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Cape Light Compact 2018 Smart A/C Savings Program Evaluation

Report for Cape Light Compact Filing

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EXECUTIVE SUMMARY

Cape Light Compact's (CLC's) residential customers can contribute toward reducing system peak demand by participating in the Smart A/C Savings program. CLC first offered the Smart A/C Savings to 22 customers in 2016 with the direct install of Centralite thermostats. The program has continued to grow, with a total enrollment of 91 devices in 2018.

Navigant Consulting, Inc.'s (Navigant's) evaluation of the 2018 demand response (DR) season confirmed the program was successful both in testing the effectiveness of thermostats as a residential DR technology and in customer acceptance of the program offering. This study also identified challenges associated with integrating mini-split systems into DR programs to assist in reducing household peak demands.

Program Summary

The Smart A/C Savings program aims to reduce peak demand of residential customers with central air conditioners (ACs) and mini-split heat pumps by allowing CLC to control the thermostat setpoint during periods of peak demand. The 2018 program included four Wi-Fi thermostat manufacturers: ecobee, Honeywell, Centralite, and Sensibo. CLC could call events between June 1 and September 30 on non-holiday weekdays between 10 a.m. and 9 p.m. Events were typically called for 4 hours, with the program staggering adjustments back to original settings during the last hour of the event to prevent all participants' AC units from coming back online at one time. During events, the aim was to increase setpoints by between 2°F and 4°F for all thermostat types unless the customer chose to opt out of the event or manually adjust their thermostat setpoint.

Evaluation Objectives and Methods

Navigant completed an impact and process evaluation of CLC's residential Wi-Fi thermostat DR program in 2016. The 2018 evaluation focused on further testing the scalability of the program and the experience with mini-split systems.

The evaluation team identified several key research questions aimed at assessing the effectiveness of the DR offering and the success of program improvements since 2016. The team placed the research questions into four categories:

- Technology and program offering
- Program design and implementation
- DR impacts
- Persistence

Navigant conducted the following activities as part of its evaluation of CLC's 2018 DR program:

- **Participation assessment:** For all enrolled devices, the evaluation team analyzed device telemetry data to assess opt-out rates during events throughout the DR season, providing insight into customers' general thermostat usage behavior, customer acceptance of the DR solution, and

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the ability to successfully leverage Sensibo devices for DR. In addition, this participation assessment provided insight into Wi-Fi connectivity issues, informing the scalability of the program.

- **Customer surveys:** In 2018, the team conducted a web-based post-event survey and a post-season survey to solicit feedback regarding customer motivations for program participation, event awareness and comfort level, customer acceptance of the technology and program offering, actions taken during the event, and customer satisfaction.
- **Interim impact estimate:** Navigant informed an interim 2018 demand savings estimate for enrolled mini-splits and central ACs by leveraging the 2017 Residential Baseline Load Shape Study and previously completed Wi-Fi thermostat DR evaluations in Massachusetts.

Participation Assessment Results

Using thermostat telemetry and event data provided by People Power Company (PPC), Navigant identified device participation categories to characterize participant and device behavior during event periods to identify key trends. For each event day, the evaluation team categorized enrolled devices into one of 10 participation categories, described in Table 1. On a per-event basis, the team excluded devices falling into the first two categories ("Not Enrolled Yet" and "Missing Parameters Data") from the analysis presented in Section 3.3 of this report.

Table 1. Event Participation Categories

Participation Category	Definition
Not Enrolled Yet	Device enrolled after event occurred.
Missing Parameters Data	Device is missing altogether from the "Parameters" file, which includes indoor temperature, setpoint, and setpoint state changes.
Full Participant	Device used the DR setpoint or a more efficient setpoint for the full event.
Opt Out	Device actively opted out of an event by manually overriding the event setpoint with a negative setpoint adjustment.
Non-Cooling Mode	Device was in off, auto, heat, dry, or fan only mode during the event.
Systematic Fluctuation – Success	Repeated and fluctuating setpoint adjustments were attempted by bot during event period. However, indoor goes up an expected number of degrees, indicating event signal correctly initiated the event. See Figure A-3 in Appendix A for an example.
Systematic Fluctuation – Fail	Repeated and fluctuating setpoint adjustments were attempted by bot during event period. Indoor temperature does not go up an expected number of degrees, indicating event signal did not correctly initiate the event. See Figure A-2 in Appendix A for an example.
Disconnected	Device data indicated that there was no connectivity during the event.
Unknown	Unable to determine whether or not program successfully engaged device for event and/or whether or not participant opted out.

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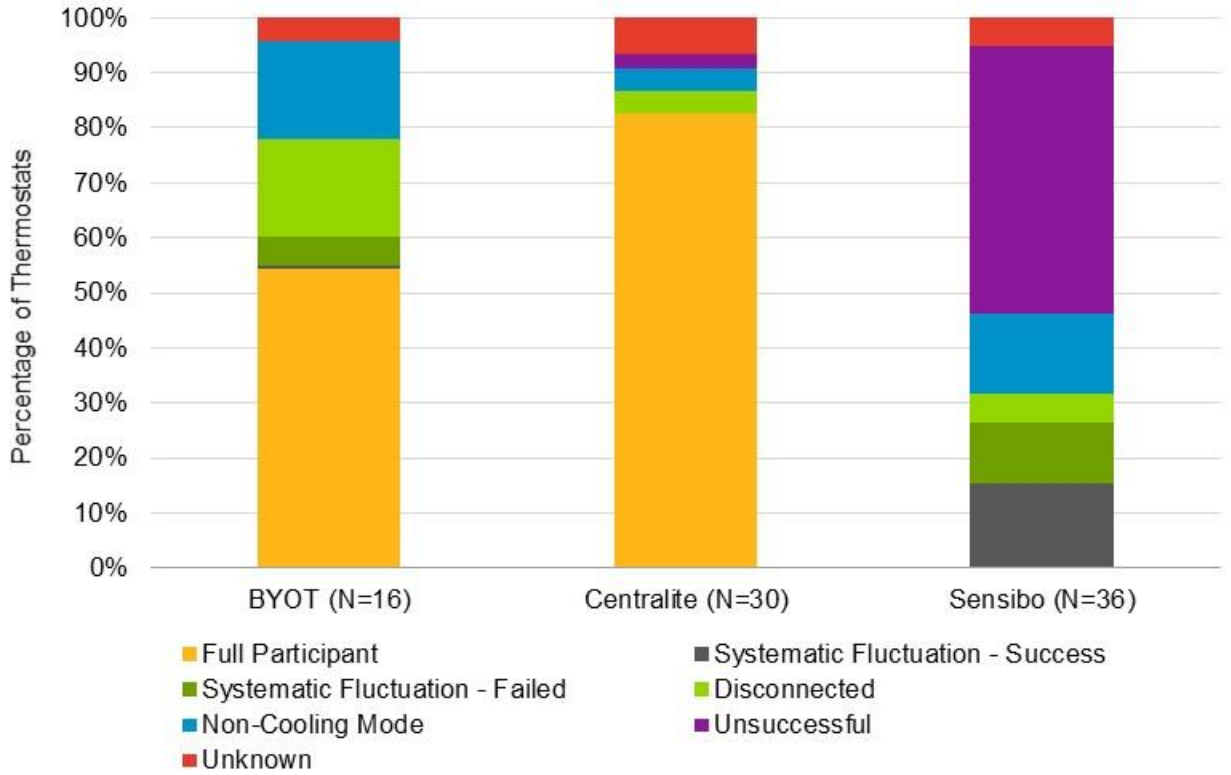
Participation Category	Definition
Unsuccessful	Device has non-missing telemetry data ("Parameters" data) but did not receive any positive bot-sourced setpoint adjustments during the event period. In many instances, the performance reports indicate offline.

Source: Navigant analysis of device telemetry data from PPC.

Figure 1 displays the average participation for each thermostat type, showing considerable variation by device type. Centralite devices had the highest average rate of full participation at 83%, while bring your own thermostat (BYOT) averaged 54%. Of Sensibo devices, 26% experienced repeated setpoint adjustments, referred to in this report as systematic fluctuations. Roughly half of the devices with systematic fluctuations were successfully called for the event and appear to have experienced the change in setpoint and indoor temperature.

All participants had the ability to opt out during the event by overriding the event setpoint. However, based on the telemetry data available and the participation criteria for opt outs assumed, no instances of opt outs were identified in the data.

Figure 1. Average Participation by Device Type



Source: Navigant analysis of device telemetry data from PPC

Customer Experience Results

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Navigant conducted two customer experience surveys—post-event and post-season—to evaluate program implementation, customer perceptions of the program offering and operations, and customer behavior during events. The surveys were sent by email to all program participants, who were offered an Amazon e-gift card incentive if the survey was completed. The post-event survey contained questions aimed at several research areas that overlapped with those in the post-season survey. Table 2 compares the research objectives outlined in each of the two surveys.

Table 2. Customer Experience Survey Topic Comparison

Research Category	Research Objective	Post-Event Survey	Post-Season Survey
Motivation	What factor(s) motivated program participation?		✓
Behavior	How did participants typically use their ACs during the summer? How were participants using their ACs immediately before an event on August 29?	✓	
Event Awareness	How aware were participants about when events occurred? How did they know when the event was occurring?	✓	
Comfort	What impact did events have on participant comfort? Did participants opt out of events? Why? How easy or difficult was it to override the event setpoint?	✓	✓
Performance Reports	How frequently did participants review performance reports? Was the information provided in these reports useful?		✓
Satisfaction	How likely are participants to participate in the program in the future? How satisfied were particiants with different aspects of the program? In what ways have participants indicated the program could improve?	✓	✓

Source: Navigant

Navigant analyzed the multiple choice and open-ended responses to the post-event and post-season surveys. The key findings are summarized in Table 3.

Table 3. Customer Experience Findings

Research Category	Findings
Motivation	Survey respondents were motivated to participate in the program to receive participation incentives (69%), to save money (64%), and to reduce their environmental impact (56%).
Behavior	Of survey respondents, 65% generally only turned cooling on as needed—when it was hot or humid.
Event Awareness	Of post-event survey respondents, 100% were aware an event had occurred on August 29 and 92% were satisfied by event notification.

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Research Category	Findings
Comfort	Of BYOT and Centralite survey respondents, 50% described the comfort level of their home as "about the same" when compared to a day with similar temperatures. For Sensibo respondents, this percentage was higher, at 75%.
Performance Reports	Of all survey respondents, 75% were aware they received performance reports after every event. Of those who were aware they received performance reports, 80% found the reports to contain "very useful" or "somewhat useful" information.
Satisfaction	Of 2018 post-season survey respondents, 86% are "very likely" or "likely" to participate in the program in the future. Negative issues were mainly related to Sensibo device setup support, operability, and connectivity.

Source: Navigant

Interim Savings Estimate

By the end of the 2018 summer season, there were 25 enrolled participants with Sensibo devices (45 devices), 19 Centralite participants (32 devices), seven participants with ecobee thermostats (15 devices) and one enrolled Honeywell thermostat. The data available from the Sensibo devices (as well as from the Presence app) does not include data on system mode; therefore, thermostat runtime cannot be inferred. Thermostat runtime is necessary to evaluate DR impacts for Sensibo participants unless metering had been installed. As a result and due to the low enrollment of ecobee and Honeywell thermostats in 2018, CLC and Navigant did not evaluate the demand impacts associated with the 2018 DR program.

In lieu of evaluated impacts, in this report, Navigant provides interim demand savings estimates for enrolled mini-splits and central ACs participating in CLC's DR program. For these estimates, Navigant leveraged the 2017 Residential Baseline Load Shape Study[1] and National Grid's 2017 Wi-Fi Thermostat DR Evaluation.[2]

The demand savings estimates outlined below are indicative and not evaluated results for CLC's 2018 DR program. As such, they are intended as interim demand savings values until program impacts are evaluated (in future years). In addition to climate region, participant demographics, and event criteria, some differences between CLC's 2018 DR program and National Grid's 2017 DR program could account for differences in the estimate of demand savings (these are noted in section 5.1).

Navigant's 2018 per-device demand savings estimates are 0.19 kW and 0.62 kW for mini-split heat pumps and central ACs, respectively. Both estimates assume that events are called on non-holiday weekdays where the temperature reaches 86°F degrees or higher.

[1] *Navigant, RES 1 Baseline Load Shape Study, prepared for the Electric and Gas Program Administrors of Massachusetts, July 27, 2018, http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf*

[2] *Navigant, 2017 Residential Wi-Fi Thermostat DR Evaluation, prepared for National Grid, March 30, 2018, http://ma-eeac.org/wordpress/wp-content/uploads/2017-NGrid-DR-Eval-Final-Report-2018-03-30.pdf*

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Key Findings and Considerations

Based on the 2018 evaluation, Navigant has identified the considerations provided in Table 4 for CLC.

Table 4. Considerations

Consideration
• **Consideration #1:** Sensibo devices cannot capture all manual setpoint and device mode changes made by participants or the mini-split runtime. Therefore, if there is a desire to continue to leverage Sensibo devices for DR, end-use or whole-home interval meters should be installed to facilitate evaluation of event behavior as well as demand impacts.
• **Consideration #2:** Sensibo devices and the Honeywell thermostats exhibited unexpected temperature setpoint profiles during events (i.e., systematic fluctuations). This suggests further testing of the integration of these device types with the DR software platform used is needed.
• **Consideration #3:** In addition to incentives, program participants were motivated to enroll in the program to reduce environmental impacts. Further emphasize environmental benefits in future marketing efforts.
• **Consideration #4:** BYOT participants cited remote control of their home's temperature as the primary driver for getting a Wi-Fi thermostat. Two of eight BYOT survey respondents received a MassSave incentive toward their thermostat purchase. In future marketing efforts, continue to market MassSave rebates and emphasize the benefits of remote control (e.g., convenience, potential for savings)
• **Consideration #5:** Sensibo and BYOT devices in auto and dry modes were treated the same by the program as devices in off or heat modes—they were not engaged for DR events. Investigate opportunities to engage these devices for events if there is a potential for demand savings.
• **Consideration #6:** Program literature stated that setpoints would be increased by 3°F -4°F during events. The median indoor temperature change for full participants across events and devices types was 2°F -3°F, but changes in indoor temperature did reach as much as 7°F. Ensure all setpoint adjustments do not exceed what is stated in program literature.
• **Consideration #7:** Refresh interim savings estimate with forthcoming 2018 Residential Baseline Load Shape Study and 2018 National Grid DR savings estimates. Consider a small interval meter study to capture demand savings from devices where runtime is not available (Sensibos).

Source: Navigant

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1. PROGRAM SUMMARY

The Smart A/C Savings program aims to reduce the peak demand of residential customers in Cape Light Compact's (CLC's) service territory using Wi-Fi thermostat technology. The program launched in 2016 and has since expanded to 93 registered devices[3] and four types of Wi-Fi devices. There were two notable changes since the previous evaluation was conducted in 2016:

- Introduced the bring your own thermostat (BYOT) model to target customers with ecobee and Honeywell devices, including those installed through the Home Energy Services (HES) program
- Used a software platform provided by People Power Company (PPC) available for customers on the Presence app to control mini-split systems

To provide an opportunity for customers with mini-splits to participate in the program, CLC supplied these customers with Sensibo Sky devices (Sensibo). CLC is the first program administrator to test the Sensibo technology for demand response (DR).

Table 1-1. 2018 Smart A/C Savings Program Summary

2018 Program Summary	Program Parameters
DR Season	June 1 to September 30
Potential Event Days	Non-holiday weekdays
Potential Event Times	10 a.m. to 9 p.m.
Maximum Number of Events per Season	None
Event Duration	3-4 hours[4]
Pre-Cooling Temp Adjustment	N/A
DR Event Temp Adjustment	2°F-4°F
Sign-Up Incentive	$25 (central air conditioner [AC] participants only)[5]
Participation Incentive	$25
Participation Requirement	75% of events

Source: Information provided by CLC, PPC or obtained from program website
https://www.capelightcompact.org/smart-ac/

Table 1-2 summarizes Smart A/C Savings program participant and device enrollment as of the end of the 2018 summer season by end use (central AC and mini-split heat pump) and device type (Sensibo,

[3] There were 93 devices enrolled in the program by September 30, 2018. Two of these devices enrolled in the month of September, after all DR events had taken place. Therefore, Navigant included only 91 devices in its Participation Assessment described in section 3 of this report.

[4] Program literature stated: "Each event is called for a 4-hour period. However, participant thermostats may not be adjusted back to its pre-Event setting until up to two hours after the event to prevent all participants' A/C units from coming back online at one time." During 2018, one event (on July 5) was only 3 hours. Additionally, event end times were staggered during the last hour of each event (i.e., in the 4 hour of the event for all events except that on July 5)

[5] Mini-split heat pump participants receive a free Sensibo device in lieu of the sign-up incentive.

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ecobee, Honeywell, and Centralite). The technology offer associated with each device type is also indicated.

Table 1-2. 2018 Smart A/C Savings Program Device Enrollment

End-Use Type	Technology Offer	Device Types	2018 Participants	2018 Devices
Mini-Split Heat Pump	Free device; self-install	Sensibo Sky	25	45
Central AC	BYOT	BYOT: ecobee Wi-Fi Thermostat	7	15
Central AC	BYOT	BYOT: Honeywell Lyric Wi-Fi Thermostat	1	1
Central AC	Direct install (2016)	Centralite Thermostat	19	32
Total			**52**	**93**

Source: 2018 program enrollment was determined using enrollment data provided by PPC

Of the 19 participants with Centralite thermostats enrolled in the 2018 program, 12 also participated in CLC's 2016 DR offering. An additional person who participated in 2016 (with a Centralite thermostat) had since purchased two ecobee thermostats, which they re-enrolled into the 2018 program.[6] Ten 2016 Centralite participants did not re-enroll to participate in the 2018 program.

Figure 1-1 shows the increase in enrollment from 2016 to the end of the summer 2018 season by device type. Marketing efforts in the spring and summer of 2017 and 2018 increased the enrollment of participants with Sensibo devices and assisted with the introduction of BYOT devices in 2018. Enrollment increased by seven devices between July and August of the 2018 program season alone: three BYOT, two Sensibo, and two Centralite. As of August 30, 2018, there were 91 devices enrolled in the program.

[6] There were 19 participants with Centralite devices in the 2018 program. Because only 12 of these are associated with 2016 program participation, Navigant assumes that the remaining seven 2018 participants with Centralite devices enrolled in CLC's DR program following the last event in the summer of 2016.

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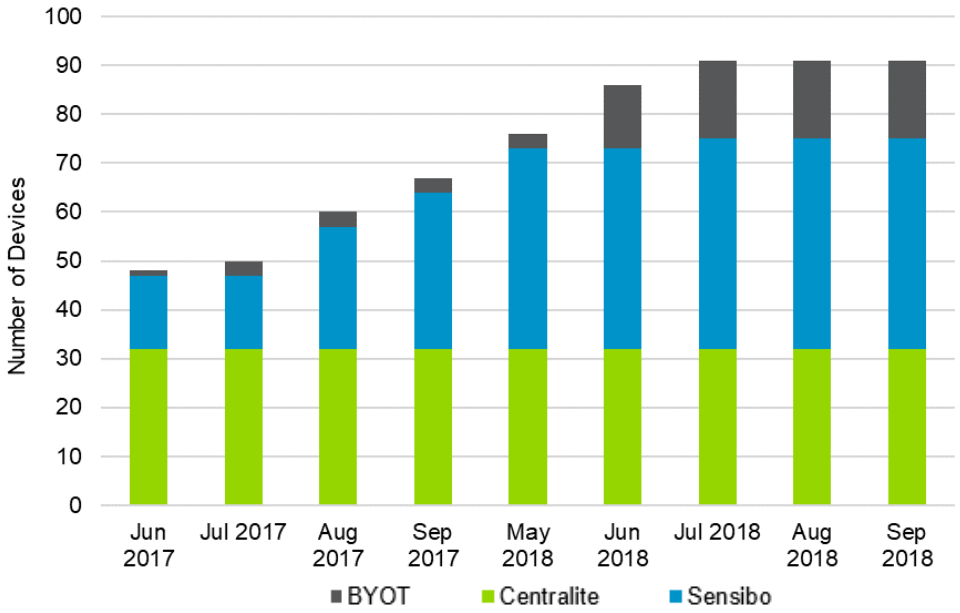
Figure 1-1. Device Enrollment: 2017-2018



Source: Data provided by PPC

Figure 1-2 shows the timing and duration of the eight DR events. Each event lasted approximately 3-4 hours with staggered event end times across devices to minimize the aggregate effects of snapback. Most events ended between 6:30 p.m. and 7:00 p.m. The event algorithm sought to realize demand reduction impacts over the entire event by imposing incremental setbacks (~0.5°C or ~0.9°F) every hour.

The figure also shows the maximum daily temperature in Barnstable, Massachusetts on each event day. Events on August 16, August 28, and August 29 reached 90°F.

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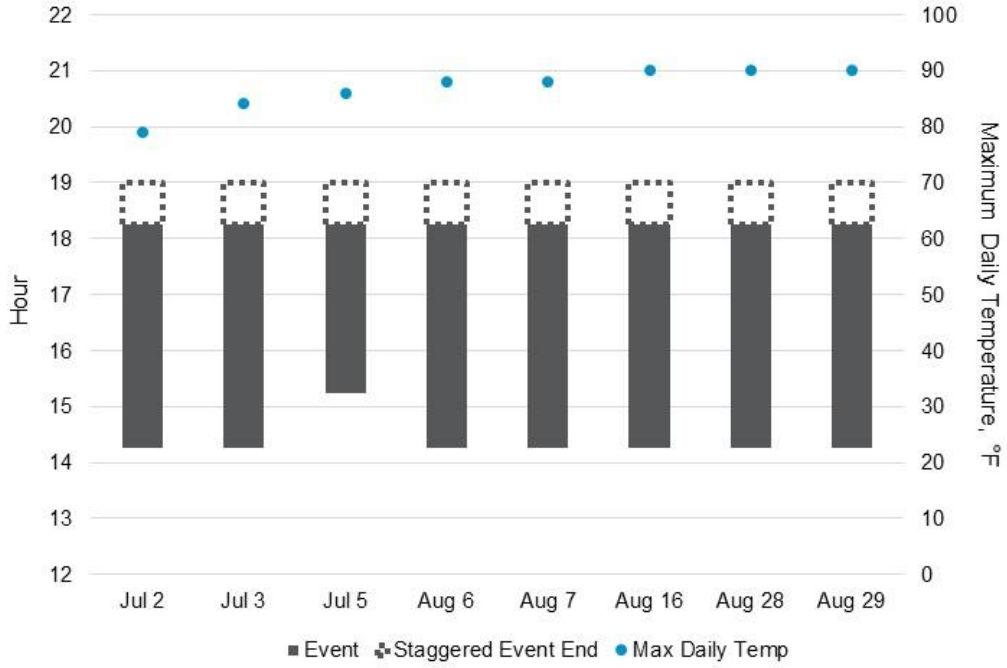
Figure 1-2. Timing and Temperature of Events in the 2018 Season



Source: Event timing was determined using telemetry data and an event data file provided by PPC. Maximum daily temperature for Barnstable, Massachusetts is from https://www.wunderground.com/.

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2. EVALUATION OBJECTIVES AND METHODS

Navigant conducted the following activities as part of the evaluation of CLC's 2018 DR program:

- **Participation assessment:** For all enrolled devices, the evaluation team analyzed device telemetry data to assess opt-out rates during events throughout the DR season, providing insight into customers' general thermostat usage behavior, customer acceptance of the DR solution, and the ability to successfully leverage Sensibo devices for DR. In addition, this participation assessment provided insight into Wi-Fi connectivity issues, informing the scalability of the program.
- **Customer surveys:** In 2018, the team conducted a web-based post-event survey and a post-season survey to solicit feedback regarding customer motivations for program participation, event awareness and comfort level, customer acceptance of the technology and program offering, actions taken during the event, and customer satisfaction.
- **Interim impact estimate:** Navigant informed an interim 2018 demand savings estimate for enrolled mini-splits and central ACs by leveraging the 2017 Residential Baseline Load Shape Study and previously completed Wi-Fi thermostat DR evaluations in Massachusetts.[7]

The 2018 evaluation identified several key research questions aimed at assessing the effectiveness of the DR program and the success of its improvements since 2016. These questions are outlined in the following section.

2.1 Evaluation Objectives

The 2018 evaluation focused on further testing the scalability of the program and the experience with mini-split systems. The evaluation explored the following research questions:

- Technology and program offering
    - For participants with Honeywell, ecobee, and Sensibo devices, what is customer acceptance of the solution (i.e., technology and program)?
    - Do the Honeywell, ecobee, and Centralite Wi-Fi thermostats maintain connectivity throughout the season?
    - Was the addition of mini-splits successful—was the Sensibo device able to control temperature setpoints and maintain connectivity during the season?
    - What are the primary motivations for program enrollment?

[7] As confirmed in 2017, runtime data is not available for Sensibo (mini-split) devices and Centralite thermostats. Although adequate telemetry data for inferring AC compressor runtime is available for Honeywell thermostats and may be available for ecobee thermostats, there were only a few customers enrolled with Honeywell or ecobee thermostats for the 2018 demonstration. As a result, Navigant recommends CLC conduct a full-scale impact evaluation in 2019 for all participants through the use of end-use interval metering or for only Honeywell and ecobee participants (i.e., once more devices have enrolled).

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- Program design and implementation
  - What marketing approaches are the most effective for targeting customers for the program?
  - How aware are customers of events?
  - What is customer satisfaction with event notification?
  - For all participants, what are the opt-out rates during DR events and throughout the DR season?
  - How satisfied are customers with the amount and nature of communications and level of support provided by the program?
- DR impacts
  - What are average demand impacts during DR events?
- Persistence
  - Are customers who participated in 2016 still participating in 2018?
  - Have changes to the 2018 program improved customer acceptance/satisfaction at different project stages (e.g., enrollment, event notification)?
  - Will customers continue to participate in the program?

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3. PARTICIPATION ASSESSMENT

Navigant analyzed participants' thermostat telemetry data to characterize program participation during each event. The participation assessment supplements the feedback obtained in the customer experience surveys by providing insights into participant and device behavior during event periods.

3.1 Approach

Using thermostat telemetry and event data provided by PPC, Navigant identified device participation categories to characterize participant and device behavior during event periods to identify key trends. For each event day, the evaluation team categorized enrolled devices into one of 10 participation categories, described in Table 3-1. On a per-event basis, the team excluded devices falling into the first two categories ("Not Enrolled Yet" and "Missing Parameters Data") from the analysis presented in Section 3.3 below.

Table 3-1. Event Participation Categories

Participation Category	Definition
Not Enrolled Yet	Device enrolled after event occurred.
Missing Parameters Data	Device is missing altogether from the "Parameters" file, which includes indoor temperature, setpoint, and setpoint state changes.
Full Participant	Device used the DR setpoint or a more efficient setpoint for the full event.
Opt Out	Device actively opted out of an event by manually overriding the event setpoint with a negative setpoint adjustment.
Non-Cooling Mode	Device was in off, auto, heat, dry, or fan only mode during the event.
Systematic Fluctuation – Success	Repeated and fluctuating bot-sourced setpoint adjustments were attempted during event period. However, event signal correctly initiated the event.
Systematic Fluctuation – Fail	Repeated and fluctuating bot-sourced setpoint adjustments were attempted during event period. Event signal did not correctly initiate the event.
Disconnected	Device data indicated that there was no connectivity during the event.
Unknown	Unable to determine whether or not program successfully engaged device for event and/or whether or not participant opted out.
Unsuccessful	Device has non-missing telemetry data ("Parameters" data) but did not receive any positive bot-sourced setpoint adjustments during the event period. In many instances, the performance reports indicate offline.

Source: Navigant analysis of device telemetry data from PPC

It is important to note that participant category assignment followed a hierarchy. After the excluded categories (Not Enrolled Yet and Missing Parameters Data), thermostats were flagged for Systematic Fluctuation, Disconnected, Non-Cooling Mode, Full, Unsuccessful and Unknown, in that order. That said,

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the criteria used for the first three categories (Systematic Fluctuation, Disconnected, Non-Cooling) resulted in categories that were mutually exclusive. Devices flagged as Systematic Fluctuation would have been flagged as Unsuccessful or Unknown had the Systematic Fluctuation categorization not been used.

Charts displaying the setpoint and actual indoor temperature over the event period for an example device in the Full Participant and Systematic Fluctuation Success and Fail categories are located in Appendix A.

3.2 Data Review

Prior to device categorization, Navigant reviewed different data sources provided by PPC to check for missing data and data quality issues. Table 3-2 describes the five data sources Navigant received from PPC.

Table 3-2. Data Sources

Data File	Contents
"Users"	All enrolled participants, program start and drop-out date (if applicable)
"Events"	Dates and time windows of event periods
"Parameters"	State change indoor temperature readings, setpoints, and device mode[8] settings
"Commands"	Source of setpoint adjustments (i.e., Rule, Manual, Bot)
"Device Activity"	Timestamped periods of connectivity interruption

Source: Data provided by PPC

This data review revealed the following issues:

- All devices were missing data on the source of the setpoint adjustments ("Commands" file) for the events on August 6, 7, and 16, 2018. Because data on the source of setpoint adjustments was not available for these events, Navigant could not verify whether there were any opt outs during these events.
- Some devices were missing "Commands" data for certain event days even though the "Parameters" file indicated setpoint adjustments were made.
- Certain devices were missing altogether from some files. As previously noted, devices missing altogether from "Parameters" data were removed from the analysis.
- "Parameters" data indicated more instances of connectivity interruption than was reflected in "Device Activity" data.

Table 3-3 provides the final count of devices included in the analysis (presented in Section 3.3) after removing devices that were not enrolled by a given event date or that are missing "Parameters" data. The final analysis includes between 77 and 82 devices, depending on the event. The table also shows the breakdown of analyzed devices by device type (BYOT, Centralite, Sensibo).

[8] Device mode should be distinguished from AC system mode. PPC could not provide data on AC system mode changes for Sensibo and Centralite devices. Data on AC system mode changes is necessary to infer AC compressor runtimes.

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Table 3-3. Device Summary

Device Count by Event	Event Dates							
	7/2/2018	7/3/2018	7/5/2018	8/6/2018	8/7/2018	8/16/2018	8/28/2018	8/29/2018
Enrolled Devices as of 8/30/2018	**91**	**91**	**91**	**91**	**91**	**91**	**91**	**91**
Not Enrolled Yet	7	7	7	0	0	0	0	0
Missing Parameters Data	7	7	7	9	9	9	9	9
Devices Included in Analysis	**77**	**77**	**77**	**82**	**82**	**82**	**82**	**82**
BYOT	13	13	13	16	16	16	15	16
Centralite	28	28	28	30	30	30	30	30
Sensibo	36	36	36	36	36	36	36	36

Source: Navigant analysis of enrollment and telemetry data provided by PPC

3.3 Findings

For each event, Navigant classified all devices based on event participation behavior into one of the categories outlined in Table 3-1. The following section summarizes the findings of this analysis.

Figure 3-1 shows the average participation by device type over all the events in the 2018 summer season. On average, 83% of Centralite devices and 57% of BYOT devices fully participated in the events.

The rate of devices in a non-cooling mode is similar for BYOT (18%) and Sensibo (15%) but lower for Centralite (4%).

The majority of Sensibo devices were categorized as unsuccessful or as systematic fluctuations (both failed and successful). Rates of unsuccessful devices were highest for Sensibo devices (49%), compared to 0% and 3% for BYOT and Centralite devices, respectively. Besides Sensibo devices, only the Honeywell device exhibited systematic fluctuations.

All participants had the ability to opt out during the event by overriding the event setpoint. However, based on the telemetry data available and the participation criteria for opt outs assumed, no instances of opt outs were identified in the data.

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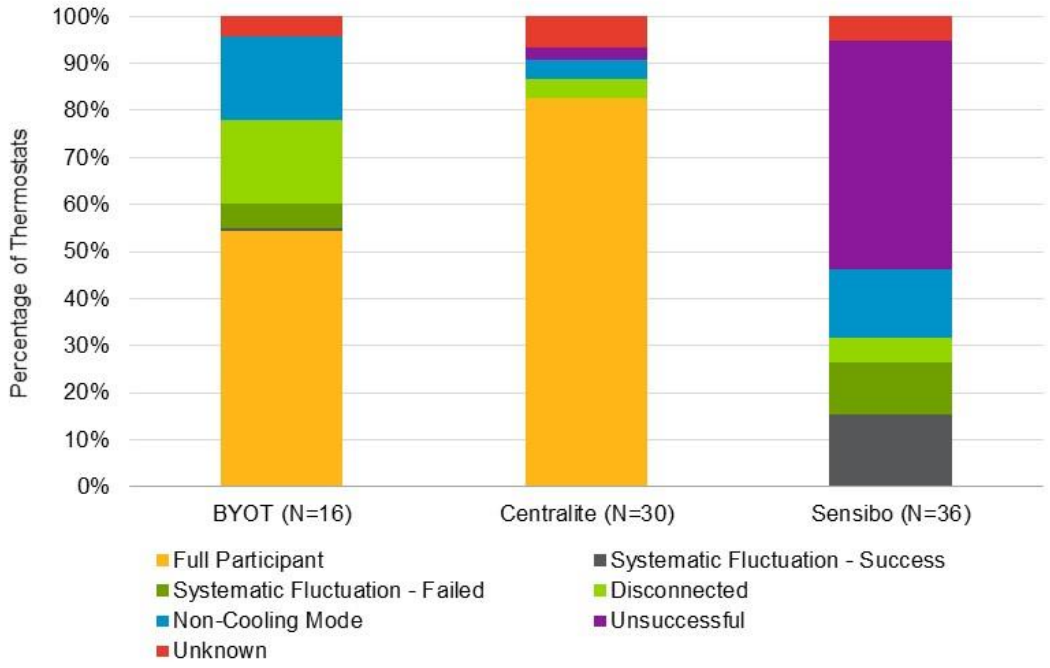
Figure 3-1. Average Participation Over All 2018 Events[9]



Source: Navigant analysis of device telemetry data from PPC

Figure 3-2 provides the participation categorization of all analyzed devices during the 2018 DR season. Throughout the season, on average, there were 31 devices that fully participated during events without any apparent technical issues. The evaluation team categorized the remaining devices on event days into the other six categories to identify why a device did not appear to fully participate in an event.

[9] The sample size is n=77 on July 2, 3, and 5, 2018, and n=82 for all other events. Variation in sample size occurs due to the exclusion of "Not Yet Enrolled" and "Missing Data" device categories in the analysis.

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Figure 3-2. Device Participation by Event (n=77 or 82)[10]

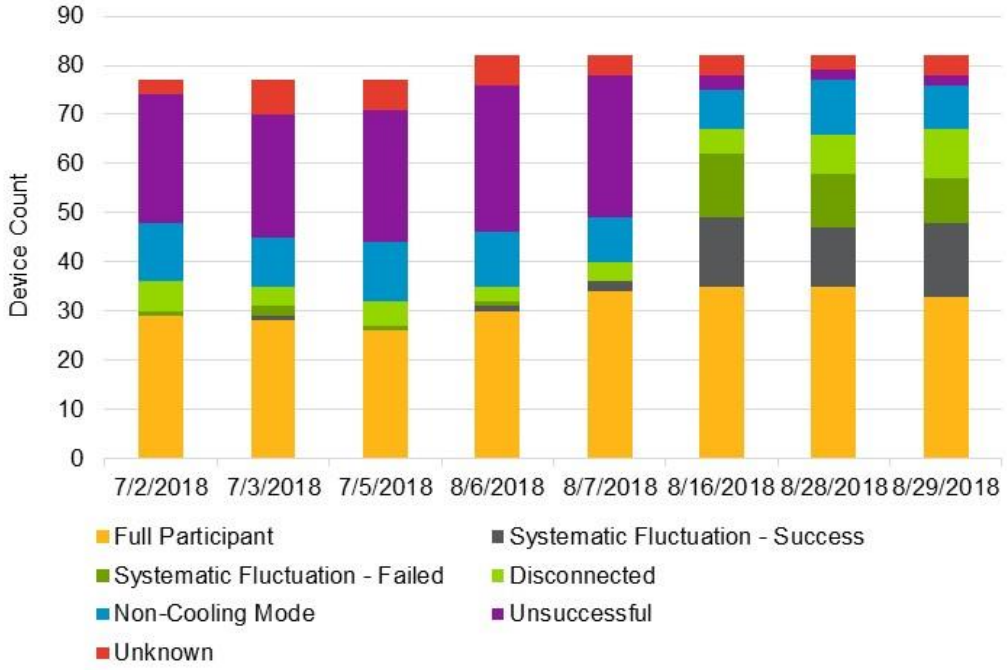

Figure 3-3 shows that between 38% and 63% of BYOT devices were categorized as full participants across all events. Compared to the other device types, BYOT had the highest rates of connectivity issues on the event date and the highest rate of devices in a non-cooling mode at the start of the event. The BYOT subset includes one Honeywell thermostat. This device was the only non-Sensibo device to experience systematic fluctuations, which occurred on every event day except August 28, 2018.

[10] The sample size is n=77 on July 2, 3, and 5, 2018, and n=82 for all other events. Variation in sample size occurs due to the exclusion of "Not Yet Enrolled" and "Missing Data" device categories in the analysis.

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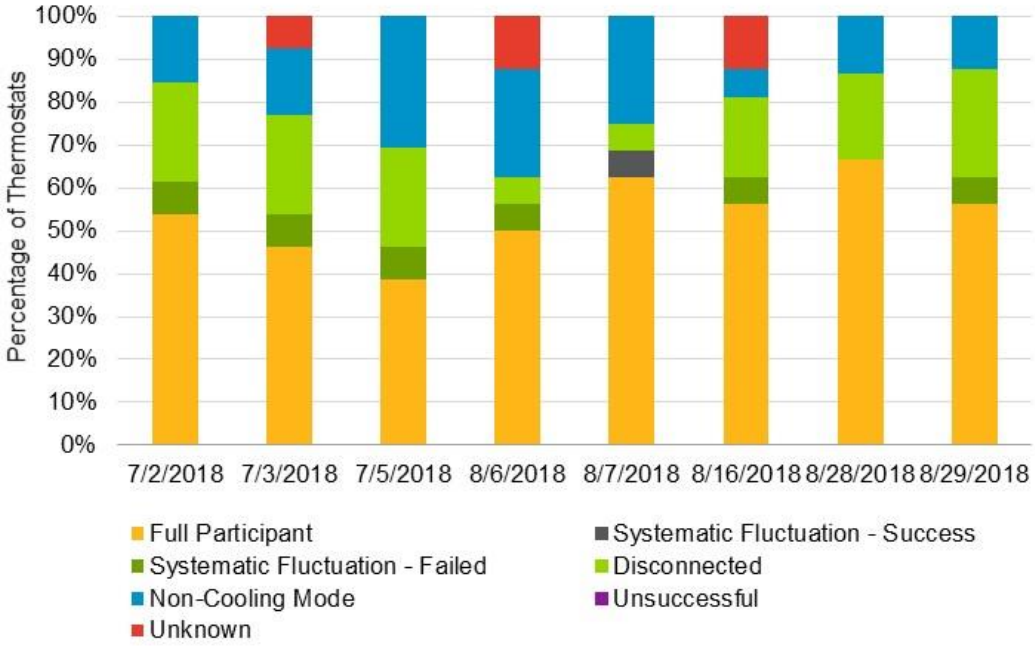
Figure 3-3. Participation of BYOT Devices (n=16)[11]



Source: Navigant analysis of device telemetry data from PPC.

Figure 3-4 shows the categorization of Centralite devices for each event. Centralite thermostats had the highest rate of full participants when compared to other device types, ranging between 76% and 90%. On August 6 and 7, 2018, 7% of Centralite thermostats were designated as unsuccessful. All other event days contained no instances of unsuccessful Centralite devices. No Centralite devices were found to be disconnected during events occurring in July. Across August events, the percentage of disconnected Centralite devices ranged from 3% to 10%.

[11] The sample size is n=13 on July 2, 3, and 5, 2018, and n=16 for all other events. Variation in sample size occurs due to the exclusion of "Not Yet Enrolled" and "Missing Data" device categories in the analysis.

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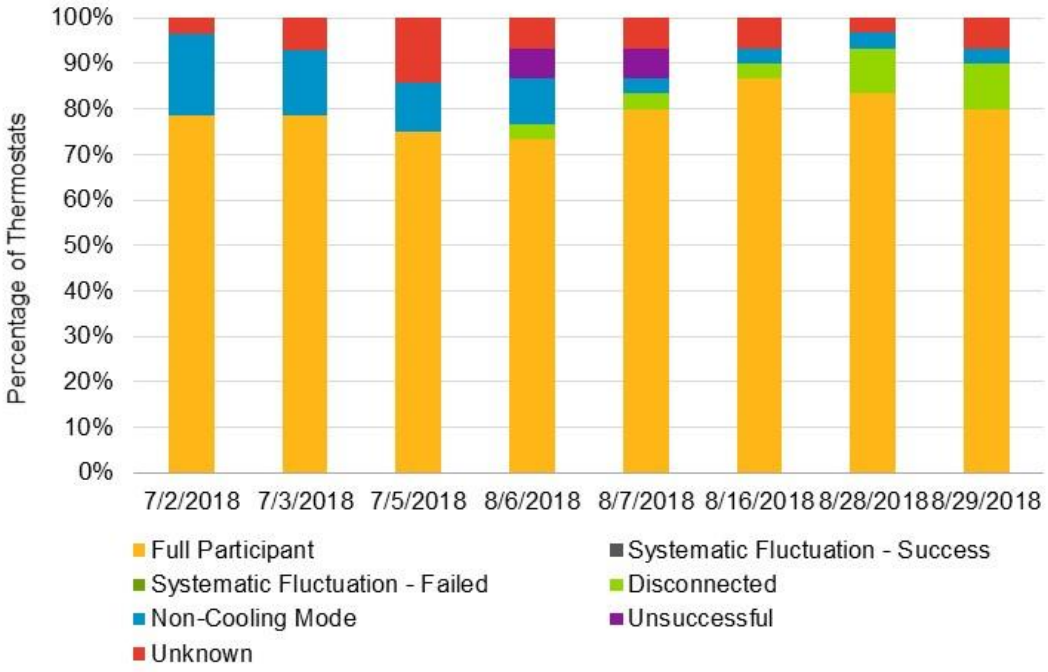
Figure 3-4. Participation of Centralite Thermostats (n=30)[12]



Source: Navigant analysis of device telemetry data from PPC

Figure 3-5 shows the participation categories of Sensibo devices on each event date in the 2018 season. For the majority of Sensibo devices, there was no indication of event setpoint adjustments being attempted until the August 16, 2018 event. For the first five events, between 69% and 78% of Sensibo devices were classified as unsuccessful, either due to the event signal not being sent or the device not receiving the event signal correctly. For the last three events of the season, the majority of devices experienced systematic fluctuations. A little over half of the devices that experienced systematic fluctuations appeared to have successfully participated in the events (i.e., event setpoint successfully initiated), while the remaining devices that experienced systematic fluctuations were not properly initiated for the event.

[12] The sample size is n=28 on July 2, 3, and 5, 2018, and n=30 for all other events. Variation in sample size occurs due to the exclusion of "Not Yet Enrolled" and "Missing Data" device categories in the analysis.

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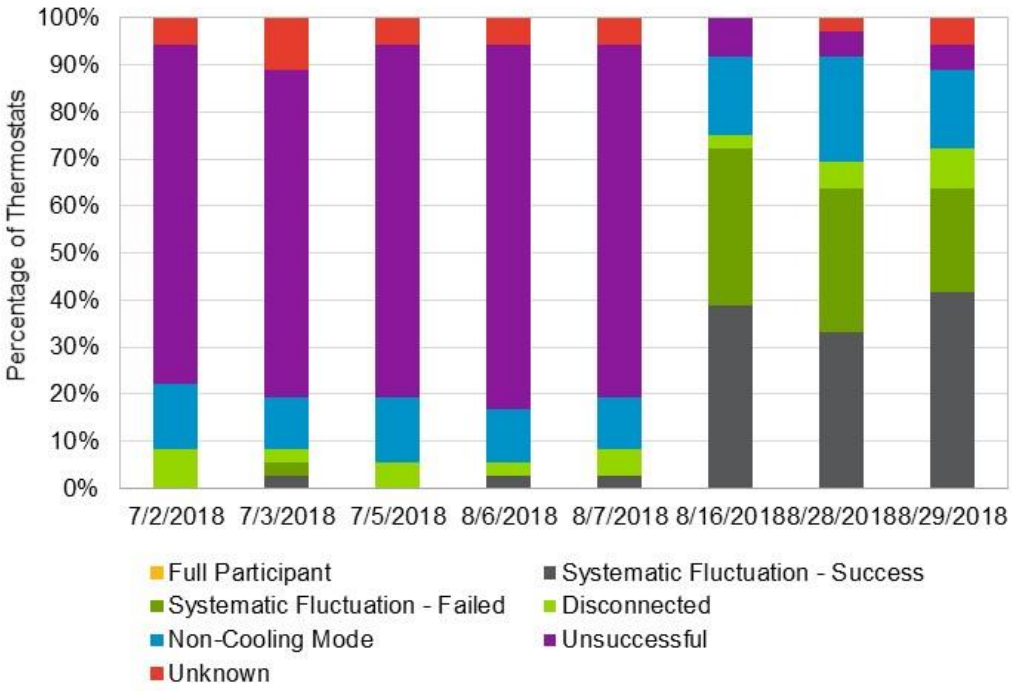
Figure 3-5. Participation of Sensibo Devices (n=36)



Source: Navigant analysis of device telemetry data from PPC

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4. CUSTOMER SURVEYS

Navigant conducted two customer experience surveys to evaluate program implementation, customer perceptions of the program offering and operations, and customer behavior during events. The following sections describe the commonalities and differences in the approach taken with the post-event and post-season surveys as well as their findings.

4.1 Approach

Navigant used a common approach to conduct the post-event and post-season surveys during the 2018 summer season. The surveys were sent by email to all program participants, who were offered an Amazon e-gift card incentive if the survey was completed. The post-event survey contained questions aimed at several research areas that overlapped with those in the post-season survey. Table 4-1 compares the research objectives outlined in each of the two surveys. As shown below, both surveys aimed to gather feedback in the comfort and satisfaction categories. Appendix B includes the survey instruments.

Table 4-1. Customer Experience Survey Topic Comparison

Research Category	Research Objective	Post-Event Survey	Post-Season Survey
Motivation	What factor(s) motivated program participation?		✓
Behavior	How did participants typically use their ACs during the summer? How were participants using their ACs immediately before an event on August 29?	✓	
Event Awareness	How aware were participants about when events occurred? How did they know when the event was occurring?	✓	
Comfort	What impact did events have on participant comfort? Did participants opt out of events? Why? How easy or difficult was it to override the event setpoint?	✓	✓
Performance Reports	How frequently did participants review performance reports? Was the information provided in these reports useful?		✓
Satisfaction	How likely are participants to participate in the program in the future? How satisfied were particiants with different aspects of the program? In what ways have participants indicated the program could improve?	✓	✓

Source: Navigant

Navigant conducted both surveys online and contacted program participants by email. Additional characteristics of both surveys are outlined in Table 4-2.

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Table 4-2. Customer Experience Survey Characteristics

Survey Characteristics	Post-Event Survey	Post-Season Survey
Timing	Conducted within 24 hours of the event on August 29, 2018 • First batch of emails sent out at 9:00 p.m. ET on August 29, 2018 • Reminder sent on August 30, 2018 at 12:00 p.m. ET	Conducted after the last event in the summer 2018 season • Survey sent out on October 15, 2018 at 4:00 p.m. ET • First reminder sent on October 18, 2018 at 2:00 p.m. ET • Second reminder sent on October 23, 2018 at 3:30 p.m. ET
Implementation and Incentive	Survey sent via email with offer of $5 Amazon e-gift card	Survey sent via email with offer of $10 Amazon e-gift card
Sample Size	All participants (51)	All participants (52)
Response Rate	67% (34)	69% (36)
Survey Length	19 questions[13]	26 questions[14]

Source: Navigant analysis

Post-event survey: Navigant fielded a post-event survey to enrolled 2018 program participants following an event on August 29, 2018. The goal was to gather immediate feedback on how participants experienced the event. Survey respondents received a $5 Amazon e-gift card for completing the post-event survey.

Post-season survey: Navigant conducted a post-season survey of 2018 program participants to gather feedback related to customer experience and satisfaction with the program over the course of the summer. The post-season survey was sent via email to all program participants following the end of the 2018 program season. It included an offer for a $10 Amazon e-gift card if the survey was completed.

4.1.1 Survey Sample and Response Rate

Table 4-3 provides the number of survey completes by analysis group for the post-event survey. Navigant sent the post-event survey by email to all 51 enrolled participants following the event on August 29, 2018 from 3 p.m.-7 p.m. ET. August 29 (Wednesday) had a maximum temperature of 91°F and was the second of back-to-back events during a hot week. The response rate for the post-event survey was extremely high, averaging 67%, revealing a high level of interest and engagement among program participants.

[13] Survey length varies with participant responses and device type. For the full survey instruments, including skip logic, see Appendix B.

[14] Survey length varies with participant responses and device type. For the full survey instruments, including skip logic, see Appendix B.

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Table 4-3. Post-Event Survey Sample Characteristics and Response Rate

End Use Type	Device Types	Participants in Sample Frame	Number of Completes	Response Rate
Central AC	BYOT	8	7	88%
Central AC	Centralite Thermostat	19	11	58%
Mini-Split Heat Pump	Sensibo Sky	24	16	67%
Total		**51**	**34**	**67%**

Source: Navigant analysis

As shown in Table 4-4, response rates for the post-season survey were similar to the post-event survey, averaging 69%, further revealing the high level of engagement among the group of participants. All but five participants who responded to the post-event survey also responded to the post-season survey, while seven additional participants who did not respond to the post-event survey responded to the post-season survey.

Table 4-4. Post-Season Survey Sample Characteristics and Response Rate

End Use Type	Device Types	Participants in Sample Frame	Number of Completes	Response Rate
Central AC	BYOT	8	8	100%
Central AC	Centralite Thermostat	19	13	68%
Mini-Split Heat Pump	Sensibo Sky	25	15	60%
Total		**52**	**36**	**69%**

Source: Navigant analysis

4.2 Findings

The following sections summarize the findings gathered from the post-event and post-season surveys.

4.2.1 Customer Motivations

The most frequently cited reasons for participating in the program were incentives and the potential to save money. The latter implies that participants believe a DR program may result in energy savings. Additionally, there was a high interest reducing environmental impact among Sensibo and Centralite participants. Sensibo participants were also motivated to enroll in the program to try the Sensibo device for free.

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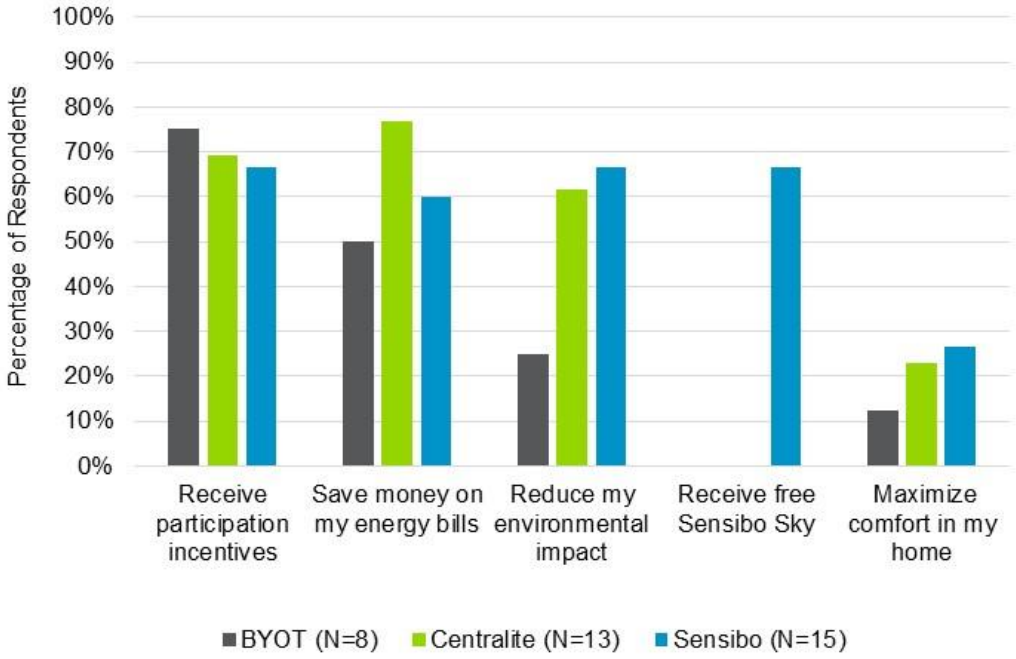
Figure 4-1. Which of the following were motivations for your participation in Cape Light Compact's Smart A/C Savings program in 2018? (Select all that apply)[15]



Source: Navigant analysis of post-season survey data

In addition to reasons for enrolling in CLC's DR program, respondents with BYOT devices were asked about their motivations for buying a Wi-Fi thermostat. All of the BYOT respondents indicated that they were motivated by the ability to control temperatures remotely. Two of these respondents cited receiving additional incentives from MassSave toward the purchase of their thermostat as a motivating factor.

4.2.2 Participant Behavior

As part of the post-event survey, participants were asked about their typical AC usage behavior. Respondents with Centralite and BYOT devices were roughly split between only turning cooling on as needed when it is hot or humid and setting a temperature schedule. In contrast, the majority of Sensibo respondents indicated they only turn on cooling when it is hot or humid. This may indicate that mini-splits are more commonly used as secondary cooling sources in the home than central ACs. The Other category on Figure 4-2 consists of three respondents with Sensibo devices: two who indicated they run their devices in dry mode and one who only runs their AC when they are in the room.

[15] Note that only participants with a Sensibo device had the option to select "Free Sensibo Sky."

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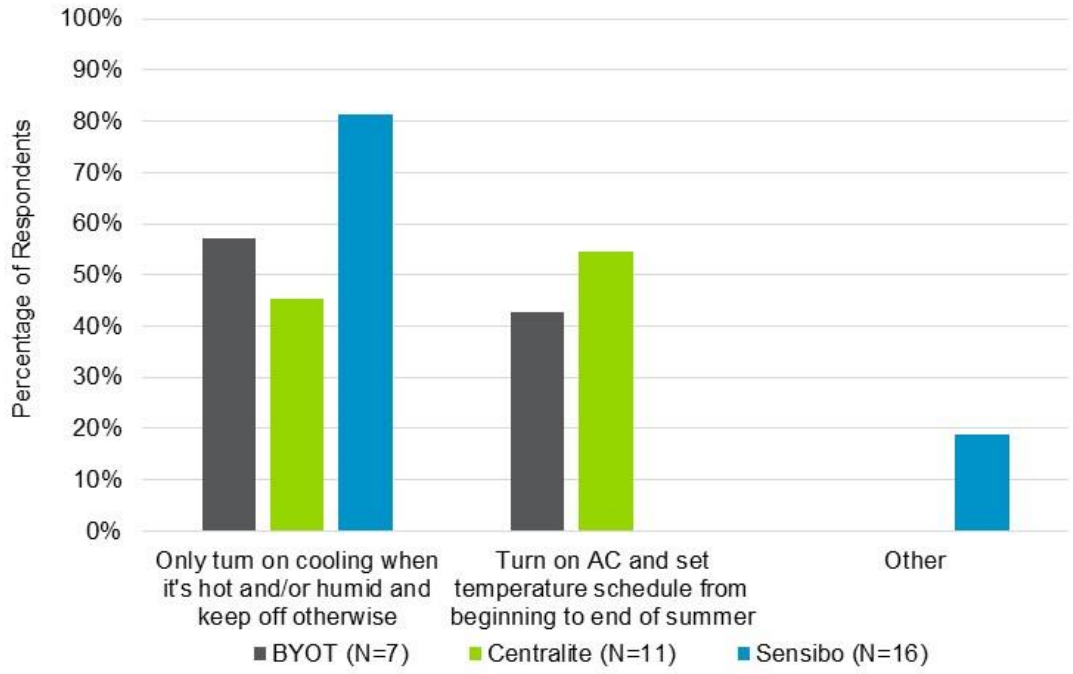
Figure 4-2. Which of the following best describes the way you use your air conditioner?



Source: Navigant analysis of post-event survey data

Post-event survey respondents were also asked about the system mode of their ACs at the time of the August 29 event. Over 85% of respondents indicated that their ACs were in cooling mode prior to the start of the event. Three Sensibo respondents indicated they had their systems in dry mode, and one Sensibo respondent indicated that their system was in cooling mode but was not signaled for the event.

4.2.3 Event Awareness

All of the post-event survey respondents indicated that they were aware of the event on August 29. They were then asked how they became aware of the event. Navigant grouped the open-ended responses into the six categories shown in Figure 4-3. Of respondents, 85% indicated they received an email and 24% received a text/app notification. One respondent cited notification via the thermostat itself (a beeping sound on the Sensibo), and two respondents became aware of the event when they noticed a change in temperature.

Of post-season survey respondents who recalled being notified about events, 92% were satisfied with event notification.

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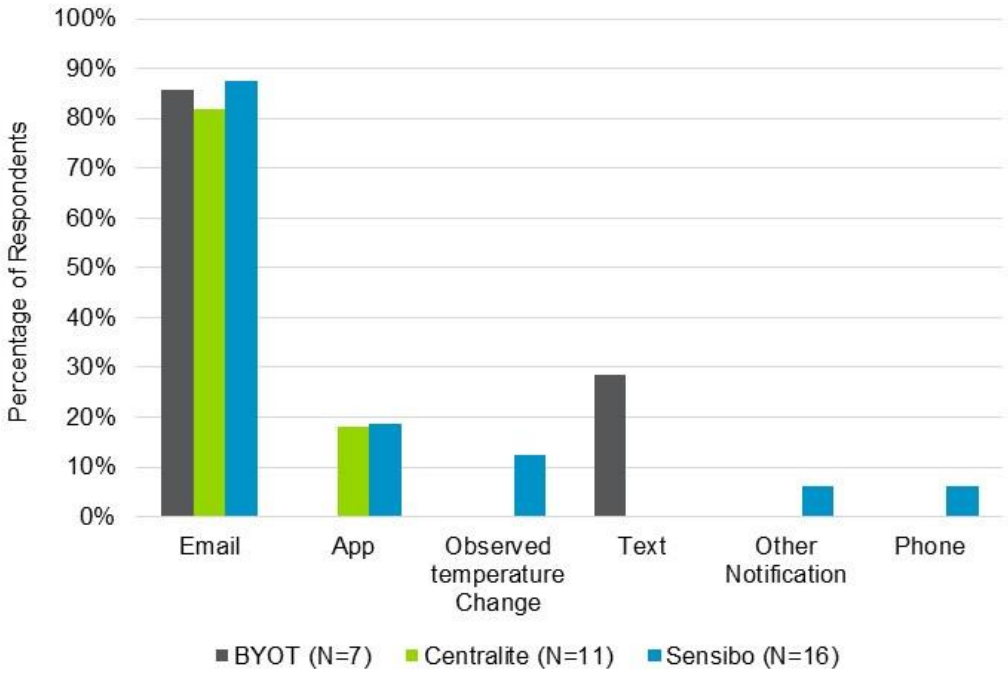
Figure 4-3. How did you know the event on August 29, 2018 was occurring?



Source: Navigant analysis of post-event and post-season survey data

4.2.4 Comfort

As shown in Figure 4-4, consistent with post-event survey findings, 50% of post-season survey respondents with BYOT and Centralite devices indicated their comfort level during events was about the same as on other days with similar temperatures. Comparatively, close to 70% of post-season survey respondents with Sensibo devices reported being unaffected by events (also consistent with post-event survey findings). These results are corroborated by the participation assessment (discussed in Section 3) in that, on any given event day, the event was not successfully initiated for a large percentage of Sensibo devices.

Only one respondent (BYOT) indicated that they were much less comfortable during events. This respondent commented that the event setpoint adjustments ranged between 5°F and 8°F. The data shows that while the average setpoint adjustment is between 2° and 3°, approximately 4% of devices categorized as full participants experienced a 5°F -7°F change in indoor temperature.

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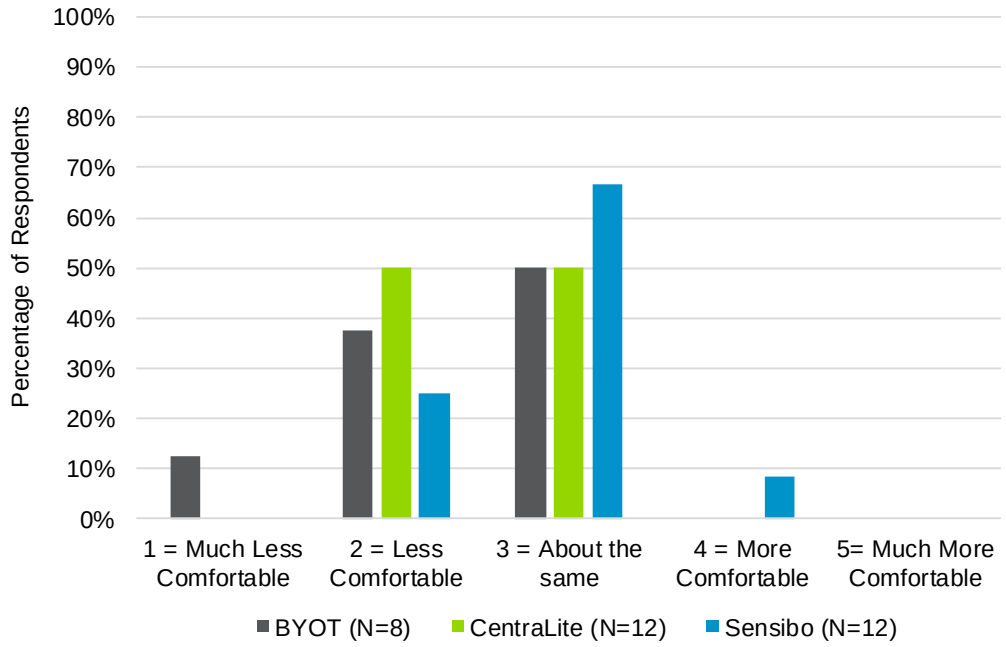
Figure 4-4. During the events, how would you describe your comfort compared to afternoons with similar outdoor temperatures?



Source: Navigant analysis of post-season survey data

As shown in Figure 4-5, the majority of post-season survey respondents indicated that they had never opted out of an event by overriding the event setpoint, while 8% (three of 36) indicated that that had opted out of at least one event. Two of these participants reported opting out of some events and one reported opting out rarely. However, based on the criteria used to classify devices as opt outs, Navigant did not identify any devices that had successfully opted out of an event. When given the opportunity to comment on the ease of opting out, none of the three respondents who reported opting out indicated having any difficulty doing so. Two reported it was "very easy" to opt out.

For comparison purposes, eight of the 15 interviewed participants in 2016 appeared to have opted out of an event at least once during the 2016 season (based on analysis of telemetry data conducted in 2016).

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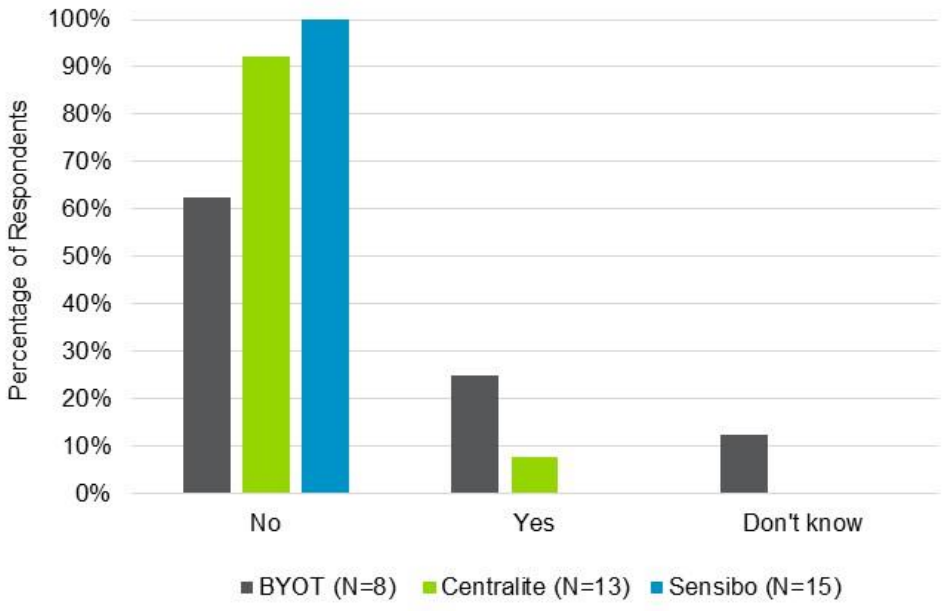
Figure 4-5. On event days, did you ever opt out or override your device setting to stop the program from adjusting your device during the event?



Source: Navigant analysis of post-season survey data

4.2.5 Performance Reports

The post-season survey asked respondents for feedback regarding the usefulness of the performance reports generated and sent to participants by PPC following each event. Of participants surveyed, 75% were aware that PPC sent performance reports via email following the end of each event. Of these respondents (27), 80% always or often reviewed the reports following events. The remaining 20% reviewed reports occasionally.

Approximately half of respondents who indicated that they viewed the performance reports thought that they were "somewhat useful" and 30% thought they were "very useful."

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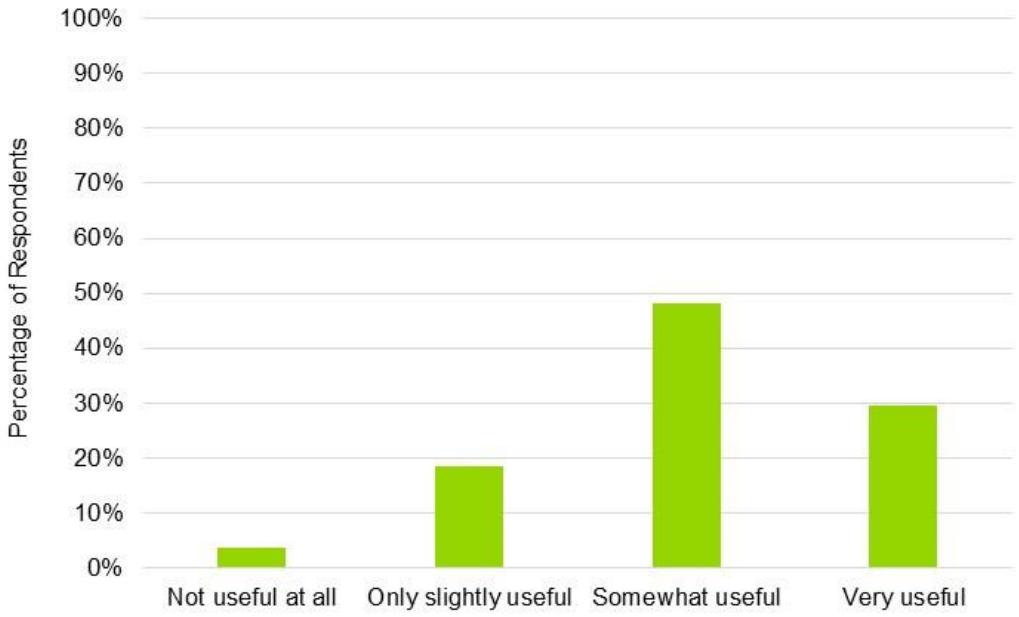
Figure 4-6. How useful did you find the information provided in the performance reports to be?



Source: Navigant analysis of post-season survey findings

4.2.6 Satisfaction

Overall satisfaction with CLC's 2018 Smart A/C Savings program was high. As shown in Figure 4-7, 63% (5 of 8) of the respondents with BYOT devices, 92% (12 of 13) of those with Centralites, and 93% (14 of 15) of those with Sensibos are likely to continue with the program. The majority of respondents were "very satisfied" or "satisfied" with the program's event notifications (92%), number of events (83%), length of events (83%), and the timing of events (81%). Many participants expressed their satisfaction with the program overall in the open-ended survey questions. The following are examples of encouraging comments submitted by survey respondents:

- "A worthwhile program"
- "I think the program is wonderful and it really makes me think about my usage!"
- "This is an excellent program. I believe it works great and has good results saving energy."
- "I think it is performing quite well."

In addition to receiving positive feedback from survey respondents, Navigant received feedback on areas for program improvement. The feedback is categorized by topic area and is shown in Table 4-5.

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Table 4-5. Areas for Program Improvement

Program Areas	Suggestions for Program Improvement
Sensibo Connectivity or Technical Issues	Some of the respondents with Sensibo devices offered insight into the issues they are seeing, including: • "AC is off but Sensibo is still trying to run program. Summer heat is over, no need to run program." • "If I use the system on the dry setting the Sensibo thinks I have the heat on I get messages after the event." • "The [Sensibo] devices are unstable. Sometimes the app says they are off when they are on and on when they are off." • "[The Sensibo] frequently disconnects from Wi-Fi and needs reprogramming."
Customer Support	• More support during the initial install of Sensibo and additional help with other equipment installations • Better sync with all of the thermostat functions • A dedicated help desk for technical issues
Incentives	• "Offer incentives for referrals" • Provide more smart thermostats for free as part of the program
Program Communications or Event Notification	• Inform participants that they should make the household aware that thermostat is being controlled remotely • "Maybe more advanced program notice based on the heat forecast for the upcoming days."
Comfort	• Start events earlier • "Lower the Delta degree rise that you make to set thermostat set back to you."

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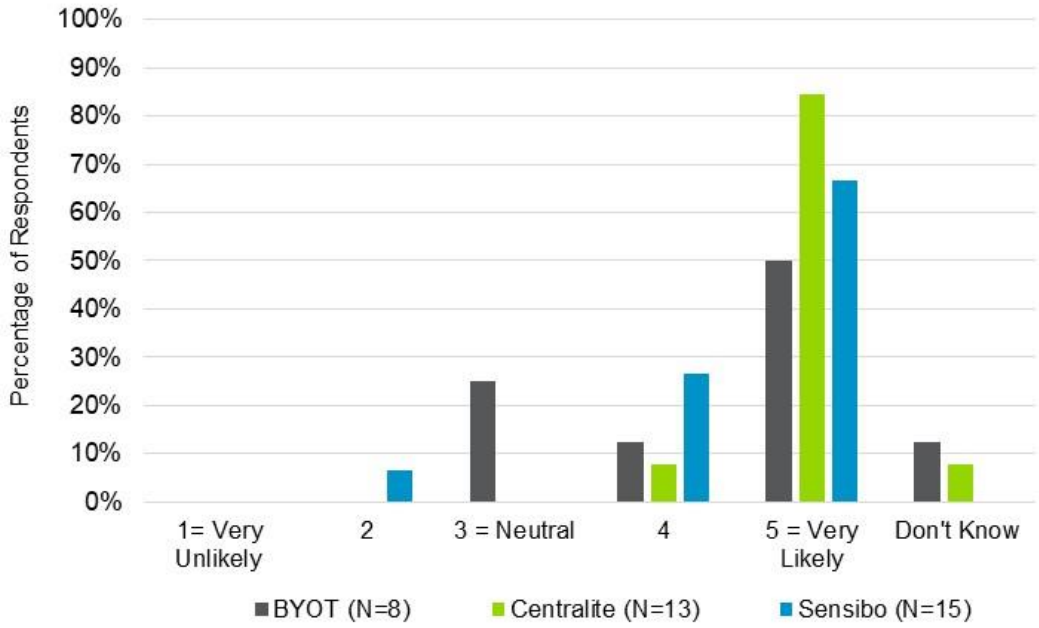
Figure 4-7. In future summers, on a scale of 1-5, where 1 is "Very Unlikely" and 5 is "Very Likely," how likely would you be to participate in CLC's Smart A/C Savings program?



Source: Navigant analysis of post-season survey data

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5. 2018 INTERIM DEMAND SAVINGS ESTIMATE

5.1 Approach

By the end of the 2018 summer season, there were 25 enrolled participants with Sensibo devices (45 devices), 19 Centralite participants (32 devices), seven participants with ecobee thermostats (15 devices) and one enrolled Honeywell thermostat. The data available from the Sensibo devices (as well as from the Presence app) does not include data on system mode; therefore, thermostat runtime cannot be inferred. Thermostat runtime is necessary to evaluate DR impacts for Sensibo participants unless metering had been installed. As a result, and due to the low enrollment of ecobee and Honeywell thermostats in 2018, CLC and Navigant did not evaluate the demand impacts associated with the 2018 DR program.

In lieu of evaluated impacts, in this section, Navigant provides 2018 demand savings estimates for enrolled mini-splits and central ACs participating in CLC's DR program. For these estimates, the evaluation team leveraged the 2017 Residential Baseline Load Shape Study[16] and National Grid's 2017 Wi-Fi Thermostat DR Evaluation[17] for Massachusetts. These savings estimates will serve to inform CLC's estimates for the 2019-2021 Energy Efficiency Program.

The demand savings estimates outlined below are indicative and not evaluated results for CLC's 2018 DR program. As such, they are intended as interim demand savings values until program impacts are evaluated (in future years). In addition to climate region, participant demographics, and event criteria, some differences between CLC's 2018 DR program and National Grid's 2017 DR program could account for differences in actual demand savings achieved, as outlined in Table 5-1.

[16] Navigant, *RES 1 Baseline Load Shape Study*, prepared for the Electric and Gas Program Administrors of Massachusetts, July 27, 2018, http://ma-eeac.org/wordpress/wp-content/uploads/RES-1-FINAL-Comprehensive-Report-2018-07-27.pdf

[17] Navigant, *2017 Residential Wi-Fi Thermostat DR Evaluation,* prepared for National Grid, March 30, 2018, http://ma-eeac.org/wordpress/wp-content/uploads/2017-NGrid-DR-Eval-Final-Report-2018-03-30.pdf

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Table 5-1. CLC 2018 and National Grid 2017 DR Program Parameters

Parameter	CLC 2018 DR Program	National Grid 2017 DR Program
Pre-Cooling	None	EB: None HW: -1°F-2°F Nest: Optimized
DR Setback Strategy	+2°F -4°F	+3°F, all at once at start
Event Duration	3-4 hours	3-4 hours
Event Period	3 p.m.-7 p.m.	HW/EB: 2 p.m.-5 p.m. Nest: 2 p.m.-5 p.m. or 2 p.m.-6 p.m.
Max Events in a Season	None	HW/EB: None Nest: 40
Participation Incentive	$25; 75% of events	HW/EB: $25; 75% of events Nest: $25; no requirement
Device Types	Sensibo Sky, Centralite, ecobee, Honeywell	ecobee, Honeywell, Nest

EB = ecobee; HW = Honeywell

Source: Information provided by CLC, PPC, or obtained from the program website https://www.capelightcompact.org/smart-ac/ *and the 2017 Residential DR Final Evaluation report for National Grid*

5.2 Findings

Navigant's 2018 per-device demand savings estimates are 0.19 kW and 0.62 kW for mini-split heat pumps and central ACs, respectively. Both estimates assume that events are called on non-holiday weekdays where the temperature reaches 86°F or higher. Navigant's analysis is described in the following subsections.

5.2.1 Mini-Split Heat Pumps

The impact of a summer DR program for mini-split heat pumps has not yet been evaluated in Massachusetts or any relevant jurisdictions. Therefore, to derive an estimate of demand savings attributable to CLC's 2018 DR program for mini-split heat pumps, Navigant leveraged end-use metering data for mini-split heat pumps from the 2017 Residential Baseline Load Shape Study for the 2017 summer period. The evaluation team constructed an average daily load shape for mini-split heat pumps reflecting 2017 weekdays for which the maximum temperature during the peak period was above 85°F—i.e., hot days [18] (see 6.Appendix C, Figure C-1). The size of the statewide metering sample for mini-split heat pumps was 16 units.

Table 5-2 contains the average load coincident with the summer peak period of 3 p.m. to 7 p.m. for hot days (0.51 kW). Using the National Grid *2017 Residential Wi-Fi Thermostat DR Evaluation* report, Navigant developed a DR factor to apply to average coincident load to account for the rate of event participation (inverse of opt-out rate), of devices in off or heating mode, of failed and disconnected devices, and the additional derating associated with a 3°F temperature setback strategy (Table 5-3).

[18] In Worcester, Massachusetts.

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Although the average coincident load assumed reflects the period of 3 p.m. to 7 p.m., the DR factors used reflect National Grid's 2017 event period of 2 p.m. to 5 p.m.

After applying the aggregate DR factor (0.4), Navigant estimated potential load reduction during the peak period due to DR to be 0.19 kW for mini-split heat pumps.

Table 5-2. Unit Impact Metrics: Mini-Split Heat Pumps

Source	Year of Publication	Average Coincident Load (kW)	DR Factor	Demand Savings per Mini-Split during Peak (kW)
MA Baseline Study End-Use Metering – Hot Days (3 p.m.-7 p.m.)	2017	0.51	0.4	**0.19**

Sources: 2017 Residential Baseline Load Shape Study

Table 5-3. DR Factor Assumptions

DR Factor	Definition	Value
Participation Rate	Fraction of participants that did not opt out during event	0.9[19]
System in Cooling Mode	Fraction of HVAC systems on and in cooling mode before and/or during event	0.8[20]
Not Failed	Fraction of devices that did not fail to receive event signal for a reason unexplained by other categories	0.97[21]
Connectivity	Fraction of devices that were connected to Wi-Fi during the event	0.97[22]
Temperature Setback Strategy	Derating to account for the fact that the HVAC system is not turned off entirely during events	0.6[23]
Final DR Factor		**0.4**

Source: National Grid 2017 Residential Wi-Fi Thermostat DR Final Evaluation

[19] Assumed weighted average participation rate across all events and device types as found in the National Grid *2017 Residential Wi-Fi Thermostat DR Final Evaluation* report for central ACs.

[20] Assumed weighted average rate of devices in cooling mode across all events and device types as found in the National Grid *2017 Residential Wi-Fi Thermostat DR Final Evaluation* report for central ACs.

[21] Assumed weighted average rate of devices that failed to receive event signal across all events and device types as found in the National Grid *2017 Residential Wi-Fi Thermostat DR Final Evaluation* report for ACs.

[22] Assumed weighted average connectivity rate across all events and device types as found in the National Grid *2017 Residential Wi-Fi Thermostat DR Final Evaluation* report for central ACs.

[23] Assumed an additional derating factor of 0.6 reflecting the fact that the temperature setback strategy entails a cycling of the AC compressor aimed at maintaining a certain temperature. This additional 0.6 derating factor was back-calculated from the evaluated total derating factor (0.4) and the combined participation rate, cooling mode rate, and failed/connectivity rate derating factors (0.7) as estimated in the National Grid *2017 Residential Wi-Fi Thermostat DR Final Evaluation* report for central ACs.

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5.2.2 Central Air Conditioners

National Grid has demonstrated and evaluated a DR program for central ACs, harnessing Wi-Fi thermostat technology and a 3°F temperature setback strategy. For 2017, National Grid estimated savings to be 0.57 kW per device,[24] for an event period of 2 p.m.-5 p.m. This value reflects the average treatment effect (ATE) on event days with an average temperature above 85°F,[25] as detailed in the 2017 evaluation of National Grid's residential DR program impacts.[26] The ATE factors in all enrolled devices (not just those that participate in a given event), thus accounting for the various derating factors described in the mini-split heat pump section.

In addition to the impact estimate based on National Grid's 2017 DR evaluation, Table 5-4 contains the average central AC load coincident with the summer peak period of 3 p.m.-7 p.m. for hot days (1.54 kW). Using the 0.4 DR factor based on National Grid's 2017 DR evaluation (previously described), Navigant estimated potential load reduction during CLC's peak period (3 p.m.-7 p.m.) due to DR to be 0.62 kW for central ACs.

Although the average coincident load of 1.54 kW reflects average load during the period of 3 p.m.-7 p.m., the DR factors used reflect National Grid's 2017 event period of 2 p.m.-5 p.m.

Table 5-4. Unit Impact Metrics – Central ACs

Source	Year of Publication	Average Coincident Load (kW)	DR Factor	Demand Savings per Central AC during Peak (kW)
2017 National Grid Residential DR Final Evaluation (2 p.m.-5 p.m.)	2017	N/A	N/A	0.57
MA Baseline Study End-Use Metering – Hot Days (3 p.m.-7 p.m.)	2017	1.54	0.4	0.62

Sources: 2017 Residential Baseline Load Shape Study and National Grid 2017 Residential Wi-Fi Thermostat DR Evaluation

[24] Impacts associated with a larger temperature setback could be even higher. For example, the evaluation of National Grid New York's 2017 coolControl program found that, on average, each Emerson Sensi Wi-Fi thermostat curtailed 0.93 kW during events from *National Grid Dynamic Load Management Programs Annual Report for 2017 Capability Period*.

[25] The two events days with temperatures of greater than 85°F were July 20 and 21, 2017.

[26] Navigant, *2017 Residential Wi-Fi Thermostat DR Evaluation*, prepared for National Grid, March 30, 2018, http://ma-eeac.org/wordpress/wp-content/uploads/2017-NGrid-DR-Eval-Final-Report-2018-03-30.pdf

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6. KEY FINDINGS AND CONSIDERATIONS

Table 6-1 contains key findings from the participation assessment, customer survey, and interim demand savings efforts. Findings are categorized by topic: data issues, customer motivations, customer behavior, event awareness, event participation, customer comfort, performance reports, satisfaction, and interim demand savings estimate

In addition, Table 6-2 presents some considerations for CLC's DR program going forward based on these findings.

Table 6-1. Key Findings

Topic	Findings
Customer Motivations	• Survey respondents (across device types) were motivated to participate in the program to receive participation incentives (69%), save money (64%), and reduce their environmental impact (56%). Additionally, two-thirds of respondents with mini-splits cited the free Sensibo device as a motivation for enrolling. *(Post-Season Survey)* • All eight BYOT respondents indicated they were motivated to get a Wi-Fi thermostat in the first place and by the ability to control temperatures remotely. *(Post-Season Survey)*
Customer Behavior	• Of survey respondents, 65% generally only turned cooling on as needed—when it was hot or humid. *(Post-Event Survey)* • At the time of the August 29 event, 85% of respondents reported having their devices in cooling mode. *(Post-Event Survey)*
Event Awareness	• Of respondents, 100% were aware an event had occurred on August 29. *(Post-Event Survey)* • Most respondents reported knowing that an event was occurring from an email; only two respondents attributed awareness to a change in temperature. *(Post-Event Survey)* • Of survey respondents, 92% were satisfied by event notification. *(Post-Season Survey)*

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Topic	Findings
Event Participation	• Devices in auto, dry, and fan-only modes were treated the same by the program as devices in off or heat modes. In other words, event setpoints were not triggered for these devices. *(Participation Assessment)* • Across all events, 18% and 15% of BYOT and Sensibo devices, respectively, were in non-cooling mode compared to only 8% for Centralite. Additionally, 13% and 10% of BYOT and Sensibo devices, respectively, were in non-cooling mode for 50% or more events. This may be because there is a greater number of non-cooling mode options for the BYOT and Sensibo devices. *(Participation Assessment)* • The program was largely unsuccessful in engaging Sensibo devices for events prior to August 16. *(Participation Assessment)* • No Centralite or ecobee devices exhibited systematic fluctuations, whereas the majority of Sensibo devices (starting on August 16) and the Honeywell device did. This indicates a potential integration issue with PPC's software platform. *(Participation Assessment)* • Across all events, 18% of BYOT devices appeared to be offline during events versus only 5% and 4% for Sensibo and Centralite devices, respectively. *(Participation Assessment)*
Customer Comfort	• Of BYOT and Centralite survey respondents, 50% described the comfort level of their home as "about the same" when compared to a day with similar temperatures. For Sensibo respondents, this percentage was higher, at 75%. Only one BYOT participant reported being much less comfortable *(Post-Season Survey)*, which aligns with the participation assessment's findings. • For full participants, the median change in indoor temperature ranged between 2°F and 3°F. However, the maximum increase in indoor temperature was observed to be 7°F. *(Participation Assessment)* • Three of 36 post-season survey respondents indicated that they opted out of at least one event during the season. These respondents did not indicate they had any trouble successfully opting out. However, this was not corroborated by telemetry data. It is possible opt outs occurred on August 6, 7, or 16, or occurred after 6:20 p.m. These were not flagged as an opt out because the program began adjusting setpoints for some thermostats at that time. *(Participation Assessment)* • In addition, available data indicated four participants (only one overlaps with the previous bullet), made manual, negative setpoint adjustments during events. However, based on the data, these attempts do not appear to have been successful at lowering indoor temperature or preventing subsequent positive setpoint adjustments to be made by a bot. *(Participation Assessment)*

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Topic	Findings
Performance Reports	• Of all survey respondents, 75% were aware they received performance reports after every event. Of those who recalled the reports, 80% always or often reviewed the reports following events. The remaining 20% reviewed reports occasionally. *(Post-Season Survey)* • Of those who were aware they received performance reports, 30% found the reports to contain "very useful" information, while 50% felt that the information was "somewhat useful." The remaining 20% found the information only "slightly useful" or "not useful at all." *(Post-Season Survey)*
Satisfaction	• Consistent with 2016 post-season interview findings, 86% of 2018 post-season survey respondents are "very likely" or "likely" to participate in the program in the future. Only one participant indicated they were "unlikely" to participate again (a Sensibo participant). • Respondents were mainly very satisfied with event notification and the characteristics of events (i.e., number, length, timing). *(Post-Season Survey)* • Issues cited in both the post-event and post-season surveys mostly related to Sensibo device setup support, operability, and connectivity.
Interim Demand Savings Estimate	• Because of sample size and data constraints, an interim savings estimate was determined by using the 2017 Residential Baseline Load Shape Study and National Grid's 2017 Wi-Fi thermostat DR evaluation for Massachusetts. • The 2018 per-device demand savings estimates are 0.19 kW and 0.62 kW for mini-split heat pumps and central air conditioners, respectively.

Source: Navigant

Table 6-2. Considerations

Consideration
• **Consideration #1:** Sensibo devices cannot capture all manual setpoint and device mode changes made by participants or the mini-split runtime. Therefore, if there is a desire to continue to leverage Sensibo devices for DR, end-use or whole-home interval meters should be installed to facilitate evaluation of event behavior as well as demand impacts.
• **Consideration #2:** Sensibo devices and the Honeywell thermostats exhibited unexpected temperature setpoint profiles during events (i.e., systematic fluctuations). This suggests further testing of the integration of these device types with the DR software platform used is needed.
• **Consideration #3:** In addition to incentives, program participants were motivated to enroll in the program to reduce environmental impacts. Further emphasize environmental benefits in future marketing efforts.
• **Consideration #4:** BYOT participants cited remote control of their home's temperature as the primary driver for getting a Wi-Fi thermostat. Two of eight BYOT survey respondents received a MassSave incentive toward their thermostat purchase. In future marketing efforts, continue to market MassSave rebates and emphasize the benefits of remote control (e.g., convenience, potential for savings)
• **Consideration #5:** Sensibo and BYOT devices in auto and dry modes were treated the same by the program as devices in off or heat modes—they were not engaged for DR events. Investigate opportunities to engage these devices for events if there is a potential for demand savings.

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Consideration
• **Consideration #6:** Program literature stated that setpoints would be increased by 3°F -4°F during events. The median indoor temperature change for full participants across events and devices types was 2°F -3°F, but changes in indoor temperature did reach as much as 7°F. Ensure all setpoint adjustments do not exceed what is stated in program literature.
• **Consideration #7:** Refresh interim savings estimate with forthcoming 2018 Residential Baseline Load Shape Study and 2018 National Grid DR savings estimates. Consider a small interval meter study to capture demand savings from devices where runtime is not available (Sensibos).

Source: Navigant

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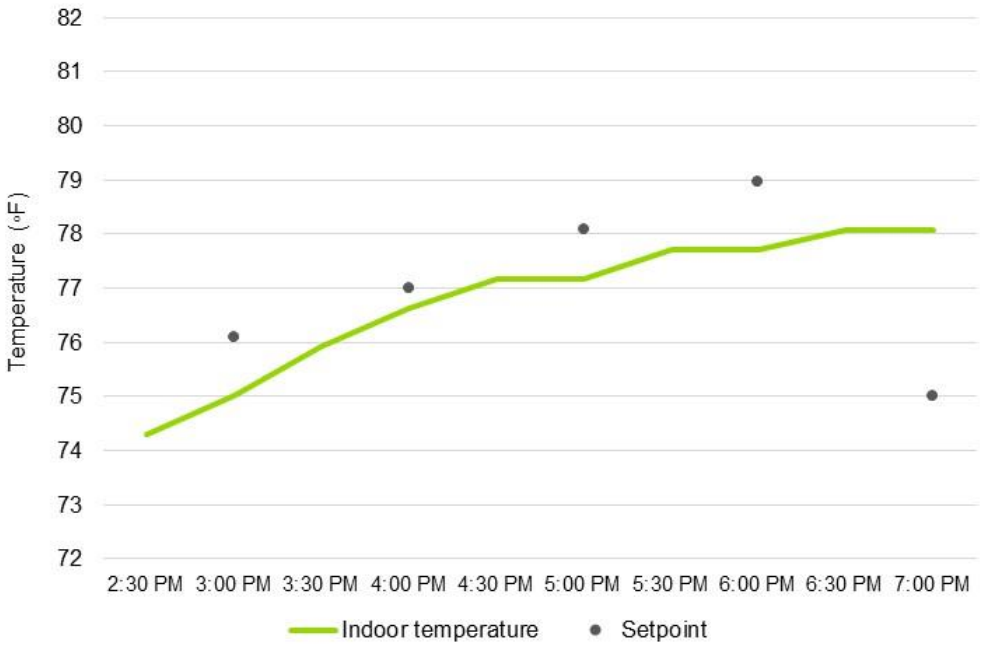
APPENDIX A. EXAMPLE DEVICE EVENT PROFILES

Figure A-1. Full Participant



Source: Navigant analysis of device telemetry data from PPC

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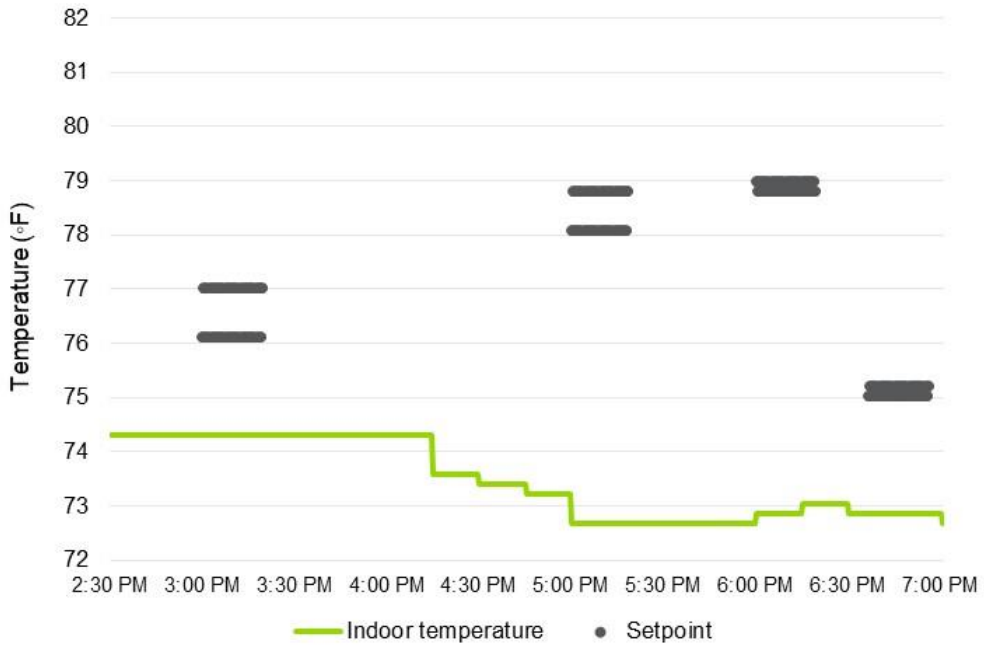
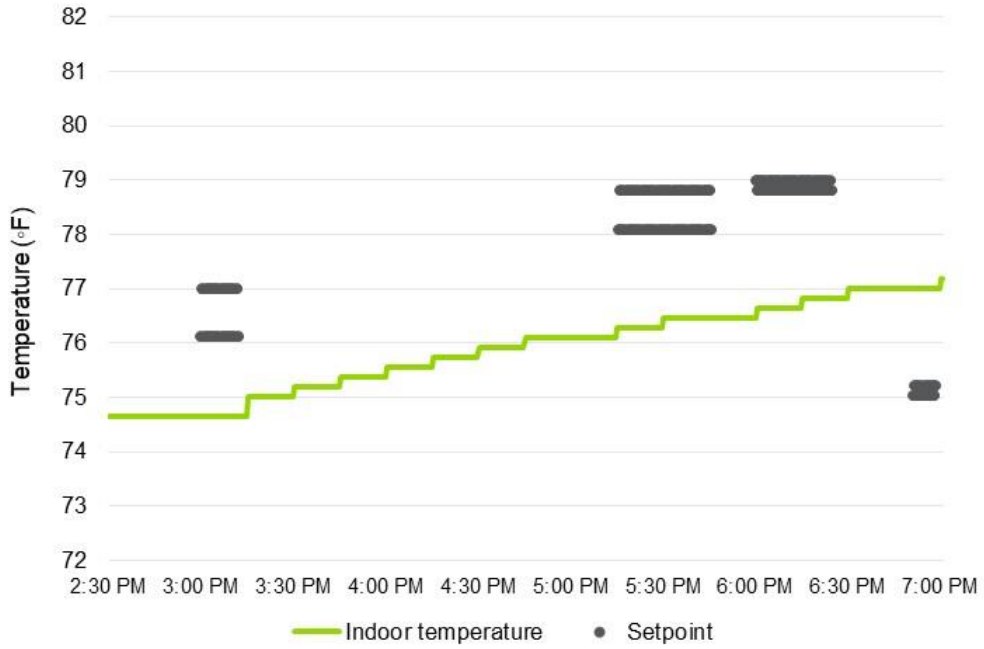
Figure A-2. Systematic Fluctuation – Failed Attempt



Source: Navigant analysis of device telemetry data from PPC

Figure A-3. Systematic Fluctuation – Successful Attempt



Source: Navigant analysis of device telemetry data from PPC

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APPENDIX B. SURVEY INSTRUMENTS

B.1 Cape Light Compact's Smart A/C Savings Program Post-Event Survey

[SURVEY EMAIL COMMUNICATION]

Email Subject Line: Earn an Amazon Gift Card from Cape Light Compact by telling us about your Smart A/C Savings Program experience!

Dear [Name],

As a participant in the Smart A/C Savings Program, Cape Light Compact would like your feedback to help improve the program. We invite you to take this 5-minute survey in exchange for a **$5 Amazon Gift Card**. This survey is being administered by Cape Light Compact's third-party evaluator, Navigant, and your responses will be treated as confidential.

Since we have several questions about your experience with the Smart A/C Savings Program, we ask that the person in your household who is most familiar with the program and the **[INSERT DEVICE_TYPE]** takes this survey. At the end of the survey, you will be asked to provide your name and email so that we can send you the Amazon Gift Card.

Follow this link to the Survey: **[Link to Survey]**

Or copy and paste the URL below into your internet browser: **[Link to Survey]**

Sincerely,

The Cape Light Compact and the Navigant Evaluation Team

Follow this link to opt out of future Smart A/C Savings Program survey emails: **[Click here to unsubscribe]**

[SAMPLE VARIABLES]

Variable	Value
EVENT_DATE	August 29th, 2018
DEVICE_TYPE	Wi-Fi Thermostat, Sensibo
END_USE_TYPE	Central air conditioner, ductless mini-split
EVENT_STARTTIME	3:00 PM
EVENT_ENDTIME	7:00 PM

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[SURVEY START]

Customer Event Awareness

1. The Smart A/C Savings Program helps you earn incentives from Cape Light Compact for saving energy during periods of high energy demand (aka "Events"), while still keeping you comfortable. During an Event, Cape Light Compact has the ability to adjust the cooling of your **[INSERT END_USE_TYPE]** by sending a signal to your **[INSERT DEVICE_TYPE]** and adjusting your **[INSERT DEVICE_TYPE]** setpoint.

   Has Cape Light Compact called an Event since you enrolled in the Smart A/C Savings Program?
   a. Yes
   b. No
   c. Don't know

[IF Q1 = a, CONTINUE. ELSE SKIP TO Q5]

2a. Were you aware that an Event occurred on **[INSERT EVENT_DATE]**?
   a. Yes
   b. No
   c. Don't Know

[IF Q2a = a, CONTINUE. OTHERWISE SKIP TO Q5]

2. How did you know when the Event on **[INSERT EVENT_DATE]** was occurring? **[OPEN-END]**

3. In general, how satisfied are you with the notification you received about the Event on **[INSERT EVENT_DATE]**?

   Please rate your satisfaction on a scale of 1 to 5, where 1 means "Very Dissatisfied" and 5 means "Very Satisfied."

a. Very Dissatisfied	b.	c.	d.	e. Very Satisfied	f. Have not received notifications	g. Don't Know
1	2	3	4	5		

[IF Q3 = a-d (1-4), CONTINUE. OTHERWISE SKIP]

4. How could the Event notifications be improved? **[OPEN-END, OPTIONAL]**

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5. Cape Light Compact called an Event on **[INSERT EVENT_DATE]**, starting at **[INSERT EVENT_STARTTIME]** and ending at **[INSERT EVENT_ENDTIME]**.

   Which of the following statements applies to you? (Select only one)
   a. I was home during this entire period.
   b. I was home for only part of this period (*specify the hours you were home*). **[OPEN-END]**
   c. I was not home during any of this period and was not monitoring my home's temperature on a smart phone app.
   d. I was not home during any of this period, but I was monitoring my home's temperature on a smart phone app.
   e. Don't Know

[IF Q5 = c OR d, CONTINUE. OTHERWISE SKIP TO Q7]

6. Was another member of your household at home on **[INSERT EVENT_DATE]**, between **[INSERT EVENT_STARTTIME]** and **[INSERT EVENT_ENDTIME]**? (Select only one)
   a. At least one other member of my household was at home for this entire period.
   b. At least one other member of my household was at home, but for only part of this period (*specify the hours during which at least one other household member was home*). **[OPEN-END]**
   c. No other members of my household were home.
   d. Don't Know

Customer Comfort

[IF Q5 = a OR b, OR IF Q6 = A OR b, CONTINUE. ELSE SKIP to Q9]

7. How would you describe the comfort level of your home on **[INSERT EVENT_DATE]** compared to a typical day with similar outdoor temperatures?

a. Much Less Comfortable	b. Less Comfortable	c. About the same	d. More Comfortable	e. Much More Comfortable	I. Don't Know
1	2	3	4	5	

[IF Q7 = a-b (1-2), CONTINUE. OTHERWISE SKIP TO Q9]

8. What caused your discomfort on **[INSERT EVENT_DATE]**? (select all that apply)
   a. Too cold
   b. Too warm
   c. Too humid
   d. Too dry
   e. Other (*Please specify*) **[OPEN-END]**
   f. Don't know

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Customer Behavior

9. We'd like to understand how you typically used your **[INSERT END_USE_TYPE]** throughout the past summer. Which of the following best describes the way you use your air conditioner? (select one)
    a. Turn on cooling at the beginning of summer, follow a temperature schedule, and turn off cooling at the end of the summer
    b. Only turn on cooling when it's hot and/or humid and otherwise have my air conditioner off or in heating mode
    c. Other (Please describe) **[OPEN-END]**

10. Which of the following best describes your [INSERT END_USE_TYPE] usage on [INSERT EVENT_DATE] prior to [INSERT EVENT_STARTTIME]? (select one)
    a. My air conditioner was following a temperature schedule
    b. My air conditioner was off or in heating mode
    c. Other (Please describe) [OPEN-END]

[IF Q10 = b, SKIP TO Q14. ELSE CONTINUE]

11. At any point before or during the Event period of **[INSERT EVENT_STARTTIME to EVENT_ENDTIME]** on **[INSERT EVENT_DATE]**, did you or any other members of your household adjust your **[INSERT DEVICE_TYPE]**'s setpoint? (select all that apply)
    a. Yes, adjusted [INSERT DEVICE_TYPE] before the hours of [EVENT_STARTTIME to EVENT_ENDTIME]
    b. Yes, adjusted [INSERT DEVICE_TYPE] during the hours of [EVENT_STARTTIME to EVENT_ENDTIME]
    c. No
    d. Don't Know

[IF Q11 ANSWER INCLUDES a, CONTINUE. OTHERWISE SKIP TO Q13]

12. Why did you or another household member adjust your thermostat before the hours of **[INSERT EVENT_STARTTIME to EVENT_ENDTIME]** on **[INSERT EVENT_DATE]**? (select all that apply)
    a. Home temperature was too cool
    b. Home temperature was too warm
    c. Did not want house to get too warm/uncomfortable later in the day
    d. Someone in the home needed the temperature adjusted for health reasons
    e. Was uncomfortable during previous Events
    f. Other (Please specify) **[OPEN-END]**
    g. Don't Know

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[IF Q11 ANSWER INCLUDES b, CONTINUE. OTHERWISE SKIP TO Q14]

13. Why did you or another household member adjust your thermostat during the hours of **[INSERT EVENT_STARTTIME to EVENT_ENDTIME]** on **[INSERT EVENT_DATE]**? (select all that apply)
    a. Home temperature was too cool
    b. Home temperature was too warm
    c. Did not want house to get too warm/uncomfortable
    d. Someone in the home needed the temperature adjusted for health reasons
    e. Was too uncomfortable during previous Events
    f. Other (*Please specify*) **[OPEN-END]**
    g. Don't Know

14. What actions, if any, did you take to reduce your electricity use on **[INSERT EVENT_DATE]** when an Event occurred? (choose all that apply)
    a. Discussed energy conservation strategies with my family
    b. Participated in activities outside of my home
    c. Did not use certain appliances
    d. Other (Please specify) **[OPEN-END]**
    e. None
    f. Don't Know

Satisfaction

15. In future summers, would you continue to participate in the Smart A/C Savings Program?
    a. Yes
    b. No. (Please explain) **[OPEN-END, OPTIONAL]**
    c. It depends. (Please explain) **[OPEN-END, OPTIONAL]**

[IF Q15 = b or c, CONTINUE. OTHERWISE SKIP TO Q17]

16. What change(s) to the Smart A/C Savings Program would encourage you to continue participating? **[OPEN-END, OPTIONAL]**

[IF Q15 = a, CONTINUE. OTHERWISE SKIP TO Q18]

17. What recommendations would you make to help improve the Smart A/C Savings Program going forward? **[OPEN-END, OPTIONAL]**

18. We have reached the end of the survey. Do you have any additional comments regarding Cape Light Compact's Smart A/C Savings Program? **[OPEN-END, OPTIONAL]**

19. Thank you for taking the time to complete this survey! Please provide your contact information so that we may email you a $5 Amazon Gift Card.
    Prefer Not To Provide Contact Information **[CHECK BOX]**
    First Name: **[OPEN-END]**
    Last Name: **[OPEN-END]**
    Email: **[OPEN-END]**

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B.2 Cape Light Compact's Smart A/C Savings Program Post-Season Survey

[SAMPLE VARIABLES]

Variable	Value
DEVICE_TYPE	Wi-Fi Thermostat, Sensibo
END_USE_TYPE	central air conditioner, ductless mini-split
PARTICIPANT_TYPE	New participant, Returning participant
CHANNEL_TYPE	BYOT, Non-BYOT

[SURVEY START]

Motivation for Participation

[If CHANNEL_TYPE = BYOT, CONTINUE. ELSE SKIP TO Q2]

1. What were your main reasons for getting a Wi-Fi thermostat(s)? (select all that apply)
    a. Ability to remotely control thermostat
    b. "Learning" features offered by the thermostat
    c. Save money on my energy bills
    d. Maximize comfort in my home
    e. Reduce my environmental impact
    f. I wanted the latest and greatest technology
    g. I was encouraged by my home energy auditor
    h. Incentive(s) offered. *(Please specify the incentive(s) you received)* **[OPEN-END]**
    i. Other. (Please specify) **[OPEN-END]**

[If PARTICIPANT_TYPE = New Participant, CONTINUE. ELSE SKIP TO Q3]

2. How did you become aware of the Cape Light Compact Smart A/C Savings Program? (Select all that apply)
    a. Cape Light Compact Website
    b. Email from Cape Light Compact
    c. Email from thermostat manufacturer
    d. Social media
    e. Cape Light Compact e-newsletter
    f. TV
    g. Print ad
    h. HES energy specialists
    i. Word of mouth
    j. Other. *(Please specify)* **[OPEN-END]**
    k. Don't Know

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3. Which of the following were motivations for your participation in Cape Light Compact's Smart A/C Savings program in 2018? (Select all that apply)
    a. Receive participation incentives
    b. Save money on my energy bills
    c. Maximize comfort in my home
    d. Reduce my environmental impact
    e. **[IF DEVICE_TYPE = SENSIBO]** Receive free Sensibo Sky
    f. Other. *(Please specify)* **[OPEN END]**

Comfort and Behavior During Events

4. The Smart A/C Savings Program helps you earn incentives from Cape Light Compact for saving energy during periods of high energy demand (aka "Events"), while still keeping you comfortable. This summer, for the Events you can recall, about how often were you or another family member home during the Event hours?
    a. Home for all Event hours
    b. Home for most Event hours
    c. Home for some Event hours
    d. Never at home during Event hours
    e. Don't know

[If Q4 = d OR e, SKIP]

5. When you or a family member were at home for any part of an Event, what actions, if any, did you take to reduce your electricity use during the Event? (select all that apply)
    a. Discussed energy conservation strategies with my family
    b. Pre-cooled my home before the event
    c. Participated in activities outside of the home
    d. Avoided use of certain appliances or electricity intensive devices
    e. None
    f. Other. (Please specify) **[OPEN END]**
    g. Don't know

[IF Q4 = a, b, OR c, CONTINUE. ELSE SKIP TO Q7]

6. During the Events, how would you generally describe your comfort compared to typical afternoons with similar outdoor temperatures? Would you say it was…?

a. Much Less Comfortable	b. Less Comfortable	c. About the same	d. More Comfortable	e. Much More Comfortable	f. Don't Know
1	2	3	4	5	

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7. On Event days, did you ever "opt-out" or override your **[DEVICE_TYPE]** setting to stop the program from adjusting your **[DEVICE_TYPE]** during the Event (either through the app or on the device itself)?
    a. Yes
    b. No
    c. Don't know

[IF Q7 = a, CONTINUE. OTHERWISE SKIP TO Q12]

8. How often would you say you chose to override the scheduled event **[DEVICE_TYPE]** setting once the event was in-progress? Would you say…
    a. Every event
    b. Most events
    c. Some events
    d. Rarely
    e. Never
    f. Unsure/Don't know

[IF Q8 = e, SKIP TO Q12]

9. For what reason(s) did you opt-out or override the **[DEVICE_TYPE]** setting during event(s)? (select all that apply)
    a. Someone in the home needed the temperature cooler (e.g., health reasons)
    b. Someone in the home wanted the temperature cooler
    c. Wanted the home cooler for a pet
    d. Felt too uncomfortable during previous Events
    e. Had guests/visitors over
    f. Other (Please specify) **[OPEN END]**
    g. Don't know

10. Using a scale of 1 to 5, where 1 means "Very Difficult or Confusing" and 5 means "Very Easy", how easy was it to opt-out of or override Events?

a. Very Difficult/ Confusing	b.	c. Neutral	d.	e. Very Easy	g. Don't Know
1	2	3	4	5	

[IF Q10 = a-b (1-2), CONTINUE ELSE SKIP TO Q12]

11. What issues did you encounter when trying to opt-out or override scheduled events? **[OPEN-END]** _____

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12. On a scale of 1 through 5, where 1 is "Very dissatisfied" and 5 is "Very satisfied", how would you rate your satisfaction with the following aspects of the **Smart A/C Savings** program?

	a. Very Dissatisfied	b.	c. Neutral	d.	e. Very Satisfied	f. Don't know
	1	2	3	4	5	
13a. Event notification						
13b. Number of Events during the 2018 summer season						
13c. Length of Events						
13d. Timing of Events (i.e., what period during the day events occurred)						

[IF Q13a = a-b (1-2), CONTINUE. ELSE SKIP TO Q15]
13. Please let us know why you are not satisfied with notification of Events.
[OPEN-END] _____

[Q13b = a-b (1-2), CONTINUE. ELSE SKIP TO Q16]
14. Please let us know why you are not satisfied with the number of Events.
[OPEN-END] _____

[Q13c = a-b (1-2), CONTINUE. ELSE SKIP TO Q17]
15. Please let us know why you are not satisfied with the length of Events.
[OPEN-END] _____

[Q13d = a-b (1-2), CONTINUE. ELSE SKIP TO Q18]
16. Please let us know why you are not satisfied with the timing of Events.
[OPEN-END] _____

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Program Information/Resources

17. How useful was the information about the Smart A/C Savings program that was provided on CLC's website?
    a. Very useful
    b. Somewhat useful
    c. Only slightly useful
    d. Not useful at all
    e. Did not review program information provided on website
    f. Don't know

18. Were you aware that CLC's Vendor, People Power, sent performance reports via email following the end of each event?
    a. Yes
    b. No
    c. Don't know

[IF Q18=a, CONTINUE TO 19, OTHERWISE SKIP TO Q21].

19. How frequently did you review the performance reports following an Event?
    a. Always
    b. Often
    c. Occasionally
    d. Never

20. How useful did you find the information provided in the performance reports to be?
    a. Not useful at all
    b. Only slightly useful
    c. Somewhat useful
    d. Very useful
    e. Don't know

Program Satisfaction

21. Do you have any comments on the usability of your **[DEVICE_TYPE]** in general over the course of the summer? _____ **[OPEN-END, OPTIONAL]**

22. In future summers, on a scale of 1-5, where 1 is "Very Unlikely" and 5 is "Very Likely," how likely would you be to participate in CLC's Smart A/C Savings program?

a. Very Unlikely	b.	c.	d.	e. Very Likely	f. Don't Know
1	2	3	4	5	

[IF Q22 = a OR b, CONTINUE. OTHERWISE SKIP TO Q24]

23. What change(s) to CLC's Smart A/C Savings program would encourage you to continue participating? **[OPEN-END, OPTIONAL]**

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[IF Q22 = c - f, CONTINUE. OTHERWISE SKIP TO Q25]

24. What recommendations would you make to help improve CLC's Smart A/C Savings program going forward? **[OPEN-END, OPTIONAL]**

25. We have reached the end of the survey. Do you have any additional comments regarding Cape Light Compact's Smart A/C Savings Program? **[OPEN-END, OPTIONAL]**

26. Thank you for taking the time to complete this survey! Please provide your contact information so that we may email you a $10 Amazon Gift Card.
    Prefer Not To Provide Contact Information **[CHECK BOX]**
    First Name: **[OPEN-END]**
    Last Name: **[OPEN-END]**
    Email: **[OPEN-END]**

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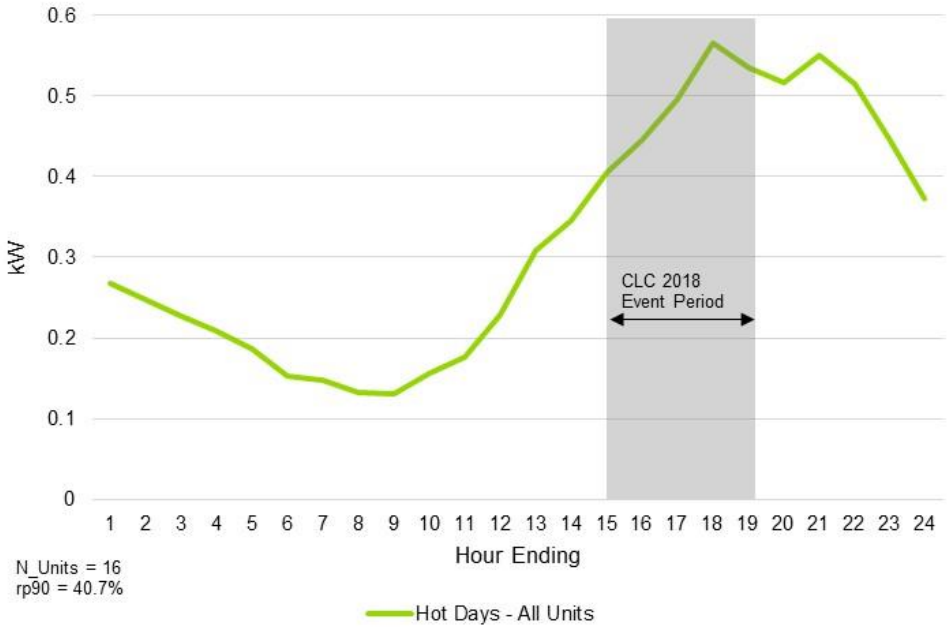
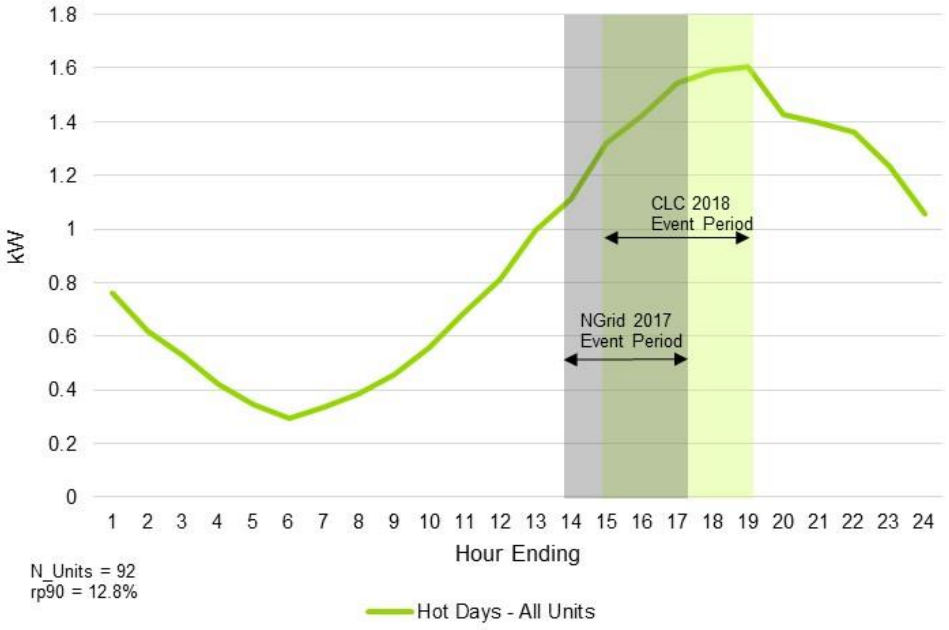
APPENDIX C. ANALYSIS OF DATA FROM THE 2017 BASELINE STUDY

Figure C-1. Ductless Mini-Split Average Daily Load on Hot Days



Source: 2017 Residential Baseline Load Shape Study

Figure C-2. Central Air Conditioners Average Daily Load on Hot Days



Source: 2017 Residential Baseline Load Shape Study

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