

PGE set a combined BYOT and Direct Install enrollment goal of 24,000 thermostats by the end of 2019. At the end of 2019, the pilot program had enrolled a total of 20,805 thermostats, 16,005 of which from the BYOT track (Table 7). In early 2020, PGE is expected to receive a boost to enrollment for BYOT Connected Savings. Ecobee plans to roll out a new platform nationwide called ecobee+, which will make it easier for customers with an ecobee to discover their utilities' demand response and energy efficiency programs. Through this new platform, PGE expects to enroll an additional 3,000 customers in Connected Savings, which will bring PGE closer to meeting its overall pilot program enrollment goal.

Table 7. 2019 Year-End BYOT and Direct Install Thermostat Enrollment Counts*

Category	BYOT		Direct Install	
	Count	Percentage of Column Total	Count	Percentage of Column Total
By Brand				
ecobee	1,682	10%	2,046	43%
Nest	12,613	79%	2,754	57%
Honeywell	1,710	11%	0	0%
By HVAC System				
Central Air Conditioner	12,733	80%	2,278	47%
Heat Pump	2,467	15%	1,999	42%
Electric Furnace	498	3%	495	10%
Unreported	307	2%	28	1%
Overall	**16,005**	**100%**	**4,800**	**100%**

* Thermostat enrollment counts as of end of 2019. These will not match counts used for the evaluation because of the time period difference.
Note, the counts of thermostats listed above may reflect instances of the same participants occurring in different groups, such as households that have multiple thermostats (e.g., one of both brands) or multiple qualifying HVAC equipment (e.g., central air conditioning and electric furnace).
Note that five BYOT customers had both a heat pump and an air conditioner. These customers were removed from the BYOT air conditioner count to retain consistency.

Event Dispatch

ecobee thermostats experienced operational issues during winter 2018/2019 and summer 2019. Resideo typically calibrates a three-degree setback on ecobee and Honeywell thermostats during events. However, for the first two winter events on February 4, 2019 and February 5, 2019, Resideo reported that 128 ecobee thermostats encountered an issue with the temperature setback. Customers with these 128 ecobee thermostats briefly received two temperature setbacks instead of one due to customer participation in PGE's demand response and Energy Trust of Oregon's energy efficiency smart thermostat programs; this means that these customers experienced a temperature setback greater than three-degrees that would have affected their comfort. Resideo did not report any temperature setback issues during the summer, but PGE said it had received four customer complaints about the temperature setback on ecobee thermostats during one of the summer events in August. Also in the summer, ecobee had an online service disruption on July 26 (event 3), which prevented any event called on that day from being activated on all ecobee thermostats.

These winter and summer operational issues on ecobee thermostats did not appear to adversely impact demand savings. In winter, ecobee thermostats (average demand reduction of 0.81 kW per participant) outperformed Nest (0.35 kW) and Honeywell (0.30 kW) thermostats. In summer, even with the inclusion of event 3 in the analysis, ecobee thermostats (average demand reduction of 0.88 kW per participant) performed on par with Nest thermostats (0.89 kW) and outperformed Honeywell (0.73 kW) thermostats. However, the temperature setback issue on ecobees may have adversely impacted customer comfort during the summer, as a statistically significant difference in the proportion of ecobee respondents (62%), than Nest (74%) and Honeywell (74%) respondents, reported feeling lower comfort

during the events. Survey sample sizes were too small for ecobee and Honeywell respondents in the winter survey to test for differences in customer comfort. See the *Program and Thermostat Brand Comparison s*ection for more details.

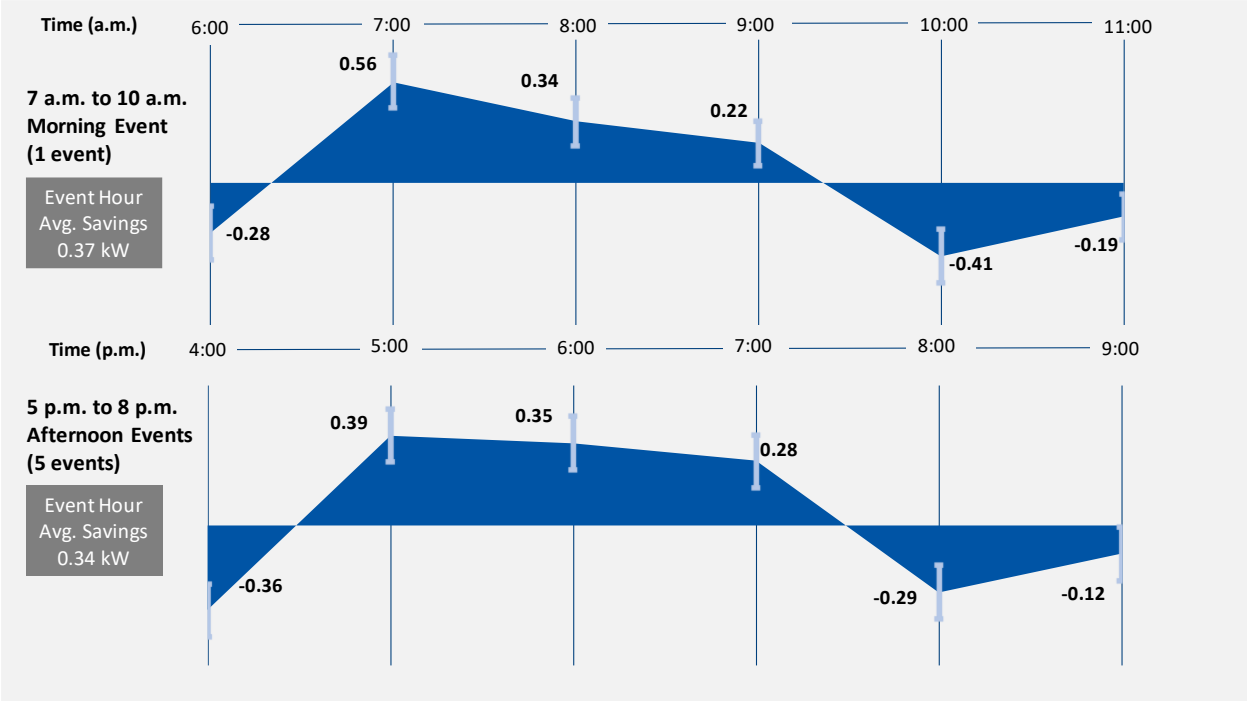
BYOT Rush Hour Rewards Winter 2018/2019

The following section provides findings about Rush Hour Rewards during winter 2018/2019.

Winter Load Impacts

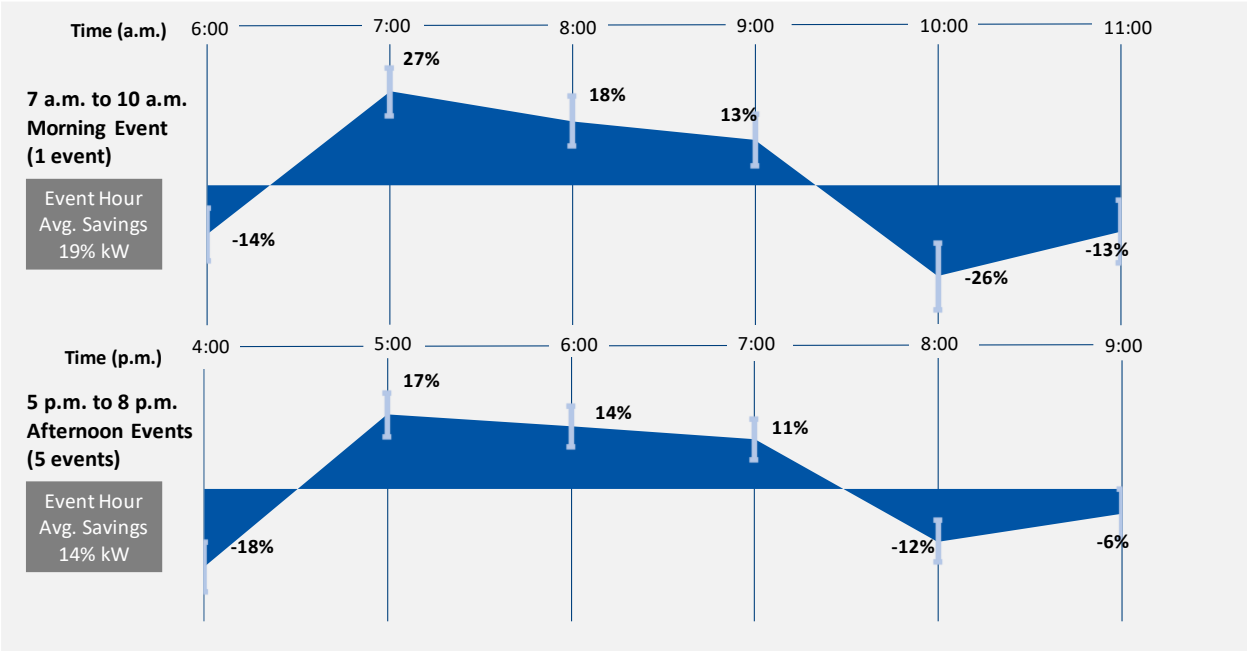
Figure 5 presents estimates of the average kilowatt impacts per participant for the hour prior to the event, each event hour, and the two hours after the event ended for afternoon and morning events. As described in Appendix A, the estimates were obtained from panel regression analysis of participant demand. Figure 6 shows the impacts as a percentage of baseline demand. The program achieved average demand savings per participant of 0.37 kW for the morning event and 0.34 kW for afternoon events. Overall the events during the winter 2018/2019 season, Rush Hour Rewards achieved average demands savings of 0.35 kW per participant. Inclusion of participants with non-electric heat sources negatively impacted reported average participant winter savings for Rush Hour Rewards; this issue is described in greater detail in *Enrollment of Non-Electric Heating Customers* section (p.37)

Figure 5. Rush Hour Rewards Winter 2018/2019: Average Demand Savings (kW) per Participant



Note: Impacts were estimated using regression analysis of customer AMI meter data for 1,689 customers. This count includes test and control group customers, and the total number of customers varied by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers.
See *Appendix B* for details.

Figure 6. Rush Hour Rewards Winter 2018/2019: Percentage Demand Savings



Note: Impacts were estimated using regression analysis of customer AMI meter data for 1,689 customers. This count includes test and control group customers, and the total number of customers varied by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for details.

For all events, savings peaked in the first hour then diminished through the remaining hours. By the last hour of the afternoon events, average demand savings per participant had decreased by 0.1 kW, approximately 28% less than the first-hour savings. Savings for events starting at 7 a.m. decreased by 0.3 kW or 60% from the first hour. This pattern follows a similar one identified in previous evaluations of the Rush Hour Rewards program.

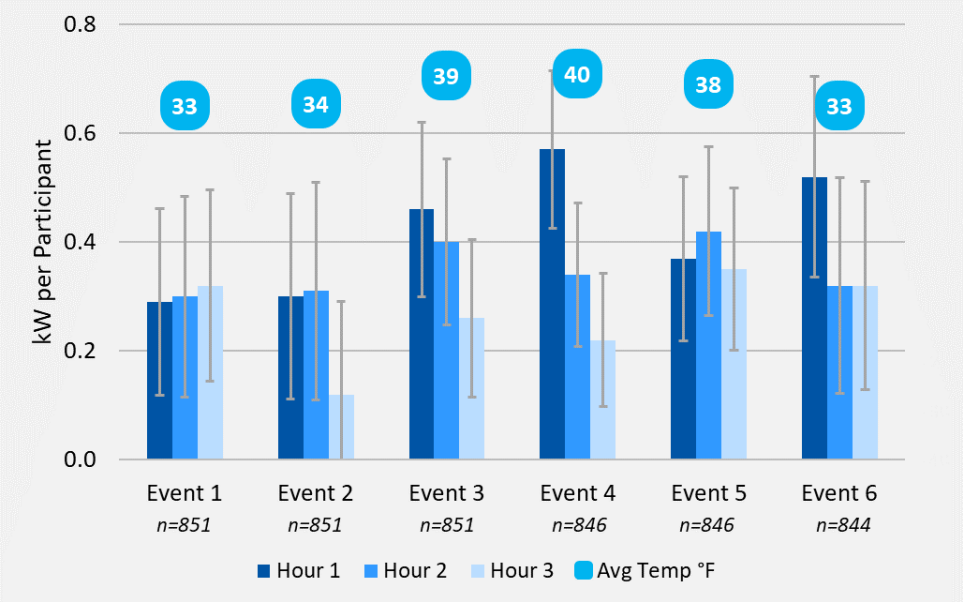
Pre-heating and snapback increased participant loads before and after events. Pre-heating of participant homes increased electricity demand by 0.3 kW (-14%) for morning events and 0.4 kW (18%) for afternoon events. After events ended, demand increased above normal levels, as the thermostat attempted to return the home's interior temperature to the scheduled temperature setting. After the afternoon events, there was an increase in demand of 0.4 kW (12%) per participant home. After the morning events, demand increased by 0.3 kW (14%). Demand remained statistically greater than normal for approximately two hours after the events ended.

Winter Demand Savings Estimates by Event

Figure 7 shows the average demand savings per participant for each hour of the six winter events. For most events, first-hour savings per participant ranged 0.3 kW and 0.5 kW, while third-hour savings per participant ranged between 0.1 kW and 0.3 kW. Event 4, which occurred during the warmest winter temperature of the season, generated the highest first-hour savings. However, due to the small sample size these differences are not statistically significant. Savings were statistically significant for all event

hours except the last hour of event 2. Interestingly, though event 4 had the warmest winter temperatures, it had the highest first-hour savings.

Figure 7. Rush Hour Rewards Winter 2018/2019: Demand Savings by Event



Note: Impacts were estimated using regression analysis of customer AMI meter data. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. The ovals show the average outside temperature (°F) during the events. *n* indicates the number of test group customers in the analysis sample for the event.

As the figure shows, the average demand savings varied between events. These savings do not appear to correlate with outside temperature, though the range of event temperatures was less than 10°F. As noted above, event 4, which had the highest first-hour demand savings, was a morning event. Participant electricity demand peaked between 7:00 a.m. and 10:00 a.m. (see Table B-1 in *Appendix B. Additional Impact Findings*). Also, for each event, savings degraded from the first event hour to the third, but events 1, 2, and 5 generated slightly larger savings during the second hour.

Appendix B contains point estimates of demand savings, pre-conditioning impacts, snapback, and energy-savings impacts for each event and each event start time. The energy savings were estimated by summing the kW load impacts over the first pre-event hour, event hours, and the first four post-event hours. Load impacts for later post-event hours were not statistically significant and therefore were not included in the energy savings calculations. The energy impacts were close to zero. (See Table B-5.*)* For events 3, 4, and 5, energy savings were negative, ranging between -.04 kWh and -0.6 kWh per participant. Events 1, 2, and 6 had slightly positive savings, indicating that the increased energy usage before and after the event more than offset the event savings.

Winter Program Demand Savings

Table 8 presents estimates of total MW demand savings for the Rush Hour Rewards program during winter 2018/2019. Estimates are presented for each event hour and each event. The estimates were

obtained by multiplying the evaluated per-customer average demand savings by the number of participants who experienced load control in each event.

Table 8. Rush Hour Rewards Winter 2018/2019 Total Demand Savings (MW)

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	
Event 1	5 p.m. – 8 p.m.	0.25	0.26	0.27	0.26	851
Event 2	5 p.m. – 8 p.m.	0.26	0.26	0.11	0.21	851
Event 3	5 p.m. – 8 p.m.	0.39	0.34	0.22	0.32	851
Event 4	7 a.m.– 10 a.m.	0.49	0.29	0.19	0.32	846
Event 5	5 p.m. – 8 p.m.	0.31	0.36	0.30	0.32	846
Event 6	5 p.m. – 8 p.m.	0.44	0.27	0.27	0.33	844
Average		**0.36**	**0.30**	**0.23**	**0.29**	**848**

Note: MW savings were estimated by multiplying the per customer demand savings estimates in each event hour by the number of test group participants in the analysis sample. The number of test group participants in the analysis sample varied by event. The analysis sample excludes homes with missing AMI meter data, multiple program enrollments (that may have been assigned into both test and control groups) and net metering customer. Details regarding the analysis sample and screening are provided in the *Data Collection and Preparation* section.

Across events, demand savings averaged 0.29 MW. Note that participants in the control group (n=841) did not contribute to the total demand savings since they did not experience any load control during events. These participants have the potential to contribute to PGE's future winter demand response capacity. Event 6, which began at 5 p.m. and lasted three hours, had the largest average demand savings of 0.33 MW. Event 2, which began at 5 p.m. and lasted three hours, had the smallest average demand savings of 0.21 MW. Please reference Appendix A for additional detail of the methodology regarding treatment and control assignment.

Winter Customer Experience

After the winter event season, Cadmus administered an online survey to test and control group participants. The winter experience survey asked Rush Hour Rewards participants about their event awareness, comfort, satisfaction, and suggestions for improvement. The survey took respondents less than seven minutes to complete and respondents did not receive an incentive for completing the survey. The following sections describe the key findings from this survey. For comparison, survey results from the previously evaluated seasons are provided in *Appendix C. Rush Hour Rewards Past Survey Results.*

Winter Event Awareness

PGE called six events for Rush Hour Rewards during winter 2018/2019. The experience survey asked test group respondents whether they noticed the events and how many they noticed. Seventy percent of respondents (n=193) said they noticed events. Of those who noticed, on average, they noticed 5.4 events (n=136) of the six called. Respondents (n=137) noticed the event mostly due to the event

message display on the Nest thermostat (77%) and the event notification from the smartphone app (73%) than to a temperature change (28%).

The program does not require any customer effort during the event. As expected, 95% of respondents said participating in the winter events was easy (n=174). Specifically, 82% said it was *very easy* and 13% said it was *somewhat easy*. The 2% of respondents who found it difficult to participate in the events mentioned the following reasons:

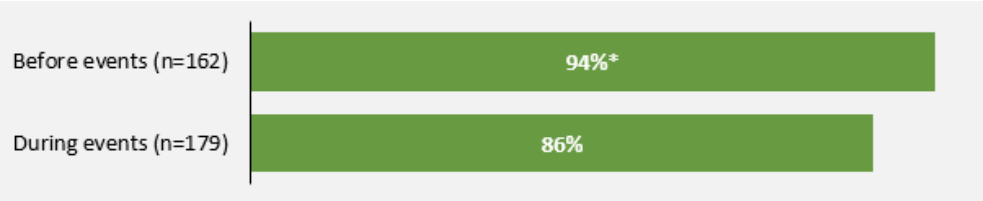
- Notifications were not early enough (two respondents)
- Health/medical reasons or baby in-home (two respondents)
- Not understanding how the program works (one respondent)

Winter Event Comfort

One in three test group respondents (33%, n=189) reported they overrode at least one of the winter events. The survey did not ask respondents to recall how many events they overrode but did ask for their reasons for overriding any of the events. Of these 60 respondents, 83% cited thermal discomfort as their reason.

Most test group respondents recalled being comfortable before and during the winter events. Figure 8 shows that before the events, 94% of respondents said their home's interior temperature was comfortable. When recalling their comfort level during events, 86% said they were comfortable, a statistically significant decrease of 8 points compared to the comfort level before the events. The surveys were conducted after the end of each event season where customers' recall of their comfort during a few days out of the season may not be as accurate or reliable. In future evaluations, a series of surveys of test and control group customers conducted immediately after an event may yield more accurate and reliable responses about customer comfort and its relationship to event overrides.

Figure 8. Rush Hour Rewards Winter 2018/2019: Percentage of Comfortable Rating Before and During Events



* Difference is statistically significant with 90% confidence (p≤0.10).

Note: Test group respondents rated their comfort level on a 0 to 10 scale, where 0 meant *extremely uncomfortable* and 10 meant *extremely comfortable*. Cadmus defined a 6 to 10 rating as *comfortable*.

Source: Winter 2018-19 Experience Survey Questions. "Overall this past winter, how comfortable was the interior temperature of your home a few hours *before* the high demand events?" and "Overall this past winter, how comfortable was the interior temperature of your home *during* the high demand events?"

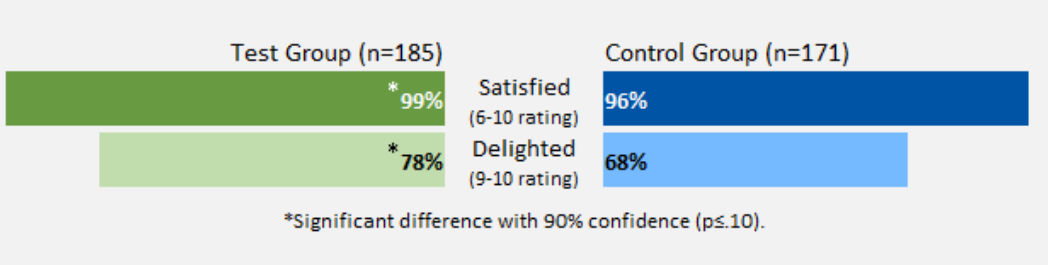
Winter Satisfaction

Test and control group respondents rated their satisfaction with the smart thermostat, the incentive check, the program, and PGE, using a 0 to 10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6 to 10 rating as *satisfied* and a 9 or 10 rating as *delighted*.

Winter Satisfaction with Smart Thermostat

Nearly all test and control group respondents were *satisfied* with their Nest smart thermostat. Figure 9 shows more test group respondents (99%) than control group respondents (96%) were *satisfied* with their Nest smart thermostat and that this difference was statistically significant. Additionally, more test group respondents (78%) than control group respondents (68%) were *delighted,* also statistically significant.

Figure 9. Rush Hour Rewards Winter 2018/2019: Satisfaction with Smart Thermostat



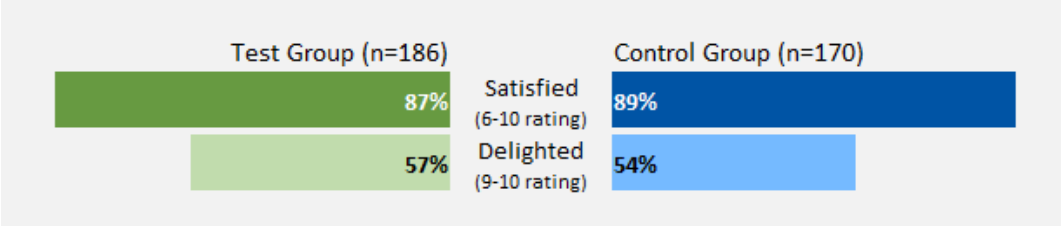
Source: Winter 2018-19 Experience Survey Question. "Please rate your overall satisfaction with the smart thermostat."

Subsequent sections of this report show that test and control group respondents did not result in statistically significant differences on their satisfaction with the incentive, the program, and PGE. In previous evaluations, test group respondents reported lower satisfaction than control group respondents, and Cadmus attributed the difference to the fact that the test group experienced the events while the control group did not. At this time, the evaluation does not have an explanation for the reversal in satisfaction between groups but will continue to investigate in future evaluations.

Winter Satisfaction with Incentive

Most respondents were satisfied with the incentive amount (Figure 10). Similar proportions of test group respondents (87%) and control group respondents (89%) were *satisfied* with the incentive. Similar proportions of test group respondents (57%) and control group respondents (54%) were *delighted*. These differences were not statistically significant. As noted above, Cadmus expected to see a higher reported satisfaction for control group respondents, who did not experience any events (which might cause inconvenience) and still received the $25 incentive, compared to test group respondents.

Figure 10. Rush Hour Rewards Winter 2018/2019: Satisfaction with Incentive

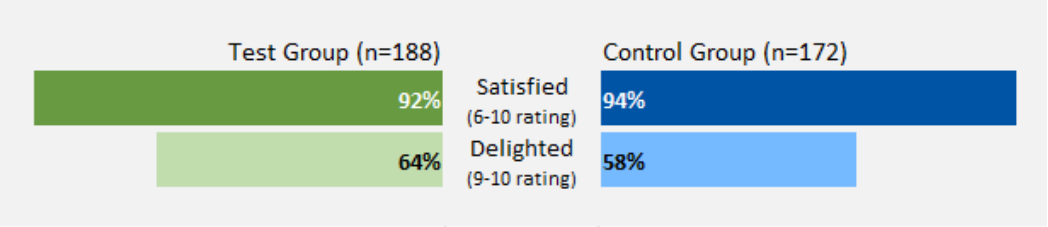


Source: Winter 2018-19 Experience Survey Question. "You have or will soon receive an incentive check for $25.00 in exchange for your participation this past winter. How satisfied are you with the incentive check?"

Winter Satisfaction with Program

The majority of respondents were satisfied with the program. Similar proportions of test group respondents (92%) and control group respondents (94%) were *satisfied* with the program (Figure 11). A slightly higher proportion of test group respondents (64%) than control group respondents (58%) were *delighted*. These differences were not statistically significant.

Figure 11. Rush Hour Rewards Winter 2018/2019: Satisfaction with Program



Source: Winter 2018-19 Experience Survey Question. "Please rate your overall satisfaction with PGE's Smart Thermostat Program."

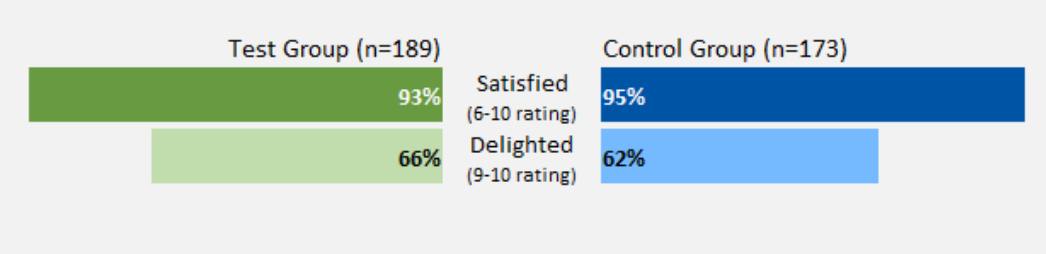
The winter experience surveys asked test and control group respondents to explain their program satisfaction ratings. Cadmus analyzed these open-end explanations according to positive or negative sentiment. Both test and control group respondents had largely positive comments about the program. Positive comments from test group respondents (n=133) most often mentioned that the program works well (49%), helps the environment/community save energy and reduce demand (15%), and pays an incentive (13%). Similar to the positive responses from the test group, control group respondents (n=128) most often said that the program works well (48%), they like receiving an incentive (14%), and the program helps the environment/community save energy and reduce demand (10%).

Test group respondents made negative comments about the incentive amount (8%), lack of event notifications (5%), and issue with pre-event notifications (3%). Control group respondents made negative comments about the incentive amount (9%), that the program did not work for them (4%), and that there was not enough information or transparency (4%).

Winter Satisfaction with Portland General Electric

Most test and control group respondents were satisfied with PGE. As shown in Figure 12, 93% of test group and 95% of control group respondents were *satisfied* with PGE. Similar proportions of test group (66%) and control group (62%) were *delighted*. There was no statistically significant difference between test and control group respondents.

Figure 12. Rush Hour Rewards Winter 2018/2019: Satisfaction with PGE



Source: Winter 2018-19 Experience Survey Question. "Please rate your overall satisfaction PGE."

Winter Customer-Suggested Improvements

The 88 test group respondents who answered the open-end question on how to improve the program most often made the following suggestions:

- Provide/improve customer education (13%)
- Increase the incentive amount (13%)
- Provide a performance/impact report (8%)

BYOT Rush Hour Rewards Summer 2019

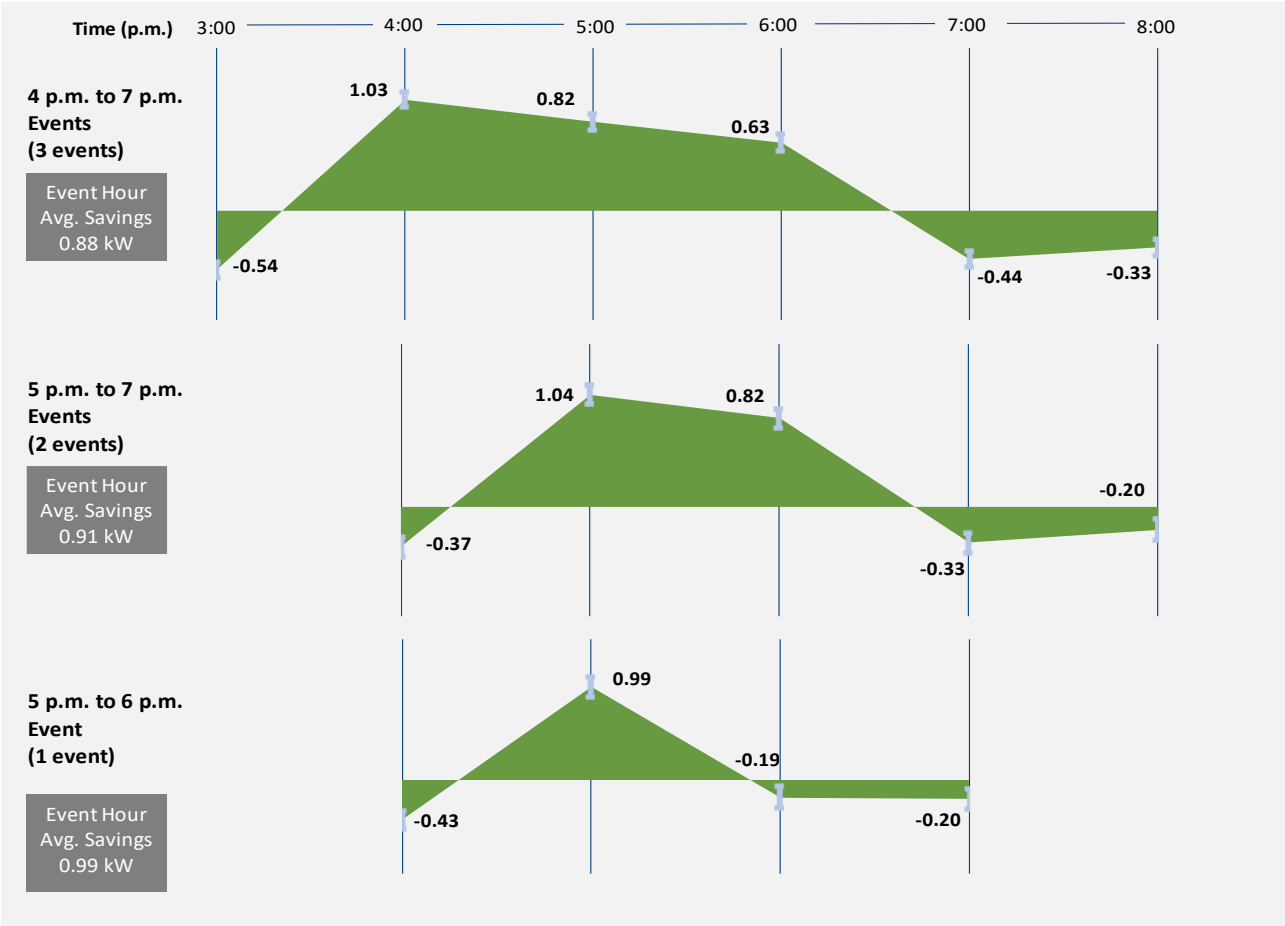
This section provides detailed findings about Rush Hour Rewards during summer 2019.

Summer Load Impacts

During summer 2019, PGE called six Rush Hour Rewards events. Three started at 4 p.m. and lasted three hours, two events started at 5 p.m. and lasted two hours, and one event started at 6 p.m. and lasted one hour.

Figure 13 presents the demand impacts for one hour prior to the event, each event hour, and two hours after the event ended. Figure 14 shows the savings as a percentage of baseline demand, estimated as the mean demand of control group participants. The program achieved average demand savings per participant of 0.89 kW (36% of baseline demand) per participant overall events.

Figure 13. Rush Hour Rewards Summer 2019: Average Demand Savings (kW) per Participant



Note: Impacts were estimated using regression analysis of customer AMI meter data for 9,791 customers. This count includes test and control group customers in the analysis sample, and the total number of customers in the analysis sample varied slightly by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for details.

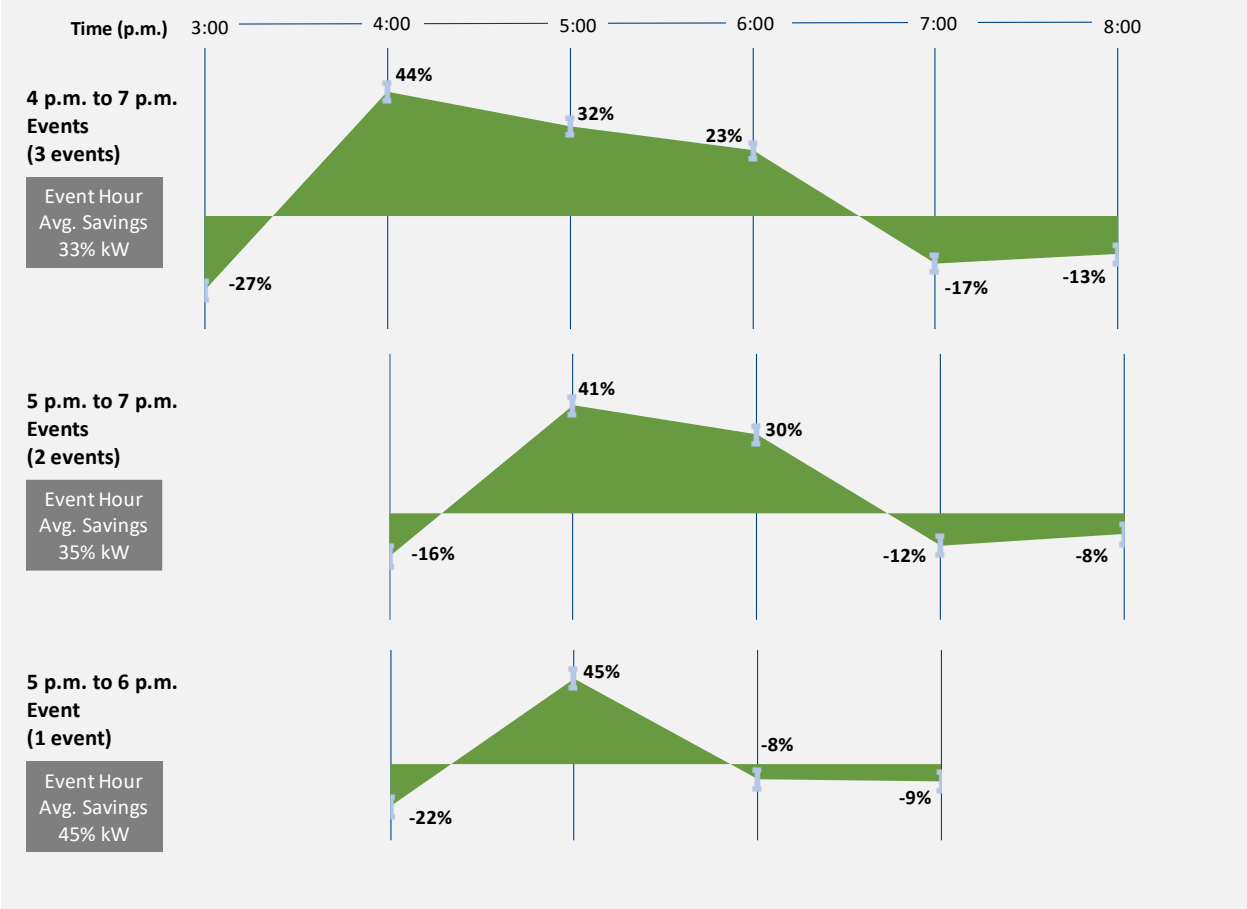
Three-hour events achieved average demand savings of 0.88 kW (33%) per participant and 0.91 kW (35%) for two-hour events (5 p.m. start time). The one-hour event saved 0.99 kW (45%). The difference in savings between events is primarily due to the degradation of savings during events. The third hour of the 4 p.m. events, which averaged 0.63 kW per participant, pulled down the overall average. The impact estimates across the first two event hours were similar for events starting at 4 p.m. and 5 p.m.

During summer events, savings peaked in the first hour, then diminished through the remaining hours, which follows a similar trend identified in previous evaluations of Rush Hour Rewards. However, this degradation was more extreme for the three-hour events (4 p.m.) than the two-hour events (5 p.m.). Between the first and second event hours, savings decreased by 0.2 kW (20%) for three-hour events and 0.2 kW (21%) for two-hour events. For three-hour events, the difference in savings between the first and third event hour was 0.4 kW or approximately 39%.

As in winter, participant electricity demand was higher than normal before and after events. Pre-cooling of participant homes increased electricity demand per participant by about 0.4 kW to 0.5 kW or 16% to

27% of baseline demand across all events. After the events ended, demand snapped back by 0.2 kW to 0.4 kW (approximately 9% to 17%) in the first hour. Demand remained statistically greater than normal for about four hours after the events ended.

Figure 14. Rush Hour Rewards Summer 2019: Percentage Demand Savings



Note: Impacts were estimated using regression analysis of customer AMI meter data for 9,791 customers. This count includes test and control group customers, and the total number of customers varied by event. Errors bars show 95% confidence intervals estimated with standard errors clustered on customers. See *Appendix B* for details.

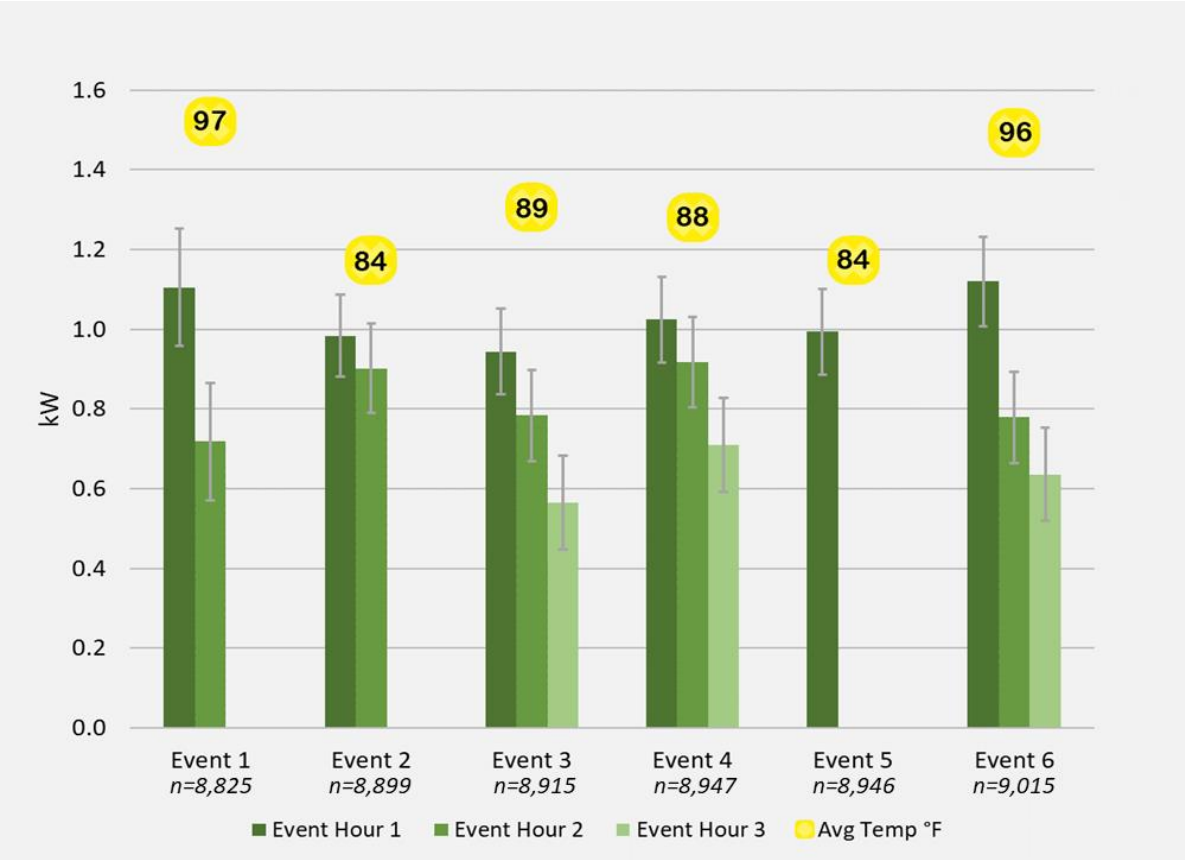
Summer Demand Savings Estimates by Event

Figure 15 shows the average demand savings per participant for each hour of the six summer events. For most events, first-hour savings per participant ranged between 0.9 kW and 1.2 kW, while third-hour savings per participant ranged between 0.4 kW and 0.8 kW. Estimated savings during the first hour of all events were within the 90% confidence interval including 1 kW. Overall, these findings are comparable to previous Rush Hour Rewards summer seasons. Degradation in savings across event hours is also evident. (See Table B-6 in *Appendix B. Additional Impact Findings,* which contains point estimates of demand savings, pre-event conditioning impacts, post-event snapback, and energy savings.)

The summer energy savings were estimated by summing load impacts across the pre-event hour, event hours, and the first four post-event hours. Load impacts for later post-event hours were not statistically

significant and therefore not included in the energy savings calculations. For summer 2019, Rush Hour Rewards resulted in an overall reduction in energy consumption on event days. The energy consumption impact ranged between -0.6 kWh and 0.7 kWh, demonstrating that the program modestly decreased customer energy consumption.

Figure 15. Rush Hour Rewards Summer 2019: Demand Savings by Event



Note: Impacts were estimated using regression analysis of customer AMI meter data. Errors bars show 95% confidence intervals estimated with standard errors clustered on customers. *n* indicates the number of test group customers in the analysis sample for the event. See *Appendix B* for details.

Summer Program Demand Savings Table 9 presents estimates of total Rush Hour Rewards demand savings during summer 2019 by event hour and the average for each event. The estimates were obtained by multiplying the evaluated average demand savings per participant by the number of test group participants in each event.

Table 9. Rush Hour Rewards Summer 2019 Total Demand Savings (MW)

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	
Event 1	5 p.m. – 7 p.m.	9.7	6.4	N/A	8.0	8,825
Event 2	5 p.m. – 7 p.m.	8.7	8.0	N/A	8.4	8,899
Event 3	4 p.m. – 7 p.m.	8.4	7.0	5.1	6.8	8,915
Event 4	4 p.m. – 7 p.m.	9.2	8.2	6.4	7.9	8,947
Event 5	5 p.m. – 6 p.m.	8.9	N/A	N/A	8.9	8,946
Event 6	4 p.m. – 7 p.m.	10.1	7.0	5.7	7.6	9,015
Average		**9.2**	**7.3**	**5.7**	**7.9**	**8,925**

Note: MW savings were estimated by multiplying the per customer demand savings estimates in each event hour by the number of test group participants in the analysis sample. The number of test group participants in the analysis sample varied by event. The analysis sample excludes homes with missing AMI meter data, multiple program enrollments (that may have been assigned into both test and control groups) and net metering customer. Details regarding the analysis sample and screening are provided in the *Data Collection and Preparation* section. ,

Across events, demand savings averaged 8 MW, with a range between 6.8 MW and 8.9 MW. Note that participants in the control group (n=398) did not contribute to the total demand savings since they did not experience any load control during events. However, they have the potential to contribute to PGE's future summer demand response capacity. Event 5, which began at 5 p.m. and lasted one hour, had the largest average demand savings of 8.9 MW. This is due to the absence of any savings degradation from later hours. Event 3, which began at 5 p.m. and lasted three hours, had the smallest average demand savings of 6.8 MW, likely diminished by the failure of the ecobee to dispatch.

Comparison to Previous Seasons

Table 10 compares evaluation estimates of average demand savings per participant and percentage demand savings for the current and previous Rush Hour Rewards seasons. The winter evaluated savings are averages across morning and evening events.

Table 10. Rush Hour Rewards: Seasonal Demand Savings Comparison

Season	Year	Event Time	Demand Savings		Avg. Event Temperature (°F)
			Average savings per participant (kW)	Percentage	
Summer	2017	Afternoon	1.01	38%	89
	2018	Afternoon	0.93	32%	88
	2019	Afternoon	0.89	36%	90
Winter	2017/2018	Morning Afternoon	0.72 0.57	28% 21%	38 40
	2018/2019	Morning Afternoon	0.34* 0.37*	20% 14%	35 40

Notes: Evaluated savings for previous years were obtained from Cadmus evaluations of Rush Hour Rewards program. Results for winter 2015/2016 and summer 2016 are publicly available from https://edocs.puc.state.or.us/efdocs/HAQ/um1708haq163627.pdf. Percentage savings equal kW savings / baseline demand.

* These savings estimates reflect the potential inclusion of non-electric heating customers in the winter participation season.

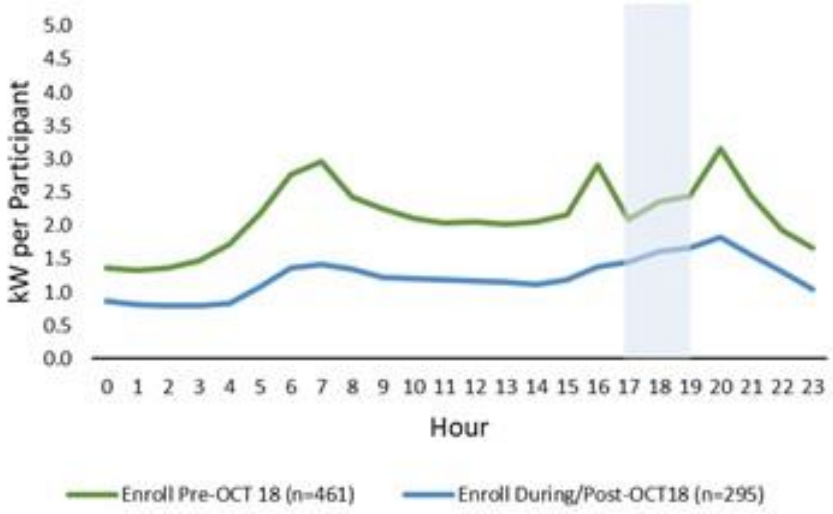
The evaluated demand savings for summer 2019 were less than in previous years. There were also no large differences in the percentage demand savings between years, suggesting that any differences may be attributable to annual fluctuations in weather and customer space cooling. Another cause could be changes over time in the composition of the participant population as program enrollments increased or in relation to participant program fatigue.

Enrollment of Non-Electric Heating Customers

In contrast to summer, the evaluated demand savings in winter 2018/2019 were much lower than in previous winters. Though some difference may have been due to annual fluctuations in weather, changes in the program population, or frequency of winter morning and evening events, the main reason was because of the enrollment of many non-electric heat customers in winter 2018/2019.

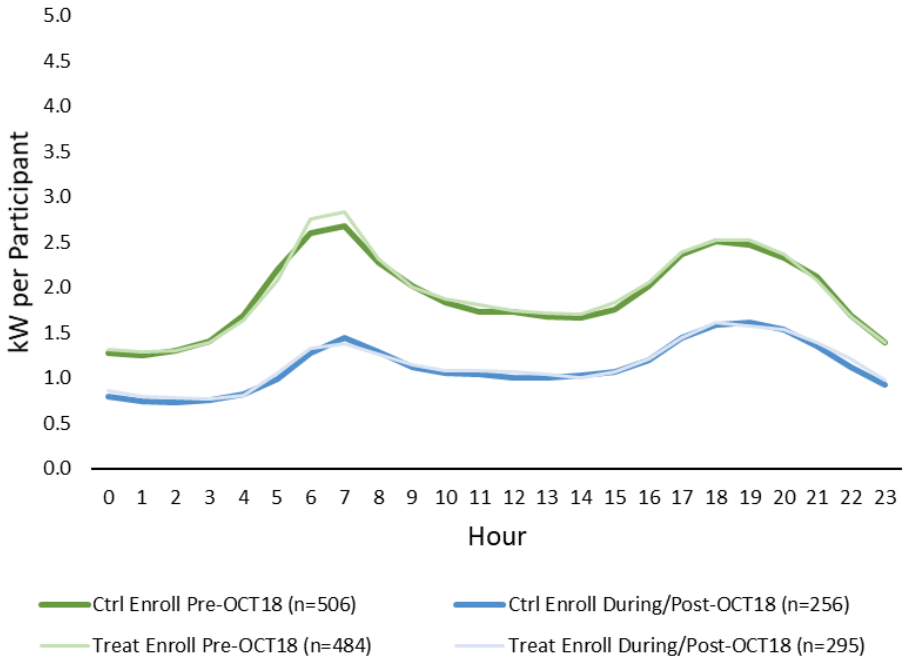
Figure 16 plots the average demand by hour of the day on afternoon event days for winter Rush Hour Rewards participants who enrolled before (n=461) and after (n=295) October 18, 2018, which is the date when Nest implemented changes to its enrollment filters. As the figure strongly suggests, customers enrolled after October 18 brought down the average demand savings and appear not to have electric heating. First, the average demand of customers enrolled after October 18 is low and relatively flat, suggesting they do not use electricity for space heating, and their daily load shape lies below that for customers enrolled before this date. Second, between 5:00 p.m. and 8:00 p.m., no tell-tale dip in electricity demand consistent with a direct load control event is evident. Instead, customer electricity demand continues to increase over this period, again suggesting that later enrollees either did not heat with electricity or did not receive signals from Nest. After Cadmus brought to PGE's attention that non-electric heating customers had been enrolled in Rush Hour Rewards, PGE began working with Nest to update the procedure for vetting winter participants.

Figure 16. Winter 2018/2019 Event Day Demand for Rush Hour Rewards Participants by Enrollment Period



Cadmus also compared nonevent day loads on Rush Hour Rewards customers enrolled before and after October 18. Similar trends in consumption are evident for non-event days, as shown in Figure 16.

Figure 17. Winter 2018/2019 Average Rush Hour Rewards Customer Demand for Non-Event Days by Enrollment Period



Summer Customer Experience

After the summer event season, Cadmus administered an online survey to test and control group participants. The summer experience survey asked Rush Hour Rewards participants about their event awareness, comfort, satisfaction, and suggestions for improvement. The survey took respondents less

than seven minutes to complete and respondents did not receive an incentive for completing the survey. The following sections describe the key findings from this survey. Survey results from the previously evaluated seasons are provided in *Appendix C.*

Summer Event Awareness

PGE called six events for Rush Hour Rewards during summer 2019. The experience survey asked test group respondents whether they noticed the events and how many they noticed. Sixty-eight percent of respondents (n=231) said they noticed events. Of those who noticed, on average, they noticed 4.2 events (n=156) of the six called. More respondents (n=180) noticed due to the event message display on the Nest thermostat (71%) and the event notification from the smartphone app (71%) than to a temperature change (39%).

The program does not require any customer effort during the event. As expected, a high proportion of respondents (93%) said participating in the summer events was easy (n=205). Specifically, 80% said it was *very easy* and 13% said it was *somewhat easy*. The 2% of respondents who found it difficult to participate in the events mentioned the following top three reasons:

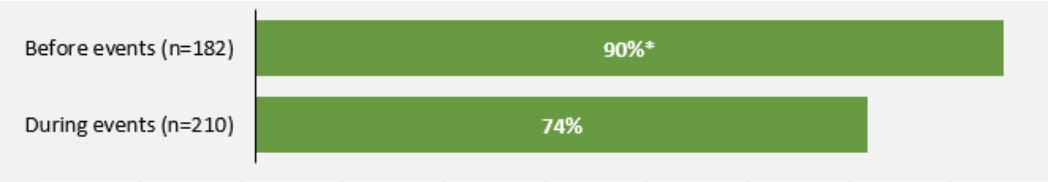
- Other household members controlling the smart thermostat (four respondents)
- The timing of the events (two respondents)
- Not understanding how the program works (two respondents)

Summer Event Comfort

Thirty-three percent of test group respondents (n=224) reported that they did override some of the summer events. Of these respondents, 74% (n=74) cited thermal discomfort as their reason.

Findings on customers' summer event comfort were similar to that of winter. Most test group respondents recalled being comfortable before and during the summer events. Figure 18 shows that before the events, 90% of respondents said their home's interior temperature was comfortable. During the events, 74% said they were comfortable, a statistically significant decrease of 16 points compared to the comfort level before events.

Figure 18. Rush Hour Rewards Summer 2019: Percentage of Comfortable Rating Before and During Events



* Difference is statistically significant with 90% confidence (p≤0.10).

Note: Test group respondents rated their comfort level on a 0 to 10 scale, where 0 meant *extremely uncomfortable* and 10 meant *extremely comfortable*. Cadmus defined a 6 to 10 rating as *comfortable*.

Source: Summer Experience Survey Questions: "Overall this past summer, how comfortable was the interior temperature of your home a few hours before the high demand events?" and "Overall this past summer, how comfortable was the interior temperature of your home during the high demand events?"

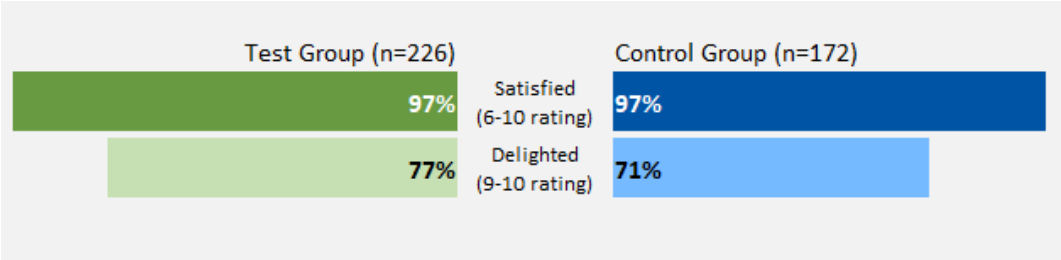
Summer Satisfaction

Test and control group respondents rated their satisfaction with the smart thermostat, the incentive check, the program, and PGE, using a 0 to 10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6 to 10 rating as *satisfied* and a 9 or 10 rating as *delighted*.

Summer Satisfaction with Smart Thermostat

Nearly all test and control group respondents were *satisfied* with their Nest smart thermostat. Figure 19 shows that 97% of test and control group respondents were *satisfied*, with 77% of test group respondents and 71% of control group respondents reporting they were *delighted*. Customers already owned their smart thermostats prior to program enrollment so, as expected, there was no statistically significant difference between test and control group respondents in their satisfaction.

Figure 19. Rush Hour Rewards Summer 2019: Satisfaction with Smart Thermostat

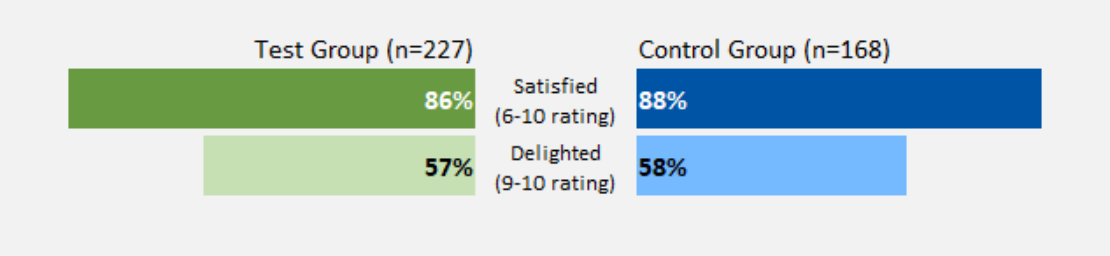


Source: Summer Experience Survey Question: "How satisfied are you with your Nest thermostat?"

Summer Satisfaction with Incentive

Most respondents were satisfied with the incentive amount. As shown in Figure 20, similar proportions of test group respondents (86%) and control group respondents (88%) were *satisfied*. Similar proportions of test group respondents (57%) and control group respondents (58%) were *delighted*. The evaluation expected to see a higher reported satisfaction for control group respondents, who did not experience any events and were not inconvenienced but still received the $25 incentive, compared to test group respondents.

Figure 20. Rush Hour Rewards Summer 2019: Satisfaction with Incentive

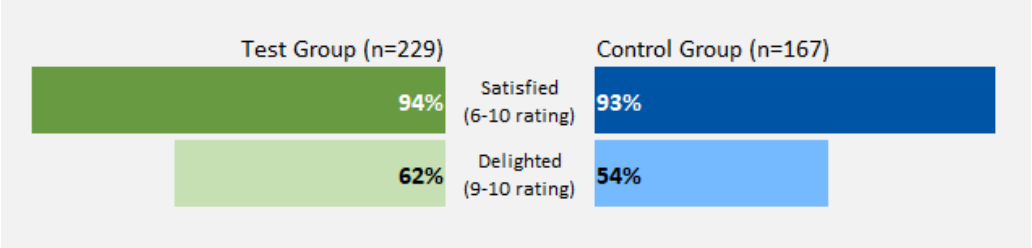


Source: Summer Experience Survey Question. "You have or will soon receive an incentive check for $25.00 in exchange for your participation this past summer. How satisfied are you with the incentive check?"

Summer Satisfaction with Program

Most respondents were satisfied with the program. A similar proportion of test group respondents (94%) and control group respondents (93%) were *satisfied* (Figure 21). A higher proportion of test group respondents (62%) than control group respondents (54%) were *delighted*, although the difference was not statistically significant.

Figure 21. Rush Hour Rewards Summer 2019: Satisfaction with Program



Source: Summer Experience Survey Question. "Please rate your overall satisfaction PGE's Smart Thermostat program"

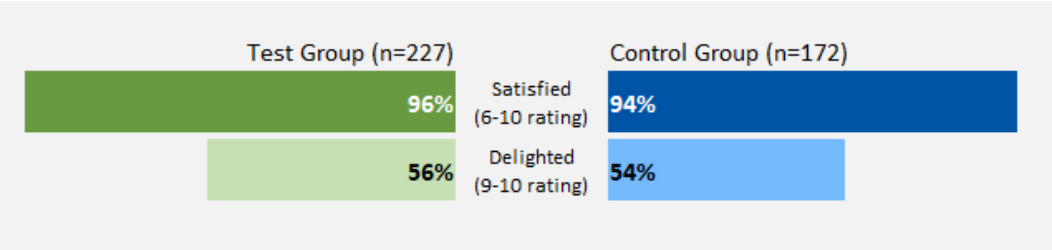
The summer experience surveys asked test and control group respondents to explain their program satisfaction ratings. Cadmus analyzed these open-end explanations according to positive or negative sentiment. Both test and control group respondents had largely positive comments about the program. Positive comments from test group respondents (n=153) most often mentioned that the program works well (51%), the program helps the environment/community save energy and reduce demand (17%), and that they like receiving an incentive (13%). Similar to responses from the test group, control group respondents (n=117) most often said that the program works well (48%), the program helps the environment/community save energy and reduce demand (15%), and the respondents like receiving an incentive (9%).

Test group respondents made negative comments about the incentive amount (9%) and that participation in the program was not worth being uncomfortable (8%). The control group respondents made negative comments about the lack the information or transparency (8%) and the incentive amount (5%).

Summer Satisfaction with Portland General Electric

Almost all respondents were satisfied with PGE. As shown in Figure 22, 96% of test group and 94% of control group respondents were *satisfied,* and this difference was not statistically significant. A similar proportion of test group respondents (56%) and control group respondents (54%) were *delighted* with PGE.

Figure 22. Summer Rush Hour Rewards: Satisfaction with PGE



Summer Experience Survey Question: "Please rate your overall satisfaction with the PGE."

Summer Customer-Suggested Improvements

The 101 test group respondents who answered the open-end question on how to improve the program most often suggested the following:

- Increase the incentive amount (16%)
- Send earlier pre-event notifications (9%)
- Change the event frequency or duration (7%)

Further review of the open-end responses indicated that eight test group respondents from the summer experience survey and nine from the winter experience survey asked for their event participation history.

Currently, PGE does not provide customers a way to check their event participation history to determine if they are on track to earning their $25 incentive check for participating in at least 50% of the event hours; PGE is considering this for the future. PGE does, however, offer information on event participation history to participants in the Peak Time Rebates program. Should participants in the Peak Time Rebates program enroll into the Smart Thermostat program, PGE could consider extending this approach and providing all customers their event participation history.

BYOT Connected Savings Winter 2018/2019

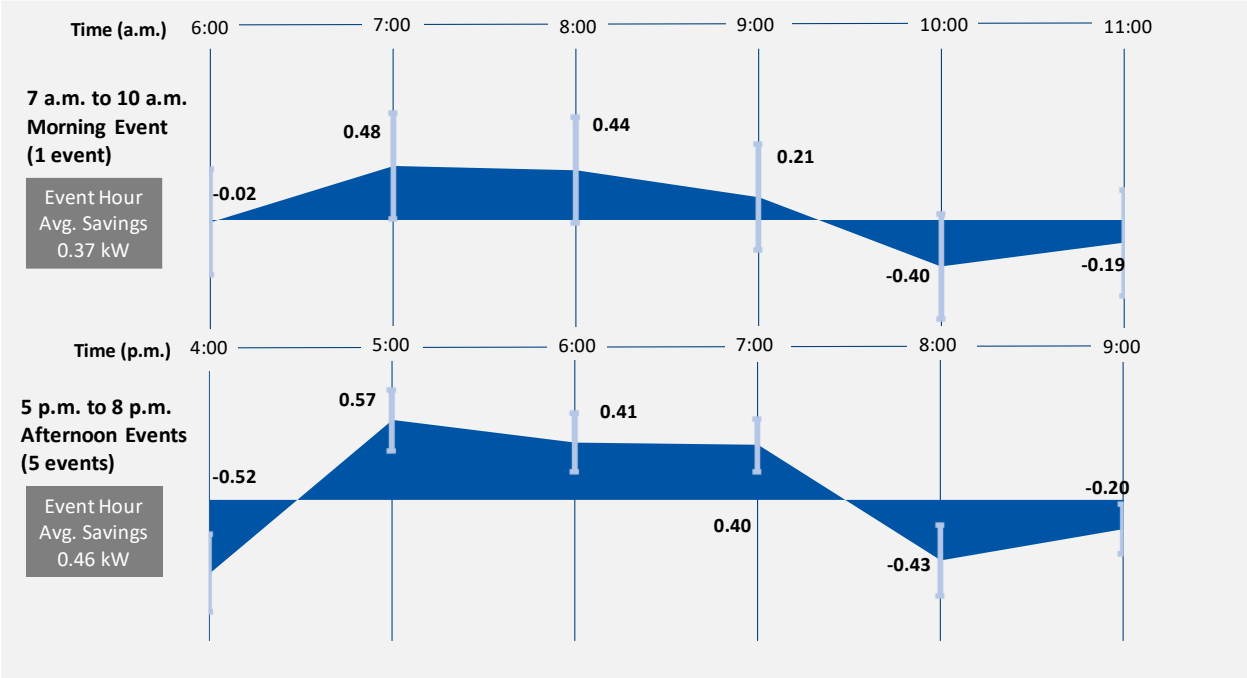
This section provides detailed findings about Connected Savings during winter 2018/2019.

Winter Load Impacts

During winter 2018/2019 PGE called Connected Savings events on the same schedule as Rush Hour Rewards events. Figure 23 presents the average kilowatt impacts per participant for one hour prior to the event, each event hour, and two hours after the event ended. Figure 24 shows the corresponding percentage savings. The program achieved average demand savings per participant of 0.37 kW for the

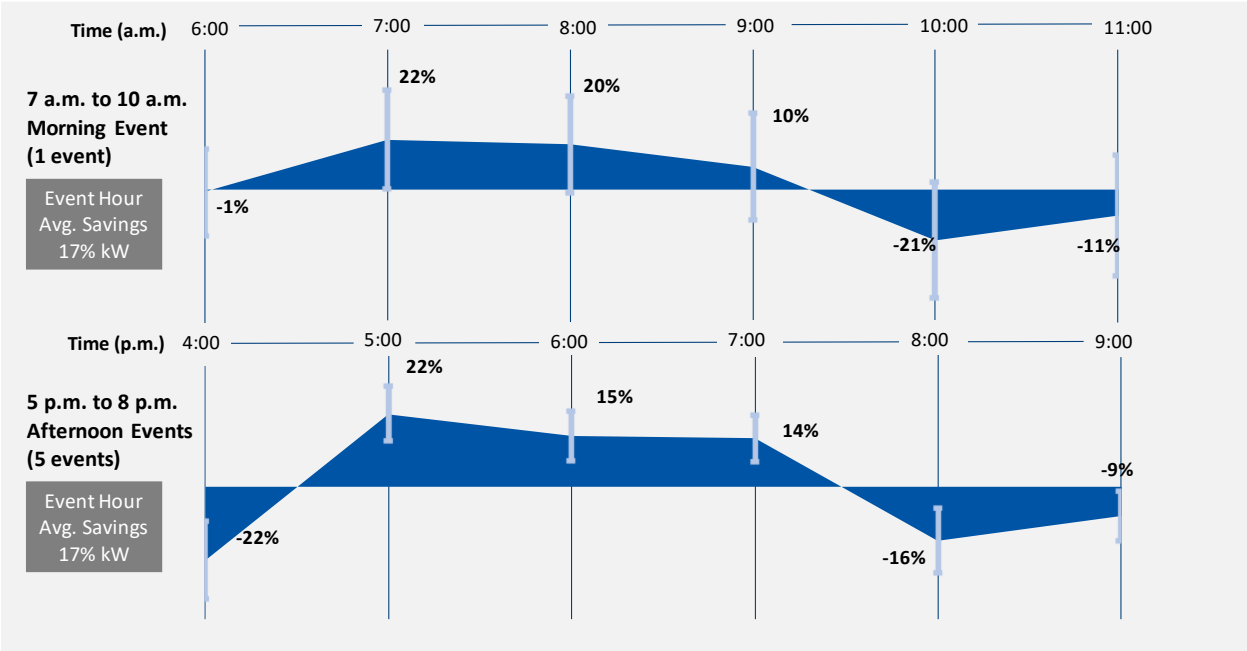
morning event and 0.46 kW for afternoon events. Over all events during the winter 2018/2019 season, Connected Savings achieved an average demand savings of 0.44 kW per participant.

Figure 23. Connected Savings Winter 2018/2019: Average Demand Savings (kW) per Participant



Note: Impacts were estimated using regression analysis of customer AMI meter data for 377 customers. This count includes test and control group customers in the analysis sample, and the total number of customers in the analysis sample varied slightly by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for details.

Figure 24. Connected Savings Winter 2018/2019: Percentage Demand Savings



Note: Impacts were estimated using regression analysis of customer AMI meter data for 377 customers. This count includes test and control group customers, and the total number of customers varied by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for details

During the 2018/2019 winter Connected Savings events, savings peaked in the first hour, then diminished through the remaining hours. This follows a similar trend to the Rush Hour Rewards savings, though the degradation was more extreme for the morning three-hour events than for the afternoon events. Due to the small sample size of connected savings the winter season, savings are not precisely estimated, and the differences in savings between hours are not statistically different.

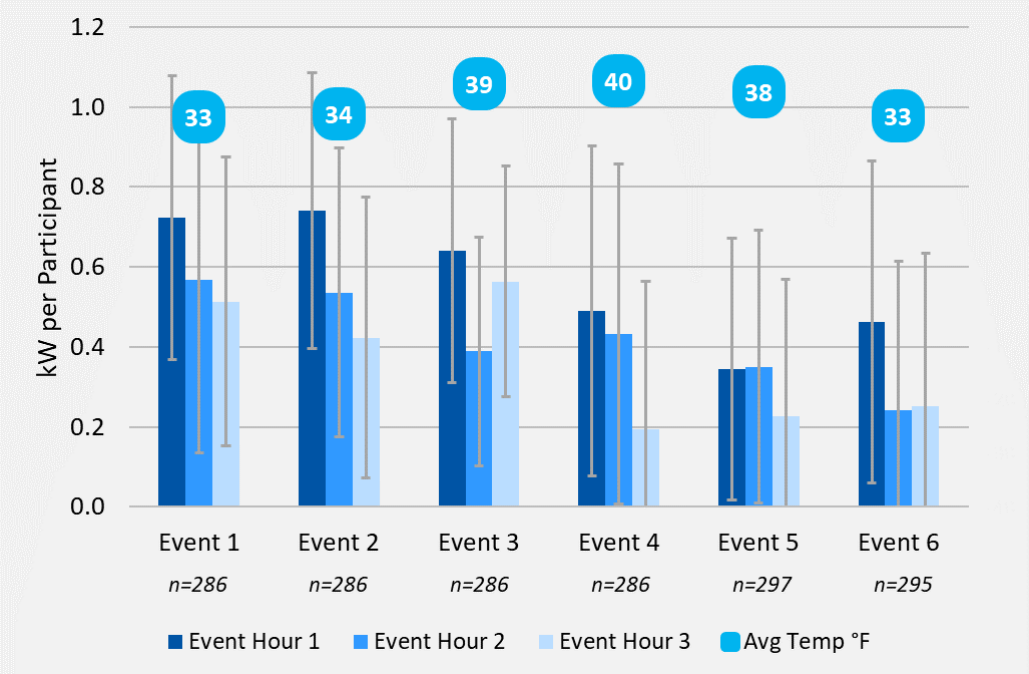
Pre-heating and snapback increased participant loads before and after events. Pre-heating of participant homes increased electricity demand by about 0.52 kW, or 22%, before afternoon events. For the morning event, the impact of pre-heating on electricity demand was small and not statistically significant, probably because most heating units had already been running to warm the home. After events ended, demand increased above usual levels, as the thermostat sought to return the home's interior temperature to scheduled setting. In the first hour after events, there was an increase in demand or snapback of 0.4 kW per participant home, or 16% for afternoon events and 21% for morning events. Demand remained greater than normal for about two hours after the events ended. It is worth noting that due to the relatively small sample sizes for the winter 2018/2019 Connected Savings season, the confidence intervals for the savings estimates are wide, especially for the morning event.

Winter Demand Savings Estimates by Event

Figure 25 shows the average demand savings per participant for each event hour of the six winter events. Savings degraded across event hours, except for event 3. For most events, first-hour savings per

participant ranged from 0.4 kW and 0.8 kW, while the final hour savings per participant ranged from 0.2 kW and 0.5 kW.

Figure 25. Connected Savings Winter 2018/2019: Demand Savings by Event



Note: Errors bars show 95% confidence intervals estimated with standard errors clustered on customers. *n* indicates the number of test group customers in the analysis sample for the event. See Appendix B for details.

During events 1, 3, and 4, energy consumption slightly decreased. However, the Connected Savings winter 2018/2019 season experienced some of the largest increases in energy consumption during events 2, 5, and 6. Event 6 is by far the largest in the history of both Connected Savings and Rush Hour Rewards *Appendix B* contains point estimates of demand savings, pre-event load impacts, post-event snapback, and energy savings.)

Winter Program Demand Savings

Table 11 presents estimates of total demand savings in the Connected Savings program during winter 2018/2019 by event hour and on average for each event. The estimates were obtained by multiplying the estimated per-participant average demand savings by the number of participants in each event.

Table 11. Connected Savings Winter 2018/2019 Total Demand Savings (MW)

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	
Event 1	5 p.m. – 8 p.m.	0.21	0.16	0.15	0.17	286
Event 2	5 p.m. – 8 p.m.	0.21	0.15	0.12	0.16	286
Event 3	5 p.m. – 8 p.m.	0.18	0.11	0.16	0.15	286

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	
Event 4	7 a.m. – 10 a.m.	0.14	0.12	0.05	0.11	286
Event 5	7 a.m. – 10 a.m.	0.10	0.10	0.07	0.09	297
Event 6	5 p.m. – 8 p.m.	0.14	0.07	0.07	0.09	295
Average		0.16	0.12	0.10	0.13	289

Note: MW savings were estimated by multiplying the per customer demand savings estimates in each event hour by the number of test group participants in the analysis sample. The number of test group participants in the analysis sample varied by event. The analysis sample excludes homes with missing AMI meter data, multiple program enrollments (that may have been assigned into both test and control groups) and net metering customer. Details regarding the analysis sample and screening are provided in the *Data Collection and Preparation* section.

Across events, demand savings averaged 0.16 MW. Event savings typically ranged between 0.12 MW and 0.21 MW. Note that participants in the control group (n=175) did not contribute to total demand savings estimates since no load control was experienced during events. However, they could have contributed to PGE's winter demand response capacity.

Winter Customer Experience

After the winter event season, Cadmus administered an online survey to test and control group participants. The winter experience survey asked Connected Savings participants about their event awareness, comfort, satisfaction, and suggestions for improvement. The survey took respondents less than seven minutes to complete and respondents did not receive an incentive for completing the survey. The following sections describe the key findings from this survey. Survey results from the previously evaluated seasons are provided in *Appendix C.*

Winter Event Awareness

PGE called six events for Connected Savings during winter 2018/2019. The experience survey asked test group respondents whether they noticed events and how many they noticed. Sixty-one percent of respondents (n=64) said they noticed events. Of those who noticed, on average, they noticed 4.3 events (n=39) of the six called. Respondents (n=40) noticed mostly due to the temperature change (68%) and the event message display on the smart thermostat (63%).

As expected, a high proportion of respondents (86%) said participating in the winter events was easy (n=57). Specifically, 67% said it was *very easy* and 19% said it was *somewhat easy*. The 10% of respondents who found it difficult to participate in the events mentioned these reasons:

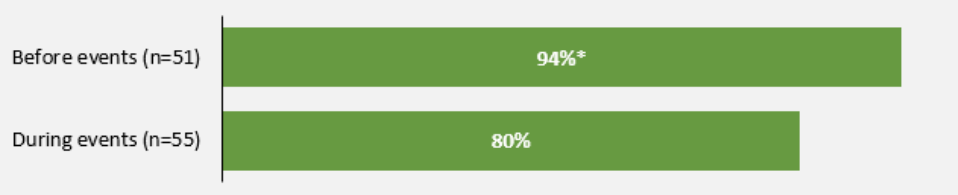
- The timing of events (three respondents)
- Health or medical reasons (two respondents)
- Having guests or visitors around (one respondent)
- Lack of notifications (one respondent)

Winter Event Comfort

Half of the test group respondents (48%, n=63) reported that they overrode some of the winter events. Of these 31 respondents, 87% cited thermal discomfort as their reason.

Findings on Connected Savings' winter event comfort were similar to those of Rush Hour Rewards where a decrease in comfort was detected. Most Connected Savings' test group respondents recalled being comfortable before and during the winter events. Figure 26 shows that, before the events, 94% said their home's interior temperature was comfortable. When recalling their comfort level during events, 80% said they were comfortable, a statistically significant decrease of 14 points compared to the comfort level before events.

Figure 26. Connected Savings Winter 2018/2019: Percentage of Comfortable Rating Before and During Events



* Difference is statistically significant with 90% confidence (p≤0.10).

Note: Test group respondents rated their comfort level on a 0 to 10 scale, where 0 meant *extremely uncomfortable* and 10 meant *extremely comfortable*. Cadmus defined a 6 to 10 rating as *comfortable*.

Source: Winter 2018-19 Experience Survey Questions. "Overall this past winter, how comfortable was the interior temperature of your home a few hours before the high demand events?" and "Overall this past winter, how comfortable was the interior temperature of your home during the high demand events?"

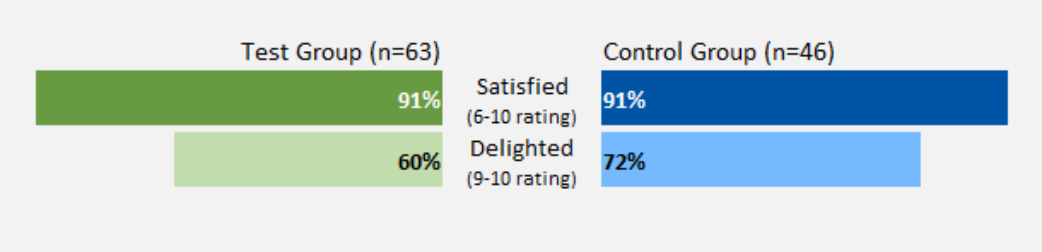
Winter Satisfaction

Test and control group respondents rated their satisfaction with the smart thermostat, the incentive check, the program, and PGE, using a 0 to 10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defines a 6 to 10 rating as *satisfied* and a 9 or 10 rating as *delighted*.

Winter Satisfaction with Smart Thermostat

Most respondents were satisfied with their smart thermostat. Figure 27 shows that 91% of both test group and control group respondents were *satisfied*. Sixty percent of test group respondents and 72% of control group respondents were *delighted*. There was no statistically significant difference between test and control group respondents in satisfaction. No difference was expected because customers already owned their smart thermostats prior to program enrollment.

Figure 27. Connected Savings Winter 2018/2019: Satisfaction with Smart Thermostat

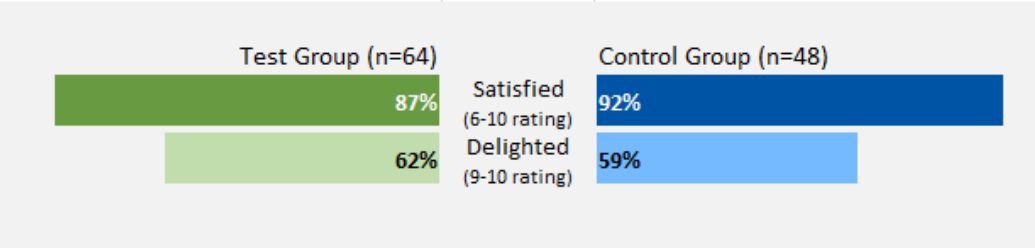


Source: Winter 2018-19 Experience Survey Question. "Please rate your overall satisfaction with the smart thermostat."

Winter Satisfaction with Incentive

Most respondents were satisfied with the incentive amount (Figure 28). Fewer test group respondents (87%) than control group respondents (92%) were *satisfied,* whereas slightly more test group respondents (62%) than control group respondents (59%) were *delighted*. These differences were not statistically significant. The evaluation expected higher reported satisfaction for control group respondents, who did not experience any events (which might cause inconvenience) and still received the $25 incentive, compared to test group respondents.

Figure 28. Connected Savings Winter 2018/2019: Satisfaction with Incentive

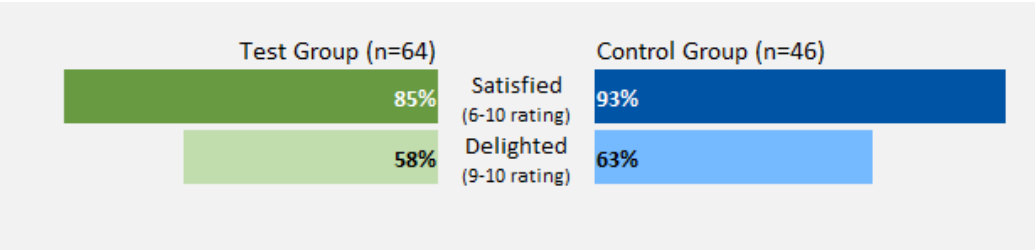


Source: Winter 2018-19 Experience Survey Question. "You have or will soon receive an incentive check for $25.00 in exchange for your participation this past winter. How satisfied are you with the incentive check?"

Winter Satisfaction with Program

Most respondents were satisfied with the program (Figure 29). More control group respondents (93%) than test group respondents (85%) were *satisfied*, and more control group respondents (63%) than test group respondents (58%) were *delighted*. These differences were not statistically significant.

Figure 29. Connected Savings Winter 2018/2019: Satisfaction with Program



Source: Winter 2018-19 Experience Survey Question. "Please rate your overall satisfaction with PGE's Smart Thermostat Program."

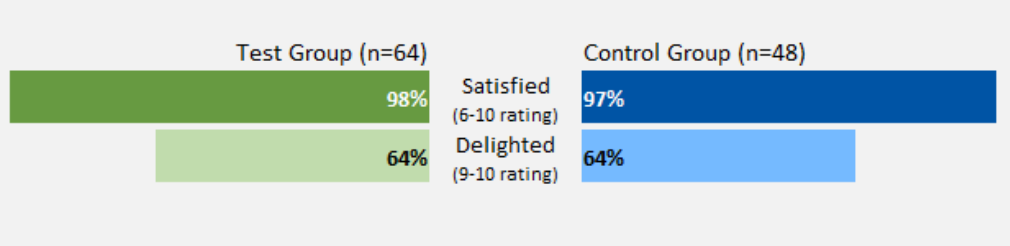
The winter experience survey asked test and control group respondents to explain their program satisfaction ratings. Cadmus analyzed their open-end explanations according to positive or negative sentiment. Both test and control group respondents had largely positive comments about the program. Positive comments from the test group respondents (n=54) most often mentioned that the program works well (37%) and helps the environment/community save energy and reduce demand (13%) and that they like receiving an incentive (4%). Similar to the responses of the test group, control group respondents (n=44) most often said that the program works well (39%) and helps the environment/ community save energy and reduce demand (9%) and that they like receiving an incentive (9%).

Test group respondents made negative comments about the lack of event notifications (13%), the program not working out for them (6%), the incentive was too small (4%), and their electricity bill was higher (4%). Control group respondents made negative comments about the incentive being too small (5%) and that they had problems using the smart thermostat (5%).

Winter Satisfaction with Portland General Electric

Nearly all test and control group respondents were satisfied with PGE. As shown in Figure 30, a similar proportion of test group (98%) and control group (97%) respondents were *satisfied* with PGE and the same proportion (64%) were *delighted* with PGE.

Figure 30. Connected Savings Winter 2018/2019: Satisfaction with PGE



Source: Winter 2018-19 Experience Survey Question. "Please rate your overall satisfaction PGE."

Winter Customer-Suggested Improvements

The 36 test group respondents who answered the open-end question on how to improve the program most often suggested these three improvements:

- Send pre-event notifications (19%)
- Send notifications or program information via text or email (14%)
- Increase the incentive amount (11%)

BYOT Connected Savings Summer 2019

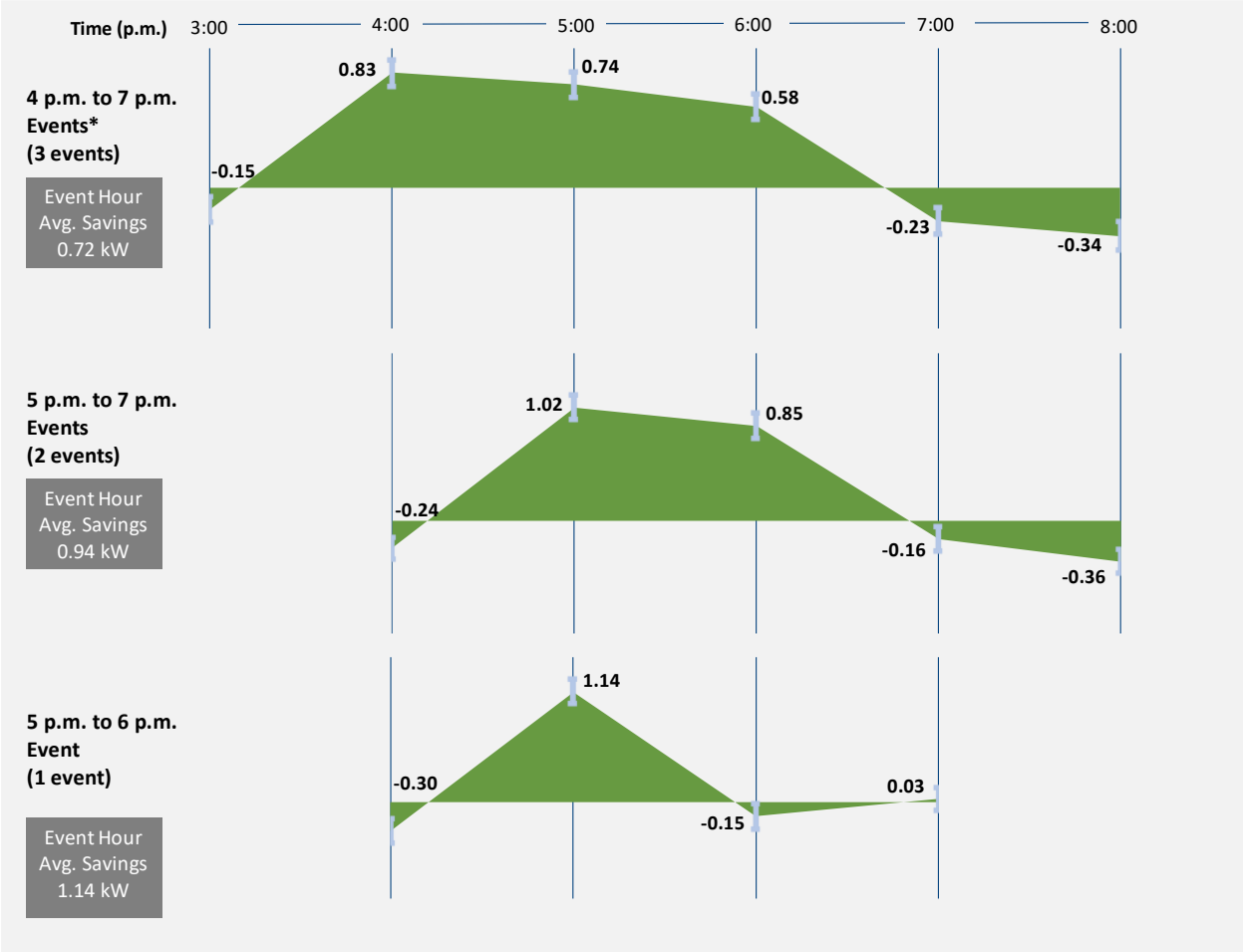
This section provides detailed findings about Connected Savings during Summer 2019.

Summer Load Impacts

During summer 2019, PGE called six Connected Savings events on the same schedule as Rush Hour Rewards events. PGE launched three events starting at 4 p.m. and lasting three hours, two events starting at 5 p.m. and lasting two hours, and one event starting at 5 p.m. and lasting one hour.

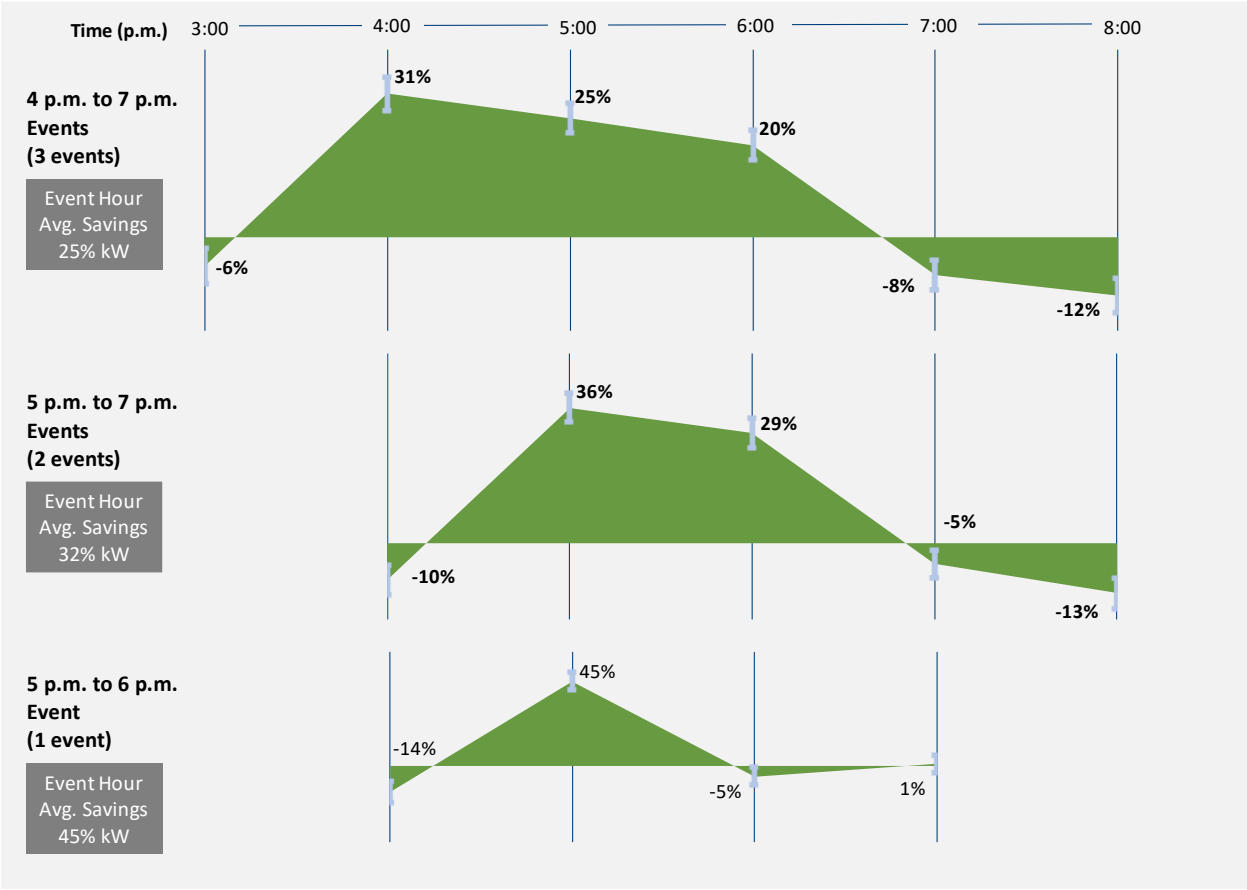
Figure 31 presents the average kilowatt impacts per participant for one hour prior to the event, each event hour, and two hours after the event ended. Figure 32 show the savings as a percentage of baseline demand. The program achieved average demand savings of 0.72 kW for the three-hour events, 0.94 kW for the two-hour events, and 1.14 kW for the one-hour event. The program achieved average demand savings per participant of 0.80 kW.

Figure 31. Connected Savings Summer 2019: Average Demand Savings (kW) per Participant Average Kilowatt Demand Savings by Event Start Time



Note: Impacts were estimated using regression analysis of customer AMI meter data for 2,202 customers. This count includes test and control group customers in the analysis sample, and the total number of customers in the analysis sample varied slightly by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for details.

Figure 32. Connected Savings Summer 2019: Percentage Demand Savings



Note: Impacts were estimated using regression analysis of customer AMI meter data for 2,202 customers. This count includes test and control group customers in the analysis sample, and the total number of customers in the analysis sample varied slightly by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for details

During summer events, savings peaked in the first hour, then diminished through the remaining hours, which follows a similar trend observed in previous evaluations of Rush Hour Rewards and Connected Savings.

Pre-cooling and snapback increased participant loads before and after events. Pre-cooling of participant homes increased electricity demand by about 0.2 kW to 0.3 kW or 6% to 14% before afternoon events. After events ended, demand increased above usual levels by between 0.2 kW and 0.3 kW per participant home or 12% to 13% of baseline demand. Demand remained statistically greater than normal for about four hours after the events ended.

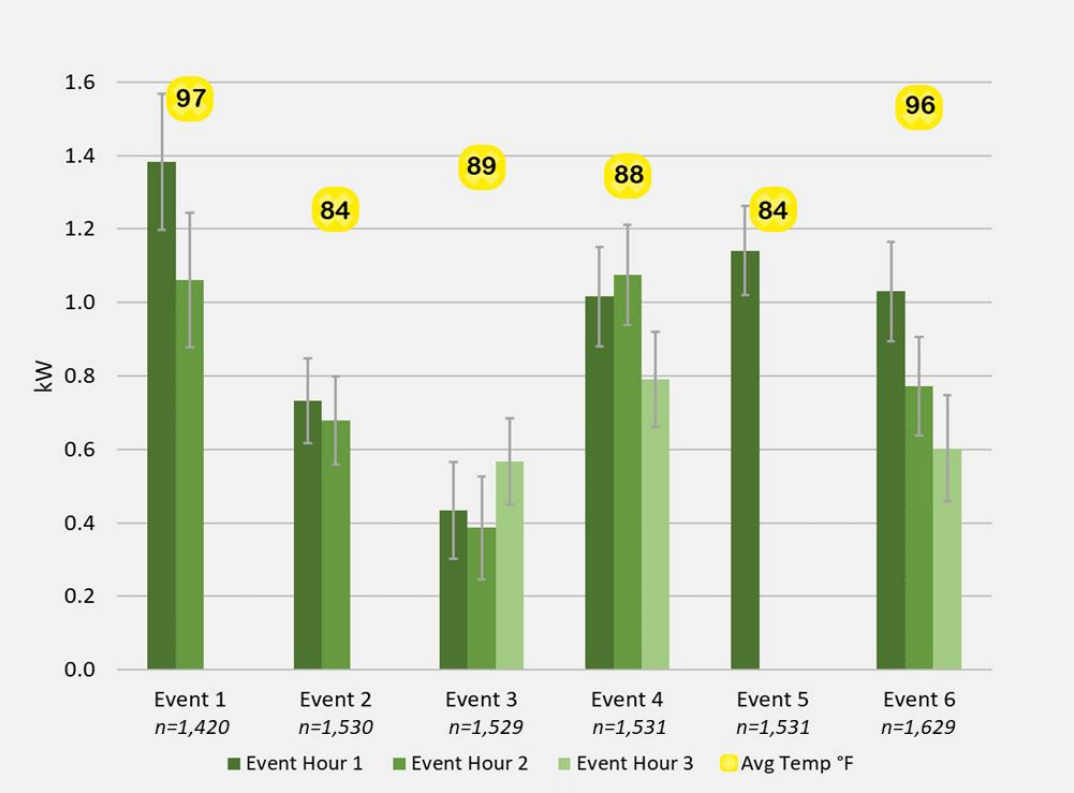
Summer Demand Savings Estimates by Event

Figure 33 shows the average demand reduction per participant for each hour of the six summer events. Slight degradation of savings across event hours is evident for most events. However, the difference in savings between the first hour and last hour is different only for event 6. Events 3 and 4 do not exhibit

degradation of savings over time. One cause may have been the disruption in the ecobee online service discussed in the *Implementation Successes and Challenges* section of the report.

Point estimates of demand savings, pre-event conditioning impacts, post-event snapback, and event-day energy savings are shown in Table B-8 in *Appendix B*. Energy savings for summer were estimated by summing load impacts across the pre-event hour, event hours, and the first four post-event hours. On average, energy savings ranged between 0.1 kWh and 1.1 kWh per participant on event days, suggesting that the program slightly decreased energy consumption overall.

Figure 33. Connected Savings Summer 2019: Demand Savings by Event



Note: Errors bars show 95% confidence intervals estimated with standard errors clustered on customers. See Appendix B for details. *n* indicates the number of test group customers in the analysis sample for the event.

Summer Program Demand Savings

Table 12 presents estimates of total Connected Savings demand savings during summer 2019 by event hour and on average for each event. The estimates were obtained by multiplying the estimated per-participant average demand savings by the number of participants in each event.

Table 12. Connected Savings Summer 2019 Total Demand Savings (MW)

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	
Event 1	5 p.m. – 7 p.m.	2.0	1.5	N/A	1.7	1,420
Event 2	5 p.m. – 7 p.m.	1.1	1.0	N/A	1.1	1,530
Event 3	4 p.m. – 7 p.m.	0.7	0.6	0.5	0.6	1,529
Event 4	4 p.m. – 7 p.m.	1.6	1.7	1.2	1.5	1,531
Event 5	5 p.m. – 6 p.m.	1.7	N/A	N/A	0.2	1,531
Event 6	4 p.m. – 7 p.m.	1.7	1.3	1.0	1.3	1,629
Average		**1.5**	**1.2**	**0.9**	**1.3**	**1,528**

Note: MW savings were estimated by multiplying the per customer demand savings estimates in each event hour by the number of test group participants in the analysis sample. The number of test group participants in the analysis sample varied by event. The analysis sample excludes homes with missing AMI meter data, multiple program enrollments (that may have been assigned into both test and control groups) and net metering customer. Details regarding the analysis sample and screening are provided in the *Data Collection and Preparation* section.

Across events, demand savings averaged 1.3 MW. Note that participants in the control group (n=570) do not contribute to the total demand savings since they did not experience load control during events. However, they could have contributed to PGE's summer demand response capacity. Events typically ranged between 0.6 MW and 1.7 MW, with the exception of event 3, which was lower due to an online service disruption of ecobee thermostats, which is discussed in the *Implementation Successes and Challenges* section of the report.

Summer Customer Experience

After the summer event season, Cadmus administered an online survey to test and control group participants. The summer experience survey asked Connected Savings participants about their event awareness, comfort, satisfaction, and suggestions for improvement. The survey took respondents less than seven minutes to complete and respondents did not receive an incentive for completing the survey. The following sections describe the key findings from this survey. Survey results from the previously evaluated seasons are provided in *Appendix D.*

Summer Event Awareness

PGE called six events for Connected Savings during summer 2019; however, one of the events failed to dispatch on ecobee thermostats.[19] The experience surveys asked test group respondents whether they noticed the events and how many they noticed. Sixty-three percent of respondents (n=186) said they noticed events. Of those who noticed, on average, they noticed 4.0 events, (n=118) of the six called.

[19] Customers with an ecobee thermostat only experienced five events due to an ecobee dispatch failure on the July 16 event.

Respondents (n=103) noticed mostly due message display on the smart thermostat (70%) and a temperature change (43%).

Most respondents (84%) said participating in the summer events was easy (n=162). Specifically, 67% said it was *very easy* and 17% said it was *somewhat easy*. The 6% of respondents who found it difficult to participate in the events mentioned the following reasons:

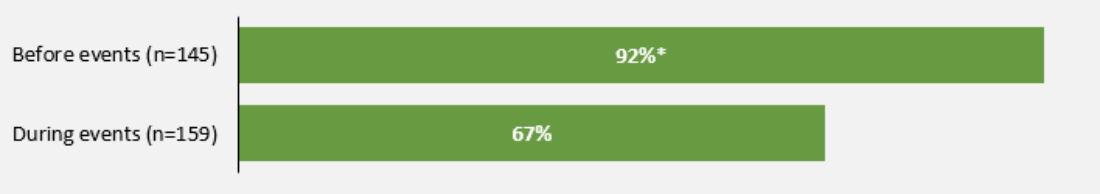
- The timing of events (six respondents)
- The lack of notifications (three respondents)
- Having guests or visitors around (three respondents)
- Not understanding how the program works (one respondent)

Summer Event Comfort

Forty-one percent of test group respondents (n=180) reported that they overrode some of the summer events. Respondents who reported overriding (n=48) most often cited thermal discomfort as their reason (75%).

The decrease in comfort observed in winter was detected again in the summer for Connected Savings. Most test group respondents recalled being comfortable before and during the summer events. Figure 34 shows that before the events, 92% of respondents said their home's interior temperature was comfortable. During the events, 67% said they were comfortable, a statistically significant decrease of 25 points compared to the comfort level before events.

Figure 34. Connected Savings Summer 2019: Percentage of Comfortable Rating Before and During Events



* Difference is statistically significant with 90% confidence (p≤0.10).

Note: Test group respondents rated their comfort level on a 0 to 10 scale, where 0 meant *extremely uncomfortable* and 10 meant *extremely comfortable*. Cadmus defined a 6 to 10 rating as *comfortable*.

Source: Summer 2018 Experience Survey Questions. "Overall this past summer, how comfortable was the interior temperature of your home a few hours before the high demand events?" and "Overall this past summer, how comfortable was the interior temperature of your home during the high demand events?"

Summer Satisfaction

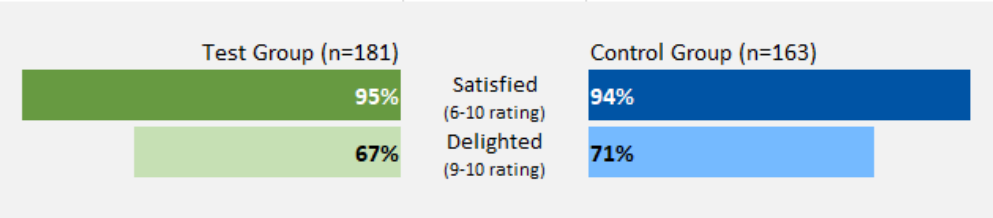
Test and control group respondents rated their satisfaction with the smart thermostat, the incentive check, the program, and PGE, using a 0 to 10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defines a 6 to 10 rating as *satisfied* and a 9 or 10 rating as *delighted*.

Summer Satisfaction with Smart Thermostat

Most respondents were satisfied with their smart thermostat. Figure 35 shows that a similar percentage of test group (95%) and control group (94%) respondents were *satisfied,* and 67% of test group

respondents and 71% of control group respondents were *delighted*. There was no statistically significant difference between test and control group respondents. No difference was expected because participants already owned their smart thermostats prior to program enrollment.

Figure 35. Connected Savings Summer 2019: Satisfaction with Smart Thermostat

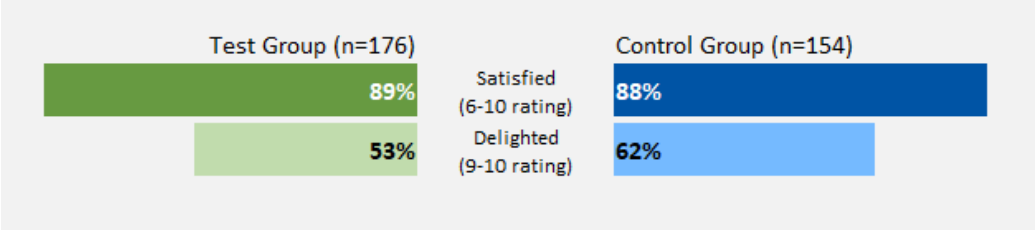


Source: Summer 2019 Experience Survey Question. "Please rate your overall satisfaction with the smart thermostat."

Summer Satisfaction with Incentive

Most respondents were satisfied with the incentive amount. Contrary to expectations, control group respondents did not show higher satisfaction with the incentive than test group respondents. They reported similar levels of satisfaction with the incentive, 89% for test group and 88% for control group (Figure 36). More control group respondents (62%) than test group respondents (53%) were *delighted* with the incentive, but the difference was not statistically significant.

Figure 36. Connected Savings Summer 2019: Satisfaction with Incentive

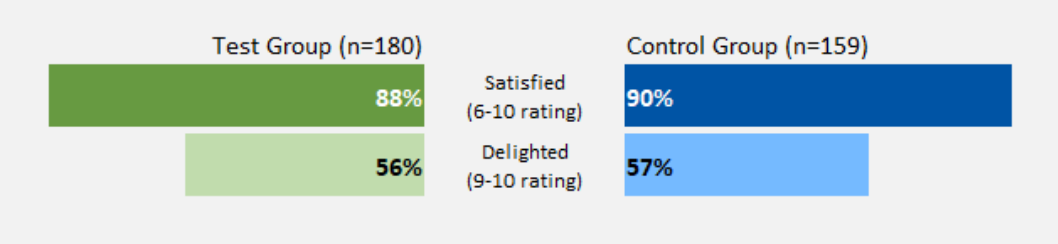


Source: Summer 2019 Experience Survey Question. "You have or will soon receive an incentive check for $25.00 in exchange for your participation this past summer. How satisfied are you with the incentive check?"

Summer Satisfaction with Program

Most respondents were satisfied with the program. A similar proportion of test group respondents (88%) and control group respondents (90%) were *satisfied* with the program (Figure 37). A similar proportion of test group respondents (56%) and control group respondents (57%) were *delighted*.

Figure 37. Connected Savings Summer 2019: Satisfaction with Program



Source: Summer 2019 Experience Survey Question. "Please rate your overall satisfaction with PGE's Smart Thermostat program."

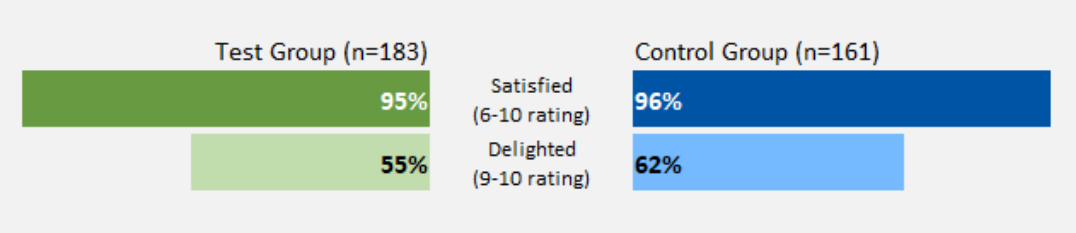
The summer experience surveys asked test and control group respondents to explain their program satisfaction ratings. Cadmus analyzed these open-end explanations according to positive or negative sentiment. Both had largely positive comments about the program. Positive comments from test group respondents (n=135) most often mentioned that the program works well (40%) and helps the environment/community save energy and reduce demand (13%) and that they like receiving an incentive (10%). The control group (n=115) cited the same positive comments as the test group, that the program works well (52%) and helps the environment/community save energy and reduce demand (11%) and that they like receiving an incentive (10%).

Test group respondents made negative comments about the participation not being worth the thermal discomfort (13%), the lack of event notifications (8%), and the incentive being too small (4%). The control group respondents frequently made negative comments about insufficient program information or transparency (6%), the incentive being too small (5%), and lack of event notifications (5%).

Summer Satisfaction with Portland General Electric

Nearly all respondents were satisfied with PGE. As shown in Figure 38, a similar proportion of test group (95%) and control group (96%) respondents were *satisfied* with PGE. A higher proportion of control group respondents (62%) than test group respondents (55%) were *delighted* with PGE, but the difference was not statistically significant.

Figure 38. Connected Savings Summer 2019: Satisfaction with PGE



Source: Summer 2019 Experience Survey Question. "Please rate your overall satisfaction with PGE."

Summer Customer-Suggested Improvements

The 108 test group respondents who answered the open-end question on how to improve the program most often suggested the following:

- Send pre-event notifications (20%)
- Improve communication (9%)
- Increase the incentive amount (9%)

On closer review of open-end responses, Cadmus found that 13 summer experience test group respondents and three winter experience survey test group respondents asked for their event participation history.

Currently, PGE does not provide customers a way to check their event participation history to determine if they are on track to earning their $25 incentive check for participating in at least 50% of the event hours; PGE is considering this for the future. PGE does, however, offer information on event participation history to its customers in the Peak Time Rebates Program. Should participants in the Peak Time Rebates program enroll into the Smart Thermostat program, PGE could consider extending this approach and providing all customers their event participation history.

Program and Thermostat Brand Comparison

This section provides a comparison of demand savings and customer experience between Rush Hour Rewards and Connected Savings and by thermostat brand.

Winter 2018/2019

Winter Demand Savings by Program

Table 13 compares average demand savings per participant for Rush Hour Rewards and Connected Savings customers during winter demand response events. Participants in both programs experienced the same events.

Across all event hours in winter, the Rush Hour Rewards program reduced demand by an average 0.34 kW and 0.37 kW per participant (20% and 14% of baseline demand) for morning and evening events, respectively. Connected Savings achieved an average demand reduction of 0.37 kW (17%) and 0.46 kW (17%) per participant for morning and evening events, respectively. For both programs, demand savings for morning and afternoon events were not statistically different.

Table 13. Winter 2018/2019 Demand Savings by Program

Program	Sample Size (n of Participants)	Event Time	Baseline Demand (kW)**	Evaluated Demand Savings*			
				Savings per Participant (kW)	Absolute Precision (kW)	Relative Precision	Percentage Savings
Rush Hour Rewards	1,689	Morning	1.89	**0.34**	± 0.10	± 30%	18%
		Afternoon	2.44	**0.37**	± 0.08	± 22%	15%
		Overall	2.35	**0.35**	± 0.07	± 20%	15%
Connected Savings	377	Morning	2.15	**0.37**	± 0.33	± 89%	17%
		Afternoon	2.69	**0.46**	± 0.16	± 17%	35%
		Overall	2.60	**0.44**	± 0.16	± 36%	17%

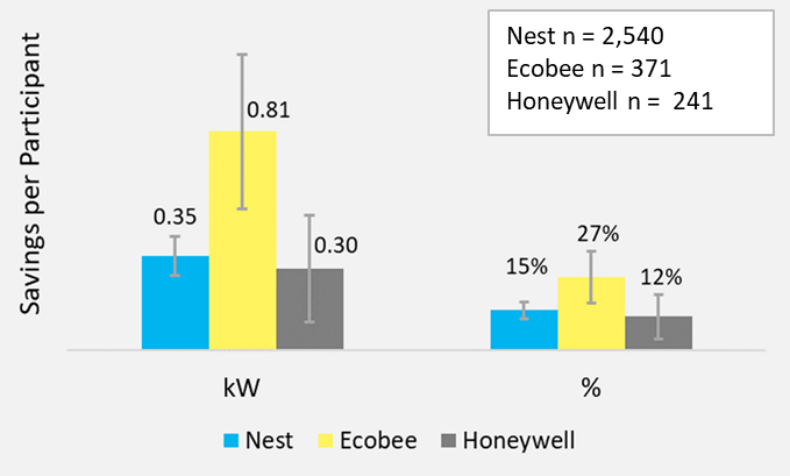
* Impacts were estimated using premise AMI meter data. Cadmus calculated the percentage demand reduction as the kilowatt demand reduction estimate divided by average control customer's demand. **blue** indicates significance at 95%.
** Estimated baseline is average control group consumption across all event hours.

Winter Demand Savings by Thermostat Brand

Cadmus also compared the demand savings from different smart thermostat brands for winter 2018/2019. Note that Honeywell and Honeywell Lyric thermostats were grouped together for this analysis.

Figure 39 shows average demand savings and savings as a percentage of baseline demand. Ecobee outperformed other brand thermostats, averaging 0.81 kW (27%). This is a difference of approximately 0.5 kW (+12%) in demand savings from other brands.

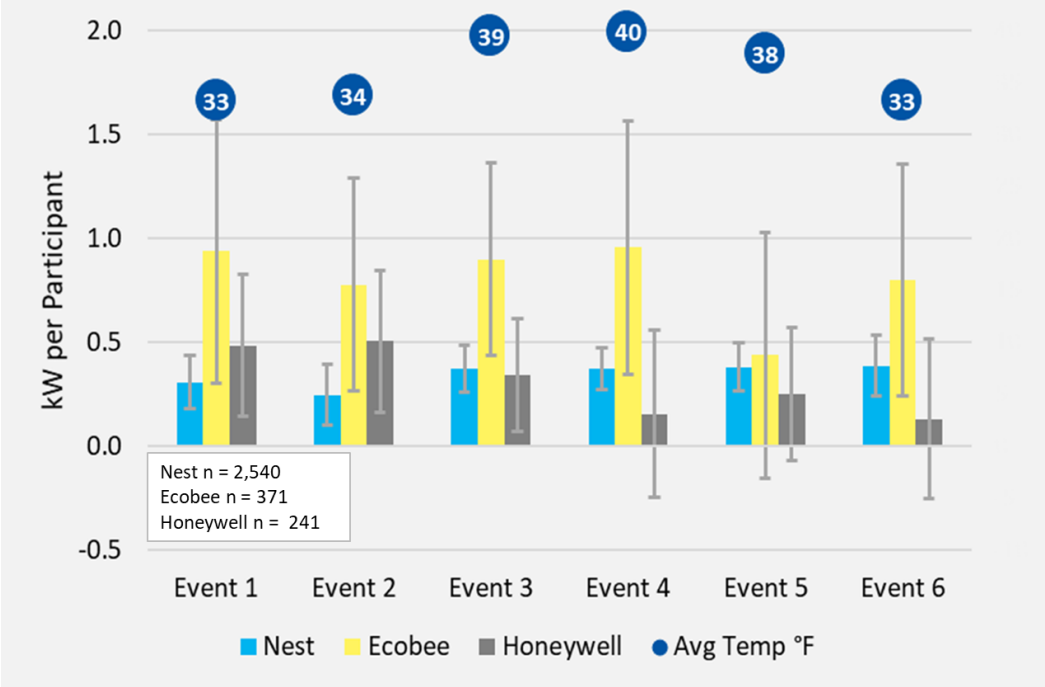
Figure 39. Winter 2018/2019 Demand Savings by Thermostat Brand



Note: Error bars indicate 95% confidence intervals based on standard errors clustered on customers. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

Figure 40 shows average demand savings by brand for each event. Again, ecobee outperformed Nest and Honeywell brand thermostats; however, the difference per event is not statistically significant as it was for overall performance in the previous figure.

Figure 40. Winter 2018/2019 Demand Savings by Event and Thermostat Brand



Note: Error bars indicate 95% confidence intervals based on standard errors clustered on customers. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

Winter Customer Experience by Program

Cadmus compared the survey results of test groups in the Rush Hour Rewards and Connected Savings (Table 14). All respondents noticed fewer events than were called. Rush Hour Rewards respondents perceived more events than did Connected Savings respondents (5.4 events in comparison to 4.3 events), probably because Nest, used in Rush Hour Rewards, sent pre-event notifications. Connected Savings uses ecobee and Honeywell thermostats, which did not notify participants of events in advance. Though more Connected Savings respondents (48%) than Rush Hour Rewards respondents (33%) reported overriding events, the comfort of most Rush Hour Rewards and Connected Savings respondents was not affected. More test group respondents in Rush Hour Rewards (99%) than Connected Savings (91%) were satisfied with their smart thermostat. More test group respondents in Connected Savings (98%) than Rush Hour Rewards (93%) were satisfied with PGE.

Table 14. Winter 2018/2019 Test Group Survey Results by Program

Survey Topic	Rush Hour Rewards (n≤193)	Connected Savings (n≤64)
General event awareness	70% noticed events	61% noticed events
Average perceived number of events	5.4 events*	4.3 events
Comfort during events	86% comfortable	80% comfortable
Overriding events	33% overrode	48% overrode*
Smart thermostat satisfaction	99% satisfied* 78% delighted*	91% satisfied 60% delighted
Incentive satisfaction	87% satisfied 57% delighted	87% satisfied 62% delighted
Program satisfaction	92% satisfied 64% delighted	85% satisfied 58% delighted
Satisfaction with PGE	93% satisfied 66% delighted	98% satisfied* 64% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Winter Customer Experience by Thermostat Brand

Table 15 shows a comparison of the test group's survey responses across the three smart thermostat brands used in the BYOT programs during winter 2018/2019. The number of ecobee (n=19) respondents was too small to conduct statistical significance testing.

Table 15. Winter 2018/2019 Test Group Survey Responses by Thermostat Brand

Survey Topic	Nest (n≤193)	Honeywell* (n≤45)	ecobee** (n≤19)
General event awareness	70% noticed events	56% noticed events	74% noticed events
Average perceived number of events	5.4 events	4.9 events	3.2 events
Comfort during events	86% comfortable	76% comfortable	88% comfortable
Overriding events	33% overrode	59% overrode***	21% overrode
Smart thermostat satisfaction	99% satisfied*** 78% delighted***	86% satisfied 57% delighted	100% satisfied 68% delighted
Incentive satisfaction	87% satisfied 57% delighted	84% satisfied 64% delighted	95% satisfied 58% delighted
Program satisfaction	92% satisfied 64% delighted	84% satisfied 58% delighted	85% satisfied 58% delighted
Satisfaction with PGE	93% satisfied 66% delighted	96% satisfied 64% delighted	100% satisfied 64% delighted

* This includes Honeywell Lyric thermostat respondent (n=1).

**The total number of responses was too small to conduct statistical significance testing for this group.

*** Difference is statistically significant with 90% confidence (p≤0.10).

Statistically significant differences emerged between Nest and Honeywell thermostats. A higher percentage of Honeywell respondents overrode events (59%) compared to respondents with a Nest thermostat (33%). A higher proportion of Nest respondents reported being *satisfied* (99%) and *delighted* (78%) with their smart thermostat than Honeywell respondents (86% *satisfied* and 57% *delighted*). It

should be kept in mind that some of the differences between thermostat brands may be attributable to the characteristics of customers who select specific thermostats rather than to the thermostats themselves.

Summer 2019

Summer Demand Savings Comparison by Program

Table 16 presents the average demand savings per participant for Rush Hour Rewards and Connected Savings participants during summer demand response events. Across all event hours, the Rush Hour Rewards program reduced demand by an average of 0.89 kW per participant (36% of baseline demand). The Connected Savings program achieved an average demand reduction of 0.80 kW per participant (28%). This difference of 0.1 kW per participant was statistically significant at the 95% confidence level.

Table 16. Summer 2019 Demand Savings by Program

Program	Sample Size (n of Participants)	Baseline Demand (kW)**	Evaluated Demand Savings*			
			Savings per Participant (kW)	Absolute Precision (kW)	Relative Precision	Percentage Savings
Rush Hour Rewards	9,791	2.46	**0.89**	± 0.03	± 0.01%	36%
Connected Savings	2,202	2.85	**0.80**	± 0.04	± 0.01%	28%

* Impacts were estimated using premise AMI meter data. Cadmus calculated the percentage demand reduction as the kilowatt demand reduction estimate divided by average control customer's demand. **blue** indicates significance at 95%.

** Baseline is average control group consumption across event hours.

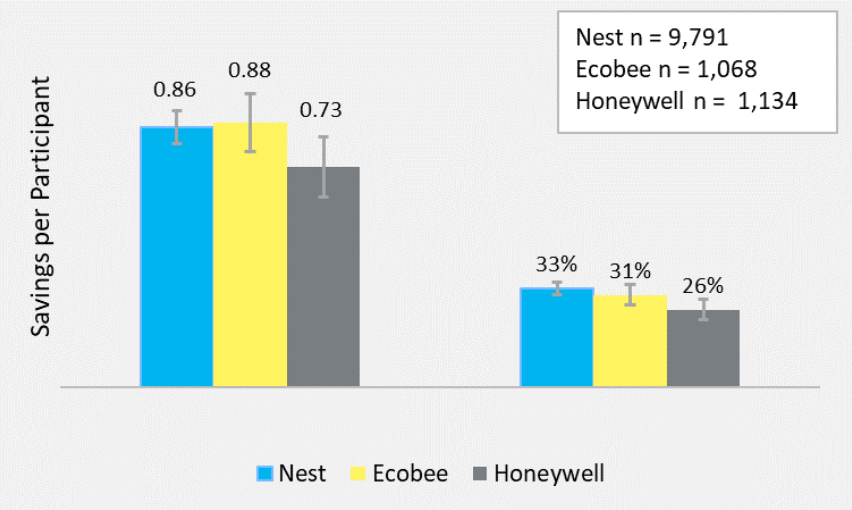
Summer Demand Savings Comparison by Thermostat Brand

Cadmus compared smart thermostat brands across the entire BYOT summer 2019 program. Customers in both programs experienced the same events.

Figure 41 shows the average kW savings and the percentage savings by thermostat brand. Ecobee slightly outperformed other brand thermostats, averaging 0.88 kW per participant. However, as a percentage of baseline demand, Nest achieved slightly higher savings of 33%. The differences in savings between brands are not statistically significant except for the difference between Nest and Honeywell percentage savings.

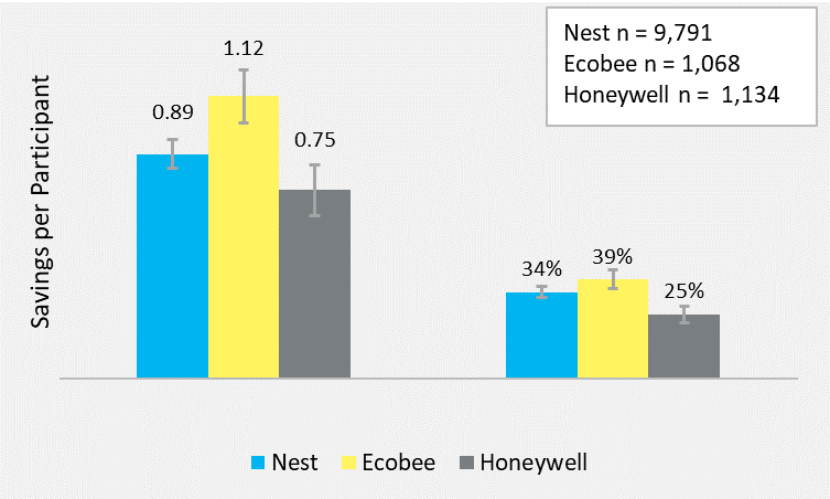
Ecobee thermostats failed to dispatch due to a widespread ecobee service connection issue during event 3, thereby diminishing the ecobee savings for this event. To control for this, Figure 42 shows the savings by thermostat brand overall events except event 3. When accounting for this event failure, the thermostat trends are more consistent with the winter 2018/2019 results where ecobee outperformed Nest and Honeywell brand thermostats both absolutely and as a percentage of baseline demand. Ecobee achieved an average demand savings of 1.12 kW (39%) about 0.2 kW to 0.3 kW (5% to 10%) higher than other brands. Moreover, with the exclusion of event 3, the differences between ecobee and non-ecobee demand savings are statistically significant at the 5% level.

Figure 41. Summer 2019 Demand Savings by Thermostat Brand (Including Event 3)



Note: Error bars indicate 95% confidence intervals based on standard errors clustered on customers. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

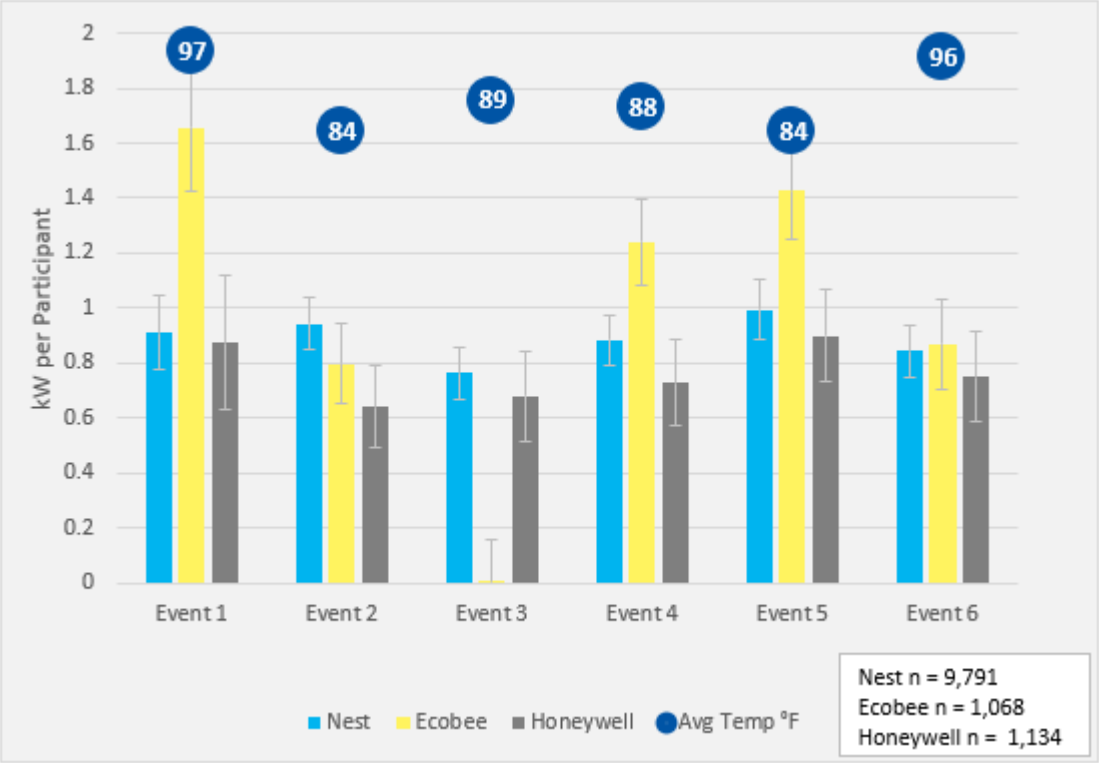
Figure 42. Summer 2019 Demand Savings by Thermostat Brand (Excluding Event 3)



Note: Error bars indicate 95% confidence intervals based on standard errors clustered on customers. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

Figure 43 shows the average demand savings by brand for each event. Again, ecobee outperformed Nest and Honeywell brand thermostats in events 1, 4, and 5. Resideo's proprietary Intelligent Demand Response (IDR) system on ecobee brand thermostats may be contributing to the variation of savings across events; however, details of IDR's dynamics have not been disclosed to Cadmus.

Figure 43. Summer 2019 Demand Savings Per Event by Thermostat Brand



Note: Error bars indicate 95% confidence intervals based on standard errors clustered on customers. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

Summer Customer Experience Comparison by Program

Cadmus compared the results of the Connected Savings test group survey to the results of the Rush Hour Rewards test group survey (Table 17). Both programs achieved similar comfort during events, perceived number of events and satisfaction results. There was only one statistically significant difference between the two programs during summer 2019. Rush Hour Rewards test group respondents were more *delighted* with their Nest thermostat (77%) than Connected Savings test group respondents were with their ecobee or Honeywell thermostats (67%). This difference may be explained by the stronger brand recognition of Nest.

Table 17. Summer 2019 Test Group Survey Results by Program

Survey Topic	Rush Hour Rewards (n≤232)	Connected Savings (n≤218)
General Event Awareness	68% noticed events	63% noticed events
Average Perceived Number of Events	4.2 events	4.0 events
Comfort During Events	74% comfortable	67% comfortable
Overriding Events	33% overrode	41% overrode
Smart Thermostat Satisfaction	97% satisfied 77% delighted*	95% satisfied 67% delighted
Incentive Satisfaction	87% satisfied 57% delighted	89% satisfied 53% delighted
Program Satisfaction	94% satisfied 62% delighted	88% satisfied 56% delighted
Satisfaction with PGE	96% satisfied 56% delighted	95% satisfied 55% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Summer Customer Experience by Thermostat Brand

Table 18 shows a comparison of the test group's responses across the three thermostat brands. Many statistically significant differences emerged between Nest, ecobee, and Honeywell thermostats. However, there was no consistent pattern with one particular brand to identify plausible explanations for the differences observed.

Table 18. Summer 2019 Test Group Survey Results by Thermostat Brand

Survey Topic	Nest (n≤231)	ecobee (n≤209)	Honeywell* (n≤143)
General Event Awareness	68% noticed events	73% noticed events	52% noticed events**
Average Perceived Number of Events	4.2 events	4.4 events	3.4 events**
Comfort During Events	74% comfortable	62% comfortable**	74% comfortable
Overriding Events	33% overrode	36% overrode	47% overrode**
Smart Thermostat Satisfaction	97% satisfied 77% delighted***	96% satisfied 72% delighted	94% satisfied 64% delighted***
Incentive Satisfaction	86% satisfied 57% delighted	90% satisfied 57% delighted	87% satisfied 57% delighted
Program Satisfaction	94% satisfied*** 62% delighted	91% satisfied 58% delighted	86% satisfied*** 55% delighted
Satisfaction with PGE	96% satisfied 56% delighted	96% satisfied 54% delighted***	94% satisfied 65% delighted***

* This includes Honeywell Lyric thermostats. There were very few Honeywell Lyric responses (n=21).

** Difference is statistically significant with 90% confidence (p≤0.10) from the other brands.

*** Difference is statistically significant with 90% confidence (p≤0.10) between two **green-shaded** brands.

Logic Model Review

Cadmus conducted a high-level review of the logic model by using the staff interview findings, customer survey findings, and impact results to determine whether the program produced the expected outcomes. Due to the limited availability of certain information and data, not all expected outcomes shown in the logic model could be thoroughly assessed.

Table 19 summarizes the findings from the logic model review in detail. The BYOT track largely operated as expected, producing most of its expected outcomes. The BYOT track did not produce the expected outcomes outlined for its program manual activity, program operations, program enrollment goal, and winter demand impacts.

Table 19. Logic Model Review of BYOT Smart Thermostat Demand Response Pilot Program

Logic Model Element		Expected Outcome	Actual Outcome
Program Activities	Capacity planning	PGE outlines the use of demand response to help manage system peak loads	PGE outlined its plan in 2019 Integrated Resource Plan.
	Program design and implementation	PGE and implementers design and administer the program	PGE and implementers administered the winter 2018/2019 and summer 2019 seasons. PGE and implementers have continued to address program delivery as needs arise.
	Evaluation	Cadmus evaluates the program	Cadmus evaluated load impacts, customer experience, and delivery.
Outputs to Program Activities	Integrated Resource Plan	PGE publishes the plan	PGE published the Integrated Resource Plan in July 2019 with smart thermostats as a demand response resource.
	Program operations manual	PGE drafts a manual for internal staff	A rough draft of a program manual is in progress.
	Marketing collateral	PGE and implementers create and disseminate collateral	OEMs marketed the program through their app and emails. PGE marketed the program through email, direct mail, and PGE website.
	Program enrollment website	Implementers create, host, and manage the website. Customers can enroll through the website.	Customers enrolled via the Rush Hour Rewards (Nest) and Connected Savings (Resideo) online enrollment webpage. Customers were provided the link to the enrollment webpage through the marketing emails, direct mail, and PGE website.
	Program information	PGE creates and disseminates educational collateral	The Rush Hour Rewards and Connected Savings enrollment webpage provides information on how the program works. PGE also provides similar information on how the program works on its website.
	Demand response platform for PGE to call events	Implementers create, host, and manage the platform. PGE can schedule events.	PGE used Nest's and Resideo's online management platform to schedule events.
	Event participation incentives	Implementers track customers' event participation. PGE mails out incentive checks to customers.	PGE reviewed the participant data (gathered by Nest and Resideo) to determine who qualified for seasonal incentives and mailed out incentive checks to participants six to eight weeks after the end of the season.

Logic Model Element		Expected Outcome	Actual Outcome
	Evaluation report	Cadmus drafts the evaluation report for PGE to submit to the Public Utility Commission of Oregon	Cadmus drafted this evaluation report as well as high-level results to PGE after the end of each season.
Short-Term and Intermediate Outcomes *(in one to two years)*	Program operations	Organized and efficient management of program	Although systems and procedures were in place, PGE encountered operational issues implementing events. These challenges are described in this report. Also, some customers with non-electric heating were mistakenly enrolled and participated in the winter season.
	Customer awareness	Customers become aware of demand response and program	Cannot be determined from this evaluation. PGE and Cadmus will explore this outcome in the Test Bed evaluation.
	Program enrollment	24,000 thermostats enrolled in BYOT and Direct Install by end of 2019	BYOT and Direct Install combined together, PGE enrolled 20,805 thermostats.
	Event participation	Customers do not override events	Cannot be accurately determined. However, customer surveys suggest that 33%-48% of customers overrode at least one event. The evaluation does not have full access to implementers' telemetry reports to analyze overrides.
	Customer satisfaction	Customers receive incentives and are satisfied with the program	Customer satisfaction with incentive and program was high. Rush Hour Rewards' customer satisfaction ranged from 86% to 87% for the incentive. Connected Savings' customer satisfaction ranged from 87% to 89% for the incentive. Between 92% to 94% of test group survey respondents said they were satisfied with Rush Hour Rewards and between 85% to 88% of test group survey respondents were satisfied with Connected Savings.
	Demand impacts	PGE achieves peak demand savings	PGE has a winter demand response planned savings value of 1.0 kW per participant for Rush Hour Rewards and Connected Savings. The evaluated winter 2018/2019 demand savings of both program services fell below this value. PGE also has a summer demand response planning value of 0.8 kW per participant. Rush Hour Rewards (0.89 kW) and Connected Savings (0.80 kW) exceeded or met this planning goal.
	Ongoing participation	Customers renew participation next season	Cannot be accurately determined. Evaluation was not tasked to analyze ongoing customer participation. PGE stated in staff interviews that few customers were opting out of the program and most customers opting out of the pilot program were due to move-outs.
Long-Term Impacts and Success *(in three to five years)*	Program goals	Meet enrollment and demand response capacity goals	To be assessed in future
	Customer engagement	Increased customer awareness, consideration, evaluation, action, and loyalty (ACEAL)	To be assessed in future
	Company goals	Improvements in reliability of electricity service, cost-effectiveness, and corporate sustainability goals	To be assessed in future

Appendix A. Evaluation Methodology

This section describes Cadmus's methodology for evaluating the BYOT track of PGE's Smart Thermostat Demand Response pilot program.

Evaluation Design

To estimate the demand response impacts of BYOT events, Cadmus worked with PGE to implement a randomized controlled trial (RCT). RCTs are the gold standard in program evaluation and expected to produce unbiased estimates of the program demand savings. This evaluation design involved randomly assigning program participants (residential customers who enrolled in the program) to a test group or control group. Test group customers received the load control signals during demand response events, while control group customers did not. Savings were estimated by comparing the average demand of test and control group customers during event hours.

Cadmus randomized customers prior to each event season by program and brand. Customers received one assignment for the whole season and were not informed about the group to which they had been assigned. If a customer had multiple smart thermostats at the time of the randomization, all thermostats were assigned to the test group or control group. For participants who enrolled after the Cadmus randomization, PGE randomly assigned them to the test group using a pre-randomized assignment list based upon the order of enrollment. Customers were rerandomized at the beginning of the next season.

Both winter and summer evaluations were implemented as RCTs, and Cadmus performed the random assignment of participant homes (premises) to test and control groups. We assigned participant homes—not thermostats—to the treatment or control groups because the impacts were measured with advanced metering infrastructure (AMI) meter data at the home level. Table A-1 through Table A-4 show winter 2018/2019 and summer 2019 random assignments of participants overall, by brand and HVAC system, for the Rush Hour Rewards and Connected Savings programs.

Table A-1. Rush Hour Rewards Participant Random Assignments – Winter 2018/2019

Category	Total	Test Group		Control	
		Count	Percentage of Total	Count	Percentage of Total
Central Air Conditioner	N/A	N/A	0%	N/A	0%
Heat Pump	1,597	799	50%	798	50%
Electric Furnace	102	59	58%	43	42%
Overall	**1,699**	**858**	**51%**	**841**	**49%**

Table A-2. Rush Hour Rewards Participant Random Assignments – Summer 2019

Category	Test Group		Control	
	Count	Percentage of Total	Count	Percentage of Total
Central Air Conditioner	6619	95%	338	5%
Heat Pump	1229	95%	60	5%
Overall	**7,848**	**95%**	**398**	**5%**

Table A-3. Connected Savings Participant Random Assignments – Winter 2018/2019

Category	Test Group		Control Group	
	Count	Percentage of Row Total	Count	Percentage of Row Total
By Brand				
ecobee	63	48%	67	52%
Honeywell Lyric	7	58%	5	42%
Honeywell Other	126	55%	103	45%
By HVAC System				
Heat Pump	175	53%	158	47%
Electric Furnace	21	55%	17	45%
Overall	**196**	**53%**	**175**	**47%**

Table A-4. Connected Savings Participant Random Assignments – Summer 2019

Category	Test Group		Control Group	
	Count	Percentage of Row Total	Count	Percentage of Row Total
By Brand				
ecobee	754	71%	314	29%
Honeywell Lyric	109	75%	36	25%
Honeywell Other	762	77%	222	23%
Overall	**1,625**	**74%**	**572**	**26%**
By HVAC System				
Central Air Conditioner	1356	73%	494	27%
Heat Pump	266	78%	76	22%
Overall	**1,622**	**74%**	**570**	**26%**

Note: HVAC system counts exclude customers with multiple brand thermostats, thus HVAC percentages do not add up to total number of thermostats.

There are typically two types of impact effects that can be measured, depending on the inclusion of distinct treatment participant groups:

(1) Intent to treat treatment effect (ITT) – the average impact per home (or other relevant unit of analysis) for homes that the utility intends to treat
(2) Treatment effect on the treated (TOT) – the average impact per treated home

In a smart thermostat demand response context, the ITT effect is the average demand savings per home for homes the utility attempts to control. It is estimated across homes (thermostats) that receive and execute the setback, homes that receive and execute the commands and then override the commands, and homes that don't receive or execute the commands due to some operational issue. In its evaluations of PGE's thermostat programs, Cadmus has estimated and reported the intent-to-treat effect because the ITT is the most relevant for utility planning, utility operations, and assessing cost-effectiveness. It reflects the impacts of operational issues and overrides on the demand savings that PGE achieved.

The estimate of the treatment effect on the treated (TOT) (sometimes also referred to as the local average treatment effect) indicates the demand savings for homes that receive and execute the setback commands. To estimate the TOT, Cadmus would need to obtain telemetry data from the demand response service providers to determine the percentage of homes that did not execute the demand response setback. We can recover an estimate of the TOT by dividing the ITT estimate by the percentage of homes that executed the setback commands. For example, if the estimate of the ITT effect equals 1 kW per home and we learn that 80% of homes successfully executed the setback, the estimate of the TOT effect equals 1 kW/0.8 = 1.2 kW. This calculation assumes that the 20% of homes that did not receive or execute the setback have zero demand savings during the event. This calculation shows the average demand savings per home for homes that executed the setback.

Data Collection and Preparation

Cadmus collected and prepared several types of data for analysis:

- ***Participant enrollment data***, provided by PGE, tracked enrollment for test group and control group participants. These data included participant name, contact information (such as address), a unique premise identifier (the point of delivery ID), and an enrollment date.
- ***Interval consumption data*** were provided by PGE for all enrolled participants. For post-enrollment periods, these included watt-hour electricity consumption at 15-minute and 60-minute intervals, measured using AMI meters. For usage periods prior to enrollment, only hourly data were available.
- ***Local weather data,*** including hourly average temperatures from December 2018 through September 2019 for five National Oceanic and Atmospheric Administration (NOAA) weather stations. Cadmus used zip codes to identify weather stations nearest to each participant's home and merged the weather data with each participant's billing data.
- ***Event data,*** including dates and times of all load control events, by season, were provided by PGE.

The AMI meter data recorded a participant's electricity consumption at 15- or 60-minute intervals and covered every month in which an event occurred. Cadmus aggregated all 15-minute interval consumption data to the participant-hour level and performed standard data-cleaning (detailed below) to address duplicate observations, outliers, and missing values.

The weather data were high-frequency, asynchronous temperature and humidity readings from five NOAA weather stations across PGE's service area. Cadmus aggregated the weather data to the hourly level and merged these data with the hourly interval consumption data.

Cadmus used the enrollment and participation data to identify participants in the test and control groups, to develop survey sample frames, and to calculate test opt-out rates. These data provided several key fields for each participant, including these:

- Assignment to test or control group
- Dates for participant enrollment and un-enrollment date, if applicable
- Participant ID and address
- Service point active status (confirming meter activity)

Robustness checks of the Connected Savings test group savings estimates indicate that the estimates were not sensitive to the specific solutions we developed.

Analysis Samples

In cleaning and preparing the AMI meter data, Cadmus encountered several issues that had to be addressed before the data could be analyzed:

- Timestamps on some AMI datasets were set to Coordinated Universal Time instead of Pacific Time.
- AMI data were not provided for all customers.
- AMI data were not provided for all customers.
- Net-metering customers' consumption was censored at zero.
- Participants enrolled in multiple programs.
- Participants had large average daily consumption over 300 kWh suggesting they were not residential customers.

Cadmus took the following steps to clean the AMI meter data and prepare for analysis:

- Removed a small number of duplicate interval readings from the data
- Summed 15-minute interval consumption data to obtain hourly interval consumption
- Dropped a small number of outliers and hourly observations missing one or more 15-minute interval readings
- Combined the consumption of meters connected to the same thermostat
- Since all events occurred on weekdays, removed holidays, weekends, and days outside of event seasons
- Adjusted time stamp from end of read period to start of read period
- Dropped one customer with two thermostats assigned to different test groups
- Dropped customers missing all AMI data

- Dropped customers enrolled in multiple programs
- Dropped customers with average daily consumption greater than or equal to 300 kW
- Dropped customers with net-metering data censored at zero

Cadmus excluded a small number of customers from the analysis sample. A customer was excluded from the analysis sample if the customer had any of the following:

- Lacked AMI meter data
- Had multiple thermostats enrolled in the program and these thermostats had been assigned to different groups (test or control). Cadmus did not create assignments for the summer 2018 season
- Had multiple smart thermostats with one or more thermostats enrolled in Rush Hour Rewards and one of more thermostats enrolled in Connected Savings[20]
- Appeared in a list of test and control group customers who were rejected from the program for a variety of reasons
- Average daily consumption greater than or equal to 300 kWh
- Enrolled in multiple PGE programs

Cadmus excluded net generation customers after confirming with PGE that the metering data recorded gross demand, not net demand, for electricity. Since the net-metering customers' demand was censored at zero, it would not have been possible to measure smart thermostat demand impacts when the customer was supplying electricity to the grid, and inclusion in the analysis would introduce bias.

Table A-5 shows the attrition of participants from the analysis sample from performing different data cleaning steps for the summer 2019 season. Each row represents a level of filtering, with the corresponding number of participants assigned to each group after the filter step. The final analysis sample includes participants used in the impact estimation and excludes a small number who had two thermostats assigned to different groups or who were missing AMI data as well as multiple program participants. Additionally, net-metering customers were excluded from the analysis due to the inability to accurately estimate demand savings for these customers. AMI meter data recording net consumption were censored at zero, so it was not possible to measure changes in the electricity net metering customers supplied to the grid.

[20] In reviewing the participant tracking data, Cadmus noticed that some customers had thermostats enrolled in Rush Hour Rewards and Connected Savings. Cadmus removed these customers to limit the potential for such customers to have thermostats assigned to both the test and control groups.

Table A-5. BYOT Final Analysis Sample Attrition

Event	Rush Hour Rewards Participant Count		Connected Savings Participant Count		Cumulative Total (%)
	Test	Control	Test	Control	
Total Program Enrollment	**10,450**		**2,374**		**100%**
Multiple Program Enrollments	9,652	794	1,742	623	99.9%
Missing AMI Data	9,620	789	1,736	622	99.6%
Net Metering Participants	9,049	749	1,631	572	93.6%
Average Daily Consumption > 300 kW	9,042	749	1,630	572	93.5%
Final Analysis Sample	**9,042**	**749**	**1,630**	**572**	**93.5%**

Note: AMI data for net metering customers were censored at zero when the customer produced more than it consumed; for this reason, net metering customers were removed from the analysis sample.

Table A-6 shows this final analysis sample by brand. Note that the total program enrollment numbers will differ from the above smart thermostat enrollment numbers, since those numbers represent individual thermostats while individual participants were randomized into test and control groups regardless of the number of thermostats they own.

Table A-6. BYOT Final Analysis Sample by Brand

Brand	Program	
	Rush Hour Rewards	Connected Savings
Nest	9,791	--
ecobee	--	1,068
Honeywell*	--	1,129
Multiple	--	5
Total (n=)	**9,791**	**2,202**

* Honeywell includes Honeywell and Honeywell Lyric brand thermostats.

Equivalency Checks

Cadmus checked for statistically significant differences in consumption on non-event days between test and control group customers in the final analysis sample.

Figure A-1 and Figure A-2 show average consumption per Rush Hour Rewards participant by hour on winter 2018/2019 and summer 2019 weekdays, respectively. The average consumption excludes days that were not event days or holidays. The figures also plot the estimated difference and confidence interval for the estimate. The figures demonstrate that the hourly differences between the two groups' consumption were small and statistically insignificant in winter and most summer hours.

The figures show that test group customers had higher electricity consumption than control group customers for every hour of the day, but the hourly differences were relatively small and statistically insignificant for most hours. Hours after 17:00 show a small difference which was statistically significant at the 10% level.

Figure A-1. Rush Hour Rewards Consumption Equivalency - Winter

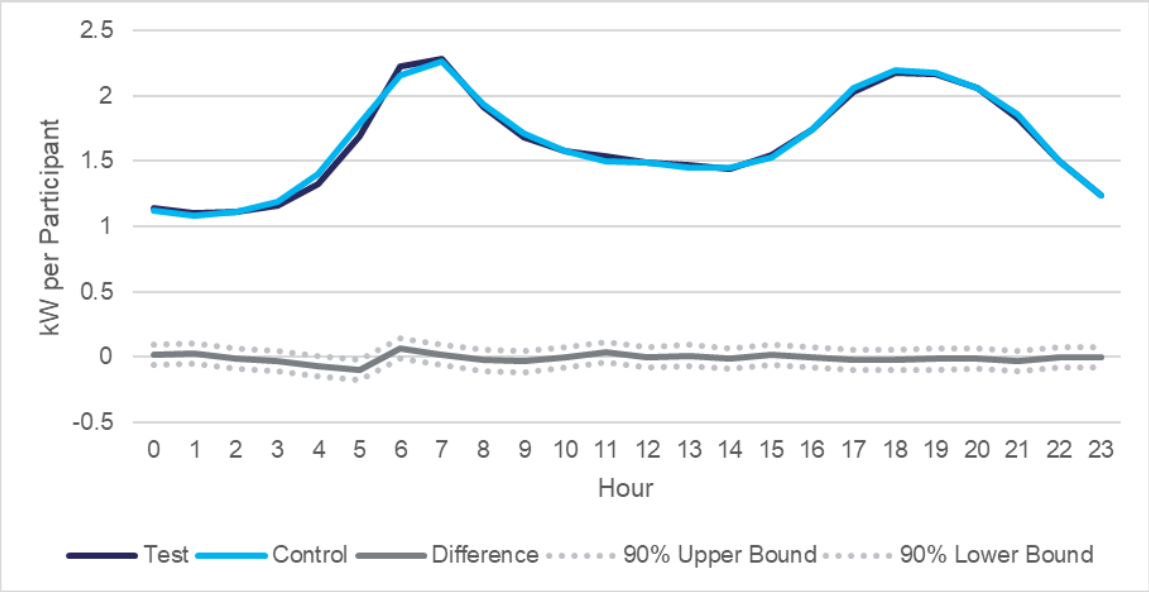


Figure A-2. Rush Hour Rewards Consumption Equivalency - Summer

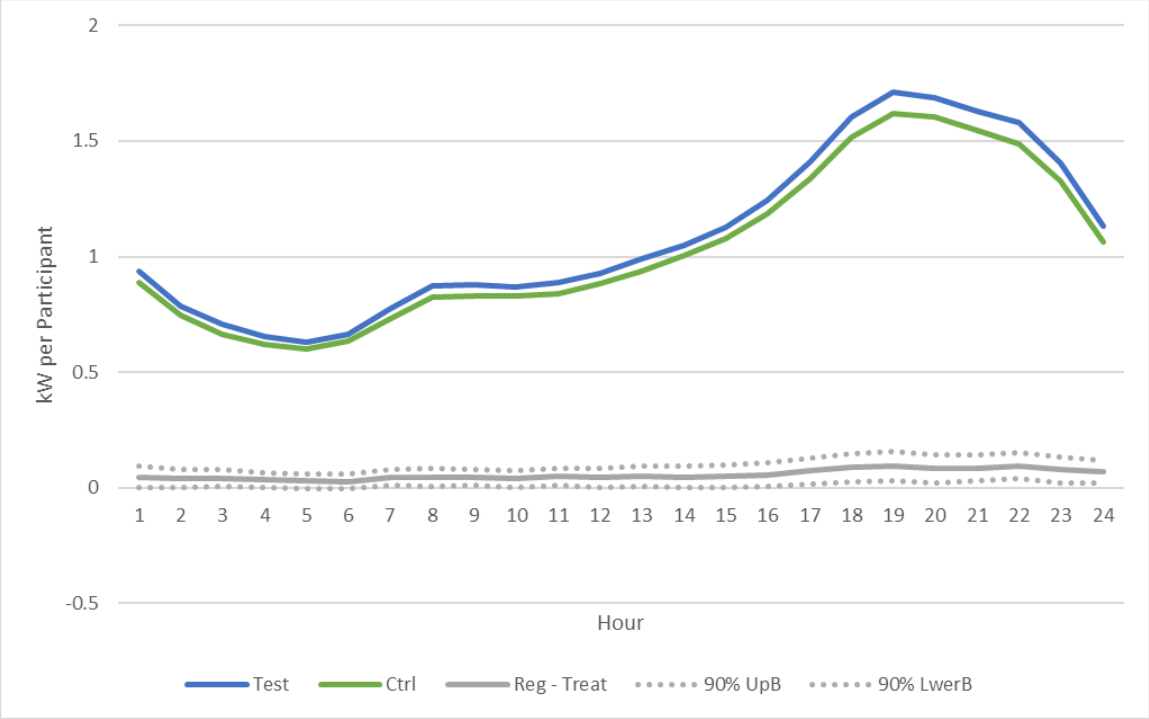


Figure A-3 shows the average daily consumption for each hour of the day on non-event, non-holiday weekdays in winter 2018/2019 for the CS program. Test and control group customer demand was not well balanced in winter because of the small sample sizes but very well balanced in summer with the larger analysis sample. In summer, the differences between the treatment and control groups are small statistically insignificant for all hours of the day.

Figure A-3. Connected Savings Consumption Equivalency - Winter

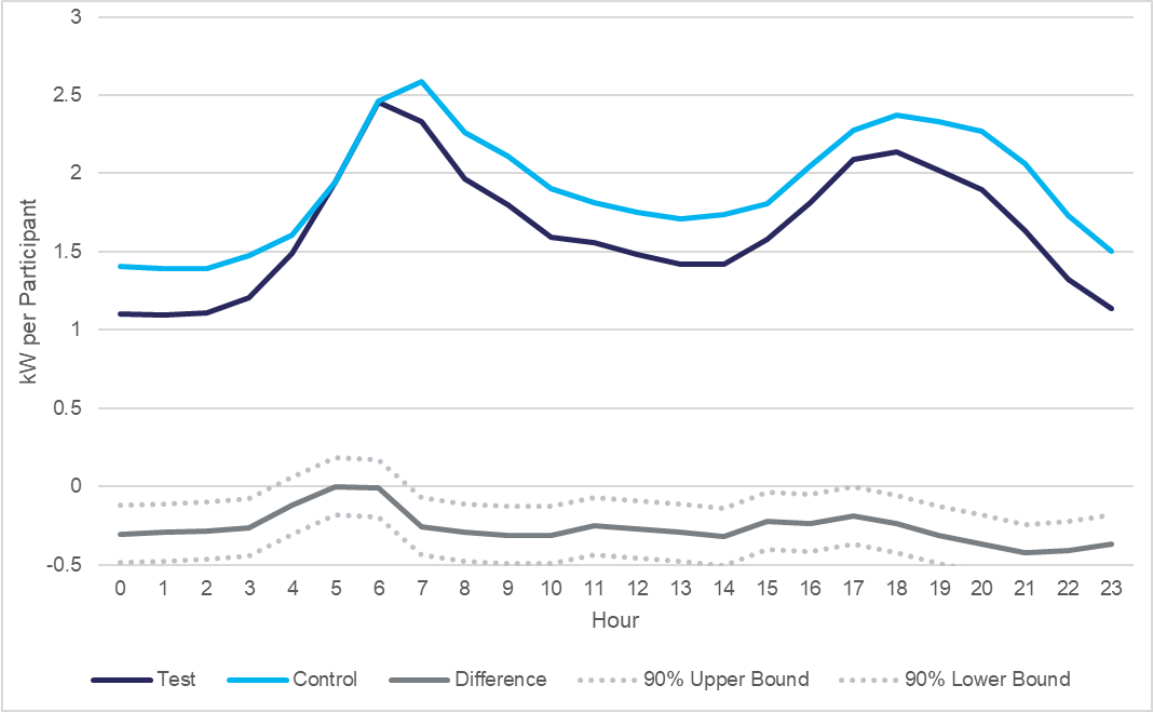
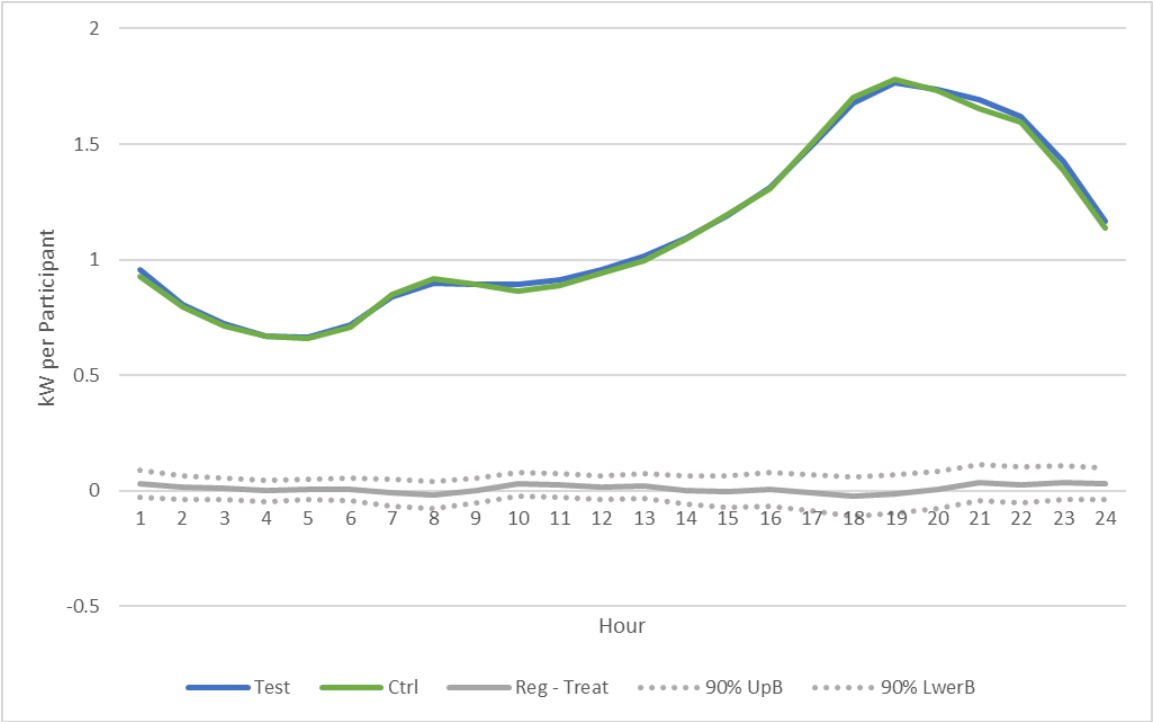


Figure A-4 shows average consumption by hour of the day in summer 2019 for Connected Savings participants in the analysis sample.

Figure A-4. Connected Savings Consumption Equivalency - Summer



Load Impact Analysis

Savings Estimation Approach

Cadmus estimated savings by collecting individual customer AMI interval consumption data and by comparing the demand of customers in the randomized test and control groups during each event hour. We employed panel regression analysis to estimate demand impacts for the two hours before, two or three hours during, and eight hours after each event. In addition to assignment to test or control group, the panel regression controlled for the impacts of hour of the day, the day of the week, weather, and differences between customers in their average demand.

Letting 'i' denote the customer, where i = 1, 2, …, N, and letting 't' denote the hour of the day, where t=1, 2, …, T, the model took the following form:

Equation 1

$$kWh_{it} = \sum_{k=0}^{23} \beta_k Hour_{kt} + \sum_{k=0}^{23} \gamma_k Hour_{kt} * DH_{it} + \sum_{m=1}^{9} \sum_{j=1}^{J} \pi_{mj} I(Event = 1)_{mjt} + \sum_{m=1}^{9} \sum_{j=1}^{3} \theta_{mj} I(Treat = 1)_i * I(Event = 1)_{mjt} + \sum_{m=1}^{9} \sum_{n=1}^{N} \varphi_{mn} I(PostEvent = 1)_{nmt} + \sum_{m=1}^{9} \sum_{n=1}^{N} \delta_{mn} I(Treat = 1)_i * I(PostEvent = 1)_{nmt} + \sum_{m=1}^{9} \sum_{l=1}^{L} \omega_{ml} I(PreEvent = 1)_{mlt} + \sum_{m=1}^{9} \sum_{l=1}^{L} \rho_{ml} I(Treat = 1)_i * I(PreEvent = 1)_{mlt} + \varepsilon_{it}$$

Where:

- kWh_{it} = Electricity consumption in kilowatt-hours of customer 'i' during hour 't'
- $Hour_{kt}$ = Indicator variable for hour of the day; equals 1 if hour 't' is the kth hour of the day, where k=0, 1, 2, …, 23, and equals 0 otherwise
- β_k = Average load impact (kWh/hour) per customer of hour 'k' on customer consumption
- DH_{it} = Heating or cooling degree hour for customer 'i' in hour 't' for a given base temperature
- γ_k = Average effect per customer of a cooling degree hour on customer consumption in hour 'k'
- $I(Event=1)_{mjt}$ = Indicator variable for event hour; equals 1 if hour 't' is the jth hour, j=1,2,…J, where J=2 or 3 depending on event length of event m, m=1, 2, …, 9, and equals 0 otherwise
- π_{mj} = Average load impact (kWh/hour) per customer during hour 'j' of event 'm,' which affects treatment and control group customers
- $I(Treat=1)_i$ = Indicator variable for assignment to treatment group; equals 1 if customer 'i' was randomly assigned to the treatment group and equals 0 otherwise
- θ_{mj} = Average load impact (kWh/hour) per treatment group customer during hour 'j' of event 'm'

φ_{mn} = Average load impact (kWh/hour) per customer during post-event hour 'n' of event 'm,' which affects treatment and control group customers

$I(PostEvent=1)_{nmt}$ = Indicator variable for post-event hour; equals 1 if hour 't' is the nth hour after the event, n=1,2,…,N, of event m, m=1, 2, …, 9, and equals 0 otherwise

δ_{mn} = Average load impact (kWh/hour) per treatment group customer during post-event hour 'n' of event 'm'

ω_{ml} = Average load impact (kWh/hour) per customer during pre-event hour 'l' of event 'm,' which affects treatment and control group customers

$I(PreEvent=1)_{mlt}$ = Indicator variable for pre-event hour; equals 1 if hour 't' is the lth hour before the event, l=1,2,…,L, of event m, m=1, 2, …, 9, and equals 0 otherwise

ρ_{ml} = Average load impact (kWh/hour) per treatment group customer during pre-event hour 'l' of event 'm'

ε_{it} = Random error for customer 'i' in hour 't'

Cadmus estimated the models by ordinary least squares (OLS) and clustered the standard errors on customers to account for correlations over time in customer demand. The model included all non-holiday weekdays days in June, July, or August 2019 for summer and January and February for winter. We estimated alternative model specifications to test the estimates' robustness to specification changes and found that the results were very robust.

Staff Interviews

In October 2019 Cadmus conducted two interviews, one with the PGE program manager and one with the Resideo implementation staff, which offers the Connected Savings program service. We did not interview the Nest implementation staff but did email about Nest about its Rush Hour Rewards program service. The interviews and email communications focused on documenting how the program operated during the winter and summer event seasons, any implementation challenges, and any successes or lessons learned to date. Cadmus used information obtained from the interviews to design the customer surveys and review the logic model.

Customer Surveys

Cadmus designed and administered four online customer surveys via email:

- BYOT Rush Hour Rewards winter 2018/2019 experience survey (fielded May 2019)
- BYOT Connected Savings winter 2018/2019 experience survey (fielded May 2019)
- BYOT Rush Hour Rewards summer 2019 experience survey (fielded October 2019)
- BYOT Connected Savings summer 2019 experience survey (fielded October 2019)

Survey Design

After each event season, Cadmus administered the experience surveys to test and control and control group participants. The experience surveys asked test group participants about their event awareness, thermal comfort, reasons for overriding the load control, and satisfaction. Control group participants were asked questions only about satisfaction. The survey took respondents less than seven minutes to complete. Respondents did not receive an incentive for completing the surveys.

Survey Sampling and Response Rates

Based on the number of participants for that season for each program, Cadmus contacted either the census or a random sample of program participants with an active PGE account. On average, the four surveys achieved a high response rate of 28%. Table A-7 and Table A-8 show the number of participants contacted and response rate for Rush Hour Rewards and Connected Savings, respectively.

Table A-7. Rush Hour Rewards: Customer Survey Samples and Response Rates

Winter 2018/2019	Population	Original Sample Frame*	Adjusted Sample Frame (Successfully Emailed)	Number of Completes (Achieved Sample)	Response Rate
By Assignment					
Test	811	811	805	193	24%
Control	780	780	774	174	22%
By HVAC System					
Heat Pump	1,514	1,514	1,503	342	23%
Electric Furnace	77	77	76	25	33%
Winter Overall	**1,591**	**1,591**	**1,579**	**367**	**23%**
Summer 2019	**Population**	**Original Sample Frame****	**Adjusted Sample Frame (Successfully Emailed)**	**Number of Completes (Achieved Sample)**	**Response Rate**
By Assignment					
Test	9,762	800	796	231	29%
Control	820	525	524	174	33%
By HVAC System					
Heat Pump	8,839	201	200	62	31%
Electric Furnace	1,743	1,124	1,120	343	31%
Summer Overall	**10,582**	**1,325**	**1,320**	**405**	**31%**

* Cadmus selected the census of records with an active PGE account for the survey.

**Cadmus selected a random sample of records stratified by assignment for the survey.

Table A-8. Connected Savings: Customer Survey Samples and Response Rates

Winter 2018/2019	Population	Original Sample Frame*	Adjusted Sample Frame (Successfully Emailed)	Number of Completes (Achieved Sample)	Response Rate
By Assignment					
Test	183	183	181	64	35%
Control	170	170	169	48	28%
By Brand					
ecobee	125	125	122	35	29%
Honeywell Lyric	11	11	11	3	27%
Honeywell Other	217	217	217	74	34%
By HVAC System					
Heat Pump	318	318	315	103	33%
Electric Furnace	35	35	35	9	26%
Winter Overall	**353**	**353**	**350**	**112**	**32%**
Summer 2019	**Population**	**Original Sample Frame****	**Adjusted Sample Frame (Successfully Emailed)**	**Number of Completes (Achieved Sample)**	**Response Rate**
By Assignment					
Test	1,806	800	800	186	23%
Control	645	429	428	165	39%
By Brand					
ecobee	1,236	639	638	208	33%
Honeywell Lyric	163	71	71	21	30%
Honeywell Other	1,052	519	519	122	24%
By HVAC System					
Heat Pump	2,040	194	194	56	29%
Electric Furnace	411	1,035	1,034	295	29%
Summer Overall	**2,451**	**1,229**	**1,228**	**351**	**29%**

* Cadmus selected the census of records with an active PGE account for the survey.

** Cadmus selected a random sample of records stratified by assignment for the survey.

Survey Data Analysis

Cadmus compiled frequency outputs, analyzed open-end comments according to thematic similarities, and ran statistical tests to determine whether survey results differed with statistical significance between subpopulations. Specifically, we compared survey results by assignment, brand, and program at the 90% confidence level (or $p \leq 0.10$ significance level).

Appendix B. Additional Impact Findings

This appendix provides additional details about the pre-event, event, and post-event demand impacts, including point estimates of demand savings by event hour and event-day conservation effect, for the summer and winter seasons.

Plots of Event Day Unconditional Mean Test and Control Group Demand

Figure B-1 through Figure B-4 show shows the average daily consumption on non-event, non-holiday weekdays in winter 2018/2019 for the Rush Hour Rewards program.

Figure B-1 and Figure B-2 show the unconditional mean demand per customer for the randomized test and control group customers for winter morning and afternoon events and summer afternoon events. The differences between the test and control group mean demand are also depicted and illustrate the event impacts before any modeling is undertaken. The impacts of the demand response events on customer demand are evident and corroborate the regression analysis findings that the events reduced demand.

Figure B-1. Rush Hour Rewards Consumption – Winter a.m. Event

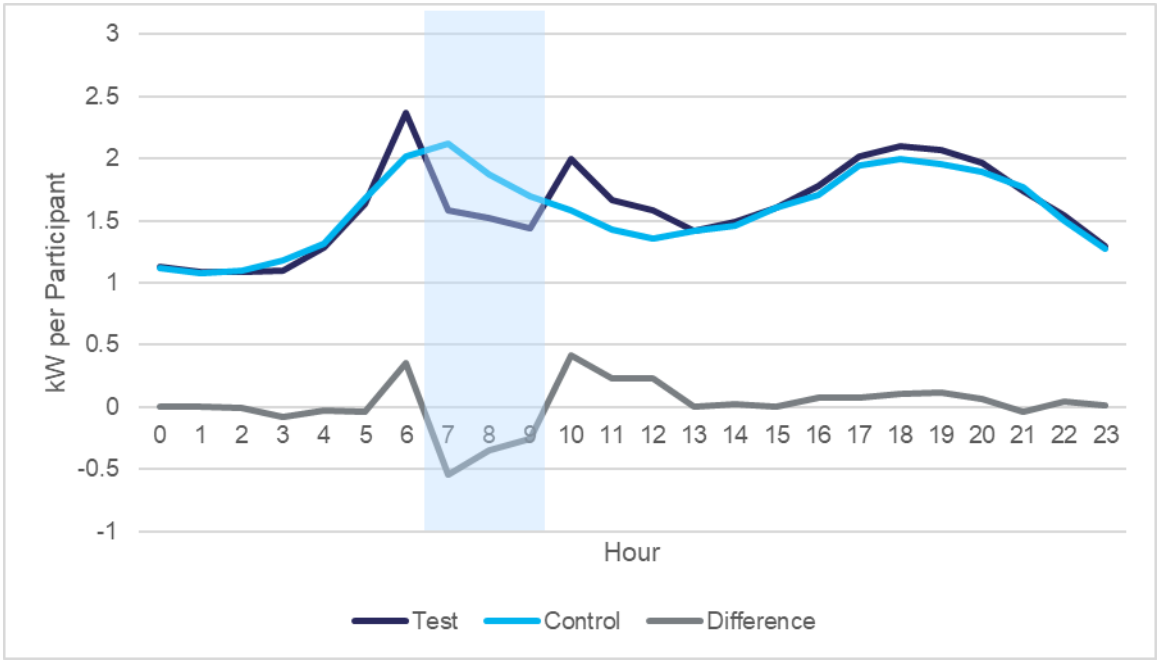


Figure B-2. Rush Hour Rewards Consumption – Winter p.m. Events

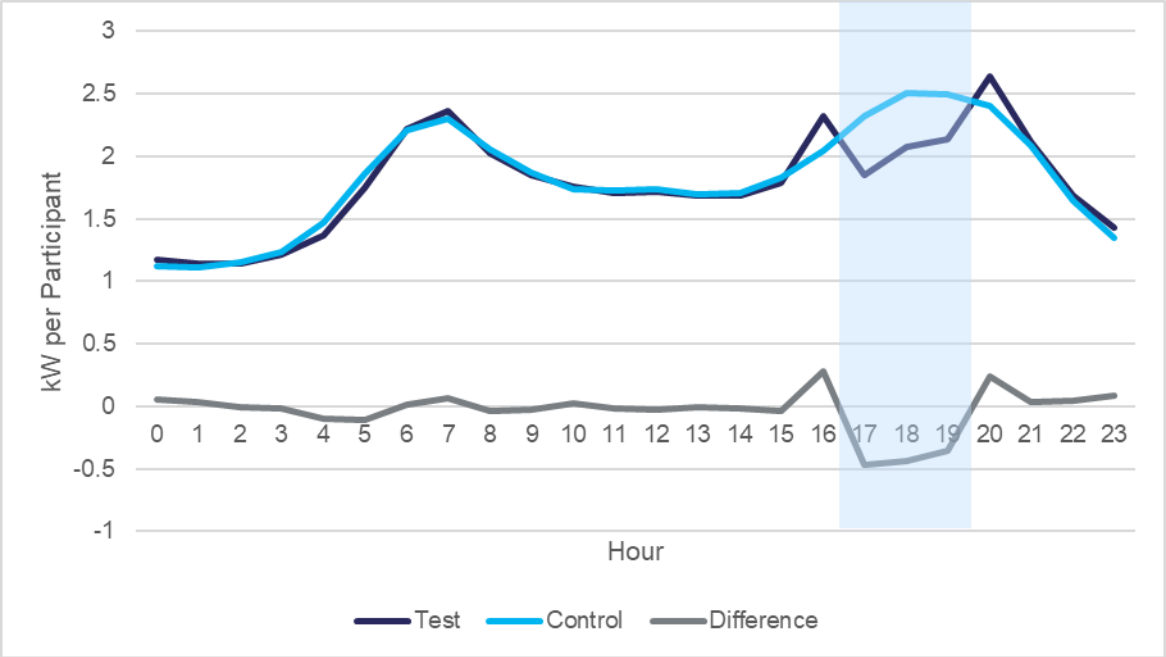


Figure B-3 and Figure B-4 show average consumption per participant across all hours of event days for test and control group customers in the analysis sample by event start time. As noted above, net metering customers were excluded from the summer 2019 analysis sample for reasons described above. The impacts of pre-conditioning, the actual event setback, and the snapback are evident.

Figure B-3. Rush Hour Rewards Consumption - Summer 4 p.m. – 7 p.m. Events

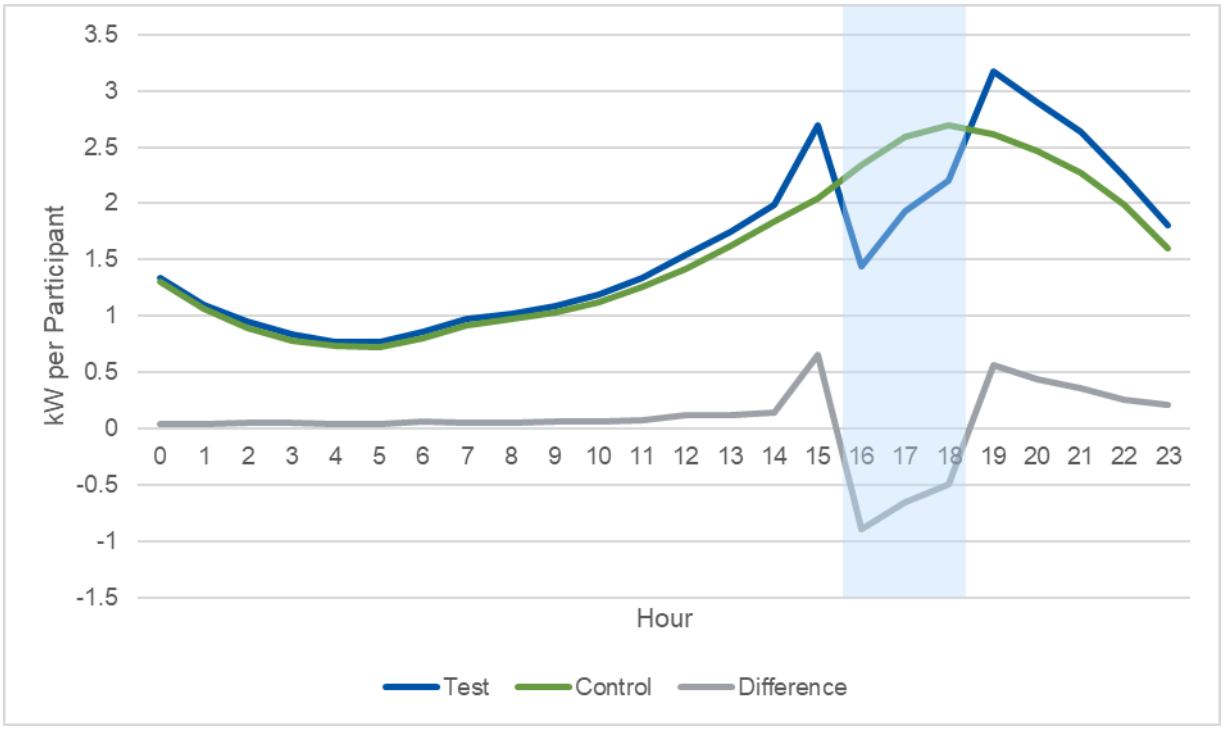


Figure B-4. Rush Hour Rewards Consumption - Summer 5 p.m. – 7 p.m. Events

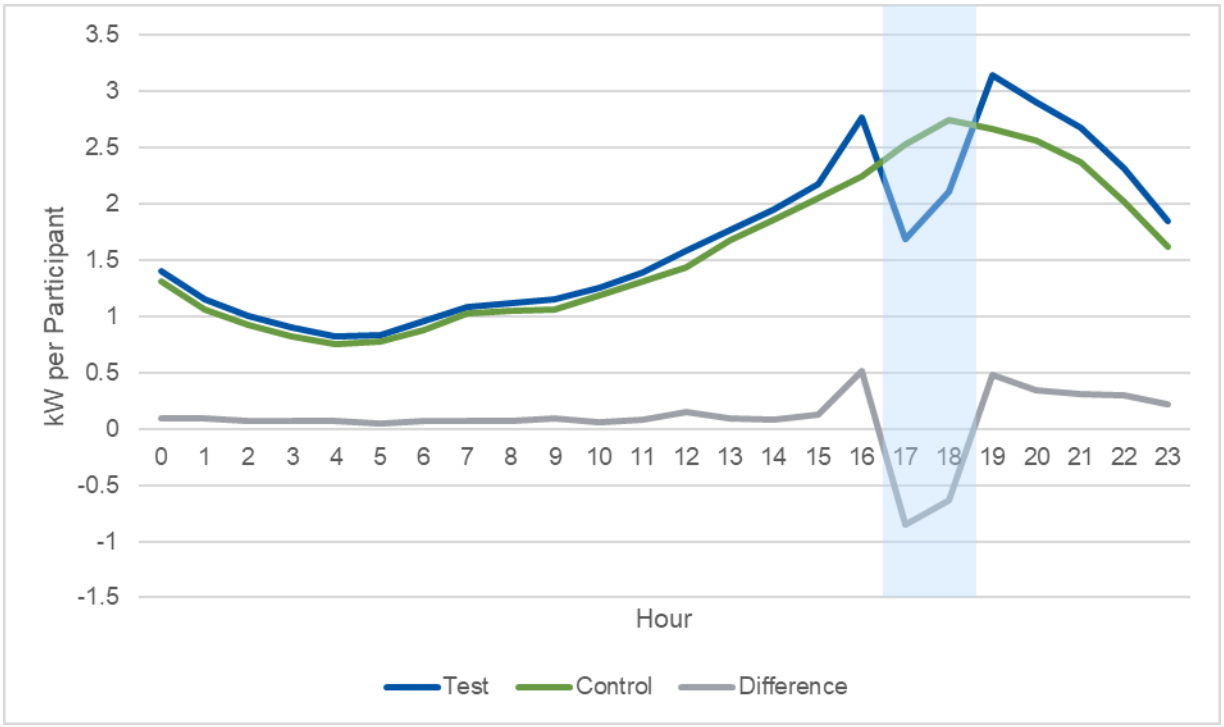


Figure B-5 through Figure B-8 show event-day consumption for Connected Savings customers for morning and evening events respectively. Demand reduction is clear during these hours.

Figure B-5. Connected Savings Consumption – Winter a.m. Event

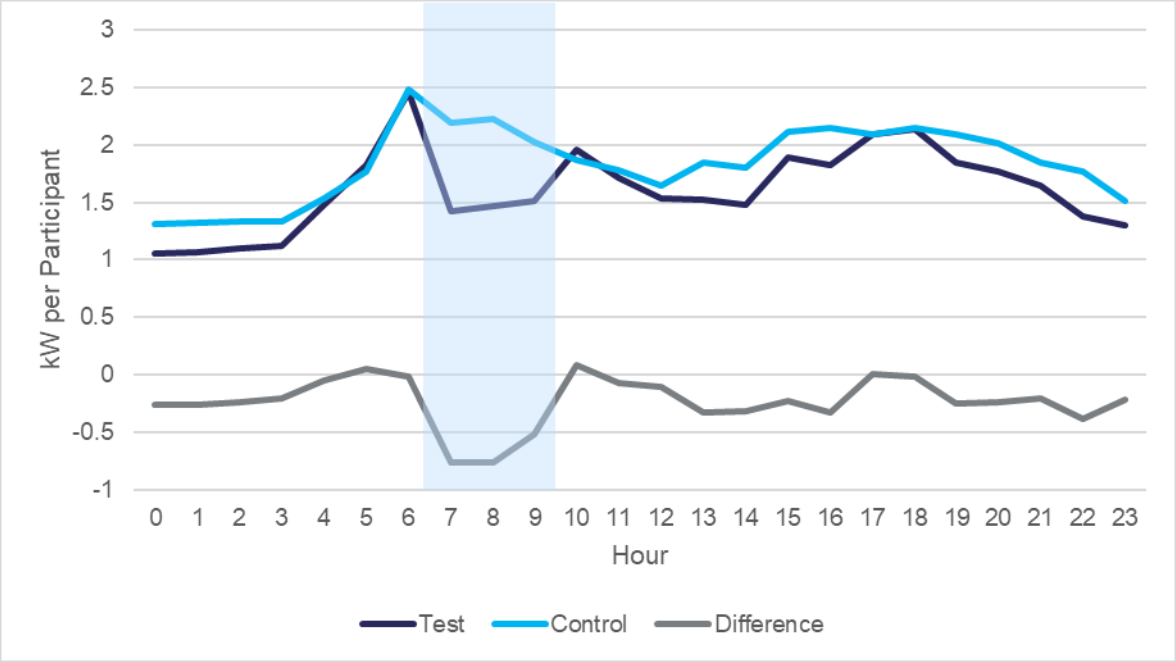


Figure B-6. Connected Savings Evening Events Consumption Plot - Winter

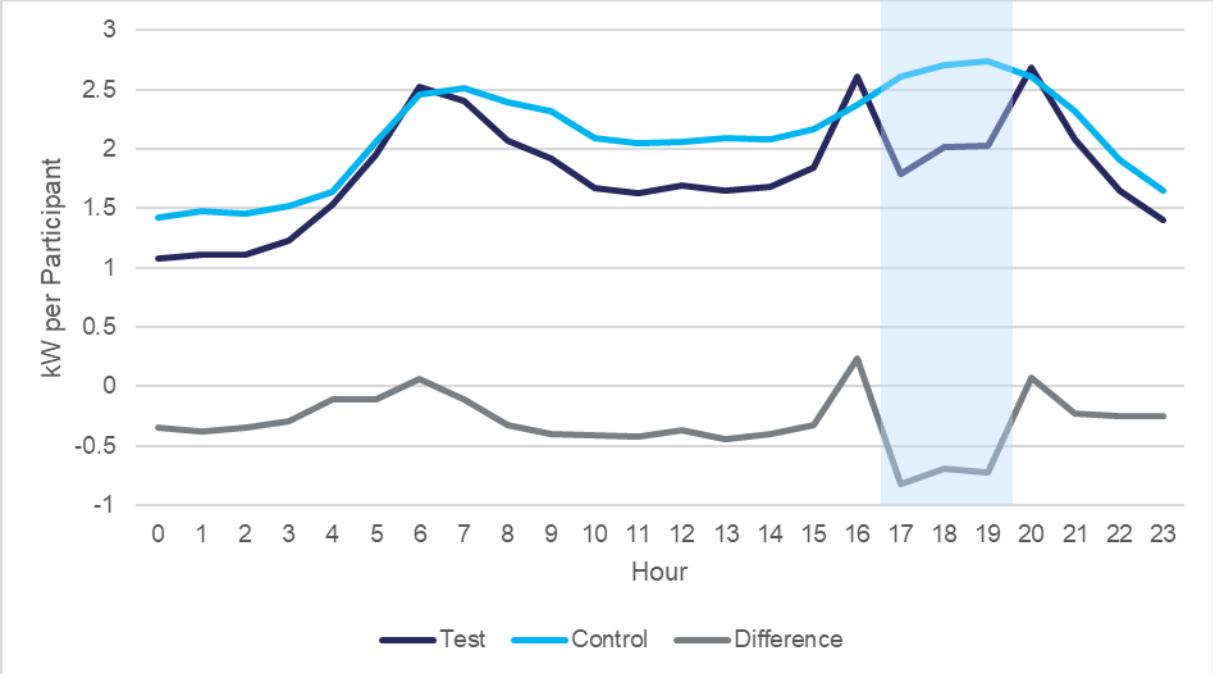


Figure B-7. Connected Savings Consumption – Summer 4 p.m. - 7 p.m. Events

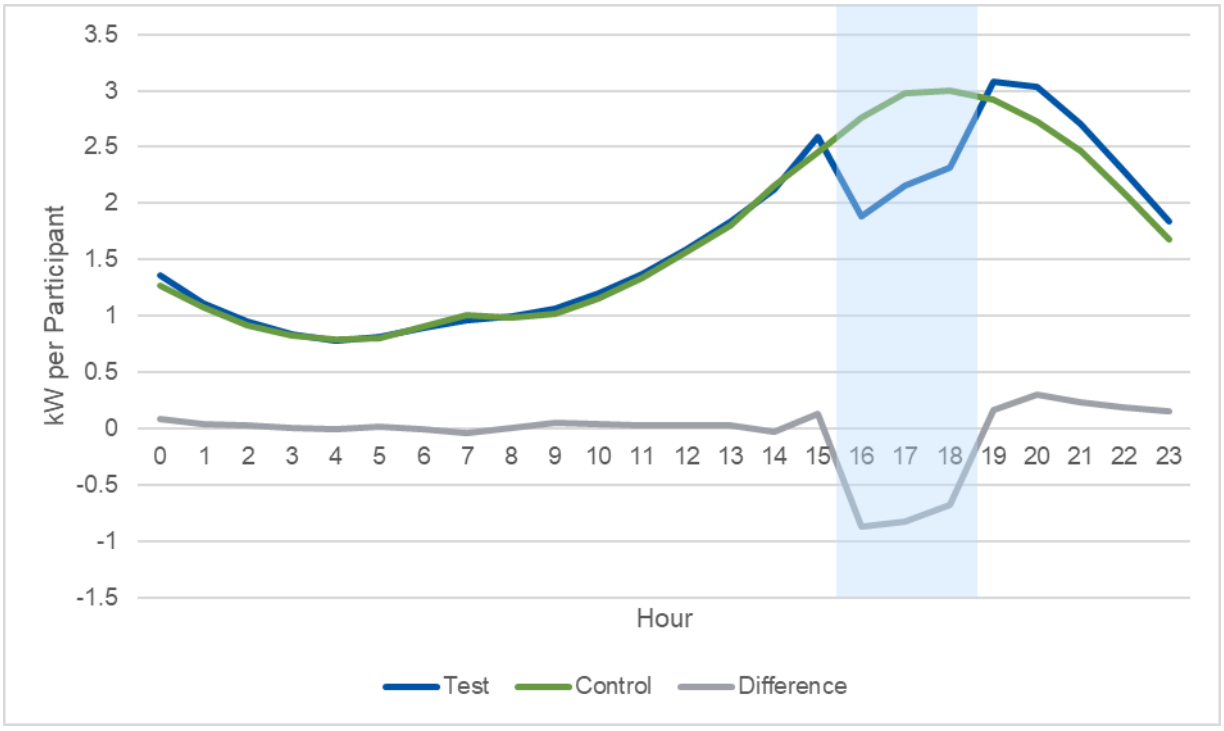
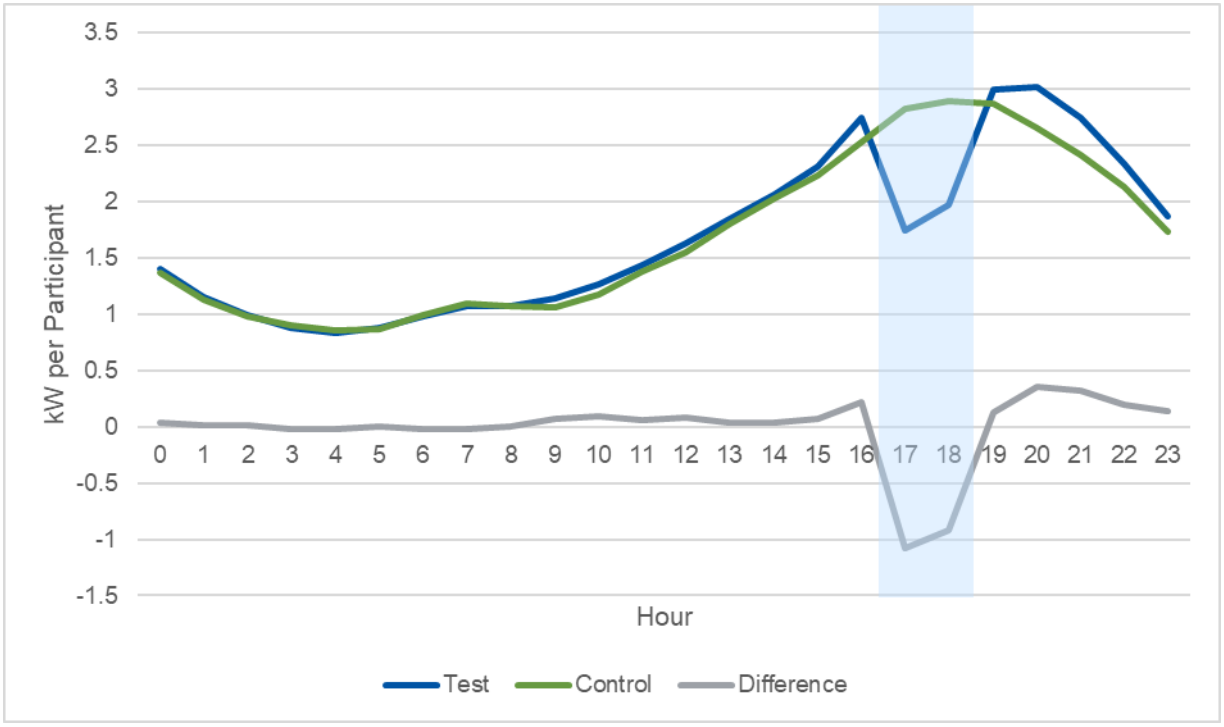


Figure B-8. Connected Savings Consumption – Summer 5 p.m. - 7 p.m. Events



Load Impact Estimates Graphs by Program, Season, and Event Start Time

Figure B-9 through Figure B-12 present estimates of the average load impacts per hour per test group participant, by season and event start time. Each figure shows the estimated load impacts, metered demand, estimated demand, and the counterfactual baseline demand. The estimated load impact was obtained from the regression model. Meter kW is customer demand at the AMI meter. Model predicted demand is the customer load predicted by the regression model. The baseline is the counterfactual demand under the assumption that the event had not occurred. The model predicted and counterfactual will only differ, if at all, during the one hour before the event, the event hours, and the eight hours after the event.

Figure B-9. Rush Hour Rewards Estimate Load Impacts – Winter 2018/2019

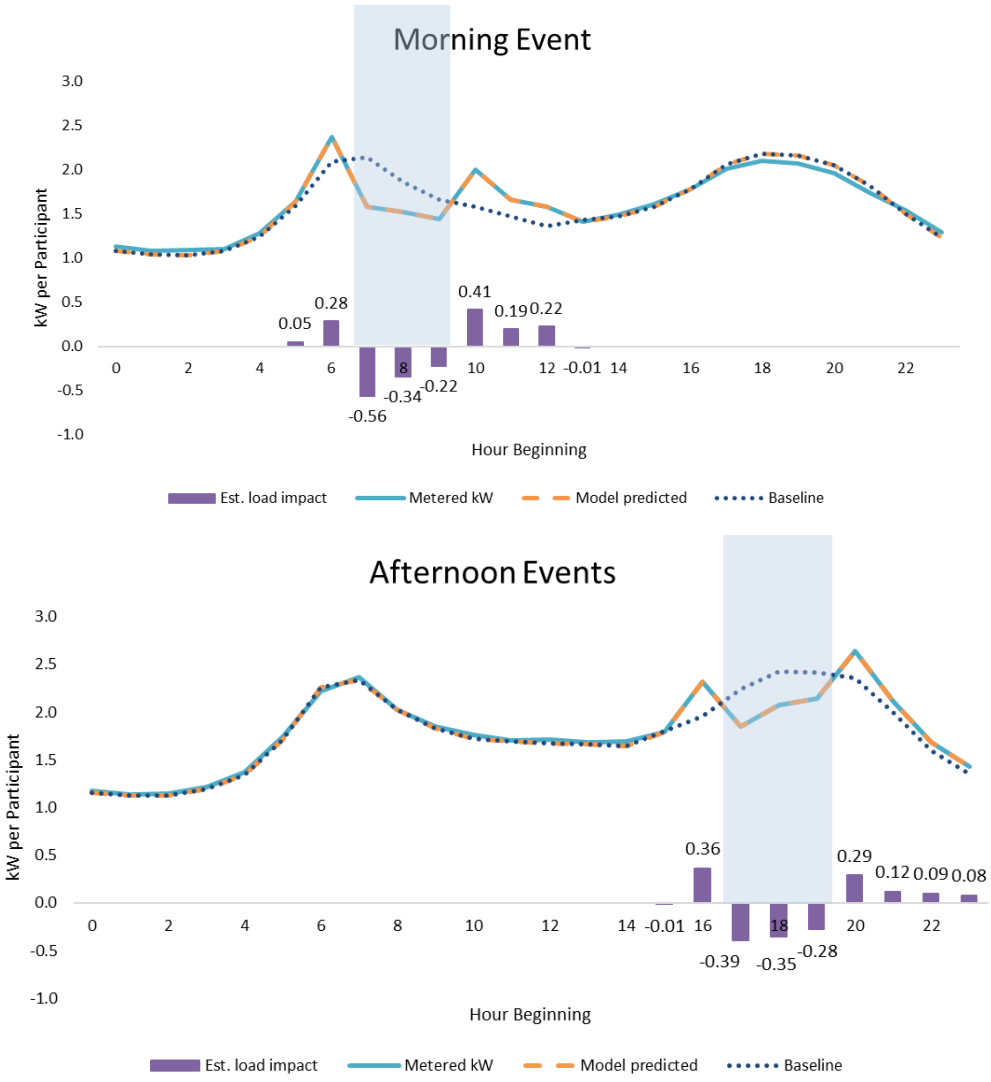


Figure B-10. Connected Savings Estimated Load Impacts– Winter 2018/2019

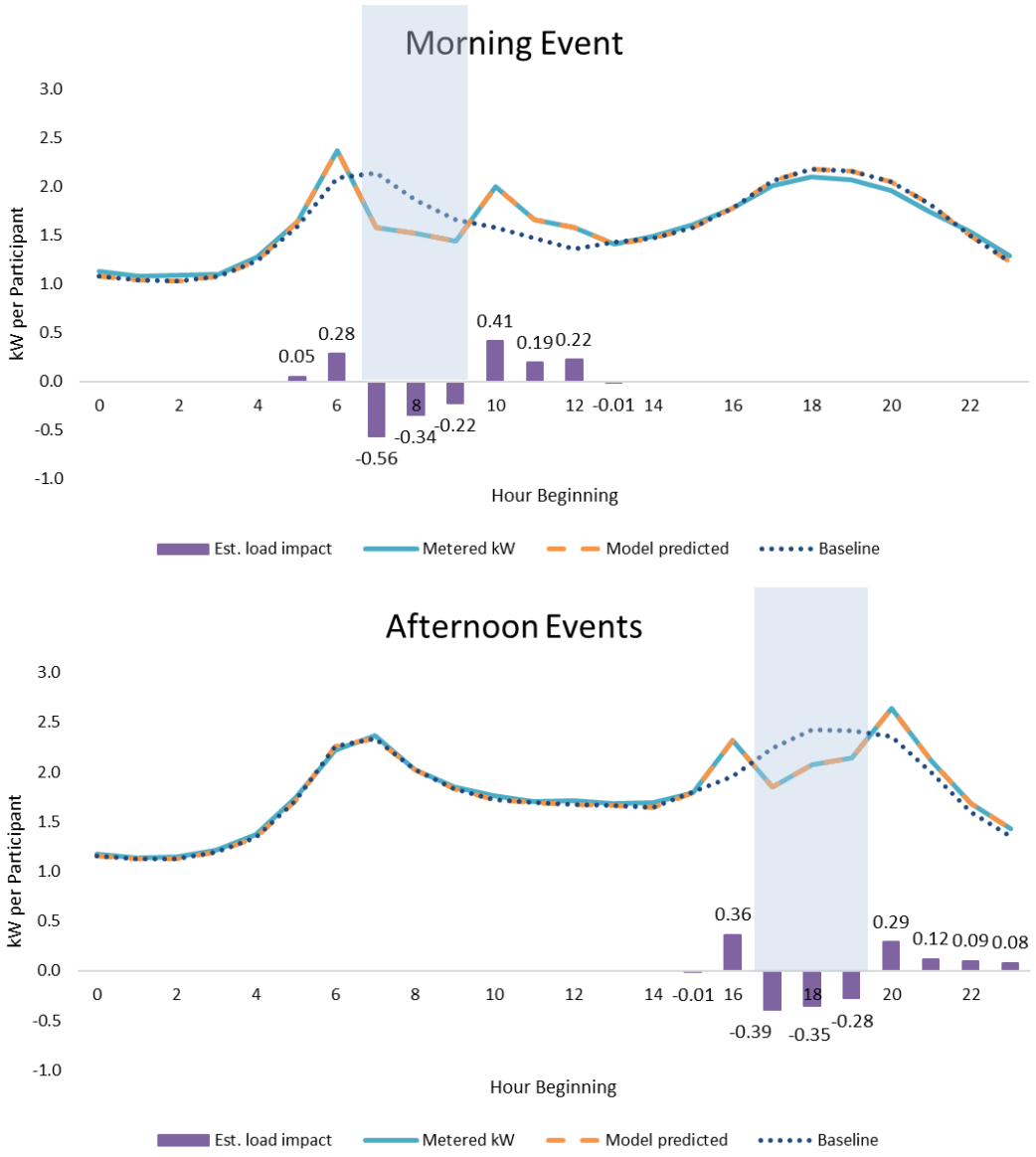


Figure B-11. Rush Hour Rewards Estimated Load Impacts by Event Time – Summer 2019

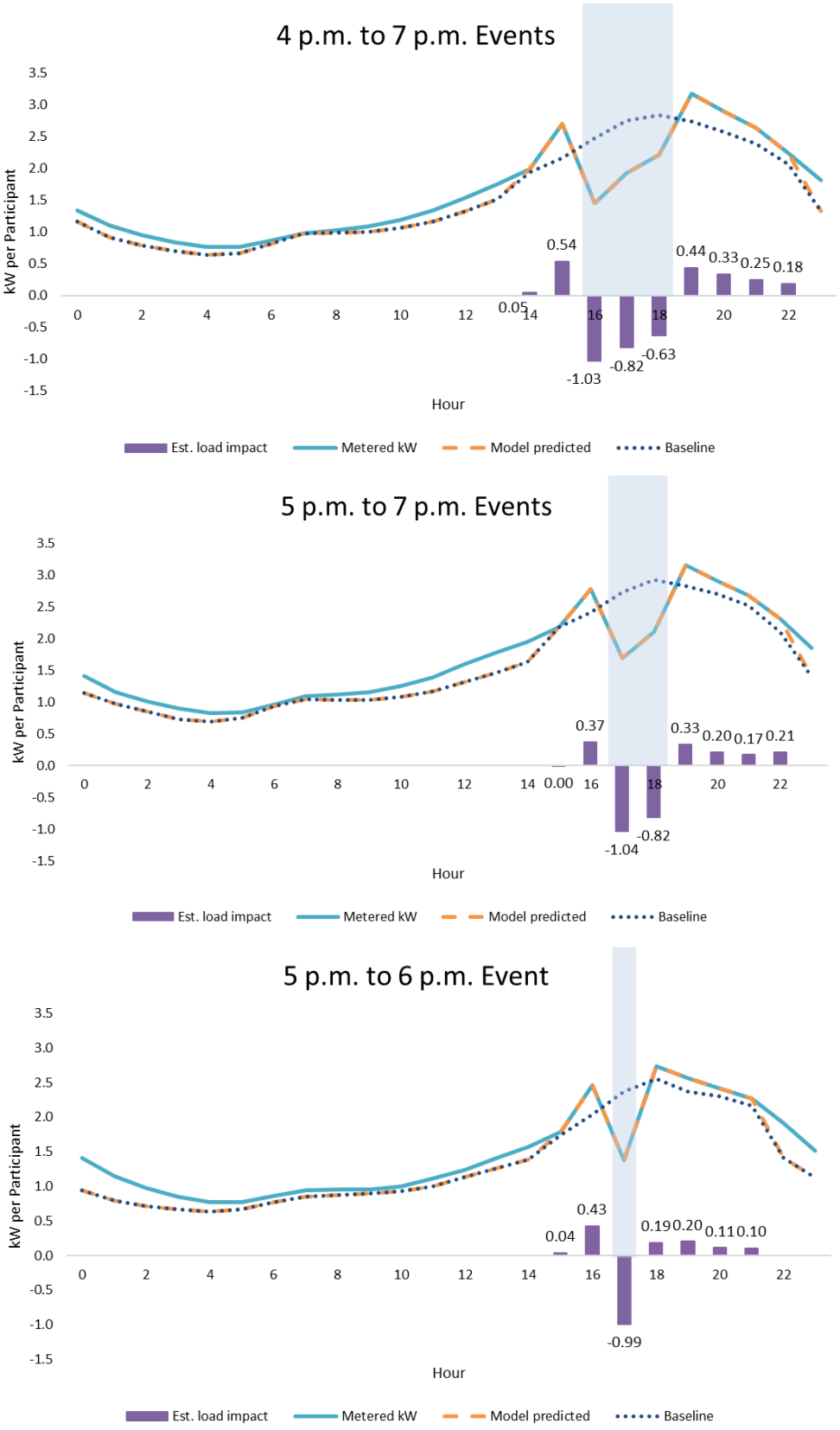


Figure B-12. Connected Savings Estimated Load Impacts– Summer 2019

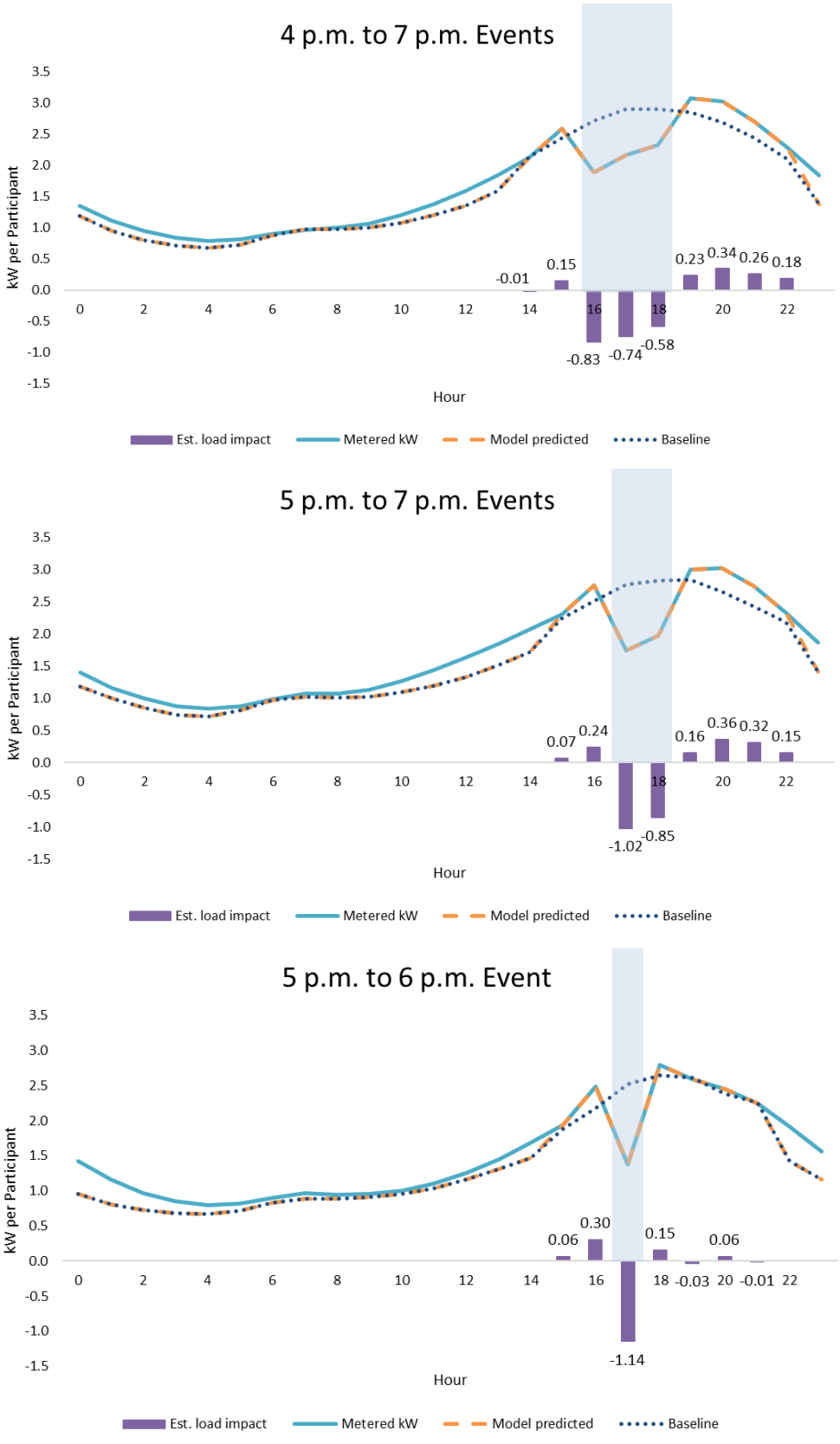


Figure B-13 through Figure B-16 provide impacts for each event in the winter 2018/2019 and summer 2019 seasons, respectively.

Figure B-13. Rush Hour Rewards Estimated Load Impacts by Event – Winter 2018/2019

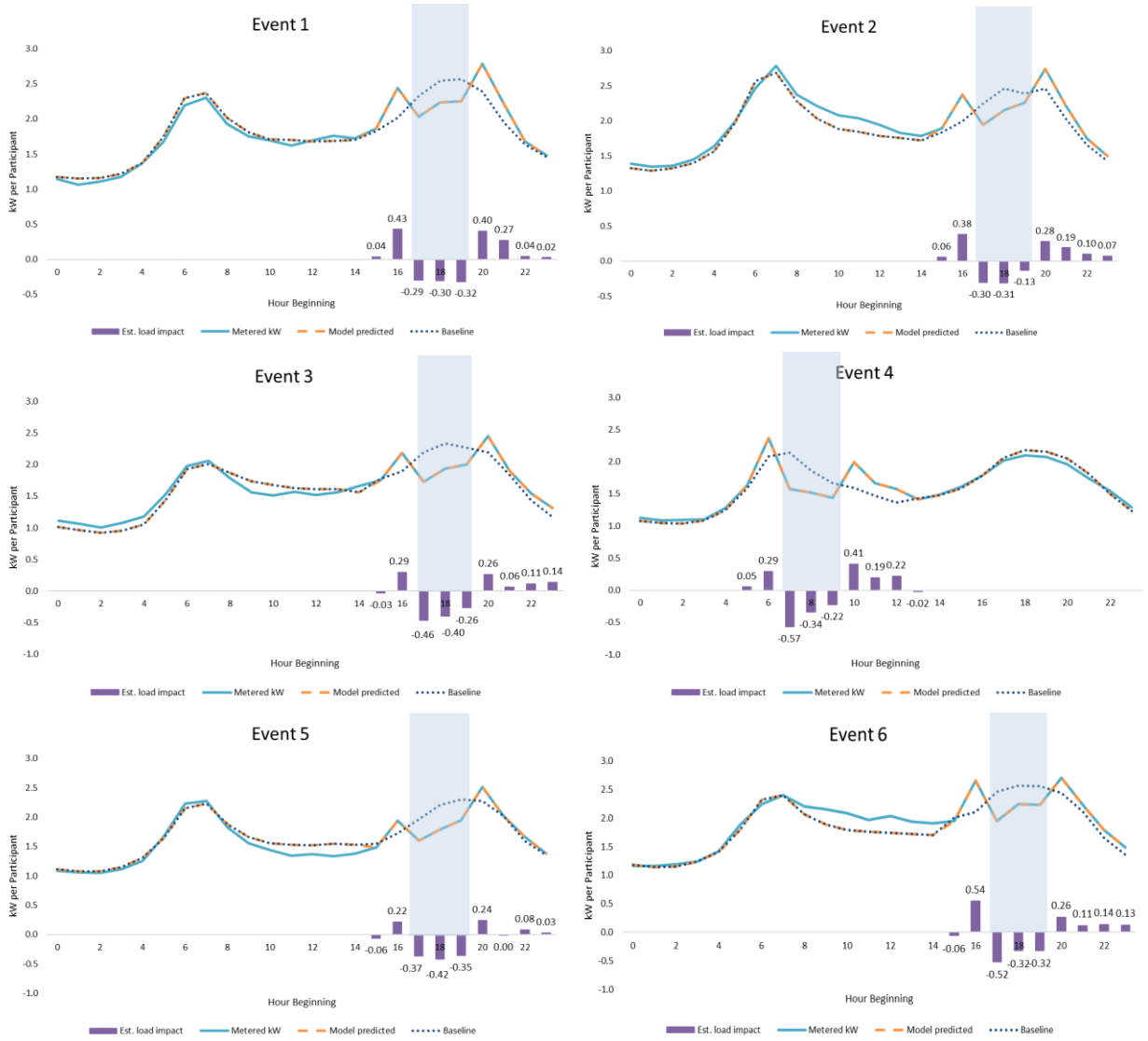


Figure B-14. Rush Hour Rewards Estimated Load Impacts by Event – Summer 2019

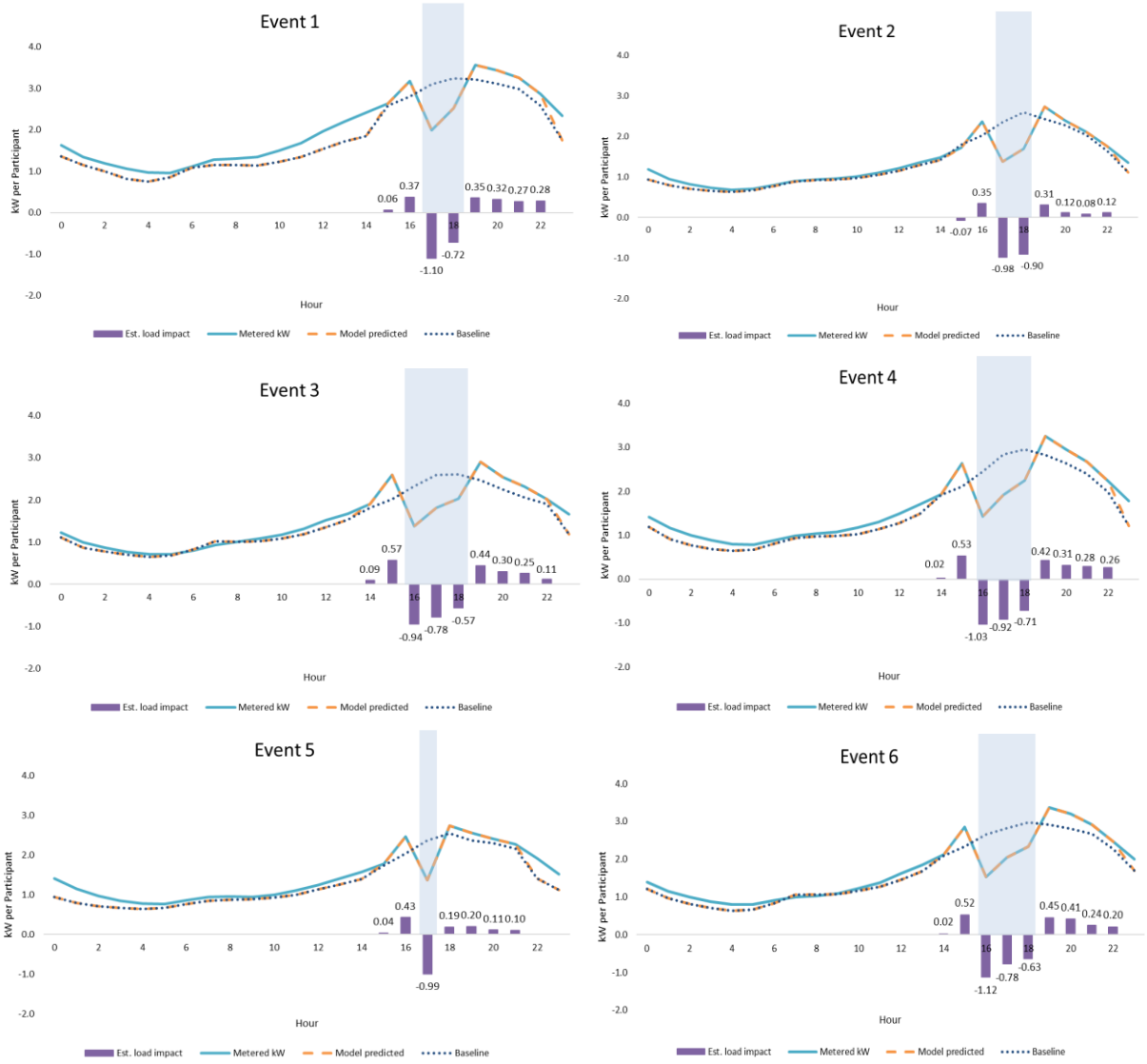


Figure B-15. Connected Savings Estimated Load Impacts by Event – Winter 2018/2019

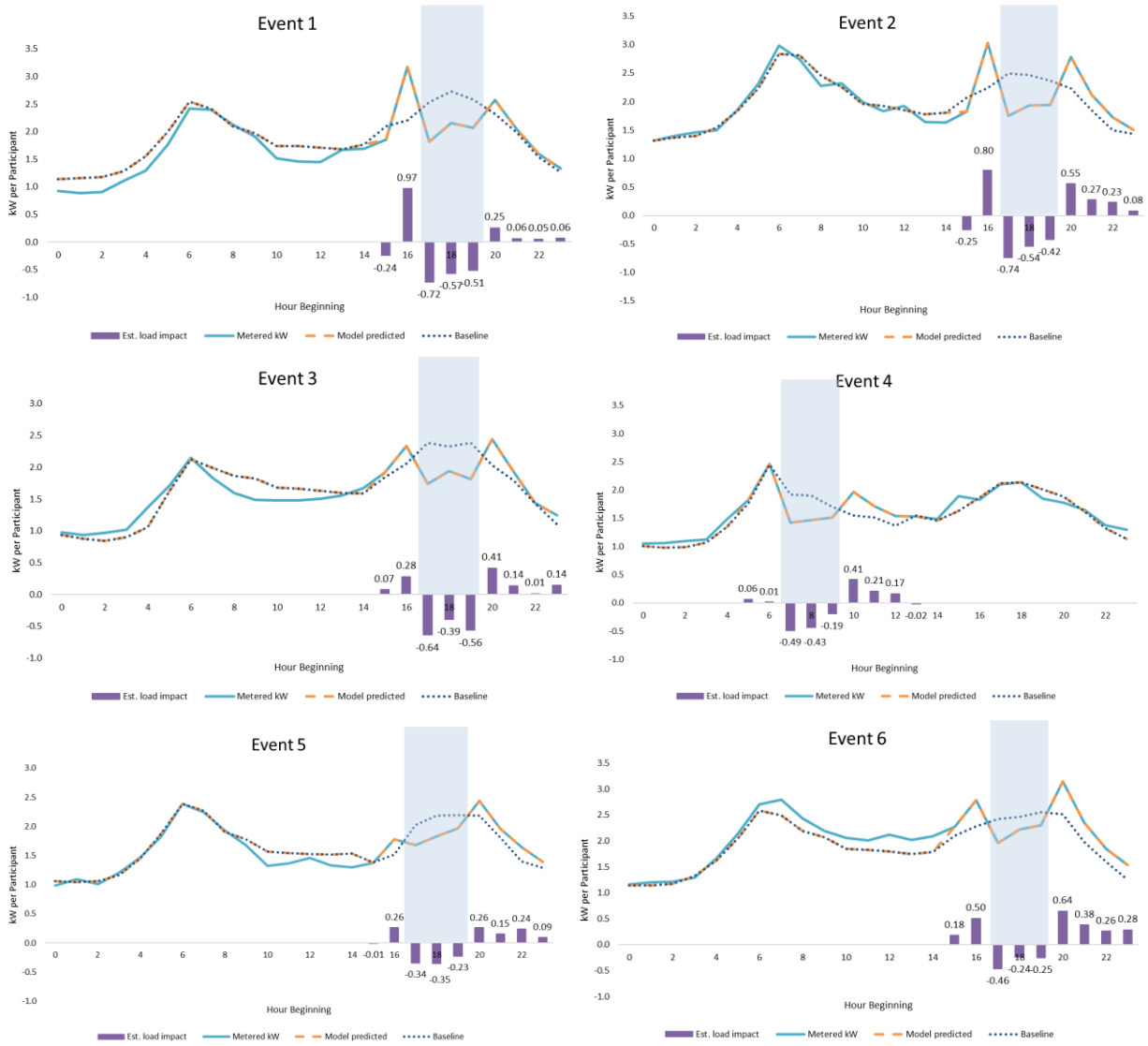
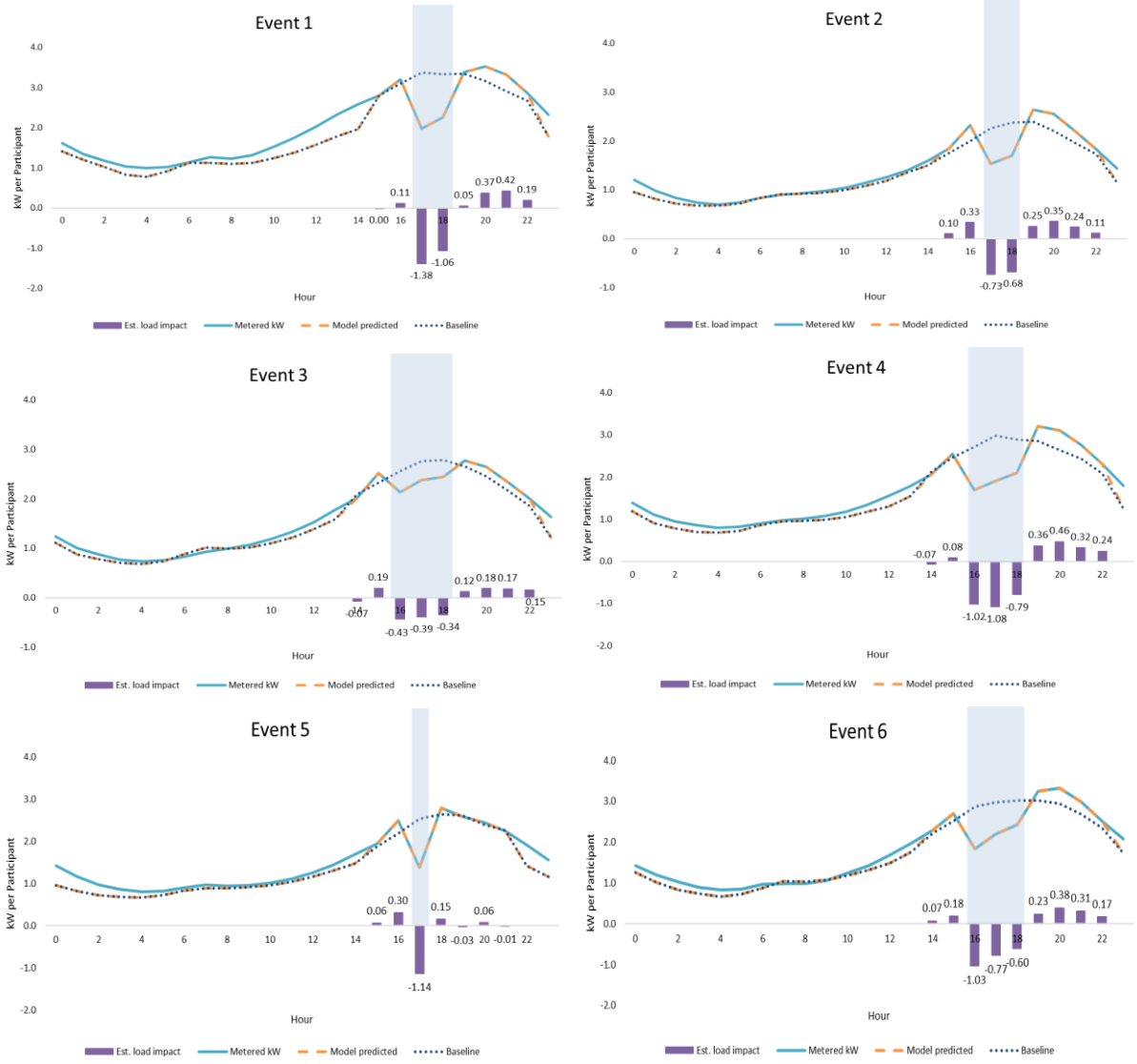


Figure B-16. Connected Savings Estimated Load Impacts by Event – Summer 2019



Event Impacts Estimates Tables by Program, Season, and Event Start Time

Table B-1 through Table B-8 provide the estimated load impacts and summaries for Rush Hour Rewards and Connected Savings by season and event start time and by season and individual events respectively.

Table B-1. Rush Hour Rewards Estimated Demand Impacts – Winter 2018/2019

Event Hour	7 a.m. to 10 a.m. (1 event)	5 p.m. to 8 p.m. (5 events)
Pre-Event Hour 1	0.28***	0.36***
Event Hour 1	**-0.56*** **	**-0.39*** **
Event Hour 2	**-0.34*** **	**-0.35*** **
Event Hour 3	**-0.22*** **	**-0.28*** **
Post-Event Hour 1	0.41***	0.29***
Post-Event Hour 2	0.19***	0.12***
Post-Event Hour 3	0.22***	0.09***
Post-Event Hour 4	0.01	0.08***
Event Avg. Demand Impact (kW)	**-0.37**	**-0.34**
Event Hour Min. Demand Impact (kW)	**-0.22**	**-0.13**
Event Hour Max. Demand Impact (kW)	**-0.56**	**-0.57**
Avg. Energy Impact (kWh)	**-0.01**	**-0.08**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. The minimum and maximum demand impacts were the smallest and greatest event hour demand impact estimates across all event hours. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-2. Rush Hour Rewards Estimated Demand Impacts – Summer 2019

Event Hour	4 p.m. to 7 p.m. (3 events)	5 p.m. to 7 p.m. (2 events)	5 p.m. to 6 p.m. (1 event)
Pre-Event Hour 1	0.54***	0.36***	0.43***
Event Hour 1	**-1.03*** **	**-1.04*** **	**-0.99*** **
Event Hour 2	**-0.82*** **	**-0.82*** **	**N/A**
Event Hour 3	**-0.63*** **	**N/A**	**N/A**
Post-Event Hour 1	0.44***	0.33***	0.19***
Post-Event Hour 2	0.33***	0.20***	-0.20***
Post-Event Hour 3	0.25***	0.17***	0.11
Post-Event Hour 4	0.18***	0.21***	-0.10
Event Avg. Demand Impact (kW)	**-0.83**	**-0.93**	**-0.99**
Event Hour Min. Demand Impact (kW)	**-0.57**	**-0.72**	**-0.99**
Event Hour Max. Demand Impact (kW)	**-1.12**	**-1.10**	**-0.99**
Avg. Energy Impact (kWh)	**-0.74**	**-0.59**	**-0.56**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. The minimum and maximum demand impacts were the smallest and greatest event hour demand impact estimates across all event hours. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-3. Connected Savings Estimated Demand Impacts – Winter 2018/2019

Event Hour	7 a.m. to 10 a.m. (1 event)	5 p.m. to 8 p.m. (5 events)
Pre-Event Hour 1	0.02	0.52***
Event Hour 1	***-0.48****	***-0.57*****
Event Hour 2	***-0.44****	***-0.41*****
Event Hour 3	***-0.21***	***-0.40*****
Post-Event Hour 1	0.40**	0.43***
Post-Event Hour 2	0.19	0.20**
Post-Event Hour 3	0.25	0.16**
Post-Event Hour 4	-0.03	0.14**
Event Avg. Demand Impact (kW)	**-0.37**	**-0.46**
Event Hour Min. Demand Impact (kW)	**-0.21**	**-0.19**
Event Hour Max. Demand Impact (kW)	**-0.48**	**-0.74**
Avg. Energy Impact (kWh)	**-0.30**	**0.07**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. The minimum and maximum demand impacts were the smallest and greatest event hour demand impact estimates across all event hours. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-4. Connected Savings Estimated Demand Impacts – Summer 2019

Event Hour	4 p.m. to 7 p.m. (3 events)	5 p.m. to 7 p.m. (2 events)	5 p.m. to 6 p.m. (1 event)
Pre-Event Hour 1	0.15***	0.24***	0.30***
Event Hour 1	**-0.83*****	**-1.02*****	**-1.14*****
Event Hour 2	**-0.74*****	**-0.85*****	**N/A**
Event Hour 3	**-0.58*****	**N/A**	**N/A**
Post-Event Hour 1	0.23***	0.16***	0.15**
Post-Event Hour 2	0.34***	0.36***	-0.03*
Post-Event Hour 3	0.26***	0.32***	0.06**
Post-Event Hour 4	0.18***	0.15***	-0.01*
Event Avg. Demand Impact (kW)	**-0.72**	**-0.94**	**-1.14**
Event Hour Min. Demand Impact (kW)	**-0.34**	**-0.68**	**-1.14**
Event Hour Max. Demand Impact (kW)	**-1.08**	**-1.38**	**-1.14**
Avg. Energy Impact (kWh)	**-0.99**	**-0.64**	**-0.67**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. The minimum and maximum demand impacts were the smallest and greatest event hour demand impact estimates across all event hours. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-5. Rush Hour Rewards Estimated Demand Impacts by Event – Winter 2018/2019

Event Hour	Event					
	1	2	3	4	5	6
Event Start Time	5:00 p.m.	5:00 p.m.	5:00 p.m.	7:00 a.m.	5:00 p.m.	5:00 p.m.
Pre-Event Hour 1	0.43***	0.38***	0.29***	0.29***	0.22***	0.54***
Event Hour 1	**-0.29*** **	**-0.30*** **	**-0.46*** **	**-0.57*** **	**-0.37*** **	**-0.52*** **
Event Hour 2	**-0.30*** **	**-0.31*** **	**-0.40*** **	**-0.34*** **	**-0.42*** **	**-0.32*** **
Event Hour 3	**-0.32*** **	**-0.13**	**-0.26*** **	**-0.22*** **	**-0.35*** **	**-0.32*** **
Post-Event Hour 1	0.40***	0.28***	0.26***	0.41***	0.24***	0.26***
Post-Event Hour 2	0.27***	0.19**	0.06	0.19***	0.00	0.11*
Post-Event Hour 3	0.04	0.10	0.11**	0.22***	0.08	0.14**
Post-Event Hour 4	0.02	0.07	0.14***	-0.02	0.03	0.13**
Event Avg. Demand Impact (kW)	**-0.30**	**-0.25**	**-0.37**	**-0.38**	**-0.38**	**-0.39**
Avg. Energy Impact (kWh)	**0.25**	**0.28**	**-0.26**	**-0.04**	**-0.57**	**0.02**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-6. Rush Hour Rewards Estimated Demand Impacts by Event – Summer 2019

Event Hour	Event					
	1	2	3	4	5	6
Event Start Time	5:00 p.m.	5:00 p.m.	4:00 p.m.	4:00 p.m.	5:00 p.m.	4:00 p.m.
Pre-Event Hour 1	0.37***	0.35***	0.57***	0.05***	0.43***	0.52***
Event Hour 1	**-1.10*** **	**-0.98*** **	**-0.94*** **	**-1.03*** **	**-0.99*** **	**-1.12*** **
Event Hour 2	**-0.72*** **	**-0.90*** **	**-0.78*** **	**-0.92*** **	**N/A**	**-0.78*** **
Event Hour 3	**N/A**	**N/A**	**-0.57*** **	**-0.71*** **	**N/A**	**-0.63*** **
Post-Event Hour 1	0.35***	0.31***	0.44***	0.42***	0.19***	0.45***
Post-Event Hour 2	0.32***	0.12**	0.30***	0.31***	0.20***	0.41***
Post-Event Hour 3	0.27***	0.08	0.25***	0.28***	0.11**	0.24***
Post-Event Hour 4	0.28***	0.12***	0.11**	0.26***	0.10**	0.20***
Event Avg. Demand Impact (kW)	**-0.91**	**-0.94**	**-0.76**	**-0.96**	**-0.99**	**-0.84**
Avg. Energy Impact (kWh)	**-0.23**	**-0.90**	**-0.62**	**-1.34**	**0.04**	**-0.71**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4 (demonstrating significance).

Table B-7. Connected Savings Estimated Demand Impacts by Event – Winter 2018/2019

Event Hour	Event					
	1	2	3	4	5	6
Event Start Time	5:00 p.m.	5:00 p.m.	5:00 p.m.	7:00 a.m.	5:00 p.m.	5:00 p.m.
Pre-Event Hour 1	0.97***	0.80***	0.28	0.01	0.26	0.50**
Event Hour 1	**-0.72*** **	**-0.74*** **	**-0.64*** **	**-0.49** **	**-0.34** **	**-0.46** **
Event Hour 2	**-0.57** **	**-0.54*** **	**-0.39*** **	**-0.43** **	**-0.35** **	**-0.24**
Event Hour 3	**-0.51*** **	**-0.42** **	**-0.56*** **	**-0.19**	**-0.23**	**-0.25**
Post-Event Hour 1	0.25	0.55***	0.41**	0.41***	0.26	0.64**
Post-Event Hour 2	0.06	0.27	0.14	0.21	0.15	0.38*
Post-Event Hour 3	0.05	0.23	0.01	0.17	0.24*	0.26
Post-Event Hour 4	0.06	0.08	0.14	-0.02	0.09	0.28*
Event Avg. Demand Impact (kW)	**-0.60**	**-0.57**	**-0.53**	**-0.37**	**-0.31**	**-0.32**
Avg. Energy Impact (kWh)	**-0.41**	**0.23**	**-0.61**	**-0.33**	**0.08**	**1.11**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4 (demonstrating significance).

Table B-8. Connected Savings Estimated Demand Impacts by Event – Summer 2019

Event Hour	Event					
	1	2	3	4	5	6
Event Start Time	5:00 p.m.	5:00 p.m.	4:00 p.m.	4:00 p.m.	5:00 p.m.	4:00 p.m.
Pre-Event Hour 1	0.11	0.33***	0.19***	0.08	0.30***	0.18***
Event Hour 1	**-1.38*** **	**-0.73*** **	**-0.43*** **	**-1.02*** **	**-1.14*** **	**-1.03*** **
Event Hour 2	**-1.06*** **	**-0.68*** **	**-0.39*** **	**-1.08*** **	**N/A**	**-0.77*** **
Event Hour 3	**N/A**	**N/A**	**-0.34*** **	**-0.79*** **	**N/A**	**-0.60*** **
Post-Event Hour 1	0.05*	0.25***	0.12*	0.36***	0.15**	0.23***
Post-Event Hour 2	0.37***	0.35***	0.18***	0.46***	-0.03	0.38***
Post-Event Hour 3	0.42***	0.24***	0.17***	0.32***	0.06	0.31***
Post-Event Hour 4	0.19*	0.11**	0.15***	0.24***	-0.01	0.17**
Event Avg. Demand Impact (kW)	**-1.22**	**-0.71**	**-0.39**	**-0.96**	**-1.14**	**-0.80**
Avg. Energy Impact (kWh)	**-1.30**	**-0.13**	**-0.35**	**-1.43**	**-0.67**	**-1.13**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4 (demonstrating significance).

Appendix C. Rush Hour Rewards Past Survey Results

This appendix presents Rush Hour Rewards results from previous online customer surveys, including the following:

- Winter 2015/2016 Experience Survey
- Summer 2016 Experience Survey
- Summer 2018 Experience Survey

Table C-1 provides the experience survey results from winter 2015/2016 for Rush Hours Rewards.

Table C-1. Rush Hour Rewards Winter 2015/2016 Experience Survey Results

Survey Topic	Test Group (n≤52)	Control Group (n≤65)
General event awareness	77% noticed events	--
Comfort during events	92% comfortable	--
Overriding events	11% overrode	--
Smart thermostat satisfaction	94% satisfied* 69% delighted	82% satisfied 60% delighted
Incentive satisfaction	92% satisfied 54% delighted	91% satisfied 73% delighted*
Program satisfaction	96% satisfied* 63% delighted	81% satisfied 67% delighted
Satisfaction with PGE	90% satisfied 48% delighted	98% satisfied 48% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Table C-2 provides the experience survey results from summer 2016 for Rush Hour Rewards.

Table C-2. Rush Hour Rewards Summer 2016 Experience Survey Results

Survey Topic	Test Group (n≤666)	Control Group (n≤389)
General event awareness	89% noticed events	--
Comfort during events	72% comfortable	--
Overriding events	28% overrode	--
Smart thermostat satisfaction	87% satisfied* 55% delighted	92% satisfied 69% delighted*
Incentive satisfaction	83% satisfied 52% delighted	89% satisfied* 69% delighted*
Program satisfaction	86% satisfied 51% delighted	87% satisfied 64% delighted*
Satisfaction with PGE	92% satisfied 48% delighted	95% satisfied* 51% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Table C-3 provides the experience survey results from summer 2018 for Rush Hours Rewards.

Table C-3. Rush Hour Rewards Summer 2018 Experience Survey Results

Survey Topic	Test Group (n≤232)	Control Group (n≤106)
General event awareness	62% noticed events	--
Comfort during events	82% comfortable	--
Overriding events	35% overrode	--
Smart thermostat satisfaction	97% satisfied 72% delighted	97% satisfied 71% delighted
Incentive satisfaction	87% satisfied 56% delighted	96% satisfied 61% delighted
Program satisfaction	91% satisfied 58% delighted	96% satisfied* 61% delighted
Satisfaction with PGE	97% satisfied 60% delighted	97% satisfied 65% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Appendix D. Connected Savings Past Survey Results

Table D-1 provides the experience survey results from summer 2018, which was the last time Cadmus administered the experience surveys for Connected Savings. Cadmus was not contracted to administer surveys for winter 2017/2018.

Table D-1. Connected Savings Summer 2018 Experience Survey Results

Survey Topic	Test Group (n≤218)	Control Group (n≤233)
General event awareness	58% noticed events	--
Comfort during events	74% comfortable	--
Overriding events	36% overrode	--
Smart thermostat satisfaction	95% satisfied 70% delighted	97% satisfied 70% delighted
Incentive satisfaction	84% satisfied 56% delighted	95% satisfied* 70% delighted*
Program satisfaction	89% satisfied 56% delighted	96% satisfied* 69% delighted*
Satisfaction with PGE	92% satisfied 58% delighted	97% satisfied 71% delighted*

* Difference is statistically significant with 90% confidence (p≤0.10).

Appendix E. Survey Instruments

CADMUS

PGE Rush Hour Rewards

Winter 2018-19 Experience Survey

Research Topics	Corresponding Question Numbers
Event awareness	A1-A5
Event participation	B1-B3
Thermal comfort	C1-C5
Satisfaction with program and thermostat	D1-D4
Satisfaction with PGE	E1

Target Audience: Treatment (test) and control group customers with a smart thermostat who are enrolled in the Rush Hour Rewards Smart Thermostat Program

Expected number of completions: How ever many over a 10-14 day fielding period

Estimated timeline for fielding: Early March 2019. One survey reminder email may be sent 5-7 days after initial email, depending on the number of completes.

Variables to be Pulled into Survey

- Email
- Name
- SPID
- Assignment (Treatment or Control)
- Brand
- HVAC System (Cooling or Heating/Cooling)

Email Invitation

To: [EMAIL]
From: Portland General Electric
Subject: How was PGE's Smart Thermostat Program?

Dear [FIRSTNAME AND LASTNAME],

Thank you for participating in PGE's Smart Thermostat Program during this recent winter. Your smart thermostat worked with PGE to shift your electricity consumption from when demand for electricity was highest. Would you take a moment to answer a few questions about your experience with the program? We value your input because we use it to improve PGE programs. Your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

Sincerely,
Will Miller
Program Manager, Portland General Electric

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take about 5 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

[ASK SECTION A TO TREATMENT ONLY]

A. Event Awareness

A1. Your smart thermostat works with PGE to shift electricity consumption from times when demand for electricity is highest. How many high demand events did you notice this past winter?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO B1]
3. Don't know

A2. Do you recall being notified of high demand events prior to their occurrence?

1. Yes
2. No

[ASK IF 0=1]

A3. How did you receive notification about the high demand events? Please select all that apply. [RANDOMIZE ORDER 1-3]

1. Notification from PGE
2. Notification from smart thermostat app
3. Display on smart thermostat
4. Other [Please describe:_____]
5. Don't know [EXCLUSIVE ANSWER]

A4. On the days of high demand events, were you aware that the events were happening?

1. Yes
2. No

[ASK IF A4=1]

A5. How did you know that the events were happening? Please select all that apply. [RANDOMIZE ORDER 1-4]

1. Display on smart thermostat
2. Notification from smart thermostat app
3. Noticed warm air was cycling on and off
4. Noticed a temperature change
5. Other [Please describe:_____]
6. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION B TO TREATMENT ONLY]

B. Event Participation

B1. About how many high demand events did you participate in this past winter where you did not override the thermostat settings during the events?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO C1]
3. Don't know

B2. How easy or difficult was it to participate in the events?

1. Very easy
2. Somewhat easy
3. Somewhat difficult
4. Very difficult
5. Don't know

[ASK IF B2=3 OR 4]

B3. What made it difficult to participate in the events? Please select all that apply. [RANDOMIZE ORDER 1-6]

1. Other household members controlling the thermostat
2. The timing of the events
3. Notifications were not early enough
4. Health/medical reasons
5. Having guests or visitors around
6. Not understanding how the program works
7. Other [Please describe:_____]
8. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION C TO TREATMENT ONLY]

C. Thermal Comfort

C1. Overall this past winter, how comfortable was the interior temperature of your home a few hours **before** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. I was not at home
13. Don't know

C2. How often did you notice a change in your home's interior temperature **during** the high demand events?

1. Always noticed
2. Sometimes noticed
3. Never noticed
4. I was not at home for any events [SKIP TO **Error! Reference source not found.**]

C3. Overall this past winter, how comfortable was the interior temperature of your home **during** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. Don't know

C4. Did you or someone in your household make changes to the thermostat settings during any of the winter events?

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

[ASK IF C4=1]

C5. Why did you or someone in your household change the thermostat settings during the events? [OPEN END TEXT ENTRY]

[ASK SECTION D TO TREATMENT AND CONTROL]

D. Satisfaction with Program and Thermostat

D1. You have or will soon receive an incentive check for $25.00 in exchange for your participation this past winter. How satisfied are you with the incentive check?

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7

9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D2. Please rate your overall satisfaction with PGE's Smart Thermostat Program.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know [SKIP TO D4]

D3. Please tell us why you gave that rating for overall satisfaction. [OPEN END TEXT ENTRY]

D4. Please rate your overall satisfaction with the smart thermostat.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D5. Please tell us how PGE can improve the Smart Thermostat Program. [OPEN END TEXT ENTRY]

D6. How motivated are you to participate in future event seasons?

1. 0 – Extremely unmotivated
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely motivated
12. Don't know

[ASK SECTION E TO TREATMENT AND CONTROL]

E. Satisfaction with PGE

E1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!

CADMUS

PGE Rush Hour Rewards

Summer 2019 Experience Survey

Research Topics	Corresponding Question Numbers
Event awareness	A1-A5
Event participation	B1-B3
Thermal comfort	C1-C5
Satisfaction with program and thermostat	D1-D4
Satisfaction with PGE	E1

Target Audience: Treatment (test) and control group customers with a smart thermostat who are enrolled in the Rush Hour Rewards Smart Thermostat Program

Expected number of completions: 350-400 completes stratified by treatment and control group

Estimated timeline for fielding: October 2019. One survey reminder email may be sent 5-7 days after initial email, depending on the number of completes.

Variables to be Pulled into Survey

- Email
- FirstName
- LastName
- SPID
- EnrollDate
- Assignment = Treatment or Control
- Brand = Nest
- System = AC, HP or EF
- Micropersona
- TestbedStatus = In Testbed or Out Testbed
- Substation
- DwellingType

Email Invitation

To: [EMAIL]
From: Cadmus on behalf of Portland General Electric
Subject: How was PGE's Smart Thermostat Program?

Dear [FIRSTNAME],

Thank you for participating in PGE's Smart Thermostat Program during this recent summer. Your smart thermostat worked with PGE to shift your electricity consumption from when demand for electricity was highest. Would you take a moment to answer a few questions about your experience with the program? Your input will be used to improve PGE programs, and your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

If you have any questions about this survey or any difficulties taking the survey, please contact Masumi Izawa at Cadmus, the research firm conducting this survey on PGE's behalf. You can reach her at (503) 467-7115 or masumi.izawa@cadmusgroup.com.

Sincerely,
Will Miller
Program Manager, Portland General Electric

Follow the link to opt out of future survey emails:
${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take about 5 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

[ASK SECTION A TO TREATMENT ONLY]

A. Event Awareness

A1. Your smart thermostat works with PGE to shift electricity consumption from times when demand for electricity is highest. How many high demand events did you notice this past summer?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO B1]
3. Don't know

A2. Do you recall being notified of high demand events prior to their occurrence?

1. Yes
2. No

[ASK IF A2=1]

A3. How did you receive notification about the high demand events? Please select all that apply. [RANDOMIZE ORDER 1-3]

1. Notification from PGE
2. Notification from smart thermostat app
3. Display on smart thermostat
4. Other [Please describe:_____] [FORCED TEXT ENTRY]
5. Don't know [EXCLUSIVE ANSWER]

A4. On the days of high demand events, were you aware that the events were happening?

1. Yes
2. No

[ASK IF A4=1]

A5. How did you know that the events were happening? Please select all that apply. [RANDOMIZE ORDER 1-4]

1. Display on smart thermostat
2. Notification from smart thermostat app
3. Noticed cool air was cycling on and off
4. Noticed a temperature change
5. Other [Please describe:_____] [FORCED TEXT ENTRY]
6. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION B TO TREATMENT ONLY]

B. Event Participation

B1. About how many high demand events did you participate in this past summer where you did not override the thermostat settings during the events?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO C1]
3. Don't know

B2. How easy or difficult was it to participate in the events?

1. Very easy
2. Somewhat easy
3. Somewhat difficult
4. Very difficult
5. Don't know

[ASK IF B2=3 OR 4]

B3. What made it difficult to participate in the events? Please select all that apply. [RANDOMIZE ORDER 1-6]

1. Other household members controlling the thermostat
2. The timing of the events
3. Notifications were not early enough
4. Health/medical reasons
5. Having guests or visitors around
6. Not understanding how the program works
7. Other [Please describe:_____] [FORCED TEXT ENTRY]
8. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION C TO TREATMENT ONLY]

C. Thermal Comfort

C1. Overall this past summer, how comfortable was the interior temperature of your home a few hours **before** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. I was not at home
13. Don't know

C2. How often did you notice a change in your home's interior temperature **during** the high demand events?
1. Always noticed
2. Sometimes noticed
3. Never noticed
4. I was not at home for any events [SKIP TO **Error! Reference source not found.**]

C3. Overall this past summer, how comfortable was the interior temperature of your home **during** the high demand events?
1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. Don't know

C4. Did you or someone in your household make changes to the thermostat settings during any of the summer events?
1. Yes
2. No
3. Don't know

[ASK IF C4=1]

C5. Why did you or someone in your household change the thermostat settings during the events? [OPEN END TEXT ENTRY]

[ASK SECTION D TO TREATMENT AND CONTROL]

D. Satisfaction with Program and Thermostat

D1. You have or will soon receive an incentive check for $25.00 in exchange for your participation this past summer. How satisfied are you with the incentive check?

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D2. Please rate your overall satisfaction with PGE's Smart Thermostat Program.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know [SKIP TO D4]

D3. Please tell us why you gave that rating for overall satisfaction. [OPEN END TEXT ENTRY]

D4. Please rate your overall satisfaction with the smart thermostat.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6

8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D5. Please tell us how PGE can improve the Smart Thermostat Program. [OPEN END TEXT ENTRY]

D6. How motivated are you to participate in future event seasons?

1. 0 – Extremely unmotivated
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely motivated
12. Don't know

[ASK SECTION E TO TREATMENT AND CONTROL]

E. Satisfaction with PGE

E1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

E2. How likely would you be to recommend the Smart Thermostat Program to a friend, family member, or colleague?

1. 0 – Extremely unlikely
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely likely
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!

CADMUS

PGE Connected Savings

Winter 2018-19 Experience Survey

Research Topics	Corresponding Question Numbers
Event awareness	A1-A5
Event participation	B1-B3
Thermal comfort	C1-C5
Satisfaction with program and thermostat	D1-D4
Satisfaction with PGE	E1

Target Audience: Treatment (test) and control group customers with a smart thermostat who are enrolled in the Connected Savings Smart Thermostat Program

Expected number of completions: However many over a 10-14 day fielding period

Estimated timeline for fielding: Early March 2019. One survey reminder email may be sent 5-7 days after initial email, depending on the number of completes.

Variables to be Pulled into Survey

- Email
- Name
- SPID
- Assignment (Treatment or Control)
- Brand
- HVAC System (Cooling or Heating/Cooling)

Email Invitation

To: [EMAIL]
From: Portland General Electric
Subject: How was PGE's Smart Thermostat Program?

Dear [FIRSTNAME AND LASTNAME],

Thank you for participating in PGE's Smart Thermostat Program during this recent winter. Your smart thermostat worked with PGE to shift your electricity consumption from when demand for electricity was highest. Would you take a moment to answer a few questions about your experience with the program? We value your input because we use it to improve PGE programs. Your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

Sincerely,
Will Miller
Program Manager, Portland General Electric

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take about 5 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

[ASK SECTION A TO TREATMENT ONLY]

A. Event Awareness

A1. Your smart thermostat works with PGE to shift electricity consumption from times when demand for electricity is highest. How many high demand events did you notice this past winter?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO B1]
3. Don't know

A2. Do you recall being notified of high demand events prior to their occurrence?

1. Yes
2. No

[ASK IF 0=1]

A3. How did you receive notification about the high demand events? Please select all that apply. [RANDOMIZE ORDER 1-3]

1. Notification from PGE
2. Notification from smart thermostat app
3. Display on smart thermostat
4. Other [Please describe:_____]
5. Don't know [EXCLUSIVE ANSWER]

A4. On the days of high demand events, were you aware that the events were happening?

1. Yes
2. No

[ASK IF A4=1]

A5. How did you know that the events were happening? Please select all that apply. [RANDOMIZE ORDER 1-4]

1. Display on smart thermostat
2. Notification from smart thermostat app
3. Noticed warm air was cycling on and off
4. Noticed a temperature change
5. Other [Please describe:_____]
6. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION B TO TREATMENT ONLY]

B. Event Participation

B1. About how many high demand events did you participate in this past winter where you did not override the thermostat settings during the events?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO C1]
3. Don't know

B2. How easy or difficult was it to participate in the events?

1. Very easy
2. Somewhat easy
3. Somewhat difficult
4. Very difficult
5. Don't know

[ASK IF B2=3 OR 4]

B3. What made it difficult to participate in the events? Please select all that apply. [RANDOMIZE ORDER 1-6]

1. Other household members controlling the thermostat
2. The timing of the events
3. Notifications were not early enough
4. Health/medical reasons
5. Having guests or visitors around
6. Not understanding how the program works
7. Other [Please describe:_____]
8. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION C TO TREATMENT ONLY]

C. Thermal Comfort

C1. Overall this past winter, how comfortable was the interior temperature of your home a few hours **before** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. I was not at home
13. Don't know

C2. How often did you notice a change in your home's interior temperature **during** the high demand events?

1. Always noticed
2. Sometimes noticed
3. Never noticed
4. I was not at home for any events [SKIP TO **Error! Reference source not found.**]

C3. Overall this past winter, how comfortable was the interior temperature of your home **during** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. Don't know

C4. Did you or someone in your household make changes to the thermostat settings during any of the winter events?

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

[ASK IF C4=1]

C5. Why did you or someone in your household change the thermostat settings during the events? [OPEN END TEXT ENTRY]

[ASK SECTION D TO TREATMENT AND CONTROL]

D. Satisfaction with Program and Thermostat

D1. You have or will soon receive an incentive check for $25.00 in exchange for your participation this past winter. How satisfied are you with the incentive check?

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7

9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D2. Please rate your overall satisfaction with PGE's Smart Thermostat Program.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know [SKIP TO D4]

D3. Please tell us why you gave that rating for overall satisfaction. [OPEN END TEXT ENTRY]

D4. Please rate your overall satisfaction with the.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D5. Please tell us how PGE can improve the Smart Thermostat Program. [OPEN END TEXT ENTRY]

D6. How motivated are you to participate in future event seasons?

1. 0 – Extremely unmotivated
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely motivated
12. Don't know

[ASK SECTION E TO TREATMENT AND CONTROL]

E. Satisfaction with PGE

E1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!

CADMUS

PGE Connected Savings

Summer 2019 Experience Survey

Research Topics	Corresponding Question Numbers
Event awareness	A1-A5
Event participation	B1-B3
Thermal comfort	C1-C5
Satisfaction with program and thermostat	D1-D4
Satisfaction with PGE	E1

Target Audience: Treatment (test) and control group customers with a smart thermostat who are enrolled in the Connected Savings Smart Thermostat Program

Expected number of completions: 350-400 completes stratified by treatment and control group

Estimated timeline for fielding: October 2019. One survey reminder email may be sent 5-7 days after initial email, depending on the number of completes.

Variables to be Pulled into Survey

- Email
- FirstName
- LastName
- SPID
- EnrollDate
- Assignment = Treatment or Control
- Brand = Honeywell, Honeywell Lyric, or Ecobee
- System = AC, HP or EF
- Micropersona
- TestbedStatus = In Testbed or Out Testbed
- Substation
- DwellingType

Email Invitation

To: [EMAIL]
From: Cadmus on behalf of Portland General Electric
Subject: How was PGE's Smart Thermostat Program?

Dear [FIRSTNAME],

Thank you for participating in PGE's Smart Thermostat Program during this recent summer. Your smart thermostat worked with PGE to shift your electricity consumption from when demand for electricity was highest. Would you take a moment to answer a few questions about your experience with the program? Your input will be used to improve PGE programs, and your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

If you have any questions about this survey or any difficulties taking the survey, please contact Masumi Izawa at Cadmus, the research firm conducting this survey on PGE's behalf. You can reach her at (503) 467-7115 or masumi.izawa@cadmusgroup.com.

Sincerely,
Will Miller
Program Manager, Portland General Electric

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take about 5 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

[ASK SECTION A TO TREATMENT ONLY]

A. Event Awareness

A1. Your smart thermostat works with PGE to shift electricity consumption from times when demand for electricity is highest. How many high demand events did you notice this past summer?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO B1]
3. Don't know

A2. Do you recall being notified of high demand events prior to their occurrence?

1. Yes
2. No

[ASK IF 0=1]

A3. How did you receive notification about the high demand events? Please select all that apply. [RANDOMIZE ORDER 1-3]

1. Notification from PGE
2. Notification from smart thermostat app
3. Display on smart thermostat
4. Other [Please describe:_____] [FORCED TEXT ENTRY]
5. Don't know [EXCLUSIVE ANSWER]

A4. On the days of high demand events, were you aware that the events were happening?

1. Yes
2. No

[ASK IF A4=1]

A5. How did you know that the events were happening? Please select all that apply. [RANDOMIZE ORDER 1-4]

1. Display on smart thermostat
2. Notification from smart thermostat app
3. Noticed cool air was cycling on and off
4. Noticed a temperature change
5. Other [Please describe:_____] [FORCED TEXT ENTRY]
6. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION B TO TREATMENT ONLY]

B. Event Participation

B1. About how many high demand events did you participate in this past summer where you did not override the thermostat settings during the events?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO C1]
3. Don't know

B2. How easy or difficult was it to participate in the events?

1. Very easy
2. Somewhat easy
3. Somewhat difficult
4. Very difficult
5. Don't know

[ASK IF B2=3 OR 4]

B3. What made it difficult to participate in the events? Please select all that apply. [RANDOMIZE ORDER 1-6]

1. Other household members controlling the thermostat
2. The timing of the events
3. Notifications were not early enough
4. Health/medical reasons
5. Having guests or visitors around
6. Not understanding how the program works
7. Other [Please describe:_____] [FORCED TEXT ENTRY]
8. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION C TO TREATMENT ONLY]

C. Thermal Comfort

C1. Overall this past summer, how comfortable was the interior temperature of your home a few hours **before** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3

5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. I was not at home
13. Don't know

C2. How often did you notice a change in your home's interior temperature **during** the high demand events?

1. Always noticed
2. Sometimes noticed
3. Never noticed
4. I was not at home for any events [SKIP TO **Error! Reference source not found.**]

C3. Overall this past summer, how comfortable was the interior temperature of your home **during** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. Don't know

C4. Did you or someone in your household make changes to the thermostat settings during any of the summer events?

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

[ASK IF C4=1]

C5. Why did you or someone in your household change the thermostat settings during the events? [OPEN END TEXT ENTRY]

[ASK SECTION D TO TREATMENT AND CONTROL]

D. Satisfaction with Program and Thermostat

D1. You have or will soon receive an incentive check for $25.00 in exchange for your participation this past summer. How satisfied are you with the incentive check?

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D2. Please rate your overall satisfaction with PGE's Smart Thermostat Program.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know [SKIP TO D4]

D3. Please tell us why you gave that rating for overall satisfaction. [OPEN END TEXT ENTRY]

D4. Please rate your overall satisfaction with the smart thermostat.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D5. Please tell us how PGE can improve the Smart Thermostat Program. [OPEN END TEXT ENTRY]

D6. How motivated are you to participate in future event seasons?

1. 0 – Extremely unmotivated
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely motivated
12. Don't know

[ASK SECTION E TO TREATMENT AND CONTROL]

E. Satisfaction with PGE

E1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4

6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

E2. How likely would you be to recommend the Smart Thermostat Program to a friend, family member, or colleague?

1. 0 – Extremely unlikely
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely likely
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!

Direct Install Smart Thermostat Demand Response Pilot Program

DRAFT EVALUATION REPORT

September 9, 2020

Prepared for:

Portland General Electric

121 SW Salmon Street

Portland, OR 97204

CADMUS

Prepared by:
Scott Reeves
Jim Stewart, PhD
Masumi Izawa
Trent Hardman
Alec Stashevsky

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Table of Contents

Tables

Figures

Acronyms, Terms, and Definitions

Acronym/Term	Definition
AMI	Advanced metering infrastructure
BYOT	Bring-your-own thermostat
Control Group	Control group refers to Direct Install participants randomly assigned *not* to receive the thermostat control signals during demand response events. The electricity demand of the control group provided a baseline for measuring the demand response event impacts. Program participants were randomly assigned to the evaluation test or control groups at the beginning of each season.
HVAC	Heating, ventilation, and air conditioning
IDR	Intelligent Demand Response
ITT	Intent to treat treatment effect – the average impact per home (or other relevant unit of analysis) for homes that the program intends to treat
kW	Kilowatt
kWh	Kilowatt-hour
MW	Megawatt
MWa	Average Megawatt
NOAA	National Oceanic and Atmospheric Administration
OLS	Ordinary least squares
PGE	Portland General Electric
RCT	Randomized controlled trial
Test Group	Test group refers to participants who were randomly assigned to receive the thermostat control signals during demand response events. Program participants were randomly assigned to the evaluation test or control groups at the beginning of each season.
TOT	Treatment effect on the treated – the average impact per treated home

Executive Summary

The 2019 Integrated Resource Plan calls for PGE to engage its customers with new technologies and programs, decarbonize its energy supply, and maintain system reliability.[1] Smart thermostat demand response can help PGE achieve these goals by providing an unobtrusive means for the utility to engage customers in managing their electricity demand, to support the planned integration of 150 MWa of renewable resources by 2023 and to provide new flexible loads and reliability services.[2]

PGE's Smart Thermostat Demand Response pilot program enables the direct management of residential customer summer and winter peak electricity demand. Through demand response service providers (also known as aggregators), PGE can control the cooling and heating loads of thousands of participating customers by remotely adjusting the setpoints of their smart thermostats.

Customers who do not have or cannot afford a smart thermostat can participate through the Direct Install track.[3] In 2018, PGE launched the Direct Install track of the Smart Thermostat Demand Response pilot program, offering customers a free or discounted smart thermostat device with a complimentary installation from a technician. Participating customers with an installed Nest thermostat were enrolled in Nest's Rush Hour Rewards program. Participating customers with an installed ecobee thermostat were enrolled in Resideo's Connected Savings program.

At the end of summer 2019 event season, PGE had enrolled approximately 3,395 summer-eligible and 2,880 winter-eligible participants in the Direct Install track, including 2,180 participants eligible for both heating and cooling seasons. Using this evaluation's estimates of per participant demand savings for summer and winter, PGE possesses approximately 2.8 MW of winter demand response capacity and 2.9 MW of summer demand response capacity from Direct Install.[4]

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1 Portland General Electric. July 19, 2019. *2019 Integrated Resource Plan*. Available at: https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning

2 According to the IRP, PGE plans to add 211 MW of demand response capacity in summer and 141 MW in winter by 2025.

3 Customers who already own or could afford to purchase a smart thermostat can participate in the pilot program through the Bring-Your-Own Thermostat (BYOT) track.

4 For this calculation, Cadmus used the average demand savings per enrolled thermostat across all event hours for each season (0.98 kW in 2018/2019 winter and 0.84 kW in 2019 summer). Though we used this straightforward average, Cadmus recognizes that demand response resources have many attributes and can be used in different ways. Demand response capacity can be calculated for events that are triggered for specific outside temperatures, PGE system load, or market condition thresholds, for subpopulations, or at different durations and dispatch times. PGE's demand response capacity depends on how it plans to use demand response.

This evaluation focuses on the Direct Install track. PGE initiated six load control events in winter 2018/2019 and six in summer 2019. Through meter data analysis, interviews with program staff, and customer surveys, and a logic model review, the evaluation assessed the load impacts, program implementation, and customer experience. The evaluation covered these objectives:

- Estimate the average kilowatt impact per participant before, during, and after the load control events
- Assess the impact of events on customer comfort
- Assess the impacts of participation on customer satisfaction with the program and PGE
- Compare Direct Install load impacts, customer comfort, and satisfaction to BYOT
- Identify opportunities for improving program marketing, customer recruitment, program performance, cost-effectiveness, and customer satisfaction

Key Findings

Table 1 presents event demand savings and customer satisfaction findings from the evaluation for winter 2018/2019 and summer 2019. In winter, the average demand savings per participant ranged between 0.97 kW and 0.99 kW, depending on the timing of the event and the thermostat brand. Customer satisfaction with the program was also high, averaging 88%. In summer, demand savings per participant averaged between 0.84 kW, and customer satisfaction was high, averaging 92%.

In addition, Table 1 shows the average demand savings per participant for demand response events with weather conditions similar to those when PGE might need to dispatch residential smart thermostats as a demand response resource to meet future peak demand. These “peak events” had average event hour temperatures greater than or equal to 96°F in summer or less than or equal to 34°F in winter. In winter, the peak event demand savings averaged 1.08 kW per participant. In summer, the peak event demand savings averaged 1.0 kW per participant.

The bottom half of Table 1 shows estimates of participant savings and satisfaction by the brand of thermostat. Participants with Nest and ecobee thermostats produced similar average demand savings and satisfaction scores.

Table 1. Key Findings from Direct Install Smart Thermostat Demand Response Pilot Program Evaluation

	Winter 2018/2019						Summer 2019				
	kW Savings*				Satisfaction**		kW Savings*			Satisfaction**	
	Planning	Evaluation			Satisfied (6-10)	Delighted (9-10)	Planning	Evaluation		Satisfied (6-10)	Delighted (9-10)
		Morning	Afternoon	Peak Event kW***				Afternoon	Peak Event kW***		
Direct Install Overall											
Overall	1	**0.99**	**0.97**	**1.08**	88%	64%	0.8	**0.84**	**0.96**	92%	73%
By Thermostat Brand											
Nest	1	**1.08**	**0.96**	**1.03**	87%	65%	0.8	**0.86**	**0.92**	91%	73%
ecobee	1	**0.84**	**1.00**	**1.14**	90%	63%	0.8	**0.82**^	**1.00**	93%	73%

* Savings values reflect the average kW demand reduction per participant during events; **blue** font indicates significance at 5% level.

** Satisfaction values reflect the percentage of survey respondents who rated their program satisfaction on a 0 to 10 rating scale.

*** Peak event savings were the average kW for events with average temperatures greater than or equal to 96°F in summer (n=2) or less than or equal to 34°F in winter (n=3).

^ A dispatch failure occurred during event 3, reducing the savings. Excluding this event, ecobee thermostats saved 1.05 kW.

Conclusions and Recommendations

Based on the evaluation findings, Cadmus came to the following conclusions and recommendations.

Load Impacts

The Direct Install track of the pilot program reduced peak electricity demand from residential space heating in winter and air conditioning in summer.

Direct Install achieved average savings of 1.0 kW and 0.8 kW per participant for winter 2018/2019 and summer 2019, respectively. This met PGE's winter and summer planning values for smart thermostat demand response savings per participant.

Significant degradation of savings occurred across event hours.

Across all Direct Install winter and summer events, savings decreased by roughly 33% between the first and second event hours, while three-hour events saw a further degradation of 50% or more between the first and last event hour. Because of this degradation, average savings understates the available capacity during the first event hour and overstates available capacity during the last event hour. PGE may be able to avoid savings degradation by working with its demand response service providers to implement Intelligent Demand Response (IDR) strategies, which optimize event dispatch and control algorithms, to better meet its capacity needs.

Direct Install provided consistent demand savings across summer and winter events, and savings were positively correlated with outside temperature.

For the five afternoon events in winter 2018/2019, first hour savings ranged from 0.95 kW to 1.48 kW per participant. The range of event hour temperatures was narrow, but the savings appear positively correlated with outside temperature. The coefficient of variation of first-hour savings (the ratio of the standard deviation of first-hour savings to the mean) was 0.17. In summer, the savings exhibited similar variability across events. For the summer events, first hour savings ranged from 0.92 kW to 1.39 kW per participant (event 3 was excluded because of the ecobee dispatch failure). The coefficient of variation of first-hour savings was 0.15. Summer savings were also positively correlated with outside temperature.

Direct Install load control events increased customer loads before and after events but did not increase energy consumption overall.

In summer, demand response increased loads by an average of 0.1 kW per participant before events due to pre-conditioning and up to 0.3 kW per participant after events due to snapback.[5] In winter, there was even more extreme increases in load from pre-conditioning and snapback, of around 0.5 kW per participant precondition for morning and afternoon events and 0.9 kW and 1.1 kW per participant for morning and afternoon events, respectively. However, pre-conditioning and snapback did not lead to an overall increase in energy consumption on event days.

Overall, ecobee thermostats provided greater demand savings per participant than Nest thermostats; however, the difference may not have been attributable to the thermostat brand or demand response program service.

In summer, Direct Install obtained larger demand savings per participant from ecobee thermostats (about 1 kW) than Nest thermostats (about 0.8 kW). This comparison excludes event 3, when ecobee experienced a dispatch failure. In winter, the program obtained approximately equal demand savings from ecobee and Nest thermostats of about 1 kW. These results do not necessarily indicate that ecobee thermostats or its demand response program service provided superior performance. Customers in Direct Install selected their own thermostat, and a customer's brand choice may have correlated with their home's energy consumption characteristics and demand response potential.

In summer, Direct Install and BYOT provided approximately the same demand response capacity per participant. In winter, Direct Install had higher demand savings per participant because of the accidental enrollment of non-electric heating customers in the BYOT program.

In summer, Direct Install and BYOT obtained approximately equal demand savings per participant. In both programs, PGE obtained 0.8 kW to 0.9 kW per participant from Nest thermostats and 1.1 kW per participant from ecobee thermostats.

---

[5] Pre-conditioning refers to the increase in heating or cooling that is scheduled for thermostats prior to a load control event dispatch. Pre-conditioning varies by thermostat type, including a variable 1°F to 3°F increase for Nest devices, while Ecobee devices have no pre-conditioning.

In winter, Direct Install obtained larger demand savings per participant than BYOT. Direct Install Nest and ecobee thermostats provided demand savings of about 1.0 kW per participant. BYOT ecobee thermostats provided demand savings of about 0.8 kW per participant. However, BYOT Nest thermostats provided demand savings of only about 0.4 kW per participant. The difference in winter savings between Direct Install Nest and BYOT Nest participants was statistically significant, with the smaller winter savings likely attributable to the enrollment in BYOT of Nest thermostat customers who did not have electric heating.

Load Impact Recommendations

- Communicate to utility operations managers that smart thermostat demand response raises electricity demand above normal levels immediately after an event ends.
- Conduct research around customer segmentation to determine if the higher demand savings of ecobee thermostats are due to customer attributes such as home size, HVAC system type, customer behaviors, such as overriding events, or superior demand response service performance. This information could support targeted marketing for future program delivery.

Customer Experience

Assessment of the customer experience was undertaken primarily through analysis of survey responses.[6]

Direct Install achieved high customer satisfaction.

As shown in Table 1 above, most test group respondents were satisfied with the program (88% in winter n=241, and 92% in summer, n=224). Satisfaction with the smart thermostats and PGE was also consistently high across both seasons. Test group respondents during the winter season said their thermostat worked great and was easy to use and that the program worked well and helped the community save energy and reduce demand. In the summer, test group respondents gave largely the same praise for the program and added that they did not notice events nor was there any or only negligible change in comfort.

Customers had a positive experience with the scheduling and installation process.

Nearly all recruitment survey respondents agreed with the positive statements about the scheduling and installation process. Specifically, 98% agreed with the statement, “The contractor was professional and courteous” (n=543). Even though PGE and CLEAResult stated that the installation wait period was three to four weeks, 93% of respondents agreed with the statement, “I didn’t wait long… to the day of

[6] The surveys achieved sample sizes of over 400 completes each, with response rates over 33%. Additional detail regarding survey design and sample sizes can be found in the *Evaluation Findings* and *Customer Surveys* sections of this report.

installation" (n=540). When asked to rate their overall satisfaction with the installation experience, 95% of respondents were satisfied and 82% were delighted (n=538).

Customers noticed fewer events than were called. Customers with Nest thermostats perceived more events than customers with ecobee thermostats.

Most respondents reported noticing the events (60%, n=162, in winter and 67%, n=235, in summer) and noticed fewer events than were called. During both seasons, customers with Nest thermostats on average perceived more events than customers with ecobee thermostats. In winter, Nest respondents, on average, noticed 6.2 events (n=59) in comparison to ecobee respondents who noticed 3.6 events (n=38), probably because Nest sends pre-event notifications. Likewise, in summer, Nest respondents on average noticed 4.5 events (n=90) in comparison to 3.3 events (n=68) noticed by ecobee customers. This was likely due to Nest sending out pre-event notifications as well as a dispatch failure of ecobee thermostats during the summer season's third event. For Nest customers, high awareness indicates that the notifications were having their intended effect and that customers were engaged. For ecobee customers, who did not receive notifications, high awareness may indicate high engagement or that some customers noticed temperature drift in their homes.

Customers perceived a change in comfort during the events. More research on the relationship between customer comfort and event overrides is needed to understand their implications for demand savings.

Approximately 36% of test group respondents (n=157) reported that they overrode at least one of the winter events and 23% of test group respondents (n=225) reported that they overrode at least one of the summer events. Respondents who reported overriding the events most often cited thermal discomfort as their reason during the winter (75%, n=55) and summer (90%, n=50). The evaluation did not have thermostat telemetry data to further assess customers' override behavior in relation to their reported comfort.

When recalling their comfort before the winter events, 89% of respondents said their home's interior temperature was comfortable (n=133). When recalling their comfort level during the winter events, 77% said they were comfortable (n=143), a statistically significant decrease of 12 points compared to the comfort level before events. In the summer, 93% of respondents said they were comfortable before the events (n=203). When recalling their comfort level during events, 79% said they were comfortable (n=206), a statistically significant difference decrease of 14 points compared to the comfort level before the events.

More installation technicians were needed to keep up with customer demand for Direct Install.

PGE and CLEAResult reported that Direct Install was very popular with customers. However, the call center could not keep up with the number of calls coming in; to alleviate this issue, customers were encouraged to self-schedule their installation appointment through the Direct Install web portal. Moreover, CLEAResult had only seven installation technicians so customers had to wait three to four weeks for an installation. PGE had aimed for 800 installations per month, but CLEAResult managed to

complete only around 500 installations per month. The program could therefore have enrolled more customers and reduced their wait time had there been more available installation technicians.

Because of the high customer demand and the growing wait list, PGE and CLEAResult had to cancel their plans to recruit and enroll mobile home communities for Direct Install. The recruitment of mobile home communities would have helped PGE meet its enrollment goal. However, without increased installation capacity, pursuing the mobile home strategy would have exacerbated the existing backlog of installation jobs. PGE is working with CLEAResult to find ways to add more installation technicians to meet demand.

Customer Experience Recommendations

- Explore ways to increase capacity to perform thermostat installations so that the program can keep up with the demand for enrollment.
- Conduct research on the relationship between customer comfort during events and event overrides. Understanding customers' event override behaviors will be critical in understanding the stability and predictability of demand savings from smart thermostats.

Implementation

Direct Install's built-in HVAC system verification process provides safeguard to control for and restrict enrollment of non-electric heating customers as winter season participants.

PGE designed the Direct Install track to overcome the customer cost barrier and the challenges with heating/cooling system verification encountered with BYOT. Direct Install has HVAC system verification steps built into the process to ensure that customers with non-electric heating or without cooling system do not get into the program. The process includes a screener on the installation scheduling web portal, another screener via telephone by a CLEAResult installation technician, and verification by the installation technician. As a result of this multi-verification process, non-electric heating customers were not enrolled, and the Direct Install winter savings were not diluted by associated non-electric heating customer enrollments. By comparison, Direct Install achieved winter demand savings (0.97 kW to 0.99 kW) that were about three times higher than BYOT (0.34 kW to 0.46 kW).

In-person program education during the installation process helped customers understand the technology and the load control events, which may have contributed to the strong demand savings observed.

As part of the installation process, CLEAResult technicians showed customers how to use their new smart thermostat device. User education had an impact, as 88% of survey respondents said it was easy to learn how to use the smart thermostat (n=546). CLEAResult technicians also explained load control events and left postcards containing program information with the customers. Most respondents said the technician's explanation was clear (95%, n=546) and the program information in the postcard was clear (81%, n=544). The in-person education may be one of the reasons Direct Install demand savings achieved strong savings in both seasons. BYOT has no in-person education component.

Implementation Recommendation

- Focus on recruiting customers for winter participation (i.e., heat pumps and electric furnaces) as these HVAC systems are harder to verify through BYOT.
  - Local HVAC contractors may further help PGE identify customers who are eligible for the BYOT track of the pilot program.

Future of Smart Thermostats as a Demand Response Resource

PGE has piloted smart thermostat demand response programs since 2015 and has recently been considering how to fully operationalize these programs as a peak capacity and other grid services resource. To operationalize thermostats as a resource, PGE power operators must have knowledge about the resource characteristics (e.g., ramping rate, capacity by 15 minute or hour intervals) and confidence that the resource will perform when called upon.

This evaluation cannot fully address questions regarding operational readiness because of several factors, including: the relatively small number of summer 2019 events (6) and winter 2019/2020 events (6); the limited number of event days with extreme temperatures; the analysis of one hour interval data instead of 15 minute interval data; and limitations in knowledge about how customers are interacting with the thermostats during events (such as the frequency with and conditions under which participants were overriding events).

Future Research to Support Use

- In the future, PGE should conduct additional research to advance the goal of operationalizing smart thermostats as demand response resources. Specifically, this research should:
  - Analyze 15-minute interval consumption data to better understand ramping of savings during the first even hour, degradation of savings across event hours, and snapback after the event ends
  - Analyze thermostat telemetry data to determine the frequency of and impacts on demand savings from participants overriding the thermostat settings during demand response events
  - Estimate hourly demand response impacts as a function of outside temperature using data from multiple seasons to characterize definitively the demand savings that PGE can expect when it needs to dispatch residential smart thermostat demand response as a resource to meet peak demand.

Introduction

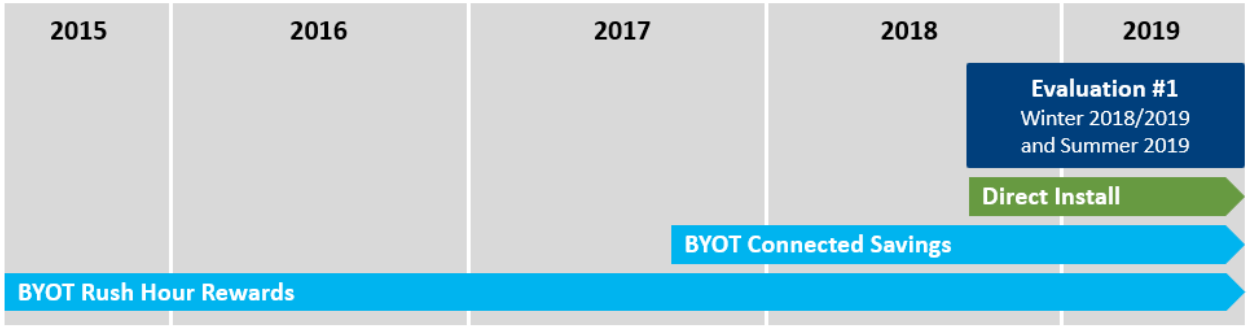
The 2019 Integrated Resource Plan calls for PGE to engage its customers with new technologies and programs, decarbonize its energy supply, and maintain system reliability.[7] Smart thermostat demand response can help PGE achieve these goals by providing an unobtrusive means for the utility to engage customers in managing their electricity demand, to support the planned integration of 150 MWa of renewable resources by 2023, and to provide new system capacity and reliability services.[8]

Residential smart thermostat demand response programs will provide an important source of PGE's future demand response capacity. These programs use control of home thermostat set points to reduce demand during periods when it is costly for the utility to supply or distribute electricity or to manage intermittent renewable energy supply. Through the Smart Thermostat Demand Response pilot program, PGE can control the cooling and heating loads of participating customers.

Customers who already own or could afford to purchase a smart thermostat can participate in the pilot program through the Bring-Your-Own Thermostat (BYOT) track. Customers who do not have or cannot afford a smart thermostat can participate through the Direct Install track.

During the implementation of Direct Install track of the pilot program, Cadmus conducted an evaluation of the winter 2018/2019 and summer 2019 seasons (Figure 1).

Figure 1. Timeline of Direct Install Pilot Program and Evaluation



For this evaluation, Cadmus assessed the Direct Install program design and delivery, load impacts, and customer experiences for each event season. Cadmus program using a randomized controlled trial (RCT), which provides highly credible evidence about the impacts. This evaluation provides PGE with

[7] Portland General Electric. July 19, 2019. *2019 Integrated Resource Plan*. Available at: https://www.portlandgeneral.com/our-company/energy-strategy/resource-planning/integrated-resource-planning

[8] According to the IRP, PGE plans to add 211 MW of demand response capacity in summer and 141 MW in winter by 2025.

valuable information about the pilot program's performance and presents insights that can be used to optimize PGE's future demand response program offerings.

Evaluation Objectives and Approach

PGE specified five objectives for the Direct Install program evaluation:

1. Estimate the average kilowatt impact per participant before, during, and after the load control events
2. Assess the impact of events on customer comfort
3. Assess the impacts of participation on customer satisfaction with the program and PGE
4. Compare Direct Install load impacts, customer comfort, and satisfaction to BYOT
5. Identify opportunities for improving program marketing, customer recruitment, program performance, cost-effectiveness, and customer satisfaction

Table 2 lists the evaluation activities and how they address the evaluation objectives. The evaluation presented in this report covers winter 2018/2019 and summer 2019 event seasons for Direct Install. *Appendix A. Evaluation Methodology* presents more details about the randomized controlled trial (RCT) and the evaluation activities, including the impact analysis and customer surveys.

Table 2. Direct Install Evaluation Activities

Activity	Description	Corresponding Evaluation Objective(s)	Outcome
Research Design	RCT: pre-season random assignment of participants into test or control group	1, 2, 3, 4	Accurate and precise estimates of impacts
Data Collection and Preparation	Collect and prepare analysis of individual customer advanced metering infrastructure (AMI) meter interval consumption data	1, 2, 3, 4	Final analysis sample for estimation of load impacts
Load Impact Analysis	Regression analysis of individual participant AMI meter interval consumption data	1, 2	Estimates of event savings
Staff Interviews	Interviews with PGE and implementation program staff to understand program implementation processes, successes, and challenges	5	Thorough understanding and documentation of the program design and implementation
Customer Surveys	Recruitment, event, and seasonal experience surveys with participants	3, 4, 5	Findings on customer engagement, marketing, event awareness, comfort, and satisfaction
Logic Model Review	An assessment of whether the program operated as expected and produced results as theorized	5	Documentation of what is and what is not producing the theorized results

Pilot Program Description

PGE designed the Smart Thermostat Demand Response pilot program to manage residential summer and winter loads during hours of peak electricity demand. Through the program, PGE can control cooling and heating loads of participating customers.

PGE established several goals and objectives for the Smart Thermostat Demand Response pilot program:

- Implement the program over winter and summer seasons by calling up to 10 peak demand events per season
- Enroll 24,000 thermostats by the end of 2019[9]
- Obtain customer participation in at least 50% of event hours per season
- Achieve positive customer experiences and high customer satisfaction

The pilot program is delivered through two customer participation tracks: Bring-Your-Own Thermostat (BYOT) for customers who already own a smart thermostat and Direct Install for customers who do not own one. PGE designed the Direct Install track to overcome the customer cost barrier and the challenges with heating/cooling system verification encountered with BYOT.

In 2018, PGE launched the Direct Install track of the Smart Thermostat Demand Response pilot program, offering customers a free or discounted smart thermostat device with a complimentary installation from a technician. PGE partnered with CLEAResult for scheduling and installation services. Participating customers with an installed Nest thermostat were enrolled in Nest's Rush Hour Rewards program and participating customers with an installed ecobee thermostat were enrolled in Resideo's Connected Savings program.[10]

Unlike the BYOT track, participants in Direct Install do not receive a $25 incentive check for each season of event participation—the incentive to enroll is to receive a free or discounted smart thermostat and a complimentary installation.

Figure 2 summarizes the Smart Thermostat Demand Response pilot program design, showing the distinctions between the Direct Install and BYOT tracks and between Rush Hour Rewards (Nest) and Connected Savings (Resideo) program implementation service providers. Nest and Resideo differ in how they carry out demand response events on their respective devices. Event implementation details are described in detail in the subsequent sections.

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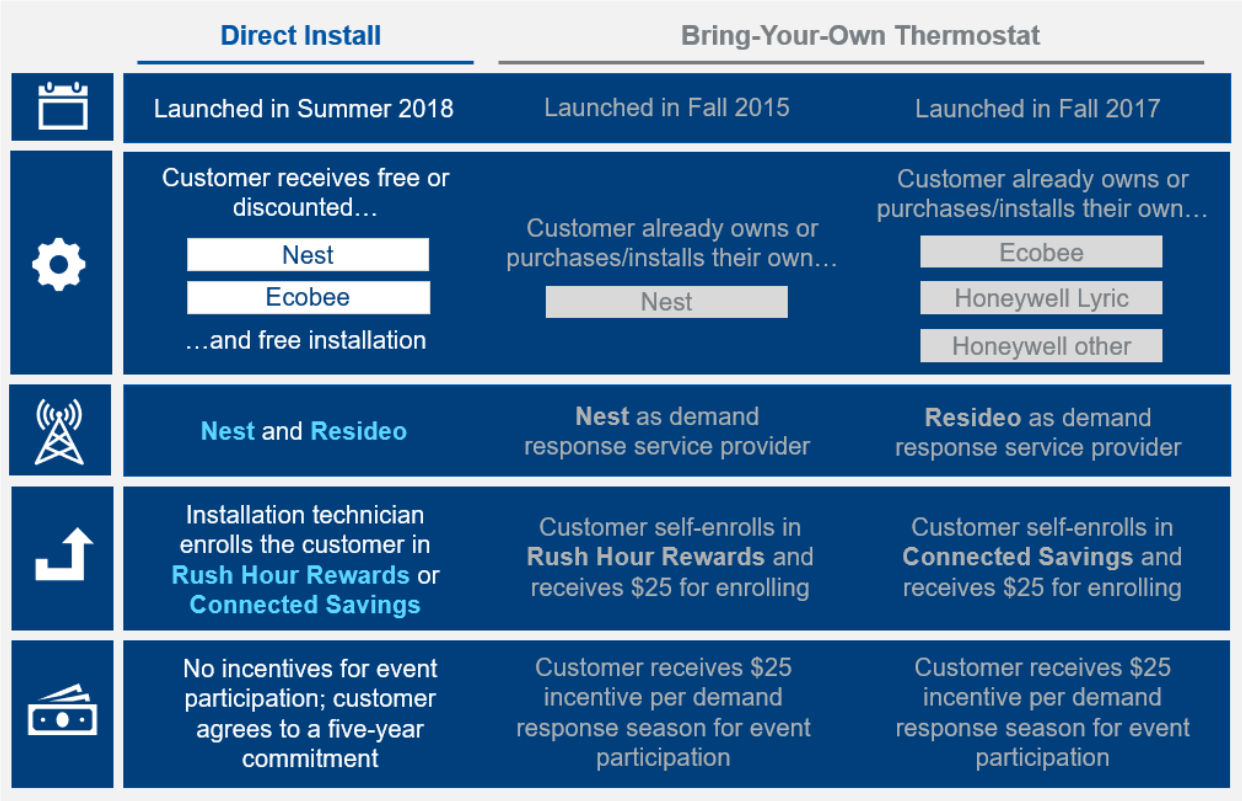
[9] PGE staff indicated in the interviews that it did not establish separate enrollment goals for the BYOT and Direct Install tracks.

[10] Whisker Labs previously operated Connected Savings. Resideo acquired Whisker Labs in May 2019.

Figure 2. Direct Install Smart Thermostat Demand Response Pilot Program Design



Direct Install Implementation

This section describes the implementation of the Direct Install track of the pilot program.

Marketing and Recruitment

PGE conducted all program marketing activities for Direct Install, promoting it to customers directly through mail and email three times a year and indirectly on the PGE website. The BYOT track had recruited many customers with air conditioning but fewer customers with electric furnaces and heat pumps. As a result, PGE targeted the Direct Install marketing to customers with either an electric furnace or a heat pump. PGE identified a list of over 90,000 customers with an electric furnace or heat pump using load analysis data, data from CLEAResult, purchased data from Axiom, and heating contractor data.

Program Eligibility Requirements

To be eligible for Direct Install, customers had to meet these requirements:

- Be a PGE residential customer with an active account
- Have a central air conditioner, ducted heat pump, or electric forced-air furnace HVAC system
- Have a Wi-Fi network in the home

Installation and Enrollment Process

Interested customers either contacted the Direct Install call center or went online to the Direct Install web portal listed in the marketing pieces. CLEAResult operated the call center and web portal, which screened the customer for program eligibility. Once determined to be eligible, the customer could schedule an installation appointment.

A few days before the scheduled installation, CLEAResult technicians called customers to verify their HVAC system and confirm the appointment date. At the home, technicians again confirmed the HVAC system through a visual verification. Customers could choose between installing a Nest or an ecobee smart thermostat. After successful installation of the smart thermostat device, technicians enrolled the customers into the program via the Nest or Resideo enrollment web portal. Technicians also educated customers on how to use their new thermostat device and about the load control events and left postcards containing this information with the customers.

Event Management

PGE contracted with Nest and Resideo to provide the demand response management system and aggregation services. When ready to call an event, PGE used Nest's and Resideo's online management platform to schedule the event one day ahead. After receiving the event dispatch, Nest and Resideo sent out Wi-Fi signals to adjust the smart thermostat settings on the event day. Table 3 shows the schedule of load control events (six in winter and six in summer) that PGE initiated.

Table 3. Direct Install Load Control Events

Season	Event	Date	Avg. Outdoor Temp.*	Start Time	Duration (hours)
Winter 2018/2019	1	2/4/2019	33°F	5:00 p.m.	3
	2	2/5/2019	34°F	5:00 p.m.	3
	3	2/12/2019	39°F	5:00 p.m.	3
	4	2/15/2019	40°F	7:00 a.m.	3
	5 ❄	2/20/2019	38°F	5:00 p.m.	3
	6 ❄	2/25/2019	33°F	5:00 p.m.	3
Summer 2019	1	6/12/2019	97°F	5:00 p.m.	2
	2	7/22/2019	84°F	5:00 p.m.	2
	3**	7/26/2019	89°F	4:00 p.m.	3
	4	8/05/2019	88°F	4:00 p.m.	3
	5	8/06/2019	84°F	5:00 p.m.	1
	6	8/28/2019	96°F	4:00 p.m.	3

* Outdoor temperature is the average temperature during event hours.

**Event failed to dispatch to ecobee thermostats due to widespread ecobee service connection issue.

❄ = snow day

Events lasted one to three consecutive hours and occurred on weekday (non-holiday) afternoons or mornings, typically when electricity demand for space conditioning was greatest (that is, on cold days during winter and hot days during summer). The winter 2018/2019 event season ran from December 1, 2018, through February 28, 2019. The summer 2019 event season ran from June 1, 2019, through September 30, 2019.

Resideo tested Intelligent Demand Response (IDR) on a small number of ecobee devices. IDR customizes the thermostat setback for individual customers based on historical heating or cooling demand and the thermal properties of a home to achieve more consistent and lasting load reductions across event hours. IDR also includes regulating the dispatch of load control signals to avoid big changes in aggregate loads due to simultaneous pre-conditioning before the event, the event initiation, or snapback after an event.

Nest did not test IDR. Table 4 shows the event details and differences between Nest and ecobee.

Table 4. Direct Install Event Implementation Details

Brand	Pre-Event Notification	Event In-Progress Notification	Pre-Conditioning before Event	Temperature Setback during Event
Nest	Displayed on thermostat screen and app (with push notifications)	Displayed on thermostat screen and app	1°F to 3°F pre-heating in winter; 1°F to 3°F pre-cooling in summer	1°F to 3°F lower in winter; 1°F to 3°F higher in summer
ecobee	Displayed on thermostat screen and app (no push notifications)	Displayed on thermostat screen and app	None	Up to 3°F lower in winter; Up to 3°F higher in summer

Test group participants' thermostats were controlled during the events while the control group were not. Test group participants could override the load control during events by adjusting the thermostat settings or hitting the event cancel button.

Unlike BYOT, participants in Direct Install do not receive a $25 incentive check for each event season — the incentive to enroll is to receive a free or discounted smart thermostat and a complimentary installation. Only customers with a heat pump could participate in both winter and summer seasons.

Logic Model

A logic model outlines how a program should be expected to succeed, given its design, by graphically presenting the relationships between program activities, outputs, and expected outcomes. The logic model serves as a useful tool for program staff, implementers, and evaluators to determine whether the program's activities and outputs are producing the outcomes as theorized.

In 2018, Cadmus developed the logic model for the Direct Install Smart Thermostat Demand Response pilot program using program materials and information obtained from the staff interviews. Figure 3 shows the Direct Install logic model. As part of the logic model, Cadmus identified and documented Direct Install's implementation barriers, challenges and risks to program success. 4 shows the mapping of these barriers, challenges, and risks, as well as solutions PGE and its partners may use to manage and overcome them. The colors used to denote the challenges, risks, and solutions correspond to the activities, outputs, and impacts in the logic model (Figure 3).

Figure 3. Logic Model of Direct Install Smart Thermostat Demand Response Pilot Program

PROGRAM THEORY

PGE's Integrated Resource Plan (2016) calls for the use of demand response (DR) to help manage system peak loads. By offering residential customers financial incentives for participation, PGE's Smart Thermostat Program will realize the goals of **enrolling 24,000 smart thermostats by 2019**. Through the Direct Install path of the program, PGE offers free or discounted smart thermostats with complimentary installation and education to qualified customers. This path attracts new customers not served by the mass-marketed Bring You Own Thermostat (BYOT) path, including low-income customers, late adopters of smart thermostats, and customers historically uninclined to participate in demand response programs. Directly installing thermostats will overcome HVAC equipment verification issues present in the BYOT path. Mandating a five-year commitment from customers will enhance the cost effectiveness of the program.

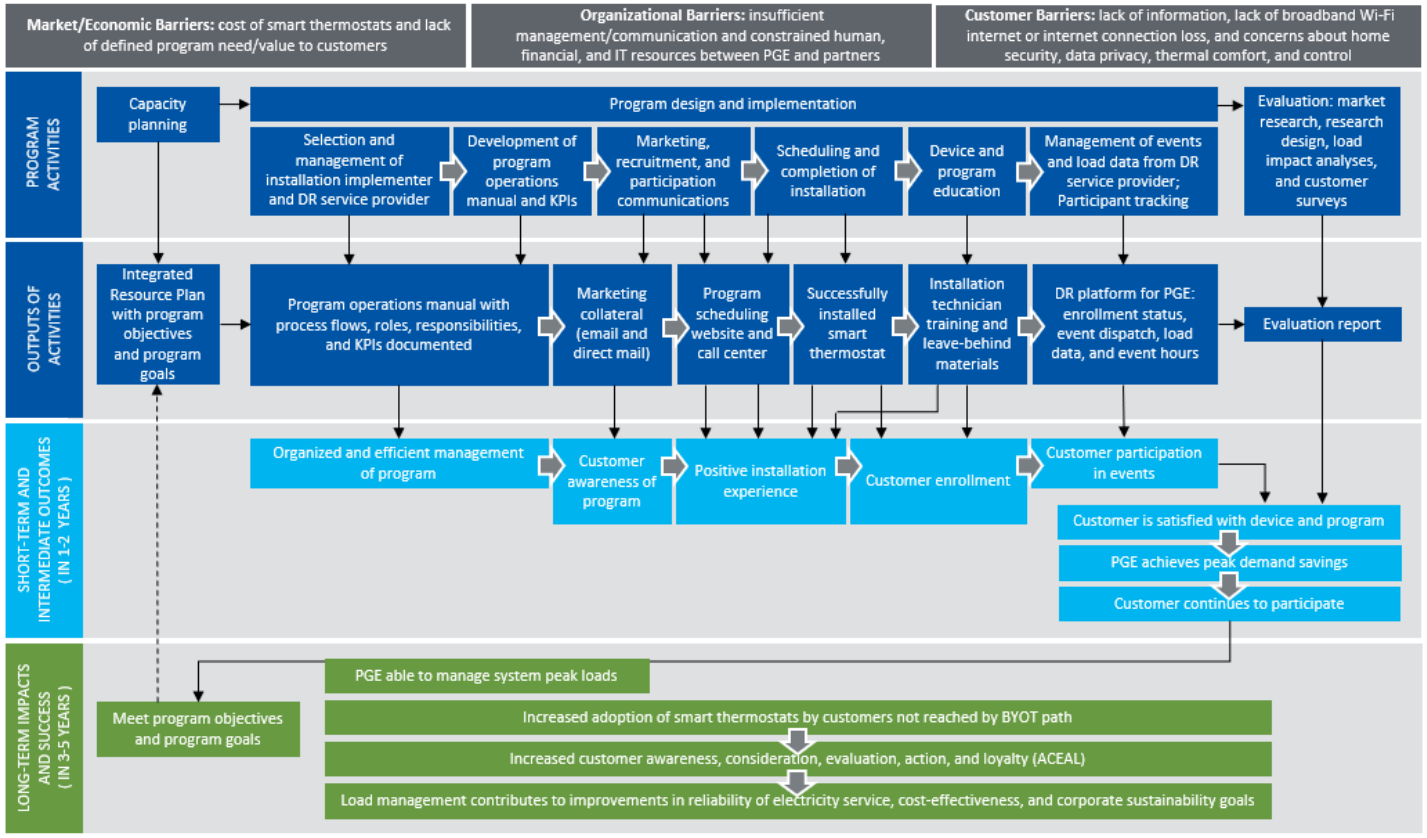
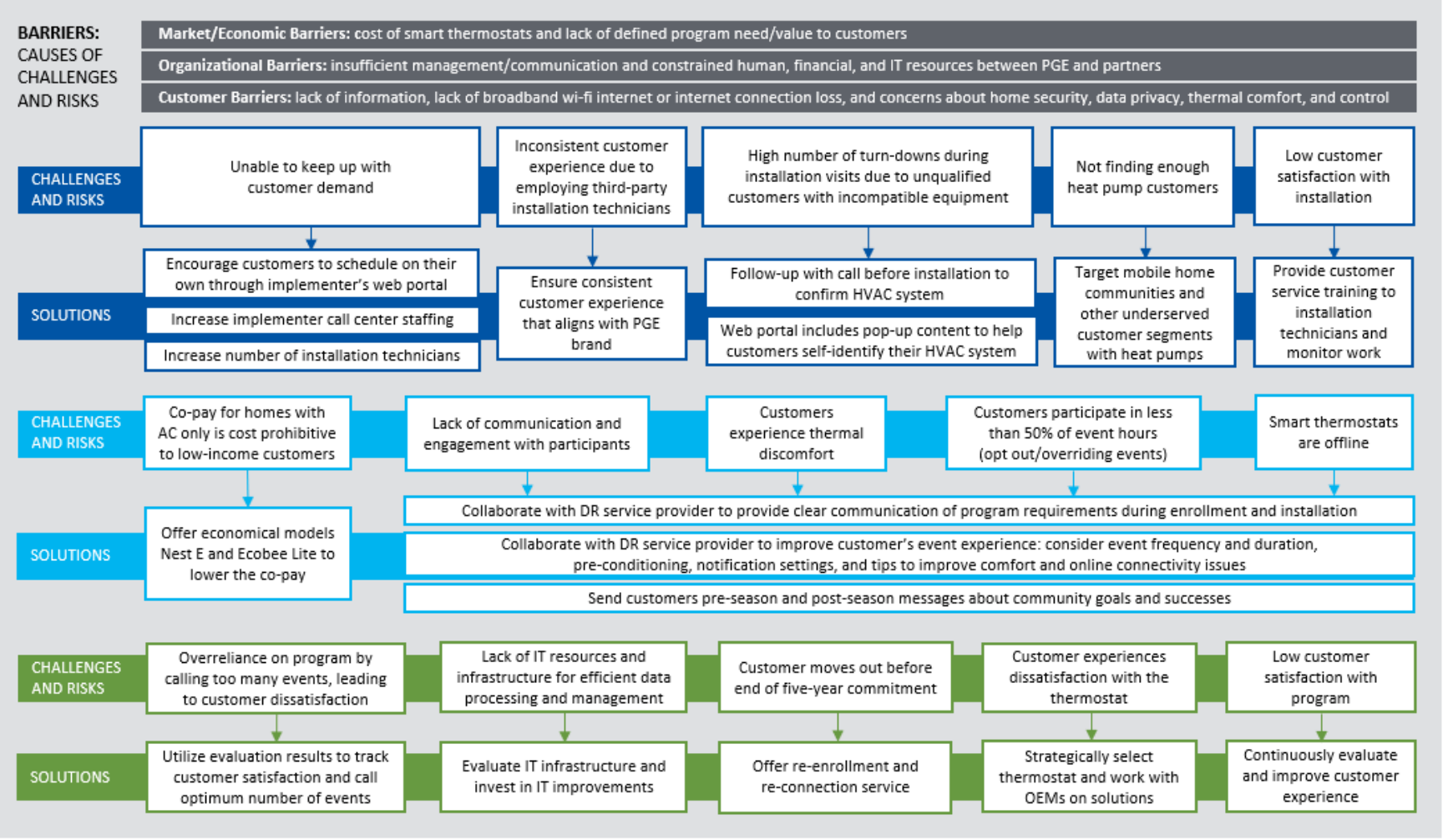


Figure 4. Map of Direct Install Implementation Barriers, Challenges, Risks, and Solutions



Evaluation Findings

This section provides the evaluation findings on the Direct Install track of the pilot program and is organized by season. The findings capture the implementation successes and challenges, demand savings, customer experience, and logic model review. The end of the section includes a comparison between Rush Hour Rewards and Connected Savings.

Implementation Successes and Challenges

Though PGE customers showed great interest in the program and had a positive installation experience, PGE did not complete as many installations as it would have liked. PGE encountered challenges keeping up with the customer demand and operational device performance issues. This section describes these program successes, challenges, and lessons learned.

Marketing and Recruitment

Customers mostly heard about Direct Install through mail. PGE conducted all marketing activities and promoted the program directly to customers through mail and email. When asked how they heard about the program, of 543 recruitment survey respondents, 62% said mail and 33% said email.

PGE's targeted marketing increased the proportion of Direct Install participants with a heat pump or electric furnace. The BYOT track recruited many customers with central air conditioners but fewer with heat pumps or electric furnaces. To increase the Smart Thermostat Demand Response pilot program's participation in the winter, PGE targeted Direct Install marketing to customers with either a heat pump or electric furnace. As shown in Table 5, Direct Install's enrollments consisted of 42% heat pumps and 10% electric furnaces by the end of 2019. In comparison, BYOT's enrollments consisted of 15% heat pumps and 3% electric furnaces.

Table 5. 2019 Year-End Direct Install and BYOT Thermostat Enrollment Counts*

Category	Direct Install		BYOT	
	Count	Percentage of Column Total	Count	Percentage of Column Total
By Brand				
ecobee	2,046	43%	1,682	10%
Nest	2,754	57%	12,613	79%
Honeywell	0	0%	1,710	11%
By HVAC System				
Central Air Conditioner	2,278	47%	12,733	80%
Heat Pump	1,999	42%	2,467	15%
Electric Furnace	495	10%	498	3%
Unreported	28	1%	307	2%
Overall	**4,800**	**100%**	**16,005**	**100%**

* Thermostat enrollment counts as of end of 2019, including those for both test and control customers. These will not match counts used for the evaluation because of the time period difference. Note, the counts of thermostats listed above may reflect instances of the same participants occurring in different

Category	Direct Install		BYOT	
	Count	Percentage of Column Total	Count	Percentage of Column Total

groups, such as households that have multiple thermostats (e.g., one of both brands) or multiple qualifying HVAC equipment (e.g., central air conditioning and electric furnace).
Note that five BYOT customers had both a heat pump and an air conditioner. These customers were removed from the BYOT air conditioner count to retain consistency.

The program had challenges keeping up with the customer demand. PGE and CLEAResult reported that Direct Install was very popular with customers. However, CLEAResult reported that because the call center could not keep up with the number of incoming calls, customers were encouraged to self-schedule their installation appointment through the Direct Install web portal. Moreover, CLEAResult had only seven installation technicians so customers had to wait three to four weeks for an installation job. PGE aimed to complete 800 installations per month, but CLEAResult was able to complete only around 500 installations per month due to the limited number of technicians.

Because of the high customer demand and the growing wait list, PGE and CLEAResult had to cancel their plans to recruit and enroll mobile home communities for Direct Install. The recruitment of mobile home communities would have helped PGE meet its enrollment goal. However, without increased installation capacity, pursuing the mobile home strategy would have exacerbated the existing backlog of installation jobs. PGE is working to find ways to balance customer demand with installation capacity, such as restricting the marketing.

Installation Process

Customers had a positive experience with the scheduling and installation process. As Figure 5 shows, nearly all recruitment survey respondents agreed with the positive statements about the scheduling and installation process. Specifically, 98% agreed with the statement, "The contractor was professional and courteous." Even though PGE and CLEAResult stated that the installation waiting list was three to four weeks, 93% of respondents agreed with the statement, "I didn't wait long… to the day of installation." When asked to rate their overall satisfaction with the installation experience, 95% of respondents were *satisfied* and 82% were *delighted* (n=538).

Figure 5. Agreement Level to Statements about Scheduling and Installation

Source: Recruitment Survey Question. "Do you agree or disagree with the following statements about your smart thermostat installation?"

The in-person customer education during the installation process proved to be understandable and helpful. As part of the installation process, CLEAResult technicians educated customers on how to use their new smart thermostat device. The user education was helpful as 88% of recruitment survey respondents said it was easy to learn how to use (n=546).

Prior to enrolling in Direct Install, 78% of recruitment survey respondents were aware of the concept of peak demand (n=543) and 36% were aware that smart thermostats can connect with PGE to shift consumption during peak demand (n=545). CLEAResult technicians also educated customers about the load control events and left postcards containing program information with the customers. Most respondents said the technician's explanation was clear (95%, n=546) and the program information in the postcard was clear (81%, n=544). The in-person education may help explain why Direct Install demand savings were three times higher than BYOT. BYOT does not have this in-person education component.

Event Dispatch

ecobee thermostats experienced operational issues during winter 2018/2019 and summer 2019, which did not adversely impact demand savings or customer comfort. Resideo typically calibrates a three-degree setback on ecobee and Honeywell thermostats during events. However, for the first two winter events on February 4, 2019 and February 5, 2019, Resideo reported that 128 ecobee thermostats encountered an issue with the temperature setback. Customers with these 128 ecobee thermostats briefly received two temperature setbacks instead of one due to customer participation in PGE's demand response and Energy Trust of Oregon's energy efficiency smart thermostat programs; this means that these customers experienced a temperature setback greater than three-degrees that would have affected their comfort. Resideo did not report any temperature setback issues during the summer, but PGE said it had received four customer complaints about the temperature setback on ecobee thermostats during one of the summer events in August. Also in the summer, ecobee had an online service disruption on July 26, 2019 (event 3), which prevented any event called on that day from being activated on ecobee thermostats. The effect on load impacts from these operational issues is discussed in the subsequent section.

These winter and summer operational issues on ecobee thermostats did not appear to adversely impact demand savings or customer comfort. In winter, ecobee thermostats (average demand savings per participant of 0.96 kW) performed on par with Nest thermostats (0.98 kW) and the winter customer experience survey did not find a statistically significant difference between ecobee respondents (79%) and Nest respondents (75%) on their comfort during the events. In summer, even with the inclusion of event 3 in the analysis, ecobee thermostats (average demand savings per participant of 0.82 kW) performed on par with Nest thermostats (0.86 kW) and the summer customer experience survey did not find a statistically significant difference between ecobee respondents (82%) and Nest respondents (76%) on their comfort during the events.

Winter 2018/2019

This section provides detailed findings about Direct Install during winter 2018/19.

Winter Load Impacts

During the Direct Install Winter 2018/2019 season, PGE launched five afternoon events starting at 5:00 p.m. and one morning event starting at 7:00 a.m. Each event lasted three hours.

Figure 6 presents estimates of the average kilowatt impacts per participant for the hour prior to the event, each event hour, and the two hours immediately after the event ended for afternoon and morning events. As described in Appendix A, the estimates were obtained from panel regression analysis of participant demand. Figure 7 shows the corresponding savings as a percentage of baseline demand, which equal the kW savings divided by baseline demand.[11] The program achieved average demand savings of 0.97 kW for morning events and 0.99 kW for afternoon events. Over all events in the winter 2018/2019 season, Direct Install achieved average demand savings of 0.98 kW per participant.

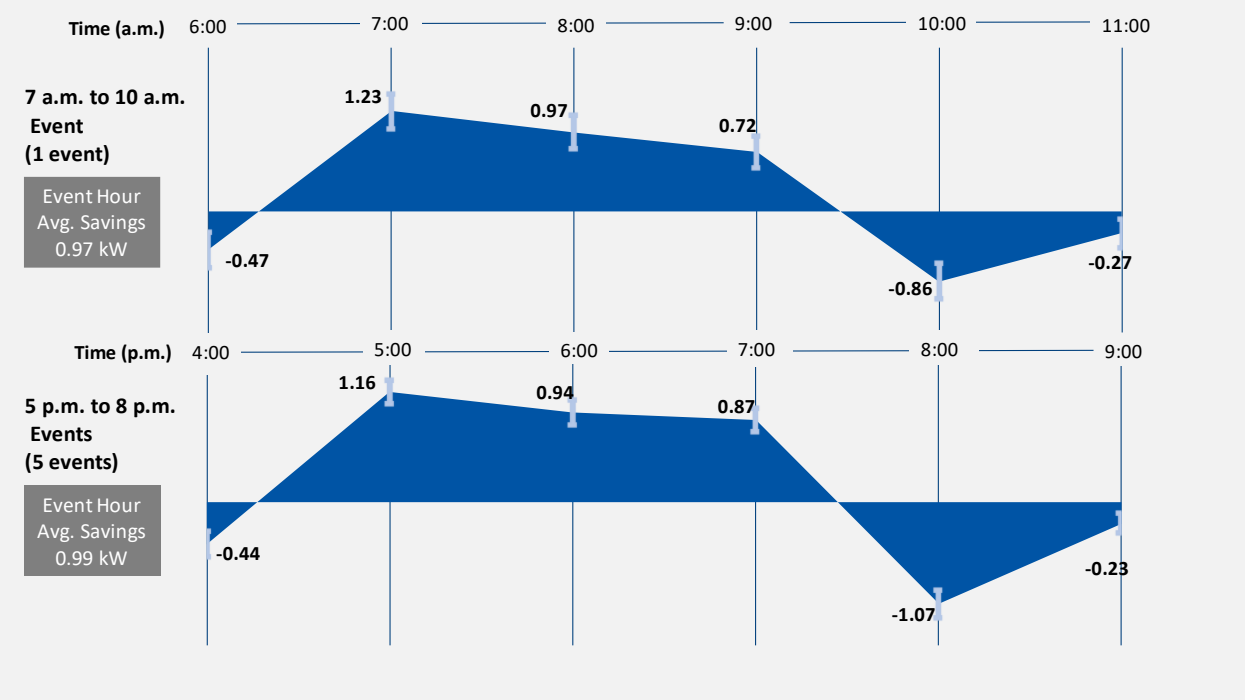
On average, savings peaked in the first hour, then diminished through the remaining hours. By the last hour of the morning event, savings had decreased by 0.5 kW (41%) from the first hour savings. Savings for afternoon events decreased by 0.29 kW (25%) from the first hour. This pattern follows a similar one identified in previous evaluations of Rush Hour Reward seasons.

Pre-heating and snapback increased participants' load before and after events. Pre-heating of participant homes increased electricity demand by 0.47 kW (14%) and 0.44 kW (14%) for morning and afternoon events, respectively.

In the first post-hour, demand increased by 0.86 kW (33%) and 1.07 kW (33%) for morning and afternoon events, respectively.

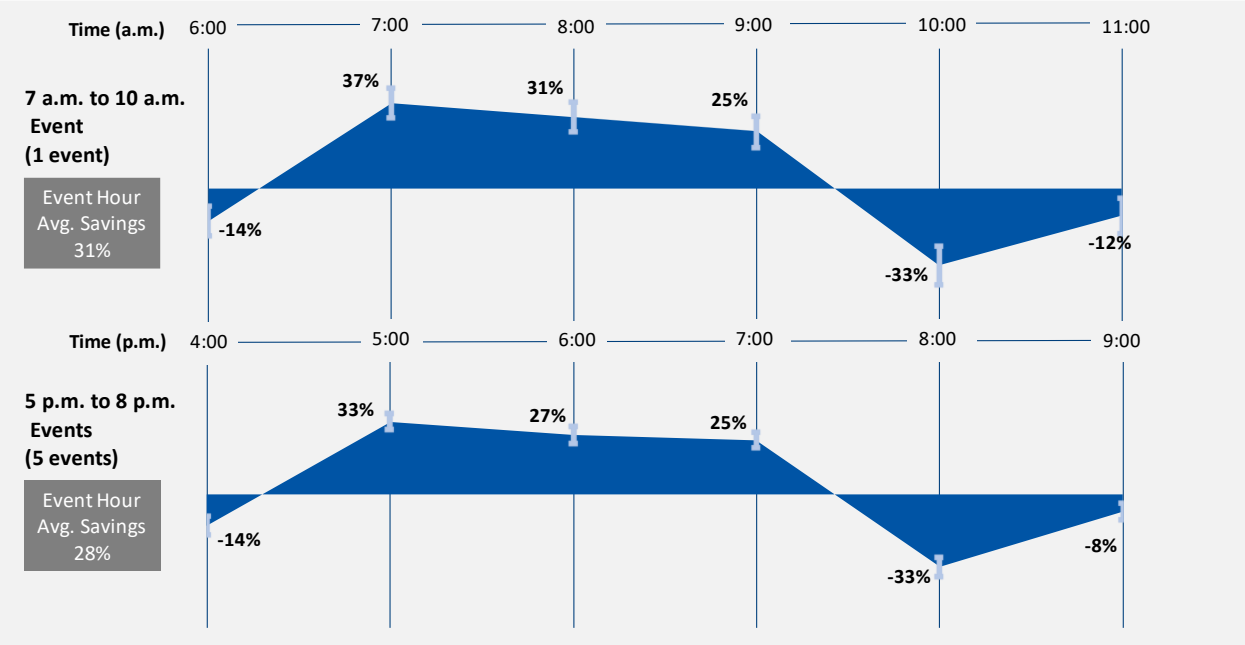
[11] Baseline demand refers to the energy demand that would have occurred in absence of the event. Baseline demand is measured at the whole house level using the demand of customers from the randomized control group. These are customers who did not experience load control event, and thus provide a baseline for what energy demand would have been.

Figure 6. Direct Install Winter 2018/2019: Average Demand Savings (kW) per Participant



Note: Impacts were estimated using regression analysis of customer AMI meter data for 1,580 customers. This count includes test and control group customers, and the total number of customers varied by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for estimation details.

Figure 7. Direct Install Winter 2018/2019: Percentage Demand Savings

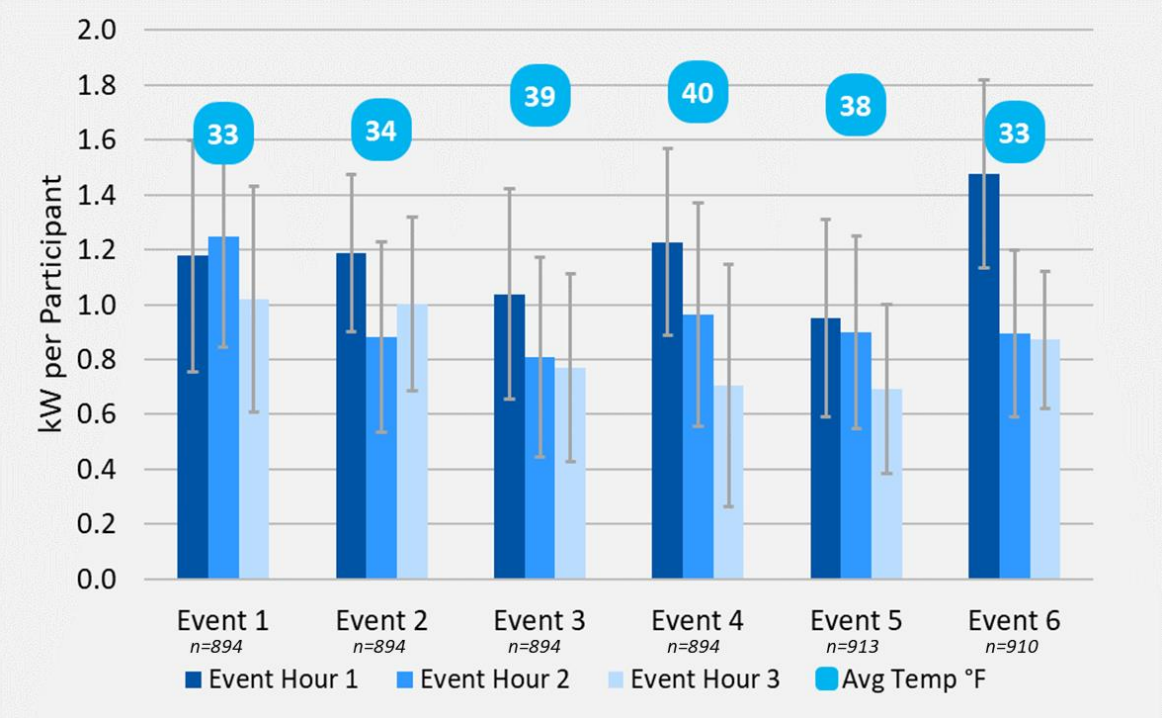


Note: Impacts were estimated using regression analysis of customer AMI meter data for 1,580 customers. This count includes test and control group customers, and the total number of customers varied by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for estimation details.

Winter Demand Savings Estimates by Event

Figure 8 shows the average demand savings per participant for each hour of the six winter events. For most events, first-hour savings per participant ranged from 1.0 kW to 1.4 kW, while third-hour savings per participant ranged from 0.6 kW to 1.0 kW. The first hour of event 6, which had the coldest outdoor temperatures with event 1, generated the largest event-hour savings of 1.4 kW.

Figure 8. Direct Install Winter 2018/2019: Demand Savings by Event



Note: Impacts were estimated using regression analysis of customer AMI meter data. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. *n* indicates the number of test group customers in the analysis sample for the event.

Except for the first event, savings decreased monotonically between the first and third event hours. Event 2 was the only event where savings were higher in the second hour than the first hour.

The energy savings for winter were estimated by summing load impacts across the pre-event hour, event hours, and the first four post-event hours. Load impacts for later post-event hours were not statistically significant and therefore not included in the energy savings calculations. On average, customers reduced their energy consumption on event days between 0.6 kWh and 1.7 kWh per participant. (See Table B-3 in Appendix B for point estimates of demand savings, pre-event and post-event demand impacts, and energy savings impacts.)

Table 6 presents estimates of total Direct Install demand savings during winter 2018/2019 by event hour and on average for each event. Estimates were obtained by multiplying the evaluated per-participant average demand savings by the number of participants in each event.

Table 6. Direct Install Winter 2018/2019: Total Demand Savings (MW)

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	
Event 1	5 p.m. – 8 p.m.	1.05	1.12	0.91	1.03	894
Event 2	5 p.m. – 8 p.m.	1.06	0.79	0.90	0.91	894
Event 3	5 p.m. – 8 p.m.	0.93	0.72	0.69	0.78	894
Event 4	7 a.m. – 10 a.m.	1.10	0.86	0.63	0.86	894
Event 5	5 p.m. – 8 p.m.	0.87	0.82	0.63	0.77	913
Event 6	5 p.m. – 8 p.m.	1.34	0.81	0.79	0.98	910
Average		**1.06**	**0.85**	**0.76**	**0.89**	**900**

Note: MW savings were estimated by multiplying the per customer demand savings estimates in each event hour by the number of test group participants in the analysis sample. The number of test group participants in the analysis sample varied by event. The analysis sample excludes homes with missing AMI meter data, multiple program enrollments (that may have been assigned into both test and control groups) and net metering customer. Details regarding the analysis sample and screening are provided in the *Data Collection and Preparation* section.

Across events, demand savings averaged 0.89 MW. Note that participants in the control group (n=581) did not contribute to the total demand savings since they did not experience any load control during events. These participants have the potential to contribute to PGE's future winter demand response capacity. Event 1, which began at 5 p.m. and lasted three hours, had the largest average demand savings of 1.03 MW. Event 5, which began at 5 p.m. and lasted three hours, had the smallest average demand savings of 0.77 MW.

Winter Customer Experience

After the winter event season, Cadmus administered an online survey to test and control group participants. The winter experience survey asked participants about their event awareness, comfort, satisfaction, and suggestions for improvement. The survey took respondents less than seven minutes to complete and respondents did not receive an incentive for completing the survey. The following sections describe the key findings from this survey.

Winter Event Awareness

The experience survey asked test group respondents how many of the six winter events they noticed. Sixty percent of respondents (n=162) said they noticed events. Of those who noticed, on average, they noticed 5.2 events out of the six called (n=97). Respondents (n=86) noticed mostly due to the event message display on the thermostat (76%) and less often due to a temperature change (40%) or the event notification from the smartphone app (37%).

The program does not require any customer effort during the event. As expected, a high proportion of respondents (79%) said participating in the winter events was easy (n=131). Specifically, 64% said it was

very easy and 15% said it was *somewhat easy*. The 7% of respondents who found it difficult to participate in the events mentioned the following reasons:

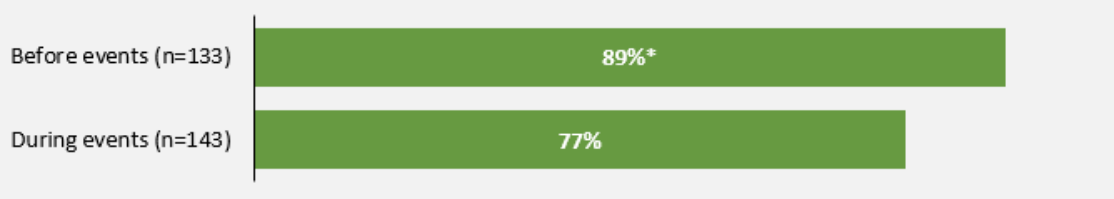
- Not understanding how the program works (four respondents)
- The timing of the events (three respondents)
- Health and medical reasons (three respondents)
- Notifications were not early enough (three respondents)

Winter Event Comfort

Approximately one in three test group respondents (36%, n=157) reported that they overrode at least one of the winter events. The survey did not have ask respondents to recall how many events they overrode but did ask for their reasons for overriding any of the events. Respondents who reported overriding most often cited thermal discomfort as their reason (75%, n=55).

The majority of test group respondents recalled being comfortable before and during the winter events. Figure 9 shows that before the events, 89% of respondents said their home's interior temperature was comfortable. When recalling their comfort level during events, 77% said they were comfortable, a statistically significant decrease of 12 points compared to the comfort level before events. The surveys were conducted after the end of each event season where customers' recall of their comfort during a few days out of the season may not be as accurate or reliable. In future evaluations, a series of surveys of test and control group customers conducted immediately after an event may yield more accurate and reliable responses about customer comfort and its relationship to event overrides.

Figure 9. Direct Install Winter 2018/2019: Percentage of Comfortable Rating Before and During Events



* Difference is statistically significant with 90% confidence (p≤0.10).

Note: Test group respondents rated their comfort level on a 0 to 10 scale, where 0 meant *extremely uncomfortable* and 10 meant *extremely comfortable*. Cadmus defined a 6 to 10 rating as *comfortable*.

Source: Winter 2018-19 Experience Survey Questions. "Overall this past winter, how comfortable was the interior temperature of your home a few hours *before* the high demand events?" and "Overall this past winter, how comfortable was the interior temperature of your home *during* the high demand events?"

Winter Satisfaction

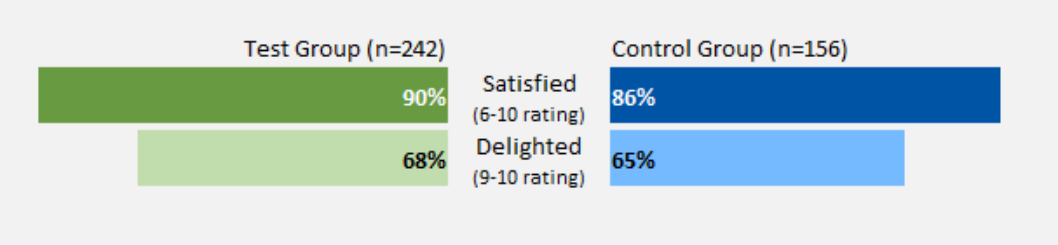
Test and control group respondents rated their satisfaction with the smart thermostat, the program, and PGE, using a 0 to 10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6 to 10 rating as *satisfied* and a 9 or 10 rating as *delighted*.

Winter Satisfaction with Smart Thermostat

Most test and control group respondents were satisfied with their smart thermostat. Figure 10 shows slightly more test group respondents (90%) than control group respondents (86%) were *satisfied* with

their smart thermostat. Slightly more test group respondents (68%) than control group respondents (65%) were *delighted*. Neither of these differences was statistically significant.

Figure 10. Direct Install Winter 2018/2019: Satisfaction with Smart Thermostat

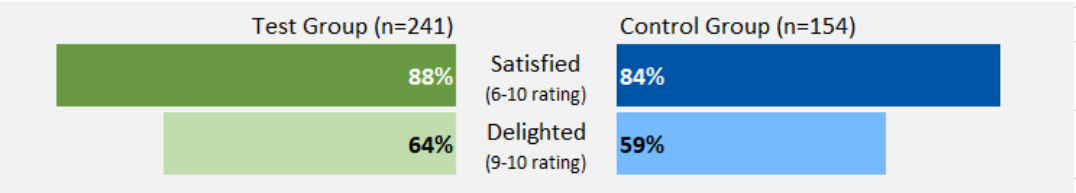


Source: Winter 2018-19 Experience Survey Question.
"Please rate your overall satisfaction with the smart thermostat."

Winter Satisfaction with Program

Most respondents were satisfied with the program (Figure 11). A slightly higher proportion of test group respondents (88%) than control group respondents (84%) were *satisfied* with the program, and a higher proportion of test group respondents (64%) than control group respondents (59%) were *delighted*. There were no statistically significant differences between test and control group respondents in program satisfaction.

Figure 11. Direct Install Winter 2018/2019: Satisfaction with Program



Source: Winter 2018-19 Experience Survey Question.
"Please rate your overall satisfaction with PGE's Smart Thermostat Program."

The winter experience survey asked test and control group respondents to explain their program satisfaction ratings. Cadmus analyzed these open-end explanations according to positive or negative sentiment. Both test and control group respondents had largely positive comments about the program. Positive comments from 194 test group respondents most often mentioned that the thermostat works great and is easy to use (31%), the program works well (22%), and the program helps community save energy and reduce demand (9%). Similar to the test group, 116 control group respondents most often said that the thermostat works great and is easy to use (30%), the program works well (13%), and respondents like the smart thermostat (9%).

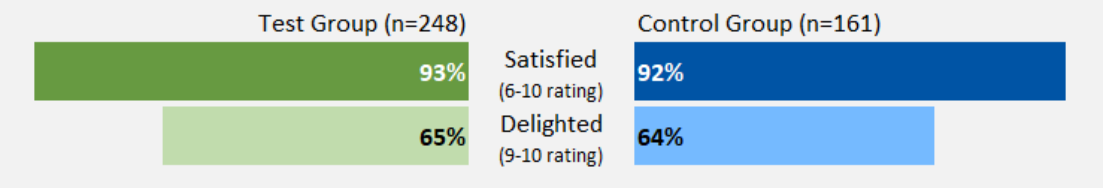
Of the 194 test group respondents, negative comments about the program most often cited problems with the smart thermostat (10%), the program not working well for respondents (5%), and not seeing lower bills (4%). The 116 control group respondents mostly made negative comments about having problems with the smart thermostat (20%), the program not lowering bills (7%), and the program not working for the respondent (3%).

In general, Cadmus found that Direct Install respondents were more likely than BYOT respondents to mention the smart thermostat device than the actual program when asked open-end questions about program satisfaction and program improvements. Direct Install participants associating the program more with the device is a reasonable outcome because the device and its installation were all part of the Direct Install program experience. PGE included customer education of the device and program as part of the installation process.

Winter Satisfaction with Portland General Electric

Most test and control group respondents were satisfied with PGE. As shown in Figure 12, a similar proportion of test group (93%) and control group (92%) respondents were *satisfied* with PGE. A similar proportion of test group (65%) than control group (64%) were *delighted*.

Figure 12. Direct Install Winter 2018/2019: Satisfaction with PGE



Source: Winter 2018-19 Experience Survey Question. "Please rate your overall satisfaction PGE."

Contrary to expectations, there were no statistically significant differences between test group and control group respondents for any of the satisfaction categories: thermostat, program, or PGE. In BYOT evaluations of the first event season, Cadmus found that the test group had lower satisfaction with the program than the control group, which was explained by the fact that the control group did not participate in and were not inconvenienced by the events. For Direct Install, the similar levels of satisfaction may be due to its program design. Unlike BYOT, both test group and control group participants in Direct Install receive a free or discounted device and both groups receive complimentary installation. This benefit may have outweighed any inconvenience from events and suggests that this upfront device offering, and installation component of Direct Install may mediate customer satisfaction.

Winter Customer-Suggested Improvements

The winter experience survey asked test and control group respondents for suggestions to improve the program. Test group respondents (n=133) most often suggested these improvements:

- Provide/improve customer education on how to use thermostat (12%)
- Improve usability of thermostat (5%)
- Provide transparency on how thermostat was changed (3%)
- Improve communication (3%)

Control group respondents (n=92) had the same top three suggestions for program improvement:

- Provide/improve customer education on how to use thermostat (18%)
- Improve usability of thermostat (8%)
- Provide transparency on how thermostat was changed (3%)

Summer 2019

This section provides detailed findings about Direct Install during summer 2019.

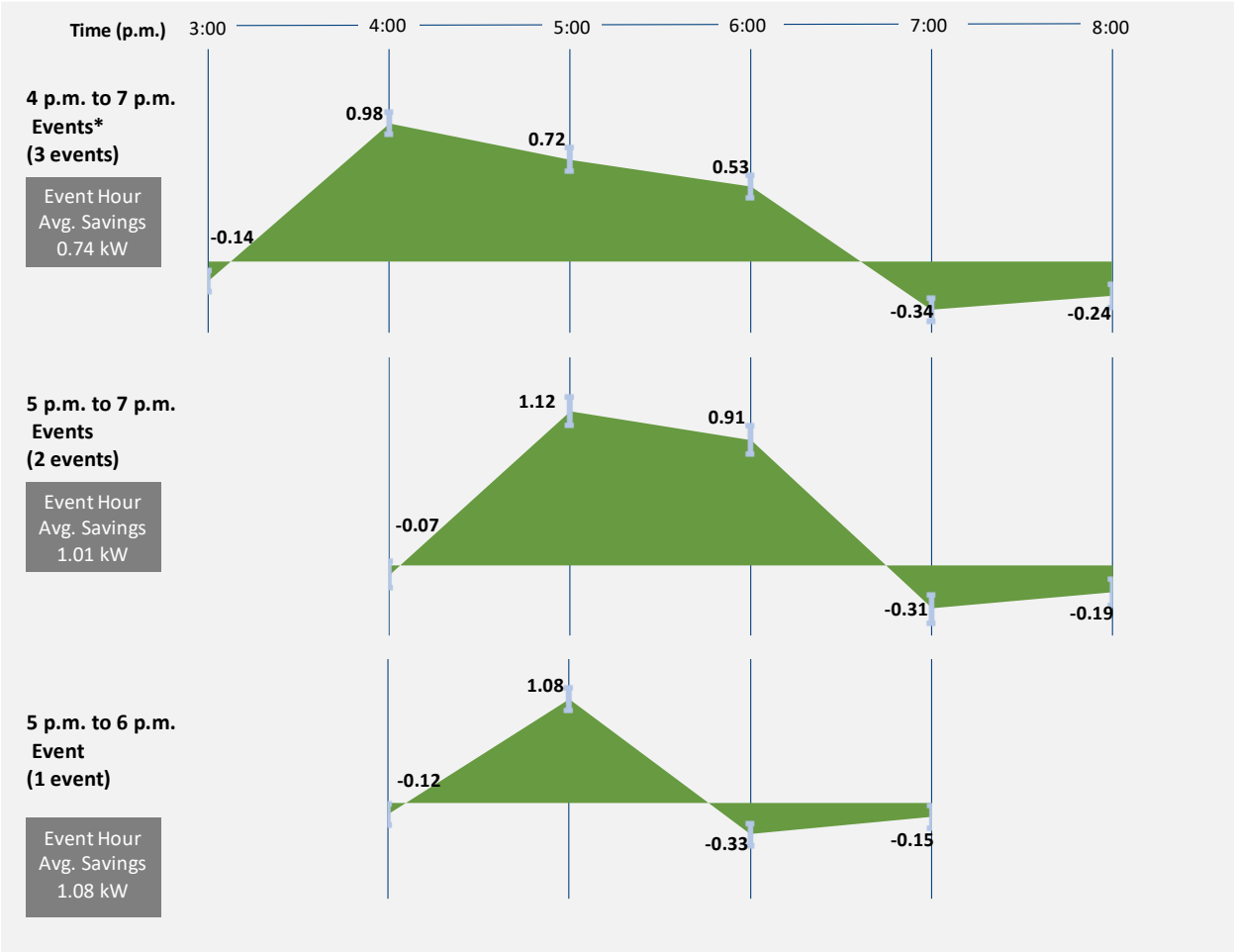
Summer Load Impacts

During summer 2019, Direct Install experienced three events starting at 4 p.m. lasting three hours, two events starting at 5 p.m. lasting two hours, and one event starting at 5 p.m. and lasting one hour.

Figure 13 presents the kilowatt impacts and Figure 14 presents the percentage impacts for one hour prior to the event, each event hour, and two hours after the event ended. The program achieved average demand savings of 0.84 kW per participant on average, with 0.74 kW per participant for three-hour events (4 p.m. start time) and 1.01 kW for two-hour events per participant (5 p.m. start time). The difference in savings between two- and three-hour events is primarily due to the degradation of savings between the second and third event hours. The impact estimates across the first two event hours were similar for events starting at 4 p.m. and 5 p.m. The one-hour event had the second highest savings per participant of 1.08 kW.

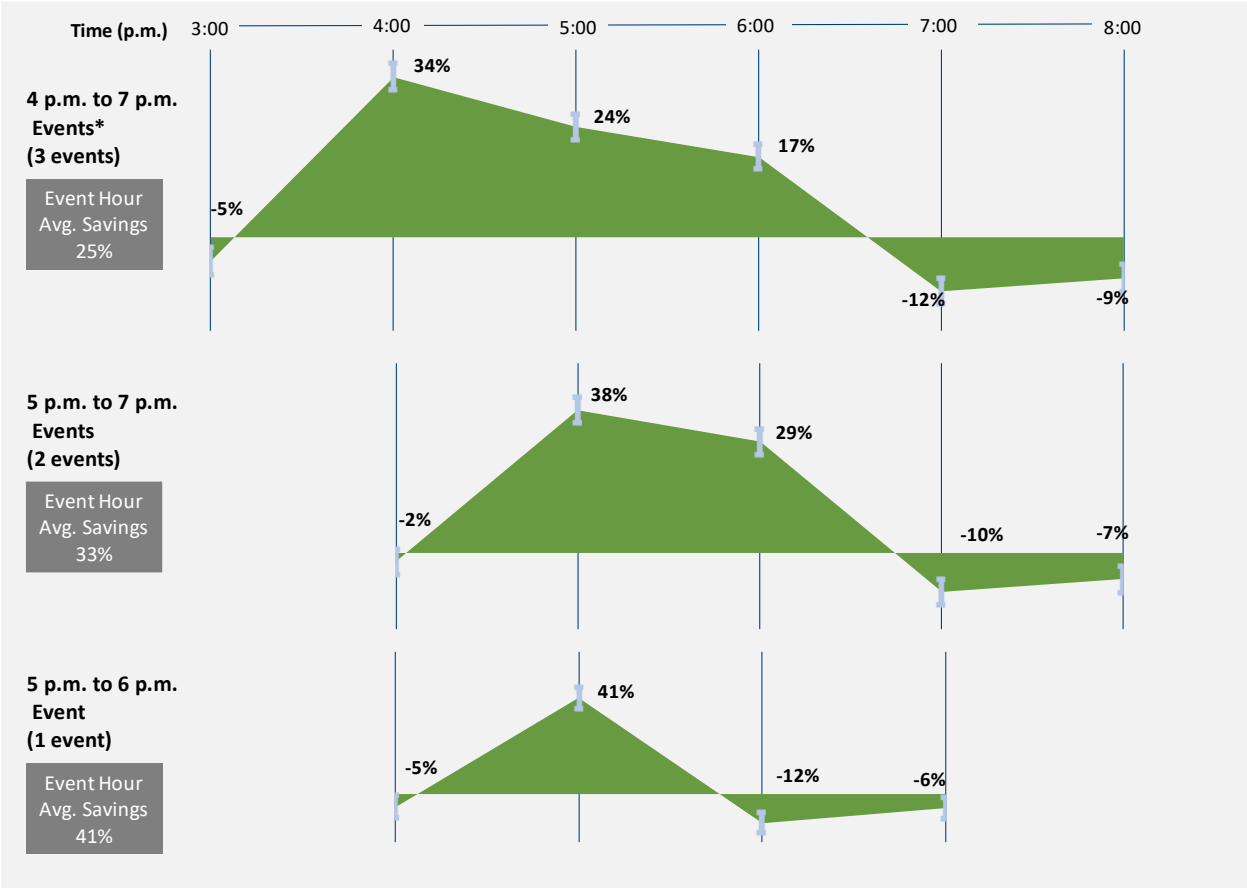
As during winter events, demand savings peaked in the first hour of summer events then diminished through the remaining hours. Participant electricity demand was also higher than normal before and after events. Pre-cooling of participant homes increased electricity demand by about 0.1 kW (4% of baseline demand) across all events. After events ended, demand increased by about 0.3 kW (10%) across all event types. Demand remained statistically greater than normal for about four hours after the events ended.

Figure 13. Direct Install Summer 2019: Average Demand Savings (kW) per Participant



Note: Impacts were estimated using regression analysis of customer AMI meter data for 2,801 customers. This count includes test and control group customers in the analysis sample, and the total number of customers in the analysis sample varied slightly by event. Errors bars show 95% confidence intervals estimated from standard errors clustered on customers. See *Appendix B* for estimation details.

Figure 14. Direct Install Summer 2019: Percentage Demand Savings



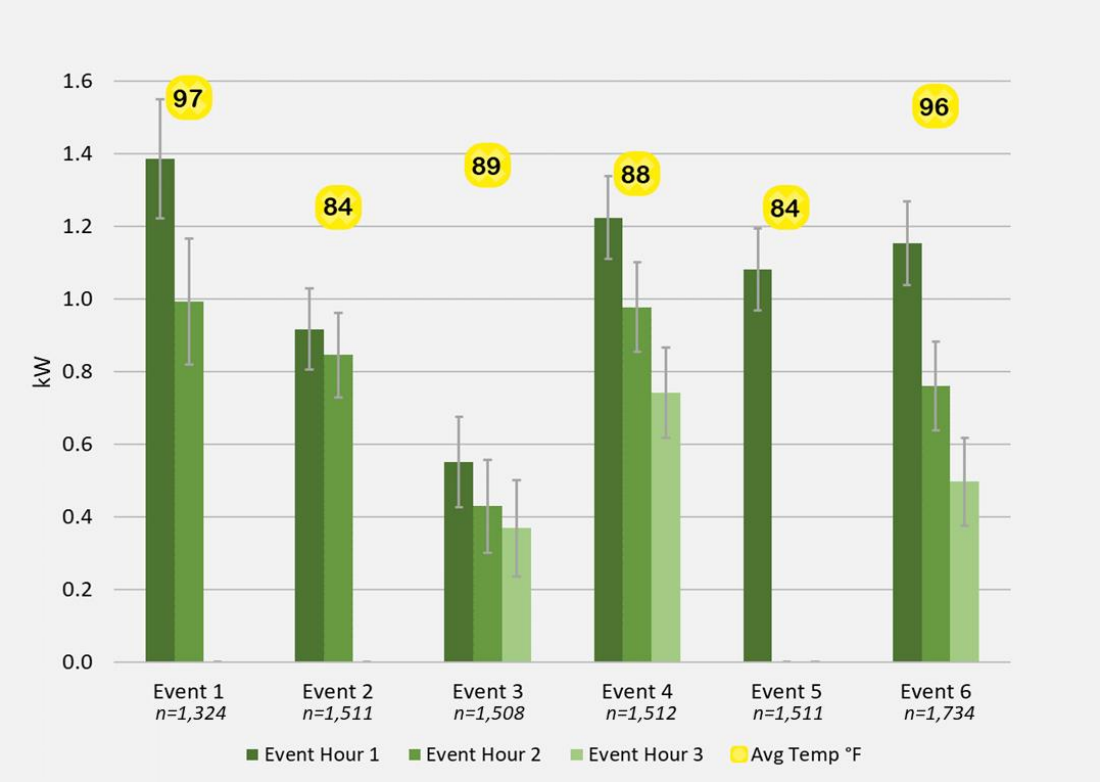
Note: Impacts were estimated using regression analysis of customer AMI meter data for 2,801 customers. This count includes test and control group customers in the analysis sample, and the total number of customers in the analysis sample varied slightly by event. Errors bars show 95% confidence intervals estimated with standard errors clustered on customers. See *Appendix B* for details.

Summer Demand Savings Estimates

Figure 15 shows the average demand savings per participant for each hour of the six summer events. For most events, first-hour savings per participant ranged from 0.8 kW to 1.4 kW. Event 3 experienced a dispatch failure during which ecobee customers did not receive the demand response signal, which in turn reduced the demand savings. Other than the difference in savings for event 3, summer 2019 findings are comparable to previous Direct Install summer seasons.

Summer energy savings were estimated by summing load impacts across the pre-event hour, event hours, and the first four post-event hours. Load impacts for later post-event hours were not statistically significant and therefore not included in the energy savings calculations. For summer 2019, the program decreased energy consumption on event days. Demand response participants decreased their energy consumption on events days by between 0.4 kWh to 1.6 kWh, depending on the event. (See Table B-4 in *Appendix B* for point estimates of demand savings, pre-event and post-event demand impacts, and energy savings.)

Figure 15. Direct Install Summer 2019: Demand Savings by Event



Note: kW impacts per participant estimated using regression analysis of AMI meter data. *n* indicates the number of test group customers in the analysis sample for the event. Errors bars show 95% confidence intervals estimated with standard errors clustered on customers. See *Appendix B* for details.

Summer Program Demand Savings

Table 7 presents estimates of total Direct Install demand savings during summer 2019 by event hour and on average for each event. The estimates were obtained by multiplying the evaluated per-participant average demand savings by the number of treatment participants in each event.

Table 7. Direct Install Summer 2019: Total Program Demand Savings (MW)

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	
Event 1	5 p.m. – 7 p.m.	1.8	1.3	N/A	1.6	1,324
Event 2	5 p.m. – 7 p.m.	1.4	1.3	N/A	1.3	1,511
Event 3	4 p.m. – 7 p.m.	0.8	0.6	0.6	0.7	1,508
Event 4	4 p.m. – 7 p.m.	1.8	1.5	1.1	1.5	1,512
Event 5	5 p.m. – 6 p.m.	1.6	N/A	N/A	1.6	1,511
Event 6	4 p.m. – 7 p.m.	2.0	1.3	0.9	1.4	1,734
Average		**1.6**	**1.2**	**0.8**	**1.3**	**1,517**

Event	Beginning and Ending Times	Demand Savings (MW)				Analysis Sample Test Group Participants per Event (n)
		Hour 1	Hour 2	Hour 3	Event Average	

Note: MW savings were estimated by multiplying the per customer demand savings estimates in each event hour by the number of test group participants in the analysis sample. The number of test group participants in the analysis sample varied by event. The analysis sample excludes homes with missing AMI meter data, multiple program enrollments (that may have been assigned into both test and control groups) and net metering customer. Details regarding the analysis sample and screening are provided in the *Data Collection and Preparation se*ction.

Across events, demand savings averaged 1.3 MW. Note that participants in the control group (n=1,061) did not contribute to the total demand savings since they did not experience any load control during events. These participants have the potential to contribute to PGE's future winter demand response capacity. Event 1, which began at 5 p.m. and lasted three hours, had the largest average demand savings of 1.6 MW. Event 3, which began at 4 p.m. and lasted three hours, had the smallest average demand savings of 0.7 MW. The ecobee dispatch failure contributed to this lower savings.

Summer Customer Experience

After the summer event season, Cadmus administered an online survey to test and control group participants. The summer experience surveys asked participants about their event awareness, comfort, satisfaction, and suggestions for improvement. The survey took respondents less than seven minutes to complete and respondents did not receive an incentive for completing the survey. The following sections describe the key findings from this survey.

Summer Event Awareness

PGE called six events during summer 2019. The experience survey asked test group respondents whether they noticed the events and how many they noticed. Sixty-seven percent of respondents (n=235) said they noticed the events. Of those who noticed, on average, they noticed 4.0 events of the six called (n=158). Respondents (n=149) mostly noticed the events because of the event message display on their thermostat (70%) and less often due to the event notification from the smartphone app (45%) and a temperature change (33%).

As the program does not require any customer effort during the event, a high proportion of respondents (87%) said participating in the summer events was easy (n=204). Specifically, 74% said it was *very easy* and 13% said it was *somewhat easy*. The 5% of respondents who found it difficult to participate in the events most often mentioned the following three reasons:

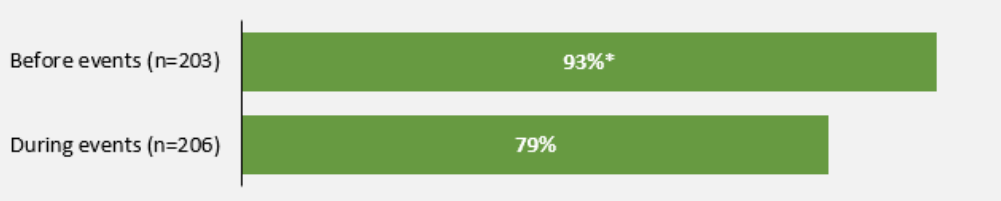
- Timing of the events (three respondents)
- Notifications were not early enough (three respondents)
- Not understanding how the program works (three respondents)

Summer Event Comfort

Twenty-three percent of test group respondents (n=225) reported that they overrode at least one of the summer events. Of these respondents who reported overriding, 90% cited thermal discomfort as their reason (n=50).

Findings on customers' summer event comfort were similar to winter. Most test group respondents recalled being comfortable before and during the summer events. Figure 16 shows that before the events, 93% of respondents said their home's interior temperature was comfortable. During the events, 79% said they were comfortable, a statistically significant decrease of 14 points compared to the comfort level before the events.

Figure 16. Direct Install Summer 2019: Percentage of Comfortable Rating Before and During Events



* Difference is statistically significant with 90% confidence (p≤0.10).

Note: Test group respondents rated their comfort level on a 0 to 10 scale, where 0 meant *extremely uncomfortable* and 10 meant *extremely comfortable*. Cadmus defined a 6 to 10 rating as *comfortable*.

Source: Summer Experience Survey Questions: "Overall this past summer, how comfortable was the interior temperature of your home a few hours before the high demand events?" and "Overall this past summer, how comfortable was the interior temperature of your home during the high demand events?"

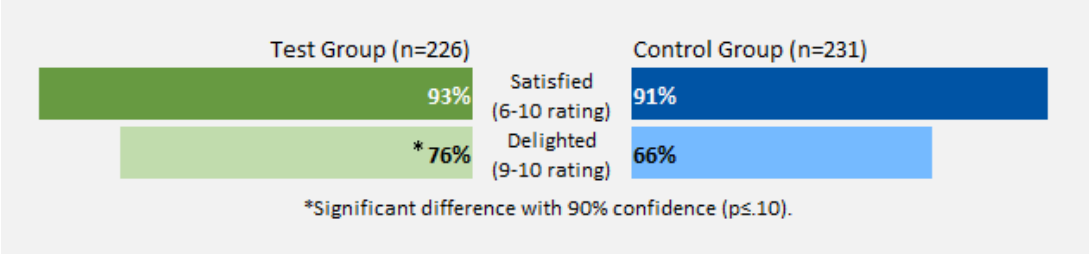
Summer Satisfaction

Test and control group respondents rated their satisfaction with the smart thermostat, the program, and PGE, using a 0 to 10 scale, where 0 meant *extremely dissatisfied* and 10 meant *extremely satisfied*. PGE defined a 6 to 10 rating as *satisfied* and a 9 or 10 rating as *delighted*.

Summer Satisfaction with Smart Thermostat

Most test and control group respondents were satisfied with their smart thermostat. Figure 17 shows that 93% of test group respondents and 91% of control group respondents were *satisfied* with their smart thermostat. Seventy-six percent of test group respondents and 66% of control group respondents were *delighted*, a statistically significant difference. Among the three satisfaction categories, this was the only statistically significant difference observed between test and control group. As discussed above, the lack of differences between test and control groups suggests that the upfront offer of the device and installation through the Direct Install track may mediate customer satisfaction.

Figure 17. Direct Install Summer 2019: Satisfaction with Smart Thermostat

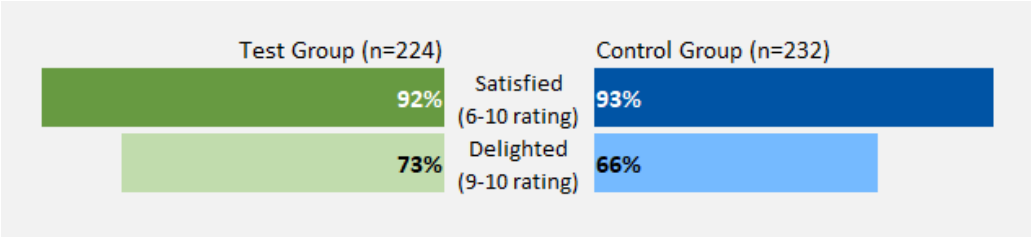


Summer Experience Survey Question: "How satisfied are you with your Nest thermostat?"

Summer Satisfaction with Program

Most respondents were satisfied with the program. Figure 18 shows that 92% of test group and 93% of control group respondents were *satisfied*. Seventy-three percent of test group respondents and 66% of control group respondents were *delighted*. There was no statistically significant difference between test and control group respondents in their satisfaction.

Figure 18. Direct Install Summer 2019: Satisfaction with Program



Source: Summer Experience Survey Question. "Please rate your overall satisfaction of PGE's Smart Thermostat program."

The summer experience surveys asked test and control group respondents to explain their program satisfaction ratings. Both test and control group respondents had largely positive comments.

Positive comments from the 163 test group respondents most often mentioned that they like the smart thermostat (21%), the program works well (20%), and they did not notice the events or noticed only a negligible change in comfort (14%). Similarly, positive comments from the 169 control group respondents most often mentioned that they like the smart thermostat (28%), the program works well (21%), and the thermostat is easy to use (10%).

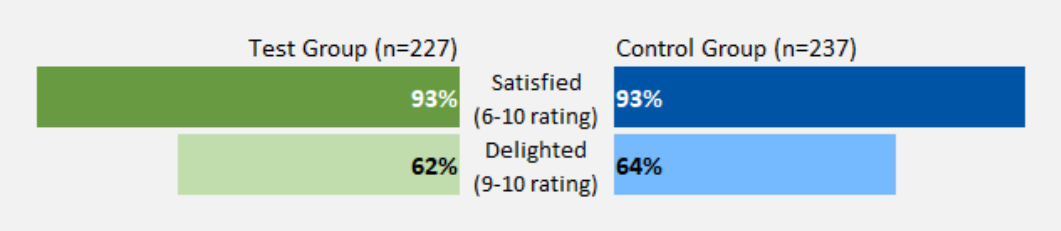
Of the 163 test group respondents, negative comments most often cited disliking the smart thermostat (6%) and thermal discomfort (4%). Of the 169 control group respondents, negative comments included disliking the smart thermostat (8%) and having problems with the smart thermostat (6%).

Similar to the winter experience survey findings, Cadmus found that Direct Install respondents in the summer were more likely than BYOT respondents to mention open-end comments about the smart thermostat device than the actual program.

Summer Satisfaction with Portland General Electric

Almost all test and control group respondents were satisfied with PGE. As shown in Figure 19, the same proportion of test group (93%) and control group (93%) respondents were *satisfied*. A statistically similar proportion of control group respondents (64%) and test group respondents (62%) were *delighted*.

Figure 19. Direct Install Summer 2019: Satisfaction with PGE



Summer Experience Survey Question: "Please rate your overall satisfaction with the PGE."

Summer Customer-Suggested Improvements

The summer experience survey asked test and control group respondents for suggestions to improve the program. Test group respondents (n=101) most often suggested these improvements:

- Send event notifications in advance (9%)
- Provide or improve customer education on how to use thermostat (7%)
- Improve communication (6%)
- Increase program marketing (6%)

Control group respondents (n=110) most often suggested these improvements:

- Provide or improve customer education on how to use thermostat (15%)
- Improve communication (15%)
- Continue the program (7%)

Thermostat Brand Comparison

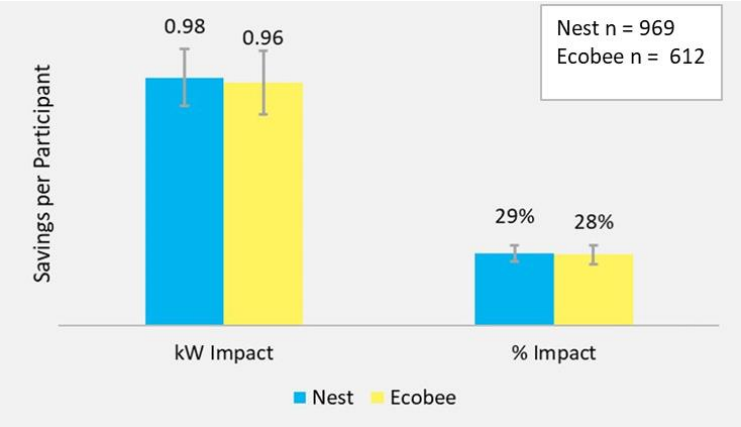
This section provides a comparison of demand savings and survey results by thermostat brand within Direct Install and thermostat brand between Direct Install and BYOT tracks.

Winter 2018/2019

Winter Demand Savings by Thermostat Brand within Direct Install

Figure 20 compares the average savings per participant of smart thermostat brands across all event hours. Nest had the highest average savings of 0.98 kW and 29% per participant. Ecobee had savings of 0.96 kW and 28% per participant. The savings were not statistically different across brands.

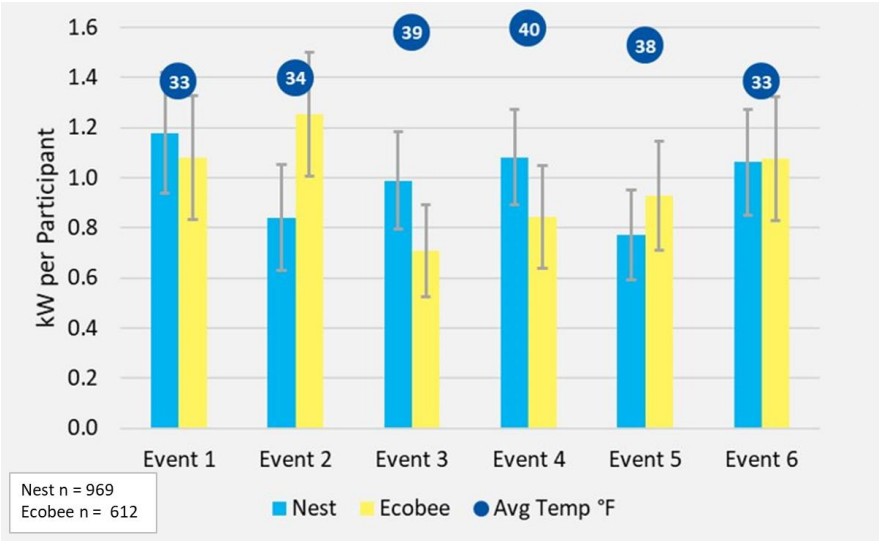
Figure 20. Direct Install Winter 2018/2019: Demand Savings by Thermostat Brand



Note: Error bars show 90% confidence intervals. Percentage savings equal kW savings divided by the baseline demand. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

Figure 21 shows average demand savings by brand for each event. Savings estimates are not statistically different for any event. Neither thermostat brand had consistently higher point estimates of savings.

Figure 21. Direct Install Winter 2018/2019: Demand Savings by Event and Thermostat Brand



Note: Error bars show 90% confidence intervals. Percentage savings equal kW savings divided by the baseline demand. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

Table 8 shows demand savings per participant by brands included in the Direct Install program. Note that only one event in the winter 2018/2019 season occurring in the morning; thus, the significance of these estimates is lower, particularly for non-Nest thermostats for which there are less participants.[12]

Table 8. Winter 2018/2019 Event Type Demand Savings (kW) by Brand

Brand	Evaluation	
	Morning	Afternoon
Nest	**1.08**	**0.96**
ecobee	**0.84**	**1.00**

*Savings values reflect the average kW demand reduction per participant during events; **blue** font indicates estimates are statistically significant. Differences between time of day within brand were statistically different at the 10% significance level.

Winter Customer Experience by Thermostat Brand within Direct Install

Table 9 shows a comparison of the test group's winter survey results between Nest and ecobee respondents in the Direct Install track. There were no statistically significant differences between Nest and ecobee test group respondents with one exception. Nest respondents, on average, noticed more events (6.2) than ecobee respondents (3.6), probably because Nest sends pre-event notifications. Overall, Nest and ecobee thermostat test group respondents had similar program experiences in winter 2018/2019.

Table 9. Direct Install Winter 2018/2019: Test Group Survey Results by Thermostat Brand

Survey Topic	Nest (n≤147)	ecobee (n≤103)
General event awareness	65% noticed events	54% noticed events
Average perceived number of events	6.2 events*	3.6 events
Comfort during events	75% comfortable	79% comfortable
Overriding events	41% overrode	29% overrode
Smart thermostat satisfaction	88% satisfied 69% delighted	93% satisfied 67% delighted
Program satisfaction	87% satisfied 65% delighted	90% satisfied 63% delighted
Satisfaction with PGE	93% satisfied 66% delighted	92% satisfied 64% delighted

*Difference is statistically significant with 90% confidence (p≤0.10).

[12] Note that the confidence intervals in table 8 represent *within brand* variation in savings. Statistically significant differences between brands may be inferred from the confidence intervals visualized in Figure 21. The confidence intervals overlap across all six events, indications that no differences in savings occurred between thermostat brands in the winter 2018/2019 season.

Winter Demand Savings by Thermostat Brand between Direct Install vs. BYOT

Table 10 compares the demand savings of thermostat brands across PGE's BYOT and Direct Install tracks. Ecobee and Nest customers achieved higher demand savings in Direct Install than BYOT. However, only the difference for Nest between Direct Install and BYOT is significant. The difference for Nest is attributable to the enrollment of large number of Nest BYOT customers who did not use electric heat in winter 2018/2019. In contrast, the Direct Install track verified the customer's heating equipment and program eligibility at the time of the thermostat installation.

Table 10. Direct Install vs. BYOT Event Savings - Winter 2018/2019

Brand	Direct Install		BYOT	
	kW savings per participant	Percentage	kW savings per participant	Percentage
Nest	0.98	29%	0.35	15%
ecobee	0.96	28%	0.81	27%
Honeywell	N/A	N/A	0.30	12%

Winter Customer Experience by Thermostat Brand between Direct Install vs. BYOT

Table 11 compares the test group's winter survey results between Direct Install Nest and BYOT Nest respondents.

Table 11. Winter 2018/2019 Test Group Survey Results: Direct Install Nest vs. BYOT Nest

Survey Topic	Direct Install Nest (n≤147)	BYOT Nest (n≤193)
General event awareness	65% noticed events	70% noticed events
Average perceived number of events	6.2 events*	5.4 events
Comfort during events	75% comfortable	86% comfortable*
Overriding events	41% overrode	33% overrode
Smart thermostat satisfaction	88% satisfied 69% delighted	99% satisfied* 78% delighted*
Incentive satisfaction	Not applicable	87% satisfied 57% delighted
Program satisfaction	87% satisfied 65% delighted	92% satisfied 64% delighted
Satisfaction with PGE	93% satisfied 66% delighted	93% satisfied 66% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Several statistically significant differences emerged. Direct Install respondents, on average, perceived a higher number of events (6.2) than BYOT Nest respondents (5.4), perhaps because it was their first season and participating in the program had not become routine. BYOT Nest respondents have experienced multiple event seasons while Direct Install Nest respondents at the time of the survey had experienced only one winter event season.

A higher percentage of BYOT Nest respondents (86%) reported being comfortable during events than Direct Install Nest respondents (75%). Additionally, a higher proportion of BYOT Direct Install Nest respondents reported being satisfied and delighted with their thermostat compared to BYOT Nest respondents. This may be because the Direct Install Nest respondents saw their thermostat respond to more events over the seasons than BYOT Nest respondents.

Due to the small sample size of BYOT ecobee respondents, Cadmus could not conduct statistical significance testing of the differences between the two tracks. Table 12 shows test group winter survey results from Direct Install ecobee and BYOT ecobee respondents.

Table 12. Winter 2018/2019 Test Group Survey Results: Direct Install ecobee vs. BYOT ecobee

Survey Topic	Direct Install ecobee (n≤103)	BYOT ecobee* (n≤19)
General event awareness	54% noticed events	74% noticed events
Average perceived number of events	3.6 events	3.2 events
Comfort during events	79% comfortable	88% comfortable
Overriding events	29% overrode	21% overrode
Smart thermostat satisfaction	93% satisfied 67% delighted	100% satisfied 68% delighted
Incentive satisfaction	Not applicable	95% satisfied 58% delighted
Program satisfaction	90% satisfied 63% delighted	85% satisfied 58% delighted
Satisfaction with PGE	92% satisfied 64% delighted	100% satisfied 64% delighted

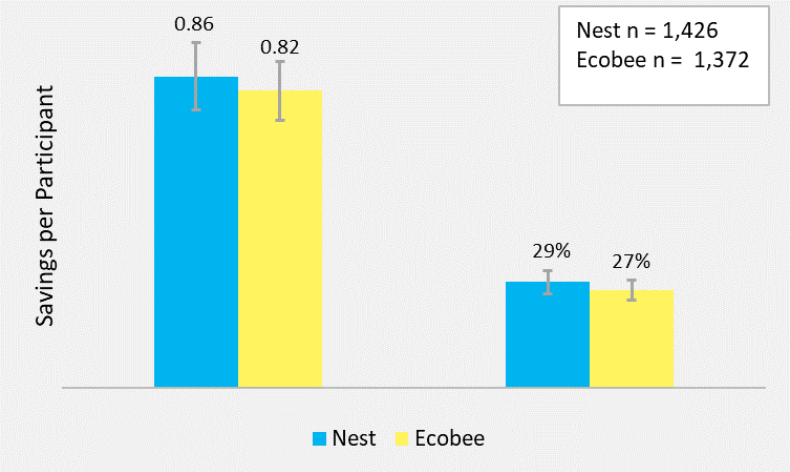
*The total number of responses was too small to conduct statistical significance testing for this group.

Summer 2019

Summer Demand Savings by Thermostat Brand within Direct Install

Figure 22 compares the average savings per participant for Direct Install participants with Nest and ecobee smart thermostats across all event hours. Nest had higher average savings of 0.86 kW (29% of baseline demand) per participant than ecobee, with savings of 0.82 kW (27%) per participant. These savings estimates are not statistically different.

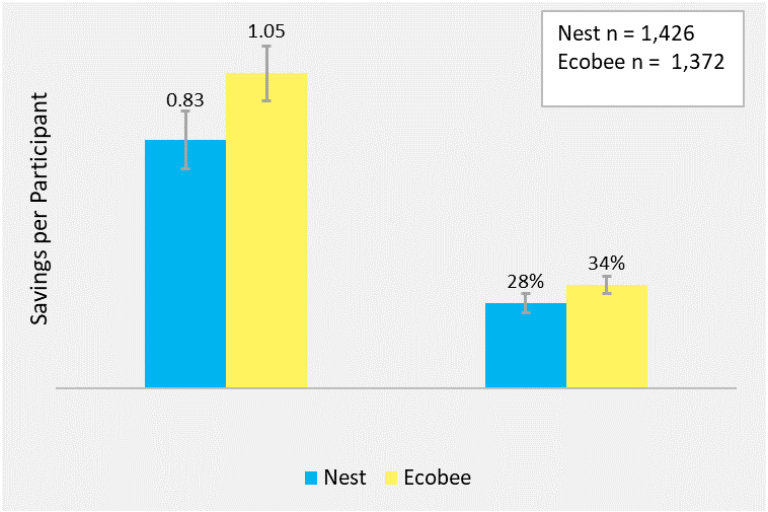
Figure 22. Direct Install Summer 2019: Demand Savings by Thermostat Brand



Note: Figure shows the average demand savings (kW) per participant. Percentage savings are kW savings per participant as a percentage of baseline demand. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

During event 3, ecobee thermostats failed to dispatch due to a widespread ecobee service connection issue, which diminished the demand savings from ecobee participants. To show the influence of this event, Figure 23 shows the savings by thermostat brand over all events excluding event 3 and that ecobee slightly outperformed Nest. Ecobee achieved average demand savings of 1.05 kW (34%), about 6% higher than Nest with 0.83 kW. When event 3 was excluded, the differences between ecobee and non-ecobee demand savings were statistically significant at the 5% level.

Figure 23. Direct Install Summer 2019: Average Demand Savings per Participant by Thermostat Brand (Excluding Event 3)

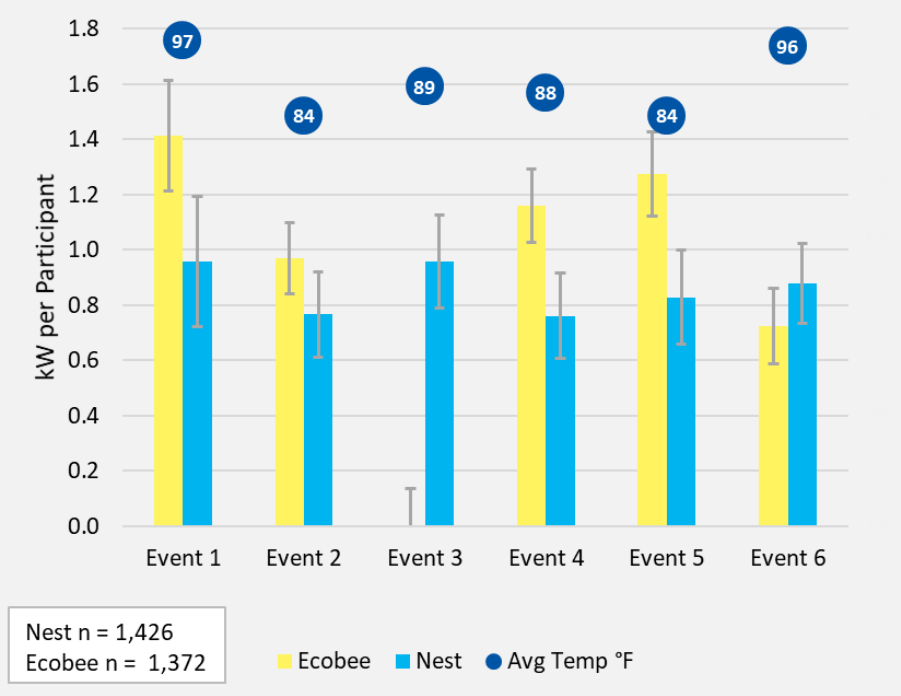


Note: Figure shows the average demand savings (kW) per participant. Percentage savings are kW savings per participant as a percentage of baseline demand. *n* indicates for each thermostat brand the number of test group participants in the analysis sample.

Figure 24 shows average demand savings by brand for each event. Here, we see ecobee thermostats achieving greater savings than Nest thermostats in Events 1, 4, and 5.

Note, during the summer 2019 season, Resideo reporting using a proprietary approach for applying Intelligent Demand Response (IDR) on a subset of its ecobee customer population. However, since details of their IDR's dynamics have not been disclosed, Cadmus does not know the specific events or number of customers who experienced IDR. This may contribute to the variation of savings across events.

Figure 24. Direct Install Summer 2019: Average Demand Savings by Event and Thermostat Brand



Note: Impacts were estimated using regression analysis of customer AMI meter data. Errors bars show 95% confidence intervals estimated with standard errors clustered on customers. See *Appendix B* for details.

Summer Customer Experience by Thermostat Brand within Direct Install

Statistically significant differences emerged between Nest and ecobee respondents in the Direct Install track. Nest respondents, on average, noticed a greater number of events (4.5) in comparison to ecobee customers (3.3), probably because of the dispatch failure of ecobee thermostats during the season's third event. However, there was no statistically significant difference between Nest and ecobee respondents in their general awareness of events.

Table 13 shows a comparison of the test group's summer survey results between Direct Install ecobee and BYOT ecobee respondents.

Table 13. Direct Install Summer 2019: Test Group Survey Results by Thermostat Brand

Survey Topic	Nest (n≤133)	ecobee (n≤102)
General event awareness	68% noticed events	67% noticed events
Average perceived number of events	4.5 events*	3.3 events
Comfort during events	76% comfortable	82% comfortable
Overriding events	27% overrode	18% overrode
Smart thermostat satisfaction	92% satisfied 76% delighted	94% satisfied 76% delighted
Program satisfaction	91% satisfied 73% delighted	93% satisfied 73% delighted
Satisfaction with PGE	96% satisfied 60% delighted	90% satisfied 64% delighted

*Difference is statistically significant with 90% confidence (p≤0.10).

Summer Demand Savings by Thermostat Brand between Direct Install vs. BYOT

Table 14 compares thermostat brand demand savings across PGE's BYOT and Direct Install tracks. The estimates exclude event 3, removing the negative effect on savings from ecobee's dispatch failure. For Nest and ecobee thermostats, BYOT savings were slightly greater than Direct Install savings, but the differences were not statistically significant. The percentage savings show the kW savings per participant relative to baseline demand. By considering the impacts relative to the entire home load, we get insight into the relative size of savings achieved from smart thermostat demand response.

Table 14. BYOT vs. Direct Install Savings – Summer 2019

Brand	Direct Install		BYOT	
	kW savings per participant	Percentage	kW savings per participant	Percentage
Nest	0.83	28%	0.89	34%
ecobee	1.05	34%	1.12	39%
Honeywell	N/A	N/A	0.75	25%

Summer Customer Experience by Thermostat Brand between Direct Install vs. BYOT

Table 15 compares test group summer survey results between Direct Install Nest and BYOT Nest respondents. Two statistically significant differences emerged. A higher proportion of BYOT respondents (97%) than Direct Install respondents (92%) were satisfied with their Nest thermostat. A higher proportion of Direct Install Nest respondents (73%) were delighted with the program compared to BYOT Nest respondent (62%). The differences in satisfaction of Nest thermostat respondents between BYOT or Direct Install should not obscure the fact that all satisfaction results are particularly high, as none dip below 91%.

Table 15. Summer 2019 Test Group Survey Results: Direct Install Nest vs. BYOT Nest

Survey Topic	Direct Install Nest (n≤133)	BYOT Nest (n≤231)
General event awareness	68% noticed events	68% noticed events
Average perceived number of events	4.5 events	4.2 events
Comfort during events	76% comfortable	74% comfortable
Overriding events	27% overrode	33% overrode
Smart thermostat satisfaction	92% satisfied 76% delighted	97% satisfied* 77% delighted
Incentive satisfaction	Not applicable	86% satisfied 57% delighted
Program satisfaction	91% satisfied 73% delighted*	94% satisfied 62% delighted
Satisfaction with PGE	96% satisfied 60% delighted	96% satisfied 56% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Table 16 compares test group summer survey results between Direct Install ecobee and BYOT ecobee respondents.

Table 16. Summer 2019 Test Group Survey Results: Direct Install ecobee vs. BYOT ecobee

Survey Topic	Direct Install ecobee (n≤102)	BYOT ecobee (n≤209)
General event awareness	67% noticed events	73% noticed events
Average perceived number of events	3.3 events	4.4 events*
Comfort during events	82% comfortable*	62% comfortable
Overriding events	18% overrode	36% overrode*
Smart thermostat satisfaction	94% satisfied 76% delighted	96% satisfied 72% delighted
Incentive satisfaction	Not applicable	90% satisfied 57% delighted
Program satisfaction	93% satisfied 73% delighted*	91% satisfied 58% delighted
Satisfaction with PGE	90% satisfied 64% delighted	96% satisfied 54% delighted

* Difference is statistically significant with 90% confidence (p≤0.10).

Several statistically significant differences emerged suggesting BYOT ecobee respondents have different experience than their Direct Install counterparts. BYOT ecobee respondents perceived, on average, a higher number of events (4.4 events vs. 3.3 events), and a higher proportion of BYOT ecobee respondents (36%) than Direct Install ecobee respondents (18%) reported overriding events.

A higher proportion of Direct Install ecobee respondents (82%) than BYOT ecobee respondents (62%) reported being comfortable during the events as well as being delighted with the program (73% Direct Install and 58% BYOT). BYOT ecobee respondents may have had a lower quality experience because of a software glitch that caused some ecobee customers to have a temperature setback greater than three

degrees. Though this did not happen to all ecobee devices, BYOT ecobee customers may have been disproportionately affected because there are far more BYOT ecobee participants than Direct Install ecobee participants.

Logic Model Review

Cadmus conducted a high-level review of the logic model by using staff interview findings, customer survey findings, and impact results to determine whether Direct Install produced the expected outcomes. Due to the limited availability of certain information and data, not all expected outcomes shown in the logic model could be thoroughly assessed.

Table 17, which follows, summarizes the findings from the logic model review in detail. Direct Install mostly operated as expected, producing most of its expected outcomes. It did not produce the expected outcomes for its program operations manual activity, program operations, and program enrollment goal.

Table 17. Logic Model Review of Direct Install Smart Thermostat Demand Response Program

Logic Model Element		Expected Outcome	Actual Outcome
Program Activities	Capacity planning	PGE outlines the use of demand response to help manage system peak loads	PGE outlined its plan in 2019 Integrated Resource Plan.
	Program design and implementation	PGE and implementers design and administer the program	PGE and implementers administered the winter 2018/2019 and summer 2019 seasons.
	Evaluation	Cadmus evaluates the program	Cadmus evaluated load impacts, customer experience, and delivery.
Outputs to Program Activities	Integrated Resource Plan	PGE publishes the plan	PGE published the Integrated Resource Plan in July 2019 with smart thermostats as a demand response resource.
	Program operations manual	PGE drafts a manual for internal staff	A rough draft of a program manual is in progress.
	Marketing collateral	PGE and implementers create and disseminate collateral	PGE conducted all program marketing activities (email, direct mail, and PGE website) and created educational postcards, which CLEAResult installation technicians handed out to customer during the in-home installation.
	Program scheduling website and call center	Implementers create, host, and manage the website and call center. Customers can enroll through the website and call center.	CLEAResult operated the call center and web portal.
	Smart thermostat installation and enrollment	Technicians successfully installs the device and enrolls customers into the program	PGE aimed to complete 800 installations per month, but CLEAResult was only able to complete around 500 installations per month due to the limited number of technicians.
	Installation technician training and leave-behind materials	PGE provides educational training and educational collateral for technicians to utilize during customer's installation appointment	PGE worked with a smart thermostat program expert on developing training and materials for CLEAResult technicians. PGE provided technicians with educational postcards to leave behind with customers.
	Demand response platform for PGE to call events	Implementers create, host, and manage the platform. PGE can schedule events.	PGE used Nest's and Resideo's online management platform to schedule events.

Logic Model Element		Expected Outcome	Actual Outcome
	Evaluation report	Cadmus drafts the evaluation report for PGE to submit to the Public Utility Commission of Oregon	Cadmus drafted this evaluation report as well as presented results to PGE after the end of each season.
Short-Term and Intermediate Outcomes (in one to two years)	Program operations	Organized and efficient management of program	Although systems and procedures were in place, PGE encountered challenges keeping up with customer demand for the program and operational device performance issues.
	Customer awareness	Customers become aware of demand response and program	Cannot be determined from this evaluation. PGE and Cadmus will explore this outcome in the Test Bed evaluation.
	Installation satisfaction	Customers have a positive scheduling and installation experience	98% of survey respondents agreed with the statement, "The contractor was professional and courteous." 93% of respondents agreed with the statement, "I didn't wait long… to the day of installation." 95% of respondents were satisfied and 82% were delighted with their overall installation experience.
	Program enrollment	24,000 thermostats enrolled in Direct Install and BYOT by end of 2019	Direct Install and BYOT combined together, PGE enrolled 20,805 thermostats. Recruitment of mobile home communities would have helped PGE meet its enrollment goal.
	Event participation	Customers do not override events	Cannot be accurately determined. Surveys, which are self-reports, suggest that 23%-36% of customers override events. Evaluation does not have full access to implementers' telemetry reports to analyze overrides.
	Customer satisfaction	Customers are satisfied with the program	Direct Install achieved high customer satisfaction. 88% of test group survey respondents were satisfied with the program in winter and 92% were satisfied with the program in summer.
	Demand impacts	PGE achieves peak demand savings	Direct Install achieved average savings of 1.0 kW and 0.8 kW per participant for winter 2018/2019 and summer 2019, respectively.
	Ongoing participation	Customers renew participation next season	Cannot be accurately determined. Evaluation was not tasked to analyze ongoing customer participation. PGE stated in staff interviews that few customers were opting out of the program and most customers opting out of the program were due to move-outs.
Long-Term Impacts and Success (in three to five years)	Program goals	Meet enrollment and demand response capacity goals	To be assessed in future
	Customer engagement	Increased customer awareness, consideration, evaluation, action, and loyalty (ACEAL)	To be assessed in future
	Company goals	Improvements in reliability of electricity service, cost-effectiveness, and corporate sustainability goals	To be assessed in future

Appendix A. Evaluation Methodology

This section describes Cadmus's methodology for evaluating the Direct Install track of the Smart Thermostat Demand Response pilot program.

Evaluation Design

To estimate the demand response impacts of the Direct Install track, Cadmus worked with PGE to implement a randomized controlled trial (RCT). RCTs are the gold standard in program evaluation and expected to produce unbiased estimates of the program savings. This evaluation design involved randomly assigning program participants (residential customers who enrolled in the program) to a test group or control group. Test group customers received the load control signals during demand response events, while control group customers did not. Savings were estimated by comparing the average demand of test and control group customers during event hours.

Cadmus randomized customers prior to each event season by program and brand. Customers were assigned to one group for the whole season and not informed about the group to which they had been assigned. If a customer had multiple smart thermostats at the time of the randomization, all thermostats were assigned to the test group or control group. For participants who enrolled after the Cadmus randomization, PGE randomly assigned them to the test group using a pre-randomized assignment list based upon the order of enrollment. Customers were rerandomized at the beginning of the next season.

Table A-1 shows random assignments of participating customers overall, by brand, and by HVAC system for the winter 2018/2019. Table A-2 shows random assignments in summer 2019.

Table A-1. Direct Install Winter 2018/2019: Random Assignments

Category	Test		Control	
	Count	Percentage of Row Total	Count	Percentage of Row Total
By Brand				
ecobee	360	59%	252	41%
Nest	642	66%	327	44%
Honeywell	3	60%	2	40%
By HVAC System				
Heat Pump	731	62%	451	38%
Electric Furnace	274	68%	130	32%
Overall	**1,005**	**63%**	**581**	**37%**

Table A-2. Direct Install Summer 2019: Random Assignments

Category	Test		Control	
	Count	Percentage of Row Total	Count	Percentage of Row Total
By Brand				
ecobee	857	62%	515	38%

Category	Test		Control	
	Count	Percentage of Row Total	Count	Percentage of Row Total
Nest	881	62%	545	38%
By HVAC System				
Central Air Conditioner	423	54%	358	46%
Heat Pump	1,315	66%	702	34%
Overall	**1,738**	**62%**	**1,060**	**38%**

There are typically two types of impact effects that can be measured, depending on the inclusion of distinct treatment participant groups:

(1) Intent to treat treatment effect (ITT) – the average impact per home (or other relevant unit of analysis) for homes that the utility intends to treat
(2) Treatment effect on the treated (TOT) – the average impact per treated home

In a smart thermostat demand response context, the ITT effect is the average demand savings per home for homes the utility attempts to control. It is estimated across homes (thermostats) that receive and execute the setback, homes that receive and execute the commands and then override the commands, and homes that don't receive or execute the commands due to some operational issue. In its evaluations of PGE's thermostat programs, Cadmus has estimated and reported the intent-to-treat effect because the ITT is the most relevant for utility planning, utility operations, and assessing cost-effectiveness. It reflects the impacts of operational issues and overrides on the demand savings that PGE achieved.

The estimate of the treatment effect on the treated (TOT) (sometimes also referred to as the local average treatment effect) indicates the demand savings for homes that receive and execute the setback commands. To estimate the TOT, Cadmus would need to obtain telemetry data from the demand response service providers to determine the percentage of homes that did not execute the demand response setback. We can recover an estimate of the TOT by dividing the ITT estimate by the percentage of homes that executed the setback commands. For example, if the estimate of the ITT effect equals 1 kW per home and we learn that 80% of homes successfully executed the setback, the estimate of the TOT effect equals 1 kW/0.8 = 1.2 kW. This calculation assumes that the 20% of homes that did not receive or execute the setback have zero demand savings during the event. This calculation shows the average demand savings per home for homes that executed the setback.

Data Collection and Preparation

Cadmus collected and prepared several types of data for analysis:

- ***Participant enrollment data***, provided by PGE, tracked enrollment for test group and control group customers. These data included participant name, contact information (such as address), a unique premise identifier (the point of delivery ID), and an enrollment date.
- ***Interval consumption data*** was provided by PGE for all enrolled participants. For post-enrollment periods, these included watt-hour electricity consumption at 15- or 60-minute

intervals, measured using advanced metering infrastructure (AMI) meters. For usage periods prior to enrollment, only hourly data were available.

- ***Local weather data,*** including hourly average temperatures from December 2017 through September 2018 for five National Oceanic and Atmospheric Administration (NOAA) weather stations. Cadmus used zip codes to identify weather stations nearest to each participant's home and merged the weather data with each participant's billing data.
- ***Event data,*** including dates and times of all load control events, were provided by PGE.

The AMI meter data recorded a customer's electricity consumption at 15- or 60-minute intervals and covered every hour of winter and summer. Cadmus aggregated all 15-minute interval consumption data to the customer-hour level and performed standard data-cleaning steps (detailed below) to address duplicate observations, outliers, and missing values.

The weather data were high-frequency, asynchronous temperature and humidity readings from five NOAA weather stations across PGE's service area. Cadmus aggregated the weather data to the hourly level and merged this with the hourly interval consumption data.

Cadmus used the enrollment and participation data to identify customers in the test and control groups, develop survey sample frames, and calculate test opt-out rates. These data provided several key fields for each customer, including the following:

- Assignment to test or control group
- Dates for participant enrollment and un-enrollment date, if applicable
- Customer ID and address
- Service point active status (confirming meter activity)

Robustness checks of the Direct Install test group savings estimates indicate that the estimates were not sensitive to the specific solutions we developed.

Analysis Samples

In cleaning and preparing the AMI meter data, Cadmus identified and addressed several issues:

- Timestamps on some AMI datasets were set to Coordinated Universal Time instead of Pacific Time.
- AMI data were not provided for all customers.
- AMI data were not provided for all customers.
- Net-metering customers' consumption was censored at zero.
- Participants enrolled in multiple programs.
- Participants had large average daily consumption over 300 kWh suggesting they were not residential customers.

Cadmus took the following steps to clean the AMI meter data and prepare for analysis:

- Removed a small number of duplicate interval readings from the data
- Summed 15-minute interval consumption data to obtain hourly interval consumption
- Dropped a small number of outliers and hourly observations missing one or more 15-minute interval readings
- Combined the consumption of meters connected to the same thermostat
- Since all events occurred on weekdays, removed holidays, weekends, and days outside of event seasons
- Adjusted time stamp from end of read period to start of read period
- Dropped one customer with two thermostats assigned to different test groups
- Dropped customers missing all AMI data
- Dropped customers enrolled in multiple programs
- Dropped customers with average daily consumption greater than or equal to 300 kW
- Dropped customers with net-metering data censored at zero

Cadmus excluded a small number of customers from the analysis sample. A customer was excluded from the analysis sample if the customer had any of the following:

- Lacked AMI meter data
- Had multiple thermostats enrolled in the program and these thermostats had been assigned to different groups (test or control). Cadmus did not create assignments for the summer 2018 season
- Appeared in a list of test and control group customers who were rejected from the program for a variety of reasons
- Average daily consumption greater than or equal to 300 kW
- Enrolled in multiple PGE programs

Cadmus excluded net generation customers but did confirm with PGE that the metering data recorded gross demand, not net demand, for electricity. Since the net-metering customers' demand was censored at zero, inclusion in the analysis will introduce bias.

Table A-3 shows attrition of customers from the analysis sample for summer 2019 because of the issues listed above. Each row represents a level of filtering, with the corresponding number of participants assigned to each group after the filter step. Total program participation is the number of unique Service Premise ID*Service Agreement Number permutations within the raw Smart Thermostat participation data obtained from PGE.

Table A-3. Direct Install Final Analysis Sample Attrition – Summer 2019

Filter	Direct Install		Percentage of Total Participating Customers
	Test (N of participants)	Control (N of participants)	
Total Program Participants	**2,856**		**100%**
Multiple Program Enrollments	1,759	1,078	99.33%
Missing AMI Data	1,758	1,076	99.23%
Net Metering Participants*	1,742	1,061	98.14%
Average Daily Consumption > 300 kW	1,740	1,061	98.07%
Final Analysis Sample	**1,740**	**1,061**	**98.07%**

* Note: AMI data for net metering customers were censored at zero when the customer produced more than it consumed; for this reason, net metering customers were removed from the analysis sample.

The final analysis sample includes participants used in the impact estimation and excludes a small number of customers who had two thermostats assigned to different groups, were missing AMI data, or were participants in multiple programs. Additionally, net-metering customers were excluded from the analysis due to the inability to accurately estimate demand savings for these customers. AMI meter data recording net consumption were censored at zero, so it was not possible to measure how much electricity net metering customers supplied to the grid.

Table A-4 shows this final analysis sample by brand.

Table A-4. Direct Install Final Analysis Sample by Brand – Summer 2019

Direct Install	
Brand	Participating Customers (N)
Nest	1,426
ecobee	1,372
Multiple	3
Total	**2,801**

Equivalency Checks of Randomized Test and Control Groups

Cadmus verified that there were no statistically significant differences in consumption between test and control group customers in the final analysis sample on non-event days.

Figure A-1 and Figure A-2 show average consumption by hour on winter 2018/2019 and summer 2019 weekdays, respectively. The average consumption excludes days that were not event days or holidays. The figures also plot the estimated difference and confidence interval for the estimate. The figures demonstrate that the hourly differences between the two groups' consumption were small and statistically insignificant across hours on non-event days.

Figure A-1. Equivalency of Test and Control Groups – Winter 2018/2019

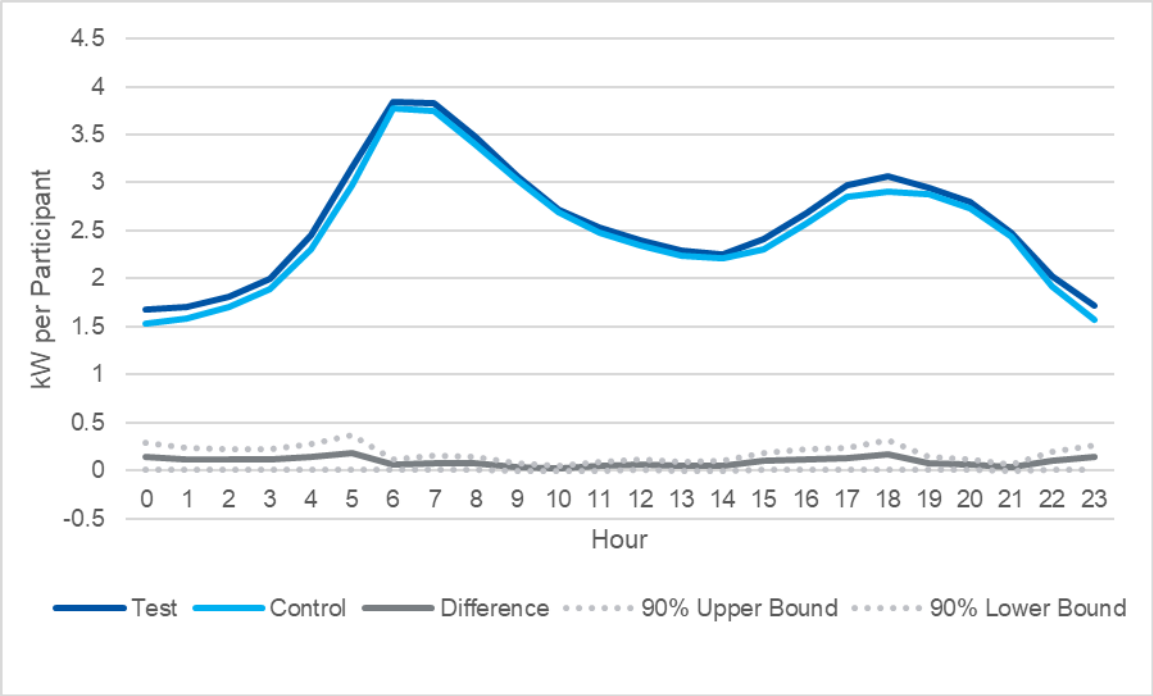
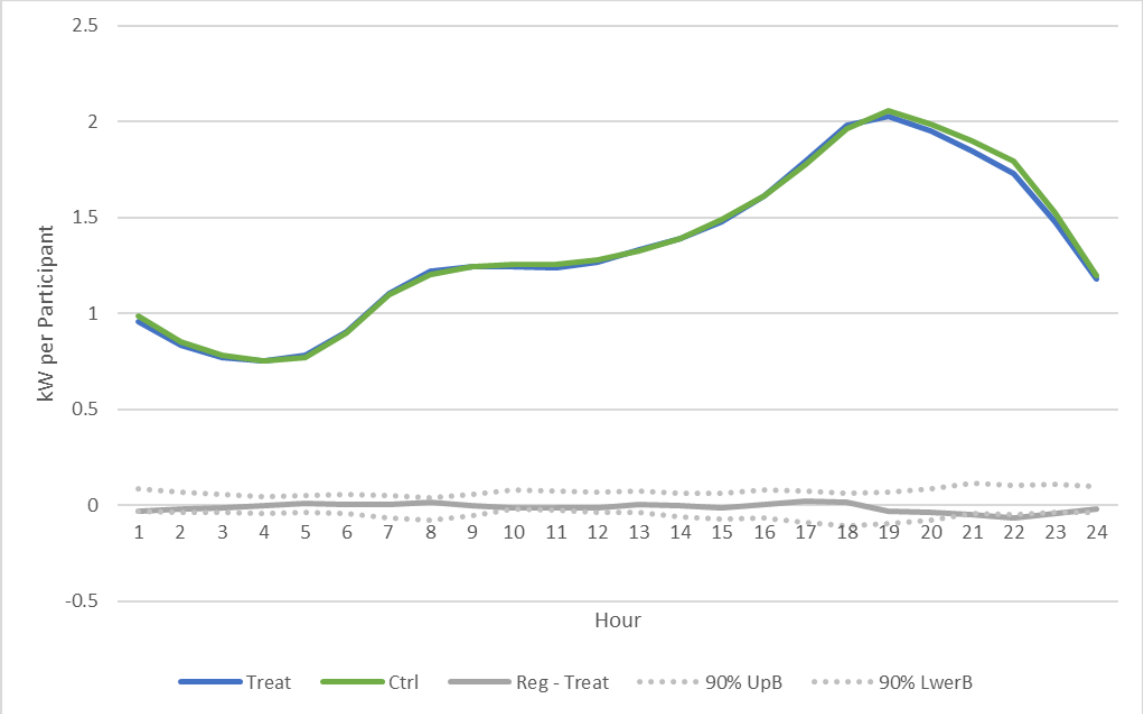


Figure A-2. Equivalency of Test and Control Groups – Summer 2019



Load Impact Analysis

Savings Estimation Approach

Cadmus estimated savings by collecting individual customer AMI interval consumption data and by comparing the demand of customers in the randomized test and control groups during each event hour. We employed panel regression analysis to estimate demand impacts for the two hours before, two or three hours during, and eight hours after each event. In addition to assignment to test or control group, the panel regression controlled for the impacts of hour of the day, the day of the week, weather, and differences between customers in their average demand.

Letting 'i' denote the customer, where i = 1, 2, …, N, and letting 't' denote the hour of the day, where t=1, 2, …, T, the model took the following form:

Equation 1

$$kWh_{it} = \sum_{k=0}^{23} \beta_k Hour_{kt} + \sum_{k=0}^{23} \gamma_k Hour_{kt} * DH_{it} + \sum_{m=1}^{9} \sum_{j=1}^{J} \pi_{mj} I(Event = 1)_{mjt} + \sum_{m=1}^{9} \sum_{j=1}^{3} \theta_{mj} I(Treat = 1)_i * I(Event = 1)_{mjt} + \sum_{m=1}^{9} \sum_{n=1}^{N} \varphi_{mn} I(PostEvent = 1)_{nmt} + \sum_{m=1}^{9} \sum_{n=1}^{N} \delta_{mn} I(Treat = 1)_i * I(PostEvent = 1)_{nmt} + \sum_{m=1}^{9} \sum_{l=1}^{L} \omega_{ml} I(PreEvent = 1)_{mlt} + \sum_{m=1}^{9} \sum_{l=1}^{L} \rho_{ml} I(Treat = 1)_i * I(PreEvent = 1)_{mlt} + \varepsilon_{it}$$

Where:

- kWh_{it} = Electricity consumption in kilowatt-hours of customer 'i' during hour 't'
- $Hour_{kt}$ = Indicator variable for hour of the day; equals 1 if hour 't' is the kth hour of the day, where k=0, 1, 2, …, 23, and equals 0 otherwise
- β_k = Average load impact (kWh/hour) per customer of hour 'k' on customer consumption
- DH_{it} = Heating or cooling degree hour for customer 'i' in hour 't' for a given base temperature
- γ_k = Average effect per customer of a cooling degree hour on customer consumption in hour 'k'
- $I(Event=1)_{mjt}$ = Indicator variable for event hour; equals 1 if hour 't' is the jth hour, j=1,2,…J, where J=2 or 3 depending on event length of event m, m=1, 2, …, 9, and equals 0 otherwise
- π_{mj} = Average load impact (kWh/hour) per customer during hour 'j' of event 'm,' which affects treatment and control group customers
- $I(Treat=1)_i$ = Indicator variable for assignment to treatment group; equals 1 if customer 'i' was randomly assigned to the treatment group and equals 0 otherwise
- θ_{mj} = Average load impact (kWh/hour) per treatment group customer during hour 'j' of event 'm'

φ_{mn} = Average load impact (kWh/hour) per customer during post-event hour 'n' of event 'm,' which affects treatment and control group customers

$I(PostEvent=1)_{nmt}$ = Indicator variable for post-event hour; equals 1 if hour 't' is the nth hour after the event, n=1,2,…,N, of event m, m=1, 2, …, 9, and equals 0 otherwise

δ_{mn} = Average load impact (kWh/hour) per treatment group customer during post-event hour 'n' of event 'm'

ω_{ml} = Average load impact (kWh/hour) per customer during pre-event hour 'l' of event 'm,' which affects treatment and control group customers

$I(PreEvent=1)_{mlt}$ = Indicator variable for pre-event hour; equals 1 if hour 't' is the lth hour before the event, l=1,2,…,L, of event m, m=1, 2, …, 9, and equals 0 otherwise

ρ_{ml} = Average load impact (kWh/hour) per treatment group customer during pre-event hour 'l' of event 'm'

ε_{it} = Random error for customer 'i' in hour 't'

Cadmus estimated the models by ordinary least squares (OLS) and clustered the standard errors on customers to account for correlations over time in customer demand. The model included all non-holiday weekdays days in June, July, or August 2019 for summer and January and February for winter. We estimated alternative model specifications to test the estimates' robustness to specification changes and found that the results were very robust.

Staff Interviews

In November 2018 and October 2019, Cadmus conducted interviews with the PGE program manager, the CLEAResult implementation staff, and the Resideo implementation staff. We did not interview the Nest implementation staff but did email Nest about its Rush Hour Rewards program. The interviews and emails focused on documenting how the program operated during the winter and summer event seasons, any implementation challenges, and any successes or lessons learned to date. Cadmus used information obtained from the interviews to design the customer surveys and review the logic model.

Customer Surveys

Cadmus designed and administered four online customer surveys:

- Direct Install recruitment survey (fielded in two waves in December 2018 and May 2019)
- Direct Install winter 2018/2019 experience survey (fielded May 2019)
- Direct Install summer 2019 event survey (fielded August 2019)
- Direct Install summer 2019 experience survey (fielded in November 2019)

Survey Design

Cadmus designed the **recruitment survey** to provide PGE with marketing, recruitment, and customer engagement insights. The survey asked recent program enrollees how they heard about the program,

their motivations for enrolling, feedback on the installation process, awareness of demand response, and satisfaction.

To provide PGE with timely customer feedback, Cadmus administered the **event survey** with test group participants during summer 2019, specifically, 24 hours after the August 6 event. The event survey asked test group participants about their event awareness, thermal comfort, reasons for overriding the load control, and satisfaction specific to this event. We did not administer an event survey for winter 2018/2019.

After each event season, Cadmus administered the **experience surveys** to test and control group participants. The experience surveys asked test group participants about their event awareness, thermal comfort, reasons for overriding the load control, and satisfaction. Control group customers were asked questions only about satisfaction.

All of these surveys took respondents less than seven minutes to complete. Respondents did not receive an incentive for completing the surveys.

Survey Sampling and Response Rates

Based on the number of participants for that season for each program, Cadmus either contacted the census or a random sample of program participants with an active PGE account. On average, the four surveys achieved a high response rate of 34%, higher than the BYOT response rate of 28%. Table A-5 through Table A-8 show the number of participants contacted and response rate for the four surveys.

Table A-5. Direct Install: Recruitment Survey Samples and Response Rates

	Population	Original Sample Frame*	Adjusted Sample Frame (Successfully Emailed)	Number of Completes (Achieved Sample)	Response Rate
By Brand					
Nest	1,024	1,024	1,020	368	36%
ecobee	505	505	469	179	38%
Overall	**1,529**	**1,529**	**1,489**	**547**	**37%**

* Cadmus selected the census of records with an active PGE account for the survey.

Table A-6. Direct Install: Winter 2018/2019 Experience Survey Samples and Response Rates

	Population	Original Sample Frame*	Adjusted Sample Frame (Successfully Emailed)	Number of Completes (Achieved Sample)	Response Rate
By Assignment					
Test	800	800	775	250	32%
Control	484	484	470	161	34%
By Brand					
Nest	718	718	714	225	32%
ecobee	561	561	526	184	35%
Unreported	5	5	5	2	40%
By HVAC System					
Electric Forced-Air Furnace	255	255	252	64	25%
Heat Pump	1029	1029	993	347	35%
Overall	**1,284**	**1,284**	**1,245**	**411**	**33%**

* Cadmus selected a census of records with an active PGE account for the survey.

Table A-7. Direct Install: Summer 2019 Event Survey Samples and Response Rates

	Population	Original Sample Frame*	Adjusted Sample Frame (Successfully Emailed)	Number of Completes (Achieved Sample)	Response Rate
By Brand					
Nest	764	520	516	171	33%
ecobee	723	520	481	176	37%
Overall	**1,487**	**1,040**	**997**	**347**	**35%**

* Cadmus selected a random sample of 1,040 test group records stratified by brand for the survey.

Table A-8. Direct Install: Summer 2019 Experience Survey Samples and Response Rates

	Population	Original Sample Frame*	Adjusted Sample Frame (Successfully Emailed)	Number of Completes (Achieved Sample)	Response Rate
By Assignment					
Test	1,815	800	795	233	29%
Control	1,112	708	705	240	34%
By Brand					
Nest	1,491	819	815	257	32%
ecobee	1,436	689	685	216	32%
By HVAC System					
Central Air Conditioner	828	512	511	154	30%
Heat Pump	2,099	996	989	319	32%
Overall	**2,927**	**1,508**	**1,500**	**473**	**32%**

* Cadmus selected a random sample of 1,508 records stratified by assignment for the survey.

Survey Data Analysis

Cadmus compiled frequency outputs, analyzed open-end comments according to thematic similarities, and ran statistical tests to determine whether survey results differed significantly between subpopulations. Specifically, Cadmus compared survey results by assignment and by brand at the 90% confidence level (or $p \leq 0.10$ significance level). Survey findings from the experience surveys are presented in the Customer Experience sections. Survey findings from the recruitment survey are presented in the Implementation Delivery section.

The event survey findings are presented in *Appendix B*. This appendix explains how Cadmus prepared the AMI meter data and handled ineligible customers and account closures.

Appendix B. Additional Impact Findings

This appendix provides additional details about the pre-event, event, and post-event demand impacts, including point estimates of demand savings by event hour and event-day conservation effect, for the summer and winter seasons.

Plots of Event Day Unconditional Mean Test and Control Group Demand

Figure B-1 through Figure B-4 show the unconditional mean demand per customer for the randomized test and control group customers for winter morning and afternoon events and summer afternoon events. The differences between the test and control group mean demand are also depicted and illustrate the event impacts before any modeling was undertaken. The impacts of the demand response events on customer demand are evident and corroborate the regression analysis findings that the events reduced demand.

Figure B-1. Average Consumption by Hour – Winter 2018/2019 (Morning Event)

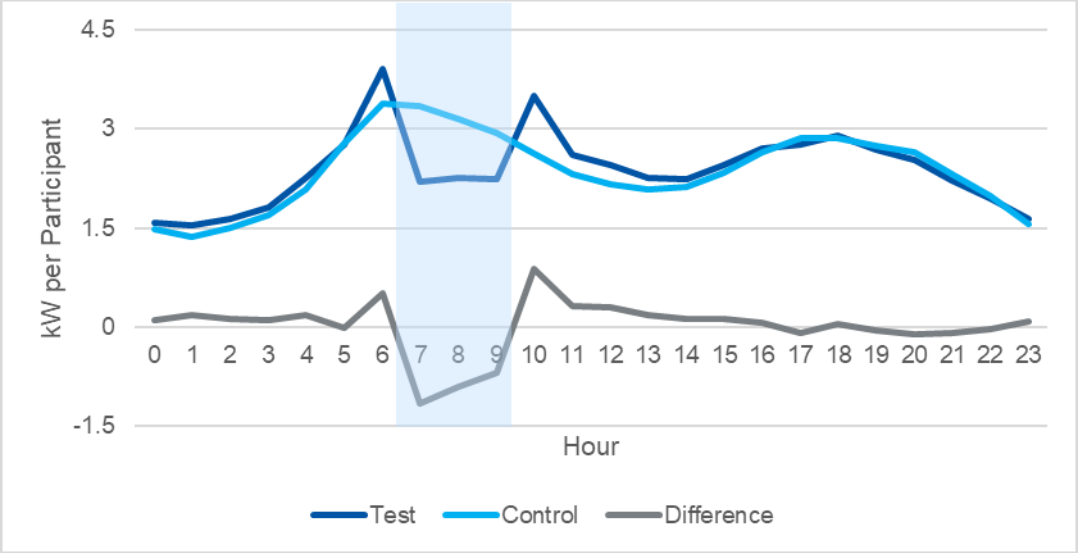


Figure B-2. Average Consumption by Hour – Winter 2018/2019 (Afternoon Events)

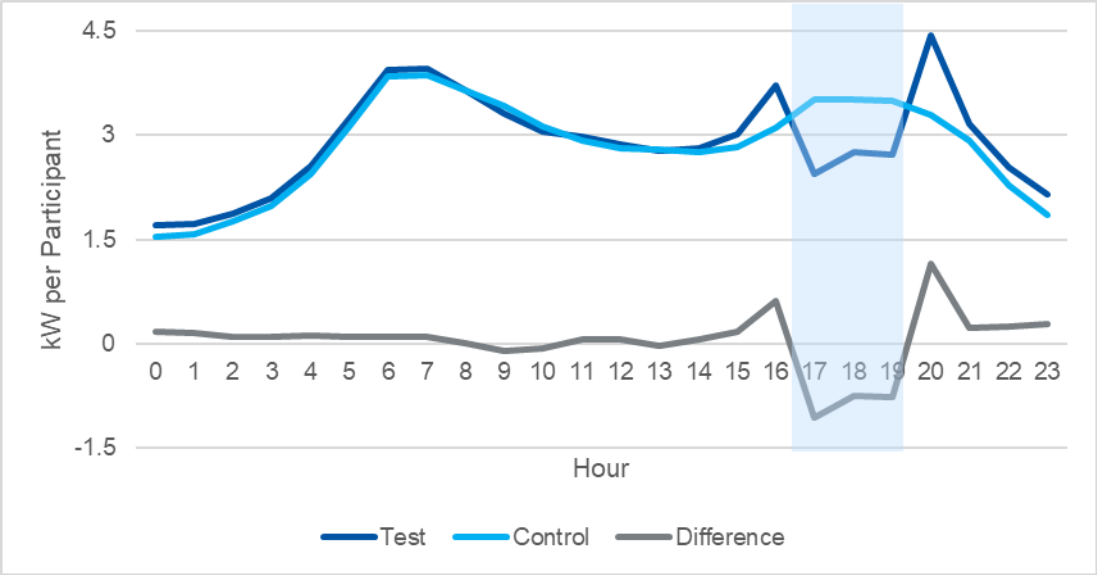


Figure B-3. Average Consumption by Hour – Summer 2019 (4 p.m. to 7 p.m. Events)

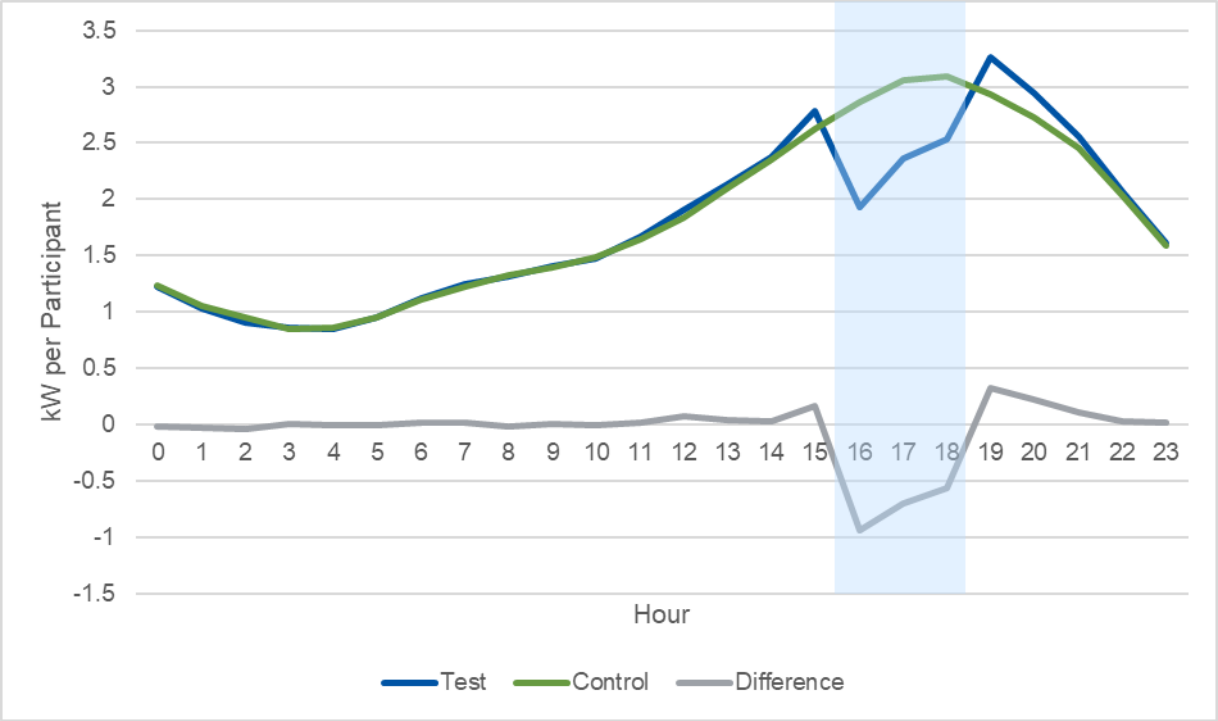
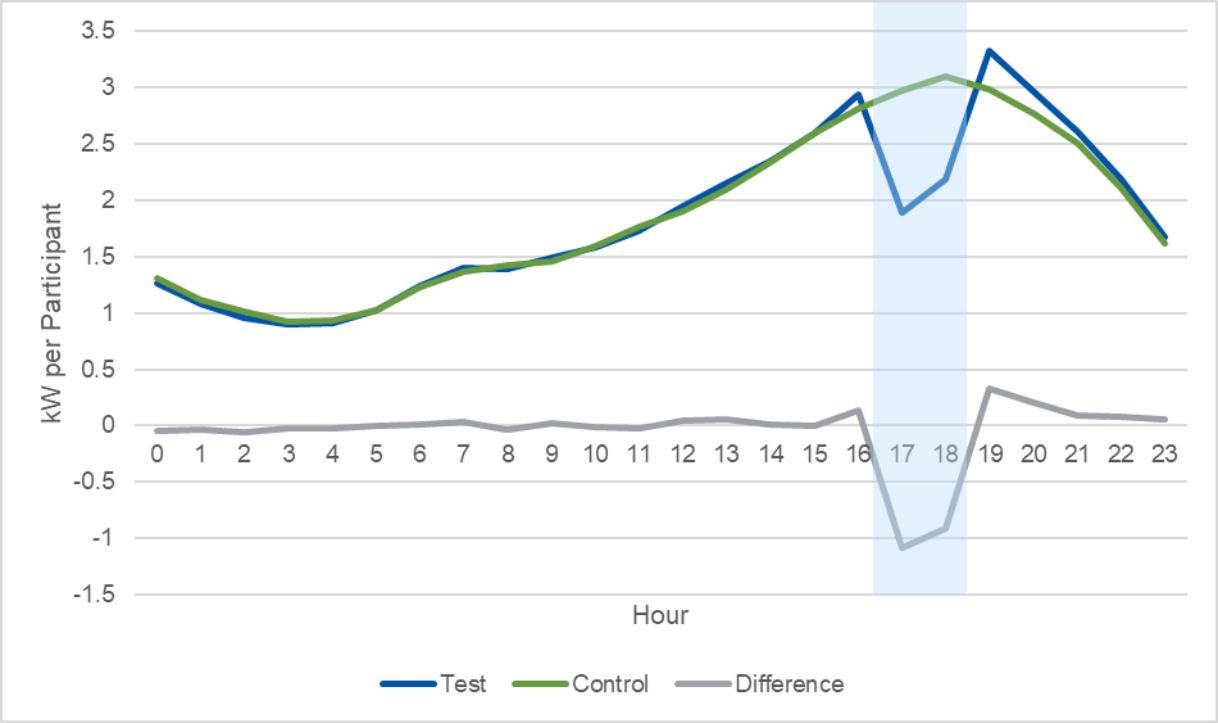


Figure B-4. Average Consumption by Hour – Summer 2019 (5 p.m. to 7 p.m. Events)



Load Impact Estimate Graphs by Program, Season, and Event Start Time

Figure B-5 and Figure B-6 present estimates of the average load impacts per hour per test group participant, by event start time for the winter 2018/2019 season.

Both figures show the mean metered demand per customer and estimates of the per-customer average load impacts, model predicted demand, and the counterfactual baseline demand. The estimated load impact was obtained from the regression model. Meter kW is customer demand at the AMI meter. Model predicted demand is the customer load predicted by the regression model. The baseline is the counterfactual demand under the assumption that the event had not occurred. The model predicted and counterfactual will only differ, if at all, during the one hour before the event, the event hours, and the eight hours after the event.

Figure B-5. Average Estimated Demand Impacts – Winter 2018/2019 (Morning Event)

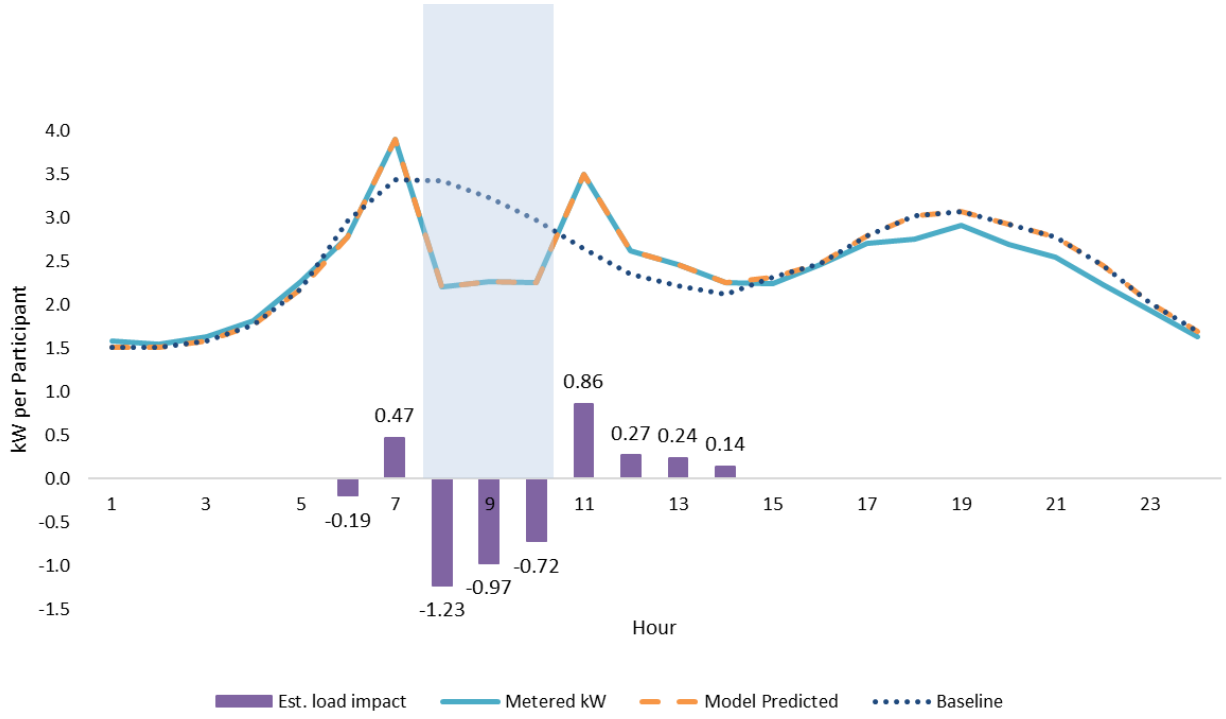


Figure B-6. Estimated Demand Impacts– Winter 2018/2019 (Afternoon Events)

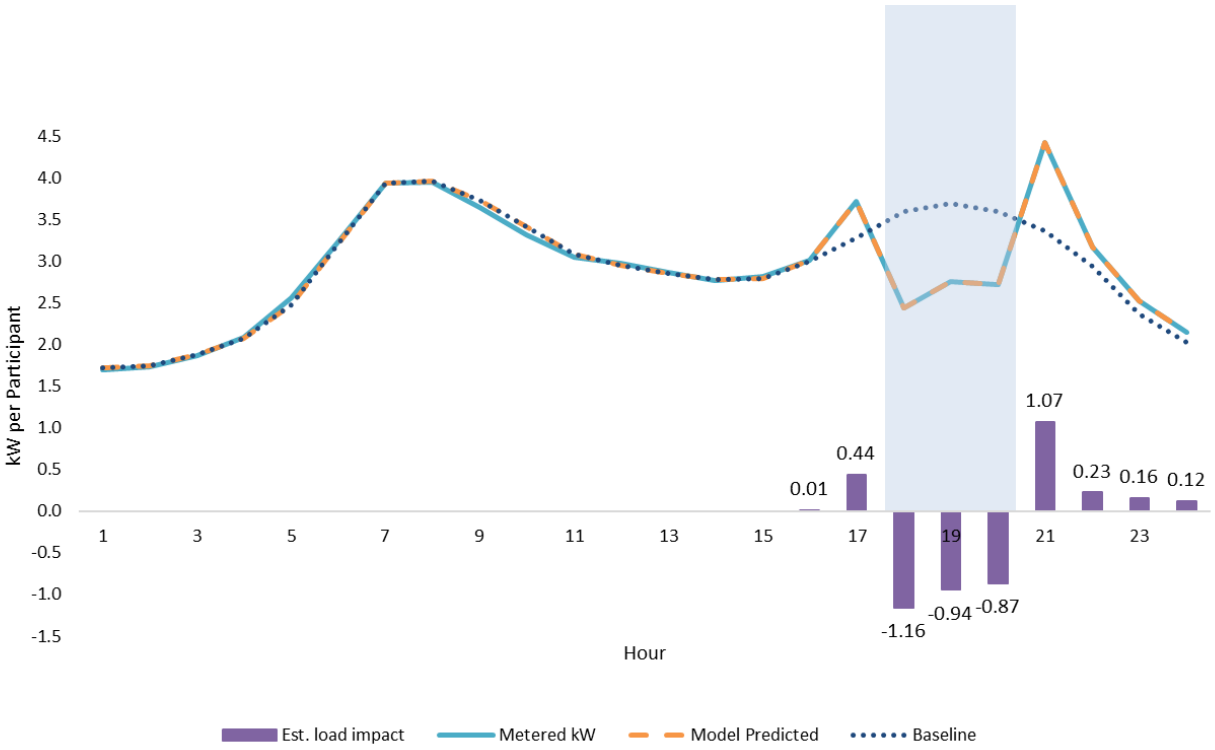


Figure B-7 through Figure B-9 present estimates of the average load impacts per hour per test group participant, by event start time for the summer 2019 season.

Figure B-7. Estimated Demand Impacts– Summer 2019 (4 p.m. to 7 p.m. Events)

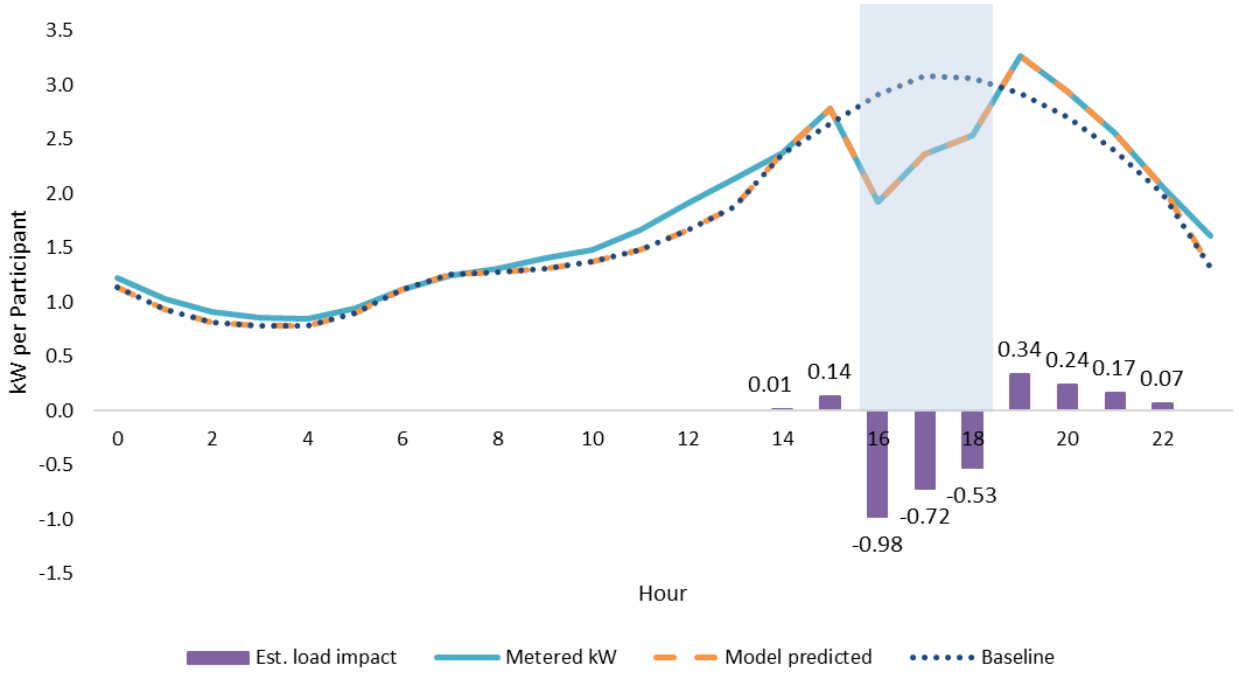


Figure B-8. Estimated Demand Impacts– Summer 2019 (5 p.m. to 7 p.m. Events)

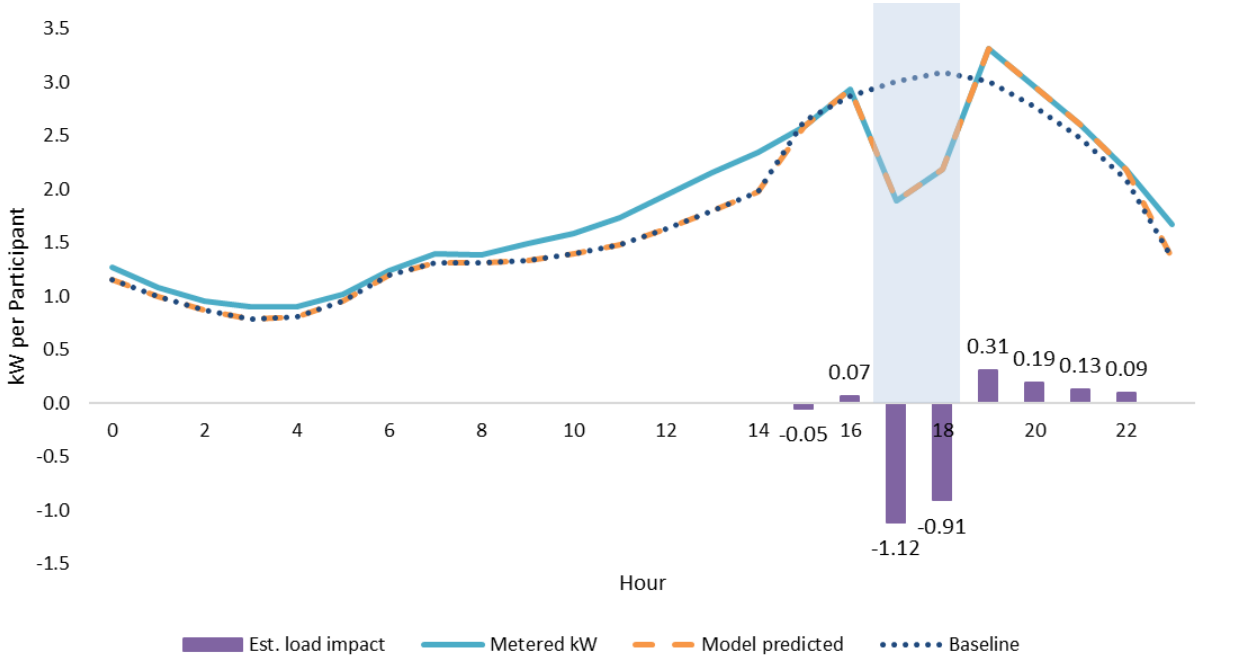


Figure B-9. Estimated Demand Impacts Per Participant – Summer 2019 (5 p.m. to 6 p.m. Event)

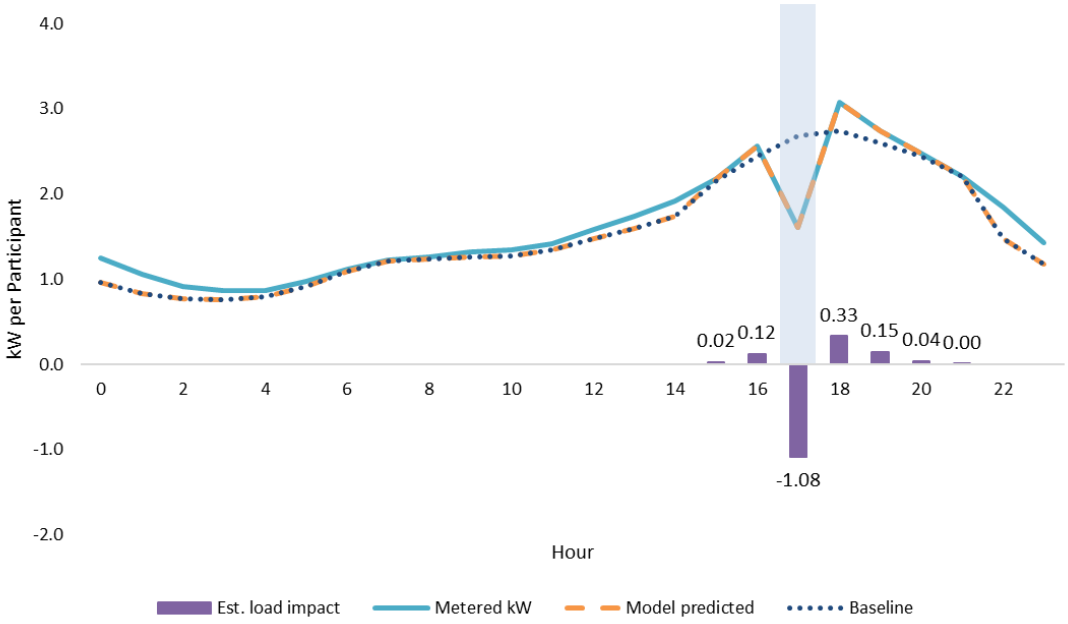


Figure B-10 and Figure B-11 provide impacts for each event in the winter 2018/2019 and summer 2019 seasons, respectively.

Figure B-10. Average Daily Load Impacts per Participant by Event – Winter 2018/2019

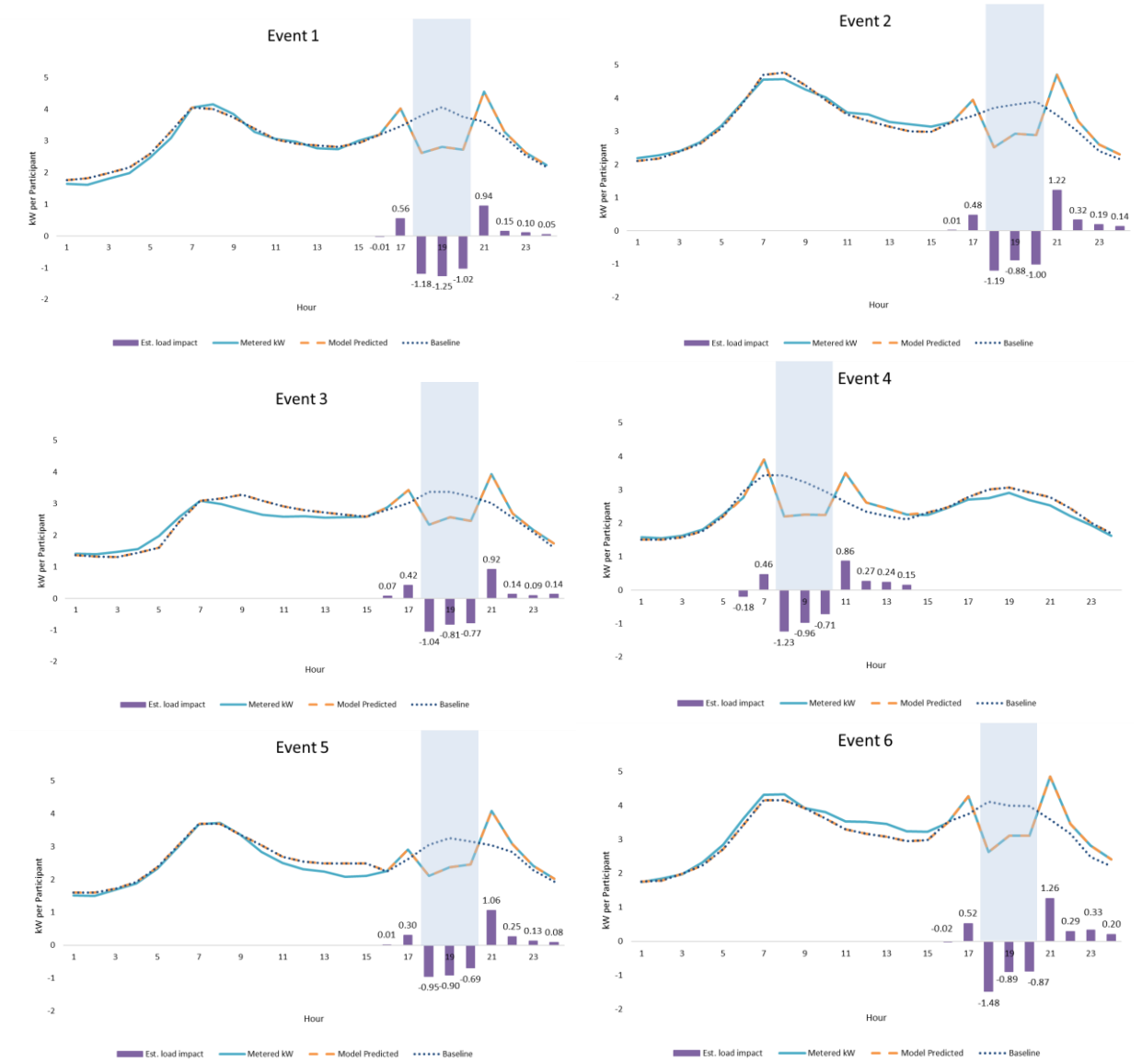
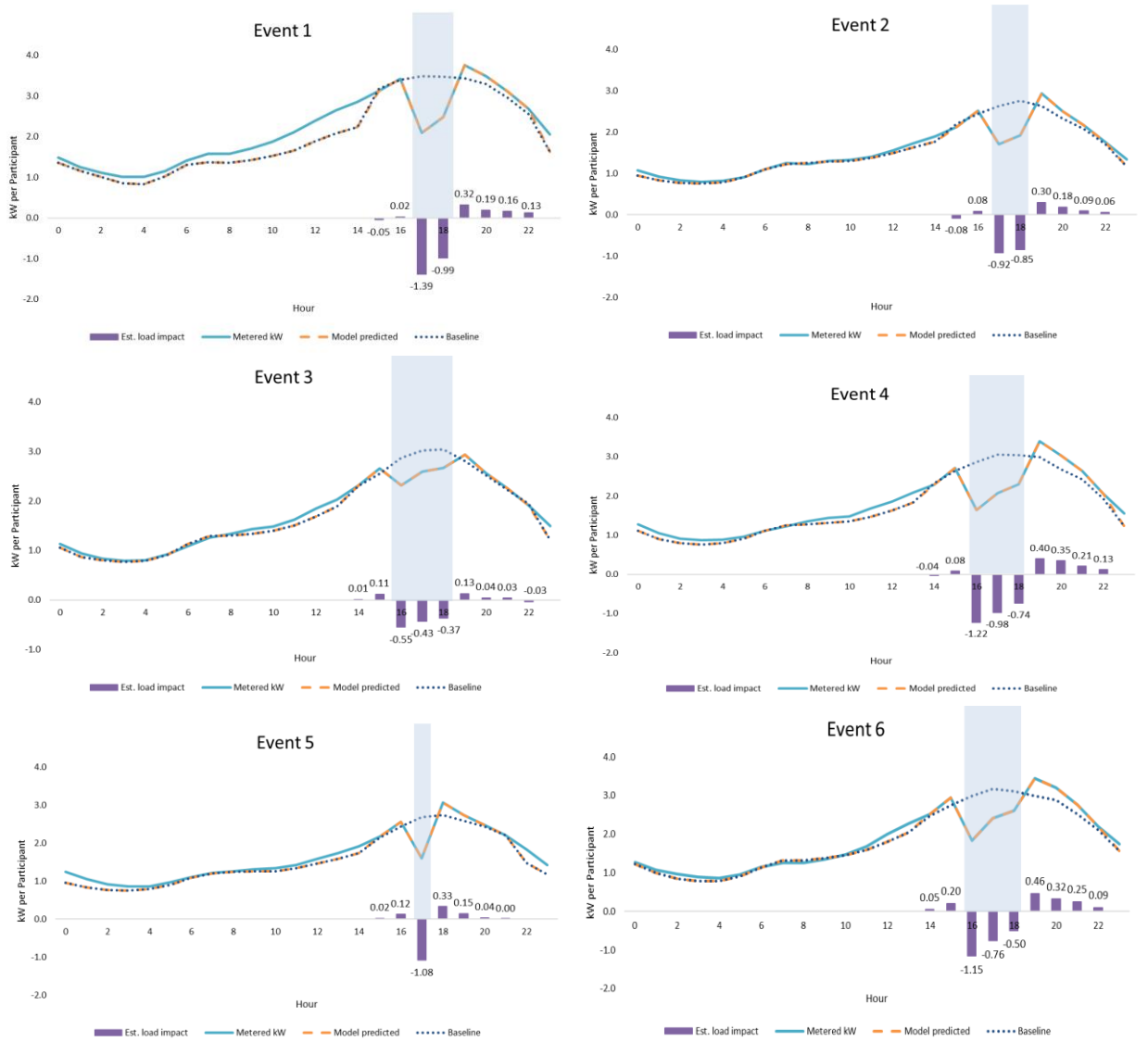


Figure B-11. Average Daily Load Impacts per Participant by Event – Summer 2019



Event Impact Estimates Tables

Table B-1 and Table B-2 provide the estimated load impacts and summaries for Direct Install winter 2018/2019 and summer 2019 events by start time, respectively. Table B-3 and Table B-4 show these estimated load impacts for each event.

Table B-1. Direct Install Demand Reduction by Event by Start Time – Winter 2018/2019

Event Hour	7 a.m. to 10 a.m. (1 event)	5 p.m. to 8 p.m. (5 events)
Pre-Event Hour 1	0.47***	0.44***
Event Hour 1	**-1.12*** **	**-1.16*** **
Event Hour 2	**-0.97*** **	**-0.94*** **
Event Hour 3	**-0.72*** **	**-0.87*** **
Post-Event Hour 1	0.86***	1.07***
Post-Event Hour 2	0.27***	0.23***
Post-Event Hour 3	0.24***	0.16***
Post-Event Hour 4	0.14	0.12***
Event Avg. Demand Impact (kW)	**-0.97**	**-0.99**
Event Hour Min. Demand Impact (kW)	**-0.71**	**-0.69**
Event Hour Max. Demand Impact (kW)	**-1.23**	**-1.48**
Avg. Energy Impact (kWh)	**-0.95**	**-0.95**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-2. Direct Install Demand Reduction by Event by Start Time – Summer 2019

Event Hour	4 p.m. to 7 p.m. (5 events)	5 p.m. to 7 p.m. (4 events)
Pre-Event Hour 1	0.14***	0.07
Event Hour 1	**-0.98*** **	**-1.12*** **
Event Hour 2	**-0.72*** **	**-0.91*** **
Event Hour 3	**-0.53*** **	**N/A**
Post-Event Hour 1	0.34***	0.31***
Post-Event Hour 2	0.24***	0.19***
Post-Event Hour 3	0.17***	0.13***
Post-Event Hour 4	0.07**	0.09***
Event Avg. Demand Impact (kW)	**-0.74**	**-1.01**
Event Hour Min. Demand Impact (kW)	**-0.37**	**-0.85**
Event Hour Max. Demand Impact (kW)	**-1.22**	**-1.39**
Avg. Energy Impact (kWh)	**-1.28**	**-1.23**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-3. Direct Install Demand Reduction by Event – Winter 2018/2019

Event Hour	Events					
	1	2	3	4	5	6
Event Start Time	5:00 p.m.	5:00 p.m.	5:00 p.m.	7:00 a.m.	5:00 p.m.	5:00 p.m.
Pre-Event Hour 1	0.56***	0.48***	0.42***	0.46***	0.30***	0.52***
Event Hour 1	**-1.18*** **	**-1.19*** **	**-1.04*** **	**-1.23*** **	**-0.95*** **	**-1.48*** **
Event Hour 2	**-1.25*** **	**-0.88*** **	**-0.81*** **	**-0.96*** **	**-0.90*** **	**-0.89*** **
Event Hour 3	**-1.02*** **	**-1.00*** **	**-0.77*** **	**-0.71*** **	**-0.69*** **	**-0.87*** **
Post-Event Hour 1	0.94***	1.22***	0.92*	0.86***	1.06***	1.26***
Post-Event Hour 2	0.15	0.32***	0.14	0.27***	0.25***	0.29***
Post-Event Hour 3	0.10	0.19**	0.09	0.24***	0.13	0.33***
Post-Event Hour 4	0.05	0.14*	0.14**	0.15*	0.08	0.20***
Event Avg. Demand Impact (kW)	**-1.15**	**-1.02**	**-0.87**	**-0.97**	**-0.85**	**-1.08**
Avg. Energy Impact (kWh)	**-1.65**	**-0.72**	**-0.91**	**-0.92**	**-0.72**	**-0.64**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4.

Table B-4. Direct Install Demand Reduction by Event – Summer 2019

Event Hour	Events					
	1	2	3	4	5	6
Event Start Time	5:00 p.m.	5:00 p.m.	4:00 p.m.	4:00 p.m.	5:00 p.m.	4:00 p.m.
Pre-Event Hour 1	0.02	0.08	0.11*	0.08	0.12**	0.20***
Event Hour 1	**-1.39*** **	**-0.92*** **	**-0.55*** **	**-1.22*** **	**-1.08*** **	**-1.15*** **
Event Hour 2	**-0.99*** **	**-0.85*** **	**-0.43*** **	**-0.98*** **	**N/A**	**-0.76*** **
Event Hour 3	**N/A**	**N/A**	**-0.37*** **	**-0.74*** **	**N/A**	**-0.50*** **
Post-Event Hour 1	0.32***	0.30***	0.13**	0.40***	0.33***	0.46***
Post-Event Hour 2	0.19**	0.18***	0.04	0.35***	0.15**	0.32***
Post-Event Hour 3	0.16*	0.09*	0.03	0.21***	0.04	0.25***
Post-Event Hour 4	0.13	0.06	-0.03	0.13***	0.00	0.09*
Event Avg. Demand Impact (kW)	**-1.19**	**-0.88**	**-0.45**	**-0.98**	**-1.08**	**-0.80**
Avg. Energy Impact (kWh)	**-1.56**	**-1.06**	**-1.07**	**-1.77**	**-0.44**	**-1.09**

Notes: Estimates obtained from Cadmus panel regression analysis of customer hourly electricity demand. ***, **, * denotes the estimate is statistically significant at the 1%, 5%, and 10% levels. Energy impacts were estimated by summing the load impacts across the pre-event hour 1, event hours, and post-event hours 1 through 4 (demonstrating significance).

Appendix C. Direct Install Event Survey Results

Table C-1 provides the summer 2019 event survey results for Direct Install. PGE called back-to-back events on August 5 and 6, 2019. Cadmus surveyed test group customers the day after the August 6, 2019, event.

Table C-1. Direct Install Summer 2019 Event Survey Results

Survey Topic	Test Group
General event awareness (n_w=345)	68% noticed events
Pre-event notification (n_w=347)	41% remembered being notified prior to event
Comfort before event (n_w=272)	85% comfortable (6-10 rating)
Comfort during event (n_w=289)	65% comfortable (6-10 rating)
Overriding event (n_w=346)	13% changed settings, mostly due to thermal discomfort
Smart thermostat satisfaction (n_w=342)	89% satisfied (6-10 rating) 64% delighted (9-10 rating)
Program satisfaction (n_w=335)	85% satisfied (6-10 rating) 56% delighted (9-10 rating)
Satisfaction with PGE (n_w=343)	95% satisfied (6-10 rating) 63% delighted (9-10 rating)

Note: Survey data were weighted by brand, as indicated by the notation n_w.

Appendix D. Survey Instruments

CADMUS

PGE Direct Install

2018 Recruitment Survey

Research Topics	Corresponding Question Numbers
Marketing	A1
Motivations and barriers	B1-B3
Installation and education	C1-C7
Satisfaction with device	D1-D2
Awareness of demand response	E1-E2
Satisfaction with PGE	F1

Target Audience: Customers who enrolled in the Thermostat Direct Install Program offered between September 4, 2018 and April 30, 2019.

Expected number of completions: As many as possible.

Estimated timeline for fielding: Cadmus will launch several recruitment surveys, the first wave in late November to early December 2018 and the second wave in early May. Depending on initial response rate, one survey reminder email will be sent 5-7 days after initial email.

Variables to be Pulled into Survey

- Email
- FirstName
- LastName
- SP ID
- Brand (Nest or Ecobee)
- System

Email Invitation

To: [EMAIL]
From: Portland General Electric
Subject: Welcome to PGE's Smart Thermostat Program! Have a few minutes?

Dear [FIRSTNAME AND LASTNAME],

Thank you for joining PGE's Smart Thermostat Program. Would you take a moment to answer a few questions about your thermostat installation experience and program enrollment? We value your input because we use it to improve PGE programs. Your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

Sincerely,
Will Miller
Product Manager, Portland General Electric

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take 5 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

A. Marketing

A1. How did you hear about PGE's Smart Thermostat Program?
1. Email from PGE
2. Direct mail from PGE
3. Don't know

B. Motivations and Barriers

B1. Prior to joining the PGE's Smart Thermostat Program, were you familiar with what a smart thermostat was?
1. Yes
2. No

B2. Why did you join PGE's Smart Thermostat Program? Please select all that apply. [RANDOMIZE ORDER 1-10]
1. To get a free/discounted smart thermostat
2. To save on energy bills
3. To save energy
4. To help avoid power shortages/outages

5. To reduce the need to build new power plants
6. To help the environment
7. My family/friend/colleague recommended it
8. Had a positive experience with other PGE programs
9. To have automated heating/cooling temperature setting
10. Want the latest smart device technology
11. Other [Please describe:_____]
12. Don't know [EXCLUSIVE ANSWER]

B3. When deciding whether to enroll in PGE's Smart Thermostat Program, did you experience the following? Please select Yes or No for each statement.
[RESPONSE CHOICES: 1=YES, 2=NO] [RANDOMIZE ORDER A-H]

A. I had concerns about letting someone into my home to install the smart thermostat
B. I needed more information about the program
C. I wasn't sure I could operate a smart thermostat
D. I wasn't sure I wanted a smart thermostat
E. I felt the program might inconvenience my household
F. I felt the program might make my home feel uncomfortable
G. I had concerns about how my thermostat data would be used
H. I had concerns about giving PGE control of my smart thermostat

C. Installation and Education

C1. Do you agree or disagree with the following statements about your smart thermostat installation? [RESPONSE CHOICES: 1=AGREE, 2=DISAGREE, 3=DON'T KNOW] [RANDOMIZE ORDER FOR ITEMS A-E]

A. Scheduling the installation appointment was easy
B. I didn't wait long from the day I booked the appointment to the day of installation
C. I received clear communication about the appointment
D. The contractor arrived at my house on time
E. The contractor was professional and courteous

C2. Your contractor should have explained to you how to use your smart thermostat. How clear was the contractor's explanation on this?

1. Very clear
2. Somewhat clear
3. Not too clear
4. Not at all clear
5. Contractor did not explain
6. Don't know

C3. Please rate your overall satisfaction with the installation experience.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

[ASK IF C3 RATING < 6]

C4. Please tell us why you were less than satisfied with the installation. [OPEN-END TEXT ENTRY]

C5. How easy or difficult was it to learn how to use your smart thermostat?

1. Very easy
2. Somewhat easy
3. Somewhat difficult
4. Very difficult
5. Don't know

[ASK IF C5=2, 3, OR 4]

C6. What was difficult about your smart thermostat? [OPEN-END TEXT ENTRY]

C7. Your contractor should have left you a one-page pamphlet on how PGE's Smart Thermostat Program works. How clear was the pamphlet's information?

1. Very clear
2. Somewhat clear
3. Not too clear
4. Not at all clear
5. Did not review the pamphlet from PGE
6. Don't know

D. Satisfaction with Device

D1. How satisfied are you with your smart thermostat?

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

[ASK IF D1 RATING < 6]

D2. Please tell us why you are less than satisfied with the smart thermostat. [OPEN-END TEXT ENTRY]

E. Awareness of Demand Response

E1. There are specific times of the day when the demand for electricity is at its highest, especially during the summer and winter. Before joining the program, were you aware of this high electricity demand?

1. Yes
2. No

E2. Before joining the program, were you aware that smart thermostats can connect with PGE to shift electricity consumption from times when electricity demand is at its highest?

1. Yes
2. No

F. Satisfaction with PGE

F1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!

CADMUS

PGE Direct Install

Winter 2018-19 Experience Survey

Research Topics	Corresponding Question Numbers
Event awareness	A1-A5
Event participation	B1-B3
Thermal comfort	C1-C5
Satisfaction with program and thermostat	D1-D4
Satisfaction with PGE	E1

Target Audience: Treatment (test) and control group customers with a Nest or Ecobee smart thermostat who are enrolled in the Direct Install Smart Thermostat Program

Expected number of completions: However many over a 10-14 day fielding period

Estimated timeline for fielding: Early March 2019. One survey reminder email may be sent 5-7 days after initial email, depending on the number of completes.

Variables to be Pulled into Survey

- Email
- Name
- SPID
- Assignment (Treatment or Control)
- Brand
- HVAC System (Cooling or Heating/Cooling)

Email Invitation

To: [EMAIL]
From: Portland General Electric
Subject: How was PGE's Smart Thermostat Program?

Dear [FIRSTNAME AND LASTNAME],

Thank you for participating in PGE's Smart Thermostat Program during this recent winter. Your smart thermostat worked with PGE to shift your electricity consumption from when demand for electricity was highest. Would you take a moment to answer a few questions about your experience with the program? We value your input because we use it to improve PGE programs. Your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

Sincerely,
Will Miller
Program Manager, Portland General Electric

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take about 5 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

[ASK SECTION A TO TREATMENT ONLY]

A. Event Awareness

A1. Your smart thermostat works with PGE to shift electricity consumption from times when demand for electricity is highest. How many high demand events did you notice this past winter?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO B1]
3. Don't know

A2. Do you recall being notified of high demand events prior to their occurrence?

1. Yes
2. No

[ASK IF 0=1]

A3. How did you receive notification about the high demand events? Please select all that apply. [RANDOMIZE ORDER 1-3]

1. Notification from PGE
2. Notification from smart thermostat app
3. Display on smart thermostat
4. Other [Please describe:_____]
5. Don't know [EXCLUSIVE ANSWER]

A4. On the days of high demand events, were you aware that the events were happening?

1. Yes
2. No

[ASK IF A4=1]

A5. How did you know that the events were happening? Please select all that apply. [RANDOMIZE ORDER 1-4]

1. Display on smart thermostat
2. Notification from smart thermostat app
3. Noticed warm air was cycling on and off
4. Noticed a temperature change
5. Other [Please describe:_____]
6. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION B TO TREATMENT ONLY]

B. Event Participation

B1. About how many high demand events did you participate in this past winter where you did not override the thermostat settings during the events?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO C1]
3. Don't know

B2. How easy or difficult was it to participate in the events?

1. Very easy
2. Somewhat easy
3. Somewhat difficult
4. Very difficult
5. Don't know

[ASK IF B2=3 OR 4]

B3. What made it difficult to participate in the events? Please select all that apply. [RANDOMIZE ORDER 1-6]

1. Other household members controlling the thermostat
2. The timing of the events
3. Notifications were not early enough
4. Health/medical reasons
5. Having guests or visitors around
6. Not understanding how the program works
7. Other [Please describe:_____]
8. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION C TO TREATMENT ONLY]

C. Thermal Comfort

C1. Overall this past winter, how comfortable was the interior temperature of your home a few hours **before** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. I was not at home
13. Don't know

C2. How often did you notice a change in your home's interior temperature **during** the high demand events?

1. Always noticed
2. Sometimes noticed
3. Never noticed
4. I was not at home for any events [SKIP TO **Error! Reference source not found.**]

C3. Overall this past winter, how comfortable was the interior temperature of your home **during** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. Don't know

C4. Did you or someone in your household make changes to the thermostat settings during any of the winter events?

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

[ASK IF C4=1]

C5. Why did you or someone in your household change the thermostat settings during the events? [OPEN END TEXT ENTRY]

[ASK SECTION D TO TREATMENT AND CONTROL]

D. Satisfaction with Program and Thermostat

D1. Please rate your overall satisfaction with PGE's Smart Thermostat Program.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8

10. 9
11. 10 – Extremely satisfied
12. Don't know

D2. Please tell us why you gave that rating for overall satisfaction. [OPEN END TEXT ENTRY]

D3. Please rate your overall satisfaction with the smart thermostat.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D4. Please tell us how PGE can improve the Smart Thermostat Program. [OPEN END TEXT ENTRY]

D5. How motivated are you to participate in future event seasons?

1. 0 – Extremely unmotivated
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely motivated
12. Don't know

[ASK SECTION E TO TREATMENT AND CONTROL]

E. Satisfaction with PGE

E1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!

CADMUS

PGE Direct Install

Summer 2019 Event Survey

Research Topics	Corresponding Question Numbers
Event awareness	A1-A4
Thermal comfort	B1-B5
Satisfaction with program and thermostat	C1-C3
Satisfaction with PGE	D1-D2

Target Audience: Treatment (test) group customers enrolled in the Thermostat Direct Install Program's 2019 summer season.

Expected number of completions: As many as possible over a 5-day fielding period

Estimated timeline for fielding: Launch the survey the morning after an event (7am PT). One survey reminder email may be sent a few days later depending on the number of completes.

Variables to be Pulled into Survey

- EMAIL
- FIRSTNAME
- LASTNAME
- ASSIGNMENT = Treatment
- BRAND = Nest or Ecobee
- SYSTEM = AC or HP
- PERSONA = Big Impactors, Borderliners, Fast Growers, Low Engagers, Middle Movers or Null
- TBSTATUS = In Testbed or Out Testbed
- SUBSTATION

Email Invitation

To: [EMAIL]
From: Cadmus on behalf of PGE
Subject: How was PGE's Smart Thermostat Program?

Dear [FIRSTNAME AND LASTNAME],

Thank you for participating in PGE's Smart Thermostat Program. It has been hot and demand for electricity to cool PGE customer homes has been higher than normal. On Tuesday, your smart thermostat worked with PGE to reduce your electricity consumption when PGE customer demand for electricity was highest. Would you take a moment to answer a few questions about Tuesday's high

demand event? We value your input because we use it to improve PGE programs. Your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

If you have any questions about this survey or any difficulties taking the survey, please contact Masumi Izawa at Cadmus, the research firm conducting this survey on PGE's behalf. You can reach her at (503) 467-7115 or masumi.izawa@cadmusgroup.com.

Sincerely,
Will Miller
Program Manager, Portland General Electric

> Follow the link to opt out of future survey emails:
> ${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take 3 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

A. Event Awareness

A1. Your smart thermostat works with PGE to shift electricity consumption from times when demand for electricity is highest. Did you notice Tuesday's high demand event between 5PM and 6PM?

1. Yes
2. No

[ASK IF **Error! Reference source not found.**=1]

A2. How did you notice the event was happening? Please select all that apply. [RANDOMIZE ORDER 1-4]

1. Display on smart thermostat
2. Notification from smart thermostat app
3. Noticed cool air was cycling on and off
4. Noticed a temperature change
5. Other [Please describe:_____]
6. Don't know [EXCLUSIVE ANSWER]

A3. Do you recall being notified of Tuesday's high demand event prior to its occurrence?

1. Yes
2. No

[ASK IF A3=1]

A4. How did you receive notification about the high demand event? Please select all that apply. [RANDOMIZE ORDER 1-2]

1. Notification from smart thermostat app
2. Display on smart thermostat
3. Other [Please describe:_____]
4. Don't know [EXCLUSIVE ANSWER]

B. Thermal Comfort

B1. How comfortable was the interior temperature of your home a few hours **before** Tuesday's high demand event? The event began at 5PM and ended at 6PM.

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3

5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. I was not at home
13. Don't know

B2. Did you notice a change in your home's interior temperature **during** the high demand event between 5PM and 6PM?

1. Yes
2. No
3. I was not at home [SKIP TO B4]

B3. How comfortable was the interior temperature of your home **during** the high demand event?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. Don't know

B4. Did you or someone in your household make changes to the thermostat settings during the event?

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

[ASK IF B4=1]

B5. Why did you or someone in your household change the thermostat settings during the event? [OPEN END TEXT ENTRY]

C. Satisfaction with Program and Thermostat

C1. Please rate your overall satisfaction with PGE's Smart Thermostat Program.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

C2. Please tell us why you gave that rating for overall satisfaction. [OPEN END TEXT ENTRY]

C3. Please rate your overall satisfaction with the smart thermostat.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D. Satisfaction with PGE

D1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4

6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D2. How likely would you be to recommend the Smart Thermostat Program to a friend, family member, or colleague?

1. 0 – Extremely unlikely
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely likely
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!

CADMUS

PGE Direct Install

Summer 2019 Experience Survey

Research Topics	Corresponding Question Numbers
Event awareness	A1-A5
Event participation	B1-B3
Thermal comfort	C1-C5
Satisfaction with program and thermostat	D1-D4
Satisfaction with PGE	E1

Target Audience: Treatment (test) and control group customers with a Nest or Ecobee smart thermostat who are enrolled in the Direct Install Smart Thermostat Program

Expected number of completions: 350-400 completes stratified by treatment and control group

Estimated timeline for fielding: October 2019. One survey reminder email may be sent 5-7 days after initial email, depending on the number of completes.

Variables to be Pulled into Survey

- Email
- FirstName
- LastName
- SPID
- EnrollDate
- Assignment = Treatment or Control
- Brand = Nest or Ecobee
- System = AC, HP or EF
- Micropersona
- TestbedStatus = In Testbed or Out Testbed
- Substation
- DwellingType

Email Invitation

To: [EMAIL]
From: Cadmus on behalf of Portland General Electric
Subject: How was PGE's Smart Thermostat Program?

Dear [FIRSTNAME],

Thank you for participating in PGE's Smart Thermostat Program during this recent summer. Your smart thermostat worked with PGE to shift your electricity consumption from when demand for electricity was highest. Would you take a moment to answer a few questions about your experience with the program? Your input will be used to improve PGE programs, and your responses will be kept confidential. Thank you for sharing your feedback with us.

Follow this link to the Survey:
[SURVEY LINK]

Or copy and paste this URL into your internet browser:
[SURVEY LINK]

If you have any questions about this survey or any difficulties taking the survey, please contact Masumi Izawa at Cadmus, the research firm conducting this survey on PGE's behalf. You can reach her at (503) 467-7115 or masumi.izawa@cadmusgroup.com.

Sincerely,
Will Miller
Program Manager, Portland General Electric

Follow the link to opt out of future emails:
${l://OptOutLink?d=Click here to unsubscribe}

Survey Start Screen

Welcome! This survey will take about 5 minutes to complete. Your responses will remain confidential and will only be used for research purposes.

[ASK SECTION A TO TREATMENT ONLY]

A. Event Awareness

A1. Your smart thermostat works with PGE to shift electricity consumption from times when demand for electricity is highest. How many high demand events did you notice this past summer?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO B1]
3. Don't know

A2. Do you recall being notified of high demand events prior to their occurrence?

1. Yes
2. No

[ASK IF 0=1]

A3. How did you receive notification about the high demand events? Please select all that apply. [RANDOMIZE ORDER 1-3]

1. Notification from PGE
2. Notification from smart thermostat app
3. Display on smart thermostat
4. Other [Please describe:_____] [FORCED TEXT ENTRY]
5. Don't know [EXCLUSIVE ANSWER]

A4. On the days of high demand events, were you aware that the events were happening?

1. Yes
2. No

[ASK IF A4=1]

A5. How did you know that the events were happening? Please select all that apply. [RANDOMIZE ORDER 1-4]

1. Display on smart thermostat
2. Notification from smart thermostat app
3. Noticed cool air was cycling on and off
4. Noticed a temperature change
5. Other [Please describe:_____] [FORCED TEXT ENTRY]
6. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION B TO TREATMENT ONLY]

B. Event Participation

B1. About how many high demand events did you participate in this past summer where you did not override the thermostat settings during the events?

1. Enter a number [NUMERIC ENTRY 1-99]
2. None [SKIP TO C1]
3. Don't know

B2. How easy or difficult was it to participate in the events?

1. Very easy
2. Somewhat easy
3. Somewhat difficult
4. Very difficult
5. Don't know

[ASK IF B2=3 OR 4]

B3. What made it difficult to participate in the events? Please select all that apply. [RANDOMIZE ORDER 1-6]

1. Other household members controlling the thermostat
2. The timing of the events
3. Notifications were not early enough
4. Health/medical reasons
5. Having guests or visitors around
6. Not understanding how the program works
   - Other [Please describe:_____] [FORCED TEXT ENTRY]
7. Don't know [EXCLUSIVE ANSWER]

[ASK SECTION C TO TREATMENT ONLY]

C. Thermal Comfort

C1. Overall this past summer, how comfortable was the interior temperature of your home a few hours **before** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6

8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. I was not at home
13. Don't know

C2. How often did you notice a change in your home's interior temperature **during** the high demand events?

1. Always noticed
2. Sometimes noticed
3. Never noticed
4. I was not at home for any events [SKIP TO **Error! Reference source not found.**]

C3. Overall this past summer, how comfortable was the interior temperature of your home **during** the high demand events?

1. 0 – Not at all comfortable
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Perfectly comfortable
12. Don't know

C4. Did you or someone in your household make changes to the thermostat settings during any of the summer events?

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

[ASK IF C4=1]

C5. Why did you or someone in your household change the thermostat settings during the events? [OPEN END TEXT ENTRY]

[ASK SECTION D TO TREATMENT AND CONTROL]

D. Satisfaction with Program and Thermostat

D1. Please rate your overall satisfaction with PGE's Smart Thermostat Program.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D2. Please tell us why you gave that rating for overall satisfaction. [OPEN END TEXT ENTRY]

D3. Please rate your overall satisfaction with the smart thermostat.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

D4. Please tell us how PGE can improve the Smart Thermostat Program. [OPEN END TEXT ENTRY]

D5. How motivated are you to participate in future event seasons?

1. 0 – Extremely unmotivated
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely motivated
12. Don't know

[ASK SECTION E TO TREATMENT AND CONTROL]

E. Satisfaction with PGE

E1. Please rate your overall satisfaction with PGE.

1. 0 – Extremely dissatisfied
2. 1
3. 2
4. 3
5. 4
6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely satisfied
12. Don't know

E2. How likely would you be to recommend the Smart Thermostat Program to a friend, family member, or colleague?

1. 0 – Extremely unlikely
2. 1
3. 2
4. 3
5. 4

6. 5
7. 6
8. 7
9. 8
10. 9
11. 10 – Extremely likely
12. Don't know

End of Survey Message

Your responses have been submitted. Thank you!