NAVIGANT

ComEd and Nicor Connected Savings Heating Season Pilot Impact Evaluation Report

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

Presented to
Commonwealth Edison Company
Nicor Gas Company

DRAFT

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ComEd and Nicor Gas Connected Savings Pilot Impact Evaluation Report

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1. Introduction

This report presents Navigant's energy impact evaluation of the joint ComEd and Nicor CY2018 Connected Savings Pilot Program. While CY2018 covers January 1, 2018 through December 31, 2018, this analysis spans the heating season from December 2017 through May 2018.[1,2] The appendices detail this evaluation's methodology.

2. Program Description

Using energy consumption and weather correlations, the Connected Savings 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 lower setpoints during the heating 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 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. In this design, the participants received personalized thermostat models and energy efficiency messages, and the control group did not. The program had 1,081 participants in the CY2018 heating season. Connected Savings used rolling enrollment and had 725 participants as of December 1, 2018. The remaining participants enrolled throughout the post-period going through May 2018.

3. Savings Summary

Total therm savings directly from gas heating were 21,170 therms. The electric savings associated with furnace fans in gas heated homes were 19,477 kWh.[3,4] Table 3-1 and
Figure 3-1 show the electric Cumulative Persisting Annual Savings (CPAS) for ComEd. The program only had one measure and the effective useful life (EUL) is one year.[5] There are no converted gas savings for ComEd to claim for this program and, as such, the electric CPAS is equal to the total CPAS.

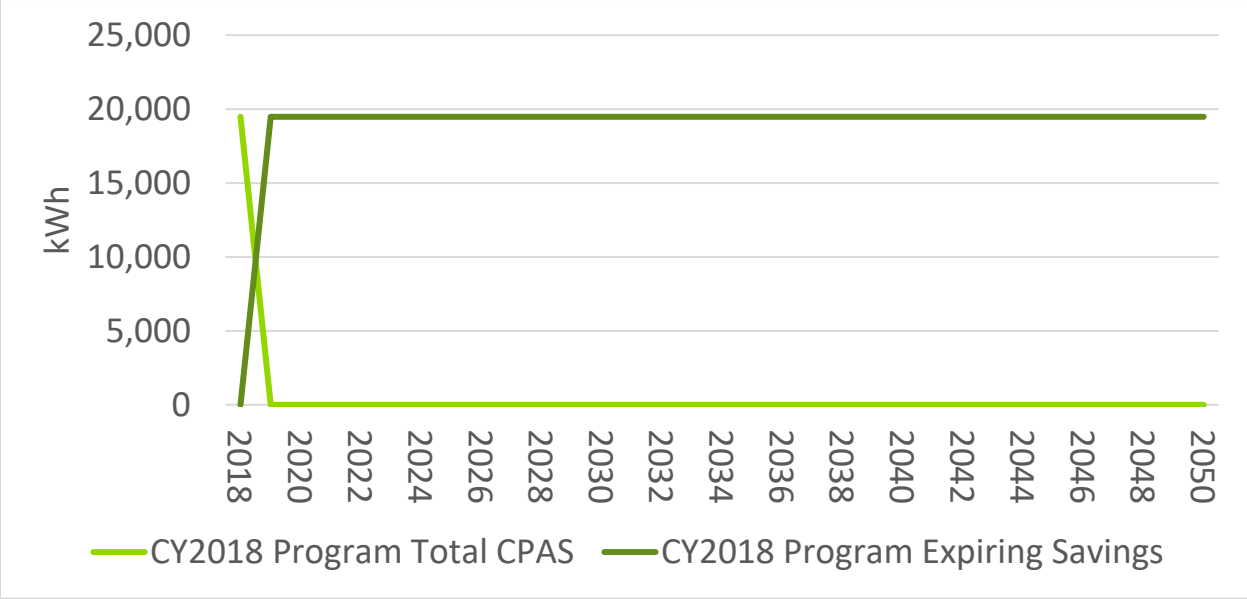
[1] This evaluation period has been agreed to by relevant parties as the program is in a pilot stage. If the pilot is converted to a full program Navigant will ensure there is no double counting of savings across the pilot and program stages.
[2] Only savings from heating were considered, any savings from cooling that may have occurred in May or April 2018 will be included in a forthcoming evaluation of the cooling season.
[3] Eligible homes had to have gas heating and as such there were no savings directly from electrically heated homes.
[4] The methodology to estimate furnace fan savings can be found in Section 6.2.
[5] This is being studied for other thermostat optimization programs and may be updated in the future.

Table 3-1. Cumulative Persisting Annual Savings (CPAS) – Electricity

End Use Type	Measure	EUL*	CY2018 Verified Gross Savings	NTGR†	Lifetime Net Savings‡	Verified Net kWh Savings 2018	2019	2020
Connected Savings	Thermostat Optimization	1	19,477	NA	19,477	19,477		
CY2018 Program Total Electric CPAS			19,477		19,477	19,477	0	0
CY2018 Program Expiring Electric Savings§							19,477	19,477

Note: The green highlighted cell shows program total first year electric savings.
* EUL is a combination of technical measure life and persistence.
† The randomized controlled trial used for this evaluation produces net savings and as such the NTGR is not applicable.
‡ Lifetime savings are the sum of CPAS net savings through the EUL.
§ Expiring savings are equal to CPAS Yn-1 - CPAS Yn + Expiring Savings Yn-1.
Source: Navigant analysis of WhiskerLabs thermostat telemetry data

Figure 3-1. Cumulative Persisting Annual Savings



Source: ComEd tracking data and Navigant team analysis.

4. Program Savings Detail

Table 4-1 summarizes the Connected Savings CY2018 incremental energy impacts. The implementer did not provide program savings estimates, so Table 4-1 does not include ex ante values. In addition, the goal of this evaluation was to estimate the program's energy savings, so it does not include a demand savings analysis.

Table 4-1. CY2018 Total Annual Incremental Electric Savings

Savings Category	Energy Savings (kWh)	Demand Savings (kW)	Summer Peak Demand Savings (kW)
Electricity			
Ex Ante Gross Savings	NA	NA	NA
Program Gross Realization Rate	NA	NA	NA
Verified Gross Savings	NA	NA	NA
Program Net-to-Gross Ratio (NTGR)	NA	NA	NA
Verified Net Savings	19,477	NA	NA

* Since this was a joint Nicor/ComEd program, Navigant assumed no electric heat among participating households.
Source: Whisker Labs telemetry data and Navigant team analysis.

5. Impact Analysis Findings and Recommendations

In CY2018, the Connected Savings Program resulted in verified savings of 5,466 kWh and 5,941 therms. 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 0.11 therms per day (or 2.85% of heating load) and 0.010 kWh per day (or 2.63% of heating load) for furnace fans, though neither result is statistically different from zero.

Recommendation 1. Increasing the number of participants in the program would likely improve the statistical precision, providing a more precise savings estimate.

Finding 2. Navigant found participants had the biggest reductions in runtime relative to controls during periods of high furnace usage. For example, participants' daily runtime was approximately 30 minutes lower than controls during early January.

Finding 3. Initially, Navigant planned on incorporating the pre-period in a fixed effects model to estimate program savings. However, upon examination of the regression output, including the pre-period caused the fixed effect to absorb much of the treatment effect for customers that started during the post period, reducing overall program savings. As a result, Navigant did not estimate a fixed effects model, but instead estimated a post-only model.

Recommendation 3. Navigant recommends clients and implementers provide pre-period usage data for all accounts in the analysis where possible. In situations where this is not possible, evaluators should test alternative model specifications (e.g., fixed effects and post only) for consistency.

6. Appendix 1. Impact Analysis Methodology

6.1 Exploratory Analysis

The exploratory analysis used thermostat telemetry data to analyze thermostat runtimes from November 2017 through May 2018 to assess the impact of thermostat optimization for participants and controls. It examined these impacts relative to the program's pre (November 2017) and post (December 2017 – May 2018) periods. Navigant seeks to standardize methods across thermostat optimization evaluations, and consequently used telemetry as opposed to billing data.

6.2 Impact analysis

This evaluation estimated energy impacts from the implementer's thermostat optimization and messaging program. Navigant relied on thermostat telemetry data and tracking data to estimate energy impacts after converting heating runtime to therms consumed.[6]

The conversion from runtime to therms is shown in Equation 1.

Equation 1. Heating Runtime to Therms Conversion

$$Therms = \left(\sum Stage\ 1\ Runtime\ hours \times \frac{80{,}900\ Btu}{hr} + \sum Stage\ 2\ Runtime\ hours \times \frac{49{,}777\ Btu}{hr}\right) \times \frac{1\ therm}{100{,}000\ Btu}$$

To determine furnace capacity, Navigant selected the top five furnace manufacturers and 93 models from Nicor's PY9 Home Energy Efficiency Rebate tracking data. These models accounted for 40% of the program's installed measures (23,600 total furnaces). The average single-stage[7] and dual-stage[8] capacity values of those furnaces were 80,900 and 49,777 Btu per hour, respectively. Navigant used those capacity values and the formula in Equation 1 to calculate each device's daily therm usage.

To calculate electric savings, Navigant assumed 100% of the participants had gas heating and accrued electric savings through furnace fans. This assumption is because all of the accounts are Nicor customers and, consequently, have gas usage. Equation 2 shows the conversion from total therms saved to total electric furnace fan savings.

Equation 2. Therms Savings to Electric Furnace Fan Savings

$$total\_kWh\_fan\_savings = portion\_gas * therms\_savings * F_e * 29.3$$
$$total\_kWh\_fan\_savings = 1.00 * therms\_savings * 0.0314 * 29.3$$

Where:

$total\_kWh\_fan\_savings$	is total electric kWh savings from furnace fans
$portion\_gas$	is the portion of homes with gas heating
$therms\_savings$	is total therm savings as estimated from the post only model
F_e	is the furnace fan energy consumption as a percentage of annual fuel consumption
29.3	is kWh per therm

6.2.1 Post Only Regression Model

Navigant used post only (PO) model to estimate savings associated with devices that received the Connected Savings Program offering. Formally, Navigant's model is specified in Equation 3.

Equation 3. Post Only Regression Model

$$EDU_{it} = \gamma_m + \beta_1(Post_t \cdot Treat_i) + \varepsilon_{it}$$

[6] Navigant was unable to use consumption data directly as, due to the program design, the thermostat telemetry data cannot be linked to ComEd account numbers.
[7] Any device that only showed run hours for Stage 1 was considered a single stage unit.
[8] Any device that showed run hours for both Stage 1 and Stage 2 was considered a dual-stage unit.

Where:

EDU_{it}	is estimated daily consumption of therms by device *i* on day *t*
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 day *t* was in the post-period (December 1, 2017 or later) and 0 otherwise
$Treat_i$	is a binary variable taking a value of 1 when device *i* was in the treatment group and 0 otherwise
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_1 is the program's estimated average daily savings in therms. To calculate total program savings, Navigant multiplied average daily therm savings by the total number of program days across all accounts before data cleaning.

6.3 Data Cleaning

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.

Table 6-1. Data Cleaning: Devices Dropped

Category	Controls		Participants	
Raw device count totals	**1,061**	**-**	**1,081**	**-**
Filter down the date range	1,056	*0.5%*	1,075	*0.6%*
Missing combustible heat interval	1,034	*2.1%*	1,049	*2.4%*
Aggregate to daily	1,034	*0.0%*	1,049	*0.0%*
Remove days non-combustible runtime	1,034	*0.0%*	1,048	*0.1%*
Filter out incomplete days	1,031	*0.3%*	1,045	*0.3%*

Source: Navigant analysis of Whisker Labs thermostat telemetry data.

7. Appendix 2. Impact Analysis Detail

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

7.1 Exploratory Analysis

Exploratory analysis of the thermostat telemetry data assessed changes in heating runtime for the Connected Savings program. Table 7-1 provides a summary of average daily heating runtime for the control and participant groups in the pre and post periods.

Table 7-1. Heating Runtime Summary

Period	Group	Nov 13, 2017 – Nov 31, 2017 Pre-Period	Dec 1, 2017 – May 31, 2018 Post-Period	Δ*	Connected Savings Effect †
Avg. Daily Heating Runtime (minutes)	Control	239	300	61	-
	Participant	240	288	48	**-13**

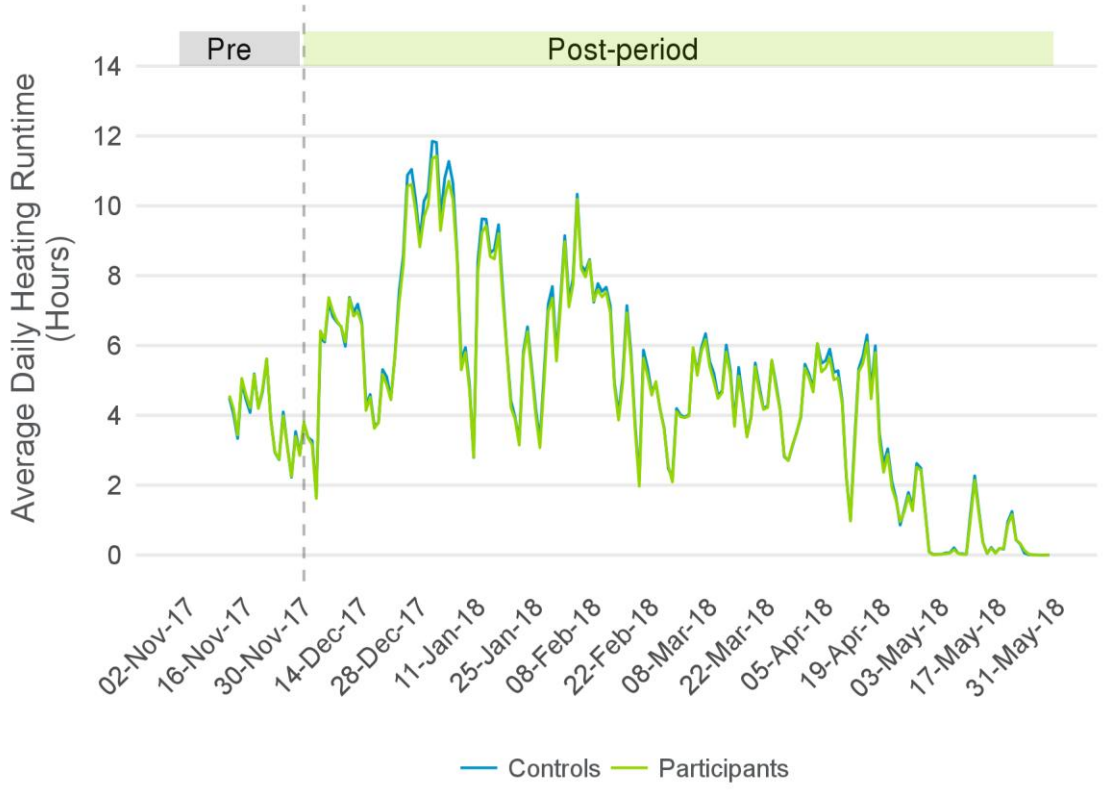
* The Δ is the difference between the post and pre-period.
† The Connected Savings effect is the difference between the Δ for the participants and controls.
Source: Navigant analysis of Whisker Labs thermostat telemetry data

7.1.1 Runtime Comparisons

This section presents findings from the exploratory analysis of average daily thermostat heating runtime. Figure 7-1 compares average daily heating runtime totals (stage 1 plus stage 2 heating) for participants and controls.

- **Pre-program period:** During the pre-program period, the treated group averaged 1 minute more runtime than the control group.
- **Post-period:** During the post-period, average daily runtime increased for participants and controls, but the increase was smaller for the treated group. As a result, average daily heating runtime decreased by an average of 13 minutes during the post-period for participants relative to controls. This is evidence that, on average, less additional heating took place for the treated group over time because of the program.

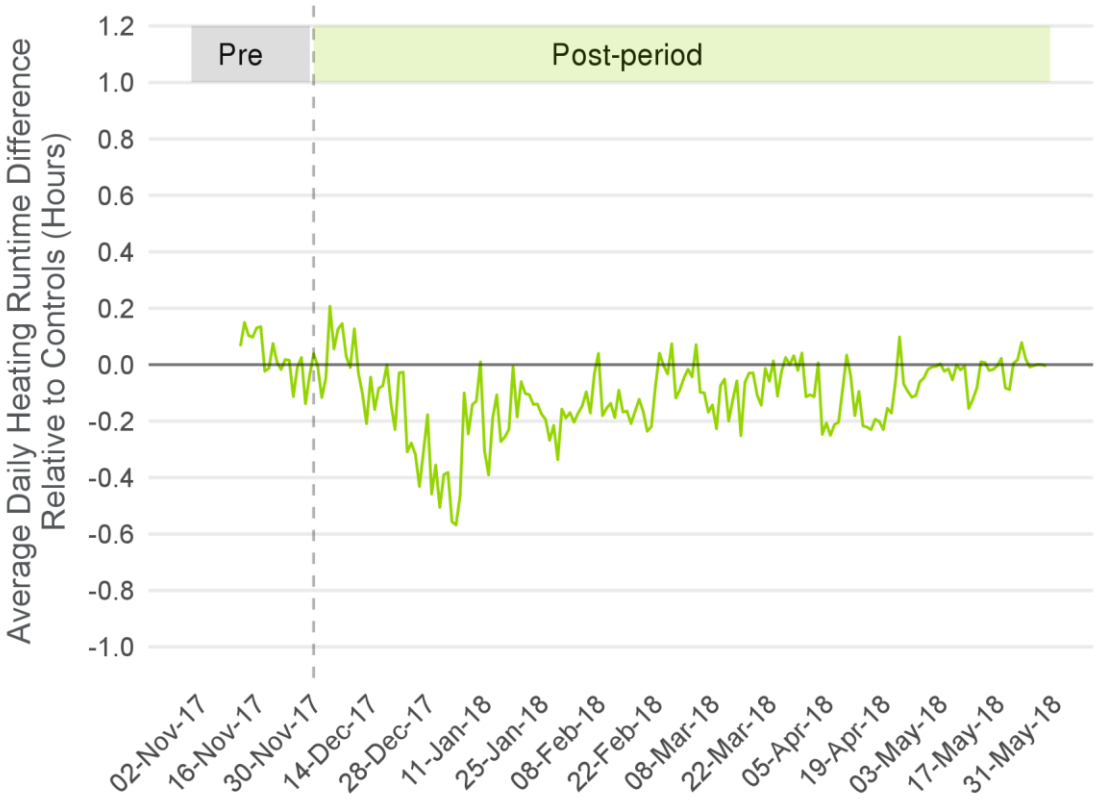
Figure 7-1. Average Daily Runtime Comparison



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

Figure 7-2 shows the difference in runtime between participants relative to controls. Instances where the runtime was below zero represented times when the participants had lower runtime, and consequently saved energy. The plot shows that the program saved most in late December and early January, which coincided with high usage across participants and controls (see Figure 7-3). Runtime differences, and consequently energy savings, decreased over the post-period, and flattened out near zero in May.

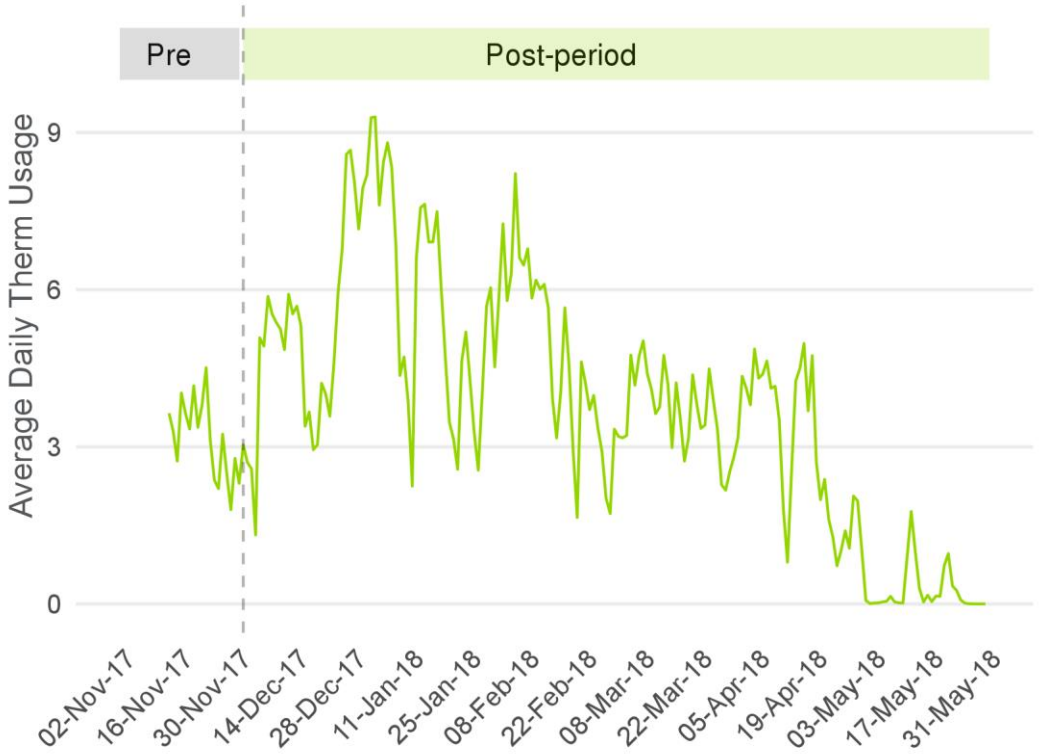
Figure 7-2. Average Daily Runtime Difference



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

Figure 7-3 illustrates the average therms used by participants and controls during the pre and post periods. Navigant converted runtime to therms using total heating runtimes and Equation 1. Figure 7-3 shows that heating usage was highest during early January, and then trended downwards throughout the post-period.

Figure 7-3. Mean Daily Therm Usage for Participants and Controls



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

7.2 Impact Analysis

Table 7-2 summarizes the impact analysis findings. Navigant calculated program savings estimates using the PO model in Equation 3. The program saved 21,170 therms and 19,477 kWh from December 1, 2017 through May 30, 2018.

Table 7-2. Impact Analysis Findings

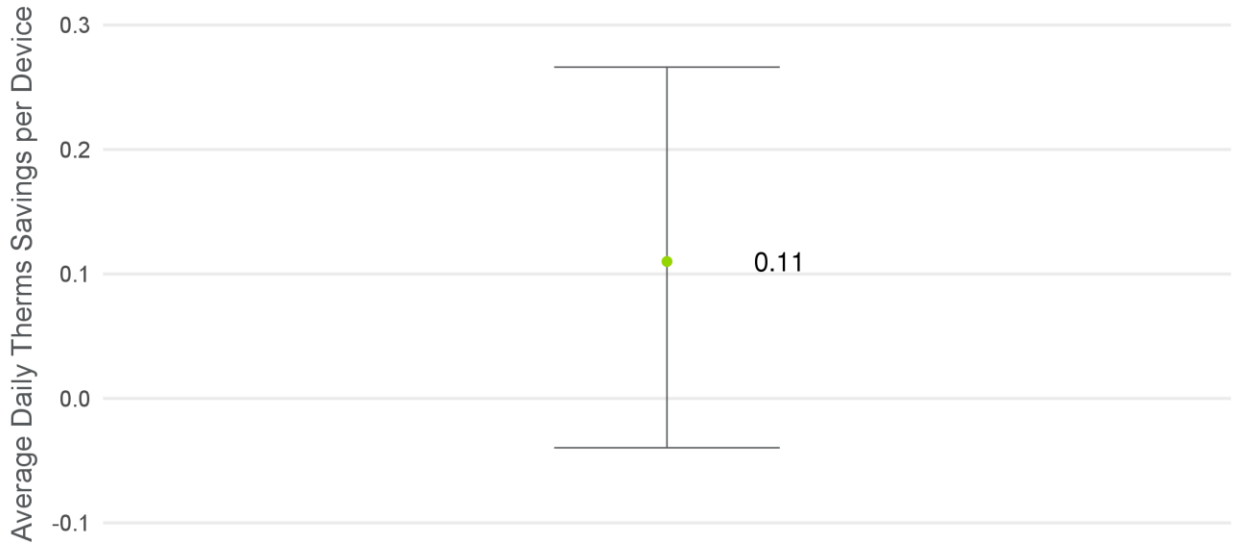
Statistic	Result	*Standard Error*
Number of thermostats in participant group	1,081	
Average daily energy savings (% of heating load)	2.85%	*2.34%*
Average daily energy savings per device (Therms)	0.11	*0.09*
Average total energy savings per device (Therms) †	20	*16*
Total energy savings (Therms) ‡	21,710	*17,368*
Converted furnace fan savings (kWh)	19,477	*15,979*

† Total savings per device is calculated as average daily savings per device times the number of days in the post-period.
‡ Total savings is calculated as total energy savings per device times the number of treatment devices.
Source: Navigant analysis of Whisker Labs thermostat telemetry data.

Figure 7-4 and Figure 7-5 provide visuals for the program impacts. The plots show per-device therms savings and as a percent of total heating load with 90% confidence intervals. Since the lower bound of the 90% confidence intervals cross zero, the pilot's impact is not statistically different from zero. However,

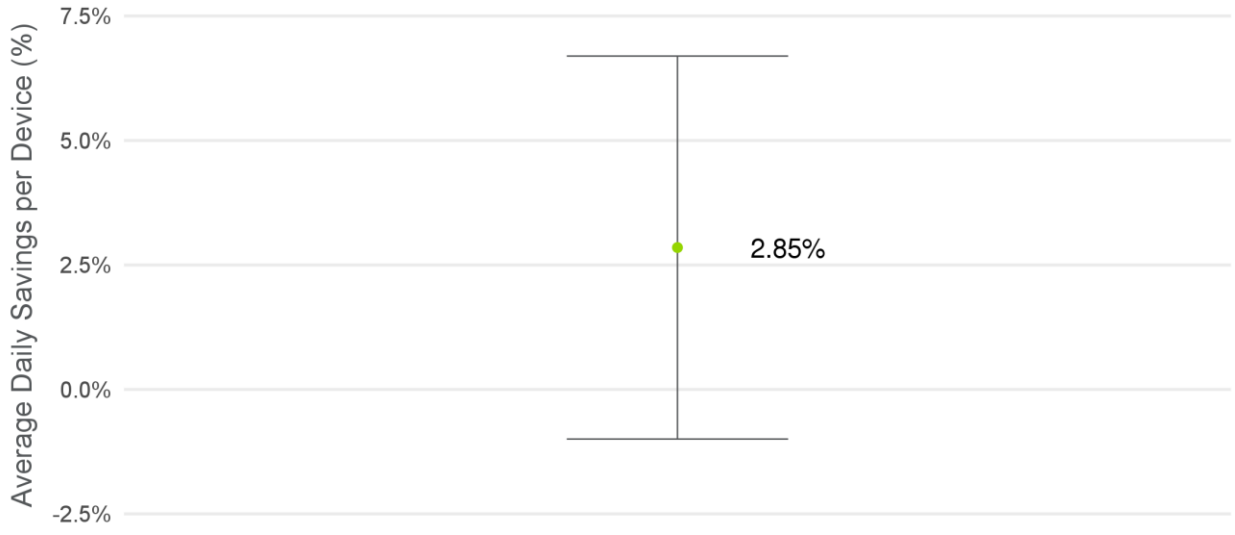
our best approximation is the program saved the regression model point estimate, which is 0.11 therms per day or 2.85% of heating load.

Figure 7-4. Average Daily Therms Savings per Device



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

Figure 7-5. Average Daly Therms Savings per Device (as % of heating load)



Source: Navigant analysis of Whisker Labs thermostat telemetry data.

8. Appendix 3. Total Resource Cost Detail

Table 8-1, 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 8-1. Total Resource Cost Savings Summary

End Use Type	Research Category	Unit	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)
Thermostat Optimization	Smart Thermostats (Furnace Fans)	Each	1,081	1	19,477	-	19,477	-
Thermostat Optimization	Smart Thermostats (Gas Savings)	Each	1,081	1	21,170	-	21,170	-

Source: Navigant analysis of Whisker Labs thermostat telemetry data.