2018 MASSACHUSETTS SUMMER THERMOSTAT OPTIMIZATION EVALUATION

Prepared for:
The Electric Program Administrators of Massachusetts

Submitted by: 77 South Bedford Street, Ste 400, Burlington, MA 01803
NAVIGANT navigant.com || March 29, 2019

STUDY OVERVIEW

About Thermostat Optimization

The Seasonal Savings (SS) program is a thermostat optimization program offered by Google designed to make incremental adjustments to scheduled setpoints over a 3-4-week period to achieve energy savings and demand reductions during the summer while maintaining customer comfort. On average, scheduled setpoints are adjusted upwards by 1.0°F-1.5°F during the cooling season, with the largest temperature adjustments taking place when customers are typically away from home (e.g., morning through early afternoon on weekdays).

Study Goal

The goal of the thermostat optimization evaluation was to confirm the technical feasibility of using thermostat setpoint adjustments to reduce household energy consumption and peak demand. The evaluation included both an exploratory analysis of thermostat setpoints and an impact analysis of energy and demand savings.

The evaluation also yielded realization rates, providing the PAs with a point of comparison between the evaluated savings and the vendor-generated savings.

APPROACH

The evaluation team relied on two analyses for the 2018 analysis:

Exploratory Analysis

- Assessed program eligibility and opt-in rates, providing insight into customer acceptance of the thermostat optimization solution
- Confirmed the thermostat optimization algorithm was operating as intended (i.e., increasing setpoints and reducing runtime for treated thermostats) over time
- Analyzed whether there are setpoint differences between weekdays/weekends and across hours of the day
- Compared data across several groups, including treated versus control
- (NGrid only) Compared data across several additional groups to better understand persistence of savings, first-year savings, and second-year savings

Impact Analysis

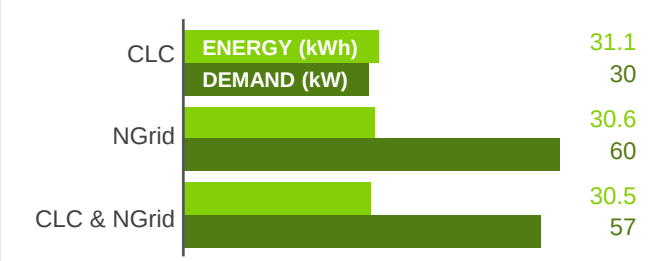
- Relied exclusively on thermostat telemetry data to estimate impacts after converting thermostat runtime to power
- Estimated whole summer, summer on-peak, and summer off-peak energy savings
- Estimate energy savings for the tune-up and post-tune-up periods
- Estimated demand savings for the summer on-peak period post program deployment
- Estimated demand savings for the full summer on-peak period assuming no demand savings prior to program launch

KEY FINDINGS

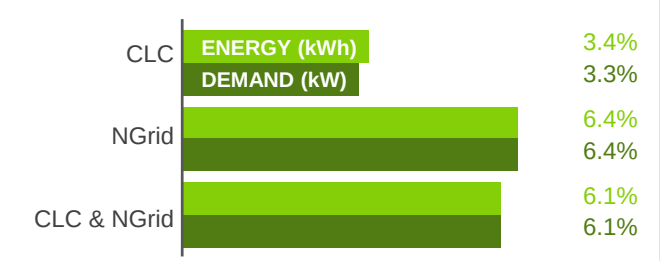
Impact Analysis

CLC and NGrid launched the summer SS program on July 2, 2018 to 16,667 customers across both territories. The energy savings achieved through September 30, 2018 and demand savings achieved through August 31, 2018 are as follows:

Per Thermostat Savings



Percent of Cooling Load Savings



Program Administrator	Measure Life	# of Participating Thermostats	kWh Savings per Thermostat	Watt Savings per Thermostat	kWh Realization Rate†	Watt Realization Rate†
National Grid	**1**	**15,186**	**30.6**	**60**	**115%**	**102%**
Cape Light Compact & National Grid‡	**1**	**16,667**	**30.5**	**57**	**115%**	**114%**

†Estimated savings are different between Navigant and Nest due to differences in the devices included in each analysis.

‡Navigant recommends CLC claim the combined per-thermostat energy and demand savings as the CLC values were not statistically significant.

RECOMMENDATIONS

1. NGrid should claim average energy savings of 30.6 kWh per treated thermostat in Massachusetts in 2018. CLC should claim average energy savings of 30.5 kWh per treated thermostat in Massachusetts in 2018.

2. NGrid should claim average demand savings of 60 W per treated thermostat in Massachusetts in 2018. CLC should claim average demand savings of 57 W per treated thermostat in Massachusetts in 2018.

3. In 2019, deploy the SS program to all Massachusetts Program Administrators (PA) to better inform a PA-specific (or statewide) savings value or realization rate for inclusion in the Technical Reference Manual.

4. The summer SS program should continue to be evaluated to assess the ability of the program to realize incremental savings associated with redeployment. The 2018 exploratory analysis found that setpoint adjustments persist and continued from 2017.

NAVIGANT

2018 Massachusetts Summer Thermostat Optimization Evaluation

Prepared for the Massachusetts Program Administrators

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EXECUTIVE SUMMARY

National Grid (NGrid) and Cape Light Compact (CLC) partnered with Nest in the summer of 2018 to offer many of their customers in Massachusetts an energy savings opportunity, the Seasonal Savings (SS) program. SS is a thermostat optimization program designed to make incremental adjustments to scheduled setpoints over a 3-4-week period (i.e., tune-up period) while maintaining customer comfort to achieve energy savings and demand reductions during the summer. On average, scheduled setpoints are adjusted upward by 1.0°F-1.5°F, with the biggest temperature adjustments typically taking place when customers are away from home (e.g., the middle of weekdays).[1] Navigant completed an impact evaluation of the 2018 SS summer program and presents the evaluation's findings in this report.[2]

Navigant's evaluation confirmed the technical feasibility of using thermostats to reduce household energy consumption and peak demand. The program achieved energy and demand savings of 464 MWh and 903 kW for NGrid and 46 MWh and 44 kW for CLC. Combined, the program generated 508 MWh and 947 kW. Average savings per thermostat are detailed in Table 1. CLC-only savings are not included in the table as Navigant recommends CLC claim the combined per-thermostat savings.

Table 1. PY2018 SS Summer Impact Savings: Per Thermostat

Program Administrator	Measure Life	# of Participating Thermostats	Summer kWh Savings	Summer kW Savings†	Summer kWh Realization Rate§	Summer kW Realization Rate§
National Grid	1	15,186	30.6	0.06	115%	102%
Cape Light Compact & National Grid (Combined) ‡	1	16,667	30.5	0.06	115%	114%

† Demand savings are calculated for 1p.m.-5p.m. on non-holiday weekdays from July 2 through August 31, 2018.

‡ Navigant recommends CLC claim the combined per-thermostat energy and demand savings as the CLC values were not statistically significant.

§ Estimated savings are different between Navigant and Nest due to differences in the devices included in each analysis.

Note: Annual on-peak and off-peak energy savings are provided in the body of the report

Source: Navigant

Because NGrid was in the second season of the program, Navigant was able to conduct additional analysis regarding whether savings were different for the second cohort, how savings were different for thermostats receiving a second year of setpoint adjustments, and whether setpoint adjustments from the first year persisted. Each of these questions help to inform how savings might change if NGrid continues to offer the program.

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

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

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Objectives and Methods

The 2018 evaluation objectives are outlined in Table 2.

Table 2. Thermostat Optimization Research Questions

Research Questions	Evaluation Approach
• How many thermostats/customers enrolled in the program by program administrator (PA)? • Did the program have the intended effect on scheduled cooling setpoints and were effects similar for all PAs? • What was the impact of SS on cooling runtime by PA, by day, and over the summer season?	Exploratory analysis
• What are the total summer and total summer on-peak and off-peak energy impacts of customers with thermostat optimization by PA? • What are the demand impacts of customers with thermostat optimization by PA? • What are the energy and demand realization rates based on a comparison of Nest-reported savings values and evaluated savings values?	Impact analysis
• What percentage of customers re-enrolled in the program? • How has the ITT group evolved from PY2017 to PY2018? • What are the scheduled cooling setpoint adjustments in PY2018 for customers that participated in two program years? How have the adjustments changed during the first year (PY2017) compared to the second year (PY2018)? • Have scheduled cooling setpoint adjustments from customers that participated in 2017 continued in 2018? • How are scheduled cooling setpoint adjustments different for the 2018 cohort in 2018 compared to the 2017 cohort in 2018? • How do the first-year scheduled cooling setpoint adjustments of the 2018 cohort compare to the adjustments of the 2017 cohort in 2017? • What are the total summer and total summer on-peak and off-peak energy impacts of customers with thermostat optimization by cohort? • What are the demand impacts of customers with thermostat optimization by cohort?	NGrid-specific analysis

Google deployed the SS program for NGrid and CLC using a randomized encouragement design (RED), in which all customers with a Nest thermostat were randomly assigned into either an intent to treat (ITT)

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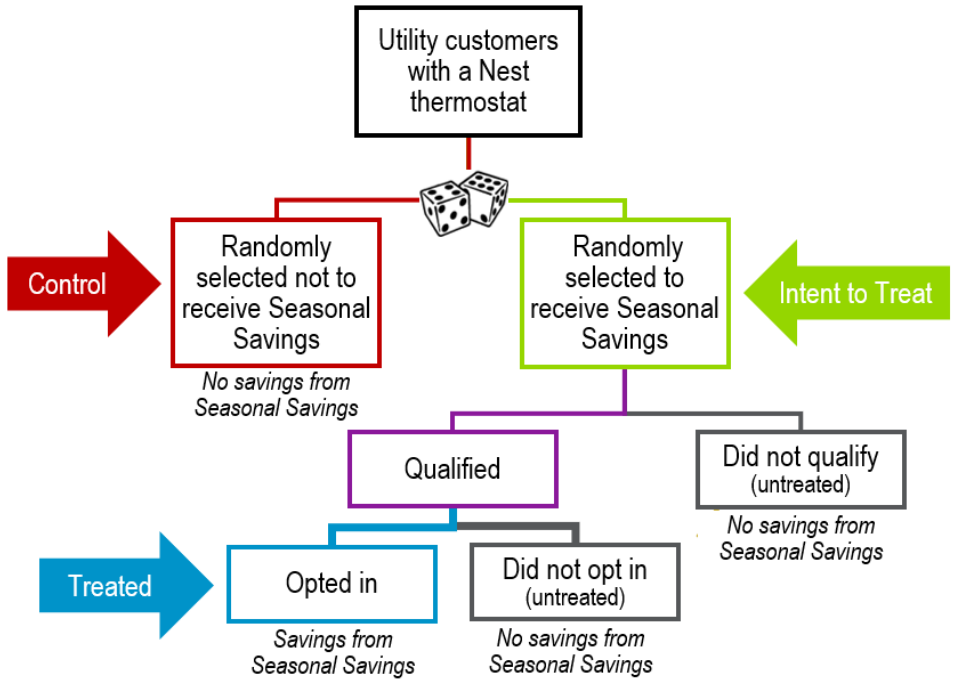
group or a control group.[3, 4] Any thermostats that were part of NGrid's PY2017 SS deployment maintained their original ITT or control group assignment.

For qualified thermostats in the ITT group, CLC and NGrid offered the SS program directly through the thermostat or through the Nest mobile application. Customers that opted in to the program (i.e., the treated group) received the SS algorithm. Thermostats part of the ITT group but that did not qualify or did not opt in were part of the untreated group. Refer to Figure 2-1 for an illustration of the RED.

Figure 1. RED Illustration



Source: Navigant

To complete the evaluation, Navigant performed an exploratory analysis of thermostat telemetry data examining scheduled setpoints and cooling runtime across the ITT, treated, and control groups. In addition, Navigant estimated impacts using regression analysis in which the savings estimate for the ITT group represents an unbiased estimate of the effect of encouragement on energy savings (where encouragement is being sorted into the ITT group). This estimate is then scaled by the program opt-in rate to estimate savings per treated thermostat.

Cape Light Compact 2018 Program Year

Google deployed the SS program for CLC on July 2, 2018 to 3,948 thermostats. In total, 2,532 thermostats (64%) qualified to receive the program offering. Of those, 1,481 thermostats (58% of qualified

[3] Some customers in the ITT (and control) group may not qualify to participate in the program. Qualification requirements include: (1) Nest thermostat installed and connected to Wi-Fi; (2) thermostat set to cooling mode; and (3) a programmed setpoint schedule.
[4] National Grid is in its second year of deployment. The random assignment of devices into the ITT group or the control group remained the same in 2018 as in 2017.

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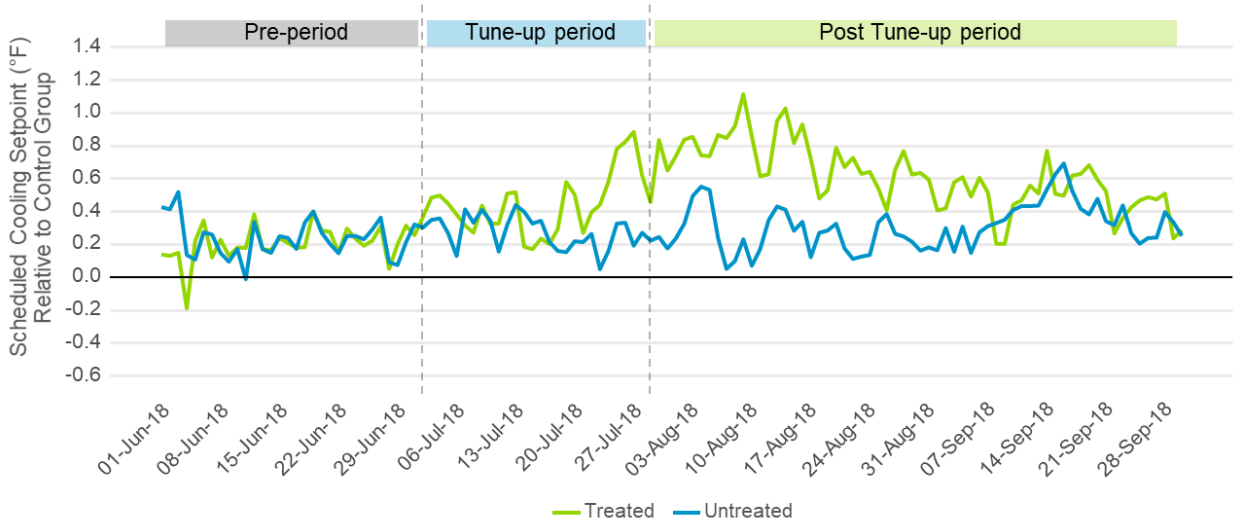
thermostats) opted in. This section summarizes the key findings from the exploratory and impact analyses.

Exploratory Analysis

Figure 2 presents the average daily scheduled cooling setpoints for the ITT subgroups (treated and untreated) compared to the control group's schedule. The average daily scheduled cooling setpoints increased for the treated group relative to the control group after the SS program began. The evaluation also revealed that adjustments to the cooling setpoint schedules were largest during weekdays.

Figure 2. Average Daily Scheduled Cooling Setpoint Comparison, ITT Subgroups: CLC



Source: Navigant analysis of Nest thermostat telemetry data

Table 3 summarizes the changes in cooling setpoint schedules. The exploratory analysis of thermostat telemetry data provided evidence that the SS program did make the intended adjustments to scheduled cooling setpoints, yielding reductions in cooling runtime.

Table 3. Summary of Exploratory Analysis: CLC

Period	Group	Pre	Post Tune-up	Δ†	SS Impact‡
Period Dates (2018)		Jun 1 – Jul 1	Jul 30 – Sep 30	–	**–**
Average Daily Outdoor Temp (°F)		64.37	70.47	6.11	**–**
Average Daily Scheduled Cooling Setpoints (°F)	Control	73.71	73.88	0.17	**–**
	ITT	73.93	74.36	0.42	**0.26**
	Treated	73.92	74.49	0.58	**0.41**
	Untreated	73.95	74.19	0.24	**–**

†The Δ is the difference between the program period and the pre-period.

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

Source: Navigant analysis of Nest thermostat telemetry data and National Oceanic and Atmospheric Administration (NOAA) temperature data

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Impact Analysis

Table 4 summarizes the findings of the impact analysis. For CLC, the SS program resulted in energy savings of 31.1 kWh per thermostat and total savings of 46 MWh between July 2, 2018 and September 30, 2018. Average peak demand savings were 30 W per thermostat, with total peak demand savings of 44 kW.

Table 4. PY2018 SS Summer Impact Summary: CLC

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	1,703
Number of Nest thermostats in ITT group	3,948
Number of Nest thermostats in treated group †	**1,481**
Summer Energy Savings (Jul 2 – Sep 30) ‡	
Average daily energy savings per treated thermostat (kWh)	0.35 ± 0.59
Average energy savings (% of cooling load)	3.4% ± 5.6%
Average total energy savings per treated thermostat (kWh)	31.1 ± 51.9
Total energy savings (MWh)	46
Summer Peak Demand Savings (Jul 2 – Aug 31) §	
Average demand savings per treated thermostat (W)	30 ± 60
Average demand savings (% of cooling load)	3.3% ± 6.6%
Total average demand savings (kW)	44

† All treated thermostats were eligible for savings (opt-in thermostats in service territory with telemetry data).

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ Demand savings are calculated for 1p.m.-5p.m. on non-holiday weekdays through August 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

National Grid 2018 Program Year

Google deployed the SS program for NGrid on July 2, 2018 to 32,204 thermostats. In total, 23,328 thermostats (75%) qualified to receive the program offering. Of those, 15,186 thermostats (65% of qualified thermostats) opted in. This section summarizes the key findings from the exploratory and impact analyses.

Exploratory Analysis

Figure 3 presents the average daily scheduled cooling setpoints for the ITT subgroups (treated and untreated) compared to the control group's schedule. The average daily scheduled cooling setpoints increased for the treated group relative to the control group after the SS program began. The evaluation also revealed that adjustments to the cooling setpoint schedules were largest during weekdays.

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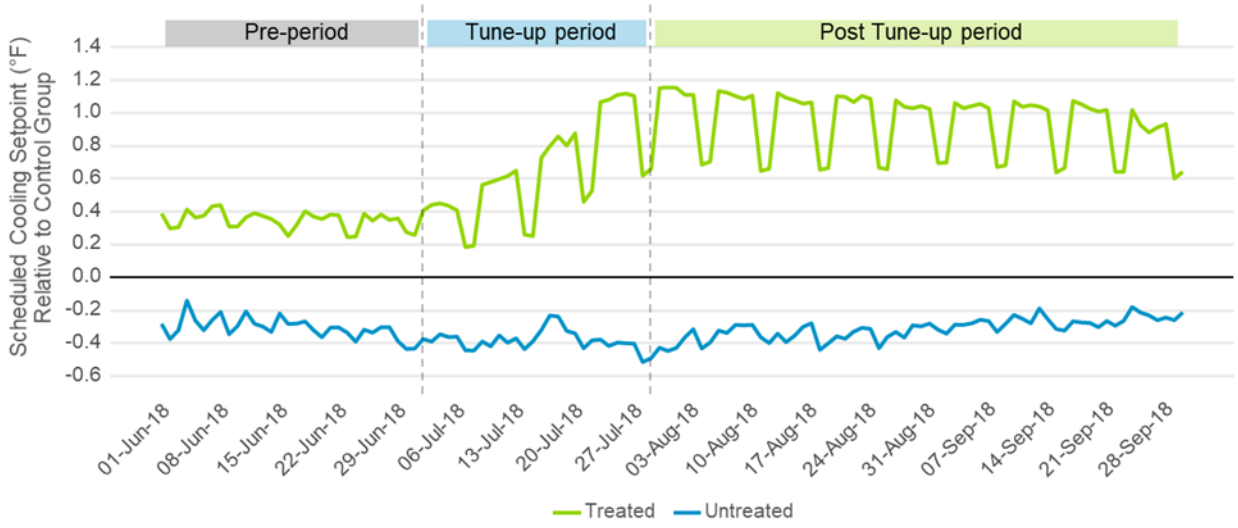
Figure 3. Average Daily Scheduled Cooling Setpoint Comparison, ITT Subgroups: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Table 5 summarizes the changes in cooling setpoint schedules. The exploratory analysis of thermostat telemetry data provided evidence that the SS program did make the intended adjustments to scheduled cooling setpoints, yielding reductions in cooling runtime.

Table 5. Summary of Exploratory Analysis: NGrid

Period	Group	Pre	Post Tune-up	Δ†	SS Impact‡
Period Dates (2018)		Jun 1 – Jul 1	Jul 30 – Sep 30	–	**–**
Average Daily Outdoor Temp (°F)		67.35	70.98	3.63	**–**
Average Daily Scheduled Cooling Setpoints (°F)	Control	74.14	74.33	0.19	**–**
	ITT	74.23	74.78	0.56	**0.37**
	Treated	74.48	75.27	0.79	**0.59**
	Untreated	73.83	74.01	0.19	**–**

†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 or treated group and the control group.
Source: Navigant analysis of Nest thermostat telemetry data and NOAA temperature data

Impact Analysis

Table 6 summarizes the findings of the impact analysis. For NGrid, the SS program resulted in energy savings of 30.6 kWh per thermostat and total savings of 464 MWh between July 2, 2018 and September 30, 2018. Average peak demand savings were 60 W per thermostat, with total peak demand savings of 903 kW.

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Table 6. PY2018 SS Summer Impact Summary: NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	13,713
Number of Nest thermostats in ITT group	32,204
Number of Nest thermostats in treated group †	**15,186**
Summer Energy Savings (Jul 2 – Sep 30) ‡	
Average daily energy savings per thermostat (kWh)	0.35 ± 0.13
Average energy savings (% of cooling load)	3.0% ± 1.2%
Average total energy savings per thermostat (kWh)	30.6 ± 11.7
Total energy savings (MWh)	464
Summer Peak Demand Savings (Jul 2 – Aug 31) §	
Average demand savings per thermostat (W)	60 ± 15
Average demand savings (% of cooling load)	6.4% ± 1.6%
Total average demand savings (kW)	903

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 15,164.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ Demand savings are calculated for 1p.m.-5p.m. on non-holiday weekdays through August 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Cape Light Compact and National Grid 2018 Program Year

This section summarizes the key findings joint impact analysis.

Impact Analysis

Table 7 summarizes the findings of the impact analysis. For CLC and NGrid combined, the SS program resulted in energy savings of 30.5 kWh per thermostat and total savings of 508 MWh between July 2, 2018 and September 30, 2018. Average peak demand savings were 57 W per thermostat, with total peak demand savings of 947 kW.

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Table 7. PY2018 SS Summer Impact Summary: CLC & NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	15,416
Number of Nest thermostats in ITT group	36,152
Number of Nest thermostats in treated group †	**16,667**
Summer Energy Savings (Jul 2 – Sep 30) ‡	
Average daily energy savings per treated thermostat (kWh)	0.35 ± 0.13
Average energy savings (% of cooling load)	3.0% ± 1.2%
Average total energy savings per treated thermostat (kWh)	30.5 ± 11.7
Total energy savings (MWh)	508
Summer Peak Demand Savings (Jul 2 – Aug 31) §	
Average demand savings per treated thermostat (W)	57 ± 15
Average demand savings (% of cooling load)	6.1% ± 1.6%
Total average demand savings (kW)	947

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 16,645.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ Demand savings are calculated for 1p.m.-5p.m. on non-holiday weekdays through August 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

National Grid Additional Analyses

NGrid was in its second year of deployment, which provided the opportunity to answer additional research questions. This section summarizes the key findings from the additional NGrid-specific analyses.

Exploratory Analysis

Figure 4 shows how the scheduled cooling setpoints for each of the four NGrid ITT combination groups in the original cohort compare to the 2-year control group. Based on the 2018 cooling setpoint schedules for thermostats treated 2 years in a row, it can be shown that there is some level of persistence from program year 2017 (PY2017) to program year 2018 (PY2018) for SS. Persistence is further explored in Section 4.4.2.3, where setpoints for customers treated in PY2017 are followed into the PY2018 pre-period. Additionally, the exploratory analysis compares first year setpoint adjustments and PY2018 setpoint adjustments across the 2017 and 2018 NGrid cohorts.

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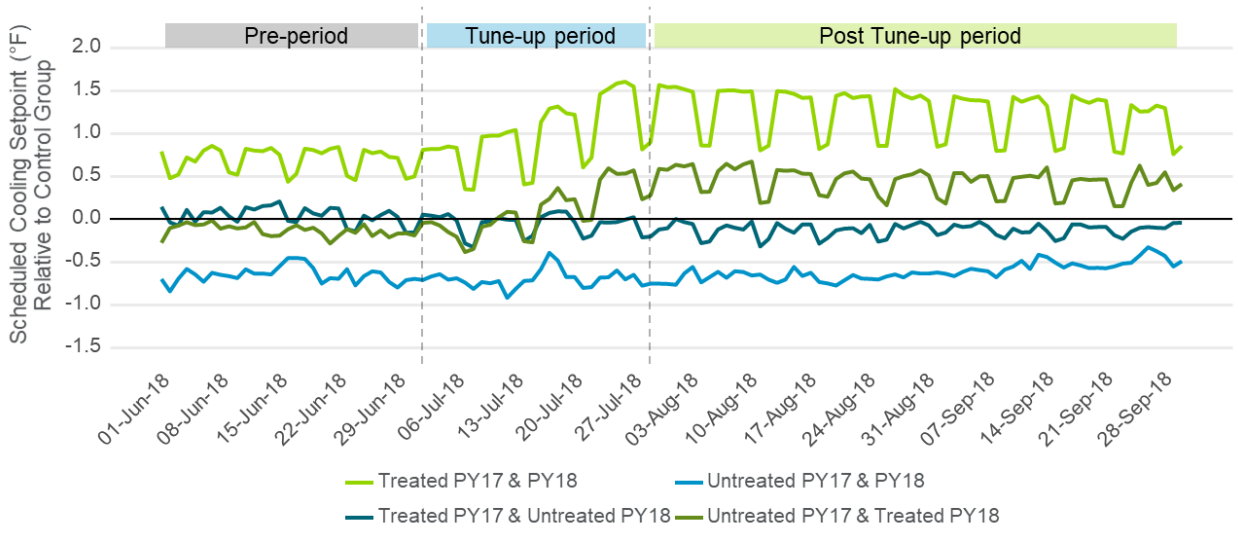
Figure 4. 2018 Scheduled Cooling Setpoint Comparison, All NGrid 2017 Cohort Groups



Source: Navigant analysis of Nest thermostat telemetry data

Impact Analysis

Table 8 summarizes the findings of the impact analysis for the 2017 and 2018 NGrid cohorts for the PY2018 summer season. For the 2017 thermostat cohort, the SS program resulted in total energy savings of 228 MWh from July 2, 2018 through September 30, 2018. Average daily energy savings were estimated to be 0.40 kWh[5] per treated thermostat, or approximately 3.5% of the cooling load for these thermostats post program launch. For the 2018 thermostat cohort, the SS program resulted in total energy savings of 235 MWh from July 2, 2018 through September 30, 2018. Average daily energy savings were estimated to be 0.31 kWh[6] per treated thermostat, or approximately 2.7% of the cooling load for treated thermostats post program launch. Difference in impacts may be attributable to the makeup of each cohort, as the 2018 cohort primarily consists of newly installed thermostats while the 2017 cohort contains thermostats installed since the Nest thermostat was first released.

[5] The 90% confidence interval is 0.20 kWh to 0.60 kWh.

[6] The 90% confidence interval is 0.13 kWh to 0.50 kWh.

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Table 8. PY2018 SS Summer Impact Summary by Cohort: NGrid

Cohort	Statistic	Treated Thermostat Savings
2017 Cohort	Number of Nest thermostats in control group	5,924
	Number of Nest thermostats in ITT group	13,962
	Number of Nest thermostats in treated group †	**6,576**
	Summer Energy Savings (Jul 2 – Sep 30) ‡	
	Average daily energy savings per thermostat (kWh)	0.40 ± 0.20
	Average energy savings (% of cooling load)	3.5% ± 1.7%
	Average total energy savings per thermostat (kWh)	34.7 ± 17.3
	Total energy savings (MWh)	228
	Summer Peak Demand Savings (Jul 2 – Aug 31) §	
	Average demand savings per thermostat (W)	71 ± 23
	Average demand savings (% of cooling load)	7.6% ± 2.4%
	Total average demand savings (kW)	465
2018 Cohort	Number of Nest thermostats in control group	7,789
	Number of Nest thermostats in ITT group	18,242
	Number of Nest thermostats in treated group †	**8,610**
	Summer Energy Savings (Jul 2 – Sep 30) ‡	
	Average daily energy savings per thermostat (kWh)	0.31 ± 0.18
	Average energy savings (% of cooling load)	2.7% ± 1.6%
	Average total energy savings per thermostat (kWh)	27.3 ± 15.9
	Total energy savings (MWh)	235
	Summer Peak Demand Savings (Jul 2 – Aug 31) §	
	Average demand savings per thermostat (W)	51 ± 20
	Average demand savings (% of cooling load)	5.4% ± 2.1%
	Total average demand savings (kW)	438

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 6,559 (2017 cohort) and 8,602 (2018 cohort).

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ Demand savings are calculated for 1p.m.-5p.m. on non-holiday weekdays through August 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Conclusions

Navigant's evaluation of the SS program for NGrid and CLC found it was successful in testing the technical feasibility of thermostat optimization and in customer acceptance of the offering. The evaluation shows promise for thermostat optimization, though important questions remain regarding incremental savings from future deployments, persistence of savings, and savings for statewide deployment. Table 9 summarizes the key evaluation findings, and Table 10 provides recommendations.

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Table 9. Key Findings

Key Findings
• Under half of thermostats in the ITT group opted in to programs—38% for CLC and 47% for NGrid.
• The cooling setpoint schedules for the treated thermostats were adjusted upward during the program period—0.41°F for CLC and 0.59°F for NGrid.
• The largest setpoint adjustments took place during the middle of the weekdays, when customers were least likely to be at home—0.76°F for CLC and 1.25°F for NGrid.
• The average energy savings per treated thermostat between July 2, 2018 and September 30, 2018 were 31.1 kWh for CLC, 30.6 kWh for NGrid, and 30.5 kWh combined.
• The program yielded average energy savings between July 2, 2018 and September 30, 2018 of 3.4% for CLC, 3.0% for NGrid, and 3.0% combined for program participants.
• The average demand savings per treated thermostat from July 2, 2018 to August 31, 2018 were 30 W for CLC, 60 W for NGrid, and 57 W combined.
• The program yielded average peak demand savings thermostat between July 2, 2018 and August 31, 2018 of 3.3% for CLC, 6.4% for NGrid, and 6.1% combined.
• The program achieved energy savings between July 2, 2018 and September 30, 2018 of 46 MWh for CLC, 464 MWh for NGrid, and 508 MWh combined.
• The program achieved demand savings between July 2, 2018 and August 31, 2018 of 44 kW for CLC, 903 kW for NGrid, and 947 kW combined.
• Navigant recommends CLC claim the combined per-thermostat energy and demand savings as the CLC values were not statistically significant.

Table 10. Recommendations

Recommendations
• **Recommendation #1:** NGrid should claim average energy savings of 30.6 kWh per treated thermostat in Massachusetts in 2018. CLC should claim average energy savings of 30.5 kWh per treated thermostat in Massachusetts in 2018.
• **Recommendation #2:** NGrid should claim average demand savings of 60 W per treated thermostat in Massachusetts in 2018. CLC should claim average demand savings of 57 W per treated thermostat in Massachusetts in 2018.
• **Recommendation #3:** In 2019, deploy the SS program to all Massachusetts PAs to better inform a PA-specific (or statewide) savings value or realization rate for inclusion in the Technical Reference Manual.
• **Recommendation #4:** The summer SS program should continue to be evaluated to assess the ability of the program to realize incremental savings associated with redeployment. The 2018 exploratory analysis found that setpoint adjustments persist and continued from 2017.

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1. INTRODUCTION

National Grid (NGrid) and Cape Light Compact (CLC) partnered with Nest in the summer of 2018 to offer their customers with an existing Nest thermostat in Massachusetts an energy savings opportunity, the Seasonal Savings (SS) program. SS is a thermostat optimization program designed to make small incremental adjustments to scheduled 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 upwards by 1.0°F-1.5°F during the cooling season, with the largest temperature adjustments taking place when customers are typically away from home (e.g., morning through early afternoon on weekdays).[7]

Figure 1-1. Illustrative Setpoint Schedule Adjustments

Source: Google

Navigant completed an evaluation of the 2018 SS summer program. The evaluation focused on developing an understanding of the technical feasibility of the solution and of customer acceptance, essential in determining whether continued or wider-scale deployment should be pursued.[8] This report presents these findings in several sections:

- Section 2 presents a summary of the evaluation methodology
- Section 3 provides an overview of the data sources and data management used in this evaluation
- Section 4 presents findings from the 2018 program year (PY2018) evaluation for CLC, NGrid, and the NGrid-specific analysis for the second-year thermostats
- Section 5 presents conclusions and recommendations

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

[8] This evaluation did not examine whether thermostat optimization is cost-effective for the electric system, program administrators, or customers.

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1.1 Evaluation Objectives

The objectives of the 2018 thermostat optimization evaluation were to answer the questions outlined in Table 1-1. Because NGrid was in its second year of deploying the SS program, additional evaluation objectives were identified.

Table 1-1. Thermostat Optimization Research Questions

Research Questions	Evaluation Approach
• How many thermostats/customers enrolled in the program by program administrator (PA)? • Did the program have the intended effect on scheduled cooling setpoints and were effects similar for all PAs? • What was the impact of SS on cooling runtime by PA, by day, and over the summer season?	Exploratory analysis
• What are the total summer and total summer on-peak and off-peak energy impacts of customers with thermostat optimization by PA? • What are the demand impacts of customers with thermostat optimization by PA? • What are the energy and demand realization rates based on a comparison of Nest-reported savings values and evaluated savings values?	Impact analysis
• What percentage of customers re-enrolled in the program? • How has the ITT group evolved from PY2017 to PY2018? • What are the scheduled cooling setpoint adjustments in PY2018 for customers that participated in two program years? How have the adjustments changed during the first year (PY2017) compared to the second year (PY2018)? • Have scheduled cooling setpoint adjustments from customers that participated in 2017 continued in 2018? • How are scheduled cooling setpoint adjustments different for the 2018 cohort in 2018 compared to the 2017 cohort in 2018? • How do the first-year scheduled cooling setpoint adjustments of the 2018 cohort compare to the adjustments of the 2017 cohort in 2017? • What are the total summer and total summer on-peak and off-peak energy impacts of customers with thermostat optimization by cohort? • What are the demand impacts of customers with thermostat optimization by cohort?	NGrid-specific analysis

Source: Navigant

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2. EVALUATION METHODS

Google deployed the SS program for NGrid and CLC using a randomized encouragement design (RED), in which all customers in a PA's service territory with a Nest thermostat were randomly assigned into one of two groups.[9] These two groups are the intent to treat (ITT) group, where participants are randomly assigned to receive the program offering, and the control group, where participants are randomly assigned to *not* receive the program offering.[10]

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

1. Nest thermostat installed and connected to Wi-Fi
2. Thermostat set to cooling mode
3. A programmed setpoint schedule

All qualified customers were provided the program offering on the thermostat itself and through Nest's mobile app. Some portion of ITT customers chose to opt in and enroll into the program, while others did not. The group of customers that opted in is referred to as the treated group. Thermostats that were part of the ITT group but either did not qualify or did not opt in are referred to as the untreated group. As described later in this section, SS savings are evaluated by comparing the ITT group (both treated and untreated thermostats) to the control group. The estimate of savings is then scaled by the opt-in rate to calculated savings from treated thermostat.

Refer to Figure 2-1 for an illustration of the RED design for the SS program.

[9] NGrid is in its second year of deployment. The random assignment of devices into the ITT group or the control group that were in the 2017 study remained the same in 2018.

[10] For each PA, 70% of thermostats were randomly assigned to the ITT group while the remaining 30% were assigned to the control group.

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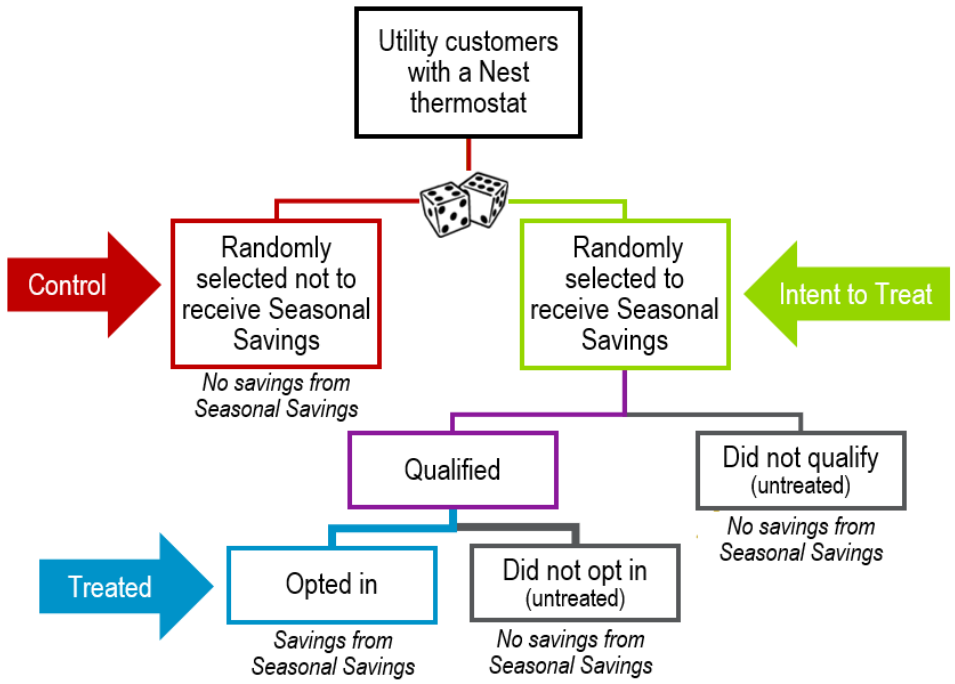
Figure 2-1. RED Illustration



Source: Navigant

The timeframe of this study is June 1, 2018 through September 30, 2018. The study was broken up into a pre-period (June 1-July 1) and a post period (July 2-September 30), as SS deployment began on July 2, 2018. The post period was further broken up into the tune-up period (July 2-July 29) and the post tune-up period (July 30-September 30) based on an analysis of the thermostat population's scheduled cooling setpoint data. The tune-up period lasted roughly 4 weeks, during which thermostats began their incremental schedule adjustments. The full effect of SS was not felt until the thermostats finished their tune-up, after which the post tune-up period began.

As noted, NGrid was in its second year of program deployment. While customers assigned to the ITT and control groups in 2017 were assigned to the same groups in 2018, qualification status and the customer decision to opt in or not opt in resulted in a variety of program participation patterns.

- **2018 New Thermostat Cohort:** Since the NGrid 2017 summer SS program ended on September 30, 2017, customers have purchased new Nest thermostats that are now included in the 2018 study—referred to in this report as the 2018 thermostat cohort. Key research questions include whether cooling setpoint schedule adjustments and thermostat-level energy impacts are different for this newest cohort of thermostats relative to the 2017 program cohort.
- **2017 Thermostat Cohort:** Thermostats in the 2017 program were again offered the program in 2018; however, not all thermostats that opted in to the program in 2017 opted in again in 2018. Key research questions include:
    - For those thermostats that participated in both 2017 and 2018, were savings during the first year of the program different than savings during the second year? (i.e., were setpoint schedules adjusted further and did customer comfort become a constraint?)

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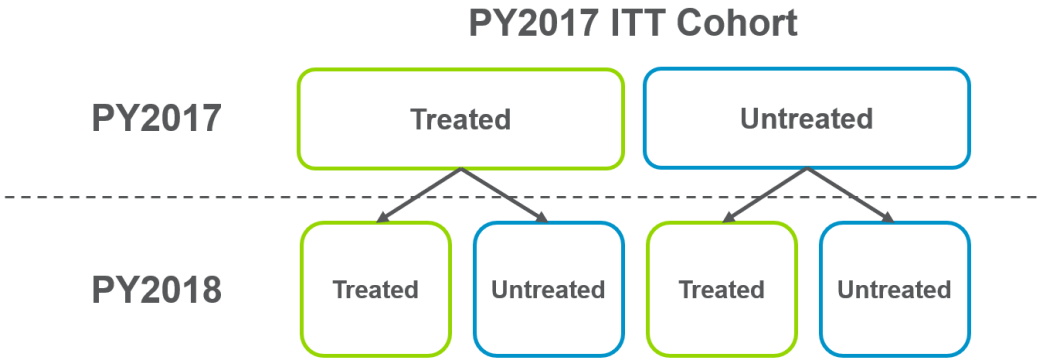
- For those thermostats that participated in 2017 but did not participate in 2018, were setpoint schedule adjustments implemented in 2017 carried forward to 2018?

Figure 2-2 presents the various combinations of the SS study participation for the 2017 ITT Thermostat Cohort. Controls are not included in this figure, as any thermostat that was a control in 2017 stayed as a control in 2018. There are now four different combinations of ITT status across the two program years:

- Treated PY17 & PY18: Thermostats treated in both 2017 and 2018
- Treated PY17 & Untreated PY18: Thermostats treated in 2017 but not in 2018
- Untreated PY17 & Treated PY18: Thermostats treated in 2018 but not in 2017
- Untreated PY17 & PY18: Thermostats that were never treated across both 2017 and 2018

This report will follow these naming conventions for these different thermostat subgroups.

Figure 2-2. ITT Assignments Across Two Program Years



Source: Navigant

Navigant's evaluation approach relied on an exploratory analysis and a regression analysis:

Exploratory analysis: The evaluation team analyzed thermostat-level participation data and thermostat telemetry data to:

- Assess program eligibility and opt-in rates, providing insight into customer acceptance of the thermostat optimization solution
- Confirm the thermostat optimization algorithm was operating as intended (i.e., increasing setpoints and reducing runtime for treated thermostats) over time
- Analyze whether there are setpoint differences between weekdays/weekends and across hours of the day
- Compare data across several groups, including treated versus control
- *(NGrid only)* Compare data across several additional groups to better understand persistence of savings, first-year savings, and second-year savings

For the exploratory analysis, the control group is often the basis of comparison and represented by the x-axis. The control group 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 not been deployed as part of

the SS program. Comparing the treated and untreated groups to each other may lead to false conclusions. Characteristics that influence whether a thermostat ends up in the treated group (connectivity, mode, etc.) may also influence the setpoints and runtime of the thermostat. Differences between the treated and untreated groups may be a result of these pre-existing characteristics, not from enrollment in the SS program.

Impact analysis: Navigant conducted the impact analysis to estimate the energy savings and peak demand savings from thermostat optimization for treated group.[11, 12] The evaluation relied exclusively on thermostat telemetry data to estimate impacts after converting thermostat runtime to power, as described by Equation 2-1.

Equation 2-1. Conversion of Runtime to Power[13]

$$\widehat{kW_{it}} = \mathbf{0.0013} + \mathbf{0.82} * \frac{\%\ \boldsymbol{Runtime} * \mathbf{36,000}}{\mathbf{10.7} * \mathbf{1,000}} + \mathbf{0.0012} * \boldsymbol{CDH70} + \mathbf{0.0055} * \boldsymbol{CDH70} * \frac{\%\ \boldsymbol{Runtime} * \mathbf{36,000}}{\mathbf{10.7} * \mathbf{1,000}}$$

Navigant converted thermostat runtime to power based on an analysis of metering data from Phase 2 of the 2017 Massachusetts Baseline Study (n=92). Navigant's assumptions regarding average size (3.0 tons) and efficiency (10.7 Energy Efficiency Ratio) of air conditioners was based on a field study (n=52) of residential Wi-Fi thermostat demand reduction program participants conducted by Navigant in October 2017. Navigant used Equation 2-1 to convert the thermostat runtime data and weather data into an estimate of power and energy consumption for the population of SS program participants.

The impact evaluation key outputs (Table 2-1) detail the energy and demand savings achieved through September 30, 2018 of the SS program. All outputs are generated for NGrid and CLC separately.

[11] Peak demand is defined as 1 p.m.-5 p.m. on non-holiday weekdays from July 2, 2018 through August 31, 2018.

[12] The savings estimate for the ITT group represents an unbiased estimate of the effect of encouragement on energy use while the savings estimate for the treated group represents an unbiased estimate of the effect of the program intervention on energy use.

[13] For example, for a 15-minute interval with 100% runtime at 80°F, the estimated power is 2.95 kW.

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Table 2-1. Summary of Key Outputs

Type	Period	Definition
Energy	Summer	All hours June 1 through September 30, while the SS program is active
	Summer On-Peak	Weekdays, non-holidays from 7 a.m. to 11 p.m. June 1-September 30, while the SS program is active
	Summer Off-Peak	All other hours from June 1 through September 30 including weekends and holidays, while the SS program is active
	Tune-Up	All hours July 2 through July 29
	Post Tune-Up	All hours July 30 through September 30
Demand	Summer On-Peak	Weekdays, non-holidays from 1 p.m. to 5 p.m., June 1-August 31, while the SS program is active
	Adjusted Summer	Weekdays, non-holidays from 1 p.m. to 5 p.m., June 1-August 31 (average will assume zero demand savings prior to program launch)

Source: Navigant

Navigant used linear fixed effects (or difference-in-differences) regression models to estimate energy and power savings associated with thermostats that were randomly assigned to receive the program offering. The respective savings estimates are the average effect of being randomly assigned to receive the SS algorithm. This value is then scaled up by the program opt-in rate to estimate the savings per treated thermostat. Table 2-2 will further iterate on the calculations of the various savings estimates.

Formally, the model used to estimate kWh savings is specified in Equation 2-2. For all models using this specification, the formatted Nest telemetry runtime data was aggregated up to the daily level for each thermostat.

Equation 2-2. Linear Fixed Effects Model – Energy Savings

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

Where,

EDU_{it} is the estimated daily usage in kWh by thermostat *i* on date *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 the date *t;* this picks up temporal differences between days, like weather and daylight hours.

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$Post_t \cdot ITT_i$	is a binary variable taking a value of 1 when thermostat *i* is in the ITT group and date *t* is on or after the start of the SS program (July 2, 2018).
β	is the average daily per-thermostat kWh impact of participating in the ITT group after July 2, 2018.
ε_{it}	is the cluster-robust error term for thermostat *i* during date *t*; these cluster-robust errors account for heteroskedasticity and autocorrelation at the thermostat level.

Navigant used the model specification in Equation 2-2 to develop energy savings estimates under a variety of guidelines:

- Summer energy savings, where EDU_{it} includes all hours June 1, 2018 through September 30, 2018 while the SS program is active.
    - Total energy savings during the post period, July 2 through September 30
    - Total energy savings during the tune-up period, July 2 through July 29
    - Total energy savings during the post-tune-up period, July 30 through September 30
- Summer on-peak energy savings, where EDU_{it} includes hours on weekdays, non-holidays between 7 a.m. and 11 p.m. while the SS program is active, June 1 through September 30.
    - Total on-peak energy savings during the post period, July 2 through September 30
- Summer off-peak energy savings, where EDU_{it} includes hours between 11 p.m. and 7 a.m., plus all hours on weekends and holidays while the SS program is active, June 1 through September 30.
    - Total off-peak energy savings during the post period, July 2 through September 30

To estimate demand savings, Navigant used a modified version of Equation 2-2 that leveraged aggregated hourly rather than daily observations. This model used similar linear fixed effects, but cooling degree hours (CDH) was added as a regressor. Equation 2-3 describes the model used to estimate power savings.

Equation 2-3. Linear Fixed Effects Model – Demand Savings

$$\boldsymbol{AHP_{ith} = \alpha_i + \gamma_t + CDH70_{ith} + \beta(Post_t \cdot ITT_i)} + \varepsilon_{ith}$$

Where,

AHP_{ith}	is estimated average power in kW used by thermostat *i* during date *t* and hour *h.*
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 the date *t;* this picks up temporal differences between days, like weather and daylight hours.
$CDH70_{ith}$	is the average cooling degree hours experienced by thermostat *i* during date *t* and hour *h*; this value is determined through temperature records from an assigned Quality Controlled Local Climatological Data weather station based on a thermostat's ZIP code.

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$Post_t \cdot ITT_i$	is a binary variable taking a value of 1 when thermostat *i* is in the ITT group and date *t* is on or after the start of the SS program (July 2, 2018).
β	is the average hourly per-thermostat kW impact of participating in the ITT group from July 2, 2018 through August 31, 2018 between 1 p.m. and 5 p.m.
ε_{ith}	is the cluster-robust error term for thermostat *i* during date *t* and hour *h*; these cluster-robust errors account for heteroskedasticity and autocorrelation at the thermostat level.

Navigant used the model specification in Equation 2-3 to develop the power savings estimates under the following guidelines

- Demand savings, where AHP_{ith} is hourly demand on weekdays, non-holidays from 1 p.m. to 5 p.m., June through August, while the SS program is active (from July 2, 2018 through August 31, 2018).
- Average demand savings, where AHP_{ith} is hourly demand on weekdays, non-holidays from 1 p.m. to 5 p.m., June 1, 2018 through August 31, 2018.

Navigant estimated energy and demand impacts for NGrid and CLC separately. To calculate total program energy savings resulting from treatment, Navigant 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. Similarly, to calculate total demand savings, Navigant multiplied average hourly demand savings by the number of thermostats in the ITT group. Table 2-2 identifies the various savings statistics Navigant calculated.

Table 2-2. Savings Calculations

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

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	Average demand savings (% of cooling load)	$\frac{\hat{\gamma}}{(Avg\ Hourly\ Treated\ Demand\ Post\ Program\ Start - \hat{\gamma})}$

Source: Navigant

In parallel with Navigant's estimation of energy and demand impacts, Nest also estimated energy and demand savings. For each PA, Navigant developed a realization rate, calculated as the ratio of Navigant's savings estimate to the savings reported by Nest. These values are shown in Analysis and Results of the report.

Finally, for NGrid, Navigant estimated first-year savings and second-year savings.

- **2018 Thermostat Cohort:** Navigant estimated Equation 2-2 using only the new thermostats added in the 2018 program year and compared average energy and demand savings per thermostat to average energy and demand savings per thermostat in 2017.
- **2017 Thermostat Cohort:** Navigant estimated Equation 2-2 using the only thermostats that were part of the 2017 deployment and compared average energy savings per thermostat in 2018 to average energy savings per thermostat in 2017.

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3. DATA SOURCES

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

- Thermostat information and 15-minute telemetry data for June 2018 through September 2018, provided by Google (Nest), with an accompanying device file containing thermostat-specific information
- Hourly weather data across Massachusetts for 2018, retrieved from the National Oceanic and Atmospheric Administration (NOAA) database

3.1 Google (Nest) Thermostat Data

Navigant relied on thermostat telemetry data from all Nest thermostats in the 2018 deployment for the exploratory and impact analyses. In working with the thermostat telemetry data, Navigant took several steps to filter and clean the data to prepare it for the regression analysis with input from the PAs.

- **No telemetry data:** Navigant received a file detailing thermostat-specific information alongside the telemetry data. If a thermostat present in this file did not appear within the telemetry file, it was marked invalid and made ineligible for savings. This is the only cleaning step that categorizes thermostats as ineligible for savings.
- **No usable runtime:** Any thermostat that had telemetry data but did not have any available cooling runtime information (i.e., all records were shown to be of value N/A for cooling runtime) was removed from the final modeling data; however, these thermostats were still eligible for savings.
- **No complete days:** Because the impact analysis requires data aggregated to the daily level, Navigant could not include aggregated daily observations that did not have numeric runtime information during all 96 of their constituent 15-minute intervals. Some thermostats were completely removed from the modeling data due to this step; however, they were still eligible for savings.
- **No pre/post period data:** If a thermostat did not have any records in either the pre or post (tune-up plus post tune-up) periods, it was removed from the analysis; however, they were still eligible for savings.

Table 3-1 and Table 3-2 show the number of thermostats that were removed from the final data for CLC and NGrid, respectively.

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Table 3-1. Data Management: CLC

	ITT		Control		Total	
	Count	Percent	Count	Percent	Count	Percent
Thermostats in Device File †	**3,948**	**69.86%**	**1,703**	**30.14%**	**5,651**	**100.00%**
No telemetry data	145	2.57%	78	1.38%	223	3.95%
Participating Thermostats ‡	**3,803**	**67.30%**	**1,625**	**28.76%**	**5,428**	**96.05%**
No usable runtime	12	0.21%	2	0.04%	14	0.25%
No complete days	6	0.11%	2	0.04%	8	0.14%
No pre/post period data	82	1.45%	42	0.74%	124	2.19%
Remaining Thermostats §	**3,703**	**65.53%**	**1,579**	**27.94%**	**5,282**	**93.47%**

† Separate from telemetry data; contains information specific to each thermostat (e.g., assigned weather station, opt-in date, etc.)
‡ Number of thermostats eligible for savings (treated only)
§ Number of thermostats included in the final modeling data
Source: Navigant analysis of thermostat enrollment and telemetry data

Table 3-2. Data Management: NGrid

	ITT		Control		Total	
	Count	Percent	Count	Percent	Count	Percent
Thermostats in Device File †	**32,204**	**70.14%**	**13,713**	**29.86%**	**45,917**	**100.00%**
No telemetry data	1,369	2.98%	570	1.24%	1,939	4.22%
Participating Thermostats ‡	**30,835**	**67.15%**	**13,143**	**28.62%**	**43,978**	**95.78%**
No usable runtime	72	0.16%	26	0.06%	98	0.21%
No complete days	81	0.18%	31	0.07%	112	0.24%
No pre/post period data	673	1.47%	275	0.60%	948	2.06%
Remaining Thermostats §	**30,009**	**65.35%**	**12,811**	**27.90%**	**42,820**	**93.26%**

† Separate from telemetry data; contains information specific to each thermostat (e.g., assigned weather station, opt-in date, etc.)
‡ Number of thermostats eligible for savings (treated only)
§ Number of thermostats included in the final modeling data
Source: Navigant analysis of thermostat enrollment and telemetry data

3.2 NOAA Temperature Data

To produce kW estimates from thermostat telemetry, Navigant used 2018 temperature data from the NOAA database for a select number of Quality Controlled Local Climatological Data weather stations (22) across Massachusetts. Navigant pulled and cleaned the data, then calculated CDH (base 70°F) for all intervals. Using a ZIP code to weather station map created by Navigant, Google assigned each thermostat to a single weather station based on its geographic location. Thus, location-specific temperature data was combined with thermostat runtime to produce kW and kWh estimates at the sub hourly and daily levels, respectively.

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In addition to the hourly temperature data, Navigant also pulled daily temperature data for eight weather stations in Massachusetts from 1999 through 2018. This data was used to perform the weather analysis, which compared the 2018 summer to summers over the past 20 years.

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4. ANALYSIS AND RESULTS

4.1 Cape Light Compact 2018 Program Year

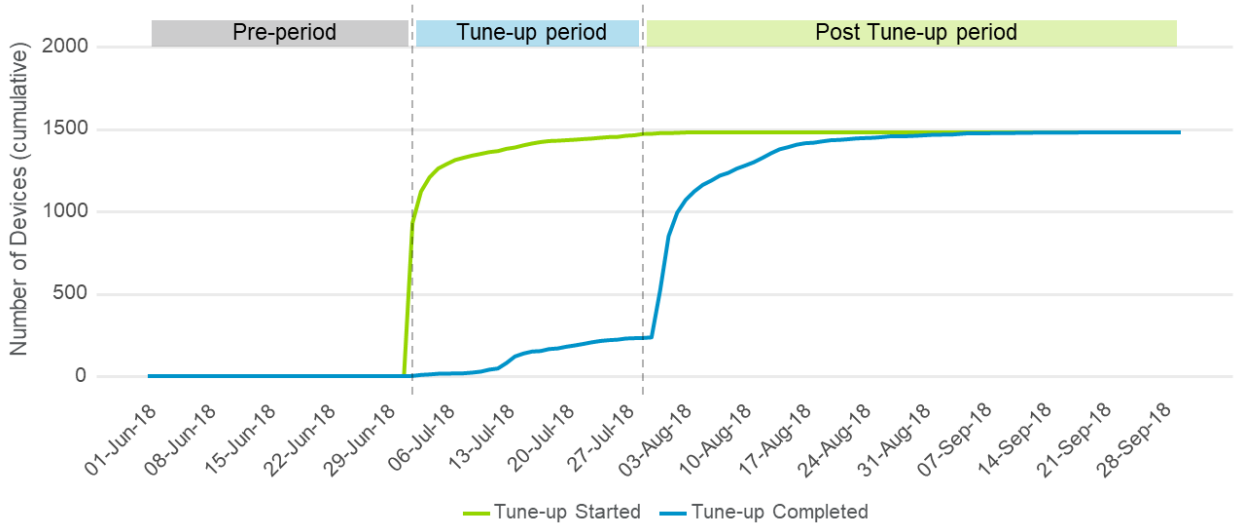
This section presents Navigant's program year 2018 evaluation of CLC's SS program:

- Section 4.1.1: Program Enrollment
- Section 4.1.2: Exploratory Analysis
- Section 4.1.3: Impact Analysis

4.1.1 Program Enrollment

In total, 1,481 thermostats within CLC's service territory were enrolled into the SS program. Figure 4-1 shows the cumulative number of thermostats enrolled in the program over the summer. The green line represents the total enrolled thermostats at each date, with the final thermostats opting in on August 3, 2018. Overall, customers were quick to enroll their thermostats into the program, with 90% of enrolled thermostats (1,328) beginning their treatment within the first week of the program offering. The blue line shows the cumulative number of thermostats that completed the SS algorithm tune-up.

Figure 4-1. Number of Enrolled Thermostats: CLC



Source: Navigant analysis of thermostat enrollment data

Figure 4-2 presents the enrollment information as a count of thermostats both starting and completing tune-up each day over the study period. The average time for the full SS algorithm to finish tune-up was approximately 29 days.

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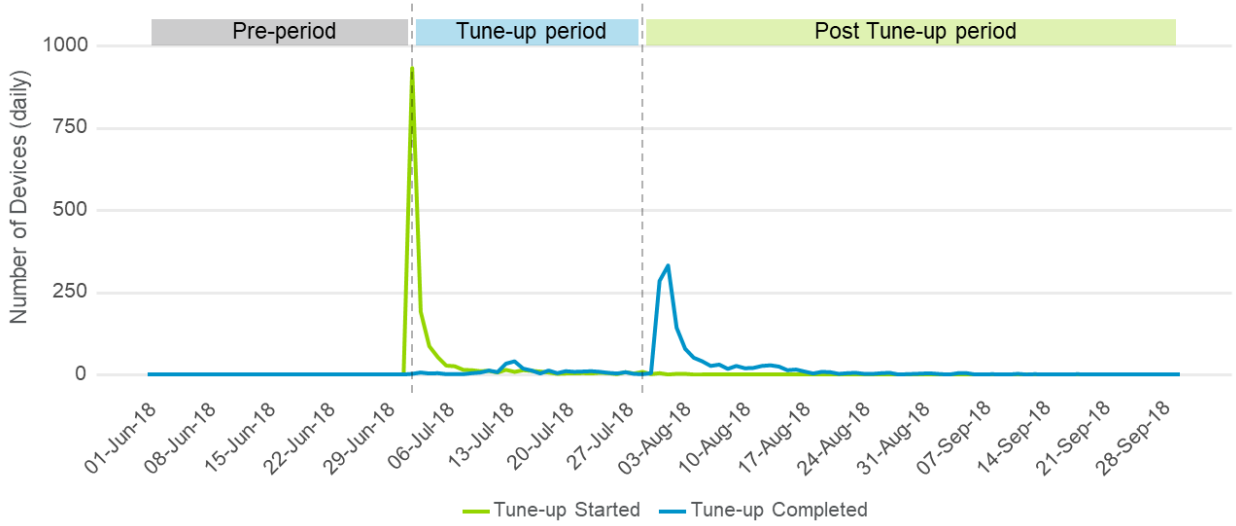
Figure 4-2. Number of Thermostats Starting and Completing Tune-Up: CLC



Source: Navigant analysis of thermostat enrollment data

Table 4-1 tallies the counts of thermostats assigned to the control and ITT groups, as well as the number of thermostats that did not qualify or did/did not opt in. The randomization assigned 70% of thermostats to the ITT group. Within the ITT, approximately 36% of those thermostats did not qualify and another 26% chose not to opt in to the SS program. The remaining 38% of ITT thermostats were enrolled into the program. The 62% of thermostats that did not participate in the program could be driven by the high preponderance of vacation homes in CLC's service territory.

Table 4-1. Implementation of SS: CLC

Category	Number	Percentage
Nests in electric service area	**5,651**	**-**
Nests in control group	1,703	30% of total
Nests in ITT group	3,948	70% of total
Nests enrolled in SS (treated group)	1,481	38% of ITT
Nests not enrolled (untreated group)	2,467	62% of ITT
Nests that did not qualify	1,416	36% of ITT
Nests that did not opt in	1,051	26% of ITT

Source: Navigant analysis of customer enrollment data

4.1.1.1 Summer 2018 Weather

The average temperature in CLC's service territory was above the 1981-2010 normal during June through September 2018. There were 3 days when the high temperature reached 90°F after the first SS offer day. The average temperature and cooling degree days for 2018 are compared to the Massachusetts 1981-2010 normal in Table 4-2.

Table 4-2. Summer 2018 Weather: CLC

Statistics		June	July	August	September
Average Temperature (°F)	2018	64.6	72.6	75.2	66.4
	1999-2018 average	64.9	71.7	70.9	64.0
	Departure	-0.3	0.9	4.3	2.4
Cooling Degree Days (base 65°F)	2018	71	247	324	97
	1999-2018 average	80	222	201	69
	Departure	-9	25	123	28

Source: Navigant analysis of Northeast Regional Climate Center data for Barnstable, MA

The average June temperature was 0.3°F below the 1999-2018 average, before being above average in July, August, and September by 0.9°F, 4.3°F, and 2.4°F, respectively. The warmer-than-average summer is also seen when comparing the number of cooling degree days in each month. Notably, August saw 324 cooling degree days, 123 more than the 1999-2018 average.

4.1.2 Exploratory Analysis

This section presents the findings from the exploratory analysis of the thermostat telemetry data. Table 4-3 provides the average daily scheduled cooling setpoints for the control, ITT, and treated and untreated subgroups. The exploratory analysis compares the scheduled cooling setpoints between the pre-period and post tune-up period for each group. The analysis found that the SS program made the intended adjustments to scheduled cooling setpoints.

Table 4-3. Summary of Exploratory Setpoint Analysis: CLC

Period	Group	Pre	Post Tune-up	Δ†	SS Impact‡
Period Dates (2018)		Jun 1 – Jul 1	Jul 30 – Sep 30	–	**–**
Average Daily Outdoor Temp (°F)		64.37	70.47	6.11	**–**
Avg. Daily Scheduled Cooling Setpoints (°F)	Control	73.71	73.88	0.17	**–**
	ITT	73.93	74.36	0.42	**0.26**
	Treated	73.92	74.49	0.58	**0.41**
	Untreated	73.95	74.19	0.24	**–**

† 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 or treated group and the control group.
Source: Navigant analysis of Nest thermostat telemetry data and NOAA temperature data

Figure 4-3 and Figure 4-4 present the relative average daily scheduled cooling setpoints for the RED groups (ITT and control) and for the treatment subgroups (treated, untreated, and control), respectively. Figure 4-5 and Figure 4-6 present this information after the control group has been differenced out from the other group(s). In these figures, the control group is the basis for comparison and is thus represented by the x-axis.

- **Pre-period:** Average scheduled cooling setpoints during the pre-period were somewhat similar between the ITT and control groups but still differed by 0.22°F,[14] as shown in Figure 4-3 and in

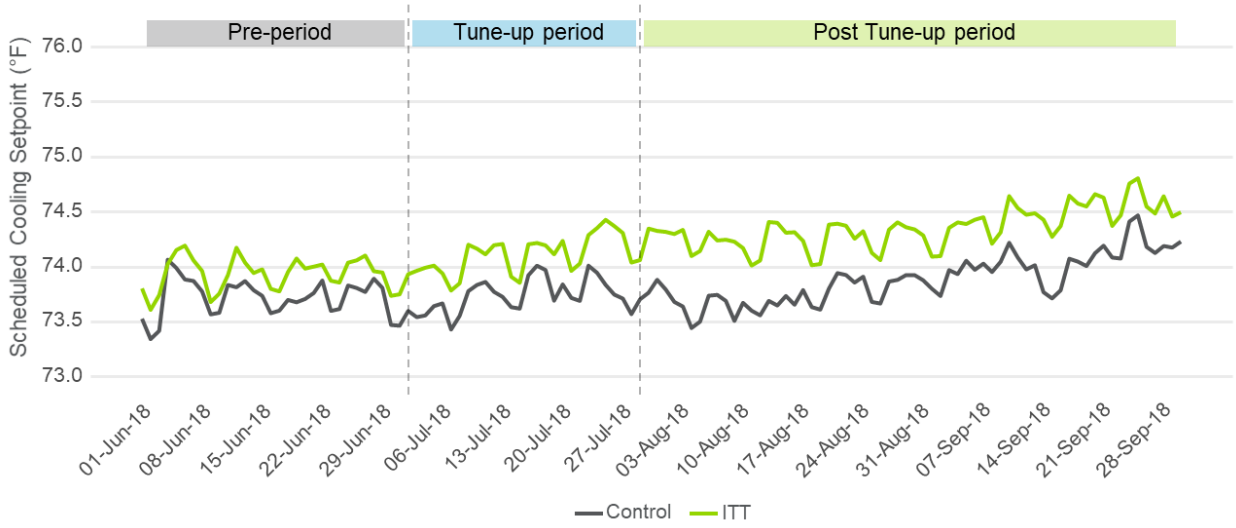
[14] This difference is larger than expected for a randomized cohort.

Figure 4-5. Conversely, the treated and untreated groups had comparable average daily scheduled cooling setpoints during the pre-period, differing only by 0.03°F. The schedule similarities can best be seen in Figure 4-4.

- **Post tune-up period:** The average scheduled cooling setpoints increased for both the ITT and control groups during the post tune-up period, but the increase was larger for the ITT group by 0.26°F. Figure 4-5 best demonstrates this as the difference between the average value for the green line in the pre-period versus the post tune-up period. Likewise, the treated and untreated subgroups saw increases during the post tune-up period as well, but the increase was largest for the treated group (0.41°F higher than the control group), as seen in Figure 4-6.

Figure 4-3 shows average scheduled cooling setpoints across all days for both the ITT and control groups.

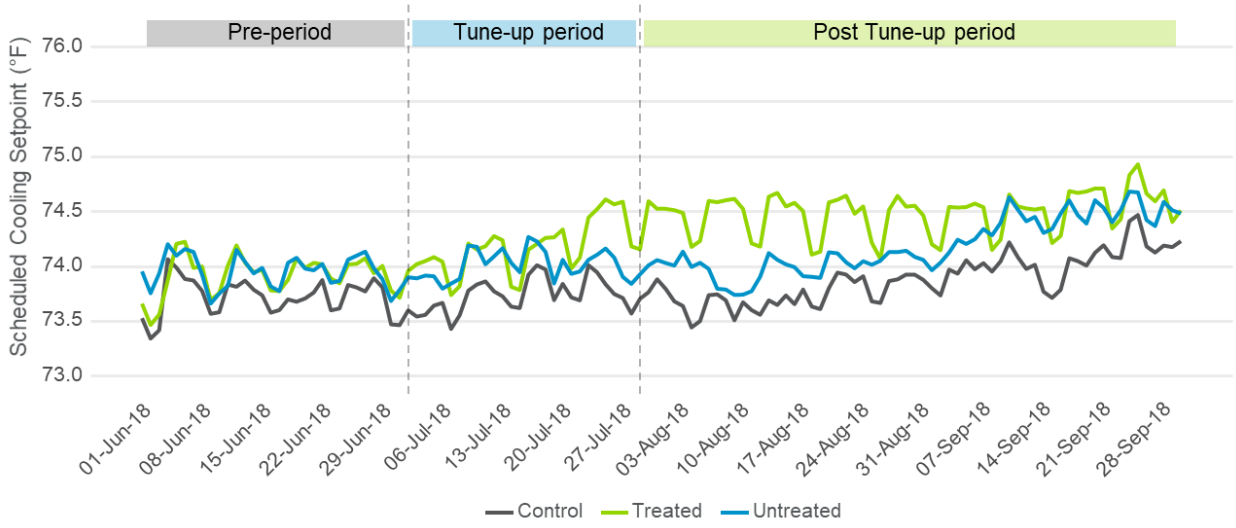
Figure 4-3. Average Daily Scheduled Cooling Setpoints: CLC



Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-4 shows average scheduled cooling setpoints across all days for the ITT subgroups (treated and untreated) as well as for the control group.

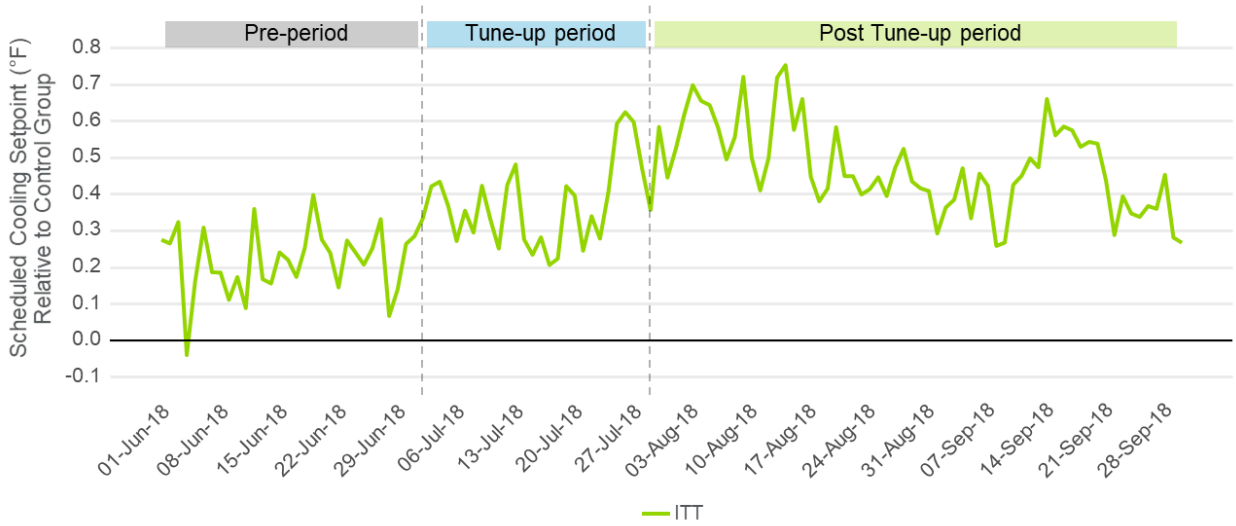
Figure 4-4. Average Daily Scheduled Cooling Setpoints, ITT Subgroups: CLC



Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-5 shows average scheduled cooling setpoints across all days for the ITT group relative to the control group. This presents the same information as Figure 4-3 but instead shows the difference between those two groups.

Figure 4-5. Average Daily Scheduled Cooling Setpoint Comparison: CLC



Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-6 shows average scheduled cooling setpoints across all days for the ITT subgroups (treated and untreated) relative to the control group. This presents the same information as Figure 4-4 but instead shows the difference between the treated and control groups as well as between the untreated and control groups.

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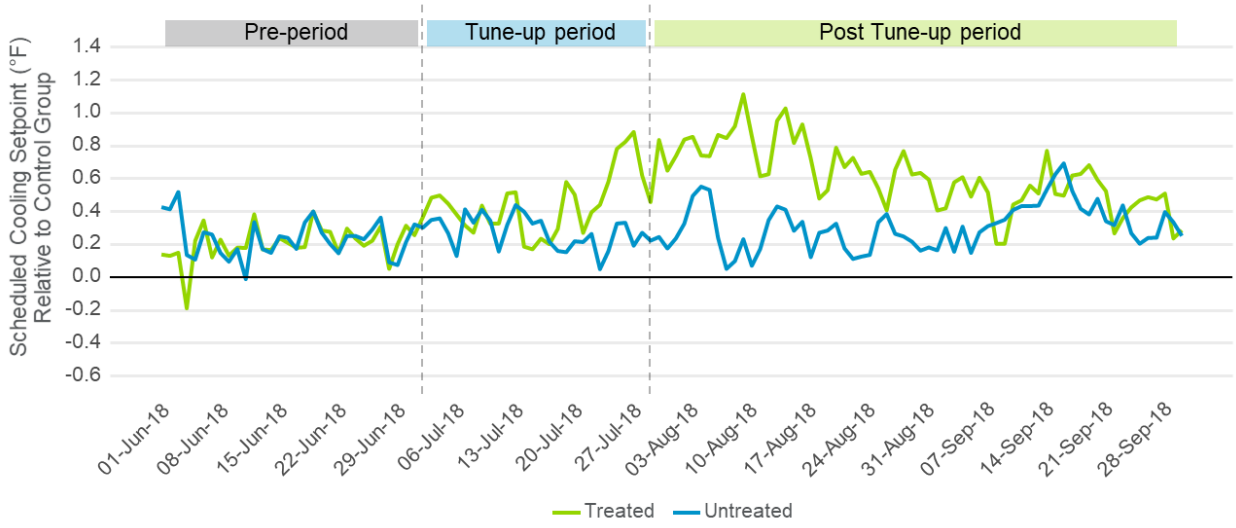
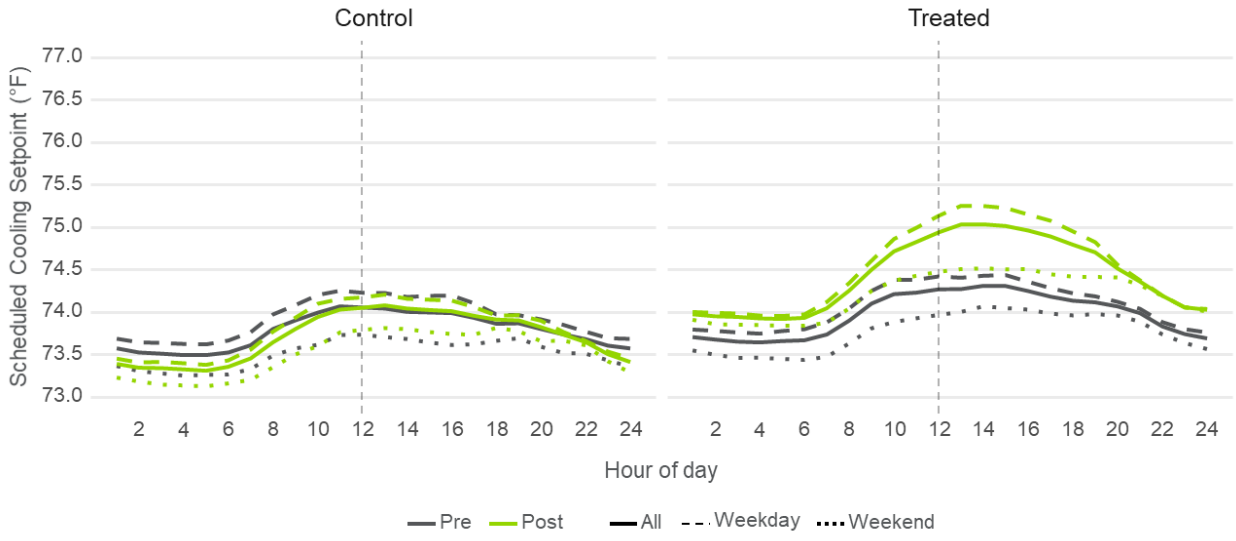
Figure 4-6. Average Daily Scheduled Cooling Setpoint Comparison, ITT Subgroups: CLC



Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-7 presents a comparison of average hourly scheduled cooling setpoints for all hours across two weeks in 2018 (June 25-July 1 during the pre-period and August 11-17 during the post period) for both the treated and control groups. Values are separated by weekday and weekend, as well as an overall mean by the hour. The SS program is designed to make the largest adjustments during times when customers are away from home (e.g., weekday daytime hours) and smaller or even downward adjustments during times when customers are at home (e.g., weekday evenings, weekends). Based on the comparisons in Figure 4-7 and the values in Table 4-4, this statement holds. Overall average scheduled cooling setpoints increased by 0.69°F between 10 a.m. and 6 p.m. and 0.35°F during all other hours during the post period week for the treated group, while the control group's overall average scheduled cooling setpoints barely changed across all hours.

Figure 4-7. Average Hourly Scheduled Cooling Setpoints, Pre and Post SS†: CLC



† Data shows hourly mean setpoint averages for two distinct weeks during the study: the week before SS began—pre (June 25-July 1), and one week in the middle of SS deployment after the tune-up period—post (August 11-17)

Source: Navigant analysis of Nest thermostat telemetry data

Table 4-4 details a breakdown of differences by day type and time of day between the control and treated groups.

Table 4-4. Change in Scheduled Cooling Setpoints, Before and After Tune-Up†: CLC

Day Type	Period	Treated Difference	Control Difference	Δ‡
Weekday	10 a.m.-6 p.m.	0.76°F	-0.05°F	0.80°F
	Other Hours	0.30°F	-0.16°F	0.47°F
Weekend	10 a.m.-6 p.m.	0.48°F	0.10°F	0.38°F
	Other Hours	0.42°F	-0.05°F	0.47°F
Overall	**10 a.m.-6 p.m.**	**0.69°F**	**0.02°F**	**0.67°F**
	Other Hours	**0.35°F**	**-0.11°F**	**0.46°F**

† Data shows hourly mean setpoint averages for two distinct weeks during the study: the week before SS began—pre (June 25-July 1), and one week in the middle of SS deployment after the tune-up period—post (August 11-17)

‡ Treated difference minus Control difference. Values in table may not compute due to rounding.

Source: Navigant analysis of Nest thermostat telemetry data

4.1.3 Impact Analysis

This section presents the findings from the energy and peak demand impact analyses, summarized in Table 4-5 (energy) and Table 4-6 (demand). Table 4-7 then presents the realization rates for the summer energy and demand savings estimates.

The SS program resulted in total energy savings of 46 MWh from July 2, 2018 through September 30, 2018. Average daily energy savings were estimated to be 0.35 kWh[15] per treated thermostat, or approximately 3.4% of the cooling load for treated thermostats post program launch. Table 4-5 presents these values as well as a breakdown of savings during on-peak hours, off-peak hours, the tune-up period, and the post tune-up period.

[15] The 90% confidence interval is (-0.24 kWh, 0.95 kWh).

Table 4-5. PY2018 SS Summer Energy Savings Summary: CLC

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	1,703
Number of Nest thermostats in ITT group	3,948
Number of Nest thermostats in treated group †	**1,481**
Summer (Jul 2 – Sep 30) ‡	
Average daily energy savings per thermostat (kWh)	0.35 ± 0.59
Average energy savings (% of cooling load)	3.4% ± 5.6%
Average total energy savings per thermostat (kWh)	31.1 ± 51.9
Total energy savings (MWh)	46
Summer (Jul 2 – Sep 30) On-Peak §	
Average daily energy savings per thermostat (kWh)	0.25 ± 0.55
Average energy savings (% of cooling load)	2.8% ± 6.0%
Average total energy savings per thermostat (kWh)	15.5 ± 33.2
Total energy savings (MWh)	23
Summer (Jul 2 – Sep 30) Off-Peak ††	
Average daily energy savings per thermostat (kWh)	0.20 ± 0.28
Average energy savings (% of cooling load)	4.6% ± 6.4%
Average total energy savings per thermostat (kWh)	17.7 ± 24.3
Total energy savings (MWh)	26
Tune-Up Period (Jul 2 – Jul 29)	
Average daily energy savings per thermostat (kWh)	0.47 ± 0.82
Average energy savings (% of cooling load)	3.7% ± 6.4%
Average total energy savings per thermostat (kWh)	12.8 ± 22.3
Total energy savings (MWh)	19
Post Tune-Up Period (Jul 30 – Sep 30)	
Average daily energy savings per thermostat (kWh)	0.39 ± 0.58
Average energy savings (% of cooling load)	4.0% ± 5.9%
Average total energy savings per thermostat (kWh)	23.8 ± 35.0
Total energy savings (MWh)	35

† All treated thermostats were eligible for savings (opt-in thermostats in service territory with telemetry data).

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ 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.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Navigant also estimated peak demand impacts from 1 p.m. to 5 p.m. on program period non-holiday weekdays through August. The SS program resulted in total peak demand savings of 44 kW between July 2 and August 31, 2018. Average demand savings were estimated to be about 30 W[16] per treated thermostat, or approximately 3.3% of the cooling load for treated thermostats, post program launch.

[16] The 90% confidence interval is (-30.6 W, 89.7 W).

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Table 4-6. PY2018 SS Summer Demand Savings Summary: CLC

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	1,703
Number of Nest thermostats in ITT group	3,948
Number of Nest thermostats in treated group †	**1,481**
Summer (Jul 2 – Aug 31) ‡	
Average demand savings per thermostat (W)	30 ± 60
Average demand savings (% of cooling load)	3.3% ± 6.6%
Total average demand savings (kW)	44
Adjusted Summer (Jun 1 – Aug 31) §	
Average demand savings per thermostat (W)	20 ± 40
Average demand savings (% of cooling load)	2.2% ± 4.4%
Total average demand savings (kW)	29

† All treated thermostats were eligible for savings (opt-in thermostats in service territory with telemetry data).

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The demand impact evaluation relies on data through August 31, 2018.

§ Adjusted Summer values are summer values adapted to be from June 1 through August 31, 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Table 4-7. Realization Rates: CLC

Estimation	Navigant	Nest	Realization Rate§
Average total energy savings per thermostat (kWh)	31	32	97%
Total energy savings (MWh)	46	45	102%
Average demand savings per thermostat (W)	30	29	103%
Average total demand savings (kW)	44	43	102%

§ Estimated savings are different between Navigant and Nest due to differences in the devices included in each analysis.

Source: Navigant analysis, Nest savings estimates

4.2 National Grid 2018 Program Year

This section presents Navigant's program year 2018 evaluation of NGrid's SS program:

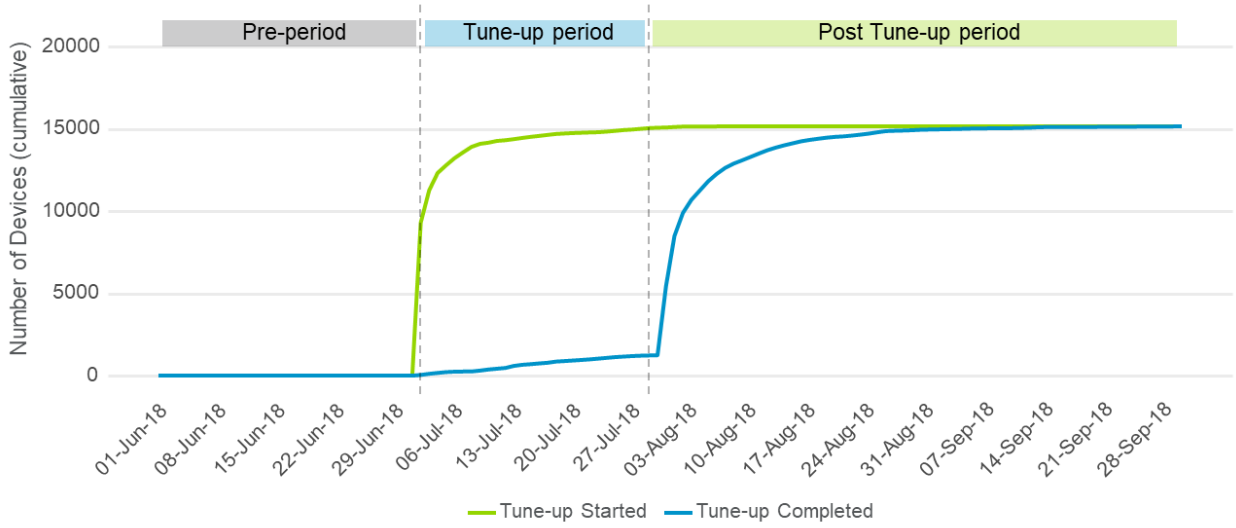
- Section 4.2.1: Program Enrollment
- Section 4.2.2: Exploratory Analysis
- Section 4.2.3: Impact Analysis

4.2.1 Program Enrollment

In total, 15,186 thermostats within NGrid's service territory were enrolled into the SS program. Figure 4-8 shows the cumulative number of thermostats enrolled in the program over the summer. The green line represents the total enrolled thermostats at each date, with the final thermostats opting in on August 6, 2018. Overall, customers were quick to enroll their thermostats into the program, with 92% of enrolled

thermostats (13,940) beginning their treatment within the first week of the program offering. The blue line shows the cumulative number of thermostats that completed the SS algorithm tune-up.

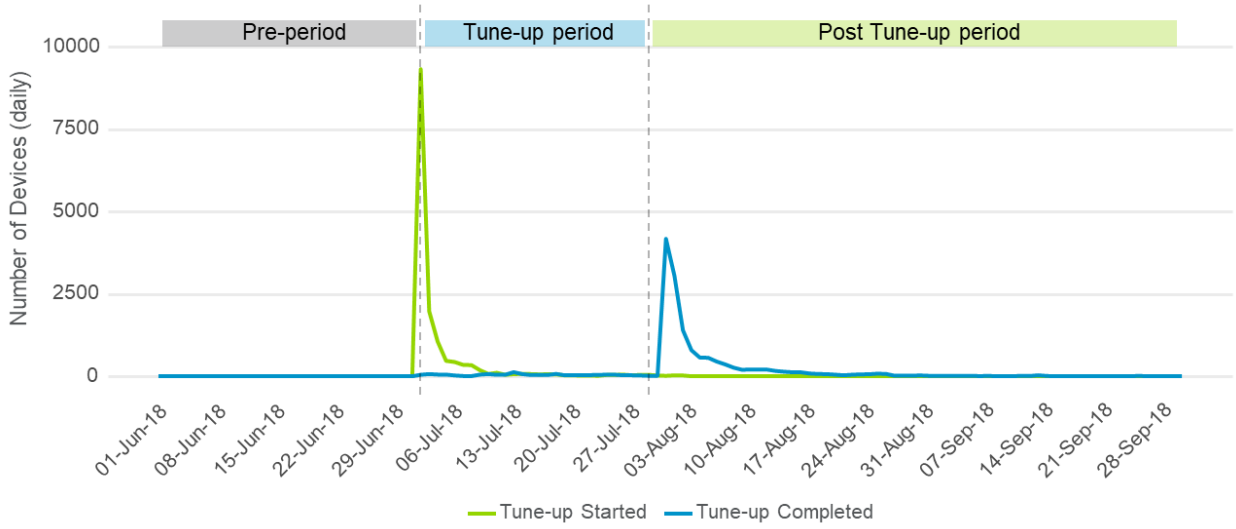
Figure 4-8. Number of Enrolled Thermostats: NGrid



Source: Navigant analysis of customer enrollment data

Figure 4-9 presents the enrollment information as a count of thermostats both starting and completing tune-up each day over the study period. The average time for the full SS algorithm to finish tune-up was approximately 31 days.

Figure 4-9. Number of Thermostats Starting and Completing Tune-Up: NGrid



Source: Navigant analysis of customer enrollment data

Table 4-8 tallies the counts of thermostats assigned to the control and ITT groups, as well as the number of thermostats that did not qualify or did/did not opt in. The randomization assigned 70% of thermostats to

the ITT group. Within the ITT, approximately 28% of those thermostats did not qualify and another 25% chose not to opt in to receive SS. The remaining 47% of ITT thermostats were enrolled into the SS thermostat optimization program.

Table 4-8. Implementation of SS: NGrid

Category	Number	Percentage
Nests in electric service area	**45,917**	**-**
Nests in control group	13,713	30% of total
Nests in ITT group	32,204	70% of total
Nests enrolled in SS (treated group)	15,186	47% of ITT
Nests not enrolled (untreated group)	17,018	53% of ITT
Nests that did not qualify	8,876	28% of ITT
Nests that did not opt in	8,142	25% of ITT

Source: Navigant analysis of customer enrollment data

4.2.1.1 Summer 2018 Weather

The average temperature in NGrid's service territory was above the 1981-2010 normal during June through September 2018. There was an average of 14 days when the high temperature reached 90°F after the first SS offer day. The average temperature and cooling degree days for 2018 are compared to the Massachusetts 1981-2010 normal in Table 4-9.

Table 4-9. Summer 2018 Weather: NGrid

Statistics		June	July	August	September
Average Temperature (°F)	2018	64.8	73.3	73.6	65.2
	1981-2010 normal	65.3	70.4	69.0	61.2
	Departure	-0.5	2.9	4.6	4.0
Cooling Degree Days (base 65°F)	2018	59	274	289	71
	1981-2010 normal	70	192	159	25
	Departure	-11	82	130	46

Source: Navigant analysis of Northeast Regional Climate Center data for Massachusetts

The average June temperature was 0.5°F below the 1981-2010 normal, before being above average in July, August, and September by 2.9°F, 4.6°F, and 4.0°F, respectively. The warmer than average summer is also seen when comparing the number of average cooling degree days in each month. Notably, August saw 289 cooling degree days, 130 more than the 1981-2010 normal.

4.2.2 Exploratory Analysis

This section presents the findings from the exploratory analysis of the thermostat telemetry data. Table 4-10 provides the average daily scheduled setpoint and average daily cooling runtime for the control, ITT, and treated and untreated subgroups. The exploratory analysis compares the scheduled cooling setpoints between the pre-period and post tune-up period for each group. The analysis found that the SS program made the intended adjustments to scheduled cooling setpoints.

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Table 4-10. Summary of Exploratory Analysis: NGrid

Period	Group	Pre	Post Tune-up	Δ†	SS Impact‡
Period Dates (2018)		Jun 1 – Jul 1	Jul 30 – Sep 30	–	**–**
Average Daily Outdoor Temp (°F)		67.35	70.98	3.63	**–**
Avg. Daily Scheduled Cooling Setpoints (°F)	Control	74.14	74.33	0.19	**–**
	ITT	74.23	74.78	0.56	**0.37**
	Treated	74.48	75.27	0.79	**0.59**
	Untreated	73.83	74.01	0.19	**–**

† 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 or treated group and the control group.

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

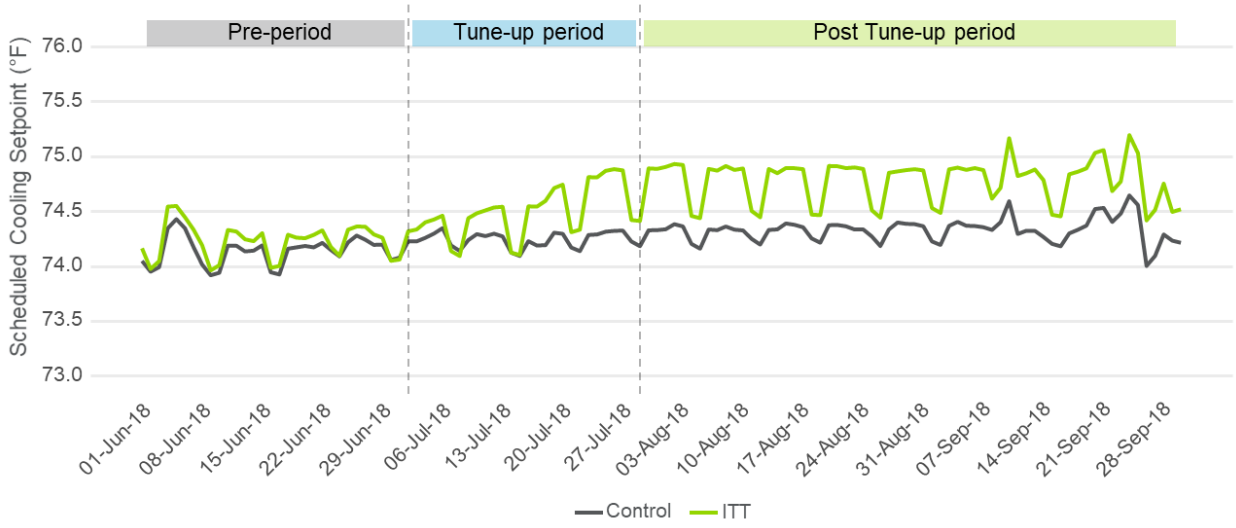
This section presents findings from the exploratory analysis of mean daily scheduled cooling setpoints, meant to demonstrate the SS algorithm's average effect on the thermostat population's schedules over time. Figure 4-10 and Figure 4-11 present the relative average daily scheduled cooling setpoints for the RED groups (ITT and control) and for the treatment subgroups (treated, untreated, and control), respectively. Figure 4-12 and Figure 4-13 present this information after the control group has been differenced out from the other group(s). In these figures, the control group is the basis for comparison and is thus represented by the x-axis.

- **Pre-period:** Average scheduled cooling setpoints during the pre-period were similar between the ITT and control groups, with a difference of only 0.09°F,[17] as shown in Figure 4-10 and Figure 4-12. Conversely, the treated and untreated groups had less comparable average daily scheduled cooling setpoints during the pre-period, with treated thermostats sitting at 0.65°F greater than their untreated counterparts. This difference is best seen in Figure 4-13. Due to different customer characteristics or preferences, it is normal to see differences between customers that opt in versus those that either did not qualify or did not enroll.
- **Post tune-up period:** The average scheduled cooling setpoints increased for both the ITT and control groups during the post tune-up period, but the increase was larger for the ITT group by 0.37°F. Figure 4-12 best demonstrates this as the difference between the average value for the green line in the pre-period versus the post tune-up period. Likewise, the treated and untreated subgroups saw increases during the post tune-up period as well, but the increase was largest for the treated group (0.59°F higher than the control group), as shown by their elevated schedule in Figure 4-11. These results provide evidence that the program had the intended effect on adjusting scheduled cooling setpoints.

Figure 4-10 shows average scheduled cooling setpoints across all days for both the ITT and control groups.

[17] This difference is not statistically significant.

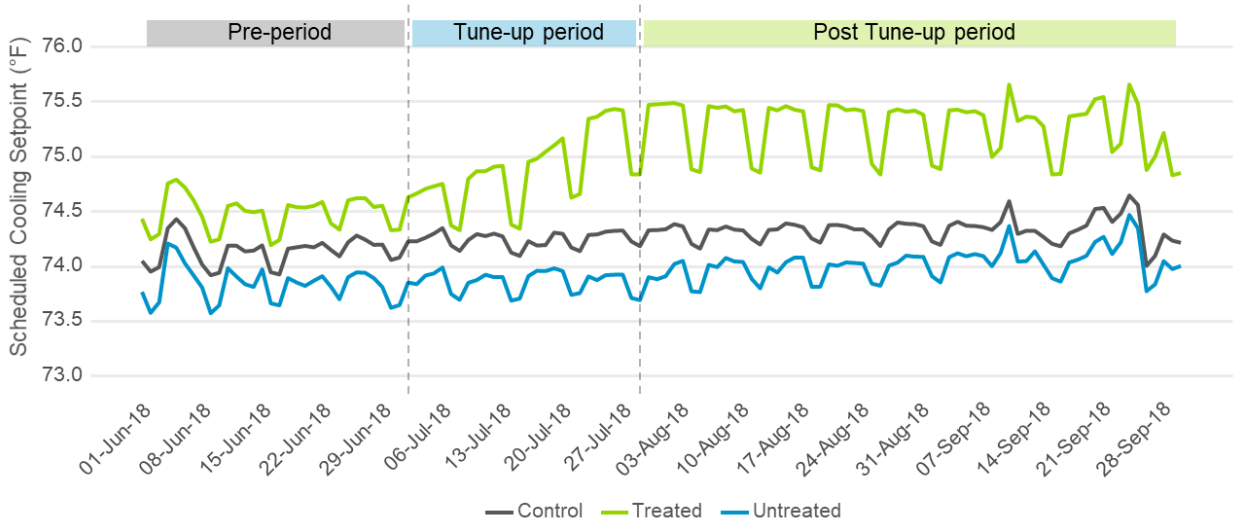
Figure 4-10. Average Daily Scheduled Cooling Setpoints: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-11 shows average scheduled cooling setpoints across all days for the ITT subgroups (treated and untreated) as well as for the control group.

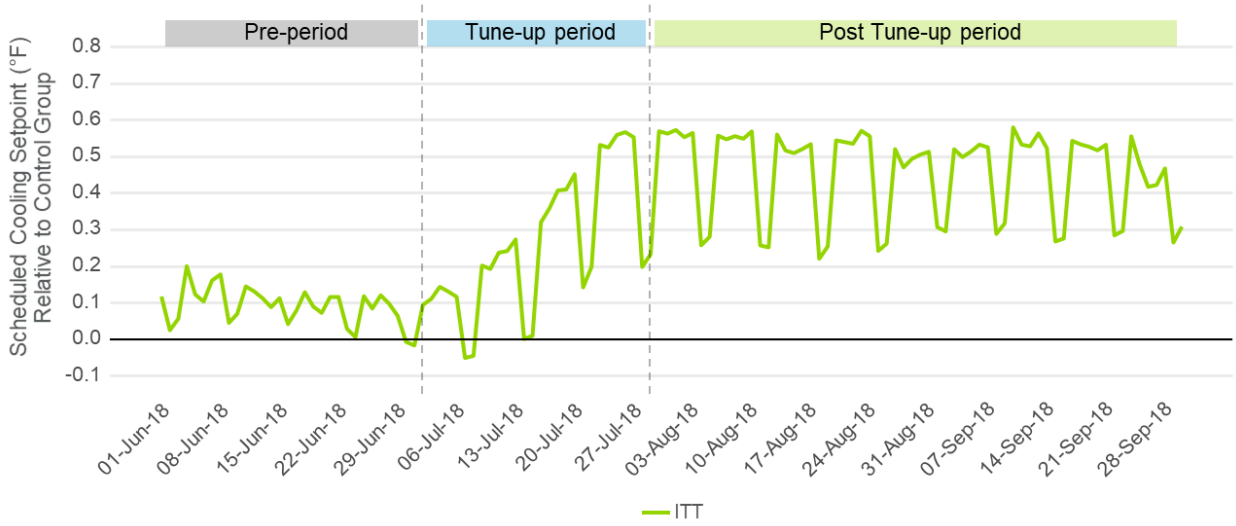
Figure 4-11. Average Daily Scheduled Cooling Setpoints, ITT Subgroups: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-12 shows average scheduled cooling setpoints across all days for the ITT group relative to the control group. This presents the same information as Figure 4-10 but instead shows the difference between those two groups.

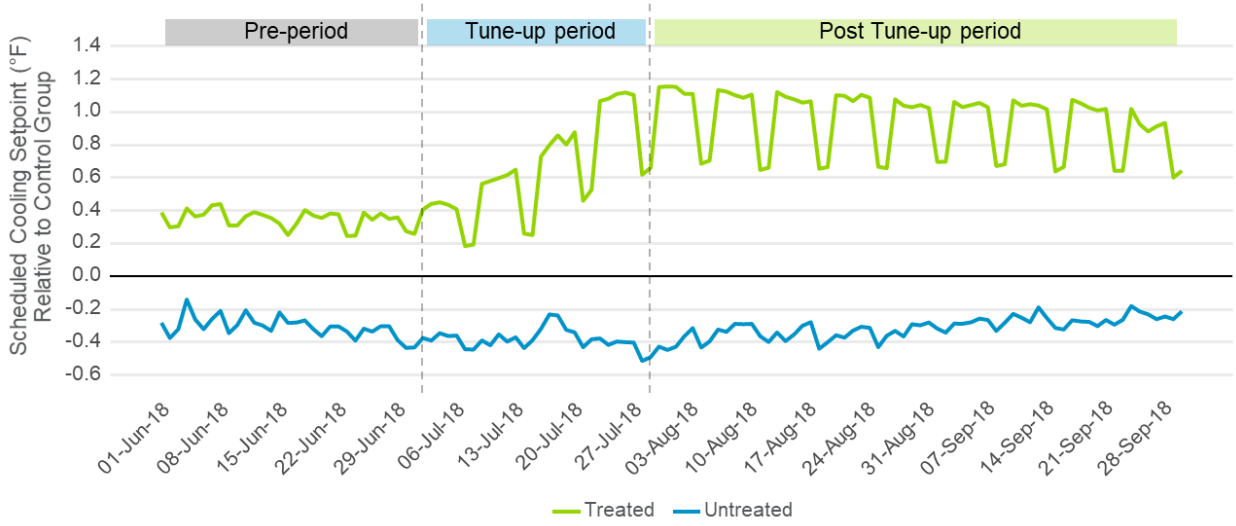
Figure 4-12. Average Daily Scheduled Cooling Setpoint Comparison: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-13 shows average scheduled cooling setpoints across all days for the ITT subgroups (treated and untreated) relative to the control group. This presents the same information as Figure 4-11 but instead shows the difference between the treated and control groups as well as between the untreated and control groups.

Figure 4-13. Average Daily Scheduled Cooling Setpoint Comparison, ITT Subgroups: NGrid

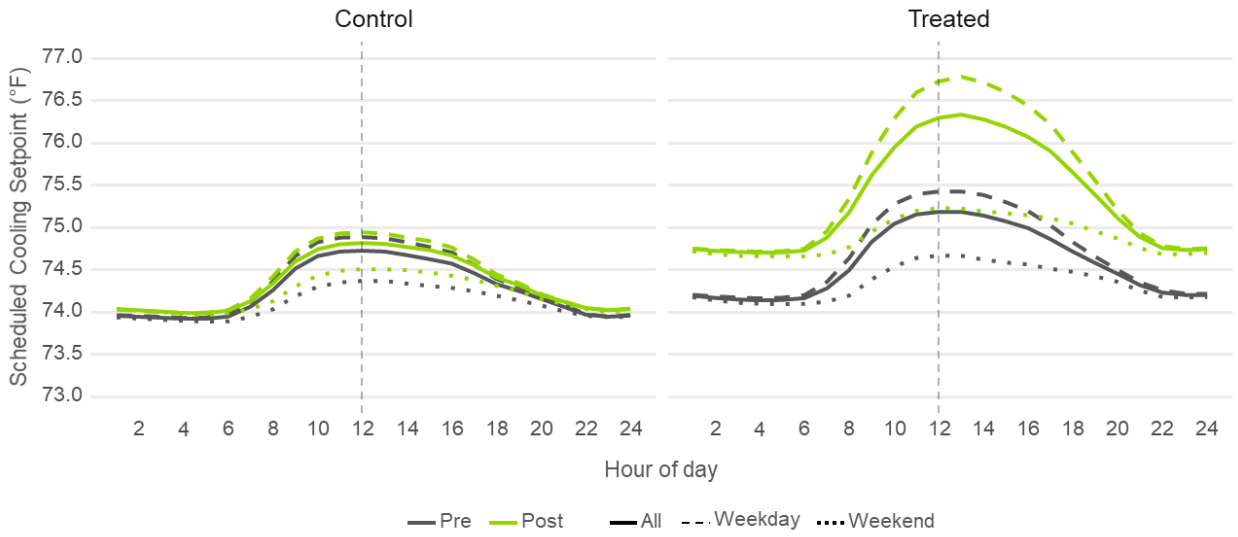


Source: Navigant analysis of Nest thermostat telemetry data

Figure 4-14 presents a comparison of average hourly scheduled cooling setpoints for all hours across two weeks (June 25-July 1 during the pre-period and August 11-17 during the post period) for both the treated and control groups. Values are separated by weekday and weekend, as well as an overall mean by the hour. The SS program is designed to make the largest adjustments during times when customers are away from home (e.g., weekday daytime hours) and smaller (or even downward) adjustments during times when customers are at home (e.g., weekday evenings, weekends). Based on the comparisons in

Figure 4-14 and the values in Table 4-11, this statement holds. Overall average scheduled cooling setpoints increased by 1.07°F between 10 a.m. and 6 p.m. and 0.62°F during all other hours during the post period week for the treated group, while the control group's overall average scheduled setpoints barely changed across all hours.

Figure 4-14. Average Hourly Scheduled Cooling Setpoints, Pre and Post SS†: NGrid



†Data shows hourly mean setpoint averages for two distinct weeks during the study: the week before SS began—pre (June 25-July 1), and one week in the middle of SS deployment after the tune-up period—post (August 11-17)

Source: Navigant analysis of Nest thermostat telemetry data

Table 4-11 details a breakdown of differences by day type and time of day by and between the control and treated groups.

Table 4-11. Change in Scheduled Cooling Setpoints, Before and After Tune-Up†: NGrid

Day Type	Period	Treated Difference	Control Difference	Δ‡
Weekday	10 a.m.-6 p.m.	1.25°F	0.06°F	1.19°F
	Other Hours	0.64°F	0.05°F	0.59°F
Weekend	10 a.m.-6 p.m.	0.57°F	0.13°F	0.44°F
	Other Hours	0.54°F	0.08°F	0.46°F
Overall	**10 a.m.-6 p.m.**	**1.07°F**	**0.09°F**	**0.98°F**
	Other Hours	**0.62°F**	**0.06°F**	**0.55°F**

† Data shows hourly mean setpoint averages for two distinct weeks during the study: the week before SS began, "pre" (June 25–July 1), and one week in the middle of SS deployment after the tune-up period, "post" (August 11-17)

‡ Treated difference minus Control difference

Source: Navigant analysis of Nest thermostat telemetry data

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4.2.3 Impact Analysis

This section presents the findings from the energy and peak demand impact analyses, summarized in Table 4-12 (energy) and Table 4-6 (demand). Table 4-14 then presents the realization rates for the summer energy and demand savings estimates.

The SS program resulted in total energy savings of 464 MWh from July 2, 2018 through September 30, 2018. Average daily energy savings were estimated to be 0.35 kWh[18] per treated thermostat, or approximately 3.0% of the cooling load for treated thermostats post program launch. Table 4-12 presents these values as well as a breakdown of savings during on-peak hours, off-peak hours, the tune-up period, and the post tune-up period.

Table 4-12. PY2018 SS Summer Energy Savings Summary: NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	13,713
Number of Nest thermostats in ITT group	32,204
Number of Nest thermostats in treated group †	**15,186**
Summer (Jul 2 – Sep 30) ‡	
Average daily energy savings per thermostat (kWh)	0.35 ± 0.13
Average energy savings (% of cooling load)	3.0% ± 1.2%
Average total energy savings per thermostat (kWh)	30.6 ± 11.7
Total energy savings (MWh)	464
Summer (Jul 2 – Sep 30) On-Peak §	
Average daily energy savings per thermostat (kWh)	0.41 ± 0.12
Average energy savings (% of cooling load)	4.1% ± 1.2%
Average total energy savings per thermostat (kWh)	24.6 ± 7.5
Total energy savings (MWh)	373
Summer (Jul 2 – Sep 30) Off-Peak ††	
Average daily energy savings per thermostat (kWh)	0.07 ± 0.07
Average energy savings (% of cooling load)	1.4% ± 1.5%
Average total energy savings per thermostat (kWh)	5.8 ± 6.0
Total energy savings (MWh)	88
Tune-Up Period (Jul 2 – Jul 29)	
Average daily energy savings per thermostat (kWh)	0.37 ± 0.19
Average energy savings (% of cooling load)	2.5% ± 1.3%
Average total energy savings per thermostat (kWh)	10.1 ± 5.3
Total energy savings (MWh)	154
Post Tune-Up Period (Jul 30 – Sep 30)	
Average daily energy savings per thermostat (kWh)	0.33 ± 0.13
Average energy savings (% of cooling load)	3.3% ± 1.3%
Average total energy savings per thermostat (kWh)	20.0 ± 8.0
Total energy savings (MWh)	303

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 15,164.

[18] The 90% confidence interval is (0.21 kWh, 0.49 kWh).

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ 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.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Navigant also estimated peak demand impacts from 1 p.m. to 5 p.m. on program period non-holiday weekdays through August. The SS program resulted in total peak demand savings of 903 kW between July 2, 2018 and August 31, 2018. Average demand savings were estimated to be about 60 W[19] per treated thermostat, or approximately 6.4% of the cooling load for treated thermostats, post program launch.

Table 4-13. PY2018 SS Summer Demand Savings Summary: NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	13,713
Number of Nest thermostats in ITT group	32,204
Number of Nest thermostats in treated group †	**15,186**
Summer (Jul 2 – Aug 31) ‡	
Average demand savings per thermostat (W)	60 ± 15
Average demand savings (% of cooling load)	6.4% ± 1.6%
Total average demand savings (kW) §	903
Adjusted Summer (Jun 1 – Aug 31) ††	
Average demand savings per thermostat (W)	40 ± 10
Average demand savings (% of cooling load)	4.2% ± 1.1%
Total average demand savings (kW) §	599

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 15,164.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The demand impact evaluation relies on data through August 31, 2018.

§ Total average demand savings is calculated as total average savings per ITT thermostat × the ITT thermostat count.

†† Adjusted Summer values are summer values adapted to be from June 1 through August 31, 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Table 4-14. Realization Rates: NGrid

Estimation	Navigant	Nest	Realization Rate§
Average total energy savings per thermostat (kWh)	31	27	115%
Total energy savings (MWh)	464	405	115%
Average demand savings per thermostat (W)	60	59	102%
Average total demand savings (kW)	903	882	102%

§ Estimated savings are different between Navigant and Nest due to differences in the devices included in each analysis.

Source: Navigant analysis, Nest savings estimates

[19] The 90% confidence interval is (44.7 W, 74.4 W).

4.3 Cape Light Compact and National Grid 2018 Program Year

Section 4.3 presents Navigant's program year 2018 evaluation of SS program for both CLC and NGrid. This section does not include an exploratory analysis on scheduled cooling setpoints and is for reporting the joint impact analysis.

- Section 4.3.1: Impact Analysis

4.3.1 Impact Analysis

This section presents the findings from the energy and peak demand impact analyses, summarized in Table 4-15 (energy) and Table 4-16 (demand). Table 4-17 then presents the realization rates for the summer energy and demand savings estimates.

The SS program resulted in total energy savings of 508 MWh from July 2, 2018 through September 30, 2018. Average daily energy savings were estimated to be 0.35 kWh[20] per treated thermostat, or approximately 3.0% of the cooling load for treated thermostats post program launch. Table 4-15 presents these values as well as a breakdown of savings during on-peak hours, off-peak hours, the tune-up period, and the post tune-up period.

[20] The 90% confidence interval is (0.22 kWh, 0.48 kWh).

Table 4-15. PY2018 SS Summer Energy Savings Summary: CLC & NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	15,416
Number of Nest thermostats in ITT group	36,152
Number of Nest thermostats in treated group †	**16,667**
Summer (Jul 2 – Sep 30) ‡	
Average daily energy savings per thermostat (kWh)	0.35 ± 0.13
Average energy savings (% of cooling load)	3.0% ± 1.2%
Average total energy savings per thermostat (kWh)	30.5 ± 11.7
Total energy savings (MWh)	508
Summer (Jul 2 – Sep 30) On-Peak §	
Average daily energy savings per thermostat (kWh)	0.39 ± 0.12
Average energy savings (% of cooling load)	4.0% ± 1.2%
Average total energy savings per thermostat (kWh)	23.7 ± 7.4
Total energy savings (MWh)	395
Summer (Jul 2 – Sep 30) Off-Peak ††	
Average daily energy savings per thermostat (kWh)	0.08 ± 0.07
Average energy savings (% of cooling load)	1.7% ± 1.5%
Average total energy savings per thermostat (kWh)	6.8 ± 5.9
Total energy savings (MWh)	113
Tune-Up Period (Jul 2 – Jul 29)	
Average daily energy savings per thermostat (kWh)	0.38 ± 0.19
Average energy savings (% of cooling load)	2.6% ± 1.3%
Average total energy savings per thermostat (kWh)	10.3 ± 5.2
Total energy savings (MWh)	172
Post Tune-Up Period (Jul 30 – Sep 30)	
Average daily energy savings per thermostat (kWh)	0.34 ± 0.13
Average energy savings (% of cooling load)	3.3% ± 1.3%
Average total energy savings per thermostat (kWh)	20.2 ± 8.0
Total energy savings (MWh)	337

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 16,645.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ 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.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Navigant also estimated peak demand impacts from 1 p.m. to 5 p.m. on program period non-holiday weekdays through August. The SS program resulted in total peak demand savings of 947 kW between July 2, 2018 and August 31, 2018. Average demand savings were estimated to be about 57 W[21] per treated thermostat, or approximately 6.1% of the cooling load for treated thermostats, post program launch.

[21] The 90% confidence interval is (42.3 W, 71.5 W).

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Table 4-16. PY2018 SS Summer Demand Savings Summary: CLC & NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	15,416
Number of Nest thermostats in ITT group	36,152
Number of Nest thermostats in treated group †	**16,667**
Summer (Jul 2 – Aug 31) ‡	
Average demand savings per thermostat (W)	57 ± 15
Average demand savings (% of cooling load)	6.1% ± 1.6%
Total average demand savings (kW) §	947
Adjusted Summer (Jun 1 – Aug 31) ††	
Average demand savings per thermostat (W)	38 ± 10
Average demand savings (% of cooling load)	4.0% ± 1.0%
Total average demand savings (kW) §	628

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 16,645.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ Total average demand savings is calculated as total average savings per ITT thermostat × the ITT thermostat count.

†† Adjusted Summer values are summer values adapted to be from June 1 through August 31, 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Table 4-17. Realization Rates: CLC & NGrid

Estimation	Navigant	Nest	Realization Rate§
Average total energy savings per thermostat (kWh)	31	27	115%
Total energy savings (MWh)	508	448	113%
Average demand savings per thermostat (W)	57	50	114%
Average total demand savings (kW)	947	824	115%

§ Estimated savings are different between Navigant and Nest due to differences in the devices included in each analysis.

Source: Navigant analysis, Nest savings estimates

4.4 National Grid Additional Setpoint Analyses

Because NGrid was in its second year of deployment, Navigant was able to investigate additional research questions. The research questions for this supplemental exploratory analysis are outlined in Table 4-18.

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Table 4-18. NGrid-Specific Research Questions

Research Area	Question
2017 Cohort in 2018	How has the ITT group evolved from PY2017 to PY2018?
Two Program Years	What are the scheduled cooling setpoint adjustments in PY2018 for customers that participated in two program years? How have the adjustments changed during the first year (PY2017) compared to the second year (PY2018)?
Persistence	Have scheduled cooling setpoint adjustments from customers that participated in 2017 continued in 2018?
2017 Cohort vs. 2018 Cohort	How are scheduled cooling setpoint adjustments different for the 2018 cohort in 2018 compared to the 2017 cohort in 2018?
First Program Year	How do the first-year scheduled cooling setpoint adjustments of the 2018 cohort compare to the adjustments of the 2017 cohort in 2017?

4.4.1 Program Enrollment

Table 4-19 presents a summary of thermostat enrollment in PY2018, differentiating by cohort (based the first year of deployment). Thermostats in the 2017 cohort took part in the previous 2017 SS study (original thermostats), while thermostats in the 2018 cohort were new to the 2018 SS study (new thermostats).

Table 4-19. Number of Enrolled Thermostats by Cohort: NGrid

	PY2017	PY2018		
	2017 Cohort	2017 Cohort	2018 Cohort	All Thermostats
Control	6,742	5,924	7,789	13,713
ITT	15,708	13,962	18,242	32,204
Treated	8,336	6,576	8,610	15,186
Untreated	7,372	7,386	9,632	17,018
Did not opt in	3,310	3,712	4,430	8,142
Did not qualify	4,062	3,674	5,202	8,876
Total	**22,450**	**19,886**	**26,031**	**45,917**

Source: Navigant analysis of Nest thermostat telemetry data

A reported 19,886 of the 22,450 thermostats from the PY2017 SS study (89%) also took part in the PY2018 study.

Table 4-20 shows the breakdown of how the ITT group composition changed between years for the thermostats from the 2017 cohort that were also a part of the 2018 study. It looks at all possible combinations of treatment status, including a breakdown of untreated thermostats by qualification status.

Among the treated thermostats, 65% (4,841) re-qualified and choose to opt in to the SS program again in 2018. As for the untreated thermostats, 77% (2,618) of those that did not qualify in 2017 also did not qualify in 2018, and 48% (1,501) of thermostats that previously did not opt in in 2017 also did not in 2018. Additionally, 40% (1,248) of thermostats that did not opt in in 2017 re-qualified and decided to opt in during PY2018.

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Table 4-20. Opt-In Status Composition for 2017 Cohort across PY2017 and PY2018: NGrid

PY2017 Status		PY2018 Status			
		Treated	Untreated		Control
			Did Not Opt In	Did Not Qualify	
Treated		**4,841**	1,918	697	0
Untreated	Did Not Opt In	1,248	**1,501**	353	0
	Did Not Qualify	484	291	**2,618**	0
Control		3	2	3	**5,924**

Source: Navigant analysis of Nest thermostat enrollment data

4.4.2 Setpoint Analysis

This section presents the findings from the setpoint analysis of the thermostat telemetry data for the additional NGrid analyses.

4.4.2.1 2017 Cohort in 2018

This section explores how the ITT group has evolved from PY2017 to PY2018.

Figure 4-15 shows how the scheduled cooling setpoints for each of the four ITT combination groups in the original cohort compare to the two-year control group.

- **Pre-period:** The group that was treated in both PY2017 and PY2018 had the highest average scheduled cooling setpoints compared to the control group before the SS program began in 2018. Notably, it is higher than the group that only received treatment in PY2017 by 0.65°F compared to the control group. Conversely, ITT thermostats that remained untreated in both years had the lowest relative setpoint schedule during this period.
- **Post tune-up period:** The average scheduled cooling setpoints increased by roughly the same amount for the two subgroups that received treatment. Thermostats receiving treatment for the first year in 2018 and the second year in 2018 increased by 0.58°F and 0.56°F, respectively, compared to the controls. Thus, thermostats treated for 2 years had the largest scheduled cooling setpoints in the post tune-up period out of all subgroups. Scheduled cooling setpoints did not change between the pre- and post tune-up periods for the group that received treatment in PY2017 but not PY2018, resulting in a relative change of -0.17°F compared to the controls.

Based on the 2018 cooling setpoint schedules for thermostats treated two years in a row, it can be assumed that there is some level of persistence between program years for SS. Persistence is further explored in Section 4.4.2.3.

Figure 4-15 shows how all four ITT subgroup combinations from the PY2017 cohort compared to the control group in the 2018 season.

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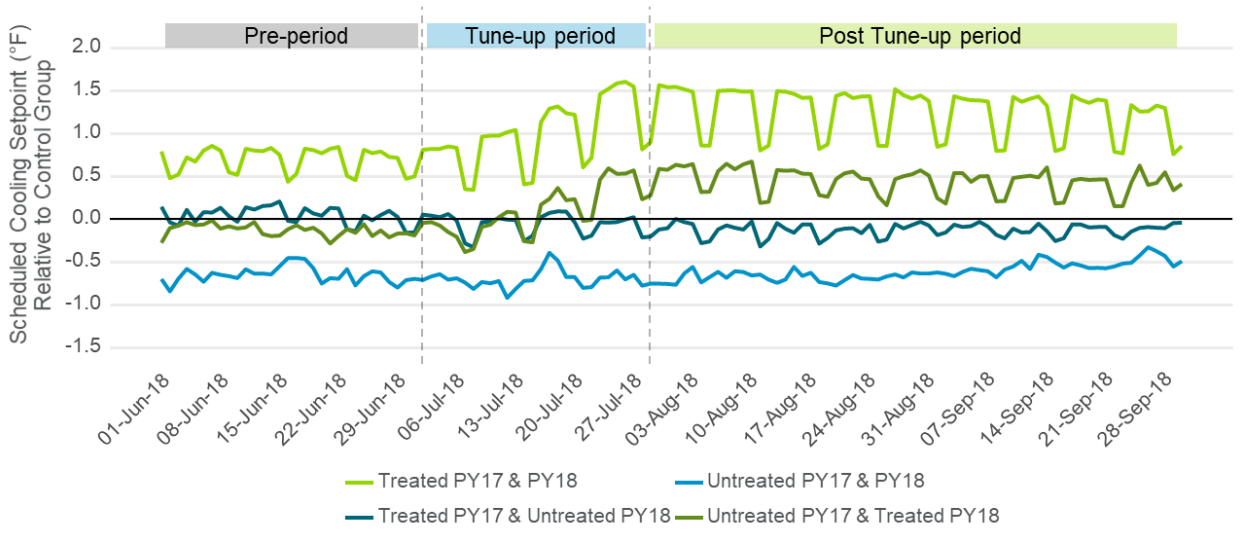
Figure 4-15. 2018 Scheduled Cooling Setpoint Comparison, All PY2017 Cohort Groups: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Table 4-21. Exploratory Analysis of 2017 Cohort: NGrid

Period	Group	Pre	Post Tune-Up	Δ†	SS Impact‡
Average Daily Outdoor Temp (°F)		67.39	71.04	3.65	–
Avg. Daily Scheduled Cooling Setpoints (°F)	**Control PY17 & PY18**	74.44	74.60	0.16	–
	Treated PY17 & PY18	75.13	75.86	0.73	**0.56**
	Treated PY17 & Untreated PY18	74.48	74.47	0.00	-0.17
	Untreated PY17 & Treated PY18	74.30	75.05	0.75	**0.58**
	Untreated PY17 & PY18	73.79	73.99	0.20	–

† The Δ is the difference between post tune-up and the pre-period.
‡ The SS impact is the difference between the Δ for the ITT or treated group and the control group.
Source: Navigant analysis of Nest thermostat telemetry data and NOAA temperature data

4.4.2.2 Two Program Years

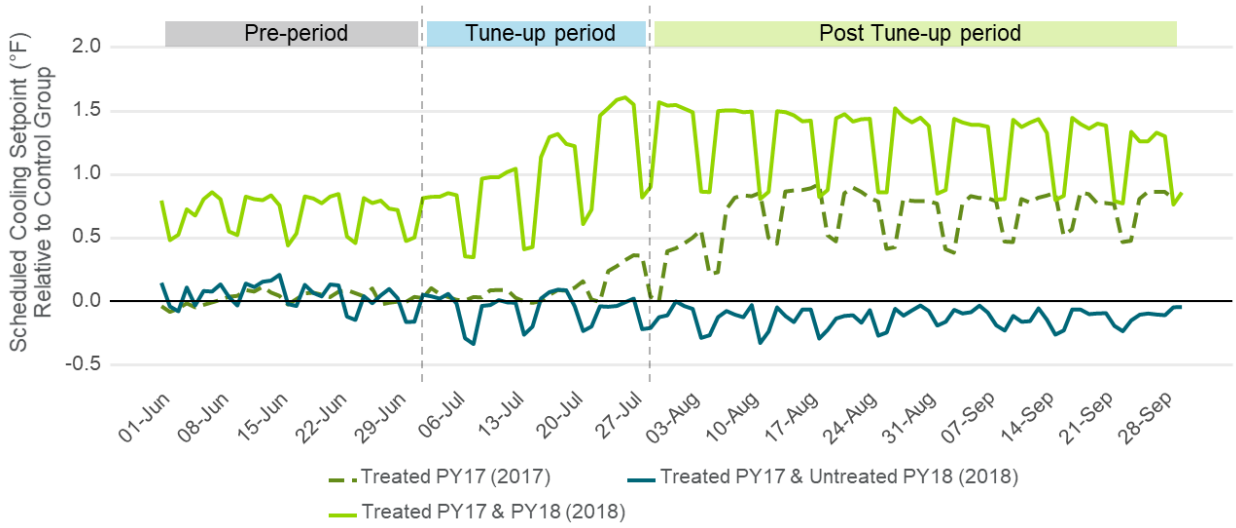
This section explores the scheduled cooling setpoint adjustments in PY2018 for customers that participated in two program years and how those setpoint adjustments changed during the first year (PY2017) compared to the second year (PY2018).

Figure 4-16 shows how the scheduled cooling setpoints for the group that was treated in 2017 compare between 2017 and 2018. In the 2018 study, this includes thermostats that were treated both years (light

green line) and thermostats that were treated only during the first year (dark blue line). The dashed dark green line represents the scheduled cooling setpoints for the treated thermostats from the 2017 summer.

- **Pre-period:** Before SS deployment, the cooling setpoint schedules in 2018 for thermostats that enrolled only in 2017 are comparable to the 2017 schedules for enrolled thermostats relative to the control group (dark blue line compared to dashed dark green line), indicating a lack of persistence into 2018. Conversely, the group that was treated both years had an average cooling setpoint schedule in 2018 during the pre-period that was greater than the 2017 pre-period average for treated thermostats compared to their control groups (difference between light green line and dashed dark green line).
- **Post tune-up period:** The second year of the summer SS program resulted in an increase in scheduled cooling setpoints of 0.56°F during the post tune-up period for thermostats that were treated in two consecutive years compared to the control group. This increase occurred on top of any adjustments from the 2017 summer that persisted into the 2018 summer. In comparison, the 2017 impact was approximately 0.70°F.

Figure 4-16. Average Daily Scheduled Cooling Setpoint Comparison: Two Program Years: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Based on the 2018 cooling setpoint schedules for thermostats treated 2 years in a row, it can be assumed that there is some level of persistence between program years for the SS program. This will be discussed further in the next section.

4.4.2.3 Persistence

This section explores whether setpoint adjustments from customers that participated in 2017 continued in 2018.

Figure 4-17 shows how the scheduled cooling setpoints for the PY2017 Treated and Untreated groups in 2017 compared to the 2018 season, relative to the control groups.

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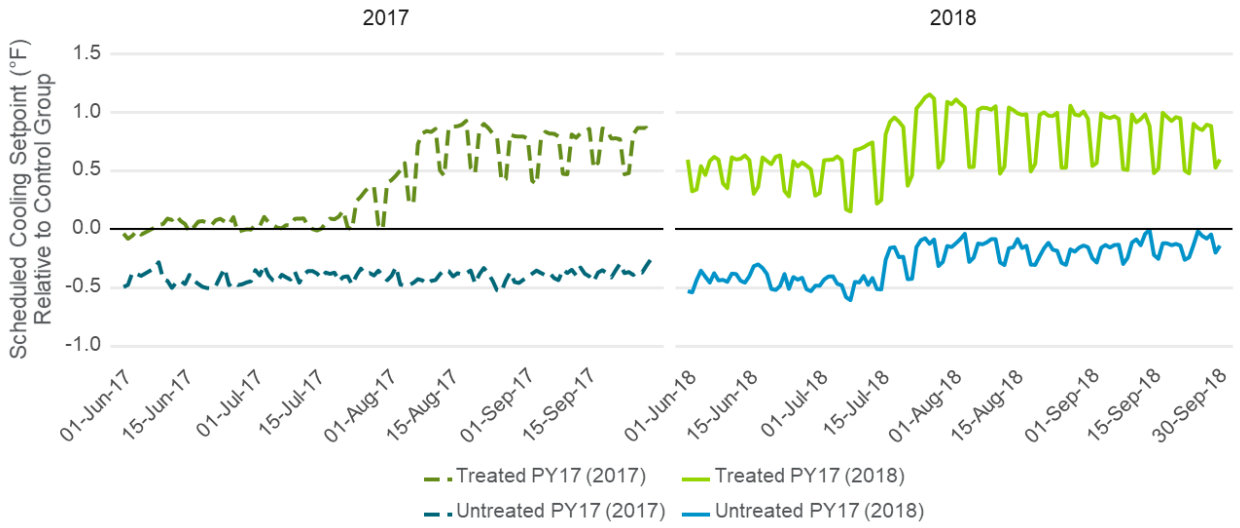
- **Pre-program period:** Compared to 2017, the 2018 average cooling setpoint schedule differences for the treated group were noticeably larger compared to each year's respective controls. When values from the 2018 pre-period are compared to data at the end of the 2017 season, there is only a slight drop-off for the PY2017 treated group's values from September 2017 to June 2018; this indicates evidence of schedule persistence (as shown in Figure 4-17). The persistence estimate is an approximately 0.53°F increase in average scheduled cooling setpoint. For comparison, in 2017, Navigant reported the estimated average SS impact to be an increase of 0.70°F between the pre- and post tune-up periods.

Figure 4-17. Scheduled Cooling Setpoint Comparison, PY2017 ITT Subgroups in Two Years: NGrid



Note: Data shown for PY2017 ITT subgroups with calendar year in parentheses. For the 2018 data, the Treated PY17 subgroup includes thermostats treated in both years or only the first year. Similarly, the Untreated PY17 subgroup includes both thermostats treated only in the second year and thermostats that never enrolled across the two program years.

Source: Navigant analysis of Nest thermostat telemetry data

A comparison between program years in broken down in Table 4-22. Based on the 2018 cooling setpoint schedules for thermostats treated 2 years in a row, it can be assumed that there is some level of persistence between program years for SS.

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Table 4-22. 2017 Cohort Setpoint Persistence: NGrid

	Group	2017 Pre-Period	2017 Post Tune-Up	2017 SS Impact	2018 Pre-Period	2017-2018 Pre-Period Δ	2018 SS Persistence
Period		Jun 1 – Jul 1, 2017	Aug 25– Sep 30, 2017	-	Jun 1 – Jul 1, 2018	-	-
Average Daily Outdoor Temp (°F)		70.26	66.06	-	67.39	-2.87	-
Avg. Daily Scheduled Cooling Setpoints (°F)	**PY2017 Control**	74.55	74.85	-	74.44	-0.11	-
	PY2017 Treated	74.51	75.51	**0.70**	74.93	0.42	**0.53**

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

4.4.2.4 2017 vs. 2018 Cohort

This section explores whether setpoint adjustments are different for the 2018 cohort in PY2018 compared to the 2017 cohort in PY2018.

Figure 4-18 shows how the scheduled cooling setpoints for the PY2018 cohort treated group (blue line) compared to the PY2017 cohort treated group that was also treated in 2018 (green line).

- **Pre-program period:** The group that was treated in both PY2017 and PY2018 had the higher average scheduled cooling setpoints compared to the control group before the SS program began in 2018 by 0.45°F; this is likely due to persistence of the SS adjustment from the first program year.
- **Post tune-up period:** The average scheduled cooling setpoint in 2018 was 0.69°F greater for the 2017 cohort compared to the 2018 cohort during the post-tune-up period. However, the impact of the SS program during 2018 was estimated to be 0.56°F and 0.62°F for the 2017 two-year treated and 2018 treated cohorts, respectively.

The average scheduled cooling setpoint during the post-tune-up period was greater for the thermostats that received 2 years of SS compared to new thermostats that opted in during PY2018. However, the impact of SS on setpoint schedules in 2018 was comparable for both groups, differing only by a few hundredths of a degree. Additionally, cooling setpoint schedule differences between weekdays and weekends were more pronounced for the groups treated two years in a row (seen as the difference between peak and trough in Figure 4-18).

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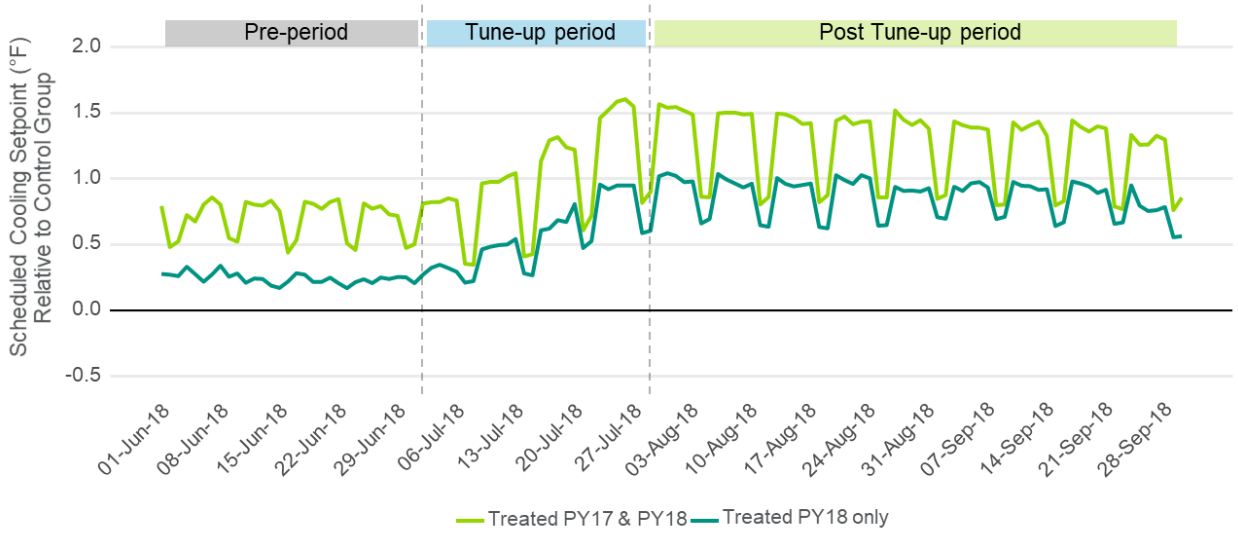
Figure 4-18. Setpoint Schedule Comparison, 2017 Cohort vs 2018 Cohort in 2018: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Table 4-23 compares the seasonal savings impacts of the 2017 and 2018 cohorts in PY2018. The impact for the 2017 cohort is slightly lower than that of the 2018 cohort.

Table 4-23. 2017 vs. 2018 Cohort Setpoint Comparison: NGrid

	Cohort	Group	Pre	Post Tune-Up	PY18 Δ†	PY18 SS Impact‡
Period Dates (2018)			Jun 1 – Jul 1	Jul 30 – Sep 30	-	-
Average Daily Outdoor Temp (°F)			67.39	71.04	3.65	-
Average Daily Scheduled Cooling Setpoints (°F)	**2017**	**Control PY17 & PY18**	74.44	74.60	0.16	-
		Treated PY17 & PY18	75.13	75.66	0.73	**0.56**
Average Daily Outdoor Temp (°F)			67.31	70.94	3.62	-
Average Daily Scheduled Cooling Setpoints (°F)	**2018**	**Control PY18 only**	73.90	74.11	0.21	-
		Treated PY18 only	74.14	74.97	0.83	**0.62**

† The Δ is the difference between post tune-up and the pre-period.
‡ The SS impact is the difference between the Δ for the ITT or treated group and the control group.
Source: Navigant analysis of Nest thermostat telemetry data and NOAA temperature data

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4.4.2.5 First Year of Program

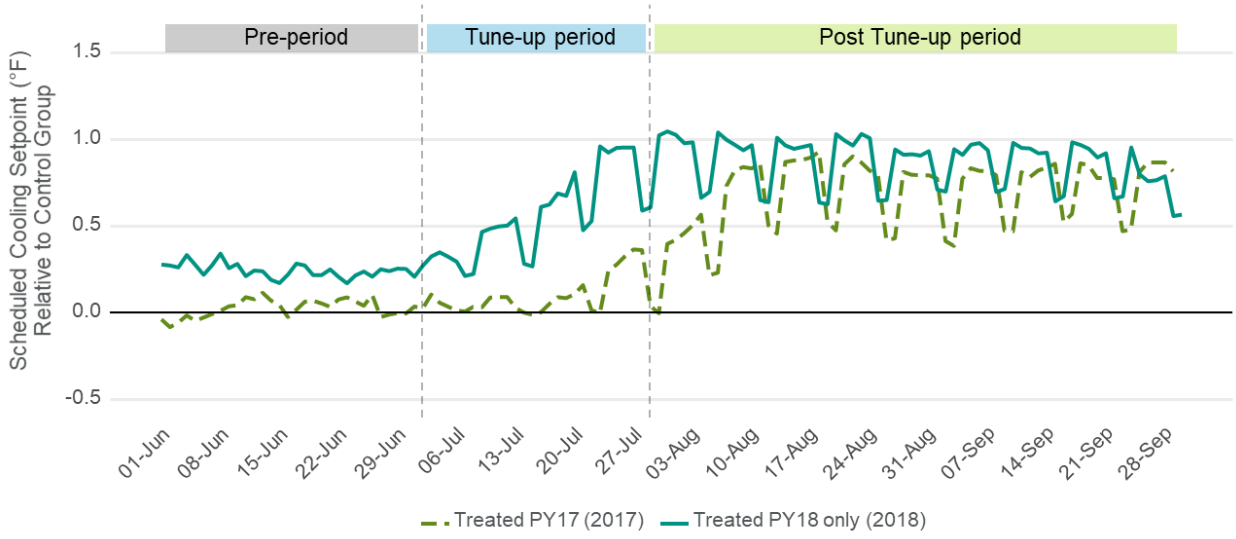
This section explores how the first-year setpoint adjustments of the 2018 cohort in PY2018 compare to the adjustments of the 2017 cohort in PY2017.

Figure 4-19 shows how the scheduled cooling setpoints for the 2018 cohort treated group in PY2018 (blue line) compared to the 2017 cohort treated group in PY2017 (green line).

- **Pre-program period:** The 2018 cohort had higher average scheduled cooling setpoints relative to the control group before the SS program began in PY2018 by 0.24°F. The 2017 cohort had lower average scheduled cooling setpoints relative to the control group before SS began in PY2017 by 0.04°F.
- **Post tune-up period:** The average scheduled cooling setpoint in 2018 was 0.1°F greater for the 2018 cohort compared to the 2017 cohort during their respective first year post tune-up periods. However, the effect of the SS program for the 2017 cohort was estimated to be 0.70°F in its first year (PY2017), while the SS effect for the 2018 cohort in its first year was 0.62°F.

The average scheduled cooling setpoint increase for the 2017 cohort in its first year relative to the 2018 cohort was greater by 0.08°F. This larger adjustment, although small, could be the result of differences between the cohorts in their first year of deployment. First, the 2018 cohort primarily consists of newly installed thermostats while the 2017 cohort contains thermostats installed since the Nest thermostat was first released. Second, 2018 had a much warmer summer than 2017. This difference in temperature could have led to customers in the 2018 cohort overriding the adjusted setpoints more frequently in PY2018 than customers in the 2017 cohort in PY2017.

Figure 4-19. Setpoint Schedule Comparison, First Year of Treatment: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Table 4-24 compares the first-year seasonal savings impacts 2018 cohort in PY2018 to the 2017 cohort in PY2017. The impact for the 2017 cohort in its first year is almost a tenth of a degree higher than the 2018 cohort in its first year.

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Table 4-24. Exploratory Analysis of 2017 and 2018 Cohorts, First Year of Treatment: NGrid

Period	Cohort	Group	Pre	Post Tune-up	Δ†	SS Impact‡
Period Dates			Jun 1 – Jul 1, 2018	Jul 30 – Sep 30, 2018	–	**–**
Average Daily Outdoor Temp (°F)			67.31	72.13	4.82	**–**
Average Daily Scheduled Cooling Setpoints (°F)	**2018**	**PY18 Control**	73.90	74.11	0.21	-
		PY18 Treated	74.14	74.97	0.83	**0.62**
Period Dates			Jun 1 – Jul 17, 2017	Aug 25 – Sep 30, 2017	–	**–**
Average Daily Outdoor Temp (°F)			70.30	66.12	-4.18	**–**
Average Daily Scheduled Cooling Setpoints (°F)	**2017**	**PY17 Control**	74.55	74.85	0.30	**–**
		PY17 Treated	74.51	75.51	1.00	**0.70**

† The Δ is the difference between post tune-up and the pre-period.
‡ The SS impact is the difference between the Δ for the ITT or treated group and the control group.
Source: Navigant analysis of Nest thermostat telemetry data and NOAA temperature data

4.4.3 Impact Analysis

This section presents the findings from the energy and peak demand impact analyses for the 2017 and 2018 cohorts during the 2018 summer season.

4.4.3.1 2017 Thermostat Cohort

This section presents the findings from the energy and peak demand impact analyses for original PY2017 NGrid thermostats, summarized in Table 4-25 (energy) and Table 4-26 (demand).

For the 2017 NGrid thermostat cohort, the SS program resulted in total energy savings of 228 MWh from July 2, 2018 through September 30, 2018. Average daily energy savings were estimated to be 0.40 kWh[22] per treated thermostat, or approximately 3.5% of the cooling load for these thermostats post program launch. Table 4-25 presents these values as well as a breakdown of savings during on-peak hours, off-peak hours, the tune-up period, and the post tune-up period.

[22] The 90% confidence interval is (0.20 kWh, 0.60 kWh).

Table 4-25. PY2018 SS Energy Summary, 2017 Cohort: NGrid

Statistic	Treated Thermostats Savings
Number of Nest thermostats in control group	5,924
Number of Nest thermostats in ITT group	13,962
Number of Nest thermostats in treated group †	**6,576**
Summer (Jul 2 – Sep 30) ‡	
Average daily energy savings per thermostat (kWh)	0.40 ± 0.20
Average energy savings (% of cooling load)	3.5% ± 1.7%
Average total energy savings per thermostat (kWh)	34.7 ± 17.3
Total energy savings (MWh)	228
Summer (Jul 2 – Sep 30) On-Peak §	
Average daily energy savings per thermostat (kWh)	0.48 ± 0.19
Average energy savings (% of cooling load)	4.8% ± 1.9%
Average total energy savings per thermostat (kWh)	29.0 ± 11.3
Total energy savings (MWh)	190
Summer (Jul 2 – Sep 30) Off-Peak ††	
Average daily energy savings per thermostat (kWh)	0.07 ± 0.10
Average energy savings (% of cooling load)	1.4% ± 2.2%
Average total energy savings per thermostat (kWh)	5.8 ± 8.7
Total energy savings (MWh)	38
Tune-Up Period (Jul 2 – Jul 29)	
Average daily energy savings per thermostat (kWh)	0.47 ± 0.30
Average energy savings (% of cooling load)	3.2% ± 2.0%
Average total energy savings per thermostat (kWh)	12.7 ± 7.9
Total energy savings (MWh)	84
Post Tune-Up Period (Jul 30 – Sep 30)	
Average daily energy savings per thermostat (kWh)	0.36 ± 0.20
Average energy savings (% of cooling load)	3.6% ± 2.0%
Average total energy savings per thermostat (kWh)	21.9 ± 11.7
Total energy savings (MWh)	143

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 6,559.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ 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.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Navigant also estimated peak demand impacts from 1 p.m. to 5 p.m. on program period non-holiday weekdays through August. The SS program for the 2017 cohort resulted in average peak demand savings of 464 kW between July 2, 2018 and August 31, 2018 across all thermostats. Average demand savings were estimated to be about 71 W[23] per treated thermostat, or approximately 7.6% of the cooling load for these thermostats post program launch.

[23] The 90% confidence interval is (48.3 W, 93.3 W).

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Table 4-26. PY2018 SS Demand Summary, 2017 Cohort: NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	5,924
Number of Nest thermostats in ITT group	13,962
Number of Nest thermostats in treated group †	**6,576**
Summer (Jul 2 – Aug 31) ‡	
Average demand savings per thermostat (W)	70.8 ± 22.5
Average demand savings (% of cooling load)	7.6% ± 2.4%
Total average demand savings (kW)	465
Adjusted Summer (Jun 1 – Aug 31) §	
Average demand savings per thermostat (W)	47.0 ± 14.9
Average demand savings (% of cooling load)	5.1% ± 1.6%
Total average demand savings (kW)	308

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 6,559.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The demand impact evaluation relies on data through August 31, 2018.

§ Adjusted Summer values are summer values adapted to be from June 1 through August 31, 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

4.4.3.2 2018 Thermostat Cohort

This section presents the findings from the energy and peak demand impact analyses for new NGrid thermostats, summarized in Table 4-27 (energy) and Table 4-28 (demand).

For the 2018 NGrid thermostat cohort, the SS program resulted in total energy savings of 235 MWh from July 2, 2018 through September 30, 2018. Average daily energy savings were estimated to be 0.31 kWh[24] per treated thermostat, or approximately 2.7% of the cooling load for treated thermostats post program launch. Table 4-27 presents these values as well as a breakdown of savings during on-peak hours, off-peak hours, the tune-up period, and the post tune-up period.

[24] The 90% confidence interval is (0.13 kWh, 0.50 kWh).

Table 4-27. PY2018 SS Energy Summary, 2018 Cohort: NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	7,789
Number of Nest thermostats in ITT group	18,242
Number of Nest thermostats in treated group †	**8,610**
Summer (Jul 2 – Sep 30) ‡	
Average daily energy savings per thermostat (kWh)	0.31 ± 0.18
Average energy savings (% of cooling load)	2.7% ± 1.6%
Average total energy savings per thermostat (kWh)	27.3 ± 15.9
Total energy savings (MWh)	235
Summer (Jul 2 – Sep 30) On-Peak §	
Average daily energy savings per thermostat (kWh)	0.35 ± 0.17
Average energy savings (% of cooling load)	3.5% ± 1.6%
Average total energy savings per thermostat (kWh)	21.2 ± 10.0
Total energy savings (MWh)	182
Summer (Jul 2 – Sep 30) Off-Peak ††	
Average daily energy savings per thermostat (kWh)	0.06 ± 0.10
Average energy savings (% of cooling load)	1.4% ± 2.0%
Average total energy savings per thermostat (kWh)	5.6 ± 8.3
Total energy savings (MWh)	48
Tune-Up Period (Jul 2 – Jul 29)	
Average daily energy savings per thermostat (kWh)	0.30 ± 0.26
Average energy savings (% of cooling load)	1.9% ± 1.7%
Average total energy savings per thermostat (kWh)	8.1 ± 7.1
Total energy savings (MWh)	69
Post Tune-Up Period (Jul 30 – Sep 30)	
Average daily energy savings per thermostat (kWh)	0.31 ± 0.18
Average energy savings (% of cooling load)	3.0% ± 1.8%
Average total energy savings per thermostat (kWh)	18.4 ± 10.8
Total energy savings (MWh)	158

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 8,602.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The energy impact evaluation relies on data through September 30, 2018.

§ 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.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

Navigant also estimated peak demand impacts from 1 p.m. to 5 p.m. on program period non-holiday weekdays through August. The SS program for 2018 Cohort resulted in total peak demand savings of 438 kW between July 2 and August 31, 2018. Average demand savings were estimated to be about 51 W[25] per treated thermostat, or approximately 5.4% of the cooling load for treated thermostats, post program launch.

[25] The 90% confidence interval is (31.1 W, 70.7 W).

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Table 4-28. PY2018 SS Demand Summary, 2018 Cohort: NGrid

Statistic	Treated Thermostat Savings
Number of Nest thermostats in control group	7,789
Number of Nest thermostats in ITT group	18,242
Number of Nest thermostats in treated group †	**8,610**
Summer (Jul 2 – Aug 31) ‡	
Average demand savings per thermostat (W)	50.9 ± 19.7
Average demand savings (% of cooling load)	5.4% ± 2.1%
Total average demand savings (kW)	438
Adjusted Summer (Jun 1 – Aug 31) §	
Average demand savings per thermostat (W)	33.8 ± 13.1
Average demand savings (% of cooling load)	3.6% ± 1.4%
Total average demand savings (kW)	290

† Total number of treated thermostats eligible for savings (opt-in thermostats in service territory with telemetry data) was 8,602.

‡ The first offer date for the SS program occurred on July 2, 2018. The SS program persists if air conditioning systems are in cooling mode. The demand impact evaluation relies on data through August 31, 2018.

§ Adjusted Summer values are summer values adapted to be from June 1 through August 31, 2018.

Note: confidence interval range (indicated by ±) is 90%.

Source: Navigant analysis

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5. CONCLUSIONS

Navigant's evaluation of the SS program for NGrid and CLC found it was successful in testing the technical feasibility of thermostat optimization and in customer acceptance of the offering. The evaluation shows promise for thermostat optimization, though important questions remain regarding incremental savings from future deployments, persistence of savings, and savings for statewide deployment. Table 5-1 summarizes the key evaluation findings, and Table 5-2 provides recommendations

Table 5-1. Key Findings

Key Findings
• Under half of thermostats in the ITT group opted in to programs—38% for CLC and 47% for NGrid.
• The cooling setpoint schedules for the treated thermostats were adjusted upward during the program period—0.41°F for CLC and 0.59°F for NGrid.
• The largest setpoint adjustments took place during the middle of the weekdays, when customers were least likely to be at home—0.76°F for CLC and 1.25°F for NGrid.
• The average energy savings per treated thermostat between July 2, 2018 and September 30, 2018 were 31.1 kWh for CLC, 30.6 kWh for NGrid, and 30.5 kWh combined.
• The program yielded average energy savings between July 2, 2018 and September 30, 2018 of 3.4% for CLC, 3.0% for NGrid, and 3.0% combined for program participants.
• The average demand savings per treated thermostat from July 2, 2018 to August 31, 2018 were 30 W for CLC, 60 W for NGrid, and 57 W combined.
• The program yielded average peak demand savings thermostat between July 2, 2018 and August 31, 2018 of 3.3% for CLC, 6.4% for NGrid, and 6.1% combined.
• The program achieved energy savings between July 2, 2018 and September 30, 2018 of 46 MWh for CLC, 464 MWh for NGrid, and 508 MWh combined.
• The program achieved demand savings between July 2, 2018 and August 31, 2018 of 44 kW for CLC, 903 kW for NGrid, and 947 kW combined.
• Navigant recommends CLC claim the combined per-thermostat energy and demand savings as the CLC values were not statistically significant.

Table 5-2. Recommendations

Recommendations
• **Recommendation #1:** NGrid should claim average energy savings of 30.6 kWh per treated thermostat in Massachusetts in 2018. CLC should claim average energy savings of 30.5 kWh per treated thermostat in Massachusetts in 2018.
• **Recommendation #2:** NGrid should claim average demand savings of 60 W per treated thermostat in Massachusetts in 2018. CLC should claim average demand savings of 57 W per treated thermostat in Massachusetts in 2018.
• **Recommendation #3:** In 2019, deploy the SS program to all Massachusetts PAs to better inform a PA-specific (or statewide) savings value or realization rate for inclusion in the Technical Reference Manual.
• **Recommendation #4:** The summer SS program should continue to be evaluated to assess the ability of the program to realize incremental savings associated with redeployment. The 2018 exploratory analysis found that setpoint adjustments persist and continued from 2017.

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APPENDIX A. COOLING RUNTIME

This appendix presents information about changes in average cooling runtime for all thermostat groups across the summer season for both Cape Light Compact (CLC) and National Grid (NGrid). This information is presented in an identical style to the setpoint exploratory analyses in Section 4.

In addition to cooling runtime, information on cumulative cooling degree hours, or CDH (base 70°F), is overlaid for comparison. CDH has a strong correlation with daily average thermostat runtimes in Massachusetts.

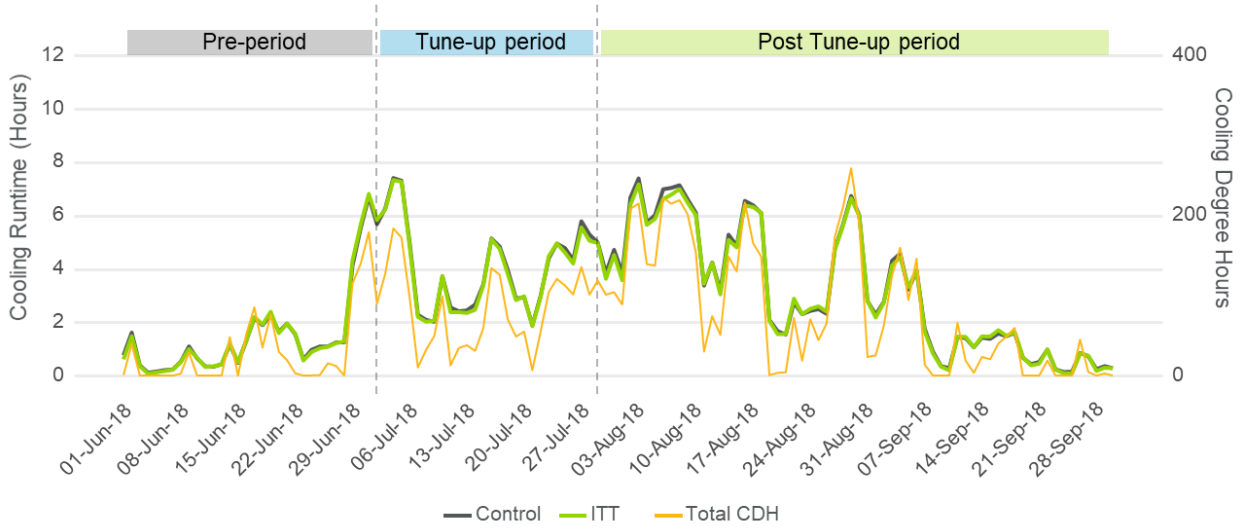
A.1 Cape Light Compact

Table A-1. Summary of Exploratory Analysis (Runtime): CLC

Period	Group	Pre	Post Tune-up	Δ†	SS Impact‡
Period Dates		Jun 1 – Jul 1	Jul 30 – Sep 30	–	**–**
Average Daily Outdoor Temp (°F)		64.37	64.37	70.47	**–**
Average Daily Cooling Runtime (min)	Control	85.29	187.74	102.45	**–**
	ITT	85.23	184.64	99.41	**-3.04**
	Treated	92.17	195.98	103.81	**1.36**
	Untreated	80.63	177.21	96.58	**–**

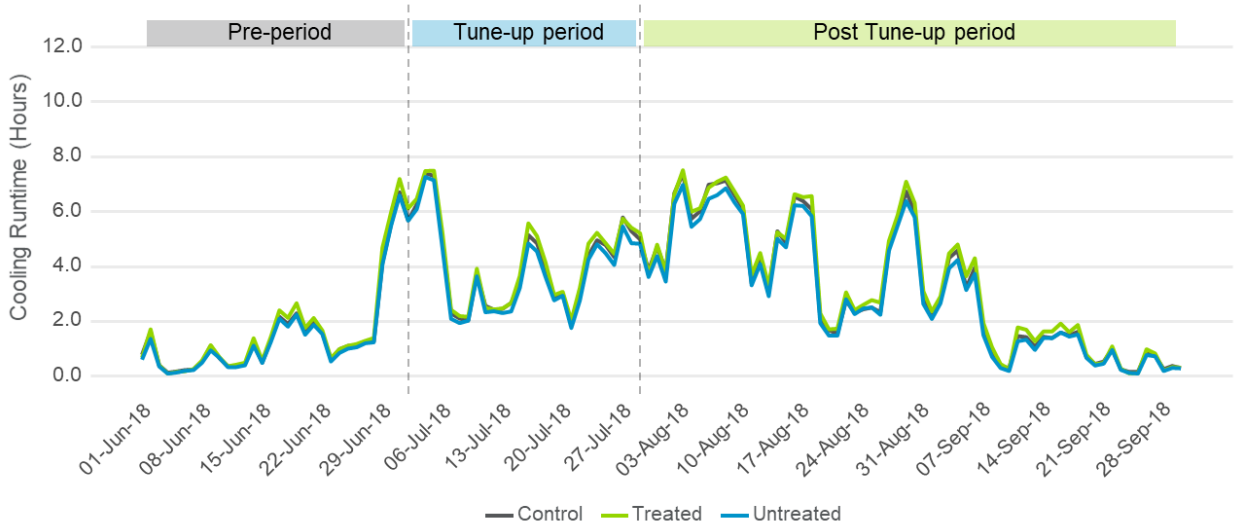
†The Δ is the difference between the post tune-up period and the pre-period.
‡The SS impact is the difference between the Δ for the ITT or treated group and the control group.
Source: Navigant analysis of Nest thermostat telemetry data and NOAA temperature data

Figure A-1. Average Daily Cooling Runtime and CDH: CLC



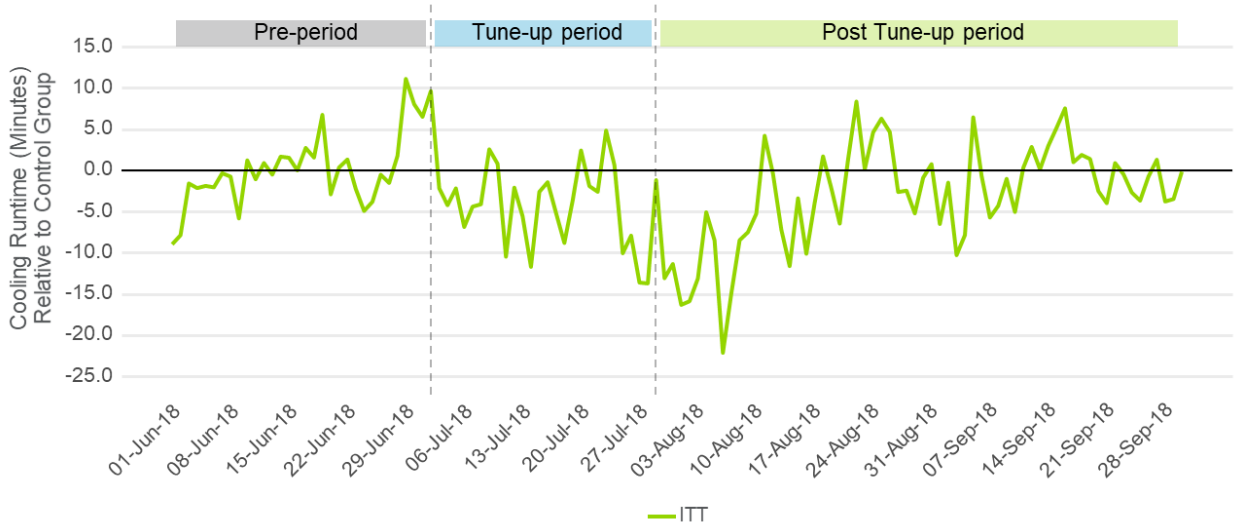
Source: Navigant analysis of Nest thermostat telemetry data

Figure A-2. Average Daily Cooling Runtime, ITT Subgroups: CLC



Source: Navigant analysis of Nest thermostat telemetry data

Figure A-3. Average Daily Cooling Runtime Comparison: CLC



Source: Navigant analysis of Nest thermostat telemetry data

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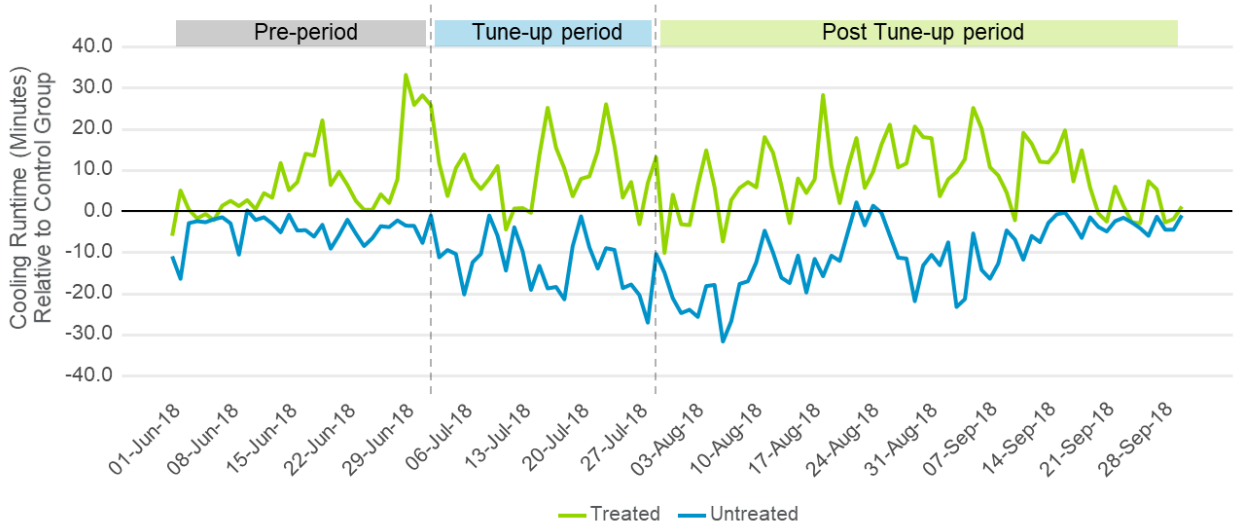
Figure A-4. Average Daily Cooling Runtime Comparison, ITT Subgroups: CLC



Source: Navigant analysis of Nest thermostat telemetry data

A.2 National Grid

Table A-2. Summary of Exploratory Analysis (Runtime): NGrid

Period	Group	Pre	Post Tune-up	Δ†	SS Impact‡
Period Dates		Jun 1 – Jul 1	Jul 30 – Sep 30	–	**–**
Average Daily Outdoor Temp (°F)		67.35	70.98	3.63	**–**
Average Daily Cooling Runtime (min)	Control	139.79	201.55	61.76	**–**
	ITT	140.90	199.60	58.70	**-3.06**
	Treated	145.25	201.25	55.99	**-5.76**
	Untreated	136.50	197.93	61.44	**–**

†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 or treated group and the control group.
Source: Navigant analysis of Nest thermostat telemetry data and NOAA temperature data

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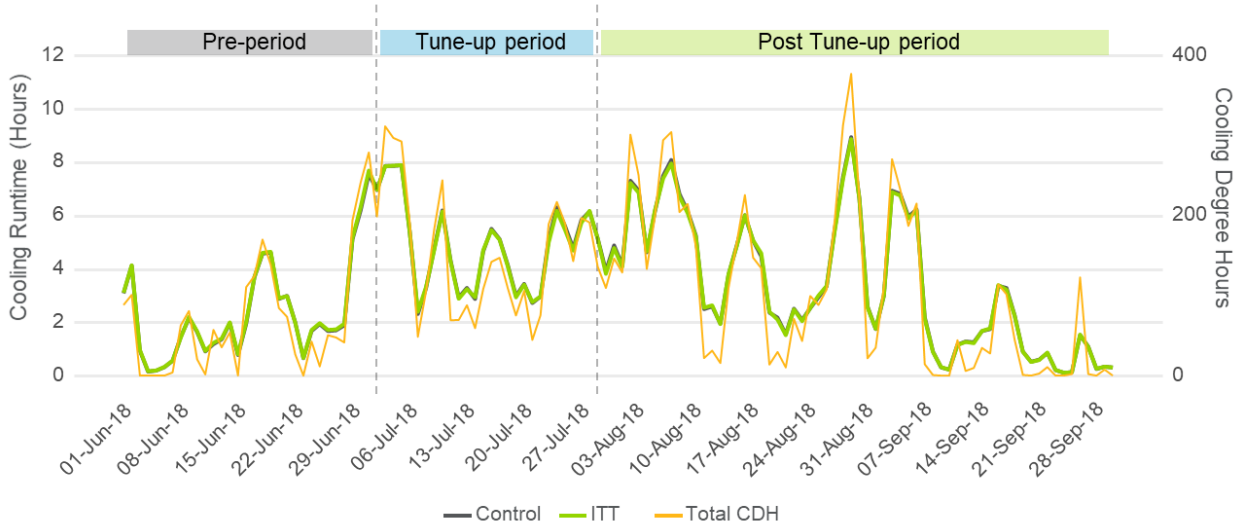
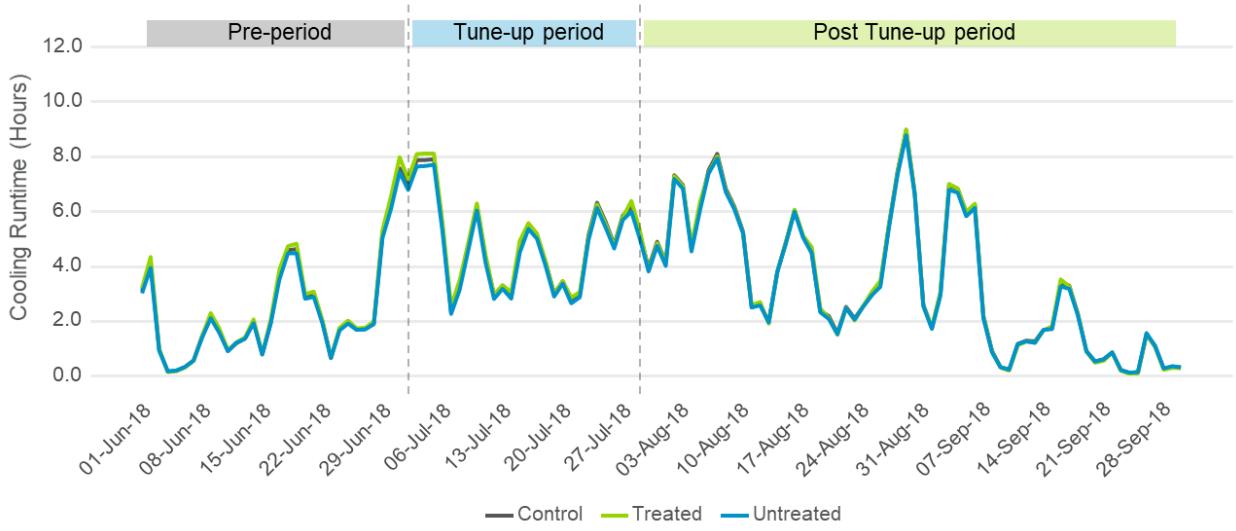
Figure A-5. Average Daily Cooling Runtime and CDH: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Figure A-6. Average Daily Cooling Runtime, ITT Subgroups: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

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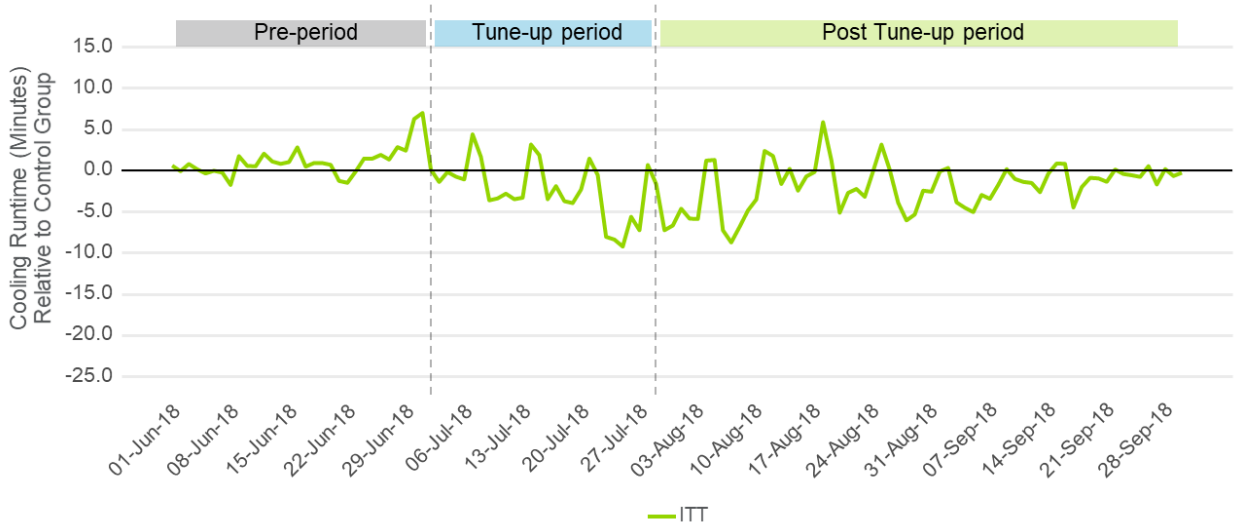
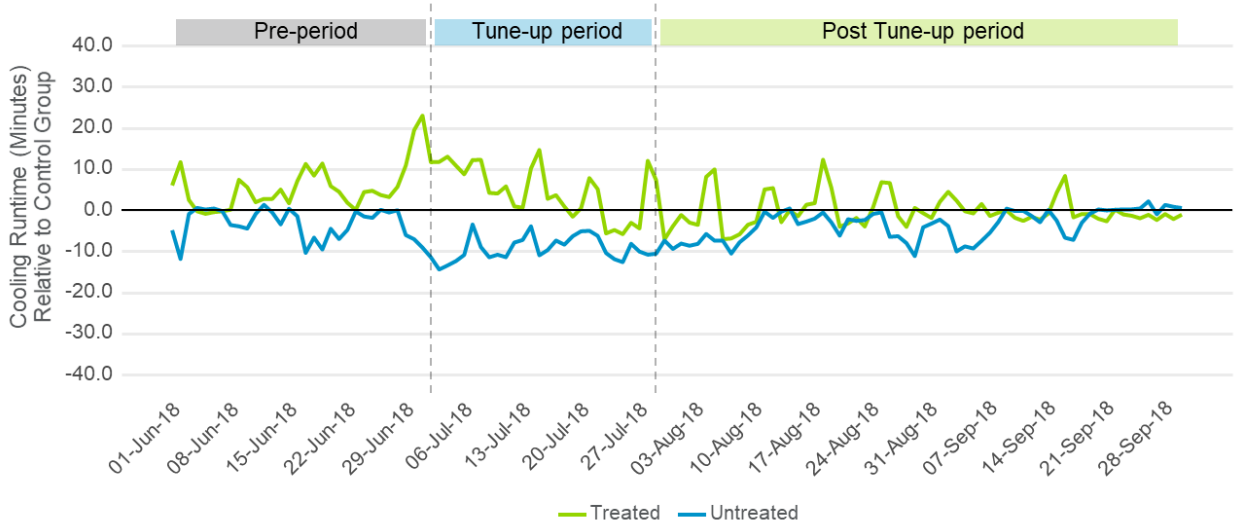
Figure A-7. Average Daily Cooling Runtime Comparison: NGrid



Source: Navigant analysis of Nest thermostat telemetry data

Figure A-8. Average Daily Cooling Runtime Comparison, ITT Subgroups: NGrid



Source: Navigant analysis of Nest thermostat telemetry data