FINAL REPORT

Integrated Controls Pilot Study

Efficiency Maine

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1 INTRODUCTION

To support the state of Maine's significant commitment to promoting the use of heat pumps, DNV (formerly ERS), along with subcontractors Dunsky Energy Consulting (Dunsky) and the FSEC Energy Research Center (together the DNV team), undertook this pilot for Efficiency Maine to assess controls that would increase customer reliance on heat pumps during the heating season in cold climates, saving residents money and reducing greenhouse gas (GHG) emissions.

1.1 Purpose

The objectives of the pilot were to identify and pilot thermostatic control options that provide optimized control of ductless split heat pumps (HPs) and existing combustion heating equipment in single family residential dwellings. The project included a research phase to identify thermostat technologies and market characterization; and a pre-post measurement & verification (M&V) phase consisting of billing, advanced metering infrastructure (AMI), and on-site data collection alongside customer satisfaction surveys.

1.2 Overview of pilot

The DNV team conducted the study in two phases. The tasks for each phase were:

Phase 1:

- Explore existing viable candidate control systems identified by DNV during the proposal process
- Update research of other possible control alternatives, including those promoted through other ratepayer-funded programs
- Interface with the Efficiency Maine's Residential Registered Vendor (RRV) network installing heat pumps to learn which control strategies are employed and currently recommended
- Solicit controls developers and producers interested in participating in a pilot
- Perform early testing and/or review provider field test results

Phase 2:

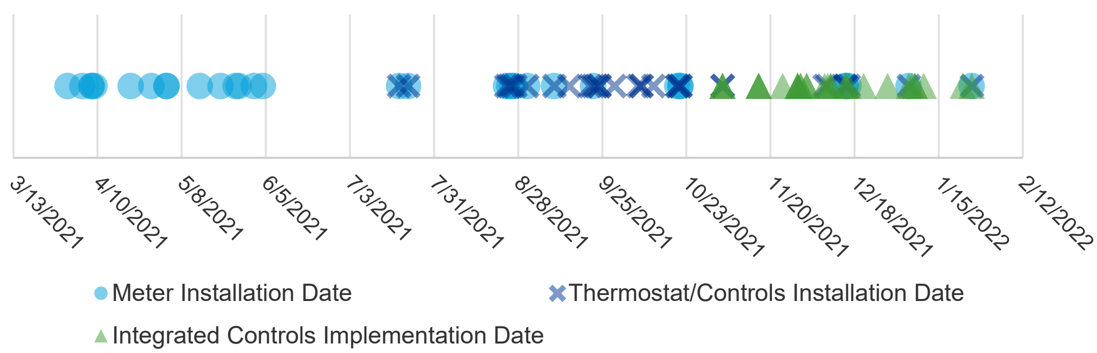
- Implement a field pilot of the selected controls system options
- Install meters to collect baseline data and monitor system performance after control system installation
- Collect AMI and delivered fuels data to augment results of metered data
- Analyze and report on results

2 APPROACH

The DNV team conducted market and technology research to select viable thermostat control equipment. Once the systems were selected for the pilot program, we conducted on-site M&V for a representative sample of sites and completed an AMI and billing analysis on all pilot participants (based on available data). With Efficiency Maine's guidance, the DNV team arrived at an initial plan to pilot the selected technology at 60 sites, with meter installations along with AMI and billing analysis at 50% of the sites, and AMI data analysis only for the remainder. Further revisions discussed in Section 3 reduced the final number of pilot sites to 31. The approach included the following elements:

- Market and technology research to identify thermostat control equipment that integrates control of HPs with other heating equipment.
- After candidate technologies were selected and the expected site-specific equipment configurations were classified, the team developed an M&V plan for on-site work and billing analysis.
- An online recruitment survey was conducted with participants from Efficiency Maine's residential heat pump program to identify eligible participants for on-site M&V and customer interest in receiving a free $370-$540 value controls system for participating in the study as well as $100 participant gift cards.
- The pilot anticipated that on-site M&V would provide baseline energy usage for each site, as well as a post-controls implementation energy usage, allowing the team to calculate site-specific kW, kWh, and fuel Btu savings. The team attempted to start on-site M&V in the winter of 2021 to collect winter baseline data; however, the pandemic impacted the availability of electricians and HVAC technicians necessary for equipment installation support and limited the customers willing to participate in the pilot. The site recruitment process extended from two months to four months, and later to over nine months, and DNV and Efficiency Maine made the decision in the summer of 2021 to begin installing the integrated thermostat controls systems, knowing that very few sites would have meters installed that were able to provide baseline data. Figure 2-1 presents the timeline of meter and integrated controls installations.

Figure 2-1. Site installation timeline



- Final meter and controller installations occurred in the fall and winter of 2021. Meter retrieval started in April 2022 and was completed in August 2022. The control systems were left in place at participating customer's residences. Metered data was analyzed for the following period: installation date for each site in 2021 through April 1, 2022.
- The M&V analysis was used to support the AMI analysis and provide additional clarity to findings that could require more data to substantiate, such as load profiles, heat rates by outdoor and indoor air temperature, and other impact objectives. The M&V analysis included billing analysis as a quality control option for non-electric equipment impacts for each site, but given the nature of delivered fuels data, there was insufficient granularity to draw any conclusions as discussed in Section 5.1.

3 THERMOSTAT TECHNOLOGIES

The objective of Phase 1 of the study was to research and identify existing viable thermostat control technologies to use in this pilot effort. Three technologies were initially recommended for implementation:

- Ecobee Smart Thermostat + Flair Puck Pro
- Resideo T9
- Jackson Systems UT32

After selection of the three technologies and completion of the Phase 1 report, the team had to eliminate the Resideo T9 and the Jackson Systems UT32 technologies from consideration for the pilot. The team learned that Honeywell, the supplier of the Resideo T9 controller, had discontinued supplying this product. As a result, the M&V phase planning continued with an adjusted distribution of sites. In August 2021, after site work was initiated and equipment orders placed, the team learned that Jackson Systems would be unable to deliver the control system for the pilot in a timely fashion to allow for installation and metering prior to the winter 2021 season. In consultation with Efficiency Maine, the team decided to proceed with a single thermostatic control technology, the Ecobee Smart Thermostat + Flair Puck Pro. The site count was reduced to 32, though one site was unable to continue due to boiler issues, reducing the final count to 31. The remainder of this report addresses the on-site M&V, analysis, and results based on the installation of an Ecobee Smart Thermostat + Flair Puck Pro at each participating site. This equipment was set up to use Flair's "droop" technology, which treats the heat pump as the primary heating source and calls for supplemental heat from the central system only when the home's average temperature from multiple temperature sensors drops below the average setpoint by a certain "droop offset" amount. The controls were set up with a default 5 degree droop at installation but the homeowner could change or remove that droop at any time.

4 SITE WORK/DATA COLLECTION

The site-specific analyses are based on AMI data, billing analysis where bills are available for quality control, and on-site metering. Sites were assigned a high-rigor, medium-rigor, or low-rigor on-site metering approach. High-rigor metering captured the heat pump power and central system amps, while medium-rigor metering captured both the heat pump and central system amps. Low-rigor sites did not receive metering; analysis was based only on AMI data.

4.1 Site selection criteria

The DNV team selected participants for this study using the results of an online survey conducted with Efficiency Maine's residential heat pump program participants. We used the response data to identify residential customers who met the project's eligibility requirements described below to create a pool from which a sample was drawn.

We planned to conduct site-specific analyses for all sites using AMI and billing data and use site-level metered data for enhanced results at medium and high-rigor sites. Based on the revised target of 32 sites for this study, we followed the low rigor, AMI-only approach for 3 sites, medium rigor approach for 18 sites and the high rigor approach for the remaining 11 sites. Site selection for rigor was initially random but as recruitment became more difficult, the team prioritized the high and medium rigor sites assigning those arbitrarily as sites agreed to the program. Low rigor sites were the last that agreed to participate in the program. The breakdown of sites by rigor classification is shown in Table 4-1.

Table 4-1. Site rigor count

Rigor	Metering Approach	Site Count
Low	No metering	3
Med	Meter both heat pump and central system amperage at main electric panel	18
High	Meter heat pump power at exterior heat pump unit and central system amperage at central system	11
Total		32[1]

After identification of the eligible participant sample, a brief phone survey was conducted with each site selected to confirm the customer's willingness to participate and to collect information to ensure their equipment was compatible with the pilot technology. We also asked potential participants for their permission to deploy metering equipment prior to measure installation to identify candidates for the medium and high rigor sites. Equipment eligibility was based on the following requirements:

- Home has a mini-split heat pump in addition to a delivered-fuel heating system.
- The heat pump zone overlaps with the delivered-fuel system zone in the home.
- The delivered-fuel system is controlled by a thermostat, and the wiring allows for (or can be modified to allow for) installation of a smart thermostat.
- Home has reliable Wi-Fi and cell signal.

4.2 On-site metering

A meter deployment visit was conducted for all medium- and high-rigor sites, starting in March 2021. During the site visit, the field staff collected detailed site information, including HVAC equipment nameplate data, building occupancy patterns, qualitative assessments of the building envelope, thermostat wiring information, and meter deployment notes. These notes

[1] One participant had boiler issues after the controller installation and did not end up participating in the full pilot.

were digitized into a template data collection form (DCF), provided in APPENDIX B, to ensure consistency in the site-level analysis.

The goal of on-site metering was to get a complete picture of the HVAC operation at the home, encompassing the following equipment:

- HP outdoor units, which include the compressor, the outdoor fan, and any onboard peripherals like electric defrost
- HP indoor units, which include onboard fans and temperature sensors for the indoor unit
- Combustion heating equipment, expected to be a mix of boilers, furnaces, and unit heaters
- Temperatures in the thermostat locations for the HP and the central heating equipment

For high-rigor sites, field staff deployed equipment as detailed in Table 4-2.

Table 4-2. High-rigor meter deployment

Equipment	Meter Location	Power	Amps	Temp
Outdoor unit	At disconnect, including both outdoor and indoor equipment	X		
Outdoor unit	Refrigerant supply (to differentiate heating and cooling)			X
Indoor unit	On indoor unit, including supply temp (probe) and return temp/rh (sensor unit)			X
Central heat	At unit's combustion fan, or in panel if not accessible		X	
Thermostat	Mounted near thermostat(s) inside the building			X

For medium-rigor sites, field staff deployed metering equipment as detailed in Table 4-3.

Table 4-3. Medium-rigor meter deployment

Equipment	Meter Location	Amps	Temp
Outdoor unit	In panel, on outdoor unit circuit	X	
Central heat	In panel, on combustion fan circuit	X	
Indoor unit	On indoor unit, including supply temp (probe) and return temp/rh (sensor unit)		X
Thermostat	Mounted near thermostat(s) inside building		X

4.3 Integrated controls installation

For all thermostat study participants—including low-, medium-, and high-rigor sites—we conducted site visits starting in July of 2021 to install and configure the selected integrated system controller. We attempted to use Efficiency Maine's RRV network for the controller installation but given the pandemic constraints on electricians and HVAC technicians, we needed to use any available electricians and HVAC technicians who could assist us. In some cases, this required the metering equipment deployment and integrated controls installation to occur during the same visit, resulting in no available baseline data for those sites. For low-rigor sites, the controller installation site visits were used as an opportunity for the site engineer to fill out a site-specific DCF with information on the existing equipment as described in Section 4.4.

During the integrated controls installation, the HVAC technician replaced the home's existing thermostat with an Ecobee smart thermostat. DNV field staff installed the Flair controls, linked the home's Flair account with the Ecobee thermostat, and tested that the HVAC equipment responded to the new controls. Before concluding the site visit, DNV field staff reviewed how to use the new controls with the homeowner. DNV prepared an installation manual for the Flair and Ecobee equipment, included in APPENDIX C. Participants were also given a $100 gift card after equipment deployment.

4.4 On-site data collection instruments

The DNV team also collected information from customers via interviews or directly from system data during the on-site M&V visit using a DCF. The DCF covered any additional contextual information we needed to accurately analyze the metered data. We used the data collection instruments developed and tested for previous HP M&V projects as a starting point for developing a specific data collection instrument for this project.

The data collected on-site from observation, measurement, and a customer interview included:

4.4.1 Observation

- Nameplate (including make and model) information for both outdoor and indoor units
- Outdoor unit compressor cut-off temperature and defrost setpoints, if available
- Presence or absence of pan heater and information about pan heater control algorithms
- Thermostat or control type and location
- Thermostat wiring configuration
- Temperature setpoints and schedule
- Pre-existing heating and cooling equipment nameplate data, where that equipment is still in place
- HP and pre-existing equipment staging and control sequence
- Photographs of logger installations

4.4.2 Measurement

- Spot measurements of operating amperage, outdoor and refrigerant line temperatures, and operating state during the site visit
- Spot measurements of combustion equipment operating efficiency

4.4.3 Interview

- Typical heating season operation; including the homeowner's typical combination of heat pump and central system heat, typical thermostat use, typical daily schedules, and any seasonal operation changes
- Whether heating capacity has changed in the served space
- Whether heating loading has changed in the served space

This data is in addition to the information collected through meters.

4.5 Survey instruments

In addition to the on-site metering and data collection, the team had committed to survey participants after the pilot implementation to obtain feedback on the program and the installed controller. Gathering feedback from participants is an essential component of M&V to assess the effectiveness of the pilot program design and delivery, and to determine how well programs are progressing toward their objectives.

Qualitative participant surveys. DNV developed a web-based survey for all pilot participants that was fielded after the metered period (starting in May 2022). The survey, provided in APPENDIX D, included roughly 20 questions and focused on participant experience, overall comfort, and perceived benefits and impact of the program. The survey was distributed to the 31[2] program participants; the team followed up with reminder emails and phone calls. If the participant was unresponsive the team attempted to collect customers responses during the meter retrieval visits, met with refusal in some cases.

Qualitative non-participant surveys. DNV developed a web-based survey for non-participants with an incentive for those survey respondents to be included in a drawing for one of seven $100 Visa Gift Cards to encourage responses. The survey provided in APPENDIX D included roughly 20 questions and focused on their experience, overall comfort, and perceived benefits from using their heat pump. It also included socio-demographic questions to glean data not available from existing data sets. The team sent online surveys invitations to all participants who installed single-zone tier 2 heat pumps through the Efficiency Maine Home Energy Savings Program who had not participated in the Integrated Controls pilot and had available email addresses. The survey was distributed to 100 customers, and two survey reminder emails were sent out.

The surveys assessed the following topics:

- Customer's reported HP use strategy by season
- Customer's perceived energy savings and energy use
- Customer's changes in setpoints and other heating/cooling equipment use
- Customer's perceived change in comfort, if any
- Customer's satisfaction with the equipment, contractor, and the program
- Customer's self-report on how they used and operated the HP and other fossil fuel heating systems
- Control system operation knowledge conveyed to customers, including training by installers and instruction documents

[2] As described below, one participant had boiler issues after the controller installation and did not end up participating in the full pilot.

5 ANALYSIS METHODS

DNV used the following methods and approaches for analyzing the collected data.

5.1 AMI and billing analysis

For each pilot participant, we estimated meter-level heating related energy use based on AMI data using a regression model. In each model, the dependent variable is hourly energy consumption, and the independent variable is hourly temperature. The non-weather dependent base load was subtracted from the AMI use before creating the models. The base load was calculated by taking the minimum value of the average hourly use binned by 5-degree temperature bins. Two models were made for each site, one before the controls were implemented and one after. The models were extrapolated to normalized annual values using TMY3 weather data. The energy consumption impacts were calculated as the difference between the two models.

The delivered fuel records were not granular enough to produce a reliable model for analysis. In most cases, there were only one or two deliveries per year. An annual fuel use was derived from the delivered fuel records for each site with sufficient data. This estimated annual fuel use value was used only as a quality control check for the estimates derived from the AMI analysis.

5.2 Metered data analysis

A similar set of temperature models were created for sites which had sufficient metered heat pump power data for both pre and post control periods. Pandemic constraints delayed meter deployment, limiting the number of sites that had pre control period heat pump data. Where applicable, the AMI models were compared to metered heat pump models. The two data sets gave different absolute results as expected but tended to agree with each other, qualitatively, with respect to increased or decreased heat pump usage due to the new controls.

The analysis of metered data for the sites proceeded as follows:

- From the heat pump metered data, the hourly power consumption was calculated and aligned with historical hourly NOAA data.
- For both the pre- and post-case, a regression model was created using the hourly power and weather data and extrapolated to normalized annual use using TMY3 weather data.
- For each normalized model, the heat pump's heating output was calculated using power-load relationships developed for models already in DNV's field performance libraries and sites with similar make/model characteristics for each hour of the TMY3 year.
- The difference in heat delivered by the heat pump was calculated by taking the difference between the heat outputs of the pre- and post-normalized models.
- The difference in heat output of the heat pump was assumed to offset the use of the fossil fuel heating system. Fossil fuel saving presented below were calculated based on this assumption.
- A site-specific Heating Seasonal Performance Factor (HSPF) was calculated for each site. The value was calculated by multiplying the rated HSPF by a performance factor adjustment. The adjustment factor was calculated by averaging the performance from the normalized models.

6 FINDINGS

The following sections present findings from the data analysis and the surveys.

6.1 Annual heating energy impacts of integrated controls

Table 6-1 and Table 6-2 present the findings of the AMI and metered data analysis and overall results on the effect of the integrated control systems on HP usage.

Table 6-1. Overall summary of AMI and metered data results

Droop[3] Enabled	Has Metered Heat Pump Data Result	Count	Average Increased Heat Pump Use per Metered Data (kWh)	Average Increased Heat Pump Use per AMI Data (kWh)	Fuel Savings per Heat Pump Data (MMBtu)	Fuel Savings per AMI Data (MMBtu)
No	**No**	7	N.A.	N.A.	N.A.	N.A.
Yes	**No**	9	N.A.	1,923	N.A.	22.6
Yes	**Yes**	16	386	1,020	5.0	13.1
Total		32	386	1,345	5.0	16.3

Table 6-2. Sites with increased HP usage

	HP data	AMI data
Count N.A.[4]	16	7
Count of sites with increased HP use	12	23
Count of sites with decreased HP use	4	2
Percent of sites with increased HP use	75%	92%

As described in the individual site reports and identified in Table 6-4, there some sites represented good or ideal situations for integrated control system usage and others that were less than ideal situations. Table 6-3 summarizes the increased HP use for the ideal and not-ideal sites that participated in the study. An ideal site is a single zone system where the heat pump zone overlaps significantly with the central heating system zone controlled by the smart thermostat. Sites with heat pumps in separate areas not covered by the fossil fueled system or with areas or rooms not served by the heat pump did not perform as well. The overall average showed increased heat pump use for the majority of sites, though a few sites (as detailed in the individual site reports in APPENDIX E) did see a decrease in HP usage.

[3] When droop is enabled, the control system will only call for the supplemental heat system when the average home temperature drops below a specified droop offset temperature. In this study, the team initially programmed each home to use the heat pump as the primary heat source, the central fuel system as the supplemental heat source, and the droop offset to five degrees.

[4] N.A. sites include homes that disabled the integrated controls or sites that did not have pre-controls metered data.

Table 6-3. Ideal situations for use of integrated control system

Ideal Use-Case?	Has HP Data Results	Count of Ideal Use-Case?	Average Increased HP Use per Metered Data (kWh)	Average Increased HP Use per AMI Data (kWh)
No	No	12	N.A.	1,131
	Yes	11	358	833
Nonideal Use-Case Total		**23**	**358**	**926**
Yes	No	4	N.A.	2,913
	Yes	5	449	1,431
Ideal Use-Case Total		**9**	**449**	**2,090**
Grand Total		**32**	**386**	**1,345**

Table 6-4 presents high-level takeaways for each site. For a full summary of each site, see APPENDIX E.

Table 6-4. Site-specific takeaways

Site ID	Droop Utilized?	Heat Pump Usage Change	Home layout	Takeaway
IT004	Yes, 3 degree offset	Increased HP use	Single zone central system. Heat pump in living room does not reach back bedrooms, although back rooms are seldom used.	Homeowner had positive experience, but felt that the technology was more complex than they needed.
IT006	Yes, 2 degree offset and combination indoor/outdoor temp trigger	Minimal change	Single zone central system. Heat pump in living room does not reliably control temp in nursery, especially when outdoor temp is low.	Homeowner requires precise control of temperature, not a good candidate for droop.
IT008	Yes, 3 degree offset	Decreased heat pump use	Single zone central system. Heat pump in living room, bedrooms right off of living room.	Second home. App may have enabled homeowners to use heat pump less when out of town because of smart away mode.
IT010	Yes, 4 degree offset	Increased heat pump use	Single zone central system on first floor, heat pump in first floor living room. Second floor separate baseboard system.	Homeowner found that they had to set temperature higher than usual to reach desired temp. Likely due to programmed offset; before controls, the homeowner usually set the boiler temperature higher than the heat pump.
IT011	Yes, 5 degree offset	Increased heat pump use	Single zone central system, supplemented with wood stove. Heat pump serves computer room.	Layout not ideal for droop (heat pump only serves one room, home uses wood stove in addition to furnace). However, homeowner has a positive experience with the technology and reported that home was warmer throughout the winter, likely because the whole-home

Site ID	Droop Utilized?	Heat Pump Usage Change	Home layout	Takeaway
				daytime setpoint (65) was higher than the previous central system setpoint (60).
IT012	Yes, 5 degree offset	Increased heat pump use	Two boiler zones (only one operational). Two heat pumps, Controls implemented for kitchen/living room heat pump.	Droop worked well for this layout because the bedroom, which is not served by the kitchen heat pump, has a separate heat pump. Therefore, the boiler and heat pump zones overlap entirely (the boiler did not need to run to accommodate the bedroom temperature).
IT015	Yes, 5 degree offset	Increased heat pump use	Single zone central system, heat pump in living room.	Heat pump meets the needs of the living room and kitchen but does not reach the bedroom well. Besides the bedroom, the homeowner experienced a more even temperature with the controls. Homeowner commented on a notable increase in electric bills (even before price increase).
IT016	Yes, 3 degree offset	Increased heat pump use	Single zone central system, heat pump in upstairs bedroom.	Because the heat pump is upstairs, it does not have much impact on the downstairs temperature. Increased heat pump use may be due to the higher setpoints more than droop. Homeowner perceived more electric use and less fuel use with controls - prior to controls homeowner left boiler running all winter.
IT017	No	Minimal change	Single zone central system, heat pump in living room. Heat pump does not reach far bedroom, homeowners sometimes supplement with electric heater.	Homeowner disabled droop due to dissatisfaction with ability to control heat pump.
IT018	Yes, 5 degree offset	Increased heat pump use	Single zone central system. Heat pump in living room can reach living room and kitchen, kitchen is often warmer due to cooking. Furnace thermostat is in kitchen.	Both AMI and heat pump data indicate controls increased heat pump use. Homeowner eventually disabled controls because home was not maintained at a satisfactory temperature.
IT019	No	Minimal change	Single zone central system. Heat pump in living room can reach kitchen, but not bedroom.	Heat pump data logger died after one day. AMI data shows slightly less heat pump use after controls were installed; however this change is minimal and not attributable to the controls because the homeowner disconnected Flair on December 20th due to dissatisfaction in the system's ability to maintain the desired setpoint.

Site ID	Droop Utilized?	Heat Pump Usage Change	Home layout	Takeaway
IT020	Yes, 5 degree offset	Increased heat pump use	Single zone central system. Heat pump in living room reaches open kitchen/living area. Thermostat is in hallway off of living room, bedrooms off of hallway.	Heat pump data logger died before controls were implemented. AMI data shows increase in heat pump use after controls were installed. Homeowner did not provide survey response.
IT024	Yes, 5 degree offset	Increased heat pump use	Single zone central system. Heat pump primarily serves living room, bedrooms upstairs.	AMI and heat pump data do not agree. The magnitude of increased heat pump use per AMI data is greater than the magnitude of decreased use per metered data. Homeowner reports increased heat pump use and increased comfort. Higher temperature setpoints likely contribute to the perceived increased use and increased comfort.
IT025	Yes, 3 degree offset	Increased heat pump use	Single zone central system. Heat pump located in sunroom/office, which is rarely used at the same time as the rest of the house.	Home layout is not ideal for droop, because heat pump is located in a sunroom used as an office and does not reach the rest of the house. During the day, the homeowner only needs the office heated (the rest of the room can be cold), and the opposite at night. Homeowner is excited about the ability to control temperature via app/internet.
IT026	Yes, 5 degree offset	Increased heat pump use	Single zone central system. Heat pump in living room, which is the most used area.	AMI data does not agree with metered heat pump data. Pre-controls heat pump data does not include low outdoor temps, which is where most significant savings occur according to AMI data. Homeowner expressed satisfaction in oil savings.
IT028	Yes, 5 degree offset	Increased heat pump use	Single zone central system. Heat pump in kitchen. Open layout kitchen/dining/living room areas.	AMI and metered data indicate increased heat pump use, which agrees with homeowner perception.
IT030	No, controls disconnected due to boiler repairs	N/A	Single zone central system.	Boiler at this home needed maintenance shortly after droop was implemented. Controls were disconnected and data loggers were removed as a result. Metered heat pump data only includes three days.
IT032	Yes, 5 degree offset	Increased heat pump use	Single zone central system. Heat pump in living room, which connects to kitchen and is most used area.	Home utilized droop with 5 degree offset. AMI data indicates increased heat pump use. Homeowner is pleased with the controls and reports fuel savings.
IT037	Yes, 4 degree offset	Decreased heat pump use	Single zone central system. Central thermostat in same room as heat pump.	Utilized droop with 4 degree offset. Meters were installed at the same time as droop, no pre-controls heat pump data. AMI data shows decreased heat pump use after controls were installed.

Site ID	Droop Utilized?	Heat Pump Usage Change	Home layout	Takeaway
IT038	Yes, 5 degree offset	Increased heat pump use	Single zone central system, small mobile home.	Metered data and AMI data both indicate increased heat pump use after controls installed. Homeowner's description of use during retrieval visit indicates lack of understanding of how the integrated controls work.
IT041	Yes, 5 degree offset	Increased heat pump use	Dual zone central system, zone overlapping with heat pump includes open living/dining/kitchen area and (now unoccupied) bedrooms. Second boiler zone includes master bedroom and basement.	Home utilized droop with a 5 degree offset; homeowner reports occasionally switching Flair to manual mode to force heat pump off. Home layout is a good candidate for droop and both metered data and AMI data indicate increased heat pump use. Homeowner believes that fuel use has decreased more than electric use has increased (overall savings).
IT060	Yes, 5 degree offset	Increased heat pump use	Large wood boiler serves four buildings (house and camp). Thermostat in home controls the radiant floor heating circulator pump. Heat pump located in living room, does not reach other areas of home or camp.	Not ideal candidate for droop because the thermostat controls the radiant floor circulator pump - the amount of wood burned unlikely to change because the boiler also serves a large camp facility. AMI data indicates increased use after controls installed.
IT070	No	N/A	Single zone central system. Heat pump is in small kitchen, minimally serves living room and does not reach bedrooms.	Not ideal candidate for droop because heat pump is primarily used for cooling. Child's bedroom is highest priority for heating, which is not served by the heat pump.
IT072	No	N/A	Single zone central system, heat pump in living room. Heat pump does not reach bedrooms, homeowner likes using boiler to keep floors warm.	Heat pump required condensate line repairs which prevented homeowner from being able to use heat pump over the course of the study. Homeowner disabled integrated controls.
IT074	Yes, 5 degree offset, cutover	Increased heat pump use	Single zone central system, heat pump located in basement rec room.	Homeowner switched from supplemental heat mode to cutover mode, so that heat pump turns off whenever the boiler turns on to bring the home up to temperature. Metered data and AMI data both indicate increase heat pump use after controls installed.
IT079	Yes, 6 degree offset	Increased heat pump use	Single zone central system, mobile home.	Not ideal candidate for droop because homeowner relies on furnace under house to prevent pipes from freezing. However, homeowner increased the droop offset and AMI data indicates increased use after controls were installed.

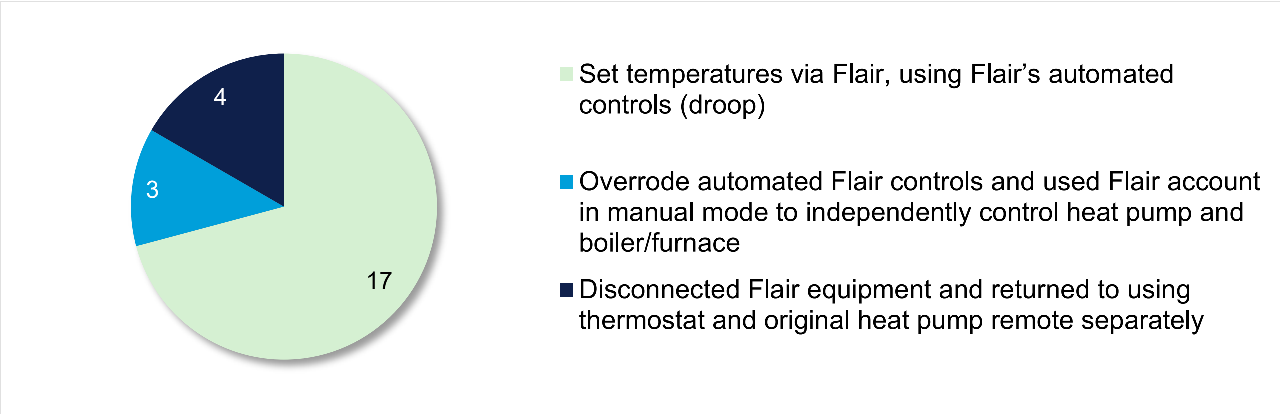
Site ID	Droop Utilized?	Heat Pump Usage Change	Home layout	Takeaway
IT084	Yes, 5 degree offset, outdoor temp trigger	Increased heat pump use	Single zone central system, heat pump in open living room/kitchen	Homeowner requested to change the supplemental heat trigger to outdoor temperature. Homeowner ultimately disabled the controls because equipment was running more than desired.
IT114	Yes, 5 degree offset	Increased heat pump use	Single zone central system, heat pump in living room, does not reach other areas of house. Thermostat in hallway near bedrooms.	Homeowner utilized droop with a 5 degree offset. Homeowner behavior did not change with controls (left setpoint alone all winter). AMI data indicates increased use.
IT116	No	N/A	Single zone central system.	Homeowner overrode Flair's automated controls and used Flair in manual mode to independently control the boiler and heat pump.
IT119	Yes, 5 degree offset	Increased heat pump use	Single zone central system. Open layout living/dining/kitchen, thermostat near heat pump.	Ideal candidate for droop because the main living area is a small open floorplan and the homeowner likes being able to use an app to control the temperature. Limited pre-controls metered data, but both metered data and AMI data indicate increased use.
IT124	Yes, 3 degree offset	Increased heat pump use	Single zone central system. Heat pump and thermostat in living room.	Ideal candidate for droop because the homeowner does not mind if the rooms outside of the heat pump zone stay cold (homeowner notes that bedrooms often 10 degrees colder than living room). Homeowner previously rarely used the heat pump in the winter and noticed a significant decrease in fuel use after implementing the controls.
IT133	No	N/A	Single zone central system, heat pump only serves 10% of home.	Homeowner disabled droop because the home layout did not allow for even heating without consistent use of the boiler. Homeowner added 1,000 square feet of house and an additional heat pump over the course of the study, contributing to the increased use observed in AMI data.

6.2 Typical controls strategies

The team initially programmed each home's droop settings to utilize the heat pump as primary heat, and the fuel system as supplemental heat, with a five-degree offset triggered by indoor temperature. With these settings, Flair prioritized the heat pump over the boiler/furnace, only calling for the boiler/furnace when the average home temperature dropped 5°F below the home's average setpoint. The boiler/furnace turned on in addition to the heat pump to bring the home temperature up, and then turned off once the home had reached the setpoint temperature.

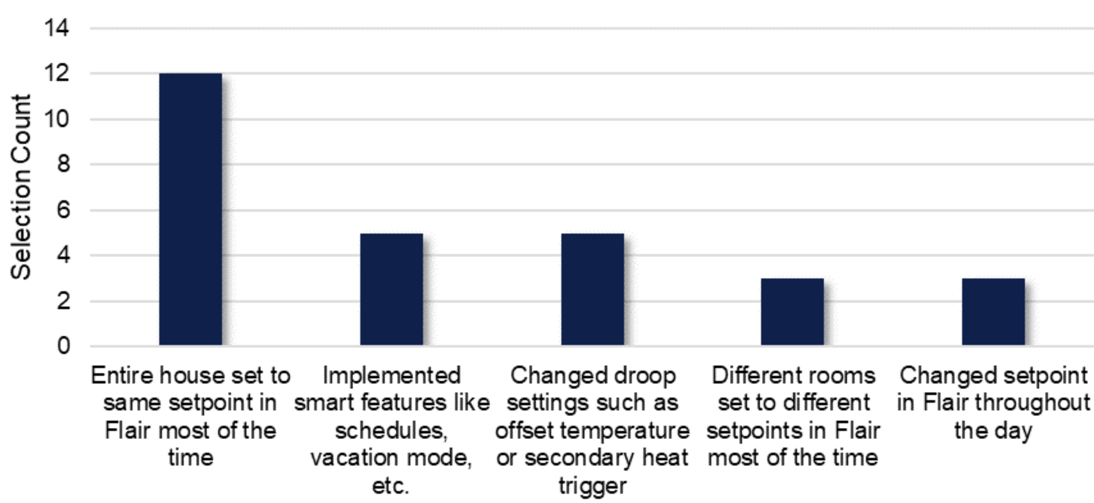
Homeowners were provided with the guidance to leave the droop settings as-is and leave their home at one setpoint as much as possible. However, homeowners are able to adjust their home's settings throughout the winter. According to the participant survey, most respondents continued to utilize droop, but some disabled droop and used the Flair account in manual mode, and others disconnected the Flair entirely.[5]

Figure 6-1. Participant survey responses to, "How did you use your Pilot Equipment and Controls over this past heating season?" (n=24)



Of the homeowners who used droop throughout the winter, five survey respondents reported changing the droop settings from what was initially programmed by the team (such as reducing the offset from 5°F to 3°F). Most participants left their setpoints constant, either setting the whole house to the same setpoint or setting different rooms to different temperature setpoints, but three respondents report changing the temperature setpoint throughout the day. Five respondents implemented smart features that would impact the home's setpoints, such as programmed schedules or vacation mode. One respondent did not answer the question.

Figure 6-2. Participant survey responses to, "How did you use your Flair account for heating after the Pilot Equipment and Controls were installed? Select all that apply." (n=17)



[5] If homeowners disconnected Flair or used Flair in manual mode, they are still using a new smart thermostat. In this study, smart thermostat savings are not differentiated from droop influence because the complete set up is treated as one integrated controls system.

6.3 Survey findings

Findings from both qualitative non-participant and participant surveys were aggregated and summarized in the following sections.

Survey results include an overview of the types of customers served by the program, including socio-demographic indicators and home and equipment characteristics, to identify the type of participant who would most benefit from the program and to determine if the pilot participants are an accurate representation of the eligible population across the state. We also highlighted trends and insights into customer perceptions and comfort using the technology, how to improve the participant experience, and key messages to increase homeowner interest and encourage participation. The results from the qualitative interviews focus on lessons learned, perceptions and experiences, and opportunities for improvement when scaling the program. Table 6-5 presents the survey disposition for the two surveys.

Table 6-5. Final survey disposition

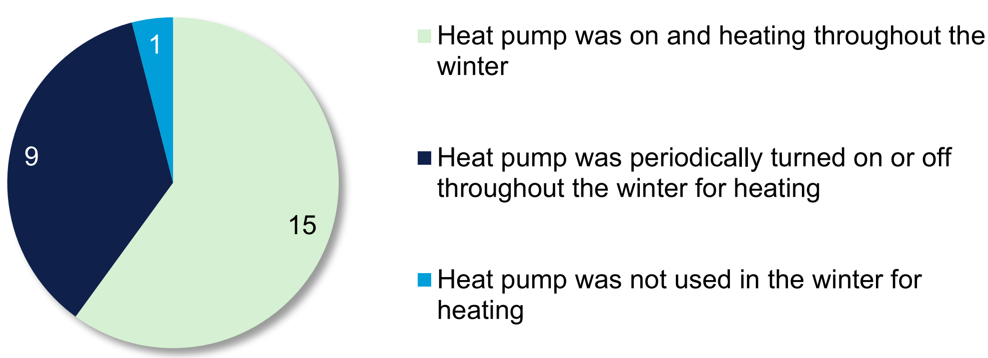
Disposition	Non-Participants	Participants
Total surveys sent	103	32
Received survey but did not complete	77	7
Completed survey	26	25

6.3.1 Participant survey

The participant survey focused on the customer experience with their heat pump and boiler operations, the integrated controller, and their perceptions about the effectiveness and impacts from the new control system. The following are highlights of the survey findings.

Prior to the integrated controls, most participants used their heat pump all winter. Participants were asked to describe their typical winter heat pump use prior to the study. All but one respondent indicated that they used their heat pump with some regularity for heating.

Figure 6-3. Participant responses to, "Before receiving the Pilot Equipment and Controls, how would you utilize your heat pump in the winter?" (n=25)



Prior to the integrated controls, some participants utilized night-time setbacks. Respondents were asked to describe their typical daytime and night-time setpoints for their heat pump and boiler/furnace. Responses indicate that 44% of respondents adjusted their heat pump setting at night, while 28% of respondents adjusted their boiler/furnace setting at night (n=25). Table 6-6 summarizes the night-time adjustment scenarios, and Table 6-7 presents the average daytime and night-time setpoints reported by respondents.

Table 6-6. Typical night-time adjustments prior to integrated controls

Boiler/Furnace Night-Time Adjustment	Count
Decrease setpoint 1-5°F at night	3
Decrease setpoint 5-10°F at night	3
Boiler/furnace off during the day, on at night	1
No change to boiler/furnace setpoint at night	18
Heat Pump Night-Time Adjustment	**Count**
Decrease setpoint 3-5°F at night	4
Decrease setpoint 5-10°F at night	2
Turn heat pump off at night	3
Increase setpoint 1-5°F at night	1
Heat pump off during the day, on at night	1
No change to heat pump setpoint at night	14

Table 6-7. Average setpoints prior to integrated controls

	Heat Pump	Boiler/Furnace
Average daytime setpoint (°F)	65.7	62.9
Average night-time setpoint (°F)	59.0	63.8

After the integrated controls were installed, 71% of respondents continued to use automated droop controls throughout the winter (n=24). Participant responses indicate that 17 homes used Flair's automated controls (droop) throughout the winter, three homes overrode Flair automated controls and used their Flair account in manual mode, and four homes disconnected the integrated controls and returned to using the heat pump and central thermostat independently, shown in Figure 6-1. One respondent skipped this question.

Reasons for disconnecting the equipment include:

- "I initially tried using the droop settings, but it caused portions of my home to be too cold due to the centralized location of the main thermostat, having a single hydronic loop and in conjunction with the heat pump only serving 10% of the home."
- "The equipment could not/did not regulate my house temp when the outside temperature was cold (15-20). When the systems were synced, I could not easily use the heat pump to dry the air."
- "The smart thermostat is cool; the Flair was not effective for my purposes."

After the integrated controls were installed, 48% of respondents perceived that their heat pump operated more often (n=24). Participants were asked if they noticed a change in their winter heat pump operation over the course of the study. Twelve respondents felt that their heat pump operates more often, eight respondents felt that their heat pump operates less often, and four respondents said they were unsure. One respondent skipped this question.

Participants were also asked about their perceived electrical consumption and money spent on electricity. The responses to these questions did not always match the perceived change in heat pump use: only 75% of the respondents who perceived an increase in heat pump use also perceived an increase in electrical consumption, and only 38% of the respondents who perceived a decrease in heat pump use also perceived a decrease in electrical consumption. The perceived change in money spent on electricity varies even more: Table 6-8 details the counts of each response pathway for this set of questions.[6]

Table 6-8. Perceived heat pump and electrical use response pathways

Perceived change in heat pump use	Perceived change in electricity consumption	Perceived change in money spent on electricity	Response count
More	More	More	8
More	More	Same	1
More	Less	Less	1
More	Not sure	More	1
More	Not sure	Not sure	1
Less	Same	More	1
Less	Same	Same	3
Less	Less	More	2
Less	Less	Less	1
Less	Not sure	Not sure	1
Not sure	More	More	3
Not sure	Same	More	1

After the integrated controls were installed, 46% of respondents perceived that their boiler/furnace operated less often (n=24). Participants were asked if they noticed a change in their winter boiler/furnace operation over the course of the study. 11 respondents felt that their boiler/furnace operated less often, 6 respondents felt that their boiler/furnace operated the same amount, 2 respondents felt that their boiler/furnace operated more, and 5 respondents said they were unsure. One respondent skipped this question.

Participants were also asked about their perceived fuel consumption and money spent on fuel. The response to these questions did not always match the perceived change in boiler/furnace use: 82% of the respondents who perceived a decrease in boiler/furnace use also perceived a decrease in fuel consumption, 67% of the respondents who perceived the same amount of boiler/furnace also perceived the same amount of fuel consumption, and only 50% of the respondents who perceived an increase in boiler/furnace use also perceived an increase in fuel consumption. The perceived change in money spent on fuel varies even more: Table 6-9 details the counts of each response pathway for this set of questions.

[6] Electricity prices increased during the study period, which may impact participant's perceptions of money spent on electricity.

Table 6-9. Perceived boiler/furnace and fuel use response pathways

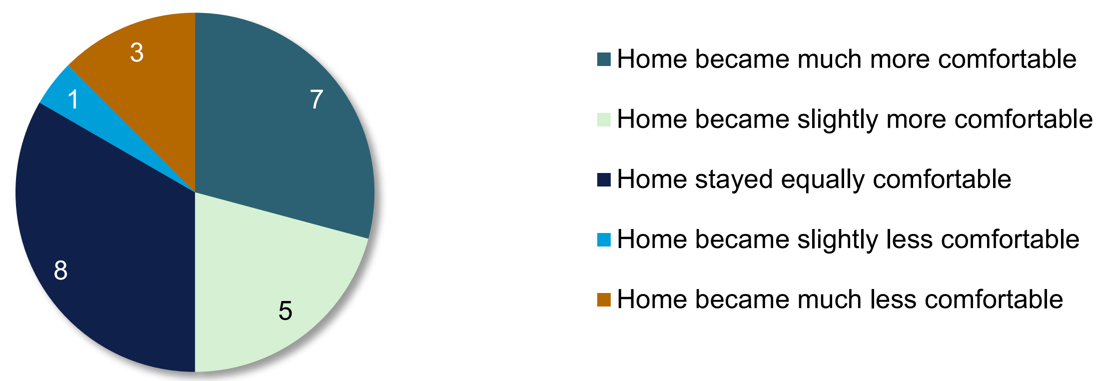
Perceived change in boiler/furnace operation	Perceived change in fuel use	Perceived change in money spent on fuel	Response count
More	More	More	1
More	Not sure	Same	1
Same	Same	Same	4
Same	Less	Less	1
Same	Not sure	Not sure	1
Less	Same	Same	1
Less	Less	Less	9
Less	Not sure	Not sure	1
Not Sure	Same	More	1
Not Sure	Less	Less	2
Not Sure	Not sure	More	1
Not Sure	Not sure	Not sure	1

When asked to elaborate on how their electric and fuel use has changed, responses included the following:

- "Fuel usage seemed to decrease, but electricity usage seemed to increase. I think our heat pump was used more often and our furnace less."
- "This is really tough to answer because during the pilot the cost of fuel went up significantly."
- "I don't believe they changed much since we primarily only used the heat pump prior to installation."
- "Electricity up by 50 percent; fuel decrease by 75 percent."
- "Really not sure. I suspect and hope we're using less oil."
- "Last year when outdoor temps went down to 20 or lower, I turned off the heat pump because I got too cold, however, I saved huge in fuel just the same. This year, I kept the heat pump on at all times so went from $90 elec to $227 elec and that was before the price hike. That was a big hike for me because the previous winter I had gone from $45 elec to about $95."
- "Often even in the dead of winter the furnace would run for maybe an hour a day, significantly less than in previous winters. Our electric bill did triple, but that was mostly offset by a lower natural gas bill."

After the integrated controls were installed, 50% of respondents reported that their home became more comfortable, and 33% of respondents reported that the comfort of their home stayed the same. Participants were asked if the comfort of their home changed since the integrated controls were installed. Twelve respondents indicated that their home became more comfortable, eight respondents reported no change in the comfort of their home, and four respondents indicated that their home became less comfortable. One respondent skipped this question.

Figure 6-4. Participant responses to, "How would you describe the difference in the comfort in your home since the thermostat and controls system was installed?" (n=24)



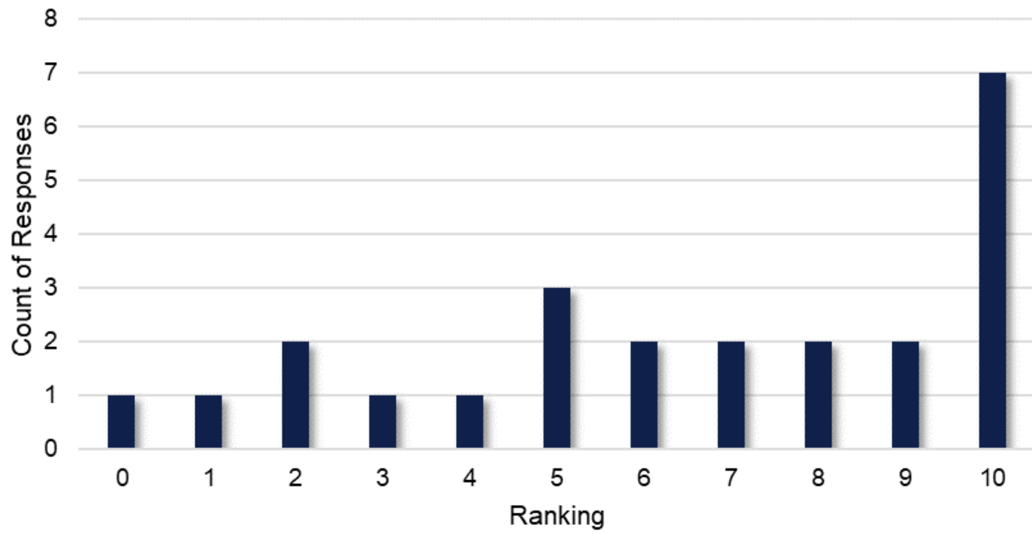
Of the 12 respondents who indicated increased comfort, four specifically mentioned using a warmer setpoint than before the integrated controls were installed. Other positive responses point to better balance and more even temperature throughout the home. When asked to elaborate on how the comfort of their home has changed, responses included:

- "I don't know if there was something special about the Flair puck, but for some strange reason I felt more empowered to turn the temperature up to where I was comfortable than I did when I was using the remote. Before the study, there were some evenings when I felt so cold that I would turn the heat pump off and turn the oil heat up."
- "Living room was a much more tolerable temperature in the winter as that is where the heat pump is installed. It did however struggle to maintain temps in our bedroom, likely because of the way our house is laid out. This sometimes meant a temp difference of 10 or more degrees from one end of the house to the other."
- "I don't have to mess with the thermostat like I used to."

Respondents ranked the ease-of-use of the integrated controls equipment an average 6.5 out of 10 (n=24). When asked to elaborate on their ranking, responses included the following comments, indicating a wide range of user experiences:

- "Flair was user friendly and intuitive. I found it pleasant to use."
- "Setting up the flair on the computer was a bit confusing even following the directions for someone who is very tech-savvy."
- "App is pretty self-explanatory."
- "I feel you need to have good computer skills to use it. Not everyone has that."

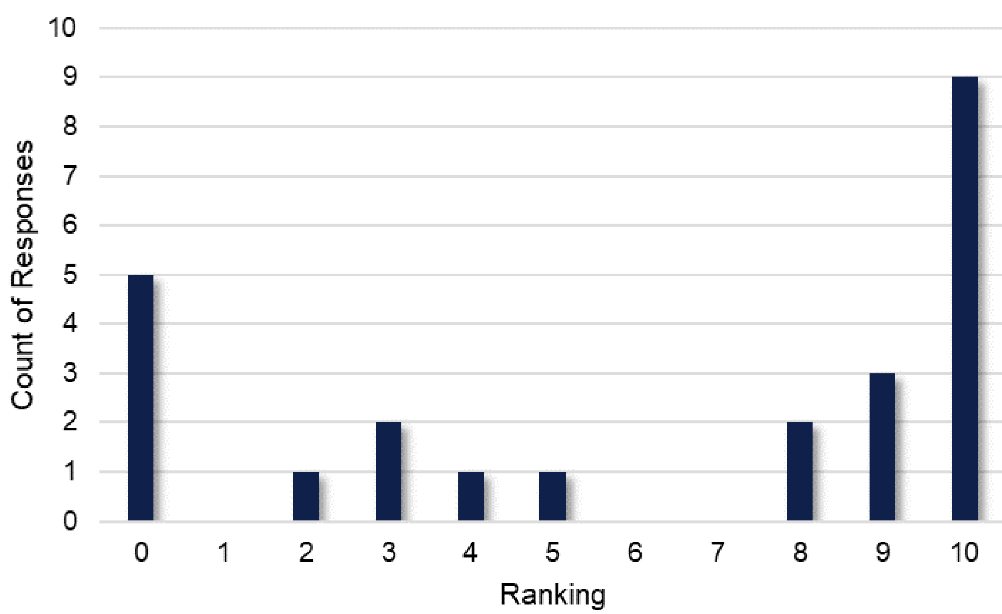
Figure 6-5. Participant responses to, "On a scale of 0 to 10, where 0 is not easy at all and 10 is extremely easy, how easy is it to operate your heating equipment with your Flair system?" (n=24)



Respondents ranked their likelihood of continuing to use the integrated controls equipment an average 6.3 out of 10 (n=24). When asked why, responses included the following:

- "Having the internet functionality was something I always wanted to have."
- "I really enjoyed it and the concept, I just wish the additional controls could be added to mimic the actual heat pump settings on the remote."
- "I'm optimistic that I can achieve similar results simply using the Ecobee and not the Flair."
- "Seems like more of a hassle since we only have one heat pump and one oil heating zone. The connection issues made it frustrating to change the settings immediately."

Figure 6-6. Participant responses to, "On a scale from 0 to 10, where 0 is very unlikely and 10 is very likely, how likely are you to keep the Flair controls system installed, and continue using it in your home?" (n=24)



6.3.2 Nonparticipant survey

The non-participant survey focused on how respondents used their heat pumps and fossil-fueled systems during the winter.

Most nonparticipants use their heat pump all winter. Respondents were asked if their home uses a heat pump throughout the winter for heating. Twenty-two respondents use their heat pump to heat their homes all winter, the remaining four use their heat pump for heating only part of the winter, while one said they do not use their heat pumps in the winter.

Most respondents use one or more additional heating systems to heat their homes in the winter. Respondents were asked if they use an additional heating system aside from their heat pump. Only one respondent exclusively uses their heat pump for heating. Of the 25 remaining respondents, most (14) use a boiler in addition to their heat pump.

Three of the four respondents who said they only use their heat pump for part of the winter, all use a boiler as an additional heat source. The remaining one uses an outdoor wood boiler with baseboards.

Table 6-10 shows the breakdown of heating system types that respondents reported using to heat their homes.

Table 6-10. Additional heating systems used by respondents (n=25)

Respondent #	Furnace (forced air) – fuel oil	Boiler – fuel oil	Boiler – propane	Electric baseboard heating	Radiant floor heating – fuel oil	Electric space heater	Fireplace or stove – wood/pellet	Outdoor wood boiler with baseboards
1		X				X	X	
2								X
3							X	
4		X					X	
5		X						
6		X						
7	X							
8					X			
9		X		X			X	
10					X		X	
11		X					X	
12		X						
13	X							
14	X							
15			X					
16	X							
17		X						
18		X						
19		X						
20		X					X	
21	X							
22	X							
23	X						X	
24		X						
25	X							

The respondent who uses their heat pump for only part of the winter and uses an outdoor wood boiler had this to say:

"The outdoor boiler is our primary heat, and by its nature it doesn't benefit us to run it low or skip days with it (since it's a pain to re-start). By nature of the heat pump, it doesn't work to heat downstairs (our heat pump is upstairs in our large open concept living area; downstairs are smaller, divided rooms so the heat pump would not work for them), so the boiler tends to be our only system. We only turn on the heat pump on especially cold days. Our primary use for it is AC in the summer."

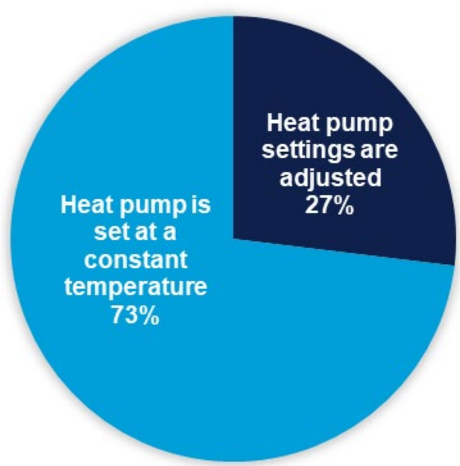
Most respondents consider their heat pump their primary source of heat. When asked which of their heating systems they consider their primary heat source, 16 of the 25 respondents say the heat pump is their primary heat source, eight of the 25 respondents said their additional heating system is their primary source of heat that they rely on, and one said they weren't sure which was the primary heat source.

Several respondents use wood stoves for supplemental heating. Nonparticipants who have additional heating systems were asked how they balance the usage between multiple heating systems. Several respondents said they use their wood stoves as supplemental heat in the winter along with their heat pump. One respondent said, "We rely on only the heat pump in spring and fall, and heat pump plus wood stove in the winter." Another said, "Wood is the cheapest and the heat pump helps keep other rooms that don't have the stove warm."

Other respondents noted that when the temperature outside gets too low, that is when they tend to rely on the supplemental heating systems. One said, "I use the heat pump until the temperature goes to 40 degrees and then the boiler is turned on." And another said "We use the heat pump until it's too cold for heat to reach outer rooms, then I rely on oil heat which I don't like to do. I'm still learning how best to use the heat pump." Another respondent said they only use the heat pump until the outside temp gets to 10 degrees or lower, then they rely on their boiler.

Most nonparticipants do not adjust their heat pump settings throughout the winter. Respondents were asked "Do you ever turn your heat pump down/off during the day, or do you use a constant setpoint throughout the winter?" Most (19) said that their heat pump is set at a constant temperature. The remaining seven adjust their heat pump settings. Figure 6-7 shows this breakdown.

Figure 6-7. Nonparticipant responses to, "Do you ever turn your heat pump down/off during the day, or do you use a constant setpoint throughout the winter?" (n=26)



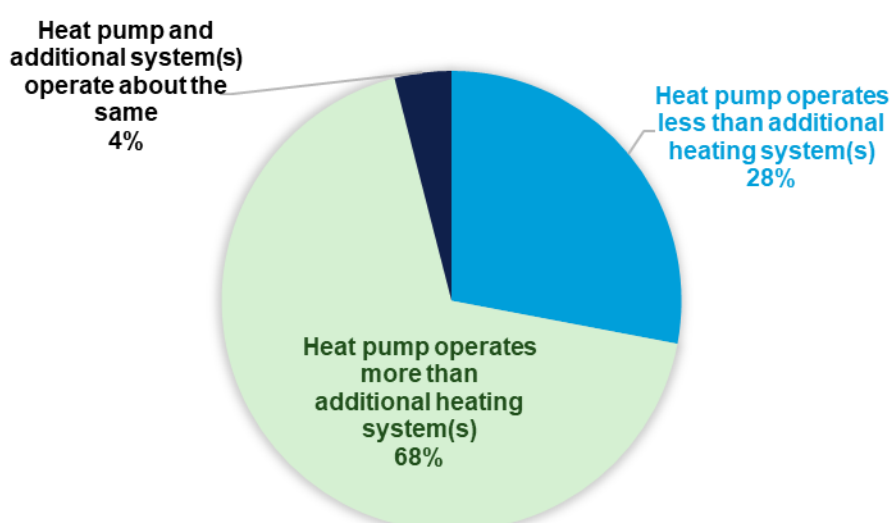
Respondents set their heat pump at a higher setpoint than their other heating systems in the winter. Respondents were asked to fill in a table providing the temperature at which they set their heat pumps and other heating systems throughout the week in winter. On average, respondents set their additional heating systems at a lower temperature than their heat pump. The range of setpoints provided for heat pumps was 58-74 degrees. The range for other heating systems was 58-70 degrees. Table 6-11 shows the average setpoints provided by respondents.

Table 6-11. Average setpoints for heat pumps and other heating systems in winter (n=25).

	Heat Pump	Other heating system
Weekday day	69.60	64.00
Weekday night	68.29	63.41
Weekend day	69.65	64.24
Weekend night	68.26	63.19

Nonparticipants largely use their heat pump more than their additional heating system(s). Respondents were asked how much they think their heat pump operates compared with their additional heating system(s). Seventeen respondents (68%) said their heat pump operates more than their additional system(s). Figure 6-8 shows the breakdown of responses.

Figure 6-8. Nonparticipant responses to, "How much do you think your heat pump operates compared with your additional heating system(s)?" (n=25)



Most nonparticipants are satisfied with the comfort of their home. When asked to describe the comfort of their home in the winter, 17 respondents replied, "just right," while the remaining 9 said "sometimes too cold." Some of the respondents who said their homes were too cold in the winter followed up with the following:

- "The heat pump alone can't adequately heat my house in the winter. If the sun is out or the wood stove is going, I'm fine, but the heat pump alone doesn't quite do it."

- “My home is drafty. I've had the attic insulated but walls are not insulated in most places. My home has small rooms and the heat from heat pump does not reach the bedrooms or living room well. The heat pump is located in the dining room / kitchen area. I have two heat pumps, one on each floor. I barely use the second-floor heat pump.”
- “The heat pump is great but not enough to heat the house during the winter. We could use one or two more units.”

They were then asked if parts of the home are harder to keep comfortable than others. Sixteen responded “yes,” and the remaining 10 responded “no.” For the most part, the respondents who said yes explained that the areas farther from the heat pump are the hardest to keep warm. Some follow-up quotes from respondents:

- “I turn on electric baseboards in unused bedrooms when visitors come. There is only electric heat upstairs not oil. Only one heat pump and it doesn't cover upstairs.”
- “The living room is too far from the heat pump.”
- “The further from the heat pump the cooler the room. I leave doors open between rooms.”
- “The office and upstairs are not sufficiently heated with the heat pump; we have some electrical heaters going to keep us comfortable.”

All respondents are satisfied with their heat pumps. Respondents were asked to describe their satisfaction with their heat pump overall. Eleven respondents said “satisfied,” and the remaining 15 said “very satisfied.” Even a respondent who said their home was sometimes too cold in the winter said they were “very satisfied” with their heat pump.

Some quotes from the “very satisfied” respondents:

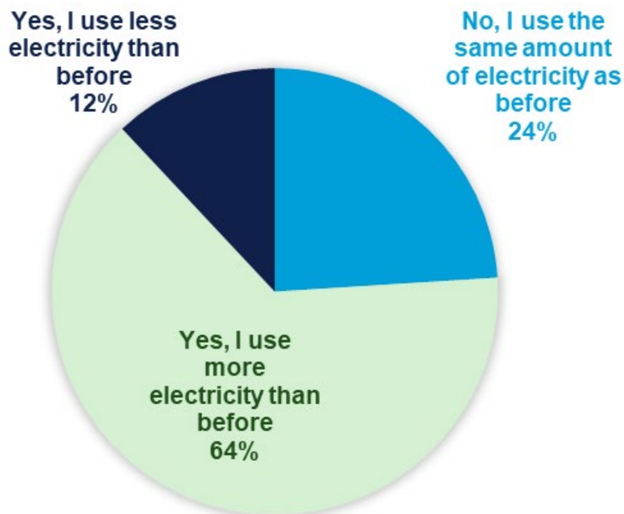
- “It is amazing. So easy to use and it responds immediately to our needs.”
- “Reduces my oil use/cost while keeping house comfortable and is AMAZING at cooling the whole first floor during heat waves! With very little change in electric bill.”
- “Heats and cools effortless, and at significant cost savings.”
- “Cheapest way to heat my house, and less work. I stopped burning wood also.”

Some quotes from respondents who responded “satisfied”:

- “It keeps the house reasonably heated while I'm away and overnight. That was not true of the wood stove alone. I also have PV panels on the roof, so I generate a lot of my own electricity for running the heat pump. Dry mode is nice on some summer days.”
- “It helps to warm up my first floor in the Fall delaying the need to turn on the oil burner. It warms the house well enough so that I can turn off the oil burner sooner in the Spring. It provides comfort on cool days, and it has saved me through the last two summer's heat waves and during this current heat wave.”
- “I appreciate the regulation of constant heat and cooling in Summer. The areas that are difficult to cool or heat pose a problem, but a second heat pump is likely required.”

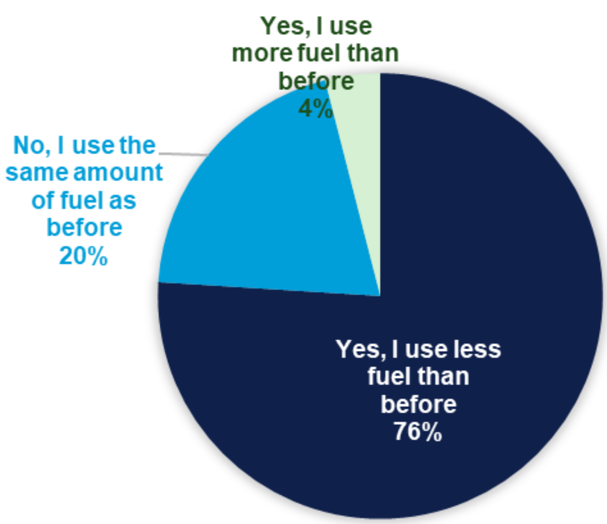
Most respondents say they use more electricity since their heat pump was installed. Respondents were asked if they’ve noticed a difference in their electricity consumption since the heat pump was installed. Most (16) respondents said that they use more electricity than before. Figure 6-9 shows the breakdown of responses.

Figure 6-9. Nonparticipant responses to, "Have you noticed a difference in your electricity consumption since the heat pump was installed?" (n=25)



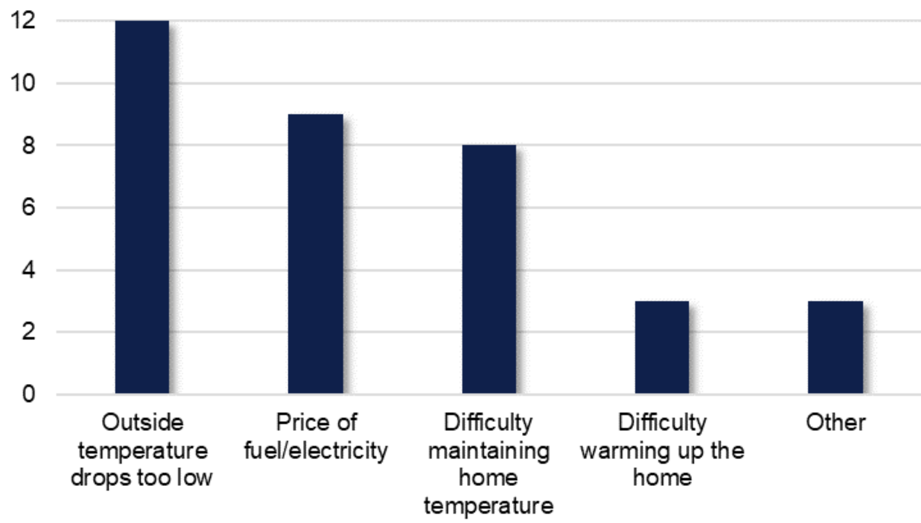
Most respondents believe they are using less fuel since their heat pump was installed. Respondents were asked if they've noticed a difference in their fuel consumption since the heat pump was installed. Most (19) said they use less fuel now, and only one said they use more. Figure 6-10 shows the breakdown of responses.

Figure 6-10. Nonparticipant responses to, "Have you noticed a difference in your fuel consumption since the heat pump was installed?" (n=25)



Low outdoor temperature prevents customers from using their heat pump as much as they would like. Nonparticipants were asked if there is anything preventing them from relying on their heat pump more than they otherwise would. They were given a list of possible reasons and were asked to select all that apply. The outside temperature dropping too low was the most often cited reason that respondents are not using their heat pump as much as they otherwise would. Figure 6-11 shows the breakdown in responses.

Figure 6-11. Nonparticipant responses to, "Does anything prevent you from relying on your heat pump more than you otherwise would? Please select all that apply" (n=26)

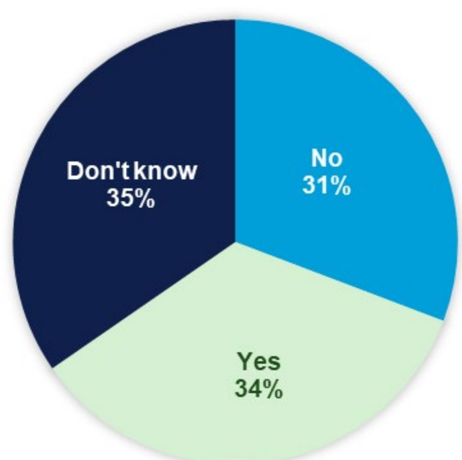


The three respondents who chose "other" had this to say:

- "I need a way to tie a heat pump to a baseboard system."
- "I used it 100% the last 2 winters". This is the respondent who does not have an additional heating system.
- "House is on a slab with plumbing running in the baseboard heater registers to keep it from freezing. If the heat pump keeps the boiler off the pipes freeze"

There is no consensus among nonparticipants on whether relying on their heat pump more would save money. Respondents were asked if they felt relying on their heat pump more than they currently do would save money. Answers were split relatively evenly between "yes," "no," and "don't know." Figure 6-12 shows the breakdown of responses.

Figure 6-12. Nonparticipant responses to, "Do you feel relying on your heat pump more than you currently do would save money?" (n=26)



Quotes from respondents who said “no”:

- “Because I still would have to purchase 2 cords of firewood to be comfortable in the coldest months.”
- “Cost has gone up of kilowatts used”

Quotes from respondents who said “yes”:

- “Oil prices are very high.”
- “I have heat pumps in a commercial building, and I know they are more efficient than oil.”

Quotes from respondents who said they didn’t know:

- “I'm not sure what my electric bill would go up to, and how that would be offset by not needing to buy wood.”
- “I haven't lived here long enough to do a comparison. Plus, the price of heating oil and the price of electricity have skyrocketed!”

7 EVALUATOR OBSERVATIONS

This section addresses the challenges encountered in the implementation of this pilot and reviews observations, conclusions, and lessons learned by the evaluation team.

7.1 Challenges

The pilot encountered significant challenges once the initial research phase was completed.

- The research phase identified three technologies but as described above, the final pilot was only able to test one control technology, the Ecobee Smart Thermostat + Flair Puck Pro.
- The equipment was not compatible or ideal in all homes. Issues impacting successful implementation included:
  - Existing HVAC equipment in some homes controlled by two-wire thermostat but smart thermostats need three-wires requiring an electrician for installation
  - The layout of the home limited the situations where the controller would work successfully. If the heat pump did not reach all areas of the home, the controller would not work effectively.
- A learning curve was necessary to master the controller installation process. A vendor could be trained to install this product, but most homeowners would face challenges installing the controller themselves.
- DNV site personnel were in constant contact with Flair throughout the process for technical support. Program scale implementation of this technology would require a designated contact to interface with the vendor and troubleshoot for customers.
- The ideal use case for this technology as described in Section 7.2 is so narrow that full program implementation would be difficult, time consuming and costly. Customers have varying preferences and often add space, equipment or change home configurations creating challenges for successful long term implementation.
- The original plan was to conduct M&V on 60 sites but due to equipment issues and the pandemic, the final site count was reduced to 31.
- The pandemic created a major shortage of available electricians and HVAC technicians to provide equipment installation support. As a result, the recruitment process extended from 2 months to over 9 months. DNV and Efficiency Maine agreed that the baseline data collection was not an option for most sites and moved ahead with installing the controllers and meters in the summer of 2021 for most sites.
- Inability to collect significant baseline information – The pilot anticipated that the on-site M&V would provide baseline energy usage for each site, as well as a post-measure implementation energy usage, allowing the team to calculate site-specific kW, kWh, and fuel Btu savings; however, timing limited the baseline data collection and thus limited the results.
- Homeowner preferences and challenges with the technology caused some customers to change their droop parameters or disable the controls entirely. This required extensive back and forth with the customers and with the vendor, Flair, to educate customers on the process and attempt to find settings that met the homeowner’s needs. In some cases, the settings used by the homeowner vary from what was initially programmed, as indicated in Section 6.
- Billing analysis of delivered fuels provided limited usefulness. Most of the delivered fuel was fuel oil and deliveries are sporadic throughout the year. It is not possible to develop a meaningful analysis of the impact of the controller and heat pump operation on delivered fuel usage based on this type of analysis.

7.2 Conclusions/lessons learned

Technology works best when the heat pump zone overlaps significantly with the central heating system zone controlled by the smart thermostat.

- The heat pump can only effectively displace fuel in areas where it can provide heat. Houses where the heat pump only reaches a small portion of the house, or does not serve the most-used rooms, are not good candidates for droop.

Technology works best when the smart thermostat is located in the area of desired control.

- Droop uses the temperature readings from the Puck and the Ecobee thermostat to determine when to call for supplemental heat.[7] A room or area of the home without any temperature sensors will not be included in the supplemental heat algorithm, which may cause that room or area to become colder than desired.
- Example: a home has a heat pump in the living room, and the thermostat controlling the boiler is also in the living room. Often, the heat pump will be able to maintain the living room setpoint, so the temperature reading for both the Puck and the thermostat will be near the setpoint, and droop will not call for supplemental heat from the boiler. As a result, bedrooms on the far end of the house which are only served by the boiler will become much colder than the living room.

Technology works best when the homeowner wants the whole home around the same temperature.

- Droop uses the average setpoint across rooms and average current home temperature to determine when to call for secondary heat. In cases where the homeowner wants to use the heat pump separately from the central system (such as a heat pump serving an office room that only needs to be heated when it's in use), droop will not allow for independent control of the heat pump and boiler/furnace.

Customers in this study have not recognized the need for these types of controls yet.

- Some participants in the study expressed interest in the ability to control their HVAC systems via app, but a larger number of participants in this study saw no benefit of using an app over the manufacturer's controls or found it frustrating to do so.
- Implementing an integrated controls system inherently involves giving up manual control of the HVAC systems. Droop allows the homeowner to specify an overall home setpoint (or individual room setpoints), rather than specifying the individual heat pump and boiler/furnace setpoints. Many participants expressed frustration or confusion at this difference because they were accustomed to sending specific commands to the heat pump and boiler/furnace.

Implementation of any type of program based on installing this control equipment will be very costly.

- Variability in types and configurations of HVAC equipment present challenges to implementation. Many existing HVAC systems in the study demographic are controlled by a two-wire (battery powered) thermostat. Smart thermostats require a three-wire connection (requires C-wire to power thermostat). The installation process to accommodate this wiring is beyond the comfort level of many homeowners, so a professional HVAC technician will be required for most installations.
- A program based on this type of equipment will be most successful if it includes a thorough vetting process, because the success of the technology is highly dependent on the home configuration and homeowner behavior.
- A program based on this type of equipment will be most successful if it includes a large customer education component. Although the technology used in this study is available at the retail level, many homeowners required training and troubleshooting beyond the customer manual. The most time was spent with homeowners who were uncomfortable with learning new technology or whose home configuration was not ideal for droop.

[7] It is possible to add additional temperature inputs to the Flair system to achieve better balance. In this study, homeowners were offered Ecobee Smart Sensors to place in the areas of the home that were of highest priority for control.

Quantifying whether fuel savings make up for increased electricity use will be very challenging.

- Because delivered fuels are delivered in batches, several heating seasons of data would be necessary to quantify decreased fuel cost as compared to increased electrical cost. The variety of heating systems and home layouts contributes to this uncertainty. The participant survey response pathways in Table 6-8 and Table 6-9 illustrate how uncertain the comparative savings can be from a user's perspective.

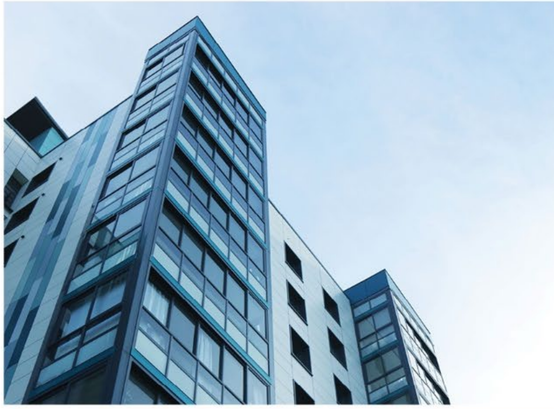
Some changes from smart thermostat may be separate from droop influence.

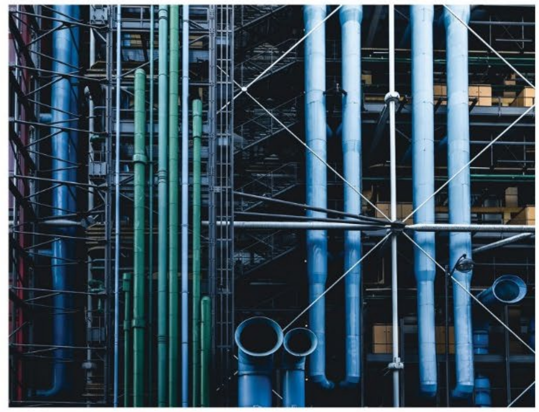
- Some customers indicated that they liked being able to control their HPs from their phones and this capability may have affected the measured HP usage outside of the controls system influence.

AMI results are useful for showing trends.

- In most cases, the AMI analysis agrees with the direction of change per metered data. AMI data alone is less reliable for the specific magnitude of the change, but the value of showing overall trends and ease of data acquisition point to the value of this tool in assessing program performance.

APPENDIX A. INTEGRATED THERMOSTAT TECHNOLOGY: PHASE I RESEARCH MEMO



Integrated Thermostat Technology: Phase I Research Memo

Prepared for

Efficiency Maine Trust
168 Capitol Street, Suite 1
Augusta, ME 04330

MSA #20200023

Prepared by

Energy & Resource Solutions, Inc.
120 Water Street
North Andover, MA 01845

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Revision 3: November 30, 2022

1 TECHNOLOGY RESEARCH

This report is the first deliverable for Efficiency Maine Trust's (the Trust) Integrated Thermostat Pilot Study. This project involves the identification of thermostatic control options that provide optimized control of ductless split heat pumps (HPs) and existing combustion heating equipment in residential buildings. The first phase of the study, as summarized in this report, was to research and identify existing thermostat technologies to use in this pilot effort. A total of four technologies are recommended for implementation in this pilot study, as detailed in the following sections.

The second phase, a pre-post M&V analysis consisting of billing and AMI analysis, as well as on-site data collection and customer satisfaction surveys, will be detailed in an M&V plan that was delivered in February 2021 and a final report, currently scheduled for delivery in July 2022.

1.1 Response to Comments from Efficiency Maine Trust

The draft version of this report was unclear on a few points, so the Efficiency Maine team requested a specific follow-up on several questions. The answers to these questions are below.

1. What would the timeline be for these technologies to be ready for implementation?
    a. The Flair Puck system is ready to go right away. Additional programming points beyond what is currently offered as a default (e.g. droop, which is not currently programmed to meet the exact criteria for the program) may be requested from Flair, and the expected turnaround time is 1-2 weeks.
    b. The Resideo system is ready with all requested controls off the shelf.
    c. The Jackson system is ready to go, though some in-field adjustment of settings may be required.
2. What is the forced changeover point recommendation, and is it necessary or any systems to operate beyond the droop requested?
    a. We do not believe that a lockout of heat pump equipment is required for the heat pump systems, assuming that the droop controls are properly configured. Remote temperature sensors are also bundled with all of the recommended technologies, which will further aid in maintaining comfort and safety in the home with the backup equipment.
    b. The Resideo and Flair systems are currently configured to have heat pump equipment lockout at low temperatures (down to -15F in the case of the Flair system) but this could be disabled if requested.
    c. The Jackson system does not have a heat pump equipment lockout.

3. What would it take to disable controls as a fail-safe if we absolutely needed to?
   a. The Flair Puck system can be disabled if necessary using settings within phone app, or on behalf of a customer remotely using a support agent.
   b. Resideo is set up to require an installer code to access the settings, but a homeowner could be given this code over the phone by support staff.
   c. The Jackson Systems thermostat would not be able to be remotely disabled.

1.2 Phase I Research Goals

The FSEC, Dunsky, and ERS research team (the Team) had several objectives for this phase of the pilot study:

- Identify potential technologies for controlling both single-zone HPs and existing combustion heating equipment in a residential building.
- Research the technologies to assess whether they meet the essential requirements for this pilot study as set forth in the work plan.
- Identify installation requirements for implementing each recommended technology and develop a recommended deployment strategy for the study.
- Analyze existing customer data to characterize the target population.
- Develop a recruitment questionnaire based on technology implementation requirements and other parameters to ensure a successful pilot.

The following sections discuss the candidate technologies that the Team considered.

1.3 Pilot Technology Requirements

Perhaps the most critical task for the research phase was the determination of whether each candidate control technology met the key control requirements as set forth by Efficiency Maine. These technology requirements are:

- **Essential Requirements –** Must all be met for a technology to be considered.
  - Designate one thermostat to be a sole point of control and integration for a single-zone heat pump and a central heating system in a home.
  - Prioritize the heat pump using a temperature droop above the central system and maintain the priority regardless of temperature adjustment at the thermostat. Prioritization is locked out and cannot be modified by the participant.

- Be compatible with heat pumps required by the Trust's Tier 2 program, which include AHRI[1]-rated HSPF[2] of 12.5 or greater, a single wall-mounted indoor unit, and a home that is not served by natural gas.

- Optional Features – Represent additional functionality that may improve customer satisfaction.
  - Company has worked on previous, similar energy efficiency or demand response programs.
  - Equipment allows for control and measurement of multiple zones.
  - Equipment includes a built-in energy meter.
  - One or more of the controllers is "smart"; that is, it learns behavior and automatically adjusts controls to save energy.
  - Platform can also be used for demand response programs.
  - Technology is Wi-Fi enabled and/or uses a phone app for control.

HP can be locked out at very low outdoor air temperatures, typically ≤ -15 °F.The Team collected the results of the technology-specific research into a decision matrix, which is provided as an appendix to this report. Further details about the research process and each technology's features may be found in the following sections.

1.4 Research Details and Approach

Effective integrated control of a HP and an existing central heating system involves operating the HP as the primary heating system and only allowing the central system to activate when the HP is no longer capable of providing the desired comfort, efficiency, or economic objectives. This changeover is based on three conditions:

- Inability of the HP to maintain a desired minimum temperature in the zone in which it is installed. Integrated controls allow a heating set point "droop" to be programmed, which represents the number of degrees below a desired set point the space temperature needs to reach before the control activates the central system.
- Inability of the HP to function efficiently due to low outdoor temperatures. Integrated controllers allow an "outdoor temperature changeover" to be programmed, which represents an outdoor temperature below which the HP operation can be locked out and the central system be allowed to operate. Many controls also allow a changeover

[1] Air Conditioning, Heating, and Refrigeration Institute
[2] Heating seasonal performance factor

temperature to be programmed that represents an outdoor temperature above which the central system can be locked out and the HP allowed to operate.

- Inability of the HP to maintain a desired minimum temperature in a zone(s) of the home other than the zone the HP is installed in. Some controls permit the temperature to be sensed in multiple zones with wireless temperature sensors and utilize either an absolute or averaged temperature in determining if the programmed droop condition has been met.

Installing integrated control products often means hardwiring controls to the HP and central heating systems, akin to traditional thermostat installation. Some integrated control products offer wireless connectivity with the HP that ease installation constraints, generally by mimicking the signal sent by the HP remote control or by cloud based/wi-fi connectivity and smart phone integration. When installing modern, integrated control products on some older central systems, one consideration is that some newer control products require a common wire, or "C-wire," to provide a continuous supply of 24 VAC power to operate touch screen displays, wi-fi capabilities, etc. Some older central systems do not have a C-wire and may require a new thermostat wire to be run unless a conversion kit is available.

1.5 Candidate Technologies

As mentioned in section 1.3, the pilot has some cutting-edge requirements that were not easily fulfilled in the existing market. This led the team to perform a technology search to weigh different options. In total, we identified 12 mini-split heat pump and furnace controller companies to inquire about their product's viability for the pilot. We contacted 8 of the 12 companies.

To best select the most viable technology candidate, we created a technology selection matrix in Microsoft Excel to best compare options. This selection matrix, with notes about the technologies, is provided in the appendix.

1.5.1 Selected Technologies

The following sections include a high-level description of the technologies reviewed. There are four technologies that the team recommends testing and one additional technology that fits all requirements but is not yet available at the time of writing. The technologies that we recommend testing are detailed more closely in this section than are the technologies that we deemed to be less fit.

1.5.1.1 Ecobee Smart Thermostat + Flair Puck Pro

This selection uses a Flair Puck Pro as a HP controller along with an Ecobee Smart Home Thermostat control for the central system. In addition, Ecobee temperature sensors are included to ensure comfort.

The Puck is a universal HP controller. It mimics the IR signal of the manufacturer's remote control so it should work with most brands of HP. The Puck has an existing integration with Ecobee through its cloud API that will be updated to include the droop control. The Puck Cloud API can control the system to ensure droop and outdoor temperature lock-out requirements. The Puck will sense temperature in the space and will prevent the central system from activating through the Ecobee unless the droop condition is met.

The participant touch point would be at the Puck. The participant will set their desired comfort level by inputting a set point either directly on the Puck or by using the Puck app. The integration could not fully lock out the Ecobee setpoint, but if any changes are made by the participant on the Ecobee, the system will revert to pre-set settings after a few minutes. The participant will be locked out from changing the droop setting on the Puck.

The team spoke to Dan Myers, CEO of Flair, during the process. Dan was well informed and quickly understood the requirements and potential challenges of the project. He was also willing to make changes to Flair's platform and algorithms to conform to the requirements of the project. In addition, Flair has worked with utilities on similar projects, including for MassSaves. He also knows some EMT staff members.

The total cost for the equipment per participant home is estimated to be around $400. This includes a Flair Puck Pro, two Ecobee remote sensors, and an Ecobee thermostat. Flair encourages training for the system install. With training, they estimate a total system install time of around 30 minutes.

Recommendation: **The team suggests testing this option in 27 homes: 4 at high rigor, 8 at medium rigor, and 15 at low rigor.**

1.5.1.2 Resideo

The Resideo T*x*[3] controller and Resideo D6 HP controller would be the principal technologies for this setup. These devices will fulfill all requirements of the pilot. This technology has the advantage of coming from one manufacturer, which should lower any integration challenges.

The D6 controller is similar to the Puck; it mimics the IR signal of the HP. It is also manufacturer agnostic, so it should work with most heat pumps. Resideo products are integrated through the Resideo cloud API and already include the droop control feature. The Resideo temperature sensors sense temperature in the space and will prevent the central system from activating

[3] Eligible controllers are the T5, T6, T9 and T10

unless the droop condition is met. According to the representative, this technology can be easily retrofitted into existing HVAC systems, and the interface was designed to create a user-friendly and curated experience.

The placement of temperature sensors for Resideo will depend on the house plan. There should be a remote temperature sensor in the master bedroom and possibly other occupied spaces if they are not located near the central thermostat.

Resideo is controlled by its Total Connect Comfort app. If homeowners have the app, they will be able to change its settings. Efficiency Maine could withhold the app from the homeowners, but as it's readily available from the Apple App Store or Google Play, there is no guarantee than some homeowners will not attempt to change the settings.

The team's conversation with Resideo was quite positive. The representative quickly captured the requirements and potential challenges of the project. The company is also a large, well-established business with 14,500 employees. (Resideo is a Honeywell spin-off.) Lastly, it is doing a few similar DR programs in Australia and Northern Europe.

This configuration is expected to cost somewhere around $350 USD for the two controllers and two remote temperature sensors. The install time is expected to be about an hour for a trained installer. Resideo has a Maine contractor (Hometown Heat Pump) that is on the EMT approved list and is trained to install this technology. Resideo's contact at Home Town Heat Pump is Darren Webber.

Recommendation: The team recommends testing this option in 27 homes: 4 at high rigor, 8 at medium rigor, and 15 at low rigor.

1.5.1.3 Jackson Systems

Jackson Systems makes a thermostat that is a good candidate for controlling both the mini-split ductless heat pumps and a central furnace or boiler. Its UT32 "Titan" thermostat has features suitable for this application: It has a programable differential or droop that can bring on a central heating system after the temperature falls below the thermostat set point. This temperature range can be adjusted between 1 and 10 degrees. It can have input from an outdoor temperature sensor to cut out the heat pump at a temperature where it is no longer efficient. Also, it can be configured with multiple indoor temperature sensors that can sense and average temperatures in other locations in the home.

To work, this thermostat would need to be paired with one of the 24V thermostat adapter kits available from many mini-split heat pump manufacturers. The connection between these could be hardwired or it could use a wireless relay designed for heat pumps. Jackson Systems' iO WR HVAC relay could be used.

In its normal operation, the UT32 does not allow for the simultaneous operation of a heat pump and a conventional heating system. As ducted heat pumps can have their evaporator/condenser coil in the discharge airstream of a furnace, hot air from the furnace would cause problems with heat pump operation. This, of course, would not be the case with a ductless heat pump. Jackson Systems says that there is a workaround using a jumper and a relay.

The remote temperature sensors are hardwired, making them somewhat more difficult to retrofit. Also, if a remote indoor temperature sensor is used, the sensor inside the thermostat itself is disabled. However, if it is desired to sense temperatures both at the thermostat location and at remote locations, a remote sensor can simply be located next to the thermostat.

The retail prices for the UT32 thermostat, the iO WR relay, and the remote sensor are $90, $165, and $23, respectively. A 24V interface kit is expected to cost approximately $150, bringing the total per-site cost to $428. Direct-wired homes could omit the remote sensor and WR relay, bringing the cost down to $240 per site.

Recommendation: Because only specific homes will have an optimal configuration for this type of control and given the potential for this type of system to include fewer features than the other recommended systems, the team recommends testing this option in 6 homes: 2 at high rigor and 4 at medium rigor.

1.5.2 Potential Technology

The technologies listed below were reviewed by but are **not recommended** by the team T These technologies each have limitations that may be overcome by the manufacturer in the future, or that may be sufficient in some homes.

1.5.2.1 Daikin

The Daikin One+ thermostat is designed to primarily control Daikin brand equipment, including its HP products, and would provide overall system integration. Two accessories can be controlled by the thermostat through the auxiliary terminals, including an auxiliary heating system. The thermostat set-up enables the heat pump to be selected as the primary heat source with a central system set up as the auxiliary, or secondary, heating system. Changeover from primary to secondary heat can be programmed based on droop and/or an outside temperature band. This programming can be protected from participant tampering with an installer code.

The Daikin One+ must be hardwired to the mini split. Participants will control their comfort by entering a heating set point either directly on the unit or by using an app. The Daikin One+ will activate auxiliary heat through a control signal sent to a relay. This system does not allow for remote temperature sensing in other zones. The Daikin One + thermostat will likely be installed in the same zone as the heat pump and not sense temperature in other zones. This is a major limitation and sites will need to be selected carefully to minimize possible temperature differences throughout the home.

The expected price of the Daikin One+ Thermostat is approximately $500 per home.

Recommendation: **Due to EMT's concerns about implementing a solution that may not meet the needs of study participants, we do not recommend that the Daikin One+ system is implemented as part of this study. However, as the sole manufacturer-specific control system that met the other needs of the project, we recommend communicating with Daikin to see if its control system may be improved for use in Maine in the future.**

1.5.2.2 Flair Puck Pros + Flair Relay

This technology consists of two to three Flair pucks and one Flair central relay, which integrates with the central heating system. With the central relay, this system bypasses the need for a central system controller such as an Ecobee. If implemented correctly, this setup could lead to a simplification of installation, lower equipment costs, reduced acquisition logistics, and a more straightforward participant interface.

Flair is currently developing the relay, which should be complete in the next few months. The company stated it would love to test this technology in this pilot. Estimated costs for the system would be around $350-$400 dollars per home. The system includes three Flair puck Pro's (two as remote temperature sensors) and the Flair relay.

Recommendation: **If Flair is able to produce a few working models, we suggest that this setup could be tested in a small sample of homes replacing the Ecobee+Flair configuration recommended in 1.4.1.1; however, the control may not be available during the timeline for this project.**

1.5.2.3 Sensibo

At first, The Sensibo Sky smart HP/AC controller was an exciting option as Sensibo is a market leader in the smart HP/AC controller space and its product works with almost all heat pumps. However, we are not recommending it due to a lack of integration with a central system controller, such as an Ecobee. The company has this integration in the works but there is no guaranteed timeline. In addition, in our various conversations with its representatives, they seemed interested to be part of the project and to fulfill the technical requirements. However, they were unenthusiastic about the size of the project and needed a minimum guarantee of volume to move forward.

1.5.2.4 Mitsubishi

Mitsubishi offers its Kumo Cloud control platform that can be set up as an integrated control. A mini-split heat pump can be connected to the cloud via a wireless interface, enabling a participant to control their comfort by entering a heating set point via an app. An auxiliary heating system can be hardwired into the Mitsubishi Kumo Station and activated based on a droop and/or outdoor temperature band that is programmed via an app. The system can also support Mitsubishi wireless temperature sensors for consideration of temperature in other zones in the home.

While functional, this system has not been recommended due to the cost, which is estimated to be >$1,000 per install. Mitsubishi does offer a low-cost, hardwired relay that can send a control signal to activate an auxiliary heating system based on droop; however, the droop is fixed and not programmable.

1.5.2.5 Fujistu

Fujitsu offers thermostat interfaces that will allow its mini splits to be controlled by third party, dual fuel thermostats. Fujitsu also offers a product that will allow its mini splits to be controlled according to outdoor temperature. However, despite repeated efforts to contact the manufacturer to discuss this control option, the team was unable to confirm that this technology would be able to meet the Efficiency Maine program requirements.

1.5.2.6 Other HP Controllers Companies: Tado, Cielo, Air Patrol, AmbiClimate

The team contacted these other HP smart controller companies: Tado, Cielo, Air Patrol, and AmbiClimate. None were as viable as the Sensibo and Puck due to a combination of factors, including: No response from the company, no open API or integration with a central controller, and not always available on the American market.

1.6 Recommended Equipment Configuration

Table 1 provides an overview of the recommended technologies for the pilot study.

Table 1. Recommended Technology Overview

Technology Type	Equipment Cost	High Rigor	Medium Rigor	Low Rigor	Technology Notes
Ecobee + Flair Smart Puck Pro	$400	4	8	15	Compatible with all systems.
Resideo T9	$350	4	8	15	Compatible with all systems.
Jackson UT32	$428	2	4	0	May not be compatible with all homes; select carefully.
Total		**10**	**20**	**30**	**60 Sites Total**

2 CUSTOMER RECRUITMENT SURVEY

Prior participants in Efficiency Maine's Home Energy Savings Program who received a single-zone Tier 2 heat pump rebate will make up the target pool of this pilot. The M&V team should be able to find participants in all areas of the state, though of course the most densely populated areas will likely be more strongly represented.

The customer recruitment survey has been deployed at the time of writing this edited draft. The questions that were included are provided below.

1. Do you still live in Maine?
2. What fuel(s) do you use for heating your home?
3. What type of heating system(s) do you use?
4. How many thermostats (heating zones) control the central heating system that is **not** your ductless split heat pump?
5. Is the area in the home served by your ductless split heat pump also heated by your central heating system?
6. Most of the advanced control systems being considered for this study require a home Wi-Fi network to operate. Do you have WiFi in your home that you are comfortable connecting to?
7. Our metering equipment uses the Verizon cellular data network to communicate data in real time during the metering period. Do you have Verizon cellular service at your home?
8. What type of residence do you live in?
9. To be eligible for this pilot study, your home needs to be served by an AMI or "smart" electric meter. Please provide your electric account number so we can verify that you have an eligible meter at your home.
10. Please provide your contact information so we can reach out to you if you are selected for participation in this study

The recruitment survey also included additional information about what the project involves in terms of metering term and duration, as well as the $100 incentive that will be provided to participants.

This recruitment survey was deployed in February and March 2021.

3 NEXT STEPS

At the time of writing this edited study, we are in the process of conducting baseline metering of high- and medium-rigor sites. We expect to deploy control technologies for all sites, including low rigor sites, by August 2021. Metering is currently planned to continue through February 2022, with a possible extension until May 2022 to account for the spring 2022 swing season.

4 APPENDICES

The following sections describe the methods for selecting the technologies and key industry contacts.

4.1 Technology Selection Matrix

With the understanding that no control technology or technologies would be a perfect fit for the pilot, the ERS team decided to create a technology selection matrix. This matrix, an Excel-based table, gives our team and EMT a robust way to compare the technologies. It also ensures transparency in the selection process.

The criteria in the matrix include all the essential characteristics of the technology (e.g., one touchpoint to control the dual-fuel system, ability to maintain droop). They also include nice-to-have characteristics, plus relevant notes on the companies contacted and our conversations with them. This documentation should give the Trust a complete understanding of the approach followed to select the best set of technologies for piloting.

We include in Table 3 an example screenshot of the matrix. Due to its dimensions, we are unable to provide a complete and legible table in this document. However, it is available as an embedded file in this report, as provided below:

Selection Criteria - Decision Matrix 011

Table 3. Decision Matrix Sample

Criteria	Notes	Essential (E) or Nice to Have (N)	Ecobee	Flair Puck Pro	Sensibo	Resideo	Mitsubishi	Daikin	Fujitsu	Tado	Cielo	Air Patrol	Ambi Climate 2	Jackson Systems
General Description of Technology and Setup	Describe high-level tech setup and how it is integrated with dual fuel system.	NA	• Ecobee is connected to a smart AC/HP controller. This would be either Sensibo or Puck. Puck is the preferred choice as it is already integrated. • Ecobee and potential remote sensors would be the slave to the Puck and would just serve as an intermediary between the Puck algorithm and the central system.	Flair Puck Pro + Central System Controller (i.e. Ecobee or Honeywell) • The universal controller controls minisplits through IR. • The Puck would integrate and control staging between the minisplit and the central system controller. • Puck is powered by two AAA batteries or USB adapter. • Can have multiple Pucks in home that	AC and Minisplit IR smart controller	• Main system controller is T5, T6, T9 or T10 thermostat. Main HP controller would be the D6 model. • All devices share a common API.	Mitsubishi Kumo Station/Kumo Cloud • Droop and outdoor change over temperature can be set up via phone app • Backup heat wired into Kumo Station • DHP connects to Kumo Station with wired or wireless adapter. • Does support remote temperature sensor	Daikin One Thermostat • Droop and outdoor change over temperature can be set up via phone app • Backup heat wired into Daikin One • DHP connects to Daikin One with wired or wireless adapter.	A few thermostat interfaces that allow Fujitsu DHP's to be controlled by 3rd Party Thermostat	RECOMMENDED TO DROP AC Controller. Has an open API, but I was unable to contact.	RECEOMMENDED TO DROP Spoke to company. Is a AC/MSHP controller but has no Open API	RECOMMEND TO DROP AC Controller - No open API and unable to contact	RECOMMENDED TO DROP AC/HP controller with Open API. I was able to contact by email, but was unable to setup a phone meeting.	Use an HVAC wireless transceiver to relay outputs from a conventional or smart thermostat with more than one heating stage to control mini-split.Mini-split would be prioritized using "W" thermostat terminal and central furnace/boiler would come on after built-in thermostat droop using "W2" or "AUX" thermostat output
Contact Name(s) and Title(s)		NA	Shawn Peterson (Account Manager)-shawn.p@ecobee.com	Dan Myers (CEO) - dan@flair.co	Kobi Manzaly (Head of Sales) - kobi@sensibo.com	Dave Holland - Sr. Manager, Business Development - dave.holland@resideo.com	Steve Vogel, Product Manager, Control Solutions	Jon Hacker, National Sales and Julian Mercado, Business Development Manager, New York	no response from inquiry					Phil Kimble, iO HVAC Controls 866 225-5032
General notes on contact and conversation	Do they understand approach? Are the interested in working with the pilot? What is our general impression?	NA	Contact had more difficulty in his comprehension of the needs. He told us that he would take it back to his engineering department. I have not been able to speak to him since despite a follow-up email asking for many of the details needed in the new	Dan immediately understood the project and our needs, and is willing to work with us to program/implement the needed features, including Droop.	The team had 3 conversations with Sensibo. (Each time there were more engineers on the call.) We had a harder time explaining the needs and they were less willing to bend over backwards to fulfill the program requirements and create an integration	Good conversation with client. Readily understood needs and seems to have a system in place that can fulfill program requirements.	Referred me to Florida sales contact. Information based on previous conversations.	Understand approach and interested in working with us.	no response from inquiry					Yet to connect
Has the company worked on similar EE or DR programs before?	Give examples	N	Unknown, but a working assumption is yes	• Yes, they have a virtual power plant project in China; • Worked with MASS Saves (on a program with an outdoor temp switch) • He knows Dan Mistro at EMT and has worked with him in the past	Yes, they have collaborated with Nest in Australia. No known integration with Ecobee. They have also worked with Green Mountain power's MSHP program. They install Sensibo with every MSHP installed.	Unknown	Listed on Mass Save list but not sure about program involvement	Listed on MassSave list but not sure about program involvement	?					Not sure; probably
Technology Criteria														
Integrates Control of DMSHP and Furnace/Boiler.	All fuel types is optional. If not, the controller needs to work with at least fuel oil. With what technologies does it integrate?	E	Yes, it is the central system controller. It can natively set a comp to Aux delta when dead band is reached.	Yes, as for a central system controller, they have suggested any EcoBee but any Honeywell works also.	They have an open API so it's very possible to integrate with Ecobee. That being said, they have not shown huge willingness to do the legwork to create the integration. Eric Martin integrated the Sensibo with a Nest in a project a few years back. He used custom code. This code is IP of the University of Florida. Sensibo is currently in the middle of talking to some companies on integrations. The timeline is unknown.	Yes, integrates with many different HPs through IR. They are compatible with a wide variety of brands. This would work with a single or multi-split systems. Their three goals in creating the integration were: 1) User-friendly for customer and installer, 2) Creating a curated experience (read: no IFTTT), and 3) Creating a cost-effective solution Can be retrofitted into existing systems-DSHP controller is	Yes, integrates with existing thermostat	Yes, integrates with existing thermostat	Provides ability for fujitsu DHP to be controlled by 3rd party thermostat					May depend on being able to access control wiring on the mini-split. Also, could be aesthetic issues.

4.2 Contact Database

Table 4 is a list of industry contacts made for this report. We have not included cases where the team was unable to speak to a company representative.

Table 4. Industry Contact Information

Company	Name	Title	Contact Info
Ecobee	Shawn Peterson	Account Manager	shawn.p@ecobee.com
Flair	Daniel Myers	CEO	dan@flair.co
Resideo	Dave Holland	Senior Manager, Business Development	dave.holland@resideo.com
Daikin	John Hacker	Sales Lead	Jon.hacker@daikinus.com
Mitsubishi	Steve Vogel	Product Manager – Control Solutions	svogel@hvac.mea.com
Jackson Systems	Phil Kimble	Product Development Manager	phil.kimble@jacksonsystems.com
Sensibo	Kobi Manzaly	Head Of Sales	kobi@sensibo.com

APPENDIX B. DATA COLLECTION FORM

General Site Data		
Site ID		
Engineer(s)		
Date & Time		
Contact Name		
Contact Phone Number		
Address		
ZIP		*will be used for weather*
Electric Utility		
Electric Account Number (from tracking)		
Delivered heating fuel used		
Fuel Provider		
Fuel Account Number		
Cords of wood used per season (if applicable)		*cords per season*
Lbs of pellets used per season (if applicable)		*lbs per season*
Year the building was built		
Approx. Sq. Footage (ft2)		
Approx. Sq. Footage (ft2) conditioned		
Approx. Sq. Footage served by heat pump		
Number of floors		
Envelope Condition		*net zero / excellent / goo*
Energy-saving upgrades performed in the last year?		*yes/no*
List any recently implemnted energy-saving measures		
At end of project: Any other energy-saving measures installed over the course of this project?		
Solar Array On-Site?		*yes/no*
If No, plans to install solar in near future?		*yes/no*
Electric Vehicle Charging?		*yes/no*
If No, plans to install EV charge in near future?		*yes/no*
Additional site notes		*for engineer to use later*
Heat Pump Data		
Heat pump indoor head location		floor and room
Heat pump thermostat/remote location		
Central heating system thermostat location		
Are there any other thermostats in the home?		*yes/no*
If so, where are the other thermostats?		
Room or space in home with priority for comfort? (e.g. baby's room, regularly occupied room, room that always runs cold)		
How was HP served space heated and cooled prior to HP installation?		
Describe current control scheme for heat pump and central heating system.		*free response; we will ca*

Site ID

Thermostat Data		
Type of thermostat controlling heat pump		*Smart/programmable/m*
What is your temperature schedule for the heat pump thermostat?	*fill out 2. Tstat setpoints tab after interview*	
Type of thermostat controlling central heating system		*take a photo and upload*
Secondary central thermostat type? (if applicable)		*thermostat zone in the s*
What is your temperature schedule for the central thermostat(s)?	*fill out 2. Tstat setpoints tab after interview*	
Remove the primary thermostat from the wall. Which terminals are connected? (note terminal labels and wire color)		*take a photo and upload*
Are there additional unused wires behind the thermostat?		*Note quantity and color*
Is the thermostat wire close to the central heating system and easily accessible?		
Would this site prefer a wired or wi-fi enabled thermostat controller?		*wired/wireless/no prefer*
Occupant information		
How many people live here total?		
Number of adults		
Number of children		
What are the general occupancy patterns in the building on a normal day?	Weekday: Weekend:	*approximate schedule*
Do you have any seasonal occupancy shifts, like heading to a vacation home or having a college student home during the summer?		
How has your occupancy pattern changed due to the coronavirus?		*free response; we will ca*
At end of project: Have your occupancy patterns changed over the course of the metering period?		
Misc. Site Notes and sketches		

Heating, Heat Pump 1																		Site ID						
	Hour																							
Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday																								
Tuesday																								
Wednesday																								
Thursday																								
Friday																								
Saturday																								
Sunday																								

Cooling, Heat Pump 1																								
	Hour																							
Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday																								
Tuesday																								
Wednesday																								
Thursday																								
Friday																								
Saturday																								
Sunday																								

Heating, central system																								
																		Site ID						
	Hour																							
Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday																								
Tuesday																								
Wednesday																								
Thursday																								
Friday																								
Saturday																								
Sunday																								

Cooling, central system																								
	Hour																							
Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday																								
Tuesday																								
Wednesday																								
Thursday																								
Friday																								
Saturday																								
Sunday																								

Heading, central system (thermostat 2)																		Site ID						
	Hour																							
Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday																								
Tuesday																								
Wednesday																								
Thursday																								
Friday																								
Saturday																								
Sunday																								

Cooling, central system (thermostat 2)																								
	Hour																							
Day	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
Monday																								
Tuesday																								
Wednesday																								
Thursday																								
Friday																								
Saturday																								
Sunday																								

Central heating system		
Equipment Type		
Fuel Type		
Make		
Model		
Input BTU Max		
Input BTU Min		
Burner staging		*single/hi-low/moc*
AFUE/Efficiency		
Combustion Fan A		
Furnace		
Supply Fan A		
Supply fan type		*SP, PSC, ECM, N/A*
Return type		*Central/balanced*
Boiler		
Qty of zones		
Qty of zone pumps		
Zone descriptions		*Note if solenoid v*
Which zone pump serves the same space as the DSHP?		
Is this system used for DHW?		*yes/no*
If multiple zones, is there a special control board?		
Other notes on central system		

	Site ID	
Ductless Split Heat Pump		
Outdoor unit make		
Outdoor unit model		
Outdoor unit compressor (FL amps)		
Outdoor unit fan (FL amps)		
Refrigerant type		
Indoor unit make		
Indoor unit model		
Indoor unit location		
Other notes on DSHP system		*onboard defrost/backup resistance heat?*
Central Cooling system		
Equipment Type		
Make		
Model		
Cooling Capacity BTU/hr		
Cooling efficiency SEER		
Compressor Amps		
Supply Fan A		
Supply fan type		*SP, PSC, ECM, N/A*
Return type		*Central/balanced*
Other notes on Central cooling system		

Site ID

DHW Equipment		
DHW Type		
DHW Fuel Type		
DHW Operation		
DHW System Make		
DHW System Model		
Was a new appliance installed to provide DHW as a result of the HP install?		
Other DHW System Notes		

Other Equipment		
Equipment Type		
Fuel Type		
Make		
Model		
Input BTU Max		
Input BTU Min		
Burner staging		
AFUE/Efficiency		
Combustion Fan A		
Other equipment notes		

Site ID	

Logger Information		
Infisense gateway ID		*last 4 characters of LORA Node ID*
Gateway connectivity		*cell/ethernet*
Infisense gateway deployment notes		
Status check website:	**status.infisense.com**	
Username:	**efficiencymaine**	
PW:	**thermostat**	
Troubleshooting:	**Tim Guiterman**	**802-557-4755**
	Martin Bures	**617.721.8145**

Infisense tips:
- Launch loggers **before leaving office** and check that they are connected to a gateway
- Plug in gateway immediately on getting to site
- Check status on infisense page (see credentials to the left) to make sure logger is connected
- Call Tim or Martin if you need help on site, or Kevin as a backup (412-728-2115)
- Send logger IDs via email, teams message, text, etc. to Kevin ASAP, even while on site, so loggers can be remotely configured
- Check one more time before leaving to make sure everything is connected

	Logger ID	Logger Type	Logger Channel	Attachment Type	CT Size	Logger Location	Notes	
Rigor	*Please always note the data logger ID (not just a CT ID). Enter last 4 digits if InfiSense logger. **Repeat logger ID for each channel of the logger.***	*i.e. InfiSense CT, InfiSense T/RH, HOBO 4-channel*	*Give each channel its own row.*	*i.e. pulse power, CT, or temp probe*	*CT capacity in amps, if applicable*	*e.g. Outdoor unit, refrigerant line. For temp probe, note whether on condenser coil or refrigerant line.*	*Take detailed deployment location notes and a photo since another technician may perform the equipment pick-up. Also capture any other peculiarities.*	
All		Infisense T/RH	A	Onboard temp/RH		Indoor head, return		
All	0	Infisense T/RH	B	plug-in temp Probe		Indoor head, supply		
All		Infisense T/RH	A	Onboard temp/RH		Central thermostat		
All		Infisense T/RH	A	Onboard temp/RH		DSHP thermostat		
All		Infisense T/RH	A	Onboard temp/RH		*optional*		
High		Infisense Industrial	A	Wattnode pulse power		Outdoor unit		
High	0	Infisense Industrial	B	4-20 mA CT		Indoor circuit		
High	0	Infisense Industrial	C	Temp Probe		Refrigeration line		
High		Netvox 1-channel CT	A	CT				
Med		Netvox 3-channel CT	A	CT				
Med	0	Netvox 3-channel CT	B	CT				
Med	0	Netvox 3-channel CT	C	CT				

SPOT MEASURMENTS

Equipment Measured	Logger ID on circuit	Phase	Amps	Volts	PF	Power (kW)	Notes	

APPENDIX C. FLAIR INSTALLATION MANUAL

Ecobee + Flair Puck Quick Start Guide

This guide is not intended as a replacement for the full installation manuals, but rather as a guide to walk the installer and site engineer through the process of installing and configuring a site.

Before you head to the site, you can download the "Flair- Climate Control" app on your smartphone. This way you can configure the Puck on your own phone and then hand off to the homeowner. https://flair.co/android or https://flair.co/ios. Just be sure to check the "I am a professional that installs Flair devices" during setup and register for a Flair Pros account.

A laptop may be easier to use than the phone app, particularly if you are using an iOS device.

1. When arriving at the site, obtain the wi-fi login credentials for the site.

2. Identify the desired location for the Flair equipment, the location of the thermostat to be replaced, and the desired location of 2 Ecobee smart home sensors.

    a. Either a Flair Puck or Flair Bridge will need to be plugged into the wall. The plugged-in unit does not need to be in the same room as the heat pump, it can be anywhere in the home.

    b. 2 Ecobee remote smart sensors are provided for each site. Fewer remote sensors may be installed if requested by the homeowner.

    c. The Ecobee remote smart sensors can be installed in any room, but it's recommended that one sensor is installed in a place that is high traffic to ensure proper comfort and function and the second sensor is installed in a place that tends to be colder than the rest of the home in the winter.

    d. The smart sensors should be installed on an interior wall about 5 feet above ground and away from direct sunlight, vents, drafts, etc. They should also be placed in a spot that is not directly in the air stream for the ductless split head.

3. The first step onsite is to install and configure the Smart thermostat (**Ecobee**).
    a. Shut off power to the HVAC system

    b. Remove old thermostat from the wall

    c. Check wires behind old thermostat
        i. **Take a photo of the wires**
        ii. If there is already a C wire, wire up the Ecobee as the old thermostat was wired (without jumpers between RC and RH)
        iii. If there is no C wire but there is an unused wire in the wall, the unused wire may be used as a C wire

iv. If there are at least 3 wires but no C wire, you will need to use the Power Extender Kit that comes in the box to make a C wire
v. If there are only 2 wires (e.g., R/W), you may…
   1. Run an additional wire at the thermostat down to the equipment
   2. Use a Fast-Stat common maker
   3. Install a 24V plug-in transformer

d. Remove the old thermostat from the wall

e. Install the new base plate

f. Install the Ecobee by pushing the wires in to the sides of the terminal blocks

g. Push the Ecobee thermostat onto the base plate until it clicks

h. Power on the HVAC system

i. Go through the steps of the configuration process using the Ecobee app
   i. Verify wire connections
   ii. Manually configure if necessary
   iii. Confirm whether any accessory items (humidifier, dehumidifier, ventilation) are installed
   iv. If using a 24V plug-in transformer, select accessory power source
   v. Install the remote smart sensors at the desired locations and connect them to the Ecobee.

j. Once the thermostat is installed, the field engineer should follow the registration prompts to set up the Ecobee account. The field engineer should use their own device (if possible) to create an Ecobee account on behalf of the homeowner using the homeowner's email and a generic password such as "Welcome1!" so that the field engineer can click through the necessary settings for setup. (The homeowner should not change the settings on their thermostat, and so will not need to download the Ecobee app on their smart phones.) **Write down the credentials as they are needed for the Puck setup!**

k. Change the following Ecobee settings, to allow integration with Flair to work
   i. Under Settings -> Preferences, change "Hold Action" to "Until I Change It"
   ii. Under Sensors, disable "Smart Home/Away" and disable "Follow Me"
   iii. Under Schedule, delete all schedule events
   iv. Note: if homeowner is interested in smart features like schedules or away mode, those can be programmed in their Flair account – having a schedule in the Ecobee account will cause conflicts with the integrated controls

4. Once the Ecobee is configured, the **Flair Puck** can be installed
   a. Like the Ecobee setup, the field engineer should setup the homeowner's Flair account on their own device using the "Flair – Climate Control" app and the

credentials chosen for the Ecobee setup. The homeowner should download and install the “Flair- Climate Control” app on their smartphone to prepare to log in to their account. **Write down the registration email! We will need to provide it to Flair in case we have to do remote adjustments to the control strategy.**

b. The Puck will need to be installed within line of sight of the ductless split as it communicates via IR. The IR communication sources are as shown in the picture below:

c. Using the setup wizard in the Flair desktop or smartphone app, go through the following steps:
   i. If using a Bridge, enable bridge setup under Account Settings and follow the prompts to connect it to Wi-Fi. Otherwise, make the first Puck a Gateway Puck in the physical device’s settings menu and follow the prompts in the app to connect it to Wi-Fi. A Puck may take up to 5 minutes to join the Flair network. After 30 minutes of discovery time, Flair will disable device discovery.
      1. Check the Wi-Fi icon on the Puck. More bars are a better signal; an X means it’s not connected to Wi-Fi.
   ii. Add split system under “IR Devices”
   iii. Download code set to the Puck and test that heat pump will respond to commands from the Puck
   iv. Test the system signal strength and position of the Puck prior to permanently installing the Pucks. Testing is crucial for successful installs. There are three types of tests:
      1. Signal strength of all Flair devices. Signal strength is viewed in the Flair app by going to Home Statistics, then changing the “Graph Data” to “RSSI (dB)”. Good signal strength is above -75dB.
      2. Position of the Puck in relation to the mini split it is controlling.
      3. Code set testing of the mini split remote-control codes that are downloaded to the Puck.
      4. Tests 2 and 3 are combined using the same test procedure found here: https://support.flair.co/hc/en-us/articles/360048695032-Testing-Mini-Splits-in-Manual-Mode
   v. Once the system is configured, click on the grey plus symbol in the app and select “Add New Thermostat” and grant access to the Ecobee account.

d. Configure integrated controls
   i. Tap the Flair Menu, then Home Settings → System Settings

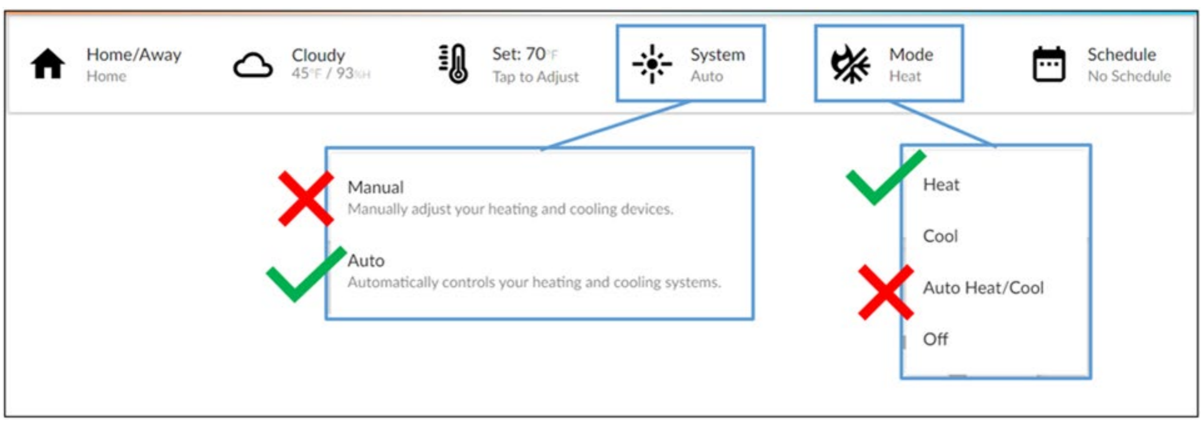
1. Set “Set Point Controller” to “Flair App”
2. Set “Default Hold Duration” to “Until next scheduled event”
3. Set "Home/Away Mode”" to “Manual”

ii. Tap Home Settings → Away Settings

1. Confirm that Away mode is set to “Off Only”

iii. In the Control Bar, set “Mode” to “Heat” or “Cool”

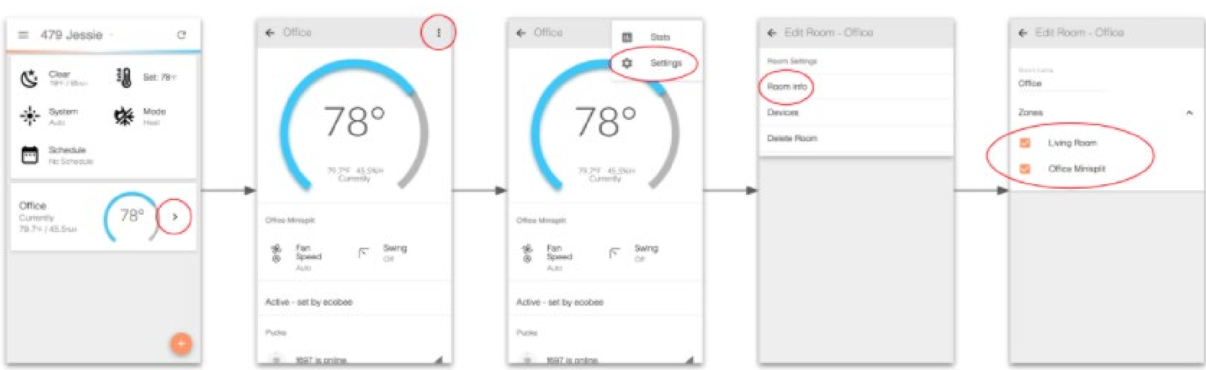
1. The homeowner may set the mode to “Heat”, “Fan”, “Dry”, or “Cool” as needed. Avoid “Auto Heat/Cool” mode as it may limit heat pump effectiveness. (See Efficiency Maine Heat Pump User Tips)
2. Note that the overall system should be set to “Auto” rather than “Manual” in the control bar. This is different from “Auto Heat/Cool” mode under the “Mode” dropdown.



iv. Each room with a Mini Split must belong to two zones: the thermostat’s zone and the mini split’s zone. To configure:

1. Tap the room
2. Tap the 3-dot menu on the room tile
3. Go to Settings → Room Info

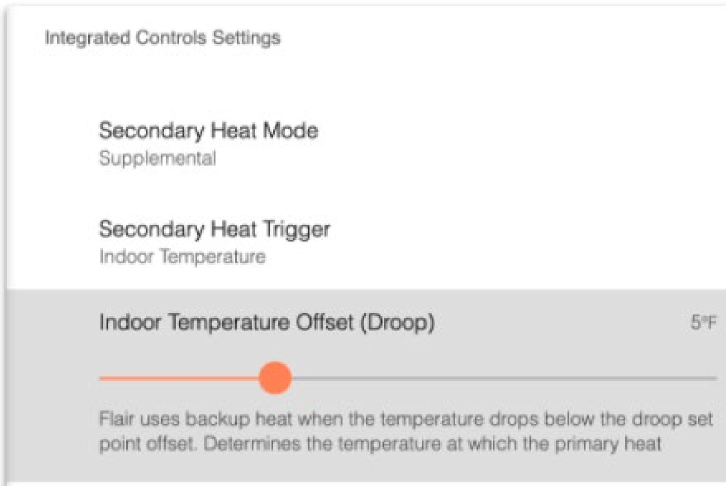
v. Check the mini split’s zone box and the thermostat’s zone box



vi. Configure the secondary heat settings

1. In the Flair Menu, Home Settings → Thermostats

2. Tap the down arrow to expand the thermostat and scroll to Integrated Control Settings.
3. Select “Use as Secondary Heating”
4. Choose “Supplemental Heat”
5. Set the “Secondary Heat Trigger” to “Indoor Temperature”
6. Set the “Indoor Temperature Offset (Droop)” to 5°F.

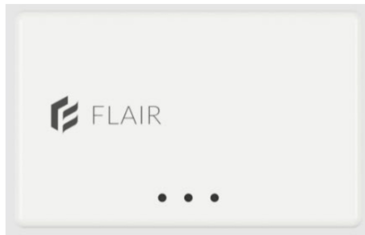


e. Test the overall controls system
   i. In the Flair app, set System to “Manual”
   ii. Use the ductless mini split widget to issue power on/off, fan speed, and swing commands to the mini split. These may take up to 60 seconds to be communicated.
   iii. Once a good location for the Puck has been found and it has been installed, set the System to “Auto” and “Mode” to “Heat” in the app.
      1. The homeowner can choose to adjust this setting later on their own if they wish.
   iv. Set the home set point at least 5°F higher than the room temperature to get the ductless split to cycle on.
   v. Once the test has been completed, reset the home set point to the homeowners desired temperature.

f. Once the Flair Puck is installed, the batteries should be removed from the heat pump handheld controller and the controller should be placed in storage (only to be used in case of Flair controller failure) to avoid confusion with the controls equipment.

g. Have the homeowner log in to the account to make sure they can access the account and are comfortable. The homeowner should change the password from the generic one used to set up the account.

5. **Teach the homeowner how to use their new system and the functionality of each piece of installed equipment.** See information below about the installed equipment.

			
Flair Puck	**Flair Bridge**	**Ecobee Thermostat**	**Ecobee Smart Home Sensors**

The equipment installed each serves an individual purpose:

- 2 Flair pucks (or 1 Flair Puck and 1 Flair bridge)
    - 1 Flair Puck acts as a sensor, which measures temperature and talks to the heat pump. It replaces the handheld controller for the heat pump and can be adjusted through the Flair app. This is the new remote for the heat pump and can be used to change the temperature setpoint for the room in which it is located. If the Puck is in a different room than the heat pump, the temperature setpoint for the heat pump and boiler/furnace should be adjusted in the Flair account (app or web browser). The best practice is to make any temperature setpoint adjustments in the home's Flair account (app or web browser).
    - 1 Flair Puck or bridge acts as the Gateway, which uses the home's Wifi to talk to the Ecobee thermostat and the sensor. It's the unit that is plugged into the wall.

- 1 Ecobee thermostat: Replaces the old thermostat in the home and controls the boiler/furnace and is linked to the Flair system. The thermostat reads the temperature of the room where it is installed (and averages the temperature readings from the smart home sensors, if installed) to keep the home comfortable.

- 2 Ecobee smart home sensors: Work with the Ecobee thermostat to detect temperature. They can be placed anywhere in the home to balance the home's temperature and help manage hot or cold spots.

The installed equipment works together to operate the heat pump and the boiler/furnace as efficiently as possible. The Flair system's purpose is to operate the heat pump as much as possible, while utilizing the boiler/furnace as needed to keep the home comfortable.

The Efficiency Maine Heat Pump User Tips are still the best practices for controlling heat pumps. These tips are taken into account when setting up the system and should be considered before changing the settings on the Flair and Ecobee systems.

The Efficiency Maine Heat Pump User Tips

1. Use your heat pump all winter.

High-performance heat pumps are the most efficient heating system, even on the coldest winter day. If you have both a heat pump and a furnace/boiler, your heat pump is the more energy-efficient choice.

2. Set it and forget it in the winter.

Heat pumps operate most efficiently when holding a steady temperature. Turning a heat pump down when you're away or asleep may actually use more energy than leaving it on. The reason is that it has to work harder to come back to the desired temperature than it does to maintain it. It's best to set it at a comfortable temperature and forget it. Adjusting the temperature for short periods of time, such as overnight, will not save money with a heat pump.

3. Set for comfort.

Many heat pump indoor units are mounted high on the wall near the ceiling. Because heat rises and heat pumps measure temperature at the indoor units, you may find you need to set your heat pump at a higher temperature than with a traditional wall thermostat setting. Set it for comfort regardless of your usual furnace/boiler setting. This may be different for heat pumps with floor units or wall-mounted thermostats.

4. Use your heat pump before your boiler/furnace.

For homes heated by both a heat pump and a boiler/furnace, relying on the heat pump whenever possible will maximize savings. This can mean different things in different homes, like setting the boiler/furnace thermostat lower or closing a radiator/damper in the rooms served by the heat pump.

5. Avoid "Auto" mode in summer and winter.

The Auto mode on heat pumps allows the heat pump to decide whether to heat or cool the space, but it doesn't always know best. To avoid accidentally air conditioning on a mid-winter sunny day or perhaps when a wood stove is running, use "Heat" mode, not "Auto." Likewise, to avoid accidentally heating on a cool summer night, use "Cool" "Dry," or "Fan," not "Auto" in the summer.

6. Optimize fan speed.

Start off with the fan setting on "Auto Fan." If that doesn't spread the heated or cooled air far enough, set the speed to the lowest level that will meet your needs.

7. Optimize air flow direction.

It's easy to re-direct airflow on a heat pump. To maximize reach, air should be directed toward the open space that is the farthest away from the indoor unit, and away from any obstructions. You may need to experiment to see what's most comfortable for you.

8. Clean your dust filters.

Heat pumps work best when dust filters are clean. Vacuum or rinse the dust filters whenever they become visibly dirty or when the indicator light comes on. The frequency of cleaning can range from weeks to months depending on use and dust volume. For details on how to take the filters out, consult your user manual.

9. Keep your outdoor unit clear.

Keep shrubs away from outdoor units and remove leaves that may become stuck in them, being careful not to bend the fins. Clear snow drifts away from outdoor units but don't worry about snow and ice accumulating on them. Heat pumps automatically defrost.

10. Have your heat pump professionally serviced.

To ensure peak performance, follow manufacturers' recommendations for professional service in addition to regular filter cleaning. Heat pumps collect more dirt in the summer, so it's best to have them serviced in the fall.

11. Match the summer mode to the weather and your needs.

There are three heat pump modes for summer. "Fan" uses the least energy and may suffice when you need a little relief, but it will not cool the room so be sure to turn it off when you leave. When it's warm and muggy, "Dry" mode can reduce the humidity and make the room feel more comfortable. "Cool" mode is the best choice for lowering the temperature and may suit the hottest days.

APPENDIX D. SURVEY INSTRUMENTS

Memo to:
Dan Mistro - Efficiency Maine Trust

From: Lucy Neiman, Alex Schultz - DNV
Date: April 27, 2022

Copied to:
Kathleen Sturtevant
Milana Pakes
Katie Ryder

INTEGRATED THERMOSTAT PILOT PARTICIPANT SURVEY

PURPOSE

The objective of this survey is to understand the customer experience, learning process, challenges, and collect general feedback from customers who participated in the Integrated Thermostat Pilot project.

INSTRUMENT

Email Survey Invitation Letter

Subject line: Feedback on your experience with Efficiency Maine's Integrated Thermostat Pilot

Hello [FIRST NAME],

Efficiency Maine appreciates your time and involvement in our Integrated Thermostat Pilot project. To complete our review, we would appreciate your taking a few minutes to complete an online web survey to tell us about your experience and learnings from the pilot project and how it has affected the operation of your heat pump and other heating equipment. We would like your feedback on the controllers installed in your home and the effects of the new controllers on your home energy usage and overall comfort.

Follow this link to complete the survey: [INSERT SURVEY LINK]

The survey should take about 10 minutes to complete. We will be scheduling the pickup of our metering equipment in the next few weeks and the Flair controller and Ecobee thermostats will remain installed in your home for you to keep. If you would like assistance with the survey or to provide any additional feedback, the DNV staff removing the meters will be glad to collect your comments.

All of your responses will be confidential, and any analyses will not identify individuals. Your response will have no impact on participation in Efficiency Maine programs and will be used only for the purposes of this study. Should you have any questions about this study, please contact the Efficiency Maine call center at (866)376-2463.

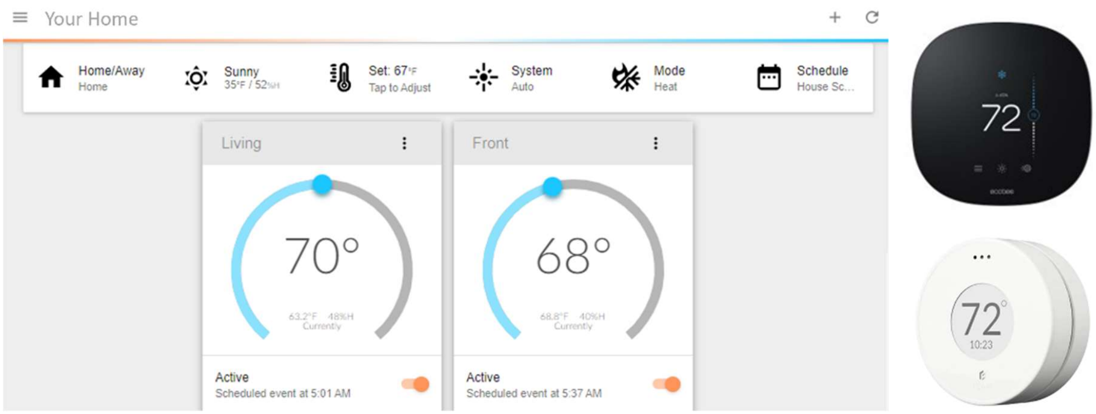
Regards,

Dan Mistro
Strategic Initiatives Manager
Efficiency Maine Trust
www.efficiencymaine.com

Mailing ID: XXXXXXXXX

SURVEY QUESTIONS

1. Are the Pilot Equipment and Controls you received to participate in this pilot still installed in your home? The Pilot Equipment and Controls are the Ecobee thermostat, Flair Puck, and Flair app seen pictured.



   a. Yes
   b. No
   c. Not sure

2. *[If Q1 ≠ yes]* Did you deactivate or uninstall the Pilot Equipment and Controls from your home?
   a. Yes
   b. No

3. *[If Q2 = Yes]* Why did you uninstall or deactivate the Pilot Equipment and Controls?
   a. [text box]

4. How long were the heat pump(s) in your home installed **before** receiving the Pilot Equipment and Controls?
   a. Less than 6 months
   b. 6 months to 9 months
   c. 9 months to 12 months
   d. 12 months to 24 months
   e. More than 24 months
   f. Don't know

5. **Before** receiving the Pilot Equipment and Controls, how would you utilize your heat pump in the **winter**?
   a. Heat pump was on and heating throughout the winter
   b. Heat pump was periodically turned on or off throughout the winter for heating
   c. Heat pump was used on rare occasions throughout the winter for heating
   d. Heat pump was not used in the winter for heating

6. Please fill out your typical **heat pump** set points **before** the Pilot Equipment and Controls were installed.

	Heat pump setpoint (F)	Boiler/furnace setpoint (F)
Weekday day		
Weekday night		
Weekend day		

Weekend night		

7. Please elaborate on your typical heat pump and boiler/furnace usage **before** the Pilot Equipment and Controls were installed. For example, if you used different temperatures during the day and night or on weekends, what time of day did you typically change the temperature?
   a. [Open text box]

8. On a scale of 0 to 10, with 0 being not at all satisfied and 10 being extremely satisfied, how satisfied were you with the Pilot Equipment and Controls installation process in your home?
   a. [0-10 scale]
   b. Why? [open ended answer]

9. On a scale of 0 to 10, with 0 being not satisfied at all and 10 being extremely satisfied, how satisfied were you with the training/instructional materials provided by the installer?
   a. [0 – 10 scale]
   b. Why? [open ended answer]

10. How did you use your Pilot Equipment and Controls over this past heating season?
   a. Set temperatures via Flair, using Flair's automated controls (droop)
   b. Overrode automated Flair controls and used Flair account in manual mode to independently control heat pump and boiler/furnace
   c. Disconnected Flair equipment and returned to using thermostat and original heat pump remote separately

11. *[If Q10 = a]* How did you use your Flair account **after** the Pilot Equipment and Controls were installed? Select all that apply.
   a. Entire house set to same setpoint in Flair most of the time (please describe)
   b. Different rooms set to different setpoints in Flair most of the time (please describe)
   c. Changed setpoint in Flair throughout the day (please describe)
   d. Implemented smart features like schedules, vacation mode, etc. (please describe)
   e. Changed droop settings such as offset temperature or secondary heat trigger (please describe)
   f. Other (please describe)

12. *[If Q10 = b or c]* Please fill out your typical setpoints for **this past** winter.

	Heat pump setpoint (F)	Boiler/furnace setpoint (F)
Weekday day		
Weekday night		
Weekend day		
Weekend night		

13. On a scale of 0 to 10, where 0 is not easy at all and 10 is extremely easy, how easy is it to operate your heating equipment with your Flair system?
   a. [0-10 scale]
   b. Why? [open ended answer]

14. Have you had any issues with your Flair controls system since it was installed?
   a. No

b. Yes (please elaborate)

15. Have you noticed your heat pump operating in the winter more or less **after** the Pilot Equipment and Controls were installed?
    a. Yes, my heat pump now operates more often
    b. Yes, my heat pump now operates less often
    c. No, my heat pump operates just as often

16. Have you noticed your boiler/furnace operating in the winter more or less **after** the Pilot Equipment and Controls were installed?
    a. Yes, my boiler/furnace operates more often
    b. Yes, my boiler/furnace operates less often
    c. No, my boiler/furnace operates just as often

17. Have you noticed a difference in your **fuel consumption** since the Pilot Equipment and Controls were installed? Note that the prices of fuel may have changed over time.
    a. Yes, I use more fuel than before
    b. Yes, I use less fuel than before
    c. No, I use the same amount of fuel as before

18. Have you noticed a difference in how much **money you spend on fuel** since the Pilot Equipment and Controls were installed? Note that the prices of fuel may have changed over time.
    a. Yes, I spend more money on fuel than before
    b. Yes, I spend less money on fuel than before
    c. No, I spend the same amount of money on fuel as before

19. Have you noticed a difference in your **electric usage** since the Pilot Equipment and Controls were installed? Note that the price of electricity may have changed over time.
    a. Yes, I use more electricity than before
    b. Yes, I use less electricity than before
    c. No, I use the same amount of electricity as before

20. Have you noticed a difference in how much **money you spend on electricity** since the Pilot Equipment and Controls were installed? Note that the prices of electricity may have changed over time.
    a. Yes, I spend more money on electricity than before
    b. Yes, I spend less money on electricity than before
    c. No, I spend the same amount of money on electricity as before

21. In your own words, please describe how your fuel and electricity usage has changed or not changed since the Pilot Equipment and Controls were installed.
    a. [text box]

22. How would you describe the difference in the comfort in your home since the thermostat and controls system was installed?
    a. Home became much more comfortable
    b. Home became slightly more comfortable
    c. Home stayed equally comfortable
    d. Home became slightly less comfortable

e. Home became much less comfortable

23. *[If Q22 ≠ c]* Please describe how the comfort in your home has changed.
    a. [Text box]

24. On a scale from 0 to 10, where 0 is very unlikely and 10 is very likely, how likely are you to keep the Flair controls system installed, and continue using it in your home?
    a. [0-10 scale]
    b. Why?

25. On a scale from 0 to 10, where 0 is very unlikely and 10 is very likely, how likely are you to recommend the Ecobee thermostat and Flair controls system to others?
    a. [0-10 scale]
    b. Why?

26. Is there any other information you would like to provide Efficiency Maine about your experience participating in this pilot?
    a. [Text box]

Thank you for participating in our survey! We appreciate your feedback.

Memo to:
Dan Mistro - Efficiency Maine Trust

From: Lucy Neiman, Alex Schultz - DNV
Date: July 20, 2022

Copied to:
Kathleen Sturtevant
Milana Pakes
Katie Ryder

INTEGRATED THERMOSTAT PILOT NONPARTICIPANT SURVEY

PURPOSE

The objective of this survey is to understand the learning process, challenges, and collect general feedback from customers who did not participate in the Integrated Thermostat Pilot project.

INSTRUMENT

Email Survey Invitation Letter

Subject line: Efficiency Maine Heat Pump Control Survey

Hello [FIRST NAME],

Efficiency Maine appreciates your time and involvement with our energy efficiency programs and hopes you are enjoying your heat pump. To help us understand the impact of heat pumps on energy usage, we would appreciate if you would take a few minutes to complete an online web survey to tell us about how you operate your heat pump in conjunction with other heating equipment. We would like your feedback on the effects of your heat pump on your home energy usage, costs and overall comfort.

Follow this link to complete the survey: [INSERT SURVEY LINK]

The survey should take about 10 minutes to complete. If you are a qualified participant of Efficiency Maine's Heat Pump program and complete the survey, you will be eligible for a drawing for a $100 Amazon gift card (from a total of 7 gift cards) as a thank you. If you would like assistance with the survey or to provide any additional feedback, please reach out to me. All of your responses will be confidential, and any analyses will not identify individuals. Your response will have no impact on participation in Efficiency Maine programs and will be used only for the purposes of this study. Should you have any questions about this study, please contact the Efficiency Maine call center at (866)376-2463 and reference the Mailing ID number found below.

Regards,

Dan Mistro
Strategic Initiatives Manager
Efficiency Maine Trust
www.efficiencymaine.com

Mailing ID: 20220629

SURVEY QUESTIONS

Heating and cooling homes with heat pump technology can be more efficient and more comfortable in some cases. These upgrades could lead to annual energy bill savings, a higher home value, and a reduced carbon footprint. Efficiency Maine is interested in learning about your experiences and practices.

QXA Does your home use a heat pump(s) throughout the winter for heating?

1. Yes, we heat with heat pumps all winter
2. No, we heat with heat pumps only for part of the winter
3. No, we do not use our heat pumps in the winter

{If QXA = 3, thank participant and end survey}

Q1. Does your home have **both** a heat pump and an additional heating system?

a. Yes
b. No, my home only uses heat pumps in the winter
c. Don't know

Q2. {If Q1 /= Yes} What are the additional heating system(s) in your home? Select all that apply.

a. Furnace (forced air) – fuel oil
b. Furnace (forced air) – natural gas
c. Furnace (forced air) – propane
d. Furnace (forced air) – electric
e. Boiler (radiators/forced hot water) – fuel oil
f. Boiler (radiators/forced hot water) – natural gas
g. Boiler (radiators/forced hot water) – propane
h. Boiler (radiators/forced hot water) – electric
i. Electric baseboard heating
j. Radiant floor heating – electric resistance
k. Radiant floor heating – propane
l. Radiant floor heating – natural gas
m. Radiant floor heating – fuel oil
n. Room heater – fuel oil
o. Room heater – natural gas
p. Room heater – kerosene
q. Room heater – propane
r. Room heater – electric
s. Fireplace or stove – wood/pellet
t. Fireplace or stove – natural gas
u. Fireplace or stove – propane
v. Other (please describe): [OPEN ENDED]

Q3. [If Q1 = Yes] How do you balance the usage between multiple heating systems?
(open response)

Q4. [If Q1 = Yes] Which of your heating systems would you consider your primary heat source you rely on first?

a. Heat pump
b. Additional heating system

c. Not sure

Q5. Do you ever turn your heat pump down/off during the day, or do you use a constant set point throughout the winter?

a. Yes, I adjust my heat pump (please explain)
b. No, my heat pump is set at a constant temperature (please explain)

Q6. [If Q1 = Yes] At what temperature do you set your heat pump and additional system(s) throughout the week?

	Heat pump setpoint (F)	Other heating system(s) setpoint(s) (F)
Weekday day		
Weekday night		
Weekend day		
Weekend night		

Q7. [If Q1 = Yes] How much do you think your heat pump operates compared with your additional heating system(s)?

a. Heat pump operates more than additional heating system(s)
b. Heat pump operates less than additional heating system(s)
c. Heat pump and additional system(s) operate about the same

Q8. How would you describe the comfort in your home during the winter?

a. Often too hot
b. Sometimes too hot
c. Just right
d. Sometimes too cold
e. Often too cold

Q9. [If Q8 = a, b, d, or e] You expressed some dissatisfaction with the comfort of your home. Please explain the reasons for the dissatisfaction (Open-ended response)

Q10. Are parts of the home harder to keep comfortable than others?

a. Yes
b. No

{If Q10 = yes}: Please describe the areas of your home that are harder to keep comfortable, and the strategies you employ to try to make them as comfortable as possible. (Open ended response)

Q11. How would you describe your satisfaction with your heat pump overall?

a. Very Satisfied
b. Satisfied
c. Neither Satisfied nor Dissatisfied
d. Dissatisfied
e. Very Dissatisfied

Q12. Why?

Q13. [If Q1 = Yes] Have you noticed a difference in your **electricity consumption** since the heat pump was installed? Note that the prices of electricity may have changed over time.

a. Yes, I use more electricity than before
b. Yes, I use less electricity than before
c. No, I use the same amount of electricity as before

Q14. [If Q1 = Yes] Have you noticed a difference in your **fuel consumption** since the heat pump was installed? Note that the prices of fuel may have changed over time.

a. Yes, I use more fuel than before
b. Yes, I use less fuel than before
c. No, I use the same amount of fuel as before

Q15. Does anything prevent you from relying on your heat pump more than you otherwise would? Please select all the apply

a. Indoor temperature
b. Outside temperature
c. Price of fuel/electricity
d. Difficulty warming up the home
e. Other (please explain)

Q16. Do you feel relying on your heat pump more than you currently do would save money?

a. Yes
b. No
c. Don't know

Q17. Why?

Q18. [For anyone who took the survey but declined to participate in the pilot] Do you remember receiving an email last year inviting you to participate in a pilot program from Efficiency Maine which would have controlled your heat pump and additional heating system with a single thermostat? This was referred to as the "Integrated Controls Pilot"

i. Yes
ii. No

Q19. {If Q18 = Yes} [For anyone who took the survey but declined to participate in the pilot] Why did you choose to not participate in Efficiency Maine's Integrated Thermostat Pilot?

a. [Open-ended response]

Q20. {If Q18 = Yes} [For anyone who took the survey but declined to participate in the pilot] Did you seek alternative control strategies to balance your heat pump with your additional heating systems?

a. [Open-ended question]

Q21. As a thank you for your time, we are offering a drawing of $100 Amazon gift cards to seven people who complete this survey. Would you like to be entered in the drawing?

a. Yes, I would like to be entered into the drawing (please provide a valid email address) [TEXT BOX]
b. No, I do not want to participate in the drawing

Q22. Is there anything else you would like to let Efficiency Maine know about your heat pump?

Thank you for participating in our survey! We appreciate your feedback.

APPENDIX E. SITE SUMMARIES

EMT Integrated Controls Individual Site Summaries “Cheat Sheet”

Summary table

Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change
Weather-normalized annual heating electric energy consumption of heat pump before installation of controls.	Weather-normalized annual heating electric energy consumption of heat pump after installation of controls.	Change in weather-normalized annual heating electric energy consumption of heat pump due to installed controls.	Percent change in weather-normalized annual heating electric energy consumption of heat pump due to installed controls.

Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Weather-normalized annual heat output of heat pump before controls installation, calculated from heat pump electric energy consumption.	Weather-normalized annual heat output of heat pump before controls installation, calculated from heat pump electric energy consumption.	Change in weather-normalized annual heat output of heat pump due to installed controls.	Delivered fuel savings due to installed controls, assuming that the increase in heat pump heating load is equal to decrease in boiler or furnace heating load.	Average annual fossil fuel consumption of the home, approximated from fuel billing data. Calculated as the sum of all records divided by the total number of days of all records multiplied by 365 days/year. Used for quality check only.	Percent change in fossil fuel consumption due to installed controls.

The summary table presents results calculated from both the metered heat pump data model and the billed usage model. Both models are temperature bin models based on location-specific outdoor air temperature (OAT). Analysts averaged the power use into 5°F bins and regressed the power use against OAT. Analysts extrapolated (normalized) the regressions to typical meteorological year (TMY3) weather data.

The metered heat pump data model uses data collected with data loggers deployed either on the heat pump’s exterior condensing unit (high rigor sites) or the home’s main electrical panel (medium rigor sites). The high rigor meters recorded true kW while the medium rigor meters recorded Amps.

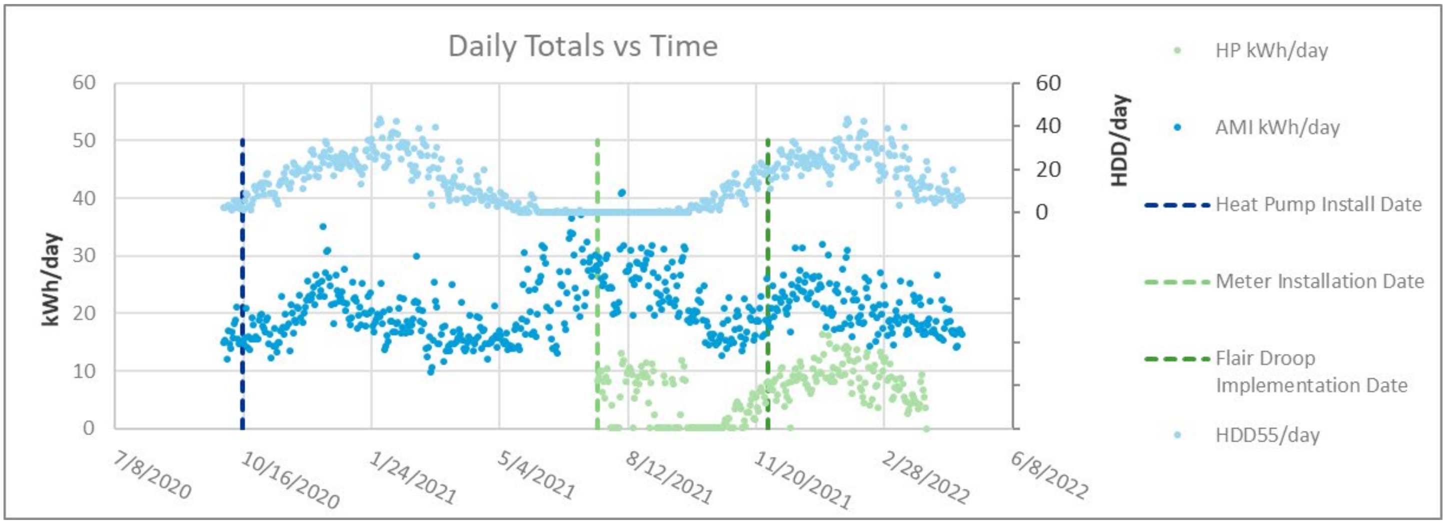
The billed usage model uses the homes electric meter AMI hourly kW data. The homes baseload power consumption was removed from the data by leaving only the weather dependent power consumption.

Site Information and Participant Impressions

Site Information	Fuel Heating System	Ductless Split Heat Pump	Key Participant Impressions (from Survey)
Information on home’s location, size, age, envelope condition, and the metering rigor used at the site.	Information on the home’s fuel heating system including type, make/model, input/output Btu, burner staging, and rated efficiency.	Information on the home’s heat pump including make/model, AHRI reference number, manufacturer rated HSPF, and site-specific HSPF. The site-specific HSPF shows the heat pump heating performance weighted by consumption at temperature using the loads modeled at TMY3 weather.	Key participant takeaways, taken from survey responses.

Daily Totals VS Time

This chart presents the home's daily totals of the raw AMI data, The metered HP data, and location-specific heating degree days (using a heating cutoff of 55°F) over time. The chart also presents the home's heat pump installation date, the data of data logger installation, and the date of controls implementation. The example below is from site IT041.



Data Summary and Heating Degree Day Weather Normalization

This table presents the totals of the observed data

Heating Degree Day Weather Normalization			Description
	HP Data	AMI Data	Data set
Heating DD base	55	55	Heating Degree-Day base temperature used in the analysis.
Base load	0	0.549	Base load of the hourly data when there is no heating or cooling.
Total pre period kWh	572	8,457	Total energy observed in the pre period data.
Total post period kWh	1,060	3,191	Total energy observed in the post period data.
Days of data pre	145	410	Total number of days observed in the pre period data.
Days of data post	124	153	Total number of days observed in the post period data.
Pre coincident HDD	674	4,462	Total heating degree-days coincident with the data observed in the pre period.
Post coincident HDD	2,998	3,277	Total heating degree-days coincident with the data observed in the post period.
TMY3 HDD	4,929		Total heating degree-days of the TMY3 weather used in weather normalization.

Setpoint Information

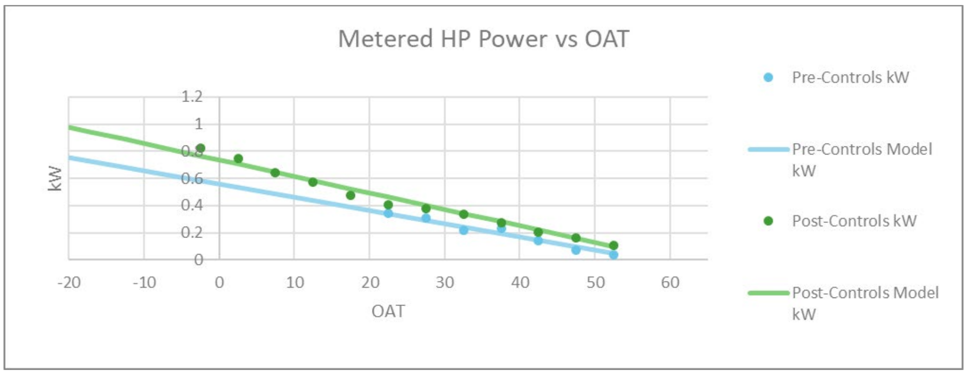
Pre-Controls Setpoints	Post-Controls Setpoints	Participant Setpoint/Behavior Description
Homeowner's typical heating setpoints, before controls installation, per survey responses.	Homeowner's typical heating setpoints, after controls installation, per survey responses.	Homeowner narrative on typical heating system operation, before and after controls installation, per open-ended survey responses.

Flair Checkpoints Table

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
Date of check.	Yes: home's Flair account had droop enabled at time of checkpoint. No: home's Flair account did not have droop enabled at time of checkpoint.	Supplemental: primary heat system (heat pump) remains on and heating when secondary heat (boiler/furnace) is added. Cutover: primary heat system will turn off when secondary heat is needed. Once home is back up to temperature, secondary heat turns off and primary heat turns back on. N/A: secondary heat not in use in home's Flair account.	Indoor temperature: Flair uses indoor temperature to determine when to call for secondary heat. Outdoor temperature: Flair uses outdoor temperature to determine when to call for secondary heat. N/A: secondary heat not in use in home's Flair account.	If secondary heat trigger is indoor air temperature, Flair will call for secondary heat when the difference between the home's average setpoint and the home's average temperate is greater than this droop offset (°F).

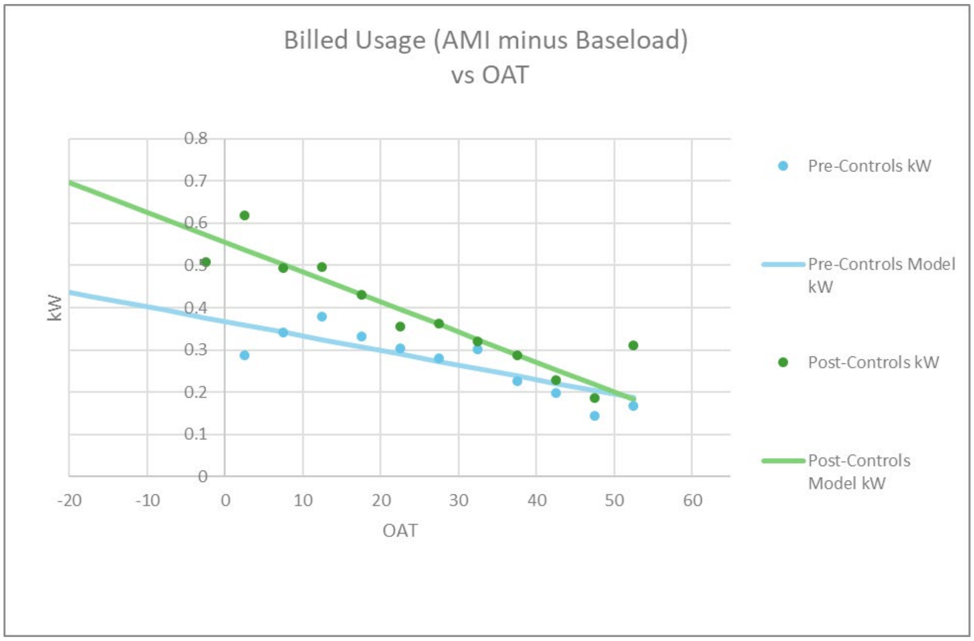
Metered HP Power vs OAT Chart

This chart presents the data points and regression results of the metered heat pump heating power model described above, with heat pump power as a function of OAT. Example below from site IT041.



Billed Usage (AMI Minus Baseload) vs OAT Chart

This chart presents the data points and regression results of the billed usage model described above, with heating weather dependent power as a function of OAT. Example below from site IT041.



Takeaways and Feedback

Analysis Takeaways
Summary of site-specific analysis results.
Participant Comments from Survey
Participant comments from survey not included elsewhere, if applicable.

Site ID	IT004

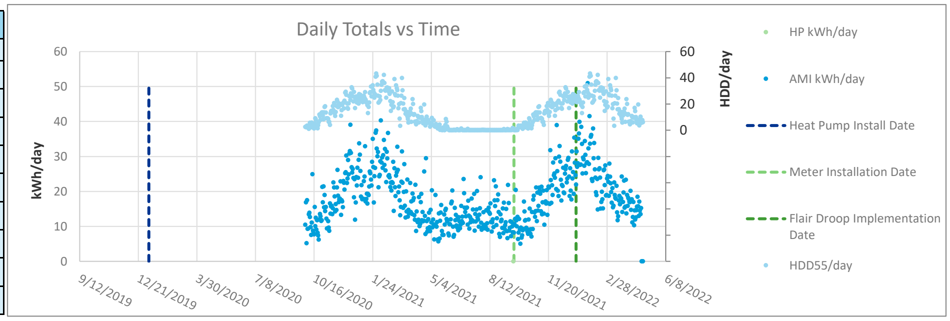
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	2,492	2,859	367	15%	29,328,983	33,647,392	4,318,409	5.1	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04106	Equipment Type	Boiler	Make	Mitsibishi
Year Built	1957	Fuel Type	Fuel Oil	Outdoor unit model	MUZ-FH09NA
Envelope Condition	Fair	Make	Peerless	Indoor unit model	MSZ-FH09NA
Approx Area (ft2)	1,175	Model	WBV-03-110-WPCT	AHRI ref #	201754296
Metering Rigor	Med	Input BTU Max	153,000	Nameplate SEER	30.5
		Input BTU Min	153,000	Nameplate HSPF	13.5
		Burner staging	single	HSPF correction factor	87%
		AFUE/Efficiency	0.84	Site Specific HSPF	11.8

Key Participant Impressions (from Survey)

Heat pump operates same with controls.
Boiler operates less with controls.
Home uses same amount fuel, and spends same amount of money on fuel.
Home uses less electricity, and spends less money on electricity.
Ease of operations of controls: 5/10
Likelihood of continuing to use Flair controls: 3/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.44
Total pre period kWh	0	7,844
Total post period kWh	0	2,497
Days of data pre	14	462
Days of data post	0	112
Pre coincident HDD	4	5,379
Post coincident HDD	0	2,383
TMY3 HDD	4,929	



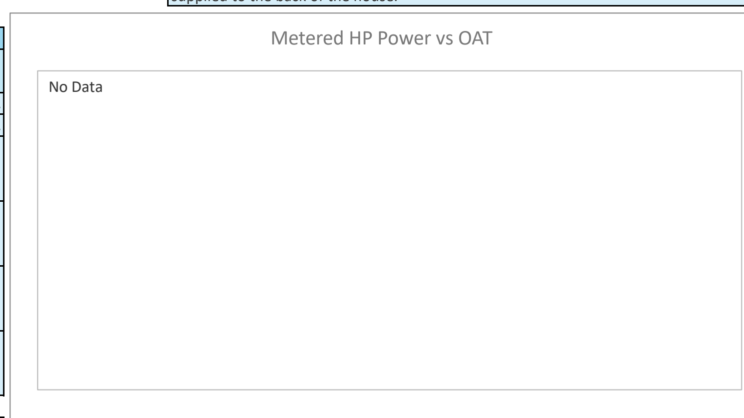
Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Setpoint
Weekday Day	76	65	Living room	76
Weekday Night	76	65	Bedroom	65
Weekend Day	76	65		
Weekend Night	76	65		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: set thermostat for boiler much lower than heat pump, because the front of the house (where the heat pump is located) is most used.
Post-Controls: because the living room sensor is in the heat pump zone and the bedroom sensor is not, ended up disabling bedroom sensor to avoid unwanted oil heat supplied to the back of the house.

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3

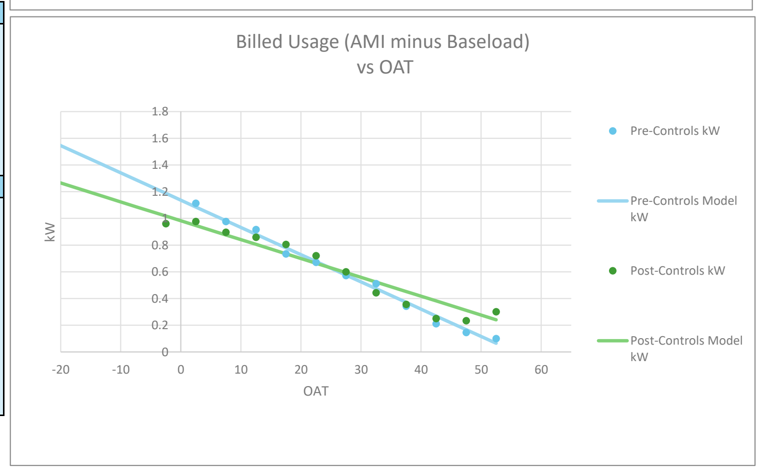


Analysis Takeaways

Heat pump logger failed after 20 days; AMI data shows increased heat pump usage after implementing droop. Homeowner chose to reduce offset from 5 degrees to 3 degrees. Home is a reasonable candidate for droop because the heat pump is located in the front, which is the area of the house that is most commonly used. Homeowner reports that they only used oil when the back bedroom was needed and it was very cold, because the heat pump does not reach that room.

Participant Comments from Survey

"I used to have to set the heat pump to 76 [in order to keep all of the rooms comfortable with only the heat pump], but we were able to lower it to 72 since the sensors would pick up if the other rooms dropped below the set temperature."
"Seems like more of a hassle since we only have one heat pump and one oil heating zone. It seems like it would be really helpful for a multi-zone system. I just think my situation is better with a smart thermostat that I can manage independently from the heat pump."

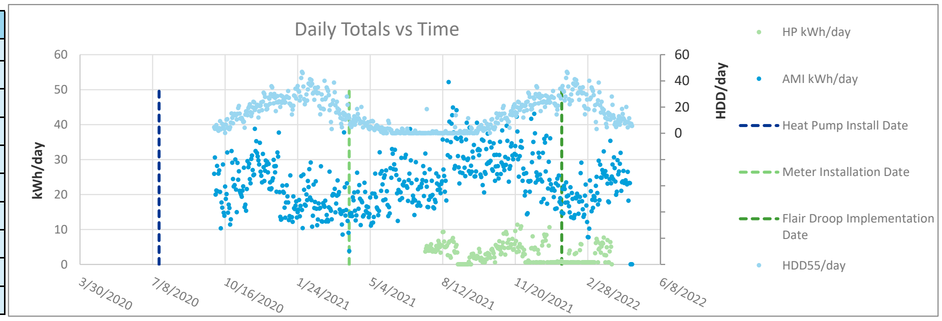


Site ID	IT006

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	716	639	-77	-11%	8,434,916	7,526,322	-908,594	-1.0	No Fuel Data	N.D.
Billed Usage Model	1,677	1,546	-131	-8%	19,755,660	18,216,636	-1,539,023	-1.7	No Fuel Data	N.D.

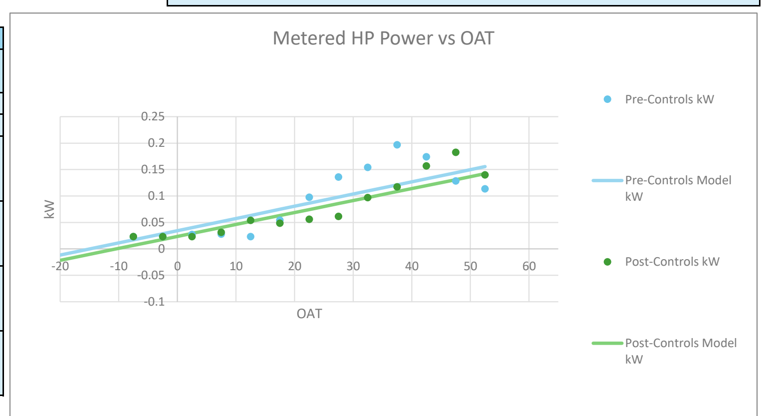
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04030	Equipment Type	Boiler	Make	Mitsubishi	Heat pump operates more with controls.
Year Built	2019	Fuel Type	Propane	Outdoor unit model	MUZ-GL12NA	Boiler operates less with controls.
Envelope Condition	Good	Make	Viessman	Indoor unit model	MSZ-GL12NA	Home uses less fuel, and spends less money on fuel.
Approx Area (ft2)	1,300	Model	BIKA 125	AHRI ref #	202680598	Home uses less electricity, and spends less money on electricity.
Metering Rigor	Med	Input BTU Max	125,000	Nameplate SEER	23.1	Ease of operations of controls: 7/10
		Input BTU Min	31,000	Nameplate HSPF	11.5	Likelihood of continuing to use Flair controls: 10/10
		Burner staging	modulating	HSPF correction factor	102%	
		AFUE/Efficiency	0.928	Site Specific HSPF	11.8	

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.636761905
Total pre period kWh	766	11,359
Total post period kWh	150	2,019
Days of data pre	210	479
Days of data post	69	95
Pre coincident HDD	2,228	6,322
Post coincident HDD	1,694	2,090
TMY3 HDD	4,953	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler	Zone	Whole Home	Pre-Controls: heat pump on and heating throughout winter
Weekday Day	70	70	Home	70	Post-Controls: homeowner switched to a small droop offset with a combination of indoor and outdoor temperature trigger mechanism because they require precise temperature control of nursery room
Weekday Night	70	70			
Weekend Day	70	70			
Weekend Night	70	70			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	CUTOVER	Indoor Or Outdoor Temperature	2
2/21/2022	Yes	CUTOVER	Indoor Or Outdoor Temperature	2
3/7/2022	No	N.A.	N.A.	N.A.
3/21/2022	Yes	CUTOVER	Indoor Or Outdoor Temperature	2

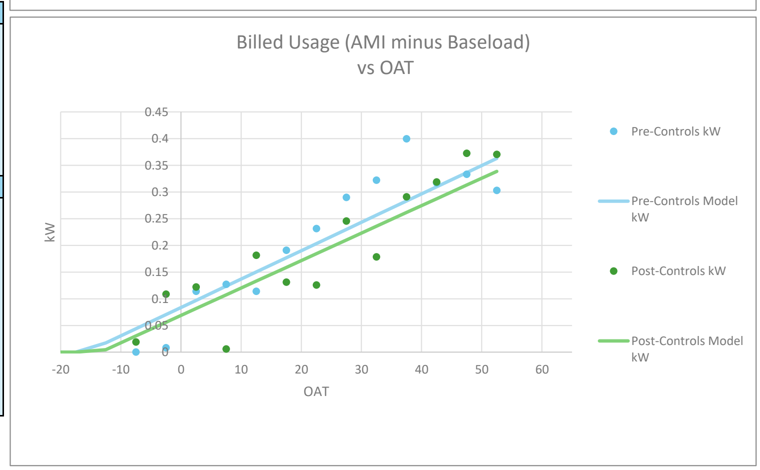


Analysis Takeaways

Homeowner requires precise temperature control of nursery, so this home is not well suited for the potential temperature swing that a 5 degree droop offset may allow for. Homeowner decreased offset and implemented an outdoor air temperature trigger so that the boiler would take over at low outdoor temperatures. Overall consumption with Flair is similar to before, likely because the temperature bounds stayed very precise, so the heating equipment operated similarly in the pre- and post-case.

Participant Comments from Survey

No response.



Site ID	IT008

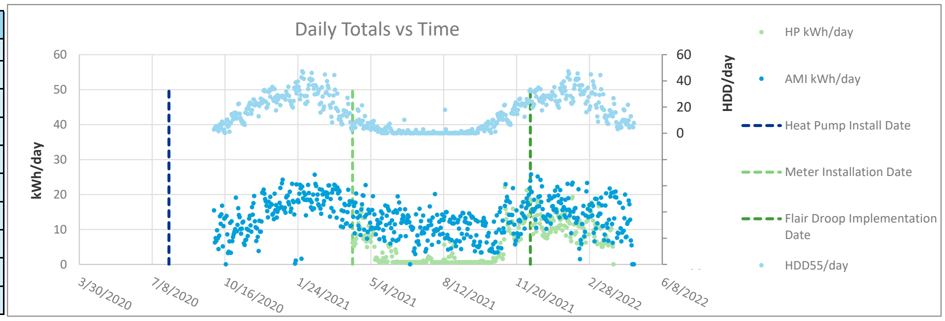
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	2,829	2,149	-680	-24%	33,392,233	25,369,553	-8,022,680	-9.6	67.2	14.3%
Billed Usage Model	1,224	1,354	130	11%	14,451,367	15,981,674	1,530,306	1.8	67.2	-2.7%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04947	Equipment Type	Forced Air / Central AC / Fur	Make	Mitsubishi
Year Built	1950s	Fuel Type	Fuel Oil	Outdoor unit model	MUZ FN06NA
Envelope Condition	Poor	Make	DMO	Indoor unit model	MSZ FH06NA
Approx Area (ft2)	1,400	Model	BFL 90	AHRI ref #	201754426
Metering Rigor	Med	Input BTU Max	90,000	Nameplate SEER	33.1
		Input BTU Min	90,000	Nameplate HSPF	13.5
		Burner staging	single	HSPF correction factor	87%
		AFUE/Efficiency	0.835	Site Specific HSPF	11.8

Key Participant Impressions (from Survey)

Heat pump operates same amount with controls.
Furnace operates less with controls.
Home not sure how fuel use has changed.
Home uses same amount of electricity, and spends same amount of money on electricity.
Ease of operations of controls: 10/10
Likelihood of continuing to use Flair controls: 10/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.372114286
Total pre period kWh	924	7,562
Total post period kWh	1,252	2,609
Days of data pre	243	594
Days of data post	114	179
Pre coincident HDD	1,283	6,845
Post coincident HDD	710	4,311
TMY3 HDD	5,323	

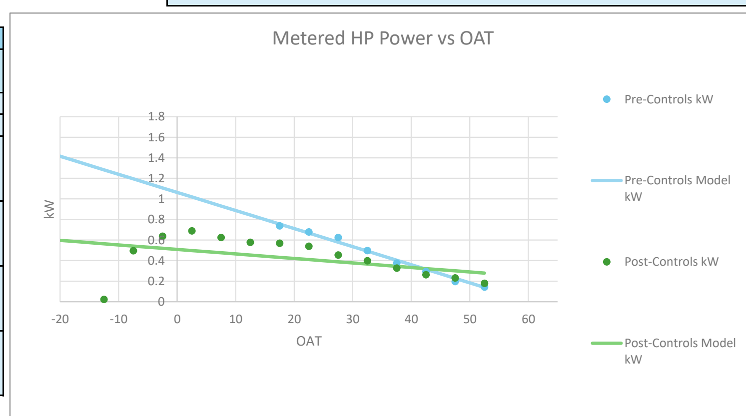


Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Forced Air / Centi	Zone	Whole Home
Weekday Day	65	62	Home	67/59 Day/Night
Weekday Night	55	52	Away	53
Weekend Day	65	62		
Weekend Night	55	62		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: utilized nightime setbacks
Post-Controls: utilized nightime setbacks and smart away mode

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3

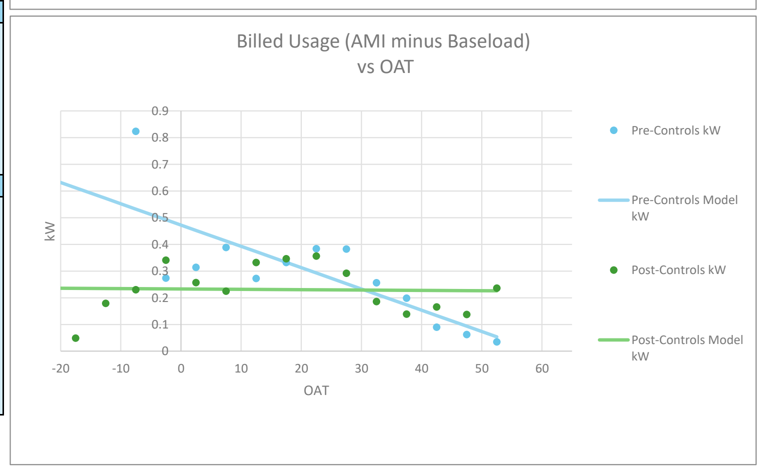


Analysis Takeaways

Data shows that heat pump runs less after controls were installed. This is a second home, so the ability to program smart away mode and adjust the temperature remotely may contribute to decreased use.

Participant Comments from Survey

No response.

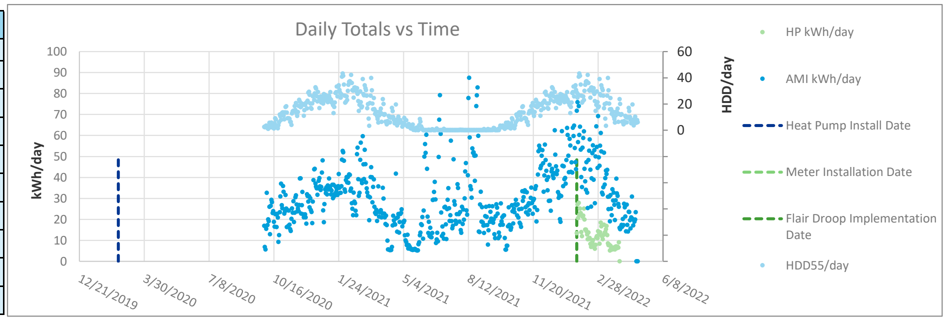


Site ID	IT010

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	2,799	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	4,828	6,425	1,598	33%	56,252,722	74,867,706	18,614,984	23.3	No Fuel Data	N.D.

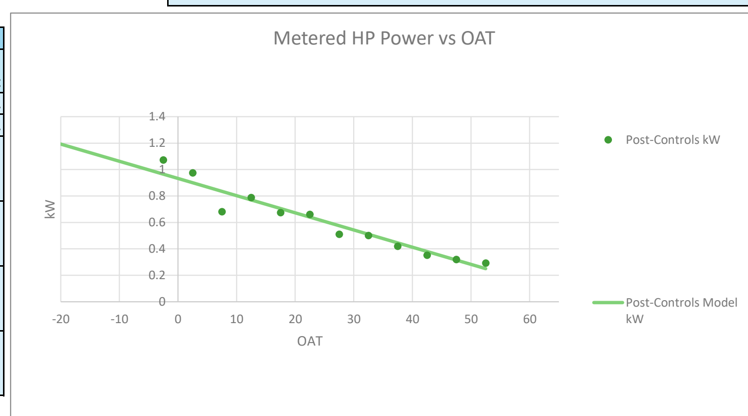
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04105	Equipment Type	Boiler	Make	Fujitsu	Not sure if/how heat pump operation changed.
Year Built	1982	Fuel Type	Fuel Oil	Outdoor unit model	AOU15RLS3	Boiler operates the same amount with controls.
Envelope Condition	Good	Make	NTI	Indoor unit model	ASU15RLS3Y	Not sure how fuel use or money spent on fuel changed.
Approx Area (ft2)	2,300	Model	CT-120	AHRI ref #	8703507	Home uses more electricity, and spends more money on electricity.
Metering Rigor	Med	Input BTU Max	0	Nameplate SEER	25.3	Ease of operations of controls: 5/10
		Input BTU Min	0	Nameplate HSPF	13.4	Likelihood of continuing to use Flair controls: 0/10
		Burner staging	0	HSPF correction factor	87%	
		AFUE/Efficiency	0.8	Site Specific HSPF	11.7	

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.485
Total pre period kWh	0	13,877
Total post period kWh	804	3,355
Days of data pre	0	482
Days of data post	65	92
Pre coincident HDD	2	5,878
Post coincident HDD	1,605	1,883
TMY3 HDD	4,929	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler	Zone	Whole Home	Pre-Controls: heat pump on and heating throughout winter
Weekday Day	70	74	Home	Varied	Post-Controls: varied setpoint, found that home was often colder than desired
Weekday Night	70	74			
Weekend Day	70	74			
Weekend Night	70	74			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4



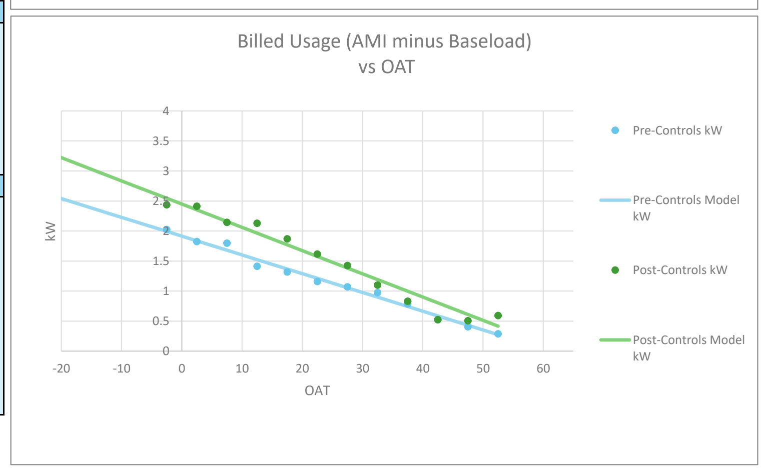
Analysis Takeaways

No pre-droop metered data because meters were installed at the same time that droop was implemented. AMI data shows increased use of heat pump with controls. Homeowner reports that home became less comfortable because it was colder in the winter, likely due to the heat pump not reaching all rooms. If the thermostat was near the heat pump and the homeowner did not utilize additional sensors, Flair would not have the colder room inputs and would not call for supplemental heat.

Participant Comments from Survey

"In the winter the house was colder. I had to turn the temp much higher than I normally do to get the desired temp. In the summer the home is much warmer than it normally is."

"It was easy to operate but was very confusing on how it worked."



Site ID	IT011

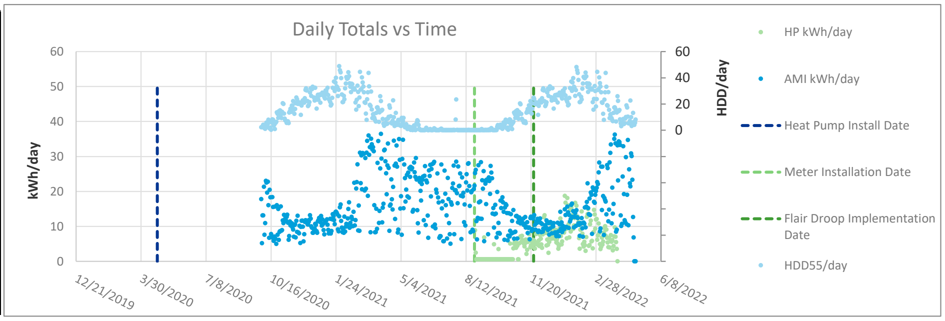
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,208	1,769	561	46%	13,957,607	20,442,250	6,484,643	8.1	25.0	-32.4%
Billed Usage Model	1,797	2,056	259	14%	20,764,311	23,759,350	2,995,039	3.7	25.0	-14.9%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04355	Equipment Type	Forced Air / Central AC / Furı	Make	Mitsubishi
Year Built	1800	Fuel Type	Fuel Oil	Outdoor unit model	MUZ-FH09NA
Envelope Condition	Fair	Make	Thermo Pride	Indoor unit model	MSZ-FH09NA
Approx Area (ft2)	1,250	Model	OL5-85	AHRI ref #	201754296
Metering Rigor	Med	Input BTU Max	106,250	Nameplate SEER	30.5
		Input BTU Min	106,250	Nameplate HSPF	13.5
		Burner staging	single	HSPF correction factor	86%
		AFUE/Efficiency	0.8	Site Specific HSPF	11.6

Key Participant Impressions (from Survey)

Heat pump operates more with controls.
Furnace operates less with controls.
Home uses less fuel, and spends less money on fuel.
Home uses more electricity, and spends the same amount of money on electricity.
Ease of operations of controls: 10/10
Likelihood of continuing to use Flair controls: 9/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.3285
Total pre period kWh	82	16,048
Total post period kWh	903	5,458
Days of data pre	21	989
Days of data post	103	349
Pre coincident HDD	163	10,957
Post coincident HDD	2,785	8,152
TMY3 HDD	5,028	

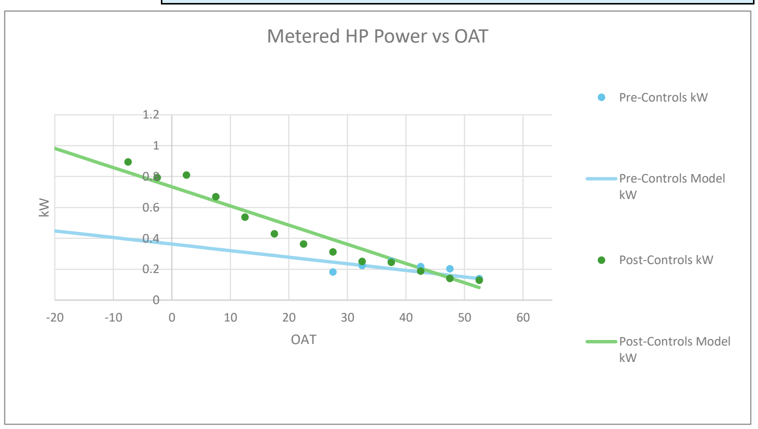


Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Forced Air / Centı	Zone	Whole Home
Weekday Day	68	60	Day	65
Weekday Night	off	60	Night	60
Weekend Day	68	60	Away	55
Weekend Night	off	60		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: heat pump used to warm computer room when in use, furnace used as back up to wood stove
Post-Controls: set entire home to one temperature in Flair and turned down at night, utilized smart away mode

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

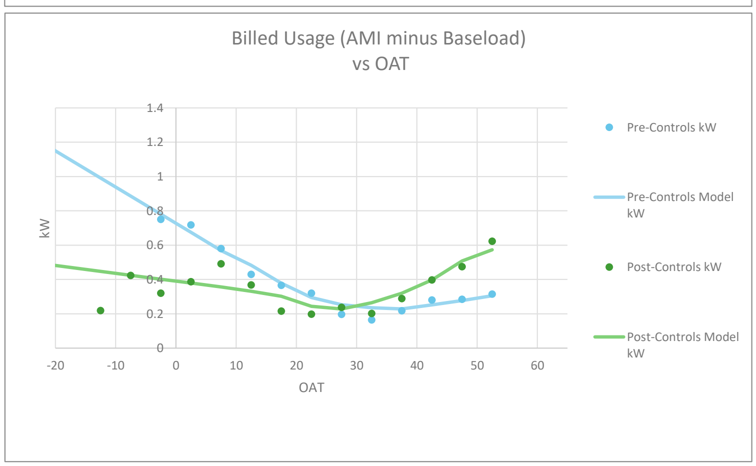


Analysis Takeaways

This home is not an ideal candidate for droop because the heat pump only serves one room and the home uses a wood stove as a significant heat source in addition to their central furnace. However, homeowner has a positive experience with the technology and reported that home was warmer throughout the winter, likely because the whole-home daytime setpoint (65) was higher than the previous central system setpoint (60).

Participant Comments from Survey

"We are now coming closer to using all the solar energy we have in the bank, so lapsing fewer credits. We also used less oil and less wood (10-15% less)."
"Good tool to manage multiple heat sources."

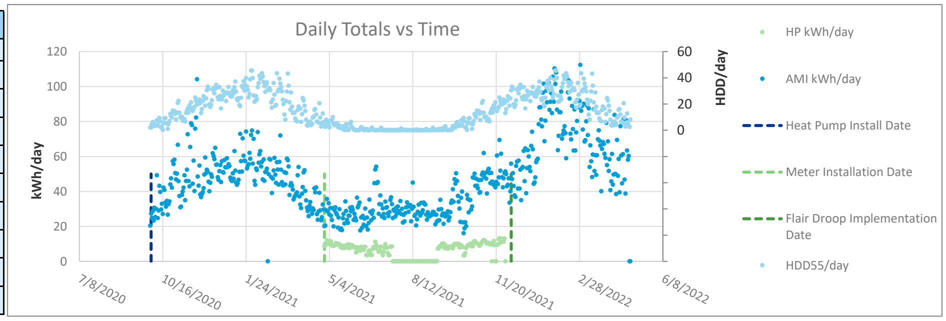


Site ID	IT012

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	2,801	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	118.3	N.D.
Billed Usage Model	4,472	9,954	5,482	123%	52,359,740	116,551,444	64,191,704	76.4	118.3	-64.6%

Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04444	Equipment Type	Boiler	Make	Fujitsu	No response.
Year Built	1920	Fuel Type	Fuel Oil	Outdoor unit model	AOU15RLS3	
Envelope Condition	Good	Make	Weil McLain	Indoor unit model	ASU15RLS3	
Approx Area (ft2)	2,250	Model	Gold series - model # obscu	AHRI ref #	8703507	
Metering Rigor	Med	Input BTU Max	170,000	Nameplate SEER	25.3	
		Input BTU Min	0	Nameplate HSPF	13.4	
		Burner staging	SINGLE	HSPF correction factor	87%	
		AFUE/Efficiency	0.84	Site Specific HSPF	11.7	

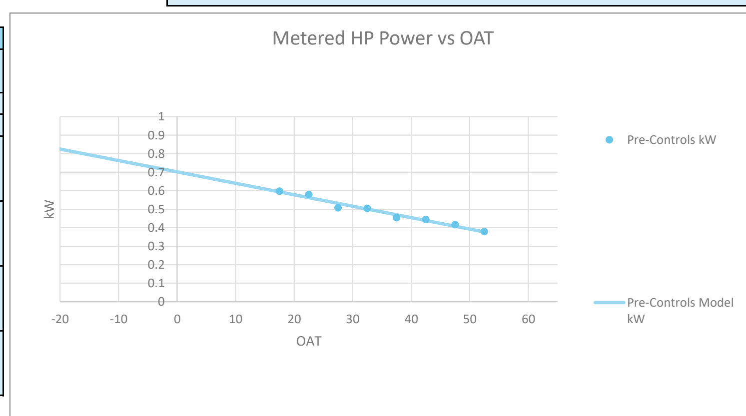
Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	1.125037523
Total pre period kWh	1,045	17,041
Total post period kWh	0	9,743
Days of data pre	113	429
Days of data post	0	141
Pre coincident HDD	660	5,135
Post coincident HDD	0	3,403
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from site visit)
Equipment	Heat Pump	Boiler	Zone	Living Room/Kitchen	Pre-controls: set heat pump at 74 and boiler at 68
Weekday Day	74	68		N.D.	Post-controls: utilized droop with 5 degree offset
Weekday Night	74	68			
Weekend Day	74	68			
Weekend Night	74	68			

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

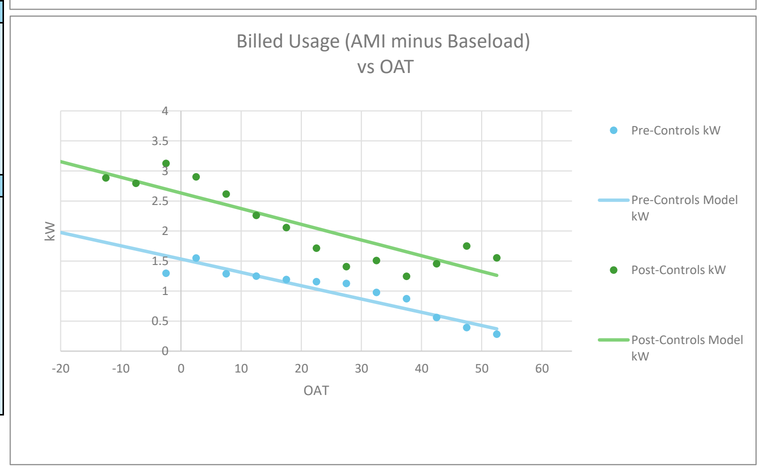


Analysis Takeaways

Heat pump data logger failed before droop was implemented. AMI data shows increased heat pump use after installation of controls. Layout is a good candidate for droop because the bedroom, which is not served by the kitchen heat pump, has a separate heat pump. Therefore, the boiler and heat pump zones overlap entirely (the boiler did not need to run to accommodate the bedroom temperature).

Participant Comments from Survey

No response.



Site ID	IT015

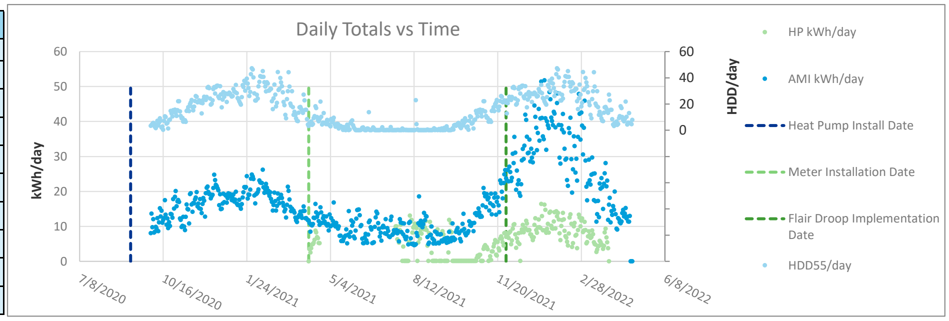
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,254	1,742	488	39%	14,589,701	20,267,580	5,677,879	6.8	77.1	-8.8%
Billed Usage Model	2,115	4,187	2,072	98%	24,618,646	48,728,578	24,109,932	28.9	77.1	-37.5%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04947	Equipment Type	Boiler	Make	Fijitsu
Year Built	2004	Fuel Type	Fuel Oil	Outdoor unit model	AOUG15LZAS1
Envelope Condition	Good	Make	Burnham	Indoor unit model	ASUG15LZAS
Approx Area (ft2)	1,460	Model	PC3WT-TBWR	AHRI ref #	204740070
Metering Rigor	High	Input BTU Max	99,000	Nameplate SEER	25.3
		Input BTU Min	99,000	Nameplate HSPF	13.4
		Burner staging	single	HSPF correction factor	87%
		AFUE/Efficiency	0.835	Site Specific HSPF	11.6

Key Participant Impressions (from Survey)

Heat pump operates more with controls.
Boiler operates less with controls.
Home uses less fuel, and spends less money on fuel.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 7/10
Likelihood of continuing to use Flair controls: 10/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.313329435
Total pre period kWh	580	5,566
Total post period kWh	1,052	4,173
Days of data pre	146	425
Days of data post	123	149
Pre coincident HDD	850	5,237
Post coincident HDD	3,355	3,628
TMY3 HDD	5,323	



Pre-Controls Setpoints		
Equipment	Heat Pump	Boiler
Weekday Day	70	70
Weekday Night	67	67
Weekend Day	70	70
Weekend Night	67	70

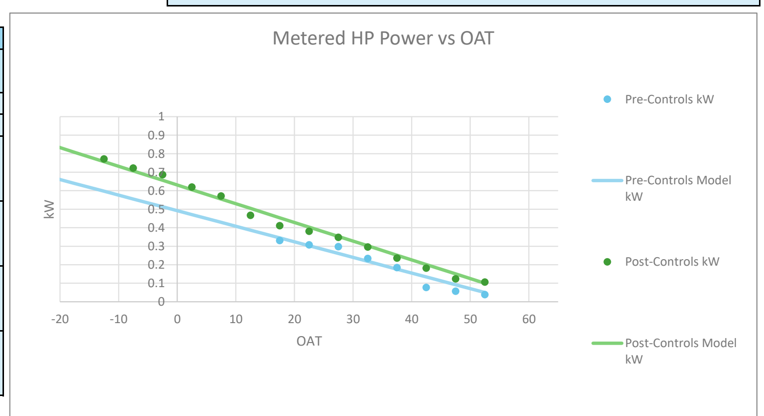
Post-Controls Setpoints		
Zone	Living Room	Hallway
Setpoint	70	68

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: implemented nighttime setbacks for both boiler and heat pump
Post-Controls: set living room (heat pump location) to 70 and hallway (thermostat location) to 68, with 5 degree droop

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

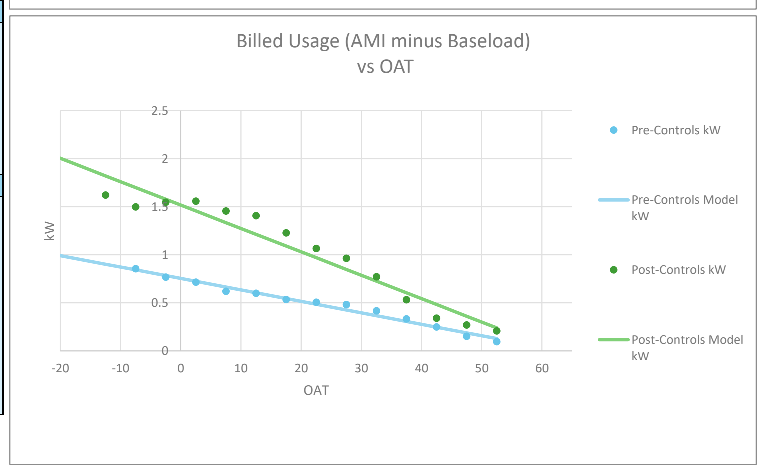


Analysis Takeaways

The data indicates that the the heat pump use increased with the new controls.

Participant Comments from Survey

"I am still a bit confused as to all the settings and different equipment and when to use each."
"Last year when outdoor temps went down to 20 or lower, I turned off the heat pump because I got too cold, however, I saved huge in fuel just the same. This year, I kept the heat pump on at all times so went from $90 elec to $227 elec and that was before the price hike. That was a big hike for me because the previous winter I had gone from $45 elec to about $95."
"Once I knew how to use it a bit more, I had a more even temperature that kept me comfortable in the major part of the house."



Site ID	IT016

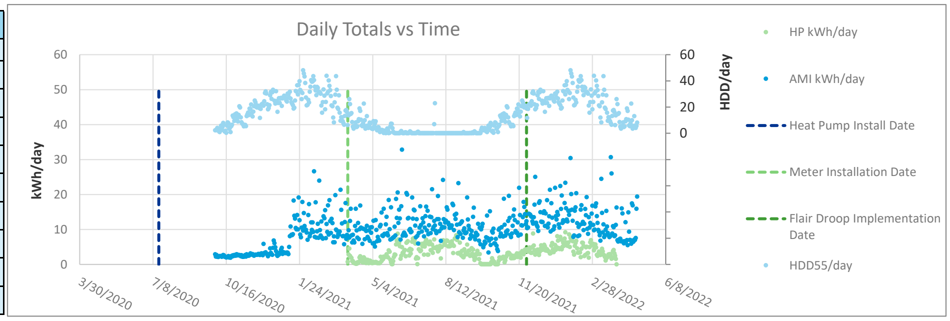
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	664	920	255	38%	7,590,955	10,509,448	2,918,493	3.5	No Fuel Data	N.D.
Billed Usage Model	852	1,924	1,072	126%	9,734,679	21,986,464	12,251,785	14.6	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04344	Equipment Type	Boiler	Make	Mitsubishi
Year Built	1955	Fuel Type	Fuel Oil	Outdoor unit model	MUZ-FH06NA
Envelope Condition	Fair	Make	H.B. Smith	Indoor unit model	MSZ-FH06NA
Approx Area (ft2)	1,380	Model	FD12	AHRI ref #	201754426
Metering Rigor	High	Input BTU Max	127,000	Nameplate SEER	33.1
		Input BTU Min	127,000	Nameplate HSPF	13.5
		Burner staging	single	HSPF correction factor	85%
		AFUE/Efficiency	0.84	Site Specific HSPF	11.4

Key Participant Impressions (from Survey)

Heat pump operates the more with controls.
Boiler operates less with controls.
Home uses less fuel, and spends less money on fuel.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 10/10
Likelihood of continuing to use Flair controls: 8/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.183333333
Total pre period kWh	704	3,853
Total post period kWh	540	1,930
Days of data pre	243	425
Days of data post	123	152
Pre coincident HDD	1,074	4,927
Post coincident HDD	635	3,542
TMY3 HDD	5,028	



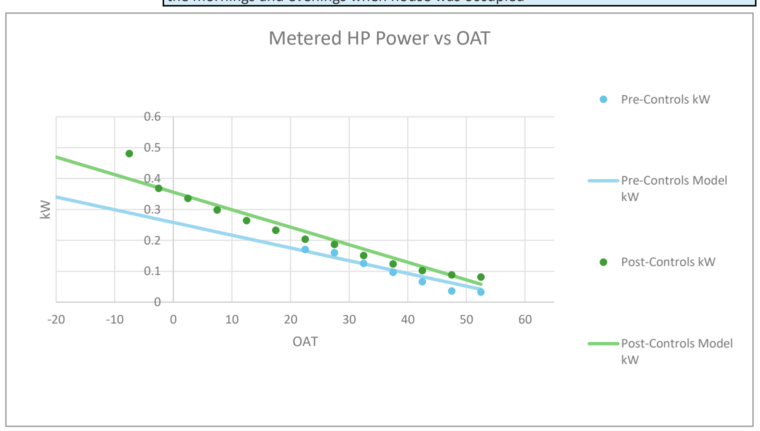
Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Setpoint
Weekday Day	62	60	Upstairs	64
Weekday Night	62	60	Downstairs	67
Weekend Day	62	60		
Weekend Night	62	60		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: periodically turned heat pump on and off throughout winter, left boiler temperature at same low temperature
Post-Controls: set upstairs (heat pump location) temperature lower than the downstairs, adjusted temperature more throughout the day so that it was warmer in the mornings and evenings when house was occupied

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3

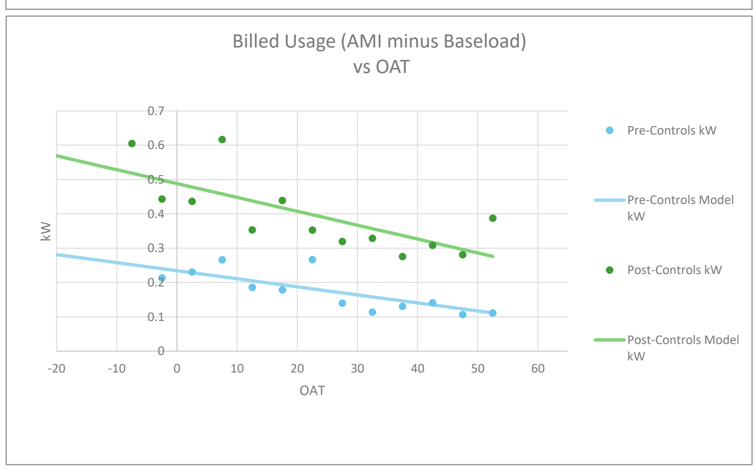


Analysis Takeaways

The metered heat pump data and the AMI data both show an increase in heat pump use after the controls were installed. The heat pump is located in the upstairs bedroom, so it has little impact on the downstairs temperature. The higher setpoints likely contribute to the increased heat pump use, and lowering the home temperature throughout the day likely contributes to the perceived decrease in boiler use.

Participant Comments from Survey

"The Flair system seemed good to use, and we did not have issues. I personally prefer the manufacturer's heat pump remote."



Site ID	IT017

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	2,303	2,649	346	15%	24,984,453	28,740,924	3,756,471	4.4	80.7	-5.4%
Billed Usage Model	7,248	8,213	966	13%	78,628,219	89,104,312	10,476,094	12.2	80.7	-15.1%

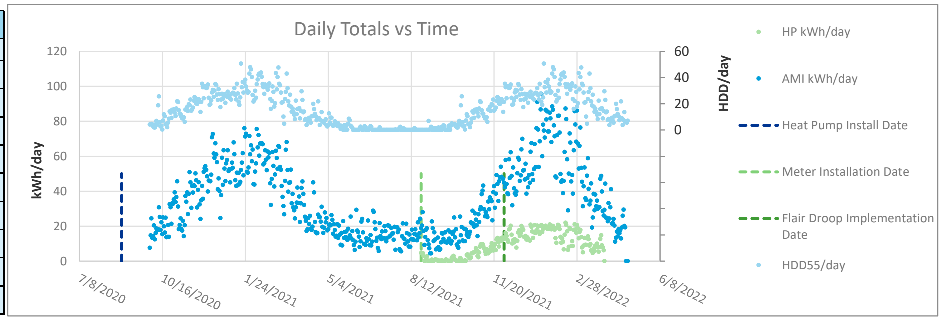
Site Information	
ZIP Code	04210
Year Built	1966
Envelope Condition	Fair
Approx Area (ft2)	1,200
Metering Rigor	High

Fuel Heating System	
Equipment Type	Forced Air / Central AC / Fu
Fuel Type	Fuel Oil
Make	Airco
Model	BCL 80 (S)
Input BTU Max	91,000
Input BTU Min	91,000
Burner staging	single
AFUE/Efficiency	0.86

Ductless Split Heat Pump	
Make	Mitsubishi
Outdoor unit model	MUZ-FH12NA
Indoor unit model	MSZ-FH12NA
AHRI ref #	201754298
Nameplate SEER	26.1
Nameplate HSPF	12.5
HSPF correction factor	87%
Site Specific HSPF	10.8

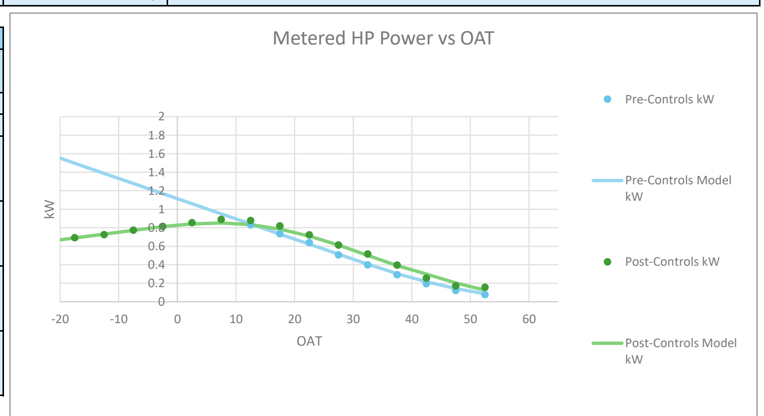
Key Participant Impressions (from Survey)
Homeowner disabled automatic droop; heat pump and furnace operate the same as before. Ease of operations of controls: 1/10 Likelihood of continuing to use Flair controls: 0/10

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.413333333
Total pre period kWh	351	12,618
Total post period kWh	1,736	7,307
Days of data pre	100	427
Days of data post	121	147
Pre coincident HDD	798	5,413
Post coincident HDD	3,377	3,674
TMY3 HDD	5,025	



Pre-Controls Setpoints			Post-Controls Setpoints			Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Forced Air / Centi	Equipment	Heat Pump	Forced Air / Central AC	Pre-Controls: heat pump on and heating throughout winter Post-Controls: disconnected Flair and returned to controlling furnace/heat pump separately
Weekday Day	68	62	Weekday Day	68	62	
Weekday Night	68	62	Weekday Nigl	68	62	
Weekend Day	68	62	Weekend Day	68	62	
Weekend Night	68	62	Weekend Nig	68	62	

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	No	N.A.	N.A.	N.A.
2/21/2022	No	N.A.	N.A.	N.A.
3/7/2022	No	N.A.	N.A.	N.A.
3/21/2022	No	N.A.	N.A.	N.A.

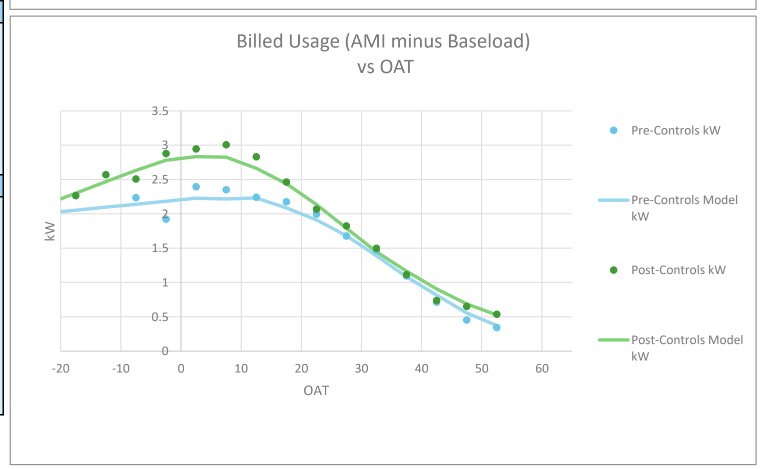


Analysis Takeaways

Homeowner did not continue using automated controls. Data shows slight increased heat pump use, which may be due to performance of the smart thermostat or program guidance to use heat pump throughout winter.

Participant Comments from Survey

"I am happy with the performance of the Ecobee. Flair did not control my heat pump."



Site ID	IT018

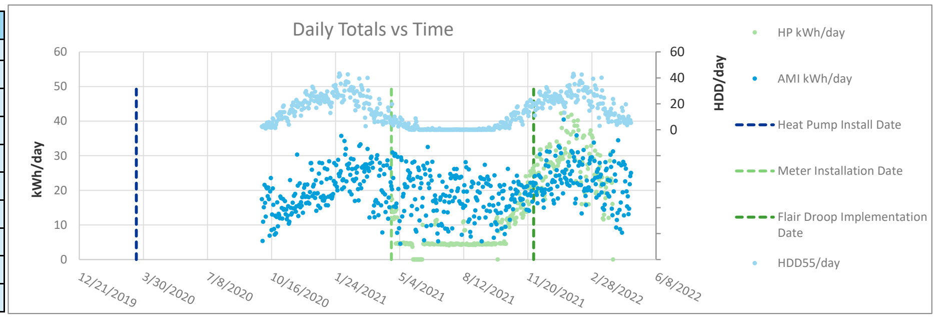
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	4,988	6,052	1,064	21%	52,323,071	63,485,261	11,162,190	14.0	37.1	-37.6%
Billed Usage Model	965	1,776	811	84%	10,121,290	18,633,291	8,512,001	10.6	37.1	-28.7%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04103	Equipment Type	Forced Air / Central AC / Furn	Make	Mitsubishi
Year Built	1950's initial,	Fuel Type	Propane	Outdoor unit model	MUZ-FH15NA
Envelope Condition	Good	Make	York	Indoor unit model	MSZ-FH15NA
Approx Area (ft2)	1,500	Model	TG9S120D20MP11B	AHRI ref #	201754300
Metering Rigor	Med	Input BTU Max	120,000	Nameplate SEER	22
		Input BTU Min	0	Nameplate HSPF	12
		Burner staging	single	HSPF correction factor	87%
		AFUE/Efficiency	0.8	Site Specific HSPF	10.5

Key Participant Impressions (from Survey)

Heat pump operates the same amount with controls.
Furnace operates more with controls.
Homeowner unsure if fuel use has changed, spends the same amount of money on fuel as before.
Home uses the same amount electricity, and spends the same amount of money on electricity.
Ease of operations of controls: 2/10
Likelihood of continuing to use Flair controls: 2/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.64666163
Total pre period kWh	942	19,116
Total post period kWh	3,394	7,883
Days of data pre	82	996
Days of data post	121	346
Pre coincident HDD	594	10,131
Post coincident HDD	2,933	7,350
TMY3 HDD	4,929	



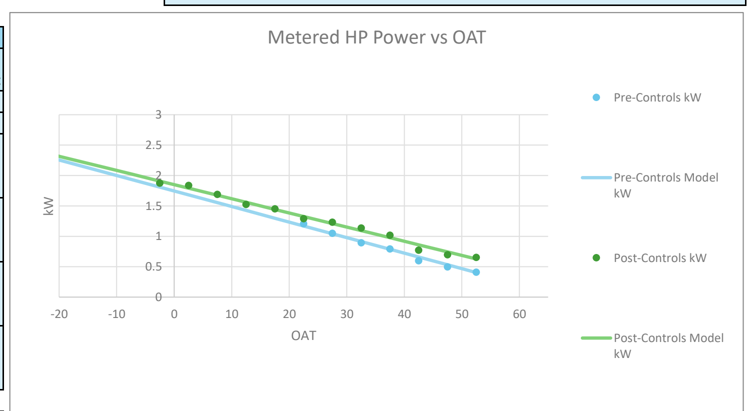
Pre-Controls Setpoints		
Equipment	Heat Pump	Forced Air / Centr
Weekday Day	68	60
Weekday Night	68	60
Weekend Day	68	60
Weekend Night	68	60

Post-Controls Setpoints	
Zone	Whole Home
Home	68

Participant Setpoint/Behavior Description (from Survey)

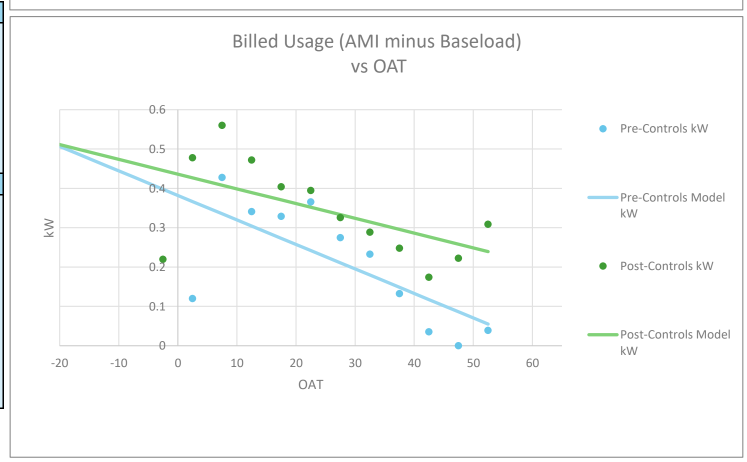
Pre-Controls: left furnace and heat pump at constant temperatures throughout winter
Post-Controls: utilized droop for several months, eventually overrode automated Flair controls and used Flair account in manual mode to independently control heat pump and boiler/furnace

Flair Checkpoints Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5



Analysis Takeaways

Homeowner used droop for most of the winter, but could not find settings that kept home at a satisfactory temperature, and eventually disconnected Flair. Both metered HP data and AMI data indicate increased heat pump usage after controls were installed.



Participant Comments from Survey

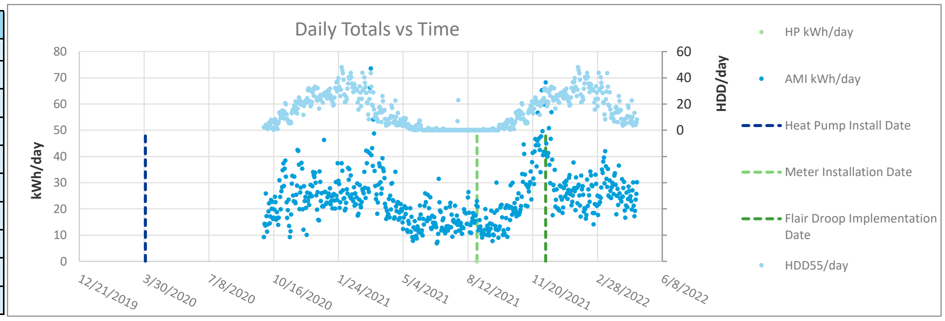
"When outside temp was very low and heat pump couldn't keep up my furnace wouldn't come on automatically. When the outside temp was warm the Flair over shot the set point."

Site ID	IT019

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	3,201	3,191	-10	0%	31,632,001	31,530,459	-101,542	-0.1	No Fuel Data	N.D.

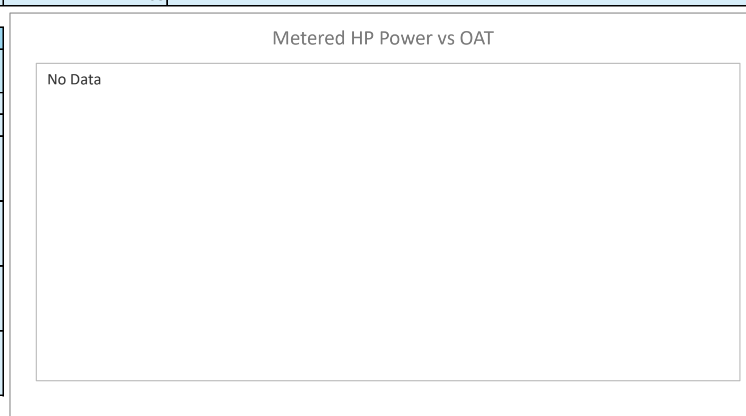
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04363	Equipment Type	Boiler	Make	Daiken	Homeowner not sure if boiler and heat pump use have changed.
Year Built	1980	Fuel Type	Fuel Oil	Outdoor unit model	RXL15QMVJU	Home uses less fuel, and spends less money on fuel.
Envelope Condition	Fair	Make	Burnham	Indoor unit model	FTX15NMVJU	Home uses more electricity, and spends more money on electricity.
Approx Area (ft2)	1,500	Model	3WFH	AHRI ref #	8849445	Ease of operations of controls: 4/10
Metering Rigor	Med	Input BTU Max	121,000	Nameplate SEER	20	Likelihood of continuing to use Flair controls: 4/10
		Input BTU Min	0	Nameplate HSPF	11.3	
		Burner staging	0	HSPF correction factor	87%	
		AFUE/Efficiency	0.86	Site Specific HSPF	9.9	

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.534997232
Total pre period kWh	0	9,821
Total post period kWh	0	3,895
Days of data pre	0	435
Days of data post	0	142
Pre coincident HDD	0	5,149
Post coincident HDD	0	3,319
TMY3 HDD	5,028	



Pre-Controls Setpoints			Post-Controls Setpoints			Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler	Equipment	Heat Pump	Boiler	Pre-Controls: utilized nighttime setbacks, periodically turned heat pump on and off througout winter
Weekday Day	68	68	Weekday Day	68	68	Post-Controls: disconnected Flair and returned to manually adjusting furnace and heat pump, utilizing the same nighttime setbacks as before the controls
Weekday Night	65	65	Weekday Nigh	65	65	
Weekend Day	68	68	Weekend Day	68	68	
Weekend Night	65	65	Weekend Nigh	65	68	

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	No	N.A.	N.A.	N.A.
2/21/2022	No	N.A.	N.A.	N.A.
3/7/2022	No	N.A.	N.A.	N.A.
3/21/2022	No	N.A.	N.A.	N.A.

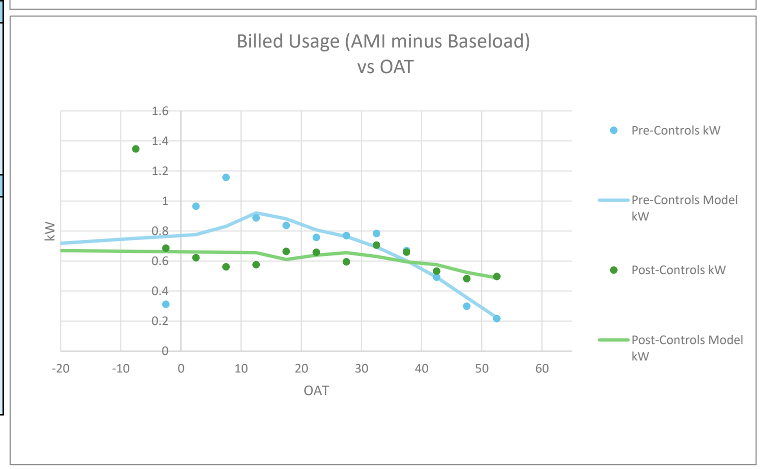


Analysis Takeaways

Heat pump data logger died after one day. AMI data shows slightly less heat pump use after controls were installed; however this change is minimal and not attributable to the controls because the homeowner disconnected Flair on December 20th due to dissatisfaction in the system's ablity to maintain the desired setpoint.

Participant Comments from Survey

"The equipment could not/did not regulate my house temp when the outside temperature was cold (15-20). When the systems were synced I could not easily use the heat pump to dry the air. I totally wanted to like this system but I felt it had its problems."

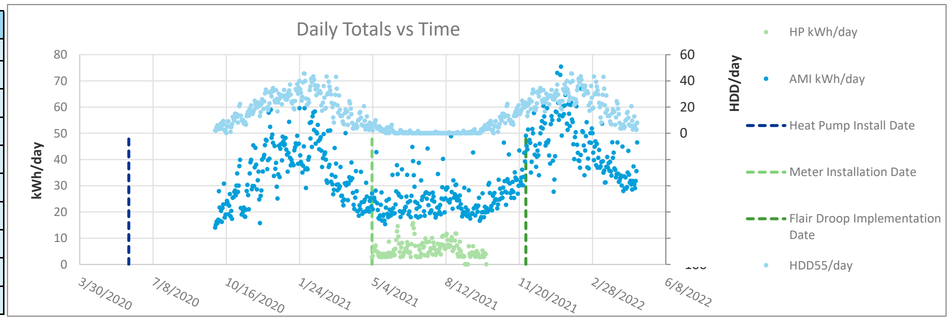


Site ID	IT020

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,827	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	62.8	N.D.
Billed Usage Model	3,598	5,099	1,501	42%	41,653,354	59,032,260	17,378,906	21.7	62.8	-34.6%

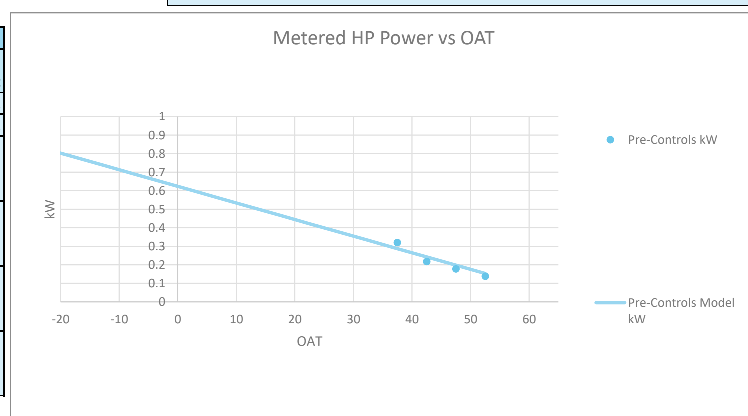
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04401	Equipment Type	Forced Air / Central AC / Furn	Make	Fujitsu	No response.
Year Built	1950	Fuel Type	Fuel Oil	Outdoor unit model	AOUG15LZAS1	
Envelope Condition	fair	Make	Lennox	Indoor unit model	ASUG15LZAS	
Approx Area (ft2)	1,080	Model	O20Q3 1/5/120 - 7A	AHRI ref #	204740070	
Metering Rigor	Med	Input BTU Max	95,000	Nameplate SEER	25.3	
		Input BTU Min	0	Nameplate HSPF	13.4	
		Burner staging	single	HSPF correction factor	86%	
		AFUE/Efficiency	0.8	Site Specific HSPF	11.6	

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.833612604
Total pre period kWh	837	12,617
Total post period kWh	0	6,805
Days of data pre	146	424
Days of data post	0	153
Pre coincident HDD	156	5,011
Post coincident HDD	0	3,602
TMY3 HDD	5,045	



Pre-Controls Setpoints		Post-Controls Setpoints		Participant Setpoint/Behavior Description (from site visit)
Equipment	Heat Pump	Forced Air / Central AC / Furnace	N.D.	Pre-Controls: when outdoor temperature is moderate, turn furnace off and use only heat pump to maintain temperature Post-Controls: utilized automated droop controls with a five degree offset
Weekday Day	N.D.	N.D.		
Weekday Night	N.D.	N.D.		
Weekend Day	N.D.	N.D.		
Weekend Night	N.D.	N.D.		

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

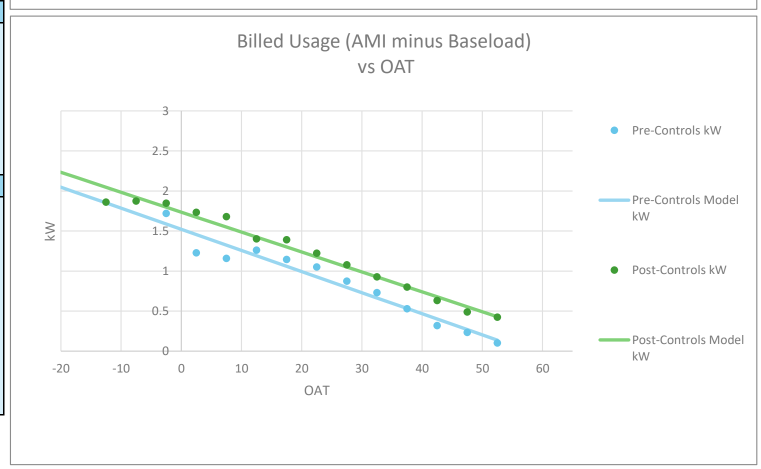


Analysis Takeaways

Heat pump data logger died before controls were implemented. AMI data shows increase in heat pump use after controls were installed. Homeowner did not provide survey response.

Participant Comments from Survey

No response.



Site ID	IT024

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,610	1,425	-185	-11%	17,362,990	15,370,943	-1,992,048	-2.1	64.8	3.2%
Billed Usage Model	1,660	3,100	1,440	87%	17,897,664	33,429,771	15,532,108	16.2	64.8	-25.0%

Site Information	
ZIP Code	04096
Year Built	0
Envelope Condition	0
Approx Area (ft2)	0
Metering Rigor	Med

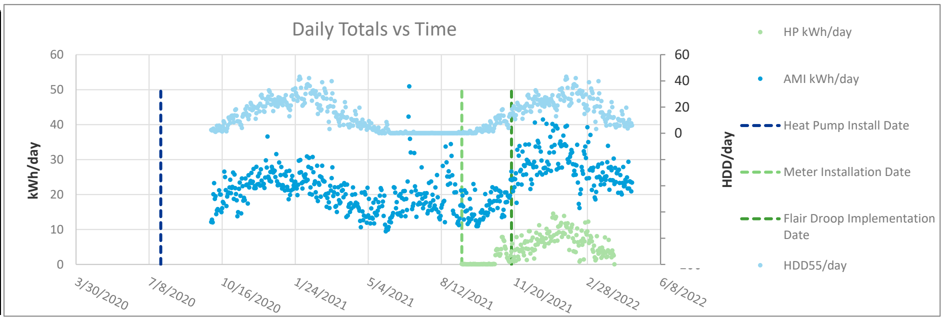
Fuel Heating System	
Equipment Type	0
Fuel Type	0
Make	0
Model	TM9V100C16MP11CA
Input BTU Max	100,000
Input BTU Min	65,000
Burner staging	0
AFUE/Efficiency	0.96

Ductless Split Heat Pump	
Make	Mitsubishi
Outdoor unit model	MUZ-FH12NA
Indoor unit model	0
AHRI ref #	201754298
Nameplate SEER	26.1
Nameplate HSPF	12.5
HSPF correction factor	86%
Site Specific HSPF	10.8

Key Participant Impressions (from Survey)

Heat pump operates more with controls.
Not sure if furnace operation, or fuel consumption, or money spent on fuel has changed with controls.
Not sure if electric use or spending on electricity has changed with controls.
Ease of operations of controls: 9/10
Likelihood of continuing to use Flair controls: 8/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.644466738
Total pre period kWh	83	8,159
Total post period kWh	893	4,650
Days of data pre	67	411
Days of data post	141	166
Pre coincident HDD	338	4,279
Post coincident HDD	3,287	3,501
TMY3 HDD	4,929	



Pre-Controls Setpoints		
Equipment	Heat Pump	N.D.
Weekday Day	70	68
Weekday Night	60	60
Weekend Day	70	68
Weekend Night	60	68

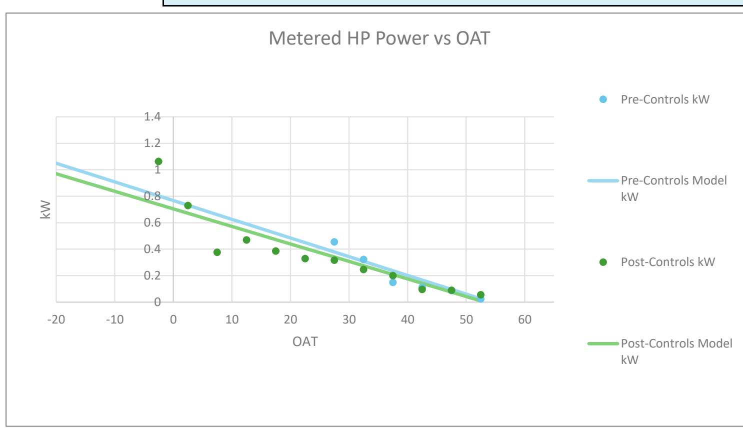
Post-Controls Setpoints	
Zone	Whole Home
Day	72
Night	65

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: heat pump on and heating throughout winter, utilized nighttime setbacks
Post-Controls: utilized droop with 5 degree offset, utilized nighttime setbacks

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

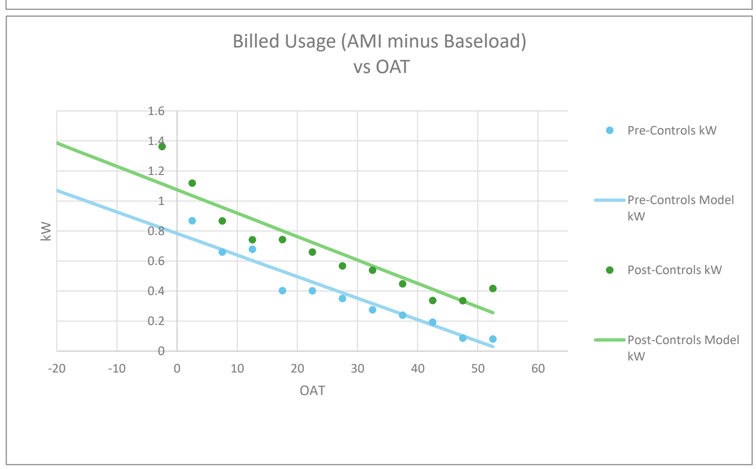


Analysis Takeaways

AMI and metered data do not agree. The magnitude of increased heat pump use per AMI data is greater than the magnitude of decreased use per metered data. Homeowner reports increased heat pump use and that the home became more comfortable. Higher temperature setpoints likely contribute to the perceived increased use and increased comfort.

Participant Comments from Survey

"Home became more comfortable... Warmer in the area heated primarily by the heat pump."



Site ID	IT025

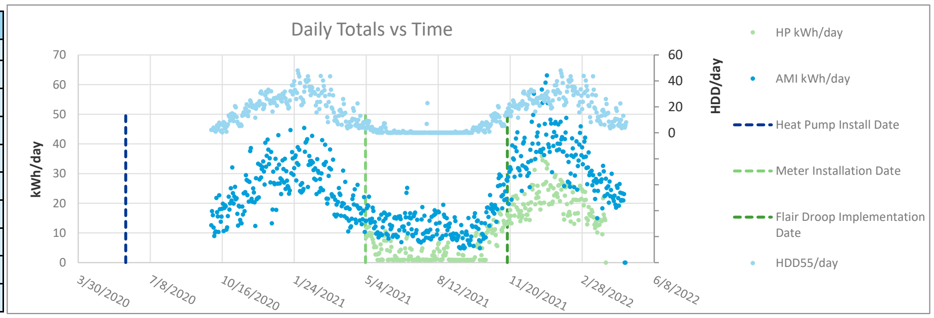
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	3,639	4,306	667	18%	35,689,397	42,229,291	6,539,894	8.0	95.3	-8.4%
Billed Usage Model	2,601	4,798	2,197	84%	25,512,604	47,056,985	21,544,381	26.3	95.3	-27.6%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04330	Equipment Type	Boiler	Make	Daikin
Year Built	1935	Fuel Type	Fuel Oil	Outdoor unit model	RXL15QMVJU
Envelope Condition	Fair	Make	Weil McLain	Indoor unit model	FTX 15NMVJU
Approx Area (ft2)	1,200	Model	P-WTGO-4	AHRI ref #	8849445
Metering Rigor	Med	Input BTU Max	145,000	Nameplate SEER	20
		Input BTU Min	126,000	Nameplate HSPF	11.3
		Burner staging	MODULATING	HSPF correction factor	87%
		AFUE/Efficiency	0.82	Site Specific HSPF	9.8

Key Participant Impressions (from Survey)

Heat pump operates more with controls.
Not sure if boiler operation has changed with controls.
Not sure if fuel use or money spent on fuel has changed with controls.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 6/10
Likelihood of continuing to use Flair controls: 10/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.472487961
Total pre period kWh	526	7,907
Total post period kWh	2,558	5,536
Days of data pre	88	411
Days of data post	126	163
Pre coincident HDD	311	4,660
Post coincident HDD	3,254	3,792
TMY3 HDD	5,028	

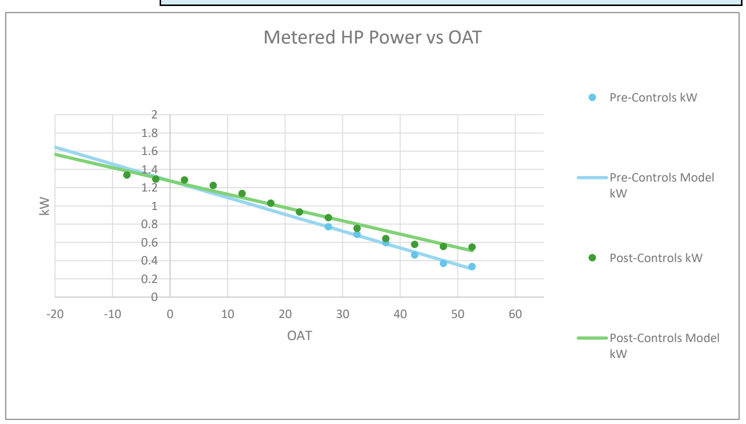


Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	
Weekday Day	72	62	Office	72
Weekday Night	Off	62	Living room	62
Weekend Day	72	62		
Weekend Night	Off	62		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: turned heat pump on in the morning and off at night
Post-Controls: adjusted droop offset each day so that the furnace would not turn on during the day when only the office is in use

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3

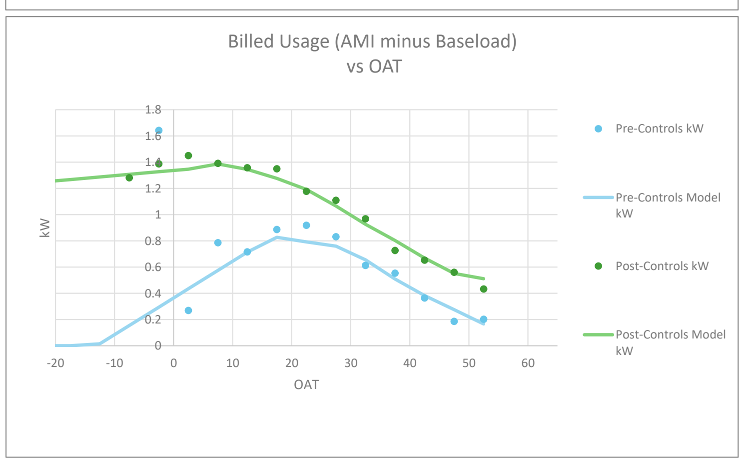


Analysis Takeaways

AMI data shows much higher increase than metered heat pump data. The homeowner began using their electric vehicle regularly this winter, likely contributing to the discrepancy. Metered data aligns with homeowner description of using their heat pump much more during the study. Home layout is not ideal for droop, because heat pump is located in a sunroom used as an office, and does not reach the rest of the house. During the day, the homeowner only needs the office heated (the rest of the house can be cold), and the opposite at night.

Participant Comments from Survey

"It took me a little while to get the hang of the Flair setpoints... You can't set the thermostat for the furnace (in my case, oil) below the heat pump setpoint minus the droop settings. There was a period there where I would change the droop settings each morning and evening so that I could set the Ecobee thermostat to a lower temperature. I ended up giving up on that after while and just letting the ecobee thermostat stay higher than I would normally let it be."
"The placement of the Flair puck took some experimentation also. [Study field staff] sent me a graphic of how the IR blasters were supposed to work, but found that I needed to have the puck closer to the heat pump than I would have thought it needed to be."

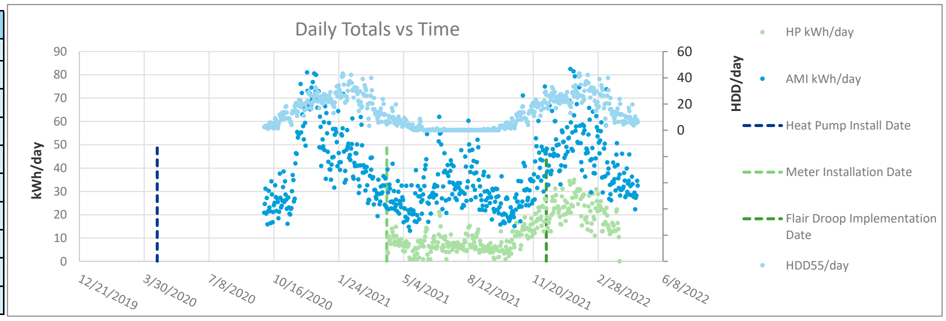


Site ID	IT026

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	4,553	4,590	37	1%	44,956,663	45,326,049	369,386	0.4	42.4	-1.0%
Billed Usage Model	5,403	6,609	1,206	22%	53,348,293	65,261,465	11,913,173	14.2	42.4	-33.4%

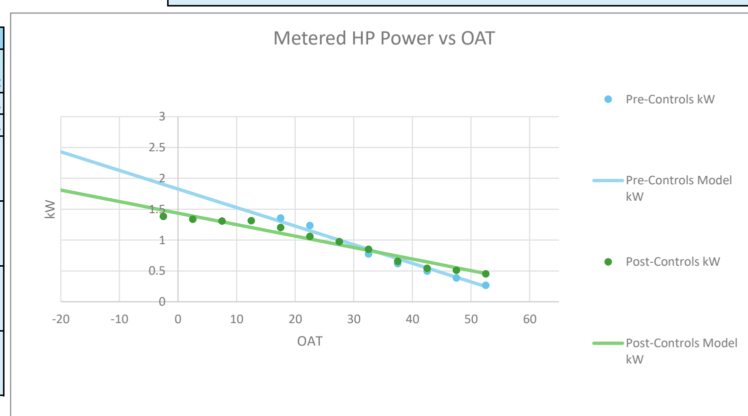
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04102	Equipment Type	Boiler	Make	Diken	Heat pump operates more with controls.
Year Built	1950	Fuel Type	Fuel Oil	Outdoor unit model	RXL15QMVJU	Boiler operates less with controls.
Envelope Condition	Fair	Make	Peerless	Indoor unit model	FTX15NMVJU	Home uses less fuel, and spends less money on fuel.
Approx Area (ft2)	1,152	Model	WBV-03-WPCTL	AHRI ref #	8849445	Home uses more electricity, and spends more money on electricity.
Metering Rigor	Med	Input BTU Max	131,000	Nameplate SEER	20	Ease of operations of controls: 10/10
		Input BTU Min	75,000	Nameplate HSPF	11.3	Likelihood of continuing to use Flair controls: 9/10
		Burner staging	hi-low	HSPF correction factor	87%	
		AFUE/Efficiency	0.84	Site Specific HSPF	9.9	

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.722
Total pre period kWh	1,401	15,544
Total post period kWh	2,227	6,438
Days of data pre	149	435
Days of data post	101	142
Pre coincident HDD	752	4,724
Post coincident HDD	2,517	3,055
TMY3 HDD	4,929	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler	Zone	Whole Home	Pre-Controls: heat pump on and heating throughout winter, occasionally turned heat pump down at night
Weekday Day	68	70	Home	70	Post-Controls: set whole house around 70
Weekday Night	68	70			
Weekend Day	68	70			
Weekend Night	68	70			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

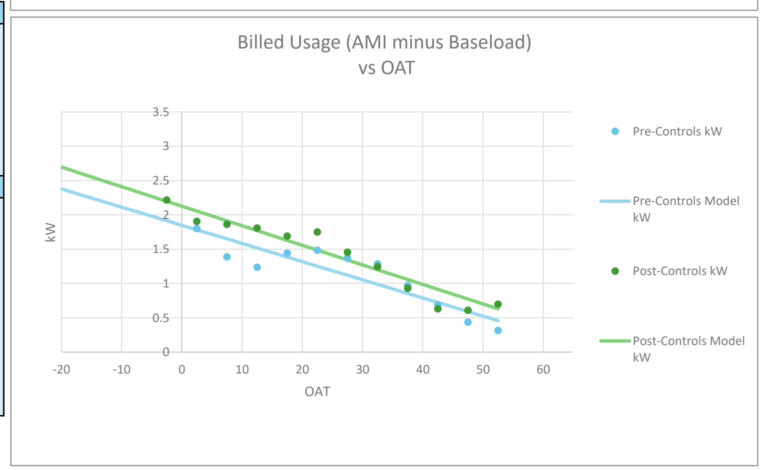


Analysis Takeaways

AMI data does not agree with metered heat pump data. Pre-controls heat pump data does not include low outdoor temps, which is where most significant savings occur according to AMI data.

Participant Comments from Survey

"I feel you need to have good computer skills to use it. Not everyone has that."



Site ID	IT028

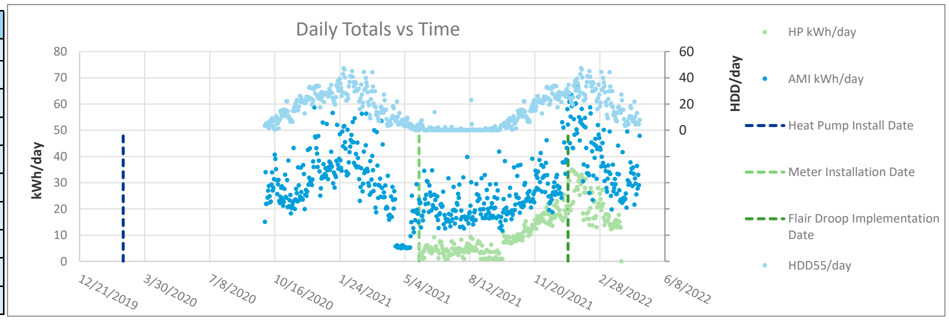
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	3,669	4,536	867	24%	36,049,674	44,570,167	8,520,493	10.2	No Fuel Data	N.D.
Billed Usage Model	2,855	4,410	1,555	54%	28,053,341	43,336,157	15,282,816	18.3	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04901	Equipment Type	Boiler	Make	Daiken
Year Built	1985	Fuel Type	Fuel Oil	Outdoor unit model	RXL15QMVJU
Envelope Condition	Good	Make	Thermo Dynamics	Indoor unit model	FXT15NMVJU
Approx Area (ft2)	1,660	Model	S-100	AHRI ref #	8849445
Metering Rigor	Med	Input BTU Max	140,000	Nameplate SEER	20
		Input BTU Min	140,000	Nameplate HSPF	11.3
		Burner staging	single	HSPF correction factor	87%
		AFUE/Efficiency	0.836	Site Specific HSPF	9.8

Key Participant Impressions (from Survey)

Heat pump operates more with controls.
Boiler operates less with controls.
Home uses less fuel, and spends less money on fuel.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 10/10
Likelihood of continuing to use Flair controls: 10/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.815432522
Total pre period kWh	1,460	12,394
Total post period kWh	1,590	4,313
Days of data pre	146	466
Days of data post	74	111
Pre coincident HDD	1,643	6,322
Post coincident HDD	2,073	2,559
TMY3 HDD	5,323	

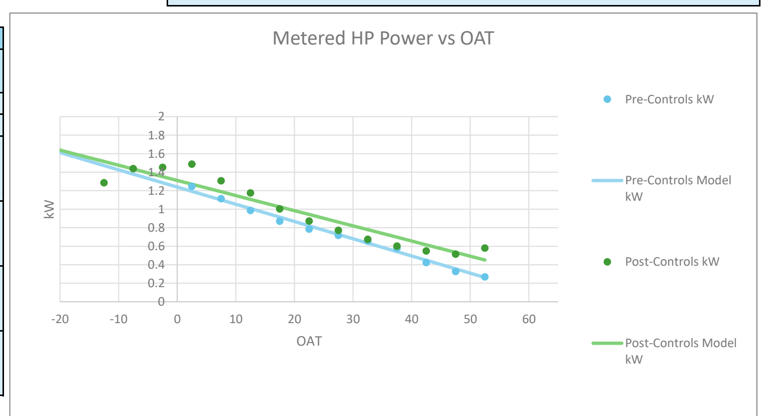


Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Whole Home
Weekday Day	68	68	Day	68
Weekday Night	65	62	Night	62
Weekend Day	68	68		
Weekend Night	65	68		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: utilized nighttime setbacks for both heat pump and boiler
Post-Controls: utilized nighttime setbacks for whole home

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

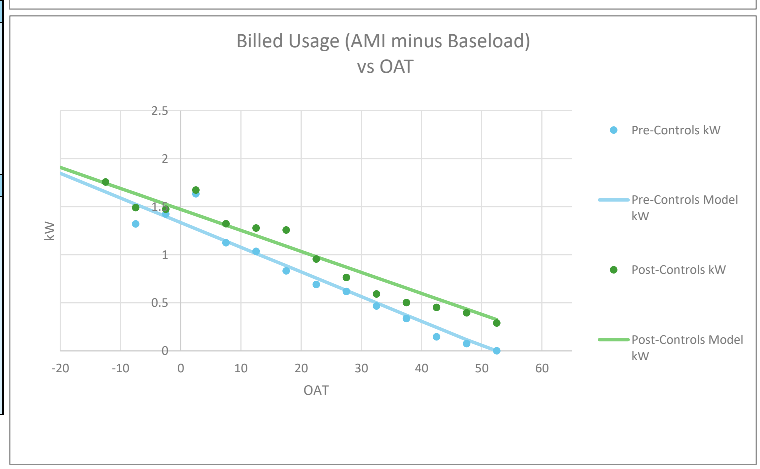


Analysis Takeaways

Home utilized droop with 5 degree offset throughout heating season. AMI and metered data indicate increased heat pump use, which agrees with homeowner perception.

Participant Comments from Survey

"Sometimes seemed cooler than set."
"Electricity up by 50 percent; fuel decrease by 75 percent."

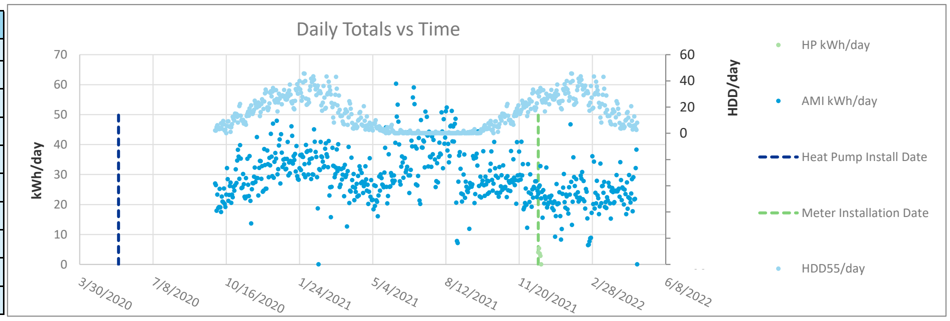


Site ID	IT030

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	6,296	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.

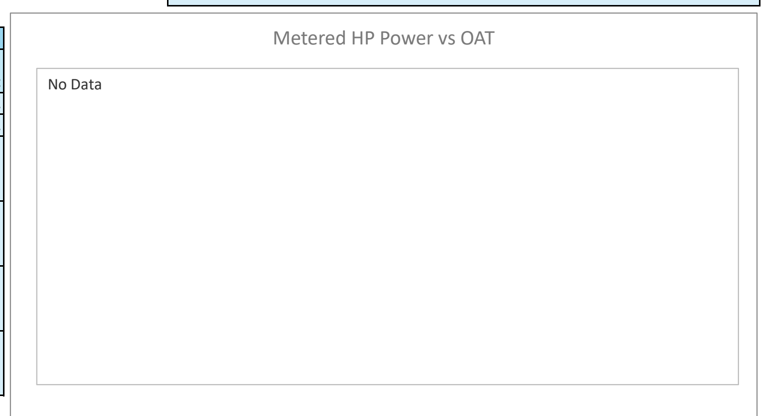
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04412	Equipment Type	Boiler	Make	Fujitsu	No response.
Year Built	1960s	Fuel Type	Fuel Oil	Outdoor unit model	AOUG15LZAS1	
Envelope Condition	Good	Make	0	Indoor unit model	ASUG15LZAS	
Approx Area (ft2)	1,700	Model	0	AHRI ref #	204740070	
Metering Rigor	High	Input BTU Max	0	Nameplate SEER	25.3	
		Input BTU Min	0	Nameplate HSPF	13.4	
		Burner staging	0	HSPF correction factor	N.D.	
		AFUE/Efficiency	0.8	Site Specific HSPF	N.D.	

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0
Total pre period kWh	0	16,610
Total post period kWh	13	0
Days of data pre	0	687
Days of data post	3	0
Pre coincident HDD	0	8,751
Post coincident HDD	96	0
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler		N.D.	No response. Controls disconnected
Weekday Day	N.D.	N.D.			
Weekday Night	N.D.	N.D.			
Weekend Day	N.D.	N.D.			
Weekend Night	N.D.	N.D.			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	No	N.A.	N.A.	N.A.
2/21/2022	No	N.A.	N.A.	N.A.
3/7/2022	No	N.A.	N.A.	N.A.
3/21/2022	No	N.A.	N.A.	N.A.

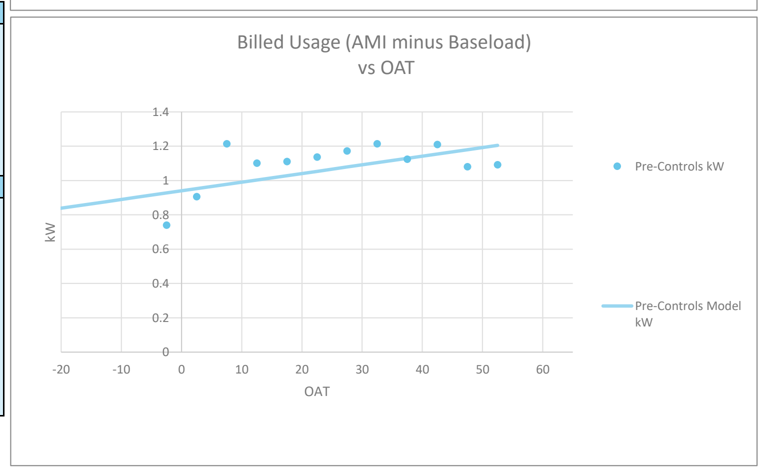


Analysis Takeaways

Boiler at this home needed maintenance shortly after droop was implemented. Controls were disconnected and data loggers were removed as a result. Metered heat pump data only includes three days.

Participant Comments from Survey

No response.



Site ID	IT032

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	3,305	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	1,153	4,842	3,690	320%	13,504,874	56,725,040	43,220,166	N.D.	No Fuel Data	N.D.

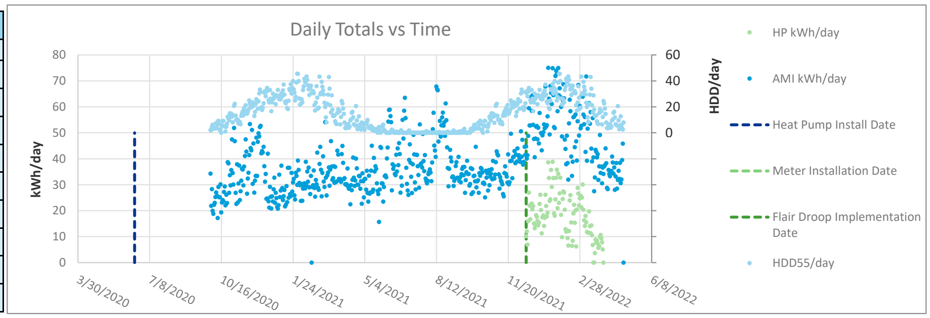
Site Information	
ZIP Code	04401
Year Built	N/A
Envelope Condition	Good
Approx Area (ft2)	1,800
Metering Rigor	High

Fuel Heating System	
Equipment Type	Forced Air / Central AC / Furn
Fuel Type	Fuel Oil
Make	Williamson
Model	TLB-105-DD-RS2
Input BTU Max	D.K.
Input BTU Min	D.K.
Burner staging	single
AFUE/Efficiency	D.K.

Ductless Split Heat Pump	
Make	Fujitsu
Outdoor unit model	AOUG15LZAS1
Indoor unit model	ASUG15LZAS
AHRI ref #	204740070
Nameplate SEER	25.3
Nameplate HSPF	13.4
HSPF correction factor	87%
Site Specific HSPF	11.7

Key Participant Impressions (from Survey)
Heat pump operates more with controls.
Boiler operates less with controls.
Home uses less fuel, and spends less money on fuel.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 9/10
Likelihood of continuing to use Flair controls: 10/10

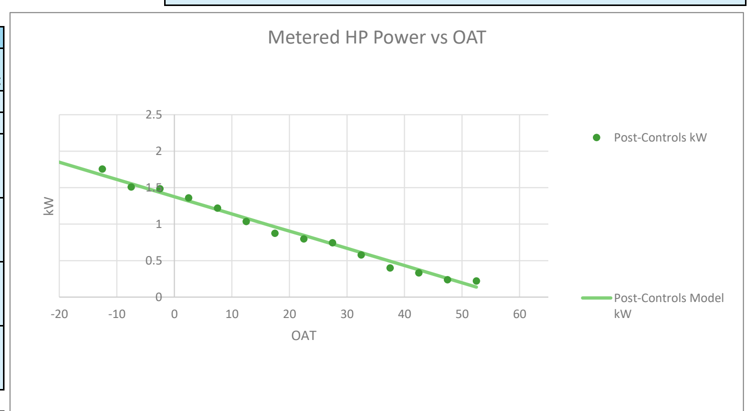
Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	1.15
Total pre period kWh	2	15,270
Total post period kWh	1,938	6,601
Days of data pre	1	437
Days of data post	107	135
Pre coincident HDD	0	5,312
Post coincident HDD	2,948	3,230
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Forced Air / Centi	Zone	Whole Home
Weekday Day	72	72	Home	72
Weekday Night	72	72		
Weekend Day	72	72		
Weekend Night	72	72		

Participant Setpoint/Behavior Description (from Survey)
Pre-Controls: maintained constant set point
Post-Controls: maintained constant set point

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

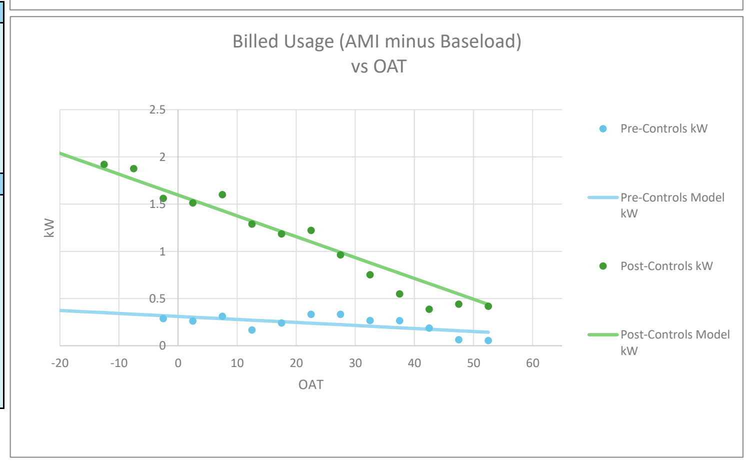


Analysis Takeaways

Home utilized droop with 5 degree offset. AMI data indicates increased heat pump use. Homeowner is pleased with the controls and reports fuel savings. No pre-controls metered data.

Participant Comments from Survey

"Electric prices went up, but still cheaper than using fuel oil... Kept our fuel oil costs down."
"I don't have to mess with the thermostat like I used to."



Site ID	IT037

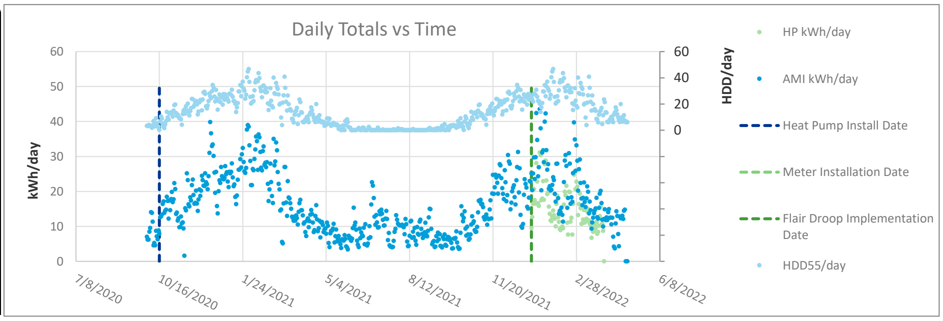
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	2,872	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	40.1	N.D.
Billed Usage Model	2,520	2,316	-204	-8%	27,534,832	25,308,121	-2,226,711	-2.3	40.1	5.8%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04553	Equipment Type	Boiler	Make	Daiken
Year Built	2014	Fuel Type	Propane	Outdoor unit model	RXL15QMVJVA
Envelope Condition	Good	Make	Well-Mclain	Indoor unit model	FTX15NMVJU
Approx Area (ft2)	995	Model	WMB-120C	AHRI ref #	8849330
Metering Rigor	Med	Input BTU Max	120,000	Nameplate SEER	20
		Input BTU Min	12,000	Nameplate HSPF	12.5
		Burner staging	single	HSPF correction factor	87%
		AFUE/Efficiency	0.964	Site Specific HSPF	10.9

Key Participant Impressions (from Survey)

No response.

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.319534247
Total pre period kWh	0	6,739
Total post period kWh	1,303	2,247
Days of data pre	0	446
Days of data post	86	113
Pre coincident HDD	1	5,580
Post coincident HDD	2,199	2,503
TMY3 HDD	4,222	

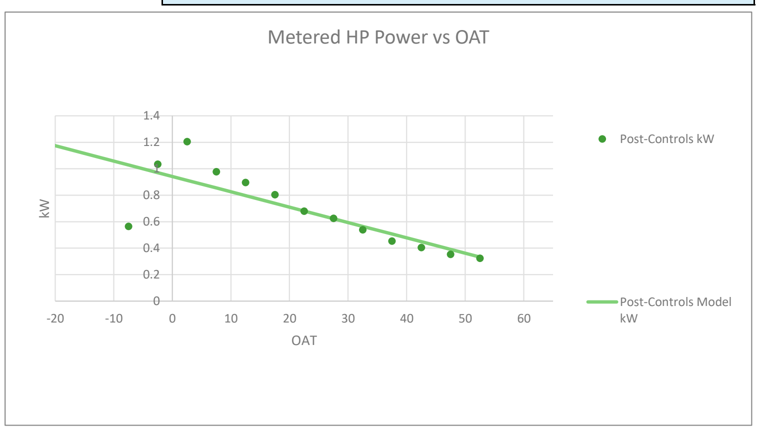


Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Whole Home
Weekday Day	N.D.	N.D.	Home	64
Weekday Night	N.D.	N.D.	Away	62
Weekend Day	N.D.	N.D.		
Weekend Night	N.D.	N.D.		

Participant Setpoint/Behavior Description (from Survey)

No response.

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	4

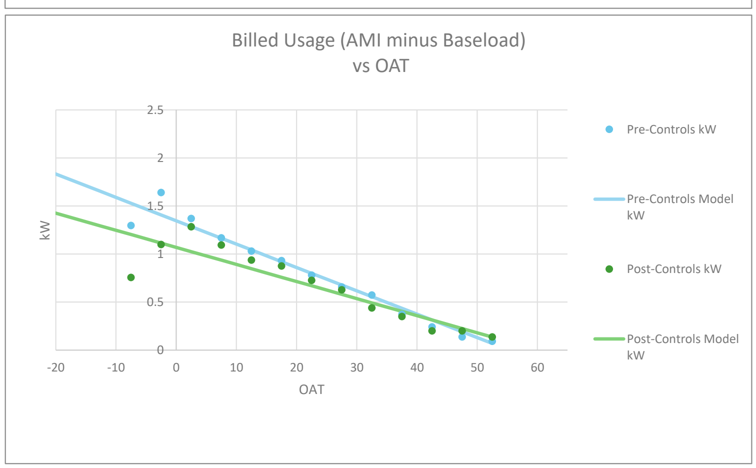


Analysis Takeaways

Utilized droop with 4 degree offset. Meters were installed at the same time as droop, no pre-controls heat pump data. AMI data shows decrease in heat pump use after controls installed.

Participant Comments from Survey

No response.

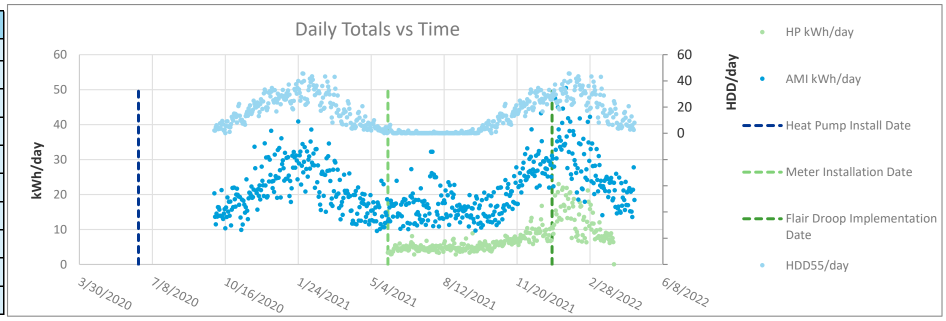


Site ID	IT038

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,844	2,463	619	34%	21,570,799	28,810,969	7,240,171	9.1	No Fuel Data	N.D.
Billed Usage Model	1,804	2,731	928	51%	21,099,957	31,949,199	10,849,242	13.6	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04953	Equipment Type	Forced Air / Central AC / Fur	Make	Fujitsu	No survey response.
Year Built	2017	Fuel Type	propane	Outdoor unit model	AOUG15LZAS1	
Envelope Condition	good	Make	Nordine	Indoor unit model	0	
Approx Area (ft2)	1,060	Model	M1MB 056A BW	AHRI ref #	204740070	
Metering Rigor	Med	Input BTU Max	56,000	Nameplate SEER	25.3	
		Input BTU Min	56,000	Nameplate HSPF	13.4	
		Burner staging	single	HSPF correction factor	87%	
		AFUE/Efficiency	0.8	Site Specific HSPF	11.7	

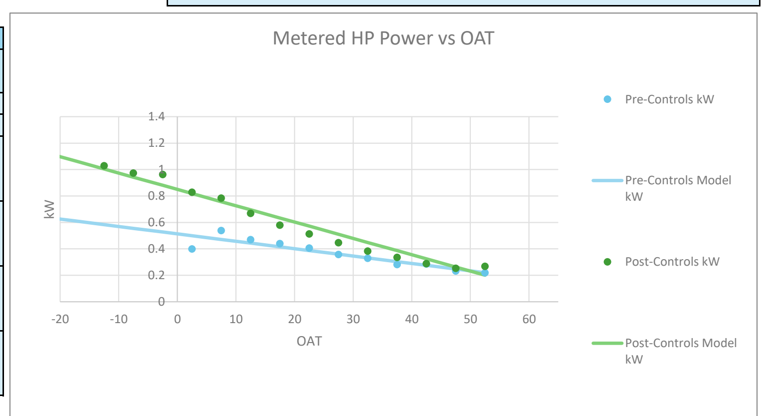
Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.60641958
Total pre period kWh	884	9,307
Total post period kWh	1,008	3,056
Days of data pre	139	463
Days of data post	81	114
Pre coincident HDD	1,516	6,016
Post coincident HDD	2,225	2,598
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Forced Air / Centi	Zone	Whole Home	Pre-Controls: summarize from survey responses
Weekday Day	N.D.	N.D.	Home	64	Post-Controls: uses Flair account to set home temperature, uses puck to update
Weekday Night	N.D.	N.D.	Away	62	
Weekend Day	N.D.	N.D.			
Weekend Night	N.D.	N.D.			

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

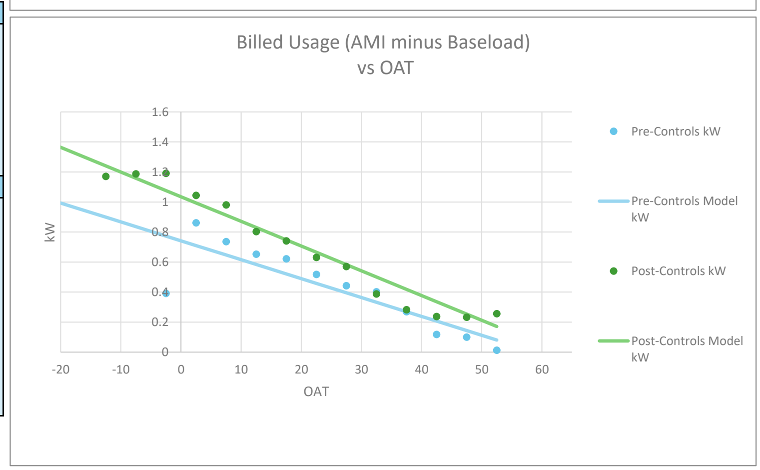


Analysis Takeaways

Metered data and AMI data both indicate increased heat pump use after controls installed. Homeowner's description during the site visit of "using the puck to control the heat pump and using Flair to control the furnace" indicates lack of understanding of how the integrated controls work, because the equipment-specific setpoints can only be programmed if the Flair account is in manual mode.

Participant Comments from Survey

No response.



Site ID	IT041

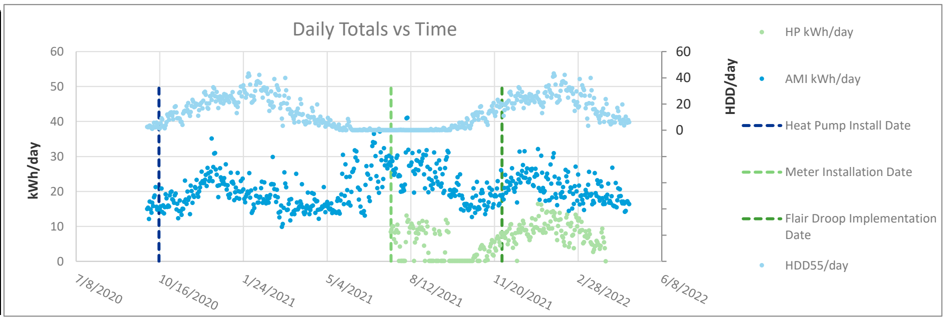
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,290	1,831	542	42%	14,021,173	19,910,572	5,889,400	6.2	No Fuel Data	N.D.
Billed Usage Model	1,439	1,796	357	25%	15,644,006	19,523,575	3,879,569	4.1	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04064	Equipment Type	Boiler	Make	Mitsubishi
Year Built	2020	Fuel Type	Propane	Outdoor unit model	MUZ-FH12NA
Envelope Condition	Good	Make	Viessmann	Indoor unit model	MSZ-FH12NA
Approx Area (ft2)	1,600	Model	Vitodens 100-W B1KA 125	AHRI ref #	201754298
Metering Rigor	High	Input BTU Max	125,000	Nameplate SEER	26.1
		Input BTU Min	21,000	Nameplate HSPF	12.5
		Burner staging	Modulating	HSPF correction factor	87%
		AFUE/Efficiency	0.95	Site Specific HSPF	10.9

Key Participant Impressions (from Survey)

Heat pump operates more with controls.
Boiler operates the same amount with controls.
Home uses less fuel, and spends less money on fuel.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 5/10
Likelihood of continuing to use Flair controls: 10/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.549
Total pre period kWh	572	8,457
Total post period kWh	1,060	3,191
Days of data pre	145	410
Days of data post	124	153
Pre coincident HDD	674	4,462
Post coincident HDD	2,998	3,277
TMY3 HDD	4,929	



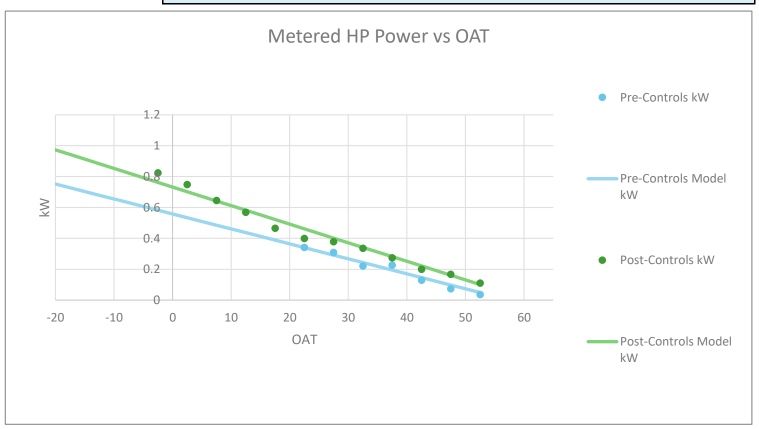
Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Whole Home
Weekday Day	64	60	Home	64
Weekday Night	64	60	Away	62
Weekend Day	64	60		
Weekend Night	64	60		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: heat pump on and heating throughout winter
Post-Controls: utilized automated droop and smart away mode, would occasionally switch to manual mode to force heat pump off in the interest of savings electricity

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

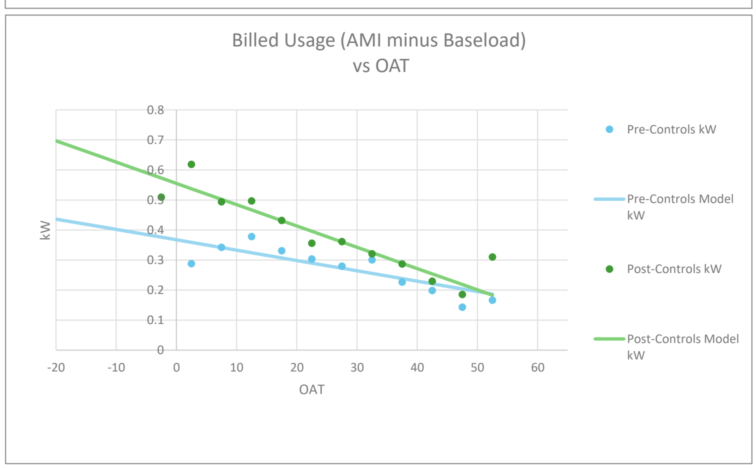


Analysis Takeaways

Home utilized droop with a 5 degree offset; homeowner reports occasionally switching Flair to manual mode to force heat pump off. Home layout is a good candidate for droop and both metered data and AMI data indicate increased heat pump use. Homeowner believes that fuel use has decreased more than electric use has increased (overall savings).

Participant Comments from Survey

"I really enjoyed [the controls] and the concept, I just wish the additional controls could be added to mimic the actual heat pump settings on the remote. On the actual heat pump remote, I had a lot more customizable settings for fan output and direction which greatly helped us in correctly heating our specific space."
"Setting up the flair on the computer was a bit confusing even following the directions for someone who is very tech-savy."
"Being able to control the temperature from my phone and not having to be home has been great."

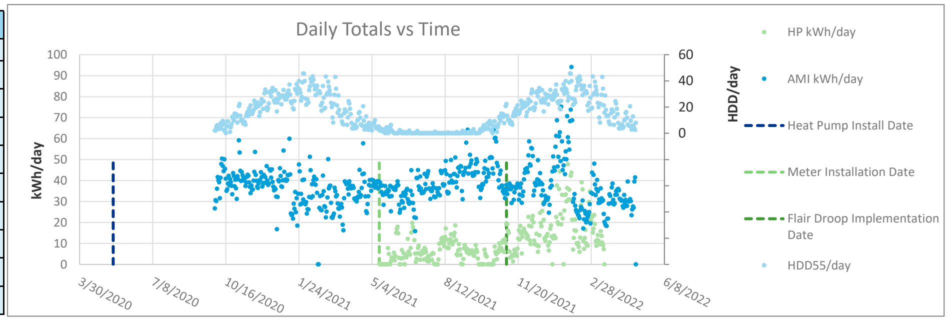


Site ID	IT060

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	2,923	3,511	588	20%	33,468,579	40,206,037	6,737,458	8.4	No Fuel Data	N.D.
Billed Usage Model	2,884	3,201	317	11%	33,026,743	36,661,804	3,635,061	4.5	No Fuel Data	N.D.

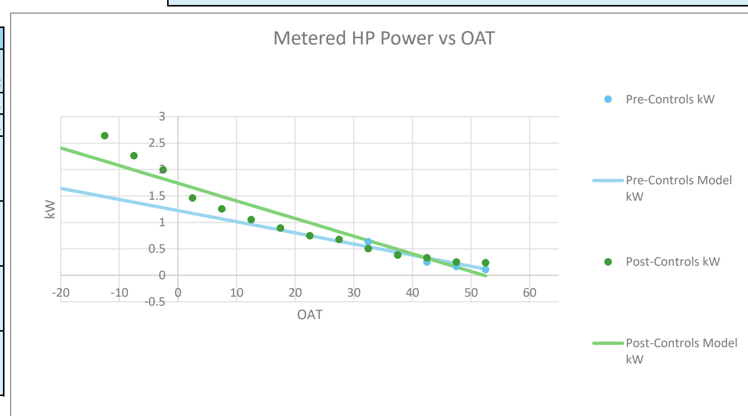
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04453	Equipment Type	Other, specify:	Make	Fujitsu	No response.
Year Built	1990	Fuel Type	0	Outdoor unit model	AOUG15LZAS1	
Envelope Condition	Good	Make	Central Boiler	Indoor unit model	ASUG15LZAS	
Approx Area (ft2)	1,020	Model	CL 5036	AHRI ref #	204740070	
Metering Rigor	High	Input BTU Max	unk	Nameplate SEER	25.3	
		Input BTU Min	unk	Nameplate HSPF	13.4	
		Burner staging	Single	HSPF correction factor	85%	
		AFUE/Efficiency	0.8	Site Specific HSPF	11.5	

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	40
Base load	0	0.81
Total pre period kWh	946	14,904
Total post period kWh	2,202	6,528
Days of data pre	173	395
Days of data post	130	176
Pre coincident HDD	320	4,532
Post coincident HDD	2,389	3,978
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Other, specify:	Zone	Whole Home	No response.
Weekday Day	N.D.	N.D.	Home	64	
Weekday Night	N.D.	N.D.	Away	62	
Weekend Day	N.D.	N.D.			
Weekend Night	N.D.	N.D.			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

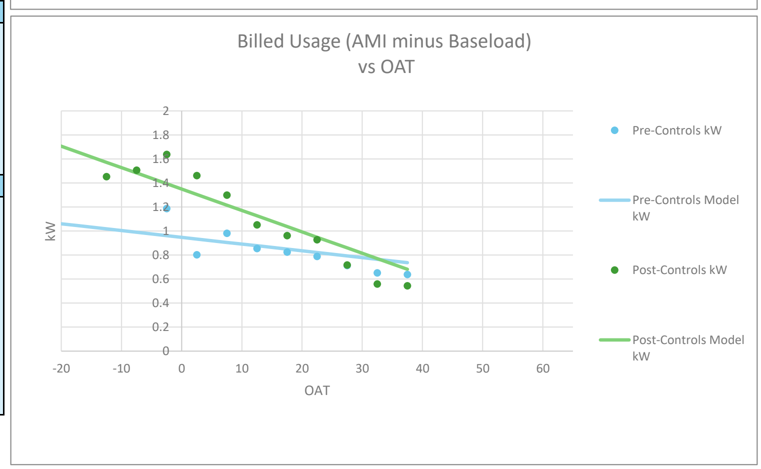


Analysis Takeaways

Utilized droop with 5 degree offset. Meters were installed at the same time as droop was implemented. AMI data indicates increased use after controls installed. This site is not an ideal candidate for droop because the thermostat controls the radiant floor circulator pump - the amount of wood burned is unlikely to change because the boiler also serves a large camp facility.

Participant Comments from Survey

No response.



Site ID	IT070

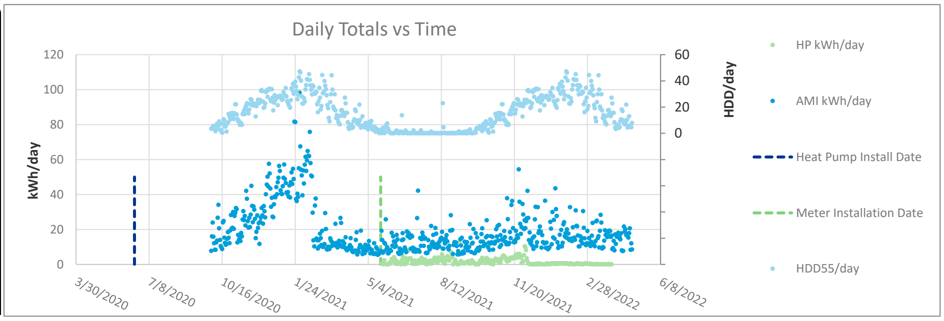
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	269	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	5,148	N.D.	N.D.	N.D.	60,594,455	N.D.	N.D.	N.D.	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04927	Equipment Type	Boiler	Make	Fijitsu
Year Built	1972	Fuel Type	Fuel Oil	Outdoor unit model	AOUG15LZAS1
Envelope Condition	Fair	Make	New Yorker	Indoor unit model	ASUG15LZAS
Approx Area (ft2)	0	Model	AP-590U	AHRI ref #	204740070
Metering Rigor	High	Input BTU Max	119,000	Nameplate SEER	25.3
		Input BTU Min	0	Nameplate HSPF	13.4
		Burner staging	Single	HSPF correction factor	88%
		AFUE/Efficiency	0.84	Site Specific HSPF	11.8

Key Participant Impressions (from Survey)

Disabled controls, change in electric and fuel use N/A
Ease of operations of controls: 0/10
Likelihood of continuing to use Flair controls: 0/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0
Total pre period kWh	373	11,119
Total post period kWh	0	0
Days of data pre	379	687
Days of data post	0	0
Pre coincident HDD	4,074	9,068
Post coincident HDD	0	0
TMY3 HDD	5,323	

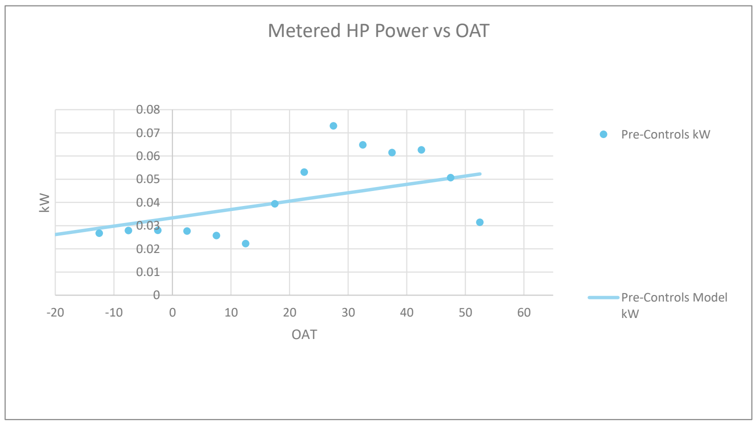


Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Whole Home
Weekday Day	60	65	Home	64
Weekday Night	60	65	Away	62
Weekend Day	60	65		
Weekend Night	60	65		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: rarely used heat pump when outdoor temperature drops below 30
Post-Controls: disconnected controls, returned to using thermostat and heat pump remote as before

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	No	N.A.	N.A.	N.A.
2/21/2022	No	N.A.	N.A.	N.A.
3/7/2022	No	N.A.	N.A.	N.A.
3/21/2022	No	N.A.	N.A.	N.A.

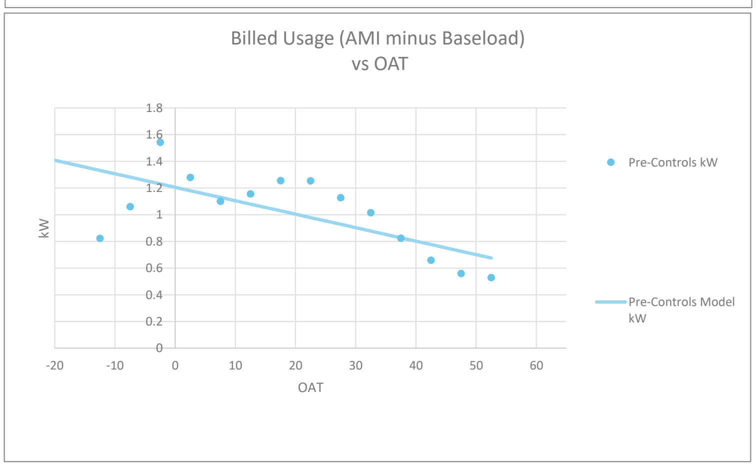


Analysis Takeaways

Not ideal candidate for droop because heat pump is primarily used for cooling. Child's bedroom is highest priority for heating, which is not served by the heat pump. Homeowner did not want heat pump continuously running and disabled integrated controls.

Participant Comments from Survey

"I recommend the Ecobee, not Flair."

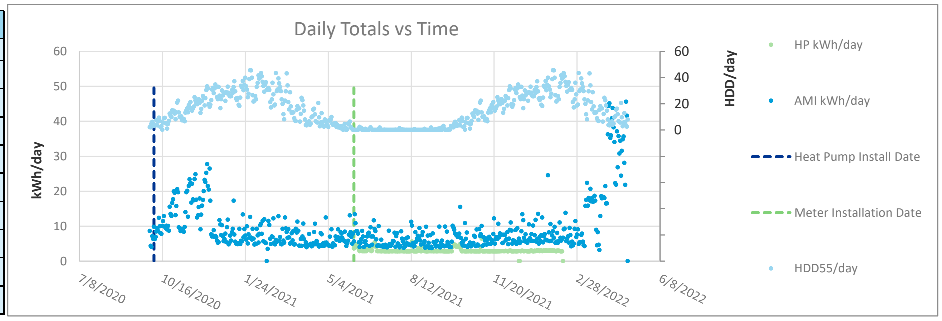


Site ID	IT072

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	704	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	2,203	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.

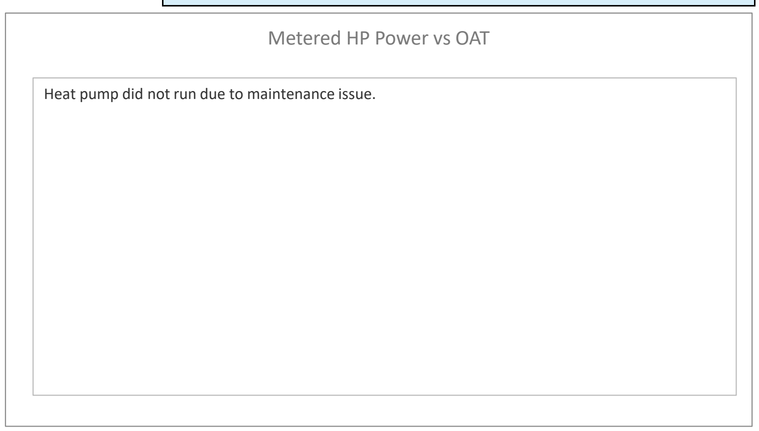
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04401	Equipment Type	Boiler	Make	Fujitsu	No response.
Year Built	1955	Fuel Type	Fuel Oil	Outdoor unit model	AOUG15LZAS1	
Envelope Condition	Fair	Make	Buderus	Indoor unit model	ASUG15LZAS (assum	
Approx Area (ft2)	1,200	Model	G115/5	AHRI ref #	204740070	
Metering Rigor	Med	Input BTU Max	130,000	Nameplate SEER	25.3	
		Input BTU Min	130,000	Nameplate HSPF	13.4	
		Burner staging	single	HSPF correction factor	N.D.	
		AFUE/Efficiency	0.857	Site Specific HSPF	N.D.	

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0
Total pre period kWh	752	5,323
Total post period kWh	0	0
Days of data pre	379	687
Days of data post	0	0
Pre coincident HDD	2,646	8,751
Post coincident HDD	0	0
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler	Zone	Whole Home	No response.
Weekday Day	N.D.	N.D.	Home	64	
Weekday Night	N.D.	N.D.	Away	62	
Weekend Day	N.D.	N.D.			
Weekend Night	N.D.	N.D.			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	No	N.A.	N.A.	N.A.
2/21/2022	No	N.A.	N.A.	N.A.
3/7/2022	No	N.A.	N.A.	N.A.
3/21/2022	No	N.A.	N.A.	N.A.

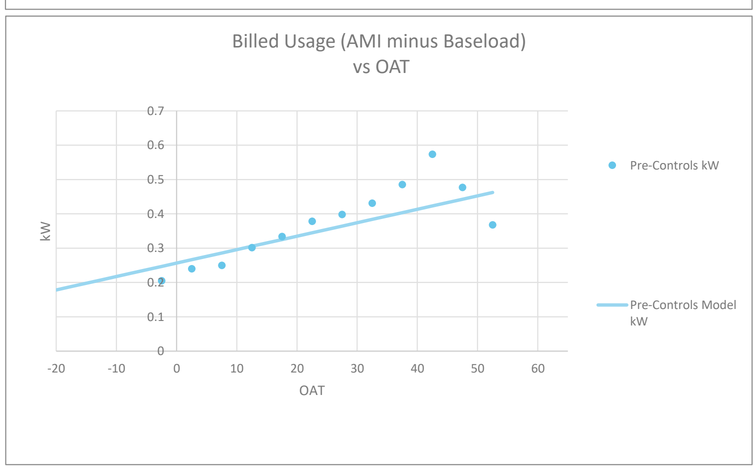


Analysis Takeaways

Heat pump required condensate line repairs which prevented homeowner from being able to use heat pump over the course of the study. Homeowner disabled integrated controls.

Participant Comments from Survey

No response.

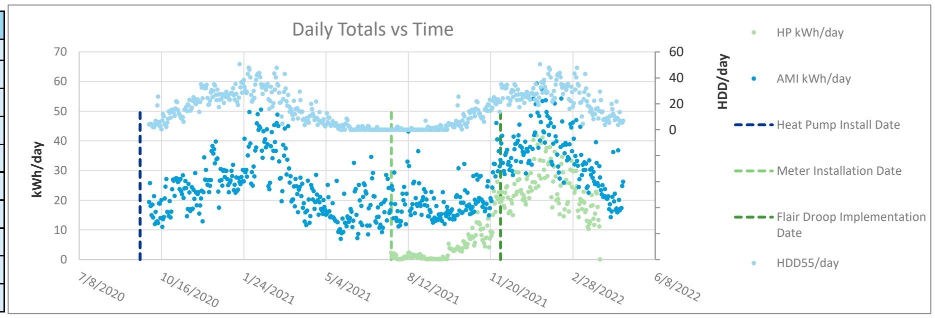


Site ID	IT074

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	3,487	4,913	1,426	41%	40,508,018	57,074,024	16,566,007	17.4	59.7	-29.2%
Billed Usage Model	2,356	3,887	1,531	65%	27,376,730	45,162,961	17,786,231	18.7	59.7	-31.4%

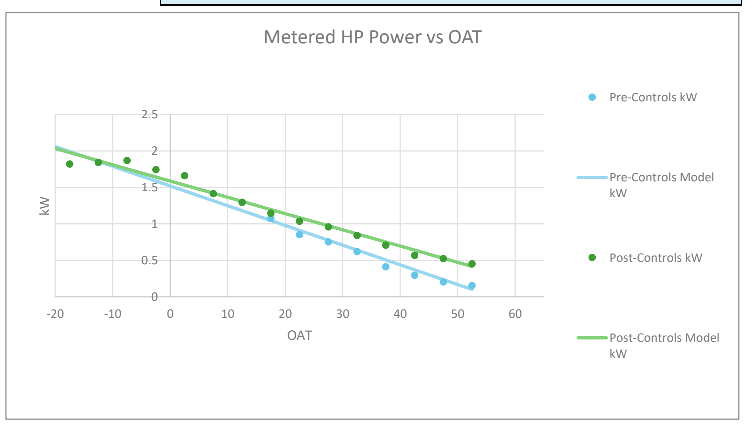
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04015	Equipment Type	Boiler	Make	Fujitsu	Not sure how heat pump use has changed.
Year Built	1975	Fuel Type	Propane	Outdoor unit model	AOUG15LZAH1	Boiler operates less with controls.
Envelope Condition	Poor	Make	Giannoni France	Indoor unit model	ASUG15LZAS	Home uses less fuel, and spends less money on fuel.
Approx Area (ft2)	1,400	Model	PCI18/8-H	AHRI ref #	204740071	Home uses more electricity, and spends more money on electricity.
Metering Rigor	High	Input BTU Max	80,182	Nameplate SEER	25.3	Ease of operations of controls: 8/10
		Input BTU Min	16,036	Nameplate HSPF	13.3	Likelihood of continuing to use Flair controls: 9/10
		Burner staging	MODULATING	HSPF correction factor	87%	
		AFUE/Efficiency	0.95	Site Specific HSPF	11.6	

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.682552096
Total pre period kWh	585	9,626
Total post period kWh	2,856	5,123
Days of data pre	133	427
Days of data post	121	150
Pre coincident HDD	806	5,413
Post coincident HDD	3,377	3,691
TMY3 HDD	5,025	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler	Zone	Whole Home	Pre-Controls: heat pump on and heating throughout winter, utilized nighttime setbacks
Weekday Day	74	68	Home	64	Post-Controls: set overall home setpoint in Flair
Weekday Night	70	68	Away	62	
Weekend Day	74	68			
Weekend Night	70	68			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	No	b[illegible]![illegible]	b[illegible]![illegible]	N.A.
2/21/2022	No	b[illegible]![illegible]	b[illegible]![illegible]	N.A.
3/7/2022	No	b[illegible]![illegible]	b[illegible]![illegible]	N.A.
3/21/2022	No	b[illegible]![illegible]	b[illegible]![illegible]	N.A.

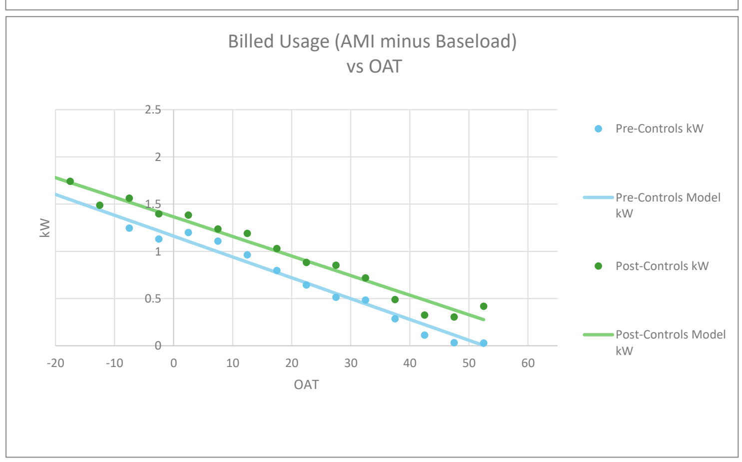


Analysis Takeaways

Homeowner switched from supplemental heat mode to cutover mode, so that heat pump turns off whenever the boiler turns on to bring the home up to temperature. Metered data and AMI data both indicate increase heat pump use after controls installed.

Participant Comments from Survey

"I immediately realized the equipment was using the heat pump more efficiently."
"With rising costs in electricity, the cost to run our heat pump has increased. [However], we are using less propane now."
"Very glad to have been selected for this program, we are satisfied with all the results."

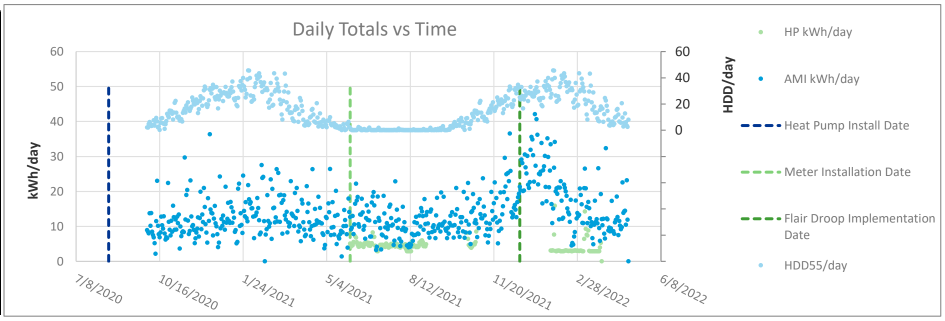


Site ID	IT079

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,206	904	-303	-25%	14,266,370	10,685,991	-3,580,379	-4.2	54.4	7.7%
Billed Usage Model	3,287	3,898	611	19%	38,873,459	46,092,817	7,219,358	8.5	54.4	-15.6%

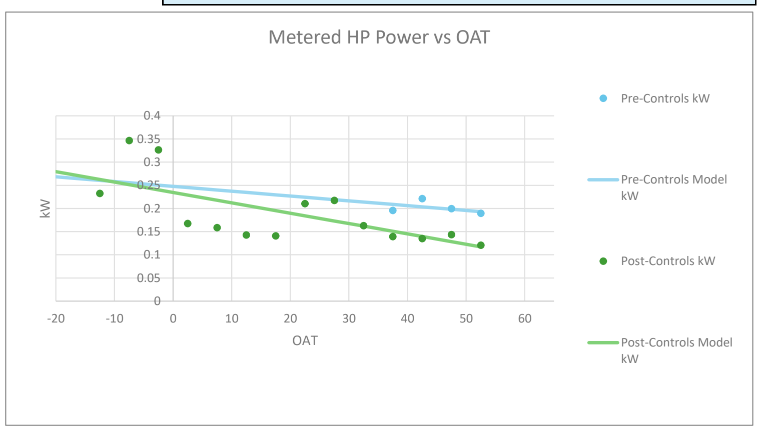
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04401	Equipment Type	Forced Air / Central AC / Furn	Make	Fujitsu	No response.
Year Built	1997	Fuel Type	Kerosene	Outdoor unit model	AOUG15LZHA1	
Envelope Condition	Fair	Make	Thermo Pride (Thermo Produ	Indoor unit model	ASUG15LZAS	
Approx Area (ft2)	1,060	Model	OME-72D36	AHRI ref #	204740071	
Metering Rigor	Med	Input BTU Max	85,000	Nameplate SEER	25.3	
		Input BTU Min	70,000	Nameplate HSPF	13.3	
		Burner staging	hi-low	HSPF correction factor	89%	
		AFUE/Efficiency	0.85	Site Specific HSPF	11.8	

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0
Total pre period kWh	218	5,478
Total post period kWh	211	2,338
Days of data pre	46	443
Days of data post	54	130
Pre coincident HDD	89	5,502
Post coincident HDD	1,523	3,043
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Forced Air / Centr	Zone	Whole Home	Pre-Controls: heat pump periodically turned on or off throughout winter
Weekday Day	62	62	Home	64	Post-Controls: no response
Weekday Night	62	62	Away	62	
Weekend Day	62	62			
Weekend Night	62	62			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	6
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	6
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	6
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	6

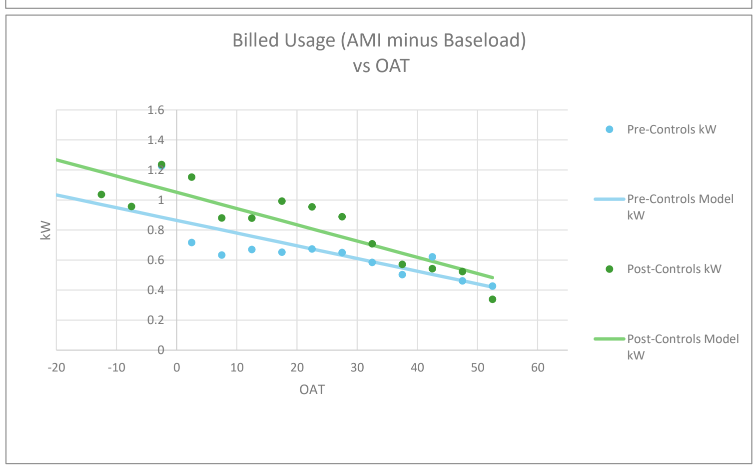


Analysis Takeaways

Not ideal candidate for droop because homeowner relies on furnace under house to prevent pipes from freezing. However, homeowner increased the droop offset settings. AMI data indicates increased use after controls were installed.

Participant Comments from Survey

No response.



Site ID	IT084

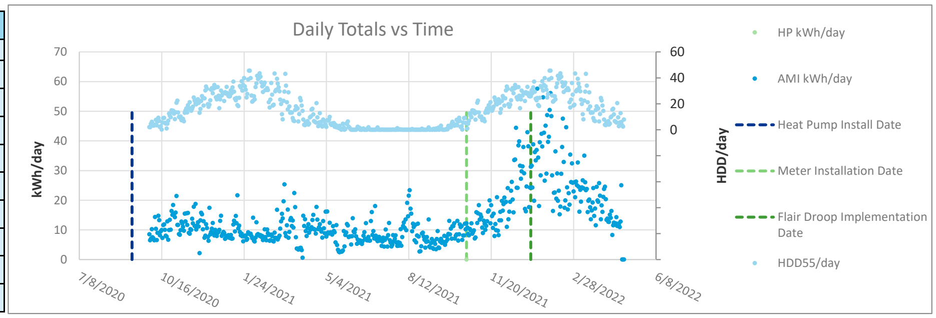
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	51.9	N.D.
Billed Usage Model	1,055	3,792	2,737	259%	10,413,155	37,427,720	27,014,565	29.1	51.9	-56.1%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04472	Equipment Type	0	Make	Daiken
Year Built	2019	Fuel Type	0	Outdoor unit model	RXL15QMVJUA
Envelope Condition	Excellent	Make	Viessman	Indoor unit model	0
Approx Area (ft2)	1,380	Model	B1KA 125	AHRI ref #	8849445
Metering Rigor	Low	Input BTU Max	125,000	Nameplate SEER	20
		Input BTU Min	31,000	Nameplate HSPF	11.3
		Burner staging	0	HSPF correction factor	87%
		AFUE/Efficiency	0.928	Site Specific HSPF	9.9

Key Participant Impressions (from Survey)

Heat pump operates more with controls.
Boiler operates more with controls.
Home uses more fuel, and spends more money on fuel.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 2/10
Likelihood of continuing to use Flair controls: 0/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.310341259
Total pre period kWh	0	5,012
Total post period kWh	0	2,786
Days of data pre	0	463
Days of data post	0	111
Pre coincident HDD	0	6,016
Post coincident HDD	0	2,585
TMY3 HDD	5,045	

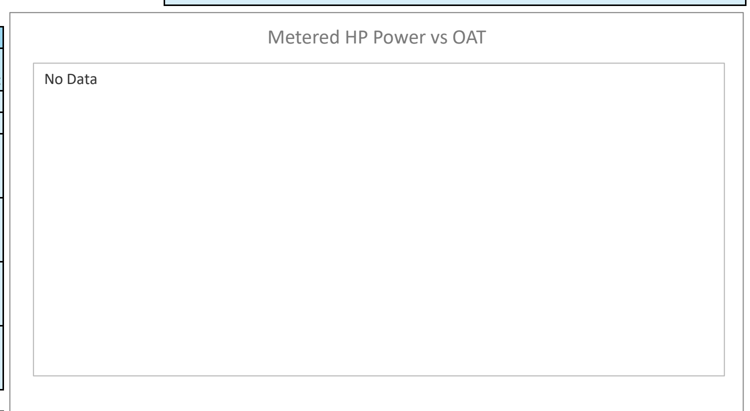


Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	N.D.	Zone	Whole Home
Weekday Day	68	off	Home	64
Weekday Night	off	55	Away	62
Weekend Day	68	off		
Weekend Night	off	off		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: used heat pump during the day and turned off at night
Post-Controls: changed temperature in Flair in the morning and at night

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Outdoor Temperature	5
2/21/2022	No	N.A	N.A	N.A
3/7/2022	Yes	DISABLED	Outdoor Temperature	5
3/21/2022	Yes	DISABLED	Outdoor Temperature	5

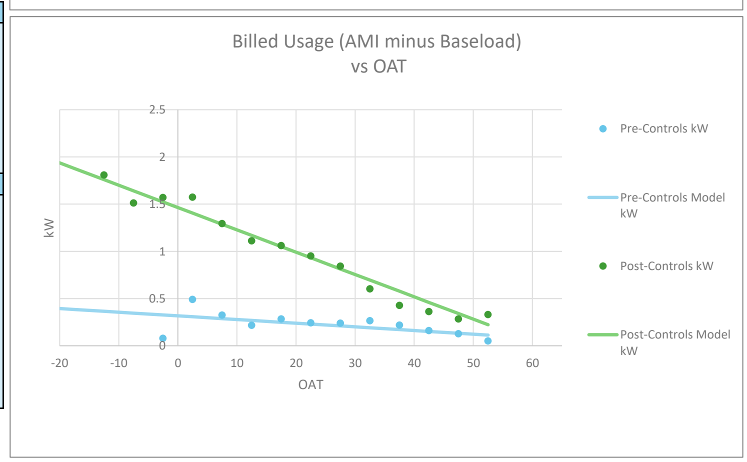


Analysis Takeaways

Homeowner requested to change the supplemental heat trigger to outdoor temperature. Homeowner ultimately disabled the controls because equipment was running more than desired. AMI data indicates that the heat pump did little heating before the controls were installed and ran significantly more after the controls were installed. Low rigor site so no metering.

Participant Comments from Survey

"The fan ran all winter no matter the temp. My electric bills skyrocketed and my propane usage was not significantly reduced. I feel I can get a much better result by operating the baseboard and heat pump manually."
"No matter the setting the house stayed hot all night."



Site ID	IT114

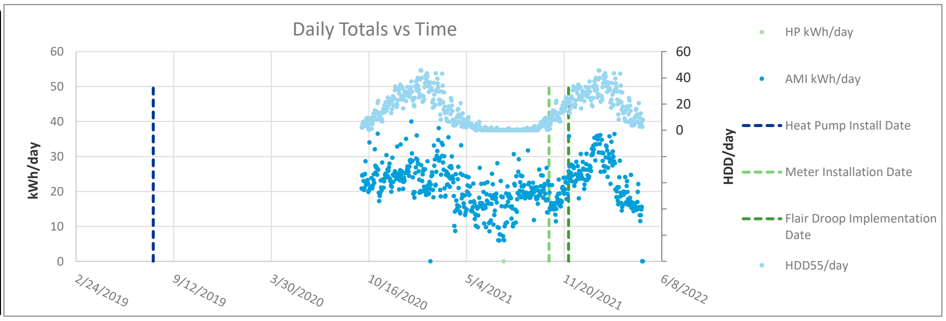
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	3,418	3,441	23	1%	40,323,296	40,591,801	268,505	0.3	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04411	Equipment Type	Boiler	Make	Fujitsu
Year Built	1962	Fuel Type	Fuel Oil	Outdoor unit model	AOU15RLS3
Envelope Condition	Good	Make	Frontier	Indoor unit model	0
Approx Area (ft2)	Unsure (checl	Model	EK-1F	AHRI ref #	204740070
Metering Rigor	Low	Input BTU Max	0	Nameplate SEER	25.3
		Input BTU Min	0	Nameplate HSPF	13.4
		Burner staging	0	HSPF correction factor	88%
		AFUE/Efficiency	0.8	Site Specific HSPF	11.8

Key Participant Impressions (from Survey)

Not sure if heat pump and boiler operation has changed since controls were installed.
Home uses the same amount of fuel, and spends more money on fuel.
Home uses the same amount of electricity, and spends more money on electricity.
Ease of operations of controls: 10/10
Likelihood of continuing to use Flair controls: 10/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.35
Total pre period kWh	0	8,833
Total post period kWh	0	3,669
Days of data pre	0	421
Days of data post	0	150
Pre coincident HDD	0	4,949
Post coincident HDD	0	3,572
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Whole Home
Weekday Day	70	68	Home	64
Weekday Night	70	65	Away	62
Weekend Day	70	68		
Weekend Night	70	68		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: left heat pump at same temp all winter, turned down boiler at night
Post-Controls: left Flair at same setpoint all winter

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

Metered HP Power vs OAT

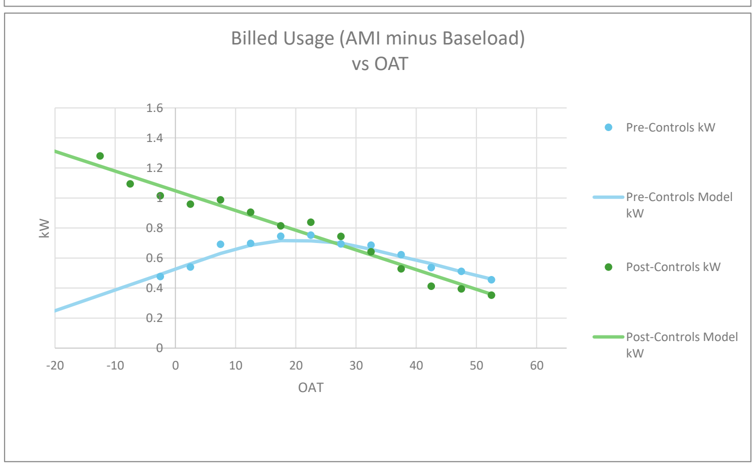
No Data

Analysis Takeaways

Homeowner utilized droop with a 5 degree offset. Homeowner behavior did not change with controls (left setpoint alone all winter). AMI data indicates increased use at lower temperatures. Low rigor site so no metering.

Participant Comments from Survey

"I don't think the usage changed but the price of electricity and fuel have gone up."



Site ID	IT116

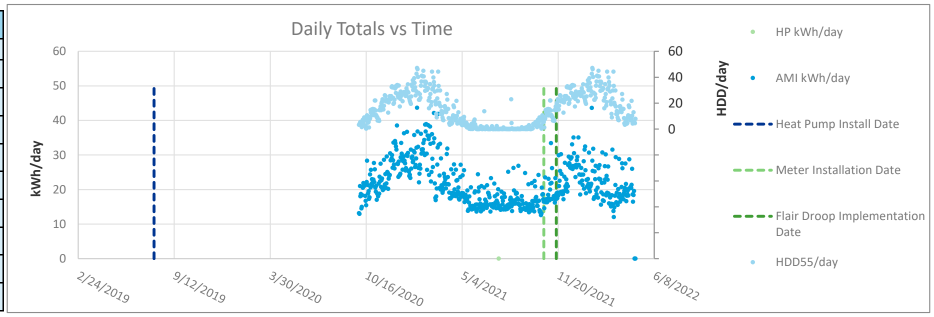
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	2,618	1,808	-810	-31%	30,826,918	21,286,033	-9,540,886	-10.5	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04937	Equipment Type	0	Make	Fujitsu
Year Built	1940	Fuel Type	Propane	Outdoor unit model	AOUG15LZAS1
Envelope Condition	Good	Make	Weil McLain	Indoor unit model	0
Approx Area (ft2)	1,100	Model	GV90+4	AHRI ref #	204740070
Metering Rigor	Low	Input BTU Max	105,000	Nameplate SEER	25.3
		Input BTU Min	0	Nameplate HSPF	13.4
		Burner staging	0	HSPF correction factor	88%
		AFUE/Efficiency	0.912	Site Specific HSPF	11.8

Key Participant Impressions (from Survey)

Heat pump operates the same amount with controls.
Boiler operates the same amount with controls.
Home uses the same amount of fuel, and spends the same amount of money on fuel.
Home uses the same amount of electricity, and spends the same amount of money on electricity.
Ease of operations of controls: 3/10
Likelihood of continuing to use Flair controls: 0/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.614
Total pre period kWh	0	8,800
Total post period kWh	0	3,659
Days of data pre	0	411
Days of data post	0	163
Pre coincident HDD	0	4,949
Post coincident HDD	0	3,916
TMY3 HDD	5,323	



Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	N.D.	Zone	Whole Home
Weekday Day	72	68	Home	64
Weekday Night	72	68	Away	62
Weekend Day	72	68		
Weekend Night	72	68		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: heat pump on and heating throughout winter
Post-Controls: used Flair account in manual mode to independently control boiler and heat pump

Flair Checkpoints Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

Metered HP Power vs OAT

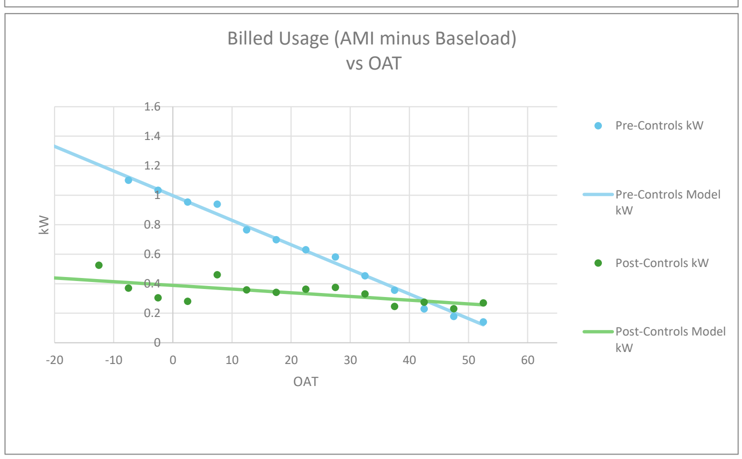
No Data

Analysis Takeaways

Homeowner overrode Flair's automated controls and used Flair in manual mode to independently control the boiler and heat pump because they did not like the Puck. AMI data shows decreased use of heat pump after the controls were installed, which disagrees with the customer's perception. Low rigor site so no metering.

Participant Comments from Survey

"It didn't change much. I already had a smart thermostat. The Puck wasn't helpful."



Site ID	IT119

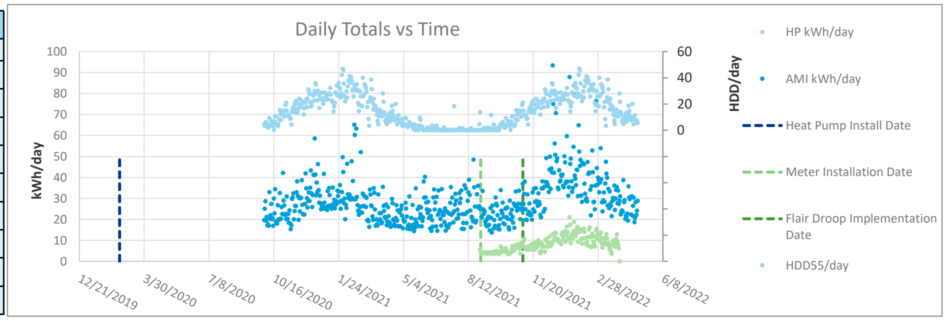
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	2,071	2,381	310	15%	24,538,725	28,208,022	3,669,297	4.2	No Fuel Data	N.D.
Billed Usage Model	1,706	3,673	1,967	115%	20,220,469	43,523,612	23,303,143	26.5	No Fuel Data	N.D.

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04048	Equipment Type	Boiler	Make	Fujitsu
Year Built	1985	Fuel Type	Fuel Oil	Outdoor unit model	AOU15RLS3H
Envelope Condition	Good	Make	Biani	Indoor unit model	0
Approx Area (ft2)	1,360	Model	B10/4	AHRI ref #	8703508
Metering Rigor	Med	Input BTU Max	107,000	Nameplate SEER	25.3
		Input BTU Min	107,000	Nameplate HSPF	13.3
		Burner staging	single	HSPF correction factor	89%
		AFUE/Efficiency	0.88	Site Specific HSPF	11.8

Key Participant Impressions (from Survey)

Heat pump operates the same amount with controls.
Boiler operates the same amount with controls.
Home uses the same amount of fuel, and spends the same amount of money on fuel.
Homeowner unsure of how electricity usage or money spent on electricity has changed.
Ease of operations of controls: 10/10
Likelihood of continuing to use Flair controls: 10/10

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.86947286
Total pre period kWh	324	10,191
Total post period kWh	1,478	6,317
Days of data pre	69	399
Days of data post	149	178
Pre coincident HDD	282	4,580
Post coincident HDD	3,537	3,850
TMY3 HDD	4,953	



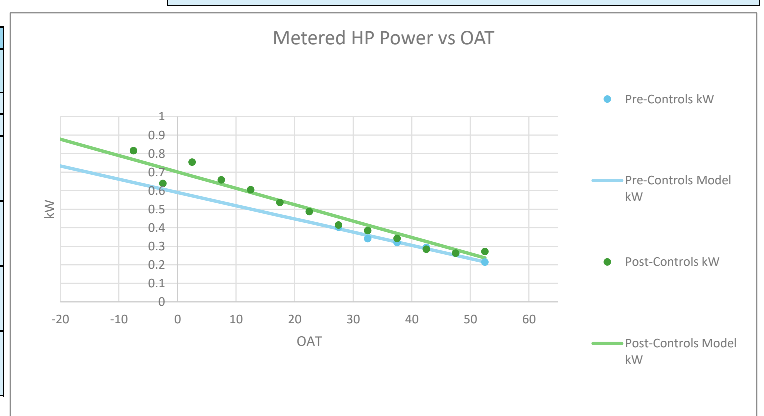
Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Whole Home
Weekday Day	65	60	Home	64
Weekday Night	68	60	Away	62
Weekend Day	68	60		
Weekend Night	65	60		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: heat pump on and heating throughout winter
Post-Controls: whole home set to same temperature in Flair

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	Yes	N.D.	N.D.	N.D.
12/2/2022	Yes	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
2/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/7/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5
3/21/2022	Yes	SUPPLEMENTAL	Indoor Temperature	5

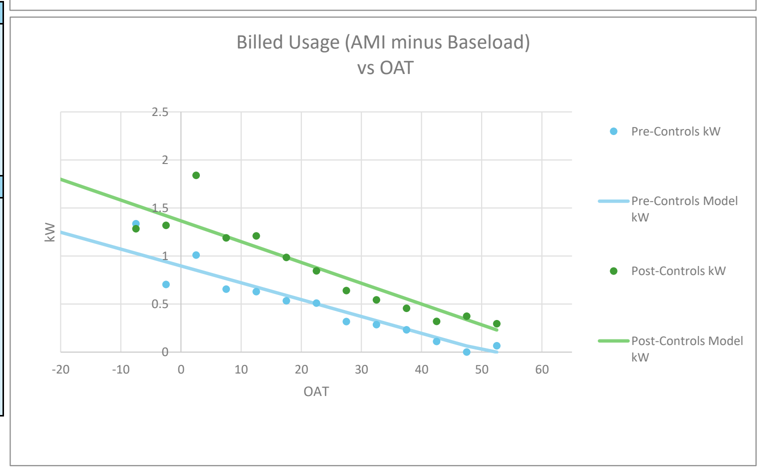


Analysis Takeaways

Utilized droop with a five degree offset. Metered data and AMI data both indicate increased use after droop implemented. Homeowner does not report any significant change in comfort.

Participant Comments from Survey

"Easy to use."

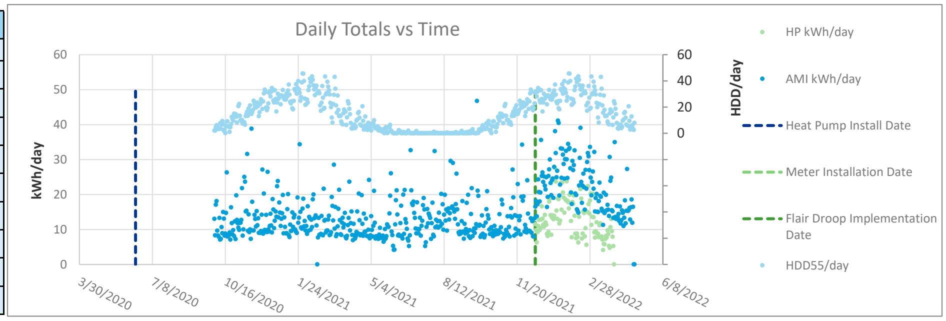


Site ID	IT124

Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	N.D.	2,443	N.D.	N.D.	N.D.	N.D.	N.D.	N.D.	No Fuel Data	N.D.
Billed Usage Model	835	2,949	2,114	253%	8,689,850	30,698,669	22,008,819	27.5	No Fuel Data	N.D.

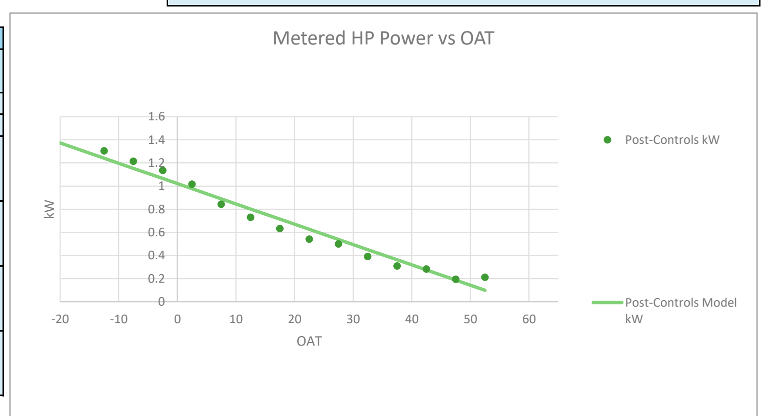
Site Information		Fuel Heating System		Ductless Split Heat Pump		Key Participant Impressions (from Survey)
ZIP Code	04401	Equipment Type	Boiler	Make	Daikin	Heat pump operates more with controls.
Year Built	1968	Fuel Type	Natural Gas	Outdoor unit model	RXL15QMVJU	Boiler operates less with controls.
Envelope Condition	Good	Make	Frontier	Indoor unit model	FTX-15NMVJU	Home uses less fuel, and spends less money on fuel.
Approx Area (ft2)	850	Model	EK-1F	AHRI ref #	8849445	Home uses more electricity, and spends more money on electricity.
Metering Rigor	High	Input BTU Max	0	Nameplate SEER	20	Ease of operations of controls: 6/10
		Input BTU Min	0	Nameplate HSPF	11.3	Likelihood of continuing to use Flair controls: 5/10
		Burner staging	0	HSPF correction factor	92%	
		AFUE/Efficiency	0.8	Site Specific HSPF	10.4	

Heating Degree Day Weather Normalization	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.346666667
Total pre period kWh	0	5,530
Total post period kWh	1,388	2,971
Days of data pre	0	436
Days of data post	107	135
Pre coincident HDD	0	5,307
Post coincident HDD	1,609	3,232
TMY3 HDD	5,045	



Pre-Controls Setpoints			Post-Controls Setpoints		Participant Setpoint/Behavior Description (from Survey)
Equipment	Heat Pump	Boiler	Zone	Whole Home	Pre-Controls: primarily used furnace to heat home, turned on heat pump for a few hours in the evening when in the living room
Weekday Day	N/A	66	Home	64	Post-Controls: set whole home temperature to be warmest in the evenings, and cooler at night and when out of the home during the day
Weekday Night	72	66	Away	62	
Weekend Day	N/A	66			
Weekend Night	72	66			

Flair Checkpoints				
Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Or Outdoor Temperature	3
2/21/2022	Yes	SUPPLEMENTAL	Indoor Or Outdoor Temperature	3
3/7/2022	Yes	SUPPLEMENTAL	Indoor Or Outdoor Temperature	3
3/21/2022	Yes	SUPPLEMENTAL	Indoor Or Outdoor Temperature	3

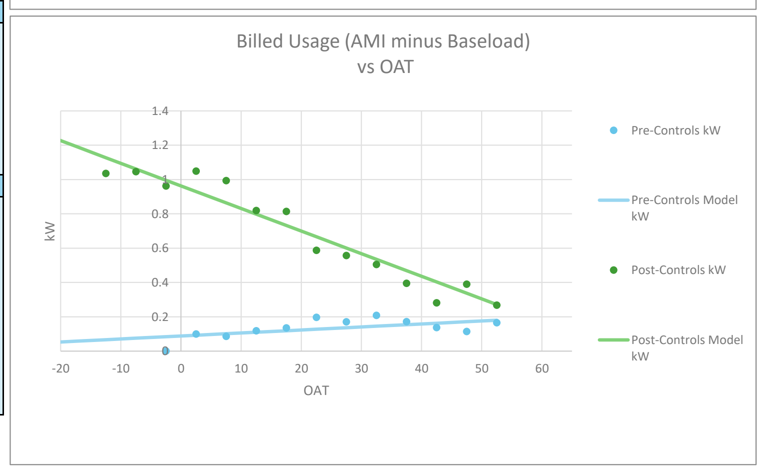


Analysis Takeaways

Homeowner utilized droop with a three degree offset. This home used the heat pump very little in the winter prior to installing the controls, which is supported by the significant use increase reflected in the data.

Participant Comments from Survey

"When the Flair worked it was great. However it required a lot of adjusting early on. Ideally heat pump integration could be accomplished using just the Ecobee."
"The Flair and heat pump did a great job maintaining a set temperature. Often even in the dead of winter the furnace would run for maybe an hour a day, significantly less than in previous winters. Our electric bill did triple, but that was mostly offset by a lower natural gas bill. I think in future winters we would likely deactivate the heat pump on those nights below 0 degrees to save in electricity costs."



Site ID	IT133

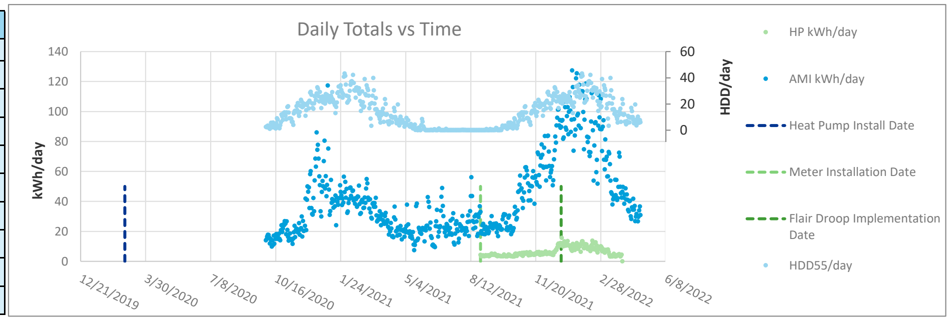
Results Summary	Pre-Controls HP Heating (kWh)	Post-Controls HP Heating (kWh)	Electric Heating Impact (kWh)	Heating kWh % Change	Pre-Controls HP Heating Load (Btu)	Post-Controls HP Heating Load (Btu)	HP Load Impact (Btu)	Fuel Savings (MMBtu)	Fossil Fuel Annual MMBtu	Fossil Fuel % Impact
Metered HP Data Model	1,361	1,832	471	35%	16,091,716	21,660,805	5,569,089	5.9	84.0	-7.0%
Billed Usage Model	4,648	11,994	7,346	158%	54,963,808	141,832,072	86,868,264	91.4	84.0	-108.8%

Site Information		Fuel Heating System		Ductless Split Heat Pump	
ZIP Code	04038	Equipment Type	Boiler	Make	Fujitsu
Year Built	1840	Fuel Type	Natural Gas	Outdoor unit model	AOU15RL#3H
Envelope Condition	Excellent	Make	Bosch	Indoor unit model	ASU15RLS3Y
Approx Area (ft2)	2,200	Model	ZWB 28-3	AHRI ref #	8703508
Metering Rigor	High	Input BTU Max	100,800	Nameplate SEER	25.3
		Input BTU Min	24,600	Nameplate HSPF	13.3
		Burner staging	modulating	HSPF correction factor	89%
		AFUE/Efficiency	0.95	Site Specific HSPF	11.8

Key Participant Impressions (from Survey)

Heat pump operates the same amount with controls.
Boiler operates the same amount with controls.
Home uses the same amount of fuel, and spends the same amount of money on fuel.
Home uses more electricity, and spends more money on electricity.
Ease of operations of controls: 8/10
Likelihood of continuing to use Flair controls: 3/10

Heating Degree Day Weather Normalization		
	HP Data	AMI Data
Heating DD base	55	55
Base load	0	0.83
Total pre period kWh	599	15,320
Total post period kWh	791	8,808
Days of data pre	124	454
Days of data post	94	123
Pre coincident HDD	1,238	5,183
Post coincident HDD	2,317	2,597
TMY3 HDD	4,929	



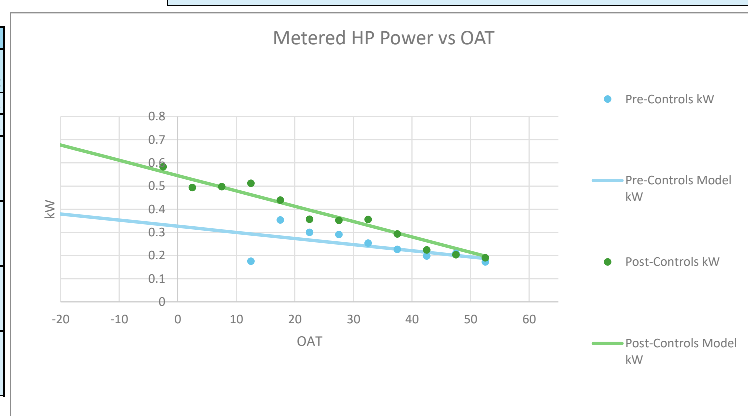
Pre-Controls Setpoints			Post-Controls Setpoints	
Equipment	Heat Pump	Boiler	Zone	Whole Home
Weekday Day	72	65	Home	64
Weekday Night	72	65	Away	62
Weekend Day	72	65		
Weekend Night	72	65		

Participant Setpoint/Behavior Description (from Survey)

Pre-Controls: heat pump on and heating throughout winter
Post-Controls: used droop for a few weeks, disabled integrated controls and returned to previous setpoints

Flair Checkpoints

Date	Droop Enabled?	Secondary Heat Mode	Secondary Heat Trigger	Droop Offset
11/29/2021	No	N.D.	N.D.	N.D.
12/2/2022	No	N.D.	N.D.	N.D.
2/4/2022	Yes	SUPPLEMENTAL	Indoor Temperature	3
2/21/2022	No	N.A.	N.A.	N.A.
3/7/2022	Yes	DISABLED	Indoor Temperature	3
3/21/2022	Yes	DISABLED	Indoor Temperature	3

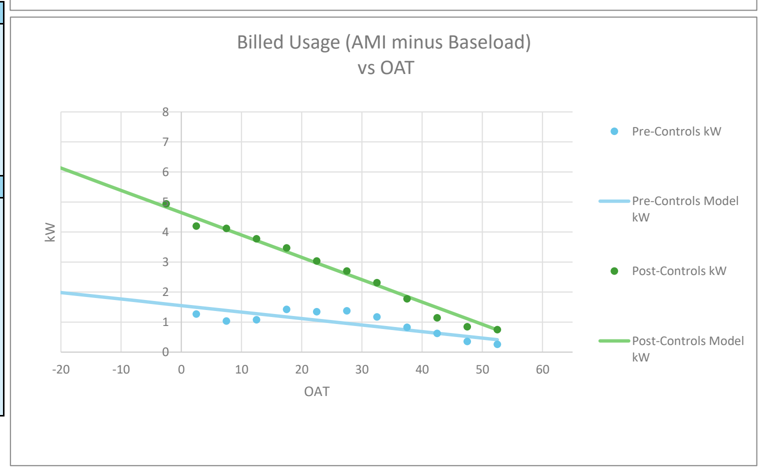


Analysis Takeaways

Homeowner disabled droop because the home layout did not allow for even heating without consistent use of the boiler. Homeowner added 1,000 square feet of house and an additional heat pump over the course of the study, contributing to the increased use observed in AMI data.

Participant Comments from Survey

"I initially tried using the droop settings but it caused portions of my home to be too cold due to the centralized location of the main thermostat, having a single hydronic loop and in conjunction with the heat pump only serving 10% of the home."



About DNV