Memorandum

To: **Massachusetts Program Administrators and Energy Efficiency Advisory Council Consultants**

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Date: **April 16, 2021**

Re: **Wi-Fi Thermostat Process Evaluation: Customer Survey Findings**

Background

The Guidehouse evaluation team is conducting a statewide Massachusetts Wi-Fi Thermostat Evaluation study (RES 24) for the Massachusetts Program Administrators (PAs) and the Energy Efficiency Advisory Council (EEAC) consultants. The primary goal of this study is to estimate overall electric savings, heating and cooling electric savings, and gas heating savings due to Wi-Fi thermostats delivered through Mass Save retail channels. A key component of the study is a large-scale survey of retail channel thermostat purchasers who received Mass Save rebates in 2018 and 2019. The evaluation team will use the demographic variables derived from the survey in its impact evaluation to:

- Improve matching of the treatment group (earlier participants) and a matched comparison group (later participants)
- Include directly in the regression modeling to minimize selection bias and misspecification bias[1]

This study also provides the PAs with primary data characterizing thermostat adopters, which may help shed light on why evaluated savings fall below or above expected savings. The survey investigated customer behavior regarding Wi-Fi thermostats, characteristics of Wi-Fi thermostat adopters, and concurrent household changes typically associated with the installation of a Wi-Fi thermostat. The survey was designed to explore the causal mechanisms and channels behind savings, paint a clearer picture of customer behaviors that may affect savings (e.g., setpoints, schedule, fiddling behavior), and qualitatively explore which characteristics may be changing over time in the thermostat-adopting population.

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[1] Previous studies have employed matching methods based solely on past energy usage. This study will explore whether adding survey data on installation, demographics, or the behavioral and attitudinal characteristics of participants (including concurrent equipment installations) will improve regression models.

This memo summarizes findings on the characteristics and behaviors of Wi-Fi thermostat adopters from surveys conducted with two populations of Wi-Fi thermostat rebate recipients:

- **Wave 1:** 2018 rebate recipients; n=2,412 survey responses; fielded between August and September 2019[2]
- **Wave 2:** 2019 rebate recipients; n=2,978 survey responses; fielded between July and November 2020

The Guidehouse team fielded the Wave 2 survey during the COVID-19 pandemic, though all surveyed customers purchased thermostats before the pandemic's outbreak in Q1 2020. We designed the survey to capture the use of the old thermostat prior to purchasing the new Wi-Fi thermostat, as well as use of the new thermostat before the pandemic began. Specifically, the team modified the main set of survey questions fielded in Wave 2 to reference the period before the COVID-19 pandemic (i.e., before March 2020). The survey explicitly asked customers to think about their homes, heating and cooling, and thermostat use before March 2020, to mitigate the potential for their answers to be skewed by sometimes markedly different experiences and behaviors during the pandemic relative to before.

Considering that Wave 2 survey respondents are intended to serve as a comparison group for Wave 1 respondents in the impact evaluation, the evaluation team is most interested in behaviors that occurred before 2020 because the impact evaluation will focus on 2018 savings. Within that analysis the role of the Wave 2 survey is to validate the use of the 2019 purchasers as a comparison group for 2018 purchasers.

To understand how the pandemic may have affected customers' home occupancy and behaviors, the team asked a separate set of questions about the COVID-19 time period (March 2020 through survey completion). This demarcation hopefully helped further isolate the COVID-19 period and experience as separate from the main survey questions. The COVID-19-specific findings are reported separately in the COVID-19 Occupancy and Behaviors section.

Summary of Key Findings

This section will present behavioral, demographic, and concurrent household change results for the overall population of thermostat adopters surveyed (i.e., pooling 2018 and 2019 participants). It will then identify (a) differences between participants in 2018 and 2019 and (b) participants who replaced a manual or programmable thermostat.

Overall Survey Results

Survey results suggest participants' thermostat behavior changed after purchasing a Wi-Fi thermostat, as they started to take advantage of the device's scheduled and automated features and the ability to adjust setpoints remotely. Respondents reported using the automated or learning mode, or setting a program or schedule, more frequently with their new Wi-Fi thermostat. They also reported manually controlling their devices less frequently. Respondents indicated they used more efficient average setpoints with their new Wi-Fi thermostats relative to old thermostats, specifically at night and when the home was unoccupied. Average summer setpoints were statistically higher during the day or evening, when people were home and when the home was unoccupied. Respondents mentioned adjusting the thermostat remotely for heating or cooling as a key difference relative to how they used their old thermostat.

Demographic findings from the survey suggest that though many types of households participated in the program, few were low or moderate income. Only 14% of respondents reported low-to-moderate incomes[3] for their household size, compared with 29 - 41% of Massachusetts household, while 62%

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[2] See Table 2 for detailed installation dates and sample frame disposition.
[3] Similar to Home Energy Services thresholds, Guidehouse considered 2018 self-reported income between 61% and 80% of the state median income (per Low Income Home Energy Assistance Program (LIHEAP) guidelines) to be moderate income and

reported incomes above 120% of the state median for their household size. [4] About half (52%) of respondents reported having at least one adult in the household who does not work or attend school out of the home (including working or attending school from home, retired, stay-at-home caregivers, medical/disability/parental leave, or currently unemployed). Approximately 50% of respondents reported having at least one child under 18 in the household and 25% a child under 6. While nearly all respondents reported speaking English at home (98%), 25% reported they also speak a language other than English at home.

Many participants reported experiencing home or household changes concurrent with thermostat installation. The most frequent housing-related change that people reported in the past 2 years was installing a new heating or cooling system (20% of respondents). Among those who installed a new heating or cooling system in the last 2 years, 45% completed the project within 2 months (before or after) of installing their new thermostat. In total, 9% of the sample installed a new heating or cooling system within 2 months of installing a new thermostat, and 5% added new or more insulation within 2 months of thermostat installation. The most frequently reported household change in the past 2 years was a new infant in the home (9% of respondents). Among respondents who reported a new infant in the home in the past 2 years, 24% placed the timing within 2 months of the thermostat installation. In total, 2% of the sample reported a new infant within 2 months of installing a new thermostat.

Most respondents (97%) indicated they purchased the unit to replace an existing thermostat, while 3% purchased it for an area that did not previously have a thermostat. Of those who purchased it to replace an existing thermostat, 53% replaced a programmable thermostat, 34% a manual thermostat, and 12% a Wi-Fi or learning thermostat. A small number of respondents (6%) did not install the Wi-Fi thermostat and an additional 6% did not install the device at their service address. These findings suggest estimation of savings should account for the type of equipment replaced, whether the thermostat was installed, and whether the new thermostat is in use.

Comparison Between Groups

The evaluation team analyzed responses from 2018 and 2019 participants using a Chi-Square test to determine whether there were any systematic differences between the two groups. We conducted symmetric statistical tests to identify differences between adopters who replaced manual versus programmable thermostats. Similarities and differences inform our approach to matching and impact analysis. Differences or similarities between the years clarify the extent to which there are any trends we should be aware of as additional context for our findings. Behavioral differences between participants who replaced manual versus programmable thermostats also help clarify channels for savings and suggest whether Wi-Fi thermostat savings might reasonably be higher or lower for one group relative to another.

As illustrated in Figure 1, survey responses by the two groups are more alike than different. Each dot represents a unique survey question or follow-up question, with green dots, indicating statistically indistinguishable responses and orange dots indicating statistically different responses. More than half (66%) of responses were not statistically different between 2018 and 2019 participants. 2019 adopters showed similar thermostat usage behavior (e.g. use of away settings, manual temperature changes) relative to 2018 adopters during respective baseline periods, adding to our confidence in utilizing 2019 adopters as our comparison group in the impact analysis. The proportion of manual versus programmable thermostat replacers is not statistically different between 2018 and 2019 participants. Some of the key similarities suggested by identical survey responses between the two groups include:

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income less than 60% of state median income to be low income: https://www.mass.gov/files/documents/2018/04/27/FY2018LIHEAPIncomeEligibility.pdf

[4] The Census does not provide a direct comparison so the team considered two estimates: The moderate income threshold of 80% state median income for household size equates to about 360% of the Federal Poverty Line (FPL) and (1) 29% of families reporting income at or below 300% of the FPL for their household size, while (2) 41% of families are at or below 400% FPL for their household size. As an additional comparison, the moderate income of threshold of 80% state median income equates to an income of about $75,000 for a family of three (close to the average in this survey), and 49% of Massachusetts households have incomes below $75,000 regardless of household size. Source: Source: US Census American Community Survey, 2014-2018 5-Year Estimates.

- Thermostat installation status

- Household size

- Winter and summer adjustment method (i.e., automated or manual) with old thermostat

- Winter and summer adjustment frequency with old thermostat

- Temperature profiles with old thermostats

- Technology adoption

Figure 1. Statistical Significance of Survey Responses by 2018 and 2019 Participants
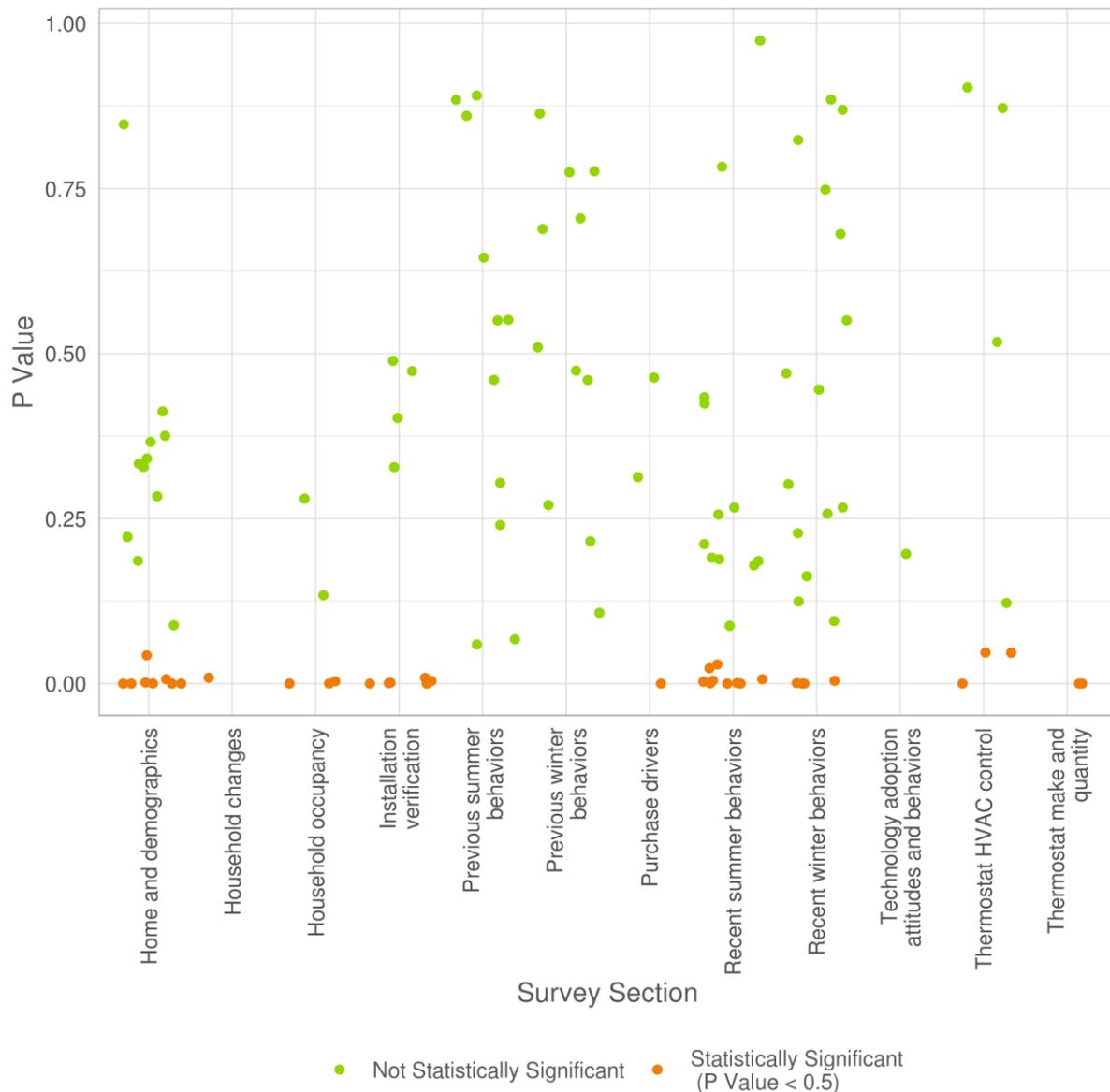
Given the overall similarity of these groups in terms of demographics, behavior and the type of thermostat replaced, participants from 2019 should serve as a suitable comparison group for 2018 participants in estimating impacts. Most differences between these groups were in terms of demographics, motivations for participation and recent summer usage behaviors. These differences are explored in the 2018 Versus 2019 Participants section, and will be carefully accounted for in our matching and impact estimation strategies to mitigate remaining sources of bias.

While responses from 2018 Versus 2019 participants were more similar than different, especially in areas we might expect to impact usage such as behaviors, those replacing manual versus programmable thermostats showed more compelling differences. ***We found consistent differences in thermostat usage behaviors between the adopters who replaced programmable or manual devices. Homes that replaced manual thermostats were more likely to frequently adjust temperatures with their old thermostat, while adopters who previously had a programmable thermostat were more likely to use the away or automated setting with the old device***. As this difference in usage would likely affect energy consumption, the impact evaluation team should account for replacement device type in the matching process, and in the estimation of impacts.

In terms of demographics and home characteristics, programmable thermostat replacers installed their Wi-Fi thermostats in homes that were more frequently occupied and were more likely to have someone in the home all the time during weekdays throughout the summer and winter. They had larger families and homes relative to manual thermostat replacers and were more likely to be homeowners. Our exploration of similarities and differences between respondents from either year is provided in greater detail in the section Manual Versus Programmable Thermostat Replacers. Table 1 details questions where responses between programmable and manual thermostat replacers were statistically significantly different.

Table 1. Statistically Different Survey Responses by Thermostat Replacement Group

Topic	Programmable Replacers Relative to Manual
Installation verification	Homes are more frequently occupied
Heating and cooling systems	More likely for the new device to control heating and air conditioning
	More likely to have electric baseboard heat
Household occupancy	More likely to have children between 7 and 17
Recent winter behaviors	More likely to change temps throughout the day and night this winter
	Adjusted temperatures less frequently this winter
	More likely to be home all the time during winter weekdays
Recent and previous summer and winter behaviors	More likely to use away setting or automated setting on old and new thermostat during winter and summer
	Less likely to keep temperature the same during summer and winter days with the old thermostat
Recent summer behaviors	More likely to use away setting or automated setting when home was unoccupied for heating
	More likely to be home during the day
Previous summer and winter behaviors	More likely to change temps with old thermostat
	Adjusted temps less frequently during winter and summer with the old thermostat
Previous winter behaviors	Less likely to change how household manages heat
Home and demographics	More likely to own their home
	More likely to live in a single-family home (as opposed to an apartment)
	More likely to have bigger families

Accounting for COVID-19

Our investigation of customers' behaviors specifically during COVID-19 yielded several interesting findings. Compared with prior to the pandemic, during COVID-19 customers reported:

- Spending more time at home

- Increases in the number of people living in the home, with that increase anticipated to continue through the summer

- Higher heating setpoints and more time with the heating system running each day

- Anticipated higher cooling use in the summer

The findings from our COVID-19 exploration are detailed fully in the section COVID-19 Occupancy and Behaviors. As noted above, with the exception of a COVID-19-specific section, the survey was designed to capture the time period before COVID-19 to ensure analogous data for 2018 and 2019 respondents. As such, COVID-19 behaviors are reported in a separate section below and not reflected in Combined Survey Findings

Methodology and Respondent Summary

The Guidehouse team fielded two waves of an online survey among Wi-Fi thermostat retail rebate recipients. We used a mixed-mode recruitment and reminder approach (mail and email) and provided a $30 incentive per completed response (Visa gift card). All sampled customers received an initial push-to-web postcard with PA logos through the US Postal Service, followed by an email invitation. The team sent reminder postcards 1 week after the initial mailing and email reminders approximately 3 weeks after initial contact. In each case, reminders were only sent to customers who had not yet responded.

Wi-Fi retail rebate recipients from all Massachusetts PAs formed the sample frame of rebate recipients eligible for the survey. Table 2 summarizes survey administration dates, the sample frame,[5] and the final respondent group (completed surveys) for both waves. The response rate was considerably higher in Wave 2, despite similar outreach efforts, materials, incentives and follow-up. The Guidehouse team believes this difference may be due to COVID-19 as we saw an increase in survey responses rates on numerous residential surveys in the spring, summer and fall compared with prior years. We do not anticipate the difference in response rates will impact or bias savings estimation, as demographics suggest 2018 and 2019 participants were very similar, as discussed above. Any remaining differences will be accounted for through the matching and regression design.

Table 2. Survey Administration and Sample Summary for Wave 1 and Wave 2

Category	Wave 1	Wave 2
Survey Dates	August-September 2019	July-November 2020
Thermostat Installation Dates*	Q3-Q4 2018†	Q2-Q4 2019‡
Sample Frame	22,590	20,668
Contacted Sample§	10,183	8,254
Completed Surveys‖	2,412	2,978
Response Rate	24%	36%

* The thermostat installation dates were from the rebate databases.

† The Wave 1 sample frame was retail rebate recipients with thermostat install dates from July 2018 through winter/spring 2019. The majority (83%) of rebate applications in the sample had installation dates in Q3 or Q4 2018, while 5% of installation dates were earlier in 2018 and 12% were from 2019.

‡ The Wave 2 sample frame was retail rebate recipients with thermostat install dates from July 2019 through December 2019.

§ The contacted sample received at least one postcard and email.

‖ Additional customers started but did not complete the survey. They are not included in the analysis.

Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

[5] The sample frame is the eligible list of rebate recipients in the program tracking data, from which the evaluation team drew a stratified random sample to administer the survey. In Wave 1, each PA provided tracking data for their respective program. In Wave 2, DNV GL provided program tracking data for all programs. In Wave 1, the range of installation dates varied by PA, while in Wave 2, the installation date ranges were similar across PAs.

The evaluation team designed the sample frame to be representative of thermostat installers by PA fuel type combination based on the tracking data provided, though the team performed oversampling of the smaller PA fuel type combinations to ensure sufficient responses by these smaller categories. Table 3 summarizes the sample frame and distribution of respondents by PA and fuel. Customers who submitted the rebate through National Grid and Eversource make up 43% and 40% of the sample, respectively.[6] Of the sample, 64% submitted the rebate through their natural gas provider and 36% through their electric provider. The impact evaluation group will include variables to control for PA in the regression model.

After fielding the Wave 2 survey, the implementer (DNV GL) discovered 13,695 thermostat customers not included in the initial data transfer. EFI, the program aggregator, identified these customers as *EnergyStar* in the measure description field. The evaluation team selected a random sample of these customers and fielded a second round of the Wave 2 survey with these customers to ensure they had the appropriate probability of being included in the study, thereby mitigating any unobservable bias resulting from their exclusion.

Analysis of Wave 1, Wave 2 and the combined sample is unweighted. As discussed above, any differences between Wave 1 and Wave 2 relevant to impact analysis will be addressed analytically in regression modeling and comparison group selection.

Table 3. Sample Frame and Completed Surveys (Waves 1 and 2 Combined)

Program Administrator	Fuel	Sample Frame*		Completed Surveys	
		n	%	n	%
National Grid	Gas	17,932	41%	1,632	30%
	Electric	4,417	10%	690	13%
Eversource	Gas	7,536	17%	1,098	20%
	Electric	9,386	22%	1,057	20%
Columbia	Gas	2,316	5%	492	9%
Cape Light Compact	Electric	846	2%	137	3%
Liberty	Gas	387	1%	141	3%
Unitil	Electric	154	0%	51	1%
	Gas	98	0%	32	1%
Berkshire	Gas	177	0%	60	0%
Unknown		9	0%	0	0%
Total		**43,258**	**100%**	**5,390**	**100%**

*The combined sample frame is retail rebate recipients with thermostat install dates from July 2018 through December 2019.
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

Combined Survey Findings

The main purpose of the survey was to understand customer behavior regarding Wi-Fi thermostats, characteristics of Wi-Fi thermostat adopters, and concurrent household changes typically associated with the installation of a Wi-Fi thermostat. The following sections describe findings from pooled responses across both survey waves (n=5,390 total). Differences between groups of survey participants are explored in the section Comparison Between Groups.

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[6] The Program Administrators of retail rebate recipients changed between the Wave 1 and Wave 2 sample frames – the Wave 2 sample frame had relatively more National Grid customers (and slightly more Columbia Gas), and relatively fewer Eversource customers. However, similar percentages of customers submitted the rebate through their electric vs. natural gas provider.

## 1. Purchase and Installation Drivers

Most respondents (97%) indicated they purchased the unit to replace an existing thermostat, while 3% purchased it for an area that did not previously have a thermostat. Of those who purchased it to replace an existing thermostat, 53% replaced a programmable thermostat, 34% a manual thermostat, and 12% a Wi-Fi or learning thermostat.

The majority of respondents who received rebates purchased units for their primary residence (93%), while 4% purchased units for a vacation or second home. Only 1% bought the unit for a friend or family member's home and 1% purchased the unit for a rental property. Most respondents installed the purchased Wi-Fi thermostats at the address listed on their rebate form and occupy that residence (93%). Only 6% of respondents installed the purchased thermostat at different addresses or do not occupy the home for which the thermostat was purchased.

Nearly all respondents are using their new thermostat for heating (99%) and about half are also using it for cooling (55%). Of respondents using their new thermostat for heating, the majority are using their thermostat to control natural gas heat (65%), followed by oil (26%), propane (5%), and electric heat (4%).

More than half of respondents purchased one thermostat (59%), one-quarter (25%) purchased two, and 16% purchased three or more thermostats using Mass Save rebates. The most common thermostat brand purchased was Nest (70%) followed by ecobee and Honeywell (17% and 8% of respondents, respectively).
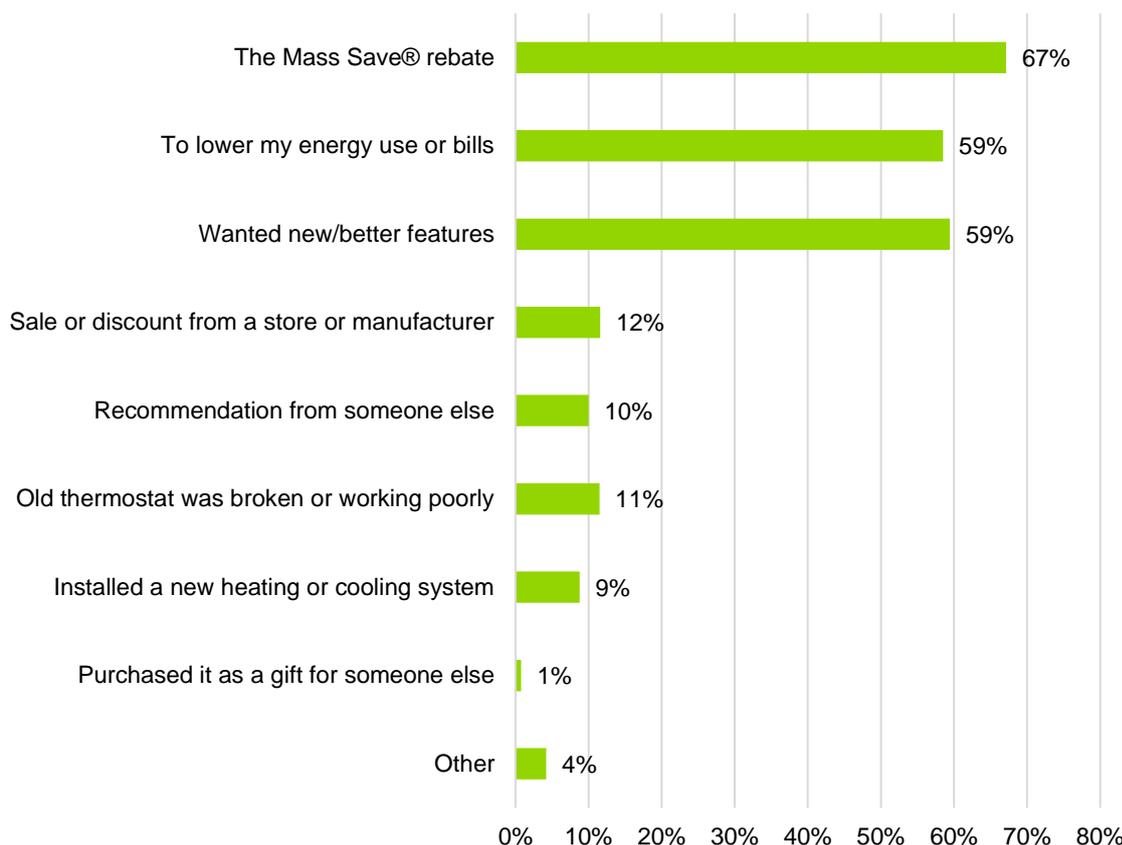
Figure 2. Percentage of Respondents Purchasing at Least One Thermostat of Each Brand (n=5,390)
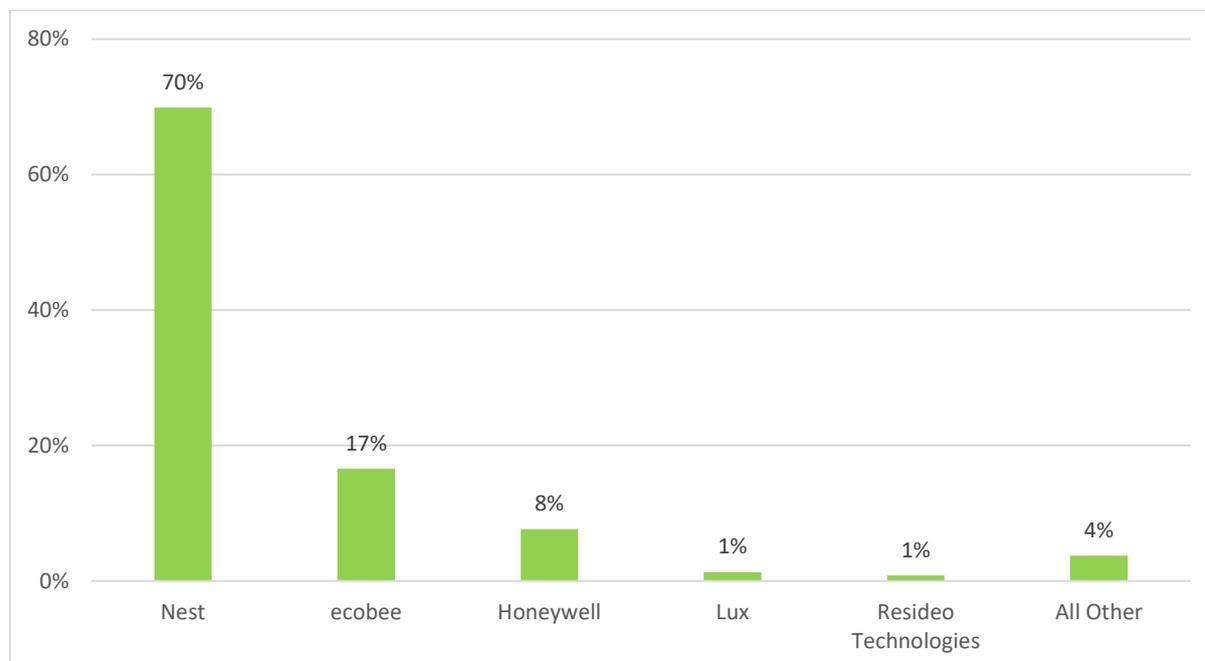
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

The survey asked respondents to select the top three reasons they were motivated to purchase a new thermostat. The Mass Save rebate motivated most respondents to purchase a new thermostat (67%). Lowering energy use or bills and wanting new or better features were equally the next two top motivators (both 59%) (see Figure 3). In the open-ended comments asking for examples of new or better features, respondents mentioned wanting to control the heat or thermostat remotely and over Wi-Fi as a motivator in open-ended comments.

Figure 3. Reasons for Purchasing a New Thermostat (n=2,688)

Reason	Percentage
The Mass Save® rebate	67%
To lower my energy use or bills	59%
Wanted new/better features	59%
Sale or discount from a store or manufacturer	12%
Recommendation from someone else	10%
Old thermostat was broken or working poorly	11%
Installed a new heating or cooling system	9%
Purchased it as a gift for someone else	1%
Other	4%

Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

The majority of respondents (70%) took the survey more than 9 months after submitting the rebate. At the time of the survey, only 6% of respondents had not installed the thermostat. Most customers who had not installed their units expressed they had difficulty or a fear of working with the wiring systems, the units were incompatible with their furnace or HVAC systems, or they had not prioritized installation because of a lack of time or seasonal considerations (e.g., heat not needed yet).[7] Some respondents realized after attempting to install the thermostat themselves that they should hire a contractor, particularly to address wiring concerns. A few respondents expressed they had experienced technical defects when installing the units, either the thermostat was incompatible with their HVAC system and malfunctioned as a result of the install or the device was defective upon delivery. The appendix contains respondent comments about barriers to installation. Several Wave 2 customers mentioned delaying due to the pandemic.

2. Behaviors with the Old and New Thermostat

All respondents who occupy the home for which the thermostat was purchased were asked how they used their old and new thermostats (as applicable) in the summer or winter.[8] For the Wave 2 survey, as described above, the evaluation team asked all respondents to think of the summer and winter

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[7] The Guidehouse team examined installation rates among customers who purchased the thermostat <9 months, 9-12 months and 12+ months before the survey and for Wave 1 respondents (not affected by COVID-19) install rates did not change over time, suggesting that those who had not installed by 9 or 12 months may be unlikely to install. For Wave 2, customers who purchased their thermostats later (late 2019) had a slightly lower install rate, and some open-ended comments indicated a COVID-related delay, so it's possible they may install later.

[8] Respondents who used the thermostat for heating and cooling were only asked about one season (randomly selected). Respondents who had the new thermostat installed in the most recent eligible season (summer or winter) were asked details for the most recent season with the new thermostat and the previous season with the old thermostat. Those who had not yet installed the new thermostat (or used it in a heating or cooling season) were only asked the most recent winter or summer with the new thermostat. For example, Wave 2 customers who installed their new thermostat in September 2019 were asked how they used their new thermostat in winter 2019-2020 (pre-pandemic) and how they used the old thermostat in winter 2018-2019.

before the COVID-19 pandemic. Heating season responses are across heating fuels; the survey asked the same questions regardless of heating fuel. Therefore, heating season behaviors may apply to behaviors within and outside of the PA structure.

With the new thermostat, respondents appeared to be shifting away from manual control of their thermostats toward automated or learning mode or a program. With their old thermostats, respondents reported manual adjustment (i.e., setting the temperature as needed) as their most common strategy—46% in winter and 42% in summer. Using the scheduling feature to program or set a schedule was the second most common strategy with the old thermostat. With the new thermostats, the percentage of respondents reporting manual control as their main strategy declined to about 20% in summer and 16% in winter. More respondents reported using automated features (i.e., allowing the temperature to adjust automatically) as their typical method—about 32% in winter and 33% in summer. Using a schedule or program remained popular with the new thermostat, with 45% of respondents reporting a schedule or program as the most typical approach in winter (33% in summer).

Figure 4. Typical Strategies for Setting Temperature
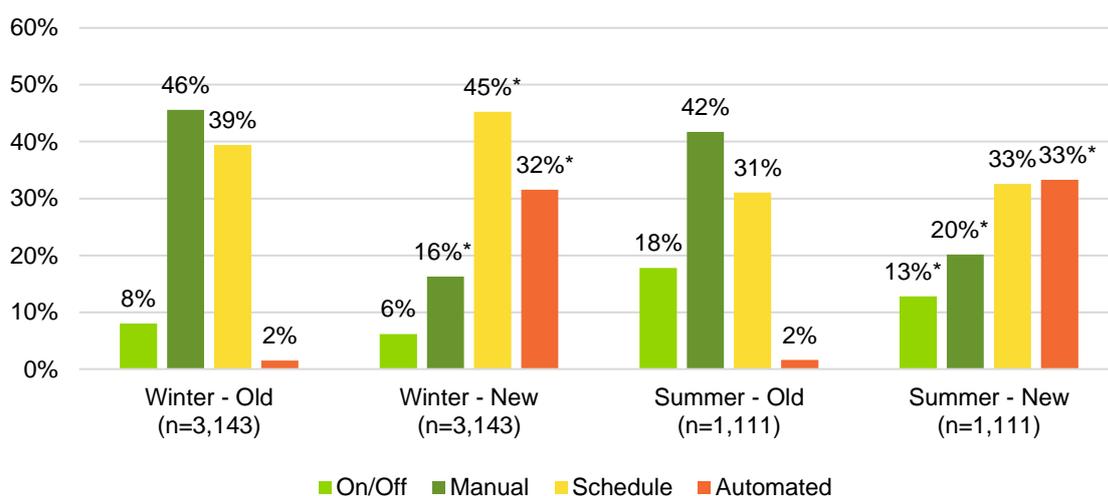
Winter - New refers to the most recent winter with the new thermostat, and Winter - Old refers to the most recent winter with the old (previous) thermostat; similar for Summer - New and Summer - Old.
*Statistically significant difference between new and old behaviors within season (p <0.05).
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

With their new thermostats, fewer respondents reported leaving or setting their thermostat to the same temperature all the time. The majority of respondents reported the temperature varies throughout the day or night using their new thermostat (91% in winter and 86% in summer) compared with the old thermostat (74% in winter and 65% in summer). Customers achieved temperature variation through automation, scheduling or programming, or manual control, as Figure 4 showed above.

Table 4. Variability in Temperature Setting by Season and Old vs. New Thermostat

| Temperature Settings	Winter - Old (n=2,953)	Winter - New (n=2,953)	Summer - Old (n=1,015)	Summer - New (n=1,015)
Temperature was the *same* all the time	25%	9%*	33%	14%*
Temperature was *different* at different times of the day/night	74%	91%*	65%	86%*
Other	1%	0%*	2%	0%*

Winter - New refers to the most recent winter with the new thermostat, and Winter - Old refers to the most recent winter with the old (previous) thermostat; similar for Summer - New and Summer - Old.
*Statistically significant difference between new and old behaviors within season (p <0.05).
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

The team's analysis found that the changes in winter and summer temperature setpoints were toward more efficient levels (relative to the old levels), particularly when homes were unoccupied. Among respondents who reported setpoints with their new and old thermostats in the winter, they reported lower night and away setpoints with the new thermostat, but there were no significant differences during times of the day or night when the home was occupied. In the summer, the pattern differs slightly—respondents reported higher (more efficient) setpoints while they were home and awake or away from home but not overnight (setpoints were similar overnight).

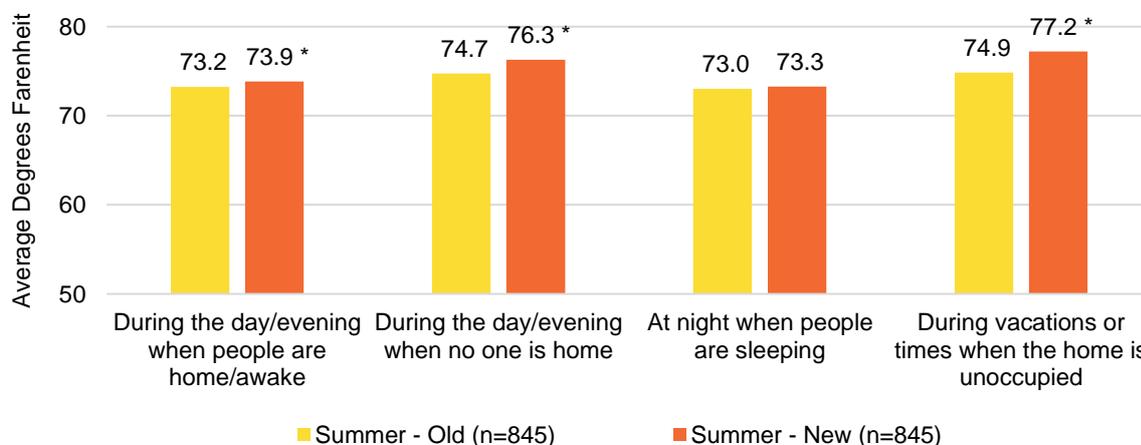**Figure 5. Typical Winter Temperature Setting by Time of Day**
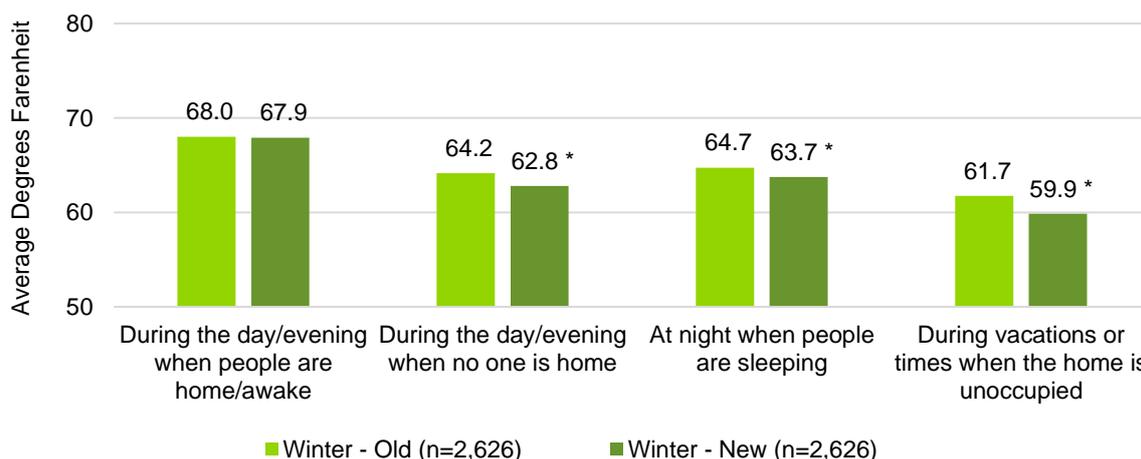
Winter - New refers to the most recent winter with the new thermostat, and Winter - Old refers to the most recent winter with the old (previous) thermostat.
*Statistically significant difference between new and old behaviors within season (p <0.05).
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

Figure 6. Typical Summer Temperature Setting by Time of Day

Summer - New refers to the most recent winter with the new thermostat, and Summer - Old refers to the most recent summer with the old (previous) thermostat.
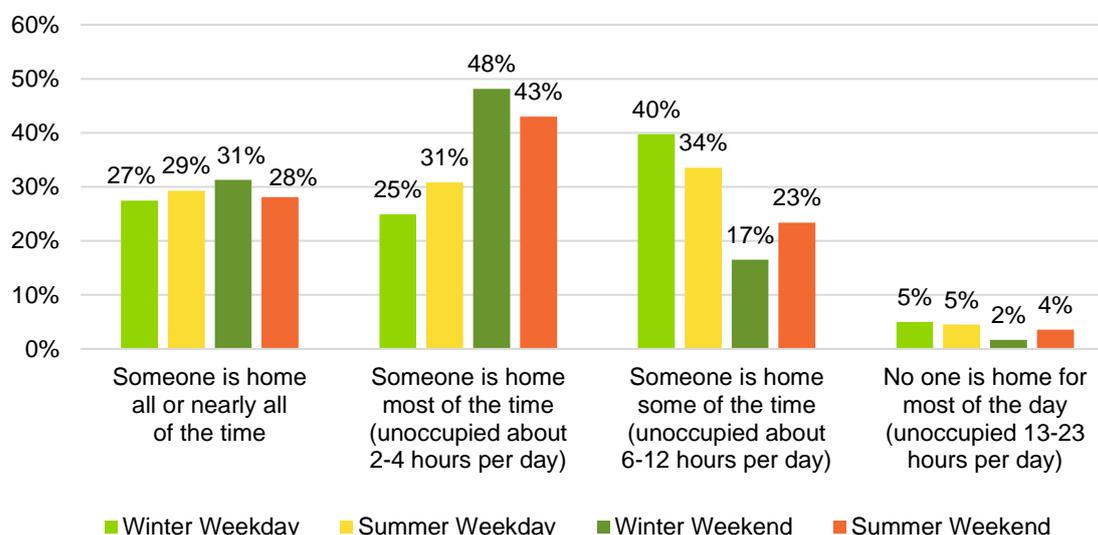*Statistically significant difference between new and old behaviors within season (p <0.05)
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

The times or hours of day that respondents were home should be considered when assessing the potential impact of setpoint changes. Wi-Fi thermostats allow households to save energy and money

by maintaining and optimizing household temperature around daily schedules of home occupancy and vacancy. Households that were unoccupied for portions of the day could have greater opportunity to save energy with Wi-Fi thermostats. Of respondents, 40% of winter respondents and 34% of summer respondents said their home was unoccupied for 6-12 hours per day on weekdays, while 31% of summer respondents and 25% of winter respondents said their home was only unoccupied for 2-4 hours on weekdays (see Figure 7). On the weekends, respondents said they were home slightly more. Across seasons and weekdays/weekends, 27%-31% of respondents (depending on the season and day-of-week) said someone was home all or nearly all the time.

Figure 7. Summer and Winter Household Occupancy Patterns (n=5,264)

Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

Respondents reported making fewer changes or adjustments using their new thermostats than their old thermostat, particularly in the winter (36% adjusted multiple times per day with the old thermostat in the winter compared with 18% with the new thermostat). The percentage of customers who made changes or adjustments once daily or 4-6 times per week stayed about the same. Slightly more respondents reported adjusting only -3 times per week, which suggests less fiddling with the new thermostat.

We found statistically significant difference in thermostat adjustment frequency by brand with the new smart thermostats. For the winter, Lux thermostats were adjusted less frequently; Honeywell devices was more likely to be adjusted once a month or never; and Nest thermostats were slightly more likely to be adjusted multiple times a day. For the summer, Nest devices were more likely to be adjusted and Honeywell thermostats were less likely.

**Table 5. Frequency of Thermostat Adjustments Made by Household Members
(by Season and Old vs. New Thermostat)**

Adjustment Behavior: Frequency of Changes/Adjustments	Winter - Old (n=2,953)	Winter - New (n=2,953)	Summer - Old (n=1,015)	Summer - New (n=1,015)
Multiple times daily	36%	18%	39%	27%
Once daily	16%	16%	19%	17%
4-6 times a week	10%	11%	11%	11%
2-3 times a week	13%	20%	10%	20%
Once a week	7%	15%	6%	10%
Once a month	5%	8%	3%	5%

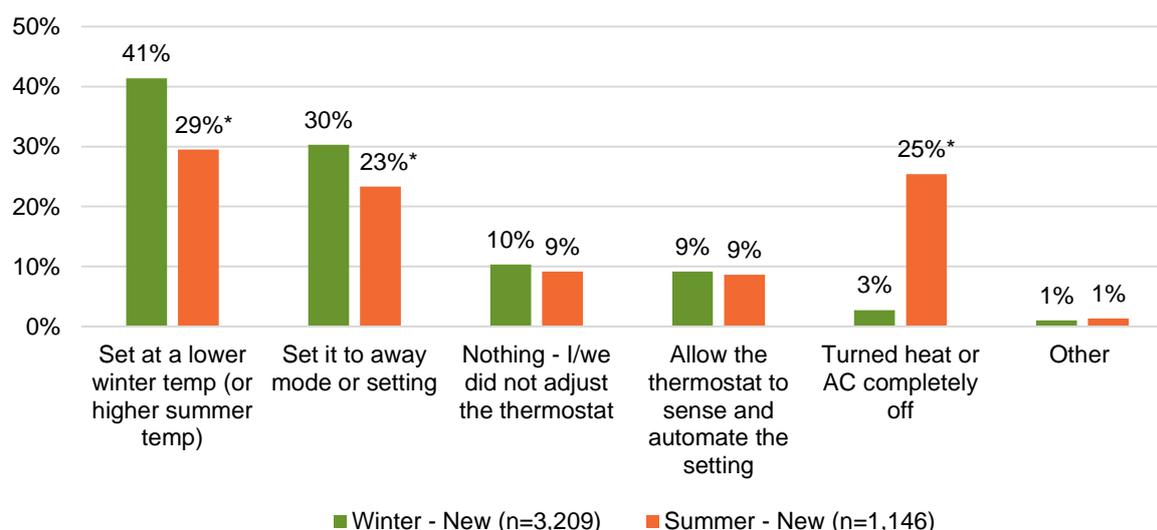|				
Never	9%	10%	9%	7%
Other	1%	2%	0%	2%

"Winter - New" refers to the most recent winter with the new thermostat and "Winter - Old" refers to the most recent winter with the previous (old) thermostat; similar for "Summer - New" and "Summer - Old."
*Statistically significant difference between new and old behaviors within-season (p<0.05).
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

When respondents were away from home for a day or more, the majority (about 90%) either adjusted their thermostat or allowed the thermostat to sense and adjust (e.g., home/away mode).[9] In the winter, the most common action was to set the heat at a lower temperature (41%), while only 3% reported turning the heat completely off. About 30% reported using the thermostat's away mode when away in the winter. Summer behaviors were a bit different, with slightly fewer (29%) manually adjusting the temperature to a higher setting and slightly fewer (23%) using an away mode; one-quarter (25%) turned their cooling systems off.[10]

Figure 8. Typical Away Strategy Using New Thermostat

Winter - New refers to the most recent winter with the new thermostat, and Summer - New refers to the most recent summer with the new thermostat.
*Statistically significant difference between seasons (p<0.05).
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

The survey also included an open-ended question for respondents to explain how they were managing their heat or cooling differently with the new thermostats to capture any behaviors the close-ended survey options did not consider. Many responses involved using features only available with Wi-Fi systems or smart/learning thermostats:

- Managing or adjusting the thermostat remotely or through their phone (31%-35% of respondents mentioned)
- Using automated, sensing or learning features (24-25% of respondents)
- Using a home/away features (11-18% of respondents)
- Pre-heating or pre-cooling homes (6-8% of respondents).

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[9] Nearly all Wi-Fi thermostats offer some type of feature or setting for times when the home is unoccupied, which the survey referred to generally as an "Away" mode or setting, though different brands may use specific names (e.g., Nest "Home/Away Assist").
[10] In the most recent summer with the new thermostat, about 36% of respondents reported turning their system on and off as needed rather than letting it remain in cooling mode all the time (63%). The evaluation team does not yet have enough responses about cooling mode in the last summer with the old thermostat to determine if there were any changes in how the cooling system was managed (e.g., manual on/off vs. always-on cooling mode) between the old and new thermostats.

However, respondents also mentioned features or behaviors that are possible without Wi-Fi or smart features:

- Programming or setting a schedule (12%-20% of respondents)
- Making fewer adjustments (10-12% of respondents).

Households using a schedule or program for the first time included those upgrading from programmable thermostats who found the new thermostat(s) easier. The appendix contains verbatim survey responses about how they are using their new thermostats differently in the winter and summer.

3. Concurrent Housing and Household Changes

Using matched comparison groups within billing analysis to estimate Wi-Fi thermostat savings may result in biased results if the timing of the thermostat installation coincides with other life changes or home improvements that affect current or future energy use. Major changes affecting the trajectory of energy use that occur around the same time as thermostat installation are difficult to disentangle without primary data; hence, the effects of major occupancy or equipment changes may bias savings findings. Capturing information on behavior and household changes directly through surveys allows the evaluation team to identify participant and comparison group households that appear to be on similar life trajectories, mitigating potential selection bias during the billing analysis phase of this study. Insights into concurrent household changes typically experienced by Wi-Fi thermostat installers may also help the PAs optimize program design and delivery.

Guidehouse asked all respondents about any changes to their home or household in the past 2 years that may affect energy use. The most common housing-related change respondents reported was installing a new heating or cooling system (20% of respondents, see column A of Table 6). Among those who installed a new heating or cooling system in the last 2 years, 45% completed the project within 2 months (before or after) of installing their new thermostat (column B of Table 6). Combining these rates, about 9% of the sample installed a new heating or cooling system within 2 months of installing a new thermostat (column C of Table 6). The second most common change was adding new or more insulation to their home (19%)—28% did this within 2 months of installing the new thermostat. In the impact analysis, we will explore using reported large changes in the matching algorithm, as well as including variables in the regression model to control for these differences

**Table 6. Housing Changes in Last 2 Years (Column A) and
Timing Relative to
Thermostat Installation (Column B) (n=4,976)**

Housing or Equipment Change	Respondents Reporting Change in Last 2 Years (Percentage)	Change Made within 2 Months of Thermostat Installation (as % of Changers)	Combined Percentage (of Respondents who Made Change within 2 Months of Install)
	(A)	(B)	(A X B)
Installed a new heating or cooling system	20%	45%	9%
Added new/more insulation in your attic, walls, or basement	19%	28%	5%
Remodeled your home	12%	25%	3%
Installed a solar PV system	4%	21%	1%
Completed an addition of conditioned space (heated or cooled)	4%	34%	1%
Purchased a plug-in electric vehicle	3%	13%	0%
Other	4%	30%	1%

None of the above	55%	N/A	N/A

Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

The most frequently reported household change was a new infant in the home (9% of respondents, see column A of Table 7). Among the 9% of respondents who reported a new infant in the home in the past 2 years, 24% placed the timing within 2 months of the thermostat installation (column B of Table 7). Combining these rates, about 2% of the sample welcomed a new infant into the home within 2 months of installing a new thermostat (column C of Table 7). The co-occurrence of other household changes within 2 months of the thermostat were similarly low (1%-2% of respondents, see column C of Table 7).

Table 7. Household Changes in Last 2 Years (Column A) and Timing Relative to Thermostat Installation (Column B) (n=2,320)

Household or Occupancy Change	Respondents Reporting Change in Last 2 Years (Percentage) (A)	Change Made within 2 Months of Thermostat Installation (as % of Changers) (B)	Combined Percentage (of Respondents who Made Change within 2 Months of Install) (A X B)
New infant in home	9%	24%	2%
Someone started spending more time outside of the home	9%	16%	1%
Adult or child (not infant) moved into the house	7%	25%	2%
Someone started spending more time in the home	6%	21%	1%
Adult or child (not infant) moved out of the house	4%	26%	1%
None of the above	71%	N/A	N/A

Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)
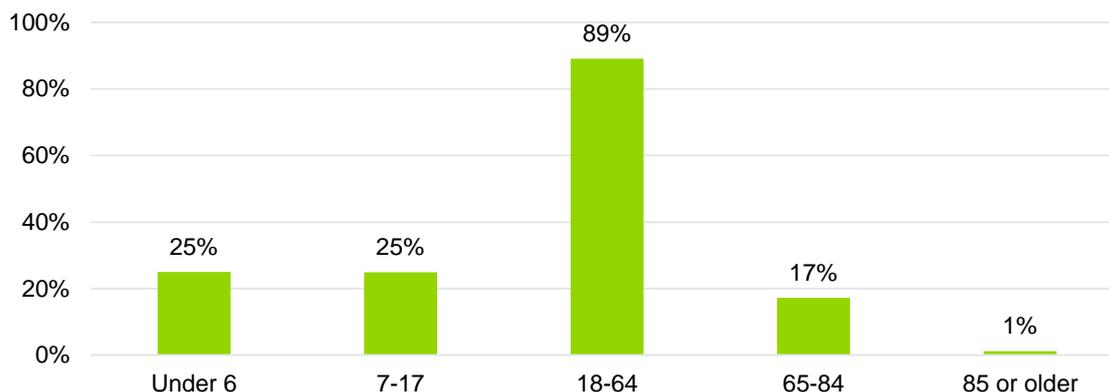
4. Purchaser Characteristics

The average household size reported by respondents was 3.0 people, slightly more than the Massachusetts average (2.5 people per household).[11] Of respondents, 38% reported having 2-person households and 42% 3- or 4-person households. As Figure 9 shows, the majority of respondents (89%) reported having at least one adult aged 18-64 in the household, while 18% reported an occupant 65 or older. About 50% of respondents reported having at least one child under 18 (compared with 29% of Massachusetts households overall with people under 18) and 25% a child under 6 (compared with 10% of Massachusetts households overall with children under 6).[12]

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[11] Source: US Census American Community Survey, 2014-2018 5-Year Estimates.
https://data.census.gov/cedsci/table?q=s1101&g=0400000US25&tid=ACSST5Y2018.S1101&hidePreview=true
[12] Source: US Census American Community Survey, 2014-2018 5-Year Estimates.
https://data.census.gov/cedsci/table?q=s1101&g=0400000US25&tid=ACSST5Y2018.S1101&hidePreview=true

Figure 9. Age Ranges of Household Members (n=5,039)

Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

Few respondent households (14%) could be classified as low or moderate income based on 2018 state median income guidelines[13] (compared with 29% - 41% of Massachusetts families).[14] The majority of respondents (62%) reported household incomes at or above 120% of the state median income for their household size. About one-quarter (24%) of respondents reported household incomes of 80%-120% of the state median income for their household size. Respondents with households having either one member or four or more members were more likely to report low or moderate income for their household size (7%-9%); 2-person households were most likely to report higher income levels (71% with incomes above 120% of the state median income).

About three-quarters (78%) of respondents reported having at least one adult working or attending school out of the home. Some of these respondents may also have household members who are not out of the home during the day. About half (52%) of respondents reported having at least one adult who does not work or attend school out of the home (including working or attending school from home, retired, stay-at-home caregivers, medical/disability/parental leave, or currently unemployed).

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[13] Similar to Home Energy Services thresholds, Guidehouse considered 2018 self-reported income between 61% and 80% of the state median income (per Low Income Home Energy Assistance Program (LIHEAP) guidelines) to be moderate income and income less than 60% of state median income to be low income: https://www.mass.gov/files/documents/2018/04/27/FY2018LIHEAPIncomeEligibility.pdf

[14] The Census does not provide a direct comparison so the team considered two estimates: The moderate income threshold of 80% state median income for household size equates to about 360% of the Federal Poverty Line (FPL) and (1) 29% of families reporting income at or below 300% of the FPL for their household size, while (2) 41% of families are at or below 400% FPL for their household size. As an additional comparison, the moderate income of threshold of 80% state median income equates to an income of about $75,000 for a family of three (close to the average in this survey), and 49% of Massachusetts households have incomes below $75,000 regardless of household size. Source: Source: US Census American Community Survey, 2014-2018 5-Year Estimates.

Figure 10. Work Status of Adults in Household (n=5,039)
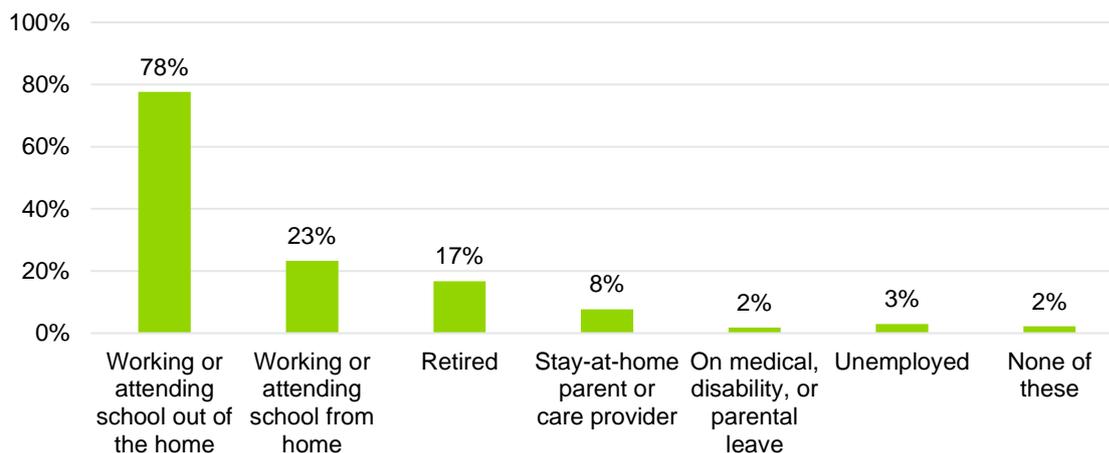
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

Nearly all respondents (98%) reported speaking English at home, and 25% reported they speak a language other than English at home. This result is similar to the Massachusetts population overall, where 23% of the population 5-years old and over speak a language other than English at home.[15] The most common non-English languages reported were Spanish (5%), Chinese (Mandarin and Cantonese combined, 4%), and Portuguese (3%).

Comparison Between Groups

The two-wave survey design was intended to (a) provide a large and diverse sample of thermostat recipients to understand behaviors, and (b) support impact analysis by enabling a matched comparison group and providing customer characteristics to include in regression models. As explained in the Background section, Wave 2 survey participants, those who received a rebated thermostat in 2019, will serve as a comparison group for 2018 rebate recipients surveyed in Wave 1, comprising the treatment group.

Similarities and differences between these groups inform our approach to matching and impact analysis. Differences or similarities between the years clarify the extent to which there are any trends we should be aware of as additional context for our findings. Behavioral differences between participants who replaced manual versus programmable thermostats also help clarify channels for savings and suggest whether Wi-Fi thermostat savings might reasonably be higher or lower for one group relative to another.

The evaluation team employed a Chi-Square analysis to identify statistically significant differences in survey responses for different questions by group. Similarities and differences between 2018 and 2019 participants, and between participants replacing different thermostat types, are explored in the following sections.

2018 Versus 2019 Participants

Participants who received rebates in 2018 and 2019 were more similar than different in their survey responses. More than half (61%) of responses were not statistically different between 2018 and 2019 participants. 2019 adopters showed similar thermostat usage behavior (e.g. use of away settings, manual temperature changes) relative to 2018 adopters during respective baseline periods, adding to our confidence in utilizing 2019 adopters as our comparison group in the impact analysis. The proportion of manual versus programmable thermostat replacers is not statistically different between

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[15] Source: US Census American Community Survey, 2013-2017 5-Year Estimates.

2018 and 2019 participants. Specific examples of questions for which there was not a statistically significant difference include:

- Thermostat installation status

- Household size

- Winter and summer adjustment method (i.e., automated or manual) with old thermostat

- Winter and summer adjustment frequency with old thermostat

- Temperature profiles with old thermostats

- Technology adoption

Figure 11 illustrates similarities and differences in responses to survey questions by 2018 and 2019 participants. Each dot represents a question and is associated with a survey section along the horizontal axis. Some sections have more or fewer questions (recent summer behaviors and purchase drivers, respectively). The dots are offset vertically so none are hidden. **This figure identifies that the majority of responses do not show statistically significant differences[16] between the 2018 and 2019 adopter groups.**

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[16] Questions with a p value below 0.05 were considered statistically significant.

Figure 11. Statistical Significance of Survey Responses by 2018 and 2019 Participants
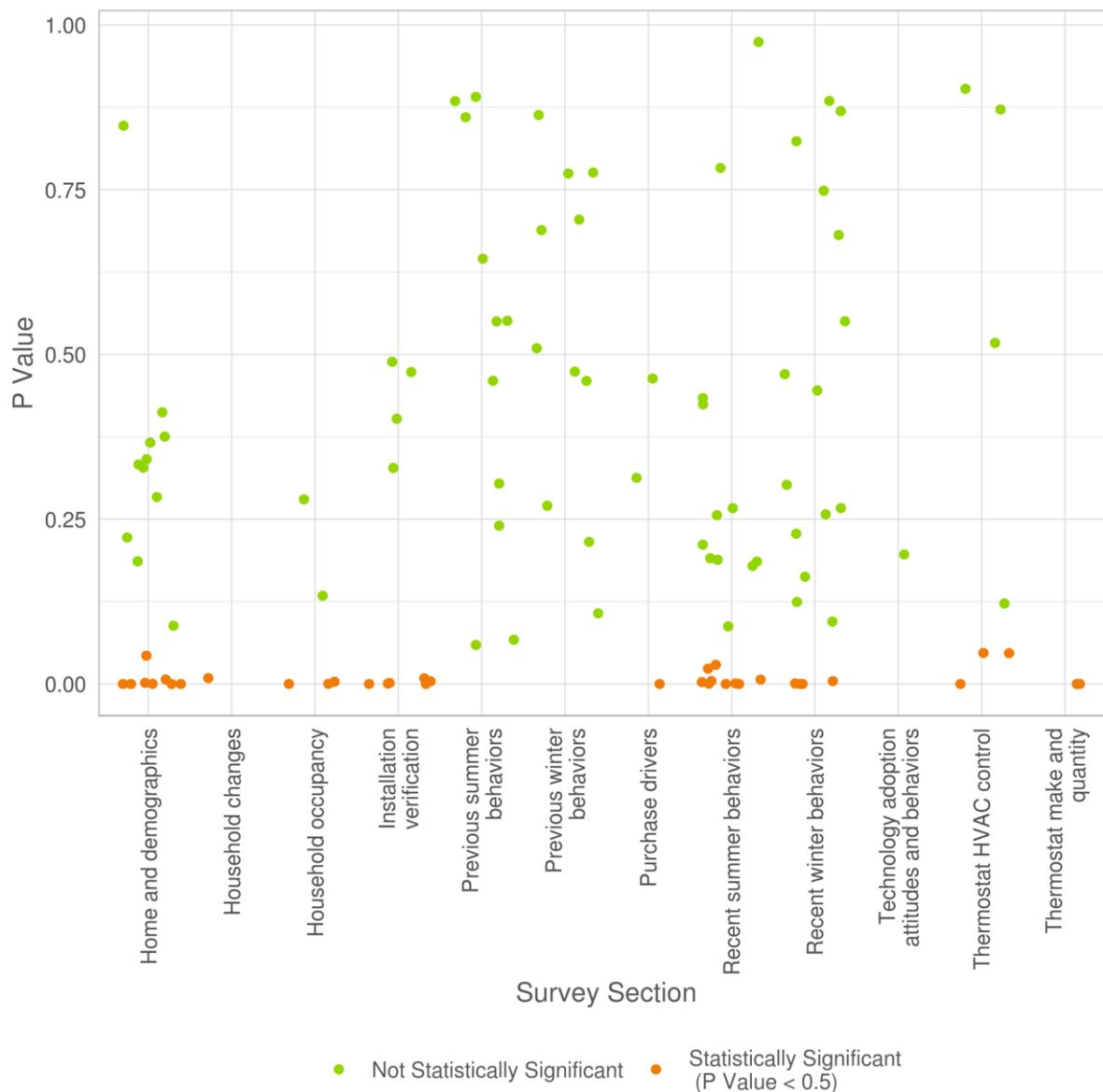
We found no statistically significant differences in pre-program thermostat behaviors between 2018 and 2019 respondents, as shown in Figure 11 for questions involving "previous summer" and "previous winter" behaviors. Despite overall similarity, survey responses of 2018 and 2019 participants differed in some statistically significant ways, as shown in Table 8. Statistically significant differences were primarily found in recent summer behavior (i.e., with the new thermostat) and demographics.[17] 2019 adopters engaged with their new thermostats manually to a greater extent, physically resetting temperatures more frequently than 2018 adopters reports. 2018 adopters were more likely to use advanced thermostat settings (e.g., schedule and automated features) when home or away for more than a day.

Demographic differences between the two groups were primarily related to household composition and renting. More 2018 participant households had retirees and adults 65 and over, while the households of 2019 adopters included more 18-64-year-old adults and 7-17-year-old children. 2019

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[17] Comparing summer weather using Boston Logan airport temperatures, 2019 had fewer cooling degree days than 2018, although July 2019 was the hottest month of the study. It is possible the extreme heat in July 2019 caused people to manually adjust their thermostat more relative to the summer of 2018.

adopters were approximately twice as likely to report being home all the time during the winter and summer (before COVID-19). 2019 adopters were more likely to rent, and live in smaller units (e.g., apartments vs. single family units). In addition, 2019 adopters were more likely to not have installed the new thermostat, or for it to be actually installed at a different address than their home. The 2018 adopter group reported being more interested in taking advantage of financial incentives while 2019 adopters reported being motivated more by environmental benefits.

Finally, 2018 adopters were less likely to purchase Nest devices (59% of 2018 respondents vs. 73% of 2019) but were more likely to have two or more thermostats in their home. Filtering to 2018 and 2019 adopters who purchased a Nest device eliminated some statistically significant differences in demographic and recent summer behavior questions. However, most of the statistically significant differences between the two groups persisted.[18] This suggests thermostat brand was not the primary driver regarding differences between the two adopter groups. Our analysis found there was no statistically significant difference between whether the adopter groups replaced a programmable or manual thermostat.

Table 8. Statistically Different Survey Responses by 2018 and 2019 Participants

Topic	2019 Adopters Relative to 2018 Adopters
Installation verification	More likely to not have installed the new thermostat
	More likely for thermostat to be installed at a different address
	More likely to purchase for a friend or family members home or second home.
Household occupancy	More likely to have children 7-17 in their home
	More likely to have adults 18-64 in their home
	Less likely to have adults 65-84 in their home
	Less likely to be retired
Concurrent household changes	Less likely to install a new HVAC system
Purchase drivers	More likely to purchase smart thermostat to save energy, and less likely to do so because of rebate
Recent summer and winter behaviors (with new thermostat)	Less likely to set thermostat to away mode or use automated setting for heating and cooling
	More likely to keep summer temperatures the same during the day and night
	More likely to be home some of the time during summer weekdays
Home and demographics	More likely to be home all of the time during week and weekend days during summer and winter (before COVID-19)
	More likely to rent than own their home
	More likely to live in a smaller home (apartment vs single family unit)
	More likely to have some high school education
Thermostat Make	More likely to purchase Nest thermostats.
Thermostat Quantity	Less likely to have 2 thermostats.

Source: Guidehouse and Illume analysis

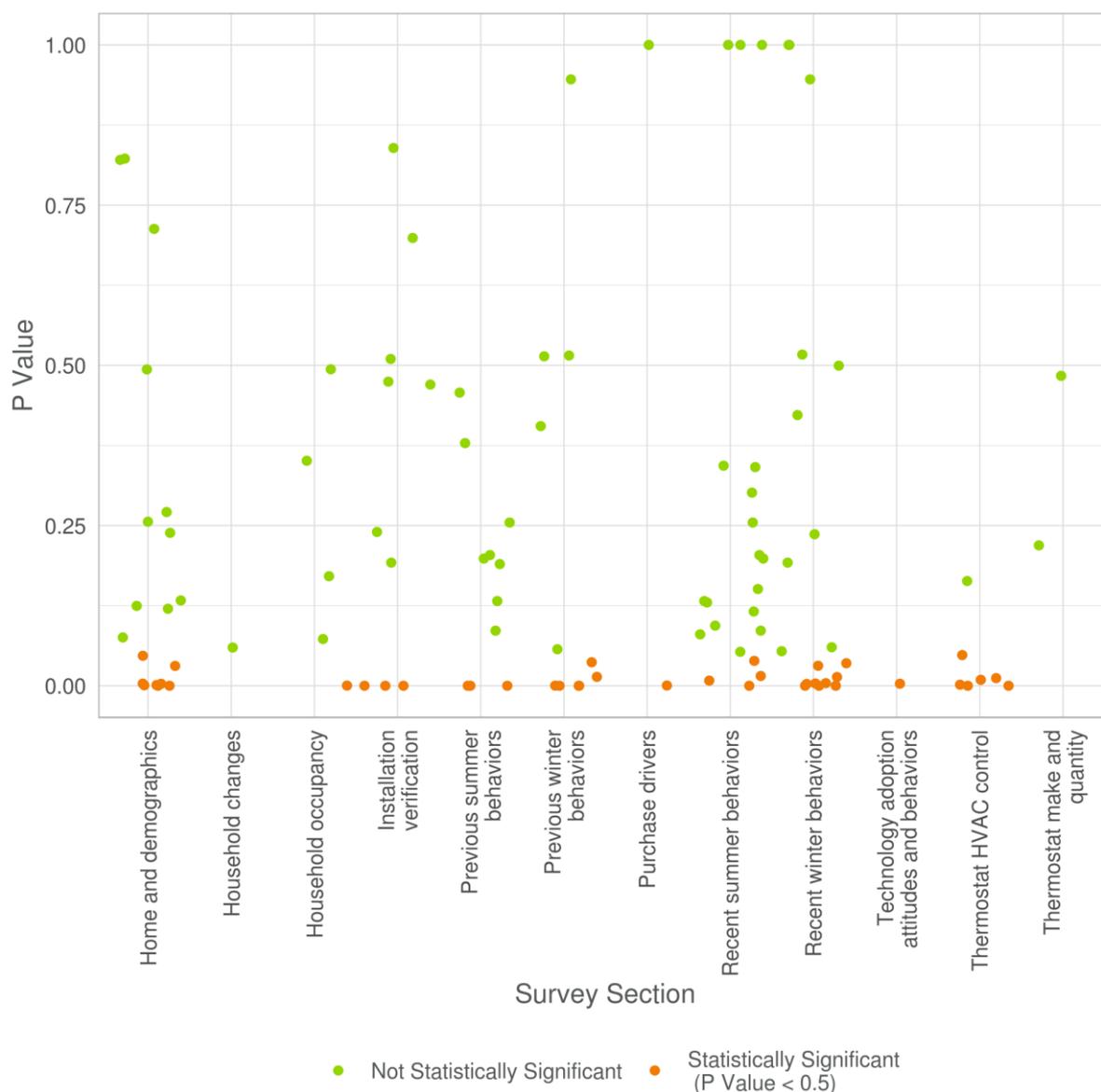## Manual Versus Programmable Thermostat Replacers

Manual and programmable thermostats entail fundamentally different approaches to temperature setting. Whereas the programmable thermostat allows users to schedule temperature changes within and across days (e.g., different weekday and weekend schedules), manual thermostats require users

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[18] The percent of statistically significant differences between the two adopter groups dropped from 34% to 28%

to physically change the setpoint to adjust temperatures, presumably leading to different energy use patterns. These behavioral differences could cause savings to differ between Wi-Fi thermostat adopters replacing manual versus programmable thermostats. We employed Chi-Square analysis to identify statistically significant differences between survey responses of participants who replaced manual versus programmable devices.

Similar to Figure 11, Figure 12 illustrates the number of responses which did or did not have a statistically significant difference[19] between participants replacing manual and programmable thermostats. Each dot represents a question and is associated with a survey section along the horizontal axis. Questions with a p value below 0.05 were considered statistically significant.

Figure 12. Statistical Significances of Survey Responses by Programmable and Manual Thermostat Replacers

For 62% of survey questions,[20] there was no statistical difference between the responses of adopters who replaced manual or programmable thermostats with smart devices. However, we found a

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[19] P-values below 0.05 indicate statistically significant differences.
[20] This is after removing questions that were only in one wave, or associated with the customer (e.g., phone number)

consistent difference in thermostat usage behaviors between the adopters who replaced programmable or manual devices. Homes that replaced manual thermostats were more likely to have frequently adjusted temperatures with their old device, while programmable thermostat adopters were more likely to have used the away or automated settings on their old thermostat. These differences align with the intuition that thermostat behavior differs between programmable and manual thermostat users. Because savings may differ as a result, our matching and impact analysis will account for the type of thermostat replaced to explore potential savings differences. Table 9, identifies some notable statistically significant survey response differences between the two groups.

Other notable differences appeared between manual and programmable thermostat replacers in terms of demographics and the types of heating and cooling systems controlled by the thermostat. Participants who previously owned a programmable thermostat were more likely to have children, own their home, have bigger families, and live in a single-family unit. They were also more likely to be home all or most of the day during winter weekdays. Adopters who replaced manual thermostats were more likely to have electric baseboard heat, while those who replaced programmable thermostats were more likely for the device to control both heating and cooling.

Table 9. Statistically Different Survey Responses by Previous Thermostat Type

Topic	Programmable Replacers Relative to Manual
Installation verification	Homes are more frequently occupied
Heating and cooling systems	More likely for the new device to control heating and air conditioning
	More likely to have electric baseboard heat
Household occupancy	More likely to have children between 7 and 17
Recent winter behaviors	More likely to change temps throughout the day and night this winter
	Adjusted temperatures less frequently in winter
	Less likely to report a change in how they manage heat compared with the previous thermostat
	More likely to be home all the time during winter weekdays
Recent and previous summer and winter behaviors	Adjusted temps less frequently during winter and summer with old thermostat
	More likely to change temps with previous thermostat
	More likely to use away setting or automated setting on old and new thermostat during winter and summer
	Less likely to keep temperature the same during summer and winter days with the old thermostat
Recent summer behaviors	More likely to use away setting or automated setting when home was unoccupied for heating
	More likely to be home during the day during summer weekdays
Home and demographics	More likely to own their home
	More likely to live in a single-family home (as opposed to an apartment)
	More likely to have bigger families

Source: Guidehouse and Illume analysis

COVID-19 Occupancy and Behaviors

In the Wave 2 survey, the evaluation team asked all respondents about occupancy, heating and cooling behaviors, and temperature management during the COVID-19 pandemic. The team asked respondents to think about heating months (March, April, May 2020) separately from cooling months (June, July, August 2020). Table 10 compares self-reported occupancy and heating/cooling changes.

Table 10. Occupancy Changes Due to the COVID-19 Pandemic

| Survey Question and Response Options	March, April, May*	June, July, August[†]
Effect on the number of people living at home	**n=2,894**	**n=2,905**
More people lived in my home	20%	22%
Fewer people lived in my home	5%	5%
No change	74%	73%
Other	1%	1%
Hours per day that the home was occupied	**n=2,889**	**n=2,899**
People were home for more hours per day	82%	71%
People were home for fewer hours per day	2%	4%
No major changes	15%	24%
Other	1%	0%
Heating or Cooling Use	**n=2,894**	**n=2,894**
I/we used the heat more (Spring) I/we may use the air conditioning more (Summer)	48%	61%
I/we used the heat less (Spring) I/we may use the air conditioning less (Summer)	8%	4%
No major changes	43%	33%
Other	1%	2%

*All respondents were asked how their household occupancy and heating use was different in March, April, and May 2020 compared to the prior year (retrospective).

[†] Because the survey was fielded during the summer, all respondents were asked how their household occupancy and cooling use may be different in June, July, and August 2020 compared to the prior year (present and prospective).

Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 2 Survey (Jul.-Nov. 2020)

The majority of respondents reported no changes in the number of people living at home during the COVID-19 pandemic for both heating and cooling months (74% and 73%, respectively). However, home occupancy increased—the majority of respondents reported their homes were occupied for more hours per day during March, April, and May (82%) or would be occupied for more hours per day in June, July, and August (71%). Figure 13 shows the times of day respondents reported being home more. Almost all respondents who reported their homes were or may be occupied for more hours per day also reported the increase in occupancy occurred or may occur during the daytime hours. Consistent across the heating and cooling months, the time window with the next highest frequency of increased occupancy responses was the morning.

Figure 13. Times During the COVID-19 Pandemic When Homes Were Occupied for More Hours per Day by Season
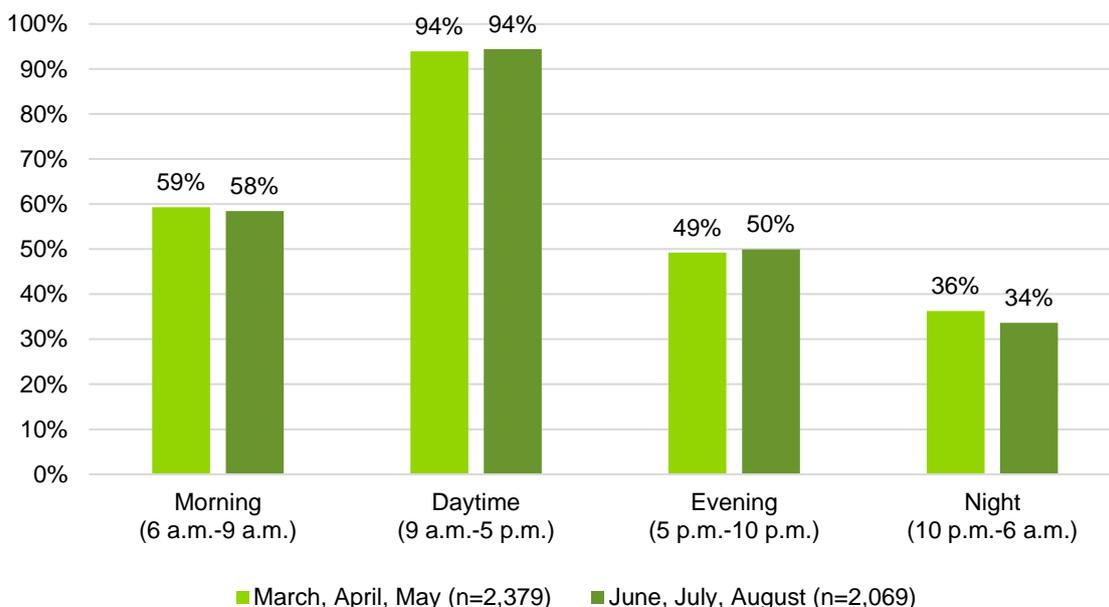
Source MA RES 24 Retail Wi-Fi Rebate Customer Wave 2 Survey (Jul.-Nov. 2020)

Nearly half of respondents reported using the heat more in the spring (48%), and a higher percentage of respondents reported expecting to use their air conditioning more over the summer (61%). Of respondents who reported using their heat more in March, April, and May, 74% responded they ran their heating system for more hours per day, 23% responded their temperature settings were higher than pre-pandemic levels, and 2% responded they used supplemental heat more than before the pandemic. Of respondents who reported they may use their air conditioning more in June, July, and August, 84% responded they may run the air conditioning for more hours per day, 9% responded their temperature settings may be lower than before the pandemic, and 8% responded they may use supplemental cooling more than before the pandemic.

Of the respondents who reported their temperature was different at different times of day or night before the pandemic, 56% reported they continued to change their daytime temperature settings or setback schedule during the heating season this March, April, and May. Of the respondents who reported their thermostats were set up for away mode before the pandemic, 69% reported they continued to use away mode during the pandemic while 31% no longer had away mode set up.

Recommendations

Based on the survey findings presented in this memo our team suggests using 2019 adopters as a comparison group for our treatment group composed of 2018 adopters. We recommend exploring and reporting findings based on several different matching strategies controlling for differences in the type of thermostat device replaced and key demographic characteristics to mitigate potential bias and illuminate associated differences in savings. Further, we recommend conducting sensitivity analyses including and removing different subsets of participants including those who did not install their Wi-Fi thermostats or installed at locations other than their service address and comparing these results with our main findings. We will also estimate regression models utilizing different strategies to control for potential remaining differences between our treatment and control groups by including indicator variables and interaction terms where appropriate to account for demographic differences. In our reporting we will share the results across these multiple matching and control strategies to shed as much light as possible on potential biases and their impact on savings.

Appendix: Open-Ended Analysis

This appendix contains a selection of verbatim comments from customers in response to the survey's open-ended questions. These responses provide customer-specific reasons why adopters did not install a thermostat and how their thermostat usage changed with the new Wi-Fi device. The comments offer additional context to the response frequency tables in the analysis above.

Reasons for Not Installing Thermostat
About 6% of customers had not installed the new thermostat at the time of the survey (5% in Wave 1 and 6% in Wave 2). This section contains a sample of respondent comments on why they had not yet installed their thermostats.

Some respondents found the process more difficult than expected, and were considering hiring a contractor:

- "It was too complicated, and we really didn't need all the features. It was replaced with another programmable thermostat." (Wave 1)
- "Complicated. I would need to hire someone to install it, and I'm not sure who to hire or how much it would cost. I thought I would easily be able to do it myself but that is not the case." (Wave 1)
- "Kept dropping Wi-Fi connection. Reluctantly went back to Nest." (Wave 1)
- "Because I'm a little intimidated to install the new one. Trying to get someone to help." (Wave 2)

Some respondents commented specifically on wiring challenges that may require hiring a contractor:

- "The Nest needs a common wire to the furnace to work best. I am waiting to hire a Nest installer to make sure it is installed correctly. Currently doing house upgrades so will be installing soon." (Wave 1)
- "We have only 10 V going to the thermostat plugs and the thermostat needs 24 V. Asked electricians how to fix this, had someone come round, but so far no answers. If you can help, please do as we have 3 thermostats that we would like to use, just sat on the shelf." (Wave 1)
- "Configuration issue with the wiring. It kept failing to trigger the heat to start." (Wave 2)
- "Have to get a C-wire installed to make the thermostat functional." (Wave 2)

Respondent comments that indicated delayed installation related to lack of time or seasonal delay include the following:

- "I just got it. It is for heating. And it is mid-summer." (Wave 1)
- "It is for a new heating system [that is] not installed." (Wave 1)
- "Chore I haven't gotten around to but hope to finish before heating season starts." (Wave 1)
- "Delayed install until warmer weather in case issues were encountered with it to avoid a heating emergency." (Wave 2)

Respondents expressed the new thermostats were incompatible with their heating or cooling systems:

- "Installed and then uninstalled. We have an old heating system. It is not compatible." (Wave 1)
- "It turned out that the Nest thermostat that I purchased was incompatible with my HVAC system and was returned for refund." (Wave 1)
- "Upgraded to a new HVAC system which required a Carrier thermostat." (Wave 1)
- "Not compatible with my heating system." (Wave 2)
- "We replaced our heating system with heat pumps. The heat pumps have their own internal thermostat." (Wave 2)

Some respondents indicated the units may have been defective or were damaging their HVAC systems, so they removed them:

- "The Nest Thermostat was not working correctly and was causing the heat to turn on more often than it was needed." (Wave 1)
- "Malfunctioned after a Nest update and fried a relay in my heating system." (Wave 1)
- "The battery appeared to be defective and would never stay charged nor get 100% charged." (Wave 1)
- "It was ruining our heating system, so we had to remove it." (Wave 2)
- "The Wi-Fi chip failed in the first one. The Wi-Fi chip in the second one lasted 6 weeks. We switched to Honeywell thermostats after that."
- "Bad quality, not working as expected. Randomly increased room temp." (Wave 2)

Other respondents simply had not prioritized installation; in Wave 2, some reported that the coronavirus pandemic delayed installation:

- "Haven't gotten around to it."
- "Haven't got around to it, not sure the benefits are motivating me." (Wave 2)"
- "Not comfortable allowing installer to come inside the house because of COVID." (Wave 2)
- "Pandemic delayed installation." (Wave 2)
- "Not sure about letting electricians inside yet." (Wave 2)

Differences in How a Household Manages Heating or Cooling with New Thermostat
After respondents answered close-ended questions about new versus old thermostat behaviors, they were asked either, *"How do you manage or use the heat differently with the new thermostat?"* (n=527 in Wave 1 and n=549 in Wave 2) or *"How do you manage the air conditioning differently with the new thermostat?"* (n=202 in Wave 1 and n=151 in Wave 2).

The evaluation team categorized a sample of open responses to analyze comments quantitatively. The most common changes survey participants mentioned[21] include the following:

- **Managing or adjusting thermostat remotely:** The most common responses involved managing or controlling the thermostat remotely or through their phone (31% of winter respondents and 35% of summer respondents[22]). However, in most cases, respondents did not say what direction they were changing the temperature (i.e., turning the heat down vs. pre-heating). They used the terms "adjust," "control," "set," and "change" to describe their remote management.
- **Use automated or sensing features:** One-quarter of respondents mentioned something about thermostat automation, sensors, or learning (using words like "automated," "it senses when…") as a big change (25% of winter and 24% of summer).
- **Programming or setting a schedule:** One in five respondents (20%) reported that setting a schedule or program for heating was a change over their old thermostat. Fewer respondents mentioned this for the summer (12%), which aligns with Figure 4. Households using a schedule or program for the first time included those upgrading from programmable thermostats that found the new thermostat(s) easier.
- **Using the home/away feature[23]:** Around 11%-18% of respondents (depending on season) explicitly mentioned using the home/away feature or allowing the thermostat to sense when they were away.

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[21] More respondents may be taking each of these actions (and many of these actions or behaviors are quantified in other questions), but they may not have mentioned a specific action in these open responses.
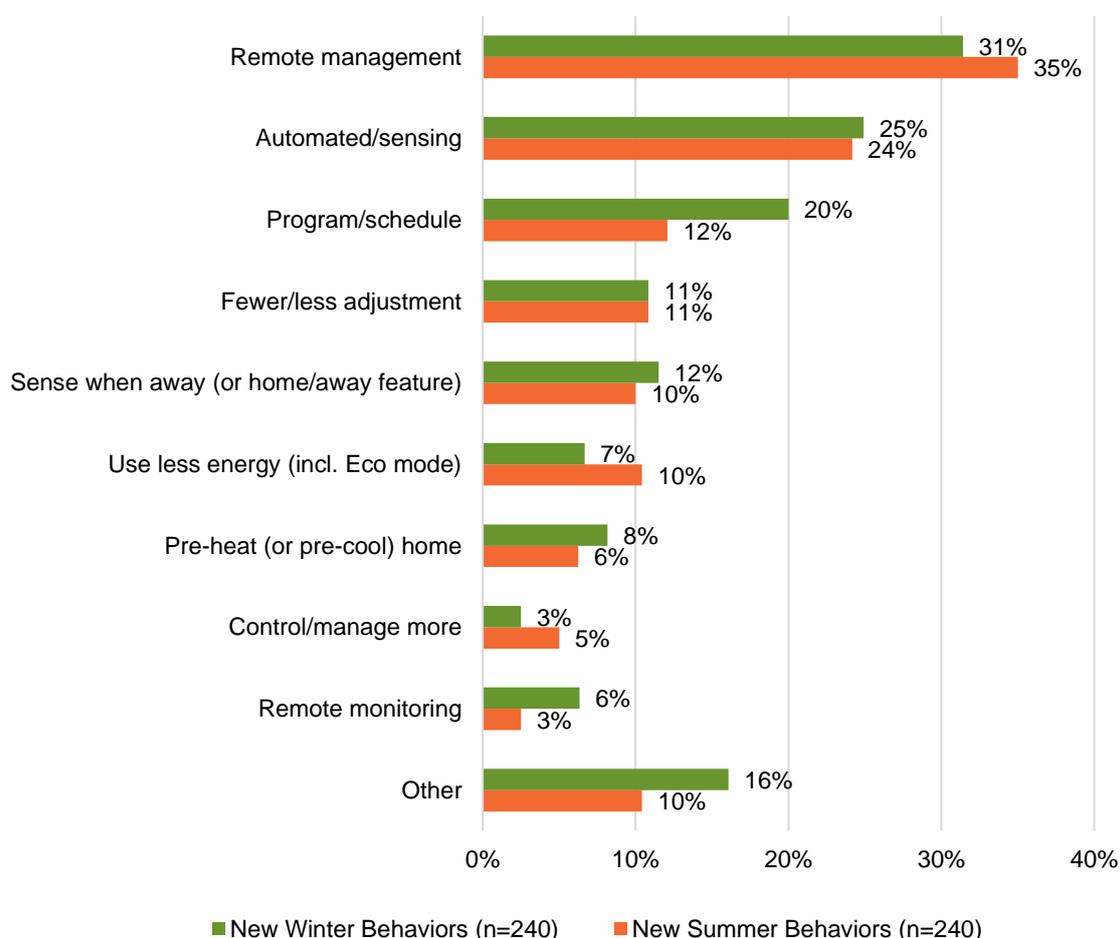[22] Guidehouse randomly selected 120 responses in each survey wave and season to code and categorize (n=480 responses).
[23] Nearly all Wi-Fi thermostats offer some type of feature or setting for times when the home is unoccupied, which the survey referred to generally as an "Away" mode or setting, though different brands may use specific names (e.g., Nest "Home/Away Assist").

- **Making fewer adjustments:** About 10%-12% observed they were adjusting their new thermostat less frequently than the old one. In most cases, respondents' comments did not reveal whether their behaviors resulted in lower or higher settings (more or less energy). In some cases, respondents reported one behavior that may reduce energy (e.g., turning the heat down when away) and one that may increase energy (e.g., pre-heating). A smaller percentage (5%-6%) felt they were managing it more frequently.
- **Pre-heating or pre-cooling home:** Some respondents reported pre-heating (8%) or pre-cooling (6%) their homes with the new thermostat (for example, before coming home from work or another period away).
- **Energy-saving or Eco mode, or using less energy:** About 7%-10% of respondents reported they were using Eco mode (or equivalent)[24] or said they were saving energy or money with the new thermostat.

Figure 14 shows common categories of respondent comments.

Figure 14. Respondent Observations (Open-Ended Comments) about Managing Heat and Air Conditioning Differently with New Thermostat

Guidehouse randomly selected 240 responses from each survey wave and season to review and code into categories.
Source: MA RES 24 Retail Wi-Fi Rebate Customer Wave 1 and Wave 2 Survey (Aug.-Sept. 2019 and Jul.-Nov. 2020)

The respondent comments listed below illustrate how respondents described changes from their old thermostat(s) to their new thermostat(s).

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[24] While some customers mentioned Nest's Eco mode by name, others described similar functionality, like, "*Allow the thermostat to be adjusted by the utility company during peak usage time."*

The most common behavior respondents mentioned was related to remote management, often when occupants forgot to adjust the temperature before leaving the house, as well as when they are home:

- "Able to control the heat when not at home - if we go away for the weekend and forget to turn it down, we can do it from our phones." (Wave 1)
- "Using Wi-Fi I can now check it on my phone. This is huge, especially if I forget to turn the settings to Eco before I leave the house." (Wave 1)
- "It is nice to use the Wi-Fi feature to adjust the temperature when we are away on vacation so that we don't come home to a hot/cold house." (Wave 1)
- "I use the Nest app on my phone which is extremely convenient, so I don't have to get out of bed in the middle of the night if I need to adjust the temperature." (Wave 2)

Some respondents mentioned using the thermostat's automated or learning features, including sensing whether they are in a particular room or adjusting to their comfort band or range:

- "Allow the thermostat to suggest the temperature." (Wave 1)
- "New [thermo]stat uses a remote sensor to regulate the temperature in a different room." (Wave 1)
- "I allow the thermostat to shadow our temperature patterns." (Wave 1)
- "It's more automated and takes the hassle out of manual handling." (Wave 2)
- "New thermostat learns your habits after a few weeks of use." (Wave 2)

Some respondents felt it was easier to set or use a program or schedule with the new thermostat (these respondents transitioned from programmable and manual thermostats):

- "It is more easily programmed with changes possible at 15-minute increments." (Wave 1)
- "It's much easier to set the schedule with the phone app. Less futzing around with the old thermostat to figure out how to program it." (Wave 1)
- "Different temps at different times instead of constant temp." (Wave 2)
- "Easier to schedule on different days and adjust all 3 floors based on when someone will be on that floor." (Wave 2)

Some respondents appreciated the home/away mode or the thermostat's ability to sense when they were away:

- "When traveling for extended periods, the new thermostat will adjust accordingly." (Wave 1)
- "New Nest automatically detects when no one is home and learns schedule and so it adjusts the temperature accordingly." (Wave 1)
- "Detecting away and arrival. Easier scheduling and custom settings." (Wave 2)
- "When we travel, the vacation setting is terrific!" (Wave 2)

Some respondents noted the new thermostats result in them making fewer adjustments:

- "Do not touch temp as much." (Wave 1)
- "We don't need to manually change the temperature all the time." (Wave 1)
- "We have far more specific temperature setting now relative to what we used to do. We used to have very basic settings, and we'd adjust the temperature manually a lot." (Wave 1)
- "Set it and forget it 90% of time." (Wave 2)
- "Less daily interaction." (Wave 2)

A few respondents explicitly mentioned pre-heating or pre-cooling their homes; in some cases, these behaviors were paired with energy-saving behaviors:

Some respondents made comments about pre-heating during heating season:

- "Will sometimes turn up heat with my phone when starting commute so house is warmer upon arrival. Will often turn heat down with my phone when I learn my wife is not working there on a particular day." (Wave 1)
- "Increase the temp before getting into home from outside or increasing the temperature in the morning before waking up." (Wave 1)
- "The thermostat understands what time of day to set higher now, and having it linked to my phone allows me to pre-warm the house or have it sense when I'm away."
- "I tended to be cold when I got home, so the new thermostat has learned to warm up by the time I'm home." (Wave 2)

Some respondents made comments about pre-cooling in the cooling season:

- "Sometimes we change the settings remotely from our phone if we are coming home and it is hot." (Wave 1)
- "Start it remotely shortly before getting home." (Wave 1)
- "I am able to turn the air conditioner on prior to coming home from work so it is not hot in the house when I get home." (Wave 1)
- "We'll use our phone to set the temperature to activate the heater/air conditioner about 30-60 minutes prior to physically getting to the house so it's the temperature we want when we get home." (Wave 2)

Some respondents felt the new thermostat's features may lead to energy savings, and a few used energy-saving or Eco mode:

- "Turn off more frequently as needed because it is easier to control using remote access." (Wave 1)
- "Much more efficient with new therm as it knows when we are away." (Wave 1)
- "Auto sensing self-adjusts my temperatures based on if I'm home or not, saving me a lot of money." (Wave 1)
- "More aware of 'eco' setting. Would keep heat lower to stay in eco mode…" (Wave 2)
- "It is helpful to keep the thermostat setting to Eco and save electricity." (Wave 2)

Table 11. Statistically Different Survey Responses by 2018 or 2019 Adopter Group (Detailed)

Question	P Value	2019 Adopters Relative to 2018 Adopters
C4	0.00	More likely to not have installed the new thermostat
C6	0.00	More likely for thermostat to be installed at a different address
C7	0.00	More likely to live in a friend or family members home or second home.
F1_1	0.00	More likely to have children 7-17 in their home
F1_3	0.00	More likely to have adults 18-64 in their home
F1_4	0.00	Less likely to have adults 65-84 in their home
F2	0.00	Less likely to be retired
G3	0.01	Less likely to install a new HVAC system
H3	0.00	More likely to purchase new thermostat to save energy, and less likely to do so because of rebate
I1	0.00	More likely to use new thermostat in winter of 2018-2019
I8	0.00	Adjusted temps more frequently during the winter
I10, N6, N5, N7, N8	0.00	More likely to be home all of the time during week and weekend days during summer and winter
I11 & K12	0.00	Less likely to set thermostat to away mode or use automated setting for heating and cooling
K2	0.00	More likely to have used old thermostat in summer of 2019
K5	0.00	More likely to use manually set thermostat, and less likely to use the automated mode
K6	0.00	More likely to keep summer temperatures the same throughout the day and night with old thermostats
K10	0.02	More likely to be home some of the time during summer weekdays
N1	0.00	More likely to rent than own their home
N2	0.00	More likely to live in a smaller home (apartment vs single family unit)
N9	0.04	More likely to have some high school education
Make	0.00	More likely to purchase Nest thermostats.
Thermostat Qty	0.00	Less likely to have 2 thermostats.

Source: Guidehouse and Illume analysis

Table 12. Survey Responses by Thermostat Replacement Group (Detailed)

Question	P Value	Programmable Replacers Relative to Manual
C8	0.00	Homes are more frequently occupied
E1	0.00	More likely for the device to control heating and air conditioning
E3	0.04	More likely to have electric baseboard heat.
F1_2	0.00	More likely to have children between 7 and 17
I5	0.00	More likely to change temps throughout the day and night this winter with new and old thermostats
I8	0.01	Adjusted temps less frequently this winter
I9 & K10	0.01	More likely to be home during summer and winter weekdays
I4, J1, K5, L1	0.02	More likely to use away setting or automated setting on old and new thermostat during winter and summer
I11	0.02	More likely to use away setting or automated setting when home was unoccupied for heating
J2 & L2	0.00	More likely to change temps with old thermostat
J6, L6	0.00	Adjusted temps less frequently during winter and summer with the old thermostat
J7	0.00	Less likely to change how household manages heat
K4	0.02	Less likely to manually turn system on and off as needed
K6	0.00	More likely to have different temperatures at different times of the day/night with old thermostats
N1	0.00	More likely to own than rent their home
N2	0.00	More likely to live in a larger home (single family unit vs apartment)
HH_SIZE	0.00	More likely to have bigger families

Source: Guidehouse and Illume analysis