Existing Manufactured Homes Heat Pump Pilot Evaluation Final Report

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CADMUS

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Executive Summary

Energy Trust of Oregon (Energy Trust), as part of its Existing Homes Program, ran a pilot to install ducted air-source heat pumps in manufactured homes that previously used electric resistance force air furnace systems. The pilot had two primary objectives: test market acceptance of $1,000 fixed-cost heat pump installations in manufactured homes and verify the energy savings produced by the retrofit. Heat pump installations occurred from November 2015 to August 2016.

Participating contractors installed 110 heat pumps through the pilot.[1] As a part of a subpilot, contractors also installed a Nest thermostat in 20 participating homes to allow CLEAResult, the program management contractor (PMC), to test the viability of conducting remote quality assurance (QA) on new heat pump installations.

Evaluation Objectives and Methodology

Cadmus conducted a process and impact evaluation of the pilot. In the process evaluation, we documented the pilot's outcomes and lessons learned, measured stakeholder satisfaction, assessed the effectiveness of remote QAs, and determined if manufactured home owners and installation contractors found the $1,000 fixed-cost installation an attractive offering.

Cadmus used the follow methods to conduct the process evaluation:

- In-depth interviews with stakeholders, including Energy Trust staff, installation contractors, and PMC staff
- Participant surveys
- Document and data reviews, including pilot documentation and tracking data

As a part of the impact evaluation, we conducted a billing analysis to assess energy savings of the pilot participants relative to a group of matched nonparticipants. Specifically, we used a variable degree-day, household-level regression modeling method, similar to the Princeton Scorekeeping Method (PRISM). The final adjusted gross savings are derived from the difference in energy use before and after the installation for these groups:

- Energy Trust Manufactured Homes Heat Pump Pilot participants
- Matched nonparticipant homes that served as the comparison group

Conclusions and Recommendations

The pilot was successful. The pilot exceeded its initial goal of 100 participants. Surveyed participants reported they were very satisfied with the quality of the contractors' work, heat pump performance, and overall pilot experience. Additionally, surveyed participants and contractors reported high

[1] Energy Trust capped the pilot at 110 installations. The PMC reported that many more installations could have occurred had there not been a cap.

satisfaction with the simplicity of the fixed-cost offer, minimal paperwork, and ease of participation. Overall, the pilot effectively balanced various program design considerations (e.g., system performance, retrofit feasibility, overall and upfront costs, the number of participating contractors).

- **Recommendation:** If cost-effective, roll out the pilot as a full-scale program offering.

Pilot staff effectively selected, listened to, and worked with contractors. Through a request for proposals (RFP) process, PMC staff used contractors' feedback to fine-tune the pilot design and selected four contractors to deliver the pilot, two of whom drove the majority of participation. These two contractors' success arose from their familiarity with the target sector and from effective marketing. Participants said their contractors' knowledge influenced their decisions to sign up for the pilot. Furthermore, the pilot's timing (during one contractor's slow season) allowed that contractor to focus on the pilot-sponsored installations. The less successful contractors (i.e., only completed a few installations) lacked effective marketing and were less engaged because they did not think the pilot would be profitable enough.

- **Recommendation:** This program design can succeed with fewer but more engaged contractors. If Energy Trust expands the pilot, it should seek contractors with experience in the target market and a strong marketing plan. Encourage contractors to minimize costs through bulk purchases from suppliers. Energy Trust could also assist with lead generation to keep contractors' costs low by identifying potential customers previously served through its programs and by coordinating with other agencies that may have provided weatherization services to this market.
- **Recommendation:** Contractors said they preferred to install ductless heat pump systems because they are higher efficiency and have lower upfront costs. Investigate whether ducted or ductless heat pumps better fit the existing manufactured homes market.

The pilot effectively attracted the intended market. The fixed-price offer achieved rapid uptake by eligible customers, who tended to have slightly lower household incomes than the general population of Oregon. Targeting manufactured homes, however, did not result in significantly higher participation rates among low-income households[2] (as discussed in Appendix A); the percentage of participating low-income households was similar to the State of Oregon's general low-income population.

- **Recommendation:** To target low-income participants, work with agencies that provide low-income weatherization assistance. These agencies serve income-verified customers with well-sealed homes.

[2] Oregon Housing and Community Services. "Weatherization Programs Income Guidelines." https://www.oregon.gov/ohcs/Pages/weatherization-oregon-income-guidelines.aspx

Participants may be willing to accept a slightly higher fixed price. Over half of the surveyed participants said they would pay more for the heat pump installed through the pilot, particularly those who were above the low-income threshold. However, two contractors said that increasing the price would dramatically reduce the participation rate, while a third contractor (who had high participation) said customers could easily accommodate a $1,000 increase. One of the contractors who said increasing the price would reduce the participation rate also ran into difficulties collecting the full participant fee from multiple customers.

- **Recommendation:** If Energy Trust reduces the incentive amount in a scaled-up program, keep the $1,000 fixed-fee offer for low-income customers and consider a fee between $1,000 and $2,000 for customers with higher incomes.
- **Recommendation:** Require contractors to have a plan to independently resolve nonpayment situations, and encourage them to collect participation fees up front and use an eligibility checklist.

Pilot participants realized significant energy savings in comparison to nonparticipants. Pilot participants realized 75% of expected savings (3,269 kWh of the expected 4,367 annual kWh). Part of these savings resulted from increased consumption in the comparison group during the post-retrofit period (834 kWh), which increased the adjusted participant savings. As a percentage of pre-installation usage, savings remained relatively constant (20% to 23%) across climate zones and pre-usage quartiles. Absolute savings appeared to be somewhat higher for heating zone 2 and for homes with higher pre-pilot energy use, as expected.

The subpilot found remote QA to be a valuable program tool. The subpilot demonstrated that the PMC could use Wi-Fi thermostats in multiple ways to conduct program QA: to validate the thermostat serial number; to confirm correct configuration and installation of thermostats; and to conduct long-term performance monitoring. The remote QA process allowed the PMC to detect and correct (or investigate) issues during each project stage.

- **Recommendation:** Incorporate remote QA using Wi-Fi thermostats into future heat pump programs, where feasible. Ensure that program staff can access the data and that the thermostat vendor remains engaged and aligned with the program's vision.

MEMO

Date: December 4, 2017
To: Board of Directors
From: Marshall Johnson, Residential Sector Senior Program Manager
Dan Rubado, Evaluation Project Manager
Subject: Staff Response to the Evaluation of the Heat Pumps in Manufactured Homes Pilot

Energy Trust's Heat Pumps in Manufactured Homes Pilot aimed to displace electric forced air furnaces with mid-efficiency central heat pump systems at a low cost to participants. The evaluation showed that the pilot was very successful in reaching its target audience, providing a quality customer experience, and producing significant energy savings in manufactured homes. If the energy savings from the pilot prove to be cost-effective, given the installation costs, Energy Trust will roll out a broader program offering. However, the nature of this offering will depend on the results of an ongoing research project on ductless heat pumps in manufactured homes, which may achieve a similar level of energy savings at a lower cost. Although Energy Trust promotes ducted and ductless heat pumps in the market, if one technology provides substantially more cost-effective energy savings in manufactured homes, the program will likely focus future efforts on the more successful technology.

The pilot offer was very popular among participants, who generally felt like they were getting a good deal through the fixed-price offer, and had high satisfaction with the systems, especially the added cooling benefit. The participating contractors were also satisfied with the pilot, the boost in business, and the simple requirements and paperwork. Some of the elements of the pilot that the program will strive to replicate in a broader offering for manufactured homes are use of a select group of qualified HVAC installers, simple installation requirements and paperwork, a flat incentive to contractors based on system size, a fixed-price offer for participants, and remote quality assurance using smart thermostats.

The program will incorporate additional elements into future offerings, including:

- A tiered participant fee structure based on income
- Working with appropriate community action agencies to target low-income customers to leverage investments and maximize participant benefits where possible
- Selecting contractors that are engaged with Energy Trust and experienced in the manufactured homes market
- Encouraging bulk purchases of equipment to drive costs down
- Assisting contractors with lead generation
- Working with interested community organizations to help expand participation to lagging markets, underserved communities, and diverse customer types

Introduction

Energy Trust of Oregon (Energy Trust) considers manufactured homes a relatively large and underserved market segment that has been slow to adopt heat pump technology, thus leaving a significant savings opportunity on the table. Due to high up-front costs and equipment space limitations, uptake of heat pumps that qualify for regular Energy Trust incentives has been limited. As such, Energy Trust saw an opportunity to create a tailored heat pump offering to overcome these barriers in the manufactured homes market.

Through the Existing Manufactured Homes Heat Pump pilot, Energy Trust offered $1,000 fixed-cost installations for heat pump systems with advanced controls to manufactured home owners with electric resistance forced air furnaces and well-maintained duct systems.[3] Participants paid their contractors a fixed cost of $1,000 regardless of the type or size of heat pump or ease of installation. Energy Trust then provided a fixed-rate reimbursement to contractors, based on system size, to cover the difference between what the homeowner paid and the pilot negotiated fees. The pilot used an RFP process to recruit the four contractors to deliver the pilot. Contractors recruited participants directly.

Participating contractors installed 110 ducted heat pumps between November 2015 and August 2016. Twenty participants also received Nest thermostats as part of a subpilot, which allowed the PMC to test if it is viable to conduct quality assurance (QA) of installations remotely. Cadmus conducted a process and impact evaluation of the pilot, addressing the following primary research questions:

- What were the pilot's results, successes, challenges, and lessons learned? Was the $1,000 fixed-cost fee attractive to eligible customers?
- What were the participating contractors' opinions of the pilot, including their own profitability and their thoughts on the fixed-cost fee? What marketing and recruitment strategies did contractors employ?
- What were the participants' energy savings?
- What were participants' motivations for participating in the pilot, in addition to their satisfaction with various elements of the pilot, and their feedback and recommendations regarding pilot improvements?
- What are the benefits and limitations of using Wi-Fi connected thermostats for remote QA?

[3] Cadmus excluded customers with homes built prior to 1985 to ensure a sample of homes in acceptable condition.

Methodology

To conduct the process evaluation, Cadmus reviewed pilot documentation, interviewed stakeholders (pilot staff and participating contractors), and surveyed pilot participants. Appendix B includes the interview and survey instruments. To conduct the impact evaluation, Cadmus completed a billing analysis of participants' energy consumption pre- and post-installation. We adjusted these findings based on the changes in pre- and post-consumption of a matched comparison group during the same timeframe.

Document Review

Cadmus reviewed all relevant pilot documents and tracking data to determine pilot performance and inform the development of stakeholder interview guides and participant survey instruments. Our review included:

- CLEAResult memos:
  - Remote QA evaluation plan (January 2016)
  - Pilot preliminary report (April 2016)
  - Remote QA analysis (February 2017)
- Contractor information and forms
- Participant tracking data (received in May 2016)

Stakeholder Interviews

In mid-2016 Cadmus conducted in-depth interviews with two Energy Trust staff members, two PMC staff members, and three of four participating installation contractors, including the two high-volume contractors. During these interviews, Cadmus discussed pilot design and implementation; contractor motivations and experiences; and the pilot's successes, challenges, and lessons learned. For the remote QA subpilot, Cadmus interviewed two PMC staff.

Customer Surveys

In July 2016, Cadmus completed telephone surveys with 61 participants to assess their decision-making, installation experiences, satisfaction with the pilot offer and heat pump system performance, awareness of regional income-qualified programs, and demographics. Cadmus provided $10 gift cards to those completing the survey.

Despite Cadmus' request, the contractors did not provide a list of customers who qualified for the pilot but declined to participate (nonparticipants). PMC tracking data listed two nonparticipants, both of whom Cadmus called three times. One nonparticipant told Cadmus that he wanted to participate, but was disqualified for not having lived in his home for one year prior to pilot implementation. We were unable to contact the other nonparticipant.

Billing Analysis

In August 2017, Cadmus conducted a billing analysis to assess energy savings associated with the Manufactured Homes Heat Pump pilot. We estimated pilot savings using a variable degree-day, household-level regression modeling method, similar to the Princeton Scorekeeping Method (PRISM).[4] We adjusted the participant gross savings using the difference of pre- and post-consumption of a carefully matched comparison group. Cadmus used the comparison group to account for exogenous factors that could have affected energy consumption during the 2015–2017 timeframe.

Cadmus created the final billing analysis dataset by combining the following data:

- ***Pilot participant characteristics,*** collected and provided by Energy Trust (including installation dates, square footage, heat sources, baseline equipment, thermostat types, and expected savings for the entire pilot participant population).
- ***Comparison group customer characteristics,*** selected by Cadmus from Energy Trust's duct-sealing measure for manufactured homes from 2010 through 2016. We only selected accounts for manufactured homes with electric resistance forced air furnaces. Because of participation in the program, these homes' ducts were likely to be in good working order. The initial comparison group included over 5,000 electric customers in Oregon. Of these, approximately 1,000 customers were from the same cities as the Energy Trust Manufactured Homes Heat Pump pilot installations and considered for final matched sample selection. However, the distribution of the nonparticipant and participant samples were different across cities, so Cadmus could not match the nonparticipant consumption at the quartile and city levels due to insufficient sample. We did, however, make sure that city distribution, square footage distribution, and pre-installation consumption were similar between the pilot participant group and the final matched nonparticipant group. The team accomplished this by filtering out nonparticipants in each city if their residences did not fall between the minimum and maximum participant home square feet. If a city was overrepresented in the sample, Cadmus selected and paired sites to maintain a similar usage distribution to the participant group. We performed the screens to ensure the nonparticipants were as similar to the participants as possible.
- ***Utility billing data***, provided by Energy Trust and included participant billing data from April 2011 through June 2017. The billing data also included customer information and incidental program participation information for other Energy Trust-supported measures. The final billing analysis sample consisted of 78 participant homes and 105 nonparticipant homes.

[4] M. Fels. "PRISM: An Introduction," *Energy and Buildings 9*, #1-2, pp. 5-18. 1986. Available online: www.marean.mycpanel.princeton.edu/~marean/images/prism_intro.pdf

- ***Oregon weather data*** included daily average temperatures from January 2011 to June 2017 for 22 weather stations and corresponded with participant locations. Cadmus also obtained Typical Meteorological Year (TMY)3 normal weather values for these stations from the National Oceanic and Atmospheric Administration (NOAA). We used TMY3 data to calculate energy use under normal weather conditions.

Cadmus matched participant pilot data with utility billing data and mapped daily heating degree-days (HDDs) and cooling degree-days (CDDs) to respective monthly billing periods using zip codes. For participants, Cadmus defined the billing analysis pre-period as the 12 months before the measure installation date and the post-period as the 12 months following the measure installation date (we removed the month of the installation from the analysis). Participant installations occurred between December 2015 and May 2016. We used the average participant installation date (February 3, 2016) as the nonparticipant pre-/post-installation cutoff date. Cadmus defined the nonparticipant pre-period as February 2015 through January 2016 and the post-period as February 2016 through January 2017.

Data Screening

Starting with the full population for the treatment and comparison groups, Cadmus identified the final analysis samples after cleaning the data and screening for several criteria. We conducted the energy consumption analysis using participants who had not moved since participation and with at least 10 months of pre- and post-period billing data. We performed account-level reviews of all individual participant pre- and post-period monthly consumption to identify anomalies that could bias the results (e.g., periods when homes were unoccupied).

To ensure the PRISM models used complete pre- and post-pilot participant and nonparticipant billing data, Cadmus selected accounts with the following criteria:

- Nonparticipants in the same cities as the participants
- A minimum of 300 days in each of the pre- and post-periods (i.e., before the earliest installation and after the latest reported installation)
- Accounts showing a consumption change of less than 70% of pre-pilot usage in either direction, which ensured a better match between participants and the comparison group
- Accounts where the same occupant was present throughout the pre-and post-periods.
- Nonparticipants not installing other Energy Trust measures in 2015, 2016, or 2017[5]

[5] The evaluated heat pump measures accounted for 97% of the savings claimed by Energy Trust at the participant sites. Due to small pilot sample sizes, Cadmus could not remove participants who installed other Energy Trust measures. It was not possible to quantify the influence of the other pilot measures because installation dates were not available for the additional measures. Due to very large influence of the heat pumps on savings, we expect the other program influence was very minimal, at most 3%.

- Cadmus also examined individual monthly billing data to check for vacancies, outliers, and seasonal usage changes. If the usage patterns remained inconsistent between pre- and post-periods, we did not include this account in the analysis. Examples include extreme monthly values, including vacancies, outliers in the billing data (seen as large spikes in usage outside expected patterns), heating or cooling system changes (e.g., adding or removing heating or cooling loads), or baseload equipment changes.[6] This included screening for accounts with large gaps in the monthly electric usage data or with zero consumption across several months (distinct from missing values).
- No change in the number of occupants from the pre- to post-period, as indicated by the participant survey.

Table 1 shows participant and nonparticipant screening criteria used for the billing analysis.

Table 1. Screen for Inclusion in Billing Analysis

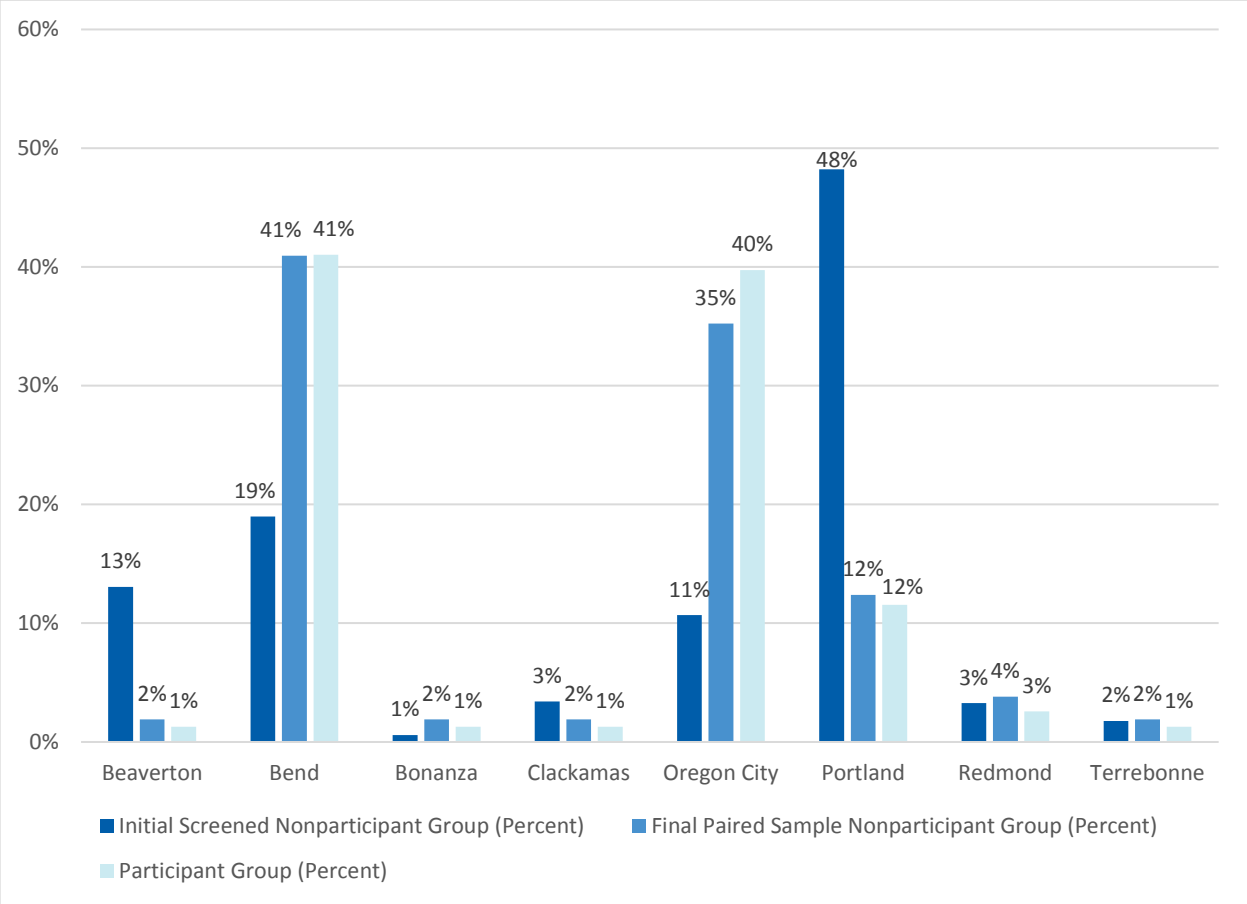
Screen	Attrition		Remaining	
	Nonparticipant	Participant	Nonparticipant	Participant
Original participant and nonparticipant population			5,425	110
Matched to participant sample with billing data (keep only nonparticipant residential accounts in participant cities only)	4,351	3	1,074	107
Less than 300 days in pre- or post-period	81	5	993	102
Increased or decreased consumption by more than 70% from pre- to post-period	26	1	967	101
Remove customers that moved from pre- to post-period (based on account name change)	160	9	807	92
Nonparticipants who installed measures in 2015, 2016, or 2017	88	-	719	92
Participant survey indicated change in occupants from pre- to post-period	-	3	719	89
Billing data outliers, vacancies	45	11	674	78
Nonparticipant paired sample selection	569	-	105	78
Final Sample			***105***	***78***

[6] Baseload changes may include adding or removing appliances (e.g., refrigerators or water heaters) or changes in occupancy; in either case, this may convolute the analysis for distinguishing the effects of the pilot.

Nonparticipant and Participant Sample Distribution by City and Pre-Retrofit Usage

Figure 1 shows the participant city distribution and compares this against initial screened and final paired nonparticipant groups.

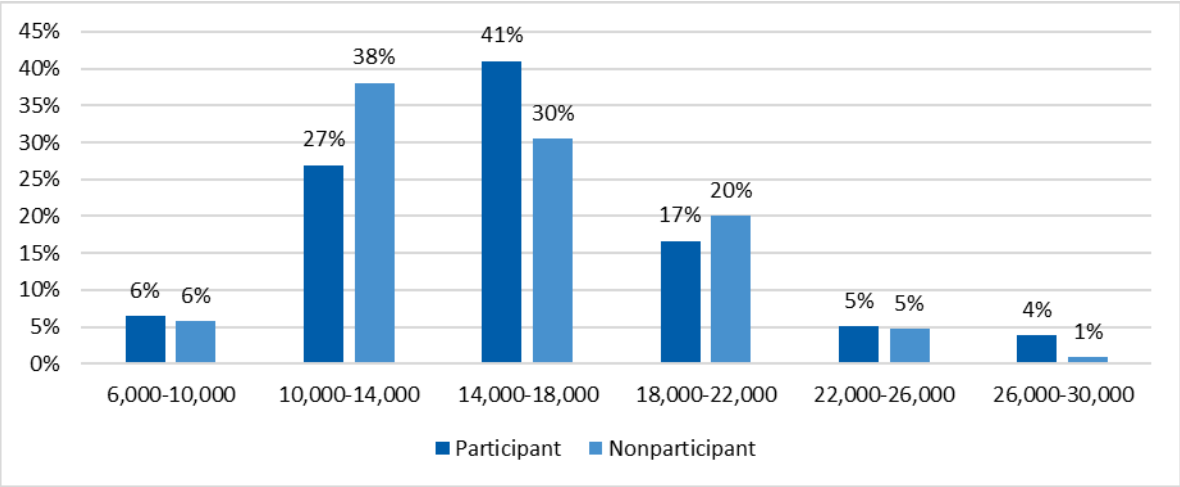
Figure 1. Participant, Initial Nonparticipants, and Final Matched Nonparticipants City Distributions



More than 80% of pilot participants lived in Bend and Oregon City. In the initial nonparticipant group, however, only 30% came from these cities, and nearly half came from Portland. The final paired nonparticipant group exhibited a geographic distribution much closer to the final participant group. Since there were a sufficient number of nonparticipants to match to the participant group by city, we did not attempt to include other nearby cities in the selection process. We did this to increase the chance that the participant and nonparticipant group demographics, housing characteristics, and socio-economic factors were similar.

Figure 2 shows the distribution of pre-retrofit kWh usage for the participant and nonparticipant groups.

Figure 2. Pre-Retrofit Usage (kWh)



PRISM Models

Cadmus estimated site-level heating and cooling PRISM models for various heating and cooling bases[7] in both the pre- and post-period for each customer using the following specification:

$$ADC_{it} = \alpha_i + \beta_1 AVGHDD_{it} + \beta_2 AVGCDD_{it} + \varepsilon_{it}$$

Where for each customer '*i*' and monthly billing period '*t*':

- ADC_{it} = Average daily kWh consumption
- α_i = The participant intercept, representing the average daily kWh baseload
- β_1 = The model space heating slope (used only in the heating only, heating + cooling model), represents the average change in daily usage resulting from an increase of one daily HDD
- $AVGHDD_{it}$ = The base 45°F to 65°F average daily HDDs for the specific location (used only in the heating only, heating + cooling model)
- β_2 = The model space cooling slope (used only in the cooling only, heating + cooling model), represents the average change in daily usage resulting from an increase of one daily CDD

[7] Cadmus used a grid search PRISM method to allow the heating degree base temperatures to vary from 45° to 65° and the cooling base temperatures to vary from 65° to 85°. If a heating and cooling model yielded incorrect signs for all models, we also estimated heating only and cooling only models. We selected the model with the correct signs on the heating and/or cooling slopes and the highest r-square as the final model.

$AVGCDD_{it}$ = The base 65°F to 85°F average daily cooling degree-days for the specific location (used only in the cooling only, heating + cooling model)

ε_{it} = The error term

Using the above model, Cadmus computed weather-normalized annual kWh consumption for each site in both the pre- and post-pilot periods as:

$$NAC_i = \alpha_i * 365 + \beta_1 LRHDD_{it} + \beta_2 LRCDD_{it}$$

Where, for each customer '*i*' and for the annual pre- and post- pilot time periods '*t*':

NAC_i = Normalized annual consumption (kWh)

$\alpha_i * 365$ = Annual baseload kWh usage (non-weather sensitive)

$LRHDD_{it}$ = Annual, long-term HDDs of a normal weather year from NOAA TMY3 data, based on home location

$\beta_1 LRHDD_{it}$ = Weather-normalized, annual heating usage (kWh) (i.e., Heat-NAC)

$LRCDD_{it}$ = Annual, long-term cooling degree-days of a normal weather year from NOAA TMY3 data, based on home location

$\beta_2 LRCDD_{it}$ = Weather-normalized, annual cooling usage (i.e., Cool-NAC)

Savings Calculation

Cadmus derived adjusted gross energy savings using the following equation to adjust the evaluated participant savings based on changes in the comparison group's energy use. This adjustment accounted for exogenous factors that occurred outside of the pilot effect (all terms in the equation are averages). Similar to a straight difference-in-difference approach, this accounted for potential distinctions between each groups' average annual weather-normalized pre-treatment usage.

$$Adj.\,Gross\,Savings = (Pre\,Usage_{Treat.}) \left(\frac{Change\,In\,Usage_{Treat.}}{Pre\,Usage_{Treat.}} - \frac{Change\,In\,Usage_{Comp.}}{Pre\,Usage_{Comp.}} \right)$$

Subgroup Analysis

Wherever an analysis subset variable was available for both participant and nonparticipant groups, we calculated adjusted gross savings by comparing with the same nonparticipant subgroup. However, we did not match the nonparticipant group by pre-period usage to the participant group at the subgroup level. As a result, the nonparticipant usages may not match the participant usages and weighted savings may not necessarily match overall results. If a variable was only available for participants, we only applied the overall nonparticipant delta to obtain adjusted gross savings.

Pilot Design and Results

Pilot Design

Energy Trust designed the pilot to be financially attractive and streamlined, with minimal paperwork for participants and contractors. All eligible customers paid a fixed fee of $1,000 for a new heat pump regardless of the heat pump brand (Payne, Kelvinator/Intertherm), heat pump size (1.5 tons to 3.5 tons), or characteristics of customers' manufactured homes (e.g., age, size, and existing condition). Energy Trust paid the four participating contractors a flat fee based on the size of the heat pump, regardless of the amount of effort required to install the equipment.

Eligibility

Participant Qualifications

Participants met the following requirements to qualify for pilot:

- Lived in a manufactured home built in or after 1985
- Used an electric furnace as the primary form of heat
- Did not have an existing heat pump (however, an existing air conditioning was allowed)
- Lived in the home for at least one year prior to the installation
- Planned to live in home for at least one year after the installation
- Agreed to not install insulation, ductwork, or window upgrades for one year after the installation
- Served by Pacific Power or Portland General Electric (PGE)

Energy Trust targeted homes it had previously served through other programs for the pilot, assuming these homes had functional and sealed duct systems.

Contractor Qualifications

PMC staff distributed the RFP for this pilot via e-mail to approximately 700 contractors and received 11 bids. PMC staff rated bidding contractors based on their business profile (e.g., financial stability, manufactured home experience, heat pump experience, length of time in business), support for projects (e.g., financing offered, marketing efforts), customer service, work quality and pricing, and service territories. After two rounds of bids, PMC staff selected four contractors to offer the pilot. Between the two rounds of bids, the PMC revised the heat pump requirements because the original round of bids from contractors were too high for the pilot to be cost-effective. Revisions included a bid for the heat pump replacement only, without replacing the furnace; a change to the Heating Seasonal Performance Factor (HSPF) rating from 8.2 to 7.7 (federal minimum); requirement for a 12-inch crossover, except in cases where a 12-inch duct will not fit.

Installations by Contractor

Four contractors installed 110 heat pumps in manufactured homes in Deschutes, Clackamas, Multnomah, Washington, and Klamath counties in Oregon, as shown in Table 2. Two contractors accounted for 96% of installations. Although there were ultimately 110 pilot installations, the data Cadmus reviewed at the time of the evaluation only included details on 109 installations. The other tables in this section reflect the 109 installations we reviewed.

Table 2. Number of Heat Pumps Installed by County

County Installed	Heat Pump Installation Count
Deschutes	53
Clackamas and Multnomah	52
Washington	3
Klamath	1
Total	**109**

Housing Characteristics of Participants

According to the program tracking data, contractors installed most of the heat pumps in manufactured homes with these common characteristics:

- 94% were double-wide homes; the remaining 6% were single-wide or triple-wide homes
- 80% were built in the 1990s, 12% were built in the 2000s, and 8% were built between 1986 and 1989
- 77% were inside a mobile home park

Because of the homogeneity of home characteristics, Cadmus could not draw conclusions about whether different types of manufactured homes had different levels of savings, as most heat pumps were installed in double-wide manufactured homes built in the 1990s and located in a manufactured home park.

Heat Pump Characteristics

Through the pilot, contractors replaced electric resistance forced air furnaces with mid-efficiency ducted heat pumps. Table 3 shows the number of heat pumps installed by manufacturer (split almost evenly between Payne and Kelvinator/Intertherm) and tonnage (comprised mostly of 2-ton units).

Table 3. Heat Pumps Installed by Manufacturer and Tonnage

Manufacturer	Heat Pump Tonnage				Total
	1.5 tons	2 tons	2.5 tons	3 tons	
Kelvinator/Intertherm	0	27	18	8	**53**
Payne	3	36	14	3	**56**
Total	**3**	**63**	**32**	**11**	**109**

Table 4 shows the number of heat pumps by HSPF.

Table 4. Heat Pumps Installed by HSPF

HSPF	Count	Percentage
8.0	15	14%
8.2	48	44%
8.5	45	41%
9.0	1	1%
Total	**109**	**100%**

Table 5 and Table 6 list the distributions of Seasonal Energy Efficiency Ratio (SEER) and strip heat kW.

Table 5. Heat Pumps Installed by SEER

SEER	Count	Percentage
13.0	17	16%
13.5	22	20%
14.0	69	63%
15.0	1	1%
Total	**109**	**100%**

Table 6. Homes with Backup Strip Heat

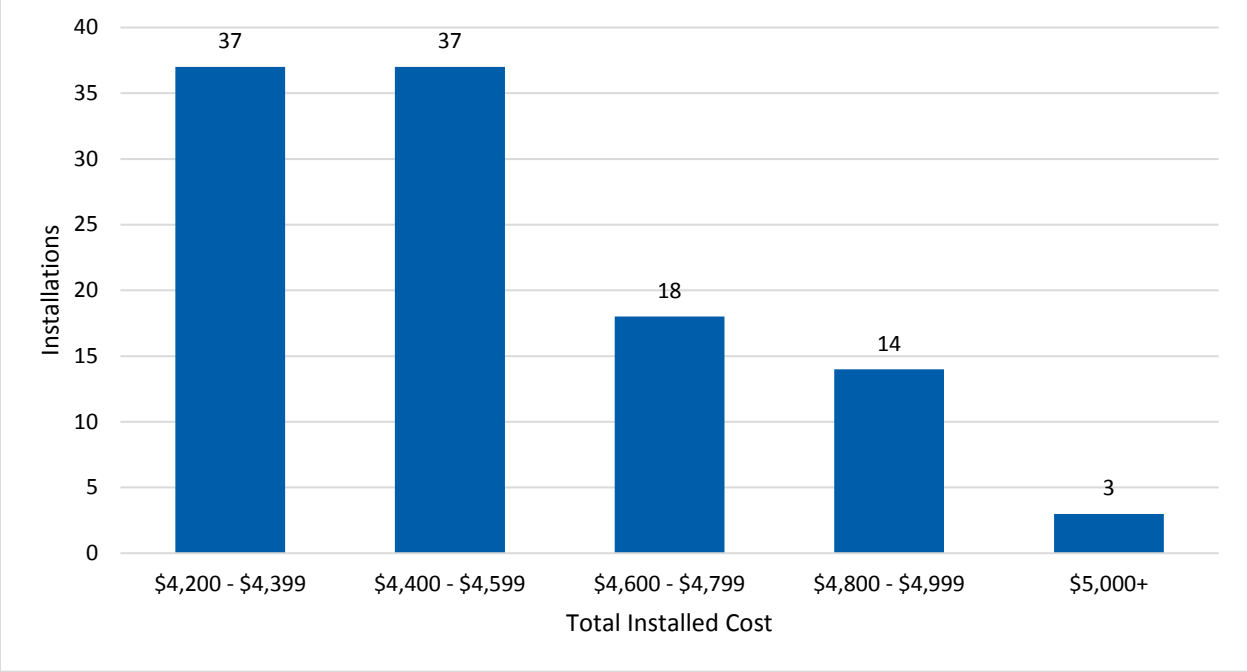
Backup Strip Heat (kW)	Count	Percentage
10	13	12%
12	3	3%
13	1	1%
15	83	76%
17	2	2%
20	4	4%
No backup strip heat	3	3%
Total	**109**	**100%**

Heat pumps installed through the pilot most commonly had HSPF ratings of 8.2 (44%) or 8.5 (41%), a SEER of 14 (64%), and backup strip heat rated at 15 kW (76%).

Cost of Installations

As previously described, participants paid their contractors a fixed cost of $1,000 regardless of the type or size of heat pump or ease of installation. Energy Trust then paid contractors a fixed-rate reimbursement. As shown in Figure 2, contractors' total fees (Energy Trust plus participant contribution) ranged from roughly $4,200 to $5,200 per installation, with an average of $4,513. Energy Trust negotiated total installed costs with each contractor during the RFP process based on the size of the system.

Figure 3. Distribution of Total Installed Cost per Heat Pump



Staff and Contractor Interview Results

This section outlines the results of stakeholder interviews, conducted in May 2016.

Staff Interviews

Input from Energy Trust and PMC staff is critical to understanding the successes and challenges of the pilot design and the contractor RFP process as well as lessons learned. Cadmus interviewed two staff from Energy Trust and two from the PMC.

Successes

The pilot achieved overwhelming and rapid response to its fixed-cost offer. Launched in November 2015, participating contractors installed most of the pilot heat pumps from December through February 2016. Energy Trust and PMC staff attributed this success to the low up-front cost that, as one PMC staff member said, enabled participants to "cut heating bills in half." Energy Trust staff also credited the pilot's success to untapped demand in the existing manufactured homes market.

The pilot benefited from the marketing and word-of-mouth campaigns carried out by the two high-volume contractors. PMC staff said that contractors benefited from the simple-sizing guidelines, which helped them negotiate prices with suppliers. The homogeneity of manufactured homes, specifically those of the participants, contributed to the success of the fixed-cost structure, which would otherwise be more complicated to implement in single-family homes.

Energy Trust purposefully designed the pilot to minimize paperwork and reporting, benefiting participants and contractors. PMC staff said the streamlined system kept the reservation and application process as simple as possible for participating contractors. PMC staff attributed the low participant attrition to careful training of the contractors on program prerequisites and providing them with a checklist[8] to assess eligibility. As a result, the PMC did not reject any contractor applications for reimbursement.

Challenges

Energy Trust and PMC staff struggled to settle upon a final fixed, up-front cost for participating customers; they needed to ensure pilot cost-effectiveness without excluding too many potential participants. Pilot implementation staff initially set the fee at $500 per participant but raised it during two rounds of RFP bids from contractors. Pilot staff did not want to set the fee too high but had little data to help inform an appropriate price. In addition, Energy Trust knew financing may not be a realistic option for many participants who may have poor credit history or would not be able to take out a loan. This pilot represents the first time Energy Trust has asked for money from this customer segment in

[8] PMC staff said that one contractor printed out the checklist and had homeowners initial each line item at the initial meeting to ensure applications would not be rejected.

exchange for an investment. At Energy Trust's encouragement, contractors offered customers financing options, but few accepted the offer.

Lessons Learned

PMC staff characterized one lesson learned as "us opening our ears" to let contractors help guide pilot specifications. Between two rounds of RFP bids, contractors offered recommendations to help the PMC revise the requirements to make the pilot cost-effective and also attractive to contractors who wished to participate.

Energy Trust also learned it needed to coordinate with low-income service providers and community action agencies earlier in the pilot to achieve expectations for low-income household participation. The qualification screening for the pilot did not include income criteria, instead focusing only on home characteristics.

Contractor Interviews

Input from contractors is essential to better assess the pilot design and gain insight into customer reactions to the pilot. Cadmus interviewed the pilot's two high-volume contractors and one of its low-volume contractors.

Awareness and Motivations to Participate

All three interviewed contractors learned about the pilot via an e-mail from Energy Trust and/or Portland General Electric. Contractors were intrigued by the opportunity to install a large number of heat pumps. One contractor noted the simplicity of the fixed-cost pricing mechanism allowed his firm flexibility to take on more projects, even if it meant taking "the good with the bad" in terms of profitability per project. Another said the number of residential retrofit projects decreases during the winter months in his service territory, so launching the pilot in November was a key motivator for participation; had the pilot run during the summer or fall, "the pilot would have been a burden." The low-volume contractor said the pilot was not profitable enough.

Profitability from Participating

Contractors were satisfied with the fixed-cost pricing and reimbursement schedules and said they aligned well with the actual cost of installations. Contractors said their per-unit profit decreased because of time spent on customer recruitment, the amount of labor required for each project (which varied in cases where contractors needed to upgrade existing equipment), and time spent responding to the RFP changes. One contractor said per-unit profit decreased by about $400 because of varying complexity of installations, but the increase in sales volume helped offset the decrease in profit. The pilot gave contractors the ability to order heat pumps in bulk, which helped to reduce per-unit costs by negotiating with suppliers.

The low-volume contractor "preferred to work independently but enjoyed working with Energy Trust."

Marketing and Recruitment

The high-volume contractors used different methods to market and recruit participants for the pilot. One asked managers of manufactured home parks to distribute fliers to homeowners, then rewarded managers with one $25 prepaid Visa card per homeowner they referred as a potential participant. This contractor also performed two postcard mailings from "a very refined mailing list" that omitted homes that would not qualify for the pilot. The other high-volume contractor did not formally market the pilot, but used word of mouth and the company's reputation to attract potential participants in the 10 manufactured home parks it services. This contractor said that it would not be cost-effective to develop a marketing campaign for a relatively small number of installations. The low-volume contractor also relied on word of mouth.

One high-volume contractor used payback analysis when communicating the offer to potential participants, whereas the other high-volume contractor did not, saying customers might interpret an estimate as a guarantee and can be disappointed if they do not achieve the savings that were predicted.

Financing

The three interviewed contractors all offered financing to customers. One contractor said he had "maybe one" customer who enrolled in a six-month, zero-interest finance program through an approved lender. All other participants paid for their heat pump up front.

One contractor said banks and lenders are less interested in financing projects with such small installation costs, and that the legwork involved in structuring the loan is not worth the effort. This contractor recommended financing the pilot with small charges on participants' monthly utility bills (known as on-bill repayment).

Installation Preferences

Each contractor Cadmus interviewed prefers to install ductless heat pumps, which offer higher efficiency while incurring lower up-front and monthly operational costs than ducted heat pumps. All three of these contractors installed backup strip heat based on the load calculation of the home, calculated based on home square footage, location, and local weather patterns.

Feedback on Participant Fee

Contractors thought the $1,000 fixed-cost price was "just right." One high-volume contractor and one low-volume contractor said a $500 or $1,000 increase would dramatically reduce the participation rate. The other high-volume contractor thought customers could accommodate a $1,000 increase "without blinking."

A year after the pilot installations, one contractor still had an unpaid balance, from multiple homeowners, totaling $2,500. This contractor normally collects 50% up front, with the remainder being due 30 days after installation. However, the contractor did not collect the initial payment in two cases. This contractor has not dealt with nonpayment before and had no formal mechanism in place to deal with this scenario, aside from attempting to call the customers to request payment.

Participant Survey Findings

Cadmus surveyed 61 participants out of a sample size of 109 participants (56% response rate) to gather demographic information and gauge awareness of and motivations for participating in the pilot, opinion of the cost of the heat pump, satisfaction, experience with income-qualified programs, and suggestions for how to improve the pilot.

Demographics

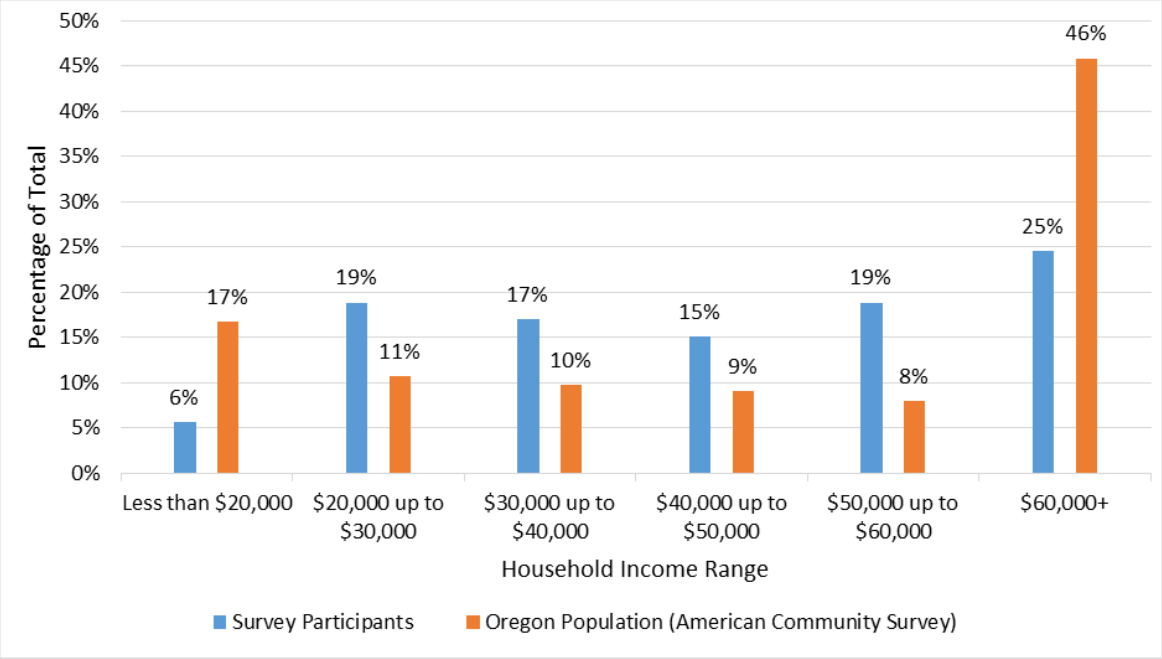
The average household size is 2.3 residents; only 11% of respondents live in homes with four or more residents. Seventy percent of respondents have lived in their home for at least three years. Almost 90% of respondents are white, and all respondents speak English as the primary language in their households. Thirty-seven percent of respondents completed high school, while almost two-thirds of respondents (63%) completed at least two years of college. Ninety percent have wireless internet in their home, enabling them to accommodate a smart thermostat.

Of the 53 respondents who reported their household income range, 57% had incomes below $50,000. Oregon had an estimated 2015 median household income of $54,148.[9] Figure 4 shows the distribution of survey participant income ranges in comparison to the 2015 Oregon household income distribution.[10] Participants were more likely to have household incomes below $60,000 a year than the general population.

[9] United States Census Bureau. "Household Income: 2015 American Community Survey Briefs." http://bit.ly/2ex6JkV

[10] United States Census Bureau. "Household Income in the Past 12 Months." https://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?pid=ACS_15_1YR_B19001&prodType=table

Figure 4. Income Distribution: Survey Respondents and Oregon Population

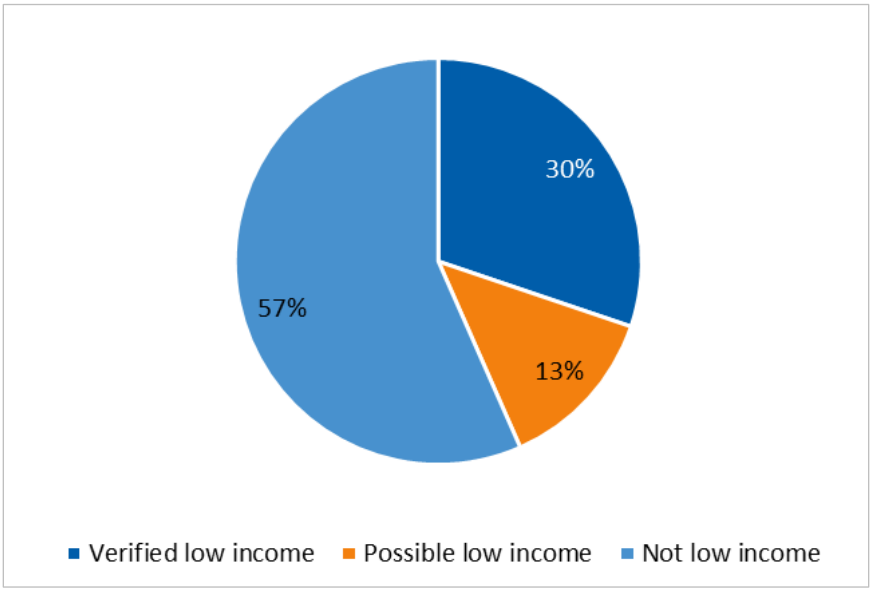


To determine whether each survey respondent qualifies as low income, Cadmus compared self-reported income ranges and participant household numbers to Oregon's Weatherization Programs Income Guidelines. In Oregon, 31% of households fall under the definition of low income used by Oregon's Weatherization Programs Income Guidelines, which is a household income at or below 200% of the Federal Poverty Level.[11] Based on these guidelines, Cadmus confirmed 16 survey respondents (30%, n=53) qualify as low income, similar to the general population, 30 (57%) are not low income, and seven were potentially low-income but could not be verified (see Figure 5).[12]

[11] The Henry J. Kaiser Family Foundation. "Distribution of the Total Population by Federal Poverty Level." http://kaiserf.am/2cRb7um

[12] See Appendix A for an explanation of the mapping of survey respondents to income.

Figure 5. Income of Survey Respondents Classified by Oregon's Income Guidelines



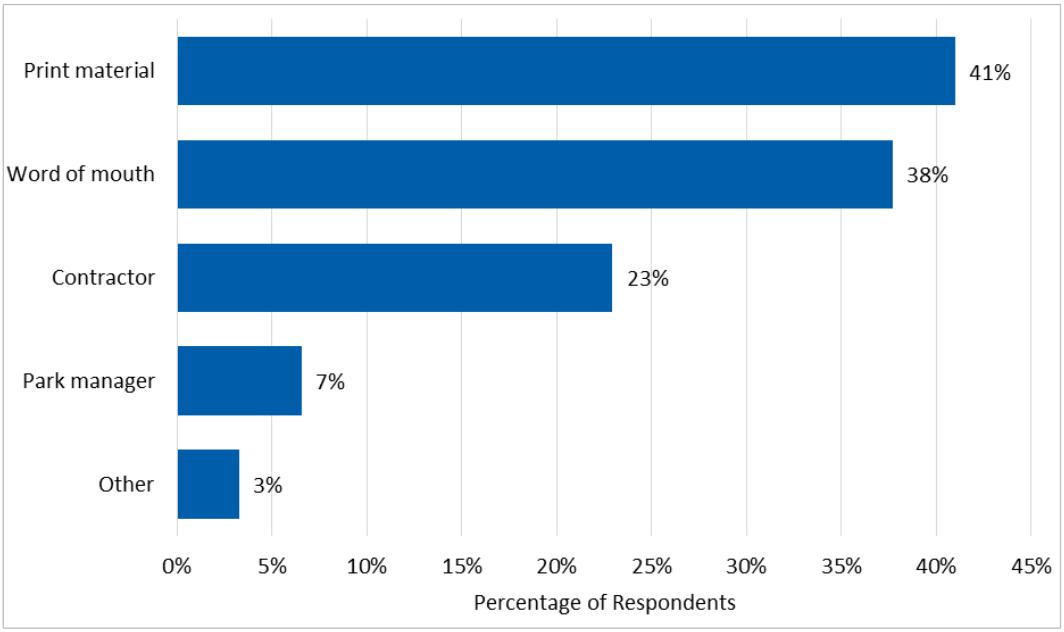
About 72% of respondents (n=61) did not know of any organizations in their area that offer assistance to help residents save energy or use renewable energy at home. Of the 16 respondents that we determined were low income, 10 did not know of any organizations in their area that offer assistance to help residents save energy or use renewable energy at home, four mentioned community action agencies (three people cited NeighborImpact and one mentioned Clackamas County Social Services), and two people mentioned utilities (one mention each of Pacific Power and PGE).

When prompted with the name of their local community action agency, 54% of respondents were not aware of their local agency and another 36% had heard of but never worked with the agency (n=61). Of the group of 16 low-income respondents, three people had worked with Clackamas County Social Services and one person had worked with NeighborImpact. An additional four people were aware of NeighborImpact but had not worked with them. The remaining eight people were not aware of their local community action agency.

Participant Awareness of the Pilot

Survey respondents learned about the pilot through a variety of channels (see Figure 6), most frequently through print material (41%), word of mouth (38%), and directly from the contractor (23%).

Figure 6. Survey Respondents Awareness of Pilot



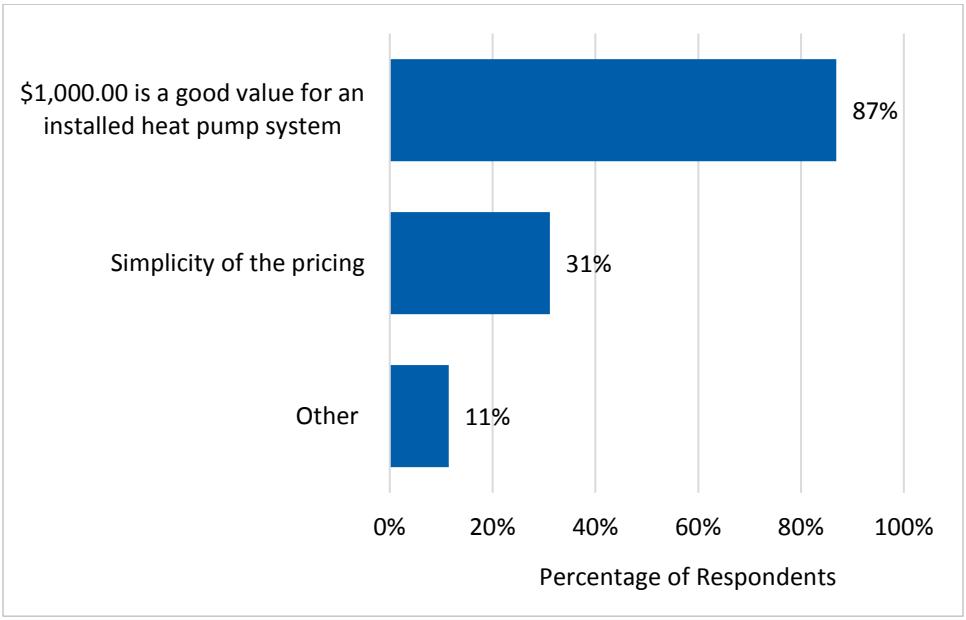
Source: Survey Question C1. "How did you learn about the Energy Trust heat pump study?" (multiple responses allowed; n=61)

Motivations for Participation

About two-thirds of respondents (64%, n=61) thought about buying a heat pump prior to learning about the pilot. Almost all indicated that they did not previously make the purchase because of the cost of buying a new heat pump and having it installed. When asked what they like about the pilot offer, most respondents (87%) said $1,000 is a good value for an installed heat pump, while 31% appreciated the simplicity of the pricing, and 11% discussed the friendliness or reputation of the contractor, the financing offered by contractor, or the brand of the heat pump (see Figure 7).

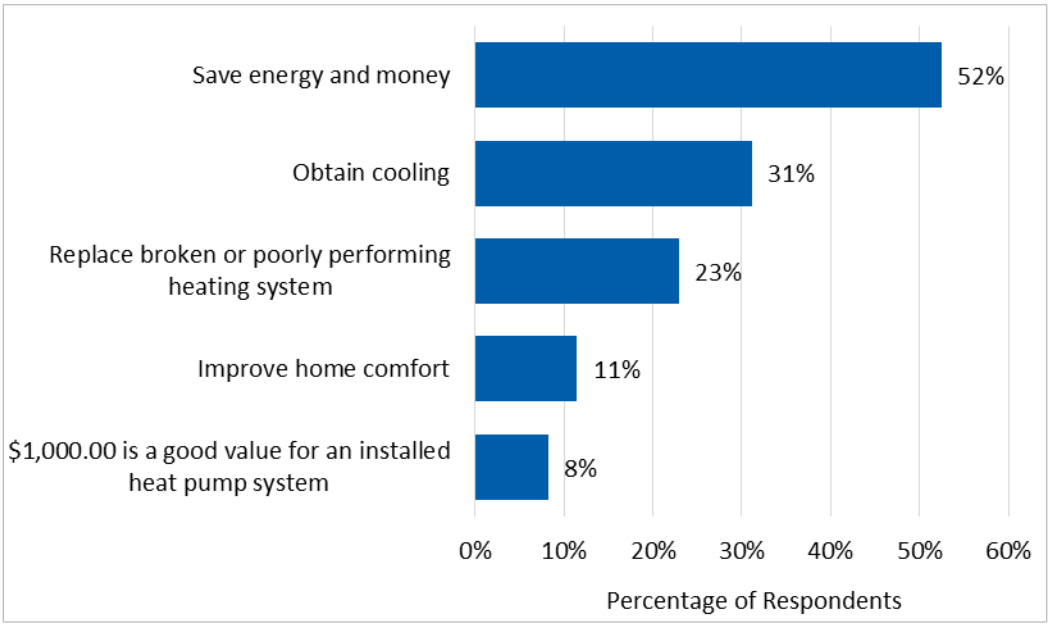
As shown in Figure 8, motivations for participating in the pilot varied among respondents, who most commonly wanted to save energy and money (45%), followed by reasons related to home improvement, including obtaining cooling (31%), replacing a broken or poorly performing system (23%), and improving home comfort (11%).

Figure 7. Best Features of the Heat Pump Offer



Source: Survey Question D4. "The study offered you a new heat pump for a flat fee of $1,000. What did you like about this offer?" (multiple responses allowed; n=61)

Figure 8. Reasons for Participation

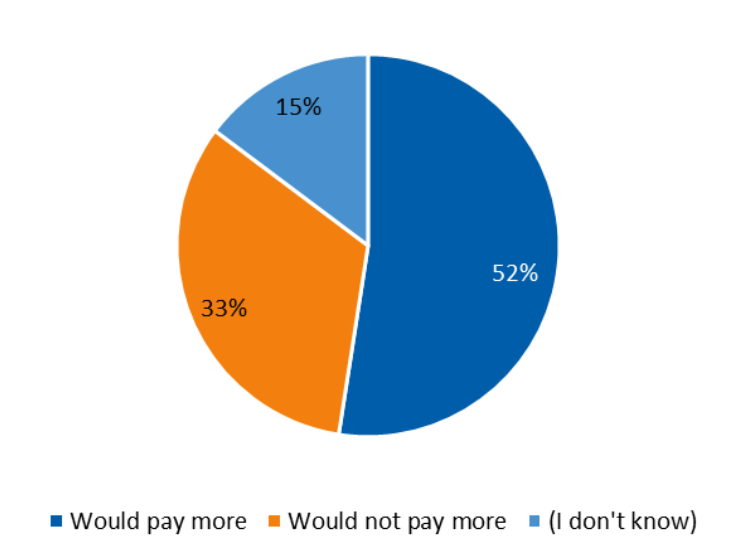


Source: Survey Question D1. "Why were you interested in installing a heat pump system?" (multiple responses allowed; n=61)

Cost of Heat Pump System

Fifty-two percent of respondents (n=61) indicated that they would have paid more than $1,000 to have a new heat pump installed in their home, while 33% said they would not pay more (Figure 8). The remaining 15% of respondents did not know if they would pay more than $1,000 for a new heat pump.

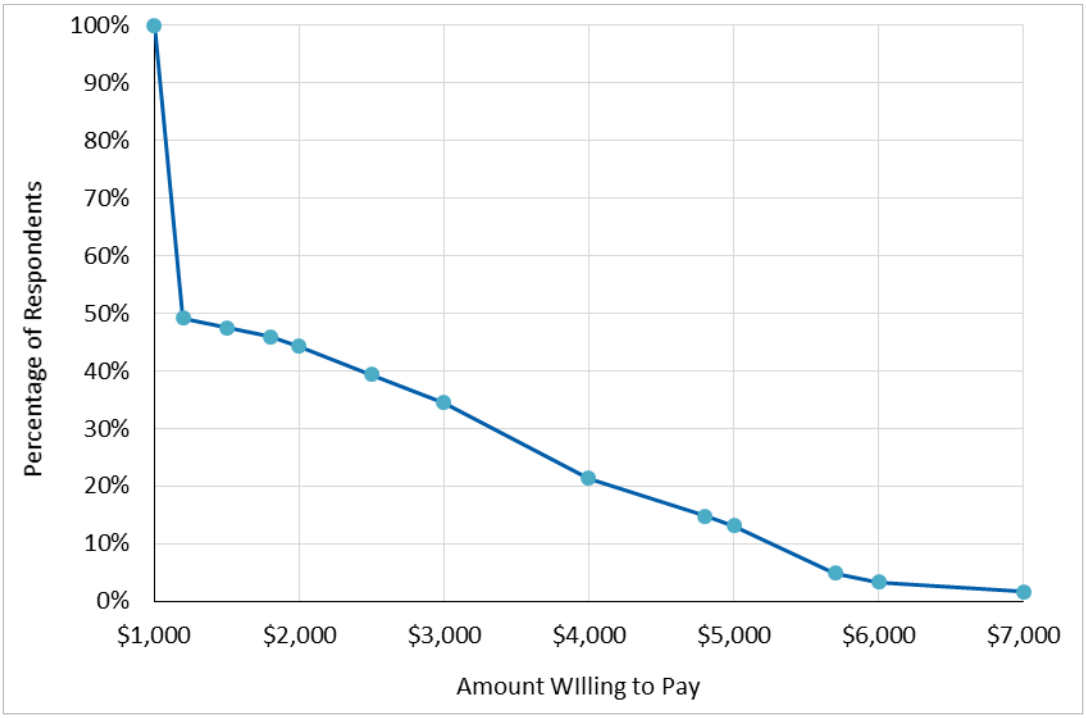
Figure 9. Willingness to Pay More for New Heat Pump



Source: Survey Question D5. "Through this study, you paid $1,000 for the new heat pump and its installation. Would you have purchased the same heat pump if your cost was more than $1,000?" (n=61)

Of the 32 respondents who indicated that they would have paid more than $1,000 to have a new heat pump installed in their home, 30 (49% of the entire survey sample) provided a specific dollar amount they would be willing to pay more than $1,000. Twenty-one respondents (34%) said they would pay a maximum of $3,000 or more; $3,000 was the amount cited most frequently. Figure 10 shows that 100% of the 61 survey participants were willing to pay $1,000 for their heat pump and then plots the maximum dollar amounts over $1,000 that 30 survey respondents said they would be willing to pay.

Figure 10. Surveyed Participants' Maximum Amount Willing to Pay



Source: Survey Question D6. "What is the maximum amount you would have been willing to pay for your new heat pump and its installation? Please answer with a total maximum amount that includes the $1,000 you paid." (n=61)

Income of Survey Respondents

When dividing respondents by their income classification, 38% of verified low-income respondents (six out of 16 respondents), said they would be willing to pay more than $1,000 for a new heat pump, compared to 67% of the not low-income respondents, or twenty out of 30 respondents (see Table 7). These results suggest that Energy Trust could raise prices for households that do not qualify as low income under the Oregon Housing and Community Services' Weatherization Programs Income Guidelines.

Table 7. Willingness to Pay by Income Designation

Low Income Household?	Would Pay More	Would Not Pay More	Don't Know
Verified low income	6	8	2
Possible low income	4	2	1
Not low income	20	6	4
Overall	**30**	**16**	**7**

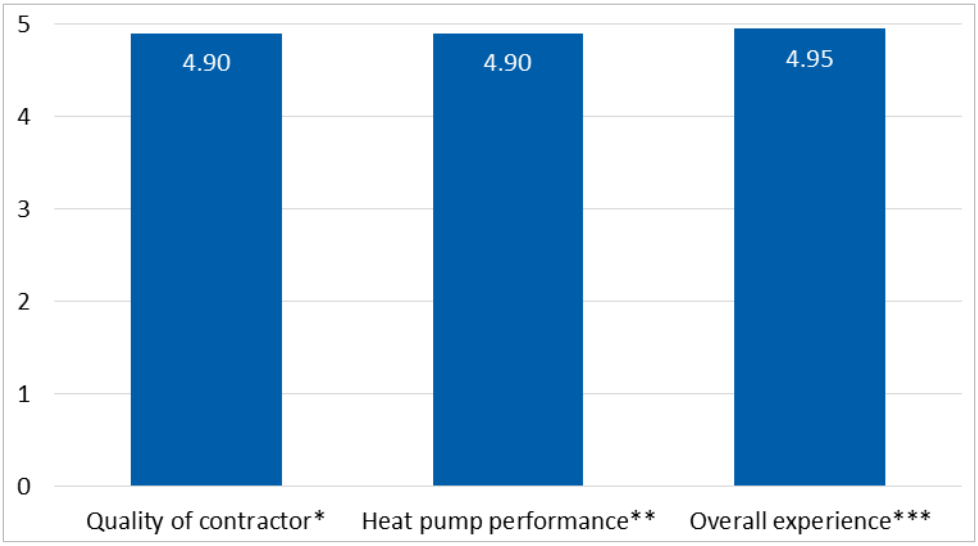
Source: Survey Question D5. "Through this study, you paid $1,000 for the new heat pump and its installation. Would you have purchased the same heat pump if your cost was more than $1,000?" (n=53)

Satisfaction

Almost all of the survey respondents reported satisfaction with all aspects of the pilot (see Figure 11). Ninety-three percent of respondents (n=61) were very satisfied with the service provided by the

contractor who installed their heat pump. On a scale of 1 to 5, where 1 indicates being "not at all satisfied" and 5 indicates being "very satisfied," on average, respondents rated their satisfaction with the contractor's service as a 4.90. Similarly, 92% of respondents (n=60) were very satisfied with the performance of their new heat pump, also providing an average rating of 4.90. When asked about their overall experience—from learning about the pilot through the installation of the heat pump—respondents were very satisfied 97% of the time, and provided an average rating of 4.95.

Figure 11. Participant Satisfaction Ratings



* Source: Survey Question E1. "Please rate your satisfaction with the service provided by the contractor who installed the heat pump on a 5-point scale, where 5 is 'very satisfied' and 1 is 'not at all satisfied.'" (n=61)

** Source: Survey Question F2. "Please rate your satisfaction with the performance of your new heat pump on a 5-point scale, where 5 is 'very satisfied' and 1 is 'not at all satisfied.'" (n=60)

*** Source: Survey Question E3. "Thinking back over the entire experience, from learning about the heat pump offer, paying $1,000 for the heat pump, through the installation of the heat pump, please rate your overall satisfaction with the Energy Trust study on a 5-point scale, where 5 is 'very satisfied' and 1 is 'not at all satisfied.'" (n=60)

Participants said contractors provided "excellent service," citing qualities such as "efficient," "courteous," and "helpful." Participants also appreciated that their contractors kept to the agreed-upon installation schedule. Many participants said their contractor was good at explaining the heat pump offer and could answer questions specific to their manufactured home, giving those participants confidence in the pilot and that the contractor would provide a professional service. Many participants appreciated that the contractor took time to give them information and show them how to use the heat pump. One respondent had a problem with the heat pump three months after the contractor installed it, and the contractor returned and fixed the problem for free.

Only four of 61 survey respondents rated their satisfaction with the contractor as less than very satisfied, giving a rating of 3 or 4. Three of these respondents were all customers of one high-volume

contractor. One respondent said that the contractor broke a water line under their house, another said the contractor rescheduled to an inconvenient time for the customer, and the third said that it took the contractor three days to return and fix a loud noise from the heat pump. The forth respondent, a customer of the other high-volume contractor, was unhappy that the contractor could not decrease the amount of noise from the heat pump.

As stated above, 92% of respondents (n=60) were very satisfied with the performance of their new heat pumps, offering an average rating of 4.90. Those who rated their satisfaction as a 4 or 5 said that their system heats and cools more effectively, their utility bills are lower, the thermostat/controls are easier to use, and that the home is more comfortable overall. Only one respondent rated the performance of their new heat pump as a 3, stating that the new system is loud and the controls are more difficult to operate and use.

When asked if their homes were more comfortable, less comfortable, or if there was no change in comfort, 55 of the 56 respondents said their homes were more comfortable. One participant said, "when you don't have air conditioning and then all of a sudden you have it, you notice the difference." Many respondents said their home is more comfortable because it is now an even temperature so they can use the full space; one participant said "I don't have to hide out in just one room. I can use the whole house now." The one person whose home was less comfortable said, "It just doesn't get warm quickly; you have to prep ahead to have that temperature get there, it is not instant heat. The cooling is great."

As stated above, 97% of respondents were very satisfied with their overall experience—from learning about the pilot through installing the heat pump—and gave an average rating of 4.95. One respondent said "everything with the experience was good, I don't have any complaints." Others cited the lack of extensive paperwork required to participate, with one respondent saying, "I didn't have to do anything except for a couple calls and a few signatures." Others also said the pilot was "straightforward" with "no hidden fees" and "not a ton of paperwork." People also cited the seamless transitions between the paperwork, the contractor, and the inspector.

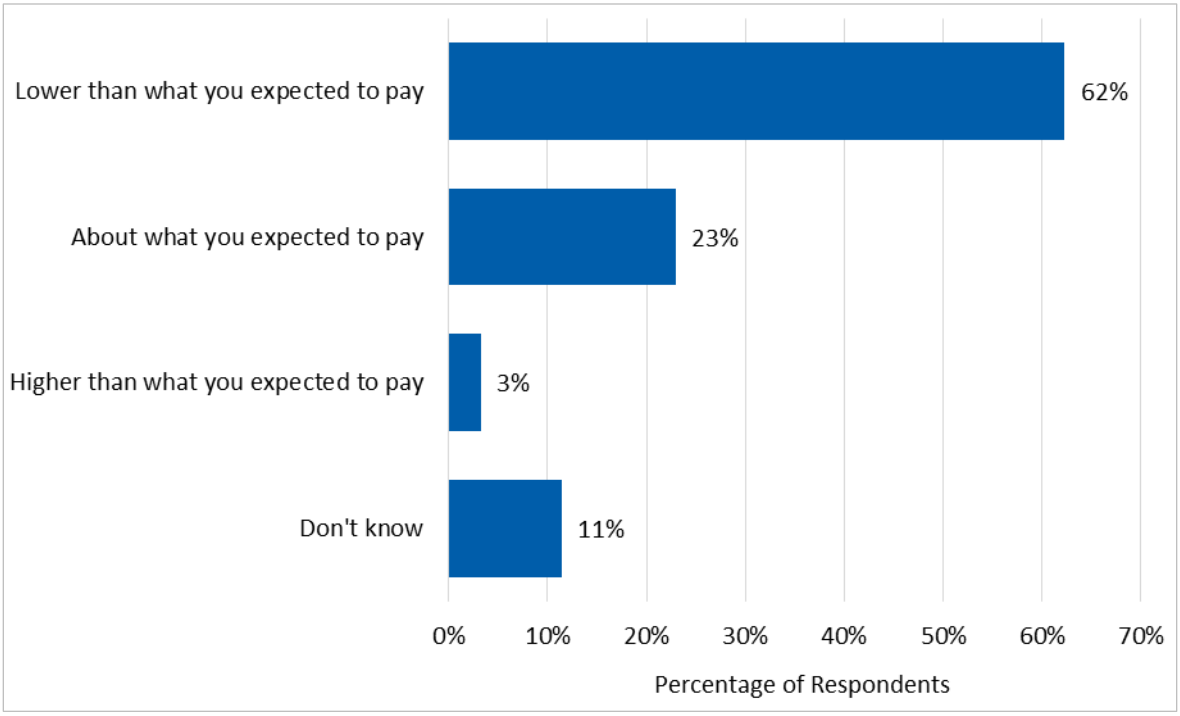
Some participants positively acknowledged that the study focused on their type of home, with one stating, "I think the idea that you're [Energy Trust is] trying to get more economical things going for mobile homes is a very great idea." Another called the study a "unique opportunity" that "doesn't come around all the time." The following respondents commented on the value that the study represents:

- "It [the pilot] enabled us to have something that would have been impossible. We would not have been able to afford it [the heat pump]."
- "I feel like I won the lottery with this study."
- "It's a great program since it saves people money in the short term and in the long run."
- "We were able to get the pump installed at very good price and reduce our electric bill in half."

Utility Bills and Energy-Saving Behaviors

Most respondents (62%) said that their utility bills are lower than they expected, while 23% said their bills are around what they expected. Only 3% (two respondents) said their electricity bills are higher than they expected (Figure 12).

Figure 12. Respondents' Expectations for Electricity Bill

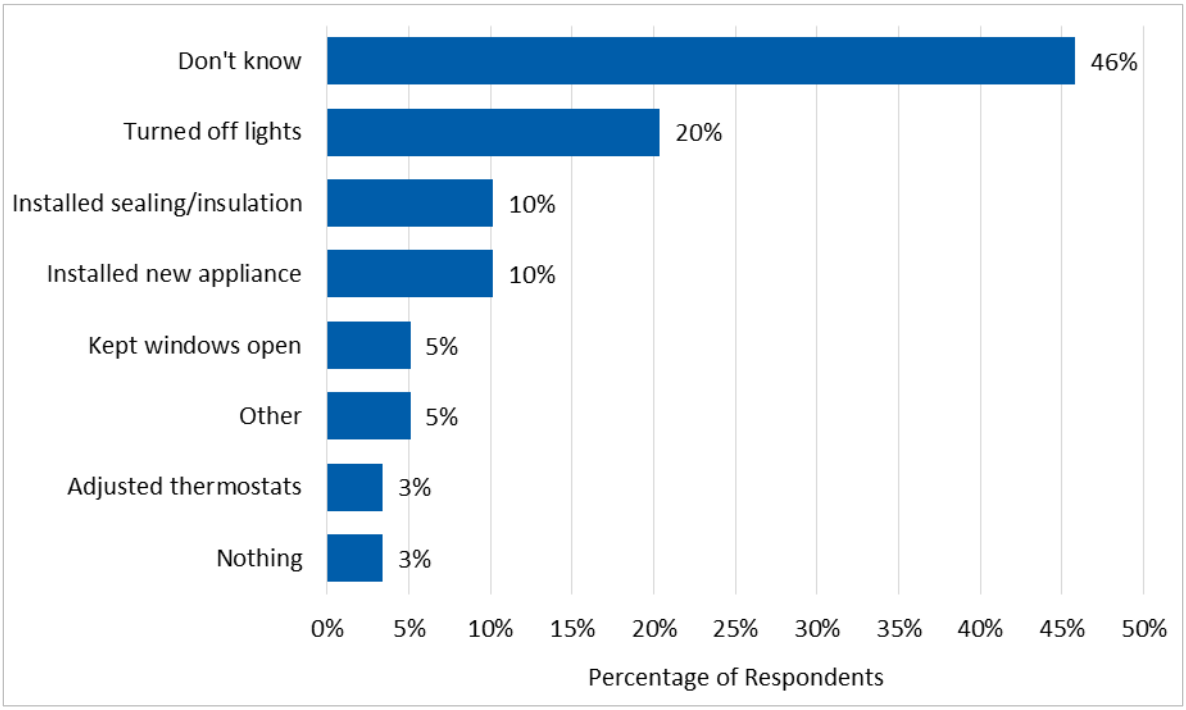


Source: Survey Question F8. "Was your electricity bill…lower than you expected to pay? Higher than you expected to pay? Or about what you expected to pay?" (n=61)

Ninety-five percent of respondents reported that, aside from weather-related differences, no changes occurred that would have caused their energy usage to be higher or lower than in the previous year. Three respondents said they had installed major appliances since the installation of their new heat pump.

Fifty-five percent of respondents said they engaged in additional energy-saving behaviors in the year prior to the survey, most which included turning off lights more frequently when leaving a room, installing new appliances (comprised of purchasing new clothes washers and dryers and replacing incandescent lights with energy-efficient bulbs), and installing insulation and air/duct sealing (Figure 13).

Figure 13. Additional Energy-Savings Behaviors by Respondents



Source: Survey Question G1. "Other than installing a new heat pump, what steps, if any, have you taken in the past 12 months to reduce the amount of energy you use in your home?" (multiple responses allowed; n=61)

Surveyed Participant Pilot Suggestions

Twenty-three of 61 respondents (38%) offered suggestions for the pilot. Among this group, approximately 39% suggested that Energy Trust publicize the pilot more through increased advertising. About 17% of respondents recommended that Energy Trust further lower the cost of heat pumps installed through the pilot. Other recommendations included reporting savings to participants, offering the pilot for a longer period of time and to a larger demographic, opening up the pilot to more utilities, and prioritizing elderly and low-income participants.

Remote QA Subpilot Findings

Cadmus interviewed PMC staff about the remote QA subpilot, which used data from Nest thermostats to verify that contractors properly installed heat pumps through the Existing Manufactured Homes Heat Pump pilot and to identify units that performed relatively poorly (i.e., a high auxiliary heat ratio). This section describes findings from the PMC memorandums to Energy Trust and Cadmus' interviews with key PMC staff members.

Background

Most pilot installations included a Honeywell or Carrier thermostat. The PMC paid contractors to install (at no charge to the customer) Nest thermostats[13] in up to 20 homes. Customers eligible for the Nest thermostat had to have Wi-Fi internet and an e-mail address in addition to meeting the qualification criteria for the pilot.

According to documentation provided by the PMC, contractors installed 20 thermostats, but one thermostat was not connected to the internet, yielding no useful data. Nest staff examined the thermostat settings, auxiliary heat runtimes, and compressor runtimes of 19 heat pumps operating between September 1, 2016, and December 31, 2016. In January 2017, Nest reported to the PMC that six thermostats were initially not set to the control settings prescribed by the pilot (heat pump balance set to max savings). Furthermore, their analysis detected two incorrectly installed heat pumps. The PMC notified the installing contractor, who corrected the errors.

Nest also provided the PMC with the auxiliary heat ratio (hours of auxiliary heat use divided by the hours of compressor use) for these systems.[14] Using this information, the PMC selected nine sites for further in-person investigations, including three sites with the highest auxiliary heat ratios and six sites without remotely detected issues. While on site, the PMC conducted the following tests/measurements:

- Blower door to help confirm sizing guidelines and overall heat loss
- Duct leakage testing to determine if duct leakage rates fell within expected ranges
- Temperature gain across the coil to calculate as-found capacity
- Configuration of thermostat settings
- Air-flow testing to calculate as-found capacity
- Heating capacity calculation to calculate actual capacity compared to nominal capacity

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[13] A Nest smart thermostat collects data and programs itself after observing the user's temperature-setting and energy-using behavior for one week. More information is available online: https://nest.com/thermostats/nest-learning-thermostat/overview

[14] Nest found the majority (15) of thermostats used auxiliary heat less than 5% of the time, and of those, seven used no auxiliary heat at all. The PMC indicated this was "a significant success for the pilot."

- Adherence to sizing guidelines
- Refrigerant charge checks to detect leakage

The PMC found the three sites with the highest auxiliary heat ratios (9%, 14%, and 49%) had less-than-ideal thermostat settings:

- At the site with a 9% auxiliary heat ratio, the thermostat was set to maximum comfort rather than maximum savings, and the PMC found very low system capacity (likely due to low airflow).
- At the site with a 14% auxiliary heat ratio, the thermostat was correctly set to maximum savings mode, but the homeowner used deep setbacks.[15] The PMC concluded that an opportunity exists for customer education in such cases.
- At the site with a 49% auxiliary heat ratio, the PMC found the compressor locked out at 35˚F and below, which turned the heat pump into an electric furnace (operating on the strip heat) any time the outdoor temperature fell below 35˚F. Despite a follow-up visit from the contractor, the error persisted. The PMC staff fixed this issue during the on-site inspection and noted the thermostat was commissioned incorrectly.

Of the nine inspected sites, four were not set to the pilot-prescribed setting of "heat pump balance set to max savings." The PMC concluded the Nest thermostat proved a useful tool in finding incorrectly commissioned thermostats immediately after installation and for monitoring performance long-term (via the auxiliary heat ratio). Based on this experience, the PMC provided several recommendations to Energy Trust regarding Wi-Fi-connected thermostats used for remote QA in heat pump installations:

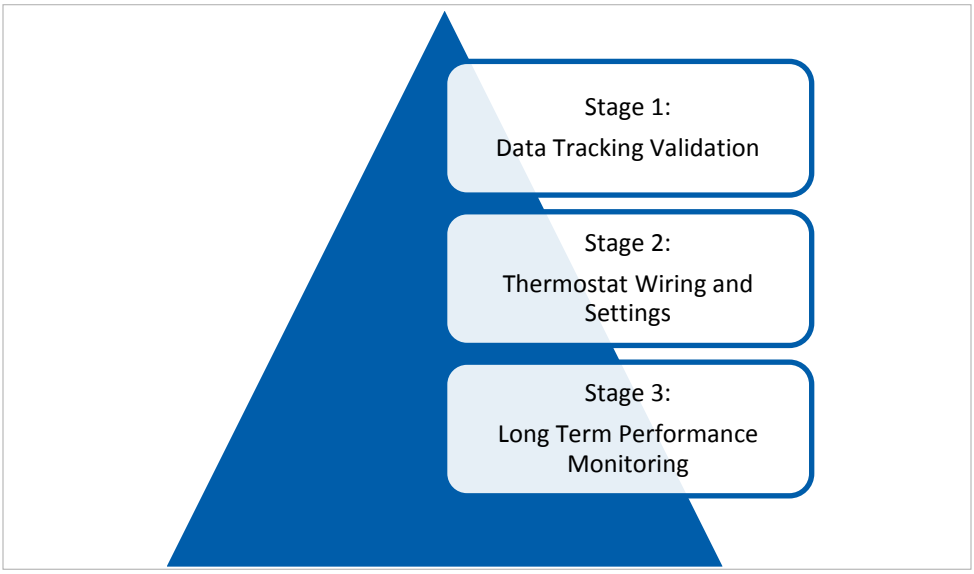
- Require immediate reporting from thermostat manufacturers to verify thermostats are commissioned correctly (control of auxiliary heat and compressor).
- Request the thermostat manufacturer report on auxiliary heat and compressor usage after the first heating season, enabling the PMC to target QC visits for sites with high auxiliary heat usage.
- Work with manufacturers to enable auto-correction of any incorrectly commissioned thermostats remotely.
- Pre-approve system sizing to ensure contractors follow sizing guidelines.
- Explore whether fans in certain homes should be replaced to improve air flow and, thus, capacity.
- Explore using the auxiliary heat and compressor run times to estimate overall efficiency and energy consumption compared to modeled results.

[15] Using deep nighttime setbacks on a heat pump system may cause the thermostat to call for auxiliary heat in the morning in order to quickly reach the desired temperature. Without such a deep setback, it is possible a comfortable temperature could have been maintained throughout the night using just the heat supplied by the compressor.

Multiple Stages of QA

Figure 13 illustrates how the remote QA process occurred in multiple stages.

Figure 14. Remote QA Stages



Initially, the PMC found four thermostat serial numbers were recorded in their database incorrectly. The serial numbers were associated with products located in areas outside of Oregon, enabling the PMC to go back to the contractor and obtain the correct numbers.

The second stage of remote QA involved the PMC working with the manufacturer to detect if thermostats were set up correctly and to take actions to alert installation contractors about any deficiencies. Typical thermostats can lock out auxiliary heat at a given ambient temperature (such as 35°F), whereas Nest thermostats can lock out based on balance point management, optimized for savings or comfort, with the balance point adjusted based on heat pump performance and weather, thus avoiding a hard lockout at a prescribed temperature. For the Nest sub-pilot, the PMC can determine whether contractors are using the hard lockout approach or the pilot preferred setting of balance point max savings.

The PMC attributed the contractors' incorrect Nest settings to the learning curve associated with working with new technology ("neither contractor that installed Nest was intimately familiar" with the thermostat) as well as a reluctance to lock out auxiliary heating to avoid being called back to a customer's home due to comfort complaints ("the worst thing in a contractor's life is being called back for a visit they won't get paid for").

PMC staff said, "Being able to do 100% QC [quality control] is incredible." A typical on-site QC process would sample only 5% to 10% of total installations, and the low detection rate meant contractors could have an incentive to make "more money doing it wrong than doing it right." Furthermore, the typical QC process doesn't look at thermostat settings and the aux heat ratio, and only verifies the make/model

were recorded correctly, which the PMC says are not the things that most influence savings. The remote QA process allowed the program to better target known or probable issues within the subpilot sample. Additionally, because the PMC can perform remote QA immediately after installation, it can identify incorrect installations quickly and reinforce contractor training on how to correctly commission thermostats.

The third remote QA stage derives from Nest's analysis of long-term heat pump performance via the auxiliary heat ratio. Theoretically, if the first two remote QA stages are effective, the third stage can be used to detect issues related to manual overrides of thermostat settings or system problems such as low air flow.

Working with Thermostat Manufacturers

The PMC attributed the subpilot's success to its good, long-standing relationship with Nest, which enabled them to conduct the remote QA and obtain data on pilot installations. The PMC indicated that supporting such a pilot going forward would require an "upfront investment in relationship-building with manufacturers" to set up data exports and to construct algorithms to identify outliers. Otherwise, the remote QA process itself costs "next to nothing." Expanding remote QA to other thermostat brands include requiring a data-sharing agreement or requiring homeowners to provide access to online data.

Limitations on Remote QA

Limitations for deploying remote QA likely result from market acceptance of smart thermostats and heat pump systems that use proprietary thermostats. PMC staff said not all homes are well-suited for Nest thermostats because they lack wireless internet, the customer prefers a simpler or manual thermostat, or for other reasons. Furthermore, some higher-end heat pump systems use proprietary thermostats and are manufactured by large HVAC corporations that might not be as amenable to sharing data.

Billing Analysis Results

This section presents evaluated savings for the Manufactured Homes Heat Pump pilot in absolute and percentage terms. Further, we report realization rates of the evaluated savings compared to the pilot planning (and reported) estimates of savings.

Energy Savings—Pilot-Level

Participants achieved a 21% reduction in overall electric usage; an average of 3,269 kWh per year. With pilot reported savings averaging 4,367 kWh, this translates to a 75% realization rate. Table 9 shows the evaluated electric savings and compares changes in energy consumption from the pre- to post-pilot periods for the participant and nonparticipant groups. These results included Pre-installation weather-Normalized Annual Consumption (Pre-NAC) to characterize average energy consumption of the participant and comparison groups prior to pilot treatment.

Table 8 and all subsequent savings results tables include adjusted gross savings, which Cadmus calculated based on the percentage of savings. Additionally, considering pilot impacts in terms of savings as a percentage of Pre-NAC provides a helpful metric for comparing and assessing the magnitude of pilot impacts.

Table 8. Overall Pilot-Level Savings

Group	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision of Savings at 90% Confidence Level	Savings as % of Pre-NAC	
			Evaluated	Reported			Evaluated	Reported
Comparison	105	15,171	-834	n/a	n/a	±39%	-6%	n/a
Participant	78	15,825	2,398	4,367	55%	±14%	15%	28%
Adj. Gross Savings			**3,269**	**4,367**	**75%**	**±14%**	**21%**	**28%**

Figure 15 shows the distribution of savings for participants and nonparticipants. Nonparticipants increased their usage, on average, leading to a positive adjustment to participants' average savings.

Figure 15. Percent Savings Distribution

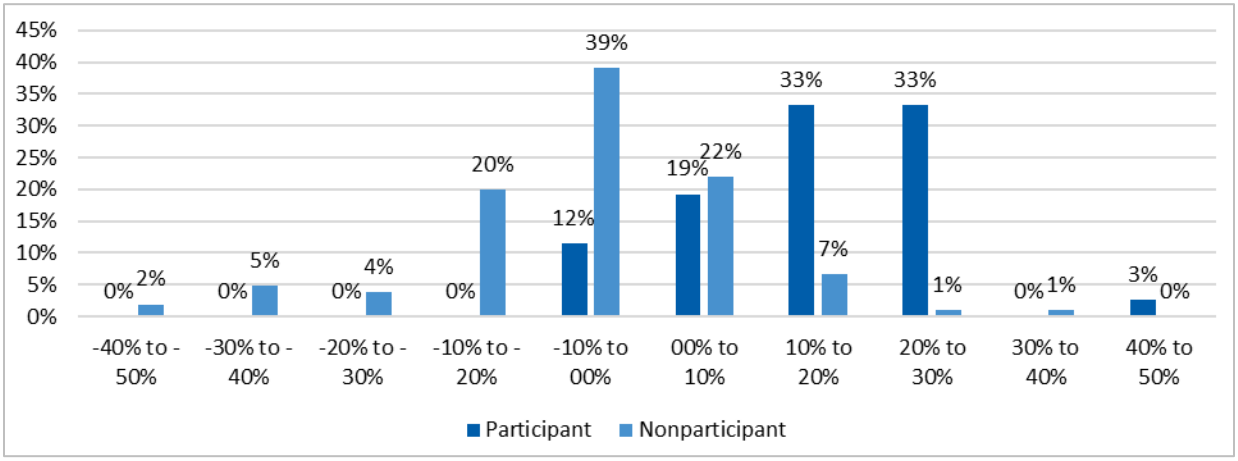


Table 9 summarizes the changes in base load and weather-sensitive (heating + cooling) energy consumption from the pre- to post-pilot periods.[16]

Table 9. Overall Pilot-Level Savings (Weather Sensitive and Base Load)

Group	n	Base Load Usage	Base Load Change*	Base Load Change as % of Pre-Base Load Use	Weather Sensitive Usage	Change in Weather Sensitive Use*	Change in Weather Sensitive Use as % of Pre-Weather Sensitive Use	Relative Precision of Weather Sensitive Savings at 90%
Comparison	105	9,035	233	3%	6,136	-1,067	-17%	±34%
Participant	78	8,759	-640	-7%	7,066	3,038	43%	±14%
Adj. Gross Savings	**78**	**8,759**	**-866**	**-10%**	**7,066**	**4,267**	**60%**	**±13%**

*pre-usage minus post usage

Model results show that participants increased base loads by 866 kWh, or about 10%, while simultaneously reducing weather-sensitive loads. This could have resulted from an increase in fan usage from the heat pump or possibly an increase in cooling usage, new appliances, or plug loads. PRISM models, however, do not always accurately disaggregate the base, heating, and cooling loads. The weather-sensitive savings equal 4,267 kWh, or about 60% of the entire weather-sensitive usage of 7,066

[16] Heating usage accounts for 96% of the weather sensitive usage, and cooling load accounts for 4% of the weather sensitive usage.

kWh. Though the weather-sensitive savings equal 98% of the 4,367 kWh reported savings, the increase in participants' base load usage accounts for the lower realization rate of 78%.[17]

Energy Savings—Utility/Climate Zone Level

The following tables summarize savings at the utility level (i.e., for Pacific Power and PGE). In this pilot, Pacific Power customers correspond to heating zone 2 and PGE customers to heating zone 1.

Table 10 shows that Energy Trust Manufactured Homes Heat Pump pilot participants in PGE/zone 1 achieved a 20% reduction in electric usage, saving an average of 3,077 kWh per year. With reported savings of 4,202 kWh, this translates to a 73% realization rate. Participants in Pacific Power/zone 2 achieved a 21% reduction in electric usage, saving an average of 3,447 kWh per year. With reported savings of 4,559 kWh, this translates to a 76% realization rate.

Table 10. Savings by Climate Zone

Group	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision of Savings at 90%	Savings % of Pre-NAC	
			Evaluated	Reported			Evaluated	Reported
Heating Zone 1								
Comparison	54	14,365	-478	n/a	n/a	±84%	-3%	n/a
Participant	42	15,247	2,570	4,202	61%	±19%	17%	28%
Adj. Gross Savings			**3,077**	**4,202**	**73%**	**±21%**	**20%**	**28%**
Heating Zone 2								
Comparison	51	16,024	-1,212	n/a	n/a	±41%	-8%	n/a
Participant	36	16,500	2,199	4,559	48%	±21%	13%	28%
Adj. Gross Savings			**3,447**	**4,559**	**76%**	**±20%**	**21%**	**28%**

Table 11 summarizes changes in base load and weather-sensitive (heating + cooling) energy consumption from the pre- to post-pilot periods for zone 1 and zone 2. The models show that participants in PGE/zone 1 increased their base load by 710 kWh or about 8%. This may have resulted from an increase in fan usage from the heat pump or possibly an increase in cooling usage, other new loads, or model error in the disaggregation of energy use. The weather-sensitive savings equal 3,799 kWh or about 58% of the entire weather-sensitive usage of 6,598 kWh. Though weather-sensitive savings equal 90% of the 4,202 kWh reported savings, the increase in participants' base load usage leads to the lower realization rate of 73%.

[17] This is calculated as (4,267-866)/4,367=78%. The difference between this calculation and the overall calculation is that we applied a percent change adjustment to both the base load and the weather-sensitive usage, instead of just the overall change in usage as in Table 8 that produces a 75% realization rate.

Participants in Pacific Power/zone 2 increased their base load by 996 kWh or about 11%, on average. This could have resulted from an increase in fan usage from the heat pump or possibly even an increase in cooling usage. The weather-sensitive savings equal 4,650 kWh or about 61% of the entire weather-sensitive usage of 7,611 kWh. Though the weather-sensitive savings equal 102% of the 4,559 kWh reported savings, the increase in participants' base load usage leads to the lower realization rate of 76%.

Table 11. Changes in Weather Sensitive and Base Load by Climate Zone

Group	n	Base Load Usage	Base Load Change	Base Load Change as % of Pre-Base Load Use	Weather Sensitive Usage	Change in Weather Sensitive Use	Change in Weather Sensitive Use as % of Pre-Weather Sensitive Use	Relative Precision of Weather Sensitive Savings at 90%
Heating Zone 1								
Comparison	54	8,894	-243	-3%	5,471	-235	-4%	±191%
Participant	42	8,649	-946	-11%	6,598	3,515	53%	±16%
Adj. Gross Savings	**42**	**8,649**	**-710**	**-8%**	**6,598**	**3,799**	**58%**	**±19%**
Heating Zone 2								
Comparison	51	9,184	736	8%	6,840	-1,948	-28%	±26%
Participant	36	8,888	-283	-3%	7,611	2,482	33%	±24%
Adj. Gross Savings	**36**	**8,888**	**-996**	**-11%**	**7,611**	**4,650**	**61%**	**±17%**

Energy Savings – Pre-Usage Quartile Level

The following two tables summarize savings for four pre-period usage quartiles. Table 12 shows participants achieved 20% to 23% reductions in electric usage by pre-usage quartiles.

Table 12. Pre-Usage Quartile Savings

Group	Pre-Usage Quartile	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision of Savings at 90%	Savings as % of Pre-NAC	
				Evaluated	Reported			Evaluated	Reported
Comparison	1	37	11,249	-457	n/a	n/a	±93%	-4%	n/a
	2	27	14,199	-1,072	n/a	n/a	±57%	-8%	n/a
	3	14	16,459	-1,454	n/a	n/a	±73%	-9%	n/a
	4	27	20,848	-793	n/a	n/a	±93%	-4%	n/a
Participant	1	20	10,893	1,919	4,345	44%	±26%	18%	40%
	2	19	14,178	1,717	4,296	40%	±41%	12%	30%
	3	19	16,472	2,332	4,446	52%	±22%	14%	27%
	4	20	21,707	3,588	4,381	82%	±21%	17%	20%
Adj. Gross Savings	**1**	**20**	**10,893**	**2,362**	**4,345**	**54%**	**±28%**	**22%**	**40%**
	2	**19**	**14,178**	**2,787**	**4,296**	**65%**	**±33%**	**20%**	**30%**
	3	**19**	**16,472**	**3,786**	**4,446**	**85%**	**±31%**	**23%**	**27%**
	4	**20**	**21,707**	**4,413**	**4,381**	**101%**	**±24%**	**20%**	**20%**

Savings by quartile increased from 2,362 kWh in quartile 1 to 4,413 kWh in quartile 4. With reported savings ranging from 4,300 kWh to 4,450 kWh, the lowest quartile achieved a 54% realization rate while the highest quartile achieved a 101% realization rate. In the lowest quartile, the average reported savings of 4,345 kWh is 40% of the entire pre-period usage, which appears to be overstated.

Table 13 summarizes savings by pre-period usage quartiles through changes in base load and weather-sensitive (heating + cooling) energy consumption from the pre- to post-pilot periods for the participants and the nonparticipant groups. Pilot participants in the four pre-period usage quartiles increased their base loads between 337 kWh and 1,635 kWh or about 7% to 18%. This may have resulted from an increase in fan usage from the heat pump or possibly an increase in cooling usage, other new loads, or model error in the disaggregation of energy use. The weather-sensitive savings range from 2,707 kWh (or about 47% of the entire weather-sensitive usage in quartile 1) to 5,604 kWh (or 64% of the entire weather-sensitive usage in quartile 4).

Table 13. Pre-Usage Quartile Savings (Weather Sensitive and Base Load)

Group	Pre-Usage Quartile	n	Base Load Usage	Base Load Change	Base Load Change as % of Pre-Base Load Use	Weather Sensitive Usage	Change in Weather Sensitive Use	Change in Weather Sensitive Use as % of Pre-Weather Sensitive Use	Relative Precision of Weather Sensitive Savings at 90%
Comparison	1	37	6,548	-339	-5%	4,702	-118	-3%	±333%
	2	27	8,378	37	0%	5,821	-1,109	-19%	±63%
	3	14	9,060	961	11%	7,399	-2,414	-33%	±41%
	4	27	13,087	835	6%	7,761	-1,628	-21%	±54%
Participant	1	20	5,123	-642	-13%	5,770	2,562	44%	±30%
	2	19	7,799	-1,116	-14%	6,379	2,834	44%	±31%
	3	19	9,200	-659	-7%	7,272	2,991	41%	±31%
	4	20	12,890	-166	-1%	8,818	3,754	43%	±26%
Adj. Gross Savings	**1**	**36**	**5,123**	**-377**	**-7%**	**5,770**	**2,707**	**47%**	**±32%**
	2	**36**	**7,799**	**-1,151**	**-15%**	**6,379**	**4,049**	**63%**	**±23%**
	3	**36**	**9,200**	**-1,635**	**-18%**	**7,272**	**5,364**	**74%**	**±25%**
	4	**36**	**12,890**	**-989**	**-8%**	**8,818**	**5,604**	**64%**	**±24%**

Additional subgroup comparisons can be found in Appendix D. Billing Analysis: Additional Subgroup Comparisons.

Conclusions and Recommendations

The pilot was successful. The pilot exceeded its initial goal of 100 participants. Surveyed participants reported they were very satisfied with the quality of the contractors' work, heat pump performance, and overall pilot experience. Additionally, surveyed participants and contractors reported high satisfaction with the simplicity of the fixed-cost offer, minimal paperwork, and ease of participation. Overall, the pilot effectively balanced various program design considerations (e.g., system performance, retrofit feasibility, overall and upfront costs, the number of participating contractors).

- **Recommendation:** If cost-effective, roll out the pilot as a full-scale program offering.

Pilot staff effectively selected, listened to, and worked with contractors. Through a request for proposals (RFP) process, PMC staff used contractors' feedback to fine-tune the pilot design and selected four contractors to deliver the pilot, two of whom drove the majority of participation. These two contractors' success arose from their familiarity with the target sector and from effective marketing. Participants said their contractors' knowledge influenced their decisions to sign up for the pilot. Furthermore, the pilot's timing (during one contractor's slow season) allowed that contractor to focus on the pilot-sponsored installations. The less successful contractors (i.e., only completed a few installations) lacked effective marketing and were less engaged because they did not think the pilot would be profitable enough.

- **Recommendation:** This program design can succeed with fewer but more engaged contractors. If Energy Trust expands the pilot, it should seek contractors with experience in the target market and a strong marketing plan. Encourage contractors to minimize costs through bulk purchases from suppliers. Energy Trust could also assist with lead generation to keep contractors' costs low by identifying potential customers previously served through its programs and by coordinating with other agencies that may have provided weatherization services to this market.
- **Recommendation:** Contractors said they preferred to install ductless heat pump systems because they are higher efficiency and have lower upfront costs. Investigate whether ducted or ductless heat pumps better fit the existing manufactured homes market.

The pilot effectively attracted the intended market. The fixed-price offer achieved rapid uptake by eligible customers, who tended to have slightly lower household incomes than the general population of Oregon. Targeting manufactured homes, however, did not result in significantly higher participation

rates among low-income households[18] (as discussed in Appendix A); the percentage of participating low-income households was similar to the State of Oregon's general low-income population.

- **Recommendation:** To target low-income participants, work with agencies that provide low-income weatherization assistance. These agencies serve income-verified customers with well-sealed homes.

Participants may be willing to accept a slightly higher fixed price. Over half of the surveyed participants said they would pay more for the heat pump installed through the pilot, particularly those who were above the low-income threshold. However, two contractors said that increasing the price would dramatically reduce the participation rate, while a third contractor (who had high participation) said customers could easily accommodate a $1,000 increase. One of the contractors who said increasing the price would reduce the participation rate also ran into difficulties collecting the full participant fee from multiple customers.

- **Recommendation:** If Energy Trust reduces the incentive amount in a scaled-up program, keep the $1,000 fixed-fee offer for low-income customers and consider a fee between $1,000 and $2,000 for customers with higher incomes.
- **Recommendation:** Require contractors to have a plan to independently resolve nonpayment situations, and encourage them to collect participation fees up front and use an eligibility checklist.

Pilot participants realized significant energy savings in comparison to nonparticipants. Pilot participants realized 75% of expected savings (3,269 kWh of the expected 4,367 annual kWh). Part of these savings resulted from increased consumption in the comparison group during the post-retrofit period (834 kWh), which increased the adjusted participant savings. As a percentage of pre-installation usage, savings remained relatively constant (20% to 23%) across climate zones and pre-usage quartiles. Absolute savings appeared to be somewhat higher for heating zone 2 and for homes with higher pre-pilot energy use, as expected.

The subpilot found remote QA to be a valuable program tool. The subpilot demonstrated that the PMC could use Wi-Fi thermostats in multiple ways to conduct program QA: to validate the thermostat serial number; to confirm correct configuration and installation of thermostats; and to conduct long-term performance monitoring. The remote QA process allowed the PMC to detect and correct (or investigate) issues during each project stage.

- **Recommendation:** Incorporate remote QA using Wi-Fi thermostats into future heat pump programs, where feasible. Ensure that program staff can access the data and that the thermostat vendor remains engaged and aligned with the program's vision.

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[18] Oregon Housing and Community Services. "Weatherization Programs Income Guidelines." https://www.oregon.gov/ohcs/Pages/weatherization-oregon-income-guidelines.aspx

Appendix A. Mapping of Survey Respondents to Income Demographics

Cadmus mapped survey respondents to Oregon's Weatherization Programs Income Guidelines to determine whether each respondent qualifies as low income. We compared self-reported household income and the number of occupants to income guidelines provided by the Oregon Housing and Community Services, shown in Table 14.

Table 14. Income Guidelines for Oregon, Effective July 1, 2016

Household Unit Size	Annual Income	Monthly Income
1	$23,760	$1,980
2	$32,040	$2,670
3	$40,320	$3,360
4	$48,600	$4,050
5	$56,880	$4,740
6	$65,160	$5,430
7	$73,460	$6,121.67
8	$81,780	$6,815
9	$90,100	$7,508.33
10	$98,420	$8,201.67
11	$106,740	$8,895
12	$115,060	$9,588.33
each additional member	$8,320	$693.33

Source: U.S. Department of Energy. *Poverty Income Guidelines by Family Size.* 200% of Federal Poverty Level by Household Size. For use in Federal Fiscal Year 2016

Cadmus confirmed that 16 survey respondents qualified as a low-income household, and 38 respondents did not qualify (see Table 15). The State of Oregon's income guidelines are set at discrete thresholds, whereas survey respondents reported their annual household income within ranges (e.g., $30,000 to $39,999). Therefore, Cadmus could not verify the low-income status of four respondents (8%). The total respondent count equals 53 because eight participants did not report their income.

Table 15. Low-Income Survey Respondents

Low-Income Household?	Count	Percentage
Yes	16	30%
Maybe	7	13%
No	30	57%
Total	**53**	**100%**

Appendix B. Interview Guides and Survey Instruments

This report's accompanying volume presents the following interview guides and survey instruments:

- Participant survey instrument
- Contractor interview guide
- Stakeholder interview guides

CADMUS

Energy Trust of Oregon
Evaluation of Existing Manufactured Homes Heat Pump Pilot
Participant Survey

Researchable Questions	Section
Program Awareness: To understand effectiveness of marketing and recruitment efforts.	C
Motivators: To assess reasons why the household participated in the pilot and assess the appeal of the fixed-price offer/incentive structure.	D
Satisfaction: To understand customers' satisfaction with the installation contractor and the heat pump offer. .	E
Satisfaction with Heat pump: To assess satisfaction with performance of heat pump, to assess comfort of home, to ask for observation of electricity bill savings and to verify thermostat settings	F
Energy-saving behaviors: To measure changes in energy-saving behavior because of the installation.	G
Experience with other income-qualified programs: To understand experience with other programs serving XMH residents.	H
Demographics: To gather customers' demographic and home characteristics.	I

Sample Methodology: The participant survey will be conducted via telephone. Cadmus will provide a list of all customers who were eligible[1] for the heat pump offer and participated. We will attempt to contact all 100+ customer pilot participants in order to reach 70 completes. We will attempt to contact each telephone record up to five times.

Target Quota = [70 completes]

Customer	Target Quota	Survey Target
Participants	70	All eligible

General Instructions

- Interviewer instructions are in green **[LIKE THIS]**.
- CATI programming instructions are in red **[LIKE THIS]**.
- Items that should not be read by the interviewer are in parentheses like this ( ).
- **[THANK AND TERMINATE TEXT]** Thank you. Those are all my questions. We appreciate you taking our call. Have a good day.

[1] To be eligible, the home must be manufactured from 1982 or after, with primary heat supplied by electric resistance forced air furnace, and receiving service from Pacific Power or Portland General Electric. Participant must have lived in their home for at least a year prior to installation and planning to stay for at least a year after installation.

Variables to be Pulled into Survey

- Customer name
- Telephone number
- Contractor
- Community Action Agency
- Installation month and year
- Participant address (site address, city, state, zip)

Participant County	Community Action Agency
Washington	Community Action
Crook, Deschutes, Jefferson	NeighborImpact
Klamath/Lake	Klamath/Lake Community Action Services
Clackamas	Clackamas County Social Services
Multnomah	Multnomah County Department of Human Services

General survey notes:

- All sections are asked during both Phase I and Phase II surveys except for the sections where it is marked to only ask the questions in Phase I or in Phase II.

A. Introduction

A1. Hello, I'm **[INSERT NAME]** calling from VuPoint Research on behalf of Energy Trust of Oregon. I'm not selling anything. Energy Trust is actively seeking your feedback and opinions about a heat pump that was installed in your home. You probably recently received a letter about this survey. May I speak with **[CUSTOMER NAME]**?

1. Yes
2. No, person is not able to come to phone **[GET NAME AND PHONE NUMBER, SCHEDULE CALL BACK]**

98. (Don't know) **[ASK TO SPEAK WITH SOMEONE WHO KNOWS AND BEGIN AGAIN]**
99. (Refused) **[THANK AND TERMINATE]**

[SCHEDULING SCRIPT]
[IF RESPONDENT IS NOT AVAILABLE: "We would like to call back when 'you are' OR 'he or she is' available. What is the best time to call back?" Is this the best phone number to reach you/he/she on when we try back?" **TRY TO GET SPECIFIC TIME AND DATE. IF RESPONDENT IS UNSURE, PROVIDE A POSSIBLE DATE AND WORK FROM THERE.** "I'll plan to call back tomorrow at about 6 pm PST. Does that time work for you?"]

A2. Are you currently talking to me on a regular landline phone or a cell phone?

1. (Landline phone)
2. (Cell phone)
98. (Don't know)
99. (Refused)

A3. **[ASK IF A2=2]** Are you currently in a place where you can talk safely and answer my questions?

1. (Yes)
2. (No, schedule callback)
3. (No, do not call back) **[THANK AND TERMINATE]**
98. (Don't know) **[SCHEDULE CALLBACK]**
99. (Refused) **[THANK AND TERMINATE]**

B. Screeners

Everyone answers the questions in this section. These questions ensure we are speaking to the person in the household who is the most familiar with participation in the pilot.

As part of an Energy Trust pilot study of heat pumps in manufactured homes, **[CONTRACTOR]** installed a heat pump system for a flat fee of $1000. Do you recall having a heat pump installed within the past year?

1. Yes
2. No **[THANK AND TERMINATE]**
98. Don't know **[ASK TO SPEAK WITH SOMEONE WHO WOULD KNOW AND START AGAIN AT A1. IF NO ONE, THEN THANK AND TERMINATE]**
99. Refused **[THANK AND TERMINATE]**

Great, we'd like to ask you some questions about the heat pump installation and performance. You will receive a $10 Visa gift card for completing this survey. This call may be monitored or recorded for quality assurance purposes.

BACK-UP INFORMATION, NOT TO BE PROGRAMMED:

1. **[IF RESPONDENT ASKS HOW LONG, SAY: "APPROXIMATELY 10 TO 15 MINUTES."]**
2. **[IF NEEDED, STATE "THIS SURVEY IS FOR RESEARCH PURPOSES ONLY AND THIS IS NOT A MARKETING CALL. THIS IS THE PRIMARY WAY FOR CUSTOMERS TO PROVIDE INPUT INTO THE REBATE PROGRAMS ENERGY TRUST OF OREGON OFFERS. YOUR PERSPECTIVES HELP ENERGY TRUST OREGON DECIDE ABOUT THEIR ENERGY-EFFICIENCY PROGRAM OFFERINGS."]**
3. **[ONLY IF ASKED FOR AN ENERGY TRUST OF OREGON CONTACT TO VERIFY THE SURVEY AUTHENTICITY, OFFER DAN RUBADO 503.459.4069]**

C. Program Awareness

This section is used to understand how the customer found out about the heat pump installation offer from Energy Trust of Oregon and assess the effectiveness of the marketing and recruitment efforts.

C1. How did you learn about the Energy Trust heat pump study? **[DO NOT READ LIST; RECORD MULTIPLE RESPONSES]**?

1. (From **[CONTRACTOR NAME]**)
2. (Word of mouth (from neighbor or friend))
3. (Park Manager)
4. (Print material (from a flyer or mailer))
5. (Other) **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**

98. (Don't know)
99. (Refused)

D. Motivators

This section is used to assess reasons why the household participated in the pilot and the appeal of paying a fixed price of $1000 for a heat pump.

D1. And why were you interested in installing a heat pump system? **[MULTIPLE RESPONSES ACCEPTED] [DO NOT READ LIST]**

1. (Save energy and money)
2. (Improve home comfort)
3. (Replace broken or poorly performing heating system)
4. (Obtain cooling)
5. (Installation through a trusted contractor)
6. ($1,000 is a good value for an installed heat pump system)
7. (Offer through Energy Trust of Oregon)
8. (Other) **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**

98. (Don't know)
99. (Refused)

D2. Before you learned about Energy Trust's heat pump study, were you thinking of buying a heat pump? **[SINGLE RESPONSE]**

1. (Yes)
2. (No)

98. (Don't know)
99. (Refused)

D3. **[ASK IF D2=1]** What prevented you from purchasing the heat pump at that time?

1. **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**
98. Don't know
99. Refused

D4. The study, offered you a new heat pump for a flat fee of $1,000. What did you like about this offer? **[MULTIPLE RESPONSES ACCEPTED] [DO NOT READ LIST]**

1. (Simplicity of the pricing)
2. ($1,000 is a good value for an installed heat pump system)
3. (Contractor offered financing for the $1,000 upfront fee)
4. (Other) **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**
98. (Don't know)
99. (Refused)

D5. Through this study, you paid $1,000 for the new heat pump and its installation. Would you have purchased the same heat pump if your cost was more than $1,000?

1. (Yes)
2. (No)
98. (Don't know)
99. (Refused)

D6. **[IF D5=1]** What is the maximum amount you would have been willing to pay for your new heat pump and its installation? Please answer with a total maximum amount that includes the $1,000 you paid.

[RECORD NUMERIC RESPONSE OVER $1,000] DK = 97 REFUSED = 98

E. Satisfaction

This section is used to assess the participant's satisfaction with their contractor and the heat pump offer.

Now, I'd like to ask you some questions about your satisfaction with the study.

E1. Please rate your satisfaction with the service provided by the contractor who installed the heat pump on a 5-point scale, where 5 is very satisfied and 1 is not at all satisfied. **[DO NOT READ, RECORD RESPONSE]:**

1. Not at all satisfied
2.
3.
4.
5. Very satisfied
98. (Don't know)
99. (Refused)

E2. [ASK IF E1 = 1,2,3,4,5]Why did you rate your satisfaction with the service provided by the contractor as a **[INSERT ANSWER FROM E1]**? **[OPEN-ENDED RESPONSE]**
[RECORD RESPONSE: _____]

E3. Thinking back over the entire experience, from learning about the heat pump offer, paying $1,000 for the heat pump, through the installation of the heat pump, please rate your overall satisfaction with the Energy Trust study on a 5-point scale, where 5 is very satisfied and 1 is not at all satisfied. **[READ LIST]**

1. Not at all satisfied
2.
3.
4.
5. Very satisfied

98. (Don't know)
99. (Refused)

E4. [ASK IF E3 = 1,2,3,4,5]Why did you rate your satisfaction with the Energy Trust heat pump study as a **[INSERT ANSWER FROM E3]**? **[OPEN-ENDED RESPONSE]**
[RECORD RESPONSE: _____]

E5. What suggestions, if any, do you have for improving the offer or the participation experience?

1. **(NONE)**
2. **[RECORD RESPONSE] [OPEN-ENDED RESPONSE]**

F. Satisfaction with Heat Pump Performance

This section is used to assess the participant's satisfaction with their new heat pump system. In this section we will also gather observed electricity bill savings.

The next questions are to find out about your satisfaction with the performance of your new heat pump system.

F1. Your heat pump was installed in **[INSTALLATION MONTH+ YEAR],** since then, have you used your new heat pump for **[READ LIST]:**

1. Heating
2. Cooling
3. Both heating and cooling, or
4. Neither **[PROBE: SO JUST TO CLARIFY, YOU HAVEN'T USED YOUR NEW HEAT PUMP SINCE IT WAS INSTALLED?]**

[CONTINUE IF F1=1, 2, OR 3; IF F1=4 THEN SKIP TO ENERGY SAVING BEHAVIORS] [IF F1=4 THEN SAY "SINCE YOU HAVEN'T USED YOUR HEAT PUMP YET WE WILL CALL YOU BACK NEXT YEAR TO ASK YOU A FEW QUESTIONS ABOUT THE EQUIPMENT"]

F2. Please rate your satisfaction with the performance of your new heat pump on a 5-point scale, where 5 is very satisfied and 1 is not at all satisfied? **[DO NOT READ, RECORD RESPONSE]**

1. Not at all satisfied
2.
3.
4.
5. Very satisfied
98. (Don't know)
99. (Refused)

[IF F2=4 OR 5 THEN CONTINUE TO F3; IF F2=1, 2 OR 3 THEN SKIP TO F4; IF F2=98 OR 99 THEN SKIP TO F5]

F3. Why is that? **[DO NOT READ LIST, RECORD UP TO THREE RESPONSES]**

1. (The system functions correctly)
2. (My utility bill is lower)
3. (My home is more comfortable)
4. (My maintenance/repair costs are lower)
5. (The system heats/cools more effectively than the previous system)
6. (The system is quieter than the previous system)
7. (The thermostat/controls are easier to operate and use)
8. (The system conditions the air better than the previous system (e.g. dehumidification))
9. (Other) **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**
98. (Don't know)
99. (Refused)

F4. Why is that? **[DO NOT READ LIST, RECORD UP TO THREE RESPONSES]**

1. (The system has not been functioning correctly/has had issues)
2. (My utility bill is higher)
3. (My home is less comfortable)
4. (My maintenance/repair costs are higher)
5. (The system heats/cools less effectively than the previous system)
6. (The system is louder than the previous system)
7. (The thermostat/controls are more difficult to operate and use)
8. (The system conditions the air worse than the previous system (e.g. dehumidification))
9. (Other) **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**

98. (Don't know)
99. (Refused)

F5. Since the installation of the new heat pump, has your home become… **[READ OPTIONS 1,2,3 ONLY]**

1. More comfortable,
2. Less comfortable, or
3. There was no change in comfort?

98. (Don't know)
99. (Refused)

F6. **[IF F5=1 OR 2]** Why do you say it has become **[INSERT RESPONSE FROM F5]**? **[OPEN-ENDED RESPONSE]**
[RECORD RESPONSE: _____]

F7. Have you paid an electricity bill since the heat pump was installed? **[SINGLE RESPONSE]**

1. (Yes)
2. (No)

98. (Don't know)
99. (Refused)

F8. **[IF F7=1]** Was your electricity bill…

1. Lower than what you expected to pay?
2. Higher than what you expected to pay?
3. Or about what you expected to pay?

98. (Don't know)
99. (Refused)

G. Energy-Saving Behaviors

G1. Other than installing a new heat pump, what steps, if any, have you taken in the past 12 months to reduce the amount of energy you use in your home? **[MULTIPLE RESPONSE]** **[DO NOT READ LIST]**

1. (Installed new appliance **[SPECIFY]**)
2. (Turned off lights)
3. (Took shorter or fewer showers)
4. (Washed clothes in cold water)
5. (Adjusted thermostats)
6. (Unplug devices when not in use)
7. (Hang clothes on clothesline)
8. (Other) **[OPEN-ENDED RESPONSE]** **[RECORD RESPONSE]**

98. (Don't know)
99. (Refused)

G2. Since your new heat pump was installed, were any large appliances or equipment installed in your home that require additional electricity usage?

1. (Yes) **[SPECIFY APPLIANCES OR EQUIPMENT]** **[OPEN-ENDED RESPONSE]** **[RECORD RESPONSE]**

98. (Don't know)
99. (Refused)

G3. Other than weather, were there any other changes that occurred since your heat pump was installed that would cause your energy usage to be higher or lower than the previous year?

1. (Yes, higher, please describe) **[OPEN-ENDED RESPONSE]** **[RECORD RESPONSE]**
2. (Yes, lower, please describe) **[OPEN-ENDED RESPONSE]** **[RECORD RESPONSE]**
3. (No)

98. (Don't know)
99. (Refused)

H. Experience with other Income-Qualified Programs

This section is used to understand the customers experience with other income-qualified programs.

H1. Do you know of any organizations in your area that offer assistance to help you save energy or use renewable energy at home? IF YES: Which ones? **INTERVIEWER: DO NOT READ.[MULTIPLE RESPONSE]**

1. (No) **[EXCLUSIVE]**
2. (Energy Trust of Oregon)
3. (PGE or Portland General Electric)
4. (Pacific Power or PacifiCorp)
5. (Northwest Natural)
6. (Cascade Natural Gas)
7. (Community Action)
8. (NeighborImpact)
9. (Klamath/Lake Community Action Services)
10. (Clackamas County Social Services)
11. (Multnomah County Department of Human Services)
12. (Other, please specify) **[OPEN-ENDED RESPONSE]** **[RECORD RESPONSE]**
98. (Don't know) **[EXCLUSIVE]**
99. (Refused) **[EXCLUSIVE]**

H2. Do you know about or have you ever worked with your local community action agency called **[COMMUNITY ACTION AGENCY]**?

1. (Yes, aware of but never worked with)
2. (Yes, worked with them in the past)
3. (No, not aware of this agency)
98. (Don’t know)
99. (Refused)

I. Demographics

I1. Is your home a… **.[SINGLE RESPONSE]** **[THIS QUESTION IS HERE SO WE CAN CHECK PROJECT TRACKING DATA]READ LIST**

1. Single-wide
2. Double-wide
3. Triple-wide
4. Other, please specify: **[OPEN-ENDED RESPONSE]** **[RECORD RESPONSE]**
98. Don't know
99. Refused

I2. Do you have wireless internet in your home? **.[SINGLE RESPONSE]** **[THIS QUESTION WILL HELP US UNDERSTAND HOW MANY OF THE PARTICIPANTS COULD HAVE NEST THERMOSTATS]**

1. (Yes)
2. (No)
98. (Don't Know)
99. (Refused)

I3. How long have you lived in your home? **[INTERVIEWER: DO NOT READ ITEMS, PROBE TO CODE.][SINGLE RESPONSE]**

1. (Less than a year)
2. (1-2 years)
3. (3-5 years)
4. (6-10 years)
5. (More than 10 years)

I4. How many months of the year is your home occupied? **INTERVIEWER: DO NOT READ ITEMS, PROBE TO CODE.**

00	Less than one month
01	1 month
02	2 months
03	3 months
04	4 months
05	5 months
06	6 months
07	7 months
08	8 months
09	9 months
10	10 months
11	11 months
12	All year round (or 12 months of the year)

I5. Including yourself, how many people normally live in your household on a full-time basis? Please exclude anyone who is just visiting, or away at college or in the military. Include all members of your household whether or not they are related to you.

1. **[ENTER NUMERIC RESPONSE]**
98. Don't Know
99. Refused

I6. Has the number of people living in your household changed in the last year? **INTERVIEWER: DO NOT READ ITEMS, PROBE TO CODE.**

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

I7. **[IF I6=2**] Has the number of people living in your house…

1. Increased? By how many? **[RECORD NUMERIC RESPONSE: _____]**
2. Decreased? By how many? **[RECORD NUMERIC RESPONSE: _____]**

I8. What is the last grade or level of school you have completed? **INTERVIEWER: DO NOT READ ITEMS, PROBE TO CODE. [SINGLE RESPONSE]**

1. (Less than high school degree)
2. (High school graduate)
3. (Some college – but less than two years of college)
4. (Some college – two years or more/AA degree)
5. (Technical or trade school)
6. (College graduate/Bachelor's degree, BA, BS)
7. (Postgraduate courses)
8. (Master's degree)
9. (MBA or Law degree)
10. (PhD or MD)
11. (Other, please specify) **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**
98. (Don't know)
99. (Refused)

I9. Which of the following describes your household income in 2015? **INTERVIEWER: READ ITEMS [SINGLE RESPONSE]**

1. Less than $50,000
2. $50,000 to under $100,000
3. $100,000 or more
98. (Don't know)
99. (Refused)

I10. **[ASK IF I9=1]** Is it? **INTERVIEWER: READ ITEMS. [SINGLE RESPONSE]**

1. Less than $20,000
2. $20,000 to under $30,000
3. $30,000 to under $40,000
4. $40,000 to under $50,000
98. (Don't know)
99. (Refused)

I11. **[ASK IF I9=2]** Is it? **INTERVIEWER: READ ITEMS. [SINGLE RESPONSE]**

1. $50,000 to under $60,000
2. $60,000 to under $75,000
3. $75,000 to under $100,000
98. (Don't know)
99. (Refused)

I12. **[ASK IF I9=3]** Is it**: INTERVIEWER: READ ITEMS. [SINGLE RESPONSE]**

1. $100,000 to under $150,000
2. $150,000 to under $200,000
3. Over $200,000
98. (Don't know)
99. (Refused)

I13. Which of the following ethnic groups best describes you? Are you: **INTERVIEWER: READ ITEMS. [SINGLE RESPONSE]**

1. White or Caucasian
2. Black or African American
3. Latino, Hispanic, or Mexican
4. Asian or Pacific Islander
5. Native American
6. Mixed Race
7. Something else **[PLEASE SPECIFY] [OPEN-ENDED RESPONSE]**
98. (Don’t Know)
99. (Refused)

I14. Is English the primary language spoken in your household? **[SINGLE RESPONSE]**

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

I15. **[ASK IF I14=2]** What is the primary language used in your household? **INTERVIEWER: DO NOT READ ITEMS, PROBE TO CODE. [SINGLE RESPONSE]**

1. (Spanish)
2. (German)
3. (Chinese)
4. (Korean)
5. (Vietnamese)
6. (Tagalog)
7. (Russian)
8. (Japanese)
9. (Other, please specify) **[OPEN-ENDED RESPONSE] [RECORD RESPONSE]**

98. (Don't know)
99. (Refused)

I16. Lastly, I need to confirm your address so that I may send you a $10 Visa gift card. Is your correct address, **[ADDRESS]?**

1. Yes
2. No, **[ENTER CORRECT ADDRESS**: _____]

Thank you for taking the survey. We appreciate your time. Have a nice day!

CADMUS

Energy Trust of Oregon
Evaluation of Existing Manufactured Homes Heat Pump Pilot
May 2016

Respondent name: _____

Respondent phone: _____

Interview date: _____ Interviewer name: _____

Audience: Installation Contractors

Purpose: Document contractor's motivations and experiences. Compile nonparticipant contact list.

These in-depth interviews will be conducted by Cadmus staff in person or by telephone. Interviews will be scheduled in advance via email. The interview will take 30-45 minutes.

Table 1 outlines the installation contractors we plan to interview and their codes.

Table 1. List of Interviewees

Category	N	Name	Company	Interviewee Code	Services Provided
Contractors	4	XXX	XXX	Con1	**RES + COMM:** ducted HP, ductless HP, gas furnace (ducting, ventilation, thermostat w/ sensor)
		XXX	XXX	Con2	**RES:** ductless HP, furnace, air handler, geothermal heating, infrared space heater, high-efficiency small ductwork, high-velocity heating (air cleaner, UV germicidal light, de/humidifier, duct cleaning, thermostat w/ sensors)
		XXX	XXX	Con3	**RES:** ductless HP, limited-length ducted HP (duct sealing, air sealing/insulation, water heating systems, HPwES audits)
		XXX	XXX	Con4	**RES + COMM:** gas furnace, ductless HP, mini split system, indoor HP (air purifier, humidifier, thermostat, tune-ups)

Table 2 that identifies which contractors members outlined in Table 1 we will ask each set of questions.

Table 2. List of Interview Key Questions Mapped to Interview Section and Interviewee Code

Pilot Research Objectives	Interview Section	Interviewee Code
Assess contractor motivations and experiences	Section A	Con1, Con2, Con3, Con4
Determine barriers for nonparticipants	Section B	Con1, Con2, Con3, Con4
Marketing-specific questions	Section C	Con1, Con2
Firmographics	Section D	Con1, Con2, Con3, Con4

CADMUS

Thank you for making the time to speak with me. The Cadmus Group is an independent third-party evaluator that is interviewing contractors about Energy Trust's manufactured home heat pump pilot. Your input is an important part of our evaluation. We'd like to hear about your experience with the pilot and working with customers living in manufactured homes.

A. Contractor Motivations and Experiences

A1. How did you learn about the RFP?

A2. Why did your firm participate in the pilot? [IF NECESSARY: Which components of the pilot most appealed to your firm?]

A3. How did [OPTION A-E] contribute to your success in the pilot? [PROBE: GATHER DETAILS ABOUT EACH TOPIC BELOW.]

a) Simple flat fee structure [PROBE IF NEEDED: WAS THIS EASY TO UNDERSTAND FOR THE CUSTOMER?]
b) Cost of the system for participants
c) Offering financing
d) Your marketing efforts
e) Backing by Energy Trust (a trusted name)

A4. Did participating in the pilot impose any restrictions that made recruitment and installation more costly than usual?

A5. You were asked to quote fixed prices for different sized systems and to ensure per-unit costs included installation. [IF NECESSARY: Energy Trust and the homeowner would not pay more for a difficult installation or less for an easy installation.]

a) How did the costs specified in the price schedule compare to the actual costs of installation? [PROBE: Did the average installation cost more or less than you expected?]
b) Was the $1,000 flat fee paid by homeowners adequate, too high, or too low? Why?
    i. How many of your [NUMBER OF CUSTOMERS] customers do you think would have paid more?
    ii. [IF A5b-i > 0] How much more do you think they would have paid?
c) If the homeowner were asked to pay more than $1,000, how many fewer units do you think you would have sold?

A6. The equipment specification was changed between the first and second rounds of the RFP process. Which changes, if any, affected your costs of installation?

a) How/why did this change(s) affect your costs?

A7. Did you offer financing to customers?

a) [IF YES] What type of financing?
b) [IF YES] How many customers used it?

A8. How did you explain the pilot offer to potential customers? [IF NECESSARY: Did you explain to your customers the long-term cost and energy savings associated with an efficient heat pump?]

a) Did you show them any type of payback analysis?

A9. How did your profitability during the pilot compare to the profitability of your typical installations?
   a) Did the pilot's fixed-price model work better or worse for you than operating independently?
   b) [ONLY ASK CON1, CON2] In order to participate in this pilot, did you have to make a tradeoff between project volume and profitability?

A10. Outside of this pilot, in what kinds of situations would you recommend a ducted heat pump over a ductless heat pump, or vice versa, for a manufactured home that already has a decent duct system?

A11. During the pilot, how did you decide which size of backup strip heat to install?
   a) How about size of heat pump?
   b) How, if at all, did this decision during the pilot differ from how you typically decide outside the pilot?

A12. [ONLY ASK CON1, CON2] As part of sub-pilot, your company also installed Nest thermostats, what were the reactions of customers to the Nest thermostat?
   a) What feedback did you receive regarding participants experience with the Nest thermostat?

A13. How was your experience with Energy Trust's quality assurance process?

A14. Would you want to participate in a similar program offering in the future if this pilot becomes an ongoing incentive targeting manufactured homes? Why or why not?

A15. What, if anything, would you do differently during the pilot if it became an ongoing program offering?

A16. Overall, how satisfied were you with the pilot [PROBE IF NEEDED: VERY SATISFIED, SOMEWHAT SATISFIED, NOT TOO SATISFIED, NOT SATISFIED AT ALL], and why?

B. Barriers for Nonparticipants

B1. How did you recruit customers?
   a) How effective was your recruitment strategy?
   b) What difficulties, if any, did you face when recruiting customers?

B2. What characteristics, if any, did you notice that made a customer more or less likely to accept the offer? [PROBE: CUSTOMER CHARACTERISTICS INCLUDE HOMEOWNER OR PROPERTY OWNER, HOME VINTAGE, HOME TYPE (SINGLE-WIDE, DOUBLE-WIDE, TRIPLE-WIDE), HOME SQUARE FOOTAGE, HEATING OR COOLING SYSTEM (SIZE OF ELECTRIC FURNANCE OR IF THERE IS AN AC UNIT PRESENT), HOME LOCATION.]

B3. Why were homeowners typically disqualified from participation?
   a) How often did you encounter this?

B4. Did any homeowners qualify for the pilot but choose not to participate?
   a) [IF YES] Why do you think they chose not to participate?
   b) We would like to survey these homeowners on why they declined the offer. Can you help put us in touch with them?

C. Marketing [ONLY CON1, CON2]

Your work to actively market the pilot was a main factor in its rapid uptake.

C1. What is your experience with the manufactured homes market?
   a) In terms of energy use and efficiency, what makes the manufactured homes market different from site-built homes?

C2. What kind of marketing and outreach did you do to promote the pilot?
   a) What method(s) were most/least successful?

C3. Have you used these marketing tactics in the past with manufactured home owners?

C4. What marketing strategies do you use that work especially well with the manufactured homes market?
   a) To promote sales, do you leverage the heat pump's ability to heat AND cool? [PROBE: How is the AC positioned? Find out if it is part of the sales conversation.]

D. Firmographics

D1. How many employees work at your firm?

D2. In what year was your firm founded?

D3. How many installations of ducted heat pumps would you say you complete each year?
   a) What fraction of those would you say take place in manufactured homes?

D4. Have you worked with the community action agency [COMMUNITY ACTION AGENCY]?

Participant County	Community Action Agency
Clackamas	Clackamas County Social Services
Crook, Deschutes, Jefferson	NeighborImpact
Klamath/Lake	Klamath/Lake Community Action Services
Multnomah	Multnomah County Department of Human Services
Washington	Community Action

E. Wrap Up

E1. Before we wrap up, do you have any additional feedback or anything else you would like to share regarding the pilot that we didn't cover?

E2. [IF B5b = YES] Can you please share with us the contact information of nonparticipants? We'd prefer phone numbers so we can conduct a phone survey. [DISCUSS HOW WE WILL OBTAIN THE CONTACT DETAILS FROM THE CONTRACTOR]

E3. If I have any questions as I review my notes, what is the best way to follow-up with you?

We appreciate your time. Have a nice day!

CADMUS

Energy Trust of Oregon
Evaluation of Existing Manufactured Homes Heat Pump Pilot
May 2016

Respondent name: _____

Respondent phone: _____

Interview date: _____ Interviewer name: _____

Audience: Energy Trust and Program Management Contractor (PMC)

Purpose: Document pilot implementation, results, successes, challenges and lessons learned.

These in-depth interviews will be conducted by Cadmus staff in person or by telephone. Interviews will be scheduled in advance via email. The interview will take 45 minutes to an hour. Interviews will be conducted in groups where appropriate.

Table 1 outlines the key staff we plan to interview and their codes:

Table 1. List of Interviewees

Category	Name	Role/Company	Interviewee Code
Energy Trust Program Staff	Marshall Johnson	Energy Trust Sponsor	ET1
	Andrew Shepard	Energy Trust Oversight	ET2
PMC Staff	Bruce Manclark	CLEAResult Technical Advisor	PMC1
	Lucinda Gilman	CLEAResult Project Manager	PMC2

Table 2 identifies which key staff members outlined in Table 2 we will ask each set of questions.

Table 2. List of Staff Interview Key Questions Mapped to Objective and Interviewee Code

Pilot Research Objectives	Interview Section	Interviewee Code
Document pilot implementation, results, successes, and lessons learned	Section A	ET1, ET2, PMC1, PMC2
Assess participant and nonparticipant motivations and experiences	Section B	ET1, ET2, PMC1, PMC2
Assess contractor motivations and experiences	Section C	ET1, ET2, PMC1, PMC2
Assess the usefulness of remote QA using Nest data	Section D	PMC1, PMC2

As part of the evaluation of the manufactured home heat pump pilot, Cadmus is conducting in-depth interviews with Energy Trust program administration staff and PMC implementation staff. The purpose of these interviews is to document decisions made during pilot design and implementation, what worked well, and areas where there were challenges. Cadmus developed the following questions after reviewing the implementation plan, project forms, and other pilot documents.

A. Pilot Implementation, Results, Successes, and Lessons Learned

A1. First, tell me about Energy Trust's interest in targeting the manufactured homes sector. What were your objectives in targeting this sector? Why? [PROBE QUESTIONS, ONLY ASK IF NEEDED: HOW DO YOU KNOW THIS TARGET MARKET IS UNDERDEVELOPED? WHAT MAKES THE SECTOR UNIQUE?]

A2. What is the program's strategy for increasing ducted and ductless heat pumps in this market? For manufactured homes with decent duct systems, in what situations is one preferable to the other?

A3. The goal was to install ducted heat pumps in up to 110 manufactured homes with electric forced-air furnaces. Eligible participants included those that received services from Energy Trust in the past and live in Portland metro area, Bend and Southern Oregon.

a) How was the eligibility criteria of manufactured home vintage (1982 or newer) determined? [PROBE IF NEEDED: How did the 1994 HUD code update impact this decision?]

A4. Installations moved very quickly. The majority of heat pumps were sold in December and installed in January and February. What do you think the following factors account for the rapid uptake of the offer? [PROBE TO GATHER DETAILS ABOUT EACH TOPIC BELOW.]

a) Cost of the system for participants?
b) Marketing of pilot by installation contractor?
c) Quality of installation contractor?
d) Comfort needs of participants/pent up demand?

A5. Which aspects of the pilot were successful?

a) [PROBE AS NEEDED] Why do you say that?

A6. And what aspects have been most challenging? What were the main lessons learned?

a) [PROBE AS NEEDED] Why do you say that?

A7. To what extent do you believe this approach could increase saturation of heat pumps in manufactured homes market?

A8. What have you considered as further/alternative ways to incentivize contractors to sell and manufactured homeowners to buy heat pumps?

A9. Changes were made to pilot marketing plans. Did Energy Trust send out letters to potential customers or was the outreach done by contractors only? How did these changes affect customer awareness of the pilot?

A10. A couple changes were made to the contractor RFP process.

a) How did the changes that were made to the equipment specifications affect the pilot, including cost to Energy Trust and estimated savings?
b) In the first round of bids the homeowner was going to pay a fixed fee of $500, which was then raised to $1,000. How did this change affect the pilot, including cost to Energy Trust and estimated savings?

A11. Were any other changes made to the pilot?
   a) [IF YES] What were the changes?
   b) [IF YES] Why did you make those changes?

A12. What, if anything, would you do differently if this pilot becomes an ongoing program offering?
   a) What would need to happen for this pilot to become an ongoing part of Energy Trust's existing homes program?

B. Assess Participant and Nonparticipant Motivations and Experiences

B1. Why did the program decide to go with a flat rate fee structure for this pilot and how was the homeowner fixed-price amount of $1,000 determined?

B2. What feedback did you receive about the participant experience and their motivations for participating (either directly from participants or from contractors)?

B3. Did you find any differences in program participation by customer characteristics? PROBE: CUSTOMER CHARACTERISTICS INCLUDE HOMEOWNER OR PROPERTY OWNER, HOME VINTAGE, HOME TYPE (SINGLE-WIDE, DOUBLE-WIDE, TRIPLE-WIDE), HOME SQUARE FOOTAGE, HEATING OR COOLING SYSTEM (SIZE OF ELECTRIC FURNANCE OR IF THERE IS AN AC UNIT PRESENT), HOME LOCATION

B4. Regarding nonparticipants (those eligible for the pilot but declined to participate), what were the most common reasons for not participating?

B5. What were the most common reasons for disqualification?

B6. What, if anything, would you change about the fixed price offer to customers if this becomes an ongoing offering?

C. Assess Contractor Motivations and Experiences

C1. How did the pilot distribute the RFP to contractors? (was it a short list or the entire Energy Trust HVAC Trade Ally List?)
   a) Did you have any difficulty recruiting installation contractors and getting them to participate in the pilot?
   b) [IF YES] What if any feedback did you receive from them about barriers to participation?

C2. What feedback did you receive from contractors about their satisfaction with the pilot?
   a) Did contractors request additional information or support?

C3. Contractors were asked to quote fixed prices for different sized systems and to make sure costs included all installation costs (i.e. Energy Trust and the homeowner would not pay more for a difficult installation or less for an easy installation)
   a) How appealing was the flat rate fee to contractors? [PROBE AS NEEDED: Why do you say that?]
   b) How does the fee compare to reported costs and what contractors are normally paid?

C4. Why did two contractors actively market the pilot, while the other two did not?

C5. Besides active marketing were there other factors that made Bend Heating and Clean Air Act more successful?

C6. What, if anything, would you change about contractor recruitment or the fixed fee structure if this becomes an ongoing offer?

D. Assess the Usefulness of Remote QA Using Nest Data

D1. Standard installations of heat pumps in the main pilot moved very quickly while uptake of installations in the Nest sub pilot was slower. Why do you think that is? [PROBE AS NEEDED: Was it due to the time it took to work out the details of the pilot between Nest, Energy Trust and CLEAResult? Or was it difficult to find customers that wanted to or could participate (e.g. customers must havw wireless internet connection)?]

D2. The traditional spot check QA approach allows for checking installation, while remote QA (theoretically) enables long-term performance monitoring.

a) What are you expecting to happen as a result of the remote QA?
b) What would need to happen in order to justify adding remote QA as a standard part of the QA protocol for heat pump installations?
c) How does the cost compare between traditional spot check QA approach and remote QA using a Nest thermostat? Are these costs similar for other thermostat companies?

D3. Nest thermostat data can flag poorly performing heat pumps for inspection.

a) What data are you expecting to receive from Nest? Are there any limitations to this data?
b) If this pilot became an ongoing offer, is it possible to scale this process to encompass more heat pumps? What are the advantages and disadvantages to replicating this process on a larger scale?
c) Can you obtain similar data from other thermostat companies?

D4. What feedback from contractors did you receive regarding participants experience with the Nest thermostat?

E. Wrap Up

E1. Do you have any additional feedback or anything else you would like to share regarding the pilot that we haven't yet covered?

E2. We are planning to conduct surveys with participants and nonparticipants. Do you have any specific questions that you want to make sure are included in this survey?

a) [IF YES] Please describe

Thank you for your input. If I have any questions as I review my notes, what is the best way to follow-up with you?

We appreciate your time. Have a nice day!

Appendix C. Oregon Climate Zone by County

County	Oregon Heating Zone	County	Oregon Heating Zone
Baker	2	Malheur	1
Benton	1	Marion	1
Clackamas	1	Morrow	1
Clatsop	1	Multnomah	1
Columbia	1	Polk	1
Coos	1	Sherman	2
Crook	2	Tillamook	1
Curry	1	Umatilla	1
Deschutes	2	Union	2
Douglas	1	Wallowa	3
Gilliam	1	Wasco	1
Grant	2	Washington	1
Harney	3	Wheeler	2
Hood River	1	Yamhill	1
Jackson	1		
Jefferson	2		
Josephine	1		
Klamath	2		
Lake	2		
Lane	1		
Lincoln	1		
Linn	1		

Appendix D. Billing Analysis: Additional Subgroup Comparisons

The following four tables summarize the savings for various subgroups.

Table 16 shows Manufactured Homes Heat Pump pilot savings for various subgroups in the body of the report. The smallest square footage quartile of homes achieved 92% of the estimated savings, while the other quartiles ranged from 65% to 72%.

In terms of pre-period quartiles of usage, the Pacific Power larger-usage homes (quartiles 3, 4) realized the estimated savings (96% to 104% realization rates), while the smaller-usage homes (quartiles 1 and 2) showed less savings than expected (34% to 71% realization rates). Pacific Power's percentage of savings by quartile ranged from 14% to 25%. In terms of pre-period quartiles of usage, the PGE larger-usage homes realized more savings (70% to 97% realization rates) than the smaller-usage homes (60% to 68% realization rates). PGE's percentage of savings by quartile ranged from 19% to 24%.

Table 16. Adjusted Gross Savings (Part 1)

Group	Subgroup	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision at 90% (+/-)	Savings Pct. of Pre-NAC	
				Model	Reported			Model	Reported
Overall	Overall	78	15,825	3,269	4,367	75%	14%	21%	28%
Pacific Power/Z2	PAC/Zone2	36	16,500	3,447	4,559	76%	20%	21%	28%
PGE/Z1	PGE/Zone1	42	15,247	3,077	4,202	73%	21%	20%	28%
Pre Quartile	Pre Q=1 All	20	10,893	2,362	4,345	54%	28%	22%	40%
Pre Quartile	Pre Q=2 All	19	14,178	2,787	4,296	65%	33%	20%	30%
Pre Quartile	Pre Q=3 All	19	16,472	3,786	4,446	85%	31%	23%	27%
Pre Quartile	Pre Q=4 All	20	21,707	4,413	4,381	101%	24%	20%	20%
Sqft Quartile	Sqft Q=1 All	17	14,265	3,969	4,328	92%	24%	28%	30%
Sqft Quartile	Sqft Q=2 All	22	14,987	2,882	4,413	65%	28%	19%	29%
Sqft Quartile	Sqft Q=3 All	19	16,650	2,959	4,352	68%	34%	18%	26%
Sqft Quartile	Sqft Q=4 All	20	17,288	3,124	4,363	72%	29%	18%	25%
Pacific Power/Z2 Pre Quartile	Pre Q=1 PAC/Z2	9	11,090	1,539	4,559	34%	56%	14%	41%
Pacific Power/Z2 Pre Quartile	Pre Q=2 PAC/Z2	9	15,000	3,235	4,559	71%	34%	22%	30%
Pacific Power/Z2 Pre Quartile	Pre Q=3 PAC/Z2	9	17,212	4,364	4,559	96%	34%	25%	26%
Pacific Power/Z2 Pre Quartile	Pre Q=4 PAC/Z2	9	22,697	4,739	4,559	104%	37%	21%	20%
Pacific Power/Z2 Sqft Quartile	Sqft Q=1 PAC/Z2	12	16,699	4,682	4,559	103%	28%	28%	27%
Pacific Power/Z2 Sqft Quartile	Sqft Q=2 PAC/Z2	6	12,232	2,532	4,559	56%	50%	21%	37%
Pacific Power/Z2 Sqft Quartile	Sqft Q=3 PAC/Z2	9	19,047	3,479	4,559	76%	40%	18%	24%

Group	Subgroup	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision at 90% (+/-)	Savings Pct. of Pre-NAC	
				Model	Reported			Model	Reported
Pacific Power/Z2 Sqft Quartile	Sqft Q=4 PAC/Z2	9	16,531	1,791	4,559	39%	53%	11%	28%
PGE/Z1 Pre Quartile	Pre Q=1 PGE/Z1	10	10,525	2,507	4,202	60%	37%	24%	40%
PGE/Z1 Pre Quartile	Pre Q=2 PGE/Z1	11	13,831	2,837	4,202	68%	43%	21%	30%
PGE/Z1 Pre Quartile	Pre Q=3 PGE/Z1	11	15,565	2,961	4,202	70%	54%	19%	27%
PGE/Z1 Pre Quartile	Pre Q=4 PGE/Z1	10	21,177	4,091	4,202	97%	26%	19%	20%
PGE/Z1 Sqft Quartile	Sqft Q=1 PGE/Z1	9	13,548	3,349	4,202	80%	39%	25%	31%
PGE/Z1 Sqft Quartile	Sqft Q=2 PGE/Z1	12	14,496	2,466	4,202	59%	40%	17%	29%
PGE/Z1 Sqft Quartile	Sqft Q=3 PGE/Z1	12	14,305	2,571	4,202	61%	50%	18%	29%
PGE/Z1 Sqft Quartile	Sqft Q=4 PGE/Z1	9	19,202	4,449	4,202	106%	36%	23%	22%
County	Clackamas	35	15,001	3,047	4,202	73%	24%	20%	28%
County	Deschutes	35	16,548	3,595	4,559	79%	19%	22%	28%
County	Klamath	1	14,820	-498	4,559	-11%	450%	-3%	31%
County	Multnomah	4	12,596	1,992	4,202	47%	87%	16%	33%
County	Washington	3	21,646	5,173	4,202	123%	31%	24%	19%
City	Beaverton	1	15,130	4,946	4,202	118%	14%	33%	28%
City	Bend	32	16,660	3,622	4,559	79%	20%	22%	27%
City	Bonanza	1	14,820	721	4,559	16%	171%	5%	31%
City	Clackamas	1	21,179	4,642	4,202	110%	24%	22%	20%
City	Oregon City	31	15,185	3,156	4,202	75%	24%	21%	28%
City	Portland	9	14,813	2,660	4,202	63%	45%	18%	28%
City	Redmond	2	15,170	3,941	4,559	86%	59%	26%	30%
City	Terrebonne	1	15,718	2,030	4,559	45%	132%	13%	29%

Group	Subgroup	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision at 90% (+/-)	Savings Pct. of Pre-NAC	
				Model	Reported			Model	Reported
Energy Trust Region	Central Oregon	35	16,548	3,521	4,559	77%	19%	21%	28%
Energy Trust Region	Portland Metro & Hood River	42	15,247	3,077	4,202	73%	21%	20%	28%
Energy Trust Region	Southern Oregon	1	14,820	721	4,559	16%	171%	5%	31%

Table 17 shows additional Energy Trust Manufactured Home Heat Pump pilot adjusted gross savings estimates for other subgroups. Except for the single site in the 1.5 AC ton subgroup, the realization rates remained fairly similar by air-conditioner tonnage.

Standard installation types achieved a higher realization rate (76%) than the remote QA installation type (70%), though this difference is not statistically significant at the 90% confidence level. Furthermore, we expect the remote QA subpilot will produce minimal impacts as the thermostat vendor did not complete its analysis of system performance until January 2017. Contractors may have been more likely to incorrectly set up the Nest thermostat when compared to setting a hard lock out for a standard thermostat.

Manufactured homes in parks achieved a higher realization rate (78%) compared to manufactured homes on private land (59%).

Table 17. Adjusted Gross Savings (Part 2)

Group	Subgroup	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision at 90% (+/-)	Savings Pct. of Pre-NAC	
				Model	Reported			Model	Reported
AC Tons	Tons:1.5	1	10,163	1,890	4,559	41%	17%	19%	45%
AC Tons	Tons:2	44	15,851	3,338	4,381	76%	16%	21%	28%
AC Tons	Tons:2.5	24	15,498	3,162	4,366	72%	21%	20%	28%
AC Tons	Tons:3	9	17,200	3,370	4,281	79%	39%	20%	25%
Thermostat Type	Tstat:APPLE*	1	17,455	2,469	4,559	54%	13%	14%	26%
Thermostat Type	Tstat:CARRIER	3	21,646	5,799	4,202	138%	23%	27%	19%
Thermostat Type	Tstat:HONEYWELL	53	14,892	3,181	4,370	73%	16%	21%	29%
Thermostat Type	Tstat:NEST	15	16,792	3,185	4,345	73%	30%	19%	26%
Vintage	1970-1979	2	14,130	4,125	4,381	94%	17%	29%	31%
Vintage	1980-1989	9	16,128	3,000	4,400	68%	40%	19%	27%
Vintage	1990-1999	61	16,139	3,586	4,366	82%	19%	22%	27%
Vintage	2000-2013	6	12,750	2,358	4,321	55%	71%	18%	34%
MH Type	Double-wide	73	15,783	3,203	4,363	73%	15%	20%	28%
MH Type	Single-wide	2	14,214	3,859	4,381	88%	12%	27%	31%
MH Type	Triple-wide	2	16,289	3,476	4,559	76%	19%	21%	28%
Installation Type	Remote QA	17	16,560	3,036	4,349	70%	28%	18%	26%
Installation Type	Standard	61	15,620	3,334	4,372	76%	15%	21%	28%
Property Type	Park	63	15,543	3,390	4,327	78%	15%	22%	28%
Property Type	Private Land	14	17,316	2,674	4,559	59%	25%	15%	26%
Replaced Furnace kW	10	8	15,212	3,620	4,381	83%	23%	24%	29%
Replaced Furnace kW	12	2	10,777	2,581	4,326	60%	31%	24%	40%
Replaced Furnace kW	15	49	15,318	2,963	4,202	71%	18%	19%	27%
Replaced Furnace kW	15.5	1	21,706	5,264	4,381	120%	6%	24%	20%
Replaced Furnace kW	16.5	1	28,103	5,168	4,326	119%	6%	18%	15%
Replaced Furnace kW	17	2	16,702	4,505	4,202	107%	28%	27%	25%

Group	Subgroup	n	Pre-NAC	Average Savings (kWh)		Realization Rate	Relative Precision at 90% (+/-)	Savings Pct. of Pre-NAC	
				Model	Reported			Model	Reported
Replaced Furnace kW	20	3	15,131	2,609	4,381	60%	82%	17%	29%
Community Action Agency	Clackamas County Social Services	35	15,001	3,285	4,202	78%	19%	22%	28%
Community Action Agency	Community Action	3	21,646	5,799	4,559	127%	23%	27%	21%
Community Action Agency	Klamath/Lake Community Action Services	1	14,820	172	4,202	4%	187%	1%	28%
Community Action Agency	Multnomah County Department of Human Services	4	12,596	2,690	4,202	64%	52%	21%	33%
Community Action Agency	Neighbor Impact	35	16,548	3,190	4,559	70%	17%	19%	28%

* Name reflects the value in the tracking data.

Table 18 summarizes adjusted gross savings for weather-sensitive and base load components for various subgroups.

Table 18. Adjusted Gross Savings (Part 1 Weather Sensitive and Base Load)

Group	Subgroup	n	Base Load Usage	Base Load Change	Base Load Percent Change as Pct of Pre Base Load Use	Weather Sensitive Usage	Weather Sensitive Savings	Weather Sensitive Savings as Pct of Pre Weather Sensitive Use	Relative Precision Weather Sensitive Usage at 90%
Overall	Overall	78	8,759	-866	-10%	7,066	4,267	60%	13%
Pacific Power/Z2	PAC/Zone2	36	8,888	-996	-11%	7,611	4,650	61%	17%
PGE/Zone 1	PGE/Zone1	42	8,649	-710	-8%	6,598	3,799	58%	19%
Pre Quartile	Pre Q=1 All	20	5,123	-377	-7%	5,770	2,707	47%	32%
Pre Quartile	Pre Q=2 All	19	7,799	-1,151	-15%	6,379	4,049	63%	23%
Pre Quartile	Pre Q=3 All	19	9,200	-1,635	-18%	7,272	5,364	74%	25%
Pre Quartile	Pre Q=4 All	20	12,890	-989	-8%	8,818	5,604	64%	24%
Sqft Quartile	Sqft Q=1 All	17	7,203	-278	-4%	7,062	4,607	65%	19%
Sqft Quartile	Sqft Q=2 All	22	7,537	-1,316	-17%	7,451	4,352	58%	25%
Sqft Quartile	Sqft Q=3 All	19	9,624	-1,484	-15%	7,027	4,629	66%	23%
Sqft Quartile	Sqft Q=4 All	20	10,606	-345	-3%	6,683	3,411	51%	40%
Pacific Power/Z2 Pre Quartile	Pre Q=1 PAC/Z2	9	5,297	-963	-18%	5,793	2,841	49%	44%
Pacific Power/Z2 Pre Quartile	Pre Q=2 PAC/Z2	9	7,522	-996	-13%	7,478	4,401	59%	38%
Pacific Power/Z2 Pre Quartile	Pre Q=3 PAC/Z2	9	9,503	-919	-10%	7,709	5,172	67%	28%
Pacific Power/Z2 Pre Quartile	Pre Q=4 PAC/Z2	9	13,230	-1,105	-8%	9,467	6,136	65%	29%
Pacific Power/Z2 Sqft Quartile	Sqft Q=1 PAC/Z2	12	8,091	-668	-8%	8,608	6,325	73%	20%

Group	Subgroup	n	Base Load Usage	Base Load Change	Base Load Percent Change as Pct of Pre Base Load Use	Weather Sensitive Usage	Weather Sensitive Savings	Weather Sensitive Savings as Pct of Pre Weather Sensitive Use	Relative Precision Weather Sensitive Usage at 90%
Pacific Power/Z2 Sqft Quartile	Sqft Q=2 PAC/Z2	6	6,388	-1,224	-19%	5,844	3,547	61%	40%
Pacific Power/Z2 Sqft Quartile	Sqft Q=3 PAC/Z2	9	10,459	-2,071	-20%	8,588	5,671	66%	30%
Pacific Power/Z2 Sqft Quartile	Sqft Q=4 PAC/Z2	9	10,046	-377	-4%	6,485	2,110	33%	78%
PGE/Z1 Pre Quartile	Pre Q=1 PGE/Z1	10	5,232	-325	-6%	5,293	2,770	52%	43%
PGE/Z1 Pre Quartile	Pre Q=2 PGE/Z1	11	6,870	-1,278	-19%	6,961	4,014	58%	40%
PGE/Z1 Pre Quartile	Pre Q=3 PGE/Z1	11	9,378	-760	-8%	6,187	3,744	61%	38%
PGE/Z1 Pre Quartile	Pre Q=4 PGE/Z1	10	13,221	-676	-5%	7,956	4,842	61%	43%
PGE/Z1 Sqft Quartile	Sqft Q=1 PGE/Z1	9	7,717	-220	-3%	5,830	3,585	61%	31%
PGE/Z1 Sqft Quartile	Sqft Q=2 PGE/Z1	12	6,437	-1,664	-26%	8,060	3,531	44%	32%
PGE/Z1 Sqft Quartile	Sqft Q=3 PGE/Z1	12	8,902	-943	-11%	5,404	3,543	66%	36%
PGE/Z1 Sqft Quartile	Sqft Q=4 PGE/Z1	9	12,193	367	3%	7,009	4,062	58%	54%
County	Clackamas	35	8,463	-786	-9%	6,539	3,882	59%	19%
County	Deschutes	35	8,888	-971	-11%	7,659	4,821	63%	16%
County	Klamath	1	8,889	-2,395	-27%	5,931	1,861	31%	244%
County	Multnomah	4	6,096	-789	-13%	6,500	2,616	40%	117%
County	Washington	3	14,226	50	0%	7,420	5,127	69%	82%

Group	Subgroup	n	Base Load Usage	Base Load Change	Base Load Percent Change as Pct of Pre Base Load Use	Weather Sensitive Usage	Weather Sensitive Savings	Weather Sensitive Savings as Pct of Pre Weather Sensitive Use	Relative Precision Weather Sensitive Usage at 90%
City	Beaverton	1	9,465	1,522	16%	5,665	3,281	58%	70%
City	Bend	32	9,142	-791	-9%	7,517	4,679	62%	18%
City	Bonanza	1	8,889	-3,348	-38%	5,931	3,471	59%	145%
City	Clackamas	1	14,023	796	6%	7,156	5,865	82%	38%
City	Oregon City	31	8,425	-923	-11%	6,760	4,113	61%	19%
City	Portland	9	8,731	-217	-2%	6,082	2,820	46%	71%
City	Redmond	2	4,858	-1,244	-26%	10,312	6,080	59%	25%
City	Terrebonne	1	8,810	-2,977	-34%	6,909	4,591	66%	162%
Energy Trust Region	Central Oregon	35	8,888	-927	-10%	7,659	4,682	61%	17%
Energy Trust Region	Portland Metro & Hood River	42	8,649	-710	-8%	6,598	3,799	58%	19%
Energy Trust Region	Southern Oregon	1	8,889	-3,348	-38%	5,931	3,471	59%	145%

Table 19 shows additional summaries of adjusted gross savings for weather-sensitive and base load components for various subgroups.

Manufactured homes in parks achieved higher weather-sensitive savings of 4,451 kWh compared to those on private land at 3,604 kWh.

Table 19. Adjusted Gross Savings (Part 2 Weather Sensitive and Base Load)

Group	Subgroup	n	Base Load Usage	Base Load Change	Base Load Percent Change as Pct of Pre Base Load Use	Weather Sensitive Usage	Weather Sensitive Savings	Weather Sensitive Savings as Pct of Pre Weather Sensitive Use	Relative Precision Weather Sensitive Usage at 90%
AC Tons	Tons:1.5	1	6,167	-103	-2%	3,997	1,970	49%	19%
AC Tons	Tons:2	44	8,386	-954	-11%	7,465	4,503	60%	13%
AC Tons	Tons:2.5	24	8,499	-882	-10%	6,999	4,190	60%	24%
AC Tons	Tons:3	9	11,569	-473	-4%	5,631	3,578	64%	34%
Thermostat Type	Tstat:APPLE	1	9,319	-1,974	-21%	8,136	4,658	57%	8%
Thermostat Type	Tstat:CARRIER	3	14,226	-719	-5%	7,420	6,251	84%	65%
Thermostat Type	Tstat:HONEYWELL	53	7,831	-833	-11%	7,061	4,221	60%	14%
Thermostat Type	Tstat:NEST	15	10,182	-1,046	-10%	6,610	4,195	63%	29%
Vintage	1970-1979	2	7,914	2,193	28%	6,216	2,040	33%	32%
Vintage	1980-1989	9	8,789	-1,049	-12%	7,338	4,132	56%	41%
Vintage	1990-1999	61	8,869	-967	-11%	7,269	4,725	65%	16%
Vintage	2000-2013	6	7,880	601	8%	4,869	1,729	36%	98%
MH Type	Double-wide	73	8,794	-974	-11%	6,990	4,298	61%	13%
MH Type	Single-wide	2	5,588	35	1%	8,626	4,399	51%	68%
MH Type	Triple-wide	2	8,053	590	7%	8,237	3,216	39%	15%
Installation Type	Remote QA	17	10,069	-1,092	-11%	6,491	4,088	63%	27%
Installation Type	Standard	61	8,394	-803	-10%	7,226	4,318	60%	13%
Property Type	Park	63	8,624	-935	-11%	6,919	4,451	64%	13%
Property Type	Private Land	14	9,460	-760	-8%	7,856	3,604	46%	26%
Replaced Furnace kW	10	8	4,938	-582	-12%	5,839	3,383	58%	36%
Replaced Furnace kW	12	2	8,588	-1,391	-16%	6,730	4,238	63%	30%
Replaced Furnace kW	15	49	17,932	-2,135	-12%	3,774	2,295	61%	28%

Group	Subgroup	n	Base Load Usage	Base Load Change	Base Load Percent Change as Pct of Pre Base Load Use	Weather Sensitive Usage	Weather Sensitive Savings	Weather Sensitive Savings as Pct of Pre Weather Sensitive Use	Relative Precision Weather Sensitive Usage at 90%
Replaced Furnace kW	15.5	1	4,938	517	10%	5,839	3,690	63%	10%
Replaced Furnace kW	16.5	1	8,588	-3,668	-43%	6,730	6,292	93%	6%
Replaced Furnace kW	17	2	17,932	-1,145	-6%	3,774	2,666	71%	88%
Replaced Furnace kW	20	3	4,938	-346	-7%	5,839	2,830	48%	22%
Community Action Agency	Clackamas County Social Services	35	14,226	-1,967	-14%	7,420	5,163	70%	13%
Community Action Agency	Community Action	3	8,889	-449	-5%	5,931	4,997	84%	81%
Community Action Agency	Klamath/Lake Community Action Services	1	6,096	-1,780	-29%	6,500	3,018	46%	12%
Community Action Agency	Multnomah County Department of Human Services	4	14,226	-3,491	-25%	7,420	5,100	69%	37%
Community Action Agency	NeighborImpact	35	8,889	-453	-5%	5,931	2,970	50%	24%