2019/20 Massachusetts Winter Thermostat Optimization Evaluation

Prepared for:
Massachusetts Program Administrators

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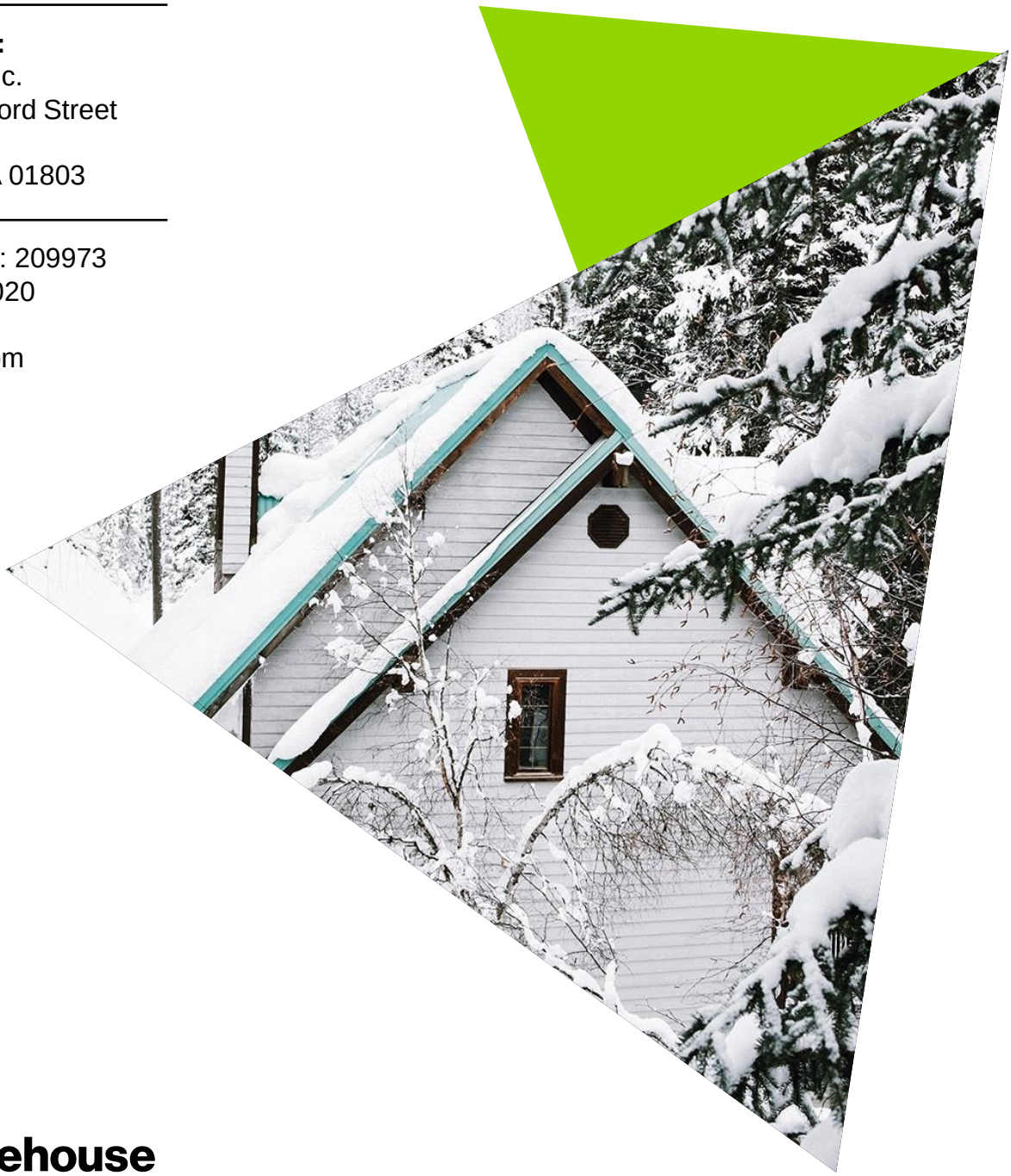

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Study Overview

About Thermostat Optimization

The winter Seasonal Savings (SS) program is a thermostat optimization program offered by Google that is designed to make incremental adjustments to scheduled setpoints over a 3-4-week period to achieve energy savings and demand reductions while maintaining customer comfort. On average, scheduled setpoints are adjusted downward by 0.5°F-1°F during the heating season, with the largest temperature adjustments taking place when customers are typically asleep (i.e., late evening through early morning).

Study Goal

The goal of this evaluation was to conduct an energy impact evaluation with an exploratory analysis using thermostat telemetry data from Google's SS program in Massachusetts during the 2019/20 winter. In the 2019/20 winter, the program was deployed to Massachusetts Program Administrator (PA) customers who had a Nest thermostat installed, specifically natural gas customers for Eversource and National Grid (including non-natural gas devices in natural gas homes) and non-natural gas customers for Cape Light Compact.

Approach

The evaluation team conducted two analyses for the 2019/20 evaluation:

Exploratory Analysis

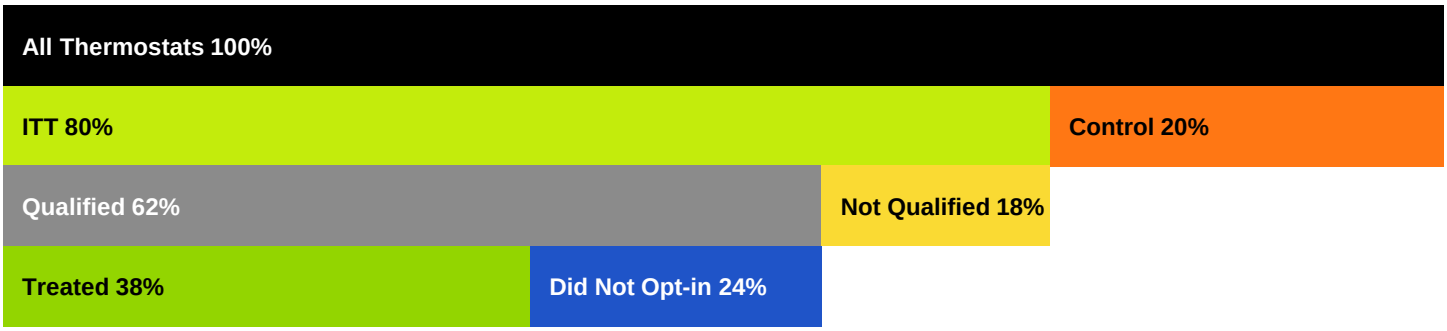
- Compared enrollment and re-enrollment rates across PAs to assess customer acceptance of the program over multiple years.
- Analyzed setpoints (scheduled and actual) and thermostat heating runtime to assess whether the impact of thermostat optimization was evident in the data.
- Compared data for devices treated in both 2018/19 and 2019/20 with those treated just one year or the other.
- Analyzed differences between weekdays and weekends.

Impact Analysis

- Deployed as a randomized encouragement design (RED), with 80% of devices in the intent-to-treat (ITT) group and 20% in the control group. Devices were re-randomized compared to the 2018/19 deployment of the same program.
- Relied exclusively on thermostat telemetry data to estimate impacts after converting thermostat runtime to estimated energy.
- Estimated total savings for each PA:
  - For natural gas devices, savings were estimated with 2019/20 data.
  - For other fuel type devices, savings were calculated using 2018/19 savings rates.
- Estimated electric energy savings for winter on-peak and off-peak hours using savings percentages from 2018/19.

Program Population and Deployment

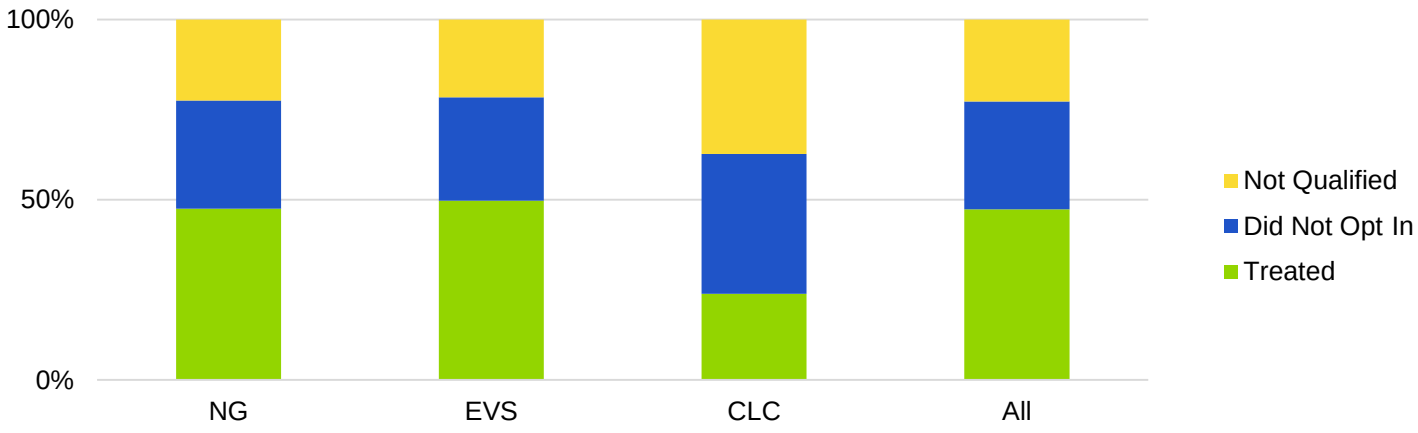
The winter 2019/20 SS deployment targeted 145,659 thermostats in the National Grid, Eversource, and Cape Light Compact service areas. Of the total targeted population, 20% of devices were sorted into a control group. The remaining 80% were part of the ITT group and could qualify to receive the SS offer if they were connected to Wi-Fi and had an open Google Nest account, were in heating mode, and had a heating setpoint schedule. Overall, **47% of the ITT devices qualified and opted in to the program**, receiving the SS treatment (55,513 devices).



Source: Guidehouse analysis of Nest thermostat enrollment data

Overall, 77% of ITT devices qualified for the program and 47% opted in to the SS program. **Cape Light Compact continues to have lower qualification (63%) and opt-in (38%) rates than National Grid and Eversource (qualification = 78% and opt-in = 48%).** This is likely due to different home usage and heating needs on the Cape. Qualification and opt-in rates were slightly lower than in 2018/19. The percentage of ITT thermostats that did not qualify rose from 18% to 23% and the percentage of qualified thermostats that opted-in fell from 65% to 61%. **Almost two-thirds of customers offered the program for a second time in 2019/20 after enrolling in 2018/19 chose to opt in to the program for another year.** The reenrollment rate was lower for Cape Light Compact (~50%).

ITT Group Enrollment In Seasonal Savings



NG = National Grid; EVS = Eversource; CLC = Cape Light Compact

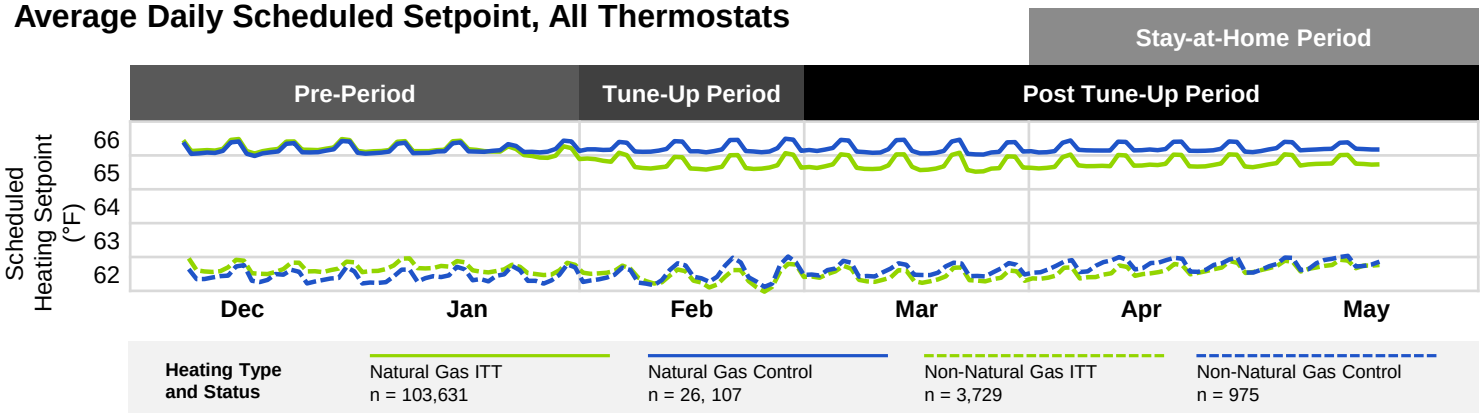
Source: Guidehouse analysis of Nest thermostat enrollment data

Key Findings

Exploratory Analysis

The exploratory analysis compared the average daily scheduled heating setpoints for the ITT group relative to the control group's schedule for natural gas and non-natural gas customers. **The average daily scheduled heating setpoints decreased by around 0.80°F for the treated group relative to the control group after the SS program began** (a bit higher than 2018/19 when the decrease was approximately 0.67°F). Actual setpoints also decreased during the program period for the ITT group relative to the control group (by 0.57°F), as did runtime (by 4 minutes). The stay-at-home orders in Massachusetts related to the coronavirus pandemic did not affect the relative positioning of the treatment and control group.

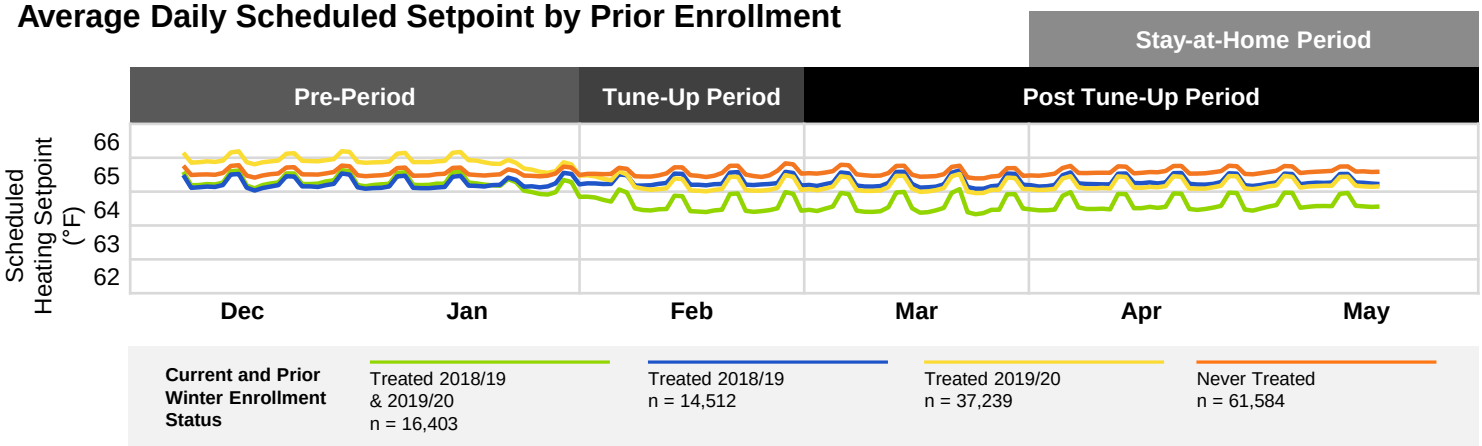
Average Daily Scheduled Setpoint, All Thermostats



Source: Guidehouse analysis of thermostat telemetry data

Reviewing scheduled and actual setpoints and runtime based on when customers were treated (2018/19, 2019/20, both, or neither) shows some persistence in setpoints and that the program effect builds over time. Devices treated only in 2018/19 and in both 2018/19 and 2019/20 have similar pre-period scheduled setpoints. Their setpoints are about 0.5°F lower than the devices that were never treated. Devices treated in both 2018/19 and 2019/20 continue to have decreases to their setpoints in the 2019/20 program period. In the 2019/20 program period, devices treated only in 2019/20 end up similar to (slightly lower than) devices treated only in 2018/19.

Average Daily Scheduled Setpoint by Prior Enrollment



Source: Guidehouse analysis of thermostat telemetry data

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Key Findings

Impact Analysis

The Massachusetts PAs launched the winter SS program on January 8, 2020 to 55,513 customers across the three service areas. Per-thermostat energy savings were estimated at the statewide level for natural gas and non-natural gas devices. The energy savings achieved through April 30, 2020 are as follows:

	Statewide Per-Thermostat Savings		Percentage of Heating Load Savings	
	Fuel (MMBtu)	Electric (kWh)	Fuel (%)	Electric (%)
Natural Gas	1.2	5.4	3.6%	3.6%
Non-Natural Gas	0.8	15.2	2.7%	6.0%

Natural Gas Savings Summary

PA	Heating Fuel Type	Measure Life	No. of Participating Thermostats	Verified MMBtu Savings†	Verified kWh Savings†
Statewide	**Natural Gas**	**1**	**52,284**	**60,796**	**281,641**
Eversource	Natural Gas	1	15,977	18,578	86,064
National Grid	Natural Gas	1	36,308	42,219	195,582

Non-Natural Gas Savings Summary

PA	Heating Fuel Type	Measure Life	No. of Participating Thermostats	Verified MMBtu Savings†	Verified kWh Savings†
Statewide	**Non-Natural Gas**	**1**	**2,449**	**1,886**	**37,167**
Cape Light Compact	Electric	1	32	-	486
	Oil	1	700	575	10,624
	Propane	1	228	187	3,460
Eversource	Electric	1	46	-	698
	Oil	1	392	322	5,949
	Propane	1	129	106	1,958
National Grid	Electric	1	77	-	1,169
	Oil	1	644	529	9,774
	Propane	1	201	165	3,050

†Total savings are calculated using the statewide per-thermostat savings. For example, to calculate total oil kWh savings for Cape Light Compact, the statewide per thermostat savings for non-natural gas devices of roughly 15.2 kWh is multiplied by 700 participating Cape Light Compact oil thermostats for a total of 10,624 kWh.

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Recommendations and Considerations

Recommendations

Savings

In 2019/20, the PAs should claim savings as shown in the tables on the previous page.

In 2019/20, the PAs should claim electric savings broken down into on-peak and off-peak savings based on the following percentages:

- Natural gas: 28% on-peak, 72% off-peak
- Non-natural gas: 32% on-peak, 68% off-peak

These percentages should be multiplied by the verified kWh savings shown in the tables on previous page.

Considerations

SS and Wi-Fi Thermostats

Because SS will now be a standard offering for all Google Nest thermostats, SS savings should be incorporated into ongoing Wi-Fi thermostat evaluations.

Any study of Google Nest thermostats using data after the 2019/20 heating season will inherently include SS savings.

In future Google Nest thermostat evaluations, seek to assess the persistence and/or limits of the SS algorithm.

Other Temperature Optimization Algorithms

Given that SS has proven the viability of temperature optimization algorithms for increasing thermostat savings, the PAs could explore offering similar algorithms to other manufacturer's devices.

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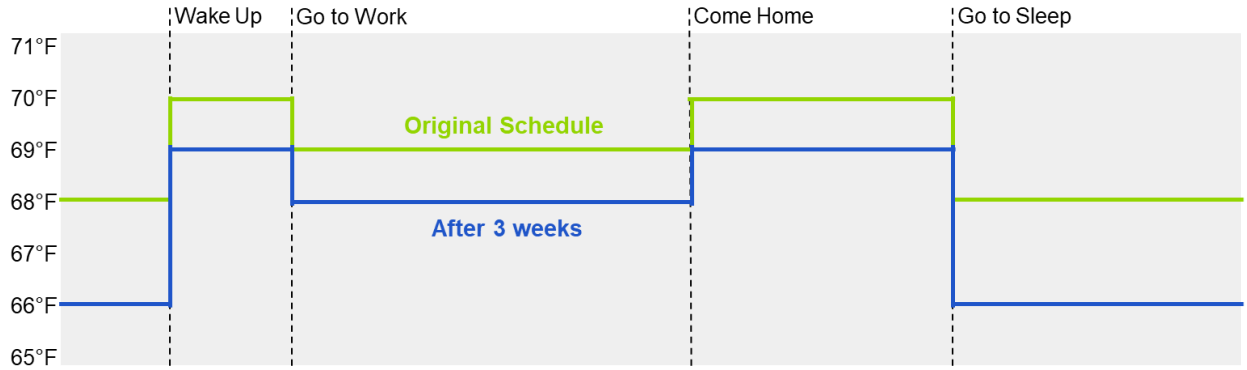
1. Introduction

The Massachusetts Program Administrators (PAs) of National Grid, Eversource, and Cape Light Compact partnered with Google in the 2019/20 winter season to offer their customers with an existing Google Nest thermostat an energy savings opportunity to participate in the Seasonal Savings (SS) program. SS is a thermostat optimization offering designed to make small incremental adjustments to scheduled temperature setpoints over a 3-4-week period (i.e., tune-up period) while maintaining customer comfort (Figure 1-1). On average, scheduled setpoints are adjusted downward by 0.5°F-1°F during the heating season, with the largest temperature adjustments taking place overnight when customers are typically asleep.[1]

The 2019/20 season was the second winter in which the PAs offered the SS program. Devices were re-randomized between the control and intent-to-treat (ITT) groups between the 2018/19 and 2019/20 winter seasons. Two items are worth noting for devices that opted in to the program in 2018/19 (the year before this evaluation):

- When a thermostat goes into heating mode after being adjusted by the SS algorithm the previous heating season, the SS-adjusted schedule from the end of the previous season persists unless the customer makes manual changes.
- If a customer signs up for the SS program again, further changes are made to their thermostat's already-adjusted schedule.

Figure 1-1. Illustrative Setpoint Schedule Adjustments



Source: Guidehouse

Guidehouse Inc. (Guidehouse or the evaluation team) evaluated the 2019/20 winter SS program.[2] This report presents the evaluation team's findings in several sections:

- Section 2 summarizes the evaluation's methods.
- Section 3 outlines the data sources and data management used in this evaluation.
- Section 4 presents results from the exploratory and impact analyses.

[1] "Learn about Seasonal Savings," Google Nest Help, https://nest.com/support/article/What-is-Seasonal-Savings.

[2] This evaluation did not examine whether thermostat optimization is cost-effective for the heating system, PAs, or customers.

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- Section 5 presents Guidehouse's findings and recommendations.

The coronavirus outbreak makes 2020 a unique year. The effect of the pandemic on the SS program is discussed throughout this report. The report also includes a section about how stay-at-home orders and other customer behavior changes affected thermostat usage, independent of SS in Appendix C.

1.1 Evaluation Objectives

Table 1-1 lists the objectives of the 2019/20 winter thermostat optimization evaluation.

Table 1-1. Thermostat Optimization Research Questions

Research Questions	Evaluation Approach
• What percentage of thermostats in the ITT group enrolled in the SS program by PA? • Did the program have the intended effect on scheduled and actual setpoints and were effects similar across the relevant PA and fuel type categories? • What was the impact of SS on heating runtime by PA, by day, and over the winter season? • How does SS affect scheduled setpoints, actual setpoints, and heating runtime for subpopulations of customers based on how many times and when they were treated?	Exploratory analysis
• What are the total winter natural gas energy impacts for treated devices by PA while the SS program is active? Based on percentage savings from 2018/19, what are non-natural gas energy and savings?† • How much electric energy was saved during on-peak and off-peak hours based on on-peak and off-peak percentages from 2018/19?‡ • How do savings compare between Google-reported savings values and evaluated savings values for total natural gas energy and auxiliary electric energy?	Impact analysis

† Sample sizes were too small to reliably estimate savings for non-natural gas devices with 2019/20 data. This point is discussed further is Section 2.3.3.

‡ On-peak and off-peak savings could not be estimated directly with 2019/20 data because this year's data is daily rather than hourly.

Source: Guidehouse

1.2 Nest Thermostat Population

Initially, before any data cleaning,[3] there were 145,659 Nest thermostats considered for the SS offering in winter 2019/20, which includes 28,413 control devices (20%) and 117,246 ITT devices (80%). Of the 117,246 ITT devices, 55,513 devices (47% of ITT) were treated, meaning that they opted in to the SS program. Figure 1-2 shows the number of thermostats by PA, broken out by enrollment group. The ITT group is divided into those who did not qualify, those

[3] See Section 3.1 for discussion of data cleaning.

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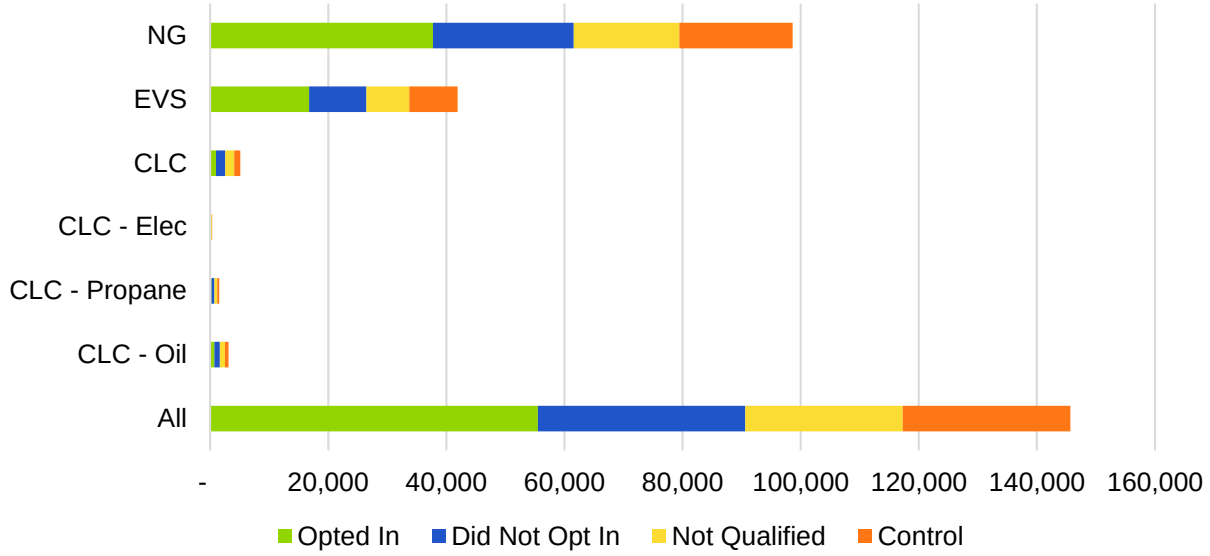
who qualified but did not opt in, and those who qualified and opted in to be treated; this breakdown is discussed further in Section 1.3.

Figure 1-2.Thermostat Counts by PA and Enrollment Group, Winter 2019/20



NG = National Grid; EVS = Eversource; CLC = Cape Light Compact

Source: Guidehouse analysis of Nest thermostat enrollment data

The SS winter program first launched in 2018 for all three PAs. For comparison, in 2018/19 there were approximately 140,000 devices considered for the SS offering, with just over 52,000 treated. One key difference between 2019/20 and 2018/19 is that National Grid and Eversource only offered the program to natural gas customers this year;[4] Cape Light Compact continued to offer the program to all fuel types.

The assignment of customers to a heating fuel type followed the same logic as the 2018/19 evaluation (as Figure 1-3 shows):[5]

- Google assigned the Nest population to fuel types based on thermostat wiring and customer reporting when the thermostat was first installed.[6]
- Google mapped each thermostat to a PA based on customer ZIP codes and the corresponding PA service areas.[7]
- Thermostats with heat pump wiring were mapped to electric heat pumps.

[4] For National Grid and Eversource, the program was offered to all devices for natural gas customers, even if the device used another fuel type. Approximately 4% of National Grid and Eversource devices were connected to non-natural gas heating systems.

[5] Approximately 2% of devices were missing a heating fuel and were dropped from the analysis as discussions with Google revealed that they should not be considered part of the program.

[6] In addition, Google provided an indication of whether the heating equipment is a boiler or furnace, and whether it has one or multiple stages.

[7] Cape Light Compact electric customers in the National Grid gas service area were designated as National Grid gas customers.

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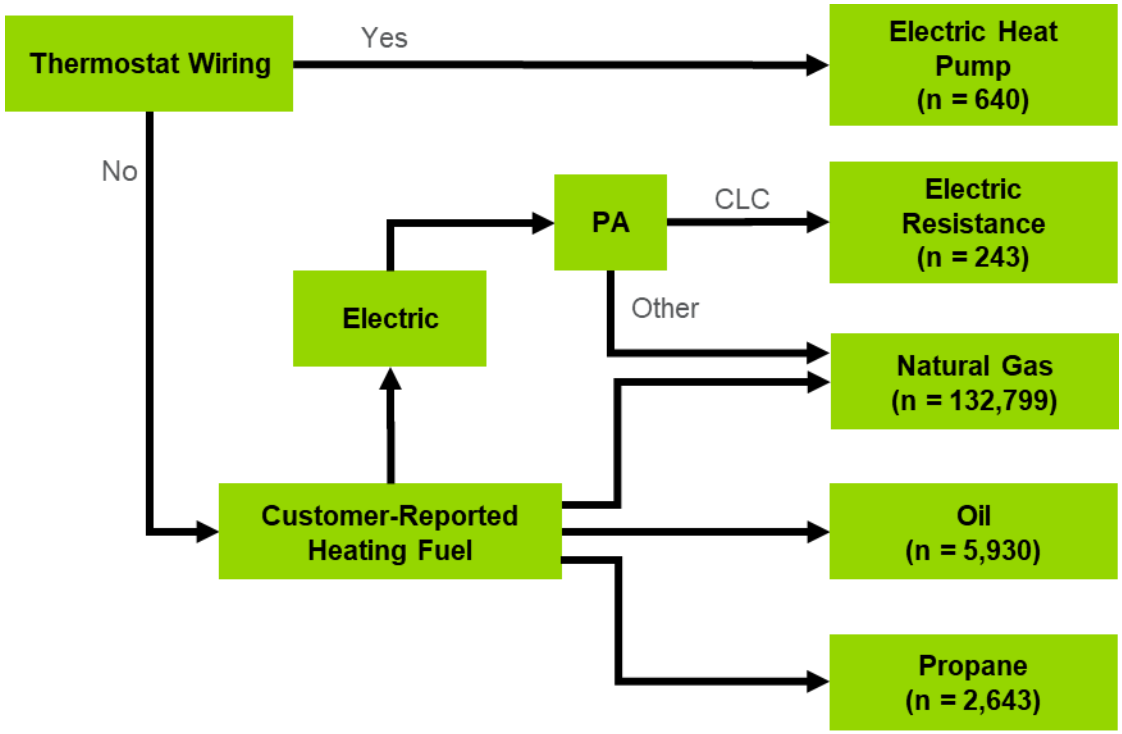
- Thermostats without heat pump wiring were assigned primarily to the self-reported heating fuel.
    - Customers that self-reported electric heat but did not have heat pump wiring were assigned to the natural gas fuel type, except for Cape Light Compact customers.
    - Cape Light Compact customers that self-reported a gas fuel type were mapped to propane because there is no natural gas service in that area.

Figure 1-3. Assignment of Heating Fuel Type



CLC = Cape Light Compact; Other = National Grid or Eversource

Source: Guidehouse analysis of Nest thermostat enrollment data

1.3 Program Enrollment

The SS program is implemented as a randomized encouragement design (RED). For the 2019/20 winter season, Google assigned 80% of devices to the ITT group and 20% to the control group.[8] Only thermostats in the ITT group could qualify and enroll in the program. For this season, of the 145,659 thermostats considered for the SS program, 117,246 (80%) were in the ITT group and 28,413 (20%) were in the control group.

Figure 1-4 shows the breakdown of ITT devices by their treatment status. Cape Light Compact continued to have lower qualification (63%) and opt-in (38%) rates than National Grid and Eversource (qualification = 78% and opt in = 48%). This is likely due to different home usage and heating needs on Cape Cod. Qualification and opt-in rates were slightly lower this year than in 2018/19. Compared with 2018/19, the percentage of ITT thermostats that did not qualify rose

[8] To increase participation, this ratio of ITT to controls was an increase from the 70/30 ratio used in 2018/19.

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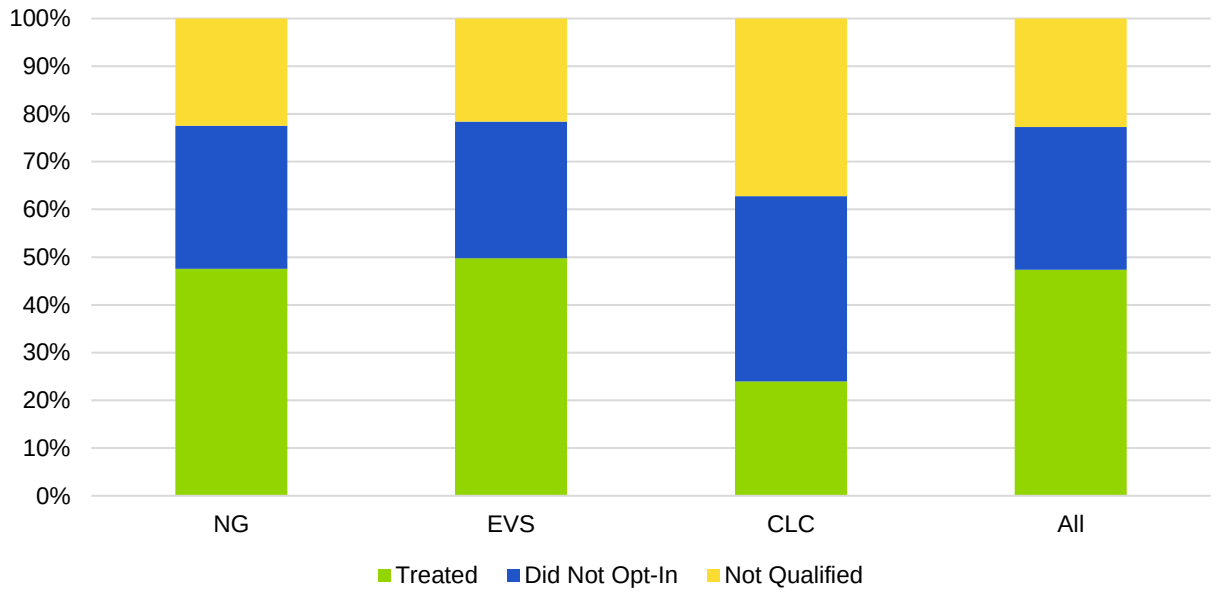
from 18% to 23% and the percentage of qualified thermostats that opted in fell from 65% to 61%.

Figure 1-4. ITT Group 2019/20 Winter Enrollment Comparison



NG = National Grid; EVS = Eversource; CLC = Cape Light Compact

Source: Guidehouse analysis of Nest thermostat enrollment data

1.4 Winter 2019/20 Weather

The 2019/20 winter was considerably warmer than 2018/19 and warmer than the 20-year historical average, particularly in January-March. December 2019-April 2020 had 4,274 heating degree days (HDD), which was 7% fewer than the December 2018-April 2019 period which had 4,593 HDD; considering just January-March, 2020 had 16% fewer HDD than 2019. The 2019/20 heating season was the second warmest January-March since 2000.[9] A monthly comparison of the winter 2019/20 average temperature and HDD with 2018/19 and the 20-year average is shown in Figure 1-5.

[9] The warmest January-March was 2012.

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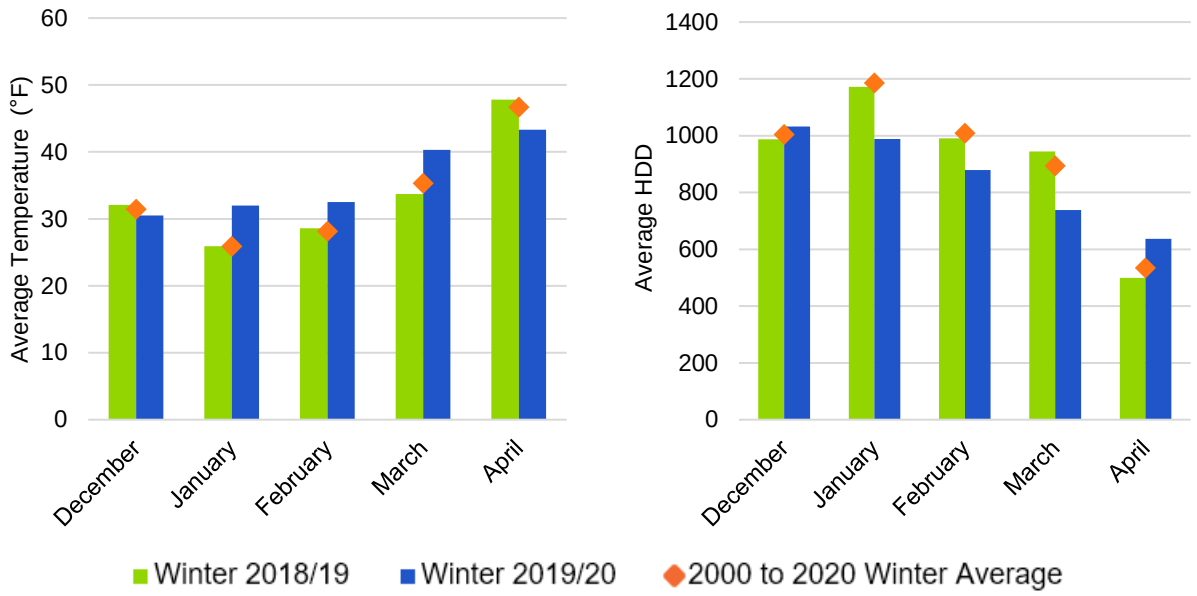
Figure 1-5. Average Winter (December-April) Temperatures and HDD, Massachusetts



HDD are base 65°F.

Source: Guidehouse analysis of the monthly/seasonal climate summary tables for Massachusetts available from the Northeast Regional Climate Center

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2. Evaluation Methods

This section describes the methods Guidehouse used to evaluate the 2019/20 winter SS program deployment.

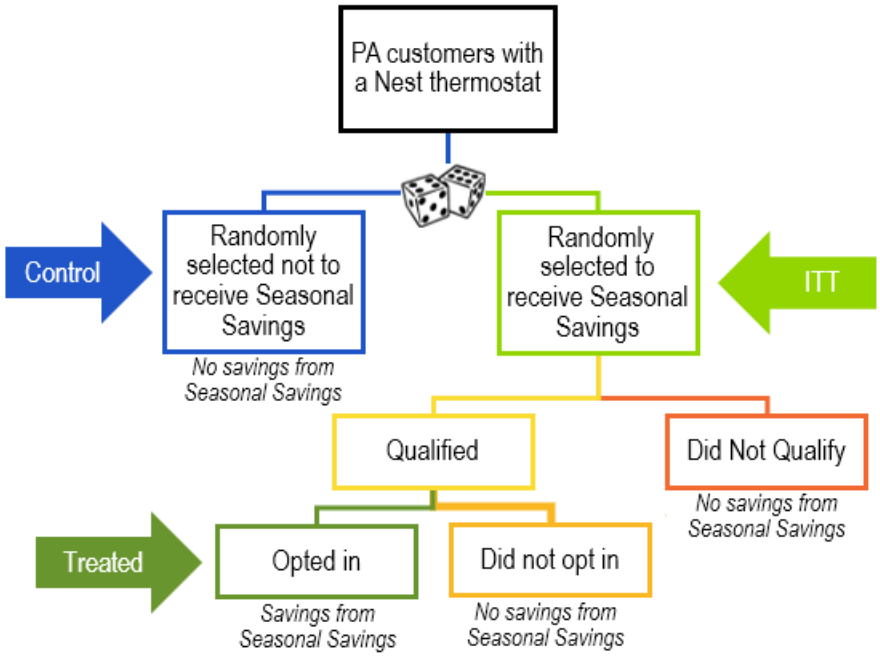
2.1 Experimental Design

Google deployed the SS program using a RED, in which all customers in a PA's service area with a Nest thermostat were randomly assigned into one of two groups:

- **ITT:** Participants randomly assigned to receive the program offering.
- **Control:** Participants randomly assigned to not receive the program offering.[10]

Prior to conducting the evaluation, Guidehouse verified the balance of the ITT and control groups across key variables (e.g., scheduled setpoints and runtime).[11] Figure 2-1 illustrates the RED for the SS program.

Figure 2-1. RED Illustration



Source: Guidehouse

Some thermostats in the ITT group do not qualify to participate in the program. Qualification requirements include the following:

- A Nest thermostat installed and connected to Wi-Fi.

[10] For each PA in the 2019/20 winter season, 80% of thermostats were randomly assigned to the ITT group while the remaining 20% were assigned to the control group.

[11] Appendix A contains the results of the post-deployment balance checks.

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- An online Google Nest account.
- A heating system connected to the thermostat.
- A heating setpoint schedule programmed.

Google opted to re-randomize all devices in the SS program between the ITT and control groups for the 2019/20 season, compared to 2018/19. This means that some customers treated in the 2018/19 season are in the 2019/20 control group and vice versa.

The program offering was provided to all qualified ITT customers on the thermostat itself and through a mobile app. Overall, a majority of qualified ITT customers chose to opt in and enroll in the program (61%) while 39% of qualified thermostats were not enrolled. Throughout this report customers that opted in are referred to as treated and the treated group.[12] Thermostats that were part of the ITT group but did not qualify or did not opt in are referred to as untreated or the untreated group.

Table 2-1 tallies the thermostats assigned to the control and ITT groups, including the number of thermostats that did not qualify and did or did not opt in. Within the ITT group, approximately 23% of the assigned thermostats did not qualify and another 30% chose not to opt in to the SS program. The remaining 47% of ITT thermostats were enrolled in the program.

Table 2-1. 2019/20 Winter SS Program Implementation Summary

	Nest Thermostats	Percentage of All	Percentage of ITT	Percentage of Qualified
All Thermostats	**145,659**	**100%**	**-**	**-**
Control	28,413	20%	-	-
ITT	117,246	80%	100%	-
Not Qualified	26,631	18%	23%	-
Qualified	90,615	62%	77%	100%
Did Not Opt In	35,102	24%	30%	39%
Opted In	55,513	38%	47%	61%

Source: Guidehouse analysis of Nest thermostat enrollment data

Table 2-2 shows device counts in the ITT and control groups, as well as the qualification and opt-in rates by PA. Qualification rates and opt-in rates were similar to 2018/19.

[12] When discussing devices that are treated in both 2018/19 and 2019/20, the evaluation team does not observe whether the device's schedule is changed or reset between seasons. This data limitation is further discussed in Section 3.1.

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Table 2-2. 2019/20 Winter SS Program Implementation Summary by PA

2019 Status	Qualification	Treatment	NG	EVS	CLC	All
ITT	**All ITT**	**All ITT**	79,426	33,746	**4,074**	**117,246**
	Qualified	Treated	37,748	16,789	976	55,513
		Untreated	23,845	9,676	1,581	35,102
	Not Qualified	Untreated	17,833	7,281	1,517	26,631
	Qualification Percentage of ITT		*78%*	*78%*	*63%*	*77%*
	Opt-In (Treated) Percentage of Qualified		*61%*	*63%*	*38%*	*61%*
Control	**-**	**Control**	19,196	8,179	**1,038**	**28,413**
		Total	98,622	41,925	**5,112**	**145,659**

NG = National Grid; EVS = Eversource; CLC = Cape Light Compact

Source: Guidehouse analysis of Nest thermostat enrollment data

2.2 Exploratory Analysis

Guidehouse analyzed thermostat-level participation data and thermostat telemetry data to:

- Compare enrollment and reenrollment rates across PAs to assess customer acceptance of the program over multiple years.
- Analyze setpoints (scheduled and actual) and thermostat heating runtime to assess whether the impact of thermostat optimization was evident in the data.
- Compare data for devices treated in both 2018/19 and 2019/20 with those treated just one year or the other.
- Analyze differences between weekdays and weekends.

For the exploratory analysis, the control group is often the basis of comparison and serves as the counterfactual for the combined treated and untreated groups (the ITT group)—i.e., what would have happened had the thermostats in the ITT group not been deployed as part of the SS program? Comparing the treated and untreated groups may lead to false conclusions because the characteristics that influence whether a thermostat ends up in the treated group (e.g., connectivity, mode, schedule) may also influence the setpoints and runtime of the thermostat. The differences between the treated and untreated groups may be a result of preexisting characteristics, not necessarily from enrollment in the SS program.[13]

For the multiyear portion of the exploratory analysis, Guidehouse was only able to observe the opt-in status for devices during the 2018/19 winter season (i.e., whether a device was treated or not treated). Google did not share data that would allow the evaluation team to differentiate between devices that were in the control group, in the untreated group (both unqualified and qualified but did not opt in), or that were not part of the program in 2018/19. For this reason,

[13] Guidehouse's (FKA Navigant) past reports on the SS program for the MA PAs contain graphics showing the differences between the treated and untreated groups. See for example, Figure 4-3 in the 2018/19 winter report.

Navigant. *Winter 2018-2019 Massachusetts Temperature Optimization Evaluation*. Prepared for: the Massachusetts Program Administrators.

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devices are binned based on the years they were treated without references to control group status.

Guidehouse was also not given data from Google that would allow us to link thermostat telemetry data across seasons. For example, the evaluation team does not know if a customer who opted in to the program in 2018/19 reset their device's schedule at the beginning of the 2019/20 season. In addition, daily telemetry data shared with the Guidehouse team does not indicate when or how changes are made to scheduled setpoints. Thus, the team cannot readily observe when customers are making manual changes to their setpoints during the 2019/20 season. While differences between scheduled and actual setpoints may be indicative of manual overrides, there are several reasons that scheduled and actual setpoints differ (for example, use of Nest's Home/Away Assist feature).

2.3 Impact Analysis

Guidehouse conducted the impact analysis to estimate the energy savings from SS for treated devices. The impact analysis for natural gas devices consisted of a runtime to energy conversion, regression modeling to calculate savings, and a comparison with Google's calculated savings. For non-natural gas devices, Guidehouse applied percentage savings from the 2018/19 evaluation to baseline usage (converted from runtime) for 2019/20.

2.3.1 Runtime to Energy

The data provided by the Nest thermostats included the runtime of each controlled piece of equipment but not the energy consumed by each piece of equipment. This subsection describes the process Guidehouse used to convert the runtime provided by the thermostats into a measure of energy consumption for each piece of equipment.

Space heating equipment is usually rated based on its capacity and efficiency. The capacity can be provided in two forms: input capacity or output capacity. Input capacity is more commonly used for fuel-powered equipment such as furnaces; it specifies the amount of energy consumed by the piece of equipment per unit of time. Output capacity is more often used for heat pumps and specifies the amount of heat provided by the unit per unit time. Input capacity is linked to the amount of energy that a utility must provide to the equipment, while output capacity is linked to the amount of energy that must be provided to the conditioned space to meet the heating load. These two variables are connected to each other via the operating efficiency of the equipment, as shown in Equation 2-1.

Equation 2-1. Input-Output Capacity Relationship

$$Output\ Capacity = Input\ Capacity \times Efficiency$$

In the 2018/19 analysis for natural gas-fired space heating equipment, Guidehouse estimated the typical capacity and operating efficiency based on several data sources, including previous potential studies, the RES 1 Baseline Load Shape Study, past regulatory analyses for the United States Department of Energy, and the Massachusetts Technical Reference Manual.

To calculate the hourly energy consumption of each piece of equipment, Guidehouse multiplied the input capacity (energy per hour) by the percentage of the hour the Nest thermostat recorded runtime, as shown in Equation 2-2.

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Equation 2-2. Input Capacity to Energy Consumption

$$Energy\ Consumption = Input\ Capacity \times Percent\ Runtime$$

Unlike houses heated by furnaces or heat pumps, houses heated by boilers are typically divided into different zones and each zone has its own hydronic heat loop and thermostat. Unlike furnaces and heat pumps, many boiler models retain a significant amount of heat within the boiler when the gas valve is not firing. To account for these differences in boiler-heated homes, Guidehouse used data from a previous boiler metering study to develop a ratio of the amount of time a boiler-controlling thermostat is calling for heat to the amount of time the boiler is consuming energy to produce heat.

After estimating the primary heating fuel use, Guidehouse estimated the associated electric usage for furnace fans and boiler pumps (auxiliary electric consumption). These conversions enabled Guidehouse to fully quantify the energy impacts from this program.

In this 2019/20 analysis, Guidehouse updated our consumption estimates for natural gas furnaces and boilers based on a new RES 1 Baseline Load Shape Study analysis, in which Guidehouse disaggregated space heating consumption for natural gas furnace and boiler customers with and without Wi-Fi thermostats.[14] The evaluation team compared this disaggregated space heating consumption from the 2018/19 winter with the thermostat call time data from the same time period to refine its estimates of hourly fuel consumption for natural gas furnaces and boilers.

These updates resulted in fuel consumption (that is, therms per hour of heating call time) values that were approximately 15% higher than those for 2018/19 for natural gas furnaces and 10% lower for natural gas boilers. This update did not include non-natural gas devices; as such, the consumption estimates for non-natural gas devices remained unchanged from 2018/19.

The resulting conversion factors for fuel and electric consumption are found in Table 2-3. The converted consumption values for natural gas devices were used in the regression analysis described in Section 2.3.2, while the values for non-natural gas devices were used to calculate baseline consumption for the method described in Section 2.3.3. These updated values were also shared with Google to use in their savings estimation.

[14] Disaggregation by thermostat capability is important since Wi-Fi thermostat customers may have a different average equipment capacity than the general population. For example, Wi-Fi thermostats may be more prevalent in larger homes with higher-capacity heating equipment or customers with Wi-Fi thermostats may buy more efficient (and lower capacity) equipment because they are more energy conscious than the general population.

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Table 2-3. Runtime to Energy Conversion Factors

	Call Time to Runtime Ratio for Fuel Consumption	Fuel Consumption (Therms per Hour of Heating Call Time)	Auxiliary Electric Consumption / Electric Consumption (kWh per Hour of Heating Call Time)
Natural Gas – High Stage Furnace	NA†	0.91	0.480
Natural Gas – Low Stage Furnace	NA†	0.58	0.258
Natural Gas – Boiler	NA†	0.82	0.300
Oil – Furnace	1:1	0.92	0.480
Oil – Boiler	1:0.7	0.86	0.300
Propane – Furnace	1:1	0.74	0.480
Electric – Central Heat Pump (No Elec. Res.)	1:1	N/A	3.300
Electric – Space Heater	1:1	N/A	7.800

Source: Guidehouse analysis
†This ratio is subsumed in the analysis for natural gas equipment, since results are based on thermostat call time data and disaggregated consumption data.

2.3.2 Regression Modeling for Natural Gas Devices

Guidehouse used a linear fixed effect (or difference-in-difference) regression model to estimate energy savings for natural gas devices. These savings are associated with the thermostats randomly assigned to receive the program offering—i.e., the savings estimate is the average effect of being randomly assigned to be offered the SS algorithm. This savings value is then scaled by the program opt-in rate to estimate the savings per treated thermostat.[15] Table 2-4 details the calculations of the various savings estimates.

Equation 2-3 specifies the model the evaluation team used to estimate energy savings during the program period. This model was run for fuel and electric savings separately.

Equation 2-3. Linear Fixed Effects Model

$$EDU_{it} = \alpha_i + \gamma_t + \beta(Post_t \times ITT_i) + \varepsilon_{it}$$

Where,

EDU_{it} is the estimated daily usage (in therms or kWh) by thermostat *i* on day *t.*

α_i is a thermostat-specific fixed effect for thermostat *i*; this picks up all thermostat-specific characteristics that do not change through time like household square footage.

γ_t is a time-specific fixed effect for day *t;* this picks up temporal differences across days like weather and daylight hours.

[15] This scaling assigns all savings to thermostats treated in the winter season for 2019/20, even if some savings come from persistence from devices treated in the previous year.

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$Post_t \times ITT_i$	is a binary variable taking a value of 1 when thermostat *i* is in the ITT group and day *t* is on or after the start of the SS program (January 8, 2020).
β	is the average daily per-thermostat impact (therms or kWh) of participating in the ITT group after January 8, 2020.
ε_{it}	is the cluster-robust error term for thermostat *i* during day *t*; cluster-robust errors account for heteroskedasticity and autocorrelation at the thermostat level.

The evaluation team used this model to estimate statewide natural gas and auxiliary electric savings. Guidehouse developed total energy savings estimates during the program period (tune-up and post-tune-up periods combined). The program period spans from January 8, 2020 to April 30, 2020.

Because Guidehouse received daily rather than hourly data from Google this year, electric savings for on-peak, off-peak, and demand periods could not be directly estimated using 2019/20 data. The evaluation team estimated on- and off-peak electric savings using the same percentage of savings these periods made up for natural gas devices in the 2018/19 analysis (28% on-peak and 72% off-peak). No electric winter demand savings were found in 2018/19, so no demand savings can be claimed for 2019/20.

Guidehouse estimated energy impacts for natural gas devices for National Grid and Eversource individually and combined. The evaluation team multiplied average daily energy savings by the appropriate number of program days (after the first program start date) and the number of thermostats in the ITT group to calculate total program energy savings that resulted from treatment. Table 2-4 identifies the various savings statistics.

Table 2-4. Savings Calculations

Savings Type	Statistic	Calculation
Energy	Average daily savings per treated thermostat	$\hat{\gamma} = \frac{-\hat{\beta}}{SS\ Opt\ In\ Rate}$
	Total savings	$-\hat{\beta} \times Total\ Number\ of\ ITT\ Days\ Post\ Program\ Start$
	Average total savings per treated thermostat	$\frac{Total\ Savings}{Total\ Number\ of\ Treated\ Thermostats}$
	Average savings (Percentage of heating load)	$\frac{\hat{\gamma}}{(Avg\ Daily\ Treated\ Energy\ Usage\ Post\ Program\ Start + \hat{\gamma})}$

Source: Guidehouse

2.3.3 Savings Calculation for Non-Natural Gas Devices

For the 2019/20 season, National Grid and Eversource only offered the SS program to natural gas customers, dramatically reducing the number of customers available to model non-natural gas device savings. In the 2018/19 evaluation, almost 18,000 non-natural gas devices participated in the program compared with less than 2,500 in 2019/20. With so few non-natural

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gas devices, Guidehouse and Google agreed that regression modeling was unreliable to estimate savings.[16]

Instead, Guidehouse estimated savings using the same percentage savings as the 2018/19 evaluation and applied them to the 2019/20 usage baselines. Although the same savings were claimed for all non-natural gas devices in the 2018/19 evaluation, the evaluation team used the per fuel type savings to account for the change in mix of non-natural gas devices by fuel type between the two years.[17] Table 2-5 shows the percentage savings by fuel type for non-natural gas devices from the 2018/19 evaluation.

Table 2-5. Non-Natural Gas Percentage Savings from 2018/19

Fuel Type	Percentage Savings – Fuel	Percentage Savings – Electric
Oil	3.0%	3.0%
Propane	1.5%	1.4%
Electric	-	10.0%

Source: Guidehouse 2018/19 SS evaluation

Guidehouse multiplied the percentage savings by baseline usage per day by fuel type to get fuel and electric savings per day per device for each fuel type. The evaluation team then took a weighted average across devices to get a single fuel and electric savings value for all non-natural gas devices.[18] This value was multiplied by the number of days treated devices were in the program to get total savings.[19]

Guidehouse estimated on- and off-peak electric savings using the same percentage of savings these periods made up for non-natural gas devices in the 2018/19 analysis—32% on-peak and 68% off-peak. No electric winter demand savings were found in 2018/19, so no demand savings will be claimed for 2019/20.

[16] Google did run regressions for non-natural gas devices but found the relative precision at 90% confidence to be 69% of the savings estimate for fuel and 116% for electric (compared with 39% and 55% for 2018/19).

[17] In 2018/19, 75% of non-natural gas devices were oil, 16% propane, and 10% electric; in 2019/20, the same percentages were 71%, 23%, and 6%. This result shows a shift away from oil and electric and toward propane, which is likely explained by the higher share of Cape Light Compact thermostats among the non-natural gas devices in 2019/20 compared with 2018/19.

[18] The weighted average considered the number of devices per fuel type and the baseline usage of each fuel type.

[19] Treated device days go from January 8 to April 30 but are discounted for devices that joined the program late or left early, for example due to an account closure.

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3. Data Sources

For this program evaluation, Guidehouse used data from two sources:

- Google-provided daily telemetry data for December 2019 through April 2020 and an accompanying thermostat-specific information file.[20]
- Hourly weather data for December 2019 through April 2020, retrieved from the National Oceanic and Atmospheric Administration (NOAA) database for selected weather stations across Massachusetts.

3.1 Google Nest Thermostat Data

Guidehouse relied on thermostat telemetry data provided by Google for all Nest thermostats in the winter 2019/20 deployment for the exploratory and impact analyses. With input from the PAs, Guidehouse took several steps to filter and clean the thermostat telemetry data to prepare it for these analyses:

- **Closed account:** Any thermostat that appeared in the data but (a) had a closed Google Nest account or (b) the customer requested Google to remove their data was marked as invalid and made ineligible for savings.
- **No telemetry data:** If a thermostat present in the thermostat-specific information file did not have any data in the telemetry file from Google, it was marked as invalid and made ineligible for savings.
- **No reported fuel type:** Any thermostat that did not report a valid fuel type (either gas, electric, propane, or oil) was removed from the data and made ineligible for savings as these thermostats were not likely connected to a heating system and should not be considered part of the program.

The remaining steps were taken only for the regression analysis for natural gas devices:

- **Non-natural gas devices:** Any thermostat that reported a heating type other than natural gas was dropped from the regression analysis. Savings are still claimed for these devices through the alternative method described in Section 2.3.3.
- **No weather station:** Any thermostat without a weather station identifier, which occurred when a thermostat's assigned weather station had fewer than 50 devices assigned to it.[21] These devices were still eligible for savings.
- **No data during season:** If a thermostat present in both the thermostat-specific information file and the telemetry data file did not have any data between December 1, 2019 and April 30, 2020, it was removed from the modeling approach as Guidehouse only analyzed data during this timeframe. However, these devices were still eligible for savings.
- **No complete days:** Guidehouse removed observations from the telemetry data that did not have complete daily runtime information for a given date. Some thermostats were

[20] The change from 15-minute interval data received for the 2018/19 evaluation to daily data this year limited the team's ability to conduct certain analyses (described in Section 2).

[21] Google did not share this data because of customer privacy concerns.

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completely removed from the modeling data because of this step; however, they were still eligible for savings.

- **No pre-/program period data:** If a thermostat did not have any records in either the pre- or program (tune-up plus post-tune-up) periods, it was removed from the analysis. These devices were still eligible for savings.

Table 3-1, Table 3-2, and Table 3-3 show the number of thermostats Guidehouse removed from the data for National Grid, Eversource, and Cape Light Compact, respectively; approximately 11% of thermostats were excluded from the regression analysis for National Grid and Eversource. In each of these tables, participating thermostats refers to the number of devices Guidehouse verified as active during the program year. In particular, all treated devices from the ITT group included in this count were considered eligible for savings. Thermostats in models refers to the natural gas devices that made it through all cleaning steps and were included in the regression analysis. Because no modeling was completed on Cape Light Compact data, Table 3-3 only shows the cleaning steps up to the number of devices included in the final savings calculations.

Table 3-1. Data Management, National Grid

Cleaning Step	ITT		Control		Total	
	Count	Percent	Count	Percent	Count	Percent
Thermostats in device file	**79,426**	**100%**	**19,196**	**100%**	**98,622**	**100%**
Closed account†	2,138	2.69%	-	-	2,138	2.17%
No telemetry data	1,577	1.99%	631	3.29%	2,208	2.24%
No reported fuel type‡	2,083	2.62%	-	-	2,083	2.11%
Participating thermostats	**73,628**	**92.70%**	**18,565**	**96.71%**	**92,193**	**93.48%**
Non-natural gas devices	2,134	2.69%	490	2.55%	2,624	2.66%
No weather station	67	0.08%	12	0.06%	79	0.08%
No data during season	15	0.02%	4	0.02%	19	0.02%
No complete days	27	0.03%	4	0.02%	31	0.03%
No pre-/program period data	672	0.85%	223	1.16%	895	0.91%
Thermostats in models	**70,713**	**89.03%**	**17,832**	**92.89%**	**88,545**	**89.78%**

† The issue of account closures affects the ITT and control groups equally. However, it is only observed for the treated customers in the ITT group due to an ad hoc extract Google made from their SS participation reporting table capturing devices enrolled in the program prior to the deletion of the closed customer account.

‡ The issue of no reported fuel type only occurs in the ITT group as SS is deployed to all thermostats in any home that has a thermostat in the ITT group, including devices which were not included in the original target population for any reason (e.g., thermostats that do not control a heating system, and thermostats that have irregular wiring making system type unclear). These devices not in the target population do not have a reported fuel type and are not considered part of the program.

Source: Guidehouse analysis of thermostat enrollment and telemetry data

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Table 3-2. Data Management, Eversource

Cleaning Step	ITT		Control		Total	
	Count	Percent	Count	Percent	Count	Percent
Thermostats in device file	**33,746**	**100%**	**8,179**	**100%**	**41,925**	**100%**
Closed account†	1,087	3.22%	-	-	1,087	2.59%
No telemetry data	663	1.96%	257	3.14%	920	2.19%
No reported fuel type‡	820	2.43%	-	-	820	1.96%
Participating thermostats	**31,176**	**92.38%**	**7,922**	**96.86%**	**39,098**	**93.26%**
Non-natural gas devices	1,269	3.76%	288	3.52%	1,557	3.71%
No weather station	19	0.06%	9	0.11%	28	0.07%
No data during season	10	0.03%	2	0.02%	12	0.03%
No complete days	8	0.02%	5	0.06%	13	0.03%
No pre-/program period data	323	0.96%	111	1.36%	434	1.03%
Thermostats in models	**29,528**	**87.50%**	**7,507**	**91.78%**	**37,054**	**88.38%**

† The issue of account closures affects the ITT and control groups equally. However, it is only observed for the treated customers in the ITT group due to an ad hoc extract Google made from their SS participation reporting table capturing devices enrolled in the program prior to the deletion of the closed customer account.

‡ The issue of no reported fuel type only occurs in the ITT group as SS is deployed to all thermostats in any home that has a thermostat in the ITT group, including devices which were not included in the original target population for any reason (e.g., thermostats that do not control a heating system, and thermostats that have irregular wiring making system type unclear). These devices not in the target population do not have a reported fuel type and are not considered part of the program.

Source: Guidehouse analysis of thermostat enrollment and telemetry data

Table 3-3. Data Management, Cape Light Compact

Cleaning Step	ITT		Control		Total	
	Count	Percent	Count	Percent	Count	Percent
Thermostats in device file	**4,074**	**100%**	**1,038**	**100%**	**5,112**	**100%**
Closed account†	96	2.36%	-	-	96	1.88%
No telemetry data	109	2.68%	49	4.72%	158	3.09%
No reported fuel type‡	80	1.96%	-	-	80	1.56%
Participating thermostats	**3,789**	**93.00%**	**989**	**95.28%**	**4,778**	**93.47%**

† The issue of account closures affects the ITT and control groups equally. However, it is only observed for the treated customers in the ITT group due to an ad hoc extract Google made from their SS participation reporting table capturing devices enrolled in the program prior to the deletion of the closed customer account.

‡ The issue of no reported fuel type only occurs in the ITT group as SS is deployed to all thermostats in any home that has a thermostat in the ITT group, including devices which were not included in the original target population for any reason (e.g., thermostats that do not control a heating system, and thermostats that have irregular wiring making system type unclear). These devices not in the target population do not have a reported fuel type and are not considered part of the program.

Source: Guidehouse analysis of thermostat enrollment and telemetry data

Guidehouse applied savings estimates to treated devices that had an open Google Nest account, both telemetry and device data, and a valid reported heating fuel. Table 3-4 shows the number of devices eligible for savings through the SS program.

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Table 3-4. Devices Eligible for Savings

Cleaning Step	National Grid		Eversource		Cape Light Compact		All	
	Count	Percent	Count	Percent	Count	Percent	Count	Percent
Treated thermostats in device file	**37,748**	**100%**	**16,789**	**100%**	**976**	**100%**	**55,513**	**100%**
Closed account†	-	-	-	-	-	-	-	-
No telemetry data	5	0.01%	1	<0.01%	-	-	6	0.01%
No reported fuel type	513	1.36%	244	1.45%	16	1.64%	773	1.39%
Treated thermostats eligible for savings	**37,230**	**98.63%**	**16,544**	**98.54%**	**960**	**98.36%**	**54,734**	**98.60%**
Natural gas	36,308	96.19%	15,977	95.16%	-	-	52,285	94.19%
Non-natural gas	922	2.44%	567	3.38%	960	98.36%	2,449	4.41%

† The issue of account closures affects the treated and untreated groups equally. However, it is only observed in the treated group due to an ad hoc extract Google made from their SS participation reporting table capturing devices enrolled in the program prior to the deletion of the closed customer account.

Source: Guidehouse analysis of thermostat enrollment and telemetry data

3.2 NOAA Temperature Data

To provide context to the exploratory and impact analysis results, Guidehouse used 2019/20 temperature data from NOAA for 18 Quality Controlled Local Climatological Data weather stations across Massachusetts. Guidehouse pulled and cleaned the data, calculated HDD (base 60°F) for all intervals and produced daily weather averages. To link the weather data to individual thermostats, Google assigned each thermostat to a single weather station based on its geographic location using a ZIP code weather station map created by Guidehouse.

Of the 18 stations, 10 had complete data. One station (Blue Hill) was missing approximately 15% of its data and another (Provincetown) was missing approximately 6.5%. No other stations were missing more than 3% overall. For gaps where 4 or fewer consecutive hours were missing, Guidehouse used linear interpolation to fill in the missing hours. When more than 4 consecutive hours were missing, the team filled in the gap with a nearby weather station with similar weather patterns (see Table 3-5).

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Table 3-5. Missing Weather Data Summary

Weather Station	Missingness Summary	Replacement Station
Barnstable Municipal Airport	Five gaps of varying length, between 6 and 9 hours	Chatham Municipal Airport
Blue Hill Meteorological Observatory	Seven gaps of varying length, between 6 and 210 hours	Norwood Memorial Airport
Chatham Municipal Airport	One gap of 5 hours and one of 7 hours	Barnstable Municipal Airport
Fitchburg Municipal Airport	One gap of 9 hours	Orange Municipal Airport
Otis Air National Guard Base	One gap of 9 hours and one of 7 hours	Barnstable Municipal Airport
Plymouth Municipal Airport	One gap of 8 hours	Taunton Municipal Airport
Provincetown Municipal Airport	Five gaps of varying length, between 5 and 181 hours	Marshfield Municipal Airport
Worcester Regional Airport	One gap of 5 hours	Fitchburg Municipal Airport

Source: Guidehouse analysis of NOAA weather data

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4. Analysis and Results

This section presents results from Guidehouse's exploratory and impact analyses.

4.1 Exploratory Analysis

Key findings from Guidehouse's analysis of setpoints and thermostat heating runtime include the following:

- In winter 2019/20, 47% of ITT thermostats (and 61% of qualified thermostats) enrolled in the program. Enrollment and qualifications rates continue to be lower for Cape Light Compact than National Grid and Eversource, likely due to different home usage and heating needs on Cape Cod.
- Almost two-thirds of customers offered the program for a second time in 2019/20 after enrolling in 2018/19 chose to opt in to the program for another year. The reenrollment rate was lower for Cape Light Compact (~50%).
- Scheduled and actual setpoints and runtime all show evidence of the program effect for the ITT versus control groups. The stay-at-home period from the pandemic does not seem to affect the relative positioning of the ITT and control groups.
- Reviewing these variables based on when customers were treated (2018/19, 2019/20, both, or neither) shows some persistence in setpoints and shows the program effect builds over time.
- Scheduled setpoints for natural gas customers were about 0.25°F lower in the pre-period than in 2018/19. The SS impact on scheduled setpoints was roughly the same as 2018/19 (-0.80°F this year compared with -0.67°F last year).
- Average daily runtime for natural gas customers in the pre-period was similar across the two years (~250 minutes); however, it was lower in the 2019/20 program period (~190 minutes) compared with 2018/19 (~220 minutes), likely driven by the milder weather in January to March. The SS impact on runtime was smaller (-4 minutes this year compared with -6 minutes last year).

4.1.1 Opt-In Rate Over Time

Guidehouse looked at customer enrollment status between the 2018/19 and the 2019/20 heating seasons. For this evaluation, the team was only able identify whether or not a device was treated in 2018/19.[22] Figure 4-1 shows this season's treatment status breakdown for the devices that opted in to the program during the 2018/19 winter season. While reenrollment rates are lower for Cape Light Compact (50%), almost two-thirds (63%) of devices overall that opted in during 2018/19 and were offered the program again in 2019/20 opted in again. This reenrollment is almost identical to what the evaluation team saw for National Grid in the summer 2019 evaluation.

[22] Google did not share data that would allow the evaluation team to differentiate between devices that were in the control group, in the untreated group (both unqualified and qualified but did not opt in), or that were not part of the program in 2018/19.

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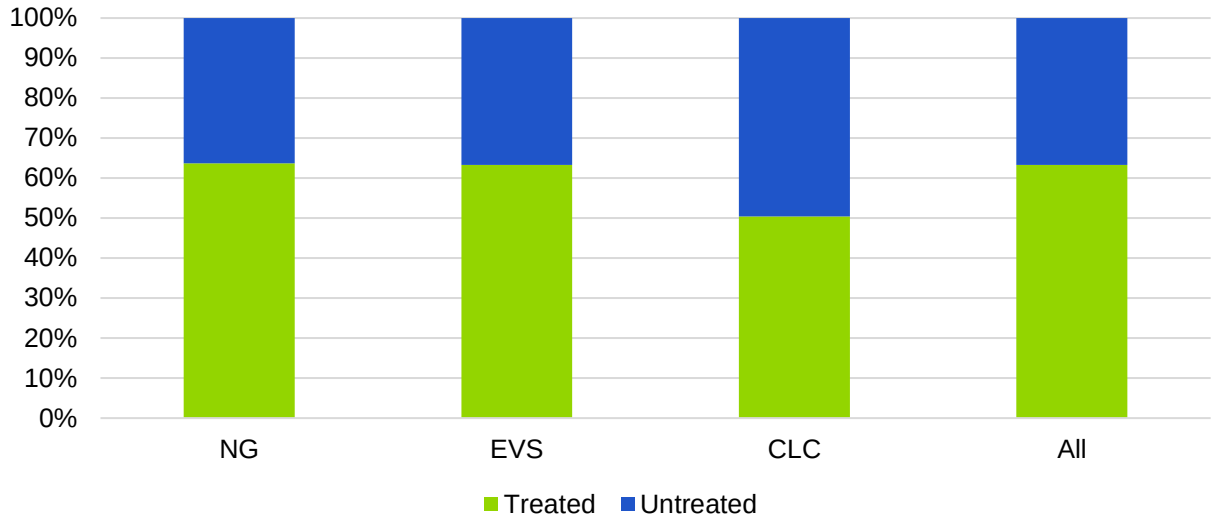
Figure 4-1. 2019/20 Season Reenrollment Rate



The untreated group encompasses devices that did not opt in and devices that did not qualify in the 2019/20 winter season.

NG = National Grid; EVS = Eversource; CLC = Cape Light Compact

Source: Guidehouse analysis of thermostat enrollment data

Using the dual-year enrollment data, Guidehouse created four subgroups to examine as part of the exploratory analysis:

- **Treated 2019/20:** Device was treated in the 2019/20 season only.
- **Treated 2018/19:** Device was treated in the 2018/19 season only.
- **Treated 2018/19 & 2019/20:** Device was treated in both the 2018/19 and 2019/20 seasons.
- **Never Treated:** Device was not treated in either the 2018/19 or 2019/20 seasons.

Overall, approximately 14% of all devices were treated in both 2018/19 and 2019/20 and 44% were never treated. The remaining 58% were treated only during one season, with the bulk of these occurring during the 2019/20 season. Figure 4-2 provides a breakdown of number of times (i.e., years) treated by PA.

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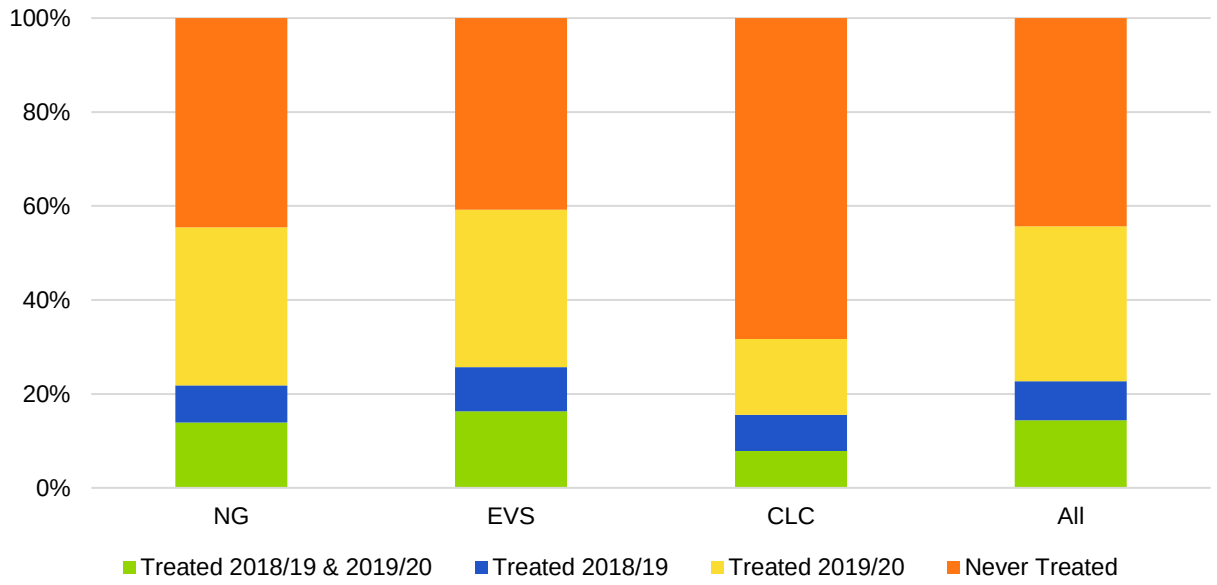
Figure 4-2. Times Treated by PA



NG = National Grid; EVS = Eversource; CLC = Cape Light Compact

Source: Guidehouse analysis of thermostat enrollment data

4.1.2 Setpoint and Runtime Analysis

The exploratory analysis compares the scheduled heating setpoints, actual heating setpoints, and heating runtimes between the pre-period and program period for each group. For this analysis, Guidehouse grouped natural gas and non-natural gas customers for comparison. The natural gas customer designation includes both natural gas devices and non-natural gas devices in the home of a natural gas customer. In practical terms, the natural gas customer designation includes all devices in National Grid and Eversource service areas, while non-natural gas customers are only devices within the Cape Light Compact service area.[23]

Figures throughout this section[24] contain a few vertical lines representing key dates: start of the SS program (January 8, 2020), end of the tune-up period (February 8, 2020), and start of the stay-at-home period in Massachusetts from the coronavirus pandemic (March 8, 2020).[25] The first two lines, which relate to the SS program timing, appear in gray while the last line, relating to the stay-at-home period, appears in red.

[23] The exploratory analysis uses all participating thermostats with the relevant data for each figure.

[24] For tabulated averages of the data shown in this section, refer to 0.

[25] Guidehouse chose this date based on publicly available mobility data showing when people began to reduce their mobility and stay home more rather than using dates of official stay-at-home orders. This mobility data is shown in Figure C-1. in 0.

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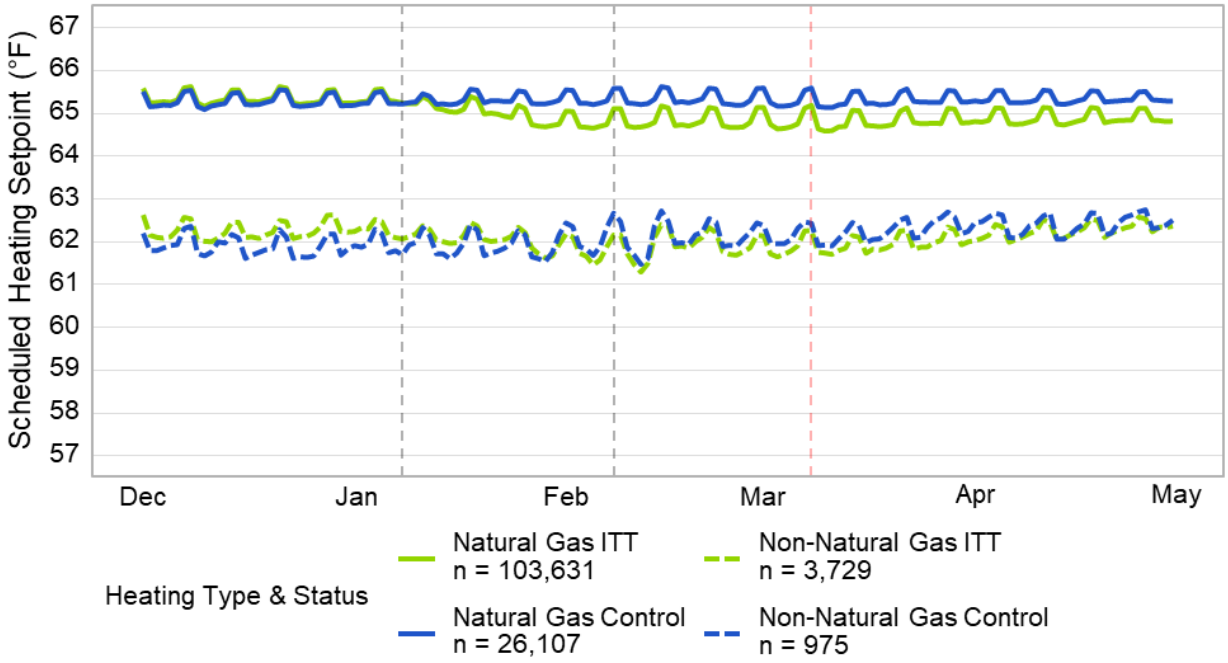
Figure 4-3 shows average scheduled heating setpoints across all days for both the ITT and control groups.[26] During the pre-period, the ITT and control groups for natural gas customers have similar setpoint schedules; this is by design and a result of the RED where thermostats are randomly assigned between these groups. Non-natural gas customers show slight differences in the pre-period, driven by the small population.[27] Average scheduled setpoints are higher during weekends and lower during weekdays, as seen by the repeated pattern of peaks and troughs. The ITT group setpoints are noticeably lower relative to the control group during the post-tune-up period, providing evidence that the SS program is resulting in an adjustment to scheduled heating setpoints while still following the peak and trough weekend/weekday pattern. While the difference in setpoints during the pre-period is negligible between the natural gas control and ITT groups at 0.06°F, the average difference widens to 0.56°F throughout the program period due to the effect of the program. The stay-at-home period had no effect on the scheduled setpoints.

Figure 4-3. Scheduled Heating Setpoints by ITT Status



Source: Guidehouse analysis of thermostat telemetry data

Figure 4-4 shows average heating setpoints across all days for both the ITT and control groups. Actual setpoints are generally slightly lower than scheduled setpoints; the differences between scheduled and actual setpoints may be indicative of manual overrides but can be caused by other reasons, for example, use of Nest's Home/Away Assist feature. Compared with the scheduled setpoints, actual setpoints have more noticeable variation over the heating season

[26] Lower setpoints for non-natural gas devices appear to be driven by a higher prevalence of devices with scheduled setpoints in the 50s (particularly 50°F and 55°F), which likely indicate unoccupied homes; this assumption makes sense as the non-natural gas customers are located on Cape Cod, which has a higher prevalence of second homes than other parts of the state. Although the two are grouped together in this figure, there is also a small difference between Eversource and National Grid (with Eversource about 0.5°F higher than National Grid) that also appears to be driven by scheduled setpoints in the 50s (more National Grid devices with scheduled setpoints of 50°F and 55°F).

[27] As shown by the balance checks in Appendix A, the pre-period differences were not statistically significant for non-natural gas (i.e., Cape Light Compact) customers.

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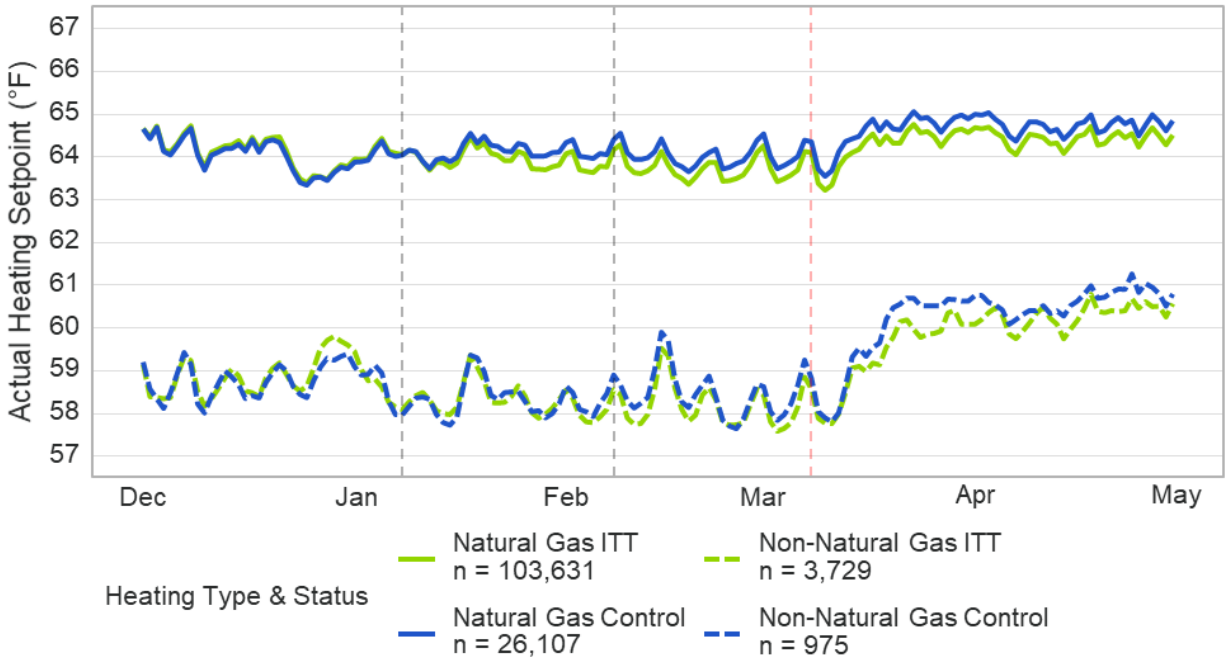
but still demonstrate the SS program effect with the ITT group declining relative to the control group during the program period. Heating setpoints for the natural gas ITT group decreased by 0.33°F relative to the control group during the program period, while this decrease was 0.34°F for the non-natural gas ITT group relative to its control group. In the latter half of the program period, the effect of stay-at-home orders in Massachusetts on thermostat setpoint behavior is visible—there is a noticeable increase in average setpoints across both groups and a loss of the peak/trough weekend/weekday patterns observed prior to that point. However, the stay-at-home period does not affect the relative difference between the setpoints of the ITT and control groups. Appendix C explores how the stay-at-home period affected device setpoints and runtime.

Figure 4-4. Actual Heating Setpoints by ITT Status



Source: Guidehouse analysis of thermostat telemetry data

Figure 4-5 presents the difference in average heating runtime over the season between the ITT and control groups, accompanied by average temperatures over the season. While the ITT group has higher average daily runtime than the control group in December and early January for natural gas and non-natural gas customers, the effect of the program caused a relative downward shift in runtime for the ITT groups relative to the control groups after the program launched. The relative decrease in runtime over the study is larger for non-natural gas devices than for natural gas, which is likely driven by a smaller sample size. Compared with the pre-period, natural gas ITT devices showed a decrease of 4 minutes of runtime in the program period relative to the control group, while this decrease was 8 minutes for the non-natural gas devices. As with the setpoints, the stay-at-home period does not appear to affect the relative runtime of the ITT groups compared with controls.

Average daily runtime for natural gas customers in the pre-period was similar between 2018/19 and 2019/20 (~250 minutes); however, it was lower in the 2019/20 program period (~190 minutes) compared with 2018/19 (~220 minutes), likely driven by milder weather in January to March. The SS impact on runtime was smaller (-4 minutes this year compared with -6 minutes

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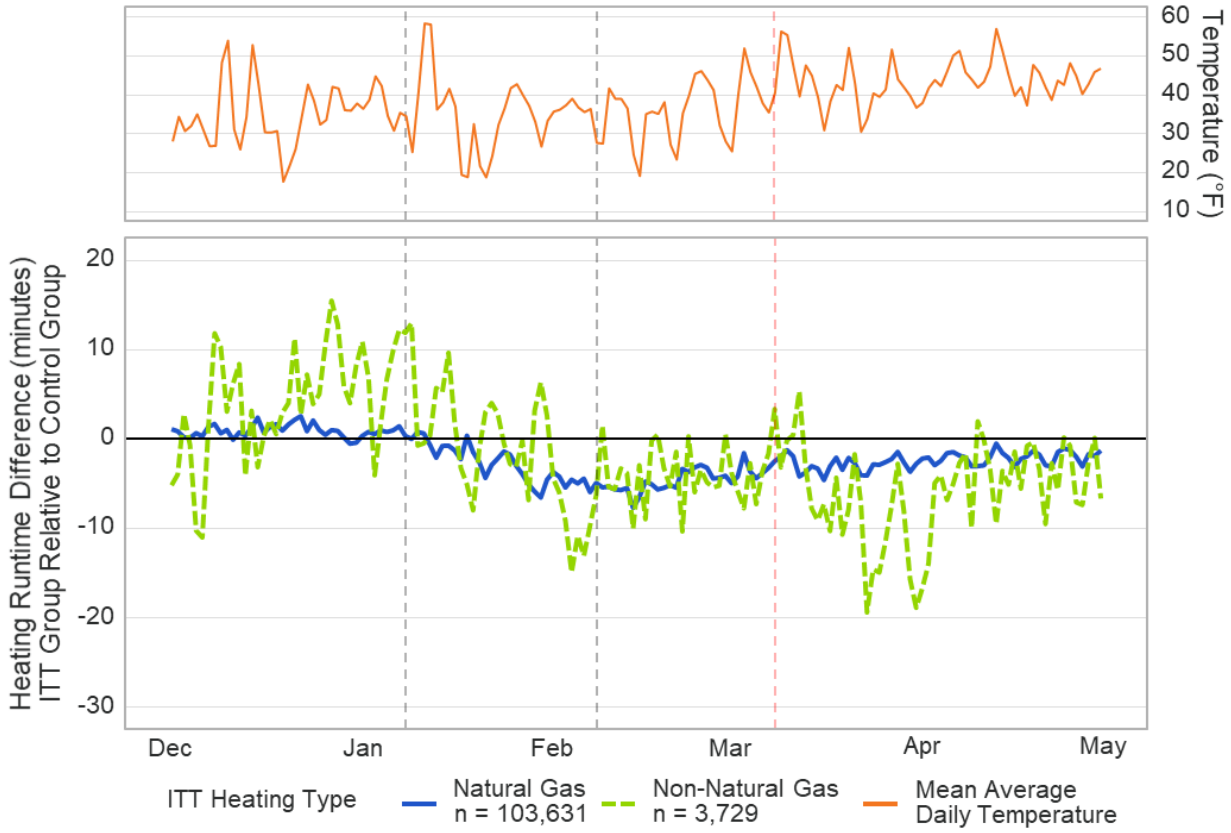
last year). A year-over-year comparison for non-natural gas is not included in this report given the change in program population and drastic decrease in device population size (almost 18,000 in 2018/19 to less than 2,500 in 2019/20).

Figure 4-5. Heating Runtime Differences by ITT Status



Source: Guidehouse analysis of thermostat telemetry data and NOAA temperature data

4.1.2.1 Breakdown by Years Treated

This section presents actual and scheduled setpoints and runtime for natural gas devices treated in various years.[28] For simplicity, the 2018/19 winter season is referred to as 2019 and the 2019/20 winter season as 2020 because the program began in January of both seasons. Using this notation, the evaluation team compares customers treated in 2019 only, 2020 only, both years, and neither year.

Figure 4-6 shows scheduled setpoints by year(s) treated. Several items are worth noting:

- The two groups treated in 2019 have similar averages before the program kicked off in 2020, but the group treated in both 2019 and 2020 has a lower average scheduled setpoint during the program period.

[28] The same comparisons for non-natural gas customers are shown in 0 and generally follow the same trends. However, the results are noisier because of the smaller sample size.

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  - The average value in the program period for the Treated 2019 group was 64.96°F, while the Treated 2019 & 2020 group had an average of 64.28°F during the same period.

- For each of the two groups that went untreated in 2020 (Treated 2019 and Never Treated), average scheduled setpoints between the pre-period and program period differed by less than 0.1°F, suggesting no changes to the customer's scheduled setpoints in 2020.
- For all devices treated in 2020 regardless of their treatment status during 2019 (Treated 2020 and Treated 2019 & 2020), the program had a similar impact in lowering scheduled setpoints.
  - For the Treated 2019 & 2020 group, average scheduled setpoints decreased by 0.77°F in the program period compared with the pre-period, while this decrease was 0.71°F for the Treated 2020 group. The Treated 2019 & 2020 group is lower in absolute setpoints in the program period because they start lower in the pre-period due to their treatment in 2019.
- The group of devices that were only treated in 2020 had the highest average scheduled heating setpoint in the pre-period at 65.70°F; as for the program period, the Treated 2020 group had similar but slightly lower average values, differing by 0.04°F on average compared with the Treated 2019 group. This result comes even though these two groups were treated during different years.

Figure 4-6. Scheduled Heating Setpoints by Prior Enrollment, Natural Gas Customers

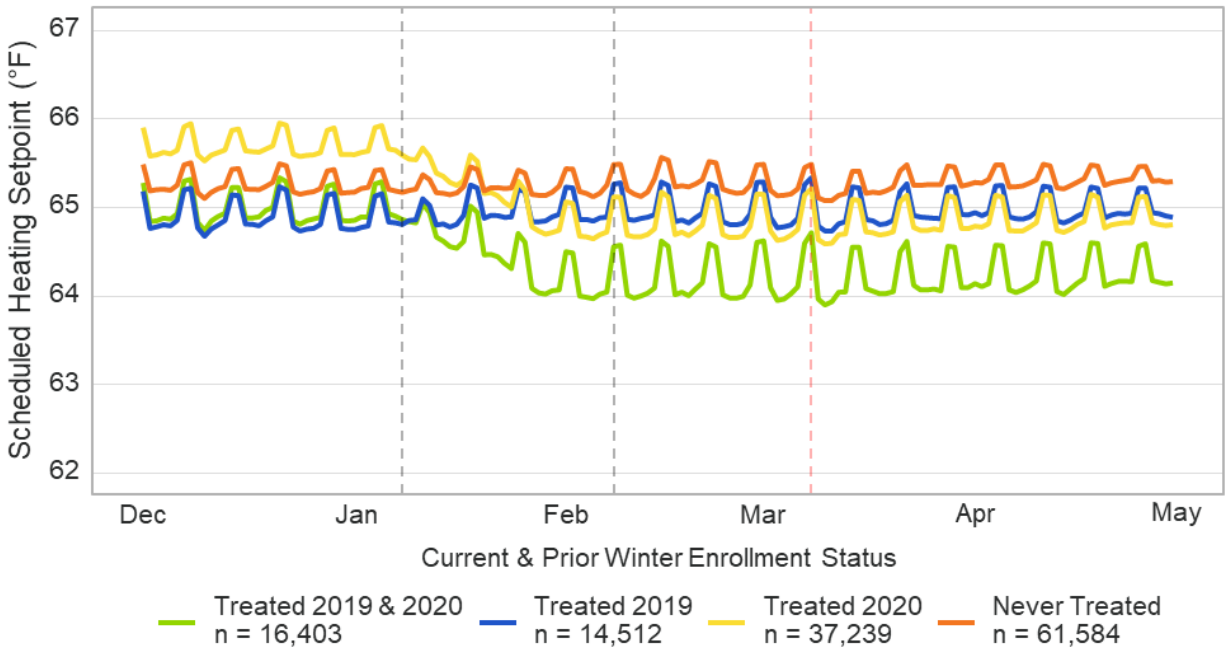

Figure presents averages for natural gas customers (i.e., devices in National Grid and Eversource service areas) only.

Source: Guidehouse analysis of thermostat telemetry data

Figure 4-7 presents the average actual scheduled heating setpoints by year(s) treated. Actual setpoints in the pre-period are lowest for the Never Treated group (contrasting with scheduled setpoints where they are the second highest). This finding may indicate that customers who do

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not opt in to the program are more likely to actively change their setpoint away from their schedule or use other features like Home/Away Assist. The other groups follow a similar trend to the scheduled setpoints:

- The devices treated in both 2019 and 2020 and only in 2019 are relatively similar in the pre-period with differences of only 0.09°F; they diverge in the program period as the devices treated during both winter seasons experienced further setpoint decreases. The devices treated during both seasons end up having lower average values than those treated only in 2019 by 0.46°F during the program period.
- The devices treated only in 2019 and only in 2020 differ in the pre-period by an average of 0.41°F (with the 2019 group lower because of the previous year's treatment) and then converge in the program period with an average difference of only 0.13°F. As with the scheduled setpoints, the average values for the actual setpoints for the devices treated only in 2020 end up slightly lower than those treated only in 2019.

Figure 4-7. Actual Heating Setpoints by Prior Enrollment, Natural Gas Customers

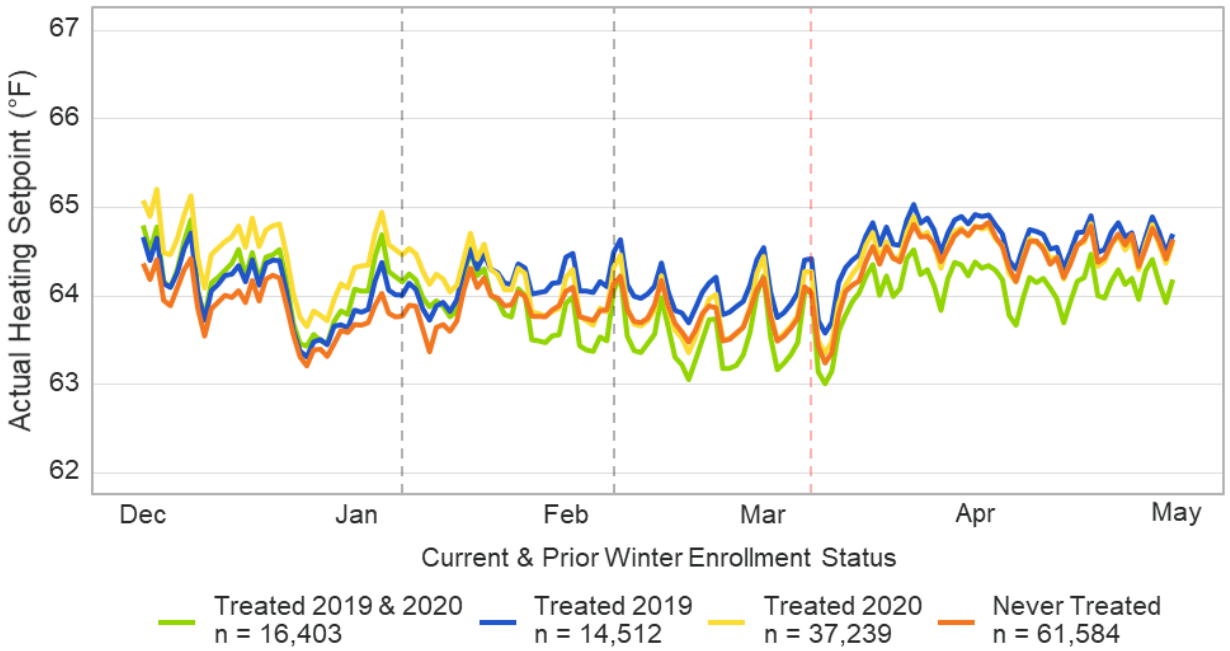

Figure presents averages for natural gas customers (i.e., devices in National Grid and Eversource service areas) only.

Source: Guidehouse analysis of thermostat telemetry data

Figure 4-8 presents the difference in average heating runtime over the season between the various treated groups when compared with the Never Treated group. Unlike the previous two figures, which showed absolute setpoints for all prior enrollment groups, this figure shows heating runtime relative to the Never Treated group. The relative differences in runtime between the groups are not apparent on a graph of absolute runtime. Relative differences in runtime by group do not match expectations as well as the setpoints do because the data is noisier, but some trends are observable.

- While both groups of devices that were treated in 2020 (Treated 2020 and Treated 2019 & 2020) had noticeable decreases in average runtime into the program period compared

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with the Never Treated group, the effect was stronger for the Treated 2020 group than the Treated 2019 & 2020 group at decreases of 14 and 11 minutes, respectively.

- The Treated 2019 group hardly showed any change relative to the Never Treated group over the 2020 season, with an average relative decrease of 1 minutes in the program period compared with the pre-period. This finding is expected because this group did not receive treatment in the 2020 season.
- The devices treated only in one year or the other (Treated 2019 and Treated 2020) converge in runtime in the program period. They are 14 minutes apart in the pre-period and less than 1 minute apart in the program period.
- The devices treated only in 2019 have lower pre-period runtime (250) than those treated in both years (254). Guidehouse expects these to be similar because both groups were treated in 2019.

Figure 4-8. Heating Runtime Differences by Prior Enrollment, Natural Gas Customers

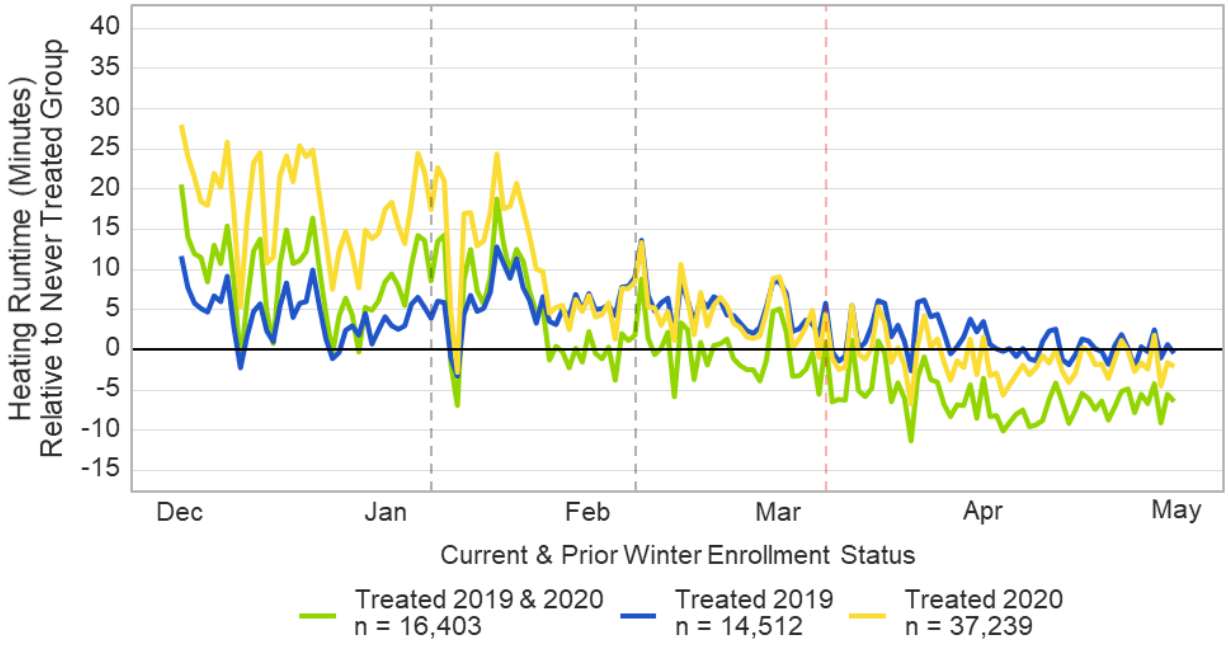

Figure presents averages for natural gas customers (i.e., devices in National Grid and Eversource service areas) only.

Source: Guidehouse analysis of thermostat telemetry data and NOAA temperature data

4.2 Impact Analysis

The impact analysis presents energy savings estimates for the 2019/20 heating season. Average program period energy savings per treated thermostat are:

- **Natural gas devices:** 11.6 therms (3.6% of fuel heating load) and 5.4 kWh (3.6% of electric heating load).
  - Compared with 2018/19, natural gas device fuel and electric savings decreased by 25% and 27%, respectively; this was likely driven by milder weather.
- **Non-natural gas devices:** 8.2 therms (2.7% of fuel heating load) and 15.2 kWh (6.0% of electric heating load)

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– Compared with 2018/19, non-natural gas device fuel and electric savings decreased by 13% and 12%, respectively; this was likely driven by milder weather resulting in lower baseline usage.

Table 4-1 and Table 4-2 present the overall verified MMBtu fuel and kWh electric savings in the 2019/20 winter season for natural gas and non-natural gas devices. Savings are shown by statewide totals and totals by PA heating fuel type. Overall, natural gas devices account for 96% of all treated devices and comprised 97% of all fuel energy savings and 88% of all electric energy savings.

Table 4-1. Natural Gas Savings Summary

PA	Heating Fuel Type	Measure Life	Participating Thermostats	Verified MMBtu Savings†	Verified kWh Savings†
Statewide	**Natural Gas**	**1**	**52,285**	**60,796**	**281,641**
Eversource	Natural Gas	1	15,977	18,578	86,064
National Grid	Natural Gas	1	36,308	42,219	195,582

† Total savings are calculated using the statewide natural gas per-thermostat savings. For example, to calculate total kWh savings for Eversource, the statewide per-thermostat savings of roughly 5.4 kWh is multiplied by 15,977 participating Eversource natural gas thermostats for a total of 86,064 kWh.

Source: Guidehouse analysis of thermostat telemetry data

Table 4-2. Non-Natural Gas Savings Summary

PA	Heating Fuel Type	Measure Life	Participating Thermostats	Verified MMBtu Savings†	Verified kWh Savings†
Statewide	**Non-Natural Gas**	**1**	**2,449**	**1,886**	**37,167**
Cape Light Compact	Electric	1	32	-	486
	Oil	1	700	575	10,624
	Propane	1	228	187	3,460
Eversource	Electric	1	46	-	698
	Oil	1	392	322	5,949
	Propane	1	129	106	1,958
National Grid	Electric	1	77	-	1,169
	Oil	1	644	529	9,774
	Propane	1	201	165	3,050

† Total savings are calculated using the statewide non-natural gas per-thermostat savings. For example, to calculate statewide total kWh savings, the statewide per-thermostat savings of roughly 15.2 kWh is multiplied by 2,449 participating thermostats for a total of 37,167 kWh.

Source: Guidehouse analysis of thermostat telemetry data

4.2.1 Natural Gas Savings

Guidehouse estimated total natural gas device savings of 60,796 MMBtu and 282 MWh from January 8 through April 30, 2020. This total represents average seasonal savings of 11.6 therms and 5.4 kWh per treated thermostat, or approximately 3.6% of fuel and electric load

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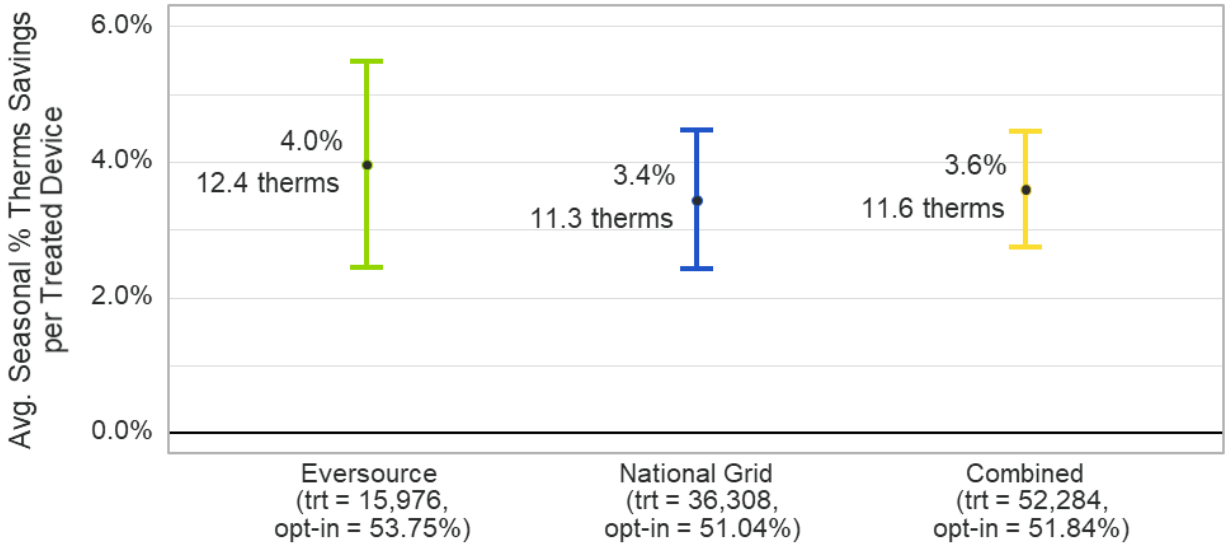
for treated thermostats post program launch.[29] Figure 4-9 shows fuel savings with confidence intervals by PA and statewide, and Figure 4-10 shows the same for electric savings. The evaluation team's estimates are not statistically different between Eversource and National Grid for fuel or electric savings.

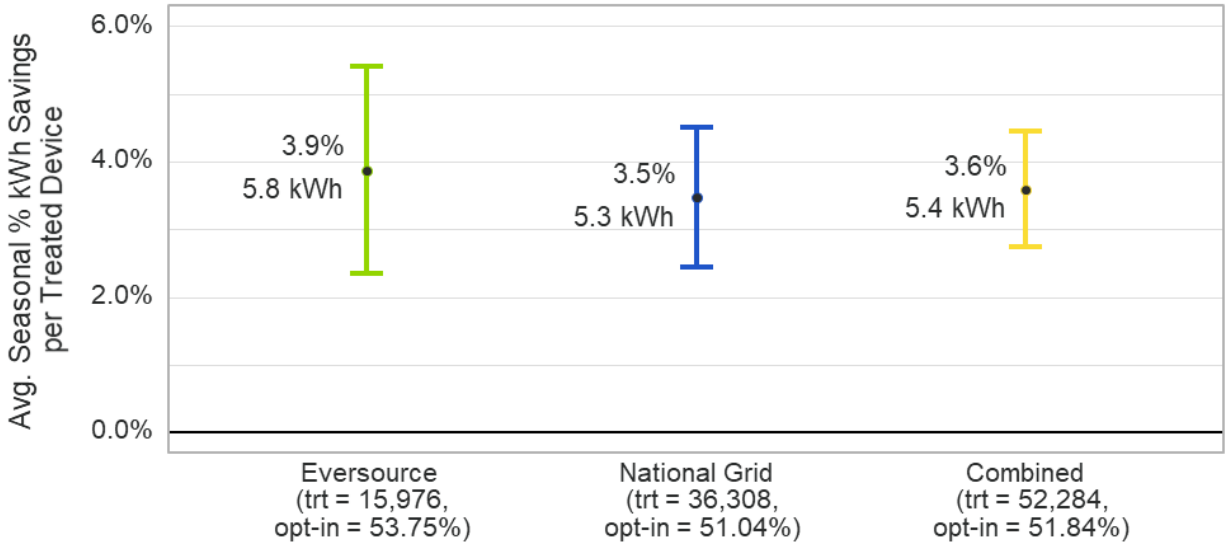
Figure 4-9. Average Therms Savings as a Percentage of Heating Load



trt = treated

Source: Guidehouse analysis of thermostat telemetry data

Figure 4-10. Average kWh Savings as a Percentage of Heating Load



trt = treated

Source: Guidehouse analysis of thermostat telemetry data

[29] In 2018/19, natural gas savings were 15.5 therms (4.7% of fuel heating load) and 7.3 kWh (4.6% of electric heating load).

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Guidehouse estimated energy savings for three different sets of hours between January 8 and April 30, 2020: all, on-peak, and off-peak. Table 4-3 details the energy savings for each period for natural gas devices. The on-peak and off-peak periods were not directly estimated (as discussed in Section 2.3.2); rather, they rely on savings percentages from 2018/19 when savings were found to be 28% on-peak and 72% off-peak for natural gas devices.

Table 4-3. Winter 2019/20 Energy Savings Summary: Natural Gas Heating

Statistic	Fuel Savings (Therms)	Electric Savings (kWh)
Number of Nest thermostats in control group	26,487	
Number of Nest thermostats in ITT group	104,804	
Number of Nest thermostats in treated group	**52,285**	
Winter (January 8-April 30)†		
Average daily energy savings per treated thermostat	0.103 ± 0.024	0.048 ± 0.011
Average energy savings (% of heating load)	3.6% ± 0.8%	3.6% ± 0.8%
Average total energy savings per treated thermostat	11.63 ± 2.74	5.39 ± 1.28
Total energy savings (in thousands)	608 ± 143	282 ± 67
Winter (January 8-April 30) On-Peak‡		
Average daily energy savings per treated thermostat	-	0.013
Average energy savings (% of heating load)	-	1.0%
Average total energy savings per treated thermostat	-	1.51
Total energy savings (in thousands)	-	79
Winter (January 8-April 30) Off-Peak§		
Average daily energy savings per treated thermostat	-	0.035
Average energy savings (% of heating load)	-	2.6%
Average total energy savings per treated thermostat	-	3.88
Total energy savings (in thousands)	-	203

Winter season values contain confidence intervals because natural gas savings were analyzed via regression. On-peak and off-peak do not contain confidence intervals because they were not directly estimated with 2019/20 data.
† The first offer date for the SS program occurred on January 8, 2020. The SS program persists if heating systems are in heating mode. The energy impact evaluation relies on data through April 30, 2020.
‡ On-peak hours are all hours from 7 a.m. to 11 p.m. on non-holiday weekdays.
§ Off-peak hours are all hours from 11 p.m. to 7 a.m. on non-holiday weekdays, plus all hours on weekends and holidays.

Source: Guidehouse analysis of thermostat telemetry data

Guidehouse also compared its savings estimates to those produced by the program implementer, Google. The evaluation team's estimates were 99% of Google's for both fuel and electric savings. This finding is similar to the realization rates found in the 2018/19 evaluation.

4.2.2 Non-Natural Gas Savings

Non-natural gas device savings were not directly estimated using 2019/20 data because of the small sample size of devices. Instead, Guidehouse calculated energy savings for three different sets of hours between January 8 and April 30, 2020 (all, on-peak, and off-peak) using savings percentages derived from the 2018/19 evaluation. Table 4-4 details the energy savings for each

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period for non-natural gas devices. In 2018/19, the evaluation team found savings to be 32% on-peak and 68% off-peak for non-natural gas devices.

Table 4-4. Winter 2019/20 Energy Savings Summary: Non-Natural Gas Heating

Statistic	Fuel Savings (Therms)	Electric Savings (kWh)
Number of Nest thermostats in control group	1,597	1,767
Number of Nest thermostats in ITT group	6,575	7,192
Number of Nest thermostats in treated group	**2,294**	**2,449**
Winter (January 8-April 30)†		
Average daily energy savings per treated thermostat	0.08	0.80
Average energy savings (% of heating load)	2.7%	6.0%
Average total energy savings per treated thermostat	8.22	15.18
Total energy savings (in thousands)	19	37
Winter (January 8-April 30) On-Peak‡		
Average daily energy savings per treated thermostat	-	0.26
Average energy savings (% of heating load)	-	1.92%
Average total energy savings per treated thermostat	-	4.86
Total energy savings (in thousands)	-	12
Winter (January 8-April 30) Off-Peak§		
Average daily energy savings per treated thermostat	-	0.54
Average energy savings (% of heating load)	-	4.08%
Average total energy savings per treated thermostat	-	10.32
Total energy savings (in thousands)	-	25

No values contain confidence intervals because non-natural gas savings were not directly estimated using the 2019/20 thermostat telemetry data.
† The first offer date for the SS program occurred on January 8, 2020. The SS program persists if heating systems are in heating mode. The energy impact evaluation relies on data through April 30, 2020.
‡ On-peak hours are all hours from 7 a.m. to 11 p.m. on non-holiday weekdays.
§ Off-peak hours are all hours from 11 p.m. to 7 a.m. on non-holiday weekdays, plus all hours on weekends and holidays.

Source: Guidehouse analysis of thermostat telemetry data

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5. Findings and Recommendations

Guidehouse's evaluation found that the winter 2019/20 SS program was successful in achieving energy savings through thermostat scheduled setpoint optimization and in customer acceptance of the offering. Table 5-1 summarizes Guidehouse's key evaluation findings; Table 5-2 lists the evaluation team's recommendations; and Table 5-3 presents considerations.

Table 5-1. Key Findings

Key Findings
• 47% of ITT thermostats and 61% of qualified ITT thermostats enrolled in the program across all three PAs.
• Enrollment and qualification rates for ITT devices are lower for Cape Light Compact than National Grid and Eversource (63% qualified and 38% of those qualified enrolled for Cape Light Compact versus 78% and 48%, respectively, for National Grid and Eversource combined). Such differences are likely due to different home usage and heating needs on Cape Cod.
• Enrollment rates by PA were similar to 2018/19. Almost two-thirds of devices that enrolled in 2018/19 and were offered the program again in 2019/20 reenrolled.
• Scheduled and actual setpoints and runtime all show evidence of the program effect for the ITT versus control groups. The stay-at-home period from the pandemic does not seem to affect the relative positioning of the ITT and control groups.
• Reviewing scheduled and actual setpoints and runtime based on when customers were treated (2018/19, 2019/20, both, or neither) shows some persistence in setpoints and shows the program effect builds over time.
• Scheduled setpoints for natural gas customers were about 0.25°F lower in the pre-period than in 2018/19. The SS impact on scheduled setpoints was roughly the same as 2018/19 (-0.80°F this year compared with -0.67°F last year).
• Average daily runtime for natural gas customers in the pre-period was similar across the two years (~250 minutes); however, it was lower in the 2019/20 program period (~190 minutes) compared with 2018/19 (~220 minutes), likely driven by milder weather in January to March. The SS impact on runtime was smaller (-4 minutes this year compared with -6 minutes last year).
• Across all three PAs, the program achieved 62,681 MMBtu of fuel energy savings and 319 MWh of electric energy savings (91 MWh on-peak and 228 MWh off-peak) between January 8 and April 30, 2020.
• For natural gas devices, the average energy savings per treated thermostat over the season was 11.6 therms (3.6% of heating load) and 5.4 kWh (3.6% of heating load) between January 8 and April 30, 2020. This was a decrease of approximately 26% from 2018/19, likely driven by milder weather.
• For non-natural gas devices, the average energy savings per treated thermostat over the season was 8.2 therms (2.7% of heating load) and 15.2 kWh (6.0% of heating load) between January 8 and April 30, 2020. This was a decrease of approximately 12% from 2018/19, likely driven by milder weather resulting in lower baseline usage.

Source: Guidehouse

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Table 5-2. Recommendations

Topic	Recommendations
Savings	• The PAs should claim the fuel and electric savings listed in Table 4-1 and Table 4-2. • In 2019/20, the PAs should claim electric savings broken down into on-peak and off-peak savings based on the following percentages: – Natural gas: 28% on-peak, 72% off-peak – Non-natural gas: 32% on-peak, 68% off-peak These percentages should be multiplied by the verified kWh savings shown in Table 4-1 and Table 4-2.

Source: Guidehouse

Table 5-3. Considerations

Topic	Considerations
SS and Wi-Fi Thermostats	• Because SS will now be a standard offering for all Google Nest thermostats, SS savings should be incorporated into ongoing Wi-Fi thermostat evaluations. • Any study of Google Nest thermostats using data after the 2019/20 heating season will inherently include SS savings. • In future Google Nest thermostat evaluations, seek to assess the persistence and/or limits of the SS algorithm.
Other Temperature Optimization Algorithms	• Given that SS has proven the viability of temperature optimization algorithms for increasing thermostat savings, the PAs could explore offering similar algorithms to other manufacturer's devices.

Source: Guidehouse

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Appendix A. Randomization Verification

This section summarizes Guidehouse's balance checks to verify Google's randomization of devices between the treatment and control groups. The balance checks were run on all thermostats that had the relevant piece of telemetry data (runtime or scheduled setpoints) in the pre-period. Table A-1 summarizes the percent difference in mean heating runtime for all ITT and control devices. Table A-2 shows the same information but for mean scheduled heating setpoints.

For heating runtime, most evaluation segments were balanced across the ITT and control groups. However, there were statistically significant and practical differences in the Eversource natural gas segment, with a difference of -2.29%. Guidehouse's difference-in-difference modeling approach accounts for small differences in pre-program period usage between the ITT and control groups. While there are large differences for some of the Cape Light Compact groups, these were not statistically significant because of the small sample sizes.

Table A-1. Randomization Verification, Heating Runtime

Heating Fuel	PA	Number of Devices*	Mean Heating Runtime		% Diff	P-Value
			ITT	Control		
Natural Gas	NG	89,813	159.65	160.77	0.70%	0.2667
Natural Gas	EVS	37,660	154.15	150.66	-2.29%	0.0205
Natural Gas	**All**	**127,473**	**158.02**	**157.77**	**-0.16%**	**0.7598**
Oil	CLC	2,960	127.46	126.90	-0.44%	0.9112
Propane	CLC	1,469	110.99	110.04	-0.86%	0.8883
Electric	CLC	344	122.14	111.30	-9.29%	0.4256
All	**CLC**	**4,773**	**122.13**	**119.87**	**-1.87%**	**0.5572**
All	**All**	**132,246**	**156.74**	**156.36**	**-0.24%**	**0.6499**

NG = National Grid; EVS = Eversource; CLC = Cape Light Compact
*Device counts includes all devices that had viable heating runtime data during the period of December 1, 2019 through January 7, 2020 (i.e., before SS launched).

Source: Guidehouse analysis of thermostat telemetry data

For scheduled heating setpoints, most evaluation segments were balanced across the ITT and control groups. However, there were statistically significant differences in the Eversource natural gas segment, with a difference of -0.18%—although this difference is practically insignificant.

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Table A-2. Randomization Verification, Scheduled Heating Setpoint

Heating Fuel	PA	Number of Devices*	Mean Scheduled Heating Target (°F)		% Diff	P-Value
			ITT	Control		
Natural Gas	NG	80,270	65.22	65.16	-0.09%	0.1316
Natural Gas	EVS	34,189	65.78	65.66	-0.18%	0.0225
Natural Gas	**All**	**114,459**	**65.39**	**65.31**	**-0.11%**	**0.0146**
Oil	CLC	2,378	62.24	62.08	-0.26%	0.5950
Propane	CLC	1,151	61.38	62.03	-1.06%	0.1385
Electric	CLC	270	62.10	61.94	-0.25%	0.8539
All	**CLC**	**3,799**	**62.17**	**61.84**	**-0.53%**	**0.1697**
All	**All**	**118,258**	**65.28**	**65.20**	**-0.13%**	**0.0066**

NG = National Grid; EVS = Eversource; CLC = Cape Light Compact
*Device counts includes all devices that had viable scheduled heating setpoint data during the period of December 1, 2019 through January 7, 2020 (i.e., before SS launched).

Source: Guidehouse analysis of thermostat telemetry data

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Appendix B. Exploratory Analysis Appendix

Table B-1 and Table B-2 show averages of daily scheduled heating setpoint, actual heating setpoint, and heating runtime over the pre-period and program period based on ITT and opt-in status. Table B-1 contains values for natural gas customers, and Table B-2 contains values for non-natural gas customers.

Table B-1. Exploratory Analysis Summary by ITT Group, Natural Gas

	Group	Pre-Period	Program Period	Δ†	SS Impact‡
Period Dates		Dec. 1-Jan. 7	Jan. 8-Apr. 30		
Average Daily Scheduled Heating Setpoints (°F)	Control	65.27	65.32	0.04	-
	ITT	65.33	64.88	-0.46	-0.50
	Treated	65.48	64.72	-0.75	-0.80
	Untreated	65.11	65.12	0.01	-0.03
Average Actual Daily Heating Setpoints (°F)	Control	64.04	64.34	0.30	-
	ITT	64.11	64.08	-0.03	-0.33
	Treated	64.37	64.10	-0.27	-0.57
	Untreated	63.83	64.06	0.23	-0.07
Averaged Daily Heating Runtimes (min)	Control	251.53	193.76	-57.76	-
	ITT	252.42	190.68	-61.74	-3.97
	Treated	260.65	192.10	-68.55	-10.79
	Untreated	243.56	189.14	-54.41	3.35

Table shows averages for natural gas customers (i.e., devices in National Grid and Eversource service areas).

† The Δ is the difference between the post-tune-up period and the pre-period.

‡ The SS impact is the difference between the Δ for the ITT groups and the control group.

Source: Guidehouse analysis of Nest thermostat telemetry data and NOAA temperature data

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Table B-2. Exploratory Analysis Summary by ITT Group, Non-Natural Gas

	Group	Pre-Period	Program Period	Δ†	SS Impact‡
Period Dates		Dec. 1-Jan. 7	Jan. 8-Apr. 30		
Average Daily Scheduled Heating Setpoints (°F)	Control	61.90	62.16	0.26	-
	ITT	62.25	62.02	-0.22	-0.49
	Treated	63.22	62.45	-0.76	-1.03
	Untreated	61.71	61.77	0.06	-0.20
Average Actual Daily Heating Setpoints (°F)	Control	58.74	59.23	0.49	-
	ITT	58.82	58.98	0.16	-0.34
	Treated	61.15	60.97	-0.18	-0.67
	Untreated	58.00	58.27	0.27	-0.22
Averaged Daily Heating Runtimes (min)	Control	191.89	161.32	-30.57	-
	ITT	195.82	157.08	-38.74	-8.17
	Treated	225.81	175.42	-50.39	-19.82
	Untreated	185.36	150.68	-34.68	-4.11

Table shows averages for non-natural gas customers (i.e., devices in Cape Light Compact service area).

† The Δ is the difference between the post-tune-up period and the pre-period.

‡ The SS impact is the difference between the Δ for the ITT groups and the control group.

Source: Guidehouse analysis of Nest thermostat telemetry data and NOAA temperature data

Table B-3 and Table B-4 show averages of daily scheduled heating setpoint, actual heating setpoint, and heating runtime over the pre-period and program period based on enrollment status across the 2018/19 and 2019/20 seasons. Table B-3 contains values for natural gas customers, and Table B-4 contains values for non-natural gas customers.

Table B-3. Exploratory Analysis Summary by Prior Enrollment, Natural Gas

	Group	Pre-Period	Program Period	Δ†	SS Impact‡
Period Dates		Dec. 1-Jan. 7	Jan. 8-Apr. 30		
Average Daily Scheduled Heating Setpoints (°F)	Never Treated	65.26	65.27	0.01	-
	Treated 2019	64.89	64.96	0.07	0.06
	Treated 2020	65.70	64.92	-0.77	-0.79
	Treated 2019 & 2020	64.99	64.28	-0.71	-0.73
Average Actual Daily Heating Setpoints (°F)	Never Treated	63.86	64.11	0.25	-
	Treated 2019	64.05	64.33	0.28	0.04
	Treated 2020	64.46	64.20	-0.26	-0.51
	Treated 2019 & 2020	64.16	63.87	-0.29	-0.54
Averaged Daily Heating Runtimes (min)	Never Treated	245.48	190.10	-55.38	-
	Treated 2019	249.73	193.40	-56.33	-0.95
	Treated 2020	263.42	193.75	-69.66	-14.29
	Treated 2019 & 2020	254.40	188.37	-66.03	-10.65

Table shows averages for natural gas customers (i.e., devices in National Grid and Eversource service areas).

† The Δ is the difference between the post-tune-up period and the pre-period.

‡ The SS impact is the difference between the Δ for the Treated groups and the Never Treated group.

Source: Guidehouse analysis of Nest thermostat telemetry data and NOAA temperature data

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Table B-4. Exploratory Analysis Summary by Prior Enrollment, Non-Natural Gas

	Group	Pre-Period	Program Period	Δ†	SS Impact‡
Period Dates		Dec. 1-Jan. 7	Jan. 8-Apr. 30		
Average Daily Scheduled Heating Setpoints (°F)	Never Treated	61.77	61.85	0.08	-
	Treated 2019	61.72	62.08	0.36	0.28
	Treated 2020	63.10	62.35	-0.75	-0.83
	Treated 2019 & 2020	63.44	62.65	-0.79	-0.87
Average Actual Daily Heating Setpoints (°F)	Never Treated	58.00	58.31	0.31	-
	Treated 2019	59.74	60.20	0.47	0.16
	Treated 2020	61.00	60.68	-0.33	-0.64
	Treated 2019 & 2020	61.45	61.55	0.10	-0.21
Averaged Daily Heating Runtimes (min)	Never Treated	184.90	152.02	-32.88	-
	Treated 2019	203.82	164.51	-39.31	-6.43
	Treated 2020	229.00	177.87	-51.13	-18.24
	Treated 2019 & 2020	219.39	170.58	-48.81	-15.93

Table shows averages for non-natural gas customers (i.e., devices in Cape Light Compact service area).

† The Δ is the difference between the post-tune-up period and the pre-period.
‡ The SS impact is the difference between the Δ for the Treated groups and the Never Treated group.

Source: Guidehouse analysis of Nest thermostat telemetry data and NOAA temperature data

Figure B-1, Figure B-2, and Figure B-3 present averages of daily scheduled heating setpoint, actual heating setpoint, and heating runtime differences over the season for non-natural gas customers (i.e., Cape Light Compact devices) based on enrollment status during the 2018/19 and 2019/20 seasons. The trends are generally similar to the natural gas customer results presented in Section 4.1.2.1, but they are noisier because of the small sample sizes.

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Figure B-1. Scheduled Heating Setpoints by Prior Enrollment, Non-Natural Gas

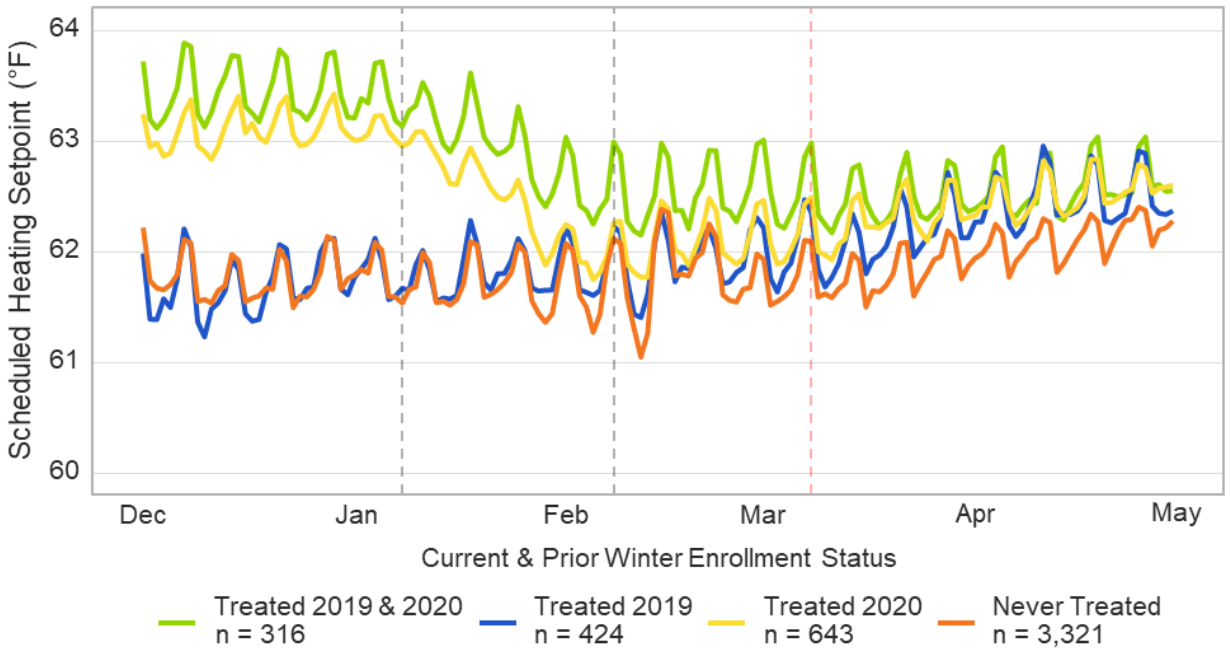

Figure shows averages for non-natural gas customers (i.e., devices in Cape Light Compact service area).
Source: Guidehouse analysis of thermostat telemetry data

Figure B-2. Actual Heating Setpoints by Prior Enrollment, Non-Natural Gas

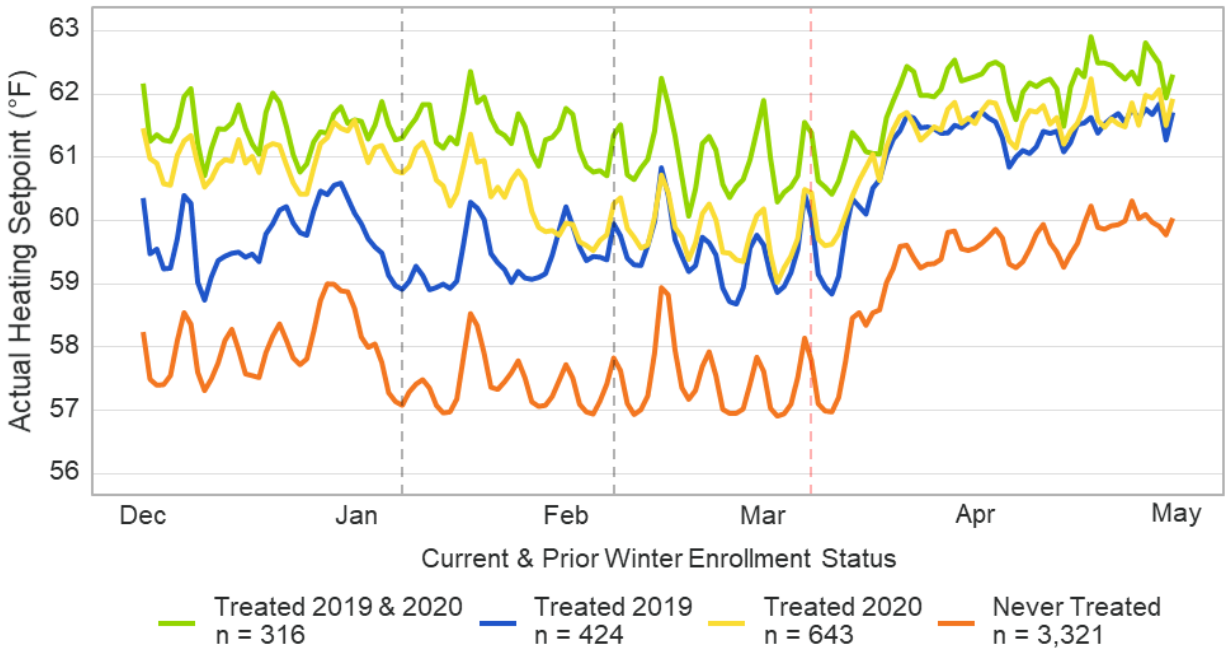

Figure shows averages for non-natural gas customers (i.e., devices in Cape Light Compact service area).
Source: Guidehouse analysis of thermostat telemetry data

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Figure B-3. Heating Runtime Differences by Prior Enrollment, Non-Natural Gas

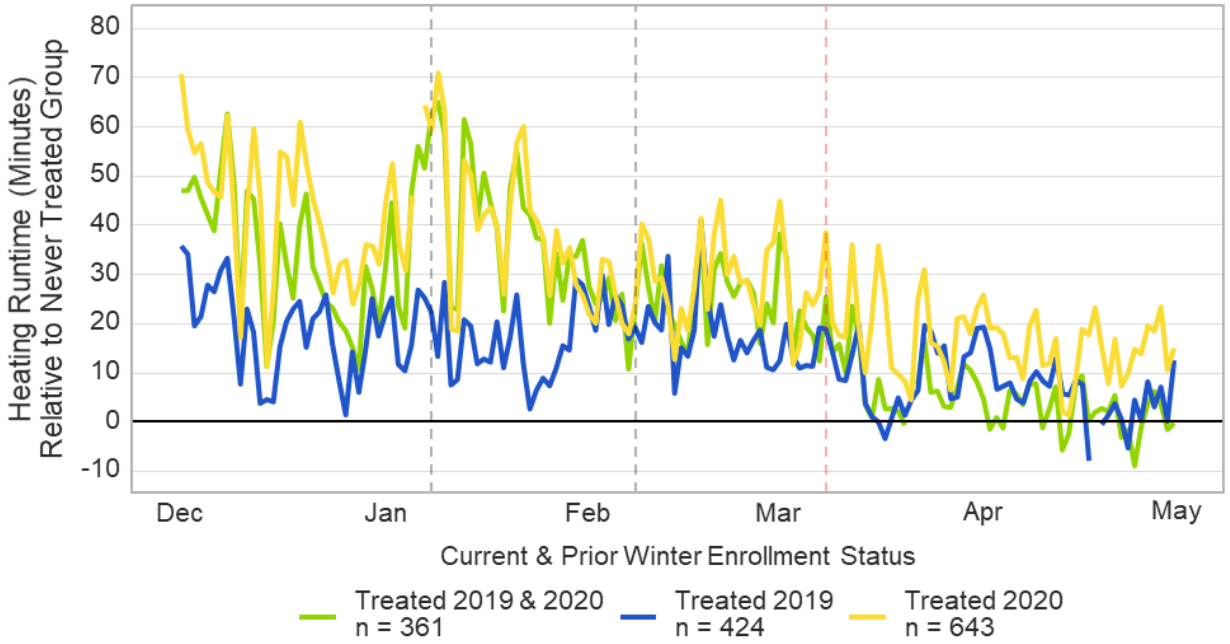

Figure shows averages for non-natural gas customers (i.e., devices in Cape Light Compact service area).

Source: Guidehouse analysis of thermostat telemetry data

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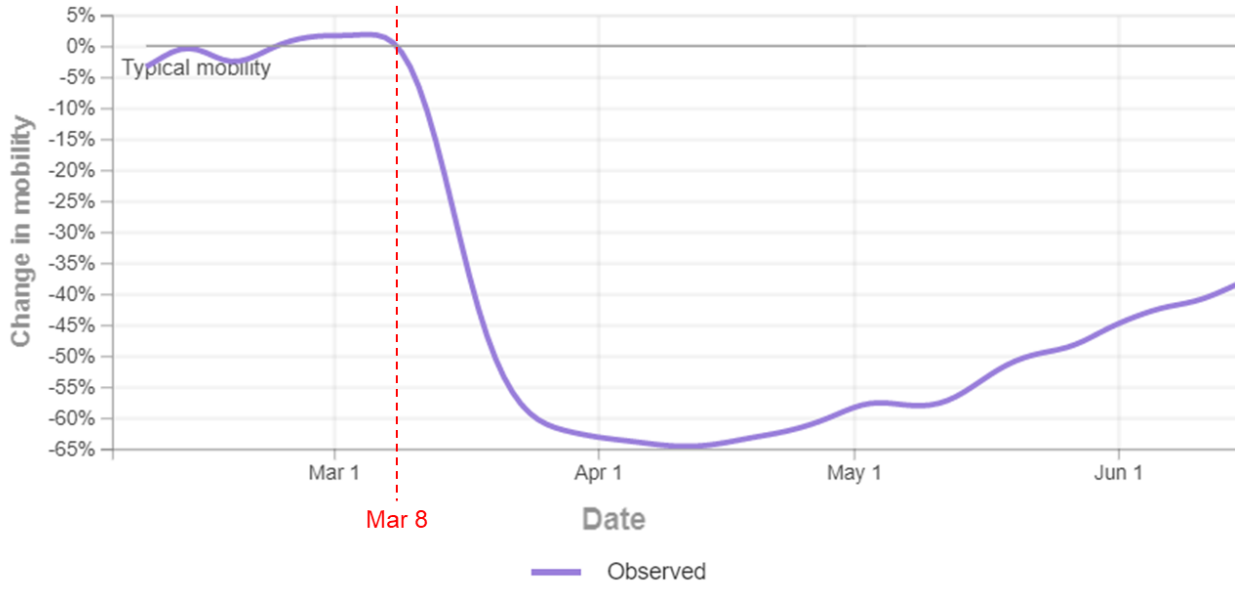
Appendix C. Effect of Staying at Home on Thermostat Usage

Alongside the evaluation, Guidehouse ran an exploratory analysis on how the effect of the stay-at-home period and social distancing in Massachusetts due to the coronavirus pandemic affected thermostat usage.

Stay-at-home orders went into effect in Massachusetts between March 15 and March 23, 2020. However, mobility began dropping rapidly starting on March 8. Figure C-1 shows the change in mobility from February through June 2020. Starting on March 8, mobility begins dropping rapidly and does not start to increase until mid-April. Because of this drop in mobility before official stay-at-home orders, Guidehouse chose to use March 8 as the start of the stay-at-home period.

Figure C-1. Social Distancing in Massachusetts as Measured by Cell Phone Mobility Data



Source: Institute for Health Metrics and Evaluation (IHME) COVID-19 Heath Data for Massachusetts; accessed September 22, 2020

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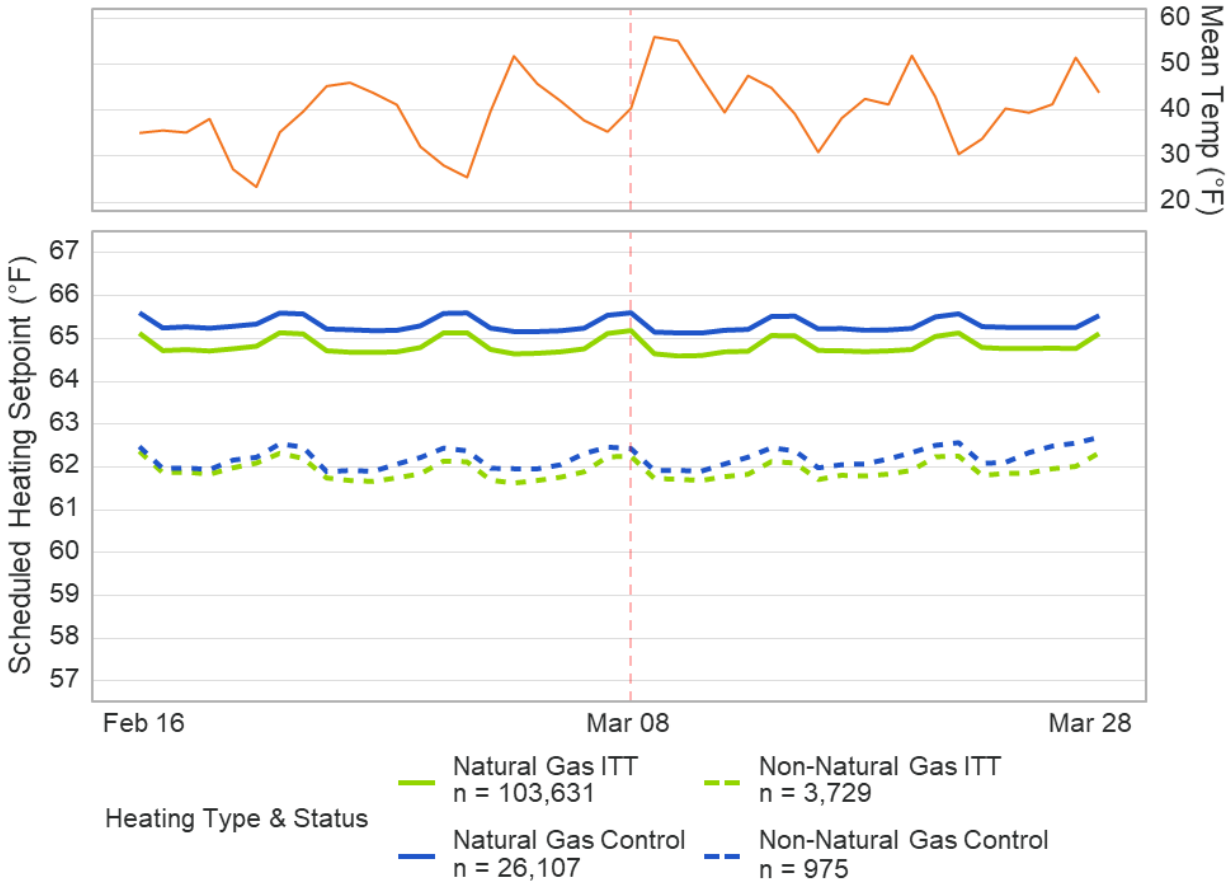
Figure C-2 shows how scheduled heating setpoints looked in the weeks before and after the stay-at-home orders went into effect for Massachusetts. Guidehouse observed a clear weekend and weekday peak and trough pattern in scheduled setpoints both before and after customers began staying at home. The weather was relatively stable in the 3 weeks before and after people began staying at home.

Figure C-2. Scheduled Heating Setpoints Before and After Stay-at-Home



Source: Guidehouse analysis of thermostat telemetry data and NOAA temperature data

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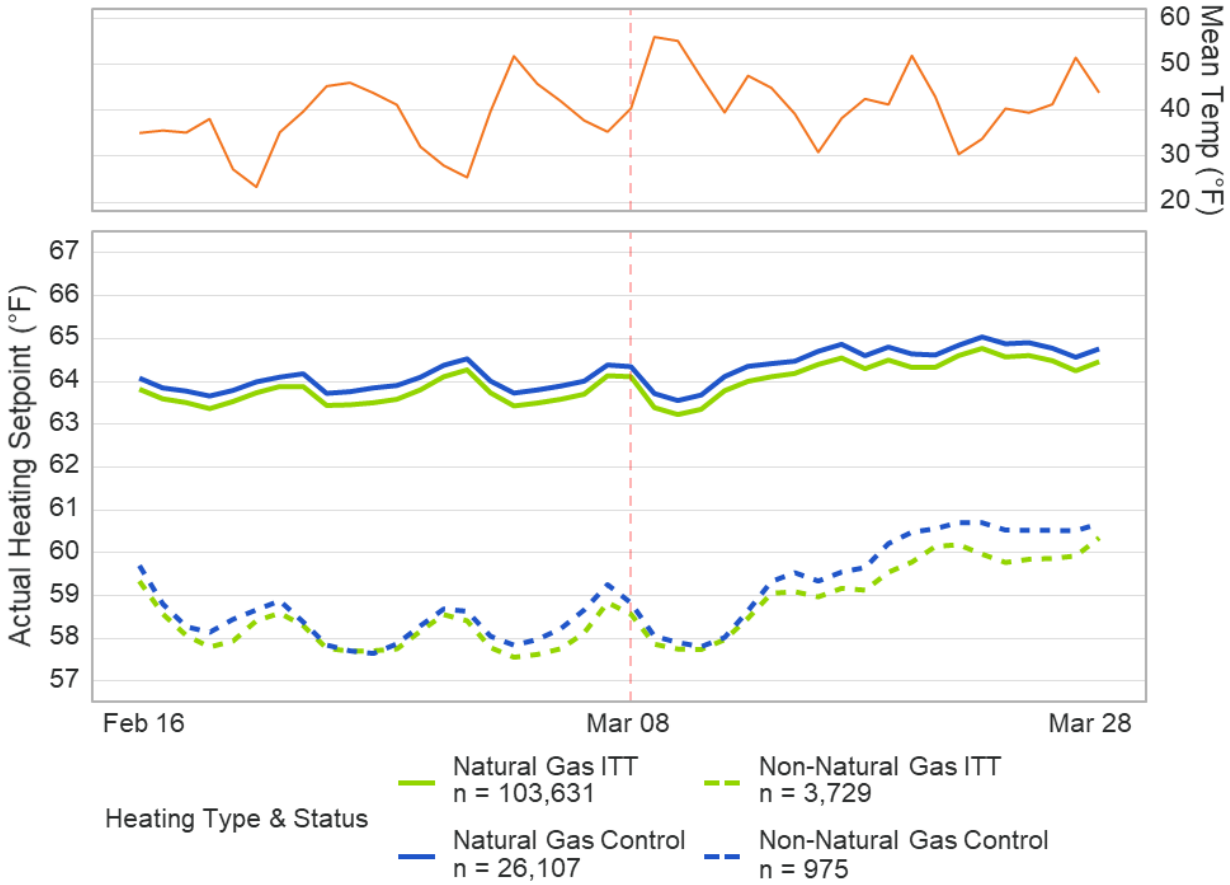
Figure C-3 presents actual heating setpoints averages in the weeks before and after people began staying at home. The evaluation team observed two things:

- A noticeable increase in average heating setpoints across all groups (approximately 0.5°F for natural gas customers and 2.5°F for non-natural gas customers). The weather was relatively stable in the 3 weeks before and after people began staying home and thus does not seem to drive the increase in actual setpoints.
- The dissolution of any obvious weekend/weekday peak/trough patterns. The lack of a dip in actual setpoints on weekdays may reflect customers keeping their home more comfortable while they are there during the day.

Figure C-3. Actual Heating Setpoints Before and After Stay-at-Home



Source: Guidehouse analysis of thermostat telemetry data and NOAA temperature data

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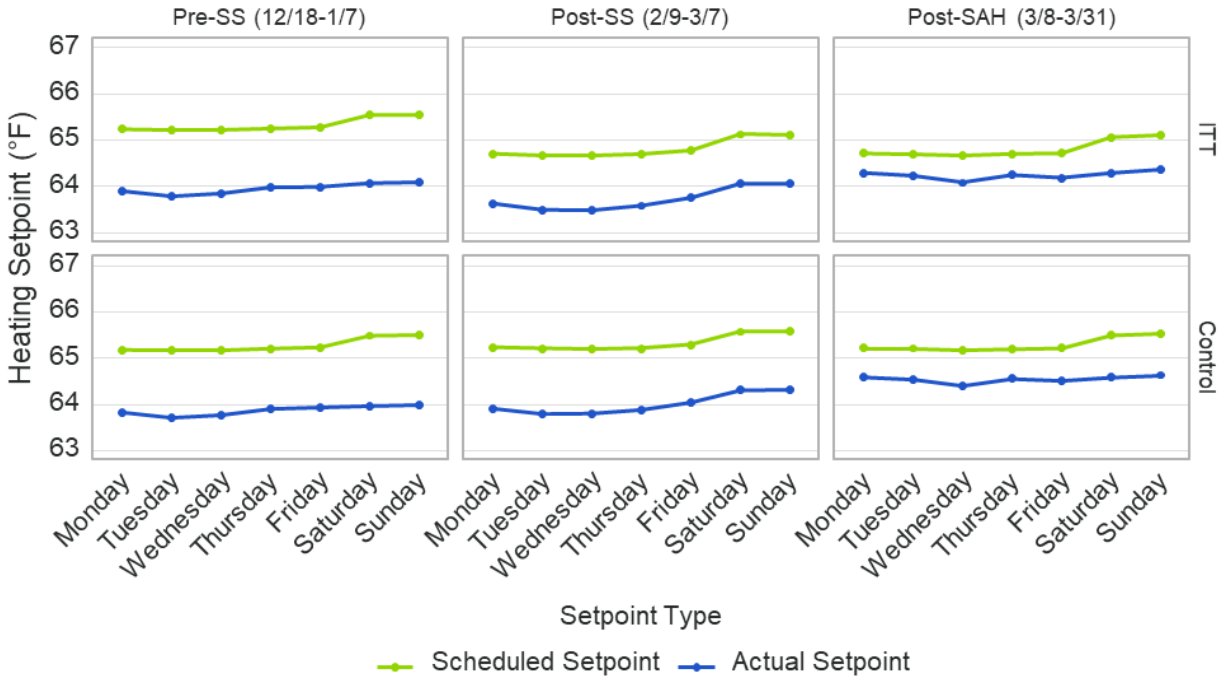
For comparison, Figure C-4 shows both scheduled and actual setpoints on the same graph. The change in actual setpoints while scheduled setpoints remained relatively stable may be driven by customers making manual changes to their setpoints. It could also reflect less use of the Home/Away Assist feature as people spend more time at home.

Figure C-4. Scheduled and Actual Setpoints through Time



SAH = Stay-at-home

Source: Guidehouse analysis of thermostat telemetry data

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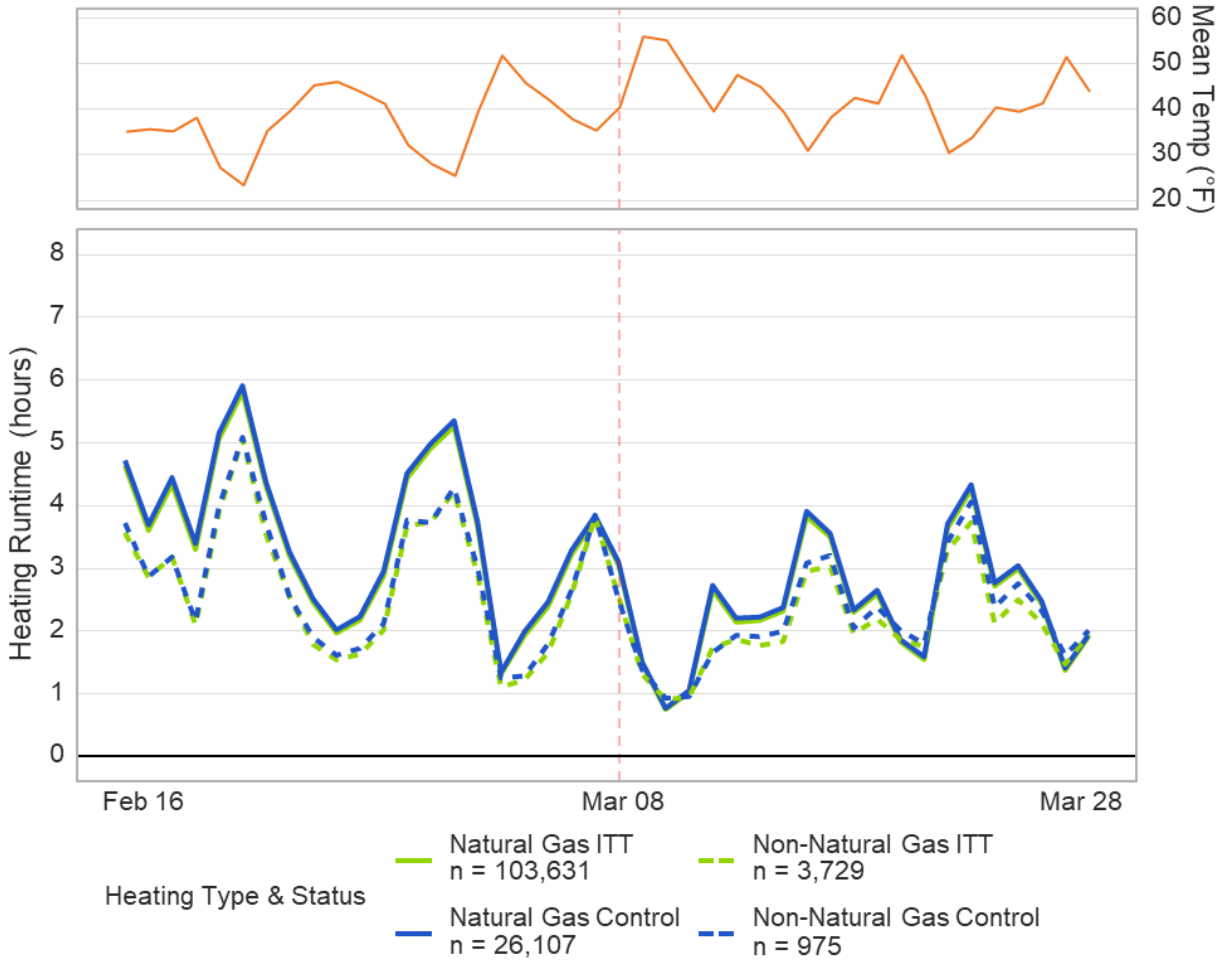
Figure C-5 presents heating runtime in hours in the weeks before and after the stay-at-home period began. Runtime does not change much before and after the stay-at-home period, even with the increase in actual setpoints. Runtime may not have changed much if customers mostly changed their actual setpoints during the day (when they would usually be at work or otherwise out of the house) when their homes were more likely to experience solar gains or free heating. Unfortunately, without hourly data Guidehouse cannot review time-of-day changes to setpoints and runtime.

Figure C-5. Heating Runtime Before and After Stay-at-Home



Source: Guidehouse analysis of thermostat telemetry data and NOAA temperature data

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