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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

<table>
<thead>
<tr>
<th>Rigor</th>
<th>Metering Approach</th>
<th>Site Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>No metering</td>
<td>3</td>
</tr>
<tr>
<td>Med</td>
<td>Meter both heat pump and central system amperage at main electric panel</td>
<td>18</td>
</tr>
<tr>
<td>High</td>
<td>Meter heat pump power at exterior heat pump unit and central system amperage at central system</td>
<td>11</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>32</td>
</tr>
</tbody>
</table>

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**

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

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

**Table 4-3. Medium-rigor meter deployment**

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

**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\textsuperscript{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

\footnote{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

<table>
<thead>
<tr>
<th>Droop Enabled</th>
<th>Has Metered Heat Pump Data Result</th>
<th>Count</th>
<th>Average Increased Heat Pump Use per Metered Data (kWh)</th>
<th>Average Increased Heat Pump Use per AMI Data (kWh)</th>
<th>Fuel Savings per Heat Pump Data (MMBtu)</th>
<th>Fuel Savings per AMI Data (MMBtu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>No</td>
<td>7</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>Yes</td>
<td>No</td>
<td>9</td>
<td>N.A.</td>
<td>1,923</td>
<td>N.A.</td>
<td>22.6</td>
</tr>
<tr>
<td>Yes</td>
<td>Yes</td>
<td>16</td>
<td>386</td>
<td>1,020</td>
<td>5.0</td>
<td>13.1</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>32</td>
<td>386</td>
<td>1,345</td>
<td>5.0</td>
<td>16.3</td>
</tr>
</tbody>
</table>

Table 6-2. Sites with increased HP usage

<table>
<thead>
<tr>
<th></th>
<th>HP data</th>
<th>AMI data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Count N.A.</td>
<td>16</td>
<td>7</td>
</tr>
<tr>
<td>Count of sites with increased HP use</td>
<td>12</td>
<td>23</td>
</tr>
<tr>
<td>Count of sites with decreased HP use</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>Percent of sites with increased HP use</td>
<td>75%</td>
<td>92%</td>
</tr>
</tbody>
</table>

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

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

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

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Droop Utilized?</th>
<th>Heat Pump Usage Change</th>
<th>Home layout</th>
<th>Takeaway</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT004</td>
<td>Yes, 3 degree offset</td>
<td>Increased HP use</td>
<td>Single zone central system. Heat pump in living room does not reach back bedrooms, although back rooms are seldom used.</td>
<td>Homeowner had positive experience, but felt that the technology was more complex than they needed.</td>
</tr>
<tr>
<td>IT006</td>
<td>Yes, 2 degree offset and combination indoor/outdoor temp trigger</td>
<td>Minimal change</td>
<td>Single zone central system. Heat pump in living room does not reliably control temp in nursery, especially when outdoor temp is low.</td>
<td>Homeowner requires precise control of temperature, not a good candidate for droop.</td>
</tr>
<tr>
<td>IT008</td>
<td>Yes, 3 degree offset</td>
<td>Decreased heat pump use</td>
<td>Single zone central system. Heat pump in living room, bedrooms right off of living room.</td>
<td>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.</td>
</tr>
<tr>
<td>IT010</td>
<td>Yes, 4 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system on first floor, heat pump in first floor living room. Second floor separate baseboard system.</td>
<td>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</td>
</tr>
<tr>
<td>Site ID</td>
<td>Droop Utilized?</td>
<td>Heat Pump Usage Change</td>
<td>Home layout</td>
<td>Takeaway</td>
</tr>
<tr>
<td>--------</td>
<td>----------------</td>
<td>------------------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>IT012</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>Two boiler zones (only one operational). Two heat pumps, Controls implemented for kitchen/living room heat pump.</td>
<td>daytime setpoint (65) was higher than the previous central system setpoint (60).</td>
</tr>
<tr>
<td>IT015</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system, heat pump in living room.</td>
<td>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).</td>
</tr>
<tr>
<td>IT016</td>
<td>Yes, 3 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system, heat pump in upstairs bedroom.</td>
<td>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).</td>
</tr>
<tr>
<td>IT017</td>
<td>No</td>
<td>Minimal change</td>
<td>Single zone central system, heat pump in living room. Heat pump does not reach far bedroom, homeowners sometimes supplement with electric heater.</td>
<td>Homeowner disabled droop due to dissatisfaction with ability to control heat pump.</td>
</tr>
<tr>
<td>IT018</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>IT019</td>
<td>No</td>
<td>Minimal change</td>
<td>Single zone central system. Heat pump in living room can reach kitchen, but not bedroom.</td>
<td>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.</td>
</tr>
<tr>
<td>Site ID</td>
<td>Droop Utilized?</td>
<td>Heat Pump Usage Change</td>
<td>Home layout</td>
<td>Takeaway</td>
</tr>
<tr>
<td>--------</td>
<td>-----------------</td>
<td>------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>IT020</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>IT024</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system. Heat pump primarily serves living room, bedrooms upstairs.</td>
<td>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.</td>
</tr>
<tr>
<td>IT025</td>
<td>Yes, 3 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system. Heat pump located in sunroom/office, which is rarely used at the same time as the rest of the house.</td>
<td>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.</td>
</tr>
<tr>
<td>IT026</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system. Heat pump in living room, which is the most used area.</td>
<td>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.</td>
</tr>
<tr>
<td>IT028</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system. Heat pump in kitchen. Open layout kitchen/dining/living room areas.</td>
<td>AMI and metered data indicate increased heat pump use, which agrees with homeowner perception.</td>
</tr>
<tr>
<td>IT030</td>
<td>No, controls disconnected due to boiler repairs</td>
<td>N/A</td>
<td>Single zone central system.</td>
<td>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.</td>
</tr>
<tr>
<td>IT032</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system. Heat pump in living room, which connects to kitchen and is most used area.</td>
<td>Home utilized droop with 5 degree offset. AMI data indicates increased heat pump use. Homeowner is pleased with the controls and reports fuel savings.</td>
</tr>
<tr>
<td>IT037</td>
<td>Yes, 4 degree offset</td>
<td>Decreased heat pump use</td>
<td>Single zone central system. Central thermostat in same room as heat pump.</td>
<td>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.</td>
</tr>
<tr>
<td>Site ID</td>
<td>Droop Utilized?</td>
<td>Heat Pump Usage Change</td>
<td>Home layout</td>
<td>Takeaway</td>
</tr>
<tr>
<td>---------</td>
<td>----------------</td>
<td>------------------------</td>
<td>-------------</td>
<td>----------</td>
</tr>
<tr>
<td>IT038</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system, small mobile home.</td>
<td>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.</td>
</tr>
<tr>
<td>IT041</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>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.</td>
<td>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).</td>
</tr>
<tr>
<td>IT060</td>
<td>Yes, 5 degree offset</td>
<td>Increased heat pump use</td>
<td>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.</td>
<td>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.</td>
</tr>
<tr>
<td>IT070</td>
<td>No</td>
<td>N/A</td>
<td>Single zone central system. Heat pump is in small kitchen, minimally serves living room and does not reach bedrooms.</td>
<td>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.</td>
</tr>
<tr>
<td>IT072</td>
<td>No</td>
<td>N/A</td>
<td>Single zone central system, heat pump in living room. Heat pump does not reach bedrooms, homeowner likes using boiler to keep floors warm.</td>
<td>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.</td>
</tr>
<tr>
<td>IT074</td>
<td>Yes, 5 degree offset, cutover</td>
<td>Increased heat pump use</td>
<td>Single zone central system, heat pump located in basement rec room.</td>
<td>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.</td>
</tr>
<tr>
<td>IT079</td>
<td>Yes, 6 degree offset</td>
<td>Increased heat pump use</td>
<td>Single zone central system, mobile home.</td>
<td>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.</td>
</tr>
</tbody>
</table>
### 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)**

- Set temperatures via Flair, using Flair’s automated controls (droop)
- Overrode automated Flair controls and used Flair account in manual mode to independently control heat pump and boiler/furnace
-Disconnected Flair equipment and returned to using thermostat and original heat pump remote separately

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)**

- Entire house set to same setpoint in Flair most of the time
- Implemented smart features like schedules, vacation mode, etc.
- Changed droop settings such as offset or secondary heat trigger
- Different rooms set to different setpoints in Flair most of the time
- Changed setpoint in Flair throughout the day

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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

<table>
<thead>
<tr>
<th>Disposition</th>
<th>Non-Participants</th>
<th>Participants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total surveys sent</td>
<td>103</td>
<td>32</td>
</tr>
<tr>
<td>Received survey but did not complete</td>
<td>77</td>
<td>7</td>
</tr>
<tr>
<td>Completed survey</td>
<td>26</td>
<td>25</td>
</tr>
</tbody>
</table>

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)

- Heat pump was on and heating throughout the winter
- Heat pump was periodically turned on or off throughout the winter for heating
- Heat pump was not used in the winter for heating

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

<table>
<thead>
<tr>
<th>Boiler/Furnace Night-Time Adjustment</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease setpoint 1-5°F at night</td>
<td>3</td>
</tr>
<tr>
<td>Decrease setpoint 5-10°F at night</td>
<td>3</td>
</tr>
<tr>
<td>Boiler/furnace off during the day, on at night</td>
<td>1</td>
</tr>
<tr>
<td>No change to boiler/furnace setpoint at night</td>
<td>18</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heat Pump Night-Time Adjustment</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decrease setpoint 3-5°F at night</td>
<td>4</td>
</tr>
<tr>
<td>Decrease setpoint 5-10°F at night</td>
<td>2</td>
</tr>
<tr>
<td>Turn heat pump off at night</td>
<td>3</td>
</tr>
<tr>
<td>Increase setpoint 1-5°F at night</td>
<td>1</td>
</tr>
<tr>
<td>Heat pump off during the day, on at night</td>
<td>1</td>
</tr>
<tr>
<td>No change to heat pump setpoint at night</td>
<td>14</td>
</tr>
</tbody>
</table>

Table 6-7. Average setpoints prior to integrated controls

<table>
<thead>
<tr>
<th></th>
<th>Heat Pump</th>
<th>Boiler/Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daytime setpoint (°F)</td>
<td>65.7</td>
<td>62.9</td>
</tr>
<tr>
<td>Average night-time setpoint (°F)</td>
<td>59.0</td>
<td>63.8</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Perceived change in heat pump use</th>
<th>Perceived change in electricity consumption</th>
<th>Perceived change in money spent on electricity</th>
<th>Response count</th>
</tr>
</thead>
<tbody>
<tr>
<td>More</td>
<td>More</td>
<td>More</td>
<td>8</td>
</tr>
<tr>
<td>More</td>
<td>More</td>
<td>Same</td>
<td>1</td>
</tr>
<tr>
<td>More</td>
<td>Less</td>
<td>Less</td>
<td>1</td>
</tr>
<tr>
<td>More</td>
<td>Not sure</td>
<td>More</td>
<td>1</td>
</tr>
<tr>
<td>More</td>
<td>Not sure</td>
<td>Not sure</td>
<td>1</td>
</tr>
<tr>
<td>Less</td>
<td>Same</td>
<td>More</td>
<td>1</td>
</tr>
<tr>
<td>Less</td>
<td>Same</td>
<td>Same</td>
<td>3</td>
</tr>
<tr>
<td>Less</td>
<td>Less</td>
<td>More</td>
<td>2</td>
</tr>
<tr>
<td>Less</td>
<td>Not sure</td>
<td>Not sure</td>
<td>1</td>
</tr>
<tr>
<td>Not sure</td>
<td>More</td>
<td>More</td>
<td>3</td>
</tr>
<tr>
<td>Not sure</td>
<td>Same</td>
<td>More</td>
<td>1</td>
</tr>
</tbody>
</table>

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.

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\(^6\) 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

<table>
<thead>
<tr>
<th>Perceived change in boiler/furnace operation</th>
<th>Perceived change in fuel use</th>
<th>Perceived change in money spent on fuel</th>
<th>Response count</th>
</tr>
</thead>
<tbody>
<tr>
<td>More</td>
<td>More</td>
<td>More</td>
<td>1</td>
</tr>
<tr>
<td>More</td>
<td>Not sure</td>
<td>Same</td>
<td>1</td>
</tr>
<tr>
<td>Same</td>
<td>Same</td>
<td>Same</td>
<td>4</td>
</tr>
<tr>
<td>Same</td>
<td>Less</td>
<td>Less</td>
<td>1</td>
</tr>
<tr>
<td>Same</td>
<td>Not sure</td>
<td>Not sure</td>
<td>1</td>
</tr>
<tr>
<td>Less</td>
<td>Same</td>
<td>Same</td>
<td>1</td>
</tr>
<tr>
<td>Less</td>
<td>Less</td>
<td>Less</td>
<td>9</td>
</tr>
<tr>
<td>Less</td>
<td>Not sure</td>
<td>Not sure</td>
<td>1</td>
</tr>
<tr>
<td>Not Sure</td>
<td>Same</td>
<td>More</td>
<td>1</td>
</tr>
<tr>
<td>Not Sure</td>
<td>Less</td>
<td>Less</td>
<td>2</td>
</tr>
<tr>
<td>Not Sure</td>
<td>Not sure</td>
<td>More</td>
<td>1</td>
</tr>
<tr>
<td>Not Sure</td>
<td>Not sure</td>
<td>Not sure</td>
<td>1</td>
</tr>
</tbody>
</table>

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.”

![Pie chart showing participant responses to comfort changes.

- 7 respondents indicated home became much more comfortable.
- 5 respondents indicated home stayed equally comfortable.
- 3 respondents indicated home became slightly less comfortable.
- 8 respondents indicated home became slightly more comfortable.
- 1 respondent indicated home became much less comfortable.

Home became much more comfortable
Home stayed equally comfortable
Home became slightly less comfortable
Home became slightly more comfortable
Home became much less comfortable
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)**

<table>
<thead>
<tr>
<th>Respondent #</th>
<th>Furnace (forced air) – fuel oil</th>
<th>Boiler – fuel oil</th>
<th>Boiler – propane</th>
<th>Electric baseboard heating</th>
<th>Radiant floor heating – fuel oil</th>
<th>Electric space heater</th>
<th>Fireplace or stove – wood/pellet</th>
<th>Outdoor wood boiler with baseboards</th>
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<td>1</td>
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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).

<table>
<thead>
<tr>
<th></th>
<th>Heat Pump</th>
<th>Other heating system</th>
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<tbody>
<tr>
<td>Weekday day</td>
<td>69.60</td>
<td>64.00</td>
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<tr>
<td>Weekday night</td>
<td>68.29</td>
<td>63.41</td>
</tr>
<tr>
<td>Weekend day</td>
<td>69.65</td>
<td>64.24</td>
</tr>
<tr>
<td>Weekend night</td>
<td>68.26</td>
<td>63.19</td>
</tr>
</tbody>
</table>

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 effortlessly, 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.
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)

![Bar chart showing responses to the question.](image)

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)

![Pie chart showing responses to the question.](image)
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. 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.

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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
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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\textsuperscript{1}-rated HSPF\textsuperscript{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

\footnote{1\textsuperscript{1} Air Conditioning, Heating, and Refrigeration Institute}
\footnote{2\textsuperscript{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 Tx 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 Fujitsu

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>
<thead>
<tr>
<th>Technology Type</th>
<th>Equipment Cost</th>
<th>High Rigor</th>
<th>Medium Rigor</th>
<th>Low Rigor</th>
<th>Technology Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecobee + Flair Smart Puck Pro</td>
<td>$400</td>
<td>4</td>
<td>8</td>
<td>15</td>
<td>Compatible with all systems.</td>
</tr>
<tr>
<td>Resideo T9</td>
<td>$350</td>
<td>4</td>
<td>8</td>
<td>15</td>
<td>Compatible with all systems.</td>
</tr>
<tr>
<td>Jackson UT32</td>
<td>$428</td>
<td>2</td>
<td>4</td>
<td>0</td>
<td>May not be compatible with all homes; select carefully.</td>
</tr>
</tbody>
</table>

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:](attachment:SelectionCriteria_DecisionMatrix_011.png)
Table 3. Decision Matrix Sample

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

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.
## General Site Data

<table>
<thead>
<tr>
<th>Field</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site ID</td>
<td></td>
</tr>
<tr>
<td>Engineer(s)</td>
<td></td>
</tr>
<tr>
<td>Date &amp; Time</td>
<td></td>
</tr>
<tr>
<td>Contact Name</td>
<td></td>
</tr>
<tr>
<td>Contact Phone Number</td>
<td></td>
</tr>
<tr>
<td>Address</td>
<td></td>
</tr>
<tr>
<td>ZIP</td>
<td>will be used for weather</td>
</tr>
<tr>
<td>Electric Utility</td>
<td></td>
</tr>
<tr>
<td>Electric Account Number (from tracking)</td>
<td></td>
</tr>
<tr>
<td>Delivered heating fuel used</td>
<td></td>
</tr>
<tr>
<td>Fuel Provider</td>
<td></td>
</tr>
<tr>
<td>Fuel Account Number</td>
<td></td>
</tr>
<tr>
<td>Cords of wood used per season (if applicable)</td>
<td>cords per season</td>
</tr>
<tr>
<td>Lbs of pellets used per season (if applicable)</td>
<td>lbs per season</td>
</tr>
<tr>
<td>Year the building was built</td>
<td></td>
</tr>
<tr>
<td>Approx. Sq. Footage (ft²)</td>
<td></td>
</tr>
<tr>
<td>Approx. Sq. Footage (ft²) conditioned</td>
<td></td>
</tr>
<tr>
<td>Approx. Sq. Footage served by heat pump</td>
<td></td>
</tr>
<tr>
<td>Number of floors</td>
<td></td>
</tr>
<tr>
<td>Envelope Condition</td>
<td>net zero / excellent / good</td>
</tr>
<tr>
<td>Energy-saving upgrades performed in the last year?</td>
<td>yes/no</td>
</tr>
<tr>
<td>List any recently implemented energy-saving measures</td>
<td></td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>Field</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heat pump indoor head location</td>
<td>floor and room</td>
</tr>
<tr>
<td>Heat pump thermostat/remote location</td>
<td></td>
</tr>
<tr>
<td>Central heating system thermostat location</td>
<td></td>
</tr>
<tr>
<td>Are there any other thermostats in the home?</td>
<td>yes/no</td>
</tr>
<tr>
<td>If so, where are the other thermostats?</td>
<td></td>
</tr>
<tr>
<td>Room or space in home with priority for comfort? (e.g. baby's room, regularly occupied room, room that always runs cold)</td>
<td></td>
</tr>
<tr>
<td>How was HP served space heated and cooled prior to HP installation?</td>
<td></td>
</tr>
<tr>
<td>Describe current control scheme for heat pump and central heating system.</td>
<td>free response; we will ca</td>
</tr>
<tr>
<td><strong>Thermostat Data</strong></td>
<td></td>
</tr>
<tr>
<td>---------------------</td>
<td>--</td>
</tr>
<tr>
<td>Type of thermostat controlling heat pump</td>
<td>Smart/programmable/m</td>
</tr>
<tr>
<td>What is your temperature schedule for the heat pump thermostat?</td>
<td>fill out 2. Tstat setpoints tab after interview</td>
</tr>
<tr>
<td>Type of thermostat controlling central heating system</td>
<td>take a photo and upload</td>
</tr>
<tr>
<td>Secondary central thermostat type? (if applicable)</td>
<td>thermostat zone in the sa</td>
</tr>
<tr>
<td>What is your temperature schedule for the central thermostat(s)?</td>
<td>fill out 2. Tstat setpoints tab after interview</td>
</tr>
<tr>
<td><strong>Remove the primary thermostat from the wall.</strong> Which terminals are connected? (note terminal labels and wire color)</td>
<td>take a photo and upload</td>
</tr>
<tr>
<td>Are there additional unused wires behind the thermostat?</td>
<td>Note quantity and color</td>
</tr>
<tr>
<td>Is the thermostat wire close to the central heating system and easily accessible?</td>
<td></td>
</tr>
<tr>
<td>Would this site prefer a wired or wi-fi enabled thermostat controller?</td>
<td>wired/wireless/no prefer</td>
</tr>
<tr>
<td><strong>Occupant information</strong></td>
<td></td>
</tr>
<tr>
<td>How many people live here total?</td>
<td></td>
</tr>
<tr>
<td>Number of adults</td>
<td></td>
</tr>
<tr>
<td>Number of children</td>
<td></td>
</tr>
<tr>
<td>What are the general occupancy patterns in the building on a normal day?</td>
<td></td>
</tr>
<tr>
<td>Weekday:</td>
<td></td>
</tr>
<tr>
<td>Weekend:</td>
<td>approximate schedule</td>
</tr>
<tr>
<td>Do you have any seasonal occupancy shifts, like heading to a vacation home or having a college student home during the summer?</td>
<td></td>
</tr>
<tr>
<td>How has your occupancy pattern changed due to the coronavirus?</td>
<td>free response; we will ca</td>
</tr>
<tr>
<td><strong>At end of project:</strong> Have your occupancy patterns changed over the course of the metering period?</td>
<td></td>
</tr>
<tr>
<td><strong>Misc. Site Notes and sketches</strong></td>
<td></td>
</tr>
</tbody>
</table>
### Heating, Heat Pump 1

| 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 | Site ID |
|------------|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|      |
| Monday     |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Tuesday    |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Wednesday  |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Thursday   |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Friday     |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Saturday   |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Sunday     |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |

### Cooling, Heat Pump 1

| 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 | Site ID |
|------------|---|---|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|      |
| Monday     |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Tuesday    |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Wednesday  |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Thursday   |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Friday     |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Saturday   |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
| Sunday     |   |   |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |      |
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### Cooling, central system

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<tr>
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<tr>
<td><strong>Fuel Type</strong></td>
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</tr>
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<tr>
<td><strong>Model</strong></td>
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<td><strong>Input BTU Min</strong></td>
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<tr>
<td><strong>Combustion Fan A</strong></td>
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</table>

### Furnace

| **Supply Fan A**               |         |
| **Supply fan type**            | SP, PSC, ECM, N/A |
| **Return type**                | Central/balanced |

### Boiler

<p>| <strong>Qty of zones</strong>               |         |
| <strong>Qty of zone pumps</strong>          |         |
| <strong>Zone descriptions</strong>          | Note if solenoid valve |
| <strong>Which zone pump serves the same space as the DSHP?</strong> |         |
| <strong>Is this system used for DHW?</strong> | yes/no |
| <strong>If multiple zones, is there a special control board?</strong> |         |
| <strong>Other notes on central system</strong> |         |</p>
<table>
<thead>
<tr>
<th>Ductless Split Heat Pump</th>
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<tr>
<td>Outdoor unit fan (FL amps)</td>
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<td>Refrigerant type</td>
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<td>Indoor unit make</td>
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<td>Indoor unit model</td>
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<td>Indoor unit location</td>
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<tr>
<td>Other notes on DSHP system</td>
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<td>Other notes on Central cooling system</td>
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Interesting data points:
- **onboard defrost/backup resistance heat?**
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<thead>
<tr>
<th><strong>DHW Equipment</strong></th>
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<tr>
<td><strong>DHW Type</strong></td>
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<tr>
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<tr>
<td>Was a new appliance installed to provide DHW as a result of the HP install?</td>
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| **Other DHW System Notes** |

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<th><strong>Other Equipment</strong></th>
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<tbody>
<tr>
<td><strong>Equipment Type</strong></td>
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<p>| <strong>Other equipment notes</strong> |</p>
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<th>Rigor</th>
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<th>Attachment Type</th>
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<tr>
<td>Med</td>
<td>Netvox 3-channel CT</td>
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<tr>
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<td>Netvox 3-channel CT</td>
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<td>C</td>
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**Spott Measurments**

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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.
   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.

<table>
<thead>
<tr>
<th>Flair Puck</th>
<th>Flair Bridge</th>
<th>Ecobee Thermostat</th>
<th>Ecobee Smart Home Sensors</th>
</tr>
</thead>
</table>

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

<table>
<thead>
<tr>
<th>1. Use your heat pump all winter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Set it and forget it in the winter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Set for comfort.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Use your heat pump before your boiler/furnace.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Avoid “Auto” mode in summer and winter.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Optimize fan speed.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Optimize air flow direction.</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

| 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
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.

<table>
<thead>
<tr>
<th></th>
<th>Heat pump setpoint (F)</th>
<th>Boiler/furnace setpoint (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend day</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th></th>
<th>Heat pump setpoint (F)</th>
<th>Boiler/furnace setpoint (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend night</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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
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
Page 5 of 5

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.
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 (radores/forced hot water) – fuel oil
   f. Boiler (radores/forced hot water) – natural gas
   g. Boiler (radores/forced hot water) – propane
   h. Boiler (radores/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
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)

c. Not sure

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

<table>
<thead>
<tr>
<th></th>
<th>Heat pump setpoint (F)</th>
<th>Other heating system(s) setpoint(s) (F)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weekday day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekday night</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend day</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend night</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

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.
EMT Integrated Controls Individual Site Summaries “Cheat Sheet”

Summary table

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather-normalized annual heating electric energy consumption of heat pump before installation of controls.</td>
<td>Weather-normalized annual heating electric energy consumption of heat pump after installation of controls.</td>
<td>Change in weather-normalized annual heating electric energy consumption of heat pump due to installed controls.</td>
<td>Percent change in weather-normalized annual heating electric energy consumption of heat pump due to installed controls.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weather-normalized annual heat output of heat pump before controls installation, calculated from heat pump electric energy consumption.</td>
<td>Weather-normalized annual heat output of heat pump before controls installation, calculated from heat pump electric energy consumption.</td>
<td>Change in weather-normalized annual heat output of heat pump due to installed controls.</td>
<td>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.</td>
<td>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.</td>
<td>Percent change in fossil fuel consumption due to installed controls.</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Site Information</th>
<th>Fuel Heating System</th>
<th>Ductless Split Heat Pump</th>
<th>Key Participant Impressions (from Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Information on home’s location, size, age, envelope condition, and the metering rigor used at the site.</td>
<td>Information on the home’s fuel heating system including type, make/model, input/output Btu, burner staging, and rated efficiency.</td>
<td>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.</td>
<td>Key participant takeaways, taken from survey responses.</td>
</tr>
</tbody>
</table>
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.

<table>
<thead>
<tr>
<th>Heating Degree Day Weather Normalization</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP Data</td>
<td>AMI Data</td>
</tr>
<tr>
<td>Heating DD base</td>
<td>55</td>
</tr>
<tr>
<td>Base load</td>
<td>0</td>
</tr>
<tr>
<td>Total pre period kWh</td>
<td>572</td>
</tr>
<tr>
<td>Total post period kWh</td>
<td>1,060</td>
</tr>
<tr>
<td>Days of data pre</td>
<td>145</td>
</tr>
<tr>
<td>Days of data post</td>
<td>124</td>
</tr>
<tr>
<td>Pre coincident HDD</td>
<td>674</td>
</tr>
<tr>
<td>Post coincident HDD</td>
<td>2,998</td>
</tr>
<tr>
<td>TMY3 HDD</td>
<td>4,929</td>
</tr>
</tbody>
</table>

Setpoint Information

<table>
<thead>
<tr>
<th>Pre-Controls Setpoints</th>
<th>Post-Controls Setpoints</th>
<th>Participant Setpoint/Behavior Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Homeowner’s typical heating setpoints, before controls installation, per survey responses.</td>
<td>Homeowner’s typical heating setpoints, after controls installation, per survey responses.</td>
<td>Homeowner narrative on typical heating system operation, before and after controls installation, per open-ended survey responses.</td>
</tr>
</tbody>
</table>
### Flair Checkpoints Table

<table>
<thead>
<tr>
<th>Date of check</th>
<th>Droop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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.</td>
<td><strong>Supplemental:</strong> primary heat system (heat pump) remains on and heating when secondary heat (boiler/furnace) is added. <strong>Cutover:</strong> 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. <strong>N/A:</strong> secondary heat not in use in home’s Flair account.</td>
<td><strong>Indoor temperature:</strong> Flair uses indoor temperature to determine when to call for secondary heat. <strong>Outdoor temperature:</strong> Flair uses outdoor temperature to determine when to call for secondary heat. <strong>N/A:</strong> secondary heat not in use in home’s Flair account.</td>
<td>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).</td>
</tr>
</tbody>
</table>

### 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**

<table>
<thead>
<tr>
<th>Analysis Takeaways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Summary of site-specific analysis results.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant Comments from Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>Participant comments from survey not included elsewhere, if applicable.</td>
</tr>
</tbody>
</table>
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

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. Heat pump operates same with controls, but we were able to lower it to 72 since the sensors would pick up if the other rooms dropped below the set temperature.

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. It 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.
Results Summary

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>716</td>
<td>639</td>
<td>-77</td>
<td>13%</td>
<td>8,434,916</td>
<td>-908,594</td>
<td>-1.0</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
<tr>
<td>1,677</td>
<td>1,546</td>
<td>-131</td>
<td>-8%</td>
<td>19,755,660</td>
<td>-1,539,023</td>
<td>-1.7</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

Site Information

- Ductless Split Heat Pump
- ZIP Code: 04030
- Equipment Type: Mitsubishi
- Year Built: 2019
- Fuel Type: Outdoor unit model MUZ-G12NA

Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th>HDD55/day</th>
<th>kW</th>
<th>AMI kWh/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>-0.1</td>
<td>-0.1</td>
<td>-0.05</td>
</tr>
<tr>
<td>-0.05</td>
<td>-0.05</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>0.05</td>
</tr>
<tr>
<td>0.05</td>
<td>0.05</td>
<td>0.1</td>
</tr>
<tr>
<td>0.1</td>
<td>0.1</td>
<td>0.15</td>
</tr>
<tr>
<td>0.15</td>
<td>0.15</td>
<td>0.2</td>
</tr>
<tr>
<td>0.2</td>
<td>0.2</td>
<td>0.25</td>
</tr>
<tr>
<td>0.25</td>
<td>0.25</td>
<td>0.3</td>
</tr>
<tr>
<td>0.3</td>
<td>0.3</td>
<td>0.35</td>
</tr>
<tr>
<td>0.35</td>
<td>0.35</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Flair Checkpoints

<table>
<thead>
<tr>
<th>Date</th>
<th>Droop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>Yes</td>
<td>CUTOVER</td>
<td>Indoor OR Outdoor Temperature</td>
<td>2</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>Yes</td>
<td>CUTOVER</td>
<td>Indoor OR Outdoor Temperature</td>
<td>2</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>No</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>Yes</td>
<td>CUTOVER</td>
<td>Indoor OR Outdoor Temperature</td>
<td>2</td>
</tr>
</tbody>
</table>

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 mechanism because they require precise temperature control of nursery room.

Participant Comments from Survey

No response.
Results Summary

<table>
<thead>
<tr>
<th>Site ID</th>
<th>Metered HP Data Model</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>IT008</td>
<td>2,829</td>
<td>2,149</td>
<td>10.90</td>
<td>8.022,680</td>
<td>9.47</td>
<td>67.7</td>
<td>-2.7%</td>
<td></td>
</tr>
</tbody>
</table>

Site Information

- **ZIP Code**: 04947
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1950s
- **Fuel Type**: Gas
- **Envelope Condition**: Poor
- **Approx Area (ft²)**: 1,400
- **Metering Rigor**: Med
- **Input BTU Max**: 33.1
- **Nameplate SEER**: 13.5
- **Burner staging**: HRDV
- **Site Specific HSPF**: 11.8
- **Flair Checkpoints**:
  - 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 heating 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.
Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>4,828</td>
<td>6,425</td>
<td>1,598</td>
<td>33%</td>
<td>56,252,722</td>
<td>74,867,706</td>
<td>18,614,984</td>
<td>23.3</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

Site Information

<table>
<thead>
<tr>
<th>Zip Code</th>
<th>04105</th>
<th>Equipment Type</th>
<th>Boiler</th>
<th>Fuel Type</th>
<th>Outdoor unit model</th>
<th>Indoor unit model</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year Built</td>
<td>1992</td>
<td>Fuel Type</td>
<td>Fuel Oil</td>
<td>Fuel type</td>
<td>Fuel Oil</td>
<td>Fuel Oil</td>
<td>Fuel Oil</td>
<td>Fuel Oil</td>
<td>Fuel Oil</td>
<td>Fuel Oil</td>
</tr>
<tr>
<td>Envelope Condition</td>
<td>Good</td>
<td>Make</td>
<td>NTI</td>
<td>Make</td>
<td>ASU15RLS3Y</td>
<td>ASU15RLS3Y</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>Approx Area (ft²)</td>
<td>2,300</td>
<td>Model</td>
<td>CT-120</td>
<td>Model</td>
<td>CT-120</td>
<td>CT-120</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>Metering Rigor</td>
<td>Med</td>
<td>Input BTU Max</td>
<td>0</td>
<td>Nameplate SEER</td>
<td>8703507</td>
<td>Nameplate SEER</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Input BTU Min</td>
<td>0</td>
<td>Nameplate HSPF</td>
<td>13.4</td>
<td>Nameplate HSPF</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burner staging</td>
<td>0</td>
<td>HPF correction factor</td>
<td>87%</td>
<td>HPF correction factor</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AFUE/ Efficiency</td>
<td>0.8</td>
<td>Site Specific HSPF</td>
<td>11.7</td>
<td>Site Specific HSPF</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

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.

Flair Checkpoints

<table>
<thead>
<tr>
<th>Date</th>
<th>Droop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
<tr>
<td>3/31/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
</tbody>
</table>

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."

Graphs:

- Daily Totals vs Time
- Metered HP Power vs OAT
- Billed Usage (AMI minus Baseload) vs OAT
### Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kW % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>1,208</td>
<td>1,769</td>
<td>561</td>
<td>46%</td>
<td>20,442,250</td>
<td>23,759,350</td>
<td>4,818</td>
<td>8.1</td>
<td>25.0</td>
<td>-32.4%</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>1,797</td>
<td>2,056</td>
<td>259</td>
<td>14%</td>
<td>20,764,311</td>
<td>23,985,039</td>
<td>3,720</td>
<td>3.7</td>
<td>25.0</td>
<td>-14.9%</td>
</tr>
</tbody>
</table>

### Site Information

- **ZIP Code**: 04355
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1800
- **Fuel Type**: Outdoor unit model
- **Envelope Condition**: Fair
- **Approx Area (ft²)**: 1,250
- **Input BTU Min**: 106,250
- **Burner staging**: Single
- **AFUE/Efficiency**: 0.8

### Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th>Date</th>
<th>HDD55/day</th>
<th>HDD56/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>12/29/2021</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>0</td>
<td>0.2</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>5</td>
<td>0.4</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>5</td>
<td>0.4</td>
</tr>
</tbody>
</table>

### Heating Degree Day vs Time

- **Daily Totals vs Time**
  - **Heat Pump Install Date**
  - **Meter Install Date**
  - **Flair Droop Implementation Date**
  - **HDD55/day**

### 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.*

###图示

- Metered HP Power vs OAT
- Billed Usage (AMI minus Baseload) vs OAT
### Site ID: IT012

#### Results Summary

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

#### Site Information

- **ZIP Code**: 04444
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1920
- **Fuel Type**: Outdoor unit model AOU15RLS3
- **Envelope Condition**: Good
- **Approx Area (ft²)**: 2,250
- **Metering Rigor**: Med
- **Input BTU Min**: 0
- **AFUE/Efficiency**: 0.84

#### Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th>HP Data/AMI Data</th>
<th>Heating DD base</th>
<th>Base load</th>
<th>Total pre period kWh</th>
<th>Total post period kWh</th>
<th>Days of data pre</th>
<th>Days of data post</th>
<th>Pre coincident HDD</th>
<th>Post coincident HDD</th>
<th>TMY3 HDD</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>55</td>
<td>0</td>
<td>1,045</td>
<td>0</td>
<td>113</td>
<td>0</td>
<td>660</td>
<td>0</td>
<td>5,045</td>
</tr>
</tbody>
</table>

#### Flair Checkpoints

<table>
<thead>
<tr>
<th>Date</th>
<th>Droop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
</tbody>
</table>

#### Participant Setpoints/Behavior Description (from site visit)

- **Equipment**: Heat Pump: set heat pump at 74 and boiler at 68
- **Zone**: Living Room/Kitchen
- **Pre-controls**: set heat pump at 74 and boiler at 68
- **Post-controls**: utilized droop with 5 degree offset

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

Analysis Takeaways

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

Participant Comments from Survey

1. I am still a bit confused as to all the settings and different equipment and when to use each.
2. 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 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.
3. 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.
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.

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."
Results Summary

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,303</td>
<td>2,649</td>
<td>346</td>
<td>13%</td>
<td>14,584,453</td>
<td>28,740,524</td>
<td>14,156,071</td>
<td>4.4</td>
<td>80.7</td>
<td>-5.4%</td>
</tr>
<tr>
<td>7,248</td>
<td>8,213</td>
<td>966</td>
<td>13%</td>
<td>28,628,219</td>
<td>89,104,312</td>
<td>10,476,094</td>
<td>12.2</td>
<td>80.7</td>
<td>-15.1%</td>
</tr>
</tbody>
</table>

Site Information

- **ZIP Code**: 04210
- **Equipment Type**: Ductless Split Heat Pump
- **Make**: Mitsubishi
- **Year Built**: 1966
- **Fuel Type**: Outdoor unit model
- **Envelope Condition**: Fair
- **Approx Area (ft²)**: 1,200
- **Equipment Model**: MUZ-FH12NA
- **Indoor unit model**: MSZ-FH12NA
- **Fuel Savings (MMBtu)**: 12.2
- **Fossil Fuel Annual MMBtu**: 80.7
- **Fossil Fuel % Impact**: -15.1%
- **Flair Checkpoints**
  - **Date**: 11/29/2021
    - **Droop** Enabled?: Yes
    - **Secondary Heat Mode**: N.D.
    - **Secondary Heat Trigger**: N.D.
  - **Date**: 12/2/2022
    - **Droop** Enabled?: Yes
    - **Secondary Heat Mode**: N.D.
    - **Secondary Heat Trigger**: N.D.
  - **Date**: 2/4/2022
    - **Droop** Enabled?: No
    - **Secondary Heat Mode**: N.A.
    - **Secondary Heat Trigger**: N.A.
  - **Date**: 2/21/2022
    - **Droop** Enabled?: No
    - **Secondary Heat Mode**: N.A.
    - **Secondary Heat Trigger**: N.A.
  - **Date**: 3/7/2022
    - **Droop** Enabled?: No
    - **Secondary Heat Mode**: N.A.
    - **Secondary Heat Trigger**: N.A.
  - **Date**: 3/21/2022
    - **Droop** Enabled?: No
    - **Secondary Heat Mode**: N.A.
    - **Secondary Heat Trigger**: 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."
Results Summary

<table>
<thead>
<tr>
<th>HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Pre-Controls HP Impact (kWh)</th>
<th>Post-Controls HP Impact (kWh)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Controls</td>
<td>Post-Controls</td>
<td>Pre-Controls</td>
<td>Post-Controls</td>
<td>HP Load Impact</td>
<td>Fuel Savings</td>
<td>Fossil Fuel</td>
<td>Fossil Fuel % Impact</td>
</tr>
</tbody>
</table>

- **Heating kWh % Change**: 21%
- **Electric Heating Impact (kWh)**: 1,064
- **Heating kWh**: 10,121,290
- **Fossil Fuel Annual MMBtu**: 37.1
- **Fossil Fuel % Impact**: 28.7%

Site Information

- **ZIP Code**: 04103
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1950's initial, but additions in 70s & 90s
- **Fuel Type**: Propane
- **Envelope Condition**: Good
- **Approx Area (ft2)**: 1,500
- **Model**: AHRI ref # 201754300
- **Input BTU Min**: 0
- **Burner staging**: single
- **HSPF correction factor**: 87%
- **AFUE/Efficiency**: 10.5

Site Data Model

- **4,988**: 6,052
- **1,064**: 21%
- **52,323,071**: 63,485,261
- **11,162,190**: 14.0
- **37.1**: 37.6%

AMI Data

- **942**: 19,116
- **3,394**: 7,883
- **82**: 996
- **121**: 346
- **594**: 10,131
- **2,933**: 7,350
- **4,929**: 4,929

Fuel Heating System

- **Electric Heating Impact (kWh)**: 1,064
- **Electric Heating % Change**: 21%

Heat Pump Install Date: 11/28/2021

Heat Pump Install Date: 12/2/2022

Flair Droop Implementation Date: 11/28/2021

Flair Droop Implementation Date: 12/2/2022

Billed Usage Data Model

- **Billed Usage**: 965
- **Electric Heating**: 1,776
- **Impact (kWh)**: 811
- **% Change**: 84%
- **Billed Usage**: 10,121,290
- **Fossil Fuel Annual MMBtu**: 37.1
- **Fossil Fuel % Impact**: 28.7%

Billed Usage Model

- **Billed Usage**: 965
- **Electric Heating**: 1,776
- **Impact (kWh)**: 811
- **% Change**: 84%
- **Billed Usage**: 10,121,290
- **Fossil Fuel Annual MMBtu**: 37.1
- **Fossil Fuel % Impact**: 28.7%

Site Specific HSPF

- **Heat Pump**: 10.5
- **Boiler/Furnace**: 12
- **Indoor Temperature**: 5

Heating Degree Day Weather Normalization

- **Heat Pump**: 120,000
- **Nameplate SEER**: 22
- **Nameplate HSPF**: 12
- **Indoor Temperature**: 5
- **Flair Droop**: N.D.
- **Indoor Temperature**: 5
- **Flair Droop**: N.D.
- **Indoor Temperature**: 5
- **Flair Droop**: N.D.
- **Indoor Temperature**: 5
- **Flair Droop**: N.D.

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 Information
- **ZIP Code**: 04363
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1980
- **Fuel Type**: Outdoor unit model RX15MVMU
- **Fuel Oil**: Indoor unit model FTX15NMVU
- **Envelope Condition**: Fair
- **Approx Area (ft²)**: 1,500
- **Model**: AHRI ref #: 8849445
- **Metering Rigor**: Med
- **Input BTU Max**: 20
- **Nameplate SEER**: 11.3
- **Burner staging**: HSPF correction factor: 87%
- **AFUE/Efficiency**: Site Specific HSPF: 9.9

### Metered HP Data
- **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.**

### Analysis Takeaways
- 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.”

### 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.”
### Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site ID</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>21.7</td>
<td>62.8</td>
<td>-34.6%</td>
</tr>
<tr>
<td>Metered HP Data Model</td>
<td>1,827</td>
<td>5,099</td>
<td>1,501</td>
<td>42%</td>
<td>41,653,354</td>
<td>59,032,260</td>
<td>17,378,906</td>
<td>62.8</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

### Site Information

- **ZIP Code**: 04401
- **Equipment Type**: Forced Air / Central AC / Furnace
- **Make**: Fujitsu
- **Year Built**: 1950
- **Fuel Type**: Fuel Oil
- **Envelope Condition**: Fair
- **Approx Area (ft²)**: 1,080
- **Model**: AUUG15LZAS
- **Input BTU Max**: 95,000
- **Fuel Savings**: 25.3
- **AFUE/Efficiency**: 0.8

### Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th></th>
<th>Heat Pump Data</th>
<th>AMI Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating DD base</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Base load</td>
<td>0</td>
<td>0.833612604</td>
</tr>
<tr>
<td>Total pre period kWh</td>
<td>837</td>
<td>14,617</td>
</tr>
<tr>
<td>Total post period kWh</td>
<td>0</td>
<td>6,805</td>
</tr>
<tr>
<td>Days of data pre</td>
<td>146</td>
<td>424</td>
</tr>
<tr>
<td>Days of data post</td>
<td>0</td>
<td>153</td>
</tr>
<tr>
<td>Pre coincident HDD</td>
<td>156</td>
<td>5,011</td>
</tr>
<tr>
<td>Post coincident HDD</td>
<td>0</td>
<td>1,602</td>
</tr>
<tr>
<td>TMY3 HDD</td>
<td>5,045</td>
<td></td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>HP Heating</td>
<td>HP Heating</td>
<td>-185</td>
<td>-11%</td>
<td>17,362,990</td>
<td>15,370,941</td>
<td>-1,992,048</td>
<td>-2.1</td>
<td>64.8</td>
<td>-25.0%</td>
</tr>
<tr>
<td>kWh</td>
<td>kWh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Site Information

- ZIP Code: 04096
- Equipment Type: Ductless Split Heat Pump
- Make: Mitsubishi
- Year Built: 0
- Fuel Type: Outdoor unit model MUI2-FH12NA
- Envelope Condition: 0
- Approx Area (ft²): 0
- Indoor unit model: 0
- Approx Rigor: Med
- Input BTU Max: 100,000
- Nameplate SEER: 26.1
- HSPF correction factor: 86%
- AFUE/Efficiency: 0.96
- Site Specific HSPF: 10.8

Metered HP Data Model
- Pre-Controls: 1,610 kWh, 1,425 kWh, -185 kWh, -11%
- Post-Controls: 1,660 kWh, 3,100 kWh, 1,440 kWh, 87%
- Fuel Savings: -1,992,048 Btu, -2.1%

Billed Usage Model
- Pre-Controls: 17,362,990 Btu, 15,370,941 Btu, -1,992,048 Btu, -2.1%
- Post-Controls: 17,897,664 Btu, 33,429,771 Btu, 15,532,108 Btu, 16.2%
- Fuel Savings: -1,992,048 MMBtu, -2.1%

Site Information

- Ductless Split Heat Pump
- ZIP Code: 04096
- Equipment Type: Ductless Split Heat Pump
- Make: Mitsubishi
- Year Built: 0
- Fuel Type: Outdoor unit model MUI2-FH12NA
- Envelope Condition: 0
- Approx Area (ft²): 0
- Indoor unit model: 0
- Approx Rigor: Med
- Input BTU Max: 100,000
- Nameplate SEER: 26.1
- HSPF correction factor: 86%
- AFUE/Efficiency: 0.96
- Site Specific HSPF: 10.8

Heating Degree Day Weather Normalization

- Pre-Controls kW: 66,100
- Post-Controls kW: 66,000
- HP Load Impact (Btu): 1,992,048
- HP Load Impact (Btu): 2.1%
- Fuel Savings: -1,992,048 MMBtu
- Fuel Savings: -2.1%

Key Participant Impressions (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
- Participant Setpoint/Behavior Description (from Survey)

Analysis Takeaways

AMT and metered data do not agree. The magnitude of increased heat pump use per AMT 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."
**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."

**Metered HP Power vs OAT**

**Billed Usage (AMI minus Baseload) vs OAT**

---

### Results Summary

<table>
<thead>
<tr>
<th>Site ID</th>
<th>IT025</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Results Summary</th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kW % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billed Usage Model</td>
<td>3,691</td>
<td>4,306</td>
<td>4,798</td>
<td>2,197</td>
<td>84%</td>
<td>42,279,371</td>
<td>47,056,985</td>
<td>6,539,894</td>
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<tr>
<td>Billed Usage Model</td>
<td>2,601</td>
<td>3,406</td>
<td>4,798</td>
<td>2,197</td>
<td>84%</td>
<td>42,279,371</td>
<td>47,056,985</td>
<td>6,539,894</td>
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### Site Information

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<tr>
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<tr>
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<tbody>
<tr>
<td>FTX 15NMVJU</td>
<td>Weil McLain</td>
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<table>
<thead>
<tr>
<th>Nameplate HSPF</th>
<th>11.3</th>
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</table>

<table>
<thead>
<tr>
<th>Fossil Fuel % Impact</th>
<th>18%</th>
</tr>
</thead>
</table>

**Equipment**
- **Fuel Type**: Fuel Oil
- **Fuel Heating System**: Gas
- **Year Built**: 2015
- **Envelope Condition**: N.D.
- **Approx Area (R2)**: 1,200

**Flair Droop Implementation Date**: 2/4/2022

**HP Installation Date**: 2/7/2022

**Flair Droop Date**: 1/21/2022

**Flair Power vs OAT**

### Flair Checkpoints

<table>
<thead>
<tr>
<th></th>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>1/20/2021</td>
<td>N.D.</td>
<td>Indoor Temperature 3</td>
<td>Indoor Temperature</td>
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</tr>
<tr>
<td>1/22/2021</td>
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<td>Indoor Temperature</td>
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<td>Indoor Temperature 3</td>
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<td>1/26/2021</td>
<td>N.D.</td>
<td>Indoor Temperature 3</td>
<td>Indoor Temperature</td>
<td>3</td>
</tr>
</tbody>
</table>

**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.

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<table>
<thead>
<tr>
<th>Results Summary</th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electrical Heating Impact (kWh)</th>
<th>Pre-Controls Heating Load (Btu)</th>
<th>Post-Controls Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>4,553</td>
<td>4,590</td>
<td>37</td>
<td>44,918,663</td>
<td>45,326,049</td>
<td>367,386</td>
<td>0.00</td>
<td>42.4</td>
<td>-1.0%</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>5,403</td>
<td>6,609</td>
<td>1206</td>
<td>53,948,293</td>
<td>65,261,465</td>
<td>11,913,173</td>
<td>14.2</td>
<td>42.4</td>
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</tr>
<tr>
<td>HP Load Impact</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Fossil Fuel Annual MMBtu</td>
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### Site Information

<table>
<thead>
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<tr>
<td>ZIP Code</td>
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<tr>
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<td>Model</td>
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<tr>
<td>Approx Area (R2)</td>
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<td>Input BTU Max</td>
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<td>Nameplate HSPF</td>
<td>11.3</td>
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<tr>
<td>Metering Rigor</td>
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<tr>
<td>Burner staging</td>
<td>hi-low</td>
<td>Nameplate HSPF correction factor</td>
<td>87%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AFUE/efficiency</td>
<td>0.84</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Controls Setpoints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Controls Setpoints</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Key Participant Impressions (from Survey)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre-Controls: heat pump on and heating throughout winter, occasionally turned heat pump down at night</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-Controls: set whole house around 70</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 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."
**Results Summary**

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,669</td>
<td>4,410</td>
<td>867</td>
<td>24%</td>
<td>36,048,674</td>
<td>44,570,167</td>
<td>8,520,493</td>
<td>10.2</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
<tr>
<td>Metered HP Data Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>2,851</td>
<td>4,410</td>
<td>1,555</td>
<td>28,053,341</td>
<td>43,336,157</td>
<td>15,282,816</td>
<td>18.3</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

**Site Information**

- **ZIP Code**: 04901
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1985
- **Fuel Type**: ENVELOPE
- **Envelope Condition**: Good
- **Approx Area (ft²)**: 1,660
- **Metering Rigor**: Med
- **Input BTU Max**: 140,000
- **Nameplate SEER**: 20
- **Nameplate HSPF**: 11.3
- **AHRI ref #**: 8849445
- **Burner staging**: Single
- **AFUE/Efficiency**: 0.836
- **Site Specific HSPF**: 9.8

**Flair Checkpoints**

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

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kW % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>6,296</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

### Site Information

- **ZIP Code**: 04412
- **Fuel Type**: Fuel Oil
- **Envelope Condition**: Good
- **Approx Area (ft²)**: 1,700
- **Metering Rigor**: High
- **Input BTU Max**: N.D.
- **Nameplate SEER**: 25.3
- **Site Specific HSPF**: N.D.

### Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th>Heating DD base</th>
<th>AMI Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>55</td>
<td>55</td>
</tr>
</tbody>
</table>

### Pre-Controls Setpoints

- **Equipment**: Heat Pump
- **Model**: N.D.
- **Heat Pump**: N.D.
- **Boiler**: N.D.
- **Weekday Day**: N.D.
- **Weekday Night**: N.D.
- **Weekend Day**: N.D.
- **Weekend Night**: N.D.

### Post-Controls Setpoints

- **Equipment**: Heat Pump
- **Model**: N.D.
- **Heat Pump**: N.D.
- **Boiler**: N.D.
- **Weekday Day**: N.D.
- **Weekday Night**: N.D.
- **Weekend Day**: N.D.
- **Weekend Night**: N.D.

### Flair Checkpoints

<table>
<thead>
<tr>
<th>Date</th>
<th>Droop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>No</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>2/22/2022</td>
<td>No</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>No</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
<tr>
<td>3/2/2022</td>
<td>No</td>
<td>N.A.</td>
<td>N.A.</td>
<td>N.A.</td>
</tr>
</tbody>
</table>

### Flair Checkpoints

- **Droop Enabled?**: No
- **Secondary Heat Mode**: N.D.
- **Secondary Heat Trigger**: N.D.
- **Droop Offset**: N.D.

### Analysis Takeaways

- **Boiler**: N.D.
- **Heat Pump**: N.D.

**No response. Controls disconnected**

### Participant Comments from Survey

- **No response.**

---

**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.**

---

**No response.**
### Results Summary

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,305</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

### Site Information

<table>
<thead>
<tr>
<th>ZIP Code</th>
<th>Equipment Type</th>
<th>Make</th>
<th>Fuel Type</th>
<th>Outdoor unit model</th>
<th>Indoor unit model</th>
<th>Approx Area (ft²)</th>
<th>Model</th>
<th>AHRI ref #</th>
<th>Metering Rigor</th>
<th>Input BTU Max</th>
<th>Input BTU Min</th>
<th>D.K.</th>
<th>Envelope Condition</th>
<th>Make</th>
<th>Indoor unit model</th>
<th>Burner staging</th>
<th>AFUE/Efficiency</th>
<th>Site Specific HSPF</th>
<th>Heat Pump/or Forced Air / Central AC / Furnace</th>
</tr>
</thead>
<tbody>
<tr>
<td>04401</td>
<td>Ductless Split Heat Pump</td>
<td>Fujitsu</td>
<td>Fuel Oil</td>
<td>AOUUG15LZAS1</td>
<td>ASUG15LZAS</td>
<td>1,800</td>
<td>TBL-10S-DD-RS2</td>
<td>204740070</td>
<td>High</td>
<td>D.K.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>Good</td>
<td>Williamson</td>
<td>AOUG15LZAS</td>
<td>Single</td>
<td>87%</td>
<td>11.7</td>
<td>Heat pump operates more with controls.</td>
</tr>
</tbody>
</table>

### Site Utilized Droop

<table>
<thead>
<tr>
<th>Date</th>
<th>Drop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Drop Offset</th>
<th>HDD55/day</th>
<th>Heat Pump Power vs OAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>12/2/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>S</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>S</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>S</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>S</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
</tbody>
</table>

### 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

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kW % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Billed Usage Model</td>
<td>2,520</td>
<td>2,316</td>
<td>-204</td>
<td>-8%</td>
<td>27,534,832</td>
<td>25,308,121</td>
<td>-2,226,711</td>
<td>-2.3</td>
<td>40.3</td>
<td>5.8%</td>
</tr>
</tbody>
</table>

#### Site Information

- **ZIP Code:** 04553
- **Equipment Type:** Ductless Split Heat Pump
- **Year Built:** 2014
- **Fuel Type:** Propane
- **Envelope Condition:** Good
- **Approx Area (ft²):** 995
- **Metering Rigor:** Med
- **Input BTU Max:** 120,000
- **Burner staging:** Single
- **AFUE/Efficiency:** 0.964
- **Site Specific HSPF:** 10.9

#### Heating Degree Day Weather Normalization

- **Heating Degree Day Weather Normalization:** 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.

#### Flair Checkpoints

<table>
<thead>
<tr>
<th>Date</th>
<th>Droop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>4</td>
</tr>
</tbody>
</table>

#### 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.
### Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>1,844</td>
<td>2,463</td>
<td>619</td>
<td>34%</td>
<td>21,570,799</td>
<td>28,810,969</td>
<td>7,240,171</td>
<td>9.1</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>1,804</td>
<td>2,711</td>
<td>928</td>
<td>51%</td>
<td>21,099,957</td>
<td>31,949,199</td>
<td>10,849,242</td>
<td>13.5</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

### Site Information

- **Site ID:** IT038
- **Zip Code:** 04953
- **Equipment Type:** Forced Air / Central AC / Furnace
- **Make:** Nordine
- **Model:** M1MB 056A BW
- **Nameplate SEER:** 25.3
- **Nameplate HSPF:** 13.4
- **Burner Staging:** Single
- **HSF, Correction Factor:** 87%
- **AFUE/Efficiency:** 0.8
- **Site Specific HSPF:** 11.7

### Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th>Date</th>
<th>HDD55/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>0.2</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>0.4</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>0.6</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>0.8</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>1.0</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>1.2</td>
</tr>
</tbody>
</table>

### 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.
I really enjoyed the controls and the concept, 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."

"I really enjoyed the [controls] and the concept, 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."
### Results Summary

<table>
<thead>
<tr>
<th>Site Information</th>
<th>Key Participant Impressions (from Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site ID</td>
<td>IT060</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>2,884</td>
</tr>
<tr>
<td>Pre-Controls HP Heating kWh</td>
<td>2,923</td>
</tr>
<tr>
<td>Post-Controls HP Heating kWh</td>
<td>3,511</td>
</tr>
<tr>
<td>Impact (kWh)</td>
<td>588</td>
</tr>
<tr>
<td>Electric Heating Impact (kWh)</td>
<td>33,026,743</td>
</tr>
<tr>
<td>Heating kWh % Change</td>
<td>588</td>
</tr>
<tr>
<td>Fuel Savings (MMBtu)</td>
<td>3,585,061</td>
</tr>
<tr>
<td>Fossil Fuel Annual MMBtu</td>
<td>No response.</td>
</tr>
<tr>
<td>Fossil Fuel % Impact</td>
<td>No response.</td>
</tr>
</tbody>
</table>

### Site Information

<table>
<thead>
<tr>
<th>Metering Rigor</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equipment Type</td>
<td>Other, specify:</td>
</tr>
<tr>
<td>Year Built</td>
<td>1990</td>
</tr>
<tr>
<td>Fuel Type</td>
<td>Outdoor unit model</td>
</tr>
<tr>
<td>Envelope Condition</td>
<td>Good</td>
</tr>
<tr>
<td>Approx Area (ft²)</td>
<td>1,020</td>
</tr>
<tr>
<td>Model</td>
<td>CL 5036</td>
</tr>
<tr>
<td>Nameplate SEER</td>
<td>20.4</td>
</tr>
<tr>
<td>AFUE/Efficiency</td>
<td>0.8</td>
</tr>
<tr>
<td>Input BTU Max</td>
<td>unk</td>
</tr>
<tr>
<td>Input BTU Min</td>
<td>unk</td>
</tr>
<tr>
<td>Burner staging</td>
<td>Single</td>
</tr>
<tr>
<td>HSPF correction factor</td>
<td>85%</td>
</tr>
<tr>
<td>Site Specific HSPF</td>
<td>11.5</td>
</tr>
</tbody>
</table>

### Heating Degree Day Weather Normalization

**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.**

### Analysis Takeaways

No response.

### Participant Comments from Survey

No response.

---

**Site Information**

- **ZIP Code**: 04453
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1990
- **Fuel Type**: Outdoor unit model
- **Envelop Condition**: Good
- **Approx Area (ft²)**: 1,020
- **Model**: CL 5036
- **Nameplate SEER**: 20.4
- **AFUE/Efficiency**: 0.8
- **Input BTU Max**: unk
- **Input BTU Min**: unk
- **Burner staging**: Single
- **HSPF correction factor**: 85%
- **Site Specific HSPF**: 11.5

**Equipment**

- **Heat Pump**: Other, specify:
- **Other**: unk
- **Zone**: Whole Home
- **Heat Pump Install Date**: 11/29/2021
- **Meter Installation Date**: 11/29/2021
- **Flair Droop Implementation Date**: 2/4/2022
- **HDD55/day**: 5,045

**Pre-Controls Setpoints**

<table>
<thead>
<tr>
<th>Date</th>
<th>Droop Enabled?</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>Yes</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
</tbody>
</table>

**Billed Usage (AMI minus Baseload)**

**Metered HP Power vs OAT**

**Participant Setpoint/Behavior Description (from Survey)**

No response.
<table>
<thead>
<tr>
<th>Results Summary</th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>269</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>60,594,455</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>5,148</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Information</th>
<th>Fuel Heating System</th>
<th>Ductless Split Heat Pump</th>
<th>Key Participant Impressions (from Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zip Code</td>
<td>04927</td>
<td>Make</td>
<td>Fijitsu</td>
</tr>
<tr>
<td>Year Built</td>
<td>1972</td>
<td>Fuel Type</td>
<td>Fuel Oil</td>
</tr>
<tr>
<td>Envelope Condition</td>
<td>Fair</td>
<td>Make</td>
<td>New Yorker</td>
</tr>
<tr>
<td>Approx Area (ft2)</td>
<td>0</td>
<td>Model</td>
<td>AP-590U</td>
</tr>
<tr>
<td>Metering Rigor</td>
<td>High</td>
<td>Nameplate SEER</td>
<td>25.3</td>
</tr>
<tr>
<td>Nameplate HSPF</td>
<td>13.4</td>
<td>Site Specific HSPF</td>
<td>11.8</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Heating Degree Day Weather Normalization</th>
<th>Daily Totals vs Time</th>
<th>Metered HP Power vs OAT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating DD base</td>
<td>55</td>
<td>Pre-Controls kW</td>
</tr>
<tr>
<td>Base load</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>Total pre period kWh</td>
<td>373</td>
<td>Pre-Controls kW</td>
</tr>
<tr>
<td>Total post period kWh</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>Days of data pre</td>
<td>379</td>
<td>Pre-Controls kW</td>
</tr>
<tr>
<td>Days of data post</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>Pre coincident HDD</td>
<td>4,074</td>
<td>Pre-Controls kW</td>
</tr>
<tr>
<td>Post coincident HDD</td>
<td>0</td>
<td>Post-Controls kW</td>
</tr>
<tr>
<td>TMY3 HDD</td>
<td>5,323</td>
<td>Pre-Controls kW</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Flair Checkpoints</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
<th>Participant Setpoint/Behavior Description (from Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date</td>
<td>Droop Enabled?</td>
<td>Secondary Heat Mode</td>
<td>Pre-Controls: rarely used heat pump when outdoor temperature drops below 30</td>
</tr>
<tr>
<td>11/29/2021</td>
<td>No</td>
<td>N.D.</td>
<td>Post-Controls: disconnected controls, returned to using thermostat and heat pump remote as before</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>No</td>
<td>N.D.</td>
<td></td>
</tr>
<tr>
<td>2/4/2022</td>
<td>No</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>2/21/2022</td>
<td>No</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>3/7/2022</td>
<td>No</td>
<td>N.A.</td>
<td></td>
</tr>
<tr>
<td>3/21/2022</td>
<td>No</td>
<td>N.A.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analysis Takeaways</th>
</tr>
</thead>
<tbody>
<tr>
<td>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.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Participant Comments from Survey</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;I recommend the Ecobee, not Flair.&quot;</td>
</tr>
</tbody>
</table>
### Site ID

**IT072**

<table>
<thead>
<tr>
<th>Results Summary</th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>706 N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>2,203 N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Site Information</th>
<th>Fuel Heating System</th>
<th>Ductless Split Heat Pump</th>
<th>Key Participant Impressions (from Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zip Code</td>
<td>04401</td>
<td>equipment type</td>
<td>Boiler</td>
</tr>
<tr>
<td>Year Built</td>
<td>1955</td>
<td>Fuel Type</td>
<td>Fuel Oil</td>
</tr>
<tr>
<td>Envelope Condition</td>
<td>Fair</td>
<td>Make</td>
<td>Buderus</td>
</tr>
<tr>
<td>Approx Area (12)</td>
<td>1,200</td>
<td>Model</td>
<td>0115/5</td>
</tr>
<tr>
<td>Metering Rigor</td>
<td>Med</td>
<td>Input BTU Max</td>
<td>130,000</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Burner staging</td>
<td>single</td>
</tr>
<tr>
<td></td>
<td></td>
<td>AFUE/efficiency</td>
<td>0.857</td>
</tr>
</tbody>
</table>

### Heating Degree Day Weather Normalization

- **Heating DD base**: 55°F
- **Base load**: 0 kW
- **Total pre period kWh**: 752 kW
- **Total post period kWh**: 0 kW
- **Days of data pre**: 379 days
- **Days of data post**: 0 days
- **Pre coincident HDD**: 2,646 HDD/day
- **Post coincident HDD**: 0 HDD/day
- **TMY3 HDD**: 5,045

### Metered HP Power vs OAT

Heat pump did not run due to maintenance issue.

### 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.
Results Summary

<table>
<thead>
<tr>
<th>Site ID</th>
<th>IT074</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,487</td>
<td>4,913</td>
<td>1,426</td>
<td>41%</td>
<td>80,598,024</td>
<td>45,166,091</td>
<td>16,566,007</td>
<td>17.4</td>
<td>59.7</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td></td>
<td></td>
<td></td>
<td>1,431</td>
<td>17,786,231</td>
<td>18.7</td>
<td>59.7</td>
<td></td>
</tr>
</tbody>
</table>

Site Information

- **ZIP Code**: 04015
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1975
- **Fuel Type**: Outdoor unit model ASUG151ZAH1
- **Envelope Condition**: Poor
- **Approx Area (ft²)**: 1,400
- **Metering Rigor**: High
- **Input BTU Max**: 80,182
- **Nameplate SEER**: 25.3
- **Burner staging**: MODULATING
- **HP Load Impact (Btu)**: 16,566,007
- **Site Specific HSPF**: 11.6
- **Fuel Heating System**: Boiler
- **Fuel Heating System Make**: Giannoni France
- **Flame Checkpoints**: Date, Drop Enabled?, Secondary Heat Mode, Secondary Heat Trigger, Drop Offset

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."
Results Summary

<table>
<thead>
<tr>
<th>Site Information</th>
<th>Fuel System</th>
<th>Ductless Split Heat Pump</th>
<th>Key Participant Impressions (from Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site ID</td>
<td>HP Heating</td>
<td>Electric Heating</td>
<td>No response</td>
</tr>
<tr>
<td></td>
<td>HP Heating</td>
<td>Heating kW</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Impact (kWh)</td>
<td>Heating kW % Change</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Heating Load (Btu)</td>
<td>HP Load Impact (Btu)</td>
<td>Fuel Savings (MMBtu)</td>
</tr>
<tr>
<td>Pre-Controls</td>
<td>1,206</td>
<td>303</td>
<td>303</td>
</tr>
<tr>
<td>Post-Controls</td>
<td>904</td>
<td>10,685</td>
<td>10,685</td>
</tr>
<tr>
<td>Heating kWh</td>
<td>14,266,370</td>
<td>3,580</td>
<td>3,580</td>
</tr>
<tr>
<td>% Change</td>
<td>46,092,817</td>
<td>7,219</td>
<td>7,219</td>
</tr>
<tr>
<td>Heating kWh</td>
<td>38,873,459</td>
<td>8.5</td>
<td>8.5</td>
</tr>
<tr>
<td>HP Load Impact</td>
<td>278</td>
<td>435</td>
<td>435</td>
</tr>
<tr>
<td>Fuel Savings</td>
<td>529</td>
<td>519</td>
<td>519</td>
</tr>
<tr>
<td>Fossil Fuel</td>
<td>544</td>
<td>7.7</td>
<td>7.7</td>
</tr>
<tr>
<td>HP Load Impact</td>
<td>1,206</td>
<td>303</td>
<td>303</td>
</tr>
<tr>
<td>Post-Controls</td>
<td>904</td>
<td>10,685</td>
<td>10,685</td>
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<td>Heating kWh</td>
<td>14,266,370</td>
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<td>3,580</td>
</tr>
<tr>
<td>% Change</td>
<td>46,092,817</td>
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</tr>
<tr>
<td>Heating kWh</td>
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<td>HP Load Impact</td>
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</tr>
<tr>
<td>Fuel Savings</td>
<td>529</td>
<td>519</td>
<td>519</td>
</tr>
<tr>
<td>Fossil Fuel</td>
<td>544</td>
<td>7.7</td>
<td>7.7</td>
</tr>
</tbody>
</table>

Site Information

- ZIP Code: 04401
- Year Built: 1997
- Equipment Type: Forced Air / Central AC / Furnace
- Make: Fujitsu
- Fuel Type: Kerosene
- Outdoor unit model: 4UJG35LZHA1
- Indoor unit model: ASUG15LZAS
- Approx Area (ft2): 1,060
- Model: OME-72D36
- Nameplate SEER: 25.3
- Nameplate HSPF: 13.3
- AFUE/Efficiency: 9.85
- Site Specific HSPF: 11.8
- Input BTU Max: 85,000
- Input BTU Min: 70,000
- Burner staging: hi-low
- HSPF correction factor: 89%
- Flare Checkpoints:
  - Date: 11/29/2021
  - Droop Enabled?: No
  - Secondary Heat Mode: N.D.
  - Secondary Heat Trigger: N.D.
  - Droop Offset: N.D.
  - Date: 12/2/2022
  - Droop Enabled?: No
  - Secondary Heat Mode: N.D.
  - Secondary Heat Trigger: N.D.
  - Droop Offset: N.D.
  - Date: 2/4/2022
  - Droop Enabled?: Yes
  - Secondary Heat Mode: SUPPLEMENTAL
  - Secondary Heat Trigger: Indoor Temperature
  - Droop Offset: 6
  - Date: 2/21/2022
  - Droop Enabled?: Yes
  - Secondary Heat Mode: SUPPLEMENTAL
  - Secondary Heat Trigger: Indoor Temperature
  - Droop Offset: 6
  - Date: 3/7/2022
  - Droop Enabled?: Yes
  - Secondary Heat Mode: SUPPLEMENTAL
  - Secondary Heat Trigger: Indoor Temperature
  - Droop Offset: 6
  - Date: 3/21/2022
  - Droop Enabled?: Yes
  - Secondary Heat Mode: SUPPLEMENTAL
  - Secondary Heat Trigger: Indoor Temperature
  - Droop Offset: 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.

**Metered HP Power vs OAT**

**Billed Usage (AMI minus Baseload) vs OAT**
### Results Summary

<table>
<thead>
<tr>
<th>Metric</th>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Electric Heating Impact kWh</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heated Usage Model (kWh)</td>
<td>3,792</td>
<td>2,737</td>
<td>259%</td>
<td></td>
<td>10,413,155</td>
<td>27,014,565</td>
<td>291</td>
<td>51.9</td>
<td>56.1%</td>
<td></td>
</tr>
<tr>
<td>Pre-Controls HP Heating</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>157</td>
<td>157</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>Post-Controls HP Heating</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>157</td>
<td>157</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

### Site Information

- **ZIP Code:** 04472
- **Fuel Type:** Outdoor unit model
- **Make:** Daiken
- **Model:** RX15QMVJUA
- **Approx Area (ft²):** 1,380
- **Metering Rigor:** Low
- **Burner staging:** 0
- **HSPF correction factor:** 87%
- **Site Specific HSPF:** 9.9
- **Metered Heat Pump Data:** N.D.
- **Billed Usage Model:** 1,055
- **Annual MMBtu:** 10,413,155
- **Fossil Fuel % Impact:** 29.1

### Heating Degree Day Weather Normalization

- **HP Data:** AMI Data
- **Heating DD base:** 55
- **Base load:** 0
- **Total pre period kWh:** 0
- **Days of data pre:** 0
- **Pre coincident HDD:** 0
- **TMY3 HDD:** 5,045

### Site Information

- **Year Built:** 2019
- **Year Built:** 2019
- **Envelope Condition:** Excellent
- **Equipment Type:** Ductless Split Heat Pump
- **Equipment Make:** Daiken
- **Equipment Model:** RX15QMVJUA
- **APX Area (R2):** 1,380
- **Metering Rigor:** Low
- **Burner staging:** 0
- **HSPF correction factor:** 87%
- **Site Specific HSPF:** 9.9

### Pre-Controls Setpoints

- **Equipment:** Heat Pump
- **Heat Pump:** N.D.
- **Zone:** Whole Home
- **Weekday Day:** 68, Off
- **Weekday Night:** Off
- **Weekend Day:** 60, Off
- **Weekend Night:** Off

### Post-Controls Setpoints

- **Equipment:** Heat Pump
- **Heat Pump:** N.D.
- **Zone:** Whole Home
- **Weekday Day:** 68, Off
- **Weekday Night:** Off
- **Weekend Day:** 60, Off
- **Weekend Night:** Off

### Flair Checkpoints

- **Date:** 11/29/2021
  - **Droop Enabled?** No
  - **Secondary Heat Mode:** N.D.
  - **Secondary Heat Trigger:** N.D.
  - **Droop Offset:** N.D.
- **Date:** 12/2/2022
  - **Droop Enabled?** No
  - **Secondary Heat Mode:** N.D.
  - **Secondary Heat Trigger:** N.D.
  - **Droop Offset:** N.D.
- **Date:** 2/4/2022
  - **Droop Enabled?** Yes
  - **Secondary Heat Mode:** SUPPLEMENTAL
  - **Secondary Heat Trigger:** Outdoor Temperature
  - **Droop Offset:** 5
- **Date:** 2/21/2022
  - **Droop Enabled?** No
  - **Secondary Heat Mode:** N.A
  - **Secondary Heat Trigger:** Outdoor Temperature
  - **Droop Offset:** N.A
- **Date:** 3/7/2022
  - **Droop Enabled?** Yes
  - **Secondary Heat Mode:** DISABLED
  - **Secondary Heat Trigger:** Outdoor Temperature
  - **Droop Offset:** 5
- **Date:** 3/21/2022
  - **Droop Enabled?** Yes
  - **Secondary Heat Mode:** DISABLED
  - **Secondary Heat Trigger:** Outdoor Temperature
  - **Droop Offset:** 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."
# Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>No Fuel Data</td>
</tr>
<tr>
<td>Billed Usage Model</td>
<td>3,418</td>
<td>3,441</td>
<td>23</td>
<td>1%</td>
<td>40,323,296</td>
<td>40,591,801</td>
<td>268,505</td>
<td>0.3</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
</tbody>
</table>

### Site Information

- **ZIP Code**: 04411
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1962
- **Fuel Type**: Outdoor unit model
- **Envelope Condition**: Good
- **Approx Area (ft²)**: Unsure (check google) - “20x60 maybe”
- **Model**: AOU15RLS3
- **Input BTU Max**: 204740070
- **Input BTU Min**: 25.3
- **Burner staging**: 13.4
- **AFUE/Efficiency**: 88%
- **Site Specific HSPF**: 11.8

### Pre-Controls Setpoints

- **Heat Pump Install Date**: N.D.
- **Meter Installation Date**: N.D.
- **Flair Droop Implementation Date**: N.D.
- **HDD55/day**: N.D.
- **AMI kWh/day**: N.D.
- **Heat Pump Install Date**: N.D.
- **Flair Droop Implementation Date**: N.D.
- **HDD55/day**: N.D.

### 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 Information

- **ZIP Code:** 04937
- **Equipment Type:** Ductless Split Heat Pump
- **Year Built:** 1940
- **Fuel Type:** Propane
- **Outdoor unit model:** AOUG15LZAS1
- **Indoor unit model:** N.D.
- **Model:** AHRI ref #: 204740070
- **Input BTU Max:** N.D.
- **Input BTU Min:** N.D.
- **Nameplate SEER:** 25.3
- **Nameplate HSPF:** 13.4
- **Burner staging:** N.D.
- **AFUE/Efficiency:** 88%
- **Site Specific HSPF:** 11.8
- **Envelope Condition:** Good
- **Approx Area (ft²):** 1,100
- **Metering Rigor:** Low
- **Nameplate Min:** 0
- **Flare Checkpoints:**
  - Date: 11/29/2021
    - Enabled?: Yes
    - Mode: N.D.
    - Heat Trigger: N.D.
    - Drop Offset: N.D.
  - Date: 12/2/2021
    - Enabled?: Yes
    - Mode: N.D.
    - Heat Trigger: N.D.
    - Drop Offset: N.D.
  - Date: 2/4/2022
    - Enabled?: Yes
    - Mode: SUPPLEMENTAL
    - Trigger: Temperature
    - Offset: 5
  - Date: 2/21/2022
    - Enabled?: Yes
    - Mode: SUPPLEMENTAL
    - Trigger: Temperature
    - Offset: 5
  - Date: 3/7/2022
    - Enabled?: Yes
    - Mode: SUPPLEMENTAL
    - Trigger: Temperature
    - Offset: 5
  - Date: 3/21/2022
    - Enabled?: Yes
    - Mode: SUPPLEMENTAL
    - Trigger: Temperature
    - Offset: 5
- **Meter Installation Date:** N.D.
- **Heat Pump Install Date:** N.D.
- **HDD55/day:** N.D.
- **HDD33/day:** N.D.
- **Heat Pump DD base:** N.D.
- **DD base:** N.D.
- **Heating DD base:** N.D.
- **Base load:** N.D.
- **Input BTU Max:** N.D.
- **Pre coincident HDD:** 0
- **Post coincident HDD:** 0
- **TMY3 HDD:** 5,323
- **Days of data pre:** 0
- **Days of data post:** 0
- **Total pre period kWh:** 0
- **Total post period kWh:** 0
- **Pre coincident HDD:** 0
- **Post coincident HDD:** 0

### Pre-Control Setpoints

- **Equipment:** Heat Pump
- **N. D.:** Heat Pump on and heating throughout winter.
- **Zone:** Whole Home
- **Weekday Day:** 72
- **Weekday Night:** 72
- **Weekend Day:** 72
- **Weekend Night:** 72

### Post-Control Setpoints

- **Equipment:** Heat Pump
- **N. D.:** Used Flair account in manual mode to independently control boiler and heat pump.
- **Zone:** Whole Home
- **Weekday Day:** 72
- **Weekday Night:** 68
- **Weekend Day:** 72
- **Weekend Night:** 68

### Key Participant Impressions (from Survey)

- **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

### Fuel Heating System

- **Fuel Type:** Propane
- **Make:** Weil McLain
- **Model:** N.D.
- **Nameplate SEER:** 25.3
- **Nameplate HSPF:** 13.4
- **Burner staging:** N.D.
- **AFUE/Efficiency:** 88%

### Key Participants

- **Fuel Heating System:**
  - Fuel type: Propane
  - Make: Weil McLain
  - Model: N.D.
  - Nameplate SEER: 25.3
  - Nameplate HSPF: 13.4
  - Burner staging: N.D.
  - AFUE/Efficiency: 88%

### Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th>HP Data</th>
<th>AMI Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating DD base</td>
<td>55</td>
</tr>
<tr>
<td>Base load</td>
<td>0</td>
</tr>
<tr>
<td>Total pre period kWh</td>
<td>0</td>
</tr>
<tr>
<td>Total post period kWh</td>
<td>0</td>
</tr>
<tr>
<td>Days of data pre</td>
<td>0</td>
</tr>
<tr>
<td>Days of data post</td>
<td>0</td>
</tr>
<tr>
<td>Pre coincident HDD</td>
<td>0</td>
</tr>
<tr>
<td>Post coincident HDD</td>
<td>0</td>
</tr>
<tr>
<td>TMY3 HDD</td>
<td>5,323</td>
</tr>
</tbody>
</table>

### 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."

### Key Participants

- **Fuel Savings (MMBtu):** N.D.
- **Fossil Fuel Annual MMBtu:** N.D.
- **Fossil Fuel % Impact:** N.D.

### Billed Usage (AMI minus Baseload) vs OAT

- **No Data**

### Metered HP Power vs OAT

- **No Data**
Results Summary

<table>
<thead>
<tr>
<th>Pre-Controls HP Heating (kWh)</th>
<th>Post-Controls HP Heating (kWh)</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>2,071</td>
<td>2,381</td>
<td>310</td>
<td>15%</td>
<td>24,518,723</td>
<td>28,208,022</td>
<td>3,669,297</td>
<td>26.5</td>
<td>No Fuel Data</td>
<td>N.D.</td>
</tr>
<tr>
<td>Metered HP Data Model</td>
<td>Billed Usage Model</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1,706</td>
<td>3,673</td>
<td>1,967</td>
<td>115%</td>
<td>20,220,469</td>
<td>43,523,612</td>
<td>23,303,143</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Site Information

- **ZIP Code**: 04048
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1985
- **Fuel Type**: Outdoor unit model
- **Envelope Condition**: Good
- **Approx Area (ft2)**: 1,360
- **Input BTU Max**: 107,000
- **Input BTU Min**: 107,000
- **Burner staging**: Single
- **AFUE/Efficiency**: 0.88
- **Input BTU Max**: 107,000
- **Input BTU Min**: 107,000
- **Nameplate SEER**: 25.3
- **Nameplate HSPF**: 11.8
- **Billed Usage Model**: 1,706, 3,673, 1,967, 115%
- **Heat Pump Install Date**: 4048
- **Meter Installation Date**: N.D.
- **Flair Installation Date**: N.D.
- **Flair Droop Implementation Date**: N.D.
- **Heating Degree Day Weather Normalization**: 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5

Flair Checkpoints

<table>
<thead>
<tr>
<th>Date</th>
<th>Droop Enabled</th>
<th>Secondary Heat Mode</th>
<th>Secondary Heat Trigger</th>
<th>Droop Offset</th>
</tr>
</thead>
<tbody>
<tr>
<td>11/29/2021</td>
<td>Yes</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>12/2/2022</td>
<td>Yes</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>2/4/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>2/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>3/7/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
<tr>
<td>3/21/2022</td>
<td>Yes</td>
<td>SUPPLEMENTAL</td>
<td>Indoor Temperature</td>
<td>5</td>
</tr>
</tbody>
</table>

Metered HP Power vs OAT

- Pre-Controls kW
- Post-Controls kW

Billed Usage (AMI minus Baseload) vs OAT

- Pre-Controls kW
- Post-Controls kW

Site ID: IT119

- **Fuel Heating System**: Make Fujitsu
- **Equipment Type**: Make
- **ZIP Code**: 04048
- **Model**: Outdoor unit model
- **Outdoor unit model**: AOU15RLS3H
- **Fuel Type**: Fuel Oil
- **Biani**: 8703508
- **Envelope Condition**: Good
- **Approx Area (ft2)**: 1,360
- **Input BTU Max**: 107,000
- **Input BTU Min**: 107,000
- **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
- **Heating Degree Day Weather Normalization**: 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5

**Key Participant Impressions (from Survey)**

- 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.

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.

Analysis Takeaways:

- 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

Billed Usage Model: 1,706, 3,673, 1,967, 115%

**Heating Degree Day Weather Normalization**

- **OAT**
- **Daily Totals vs Time**
- **Pre-Controls kW**
- **AMI kW/day**
- **Heat Pump Install Date**
- **Flair Installation Date**
- **Flair Droop Implementation Date**
- **HDD55/day**
- **HDD/day**
- **kW/day**
- **kW**
- **kWh/day**

**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

**Participant Comments from Survey**

- Easy to use.
### Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact</th>
<th>Fuel Savings</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metered HP Data Model</td>
<td>N.D.</td>
<td>N.D.</td>
<td>N.D.</td>
<td>23.5</td>
<td>8,689,850</td>
<td>30,698,669</td>
<td>22,008,819</td>
<td>27.5</td>
<td>N.D.</td>
<td>N.D.</td>
</tr>
<tr>
<td>Billing Model</td>
<td>835</td>
<td>2,949</td>
<td>2,114</td>
<td>253%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Site Information

- **ZIP Code**: 04401
- **Equipment Type**: Ductless Split Heat Pump
- **Make**: Daikin
- **Year Built**: 1968
- **Fuel Type**: Natural Gas
- **Outdoor unit model**: RX115OMVJU
- **Indoor unit model**: FTX-15NMVJU
- **Envelope Condition**: Good
- **Approx Area (ft²)**: 850
- **Model**: AHRI ref #8849445
- **Input BTU Max**: 20
- **Nameplate HSPF**: 11.3
- **Effectiveness**: 92%

### Heating Degree Day Weather Normalization

<table>
<thead>
<tr>
<th>Heating Degree Day</th>
<th>Heating DD Data</th>
<th>AMI Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heating DD base</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Base load</td>
<td>0.346666667</td>
<td></td>
</tr>
<tr>
<td>Total pre period kWh</td>
<td>0</td>
<td>5,530</td>
</tr>
<tr>
<td>Total post period kWh</td>
<td>1,388</td>
<td>2,971</td>
</tr>
<tr>
<td>Days of data pre</td>
<td>0</td>
<td>436</td>
</tr>
<tr>
<td>Days of data post</td>
<td>107</td>
<td>135</td>
</tr>
<tr>
<td>Pre coincident HDD</td>
<td>0</td>
<td>5,307</td>
</tr>
<tr>
<td>Post coincident HDD</td>
<td>1,609</td>
<td>1,232</td>
</tr>
<tr>
<td>TMF3 HDD</td>
<td>5,045</td>
<td></td>
</tr>
</tbody>
</table>

### Pre-Controls Setpoints

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Heat Pump</th>
<th>Boiler</th>
<th>Zone</th>
<th>Whole Home</th>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Participant Setpoint/Behavior Description (from Survey)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Setpoints</td>
<td>Model</td>
<td>Pre-Controls: primarily used furnace to heat home, turned on heat pump for a few hours in the evening when in the living room</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Model</td>
<td>kW</td>
<td>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</td>
</tr>
</tbody>
</table>

### 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."
### Results Summary

<table>
<thead>
<tr>
<th></th>
<th>Pre-Controls</th>
<th>Post-Controls</th>
<th>Electric Heating Impact (kWh)</th>
<th>Heating kWh % Change</th>
<th>Pre-Controls HP Heating Load (Btu)</th>
<th>Post-Controls HP Heating Load (Btu)</th>
<th>HP Load Impact (Btu)</th>
<th>Fuel Savings (MMBtu)</th>
<th>Fossil Fuel Annual MMBtu</th>
<th>Fossil Fuel % Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Site ID</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site ID</td>
<td>Billed Usage Model</td>
<td>4,648</td>
<td>11,994</td>
<td>7,346</td>
<td>158%</td>
<td>54,963,808</td>
<td>141,832,072</td>
<td>86,868,264</td>
<td>91.4</td>
<td>84.0</td>
</tr>
<tr>
<td>Site ID</td>
<td>Metered HP Data Model</td>
<td>1,361</td>
<td>1,832</td>
<td>471</td>
<td>35%</td>
<td>16,091,718</td>
<td>23,660,805</td>
<td>5,569,089</td>
<td>5.9</td>
<td>84.0</td>
</tr>
</tbody>
</table>

### Site Information

- **ZIP Code**: 04038
- **Equipment Type**: Ductless Split Heat Pump
- **Year Built**: 1840
- **Fuel Type**: Natural Gas
- **Envelope Condition**: Excellent
- **Approx Area (ft²)**: 2,200
- **Metering Rigor**: High
- **Input BTU Max**: 24,600
- **Nameplate SEER**: 25.3
- **Nameplate HSPF**: 13.3
- **Burner staging**: Modulating
- **HSPF correction factor**: 89%
- **AFUE/Efficiency**: 0.95
- **Site Specific HSPF**: 11.8
- **Heating Degree Day Weather Normalization**

### Flair Checkpoints

- **Date**: 11/29/2021
  - **Droop Enabled?**: No
  - **Secondary Heat Mode**: N.D.
  - **Secondary Heat Trigger**: N.D.
  - **Droop Offset**: N.D.

- **Date**: 12/2/2022
  - **Droop Enabled?**: No
  - **Secondary Heat Mode**: N.D.
  - **Secondary Heat Trigger**: N.D.
  - **Droop Offset**: N.D.

- **Date**: 2/4/2022
  - **Droop Enabled?**: Yes
  - **Secondary Heat Mode**: SUPPLEMENTAL
  - **Secondary Heat Trigger**: Indoor Temperature
  - **Droop Offset**: 3

- **Date**: 2/21/2022
  - **Droop Enabled?**: No
  - **Secondary Heat Mode**: N.A.
  - **Secondary Heat Trigger**: N.A.

- **Date**: 3/7/2022
  - **Droop Enabled?**: Yes
  - **Secondary Heat Mode**: DISABLED
  - **Secondary Heat Trigger**: Indoor Temperature
  - **Droop Offset**: 3

- **Date**: 3/21/2022
  - **Droop Enabled?**: Yes
  - **Secondary Heat Mode**: DISABLED
  - **Secondary Heat Trigger**: Indoor Temperature
  - **Droop Offset**: 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.”

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About DNV

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