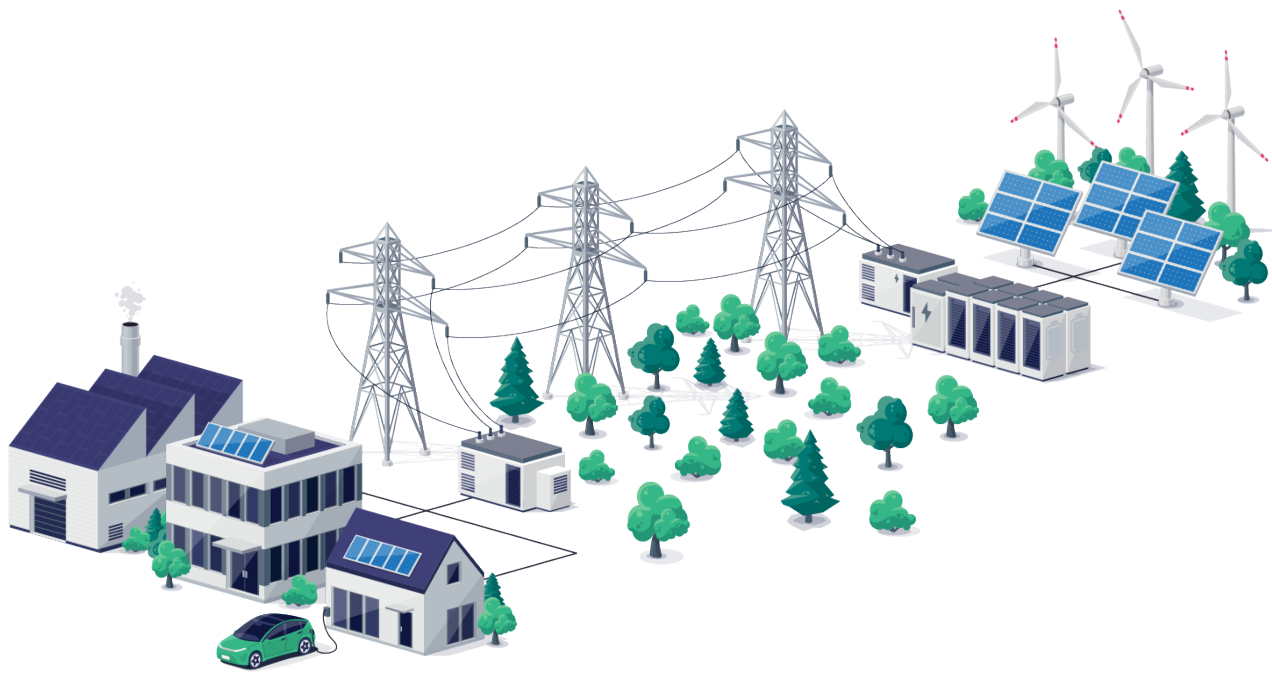
Customer Innovation

ComEd Whole Home Optimization Pilot M&V Executive Summary

Release Date

July 28, 2026



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Acknowledgements

This project was developed as part of the Customer Innovation initiative within the Commonwealth Edison (ComEd) Strategic Programs and Pilots team under internal project number CI-8069. Opinion Dynamics, with contributions from Optiwatt, produced this report for the Customer Innovation Team with overall guidance and management from Andrew DeBlasio and Kamlesh Amin. The team acknowledges the support of BrightLine Group. For more information on this project, contact Customer.Innovation@ComEd.com.

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Executive Summary

Background

The ComEd Whole Home Optimization Pilot ("WHO Pilot" or "the pilot") ran from July through October 2025, testing the optimization of customer smart thermostat–controlled cooling and electric vehicle (EV) charging to ComEd's hourly pricing signal, which is based on PJM real-time market prices. The pilot aimed to demonstrate the ability to help ComEd customers on the hourly pricing tariff to achieve electric bill savings, both (1) through daily optimization of HVAC and EV charging that affects that month's bills and (2) by curtailing energy demand during peak demand periods, thereby reducing customer exposure to capacity charges in the following year, while maintaining participant satisfaction.

Participating households were required to be ComEd customers with smart thermostat–controlled central cooling. Optionally, participants could also enroll an EV or charger used for at-home level 2 (L2) charging. Participants were required to be on ComEd's hourly pricing rate. In total, 994 ComEd customers enrolled in the WHO Pilot, bringing 1,308 smart thermostats and 383 EVs or chargers. Devices were optimized from July 14 through October 31, 2025.

Optiwatt ("the implementation team") served as the technology provider and overall implementer for the WHO Pilot. Optiwatt managed customer enrollment and engagement in the pilot through its consumer app and optimized participants' cooling and EV charging to ComEd's hourly pricing signal.

Opinion Dynamics ("the M&V team") served as the measurement and verification (M&V) partner for the WHO Pilot. The M&V team quantified the impacts of the WHO Pilot, including:

- **Daily Optimization Load Impacts:** The M&V team used non-optimized device telemetry data to construct baselines for enrolled thermostat and EV load and compared this to cooling and charging load observed during optimization to assess load impacts. HVAC and charging baselines were constructed from a combination of (1) baseline data collected upon enrollment for new Optiwatt devices and (2) a randomized rotating treatment design in which each household was placed in a control group every fourth week. Load impacts were calculated as the difference between baseline and actual load and are reported separately by device type, hour of the day, and periods defined based on the price in each hour.
- **Event Load Impacts:** Following the same methodology as for calculating daily optimization load impacts, the M&V team separately estimated impacts for each peak load reduction event. For both thermostats and EVs, we analyzed impacts for event hours and, for smart thermostats, examined energy conservation impacts for event days.
- **Customer Bill Impacts:** Using the load impacts as a starting point, we calculated customer volumetric bill impacts for the pilot period. We followed ComEd-provided methodologies to estimate average annual capacity charge impacts associated with the optimized devices.

- **Device and User Behavior:** Using device telemetry data, the M&V team developed average daily load curves for enrolled thermostats and EVs, override rates for thermostats and EVs, and plug-in and charge rates for EVs. These analyses provide context for the load impacts.

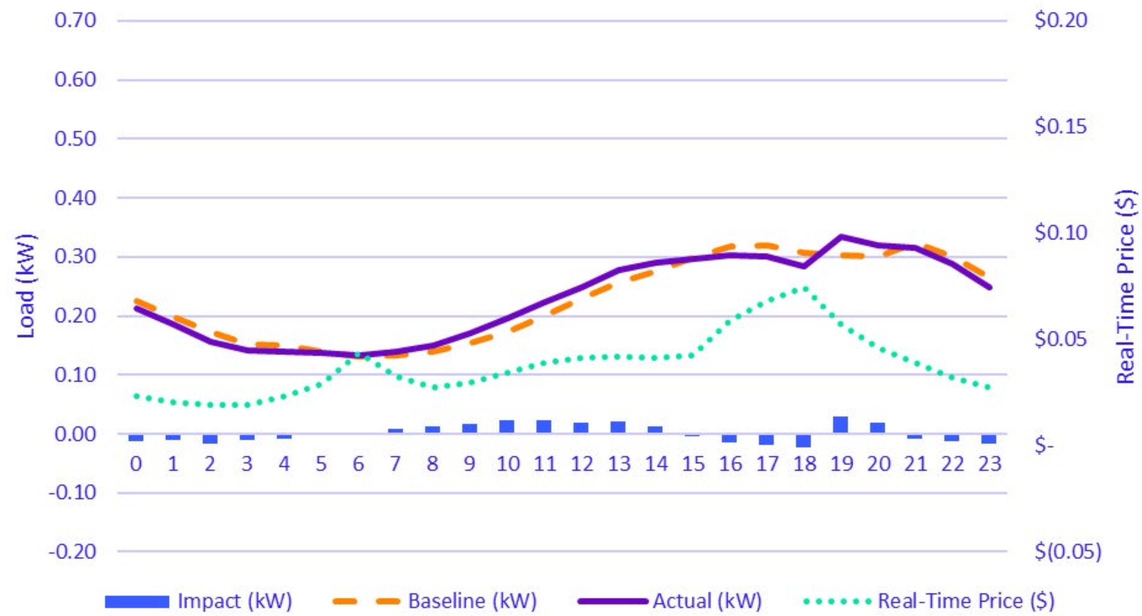
Key Findings

The WHO Pilot ran during a period of low real-time prices, limited pricing variability, and relatively mild temperatures. Ninety percent of hours in the pilot period had positive prices below $0.08/kWh, and only eight hours exceeded $0.25/kWh. Because the pilot was designed to respond to variation in energy prices, this relatively flat pricing environment limited opportunities to evaluate load-shifting behavior. It also constrained thermostat load shifting, which was triggered only when positive prices reached $0.08/kWh or more, and reduced the potential for customer volumetric bill impacts from any load shifting achieved for thermostats or EVs. Mild temperatures during the pilot further constrained the cooling load available for shifting, with average temperatures of 77°F in July and 73°F in August. The second half of the pilot occurred in the shoulder season, when cooling needs declined even further. The limits imposed by these conditions provide important context for the findings presented in this section.

Baseline thermostat load coincides with the most expensive hours of the day, presenting both opportunities and challenges for optimization. Daily optimization of thermostats to the hourly pricing signal resulted in a reduction in cooling load in the late afternoon to early evening hours (4:00 p.m. through 6:00 p.m.), when energy prices are typically high. Load reductions associated with optimization began around 3:00 p.m., aligning with rising prices, and intensified through the late afternoon, reaching their peak at 6:00 p.m. Then load increased between 7:00 p.m. and 8:00 p.m., likely reflecting HVAC systems cycling back on to maintain indoor temperatures, resulting in a modest snapback effect. Notably, this rebound occurred during hours that remained relatively high-priced, suggesting some limitations in sustained shifting of the cooling load under continued high price signals (Figure 1).[1]

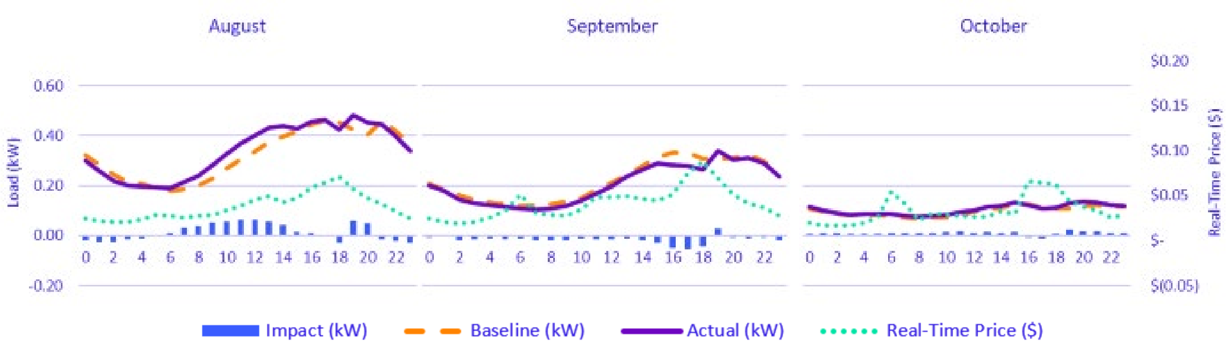
[1] We evaluated real-time pricing during the pilot period (July 14 through October 31, 2025) alongside pricing from June 1 through July 13, 2025, as well as June through August in both 2023 and 2024. Consistent with the conditions observed during July 14 through October 31, 2025, the preceding period (June 1 through July 13, 2025) exhibited a similar distribution of prices, with approximately 90% of hours exhibiting positive prices below $0.08/kWh. During that period, however, volatility was slightly higher, with 13 hours (approximately 1.3% of hours) exceeding $0.25/kWh. Pricing observed during June through August 2023 and 2024 reflects a similar overall distribution, with high-price hours remaining relatively infrequent and approximately 97% and 93% of hours, respectively, exhibiting positive prices below $0.08/kWh. Taken together, these results indicate that pricing observed during the pilot period was not materially different from conditions observed in the preceding period or in prior summer seasons.

Figure 1. Average Daily Per-Thermostat Baseline and Actual Cooling Load – Daily Optimization



Consistent with the seasonal nature of cooling demand, hourly load impacts were strongest during the summer months and tapered as the pilot entered the shoulder season. Load shifting impacts were greater in August compared to September and declined further in October (Figure 2). Monthly impacts are explored further in the Key Findings section.

Figure 2. Average Daily Per-Thermostat Baseline and Actual Cooling Load By Month



Note: See Table 29 for the underlying values corresponding to this figure. July is excluded from monthly analysis due to partial month data and a small number of treated devices, which contributes to noise in the load impact estimates.

Given the smart thermostat daily optimization strategy, which targeted hours with positive prices of $0.08/kWh or greater, the M&V team aggregated load impacts based on the real-time price during each hour and in alignment with the cost categories used for optimization. There was a small but statistically significant reduction (0.03 kW per device, a 10% reduction) in cooling load during high-cost hours.

There was no significant change in cooling load in the medium or negative cost hours, though this may be a function of the combined small setpoint adjustment and small number of hours in each category.

As expected, there was also no change in cooling load in the low-cost hours (Table 1). A targeted sensitivity analysis indicates that increasing temperature setbacks and expanding optimization hours could approximately double load impacts during higher-priced periods; however, resulting volumetric bill savings remain modest, increasing to under $1 (4% of baseline bills).

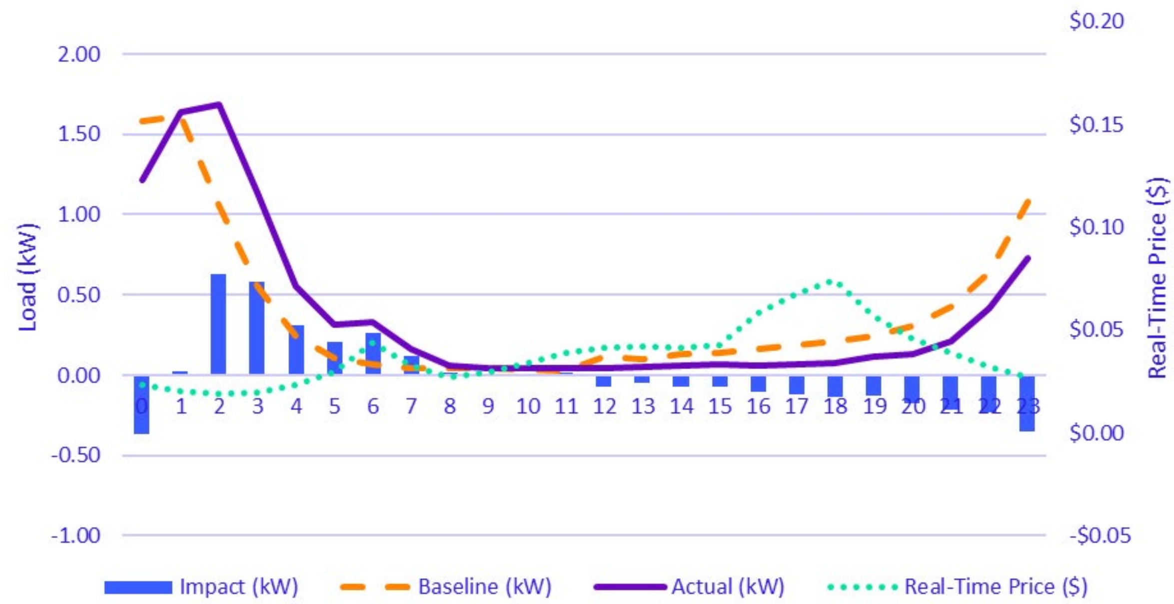
Table 1. Thermostat Daily Optimization Load Impacts by Optimization Cost Category

Cost Category	Default Shift (°F)	Total Hours	Baseline (kW)	Load Impact (kW)	% Impact	Lower CI	Upper CI
High (>14¢)	+ 2	29	0.35	-0.03	-10%	-0.05	-0.02
Medium (8-14¢)	+ 1	115	0.35	-0.01	-3%	-0.03	0.01
Low (0-7¢)	+ 0	2,078	0.23	0.00	0%	-0.01	0.00
Negative (< 0¢)	-1	65	0.09	0.01	7%	-0.01	0.02

Note: Percent impacts do not sum to 100% because they represent changes in average demand as opposed to total consumption. Total hours reflect the hours in the cost category under daily optimization, excluding event days. Confidence intervals are at 90%.

Most EV charging load for WHO Pilot participants occurs outside of peak pricing hours, with participants already charging primarily overnight before optimization. Nonetheless, the pilot produced incremental load shifting, further concentrating charging in lower-priced overnight hours. The M&V team observed a reduction in charging load from noon through midnight and an increase from 1:00 a.m. through 8:00 a.m. The largest reductions in charging load were from 11:00 p.m. to midnight, while the largest increases were from 2:00 a.m. to 3:00 a.m. In some cases, the optimization may have waited too long to initiate charging, as there was an increase in charging load from 5:00 a.m. to 7:00 a.m., even though prices tend to be relatively higher than earlier in the night (Figure 3). Notably, EV daily load optimization occurred across hours, with no minimum pricing threshold for optimization.

Figure 3. Average Daily Per-Vehicle Baseline and Actual Charging Load – Daily Optimization



For EVs, as part of the load impact analysis, the M&V team categorized each hour based on the relative real-time price in that hour compared to the other 23 hours in the day. Because the price of energy and the hours when it is most expensive can vary from day to day, this analysis allows us to understand whether the optimization consistently shifts load out of relatively more expensive hours and into relatively less expensive hours. We also examined the load impacts for the top 5% of the most expensive hours under daily optimization (i.e., excluding event days) for the entire WHO Pilot duration, as load impacts during those hours are most consequential to customer bills.

Although EV charging load was already lower in more expensive hours than it was in less expensive hours, the optimization successfully shifted about half of the remaining load out of the more expensive hours throughout the day, including during the overall highest-priced hours, while increasing load in the less expensive hours of the day (Table 2).

Table 2. Per-Device Load Impacts by Pricing Period – Daily Optimization

Pricing Period	Baseline (kW)	Actual (kW)	Impact (kW)	% Impact	Lower CI	Upper CI	Average Price
Unfavorable ($$$)	0.19	0.09	-0.10	-54%	-0.11	-0.09	$0.08
Non-Preferred ($$)	0.23	0.13	-0.10	-45%	-0.11	-0.10	$0.04
Optimal ($)	0.50	0.58	0.08	16%	0.08	0.08	$0.02
Top 5% of Hours ($$$$)	**0.18**	**0.06**	**-0.12**	**-68%**	**-0.14**	**-0.11**	**$0.15**

Note: Percent impacts do not sum to 100% because they represent changes in average demand as opposed to total consumption. Pricing periods consisted of different hour durations, typically 4 hours for unfavorable, 6 hours for non-preferred, and up to 14 hours for optimal. Confidence intervals are at 90%.

In addition to daily optimization, the WHO Pilot included demand response (DR) events on forecasted system peak days. In total, there were 12 three-hour events, all held from 2:00 p.m. to 5:00 p.m. in July and August. On average, each thermostat achieved a load reduction of 0.19 kW during events, which was 29% of the baseline cooling load. Baseline EV charging load was much lower than thermostat load during event hours, given the low incidence of charging at this time of day. However, the optimization successfully shifted nearly all of the remaining charging load out of the event hours. On average, each EV achieved a load reduction of 0.17 kW during events, representing a 92% reduction of the baseline charging load. Given the slightly larger per-device load impacts as well as the larger total number of devices, the pilot total per-event impacts were about four times greater for thermostats than for EVs (0.13 MW vs 0.03 MW; Table 3).

Table 3. Average Per-Device and Total Load Impacts During Events

Device Type	Average Per-Device			Average Per-Event Total Impact		
	Baseline (kW)	Impact (kW)	% Impact	Average Treated Devices	Baseline (MW)	Impact (MW)
Thermostat	0.60	-0.19	-29%	711	0.43	-0.13
EV	0.18	-0.17	-92%	191	0.03	-0.03

Note: Average impacts exclude events on July 15–July 17 due to a small number of treated devices.

A key objective of the WHO Pilot was to reduce costs for participants on the hourly rate, including reducing the volumetric charges on the energy bills associated with the pilot and capacity charges in the following year. The M&V team found that customer bill impacts were small and primarily driven by reductions in the upcoming year's annual capacity charges rather than savings on volumetric charges during the pilot, which were negligible, especially for thermostats. Volumetric bill impacts were a result of limited load shifting (particularly for thermostats) and low pricing variability between hours (for thermostats and EVs). The average participant saved about $7 per thermostat and $15 per EV in total. A household that enrolled one device of each type saved $22 on average, of which 87% can be attributed to annual savings on the next year's capacity charges. In total, the WHO Pilot saved participants $863 in volumetric charges and over $10,000 in capacity charges (Table 4).

Table 4. Per-Device and Total Customer Bill Impacts

Device Type	Average Per-Device			Average Enrolled Devices	Pilot Total		
	Pilot Period Volumetric Savings	Annual Capacity Charge Savings*	Total Savings		Pilot Period Volumetric Savings	Annual Capacity Charge Savings*	Total Savings
Thermostat	-$0.18	-$7.04	-$7.22	981	-$178	-$6,901	-$7,079

Device Type	Average Per-Device			Average Enrolled Devices	Pilot Total		
	Pilot Period Volumetric Savings	Annual Capacity Charge Savings*	Total Savings		Pilot Period Volumetric Savings	Annual Capacity Charge Savings*	Total Savings
EV	-$2.61	-$12.27	-$14.89	262	-$685	-$3,216	-$3,901
Total	**-$2.79**	**-$19.31**	**-$22.10**	**1,243**	**-$863**	**-$10,117**	**-$10,980**

*Assumes $120/kW-year clearing cost

Conclusion and Recommendations

This pilot served as a practical test of how far individual end-use technologies (smart thermostats and EVs) can be pushed to respond to real-time pricing signals. Given the optimization strategy deployed in the WHO Pilot, thermostat optimization primarily tested responsiveness to *extreme (negative or high)* pricing signals whereas EV optimization tested responsiveness to *relative* pricing signals within a short period of time. Overall results indicate that optimization can deliver incremental improvements, but the overall magnitude of impacts is constrained by customer behavior, optimization strategy, and market conditions. For thermostats, impacts were primarily bound by market conditions and daily optimization strategies that seek to account for customer comfort limitations by focusing load shifting on highly priced hours. For EVs, impacts were constrained by pre-existing charging behavior, with most load already occurring in lower-priced overnight hours, thereby limiting the opportunity for additional shifting away from higher-price periods. More broadly, the pilot demonstrated that the effectiveness of optimization is sensitive to price signal strength and differentiation, timing of implementation, and customer end-use flexibility and behavioral patterns.

Participant Engagement and Pilot Execution

- **Conclusion:** The WHO Pilot successfully recruited and retained a substantial number of participants and implemented the experimental design as intended. Enrollment was strong, attrition was low, and the rotating treatment and control framework was executed consistently with the planned design, supporting robust impact estimation.
    - **Recommendation:** Future efforts should leverage components of the existing engagement model, which has proven effective. Future efforts should continue to build on this pilot using rigorous experimental design practices. More specifically, future pilots should explore enhancements to support participant-level impact estimation, particularly for capacity-related outcomes. This may include approaches that leverage all available days to improve estimation stability, as well as methods to better capture customer-specific counterfactuals during critical peak periods. These enhancements would improve the ability to quantify customer-level value, including capacity charge impacts, which are not fully observable under a rotating design alone.

- **Conclusion:** The implementation team released four product improvements for smart thermostat daily optimization between July and September 2025, including user-defined cost categories, schedulable inactive times, clearer setpoint transparency, and in-app reason messaging, in direct response to participant feedback. Because these releases occurred during the pilot period without upfront planning to account for them in the research design, their individual performance contributions are incorporated into the overall results and not assessed incrementally.
    - **Recommendation:** To better understand the impacts of individual upgrades on optimization outcomes, in future pilots, the pilot team should proactively plan for new releases so that the M&V approach can be designed to account for them, as practical and feasible. For example, the team should consider implementing pilots in two phases, in which updates to the optimization strategy or user experience are deployed at a predetermined time, or testing updates on a subset of participants using experimental design.

Thermostat Optimization Performance and Constraints

- **Conclusion:** Daily thermostat optimization (implemented only during hours with positive prices of $0.08/kWh or greater) demonstrated limited load shifting given the temperature conditions and price signals observed during the WHO Pilot. Cooling load is well-aligned with high-price hours, creating a strong theoretical opportunity for optimization. However, impacts were constrained by the optimization approach and market conditions, which resulted in infrequent optimization. As a result, thermostat daily optimization overall did not produce meaningful load or bill impacts. Based on the targeted sensitivity analysis, increasing temperature setbacks and expanding optimization hours could approximately double load impacts during higher-priced periods; however, volumetric bill savings are likely to remain modest.
    - **Recommendation:** Consider reducing the price threshold at which daily optimization is deployed and testing more aggressive default temperature shifts during higher-priced hours, while being mindful of customer comfort. While these adjustments may result in greater load impacts, they introduce the risk of decreased customer comfort and associated increased overrides or attrition. Nevertheless, testing how far setpoint adjustments can be pushed under daily optimization will be valuable, especially if implemented with an experimental design (e.g., control group, mild treatment group, aggressive treatment group) to allow for robust measurement of differential load impacts, override rates, and customer satisfaction outcomes.
- **Conclusion:** Event-based dispatch demonstrated a strong, consistent load impact signal, with meaningful reductions during event hours and associated energy savings on average. The greater load reductions during events are consistent with the more aggressive thermostat setpoint adjustments utilized for events compared to daily optimization. However, given the differing optimization logic for event days compared to daily optimization, snapback was sometimes observed in highly priced hours.

Increased total cooling energy consumption was also observed on some event days, possibly caused by preconditioning.

- **Recommendation:** Refine thermostat optimization algorithms to minimize snapback during high-price hours and investigate the role of preconditioning in increasing total energy consumption.

EV Optimization Performance and Constraints

- **Conclusion:** EV optimization delivered meaningful relative load shifting, but absolute impacts and resulting bill savings were limited by pre-existing charging behavior. Participants were already charging predominantly during low-priced overnight hours before optimization, which limited the amount of load available to shift, and, therefore, the potential for additional bill savings. As a result, optimization produced incremental improvements, but absolute reductions in high-priced hours and associated bill impacts were modest.
  - **Recommendation:** Focus EV optimization on customers with less optimized baseline charging behavior. Consider segmenting customers based on charging flexibility and baseline behavior to better target customers with optimization potential.
- **Conclusion:** EV optimization did not consistently concentrate charging during the lowest-priced hours. In some cases, charging was initiated later than optimal, resulting in load extending into early morning hours when prices were higher than overnight lows. This suggests that optimization did not fully capture available low-cost periods, potentially due to discrepancies between the day-ahead price forecast and real-time prices.
  - **Recommendation:** Refine EV optimization algorithms to better prioritize the lowest-priced hours and avoid delayed charging that extends into higher-priced morning periods. This includes improving alignment between charging schedules, state-of-charge requirements, and real-time price signals to ensure low-cost windows are fully utilized.
- **Conclusion:** EV optimization to the hourly pricing signal did not mitigate, and in some periods exacerbated, the charging timer peak observed among participants in their baseline charging patterns.
  - **Recommendation:** Before deploying managed charging to the hourly pricing signal at scale, test strategies that layer optimization to the hourly pricing signal with distribution system optimization that seeks to flatten EV charging load for a given asset or geography. Notably, introducing distribution system optimization could reduce customer bill impacts from optimization but has the potential to open up new value streams which are potentially more compelling given the minimal customer bill impacts observed in the pilot.

Market Conditions and Pilot Timing

- **Conclusion:** The WHO Pilot was conducted during a period characterized by limited variation in hourly prices, a relatively small number of high-price hours, and seasonal transition to milder months with reduced cooling load. These factors significantly constrained the ability to realize volumetric bill savings and the magnitude of observable load shifting impacts, particularly for thermostats.
    - **Recommendation:** For thermostat pilots, conduct future pilots during periods with more extreme temperatures and greater price volatility, fully covering peaking conditions. Alternatively, use scenario analysis or simulation to evaluate performance under alternative pricing environments.

Bill Impacts and Value Realization

- **Conclusion:** The WHO Pilot produced limited overall bill savings, with most value driven by event-based reductions in capacity charges, rather than daily optimization. Daily optimization produced minimal to no volumetric savings and was constrained by the non-differentiated price signal, limited load shifting, and increased energy consumption in some cases. Capacity-related savings represented the majority of total bill savings. Insights into customer value beyond bill impacts, such as perceived satisfaction related to comfort, convenience, and overall experience, are limited and may represent an important area for further evaluation.
    - **Recommendation:** Position future pilots around the primary bill benefit of reducing capacity charges and scarcity pricing avoidance rather than daily bill savings, while clearly communicating the timing and source of savings (immediate vs. future, as is the case with capacity charges)
    - **Recommendation:** Conduct additional analysis to understand and quantify potential impacts under alternative price scenarios and better understand the upper bound of achievable optimization benefits.
    - **Recommendation:** Incorporate customer research into future pilots to assess satisfaction and capture non-energy benefits, such as comfort and convenience, which may represent an important component of customer value given the limited bill savings observed.