

Saving Heat: A Natural Fit for Gas Demand Response

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ABSTRACT

This paper summarizes Michaels Energy's evaluation of Xcel Energy's 2024 Heat Savers pilot program and estimates the potential for residential natural gas demand response to reduce peak demand during winter mornings in Colorado's Grand and Summit counties. Xcel Energy designed events to lower thermostat setpoints by 3°F or 4°F for four hours, including simultaneous and staggered start times. This study estimates an average reduction of 0.74 Therms per customer (1.24 Therms at baseline) during the four-hour event windows. The greatest impact occurred during the first hour of each event, with average demand reduced by 79 percent, or 0.33 Therms, compared to the baseline. Although events successfully shifted natural gas consumption away from peak morning hours, they also increased peak demand during the snapback period, averaging a 20% rise relative to the peak demand observed in control groups.

Staggered event start times, where groups began their thermostat setbacks one hour apart, were the only demand response approach to shift and reduce peak natural gas demand. This approach reduced peak demand by nearly 39% compared to events with a single start time. Additionally, larger setpoint adjustments led to higher snapback peaks, suggesting diminishing returns in peak reduction as setpoint changes increase.

Introduction

The objective of this study was to evaluate the 2024 Heat Savers Pilot Program and estimate the potential for controlled space heating to reduce peak consumption during winter mornings in Colorado's Grand and Summit counties. The following research questions are answered using customer-level results for each event:

Program Potential and Impact

- What is the potential reduction of peak natural gas demand in cold-climate regions through a residential demand response program?
- Do events lead to an overall net reduction in natural gas consumption?

Customer Behavior

- How often do customers opt out of called events?

Event Design and Optimization

- How does pre-heating affect shifting and reducing peak natural gas demand?
- What is the difference in peak gas demand reduction between 3-degree and 4-degree thermostat setback events?
- What effect does staggering event start times have on peak natural gas demand shifting?

Methodological Considerations

- How consistent are the results produced by different baseline methodologies?

To supplement this analysis, the study draws on National Grid's Bring-Your-Own-Thermostat program results in New York (National Grid NY 2021). More than 2,200 enrolled thermostats in that

program demonstrated statistically significant reductions in peak gas demand of 0.61 to 0.66 Therms during four-hour morning and evening events, with net savings observed even after accounting for preheat and rebound effects. The findings highlight how smart thermostat control can reduce gas use during critical hours while maintaining customer comfort and allowing for opt-out flexibility.

This paper provides a detailed description of available data from the 2024 Heat Savers Pilot Program. Michaels Energy used two methodologies, a control and treatment, and a 10-in-10 baseline, each providing different benefits for determining the changes in natural gas consumption resulting from this program.

Background

Regions with limited pipeline infrastructure, such as Summit and Grand Counties in Colorado, are constrained when natural gas demand exceeds the region's limited supply (Geary 2025). Xcel Energy, Colorado's largest utility provider, serves over 1.6 million customers (Perry and Jaffe 2023), and is taking the lead in solving this issue through several initiatives, such as the Mountain Energy Project (Xcel Energy 2025). Heating demand from furnaces, boilers, and other gas equipment rises in cold weather, causing peak natural gas usage during the winter days (EIA 2020). In Colorado, where 76% of households rely on natural gas for space heating, utilities consistently experience peak demand during the coldest winter days (EIA 2020).

Energy providers have two options to ensure reliable service to their customers during peak demand. First, they can alter the energy supply to their customer base, adding or removing energy commodities, transmission, and distribution capacity to meet changing needs. In the mountainous regions at the focal point of this study, increasing the supply of natural gas would require the construction of pipelines, storage tanks, or a mobile supply from liquid natural gas trucks. However, increasing pipeline capacity would conflict with Colorado's established greenhouse gas (GHG) emission reduction plans (Colorado Climate Action 2025). Colorado is the first state in the U.S. to require natural gas utilities to reduce GHG emissions, targeting a reduction in oil and gas combustion of 20% by 2030 (Colorado Climate Action 2025). Additionally, it would require significant investments that could increase costs at a time when customer affordability is a significant concern for both Xcel Energy and Colorado policymakers (State of Colorado 2025). One alternative method of ensuring service reliability is shifting energy demand and incentivizing customers to consume less natural gas during peak use periods.

Scope

The 2024 Heat Savers Pilot Program participants included 167 Xcel Energy residential gas customers in Grand and Summit counties in Colorado. Enrollment for the pilot was voluntary. Customers were required to have a smart thermostat from Ecobee, Emerson, or Honeywell to participate. Participants were compensated with up to a \$250 incentive based on the number of events they participated in. Additionally, participants were eligible for either a free smart thermostat or a \$100 enrollment incentive.

Resideo partnered with Xcel Energy for all three years of the pilot program. For January, February, and March 2024, Resideo provided 15-minute interval furnace runtime, set point, and temperature data for all 167 participants (256 unique thermostats). Runtime data is defined as the number of minutes in a 15-minute interval in which participants' furnaces produce heat; this value is recorded as Heat Interval Minutes.

Resideo data did not provide furnace capacity, a critical input for calculating energy consumption. Xcel Energy administered a participant survey in 2023 to gather this data. Twenty-three program participants responded with furnace input capacities. The average estimated furnace input capacity for Heat Savers participants was 100,313 BTU/hour, with a margin of error of $\pm 16\%$ at the 90% confidence level. Unless otherwise specified, this analysis assumes a furnace input capacity of 100,000 BTU/hour throughout the study.

Methodology

Demand response events were designed to last four hours, typically from 6:00 a.m. to 10:00 p.m. on non-holiday weekdays from January through March 2024. Figure 1 illustrates the event period alignment with the peak heating energy consumption of natural gas in Colorado. During each event, participating thermostat setpoints were reduced by either 3°F or 4°F. Participants were assigned to one of three treatment groups throughout the event season: Group A, Group B, or a Pre-Heat Approved group. The Pre-Heat Approved group allowed thermostat adjustments before the standard 6:00 a.m. event start time, enabling the evaluation of pre-heating strategies. At any time during the events, participants could change the set points of their thermostats. When this occurred, the customer was designated as “Opt-out” for that event.

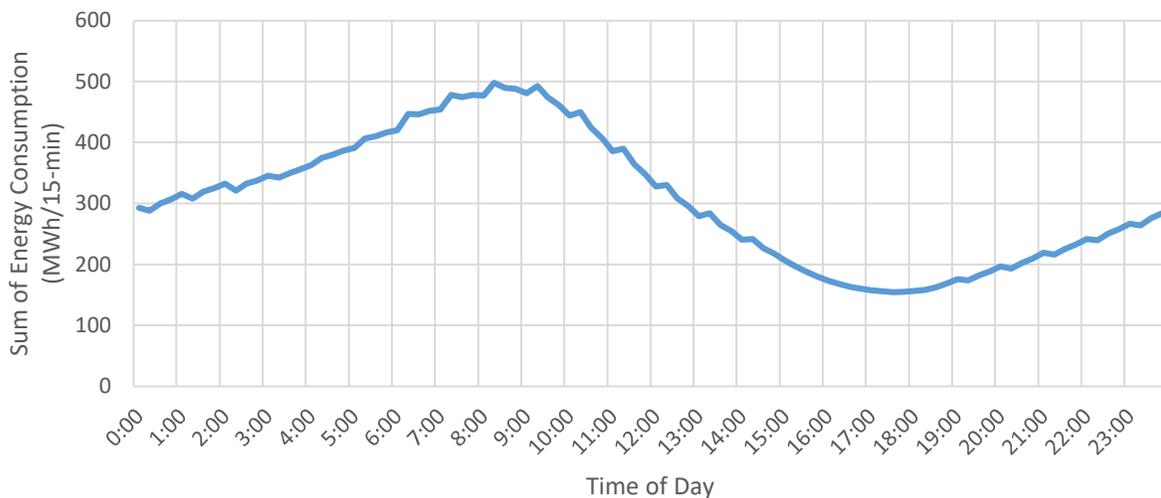


Figure 1. Sum of Natural Gas Energy Consumption from Heating. Daily average natural gas heating with 15-minute interval data, January through December 2024. *Source:* NREL 2024

The 2024 program introduced staggered events alongside traditional, single-start time events to evaluate the effects of event timing on customer consumption patterns. In staggered events, participant groups (Group A and Group B) began the events one hour apart. This design created a rolling event window across the participant pool, rather than a uniform, system-wide curtailment. By staggering start times, program administrators could observe whether the timing of a thermostat setback affects the magnitude, duration, and rebound characteristics of load reduction.

Research Design and Data Processing

The measurement and verification for the 2024 Heat Savers pilot program utilized two analysis methods (Control and Treatment, 10-in-10) to better estimate the impacts of residential demand response on natural gas consumption. The 10-in-10 approach created a unique 24-hour baseline for each thermostat and each event, allowing the research team to analyze DR performance between events. The Control and Treatment approach allowed for a direct comparison between Group A, Group B, and the Pre-Heat Approved group for each applicable event.

10-in-10 Approach

Michaels implemented the 10-in-10 baseline algorithm in Python using 15-minute interval data to estimate counterfactual energy usage for gas demand response events. This approach is adapted for natural gas demand response from a previous evaluation of electrical demand response baseline performance in California (Barquest, et al. 2022). For each customer, the algorithm selects each event day's ten most recent non-event weekdays, excluding DR days. Michaels used the ten selected days to construct an average baseline profile, capturing typical heating behavior over 24 hours within similar conditions. Event runtime is also calculated by adding the furnace's active periods.

An adjustment factor is applied to correct for real-time variability. This factor is computed as the actual to baseline runtime ratio and capped between 0.8 and 1.2 to prevent over-scaling. The baseline is then scaled accordingly, and runtime savings are calculated across event, preheat, and snapback periods, assuming a furnace capacity of 100,000 BTU/hour operating at full capacity. The algorithm identifies baseline days, computes adjusted runtime profiles, and calculates energy savings. This approach excludes participating sites where thermostats are offline or the participant has opted out.

Control and Treatment Approach

Participants from Grand and Summit counties were randomly categorized into two groups, Group A (n = 83) and Group B (n = 84), and this designation was kept throughout all events. The control and treatment approach analyzed events individually using Python. For each event, the Resideo telemetry data was restricted to the day of the event, and only thermostats that recorded heating activity for that day were retained for analysis. Further filtering ensured that only participants marked as "Full" (i.e., not "Opt out") were analyzed. Each 15-minute heat interval runtime is converted to BTUs and designated into event day bins for analysis.

Data Processing

The research team categorized the runtime data into three categories for event analysis: the event period, which is typically from 6:00 a.m. to 10:00 a.m, the preheat period, which is the event start time minus two hours, and the snapback period, which is the event end time plus two hours.

Results

The 2024 Heat Savers pilot program administered 17 demand response events from January through March (). Two events were administered for all participants, and 12 events operated under the control and treatment method. One of Group A and Group B was activated, while the other did not see a thermostat adjustment. Additionally, the pilot conducted three events under the

staggered format. Ten events included thermostat adjustments of four degrees Fahrenheit, and seven events included thermostat adjustments of three degrees Fahrenheit.

Table 1. Count and Type of Events

Event Type	Count of Events
All groups	2
Control and treatment	12
Staggered event with pre-heat only	3
Total Events	17

Overall, 167 households participated in the 2024 Heat Savers program. Participating households connected 256 individual smart thermostats. For the entirety of the data collection period (January through March), the median value for the missing 15-minute heat interval data for all participants over the three-month collection period is 1.2%. Ecobee smart thermostats were the most frequently used among participants, accounting for over 68% of all connected devices. Based on the number of thermostats, the overall participation rate, the number of active thermostats compared to the total sample, across all 17 events was 85%. The overall opt-out rate for those participants who manually changed their thermostats during the event periods was 6.5%.

Shifting Natural Gas Usage

Table 2 provides the average load shift per site per event period, with the average household consuming 0.74 fewer Therms per event for the four-hour events. An increased usage during the snapback period was expected, but the intended effect of the pre-heating period was not as expected. For the pre-heating window, the average participating household consumed 0.10 fewer Therms per event two hours before the event compared to a baseline. The research team expected treatment households to consume more energy during this period. One explanation for this result is that Ecobee thermostats, the most prevalent type in this study, recorded a timestamp for the first adjustment 2.5 hours before the start of each event. As a result, the preheating phase may have included a longer period of passive thermal maintenance, rather than active heating, thus reducing net energy consumption during that time.

For the snap-back window, defined as two hours after the event, the average participating household consumed 0.40 more Therms per event compared to the baseline. Additionally, for the entirety of the event analysis window (Event \pm 2 hours), households consumed 0.44 fewer Therms per site on activated event days.

Table 1. Control and Treatment Customer Average Usage and Demand Shift

Event Period	Time of Day	Control Average Usage (Therms)	Treatment Average Usage (Therms)	Average Load Shift per Customer (Therms)
Preheat	4:00 – 6:00	0.81	0.70	-0.11
Event	6:00 – 10:00	1.24	0.50	-0.74
Snapback	10:00 – 12:00	0.28	0.68	0.40

Figure 2 plots the 15-minute interval consumption of natural gas for the normalized customer in the sample, or the average usage for each 15-minute interval for both the control group (Group B) and the treatment group (Group A). The treatment group shows a sharp drop in usage at 6:00 a.m. and then a slight increase in usage until 10:00 a.m. due to customer furnaces turning on when indoor air temperatures reach the setpoint threshold. At 10:15 a.m., immediately following the conclusion of the event, we see a snapback increase in natural gas usage as furnaces are turned back on.

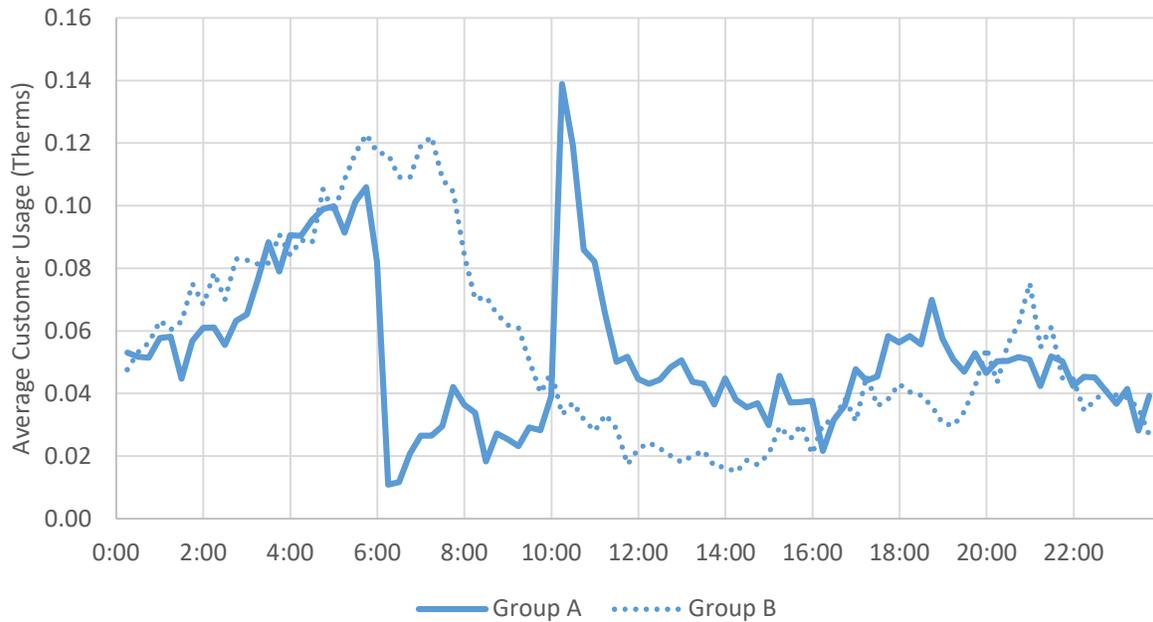


Figure 2. Standard Control and Treatment 24-Hour Usage Plot, January 31, 2024.

Figure 3 shows the average load shift, in Therms per site, for each hour of the four-hour event period. Data from all 12 control and treatment events indicate that the first hour of the demand response event shifts the most natural gas load. On average, a household will consume 0.33 fewer Therms during the first hour of an event.

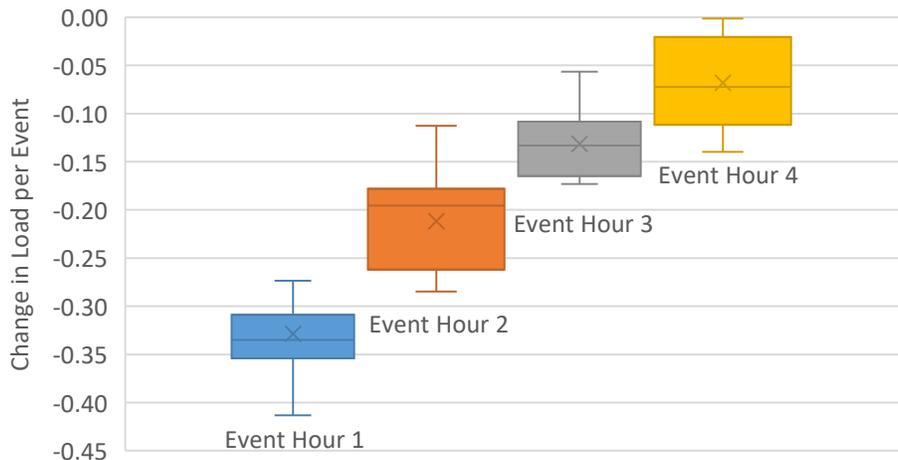


Figure 2. Change in Natural Gas Usage per Site by Event Hour

Net Natural Gas Consumption

Figure 4 shows evidence of load shifting during the event window, which includes preheat and snapback periods, for all events. However, the net natural gas consumption distribution for the event days widely spans both positive and negative directions. On average, this study estimates that a net reduction of 0.44 Therms occurs during the event window ($p\text{-value} < 0.05$). Comparatively, this study estimates that the average net reduction for the day of an event is 0.02, a value that does not meet statistical significance. One explanation for the differences in net consumption between the event window and the day of the event is that the impacts of the snapback period can last longer than two hours. Figure 2 demonstrates the extended snapback period, as the average usage of Groups A and B does not intersect until six hours after the event concludes.

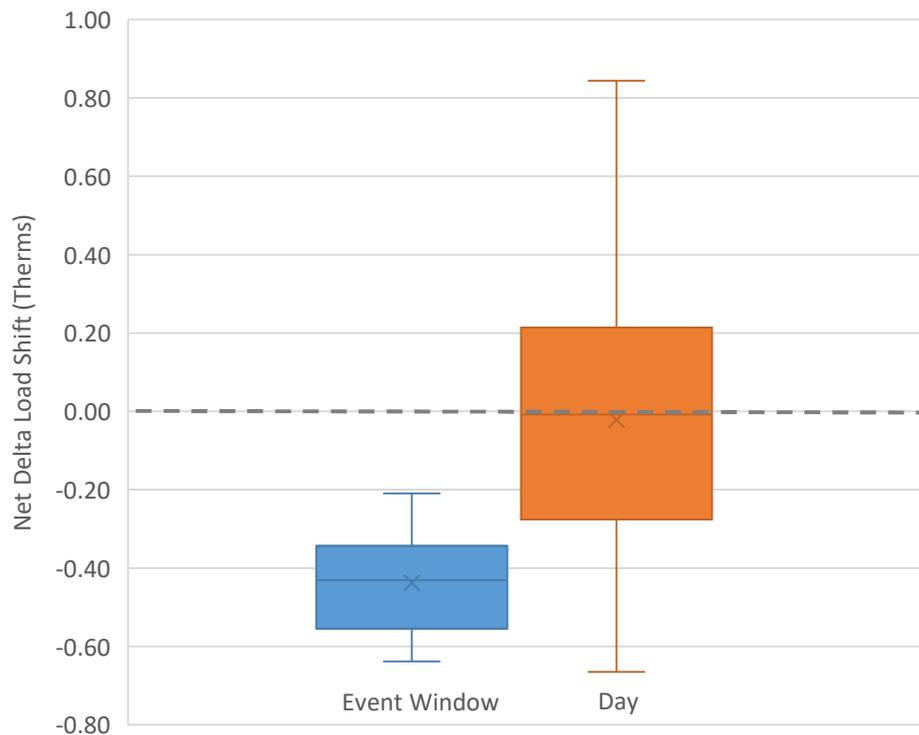


Figure 4. Net Natural Gas Usage for Control and Treatment Customers

This study found that preheating before an event impacts net natural gas consumption for the whole day of the event. Average net reduction for preheating is 0.49 ($p\text{-value} < 0.05$), equating to roughly 10% of a household's daily consumption.

Pre-Heating Period Results

Figure 5 visualizes the role of pre-heating across the three event types. For the Event Only and Pre-Heat + Event groups, the pre-heating period shows a negative delta because some thermostat manufacturers automated the event to start before 6 a.m., effectively pulling part of the event into the pre-heat window. The Pre-Heat + Event group shows positive pre-heat deltas, indicating intentional energy use before the event to raise comfort. This approach achieves significant savings during the event and limits the snapback compared to Event Only. Because the homes were pre-conditioned, customers

did not need to consume as much energy once the event ended, resulting in a smoother overall load profile. Finally, the Pre-Heat Only group shows positive pre-heat deltas without corresponding reductions during the event window. In some cases, snapback is still present, which further diminishes the value. As expected, pre-heating alone does not provide meaningful peak demand reduction and is unsuitable for a load-shifting strategy.

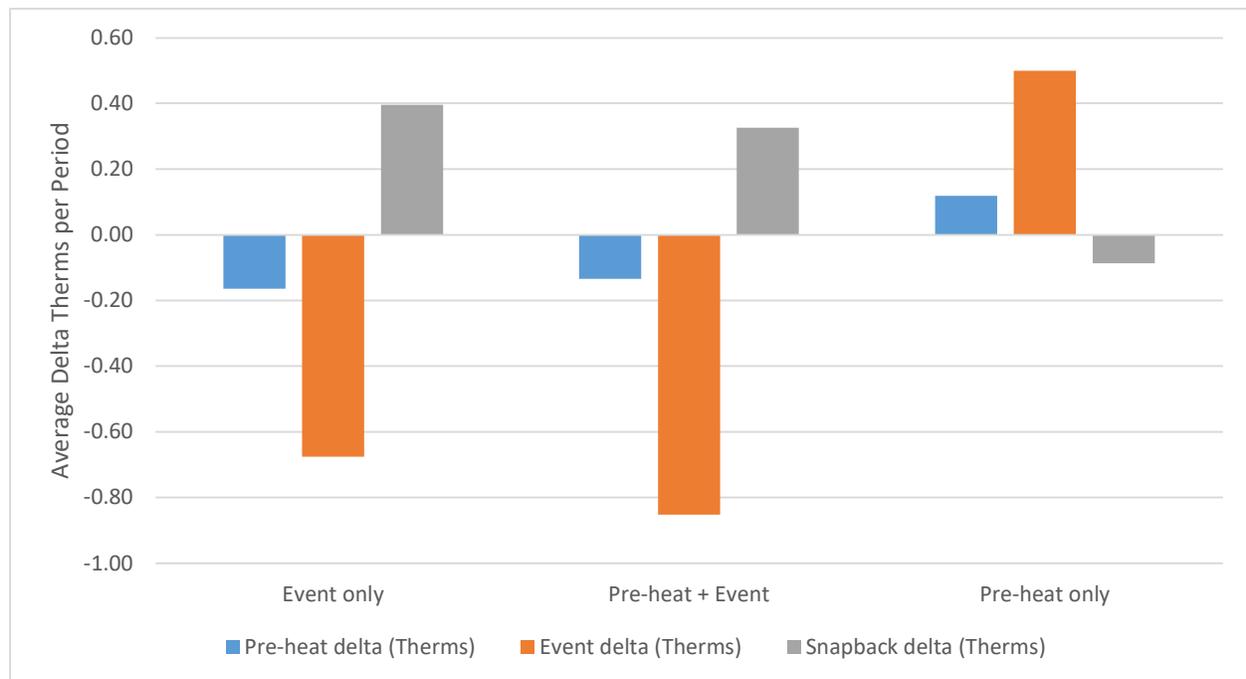


Figure 5. Demand Shift by Type and Phase of Event

Three- and Four-Degree Setpoint Events

This study found no significant difference in the amount of load shifted during the event periods when comparing three-degree (Fahrenheit) and four-degree setpoint events. Three-degree setpoint events shifted an average of 0.70 Therms per event. Four-degree setpoint events shifted an average of 0.79 Therms per event ($n = 814$, $p\text{-value} > 0.05$). However, a t-test showed a statistically significant difference in snapback peak demand between events with three-degree and four-degree setpoint changes ($n = 814$, $p\text{-value} < 0.05$), suggesting that greater setpoint changes may contribute to higher peak demand during snapback periods.

Staggered Events

The 2024 Heat Savers pilot program administered three staggered events. Group A participants started a four-hour event at 6:00 a.m. and Group B participants started a four-hour event at 7:00 a.m. on the same day. Figure 5 shows the usage for the three staggered events occurring on February 6, February 24, and March 6. Each figure shows the usage for the participating groups individually; a combined line represents the average usage of the participating groups.

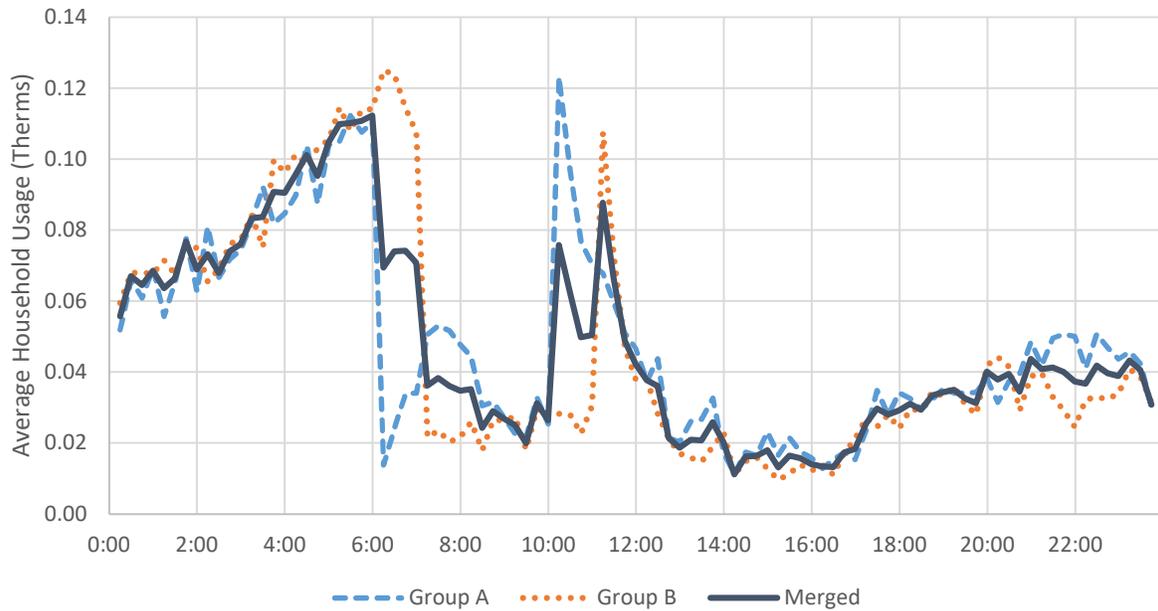


Figure 5. Staggered Event Usage, February 24, 2024

Individual analysis of the participating groups in staggered events results in findings similar to standard events; the events successfully shift natural gas usage during the event periods, and the resulting snapback peak increases compared to a baseline scenario (Table 4).

The combined effect of groups A and B in a staggered event successfully shifts natural gas usage during the event periods and reduces the snapback period peak, which is on average 38.9% less than peak demand seen in the baseline.

Analysis Method Comparison

The results of the two approaches align in the directionality of load shifting across events and periods but differ in the magnitude of the estimated shifts. The primary advantage of the control and treatment method is that it uses a simultaneously occurring control group to establish a real-time baseline for comparison. Because both treatment and control groups are subject to the same external conditions, such as temperature, time of day, and behavioral patterns, this method reduces the influence of confounding variables and improves the accuracy and validity of event impact estimates. As a result, the control and treatment approach is better suited for determining the potential reduction in peak natural gas demand attributable to a residential demand response program.

In contrast, the 10-in-10 baseline method, which compares event-day usage to the average of the past 10 non-event days, is more susceptible to variability in weather, occupant behavior, and heating system schedules across days. However, its strength lies in enabling individual-level analysis, allowing evaluators to examine participant behavior and performance consistency within and across events. This makes it useful for understanding longitudinal trends at the household level, despite its reduced precision in estimating event-specific impacts.

Conclusions

This study finds that peak demand is reduced by an average of 0.74 Therms per household during a four-hour natural gas demand response event. The first hour of the event is the most effective at shifting usage, with a reduction of 0.33 Therms per household. Across all events, 6.5% of participants opted out of an event by manually adjusting their thermostats. The events resulted in an overall net reduction in natural gas consumption of 0.44 Therms within a \pm 2-hour period. Single start-time events will successfully shift peak natural gas consumption to the beginning of the snapback period, but will likely increase peak demand higher than the baseline.

This study found that preheating prior to a demand response event significantly affects total daily natural gas usage. On average, preheating led to a net reduction of 0.49 Therms, representing approximately 10% of a typical household's daily consumption.

This study confirms that altering participants' thermostats by three or four degrees does not significantly change the amount of natural gas usage that shifts during events. However, administering an event with a larger setpoint shift will result in a greater increase in peak natural gas demand during the snapback periods.

The only consistent approach to shifting natural gas usage and reducing peak demand is to stagger the start times of participating households. Compared to a baseline scenario, the staggered-start approach results in a 38.9% reduction in peak demand.

Recommendation 1. Future natural gas demand response administration through Heat Savers should always include a control group to collect accurate baseline data. The control group should comprise 10% of the participant population or 30 households, whichever is greater. Establishing a control group enables rigorous measurement and verification of demand reductions by isolating event impacts from normal usage fluctuations due to weather, occupancy, or other variables. This is critical for evaluating program effectiveness, building stakeholder confidence, and informing future refinements to event design and participant engagement strategies. Without a control group, quantifying savings or justifying program investments becomes significantly more difficult.

Recommendation 2. To maximize peak demand reduction, future events should adopt staggered scheduling as the standard approach. A staggered event with a three-degree setpoint change is recommended based on successful administration methods from the 2024 Heat Savers season.

Recommendation 3. Continue administering future natural gas demand response events with a "pilot study" mindset. Strategies to further decrease energy demand include increasing the sample size of customers participating in pre-heating to better understand the impacts of demand shifting, and adaptive duty-cycling, in which the setpoint changes dynamically based on real-time outdoor conditions.

Recommendation 4. To increase participation, include additional thermostat manufacturers, such as Google Nest, in the study. Continue to work with participating manufacturers to improve the timing of setpoint adjustments.

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