NAVIGANT

ComEd Connected Savings Cooling Season Pilot Impact Evaluation Report

Energy Efficiency / Demand Response Plan: Program Year 2018 (CY2018) (1/1/2018-12/31/2018)

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1. Introduction

This report presents Navigant's energy impact evaluation of the ComEd CY2018[1] Total Connected Savings Wi-Fi Thermostat Optimization (Connected Savings) Pilot Program during the cooling season. The appendices contain the evaluation methodology and detailed results.

2. Program Description

Using energy consumption and weather correlations, the Connected Savings Pilot Program creates a thermodynamic model for each home to understand how it responds to weather changes. The model subsequently develops more efficient customer-specific cooling and heating schedules, which inform its adjustment of household thermostats. For example, the program's modified schedule would automatically raise setpoints during the cooling season to save energy. Based on information from the thermodynamic model, the implementer's platform also provides homeowners with personalized insights to improve energy efficiency.

Whisker Labs, the program implementer, partnered with Honeywell to set up the Connected Savings Pilot Program in 2017 using a randomized controlled trial. The implementer used a recruit and deny strategy where customers who enrolled in the program were randomly assigned to either a treatment (participant) or control (non-participant) group to estimate the program's energy impacts.[2] In this design, the participants received personalized thermostat models and energy efficiency messages, and the control group did not. The program had 1,099 participants and 1,079 controls in the CY2018 cooling season.

3. Savings Summary

The point estimate of total electric savings was 58,087 kWh; this was 0.31 kWh per thermostat per day (or 1.17% of cooling load). However, the estimate was not statistically different from zero. Because of the statistical insignificance, ComEd cannot claim any Cumulative Persisting Annual Savings (CPAS) for the CY2018 cooling season. The lack of significance is driven by the small size of the program. The program only had one measure (thermostat optimization) and the effective useful life (EUL) is one year.[3] Navigant did not estimate gas savings for this program as it was out of scope for this evaluation.[4]

4. Program Savings by Measure

The Connected Savings Pilot Program includes only one measure, thermostat optimization, and so the program savings and measure savings are the same.

5. Impact Analysis Findings and Recommendations

The main report findings and recommendations based on this analysis are detailed below.

Finding 1. The impact analysis resulted in per thermostat savings estimates of 0.31 kWh per day (or 1.17% of cooling load), although this result is not statistically different from zero.

[1] CY2018 covers January 1, 2018 through December 31, 2018
[2] Customers had to own an eligible Honeywell thermostat to enroll in the program at all (i.e., before assignment to the treatment or control group). As such, Navigant had access to thermostat runtime data for both treatment and control customers.
[3] This is being studied for other thermostat optimization programs and may be updated in the future.
[4] Gas savings are not expected for the cooling season.

Recommendation 1. Increasing the number of participants in the program would likely result in a more precise savings estimate.

Finding 2. Navigant dropped approximately 35% of participant and control records due to incomplete thermostat telemetry data.

Recommendation 2. Whisker Labs should investigate whether it could collect additional telemetry data so Navigant could provide a more comprehensive evaluation.

6. Appendix 1. Impact Analysis Methodology

6.1 Impact analysis

This evaluation estimated energy impacts from the implementer's thermostat optimization and messaging program. Navigant relied on thermostat telemetry data[5] to estimate energy impacts after converting cooling runtime to power based on Equation 6-1 from the advanced thermostats measure in the IL Technical Reference Manual (TRM).[6] To calculate average daily usage in kWh, Navigant multiplied daily kW, as calculated in Equation 6-1, by the number of hours in a day (24).

Equation 6-1. Runtime to Power Conversion

$$kW = \frac{runtime * \frac{Btu}{hr} * \frac{1}{1000} * \frac{1}{EER}}{1000}$$

Where:

$\frac{BTU}{hr}$ is the size of the AC unit, assumed to be 33,600 based on the IL TRM

EER is the cooling equipment's energy efficiency ratio, assumed to be 8.16 based on the IL TRM

6.1.1 Linear Fixed Effects Regression Model

Navigant used a linear fixed effects regression model to estimate energy savings for devices that received the Connected Savings Pilot Program offering. Formally, the model is specified in Equation 6-2.

Equation 6-2. Linear Fixed Effects Regression Model

$$ADU_{it} = \alpha_i + \gamma_m + \beta_1 Post_t + \beta_2 (Post_t \cdot Treat_i) + \varepsilon_{it}$$

Where:

ADU_{it}	is estimated average daily usage (kWh) by device *i* on day *t*
α_i	is a device-specific fixed effect for device *i*; this picks up all device-specific characteristics that do not change through time, like household square footage
γ_m	is a time-specific fixed effect for month *m;* this picks up temporal differences across months, like weather and daylight hours
$Post_t$	is a binary variable taking a value of 1 when *t* is in the post period (May 1, 2018 – October 16, 2018) and 0 otherwise
$Post_t \cdot Treat_i$	is a binary variable taking a value of 1 when device *i* is in the treatment group and day *t* is during the post-period

[5] Navigant was unable to use consumption data directly as, due to the program design, the thermostat telemetry data could not be linked to ComEd account numbers.

[6] Advanced thermostats are measure 5.3.16 in version 6 of the IL TRM.

ε_{it} is the cluster-robust error term for device *i* during day *t;* cluster-robust errors account for heteroskedasticity and autocorrelation at the household level

The coefficient β_2 is the estimate of average daily kWh energy savings due to the Connected Savings Pilot Program. To calculate total program savings, Navigant multiplied average daily kWh savings by the number of program days across all accounts before data cleaning.

6.2 Data Cleaning and Device Validity

For the purposes of the analysis, Navigant devised and conducted several data cleaning steps. Table 6-1 details the number of accounts remaining after each step, and the proportion of customers each step dropped. Each data cleaning step removed approximately the same number of customers and observations from both participants and controls, maintaining a balanced sample.

Table 6-1. Data Cleaning: Devices Dropped

Data Cleaning Step	Customers		Observations		Cust % Drop		Obs % Drop	
	Treatment	Control	Treatment	Control	Treatment	Control	Treatment	Control
Raw interval data	1,099	1,079	31,229,184	30,660,864				
Remove missing system mode	1,063	1,043	20,140,706	20,094,771	3.28%	3.34%	35.51%	34.46%
Aggregate to daily	1,063	1,043	236,907	240,421	0.00%	0.00%	98.82%	98.80%
Filter out incomplete days	1,058	1,040	157,640	153,305	0.47%	0.29%	33.46%	36.2%
Remove days with >600 device attrition*	1,058	1,040	157,291	152,917	0.00%	0.00%	0.22%	0.25%

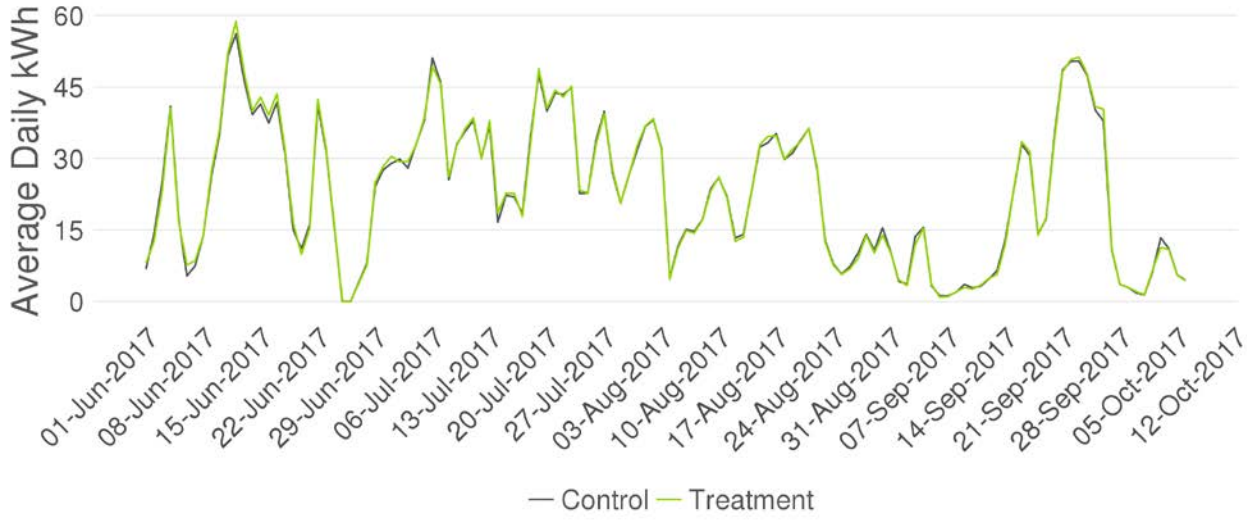
* This step dropped days that were missing more than 600 participant and control devices; these days were 2017-06-24, 2017-06-27, 2018-07-28, and 2018-07-29.

Source: Whisker Labs telemetry data and Navigant team analysis.

7. Appendix 2. RCT Validation

To test whether Connected Savings accounts were randomly assigned to participant or control groups, Navigant visually compared electricity consumption during the pre-period, and ran a regression on pre-period usage with the treatment indicator as the independent variable. Figure 7-1 illustrates almost identical participant and control daily usage during the pre-period.

Figure 7-1. Pre-Period Usage Comparison



Source: Whisker Labs telemetry data and Navigant team analysis.

In addition, Table 7-1 provides regression results that show the treatment variable was not statistically significant in describing participant and control usage during the pre-period. These results validate participant and control randomization.

Table 7-1. RCT Validation Regression Results

	Estimate	Std. Error	T Statistic	P Value
(Intercept)	24.5674	0.1032	238.024	<2e-16
treatment	-0.1052	0.1457	0.722	0.47

Source: Whisker Labs telemetry data and Navigant team analysis.

8. Appendix 3. Impact Analysis Detail

This Appendix details Navigant's exploratory and impact analyses for the Connected Savings Pilot Program.

8.1 Exploratory Runtime Analysis

Exploratory analysis of the thermostat telemetry data assessed changes in cooling runtime for the Connected Savings Pilot Program. Table 8-1 provides a summary of average daily cooling runtime for control and participant groups in the pre and post periods and Figure 8-1 provides an illustration of these results. Navigant found that Connected Savings decreased average daily cooling runtime by almost 4.5 minutes.

- **Pre-program period:** During the pre-program period, the participant group averaged 1 minute more runtime than the control group.
- **Post-period:** During the post-period, average daily runtime decreased for participants, but stayed roughly the same for controls. As a result, average daily cooling runtime decreased by an average of over four minutes for participants relative to controls. This is evidence that, on

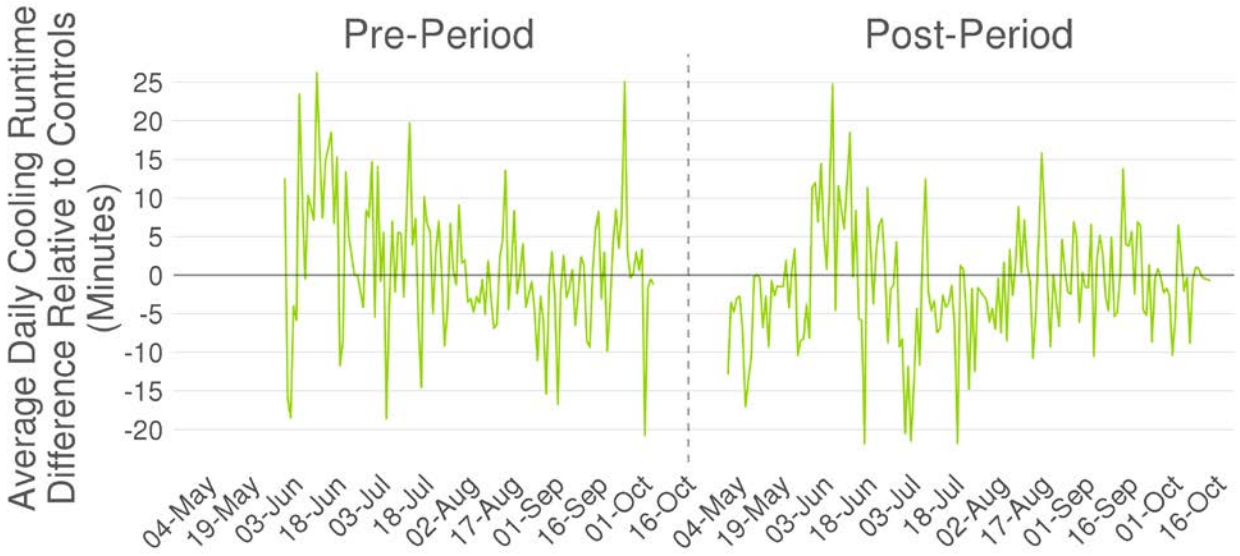
average, less additional cooling took place for the treated group over time because of the program.

Table 8-1. Cooling Runtime Summary

Period	Group	Jun 1, 2017 – Oct 6, 2017 Pre-Period	May 2, 2018 – Oct 15, 2018 Post-Period	Δ*	Connected Savings Effect †
Avg. Daily Cooling Runtime (minutes)	Control	248.60	248.89	0.30	-
	Participant	249.66	245.55	-4.11	-4.41

* The Δ is the difference between the post and pre-period.
† The Connected Savings effect is the difference between the Δ for the participants and controls.
Source: Navigant analysis of Whisker Labs thermostat telemetry data

Figure 8-1. Average Daily Runtime Difference, Treated Minus Control



Source: Whisker Labs telemetry data and Navigant team analysis.

8.2 Impact Analysis

This section presents the impact analysis findings, summarized in Table 8-2. The program resulted in total energy savings of 58,087 kWh from May 1 through October 16, 2018. However, while the regression's point estimate indicates the program saved 0.31 kWh per day, the 90% confidence interval crosses zero (see Figure 8-3), so Navigant cannot verify the program had positive energy savings.

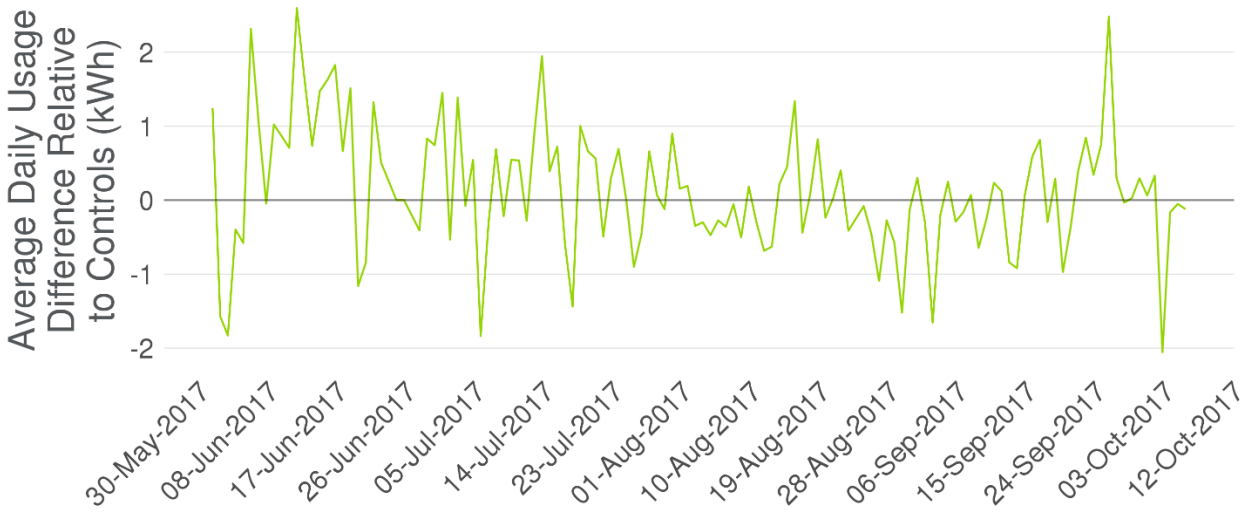
Table 8-2. Connected Savings Cooling Season Impacts

Statistic	Result	*Standard Error*
Number of thermostats in participant group	1,099	-
Number of program days*	185,731	-
Average daily energy savings (% of cooling load)	1.27%	*2.42%*
Average daily energy savings per device (kWh)	0.31	*0.60*
Average total energy savings per device (kWh) †	52.85	*100.74*
Total energy savings (kWh) ‡	58,087	*110,714*

* The combined number of days devices were in the program during the cooling season (May 1, 2018 – October 16, 2018).
† Total savings per device is calculated as total energy savings divided by the number of thermostats in the participant group.
‡ Total savings is calculated as average daily per device savings times the number of participant days.
Source: Navigant analysis of Whisker Labs thermostat telemetry data.

The regression result's broad confidence intervals were due to the program's relatively small sample size and variability in usage between participant and control devices during the program period, as illustrated by Figure 8-2. Although devices which received thermostat optimization used less energy on average during the program period, there were many days where control devices also used less energy. This dynamic contributed to lower precision in the regression results.

Figure 8-2. Average Daily Usage Difference, Treated Minus Control



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

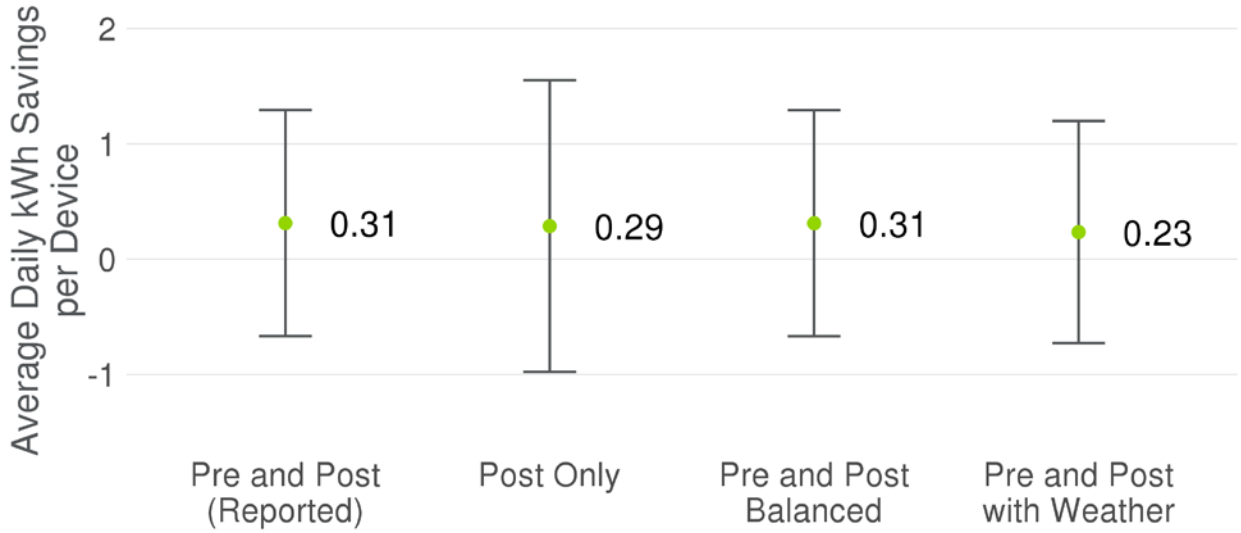
8.2.1 Sensitivity Analyses

In addition to the model specified in Equation 6-2, Navigant estimated several supplementary models as robustness checks. Figure 8-3 shows the absolute savings from each model along with the 90% confidence intervals. Figure 8-4 presents these results as percentages of cooling load. None of the models run were statistically different from one another based on Wald tests performed at the 90% confidence level. The models presented are:

- Pre and Post (Reported) provides the program's results presented in the rest of this report using Equation 6-2.

- Post Only provides results where Navigant only analyzed usage data from the post period. In Navigant's CY2018 Connected Savings heating season impact analysis,[7] about 10% of customers did not have pre-period data. This resulted in Navigant dropping those customers from the analysis. To include those customers, Navigant ran a post-only analysis. To ensure a lack of pre-period data did not have a big influence on program savings, Navigant elected to run the same Post Only model for the cooling season[8] even though the affected customers were not missing pre-period data for this cooling season analysis.
- Pre and Post Balanced provides results only using customers that had both pre and post data.
- Pre and Post with Weather provides results including weather in the model. The weather was heating and cooling degree days[9] from the closest quality-controlled NOAA weather station.

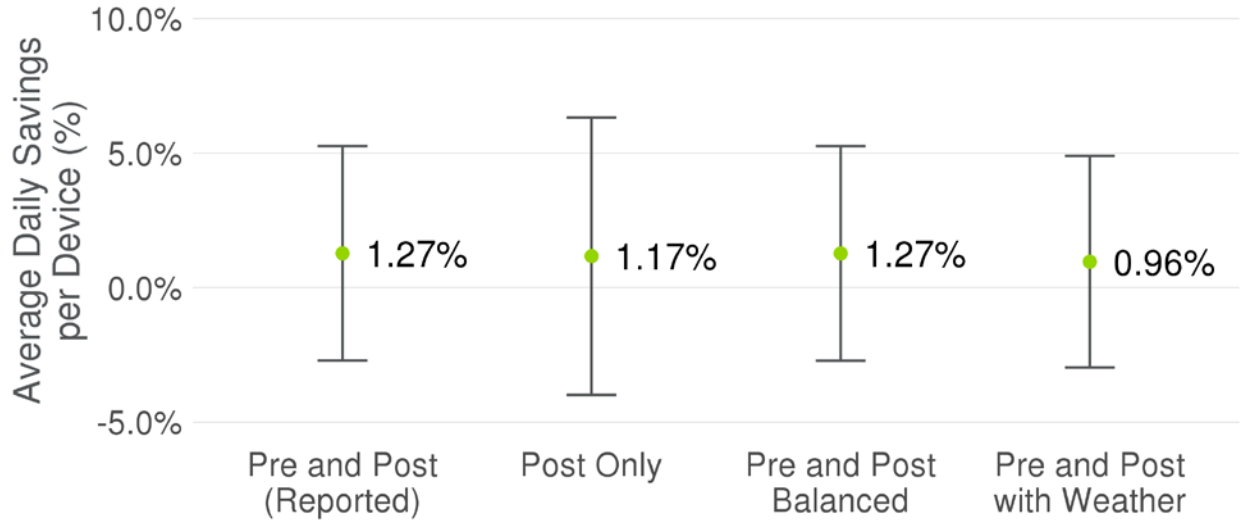
Figure 8-3. Average Daily kWh Savings per Device



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

[7] Navigant. 2019. *ComEd and Nicor Gas CY2018 Connected Savings Heating Season Pilot Impact Evaluation Report.* Presented to Commonwealth Edison Company and Nicor Gas Company.
[8] See Equation 3 from the heating season report.
[9] Heating degree days were defined as being below 60 degrees, and cooling degree days were defined as being above 65 degrees.

Figure 8-4. Average Daily Savings, Percent



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

9. Appendix 4. Total Resource Cost Detail

Table 9-1, below, shows the Total Resource Cost variable table. It includes only the cost-effectiveness analysis inputs available at the time of finalizing this impact evaluation report. Additional required cost data (e.g., measure costs, program level incentive and non-incentive costs) are not included in this table and will be provided to evaluation later. Effective Useful Life numbers in this table are subject to change and are not final.

Table 9-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Units	Quantity	Effective Useful Life	Ex Ante Gross Savings (kWh)	Ex Ante Gross Peak Demand Reduction (kW)	Verified Gross Savings (kWh)	Verified Gross Peak Demand Reduction (kW)
Connected Savings - Cooling	Thermostat Optimization	Device	1,099	1.0	NA	NA	0	NA

Source: Navigant analysis of Whisker Labs thermostat telemetry data.