



Energy Trust of Oregon Smart Thermostat Pilot Evaluation

Prepared for Energy Trust of Oregon



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March 1, 2016

Acknowledgements

The Evaluation Team would like to acknowledge the review, support, and advice given by two third-party quality assurance reviewers, Scott Pigg (Seventh Wave) and Ken Agnew (DNV-GL).

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1. Executive Summary

In 2013, Energy Trust of Oregon (Energy Trust) launched a pilot, the Nest Thermostat Heat Pump Control Pilot, to study the electric energy savings impacts of installing a smart thermostat in lieu of heat pump controls in heat-pump heated homes. It was proposed in response to the slow uptake and potentially poor installation practices for Energy Trust's heat pump control measure. The Nest Thermostat Heat Pump Control Pilot was a successful undertaking, with high participant satisfaction and robust energy savings.

In 2014, Energy Trust initiated a "Smart Thermostat Pilot" to continue testing smart thermostats and explore the potential for a new cost-effective gas savings measure. This Pilot focused on the Honeywell Lyric and the Nest Thermostat, two smart thermostats in the market. Both thermostats claimed to offer simple user interfaces with advanced features to save energy. Features included automated and occupancy-based temperature management and various remote control options. Both products were available at retail stores for approximately \$250 (at the time of the launch of this Pilot).

The primary goals of the evaluation were to:

- Quantify the annual natural gas savings that result from installing smart thermostats in single family homes heated with a gas furnace.
- Identify variations in savings between participants based on demographic and household characteristics and any differences in savings between the two thermostats.
- Obtain feedback from program staff and participants to understand thermostat installation issues, how well the thermostats worked, and what kinds of operational issues were encountered.
- Understand participants' interaction and satisfaction with the thermostats.

Ultimately, the evaluation will help determine if smart thermostats are a viable technology for achieving cost-effective gas savings in homes heated with gas furnaces, and whether they should be incented by Energy Trust.

Pilot Background

The Pilot was developed and executed by the Existing Homes program, which is implemented by CLEAResult. The program purchased all of the thermostats up-front, maintaining inventory control for the Pilot by accurately recording product serial numbers. Energy Trust offered participants discounted smart thermostats for \$219 per unit, made available through a bulk-purchase order. This study required participants to self-install (either on their own or through a contractor of their choice) their thermostat, connect it via WiFi to the internet and link it to their online Nest or Honeywell account, and then forward the account verification email to Energy Trust for participant verification and rebate processing. Participants received a \$200 rebate for their thermostat, so they only paid \$19 in the end.

The Pilot ran from the fall of 2014 through the spring of 2015, covering one entire heating season. Participants were recruited primarily through a collaborative marketing effort with NW Natural. Based on eligibility criteria provided by the program, NW Natural randomly selected and contacted a sample of 22,000 customers who paid their bills online, had a gas account for at least a year and had a winter gas usage at least twice that of summer months.

The recruitment email sent by NW Natural directed interested candidates to complete an online survey to determine if they qualified to participate in the study. The program performed additional recruiting among Energy Trust employees and program management contractors to increase the number of participants¹. Candidates who met the criteria received a follow-up qualification email from Energy Trust containing information and directions on how to purchase the thermostat. Candidates whose answers indicated they did not meet one or more of the eligibility criteria received a customized email informing them of the reason they did not qualify.

Implementation staff controlled for product selection bias by randomly assigning qualifying candidates into one of two treatment groups based on the two thermostats involved in this study. Those in the Nest group were provided a link to purchase a Nest in their qualification email, while candidates in the Lyric group received a link to purchase a Lyric.

In addition to the treatment groups, NW Natural provided approximately 1,000 randomly selected customers' information to the Energy Trust Evaluation Team to serve as a comparison group for the billing analysis. These customers met the same pre-screening criteria as those customers who were contacted. Customers in the comparison group were not contacted.

Evaluation Methodology

There were three primary components associated with this evaluation effort: staff interviews, participant surveys, and a billing analysis.

Staff interviews were conducted with the goal of collecting insight and feedback from those staff members most familiar with the Pilot and to supplement the program summary report compiled by the program management contractor, CLEAResult (see Appendix D). Interviews were held with four members of CLEAResult, and one was held with a member of the Energy Trust team.

There were two separate participant surveys administered to the entire population of Pilot participants, one in January 2015 and a second one at the end of the heating season in May 2015, but only to those who had completed the first survey. Participant surveys were conducted to understand participant

¹ The supplemental recruitment involved non-Existing Homes program management contractor staff, program delivery contractor staff, Energy Trust, and NEEA staff.

usage, perceptions, satisfaction and reactions to the thermostats, as well as changes in these metrics over time as participants became more familiar with the thermostats.

Finally, a billing analysis was performed to estimate the impacts of the thermostats on gas usage. The analysis was performed by Energy Trust Evaluation staff and reviewed by Apex Analytics, Mr. Ken Agnew of DNV-GL, and Mr. Scott Pigg of Seventhwave.

Findings

The findings presented here are ordered chronologically and align with how participants experienced the Pilot: the early stage includes participant recruitment and installation; the middle stage includes participant experiences with the thermostats, including usage of, satisfaction with, and feedback on the thermostats; and the final stage, after the first heating season in which the thermostats were installed, includes determining the gas savings associated with thermostats.

Finding 1: Recruitment – The self-installation model proved to be highly cost-effective, but may have led to substantial attrition among interested and qualified customers.

Staff concluded that the recruiting and targeting of customers was considerably improved from the approach used for the Nest Heat Pump Control Pilot. Acquiring approximately 400 participants in less than two months, with minimal cost to Energy Trust, proved the ease and success of this model. Participants that required support successfully received assistance from the manufacturers either via phone or website rather than having to rely on Energy Trust or CLEAResult staff for guidance.

The most serious recruiting challenge, however, arose at the gap between qualifying and purchasing participants: only 35% of candidates who completed the intake survey and qualified for the study actually purchased a thermostat, despite being offered a \$250 thermostat for only \$19. Staff speculated that the large drop– between those who completed the survey and qualified to participate, to those who actually purchased a thermostat– was likely due to the perceived technical difficulty of self-installation of the thermostats.

Finding 2: Installation – Thermostat installation was faster and easier for Nest participants compared to Lyric participants.

Nest participants were able to install the thermostat in less time and with less difficulty than the Lyric participants. Respondents reported that the average installation time for the Nest was less than an hour (51 minutes) whereas the Lyric took one hour and 13 minutes – a difference of only 22 minutes, but about 40% longer. Only 4% of Nest participants believed initial setup and configuration was either difficult or very difficult, compared to 17% of Lyric participants. An even higher percentage of Lyric users indicated experiencing installation issues (37%) – over three times that of the Nest user base (10%).

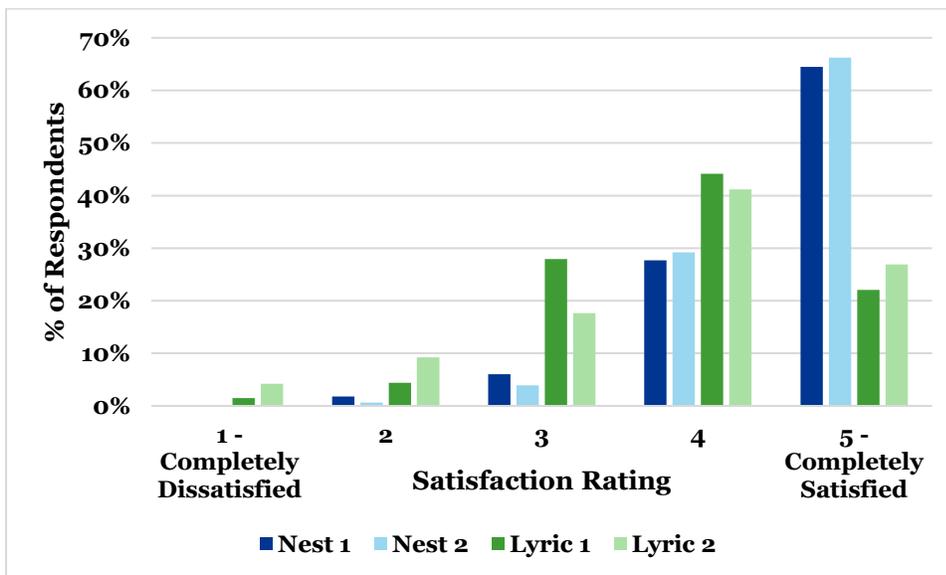
Participant satisfaction with installing the thermostat was highly dependent on the device: 90% of participants indicated a satisfaction rating of either a 4 or 5 out of 5 for the overall installation process for the Nest, while only 63% of the Lyric participants provided an equivalent satisfaction rating for their installation process.

Finding 3: Satisfaction – Nest users reported much higher rates of satisfaction with the user interface, scheduling, and overall thermostat compared to the Lyric users.

The vast majority (95%) of Nest participants rated the overall user interface either easy or very easy to use, while only 70% of Lyric participants gave the same rating for their thermostat. Scheduling proved to be the most difficult aspect of the Lyric, with over 20% of participants indicating this was somewhat or very difficult, whereas only 3% of Nest participants reported experiencing the same difficulty. Lyric participants also experienced considerably more non-installation-based issues: 50% of first-survey and 27% of second-survey respondents reporting additional issues with their Lyric thermostat; whereas 16% of first-survey and 7% of second-survey respondents experienced Nest-related post-installation issues.

In terms of overall satisfaction, Nest users gave considerably higher satisfaction ratings relative to the Lyric: over 65% of Nest users rated the thermostat a 5 out of 5, whereas only 24% of Lyric users rated the thermostat a 5 out of 5 (Figure 1). In addition, although participants were committed to retaining their thermostats for the duration of the Pilot, if given the option to return their units, only 10% of Nest participants would have returned the unit whereas over three times as many Lyric participants (34%) would have returned the thermostat.

Figure 1. Satisfaction rating with smart thermostat



Source: First and second participant surveys. Don't know/refused: Nest 1: N=0; Nest 2: N=0; Lyric 1: N=0; Lyric 2: N=1.

Finding 4: Thermostat Use – Nest users were more likely to utilize the occupancy detection features and less likely to override the unit.

One of the primary energy-saving features of the smart thermostats is occupancy detection. For the Nest, this feature is called “Auto-Away,” which minimizes heating and cooling when the device determines no one is home based on occupancy sensors (motion sensors). For the Lyric, this feature is called “geofencing,” which is dependent on the GPS location of the smartphone that is matched with the thermostat. When the Nest thermostat is installed, the Auto-Away feature should be preset as enabled, whereas for the Lyric, the geofencing is not enabled by default, and the user is required to enable the geofencing during initial setup.

Nest users overwhelmingly left Auto-Away enabled: 88% of first- and second-survey respondents reported that they left this feature enabled. The Lyric respondents were not as likely to have enabled geofencing: only 57% of Lyric users had enabled this feature by the first survey, and slightly less (50%) had this feature enabled by the second survey.

In addition, Nest participants showed a 60% relative decline in daily adjustments between the first and second survey. Lyric participants only showed a 35% relative decline in daily adjustments, indicating participants continued to rely on manual adjustments. The fact that a significant proportion of Lyric participants continued to make frequent adjustments (daily or weekly) shows that participants still were unable to rely on the thermostats to perform one of their primary functions – to automate home heating and cooling.

Finding 5: The energy savings, the most important feature associated with this study, proved to be the most notable difference between the two thermostats: Nest participants showed decreased gas consumption while Lyric participants showed increased gas consumption.

The results of this billing analysis show that the Nest thermostat was associated with significant energy savings. It produced about 6% heating load savings (34 therms/year), on average, in gas-heated homes. On the other hand, the Honeywell Lyric thermostat was associated with significant increases in energy use. The Lyric added 4-5% to heating loads (24-29 therms/year), on average, in gas-heated homes. The difference in realized energy savings between the two thermostats was unambiguous. From the subgroup analysis, the Evaluation Team determined that there was a negligible effect on overall savings from participants recruited from Energy Trust employees and contractors and from those who removed their thermostats mid-Pilot. For Nest, homes located in Oregon outside the Portland Metro area appeared to have higher gas savings than other areas. Homes where the previous thermostat was manual or not programmed appeared to have substantially higher savings among Nest participants, although there was no difference among Lyric homes. For both thermostat groups, there appeared to be lower savings in homes where the occupancy detection features had been disabled, as expected.

2. Introduction

In 2013, Energy Trust of Oregon (Energy Trust) launched a Pilot to study the electric energy savings impacts of installing a smart thermostat in lieu of heat pump controls in heat-pump heated homes. The Pilot was proposed in response to the slow uptake and potentially poor installation practices for Energy Trust’s heat pump control measure. The Nest Thermostat Heat Pump Control Pilot was a successful undertaking, with high participant satisfaction and robust energy savings.

In 2014, the Energy Trust initiated a “Smart Thermostat Pilot” to continue testing smart thermostats and explore the potential for a new cost-effective gas savings measure. This study focused on the Honeywell Lyric and the Nest Thermostat, two smart thermostats on the market at the time which did not require a common wire.² Both thermostats claimed to offer simple user interfaces with advanced features to save energy. Features included automated and occupancy-based temperature management and various remote control options. Both products were available at retail stores for approximately \$250 (at the time of the launch of this Pilot).

To help understand how this Pilot differed from the Nest Heat Pump Control Pilot, a review of the key differences is included in Table 1 below.

Table 1. Comparison between Nest Heat Pump Control Pilot and Smart Thermostat Pilot

Pilot Details	Nest Heat Pump Control	Smart Thermostat
Heating Season of Pilot	2013-2014	2014-2015
Home Heating System Requirement	Heat pump	Gas furnace
Thermostat(s)	Nest	Nest Lyric
Recruitment	Previous Energy Trust program participants (HER)	NW Natural Gas Customers*
Must be online bill pay customer	N/A	Yes
Have high-speed internet, an existing Wi-Fi network and a valid email address	Yes	Yes
Have an Apple or Android smartphone or tablet	N/A	Yes
Major home upgrades or remodel plans	None	None
Installation	Program staff	Self-install

² A common wire, or C-wire, enables the continuous flow of power to the thermostat. While power flows from the R (red) wire, it does not flow continuously. To make it continuous requires a common wire to complete the circuit. According to Emerson Climate Technologies, over 60% of homes do not have a C-wire, thereby complicating the installation of a compatible thermostat. <http://www.ac-heatingconnect.com/5-things-every-contractor-needs-to-know-about-wi-fi-thermostats/>

Pilot Details	Nest Heat Pump Control	Smart Thermostat
Participant Cost	\$0	\$19
Thermostat Cost	\$250	\$219
Direct Installation Cost	\$350	\$0
Customer Support	Energy Trust and Manufacturer	Manufacturer

* There were also supplemental recruits, including Energy Trust employee and program management contractors, who had to meet all criteria listed in the above table except for online bill pay customers.

The Nest Heat Pump Pilot was Energy Trust’s first effort to achieve energy savings through using a contractor-installed Smart Thermostat in homes heated exclusively by a heat-pump. The Smart Thermostat Pilot was proposed as an additional cost-effective approach to Energy Trust’s Nest Heat Pump Pilot.

In November 2014, Energy Trust contracted with Apex Analytics, LLC (Apex) to conduct an evaluation of their Smart Thermostat Pilot. This report documents the evaluation activities and results for this Pilot, and is organized into the following key sections:

- The Introduction Section provides a brief introduction and the overall goals and objectives for this evaluation
- The Background Section provides an overview and details about the Nest and Lyric thermostats and the Pilot (including participant selection, recruitment, and thermostat installation)
- The Methodology Section provides detailed methodological and analytical approaches used for this evaluation
- The Findings Section provides the results from the various evaluation activities
- The Conclusions and Recommendations Section offers overarching highlights from the findings section, and coalesces these findings into actionable recommendations

2.1 Evaluation Goals and Objectives

The primary goals of the evaluation were to:

- Quantify the annual natural gas savings that result from installing smart thermostats in single family homes heated with a gas furnace.
- Identify variations in savings between participants based on demographic and household characteristics and any differences in savings between the two thermostats.
- Obtain feedback from program staff and participants to understand thermostat installation issues, how well the thermostats worked, and what kinds of operational issues were encountered.
- Understand participants’ interaction and satisfaction with the thermostats.

Ultimately, the evaluation will help determine if smart thermostats are a viable technology for achieving cost-effective gas savings in homes heated with gas furnaces, and whether they should be incented by Energy Trust. The primary research questions are listed with their accompanying tasks in Table 2 below.

Table 2. Primary researchable questions and the associated tasks

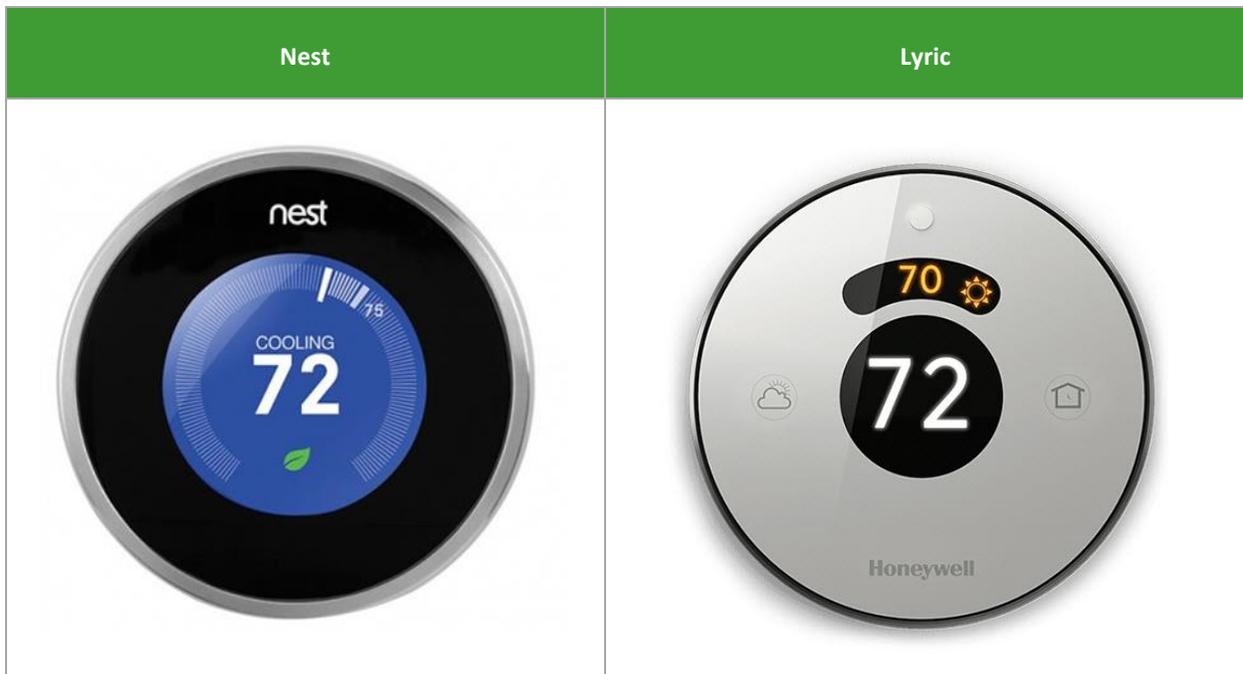
Research Questions	Task	Research Category
How much energy do smart thermostats save when self-installed in gas-heated homes? Is there a significant difference between the two products tested?	Billing Analysis	Energy savings
Do savings vary by participant demographics or housing characteristics?	Billing Analysis, Participant Survey	Energy savings
Do savings differ between homes where thermostat installation is verified, and those where it is not?	Billing Analysis	Energy savings
What is the staff perspective on the Pilot? Is it a success?	Staff Interviews	All sections
What did staff learn about smart thermostats? What are the lessons learned from the Pilot?	Staff Interviews	All sections
What are the recruitment, implementation and logistical issues encountered during the Pilot?	Participant Survey, Staff Interviews	Recruitment and Participation
What are the technical issues encountered with the thermostats during the Pilot?	Participant Survey, Staff Interviews	User Experience
What is the current range in costs for smart thermostats? Are costs likely to go down? What are the market trends?	Staff Interviews	Conclusions and Recommendations
What is the thermostat installation rate? Was the target of 400 installed thermostats achieved? Why or why not?	Staff Interviews	Recruitment and Participation; Installation
What are the characteristics of Pilot participants? What types of people are likely to adopt this measure in the future?	Participant Survey	Recruitment and Participation
What motivated customers to participate in the Pilot?	Participant Survey	User Experience
Are participants satisfied with the thermostats they purchased? What do they like or dislike about them?	Participant Survey	User Experience
Are participants satisfied with the comfort of their homes?	Participant Survey	User Experience
What are participants' experiences with thermostat installation? What are the challenges? Is self-install a viable model?	Participant Survey	Installation

Research Questions	Task	Research Category
How do participants use and interact with the thermostats? Which functions do they use? How do they rate the usability?	Participant Survey	User Experience
Do smart thermostats cause participants to change their behavior? Are participants engaged in saving energy?	Participant Survey	User Experience
Which thermostat functions are most important in saving energy?	Participant Survey, Billing Analysis	Energy savings
Do participants see a significant difference between the two products tested?	Participant Survey	User Experience

3. Background

Web-enabled smart thermostats are a promising opportunity for Energy Trust’s residential programs to develop a new measure for gas-heated homes. Smart thermostats allow customers to better manage their heating and cooling systems through a combination of automation, easy to use controls, monitoring of equipment and environmental conditions, feedback, and remote control. This Pilot assessed the gas savings potential of two smart thermostats, the Nest Learning Thermostat and the Honeywell Lyric, when self-installed by homeowners with existing gas furnaces. Figure 2 below shows the two thermostats associated with this study. In the aforementioned Nest Heat Pump Control Pilot, Energy Trust found annual energy savings to be roughly 12% of the heating load³. Several recent studies have shown Nest thermostats to deliver savings between 6% to 12% of the gas heating load⁴, though at the time of this report there is no comparable study available that includes savings for the Lyric thermostat.

Figure 2. Nest and Lyric thermostats



³ It should be noted that the Heat Pump Control Pilot electric energy savings results are not directly comparable to the results of this Smart Thermostat Pilot due to different heating systems, study design, and implementation approach.

⁴ Nest whitepaper on reports: <https://nest.com/downloads/press/documents/energy-savings-white-paper.pdf>; Nicor Gas findings: http://ilsagfiles.org/SAG_files/Meeting_Materials/2015/6-23-15_Meeting/CLEARResult_Smart_Thermostat_WhitePaper_20150505.pdf; Vectren findings: http://www.cadmusgroup.com/wp-content/uploads/2015/06/Cadmus_Vectren_Nest_Report_Jan2015.pdf?submissionGuid=c8eda45b-2759-4a31-90e3-d2ecdb9001de

The Pilot was developed as part of the Existing Homes program, and implemented by the Existing Homes program management contractor, CLEAResult. The program purchased all of the thermostats up-front, maintaining inventory control for the Pilot by accurately recording product serial numbers. By directly distributing the thermostats, the program was able to randomize the study groups (grouped by Nest versus Lyric participants), and verify thermostat installation. Participants comfortable with new technology (i.e., tech savvy) were targeted during recruitment and asked to cover part of the cost, to (1) help avoid installation issues and (2) more accurately reflect the population that will ultimately purchase smart thermostats in the market.

At the time of the Pilot study, the Nest and Lyric thermostats were the two Smart Thermostats on the market that did not require the presence of a common wire (C-wire), increasing the likelihood of a successful self-installation.⁵ These thermostats use occupancy sensing technology to reduce heating and cooling requirements while participants are not home. One of the key issues this Pilot explored was whether this setting proved to significantly impact the realized savings. Behavioral factors examined included adjustments made to thermostat, frequency of adjustments, whether the frequency of adjustments shifted over the course of the Pilot, and whether participants enabled or disabled key energy saving features. As one CLEAResult staff member aptly stated, “the goal of the Nest is to actually remove the participants’ behavioral component with respect to energy savings.”

The thermostats have a number of other potentially valuable energy management features, including the ability to learn the occupant’s schedule and adjust for occupancy (Nest), and a geofencing feature for the Lyric that adjusts for the GPS-location of the linked smartphones. Additionally, the thermostats have a dial that allows the user to interact with it in a manner similar to a manual thermostat. The Lyric requires a Smartphone for the initial setup (it first connects to the phone, rather than to the home Wi-Fi like the Nest for the initial installation⁶) and for adjusting most of the automated features (like geofencing and shortcuts), whereas manual temperature and “Away” settings can be adjusted directly to the Lyric. The Nest allows adjustments using the actual device, an app on a Smartphone, or online. There are additional features that can be accessed using a Smartphone-based application (both thermostats), or online (Nest-only), allowing homeowners to monitor the temperature of their home and adjust their thermostat remotely. The following list details the additional features that the smart thermostats offer.

⁵ The Ecobee was considered as well, but the requirement of a C-wire disqualified it from inclusion in the Pilot.

⁶ For the Lyric, the initial installation and setup is done via wireless connection directly to the user smartphone but is later connected to the home wireless signal.

Table 3. Features and naming conventions between the smart thermostats

Thermostat Feature	Nest	Lyric
Occupancy Detection: Minimizes heating to established set-point when no one is home.	Auto-Away	Geofencing
Early Warm-up: This function starts heating or cooling early so the home will be at the requested temperature at the time specified.	Early On	Adaptive Recovery
Furnace Filter Reminder: This function reminds the user to change their furnace filter based on how many hours their heating system has been running.	Filter Reminder	Smart Cues
Automated Programming: This function remembers what temperatures keep the user comfortable and creates a custom schedule for their home.	AutoSchedule	N/A
Energy Usage Tracking: This function allows the user to see exactly when their system was on and see a summary of their entire month's energy use.	Energy History	N/A
Energy Savings notification: Notification when user adjusts thermostat to a temperature that will save energy.	Nest Leaf	N/A
Pre-Programmed Settings: Create custom temperature settings for recurring events (workout, parties)	N/A	Shortcuts
Alerts: Notification for home and heating system issues (humidity, extreme conditions, maintenance issues)	Safety Temperatures	Smart Cues
Override settings for empty house	Away Mode	Away button
Considers both indoor and outdoor temperature and humidity to reach set point	Nest Sense	Fine Tune

Savings estimates for a smart thermostat installed in a gas-heated home were developed by Energy Trust in the groundwork performed for the Pilot by Energy Trust and CLEAResult, and were used for the Smart Thermostat Pilot.⁷ The savings were estimated to be about 23 therms per year based on average usage of 584 therms annually (4% reduction in total usage).

A special priced offer specific to this study – through a bulk-purchase order – allowed for the procurement of the smart thermostats for \$219 per unit, a cost savings of \$31 per unit. This Pilot involved an incentive for self-installation to expedite thermostat installation prior to the start of the heating season, with participants only paying \$19 for the thermostat (and Energy Trust offering the remaining cost as an incentive). In the future, a retail incentive where the thermostat is self-installed (as

⁷ Energy Trust Brief: *Gas Advanced Thermostat Pilot Business Brief*; September 5, 2014

opposed to program direct-install, which was done for the Nest Heat Pump Control Pilot) significantly reduces costs, but may also impact the rate of successful installations.

To assess the savings associated with two devices, Energy Trust attempted to recruit 400 homes randomly selected from a subset of NW Natural gas customers. The anticipated 400 home sample ultimately had to be supplemented with a small group (less than 10% of Pilot participants) of Energy Trust, program management, and contractor staff due to attrition and lower-than-anticipated sign-ups.⁸ Pilot participants received a deeply discounted thermostat, and their gas consumption was analyzed against a comparison group from a similar population of homes. To gather feedback regarding customer use and satisfaction with the thermostats, Energy Trust also requested that participants complete two surveys. The focus of the Pilot was for the 2014-2015 heating season, from December 2014 through May 2015. A more detailed description regarding the methodology and analysis used for this evaluation follows in the next section.

3.1 Participant Selection and Recruitment

The Smart Thermostat Pilot offered an alternative approach to participant selection, recruitment, and installation relative to the previous Nest Heat Pump Control Pilot (these differences are highlighted in Table 1). This study required participants to self-install their thermostat, connect it to the internet and link it to their online Nest or Honeywell account, and then forward the account verification email to Energy Trust for participant verification and rebate processing.⁹ A review of the participation requirements, selection, recruitment, and application process are included in the sections below.

3.1.1 Participation Requirements

Participation was open to single-family homeowners with homes primarily heated by forced-air gas furnaces. These participation requirements were consistent for the larger and supplemental pool of participants. Participants were also required to meet the following criteria:

- Be a current customer of NW Natural¹⁰
- Have high-speed internet, an existing Wi-Fi network, and a valid email address
- Have an Apple or Android Smartphone or tablet
- Not plan to make major upgrades (insulation, windows, heating system) to their home over the next year

⁸ The Evaluation Team has included details in each section where the selection or recruitment requirement process differed for the supplemental sample group.

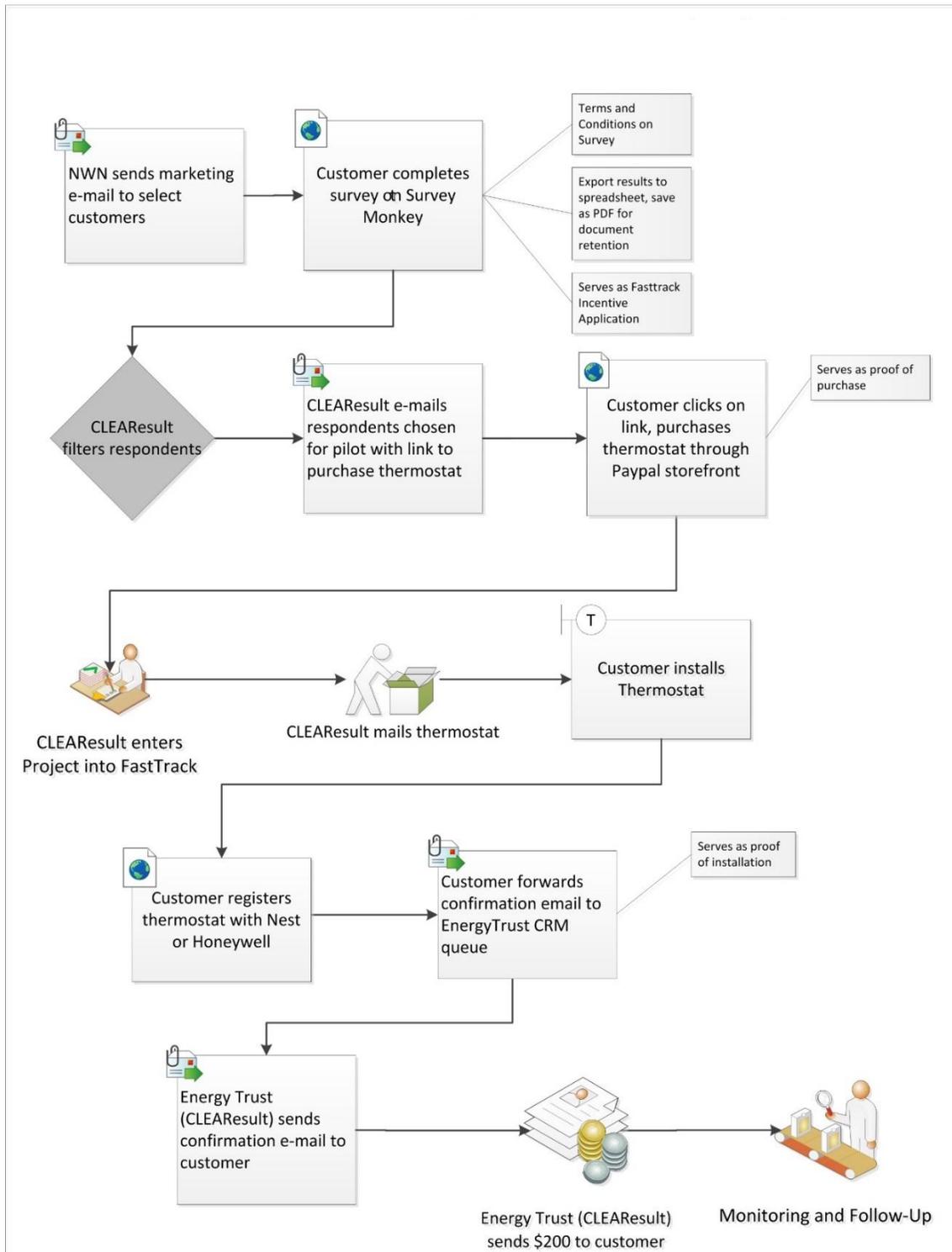
⁹ The email verification ensured installation, guarded against fraudulent resale of the unit, and avoided a more costly and time-consuming on-site verification.

¹⁰ NW Natural is a gas utility that serves more than 700,000 homes and businesses in 107 communities in Oregon and Southwest Washington.

During the application process, customers were asked to agree to terms and conditions including installing their thermostat, connecting the thermostat to an online Honeywell or Nest account, if they disliked the thermostat to not remove the thermostat earlier than May 31, 2015¹¹, and allowing Energy Trust to access their energy usage information for time periods before, during, and after the study period. Both Honeywell and Nest sell their products at retail locations and have step-by-step instructions with videos to help with installation. Additionally, both companies have call centers designed to field customer questions and further assist with any installation issues. A detailed recruitment and application process flow-chart is included in Figure 3 below.

¹¹ Participants were asked to keep the thermostats installed even if they disliked it for the duration of the study period, though all participants were allowed to keep the thermostats after the study period if they so desired.

Figure 3. Smart Thermostat Pilot recruitment process



Source: CLEARResult Smart Thermostat Pilot Year-End Report (see Appendix D). Note that FastTrack and CRM are Energy Trust’s project tracking and customer relationship management systems, respectively.

3.1.2 Recruitment

Study candidates were recruited primarily through a collaborative marketing effort with NW Natural.¹² Based on eligibility criteria provided by the program, NW Natural randomly selected and contacted a sample of 22,000 customers who:

- Paid their bills online
- Had a gas account for at least a year
- Had a winter gas usage at least twice that of summer months.

The recruitment email sent by NW Natural directed interested candidates to complete an online survey to determine if they qualified to participate in the study. Candidates who met the criteria received a follow-up qualification email from Energy Trust containing information and directions on how to purchase the thermostat. Candidates whose answers indicated they did not meet one or more of the eligibility criteria received a customized email informing them of the reason they did not qualify.

3.1.2.1 Treatment Group Selection

Implementation staff controlled for bias by a two-stage randomization sampling process. To be selected into the study design, the first stage of randomization involved the random selection of NWN customers into a treatment group that was contacted for recruitment into the pilot and a comparison group that was not contacted. Product selection bias was mitigated by then randomly assigning qualifying candidates into one of two treatment groups based on the two thermostats involved in this study.¹³ Those in the Nest group were provided a link to purchase a Nest in their qualification email, while candidates in the Lyric group received a link to purchase a Lyric. If candidates contacted the Existing Homes program to request the other thermostat in the study, staff explained that this was not possible due to the study design. All randomization was conducted via the random number generator function in Microsoft Excel 2010. Each treatment group's target population was 200 participants. A review of the two-stage randomization design is included in Figure 4 below.

3.1.2.2 Comparison Group Selection

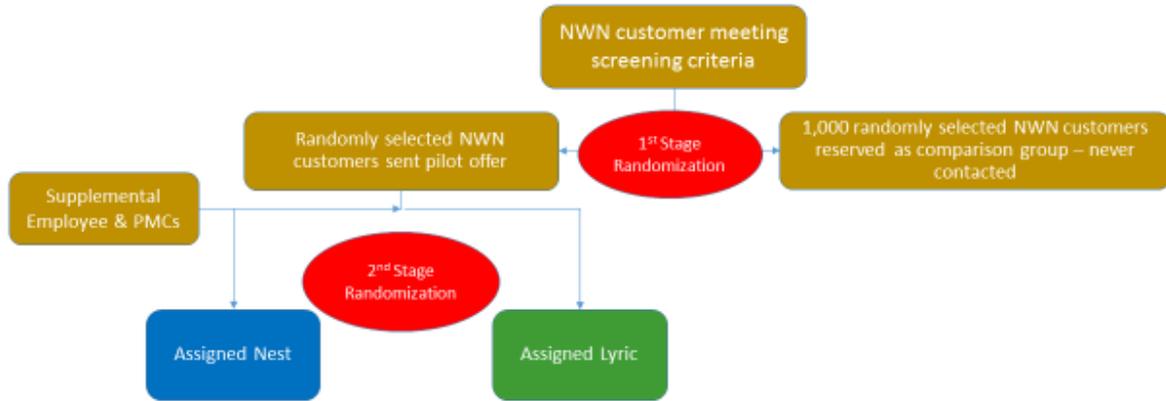
In addition to the treatment groups, NW Natural provided approximately 1,000 randomly selected customers' information to the Energy Trust Evaluation Team to serve as a comparison group for the billing analysis. These customers met the same pre-screening criteria as those customers who were contacted (additional billing analysis details are provided below in section 4.3). Customers in the

¹² Similar recruitment emails were distributed for the supplemental Energy Trust employees and contractor's recruitment, and these candidates were also required to meet eligibility criteria – namely be NW Natural customers, have had their gas accounts for over a year, and whose homes had a gas furnace.

¹³ The Energy Trust employee and contractors group were only included in the second stage of randomization – that is, to be randomly assigned a Nest or Lyric thermostat.

comparison group were not contacted. Additional discussion regarding how this process relates to the billing analysis study groups is included in greater detail below.

Figure 4. Two-stage Sample Randomization Design



3.1.3 Application

The program used an entirely online application process. Participant and site information were collected via the intake survey. By purchasing the product through CLEAResult’s PayPal account, the program had proof of the customer’s purchase. In order to receive an incentive, customers were asked to email the program, stating that they installed their thermostat and include the manufacturer’s account set up confirmation email.

3.1.4 Quality Assurance

CLEAResult also performed site visits at a random sample of participating homes to verify installation, household characteristics, heating system characteristics, and thermostat settings. The goal was to conduct visits at approximately 20% of the homes (for a total of 80 sites), divided equally between homes with the Nest and Lyric thermostats, although due to time and budget concerns the QA site visits were scaled back to 10% of homes (n=47). Quality assurance (QA) site visits began the week of January 26, 2015. The evaluation team reviewed the results of the QA site visits (summary of QA visits included in Appendix G) to validate the responses in the participant survey (furnace type, furnace AFUE, occupancy settings), and to assess participant feedback provided while CLEAResult was onsite.

4. Evaluation Methodology

There were three evaluation components associated with this study: staff interviews, participant surveys, and a billing analysis. In addition to these three efforts, the Evaluation Team also leveraged an existing summary report compiled by CLEAResult (see Appendix D) that detailed many of the findings associated with the implementation of the Pilot. A more detailed discussion regarding the methodology used for data collection and analysis for each component is presented below.

4.1 Staff Interviews

Apex developed an interview guide (see Appendix A) for program staff at Energy Trust and CLEAResult who were involved in the design, management, and implementation of the Pilot. A draft interview guide was prepared for review by Energy Trust's Evaluation staff prior to finalization. Toward the end of the Smart Thermostat Pilot, in April 2015, the Evaluation Team interviewed four CLEAResult key staff and one Energy Trust staff member. Each interview lasted approximately one hour. It was critical to debrief staff to get their perspectives on selection of the participant sample, installation and setup challenges, participant attrition, logistical and communication issues, customer reactions to the device, customer commitment to saving energy, and ideas for successful deployment of the two thermostats in the market.

4.2 Participant Surveys

The Evaluation Team developed two survey instruments and fielded two rounds of surveys to obtain feedback from participants. A core set of questions remained consistent in both surveys to gauge whether participants changed their opinions of the device during the heating season. In addition, a number of the survey questions were similar to those used in the previous evaluation of the Nest Heat Pump Control Pilot so that the results could be compared. The team provided a draft of each survey instrument to Energy Trust's Evaluation staff for review prior to finalizing it.

The Evaluation Team decided, with Energy Trust support, to administer the survey via online web-based survey software. A web-based survey was deemed the best approach, since participants all had Internet access (a requirement for the Smart Thermostat installation), and some degree of familiarity with technology due to the high-tech nature of the thermostats. The team used Sogo Survey Software, an online tool that allows researchers to develop and administer surveys, and analyze participant responses. After Energy Trust evaluation staff reviewed and approved an initial draft survey instrument in Microsoft Word, the Evaluation Team programmed the survey into the online survey tool and tested the functionality to ensure survey invitations were fully functional, and that survey responses were properly saved to the system.

The first participant survey (see Appendix B) was targeted for administration during the mid-heating season. Participant recruitment and actual implementation of the web survey occurred in late January 2015. This survey focused on customer motivations for participating in the Pilot, installation and setup of the device, attitudes about the device, valued features of the thermostat, home comfort, use of the device, commitment to saving energy, and satisfaction with the Pilot. The entire Pilot participant population (at the time of recruitment Nest: N=202; Lyric: N=161) was invited to take the first survey, whereas only those who completed the first survey (Nest: N=166; Lyric: N=137) were invited to take the second survey.

The Evaluation Team developed and sent invitation emails to enlist participants for both web surveys. After the initial emails were distributed, the team waited five days before sending a follow-up email encouraging participants who had not yet completed the survey to do so. The follow-up email reminder helped offset the decline in participation, and resulted in a burst of completed surveys.

The second participant survey (see Appendix C) was targeted for administration during the end of the heating season. The Evaluation Team invited the same participants who responded to the first survey to complete a second survey in May 2015. The main objective of the second survey was to identify any changes in metrics relative to those collected during the first survey. In addition, the surveys explored which participant characteristics and behaviors might be related to the amount of gas savings, and which features of the device might have the largest impact on savings.

Similar to the previous Nest Heat Pump Control Pilot, there were extremely high response rates for participant surveys. For the first survey, 303 out of 363 total thermostat participants responded (83% response rate), and for the second survey, 271 out of the 303 eligible participants responded (90% response rate).

4.3 Billing Analysis

A billing analysis was performed to estimate the annual heating season gas savings associated with the smart thermostat installations in participants' homes. Though there may be electric cooling savings attributable to these thermostats as well, this study focused exclusively on the potential gas savings benefits of these thermostats. A review of the data and methods used for the billing analysis are below.

4.3.1 Data Sources

Gas billing data were accessed and analyzed for the year prior to the Pilot, and the heating season months directly following thermostat installation. Thermostats were installed between mid-November 2014 and mid-January 2015. The Evaluation Team defined the pre-Pilot study period as September 1, 2013 to November 10, 2014. The post-installation study period was defined as January 25, 2015 (the date by which nearly all thermostats were installed) to October 31, 2015.

Gas usage data were retrieved from Energy Trust’s utility billing database for all participant and comparison homes. The Evaluation Team constructed a longitudinal analysis (panel) dataset of study participants and comparison homes by merging Pilot data from Energy Trust, response data from the intake survey and two follow-up surveys, daily weather data from the National Climatic Data Center, and monthly gas usage data from Energy Trust.

4.3.2 Gas Utility Data

Monthly gas usage data were cleaned before use in this analysis. The primary data cleaning tasks were to identify and remove duplicates, estimated meter readings, and meter readings with invalid or suspicious values. The gas data from NW Natural proved to be quite clean. No duplicate records or invalid values were identified, and only a few estimated readings were found. Billing periods were calculated as the number of days since the previous meter reading. Although most billing periods were roughly one month in duration, there was variability in their exact length. If a billing period was unusually short or long, defined as having fewer than 15 days or more than 67 days, the meter reading was deemed suspicious and flagged for removal later in the analysis. To better compare gas use from one month to the next, the Evaluation Team computed the average daily gas usage for each billing period, which became the primary unit of analysis. This was calculated as the monthly gas usage divided by the number of days in the billing period.

The Evaluation Team calculated the annual gas usage for the one-year period immediately preceding the Pilot for sites with at least nine valid meter readings in that time period. Outliers in pre-Pilot annual usage were defined as the top and bottom 1% of the distribution of participants in each group and flagged for removal later in the analysis. The pre-Pilot annual usage was compared between the various Nest and Lyric participant and comparison groups to ensure that the study groups being compared were similar enough to determine gas savings.

4.3.3 Study Groups

The Pilot was set up similar to a randomized encouragement design (RED) study with a second stage of randomization where treatment group homes were assigned to one of the two thermostats, once they had opted in to the study (overview included in Figure 4 above). The standard approach for determining the effect of the intervention in a RED study is to analyze the entire randomized treatment group (regardless of whether they actually receive the treatment, known as the intention-to-treat group) against the entire randomized comparison group. This preserves the initial randomization and helps control for self-selection bias inherent in opt-in study designs.

However, for this study, the typical intention-to-treat analysis could not be performed on the entire randomized treatment group, prior to opting-in, due to the very low response rate to the recruitment emails (8%).¹⁴ In addition, the original treatment recruitment pool was not randomized to one of the

¹⁴ Table 4 contains additional information about study recruitment and attrition.

two thermostat groups. Given the high proportion of non-respondents and lack of randomization to a specific treatment, it would have been impossible to determine energy impacts by analyzing the entire intention-to-treat group that was recruited for the Pilot. To address this issue, the Evaluation Team focused instead on the second stage of randomization where treatment group homes that expressed interest in the Pilot were assigned to the Nest or Lyric thermostat group. These two groups of respondents became the intention-to-treat groups for the study. The Evaluation Team acknowledges that this could introduce a self-selection bias where the treatment group homes that responded could differ in some way from those that did not respond. In the same way, they could also differ from the comparison group. However, any bias should be the same for participants assigned to each thermostat group, so the relative effect of each thermostat should be unbiased.

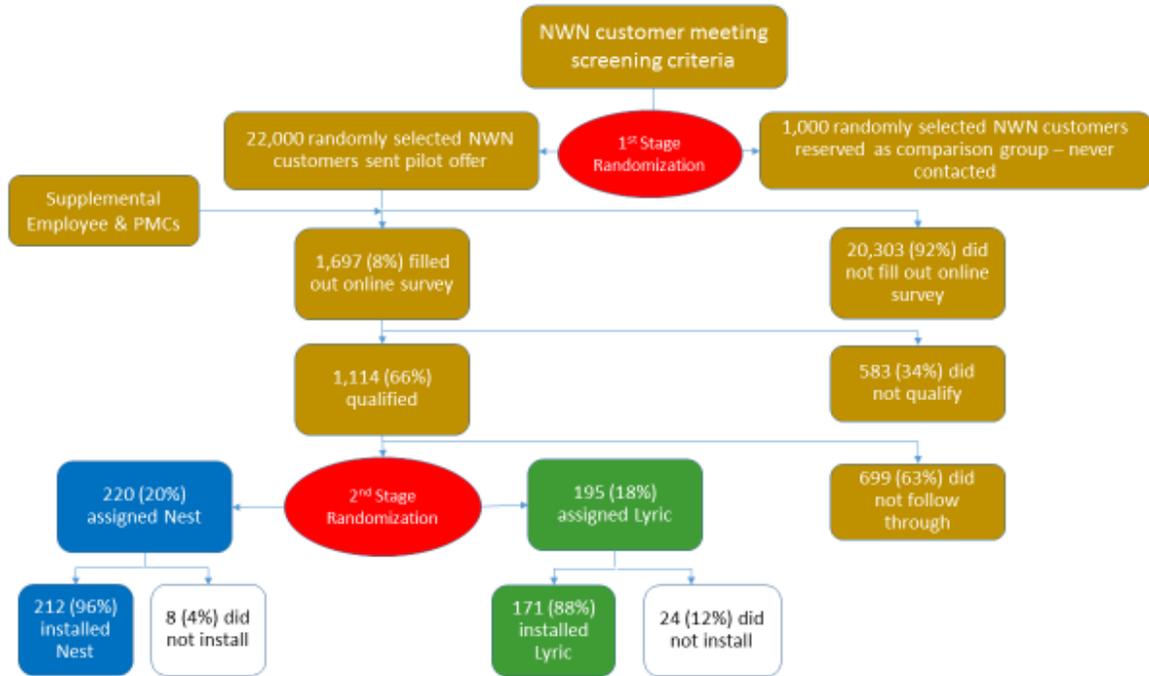
An additional problem with the study was that the conversion rate from treatment homes that expressed interest in the Pilot to those that actually received a thermostat was quite low (24%). Even using the reduced intention-to-treat group, this level of attrition significantly limited our ability to observe any effect. So, in addition to the intention-to-treat group, the Evaluation Team analyzed just the treated homes that received a thermostat against the comparison group. Unfortunately, if a strong self-selection bias was present, the comparison homes would not properly represent homes that received a thermostat. To investigate and address this potential source of bias, the Evaluation Team also synthesized a matched comparison group for each group of thermostat recipients.

Matched comparison groups for both Nest and Lyric were created by randomly selecting 200 residential NW Natural gas customers from each decile of pre-Pilot raw annual gas usage, based on the distributions of annual usage for homes that received a Nest or Lyric thermostat. This resulted in two comparison groups of 2,000 randomly selected homes each, with gas usage distributions that closely matched either the Nest or Lyric recipient homes. These matched comparison groups allowed us to conduct a quasi-experimental analysis that the Evaluation Team compared to the other analyses. The end result was that the Evaluation Team did three different comparisons for each thermostat:

- the intention-to-treat group versus the randomized comparison group,
- the thermostat recipient group versus the randomized comparison group
- the thermostat recipient group versus the matched comparison group

Given the limitations of the design and implementation of the Pilot, the Evaluation Team believe this combination of analysis approaches provides the best possible estimates of gas usage impacts. A more detailed chart demonstrating this two-stage randomization is included in Figure 5 below.

Figure 5. Pilot Two-Stage Randomization Results



4.3.4 Attrition

Pilot participant and comparison homes from all study groups were matched to gas usage data using normalized addresses. Homes that could not be matched to usage data, or which met one of our exclusion criteria (described in Table 4 below), were removed from the analysis. Table 4 describes the attrition that occurred within each study group for each step in the analysis, along with the average pre-Pilot annual gas usage. After Pilot homes were matched to usage data, billing periods that were unusually short or long were removed. Homes with less than three meter readings in either the pre-Pilot or post-installation study period were removed from the analysis. Missing and insufficient gas usage data were only minor sources of attrition in this study. Homes where thermostats were installed after the end of the installation period in January 2015 were also removed to ensure sufficient follow-up time during the heating season. Next, homes identified as having installed any Energy Trust-funded gas efficiency measures during the study period which saved more than four therms per year were removed from the analysis. This was by far the largest source of attrition across study groups. The final attrition step was to remove homes that were outliers in pre-Pilot annual gas usage, defined as the lowest and highest one percent of each treatment group. For the comparison groups, outliers were defined based on the distribution of the pertinent treatment group. Thus, outliers in the original randomized comparison group were identified four different ways, using each of the treatment group distributions.

The final sample contained 153 Nest and 127 Lyric participant homes that received thermostats, representing 72% and 74% of thermostat installations through the Pilot, respectively. There were 580 Nest and 613 Lyric homes in the final intention-to-treat group, representing 79% and 80% of the original

sample, respectively. The final randomized comparison group contained between 800 and 832 homes (82-85% of the original), depending on which study group was used as the basis for determining outliers (Table 5). The final Nest and Lyric matched comparison groups contained 1,816 and 1,781 homes, respectively, which represented 91% and 89% of the 2,000 homes that each group started with.

Table 4: Sample attrition for Pilot homes

Billing Analysis Attrition	Nest - Received T-stat	Nest - Intention-to-treat	Nest - Matched Comparison	Lyric - Received T-stat	Lyric - Intention-to-treat	Lyric - Matched Comparison	Randomized Comparison
All Pilot Homes	212	734	2,000	171	771	2,000	978
Unmatched to valid gas usage data	7	7	0	2	7	0	10
Installation date post 01/18/2015	10	10	0	6	6	0	0
Insufficient data	4	15	43	1	9	48	39
EE projects during study period	34	110	105	31	124	101	83
Low/high usage (1%)	4	12	36	4	12	70	Varies*
Final N	153	580	1,816	127	613	1,781	Varies*
Percent Homes Remaining	72%	79%	91%	74%	80%	89%	Varies*

* See Table 5 below for final sample sizes of randomized comparison group using different study groups as the basis for the outlier definitions.

Table 5: Final sample sizes of the randomized comparison group for different outlier definitions

Study Group Used as Basis for Outlier Definition	N Removed	N Remaining	% of Total Remaining
Nest - Received T-stat	46	800	82%
Nest - Intention-to-treat	16	830	85%
Lyric - Received T-stat	15	831	85%
Lyric - Intention-to-treat	14	832	85%

4.3.5 Billing Analysis Methodology

To determine the energy savings resulting from the two thermostats tested in the Pilot, the Evaluation Team created a series of regression models to analyze gas usage for the Nest and Lyric participant groups. As described above, the Evaluation Team set up three comparisons between the different study groups for each thermostat. The intention-to-treat groups were compared to the original randomized comparison group. The thermostat recipient groups were compared to the original randomized comparison group and to the matched (synthesized) comparison groups. Variables for weather, study group, and study period were used to predict the average daily gas usage for each billing period.

Although some home characteristic data were collected for participant homes, the Evaluation Team did not have these data for the comparison group, so they could not be used in the models.

Average daily temperature data from the weather station nearest to each home was used to calculate the heating degree-days (HDDs) for each billing period. Different HDD variables were computed for reference temperatures ranging from 40 to 75 degrees Fahrenheit. The HDD values were divided by the number of days in each billing period to obtain the average daily HDDs, so that the units were directly comparable to the average daily gas use. A study period flag variable was created to indicate whether each observation occurred in the pre-Pilot or post-installation period. A study group flag variable was created to indicate whether homes were in the participant or comparison group.

Once the dataset was prepared, the Evaluation Team created multi-level linear mixed-effects models for both Nest and Lyric participants using Stata statistical analysis software.¹⁵ The multi-level model was used to account for the longitudinal nature of the data, where gas usage observations were made repeatedly on each home over time. Using random effect terms in the model, an intercept and HDD coefficient were fitted to each home separately, in each study period, and then pooled across the sample using fixed effect terms. Average daily gas usage was modeled as a function of average daily HDDs, the study period, and the study group. Interaction terms between all three variables were added to model the effect of installing a smart thermostat on gas usage. Robust standard errors were computed to obtain more realistic precision estimates so that the Evaluation Team did not overstate the significance of the results. The following equation describes the linear mixed-effects model that was used.

$$Usage_{ij} = \beta_0 + \beta_1 HDD_{ij} + \beta_2 Group_{ij} + \beta_3 Post_{ij} + \beta_4 Group_{ij} * Post_{ij} + \beta_5 Group_{ij} * HDD_{ij} + \beta_6 Post_{ij} * HDD_{ij} + \beta_7 Group_{ij} * Post_{ij} * HDD_{ij} + u_{0i} + u_{1i} HDD_{ij} + u_{2i} HDD_{ij} * Post_{ij} + \epsilon_{ij}$$

Where:

$Usage_{ij}$ = the average daily electric usage for home i during billing period j ,

β = regression coefficients for each variable in the model (indexed from 0 to 7),

β_0 = fixed intercept for all homes,

HDD_{ij} = heating degree-days for home i during billing period j ,

$Group_{ij} \{0,1\}$ = dummy variable where 1 indicates that home i is part of the Nest or Lyric participant group, which is static across all i billing periods,

$Post_{ij} \{0,1\}$ = dummy variable where 1 indicates that billing period j for home i is in the post-installation period,

u_{0i} = random intercept for home i that is independent from ϵ_{ij} ,

u_{1i} = random slope coefficient of HDD for home i that is independent from ϵ_{ij} ,

u_{2i} = random coefficient of the interaction between HDD and installation period for home i that is independent from ϵ_{ij} ,

¹⁵ Stata/MP v.13.1, StataCorp LP, College Station, TX

ϵ_{ij} = model error for home i for billing period j .

As noted above, HDD variables were tested in the model with reference temperatures for every degree from 40 to 75 degrees. The reference temperature resulting in the model with the best fit was selected as the final model, based on the fit statistics (AIC and BIC). A HDD reference temperature of 59 degrees proved to have the best fit for this sample of homes.

The model provided two key parameter estimates for computing energy savings: the interaction term coefficients β_4 and β_7 . Together, these coefficients described the mean difference in the change in consumption between the participant and comparison groups from the pre- to post-installation periods for a given number of HDDs, while controlling for between-home differences. A linear combination of these two coefficients, plus the long-run annual HDDs from the Typical Meteorological Year 3 dataset (TMY3), was used to compute the weather-normalized annual gas savings in therms per home for each thermostat, as described below. The Evaluation Team also computed the pre-Pilot average annual gas usage and heating usage for the treatment group from the parameter estimates (in therms per home) to calculate the energy savings as a percent of annual gas usage and heating load.

$$\text{Annual Savings} = 365 * \beta_4 + LRHDD * \beta_7$$

$$\text{Normalized Annual Usage} = 365 * (\beta_0 + \beta_2) + LRHDD * (\beta_1 + \beta_5)$$

$$\text{Normalized Heating Usage} = LRHDD * (\beta_1 + \beta_5)$$

Where:

β = regression coefficients for each variable in the model (indexed from 0 to 7),

$LRHDD$ = long-run annual HDDs for each weather station averaged across homes in the sample, derived from TMY3.

For the intention-to-treat savings analysis, an additional step was necessary to compute gas savings attributable to the installation of one of the two thermostat models. The intention-to-treat savings estimates were divided by an adjustment factor (the proportion of homes where a thermostat was installed – 26% for Nest and 21% for Lyric) to obtain the portion of savings due to the treatment, known as the Local Average Treatment Effect (LATE). Unfortunately, due to the small proportion of homes in the intention-to-treat group that received thermostats, the observed effect sizes were small with a relatively large amount of error. The LATE adjustments simply magnified the savings and error, resulting in highly uncertain estimates.

$$\text{LATE Annual Savings} = \text{Savings} / \left(\frac{\# \text{ of Thermostat Installations}}{\# \text{ of Intention-to-Treat Homes}} \right)$$

4.3.5.1 Sensitivity Analysis

The Evaluation Team was concerned about the influence of model specification on the energy savings results, and tested several simpler regression modeling approaches to see how much the results differed. The Evaluation Team first created a simplified, fixed-effects generalized linear model that did

not control for weather. This model simply contained the study group, study period, and interaction terms with which to compute savings. Next, the Evaluation Team created a multi-level mixed-effects model accounting for the repeated gas usage observations on each home, but with no weather variables. This model only contained a random intercept term and fixed effects for the study group, study period, and interaction terms to compute savings. The Evaluation Team did not expect these models to be as accurate, since they did not control for differences in weather, but they provided a validation check on the savings results.

Next, a series of linear mixed effects models including heating degree-days were used to build up increasingly complex models with more random effect terms. Likelihood ratio tests were used to determine if the additional random effects significantly improved the fit. The final and most complex mixed model is presented above and was used to compute savings.

4.3.5.2 Subgroup Analysis

In addition to the overall savings for each thermostat, the Evaluation Team was interested to see if there were differences in savings between subgroups of participant homes for each thermostat. The first factor that the Evaluation Team analyzed was the pre-Pilot annual gas usage. The Evaluation Team assigned all participant and comparison homes into low, medium, and high usage categories based on dividing the distribution of pre-Pilot usage into thirds. To simplify the analysis and reduce the number of comparisons made, the Evaluation Team only compared thermostat recipients to the original randomized comparison group. To perform the analysis, the Evaluation Team used the same multi-level linear mixed-effects model described above, with one small change. To accommodate the smaller sample sizes in each category, the Evaluation Team had to reduce the number of terms in the model so that it would not become over-specified. This was accomplished by removing the random effect term for the interaction between HDD and installation period. The model was then run for each thermostat and usage category to estimate the gas savings for each group. For all other factors of interest, the Evaluation Team did not have any data for the comparison group. To analyze the impact of these factors on savings, the Evaluation Team simply created subsets of participant homes for each thermostat group, and compared each subset to the entire comparison group. Although this method is not as precise, since the comparison group does not match each subset as well, it allowed the Team to coarsely assess whether there were any large differences in gas savings between categories.

Data related to each of the subgroups of interest was self-reported, obtained through the participant intake survey or two follow-up surveys. The Evaluation Team assessed differences in gas savings between categories of participants for a variety of factors including housing stock, heating equipment, demographics, and experience with the thermostats; this allowed the Team to analyze whether gas savings varied within the sample, and to identify factors that might be driving those differences.

5. Findings

The following findings are based on research conducted by CLEAResult, Apex Analytics, and Energy Trust. As mentioned previously, CLEAResult designed and executed the Pilot for Energy Trust. Findings from CLEAResult's Pilot summary report (the complete report can be found in Appendix D) are included throughout this section and supplemented with information compiled during Apex's interviews with implementation and program staff. Apex led the development and analysis of the staff and participant surveys and also assisted with compiling the analysis and results across the various actors and drafting this evaluation report. Energy Trust Evaluation staff were responsible for and developed the energy savings estimates based on a billing analysis, with additional support and quality assurance reviews from both Apex and Energy Trust's third-party billing analysis reviewers, Ken Agnew and Scott Pigg.

Each section below reviews the findings from each of the distinct primary researchable question groupings of the Pilot study and leverages findings from each of the various Pilot study sources to help inform the results. To help address one of the key research questions posed in the Background section of this report, namely whether participants see a significant difference between the two products offered in the Pilot, many of the figures and text in the following section explore whether there were differences between the devices.

Because of the density of information that is displayed throughout the Findings section, there are a few important clarifications that should be reviewed. The reader should be aware that:

- Any chart or table that shows Nest 1 or Lyric 1 is referring to results of the FIRST participant survey, whereas Nest 2 or Lyric 2 refers to the results of the SECOND participant survey.
- To avoid overly busy displays, the charts and tables below are EXCLUSIVE of “don't know” and “refused” respondents – therefore some percentages will NOT sum to 100. The relative percentage or N's of those that did not know or refused to answer are provided below each figure/table (where applicable).
- For most of the results, the findings include all responses from both surveys, but the study identifies where comparisons include only the same populations (i.e., including only those respondents from the first survey that ALSO completed the second survey).
- Chi-square testing was performed to statistically test differences between the two thermostat groups for all standardized questions (e.g., satisfaction, comfort, behavior). Differences were found to be statistically significant (at the 90% confidence level) for almost every question except a few. Statistical differences are noted between each chart.

5.1 Recruitment, Participation, and Implementation

Staff members at both Energy Trust and CLEAResult agreed that the Pilot was implemented without serious technical or participant issues, especially relative to the previous Nest Heat Pump Control Pilot.

Part of the goal with this Pilot was to see what happened organically, as participants were left to handle and deal with installation themselves, rather than relying on Energy Trust or CLEAResult staff. Although there was a loss of control over the customer experience –since control was more in the participant’s hands– staff indicated that they had very few calls for technical issues, and were grateful for the self-reliance model, which reduced Pilot management costs and the burden on staff.

Staff also believed the participant direct-install approach left customers with more “skin in the game,” helped target more tech savvy customers, and mirrored how the expanded program would be implemented. Allowing participants to opt-in for the study sample design, coupled with the opportunity to purchase thermostats at close to 10% of cost, helped control who was participating; staff deemed this a “self-filtering” sample of participants. Staff concluded that the recruiting and targeting of customers was considerably improved. Acquiring nearly 400 participants in less than two months, with minimal cost to the client, proved the success (though not necessarily ease) with which recruitment and installation was implemented.

The Pilot was not without challenges. Recruitment for the study resulted in an initial response rate of 7.5% - that is 7.5% of those invited to apply for the thermostat online filled out the enrollment survey. For those that did take the enrollment survey the primary factors for disqualification were plans to remodel (n=248), lack of smartphone (n=108), and having multiple thermostats (n=102) – additional disqualification details are included below in Table 8. The most serious recruiting challenge, however, was the gap between qualifying and purchasing participants: approximately 35% of candidates who qualified for the study actually purchased a thermostat.¹⁶ Staff speculated that the large drop– between those who completed the intake survey and qualified for participation, to those who actually purchased a thermostat– was likely due to the self-installation aspect of the thermostats.¹⁷

Table 6 shows the follow-through rates for the study. NW Natural conducted recruitment in two waves for a total of 22,000 emails sent to customers who met the pre-screening criteria outlined in the participant’s section above. Incomplete responses were defined as those where most or all of the qualifying questions were left blank when submitted. The number of thermostats purchased includes 20 participants who completed the enrollment survey, qualified for a particular thermostat, and then purchased the thermostats on their own either through the manufacturer’s website or at a local hardware store, rather than through the PayPal link provided by the program. Staff included detailed participant instructions in email correspondence, but realized the instructions were not clear enough on installation and email confirmation timelines. Therefore, staff performed additional participant outreach to ensure thermostats were installed.

¹⁶ Because the two surveys Apex fielded were completed with participants, the study was not able to determine why customers that qualified for the Pilot did not participate.

¹⁷ Staff believed the self-installation aspect may have scared off prospective participants due to the perceived difficulty of wiring and installing the thermostat.

In late November 2015, the program had enough conversion data to know that from the initial wave of e-mails (to 8,000 customers) more candidates were needed to reach the study participation goal of 400. The program collaborated with Energy Trust and NW Natural to provide a second recruitment offer in early December to approximately 14,000 more customers. Volume had still not been met by late December 2015, and the program opened recruitment for the last few products through an offer delivered to Energy Trust staff and its program management and delivery contractors. While this final recruitment phase showed sales that exceeded targets (415 versus 400), the actual number of verified installations were 95% of the goal.

Table 6. Smart Thermostat Pilot recruitment

Recruitment Status	NW Natural Survey	Employee and Program Management Contractor Survey	Totals	Conversion Rate by Phase
Total recruitment emails	22,000	200+*	22,200+	-
Number of surveys started	1,612	114	1,726	8%
Number of surveys completed	1,584	113	1,697	8%
Number of candidates qualified	1,035	79	1,114	5%
Gross number of thermostats purchased	375	40	415	2%

**Offer was circulated to Energy Trust staff as well as other program management and program delivery contractors. The precise number of emails is not known.*

On average, it took the study participants seven days to install their thermostat from the time it was shipped. While the program did receive communications from a small number of participants who experienced installation issues, the vast majority of participants did not report any trouble during installation. There were eight returns due to installation issues, and 24 due to post-installation issues. The majority of post-installation issues involved units that failed on-site. In some cases, participants reported that the manufacturer’s customer service advised that they return the units. Several customers reported Honeywell customer service had them check voltages at their thermostat terminals. Table 7 provides a summary of number of installations, returns, and thermostats installed by recruitment channel and product type.

Table 7. Smart Thermostat Pilot installation rates

	Lyric			Nest		
	NW Natural	Employees and Program Management Contractors	Total Lyric	NW Natural	Employees and Program Management Contractors	Total Nest
Gross number of thermostats (purchased)	168	27	195	207	13	220
Returned/defective/shipping problem	20	4	24	8	-	8
Net thermostats in the field	148	23	171	199	13	212
Total number of thermostats with installation confirmation	148	23	171	198	13	211

Source: CLEAResult Smart Thermostat Pilot Year-End Report (see Appendix D).

Table 8 shows that of the 1,726 total enrollment surveys completed by study candidates, 613, or 36%, of individual responses did not qualify (DNQ). The most common reason for a disqualification was due to the candidate responding with plans to remodel or weatherize their home in the next year. The next most common reason for disqualifying was lack of an Apple or Android smartphone or tablet, closely followed by homes with multiple thermostats.

Table 8. Non-qualifying survey responses

	NW Natural Survey	Employees and Program Management Contractors	Total Survey Responses
Total Surveys Completed by Study Candidates	1,584	113	1,697
Did Not Qualify Detail (does not sum to 100% because multiple responses are possible):			
1. Does not have natural gas	9	1	10
2. Does not primarily heat with a gas furnace	42	4	46
3. Does not own home	30	10	40
4. Not a detached, single-family home	38	4	42
5. Home has multiple thermostats	95	7	102
6. Does not have an Android or Apple device	106	2	108
7. Does not have Wi-Fi and/or high-speed internet	25	3	28
8. Has plans to remodel in the next year	228	20	248
9. Missing Information (including did not complete surveys)	44	1	45
10. Duplicates	50	4	54
Total unique DNQ responses	578	35	613
Percent DNQ	36%	31%	36%

Source: CLEAResult Smart Thermostat Pilot Year-End Report (see Appendix D).

A total of 415 thermostats were shipped to customers, but 32 were later returned. Table 9 provides a summary of the reasons for returned product. For tracking, return reasons were placed in one of the five categories listed in the table. The most common return reason was thermostat failure after installation.

Table 9. Returned thermostat data

Reason for Return	Nest	Lyric	Total
Customer complaints	-	5	5
Installation problem – thermostat functions	1	6	7
Installation problem – defective thermostat	1	7	8
Post-installation problem – thermostat failed	3	3	6
Post-installation problem – unknown	2	1	3
Shipping problem	1	2	3
Grand Total	8	24	32

Source: CLEAResult Smart Thermostat Pilot Year-End Report (see Appendix D).

Table 10 shows the results of the “employees and contractors” survey by organization. While the exact number of offer emails sent to Energy Trust staff and program management and delivery staff is unknown, this wave of recruitment had a 49% conversion rate from candidates who received a qualification email to those who purchased a thermostat. This is high when compared to the 36% conversion rate observed in the NW Natural-driven participant pool (per totals shown in Table 6). Additionally, due to higher conversion among qualifications for Nest thermostats than for Lyrics from the NW Natural recruiting, employees and contractors candidates were randomly assigned either a Lyric or a Nest on a 2:1 basis weighted towards the Lyric to help rebalance the final study populations.

Table 10. Distribution of employee and program management contractor participants by organization

Organization	Lyric	Nest	Total
Cascade Energy	-	5	5
Energy 350	6	-	6
Energy Trust of Oregon	7	4	11
EnerNOC	1	-	1
ICF International	7	1	8
NEEA	5	1	6
Triple Point Energy	-	2	2
Unspecified	1	-	1
Grand Total	27	13	40

Source: CLEAResult Smart Thermostat Pilot Year-End Report (see Appendix D).

5.1.1 Characteristics of Participants and their Homes

The characteristics of participants’ homes and demographics were captured via two channels: CLEAResult collected some of the characteristics of participant’s homes at the beginning of the Pilot study during the intake survey, while additional participant demographic questions were included in the first participant survey. Table 11 and Table 12 provide a summary of Smart Thermostat Pilot characteristics of the participant homes. Table 13 and Table 14 provide a summary of additional smart thermostat participant information and survey responses, including household heating and cooling characteristics, and participant demographics. It should be noted here that the education and income indicators are skewed to the higher-end of the strata, likely mirroring the expected adopters of the smart technology. Also of note regarding the demographics in Table 14 is the participant age: while the high proportion of the older demographic (65+) was a notable concern with the previous Nest Heat Pump Control Pilot (representing 34% of the participants), the pre-screening process for this Pilot provided a representative sample of the population for this older demographic age group, representing only 16% of this Pilot population.¹⁸

Table 11: Summary of Smart Thermostat Pilot participant home characteristics

Group	N	Mean Square Footage	Mean Year Built	Number of Floors
Lyric	170	2,501	1977	2.02
Nest	211	2,450	1980	1.91

Source: CLEAResult participant intake survey. Includes all participants per the tracking dataset based on CLEAResult intake survey. Mean square footage and year built were based on participant weighted average using mid-points of ranges (2,000-3,000 sq ft would be 2,500; built between 1950 and 1970 would be 1960).

Table 12: Geographic distribution of Smart Thermostat Pilot homes

Group	Portland Metro		NW Oregon		Washington	
	N	% of Homes	N	% of Homes	N	% of Homes
Lyric	129	76%	25	15%	16	9%
Nest	154	73%	38	18%	19	9%

Source: CLEAResult intake survey for participants and Energy Trust tracking data for comparison group. Includes all participants per the tracking dataset based on CLEAResult intake survey.

¹⁸ This is coincidentally almost identical to the current Census-based estimate of 15.5% of Oregon population aged over 65.

Table 13: HVAC characteristics of Smart Thermostat Pilot homes from participant survey

Characteristic	Lyric (Mean or % of Homes)	Nest (Mean or % of Homes)
Mean furnace AFUE	87.4	88.7
% of homes w/ Condensing Furnace	34.5%	35.4%
% of homes w/ Central AC Unit	66.2%	82.3%
% of homes where prior thermostat was programmable	85.3%	91.0%

Source: First participant survey.

Comparing the survey responses to the CLEAResult site visits is of particular interest in the summary of additional characteristics of participant’s homes. Of those participants that received a site visit (Lyric n = 27, Nest n = 20), the recorded furnace AFUE was within 0.1 of the AFUE for those same participants that provided their AFUE in the first survey (87.2 onsite versus 87.3 survey). Similarly, there were only three QA participants that incorrectly specified the presence of central air conditioning, and two QA participants that incorrectly specified a condensing furnace.

Table 14: Summary of demographic information from participant survey*

Characteristic	Lyric N	Lyric % of Respondents	Nest N	Nest % of Respondents
Education				
<i>No college degree</i>	24	17.9%	30	18.4%
<i>College degree</i>	58	47.8%	83	50.9%
<i>Graduate degree</i>	41	30.6%	45	27.6%
Income				
<i>Less than \$50,000</i>	6	4.0%	11	6.8%
<i>\$50,000 to \$90,000</i>	30	22.4%	30	18.6%
<i>\$90,000+</i>	71	53.0%	94	58.4%
Children living in home				
<i>No</i>	74	55.2%	101	61.6%
<i>Yes</i>	59	44.0%	61	37.2%
Age				
<i>Less than 50</i>	62	44.6%	74	44.3%
<i>50 to 64</i>	48	34.5%	64	38.3%
<i>65+</i>	24	17.3%	25	15.0%
Occupants				
<i>1 person</i>	6	4.5%	15	9.2%
<i>2 people</i>	54	40.3%	64	39.3%
<i>3+ people</i>	73	54.5%	84	51.5%

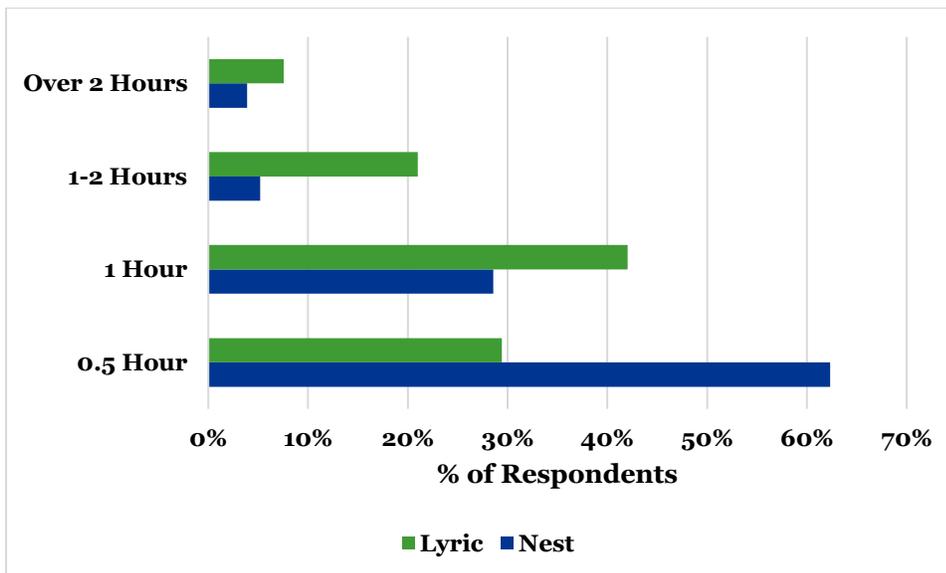
Source: First participant survey. Percentages above will not sum to 100% due to refusals.

5.2 Participant Installation

As noted above, the Smart Thermostat Pilot differed from the previous Nest Heat Pump Control Pilot by requiring participants to self-install their thermostats. Because of the self-installation requirement, almost all of the participant feedback regarding installation came directly from the participant surveys. Similarly, educating the participant about the installation and use of the device was no longer conducted through the program as part of the installation procedure. Instead, each participant was asked to read the installation instructions and seek help through manufacturer provided support (both online and phone-based) if necessary.

The self-install approach was successful, as most of the installations took approximately one hour or less and did not require additional support. According to survey results (Figure 6), participant installation duration differed between the two devices: the majority (62%) of Nest installations took a half-hour, whereas less than a third of Lyric participants (29%) took a half-hour to install. The average installation time for the Nest was less than an hour (51 minutes), whereas the average installation time for the Lyric was one hour and 13 minutes – a difference of only 22 minutes, but about 43% longer than the Nest.

Figure 6. Smart thermostat installation duration

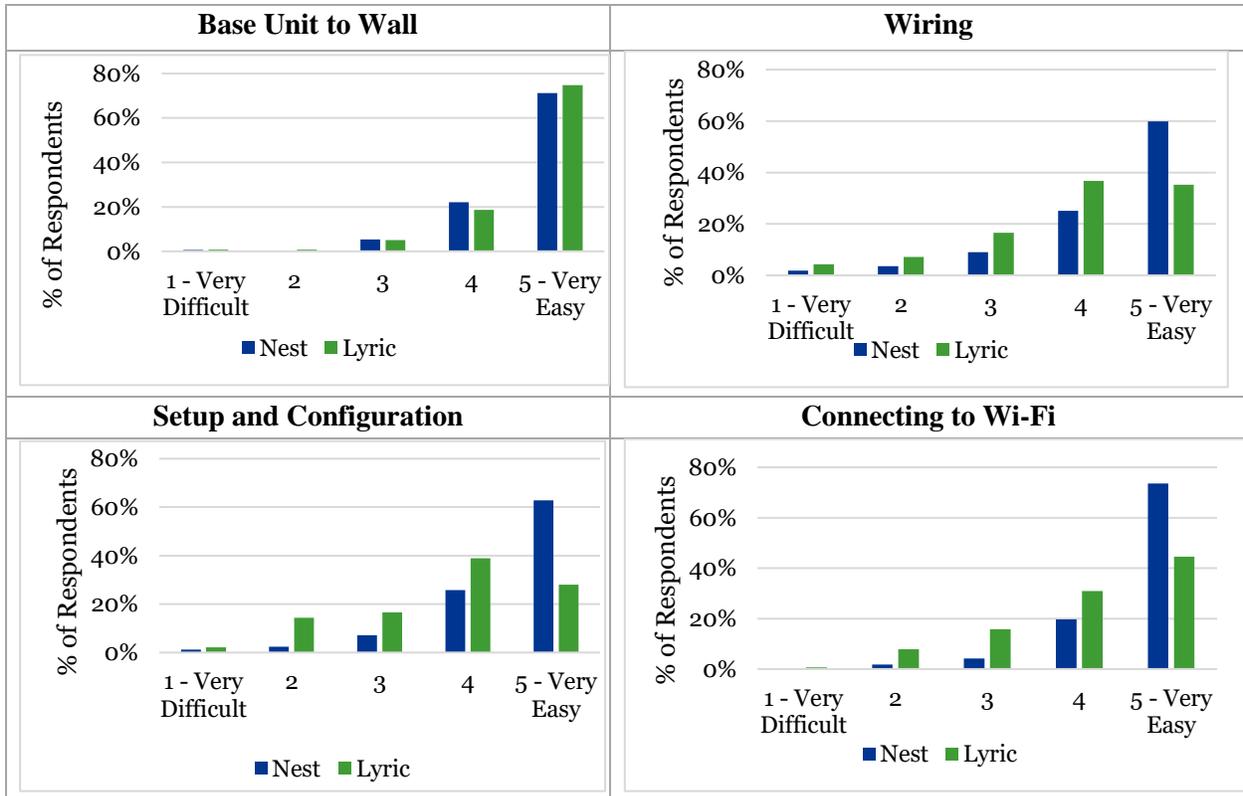


Source: First participant survey. Differences between the Nest and Lyric participants are statistically significant.

The Nest was easier to install than the Lyric, in terms of both installation duration and difficulty. The Evaluation Team asked participants to provide the level of difficulty (where “1” represented very difficult and “5” represented very easy) for four different aspects of installation: installing the base unit to the wall, connecting the wires to the thermostat, initial thermostat setup and confirmation, and connecting the thermostat to a home Wi-Fi signal (Figure 7). There was no statistical difference between Nest and Lyric participants for installing the base unit to the wall– well over 90% of both participants rated this aspect as “easy”, or “very easy”. The remaining three installation components showed

statistically significant differences between the two thermostats' participants: 85% of Nest participants found the wiring to be "easy" or "very easy", whereas 72% of Lyric believed the same; 93% of Nest participants found it "easy" or "very easy" to connect to their wireless networks, whereas 76% of Lyric participants found this "easy"; and 89% of Nest participants believed the initial setup and configuration to be "easy" or "very easy", whereas only 67% of Lyric participants felt the same way about their thermostats. The complete results of these questions can be found in Figure 7 below.

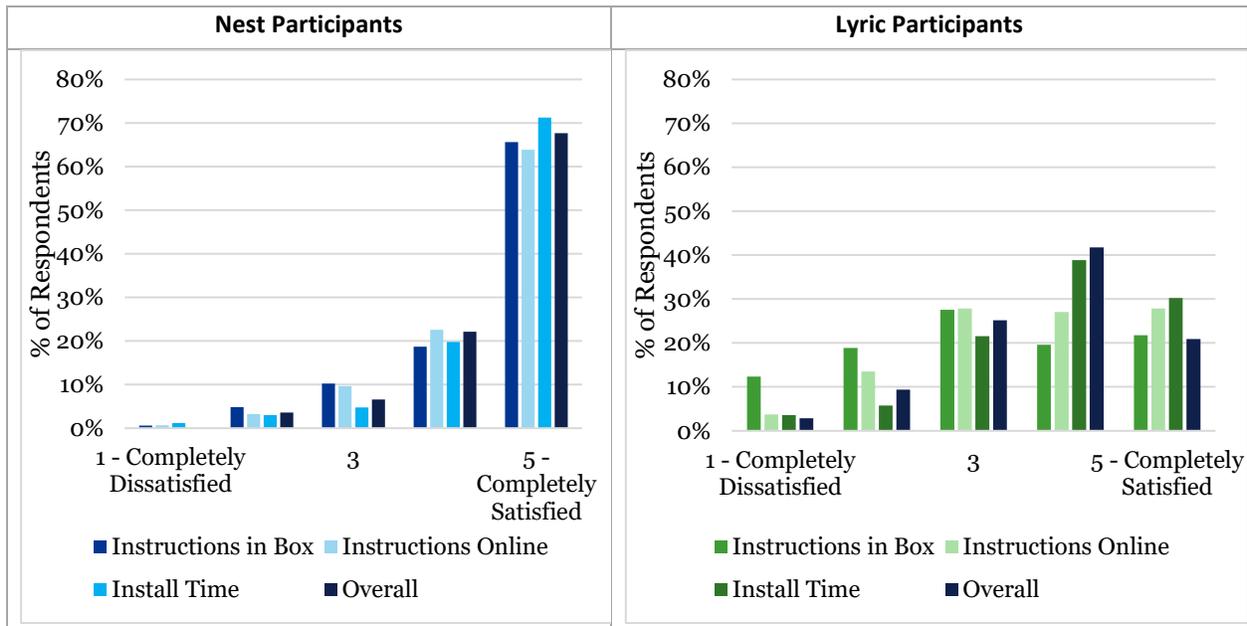
Figure 7. Ease of smart thermostat installation



Source: First participant survey. Don't know/refused: Nest N=1; Lyric N=0. Wiring, setup and configuration, and connecting to Wi-Fi were statistically different between the Nest and Lyric; there was no statistically significant difference for base unit to wall.

Similar to the difficulty ratings, the participant installation satisfaction ratings were highly dependent on the device: 90% of respondents indicated a satisfaction rating of either a "4" or "5" out of 5 for the overall installation process of the Nest (where "1" was "completely dissatisfied" and "5" "completely satisfied"), while only 63% of the Lyric users provided an equivalent satisfaction rating (Figure 8). Similarly, over 60% of all Nest respondents gave each aspect of the installation process a 5 out of 5, whereas less than 30% of Lyric users gave each aspect of the installation process a 5 out of 5 (Figure 8).

Figure 8. Satisfaction related to installation of the smart thermostat

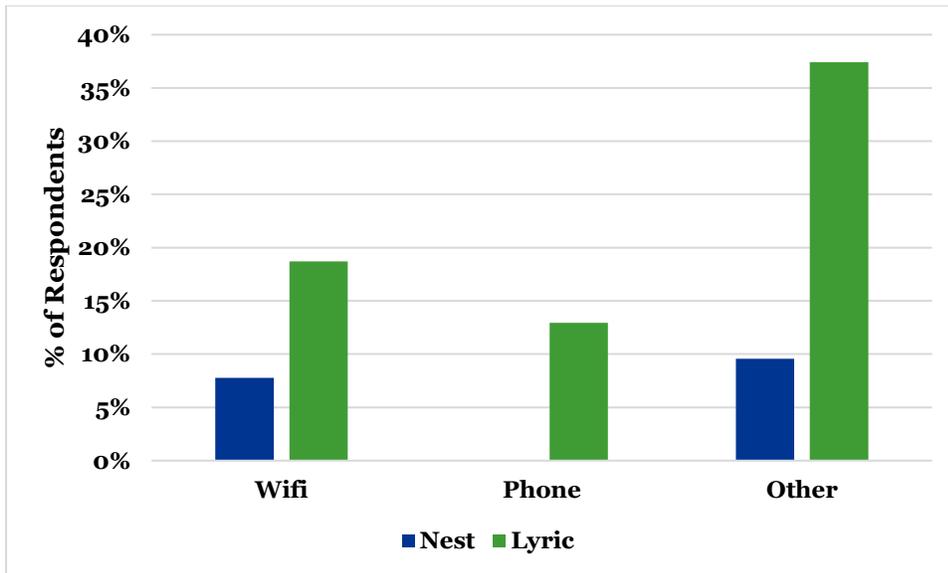


Source: First participant survey. Don't know/refused: Nest: Instructions in box N=1; Instructions online N=12; Install time N=0; Overall N=0; Lyric: Box N=1; Online N=6; Time N=0; Overall N=0. Differences between the Nest and Lyric participants are statistically significant.

Participant satisfaction with installation was highly dependent on whether the participant experienced issues during the installation process. Only 8% of Nest participants, compared with 19% of Lyric participants, indicated experiencing household Wi-Fi connectivity issues during the installation process (Figure 9). Since the initial Lyric installation and setup requires connecting to a Smartphone rather than to the home Wi-Fi-network¹⁹, 13% of the Lyric participants experienced some trouble connecting the thermostat to their phones. An even higher percentage of Lyric users indicated experiencing installation issues (37%) – over three times that of the Nest user base (10%). For Nest participants, the primary “other” issue was almost entirely related to difficulty with unique wiring situations, whereas for the Lyric, wiring was a significant issue as well, but “other” issues also included poor instructions/manual, dead battery, general settings/setup, and geofencing.

¹⁹ For the Lyric, the initial installation and setup is done via wireless connection directly to the user smartphone but is later connected to the home wireless signal.

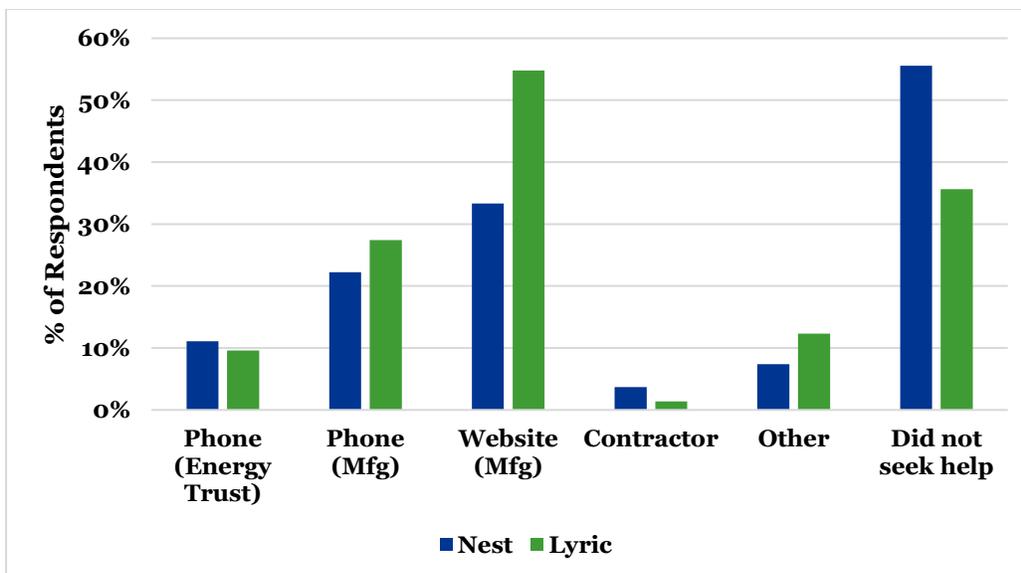
Figure 9. Participants that experienced installation issues



Source: First participant survey. Differences between the Nest and Lyric participants are statistically significant.

As noted in the Introduction section, one of the goals of the Pilot was to test whether the self-install approach would be successful, and if participants could leverage the manufacturer-based support (online, phone) for resolving installation issues. As seen in Figure 10 below, most of the participants that required support did seek assistance from the manufacturers either via phone or website. Lyric participants were more likely to reach out for support due to the higher prevalence of installation issues experienced by Lyric participants.

Figure 10. Source of support for participants that experienced installation issues



Source: First participant survey. Base is participants that experienced installation issues, not all participants. Differences between the Nest and Lyric participants are statistically significant.

Installation feedback provided by staff showed that the primary challenges specific to Nest were furnace-thermostat incompatibility (n=3), including multi-stage or modulating furnaces, and proprietary furnace-thermostats that were simply not compatible (mostly modern Carrier systems, among others). Lyric users did not have the same compatibility issues, but had several other performance issues. For example, feedback regarding thermostat issues provided in CLEAResult's Smart Thermostat Year-End report (see Appendix D) showed that while the overall incidence of thermostat failure was low (approximately 3%), there were also another 2% of participants that experienced problems that prevented them from installing the thermostat. The specific issues cited in this report were as follows:

- Three post-installation failures of Nest thermostats that had the same relay failures as the 2013 Nest Heat Pump Control Pilot. The furnace would run intermittently by itself, even when participants switched the thermostat off and removed it from the base plate. The thermostat reported an E52 error code, which Nest support calls an “overcurrent” event that trips a fuse inside the thermostat.
- One customer reported that their Lyric thermostat heated the house too much, then immediately switched over to cooling.
- Another customer reported that the Lyric would start up and appear to work, but as soon as the Lyric tried to turn on the furnace, it would restart itself (and turn off the furnace).
- Several other customers reported that their Lyrics ran their fans intermittently or semi-continuously, despite settings indicating otherwise.

5.3 User Experience

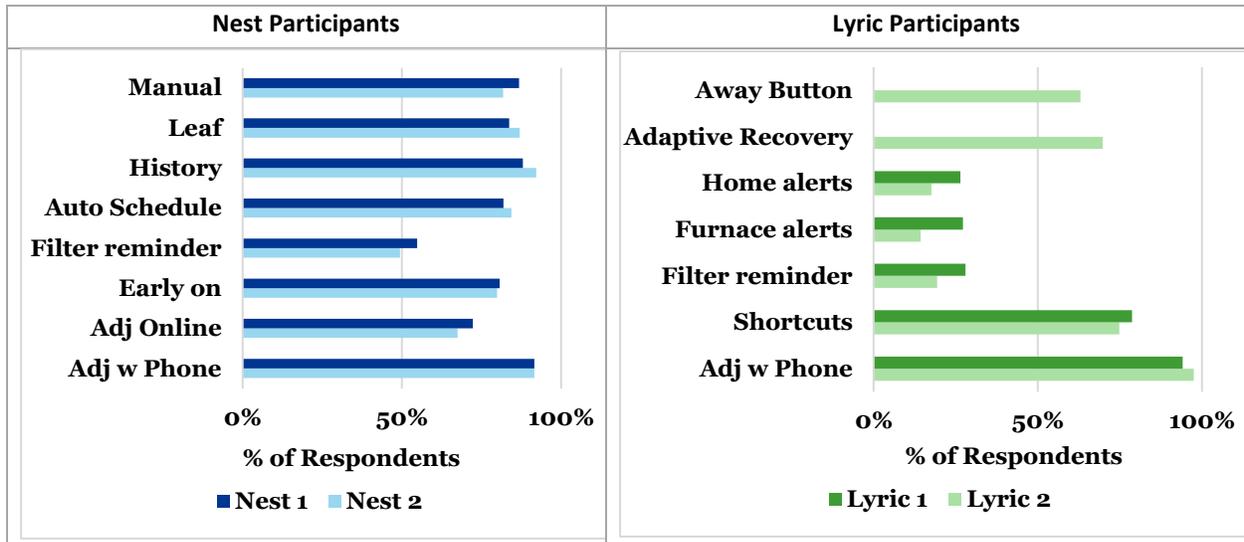
5.3.1 Features, Settings, and Participant Usage

Both thermostats offer numerous features and functionality, many of which are similar and some of which are unique to each (for a review of these features, please see Table 3 in the Background section above). The most commonly used feature of the Nest was the Nest Leaf (almost 100% of participants), closely followed by AutoSchedule (95%), and Energy History (95%). These findings mirror the findings from the Nest Heat Pump Control Pilot, which showed the same three features having the highest usage. For the Lyric, almost 100% of participants indicated using their smartphones to adjust the thermostat, while a slightly lower percentage (94%) of Nest participants adjusted their thermostats with smartphones. Since a smartphone is the primary means to adjust the Lyric, these findings are in line with a priori expectations.²⁰

²⁰ Though the usefulness of the Lyric smartphone adjustment may appear to be a positive finding, anecdotal evidence suggests that some users were frustrated with not being able to directly operate the thermostat (even while standing in front of the thermostat) having to rely solely on the use of their smartphone to make certain adjustments.

The same group of features for both Nest and Lyric were perceived to be the most useful features, with the majority of Nest participants believing all of the features were “Somewhat Useful” or “Very Useful.” The results from both survey responses are included in Figure 11 below.

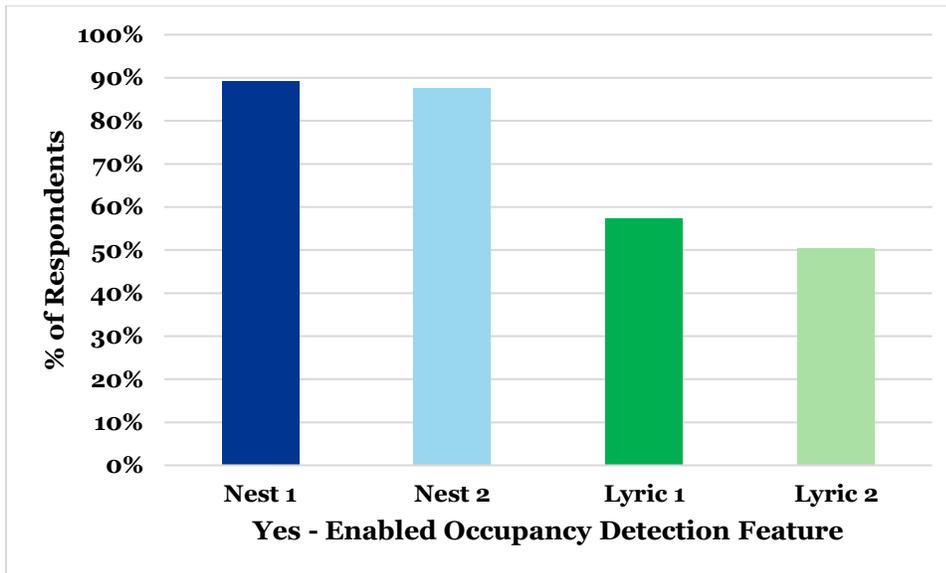
Figure 11. Percentage of survey respondents finding specific features somewhat or very useful



Source: First and second participant surveys.

One of the primary energy-saving features of the smart thermostats is occupancy detection. For the Nest, this feature is called “Auto-Away,” and minimizes heating when the device determines no one is home based on an occupancy sensor (motion sensor); for the Lyric, this feature is called “geofencing,” which utilizes the GPS location of the smartphone that is matched with the thermostat (during the Pilot period, the Lyric away settings, were activated when the smartphone exceeds two standard distances: 500 feet, or a 7 mile radius). When the Nest thermostat is installed, the Auto-Away feature should be preset as enabled, unless disabled during setup by the user. For the Lyric, the geofencing is not enabled by default, and the user is required to enable the geofencing during initial setup.

Nest users overwhelmingly left the Auto-Away function enabled: 88% of first and second survey respondents left this function enabled (Figure 12). The Lyric respondents were not as likely to have enabled the geofencing function: only 57% of Lyric users had enabled this feature by the first survey, and slightly less (50%) had this feature enabled by the second survey. Nest users’ primary reasons for disabling Auto-Away were due to being retired or working from home, or having multiple levels in their homes and concerns about changes in temperature even when people were home. The primary reasons Lyric users did not enable geofencing were: because additional household members had either no phone or an incompatible phone, the hassle of programming multiple phones to account for this issue, and feeling the functionality wasn’t useful. Because occupancy sensing is one of the primary energy savings features of both devices, the difference in utilization of this feature between the two devices suggests that Lyric participants should expect lower gas savings than Nest participants.

Figure 12. Participants enabling occupancy-based settings (Auto-Away/Nest; Geofencing/Lyric)

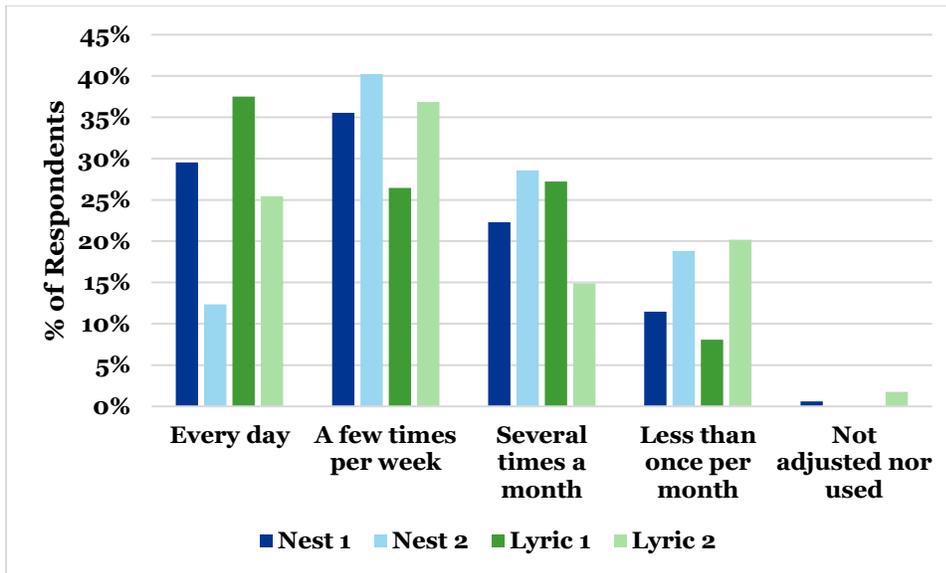
Source: First and second participant surveys. Don't know/refused: Nest 1: N=8; Nest 2: N=7; Lyric 1: N=17; Lyric 2: N=9. Differences between the Nest and Lyric participants are statistically significant.

5.3.2 Participant Behavior

Findings from the previous Nest Heat Pump Control Pilot showed that slightly over one-quarter of all participants adjusted the thermostat on a daily basis, and that daily adjustment had decreased to just 14% by the second survey – a decline of almost 50%. The Evaluation Team had concluded that study participants were adapting to the thermostat's auto-learning behavior, just as the thermostat was adapting to the participants' behavior.

For this Pilot, a slightly higher proportion of Nest participants were making daily adjustments early into the Pilot period (almost 30%), and an even higher proportion of Lyric users were doing the same (38%). The frequency of thermostat adjustments for both thermostats and both surveys can be found in Figure 13 below. As seen in Figure 13, Nest participants showed a 60% relative decline in daily adjustments between the first and second survey. Lyric participants only showed a 35% relative decline in daily adjustments, indicating thermostat performance did not influence participant behavior as much. Statistical tests also showed that while the first survey indicated that the adjustment frequency was similar between the two thermostat groups, by the second survey the adjustment frequency had diverged. This finding may also confirm that the higher proportion of Lyric users who did not enable geofencing relied on manual adjustments rather than the automation features of the Lyric. This trend may also represent the “novelty effect” of the thermostat, which diminishes over time, or the participant's learning curve in understanding how to use the device. Interestingly, a significant proportion of participants in both groups continued to make frequent adjustments (daily or weekly)

Figure 13. Frequency of adjusting smart thermostat settings or using thermostat features



Source: First and second participant surveys. Don't know/refused: Nest 1: N=1; Nest 2: N=0; Lyric 1: N=1, Lyric 2: N=0. First survey respondents were not statistically different, but by second survey, differences in adjustment frequency were statistically significant between Nest and Lyric.

Regarding their previous thermostat, the vast majority of respondents (91% of Nest survey respondents and 85% of Lyric survey respondents) indicated that they had replaced a programmable thermostat. Even with the high percentage of participants that replaced programmable thermostats, a high number of these participants (57% of Nest and 51% of Lyric participants) indicated making frequent (daily or weekly) adjustments to their previous thermostat. Nest participants appear to have made more frequent adjustments to their old thermostats than Lyric participants, though differences between the two groups were not statistically significant. Since this was a self-install Pilot, there is no way to validate these findings.

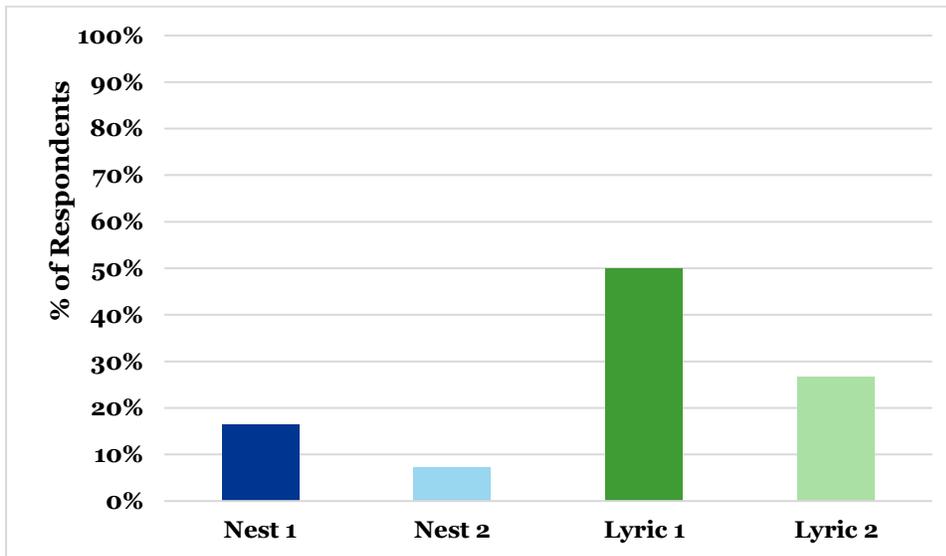
A high proportion (90%) of participants who previously owned programmable thermostats indicated that they had programmed these thermostats. This is interesting, because multiple studies have shown most programmable thermostats are never programmed.²¹ If in fact the participant population for this study programmed their thermostats, then energy-savings expectations would be lower for the programmed population than the non-programmed (and lower than those with manual thermostats). A review of the actual energy savings findings related to this issue is discussed in greater detail below in the billing analysis findings.

²¹ http://wcec.ucdavis.edu/wp-content/uploads/2013/06/364_2010ACEEE_Meier_Final3.5_06.04.10.pdf, http://m.journalnow.com/business/business_news/national_international/many-people-have-no-idea-how-to-use-their-thermostats/article_ad445b7f-b5e7-5ae6-98d2-ed06c1b4f1a1.html?mode=jqm and <http://aceee.org/files/proceedings/2012/data/papers/0193-000237.pdf>

5.3.3 Customer Satisfaction

Customer satisfaction is related to the number of issues encountered with the thermostats. Aside from installation issues already reviewed earlier, 50% of Lyric respondents in the first survey, and 27% in the second survey, reported having additional issues with their thermostat (Figure 14). Nest recipients had a considerably lower level of post-installation issues than Lyric recipients, with only 16% of Nest respondents in the first survey, and 7% in the second survey reporting additional issues.

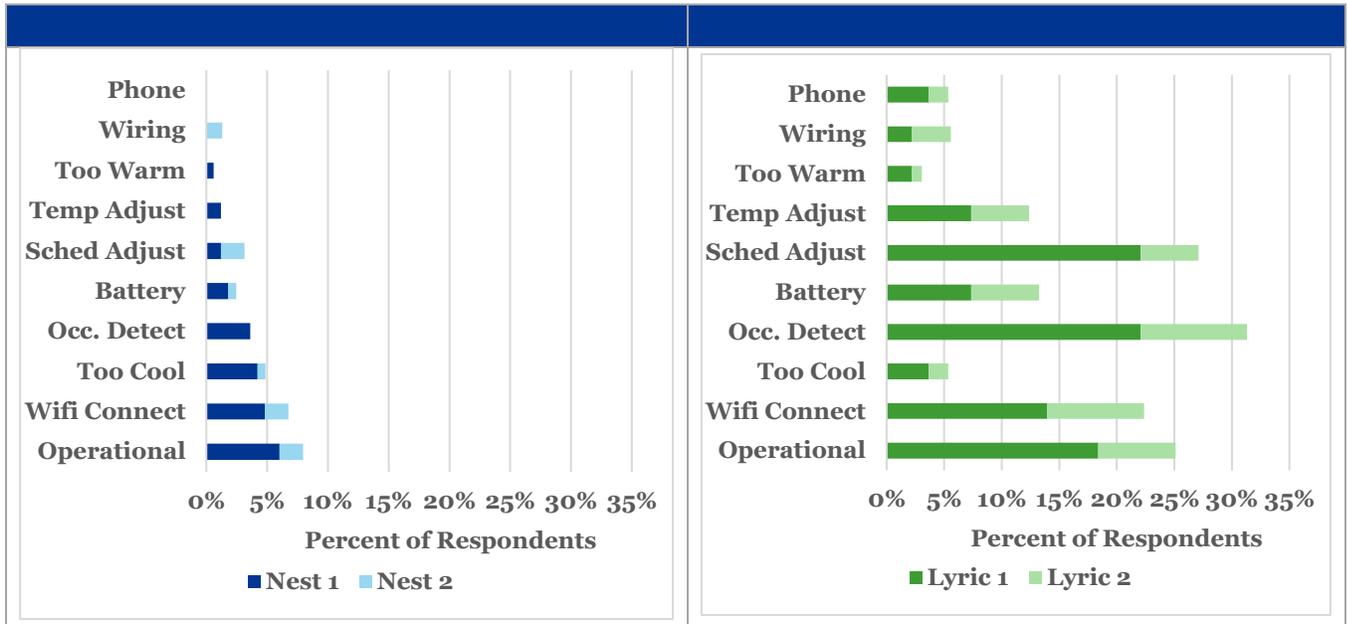
Figure 14. Additional non-installation issues with smart thermostat



Source: First and second participant surveys. Don't know/refused: Nest 1: N=2; Nest 2: N=1; Lyric 1: N=0, Lyric 2: N=3. Differences between the Nest and Lyric participants are statistically significant.

The two most pronounced issues Lyric users experienced early on in the Pilot (based on first survey results - Figure 15) were occupancy detection, and adjusting the thermostat schedule. By the second survey, these issues had been greatly reduced, with occupancy detection and Wi-Fi issues being the two most common issues for Lyric users. As noted above, Nest users experienced considerably fewer issues overall, with Wi-Fi connection and thermostat operation being the two most prevalent issues encountered early in the Pilot (first survey results). The array of additional issues are substantially less in the second round of survey responses for both thermostats, perhaps indicating that the study participants learned how to better use the thermostats over time.

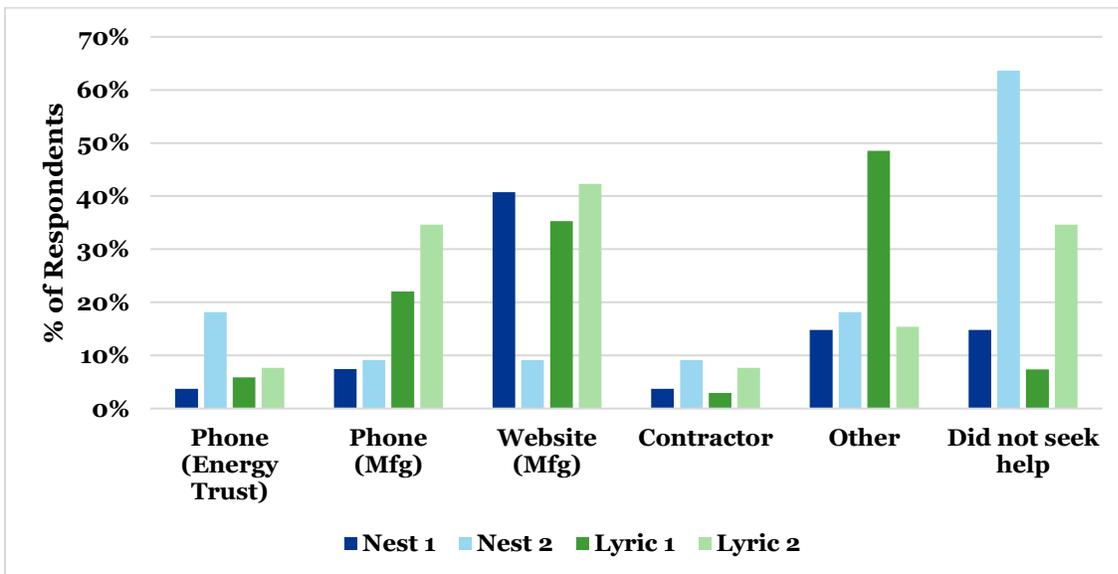
Figure 15. Percent of all participants experiencing specific non-installation issues



Source: First and second participant surveys. Don't know/refused: Nest 1: N=1; Nest 2: N=0; Lyric 1: N=0; Lyric2: N=0.

Of those participants that had post-installation problems, less than 10% of first survey participants reached out to Energy Trust for help, with most of the participants relying on friends or family (“other”), or the manufacturer website for help. A review of the channels used for support is shown in Figure 16 below.

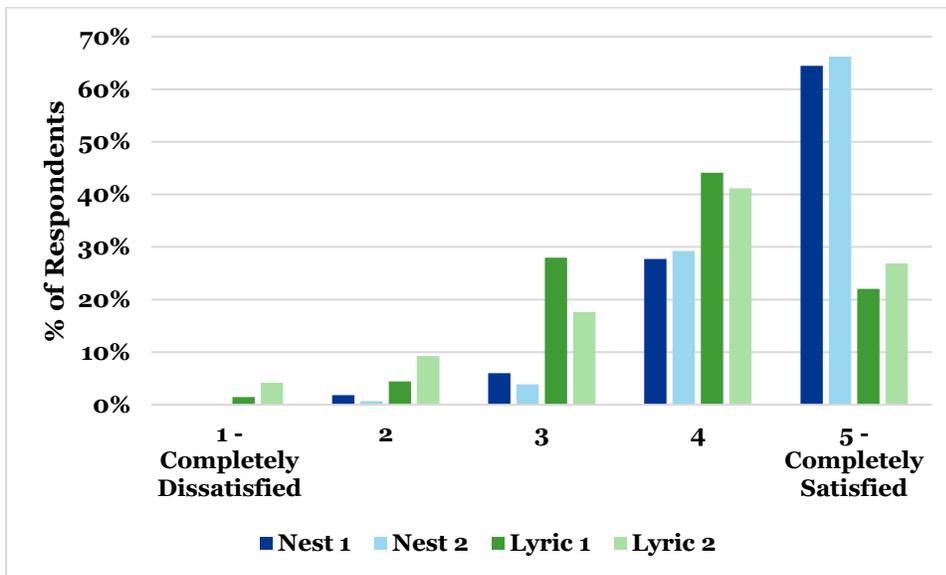
Figure 16. Source of support for participants with smart thermostat non-installation issues



Source: First and second participant surveys; DK/Ref: Nest1: N=4; Nest2: N=0; Lyric1: N=5, Lyric2: N=0; Base population are those participants with post-installation issues. Differences between the Nest and Lyric participants are statistically significant.

Overall satisfaction with the thermostats mirrored that of the installation satisfaction: Nest users gave considerably higher satisfaction ratings relative to the Lyric, and also showed increased satisfaction over time (between the first and second surveys). Over 65% of Nest users gave the thermostat a 5 out of 5 (“5” representing completely satisfied, “1” representing completely dissatisfied), whereas only 24% of Lyric users gave it a 5 out of 5. Dissatisfaction followed the same trend: while 6% of Lyric users were dissatisfied in the first survey, over 13% of users were dissatisfied by the second. For the Nest, less than 2% of first survey users were dissatisfied with the device, and this declined to less than 1% by the second survey. An overview of satisfaction ratings between the two devices is included in Figure 17 below. Almost all of the twelve respondents unsatisfied with the Lyric thermostat in the second round survey indicated that lack of reliability, issues with geofencing, and general poor user interface and software were responsible for the low satisfaction rating. The single Nest participant that ranked satisfaction as a “2” was frustrated by the apparent difficulty in shutting-off the thermostat at the end of the heating season.

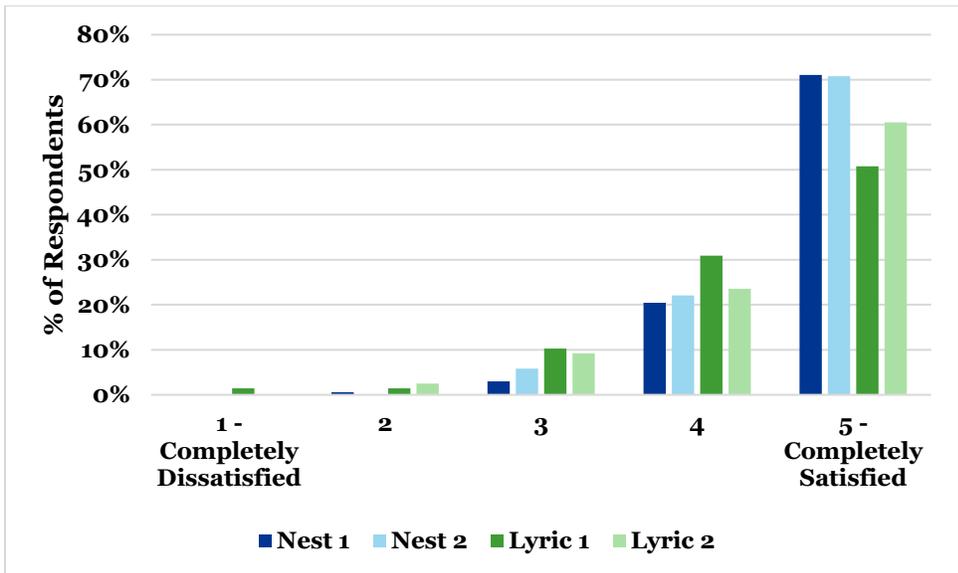
Figure 17. Satisfaction rating with smart thermostat



Source: First and second participant surveys. Don't know/refused: Nest 1: N=0; Nest 2: N=0; Lyric 1: N=0; Lyric 2: N=1. Differences between the Nest and Lyric participants are statistically significant.

Lyric participants rated participation in the Smart Thermostat Pilot higher than they rated the actual thermostat (Figure 18). Though Lyric participants had initially rated study participation lower than their Nest counterparts (based on the first survey), by the second survey the two thermostat populations' rating of study participation were not statistically different.

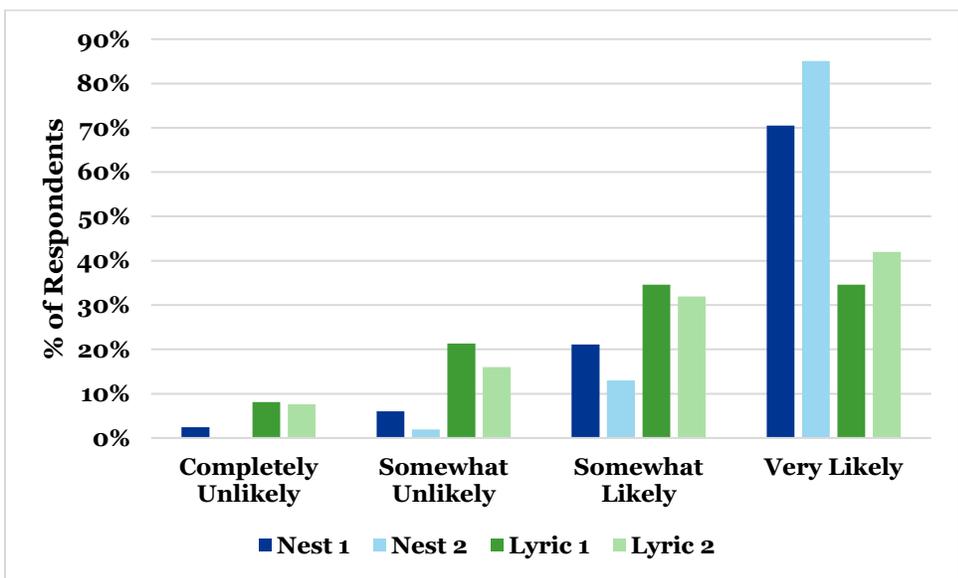
Figure 18. Satisfaction rating of participation in Smart Thermostat Pilot



Source: First and second participant surveys. Don't know/refused: Nest 1: N=8; Nest 2: N=2; Lyric 1: N=7; Lyric 2: N=4. Differences between the Nest and Lyric participants in the first survey are statistically significant, but differences in the second survey are statistically significant.

Consistent with the satisfaction ratings discussed above, there was considerably higher likelihood for Nest participants to recommend the thermostat relative to Lyric participants: 91% of the first survey respondents and 98% of the second survey respondents stated they were either “somewhat likely” or “very likely” to recommend the Nest thermostat to a friend or family member (Figure 19). For Lyric participants: 70% of first survey respondents and 74% of second survey respondents were either “somewhat likely” or “very likely” to recommend the Lyric thermostat to a friend or family member.

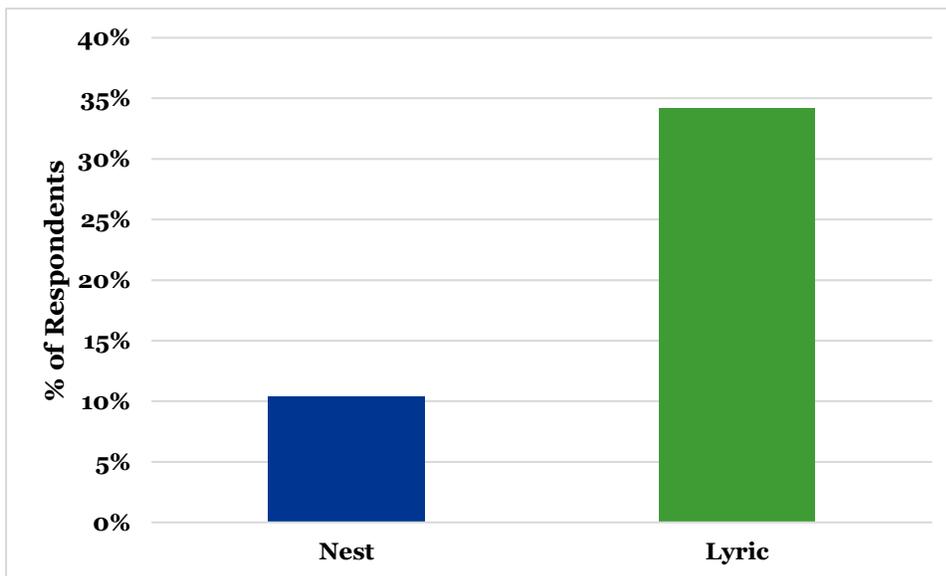
Figure 19. Likelihood to recommend smart thermostat



Source: First and second participant surveys. Don't know/refused: Nest 1: N=0; Nest 2: N=0; Lyric 1: N=2; Lyric 2: N=3.
Differences between the Nest and Lyric participants are statistically significant.

During the course of the Pilot, the Evaluation Team and program staff received some strongly negative feedback regarding the Lyric thermostat, with some users expressing a general sense of frustration with the operation of the device. Due to this feedback, the Evaluation Team decided to include a new question in the second survey that asked participants whether they would have opted to return the thermostat, assuming that they were not involved in the Pilot. Approximately 10% of Nest participants would have opted to return the thermostat, and were evenly split between those who would reinstall their old thermostat, and those who would install a new thermostat. Consistent with the other findings in this study, over one-third of Lyric participants (34%) would have opted to return the thermostat had they not participated in this Pilot.

Figure 20. If not involved in the Pilot, would you have returned the smart thermostat by now?



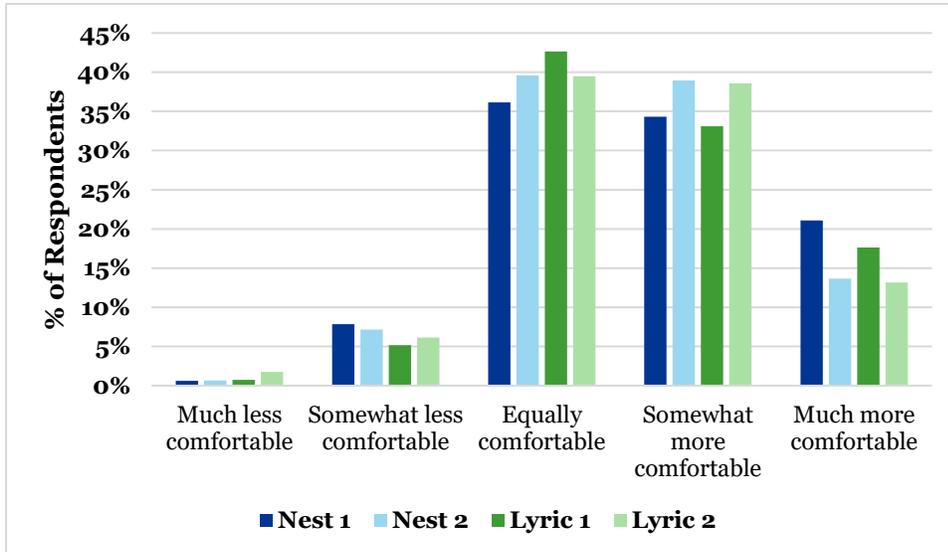
Source: Second participant survey. Differences between the Nest and Lyric participants are statistically significant.

5.3.4 Comfort of Participant Homes

One of the key findings from the previous Nest Heat Pump Control Pilot was that the non-energy benefits of the Nest were in some ways valued more highly to participants than the energy savings alone. A key indicator of non-energy benefits can be found by participants' changes in attitudes towards home comfort. Interestingly, both Lyric and Nest users did not differ over the change in comfort of their homes: over half of both Lyric and Nest survey respondents in both the first and second survey described the temperature of their home to be either "somewhat more comfortable" or "much more comfortable" after installing the thermostat. The two thermostat populations did not show a statistically significant difference in home comfort. The percentage of survey respondents who felt the

temperature was either “much less comfortable” or “somewhat less comfortable” was relatively low and remained fairly static between the first and second surveys.

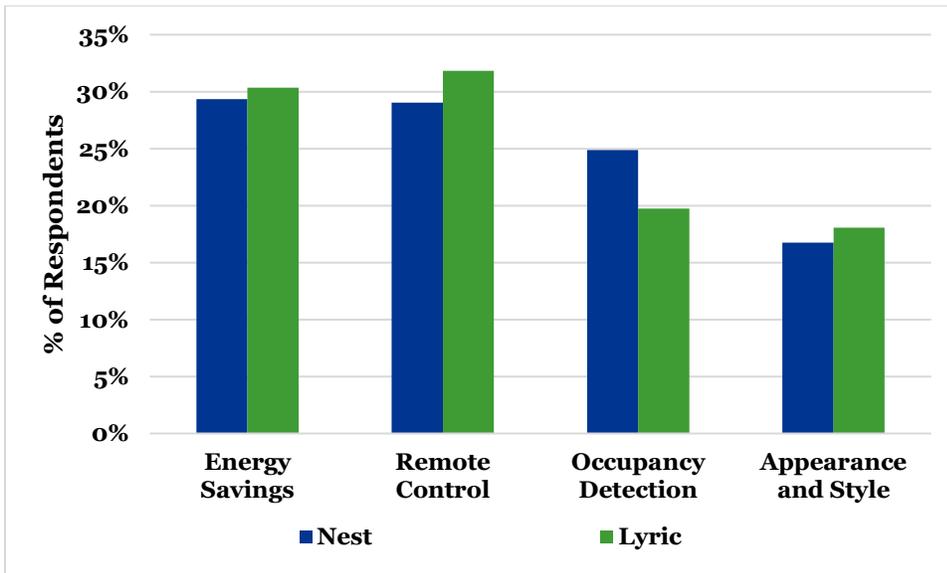
Figure 21. Comfort of home temperature compared to pre-smart thermostat period



Source: First and second participant surveys. Don't know/refused: Nest 1: N=0; Nest 2: N=0; Lyric 1: N=1; Lyric 2: N=1. Differences between the Nest and Lyric participants are not statistically significant.

Both Lyric and Nest participants agreed that energy savings, and the ability to remotely control their thermostat, were the two favorite aspects of their thermostats. The ranking of respondent’s favorite aspects of the thermostats is included in Figure 22 below. The appearance and style of the thermostats were the least favored features of both thermostats. The only statistically different aspect to the two thermostats based on the four available categories was the occupancy detection; a statistically higher proportion of Nest participants preferred the Auto-Away relative to the geofencing for Lyric users.

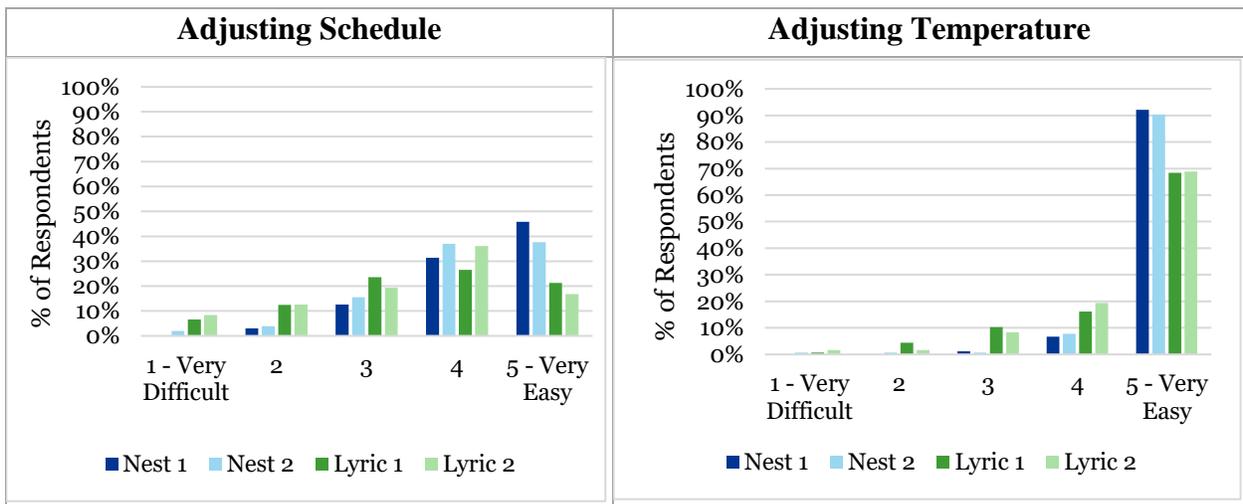
Figure 22. Favorite aspect of the smart thermostats



Source: First participant survey. Differences between the Nest and Lyric participants for energy saving, remote control, appearance and style are not statistically significant; differences for occupancy are statistically significant.

Understanding how participants ranked the ease of use for various aspects of both thermostats provides an indicator of usability for each thermostat. Included in Figure 23 below are two measures of participants’ ease of use: adjusting the schedule, and adjusting the temperature. About three-quarters of the Nest participants found schedule adjustment to be easy or very easy (a “4” or “5” on a five-point scale, where “1” is very difficult and “5” is very easy), whereas only about half of the Lyric participants stated it was easy or very easy to adjust the schedule (differences are statistically significant). Adjusting temperature proved to be considerably easier for both participant groups, with almost 100% of Nest participants and 86% of Lyric participants ranking it easy or very easy.

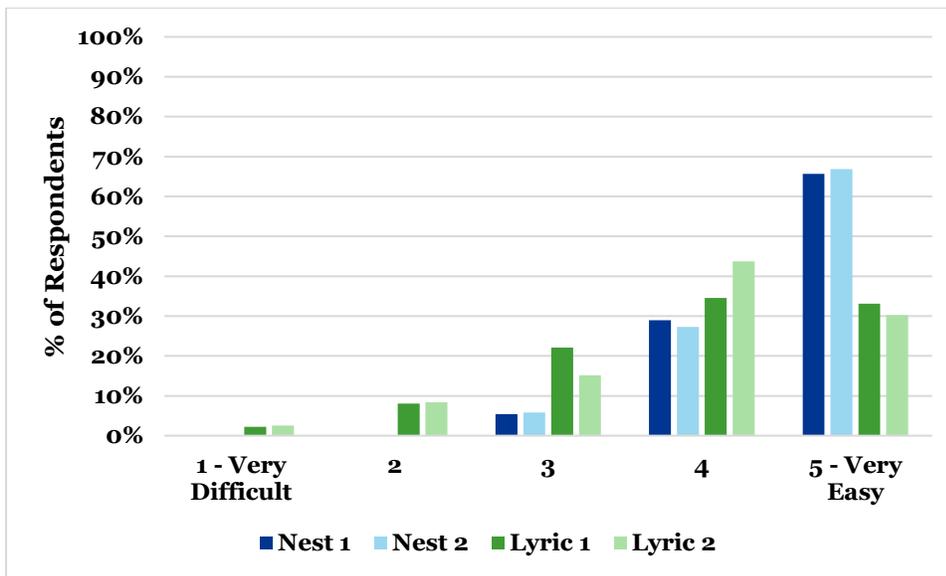
Figure 23. Ease of smart thermostat operation – schedule and temperature adjustment



Source: First and second participant surveys. Don't know/refused: Schedule: Nest 1: N=12; Nest 2: N=13; Lyric 1: N=13; Lyric 2: N=8. Don't know/refused: Temperature: Nest 1: N=0; Nest 2: N=0; Lyric 1: N=0; Lyric 2: N=0. Differences between the Nest and Lyric participants are statistically significant.

A similar trend continued for participants when asked to provide feedback on the overall user interface for each thermostat. Nest showed considerably higher satisfaction ratings, with 95% of participants rating the overall user interface either easy or very easy to use, while approximately 70% of Lyric participants gave the same ranking for their thermostat (differences between the Nest and Lyric participants are statistically significant). While there were no Nest participants that found the overall user interface difficult to use, 10% of Lyric participants rated the user interface either difficult or very difficult to use.

Figure 24. Ease of smart thermostat operation – overall user interface



Source: First and second participant surveys. Don't know/refused: Nest 1: N=0; Nest 2: N=0; Lyric 1: N=0; Lyric 2: N=0. Differences between the Nest and Lyric participants are statistically significant.

5.3.5 User experience related to implementation staff QA site visits

CLEAResult staff also had planned on administering quality assurance site visits on approximately 20% of the participants’ homes (80 homes). Due to time and budget constraints, the QA site visits were scaled back to 10% of homes (n=47), focusing slightly more on Lyric (n=27) than Nest (n=20) households due to higher incidence of negative feedback and issues associated with the Lyric. The primary objectives were to verify the installation of the thermostat, check if occupancy detection was enabled (Auto Away for Nest and geofencing for Lyric), ensure that Nest thermostats were not located in low traffic areas (whereby the Away setting could be triggered even when people were home), and log the furnace type

and efficiency (AFUE). Finally, staff also checked that AC was wired correctly, since they didn't want participants to be surprised if their AC didn't work during the summer cooling season.

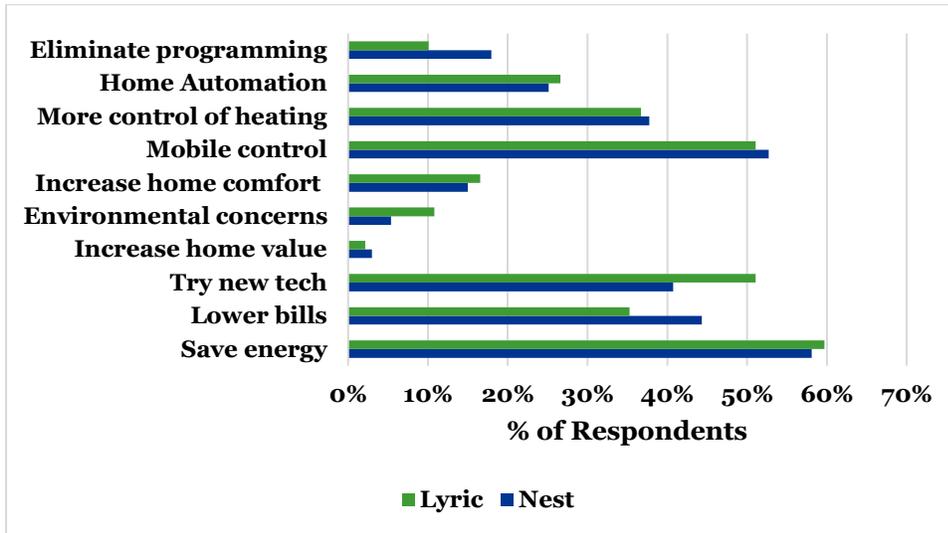
The QA site visits conducted by program staff showed that:

- All thermostats were installed, connected to the Wi-Fi network, and operating
- More than 60% of Lyric participants were not using the geofencing feature, either because they were unaware of it, couldn't get it to work, or didn't believe it applied to their lifestyle. The same proportion (60%) for the same group of participants indicated in both surveys as having not enabled the geofencing feature. This compares with 43% of all first survey respondents and 50% of all second survey respondents indicating they had not enabled this feature.
- Only 1 of the 20 (5%) Nest QA participants had disabled the Auto-Away feature, though 4 of the 20 (20%) Nest QA participants indicated disabling this feature based on the participant surveys. This compares with 11% of first survey and 12% of second survey respondents indicating they had disabled Auto-Away.
- Two participants didn't realize that the Lyric was exclusively designed for smartphone use, and lacking a smartphone, they couldn't use the geofencing.
- There were lots of complaints about the Lyric user interface, and only three Lyric users stated that they really liked it. Some Lyric participants indicated they were dissatisfied with the Lyric, and wanted the Nest.
- Staff had to set up the geofencing for several Lyric participants, as they were unable to set up the feature themselves.
- Staff perceived that Nest participants were generally more familiar with their thermostat than Lyric participants.
- Participants in both thermostat groups indicated that installation was not difficult – and QA staff believed the lack of issues can be attributed to the pre-screening process to filter prospective participants.
- Three of the 20 Nest QA sites had the thermostats installed in low-traffic areas, though only two of the three sites were deemed to have potential occupancy detection issues because of this (Auto-Away incorrectly enabling away setback temperatures when occupants are still home).

5.3.6 Participant commitment to energy savings

To understand participants' commitment to saving energy, the Evaluation Team asked participants their primary reason for participation in the Pilot. As seen in Figure 25, the most cited reason for participation in the Smart Thermostat Pilot was to save energy, with almost 60% of both Nest and Lyric respondents listing it among their top three reasons for participating. The next most frequent response was to allow mobile control of their homes (52%), followed by the desire to try new technology (45%). Participants in the Nest Heat Pump Control Pilot had overwhelmingly chosen lowering bills as the number one reason (88% of participants), possibly reflecting higher electric heating bills.

Figure 25. Reasons for Smart Thermostat Pilot participation

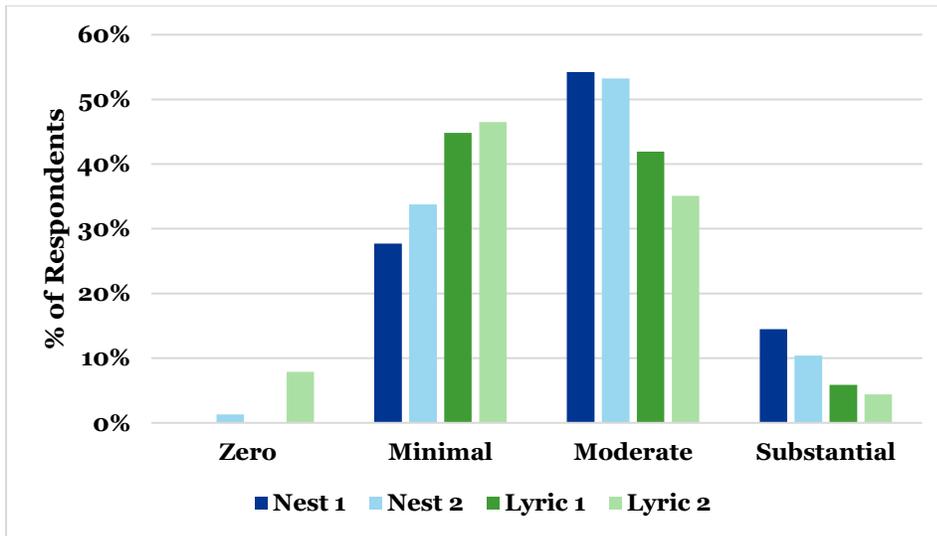


Source: First participant survey. Survey respondents could provide up to three reasons for participation, so the total sums to over 100%. Differences between the Nest and Lyric participants are statistically significant.

Participants in this Pilot were very motivated by the potential energy savings. As discussed above, the most cited reason for participation in the Pilot was to save energy (Figure 25). Saving energy was also rated as the most important single feature for both thermostats. Participants were also asked about their expectations for energy savings from each thermostat.²² Slightly higher energy savings expectations were seen in the first survey for both thermostats, with 14% of Nest and 6% of Lyric survey respondents initially indicating that they had high savings expectations (Figure 26). Nest participants had higher overall expectations for energy savings relative to Lyric participants, although both groups showed lower energy savings expectations than the previous heat pump Pilot.

²² Participants were provided three savings options in the first survey: minimal (<5% of energy bill), moderate (between 5 and 10%), and substantial (over 10%). A fourth option, zero savings, was added to the second survey to differentiate minimal (<5%) to those who believed there would be zero savings.

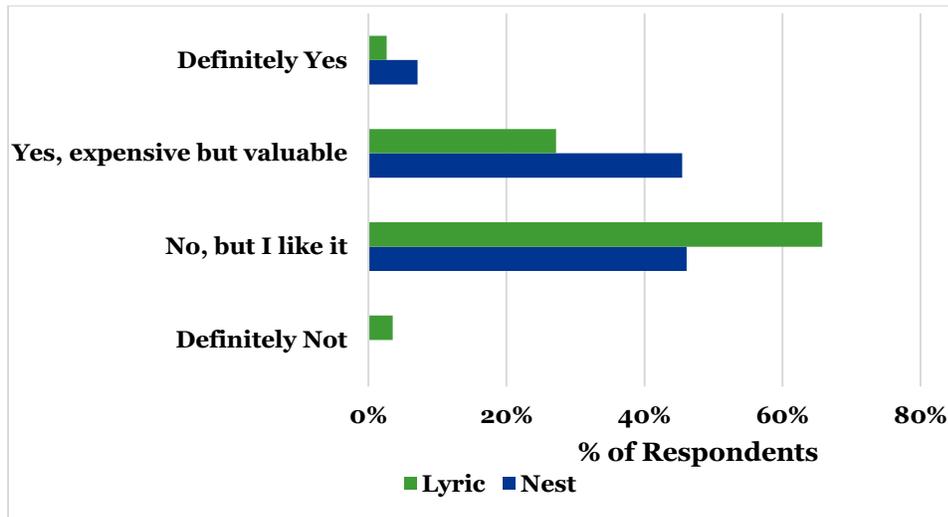
Figure 26. Energy savings expectations



Source: First and second participant surveys. Don't know/refused: Nest 1: N=6; Nest 2: N=2; Lyric 1: N=10; Lyric 2: N=7. Differences between the Nest and Lyric participants are statistically significant.

Both Nest and Lyric thermostats, in the absence of the Energy Trust incentive, are a fairly substantial investment, at approximately \$250 retail (at the time of this study). Study participants were asked whether or not they believed the full retail price was justified. Over half of the Nest respondents (52%) believed that the full retail price was warranted, with 46% believing it was too expensive but still liking the thermostats (Figure 27). Only 30% of Lyric respondents believed that the full retail price was warranted, with 66% believing it was too expensive but still liking the thermostats, and another 4% believing the Lyric was definitely not worth \$250 (Figure 27). A higher proportion of participants in the prior Nest Heat Pump Control Pilot believed the \$250 retail price made sense, though this participant group also had higher expectations for energy savings and received the thermostat free-of-charge.

Figure 27. Does the \$250 smart thermostat price tag make sense?



Source: Second participant survey. Don't know/refused: Nest: N=2; Lyric: N=1. Differences between the Nest and Lyric participants are statistically significant.

As a follow-up to the question about the thermostat price, survey respondents who believed the full retail price was reasonable were asked whether that sentiment held true if zero energy savings were associated with the thermostats. Forty-five percent of all survey respondents stated that the Nest thermostat was worth the full amount even if no energy savings were realized, with one-third of Lyric respondents believing the same, though the difference is not statistically significant. These results are similar to the proportion of Nest Heat Pump Control Pilot participants (34%) that believed their thermostats were worth the full retail price, absent any energy savings. The results suggest that study participants place a high value on the thermostats' non-energy features.

5.4 Energy Savings

One of the primary objectives of this Pilot was to determine the heating-based gas energy savings associated with the installation of the smart thermostats in gas-heated single family homes. The questions that were originally posed in relation to energy savings included:

- How much energy do smart thermostats save when self-installed in gas-heated homes?
- Is there a significant difference between the two products tested?
- Do savings vary by participant demographics or housing characteristics?
- Which thermostat functions are most important in saving energy?

The following section includes answers to these questions and provides insight into the billing analysis used to estimate the energy savings.

5.4.1 Sample Characteristics

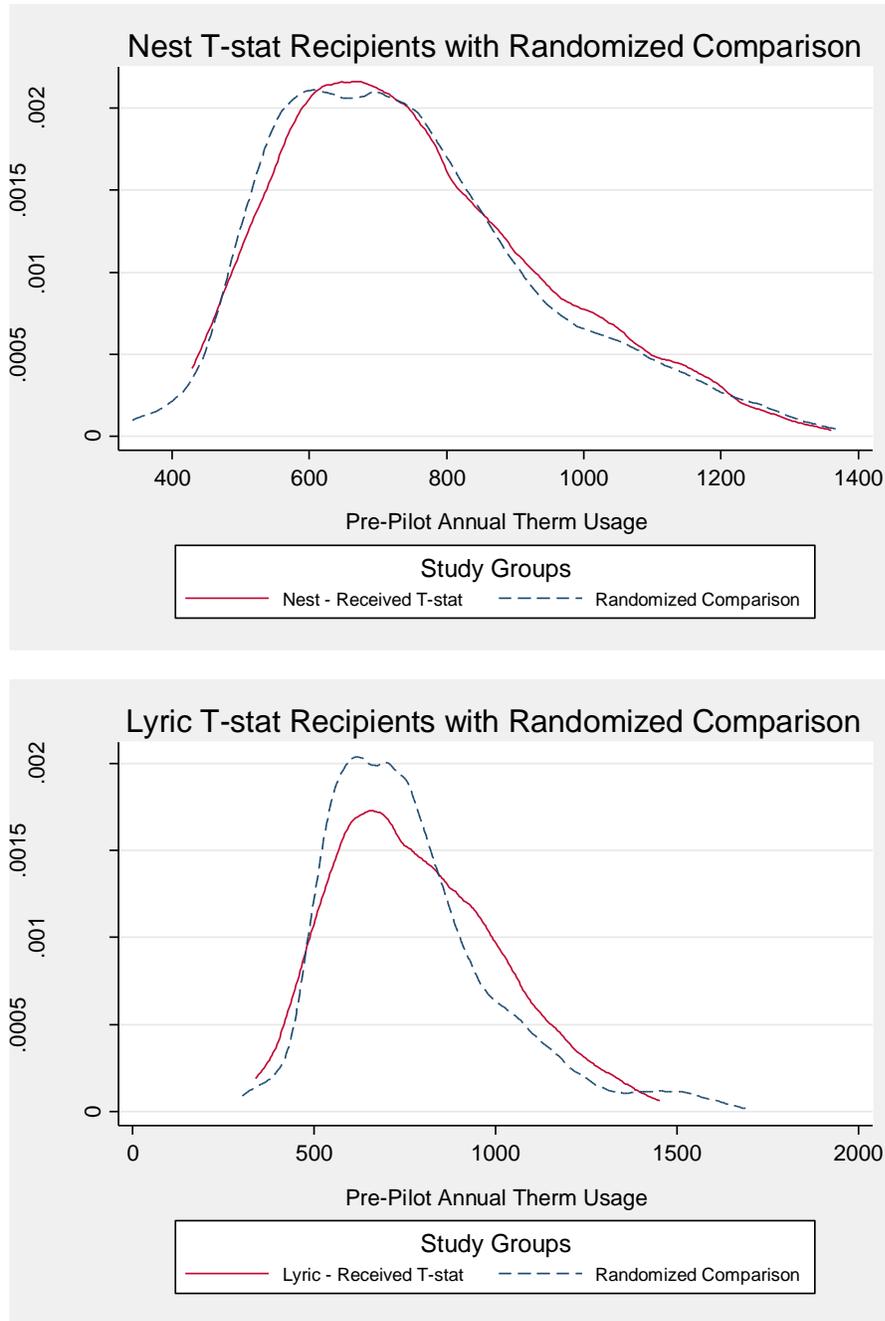
The final thermostat recipient sample contained, after attrition, 153 Nest and 127 Lyric participant homes. In addition, there were 592 Nest and 580 Lyric intention-to-treat homes available for analysis. Table 15 displays the characteristics of Pilot homes within each study group. As noted above, very limited information was available for the homes each of the comparison groups, so they could not be directly compared on most metrics. In terms of pre-Pilot raw annual gas usage, the participant and comparison group homes were very similar. Lyric recipient homes appeared to have slightly higher baseline gas usage versus to the randomized comparison group, but this difference was not statistically significant.

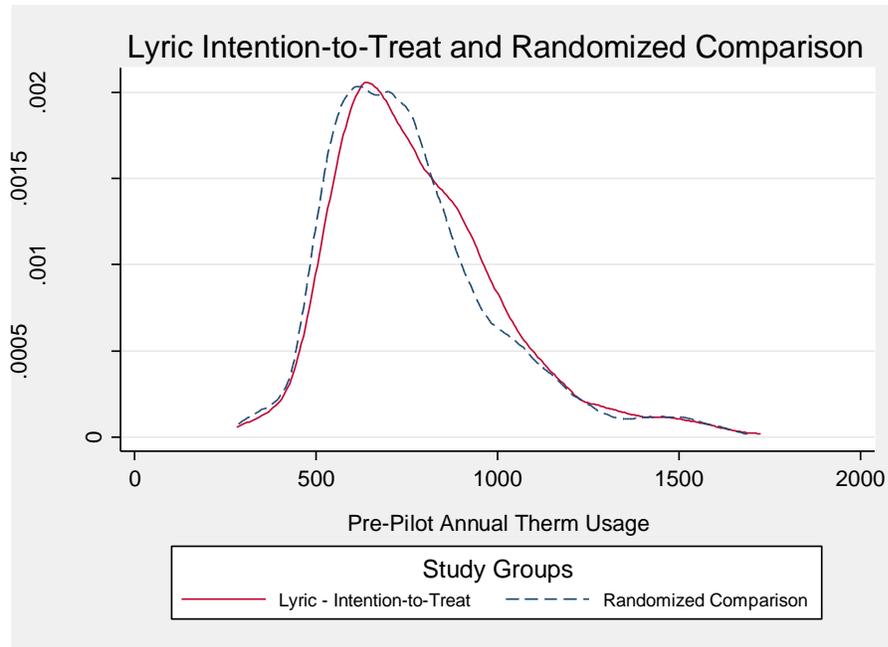
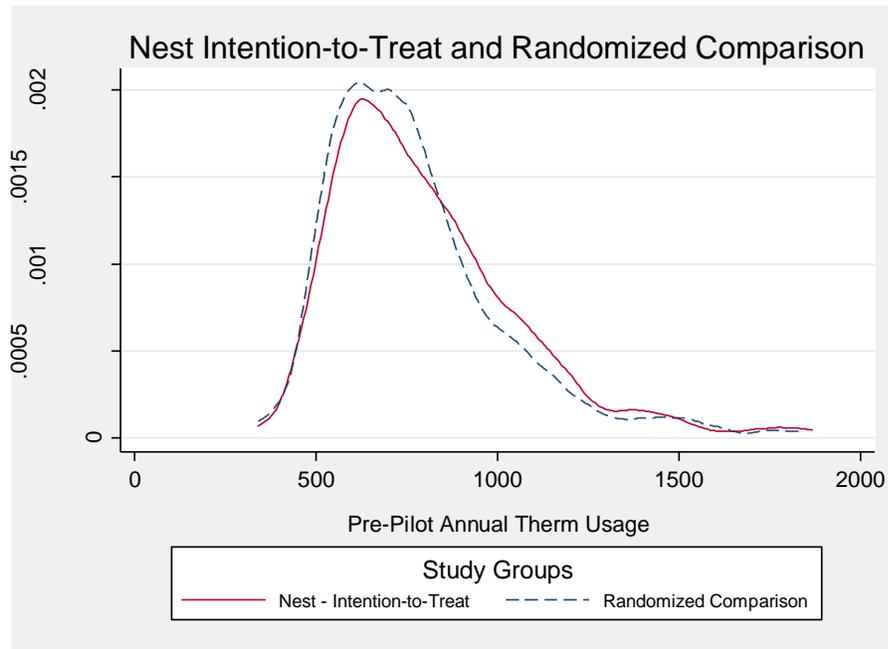
Figure 28 displays the distribution curves of mean annual gas usage for each study group, which are also very similar. In addition, the Nest and Lyric homes were predominantly located in the Portland Metro area (defined as the three counties containing and surrounding Portland, OR), were above 2,000 square feet, and had two stories, on average. Roughly half of the homes in each thermostat group were built before 1990. Less than 10% of both Nest and Lyric thermostats were installed in the homes of Energy Trust employees and contractors. Although this sub-group had slightly lower baseline gas usage than the rest of the sample, and may have very different home efficiency levels and energy related behaviors, removing them from the analysis did not meaningfully change the results.

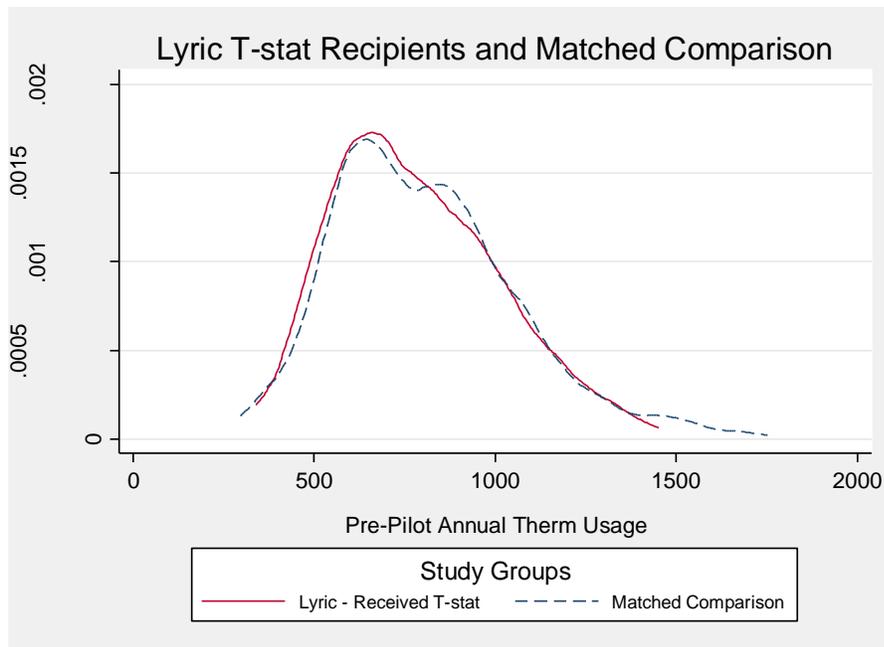
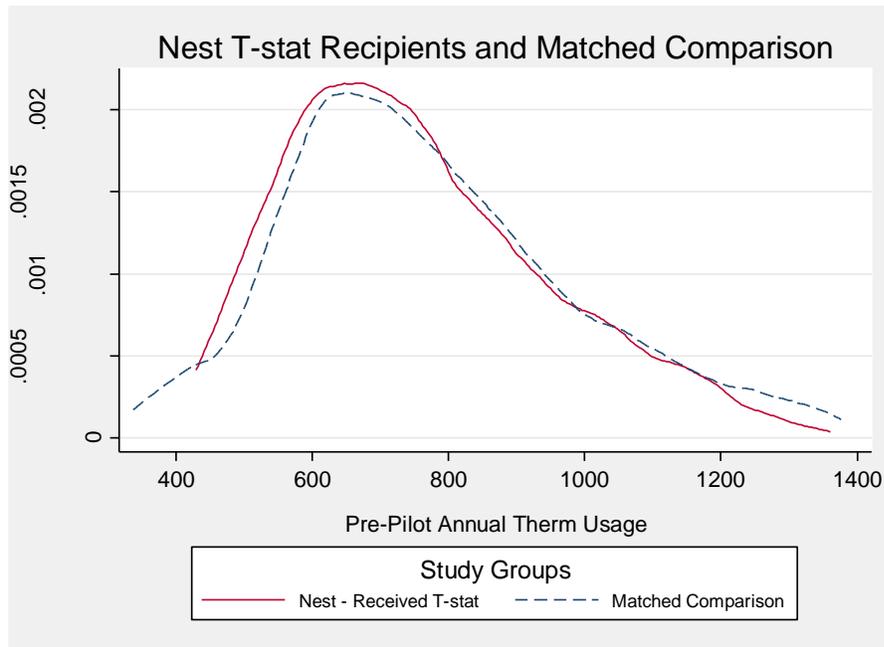
Table 15. Characteristics of Pilot participant homes prior to removing outliers in pre-Pilot annual gas usage

Study Group	N	Pre-Pilot Mean Annual Therms	% Portland Metro	% Homes ≥ 2,000 Sq. Ft.	% Two or More Stories	% Homes Built After 1990	% Energy Trust Employees & Contractors
Nest - Received T-stat	157	759	66%	63%	74%	51%	7%
Nest - Intention-to-treat	592	820	54%	58%	72%	49%	--
Lyric - Received T-stat	131	793	71%	66%	78%	46%	8%
Lyric - Intention-to-treat	625	799	53%	56%	72%	47%	--
Randomized Comparison	846	774	57%	--	--	--	--

Figure 28. Distribution of pre-Pilot mean annual gas usage in therms by study group, for each treatment and comparison group pair



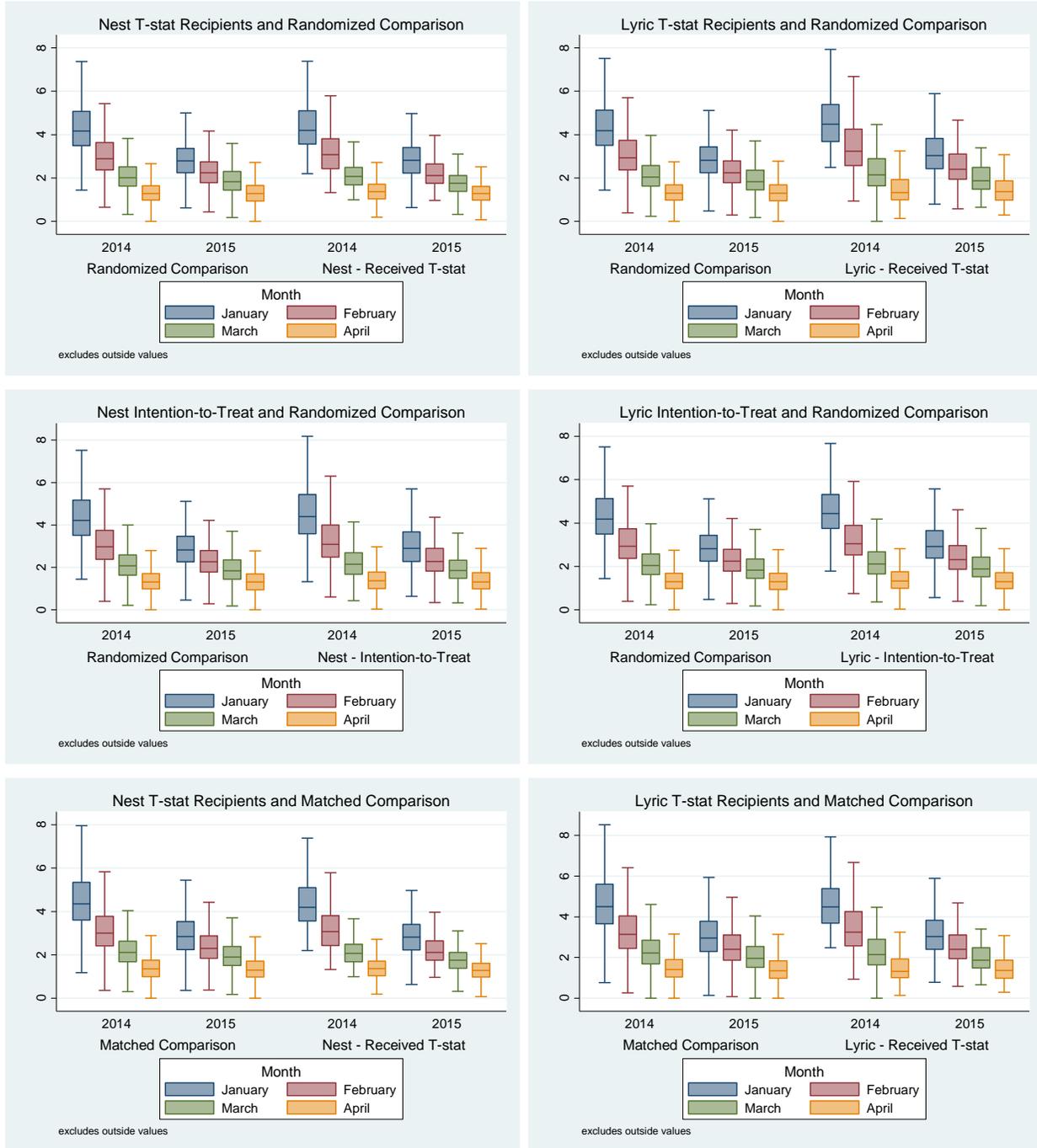




To begin exploring the monthly gas use data and comparing the change in usage over time between the pairs of study groups, the Evaluation Team aggregated raw gas usage by month of meter reading. The Evaluation Team visualized monthly gas use with box plots comparing usage in each month between January and April for 2014 and 2015, pre- and post-installation of the thermostats. Figure 29 displays monthly gas usage for the first few months of 2014 and 2015 in Nest and comparison homes, side-by-side. Figure 29 also displays the same data for Lyric and comparison homes. It is clear from these plots that gas usage for all homes was lower in the first few months of 2015 than in 2014. This is likely due to the historically warm 2014/2015 heating season in the Northwest, which resulted in lower overall gas

usage. Any differences between the participant and comparison homes, particularly the changes from 2014 to 2015, are difficult to discern in these plots.

Figure 29. Box plots of monthly distribution of gas usage by study group, for each treatment and comparison group pair, January-April 2014 and 2015



5.4.2 Energy Savings

In the following sub-sections, the Evaluation Team describes the results of the billing analysis for:

- Thermostat recipient homes compared to a randomized comparison group
- Intention-to-treat homes compared to a randomized comparison group
- Thermostat recipient homes compared to a matched comparison group

5.4.2.1 Thermostat recipient homes vs. randomized comparison group

The Evaluation Team first present the weather normalized gas savings estimates for smart thermostats by comparing thermostat recipients to the original randomized comparison group. Based on the best fit linear mixed effects model, the average annual gas savings for Nest recipients was estimated at 34 therms (90% CI: 13, 55), which was statistically significant. In contrast, Lyric recipients experienced an estimated 29 therm increase (90% CI: -58, -7) in annual gas usage, on average. This estimate was also statistically significant at the 90% confidence level. Although the savings estimates for both thermostats had relatively large standard errors (> 30% of point estimates) and wide confidence intervals, they provide a clear indication that Nest participants significantly reduced their annual gas usage, while Lyric participants increased it. The difference in estimated gas savings between the two thermostats was statistically significant. Table 16 and Table 17 summarize these results. Figure 30 and Figure 31 compare the pre- and post-installation mean annual gas usage between the participant and comparison homes, as estimated by the regression models. The increase in weather-normalized annual usage among Lyric homes is clearly visible, compared to decreased gas usage in the comparison group.

Table 16. Average annual gas savings per home for thermostat recipient homes versus the randomized comparison group.

Thermostat	Annual Therm Savings	SE	90% Conf. Interval	p-value
Nest	34	11	13, 55	0.018*
Lyric	-29	14	-55, -3	0.071*

* Statistically significant at the 90% confidence level.

Table 17. Average annual gas savings per home as a percent of average pre-Pilot gas usage for thermostat recipient homes versus the randomized comparison group

Thermostat	% Savings	% Heating Savings	Annual Therm Usage	Heating Therm Usage	% Heating Usage
Nest	4.5%	6.0%	761	566	74%
Lyric	-3.7%	-4.9%	784	596	76%

Figure 30. Estimated pre- and post-installation mean annual gas usage for Nest recipients and randomized comparison homes

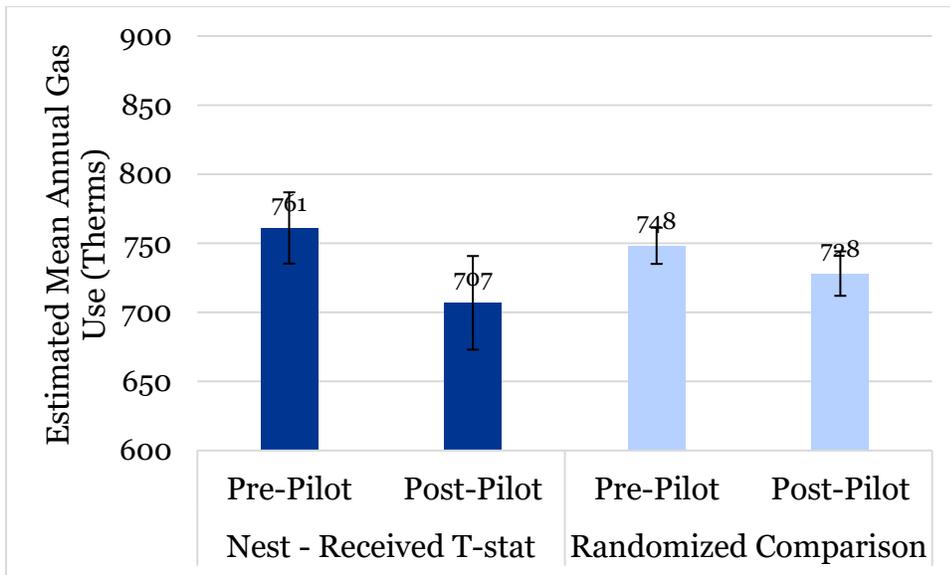
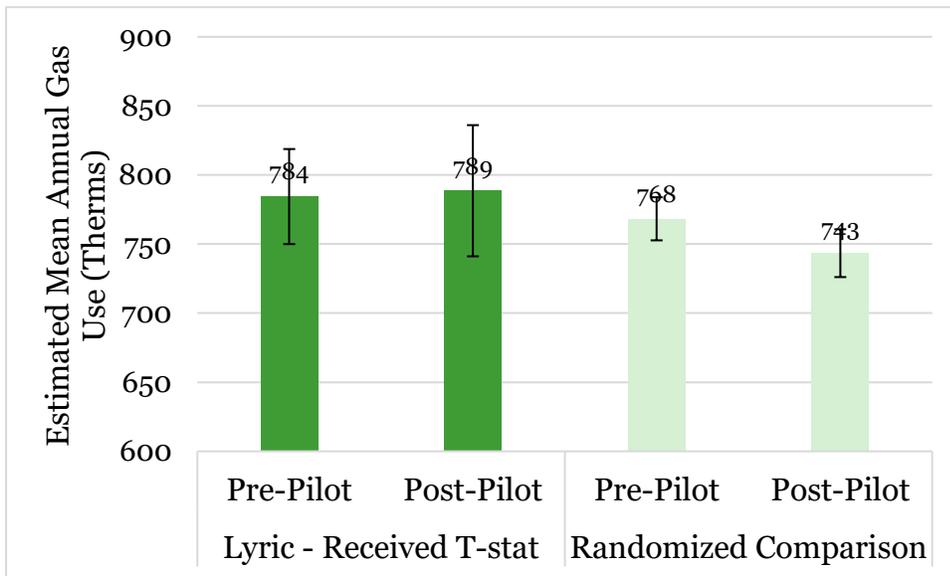


Figure 31. Estimated pre- and post-installation mean annual gas usage for Lyric recipients and randomized comparison homes



5.4.2.2 Intention-to-treat homes vs. randomized comparison group

Next, the Evaluation Team present weather normalized gas savings estimates based on comparing the intention-to-treat homes with the original randomized comparison group. After savings were calculated for the entire intention-to-treat group, using the best fit linear mixed effects model, an adjustment factor was applied to estimate the LATE savings. Using the intention-to-treat analysis with the LATE adjustment had the disadvantage of introducing a large amount of error to the savings estimate, based

on the noise from the large proportion of homes that did not receive a thermostat. The annual gas savings for Nest recipients was estimated at 40 therms (90% CI: -21, 100), on average, but this result was not statistically significant at the 90% confidence level. Lyric recipients experienced an estimated increase in annual gas use of 55 therms (90% CI: -130, -20), on average, but this was not statistically significant either. Although the savings estimates for both thermostats had very large relative standard errors and wide confidence intervals, they provide some indication that Nest participants reduced their annual gas usage, while Lyric participants increased their gas usage. These results are also within the confidence limits of the analysis above, comparing just the thermostat recipients with the randomized comparison group. Table 18 and Table 19 summarize these results. Figure 32 and Figure 33 compare the pre- and post-installation mean annual gas usage between the intention-to-treat and comparison homes, as estimated by the regression models.

Table 18. LATE annual gas savings per home for the intention-to-treat group versus the randomized comparison group

Thermostat	Annual Therm Savings	SE	90% Conf. Interval	p-value
Nest	40	32	-21, 100	0.254
Lyric	-55	40	-130, 20	0.209

Table 19. LATE annual gas savings per home as a percent of average pre-Pilot gas usage for the intention-to-treat group versus the randomized comparison group

Thermostat	% Savings	% Heating Savings	Annual Therm Usage	Heating Therm Usage	% Heating Usage
Nest	4.9%	6.6%	810	603	74%
Lyric	-7.0%	-9.2%	789	597	76%

Figure 32. Estimated pre- and post-installation mean annual gas usage for Nest intention-to-treat and randomized comparison homes

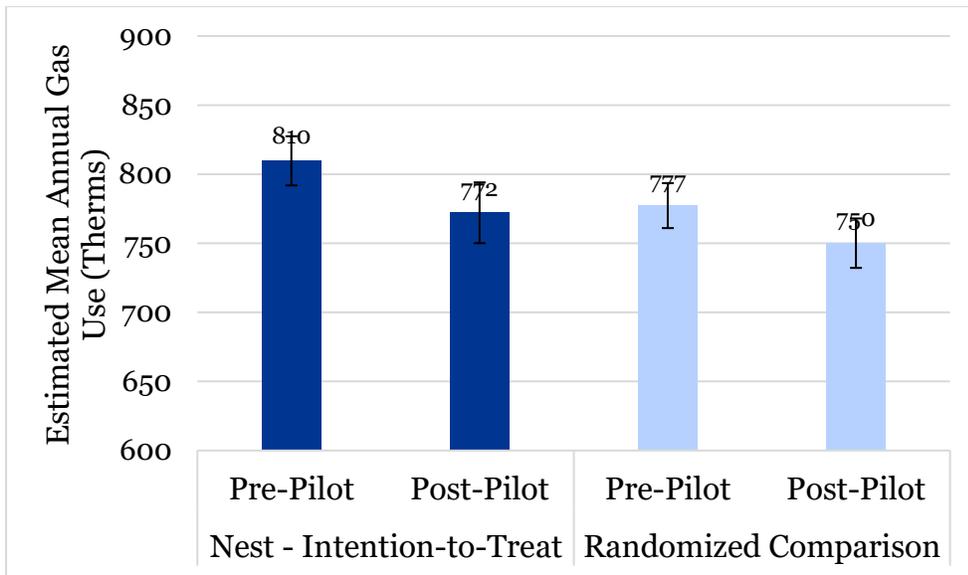
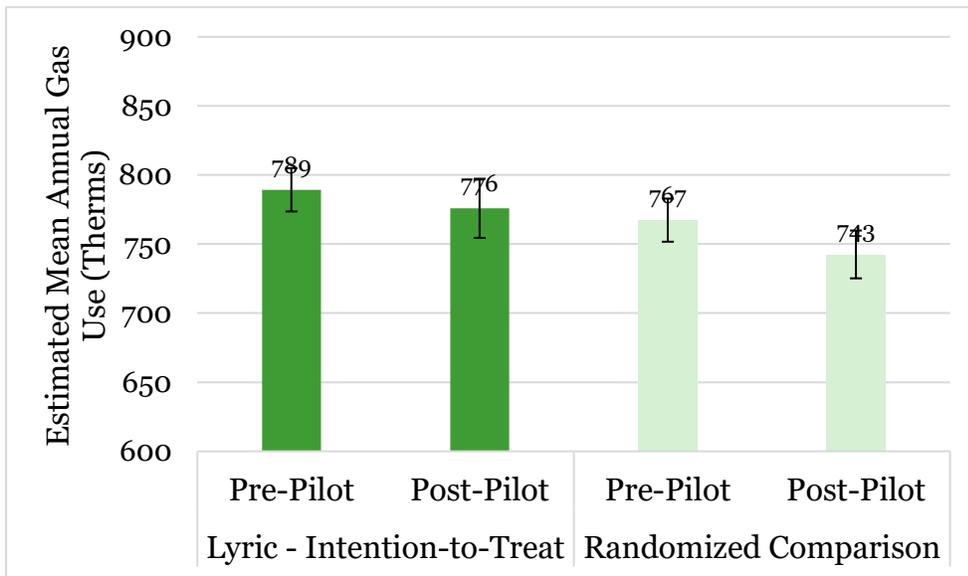


Figure 33. Estimated pre- and post-installation mean annual gas usage for Lyric intention-to-treat and randomized comparison homes



5.4.2.3 Thermostat recipient homes vs. matched comparison group

As an alternative to using the original Pilot randomization scheme, the Evaluation Team also set up a quasi-experimental analysis to compare thermostat recipients with matched comparison groups. As described in the Methods section, the matched comparison group was created by randomly selecting residential gas accounts with a similar distribution of pre-Pilot annual gas use as the thermostat recipients. The average annual weather normalized gas savings for Nest recipients was estimated at 34

therms (90% CI: 15, 53), which was statistically significant. The Evaluation Team estimated that Lyric recipients experienced a 24 therm increase (90% CI: -58, -7) in annual gas usage, on average. This increase in usage was statistically significant at the 90% confidence level. These results are very similar to the estimates above, using the original randomized comparison group. These results clearly indicate that Nest recipients significantly reduced their annual gas usage, while Lyric recipients increased it. The difference in estimated gas savings between the two thermostats was statistically significant. Table 20 and Table 21 summarize these results. Figure 34 and Figure 35 compare the pre- and post-installation mean annual gas usage between the participant and comparison homes, as estimated by the regression models. The increase in weather-normalized annual usage among Lyric homes is clearly visible, compared to decreased gas usage in the comparison group.

Table 20. Average annual gas savings per home for thermostat recipients versus the matched comparison groups

Thermostat	Annual Therm Savings	SE	90% Conf. Interval	p-value
Nest	34	10	15, 53	0.012*
Lyric	-24	12	-48, -1	0.090*

* Statistically significant at the 90% confidence level.

Table 21. Average annual gas savings per home as a percent of average pre-Pilot gas usage for thermostat recipients versus the matched comparison groups

Thermostat	% Savings	% Heating Savings	Annual Therm Usage	Heating Therm Usage	% Heating Usage
Nest	4.4%	5.9%	762	567	74%
Lyric	-3.1%	-3.9%	789	622	79%

Figure 34. Estimated pre- and post-installation mean annual gas usage for Nest recipients and matched comparison homes

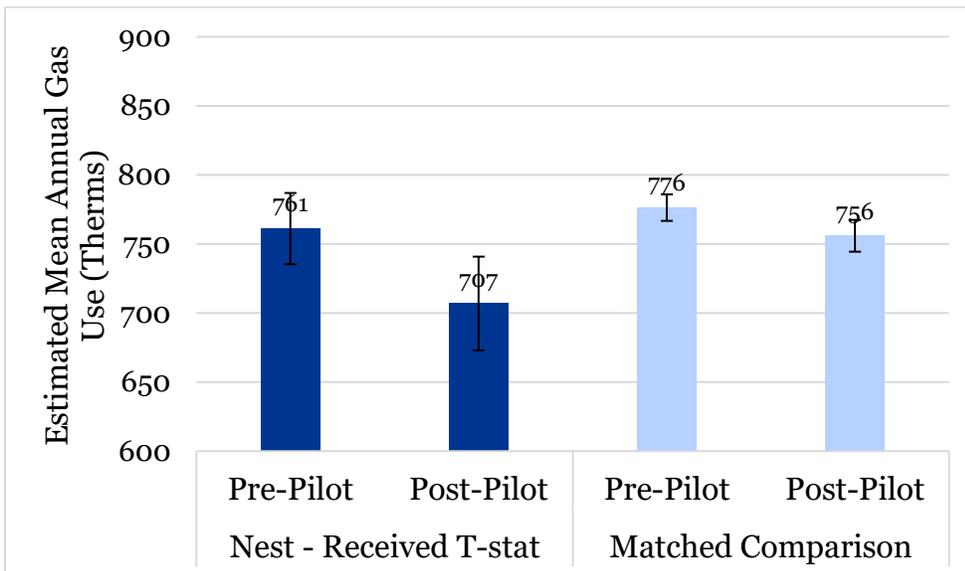
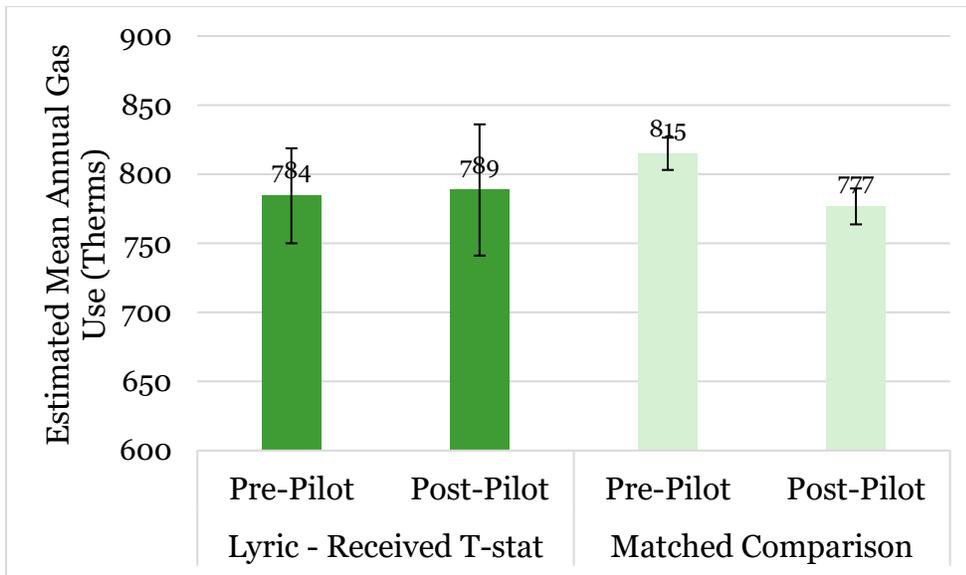


Figure 35. Estimated pre- and post-installation mean annual gas usage for Lyric recipients and matched comparison homes



5.4.3 Sensitivity Analysis

Sensitivity analysis was conducted to test the impact of model specification on the savings results. For consistency, the comparisons were made by analyzing homes that received a thermostat against the original randomized comparison group. First, the Evaluation Team created a simplified fixed effects model, with no weather variables, to compute non-normalized annual gas savings for each thermostat and assess the effect of weather. Using the simplified fixed effects model, the Evaluation Team estimated average annual Nest thermostat savings of 20 therms (90% CI: -2, 43), or 2.8% of annual gas use. This result was borderline statistically significant ($p=0.126$) and noticeably lower than the weather-normalized result. For Lyric recipients, using the simplified fixed effects model, the Evaluation Team estimated average annual savings of zero therms (90% CI: -27, 28). The non-normalized Lyric result is somewhat higher than the sub-zero weather-normalized savings estimate. Next, the Evaluation Team used a multi-level linear mixed effects model with a random intercept term to account for repeated observations, but no weather variables, to estimate gas savings. Using this model, the Evaluation Team estimated average annual savings of 21 therms (90% CI: -2, 44), or 2.8% of annual usage for Nest recipients, and 1 therm (90% CI: -26, 28) for Lyric. These estimates were very similar to the results from the simplified model.

In the next part of the sensitivity analysis, the Evaluation Team incorporated weather back into the models and tested a series of increasingly complex multi-level linear mixed effects models. First, the Evaluation Team tested a simplified multi-level mixed effects model that included a random intercept term and the full complement of fixed effects, including HDD for weather. Likelihood ratio test results showed that this model had a significantly improved fit over the same model without a random

intercept. This model estimated average annual savings of 33 therms (12, 55) for Nest recipients and -32 therms (-58, -6) for Lyric recipients. Both of these estimates were statistically significant at the 90% confidence level and were extremely close to the estimates obtained from the best fit multi-level linear mixed effects model. Next, the Evaluation Team added a single random slope term for HDD to the model. The random slope model had a significantly improved fit over the random intercept model and estimated average annual gas savings that were nearly identical to the best fit linear mixed effects model. Finally, the Evaluation Team tested the best fit linear mixed effects model, described above, which had a significantly improved fit over the random slope model.

Table 22 compares the results of several model specifications. The Evaluation Team strongly preferred the best fit multi-level mixed-effects model with weather, not only because it fit the data better, but because it accounted for the most important factors influencing gas usage and the structure of the data.

Table 22. Average annual gas savings per home for Smart Thermostat Pilot participants by model specification

Model	Thermostat	Annual Therm Savings	SE	90% Conf. Interval	p-value
Best fit multilevel model with weather†	Nest	34	11	13, 55	0.018*
	Lyric	-29	14	-55, -3	0.071*
Multilevel model with random intercept and weather	Nest	33	11	12, 55	0.021*
	Lyric	-32	14	-58, -6	0.052*
Multilevel model with random intercept but without weather	Nest	21	10	-2, 44	0.125
	Lyric	1	12	-26, 28	0.942
Simplified fixed effects model without weather	Nest	20	10	-2, 43	0.126
	Lyric	0	12	-27, 28	0.982

* Statistically significant at the 90% confidence level.

† The best fit multi-level linear mixed effects model, with complex random effects and weather variables, is the preferred model.

5.4.4 Subgroup Analysis

To gain a better understanding of how certain variables impacted changes in gas usage in Nest and Lyric homes, the Evaluation Team subset our analysis dataset based on potentially influential factors, and re-ran the models for each participant subgroup. For simplicity, only the analyses of thermostat recipients versus the randomized comparison group are shown. The results of the subgroup analyses are presented in the tables and figures below. Due to the varying number of participants for which subgroup

data were available, the total number of participants analyzed for each factor do not add up to the final sample size. Confidence intervals are shown for each savings estimate, representing the lower and upper bounds of the estimates with 90% confidence. Savings estimates with p-values less than 0.10, or 90% confidence intervals that do not cross zero, are considered to be statistically significant at the 90% confidence level. In addition, savings estimates for different subgroups where the 90% confidence intervals that do not overlap are considered statistically different. Some of the factors the Evaluation Team analyzed had large amounts of missing data, and some subgroups had very small sample sizes, so the resulting savings estimates and comparisons should be interpreted with caution. In particular, subgroups with less than 30 participants are too small to provide reliable savings estimates, even if the results appear to be statistically significant.

5.4.4.1 Energy Trust employees and contractors

It was hypothesized that the subset of participants recruited from Energy Trust employees and contractors might be different from the general population and have different savings results. Table 23 shows the savings results for Nest and Lyric with this group of participants removed from the sample. The total number of employees and contractors in the final sample was small, and their impact on the overall savings results was negligible.

Table 23. Average annual gas savings for Smart Thermostat Pilot participants with Energy Trust employees and contractors removed

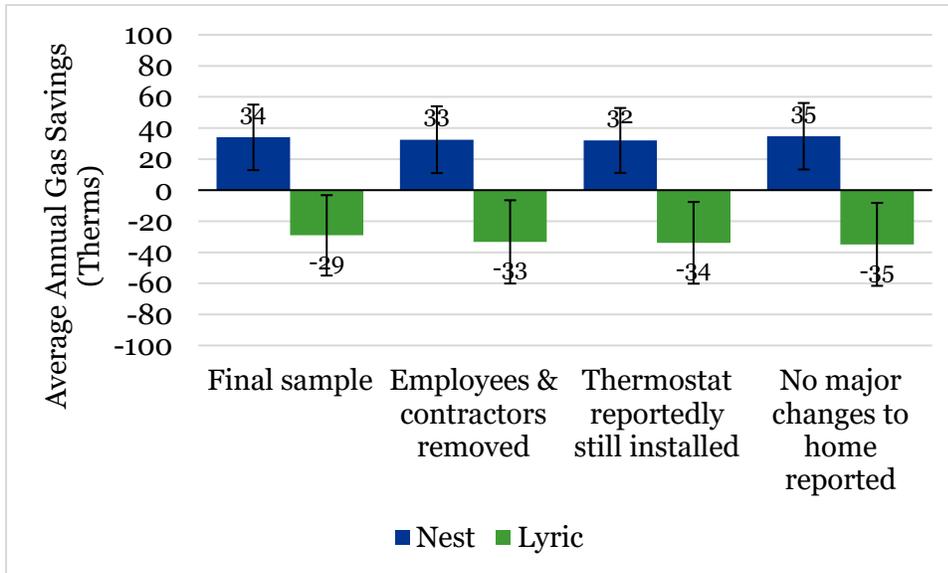
Thermostat	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	143	33	11, 51	0.024*	763	4.3%	5.7%
Lyric	116	-33	14	0.051*	786	-4.2%	-5.6%

* Statistically significant at the 90% confidence level.

5.4.4.2 Uninstalls and changes made to home

Next, the Evaluation Team removed participants from the sample who reported uninstalling their thermostat in the follow-up surveys. The number of reported uninstalls was very small in both thermostat groups, so there was no impact on the overall savings estimates. There were also a small number of participants who reported making major changes to their home during the Pilot period. Removing these homes from the analysis resulted in only very slight changes to the savings estimates. Figure 36 illustrates the negligible impact of removing homes from the final sample that underwent major changes, uninstalled thermostats and had Energy Trust employees and contractors living in them.

Figure 36. Comparison of average annual gas savings between the final participant sample, employees and contractors removed, homes with thermostats reportedly still installed, and homes with no major changes reported



5.4.4.3 Pre-Pilot gas usage

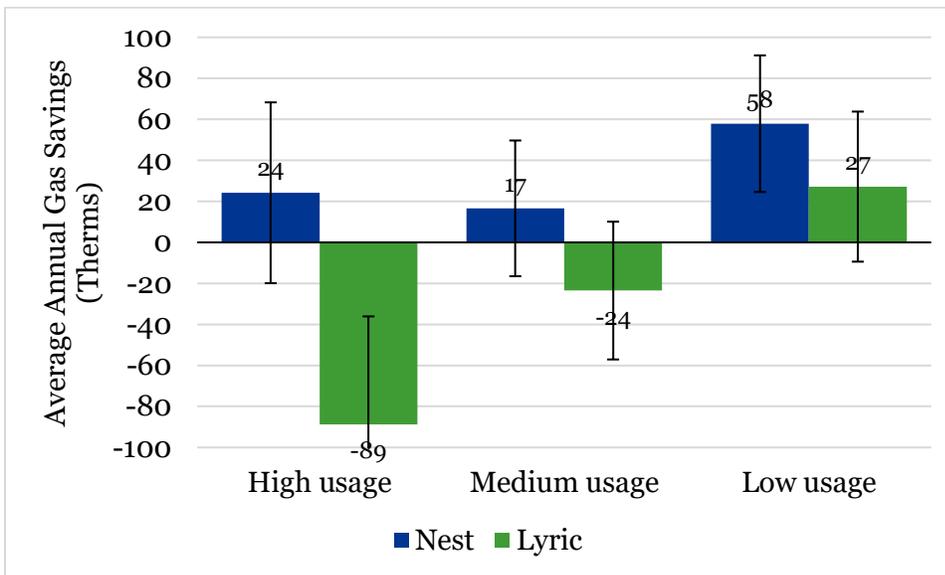
The Evaluation Team was interested in the impact of annual gas usage on savings, since many efficiency measures, including Nest thermostats installed in heat pump homes, have larger savings when installed in higher usage homes. Table 24 shows the reverse of the usual trend, with lower usage homes realizing larger savings than higher usage homes. Figure 37 illustrates these results graphically. The differences for Nest recipients were not statistically significant and could be due to random variability in the sample. However, Lyric participants saw large, significant differences between the lowest and highest usage categories. It is not clear what is driving this trend.

Table 24. Average annual gas savings for Smart Thermostat Pilot participants by pre-Pilot annual gas use

Thermostat	Pre-Pilot Annual Gas Usage	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	Low (<618 therms)	50	58	25, 91	0.013*	568	10.2%	13.3%
	Medium (618-795)	60	17	-17, 50	0.373	739	2.2%	3.0%
	High (796+ therms)	43	24	-20, 68	0.333	1,017	2.4%	3.3%
Lyric	Low (<618 therms)	43	27	-9, 64	0.202	556	7%	9%
	Medium (618-795)	35	-24	-57, 10	0.225	744	-3.2%	-4.1%
	High (796+ therms)	48	-89	-141, -36	0.015*	1,029	-8.6%	-11.7%

* Statistically significant at the 90% confidence level.

Figure 37. Comparison of average annual gas savings by pre-Pilot annual gas use



5.4.4.4 Occupancy

Occupancy tends to drive energy use in homes and it can also impact how frequently a home is vacant, which could affect a smart thermostat’s ability to increase temperature setbacks. To explore the impact of occupancy on gas savings, the Evaluation Team compared homes with different numbers of occupants. From the follow-up surveys, the Evaluation Team found that the number of occupants was stable over the course of the Pilot. Table 25 displays the results for 1-2 occupant homes, 3-4 occupant homes, and 5+ occupant homes.

Figure 38 shows these results graphically. The sample sizes available for homes with 5+ occupants were too small to produce reliable savings estimates. For Nest homes, the trend was as expected, with lower occupancy homes realizing slightly higher gas savings, although the differences were not significant. For Lyric homes, there were no clear trends or significant differences.

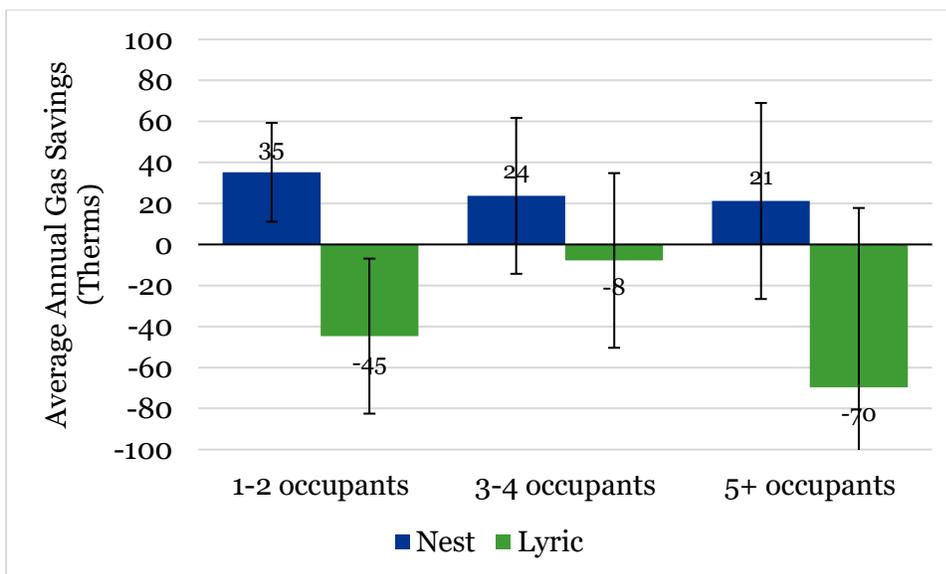
Table 25. Average annual gas savings for Smart Thermostat Pilot participants by number of occupants

Thermostat	Number of Occupants	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	1-2	56	35	11, 59	0.028*	729	4.8%	6.3%
	3-4	52	24	-14, 62	0.276	780	3.0%	4.1%
	5+	13†	21	-27, 69	0.428	740	2.9%	3.8%
Lyric	1-2	48	-45	-83, -7	0.060*	757	-5.9%	-7.5%
	3-4	45	-8	-50, 35	0.739	809	-1.0%	-1.3%
	5+	8†	-	-	-	-	-	-

* Statistically significant at the 90% confidence level.

† Savings estimates based on sample sizes less than 30 may be unreliable.

Figure 38. Comparison of average annual gas savings by number of occupants



5.4.4.5 Geographic region

From the previous study of Nest in heat pump homes, the Evaluation Team saw that savings varied slightly by geographic region. The Evaluation Team conducted a similar comparison of gas savings for this study, looking at homes located in the Portland Metro area, Oregon outside the Portland Metro area, and southwest Washington. The results of this regional comparison are presented in Table 26. Figure 39 shows the results graphically. Nest participant homes in Oregon outside the Portland Metro

area appeared to have higher gas savings, although this was not statistically different from homes located in the other regions. There were no significant differences between regions for Lyric recipients.

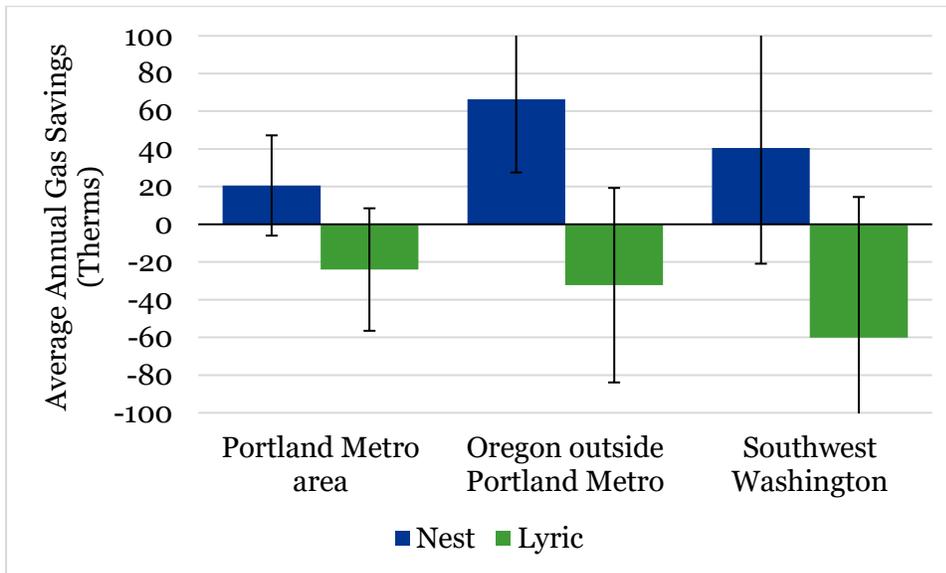
Table 26. Average annual gas savings for Smart Thermostat Pilot participants by geographic region

Thermostat	Region	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	Portland Metro	100	21	-6, 47	0.185	759	2.7%	3.7%
	Non-Portland Oregon	35	66	27, 105	0.014*	755	8.8%	11.7%
	SW Washington	18†	40	-21, 102	0.252	758	5.3%	7.1%
Lyric	Portland metro area	91	-24	-57, 7	0.186	784	-3.1%	-4.0%
	Non-Portland Oregon	24†	-32	-84, 19	0.273	773	-4.2%	-5.5%
	SW Washington	12†	-60	-135, 14	0.171	756	-7.9%	-11.5%

* Statistically significant at the 90% confidence level.

† Savings estimates based on sample sizes less than 30 may be unreliable.

Figure 39. Comparison of average annual gas savings by geographic region



5.4.4.6 Heating equipment

To investigate whether the type of heating equipment impacted the realized gas savings, the Evaluation Team compared homes reported to have condensing and non-condensing gas furnaces. The Evaluation Team anticipated that homes with more efficient heating equipment, such as condensing furnaces, would save less gas than non-condensing furnaces, because they use less fuel when operating. Table 27 displays the results of this comparison and Figure 40 displays them graphically. For Nest participants, non-condensing furnaces did appear to have higher savings, although the difference was not significant.

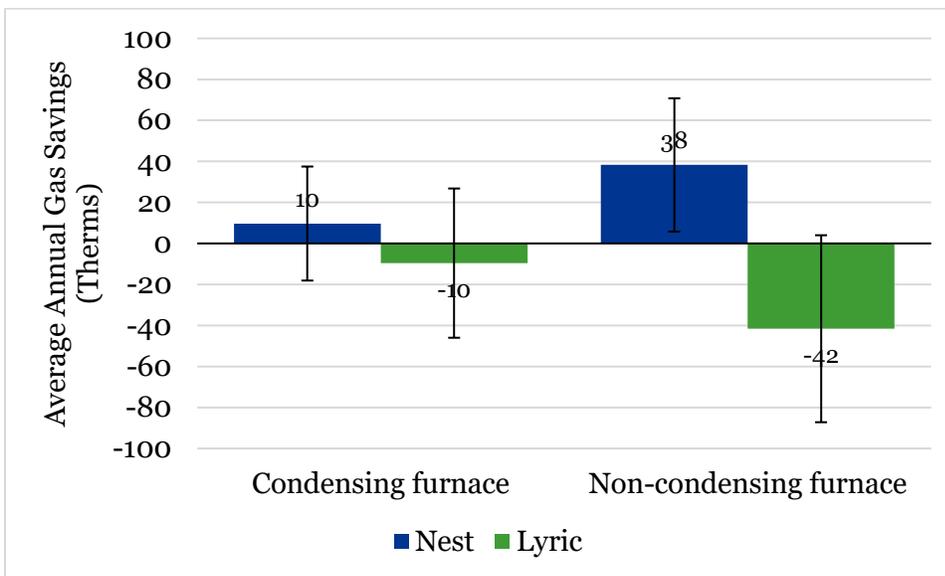
For Lyric participants, homes with non-condensing furnaces saw slightly larger increases in usage than homes with condensing furnaces, but this was not a significant difference either.

Table 27. Average annual gas savings for Smart Thermostat Pilot participants by furnace type

Thermostat	Furnace Type	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	Condensing	42	10	-18, 37	0.529	751	1.3%	1.7%
	Non-condensing	61	38	6, 71	0.061*	757	5.1%	6.8%
Lyric	Condensing	32	-10	-46, 27	0.633	775	-1.2%	-1.5%
	Non-condensing	51	-42	-87, 4	.128	816	-5.1%	-7.0%

* Statistically significant at the 90% confidence level.

Figure 40. Comparison of average annual gas savings by furnace type



5.4.4.7 Secondary heating

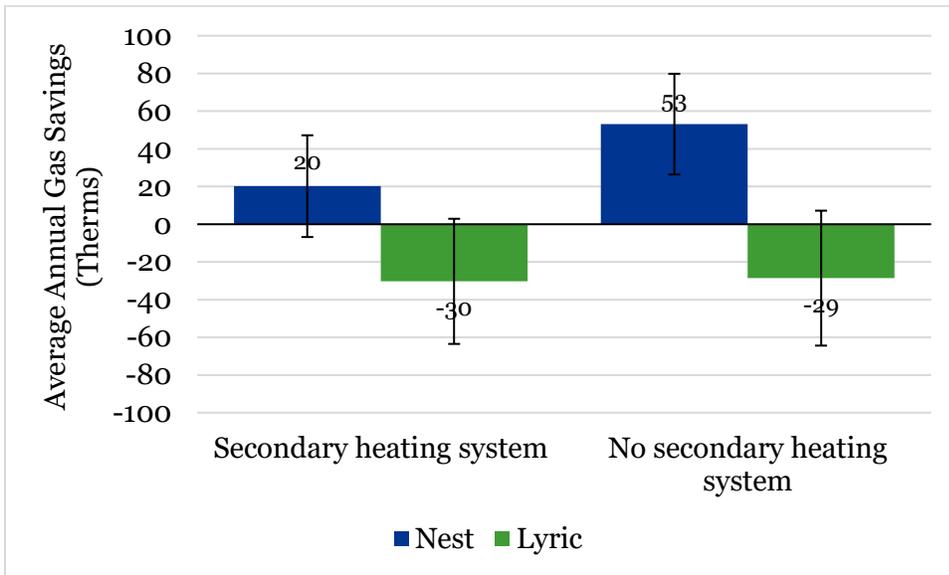
Another factor of interest was whether participants had a secondary heating system installed. In homes with secondary heating systems, such as gas fireplaces, if the secondary system is not centrally controlled, there will be lower savings potential for the thermostat. Table 28 displays the results of the comparison between homes with and without secondary heating systems. Figure 41 shows these results graphically. For Nest participants, homes with no secondary system appeared to have higher gas savings, although the difference was not significant. For Lyric homes, there did not appear to be any difference in savings.

Table 28. Average annual gas savings for Smart Thermostat Pilot participants by secondary heating system

Thermostat	Secondary Heating System	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	Yes	95	20	-7, 47	0.199	776	2.6%	3.6%
	No	57	53	26, 80	0.007*	736	7.2%	9.3%
Lyric	Yes	71	-30	-64, 3	0.128	773	-3.9%	-5.3%
	No	54	-29	-64, 7	0.174	797	-3.6%	-4.6%

* Statistically significant at the 90% confidence level.

Figure 41. Comparison of average annual gas savings by secondary heating system



5.4.4.8 Prior thermostat type

The primary energy saving strategy for smart thermostats in gas-heated homes is to increase the number of temperature setbacks and better match heating with occupant schedules. This strategy depends on the level of control and number of setbacks that homes have in place before installing a smart thermostat. To assess the impact of the pre-Pilot control strategy on gas savings, the Evaluation Team compared homes where the prior thermostat was reported to be programmed against homes where the prior thermostat was either manual or not programmed with any setbacks. The results of this comparison are displayed in

Table 29 and Figure 42. Unfortunately, the sample sizes of manual and non-programmed prior thermostats were small, so the results are not reliable. However, it appears that Nest recipients who replaced non-programmed or manual thermostats realized higher gas savings than those who replaced

thermostats with programmed setbacks. Although indicative, these differences were not statistically significant. For Lyric homes, there did not appear to be any differences in savings.

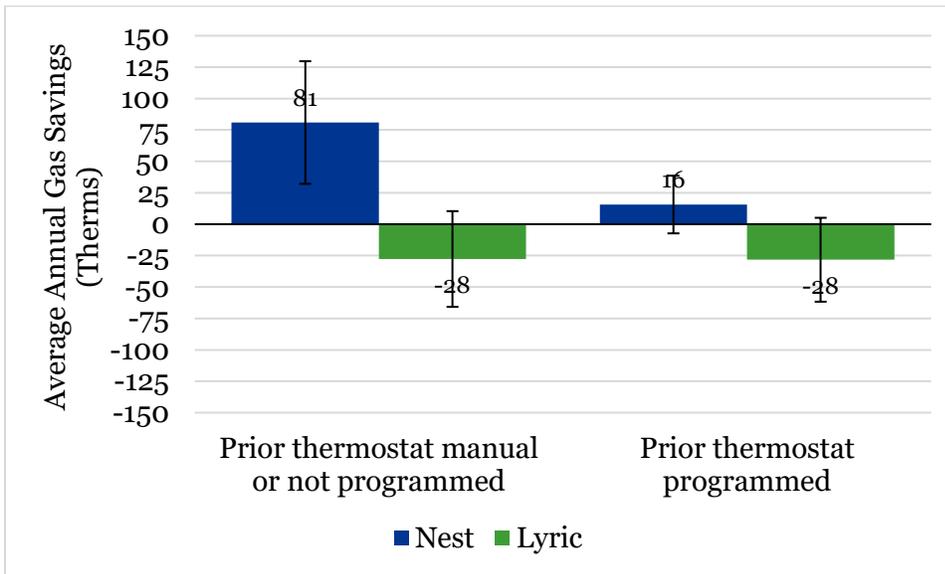
Table 29. Average annual gas savings for Smart Thermostat Pilot participants by prior thermostat type

Thermostat	Previous Thermostat	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	Manual or not programmed	20†	81	32, 130	0.016*	710	11.4%	15.9%
	Programmed w/ setbacks	104	16	-7, 39	0.237	760	2.1%	2.7%
Lyric	Manual	23†	-28	-66, 10	0.210	699	-4.0%	-5.0%
	Programmed w/ setbacks	81	-28	-62, 5	0.153	821	-3.4%	-4.6%

* Statistically significant at the 90% confidence level.

† Savings estimates based on sample sizes less than 30 may be unreliable.

Figure 42. Comparison of average annual gas savings by prior thermostat type



5.4.4.9 Occupancy detection status

The number of temperature setbacks achieved by both the Nest and Lyric thermostats depend partly on how well the occupancy detection features work in the field. From The Nest Heat Pump Control Pilot, the Evaluation Team learned that a small portion of participants disabled the occupancy detection feature because it did not work well for their home. To analyze the impact of occupancy detection on savings, the Evaluation Team compared participants who disabled occupancy detection versus those who did not. The results of this comparison are presented in Table 30 and Figure 43. The number of Nest

recipients who reported disabling the auto away feature was very small, so the results for that group are not reliable. For Lyric recipients, there were a larger number of participants who reported that they were not successful in setting up and enabling the geo-fencing feature. For both Nest and Lyric homes, participants who kept occupancy detection enabled appeared to have higher gas savings, although these differences were not significant.

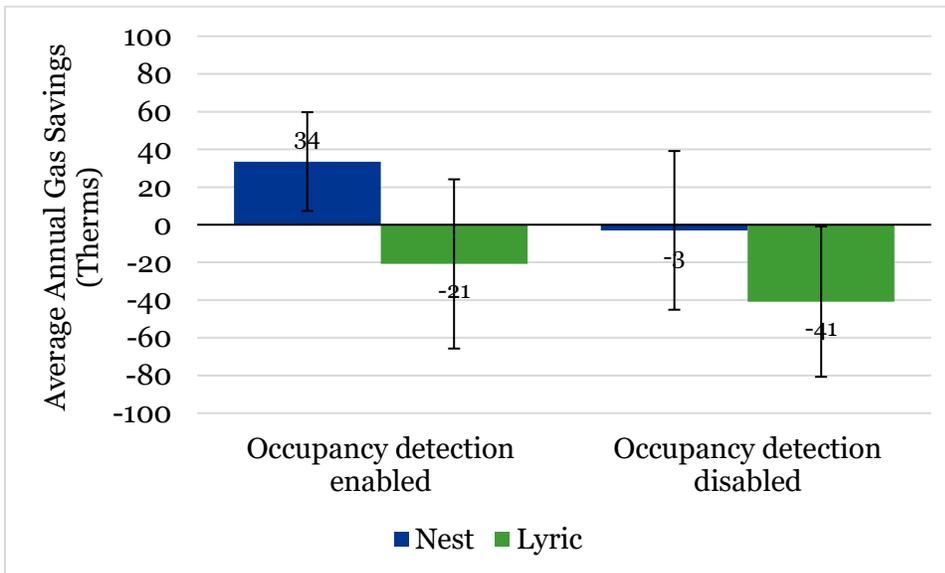
Table 30. Average annual gas savings for Smart Thermostat participants by occupancy detection status.

Thermostat	Occupancy Detection	Ptcpt. N	Annual Therm Savings	90% Conf. Interval	p-value	Annual Therm Usage	% Savings	% Heating Savings
Nest	Enabled	92	34	7, 60	0.046*	748	4.5%	6.0%
	Disabled	14†	-3	-45, 39	0.897	779	-0.4%	-0.5%
Lyric	Enabled	39	-21	-66, 24	0.411	824	-2.5%	-3.3%
	Disabled	45	-41	-81, -1	0.093*	766	-5.3%	-6.8%

* Statistically significant at the 90% confidence level.

† Savings estimates based on sample sizes less than 30 may be unreliable.

Figure 43. Comparison of average annual gas savings by occupancy detection status



The Evaluation Team also investigated the impacts of a large number of other factors on savings, including housing characteristics, participant demographics, and experiences with each thermostat. There were no coherent or consistent trends that the Evaluation Team could identify, however, and many subgroups had too few participants to produce reliable savings estimates.

6. Conclusions and Recommendations

The Smart Thermostat Pilot built on the successes and challenges experienced during the previous Nest Thermostat Heat Pump Control Pilot and in many ways improved upon the previous Pilot. Improvements included the increased speed of Pilot inception through implementation, greater planning and filtering for participant recruitment, and a new delivery approach that placed most of the installation and processing requirements on the participants (in order to reduce cost and demonstrate what a larger program delivery scheme would likely entail). The Pilot did suffer some setbacks, including low enrollment and low purchase uptake for qualifying participants, and there was also a vocal minority of participants who were very dissatisfied with their thermostat, almost entirely comprised of Lyric owners. Staff members at both Energy Trust and CLEAResult overwhelmingly felt that the Pilot was a worthwhile and successful endeavor.

The following section summarizes and distills the findings contained in this report and offers Apex's recommendations to assist Energy Trust in its efforts to launch a smart thermostat incentive for gas-heated and electric forced air furnace-heated homes and for other Pilot studies in the future.

Energy Savings

The results of this billing analysis show that the Nest thermostat was associated with significant energy savings during Energy Trust's Pilot. It produced about 6% heating load savings, on average, in gas-heated homes. On the other hand, the Honeywell Lyric thermostat was associated with significant increases in energy use during the Pilot. The Lyric added about 5% to heating loads, on average, in gas-heated homes. The difference in realized energy savings between the two thermostats was unambiguous and statistically significant.

Recommendation: *The findings from this billing analysis support the expansion of the smart thermostat incentive that Energy Trust currently offers to include homes with gas and electric forced air furnaces provided the reported gas savings more than offsets the costs for Energy Trust cost effectiveness screening. The findings do not support extending the Energy Trust incentive to include the Lyric thermostat. However, it is worth noting that the Lyric was at a much earlier phase in product development during the Pilot, and feedback from the program has allowed Honeywell to make improvements to the next generation of thermostats. Further testing of future versions of the Lyric and other smart thermostats may reveal energy savings for additional products.*

Recruitment, Participation, Installation, and Return Rates

In many ways the recruitment process was greatly improved since the Nest Heat Pump Control Pilot. Energy Trust and CLEAResult should be commended for taking the recommendation from the evaluation

of that Pilot: “Energy Trust should ensure that any future recruitment will reach a broader population of household and demographics, and should be proactive with recruitment”. For the Smart Thermostat Pilot, potential candidates were pre-screened to qualify based on more stringent criteria, and were further screened for compatibility with an additional enrollment survey. Ultimately this led to a recruitment sample that closely reflects the likely populations of candidates that may participate in the future. Additionally, with an almost completely participant-driven application and installation delivery approach, this Pilot was able to replicate the issues faced by a more realistic self-install program structure.

Unfortunately, this early stage in the Pilot was also faced with some challenges. With well over 1,000 participants completing the in-take survey and qualifying to participate in the Pilot, only one-third of the potential candidates chose to purchase the thermostat and actively participate in the Pilot. This was a lower-than anticipated uptake for the measure and resulted in additional sample being drawn from a pool of Energy Trust staff and contractors to achieve the targeted 400 installs. Even with the increased sample, there was a significant number of terminated participants, either due to returns (close to 10% of units returned), product failures, or equipment incompatibility. Overall, based on the installation aspect of the survey findings, the Evaluation Team believes that the self-install approach is definitely a viable model, though caution should be made with respect to the specific products that should be offered through the program.

Recommendation: Energy Trust should consider conducting a brief online survey to understand the low-uptake by surveying the qualified population that chose not to participate. This will help with future program planning by understanding the obstacles to engage potential successful participants. For example, if self-installation is a barrier, Energy Trust can provide a list of qualified contractors to help with installation. In addition, the Evaluation Team believes Energy Trust, in coordination with other program administrators considering a smart thermostat measure, reach out to the manufacturers and coordinate a verification approach that ensures participant privacy while also allowing measure installation verification. Finally, any future program with a similar delivery approach should factor in the 10% return rate until further research can be conducted to determine the underlying causes of the returns.

Participant Experience: Usage, Feedback, and Satisfaction

Based on the findings from staff interviews, the two participant surveys, and direct communication from several participants providing feedback on the Pilot, participants overwhelmingly preferred the Nest thermostat. Satisfaction levels with installation, user interface, scheduling adjustments, and the overall user experience were significantly higher for Nest relative to the Lyric participants. Also, considering that over three times as many Lyric participants would have returned the thermostat if given the chance, suggests that the Lyric thermostat would benefit from significant design changes. Since Lyric participants were considerably less likely to have enabled the primary energy-saving function (geofencing) relative to

Nest users (for whom the feature was enabled by default at installation), the prospects for the current version of the Lyric to demonstrate energy savings are very questionable, as confirmed by this study.

Recommendation: *Based on participant experience alone, outside of any potential energy savings, the team cannot recommend the current version of the Lyric for any future incentive offerings. Similar to the previous Nest Heat Pump Control Pilot, the Nest thermostat user experience was considerably more positive, and the team can more easily recommend the Nest for future program offerings, should the associated gas savings, balanced against the costs, offer a cost-effective solution for Energy Trust's gas measures.*

The team also recommends using additional judiciousness when Energy Trust and CLEAResult consider offering brand-new, un-vetted technologies. When the pilot began, the Lyric had only recently been released with little to no feedback or reviews available. Clearly, this product still requires considerable reprogramming and is not market-ready. Lyric participants not only gave low satisfaction ratings in the surveys, but sent direct email communication to the Evaluation Team and program staff that suggested just how negatively they felt towards this thermostat. The Evaluation Team recommends that any new measure that has not been market-vetted be in-house tested for several weeks to understand whether it is truly a viable candidate for rolling out as a Pilot. The strongest argument for this is to avoid what could be considerable negative reactions and fallout from participants unhappy with the measure.

Prospects for a comprehensive offering of a smart thermostat

The prospects for a smart thermostat incentive being rolled out to a larger audience were dependent on participant satisfaction, realized gas savings associated with the thermostat, and the success of a self-install delivery approach that could reduce the overall installed cost of the measure. The latter two were the critical factors when performing cost-effectiveness analysis. This study has shown that the Nest thermostat can offer moderate gas energy savings, while the Lyric failed in this regard. At the time of this study no other smart thermostat on the market had the advanced energy savings features Nest has that made it suitable, with the potential exception of the Ecobee 3 model, which unfortunately required the presence of a common-wire and was therefore not considered for this Pilot.

Due to this being a Pilot offering, there were some technical, logistical, and participant-related challenges experienced. As was shown in this Pilot, though, Energy Trust and CLEAResult were able to incorporate the lessons learned from the previous Nest Heat Pump Control Pilot to address many of the previous issues and plan to use the experiences from this pilot to help design a robust program should this measure pass internal cost-effectiveness tests. Participant-level interest and satisfaction with the Nest device was very high.

Recommendation: *The team believes that the Nest thermostat, provided it can meet Energy Trust's cost-effectiveness requirements, is an attractive and viable candidate for being rolled out to a larger audience*

and implemented on a larger scale for gas and electric forced air furnace-heated homes. Unfortunately, the Lyric does not currently meet energy savings standards and satisfaction levels for the team to recommend its inclusion in a program. Future iterations of the Lyric may address the shortcomings reported here and become a more viable energy saving product.

7. Appendices

A. Staff Interview Guide

Name:	Agency: ETO / CLEAResult
Title:	Participant Phone:
Survey Completion Date:	Interviewer

A.1 Introduction

Hi, thank you for taking some time out of your schedule to meet with me. My name is [name], and as you know, my firm, Apex Analytics, was hired by Energy Trust of Oregon to evaluate the Smart Thermostat Energy Pilot. As part of this evaluation, the Evaluation Team are surveying study participants, Energy Trust staff, and PMC staff to understand what has worked well, what could be improved upon and what the prospects are for an expanded rollout of smart thermostats for gas furnaces.

These interviews are meant to document your experiences so that future program implementers can learn and build upon your knowledge. Your responses will be reported in aggregate and your name will not be associated with any specific responses.

Before the Evaluation Team get started, do you have any questions for me?

Q1. Will you briefly describe your role at [AGENCY]? What are/were your responsibilities with the Gas Furnace Smart Thermostat Pilot?

Q2. What, if any, experience do you have with Nest or Lyric thermostats, prior to being involved with this pilot?

Q3. What, if any, research did you perform to understand the Nest or Lyric thermostats during the initial development of this pilot? Was there any effort to contact staff at either company to discuss this pilot and learn about their devices?

Q4. Please describe any lessons learned from the previous (heat pump) pilot that informed this pilot.

Q5. Please describe any additional lessons learned from the Smart Thermostat pilot.

A.2 Installation Experiences [CLEAResult Only]

Q6. First, did you receive any feedback on how long the installation process usually takes (per home, on average)?

- a. Were there particular issues that were commonly encountered that caused delays or required support?

Q7. How were participants educated on the installation and use of the thermostat?

- i. Do you have specific materials you provided? If so, can the Evaluation Team get copies?
- ii. Is there an outline or checklist you follow for participant education?
- iii. What kind of customer support did the program provide participants during installation?
- b. What questions did you most often hear during installation (Nest)?
- c. What questions did you most often hear during installation (Lyric)?
- d. What were the most common reactions toward the device (Nest)?
- e. What were the most common reactions toward the device (Lyric)?

Q8. How well do you think the self-install method worked in this case, compared to contractor install? Does it look promising? What worked well? What did not work well? Are there any changes that you think would be helpful?

Q9. Did participants receive any instructions specific to the energy savings features of the thermostats? How were the energy benefits of these features presented? Any other features highlighted?

Q10. What do you consider the most problematic *technological* issue(s) associated with the thermostats? (i.e. Wi-Fi router incompatibility, incorrect wiring, etc.).

Both thermostat issues:

Specific to Nest:

Specific to Lyric:

Q11. What do you consider the most problematic participant issue(s) encountered during installation? (i.e. issues that had more to do with the participant or their home, such as lost Wi-Fi passwords, not tech savvy, etc.)

Both thermostat issues:

Specific to Nest:

Specific to Lyric:

Q12. [IF PMC HAS PREVIOUS EXPERIENCE WITH SMART THERMOSTATS AS STATED IN Q2] Based on your previous experience with these thermostats, are these issues common for the technology, or were these issues particularly pronounced for the Energy Trust participant homes?

- a. [IF MORE COMMON IN PILOT THAN IN OTHER EXPERIENCES] Why do you think this group [of participants] experienced more challenges than others?
 - b. Were these issues particular to gas furnaces, or would they be present with any heating system?
- Q13. What were the best resources for solving these problems? (i.e. customer support websites, internet groups, calls to the manufacturer, manufacturer provided documentation, etc.)
- Q14. Did the Lyric make any changes to the technology during this pilot? [IF YES] Can you please describe what, if any, issues they were able to address?
- a. Are there significant issues that still need to be overcome to make this technology viable?
- Q15. Did the Nest make any changes to the technology during this pilot? [IF YES] Can you please describe what, if any, issues they were able to address?
- Q16. Are there significant issues that still need to be overcome to make this technology viable?
- Q17. Do you have any suggestions on how to more effectively screen for/identify homes that would be good candidates for this technology?
- a. Are there specific indicators at a home that could quickly identify/screen for good candidates? (What are they?)
- Q18. Were there any logistical or communications issues between the program and the participants, and, if so, can you please describe?
- [Ask interviewee if they were involved in the onsite QA visits – ask question below if CLEARResult tech was doing onsite QA visits]**
- Q19. Please tell me about the QA visits: how they went (anything you saw, learned, feedback received during these visits – **enquire if they have data compiled that they can share on QA visits**)

A.3 Customer Interactions

I want to talk briefly about your interactions with the participants following the recruitment and installation process.

- Q20. Have you received ongoing calls/concerns from pilot participants after initial installation issues were resolved?
- a. Approximately how many?
 - b. What are the most common concerns/complaints?
 - c. Can you provide documentation on these calls? (how many, resolutions, etc.)

- Q21. Based on your experience with this pilot, what do you think is the biggest barrier for customers to purchase and/or use smart thermostats (for the market in general, not just these particular participants).
- a. What could be done to overcome this/these barrier(s)?

A.4 Closing

- Q22. How has the communication and coordination gone with [FOR CLEARRESULT READ: Energy Trust; FOR ENERGY TRUST READ: CLEARresult]? Have there been any issues between the organizations? (What were they? How have they been resolved?)
- Q23. What aspects of the pilot worked particularly well?
- Q24. Would you consider this pilot a success? Based on what factors?
- Q25. What aspects of the pilot have been challenging?
- Q26. What do you think the prospects are for a gas furnace smart thermostat measure being rolled out on a larger scale, given the current state of the technology and interest in the market?
- a. What would be the most successful incentive structure for doing this (rebate at store, rebate online, contractor incentive, customer incentive, direct install, something else)?
- Q27. What suggestions would you have for other programs considering a gas furnace smart thermostat measure? (lessons learned)
- a. Recruitment?
 - b. Thermostat delivery through manufacturer confirmation of installation?
- Q28. Are there additional comments or concerns you would like to share?

B. First Participant Survey



Energy Trust Smart Thermostat Study Participant Survey

* Required Information

page 1

Hello, and welcome to Energy Trust of Oregon's Smart Thermostat Study participant survey. Your feedback will help Energy Trust evaluate new products and services to save utility customers energy and money. As a valued participant in this pilot study, the Evaluation Team would like to hear about your experiences with the Nest technology, both during the installation process and during your first few weeks of use. The information you provide will be kept confidential to the extent permitted by law. The Evaluation Team will report all responses in aggregate and will not attribute any comments to you. As an added incentive, if you complete both this survey and the second survey (in May) you will be entered into a drawing for an Apple iPad Air*. Energy Trust has contracted with Apex Analytics to administer this survey. If you are having trouble with the survey, please call Apex Analytics at XXX-XXX-XXXX. *Odds of winning depend on the number of responses; there are only 230 participants being invited to complete the survey. Apple is not involved with nor do they endorse this study. All Smart Thermostat study participants that complete the survey are eligible for the contest. Apex Analytics will randomly select a winner around June 15, 2015. Prize is one Apple iPad Air, 16GB. MSRP of \$499. Winner will be contacted via mail, email, and/or phone immediately after the drawing.

page 2

*** 1. To continue taking the survey please enter your login ID provided in the invitation letter below:** (Enter your answer in "@####@" format where @ is character and # is number)

page 3

*** 2. According to our records, you should have received and installed a Nest thermostat, is that correct?** (Select one option)

- | | |
|----------------------------------|------------------|
| <input type="radio"/> Yes | Go to Page No. 6 |
| <input type="radio"/> No | Go to Page No. 4 |
| <input type="radio"/> Don't Know | Go to Page No. 4 |

page 4

3. Sorry about that mix-up, did you receive a Lyric thermostat? (Select one option)

- | | |
|---------------------------|---|
| <input type="radio"/> Yes | Go to Page No. 5 |
| <input type="radio"/> No | Stop, you have finished the survey
If Did Not Answer Then Go to Page No. 5 |

page 5

4. To confirm, you received a Lyric thermostat? (Select one option)

- | | |
|---------------------------|--|
| <input type="radio"/> Yes | Stop, you have finished the survey
If Did Not Answer
Then Stop, you have finished the survey |
|---------------------------|--|

page 6

*** 5. Before you signed up for this Smart Thermostat Study, had you heard of the Nest thermostat?** (Select one option)

- | |
|---------------------------|
| <input type="radio"/> Yes |
| <input type="radio"/> No |

Don't Know

6. There are a number of potential reasons for participating in Energy Trust's Smart Thermostat Study. Please rank your top three motivations in order of importance, from the following drop down menus.

*(a) 1 - Motivation (Select one option)

- Save energy
- Lower my bills
- Try new technology
- Increase the value of my home
- Environmental concerns
- Increase the comfort of my home
- Ability to control thermostat from mobile device
- Ability to better control heating system
- Interest in home automation
- Eliminate the need to program the thermostat

*(b) 2 - Motivation (Select one option)

- Save energy
- Lower my bills
- Try new technology
- Increase the value of my home
- Environmental concerns
- Increase the comfort of my home
- Ability to control thermostat from mobile device
- Ability to better control heating system
- Interest in home automation
- Eliminate the need to program the thermostat

*(c) 3 - Motivation (Select one option)

- Save energy
- Lower my bills
- Try new technology

- Increase the value of my home
- Environmental concerns
- Increase the comfort of my home
- Ability to control thermostat from mobile device
- Ability to better control heating system
- Interest in home automation
- Eliminate the need to program the thermostat

On a scale from 1 to 5, where 1 is very difficult, and 5 is very easy, how easy did you find the installation process?

7. Select satisfaction rating below

	1 - Very Difficult	2	3	4	5 - Very Easy	Don't Know
*(a) Installing the base unit to wall (Select one option)	<input type="radio"/>					
*(b) Wiring (Select one option)	<input type="radio"/>					
*(c) Initial setup and configuration (Select one option)	<input type="radio"/>					
*(d) Connecting to your wireless network (Select one option)	<input type="radio"/>					

*** 8. How technologically savvy would you consider yourself? (Select one option)**

- Not at all savvy
- Moderately savvy
- Very savvy

On a scale from 1 to 5, where 1 is completely dissatisfied, and 5 is completely satisfied, how satisfied are you with the following aspects of the thermostat installation process?

9. Select satisfaction rating below

	1 - Completely Dissatisfied	2	3	4	5 - Completely Satisfied	Don't Know
*(a) Level of detail and instructions included in the box (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

* (b) Level of detail and instructions included online (website) (Select one option)	<input type="radio"/>					
* (c) Length of time it took to install (Select one option)	<input type="radio"/>					
* (d) Overall installation process (Select one option)	<input type="radio"/>					

10. Specifically, why were you unsatisfied with the installation process? [

Answer this question only if answer to Q#9(d) is 0 OR 0]

*** 11. Did you have any issues connecting the thermostat to your Wi-Fi network? (Select one option)**

- Yes
- No
- Don't Know

12. What was the issue? [Answer this question only if answer to Q#11 is Yes]

*** 13. Were there any other issues with installing or setting up the thermostat? (Select one option)**

- Yes
- No
- Don't Know

14. What was the issue? [Answer this question only if answer to Q#13 is Yes]

15. You may have required assistance due to installation issues you experienced. Please identify all resources that you may have used to deal with the problem. [Check all that apply] [Answer this question only if answer to Q#13 is Yes]

- An Energy Trust program representative assisted me (over the phone)
- A manufacturer representative assisted me (over the phone)
- Used the Nest website - including videos and/or support page
- A contractor was brought in to assist
- Other (friend, neighbor, relative - Please specify) _____

*** 16. Is your Nest thermostat still installed? (Select one option)**

- Yes Go to Page No. 8
- No Go to Page No. 7
- Don't Know Go to Page No. 8

page 7

17. Why was your Nest thermostat removed?

Stop, you have finished the survey

If Did Not Answer Then Stop, you have finished the survey

page 8

*** 18. After initial setup and installation, have you experienced any issues or complications with your use of the thermostat (not related to installation issues)?** (Select one option)

- No, I have not had any issues with the use of my thermostat
- Yes, I have had issues with the use of my thermostat
- Don't Know

*** 19. What was the problem? [Check all that apply]** [Answer this question only if answer to Q#18 is Yes, I have had issues with the use of my thermostat]

- House has been too cool
- House has been too warm
- Difficulty in making temperature adjustments
- Difficulty in making scheduling/programming adjustments
- Problems with occupancy detection (Auto-Away)
- Wi-Fi connection issues
- Wiring issues
- Battery charging issues
- Don't Know

Other please specify _____

*** 20. Did you receive assistance from an Energy Trust program representative to resolve the issue? [Check all that apply] [Answer this question only if answer to Q#18 is Yes, I have had issues with the use of my thermostat]**

- An Energy Trust program representative assisted me (over the phone)
- A Nest representative assisted me (over the phone)
- Nest website – including support page or videos
- A contractor was brought in to assist
- Don't Know
- Other (neighbor, friend, relative - Please specify) _____

*** 21. Has the problem been resolved? (Select one option) [Answer this question only if answer to Q#18 is Yes, I have had issues with the use of my thermostat]**

- Yes
- No
- Don't Know

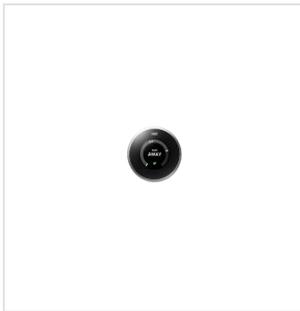
[Display this comment only if answer to Q#21 is No]

It sounds like the problem has not been resolved. Please let Energy Trust help figure out and resolve the issue you are experiencing. If you would like technical support please contact Energy Trust thermostat support group: for more pressing issues call Energy Trust support line at xxx.xxx.xxxx or for less urgent issues or questions send an email to thermostat@energytrust.org

On a scale from 1 to 5, where 1 is very difficult to use, and 5 is very easy to use, how would you rate the ease of use the following aspects of the thermostat?

22. Select difficulty rating below

	1 - Very Difficult	2	3	4	5 - Very Easy	Don't Know
* (a) Overall user interface (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* (b) Adjusting the temperature (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* (c) Adjusting the schedule (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>



*** 23. The Nest thermostat has an "Auto-Away" function enabled by default that minimizes heating when no one is home. Did you turn this setting off? (Select one option)**

- Yes
- No
- Don't Know

24. Why was this feature turned off? [Answer this question only if answer to Q#23 is Yes]

How useful are the following features or functions on your Nest thermostat?

25. .					
	Very Useful	Somewhat Useful	Not Very Useful	Not at all Useful	I have not used this function
* (a) Adjusted thermostat with smart phone (Select one option)	<input type="radio"/>				
* (b) Adjusted thermostat online (Select one option)	<input type="radio"/>				
* (c) Early On: Nest thermostat starts heating or cooling early so your home will be at the requested temperature at the time specified (Select one option)	<input type="radio"/>				
* (d) Filter Reminders: Nest thermostat reminds you to change your air filter based on how many hours your heating system has been running (Select one option)	<input type="radio"/>				
* (e) AutoSchedule: Nest thermostat remembers what temperatures keep you comfortable and creates a custom schedule for your home (Select one option)	<input type="radio"/>				
* (f) My Energy History: see exactly when your system was on and see a summary of your entire month's energy use (Select one option)	<input type="radio"/>				
* (g) Nest Leaf: the Nest Leaf appears when you turn the Nest thermostat to a temperature that will save energy (Select one option)	<input type="radio"/>				
* (h) Manual Scheduling: Nest allows you to program a custom schedule for every day of the week with as many set point as you want. (Select one option)	<input type="radio"/>				

26. Have you changed your furnace filter this winter heating season (November-April)? (Select one option)

- Yes
- No
- Don't know

27. Did you change the furnace filter as a result of the Nest reminder? (Select one option) [Answer this question only if answer to Q#26 is Yes]

- Yes
- No
- Don't Know

page 11

*** 28. How often do you adjust settings or use features of the Nest thermostat?** (Select one option)

- Every day
- A few times per week
- Several times a month
- Less than once per month
- I have not adjusted settings or used the features of my Nest thermostat
- Don't Know

*** 29. What is your favorite aspect of the Nest thermostat?**

*** 30. What additional functions, if any, would you like to see on your Nest thermostat?** (Select one option)

- There are no additional functions I would like to see on the Nest thermostat
- I would like to see the following functions on the Nest thermostat:
- Don't Know

31. Please list additional functions you would like to see on the Nest thermostat. [Answer this question only if answer to Q#30 is I would like to see the following functions on the Nest thermostat:]

page 12

*** 32. Was your previous thermostat a programmable thermostat?** (Select one option)

- Yes
- No
- Don't Know

*** 33. Was your programmable thermostat programmed? In other words, was it set to change the temperature at different times of the day (like lowering at night, or while at work during the day), or did you leave it unprogrammed (it was set to run at a constant temperature)?** (Select one option) [Answer this question only if answer to Q#32 is Yes]

- I programmed my previous thermostat for different schedules and temperatures during the day

- I did not program my previous thermostat
- Don't Know

*** 34. How often did you manually adjust the temperature on your old thermostat (like lowering at night, while at work, or on vacation)? (Select one option)**

- Every day, at least once per day
- A few times per week
- Several times a month
- A few times a year (for example, when on vacation)
- Less than once per year
- Never
- Don't Know

page 13

*** 35. Is the temperature in your home more or less comfortable now than before you installed the Nest thermostat? (Select one option)**

- Much more comfortable now
- Somewhat more comfortable now
- Equally comfortable now
- Somewhat less comfortable now
- Much less comfortable now
- Don't Know

*** 36. On a scale from 1 to 5, where 1 is completely dissatisfied and 5 is completely satisfied, how satisfied are you overall with your Nest thermostat? (Select one option)**

- 1 - Completely Dissatisfied
- 2
- 3
- 4
- 5 - Completely Satisfied
- Don't Know

37. Why are you dissatisfied with your Nest thermostat? [Answer this question only if answer to Q#36 is 1 - Completely Dissatisfied OR 2]

*** 38. On a scale from 1 to 5, where 1 is completely dissatisfied and 5 is completely satisfied, how satisfied are you overall with the Energy Trust's Smart Thermostat Study?** (Select one option)

- 1 - Completely Dissatisfied
- 2
- 3
- 4
- 5 - Completely Satisfied
- Don't Know

39. Why are you dissatisfied with the Nest Thermostat Study? [Answer this question only if answer to Q#38 is 1 - Completely Dissatisfied OR 2]

*** 40. Based on your experience to date with the Nest thermostat, how likely are you to recommend this technology to a friend or family member? (Select one option)**

- Very Likely
- Somewhat Likely
- Somewhat Unlikely
- Completely Unlikely
- Don't Know

*** 41. Which of the following statements best represents your expectations for energy savings as a result of the Nest thermostat? (Select one option)**

- I expect to see substantial energy savings (more than 10% of my energy bill)
- I expect there to be moderate energy savings (5-10% of my energy bill)
- I expect there will be minimal energy savings (less than 5% of energy bill)
- Don't Know

page 14

The following household and demographic questions are just for statistical purposes and are used in aggregate and not attributable to you. These questions are not mandatory but your responses would greatly improve our energy savings analysis.

42. Please select the cooling system you have in your home (Select one option)

- Central air conditioning
- Window (room) air conditioning units
- I do not have a cooling system

Other (Please specify) _____

43. How many people live in your home full-time? (Select one option)

- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10+
- Refused

44. Of those that live in your home full-time, are any under 18 years of age? (Select one option)

- Yes
- No
- Refused

45. In what year were you born? (4 digit year YYYY) (Enter your answer in "19##" format where # is number)

46. What is your ethnicity? Do you consider yourself to be...

- White or Caucasian
- Hispanic or Latino
- Black or African-American
- American Indian
- Pacific Islander
- Asian (Chinese, Japanese, Indian, Malaysian, Vietnamese, Cambodian)
- Refused
- Other, please specify _____

47. What is the highest level of education you have completed so far? (Select one option)

- Non-high school graduate
- High school graduate or equivalent (e.g., GED)
- Attended some college, no degree (includes junior/community college)
- Associates degree
- Bachelors degree
- Graduate or Professional degree
- Refused
- Other, please specify _____

48. Which range best describes your total household income in 2013 before taxes? (Select one option)

- Less than \$10,000
- \$10,000 to less than \$20,000

- \$20,000 to less than \$30,000
- \$30,000 to less than \$50,000
- \$50,000 to less than \$70,000
- \$70,000 to less than \$90,000
- \$90,000 to less than \$110,000
- \$110,000 to less than \$150,000
- \$150,000 to less than \$200,000
- Greater than \$200,000
- Refused

page 15

The Evaluation Team'd like to ask a few questions about the type and efficiency of your furnace. If you aren't able to answer these questions, or are unsure, please skip these questions (no answer is preferred to an uncertain one).



49. What is the efficiency rating (AFUE) of your furnace? You may be able to find this on the Energy Guide sticker on your furnace, as shown in the example photo above. If you do not know or are unable to answer then please skip this question. (Enter a value between 60 and 98)

50. Do you have a condensing furnace? Condensing furnaces have one or more PVC pipes to vent the exhaust (see photos below). (Select one option)



- Yes
- No
- Don't Know

page 16

51. Are there any other items or issues you would like Energy Trust to be aware of so they can work to improve their program offerings in the future?

52. Would you be willing to have the thermostat manufacturer share data with Energy Trust about the use of your thermostat and operation of your furnace? Energy Trust would keep this information confidential, and it would only be used to help determine energy savings. (Select one option)

- Yes
- No

Questions? Problems? Stuck? Call Apex Analytics to receive survey support – XXX-XXX-XXXX.

C. Second Participant Survey



Energy Trust Smart Thermostat Study Participant Survey

* Required Information

page 1

Hello, and welcome to Energy Trust of Oregon's Smart Thermostat Study second and final participant survey. Your feedback will help Energy Trust evaluate new products and services to save utility customers energy and money. As a valued participant in this pilot study, the Evaluation Team would like to hear about your experiences with the Honeywell Lyric technology during the past several months of use. The information you provide will be kept confidential to the extent permitted by law. The Evaluation Team will report all responses in aggregate and will not attribute any comments to you. Remember, as an added incentive, if you complete this survey you are automatically entered into a drawing for an Apple iPad Air*. Energy Trust has contracted with Apex Analytics to administer this survey. If you are having trouble with the survey, please call Apex Analytics at XXX-XXX-XXXX. *Odds of winning depend on the number of responses; there are only 303 participants being invited to complete the survey. Apple is not involved with nor do they endorse this study. All Smart Thermostat study participants that complete the survey are eligible for the contest. Apex Analytics will randomly select a winner around June 15, 2015. Prize is one Apple iPad Air, 16GB. MSRP of \$499. Winner will be contacted via mail, email, and/or phone immediately after the drawing.

page 2

*** 1. To continue taking the survey please enter your login ID provided in the invitation letter below:** (Enter your answer in "@####@" format where @ is character and # is number)

page 3

*** 2. Please tell us approximately how long it took you from start to finish to install your Lyric thermostat.** (Select one option)

- About half an hour
- One hour
- Between one to two hours
- Two hours
- Between two to three hours
- Three hours
- Between three to five hours
- A full day

*** 3. Is your Lyric thermostat still installed?** (Select one option)

- | | |
|----------------------------------|------------------|
| <input type="radio"/> Yes | Go to Page No. 9 |
| <input type="radio"/> No | Go to Page No. 4 |
| <input type="radio"/> Don't Know | Go to Page No. 4 |

page 4

*** 4. What was the primary issue that caused the Lyric removal? [Check all that apply]** (Select one option)

- House has been too cool
- House has been too warm
- Difficulty in making temperature adjustments
- Difficulty in making scheduling/programming adjustments
- Problems with occupancy detection (Geofencing)

- Could not setup thermostat correctly
- Wi-Fi or internet connection issues
- Too confusing to operate
- Was not able to properly operate my heating system
- Wiring issues
- Battery charging issues
- Issues with controlling remotely (smartphone app)
- Don't Know
- Other please specify _____

*** 5. Were there other issues that you experienced as well? [Check all that apply]**

- House has been too cool
- House has been too warm
- Difficulty in making temperature adjustments
- Difficulty in making scheduling/programming adjustments
- Problems with occupancy detection (Geofencing)
- Could not setup thermostat correctly
- Wi-Fi or internet connection issues
- Too confusing to operate
- Was not able to properly operate my heating system
- Wiring issues
- Battery charging issues
- Issues with controlling remotely (smartphone app)

- Don't Know
- Other please specify _____

*** 6. Did you receive assistance from an Energy Trust program or Honeywell representative to resolve the issue? [Check all that apply]**

- An Energy Trust program representative assisted me (over the phone)
- A Honeywell representative assisted me (over the phone)
- Honeywell website – including support page or videos
- A contractor was brought in to assist
- I did not receive assistance, I just wanted it removed
- Don't Know
- Other (neighbor, friend, relative - Please specify) _____

7. How helpful was the support in helping to address and resolve the issue?
(Select one option) [Answer this question only if answer to Q#6 is An Energy Trust program representative assisted me (over the phone) OR A Honeywell representative assisted me (over the phone) OR Honeywell website – including support page or videos OR A contractor was brought in to assist OR Other (neighbor, friend, relative - Please specify)]

- Very helpful
- Somewhat helpful
- Not helpful

On a scale from 1 to 5, where 1 is very difficult to use, and 5 is very easy to use, how would you rate the ease of use the following aspects of the thermostat?

8. Select difficulty rating below

	1 - Very Difficult	2	3	4	5 - Very Easy	Don't Know
* (a) Overall user interface (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* (b) Adjusting the temperature (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* (c) Adjusting the schedule (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

*** 9. The Lyric thermostat has a "Geofencing" function that minimizes heating when no one is home. Did you setup geofencing when initially installed?**
(Select one option)

- No - I did not setup geofencing
- Yes - I setup geofencing
- Not sure - I wasn't aware of this feature and I did not activate it

10. What is the primary reason you did not setup geofencing? (Select one option) [Answer this question only if answer to Q#9 is No - I did not setup geofencing]

- Did not want anything tracking my location
- Did not feel it was a useful feature
- I had heard that there were issues with it working correctly
- Function is not compatible with my lifestyle
- Other (Please specify) _____

11. Before you had the thermostat removed, was geofencing still enabled, or had you disabled this feature? (Select one option) [Answer this question only if answer to Q#9 is Yes - I setup geofencing]

- Geofencing is still enabled
- Geofencing has been disabled
- Don't Know

12. Why was this feature disabled? [Answer this question only if answer to Q#11 is Geofencing has been disabled]

page 6

How useful were the following features or functions on your Lyric thermostat?

13. .

	Not at all Useful	Not Very Useful	Somewhat Useful	Very Useful	I have not used this function
* (a) Adjusted thermostat with smart phone (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* (b) Adaptive Recovery: Lyric thermostat starts heating early so your home will be at the requested temperature at the time specified (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>
* (c) Created Shortcuts: Thermostat allows you to create shortcuts that will establish preset temperatures at preset days and times (vacations, parties, work-outs) (Select one option)	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>	<input type="radio"/>

How useful were each of these additional features and functions on your Lyric thermostat?

14. .

	Not at all Useful	Not Very Useful	Somewhat Useful	Very Useful	I have not used this function
* (a) Used smart cues to change air filters (Select one option)	<input type="radio"/>				
* (b) Smart cues alerted me about heating system problems (Select one option)	<input type="radio"/>				
* (c) Smart cues alerted me about unusual activity (including humidity and temperature) (Select one option)	<input type="radio"/>				
* (d) Used the Away button (Select one option)	<input type="radio"/>				

*** 15. Have you changed your furnace filter since the previous survey? (Select one option)**

- Yes
- No
- Don't know

16. Did you change the furnace filter as a result of the filter reminder on your Lyric thermostat? (Select one option) [Answer this question only if answer to Q#15 is Yes]

- Yes
- No
- Don't Know

page 7

*** 17. What was your favorite aspect of the Lyric thermostat?**

*** 18. What additional functions, if any, would you like to see on your Lyric thermostat?** (Select one option)

- There are no additional functions I would like to see on the Lyric thermostat
- I would like to see the following functions on the Lyric thermostat:
- Don't Know

19. Please list additional functions you would like to see on the Lyric thermostat. [Answer this question only if answer to Q#18 is I would like to see the following functions on the Lyric thermostat:]

page 8

*** 20. On a scale from 1 to 5, where 1 is completely dissatisfied and 5 is completely satisfied, how satisfied were you overall with your Lyric thermostat?** (Select one option)

- 1 - Completely Dissatisfied
- 2
- 3
- 4
- 5 - Completely Satisfied
- Don't Know

21. Why were you dissatisfied with your Lyric thermostat? [Answer this question only if answer to Q#20 is 1 - Completely Dissatisfied OR 2]

*** 22. On a scale from 1 to 5, where 1 is completely dissatisfied and 5 is completely satisfied, how satisfied are you overall with the Energy Trust's Smart Thermostat Study? (Select one option)**

- 1 - Completely Dissatisfied
- 2
- 3
- 4
- 5 - Completely Satisfied
- Don't Know

23. Why are you dissatisfied with the Smart Thermostat Study? [Answer this question only if answer to Q#22 is 1 - Completely Dissatisfied OR 2]

*** 24. Based on your experience to date with the Lyric thermostat, how likely are you to recommend this technology to a friend or family member? (Select one option)**

- | | |
|---|-------------------|
| <input type="radio"/> Completely Unlikely | Go to Page No. 14 |
| <input type="radio"/> Somewhat Unlikely | Go to Page No. 14 |
| <input type="radio"/> Somewhat Likely | Go to Page No. 14 |
| <input type="radio"/> Very Likely | Go to Page No. 14 |
| <input type="radio"/> Don't Know | Go to Page No. 14 |

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*** 25. During the first survey, the Evaluation Team asked about any installation or early challenges with the Lyric thermostat. Have you**

experienced any additional issues or complications while using the thermostat that were not mentioned in the previous survey? This includes any challenges not related to the initial installation. (Select one option)

- No, I have not had any additional issues with the use of my thermostat
- Yes, I have had additional issues with the use of my thermostat
- Don't Know

*** 26. What was the problem? [Check all that apply] [Answer this question only if answer to Q#25 is Yes, I have had additional issues with the use of my thermostat]**

- House has been too cool
- House has been too warm
- Difficulty in making temperature adjustments
- Difficulty in making scheduling/programming adjustments
- Problems with occupancy detection (Geofencing)
- Could not setup thermostat correctly
- Wi-Fi or internet connection issues
- Too confusing to operate
- Was not able to properly operate my heating system
- Wiring issues
- Battery charging issues
- Issues with controlling remotely (smartphone app, internet account)
- Don't Know
- Other please specify _____

*** 27. Did you receive assistance from an Energy Trust program or Honeywell representative to resolve the issue? [Check all that apply] [Answer this**

question only if answer to Q#25 is Yes, I have had additional issues with the use of my thermostat]

- An Energy Trust program representative assisted me (over the phone)
- A Honeywell representative assisted me (over the phone)
- Honeywell website – including support page or videos
- A contractor was brought in to assist
- I did not receive assistance
- Don't Know
- Other (neighbor, friend, relative - Please specify) _____

28. How helpful was the support in helping to address and resolve the issue?

(Select one option) [Answer this question only if answer to Q#27 is An Energy Trust program representative assisted me (over the phone) OR A Honeywell representative assisted me (over the phone) OR Honeywell website – including support page or videos OR A contractor was brought in to assist OR Other (neighbor, friend, relative - Please specify)]

- Very helpful
- Somewhat helpful
- Not helpful

*** 29. Has the problem been resolved?** (Select one option) [Answer this question only if answer to Q#25 is Yes, I have had additional issues with the use of my thermostat]

- Yes
- No
- Don't Know

[Display this comment only if answer to Q#29 is No]

It sounds like the problem has not been resolved. Please let Energy Trust help figure out and resolve the issue you are experiencing. If you would like technical support please contact Energy Trust thermostat support group: for more pressing issues call Energy Trust support line at XXX-XXX-XXXX or for less urgent issues or questions send an email to thermostat@energytrust.org

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On a scale from 1 to 5, where 1 is very difficult to use, and 5 is very easy to use, how would you rate the ease of use the following aspects of the thermostat?

30. Select difficulty rating below

	1 - Very Difficult	2	3	4	5 - Very Easy	Don't Know
*(a) Overall user interface (Select one option)	<input type="radio"/>					
*(b) Adjusting the temperature (Select one option)	<input type="radio"/>					
*(c) Adjusting the schedule (Select one option)	<input type="radio"/>					

*** 31. The Lyric thermostat has an "Geofencing" function that minimizes heating when no one is home. Did you setup geofencing when initially installed? (Select one option)**

- No - I did not setup geofencing
- Yes - I setup geofencing
- Not sure - I wasn't aware of this feature and I did not activate it

32. What is the primary reason you did not setup geofencing? (Select one option) [Answer this question only if answer to Q#31 is No - I did not setup geofencing]

- Did not want anything tracking my location
- Did not feel it was a useful feature
- I had heard that there were issues with it working correctly
- Function is not compatible with my lifestyle

Other (Please specify) _____

33. Is geofencing still enabled, or did you disable this feature? (Select one option) [Answer this question only if answer to Q#31 is Yes - I setup geofencing]

- Geofencing is still enabled
- Geofencing has been disabled
- Don't Know

34. Why was geofencing disabled? [Answer this question only if answer to Q#33 is Geofencing has been disabled]

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How useful are the following features or functions on your Lyric thermostat?

35. .

	Not at all Useful	Not Very Useful	Somewhat Useful	Very Useful	I have not used this function
*(a) Adjusted thermostat with smart phone (Select one option)	<input type="radio"/>				
*(b) Adaptive Recovery: Lyric thermostat starts heating early so your home will be at the requested temperature at the time specified (Select one option)	<input type="radio"/>				
*(c) Created Shortcuts: Thermostat allows you to create shortcuts that will establish preset temperatures at preset days and times (such as vacations, parties, work-outs) (Select one option)	<input type="radio"/>				

How useful are each of these additional features and functions on your Lyric thermostat?

36. .					
	Not at all Useful	Not Very Useful	Somewhat Useful	Very Useful	I have not used this function
* (a) Used smart cues to change air filters (Select one option)	<input type="radio"/>				
* (b) Smart cues alerted me about heating system problems (Select one option)	<input type="radio"/>				
* (c) Smart cues alerted me about unusual activity (including humidity and temperature) (Select one option)	<input type="radio"/>				
* (d) Used the Away button (Select one option)	<input type="radio"/>				

*** 37. Have you changed your furnace filter since the previous survey?** (Select one option)

- Yes
- No
- Don't know

38. Did you change the furnace filter as a result of the filter reminder on your Lyric thermostat? (Select one option) [Answer this question only if answer to Q#37 is Yes]

- Yes
- No
- Don't Know

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*** 39. How often do you currently adjust settings or use features of the Lyric thermostat?** (Select one option)

- Every day

- A few times per week
- Several times a month
- Less than once per month
- I have not adjusted settings or used the features of my Lyric thermostat
- Don't Know

*** 40. What is your favorite aspect of the Lyric thermostat?**

*** 41. What additional functions, if any, would you like to see on your Lyric thermostat? (Select one option)**

- There are no additional functions I would like to see on the Lyric thermostat
- I would like to see the following functions on the Lyric thermostat:
- Don't Know

42. Please list additional functions you would like to see on the Lyric thermostat. [Answer this question only if answer to Q#41 is I would like to see the following functions on the Lyric thermostat:]

*** 43. For the following features of the Lyric thermostat, please rank how valuable each feature is to you (where 1 is most valuable, 4 is least valuable): [Please rank all option(s).]**

The appearance and style of the Lyric thermostat

The Lyric thermostat has geofencing so it does not need to be programmed

Energy savings

To be able to control the Lyric thermostat remotely from your smart phone

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*** 44. Is the temperature in your home more or less comfortable now than before you installed the Lyric thermostat? (Select one option)**

- Much less comfortable now
- Somewhat less comfortable now
- Equally comfortable now
- Somewhat more comfortable now
- Much more comfortable now
- Don't Know

*** 45. On a scale from 1 to 5, where 1 is completely dissatisfied and 5 is completely satisfied, how satisfied are you overall with your Lyric thermostat? (Select one option)**

- 1 - Completely Dissatisfied
- 2
- 3
- 4
- 5 - Completely Satisfied
- Don't Know

46. Why are you dissatisfied with your Lyric thermostat? [Answer this question only if answer to Q#45 is 1 - Completely Dissatisfied OR 2]

*** 47. On a scale from 1 to 5, where 1 is completely dissatisfied and 5 is completely satisfied, how satisfied are you overall with the Energy Trust's Smart Thermostat Study? (Select one option)**

- 1 - Completely Dissatisfied
- 2
- 3
- 4
- 5 - Completely Satisfied
- Don't Know

48. Why are you dissatisfied with the Smart Thermostat Study? [Answer this question only if answer to Q#47 is 1 - Completely Dissatisfied OR 2]

*** 49. Based on your experience to date with the Lyric thermostat, how likely are you to recommend this technology to a friend or family member? (Select one option)**

- Completely Unlikely
- Somewhat Unlikely
- Somewhat Likely
- Very Likely
- Don't Know

*** 50. Which of the following statements best represents your expectations for energy savings as a result of the Lyric thermostat? (Select one option)**

- I expect there will be zero energy savings and my energy bill may even increase as a result of the Lyric Thermostat
- I expect there will be minimal energy savings (less than 5% of energy bill)
- I expect there to be moderate energy savings (5-10% of my energy bill)
- I expect to see substantial energy savings (more than 10% of my energy bill)
- Don't Know

*** 51. After using the Lyric thermostat for about six months, knowing what you know now, do you believe the retail price of approximately \$250 makes sense for this thermostat? (Select one option)**

- Definitely not - I wouldn't pay a dime for this thing
- No - I like it but it is too expensive (would not have purchased if not for Energy Trust program)
- Yes - though expensive, it is still a valuable product
- Definitely Yes - it is worth every penny
- Don't Know

*** 52. In addition to saving energy, the Lyric thermostat offers other features, including remote access (control of thermostat via smartphone), automation (the thermostat uses geofencing to automatically adjust), and a modern hi-tech style. If the Lyric thermostat provided zero energy savings (knowing it cost about \$250), do you still feel these other non-energy savings features are worth it? (Select one option)**

- Yes
- No
- Don't Know

*** 53. If you had purchased the Lyric thermostat and were not participating in this study, would you have still kept the Lyric or removed/returned it by now? (Select one option)**

- I would have returned the Lyric and reinstalled my old thermostat
- I would have returned the Lyric and purchased a different thermostat
- I would have kept the Lyric

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The following household and demographic questions are just for statistical purposes and are used in aggregate and not attributable to you. These questions are not mandatory but your responses would greatly improve our energy savings analysis.

54. Did the number of people living in your household change during the winter season (over the last six months)? (Select one option)

- One or more people moved in
- One or more people moved out
- No, nothing has changed

55. Did you renovate your home or install any new MAJOR appliances during the winter season? If so, what did you install? (Select one option)

- No, none of the above
- Yes, please specify _____

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56. Are there any other items or issues you would like Energy Trust to be aware of so they can work to improve their program offerings in the future?

Questions? Problems? Stuck? Call Apex Analytics to receive survey support – XXX-XXX-XXXX.

D. CLEAResult Implementation Report

D.1 Executive Summary

The primary purpose of this study was to evaluate the energy savings potential of the latest generation of Smart Thermostats for homes heated by gas furnaces. This was a self-install study, where participants purchased and installed the product prior to receiving an incentive from the program. This methodology allowed for the reduction in study delivery costs while gathering feedback on the feasibility of implementing self-installed thermostat incentives in the program. The study had a goal of installing 400 thermostats.

Recruitment began mid-November with recruitment emails sent by NW Natural, and the first thermostats shipped Thanksgiving week. Based on responses to the first email, a second email was needed in early December to drive up participation. Existing Homes downloaded survey results, qualified candidates and processed orders through its warehouse on a continuous basis from mid-November through the first week of January with an installation deadline of January 10, 2015. As of Monday, January 26th, there were 366 successfully installed thermostats with 15 more thermostats for which setup confirmation had not yet been received.

With the installation phase of the study complete, 2015 scope will include quality assurance, continued customer service and evaluation. It has become apparent that all participants did not fully understand the timeline for confirming installation and receiving their incentive. Existing Homes will continue to process incentives for participants who were unable to complete their thermostat installation before the study deadline.

D.2 Methodology

Thermostats

This study focused on two well-known Smart Thermostats currently in the market, the Honeywell Lyric and the Nest Learning Thermostat. Both of these thermostats claim to utilize advanced features to help save energy while being simple to use. These features include weather forecasts, advanced setback management and remote control options. Both products are available at retail stores for approximately \$250.

Both Honeywell and Nest sell their products at retail locations and have step-by-step instructions with videos to help with installation. Additionally, both companies have call centers designed to field customer questions and further assist with any installation issues.

The study required participants to install their thermostat, connect it to the internet and link it to their online Nest or Honeywell account.

Participation Requirements

Participation was open to single-family homeowners with homes primarily heated by gas forced-air furnaces. In addition, participants also were required to meet the following criteria:

- Be a current customer of NW Natural
- Have high-speed internet, an existing Wi-Fi network and a valid email address
- Have an Apple or Android smartphone or tablet
- Do not plan to make major upgrades (insulation, windows, heating system) to their home over the next year

During the application process, customers were asked to agree to terms and conditions including: install their thermostats, connect it to an online Honeywell or Nest account, to not remove the thermostat before May 31, 2015 and that Energy Trust would access their energy usage information for time periods before, during and after the study period.

Recruitment

Study candidates were recruited primarily through a collaborative marketing effort with NW Natural. Based on eligibility criteria provided by the program, NW Natural randomly selected and contacted a sample of 22,000 customers who met the following criteria:

- Current NW Natural customers
- Pay their bills online
- Have had a gas account for at least a year
- Have a winter gas usage at least twice that of the summer month.

The recruiting email sent by NW Natural directed interested candidates to complete a survey to determine if they qualified to participate in the study. Candidates who met the criteria received a follow-up email from Energy Trust containing information and directions on how to purchase their thermostat. Candidates whose answers indicated they did not meet one or more of the eligibility criteria received a customized email informing them of the reason they did not qualify.

Treatment Group Selection

Existing Homes controlled for product selection bias by randomly assigning qualifying candidates into one of two treatment groups. Those in the Nest group were provided a link to purchase a Nest in their qualification email, while candidates in the Lyric group received a link to purchase a Lyric. If candidates contacted Existing Homes to request the other thermostat in the study, staff explained that this was not possible due to the study design. All randomization was conducted via the random number generator function in Microsoft Excel 2010.

Comparison Group Selection

In addition to the treatment groups, NW Natural provided approximately 1,000 randomly selected customers’ information to Energy Trust Evaluation. These customers met the same prescreening criteria as those customers who were contacted and will comprise the comparison group for the billing analysis. Customers in the comparison group will not be contacted.

Purchase Transactions

Thermostats were purchased by CLEAResult in bulk at a reduced cost and Energy Trust was billed \$87,600 for the product in October. CLEAResult used a PayPal account to manage the transactions with the customers, with the revenue accrued and held as a credit to Energy Trust. At the end of December, CLEAResult credited Energy Trust \$73,584.00, the year to date revenue from customer purchases. Additional products were sold in January and transactions continue to occur in 2015 as customers make returns or exchanges through the PayPal system. Additionally, some participants purchased product through an online retailer, due to misunderstanding the directions in their communications. A final financial true up will occur by the end of March.

Application

The program designed this study to have an entirely online application process. Participant and site information were collected via the intake survey. By purchasing the product through CLEAResult’s PayPal account, the program had proof of the purchase for the customer. In order to receive an incentive the customer had only to email the program stating they installed their thermostat and including the manufacturers account set up confirmation email.

D.3 Data and Results

Table 1: Participant Follow-Through

	NW Natural Survey	Employees and Program Management Contractors	Totals	Conversion Rate by Phase
Total recruitment emails	22,000	200+*	22,200+	100%
Number of surveys started	1,612	114	1,726	8%
Number of surveys completed	1,584	113	1,697	8%
Number of candidates qualified	1,035	79	1,114	5%
Gross number of thermostats purchased	369	39	408	2%

*Offer was circulated to Energy Trust staff as well as other PMCs and PDCs. Precise number of emails not known.

Table 1 shows the follow-through rates for the study. NW Natural conducted recruitment in two waves for a total of 22,000 emails sent to customers who met the pre-screening criteria outlined in the participants section above. The survey tool was Survey Monkey which does not capture complete vs. incomplete responses. Incomplete responses are defined by those which most or all of the qualifying questions were left blank when submitted.

The number of thermostats purchased includes 20 participants who completed a survey, qualified for a particular thermostat, and then purchased the thermostats on their own either through the manufacturer’s website or at a local hardware store.

Table 2: Installation Rates

	Lyric			Nest		
	NW Natural	Employees and Program Management Contractors	Total Lyric	NW Natural	Employees and Program Management Contractors	Total Nest
Gross number of thermostats (purchased)	166	26	192	203	13	216
Returned/defective/shipping problem	18	1	19	8	-	8
Net thermostats in the field	147	25	173	195	13	208
Total number of thermostats with installation confirmation	143	21	164	189	13	202

Table 2 provides a summary of number of installations, returns and thermostats that are installed based on recruitment channel and product type. Data on the date when participants created a Nest or Honeywell account is available in the participant data table provided on SharePoint.

As shown above, there remain fifteen participants who have purchased a thermostat but as of January 26, 2015 have not yet confirmed that it has been installed. Seven of these participants have communicated to the program that they have either not had a chance to install or that they encountered problems that require professional assistance to complete their installations. Another two of these have not communicated their installations but came in via the employees and contractors survey, leaving five participants from the NW Natural recruitment effort who have not responded or confirmed their installation.

Table 3: Non-Qualifying Surveys Responses

	NW Natural Survey	Employees and Program Management Contractors	Total Survey Responses
DNQ Detail (does not sum to 100%):			
1. Does not have natural gas	9	1	10
2. Does not primarily heat with a gas furnace	42	4	46
3. Does not own home	30	10	40
4. Not a detached, single-family home	38	4	42
5. Home has multiple thermostats	95	7	102
6. Does not have an Android or Apple device	106	2	108
7. Does not have Wi-Fi and/or high-speed internet	25	3	28
8. Has plans to remodel in the next year	228	20	248
9. Missing Information (including DNF surveys)	44	1	45
10. Duplicates	50	4	54
Total unique DNQ responses	578	35	613
Percent DNQ	36%	31%	36%

Table 3 shows that of the 1726 total surveys completed by study candidates, 613, or 36%, of individual responses did not qualify. The most common reason for a disqualification was due to the candidate responding with plans to remodel or weatherize their home in the next year. The next most common reasons for disqualifying was lack of an Apple or Android smartphone or tablet, closely followed by homes with multiple thermostats.

The remodeling question was potentially a misunderstood question as 29 additional candidates who were initially disqualified for remodeling plans responded that, upon further explanation of what the question was asking, did not actually plan to remodel, or their remodel would not have a large energy impact (i.e. replacing the flooring in their home).

Complete survey qualification data is available in the raw survey data tables provided on SharePoint.

Table 4: Returned Thermostat Data

Reason for Return	Nest	Lyric	Total
Customer complaints	-	5	5
Installation problem - thermostat functions	1	4	5
Installation problem - defective thermostat	1	2	3
Post-installation problem - thermostat failed	3	5	9
Post-installation problem – unknown	2	1	3
Shipping problem	1	2	3

Grand Total	8	19	27
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Table 4 provides a summary of the reasons for returned product. For tracking, return reasons were placed in one of the five categories listed in the table. The most common return reason was thermostat failure after installation. Each return was notated in CRM along with any communications received by the participants.

Table 5: Employees and Program Management Contractors Purchase Distribution by Organization

Organization	Lyric	Nest	Total
Cascade Energy	-	5	5
Energy 350	5	-	5
Energy Trust of Oregon	7	4	11
EnerNOC	1	-	1
ICF International	7	1	8
NEEA	5	1	6
Triple Point Energy	-	2	2
None of the Above	1	-	1
Grand Total	26	13	39

Table 5 shows the results of the “employees and contractors” survey by organization. While the exact number of offer emails sent to PMC/PDC/Energy Trust office staff is unknown, this wave of recruitment had a 49% conversion rate from candidates receiving qualifying emails to purchases, compared to the 36% conversion rate observed in the NW Natural-driven participant pool.

Note: due to higher conversion among qualifications for Nest thermostats than for Lyrics from the NW Natural recruiting, employees and contractors candidates were randomly assigned either a Lyric or a Nest on a 2:1 basis weighted towards the Lyric to help rebalance the final study populations.

D.4 Discussion

Recruitment

Recruitment for the study resulted in high participant conversion rates with initial response rates over 7.5%. Approximately one third of survey respondents did not qualify, however this still resulted in 5% of those initially contacted by NW Natural qualifying to participate in the study.

The point at which the study encountered recruiting challenges was at the conversion from qualifying to purchasing. Approximately 35% of candidates who qualified for the study purchased a thermostat. The

reason for not purchasing product was not captured in the survey. It is possible that the specific product offered or the purchase price was a deterrent for candidates.

In late November, the program had enough conversion data to know that more candidates were needed to reach the study participation goal of 400. The program collaborated with Energy Trust and NW Natural build a second recruitment offer in early December to approximately 14,000 more customers.

In late December volume had not been met and the program opened recruitment for the last few products to employees and contractors delivered to Energy Trust and its PMCs. This final recruitment phase brought participation up to 95% of goal.

Installations

On average, it took the average study participant seven days to install their thermostat from time it was shipped. While the program did receive communications from a small number of participants who experienced issues, the vast majority of participants did not report any trouble during installation. There were eight returns due to installation issues and 12 due to post installation issues. The majority of post-installation issues involved units that failed on-site, in some cases with participants reporting that the manufacturer customer service advised that they return the units. Several customers reported Honeywell customer service had them check voltages at their thermostat terminals.

Customer Feedback

Overall customer feedback received by the program was positive. Many customers included short notes with their forwarded account setup emails stating that their thermostats were all setup and they really liked them. Several of the customers whose thermostat failed communicated that they were disappointed because they liked either the thermostat and wished they were able to keep participating in the study.

Negative feedback surrounding product was primarily from customers with Lyric thermostats, and generally focused around a lack of features. Several customers reported their frustration with the inability to program a conventional schedule into their Lyric, while others expressed frustration with the inability access any of the settings directly from the thermostat. A few customers also reported difficulty getting features like geo-fencing to work on their smartphones. The negative feedback regarding Nest thermostats that was not related to a technical issue or failure was one customer who reported frustration with the inability to adjust the temperature swing. Many conventional thermostats are configurable to only allow the temperature to drop a degree or two before turning the heat back on, however the Nest comes with a factory-set temperature swing of three degrees.

Most other feedback not related to products focused on the study process. Many customers were unsure which email they received from the manufacturer should be forwarded to the program, while others were unclear exactly what to do after installing their thermostat. The program tried to mitigate

these concerns by including an insert in the thermostat box, however this did not resolve all questions. Part of the program's difficulty in explaining precisely which email was needed to be forwarded was a result of making communications thermostat-neutral. Both Honeywell and Nest setup processes were similar enough that terms like "account setup confirmation email" applied to both, however the actual subject lines of the automated emails differed slightly for each product.

All participant interactions were notated in CRM. Emails to participants were sent through CRM and all responses were attached to the participant's CRM record. When emails were sent outside of CRM, participant responses were attached to their records later. All phone calls regarding the study were also notated in CRM.

Thermostat Issues

The overall incidence of thermostat failure was low at about 3%, with another 2% of participants experiencing problems preventing them from installing the new thermostat.

This study had three post-installation failures of Nest thermostats that exhibited symptoms very similar to the relay failures of the 2013 Nest Study. In at least two of the cases, participants reported that their furnace was running intermittently by itself even when they switched the thermostat off and removed it from the base plate. Each of these participants also stated that their thermostat reported an E52 error code, which Nest support calls an "overcurrent" event that has tripped a fuse inside the thermostat. When these participants contacted Nest support, they were informed that their HVAC system wasn't compatible with the Nest and were advised to return their thermostats.

One customer reported that his Lyric thermostat heated the house too hot then immediately switched over to cooling. Another customer reported that the Lyric would start up and appear to work, but as soon as it tried to turn on his furnace it would restart itself (and turn off the furnace). Several other customers reported that their Lyrics ran their fans intermittently or semi-continuously despite settings indicating otherwise.

Summary of Lessons Learned

- The volume of customer interactions was higher than anticipated
- More explicit directions tailored specifically to each product may have helped reduce questions
- Not all customers received an automatic account confirmation email when they created a Nest or Honeywell account
 - As neither the program nor the customer has control over whether the manufacturer sends them an email confirming they have connected their thermostat to their account, this may not be the best method for future setup verification
- Administrative time required for processing was higher than anticipated

D.5 Next Steps & Delivery in 2015

The 2015 scope of this study is quality assurance and customer service/incentive processing. There remain approximately 15 thermostats that have been purchased and shipped but installation has not yet been confirmed. Due to the study deadline of January 10, 2015 being established after the study started, an installation deadline was not developed in the initial communications to participants. The employees and contractors group were the only ones to have an installation deadline clearly communicated from the point of first contact. Of the 15 unconfirmed installations, XX are in the employees and contractors group. All customers will receive an additional communication reminder to send us their installation confirmation email.

Per the Terms and Conditions, incentives will be paid for applications submitted in a timely manner. The pilot project team should discuss whether or not to approve incentives submitted after March 31st.

Existing Homes will also support tracking and reporting for this study through the delivery of all final participant data by March as described in the 2015 Existing Homes Exhibit A-2.

7.1.1.1

7.1.1.2 Quality Assurance

Quality assurance site visits began the week of January 26, 2015. The QA goal is to conduct visits at 80 total sites, divided equally between Nests and Lyrics. In addition to verifying thermostats are installed and correctly operating the heating system, Existing Homes will also collect the following information at each visit:

- Verify basic site information
- Number of Occupants
- Heating System Data Points:
 - Verify gas furnace is the primary heat
 - Number of furnace stages
 - Furnace zoned (Y/N)
 - Number of furnaces in home
 - Presence and type of AC (central or window)
 - Other gas heating appliances
 - Type of gas furnace (atmospheric, induced draft, condensing)
 - AFUE of furnace
- Thermostat Setup Data Points:
 - Type of thermostat (Nest/Lyric)
 - Connected to Wi-Fi (Y/N)
 - Correct setup (Y/N)
 - Fan circulation settings (auto, circulate, other)
 - Auto-Away Enabled (Nest only)
 - Geo-Fencing Enabled (Lyric only)

- Serial # or Mac ID
- Notes

All QA data is being collected via a Google form in alignment with standard Existing Homes QA procedures.

E. Participant Survey Recruitment Letter



January 24, 2015
Participant Name
Participant Address
City, «State» Zip Code

421 SW Oak St., Suite 300
Portland, OR 97204

1.866.368.7878
503.546.xxxx **fax**
energytrust.org

Dear Participant Name:

Thank you again for participating in Energy Trust of Oregon's Smart Thermostat Study. Your participation will help us find new products and services to save our customers energy and money. As a valued participant in this pilot study, the Evaluation Team would like to hear about your experiences with the [Nest/Lyric] technology, both during the installation process and during your first few months of use. To provide us with feedback, the Evaluation Team would like you to take a short survey. *As an added incentive, everyone that completes this questionnaire by February 7th will be entered into a drawing for an Apple iPad Air²³!* To complete the questionnaire, please go to www.energytrust.org/NestSurvey and enter in the login ID provided below:

Login ID: «SogoProjectID_new»

The survey link will be active starting January 27th. Again, the Evaluation Team thank you for your participation in the Smart Thermostat Study and want to be sure this technology is working for you in a positive manner. Energy Trust has contracted with Apex Analytics to administer this survey. If you are having trouble with the survey, please call Analyst of Apex Analytics at 303-590-xxxx. If you have any questions about pilot study or this survey, please contact me at the number below.

Sincerely,

Energy Trust of Oregon
503-459-xxxx

²³ Odds of winning depend on the number of response, however, there are only 180 participants invited to complete the survey. Apple is not involved with nor do they endorse this study. All Smart Thermostat Study participants that complete the survey are eligible for the contest. Apex Analytics will randomly select a winner around June 14th. Prize is one Apple iPad Air, 16GB. MSRP of \$499. Winner will be contacted via mail, email, and/or phone immediately after the drawing.

F. Regression Output – Best fit Models

Thermostat Recipient Homes vs. Randomized Comparison Group

Nest Best Fit Model:

Treatment group N: 153

Comparison group N: 800

HDD Reference Temp: 60

Mixed-effects regression

Group variable: id

Number of obs = 20657

Number of groups = 953

Obs per group: min = 18

avg = 21.7

max = 23

Log pseudolikelihood = -9138.0207

Wald chi2(7) = 9798.43

Prob > chi2 = 0.0000

(Std. Err. adjusted for 953 clusters in id)

avgdailytherms	Coef.	Robust Std. Err.	z	P> z	[90% Conf. Interval]	
txgroup Tx Group, All	-.0096037	.0280585	-0.34	0.732	-.0557559	.0365484
posttx Post-Tx	.0095274	.0077978	1.22	0.222	-.0032989	.0223536
txgroup#posttx Tx Group, All#Post-Tx	-.0088479	.0143313	-0.62	0.537	-.0324209	.014725
avgdailyhdd60	.1812432	.0021188	85.54	0.000	.177758	.1847283
txgroup# c.avgdailyhdd60 Tx Group, All	.0053858	.0045316	1.19	0.235	-.002068	.0128397
posttx#c.avgdailyhdd60 Post-Tx	-.0077897	.0019922	-3.91	0.000	-.0110665	-.0045129
txgroup#posttx# c.avgdailyhdd60 Tx Group, All#Post-Tx	-.0101331	.0038236	-2.65	0.008	-.0164223	-.0038439
_cons	.5429706	.0132235	41.06	0.000	.5212199	.5647213

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Random-effects Parameters	Estimate	Robust Std. Err.	[90% Conf. Interval]	
id: Unstructured				
var(pretx)	.0121047	.0038281	.0071952	.0203642
var(pre_h~60)	.0032974	.000341	.0027817	.0039088
cov(pretx,pre_h~60)	-.0034365	.0008138	-.0047751	-.0020978
id: Unstructured				
var(posttx)	.010054	.0032565	.0059014	.0171285
var(post_~60)	.0051423	.0007696	.0040201	.0065777
var(_cons)	.1053867	.0252806	.0710272	.1563676
cov(posttx,post_~60)	-.0044514	.0010681	-.0062083	-.0026946
cov(posttx,_cons)	-.004269	.0031227	-.0094053	.0008674
cov(post_~60,_cons)	.0001954	.0043869	-.0070205	.0074112
var(Residual)	.0905711	.0076317	.0788491	.1040357

Lyric Best Fit Model:

Treatment group N: 127

Comparison group N: 831

HDD Reference Temp: 60

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```

Mixed-effects regression                               Number of obs   =   20764
Group variable: id                                   Number of groups =    958

                                                    Obs per group: min =    17
                                                    avg =           21.7
                                                    max =           23
    
```

```

Log pseudolikelihood = -10332.241                    Wald chi2(7)    =   7775.54
                                                    Prob > chi2     =    0.0000
    
```

(Std. Err. adjusted for 958 clusters in id)

avgdailytherms	Coef.	Robust Std. Err.	z	P> z	[90% Conf. Interval]	
txgroup Tx Group, All	-.0411875	.0327712	-1.26	0.209	-.0950914	.0127163
posttx Post-Tx	.0012775	.0079996	0.16	0.873	-.0118806	.0144357
txgroup#posttx Tx Group, All#Post-Tx	.0076096	.0155535	0.49	0.625	-.0179737	.0331929
avgdailyhdd60	.1863639	.0023754	78.46	0.000	.1824568	.190271
txgroup# c.avgdailyhdd60 Tx Group, All	.0102406	.0057978	1.77	0.077	.0007041	.0197771
posttx#c.avgdailyhdd60 Post-Tx	-.0083559	.0020867	-4.00	0.000	-.0117883	-.0049235
txgroup#posttx# c.avgdailyhdd60 Tx Group, All#Post-Tx	.0086751	.004962	1.75	0.080	.0005134	.0168368
_cons	.556285	.0135828	40.95	0.000	.5339432	.5786268

Random-effects Parameters	Estimate	Robust Std. Err.	[90% Conf. Interval]	
id: Unstructured				
var(pretx)	.010392	.0042538	.0053002	.0203755
var(pre_h~60)	.0044147	.000412	.0037865	.0051471
cov(pretx,pre_h~60)	-.002515	.0008978	-.0039918	-.0010382
id: Unstructured				
var(posttx)	.0104203	.003071	.0064173	.0169202
var(post_~60)	.006329	.0008153	.0051205	.0078228
var(_cons)	.1243271	.0279304	.0859181	.1799065
cov(posttx,post_~60)	-.0049132	.0011308	-.0067732	-.0030532
cov(posttx,_cons)	-.0096331	.0035828	-.0155263	-.00374
cov(post_~60,_cons)	.0018668	.0046661	-.0058082	.0095418
var(Residual)	.0996062	.0078962	.0874292	.1134792

Intention-To-Treat Homes vs. Randomized Comparison Group

Nest Best Fit Model:

Treatment group N: 580

Comparison group N: 830

HDD Reference Temp: 60

Mixed-effects regression
Group variable: id

Number of obs = 30551
Number of groups = 1410

Obs per group: min = 18
 avg = 21.7
 max = 23

Log pseudolikelihood = -16823.745

Wald chi2(7) = 11556.39
Prob > chi2 = 0.0000

(Std. Err. adjusted for 1410 clusters in id)

avgdailytherms	Coef.	Robust Std. Err.	z	P> z	[90% Conf. Interval]	
txgroup1 Tx Group, All	-.0067244	.0219752	-0.31	0.760	-.0428703	.0294215
posttx Post-Tx	.0005355	.0082266	0.07	0.948	-.012996	.0140671
txgroup1#posttx Tx Group, All#Post-Tx	.0055275	.011458	0.48	0.630	-.0133193	.0243742
avgdailyhdd60	.1873536	.0024351	76.94	0.000	.1833483	.1913589
txgroup1# c.avgdailyhdd60 Tx Group, All	.0114954	.0036717	3.13	0.002	.0054561	.0175347
posttx#c.avgdailyhdd60 Post-Tx	-.0090339	.0021318	-4.24	0.000	-.0125404	-.0055273
txgroup1#posttx# c.avgdailyhdd60 Tx Group, All#Post-Tx	-.0041095	.0029299	-1.40	0.161	-.0089286	.0007097
_cons	.57373	.0154944	37.03	0.000	.548244	.5992161

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Random-effects Parameters	Estimate	Robust Std. Err.	[90% Conf. Interval]	
id: Unstructured				
var(pretx)	.0083488	.0023278	.0052778	.0132067
var(pre_h~60)	.0045626	.0003166	.0040705	.0051141
cov(pretx,pre_h~60)	-.003283	.0008578	-.004694	-.001872
id: Unstructured				
var(posttx)	.0103487	.0039565	.005518	.0194086
var(post_~60)	.0064431	.0006111	.0055123	.0075309
var(_cons)	.1560602	.0252653	.1195757	.2036769
cov(posttx,post_~60)	-.0060358	.0012361	-.008069	-.0040025
cov(posttx,_cons)	-.0076488	.0058931	-.017342	.0020445
cov(post_~60,_cons)	.002384	.0037306	-.0037522	.0085203
var(Residual)	.1117927	.0111184	.094922	.1316618

Lyric Best Fit Model:

Treatment group N: 613

Comparison group N: 832

HDD Reference Temp: 60

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Mixed-effects regression
Group variable: id

Number of obs = 31323
Number of groups = 1445

Obs per group: min = 17
 avg = 21.7
 max = 23

Log pseudolikelihood = -14667.165

Wald chi2(7) = 13328.74
Prob > chi2 = 0.0000

(Std. Err. adjusted for 1445 clusters in id)

avgdailytherms	Coef.	Robust Std. Err.	z	P> z	[90% Conf. Interval]	
txgroup1 Tx Group, All	-.0300179	.019576	-1.53	0.125	-.0622175	.0021817
posttx Post-Tx	.0015523	.0079944	0.19	0.846	-.0115974	.0147019
txgroup1#posttx Tx Group, All#Post-Tx	.0092593	.0106447	0.87	0.384	-.0082496	.0267682
avgdailyhdd60	.1861874	.0023787	78.27	0.000	.1822747	.1901001
txgroup1# c.avgdailyhdd60 Tx Group, All	.0108745	.0033832	3.21	0.001	.0053096	.0164395
posttx#c.avgdailyhdd60 Post-Tx	-.0083569	.0020838	-4.01	0.000	-.0117845	-.0049294
txgroup1#posttx# c.avgdailyhdd60 Tx Group, All#Post-Tx	.0026476	.002852	0.93	0.353	-.0020435	.0073387
_cons	.5561696	.0135654	41.00	0.000	.5338564	.5784827

Random-effects Parameters	Estimate	Robust Std. Err.	[90% Conf. Interval]	
id: Unstructured				
var(pretx)	.0083966	.0053387	.0029506	.0238944
var(pre_h~60)	.0041006	.0002914	.0036483	.004609
cov(pretx,pre_h~60)	-.0027502	.0007363	-.0039612	-.0015392
id: Unstructured				
var(posttx)	.0101254	.0065598	.0034883	.0293904
var(post_~60)	.0061029	.0005666	.0052386	.0071099
var(_cons)	.1227852	.0180864	.0963655	.1564482
cov(posttx,post_~60)	-.0055562	.000947	-.0071138	-.0039986
cov(posttx,_cons)	-.0123841	.0064953	-.023068	-.0017002
cov(post_~60,_cons)	.0050427	.0031625	-.0001591	.0102445
var(Residual)	.094265	.0058978	.0850465	.1044827

Thermostat Recipient Homes vs. Matched Comparison Group

Nest Best Fit Model:

Treatment group N: 153

Comparison group N: 1,816

HDD Reference Temp: 60

Mixed-effects regression
Group variable: id

Number of obs = 42611
Number of groups = 1969

Obs per group: min = 17
avg = 21.6
max = 23

Log pseudolikelihood = -18758.168

Wald chi2(7) = 20846.41
Prob > chi2 = 0.0000

(Std. Err. adjusted for 1969 clusters in id)

	Coef.	Robust Std. Err.	z	P> z	[90% Conf. Interval]	
avgdailytherms						
txgroup4						
Tx Group - Nest, Re..	-.0098913	.0258317	-0.38	0.702	-.0523806	.032598
posttx						
Post-Tx	.0039164	.004495	0.87	0.384	-.0034772	.01131
txgroup4#posttx						
Tx Group - Nest, Re.. #						
Post-Tx	-.0030559	.0128241	-0.24	0.812	-.0241496	.0180379
avgdailyhdd60	.1903322	.001397	136.25	0.000	.1880344	.1926299
txgroup4#						
c.avgdailyhdd60						
Tx Group - Nest, Re..	-.0036831	.0042411	-0.87	0.385	-.0106591	.0032928
posttx#c.avgdailyhdd60						
Post-Tx	-.0071675	.0012766	-5.61	0.000	-.0092674	-.0050676
txgroup4#posttx#						
c.avgdailyhdd60						
Tx Group - Nest, Re.. #						
Post-Tx	-.0107286	.0035072	-3.06	0.002	-.0164975	-.0049598
_cons	.5429789	.0075545	71.88	0.000	.5305529	.5554049

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Random-effects Parameters	Estimate	Robust Std. Err.	[90% Conf. Interval]	
id: Unstructured				
var(pretx)	.0053048	.0015164	.0033149	.0084893
var(pre_h~60)	.0033473	.0001222	.0031523	.0035544
cov(pretx,pre_h~60)	-.0031163	.0005917	-.0040895	-.0021431
id: Unstructured				
var(posttx)	.0074211	.0020218	.0047407	.0116168
var(post_~60)	.005055	.0002083	.0047236	.0054095
var(_cons)	.0927097	.0047145	.0852706	.1007978
cov(posttx,post_~60)	-.0051261	.000893	-.006595	-.0036572
cov(posttx,_cons)	-.0065045	.0023876	-.0104318	-.0025772
cov(post_~60,_cons)	.006878	.00085	.0054798	.0082762
var(Residual)	.0923358	.0044638	.0852779	.0999779

Lyric Best Fit Model:

Treatment group N: 127

Comparison group N: 1,781

HDD Reference Temp: 61

Energy Trust of Oregon Smart Thermostat Pilot Evaluation

Mixed-effects regression
Group variable: id

Number of obs = 41346
Number of groups = 1908

Obs per group: min = 17
 avg = 21.7
 max = 23

Log pseudolikelihood = -23323.514

Wald chi2(7) = 15585.26
Prob > chi2 = 0.0000

(Std. Err. adjusted for 1908 clusters in id)

avgdailytherms	Coef.	Robust Std. Err.	z	P> z	[90% Conf. Interval]	
txgroup5						
Tx Group - Lyric, R..	-.0720802	.0307799	-2.34	0.019	-.1227086	-.0214517
posttx						
Post-Tx	.0179346	.0051431	3.49	0.000	.0094749	.0263943
txgroup5#posttx						
Tx Group - Lyric, R.. # Post-Tx	.0205979	.0143642	1.43	0.152	-.003029	.0442249
avgdailyhdd61	.188617	.0015886	118.73	0.000	.1860041	.19123
txgroup5# c.avgdailyhdd61						
Tx Group - Lyric, R..	.0000282	.0053232	0.01	0.996	-.0087277	.008784
posttx#c.avgdailyhdd61						
Post-Tx	-.0135382	.0012397	-10.92	0.000	-.0155773	-.0114991
txgroup5#posttx# c.avgdailyhdd61						
Tx Group - Lyric, R.. # Post-Tx	.0051227	.0043092	1.19	0.235	-.0019653	.0122106
_cons	.5297428	.0089462	59.21	0.000	.5150276	.5444579

Random-effects Parameters	Estimate	Robust Std. Err.	[90% Conf. Interval]	
id: Unstructured				
var(pretx)	.0120864	.0034298	.0075785	.0192758
var(pre_h~61)	.0042814	.0001978	.0039681	.0046194
cov(pretx,pre_h~61)	-.0066241	.000788	-.0079202	-.005328
id: Unstructured				
var(posttx)	.0166397	.0034159	.0118713	.0233234
var(post_~61)	.005421	.0002592	.0050109	.0058647
var(_cons)	.1374789	.0080665	.1248309	.1514085
cov(posttx,post_~61)	-.008976	.0008778	-.0104198	-.0075322
cov(posttx,_cons)	-.0240517	.0047231	-.0318206	-.0162829
cov(post_~61,_cons)	.0114305	.0011737	.0094999	.0133611
var(Residual)	.1183532	.0096003	.1035702	.1352463

G. Quality Assurance Site Visit Summary

An overview of the quality assurance site visits is included in the table below. Note that some of the results listed below may appear slightly different than those reported in Section 5.3.5 in the main body of the report. The difference can be attributed to including all QA participants for the table below while the statistics reported in the main body only includes participants that provided responses in the online participant survey.

Quality Assurance Site Visit Summary

Recruitment Status	Nest	Lyric
Total Number of Site Visits	20	27
Average Furnace AFUE	85.7	86.1
% Condensing Furnace	55%	42%
% With Central AC	70%	48%
% With Fireplaces	45%	41%
% WiFi connected	100%	100%
Average occupancy	3.0	2.7
% Geofencing enabled (Lyric)	N/A	42%
% Auto-Away enabled (Nest)	95%	N/A