2023 Load Impact Evaluation of San Diego Gas & Electric's AC Saver Day Of Program

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1. Executive Summary

San Diego Gas & Electric Company's (SDG&E) AC Saver Day Of program is a demand response resource based on central air conditioner (CAC) load control that is implemented through an agreement between SDG&E and Itron, Inc. AC Saver Day Of was previously marketed to SDG&E customers as the Summer Saver program – the program name changed to AC Saver Day Of in 2018. This report provides ex post load impact estimates for the 2023 AC Saver Day Of program. Per CPUC Decision 23-12-005[1], the AC Saver Day Of program will be discontinued starting in 2024. As such, ex ante impacts are not included in this report.

The AC Saver Day Of program is available to residential and commercial customers in the SDG&E territory. There are two enrollment options for both residential and commercial customers. Residential customers can choose between 50% or 100% cycling and commercial customers can choose between 30% and 50% cycling. AC Saver Day Of events may be called between 12 PM and 9 PM, and each event may last from a minimum of two to a maximum of four hours in duration. The incentive paid for each option varies and is based on the number of CAC tons under control at each premise. Load control is enabled through devices installed on enrolled CAC units that receive dispatch signals from the program's control system, delivered through a public paging network.

The AC Saver Day Of season runs from April 1 through October 31. Program events can be triggered up to 80 hours per year, 24 hours per month, and three consecutive days at maximum with a total of no more than 20 events per year. Events can occur on weekends but not on holidays and cannot be called more than three days in any calendar week. An AC Saver Day Of event may be triggered by temperature or system load conditions and customers are not automatically notified when an event occurs; however, customers can sign up to receive event notification.

At the end of 2023, there were 9,458 customers enrolled in the program with a total cooling capacity of 45,786 tons. These counts represent all the customers who were enrolled at some point during the 2023 season. For the 2023 program year, there were 7,360 residential customers, representing approximately 78% of AC Saver Day Of participants, and 26,691 cooling tons, accounting for about 58% of the program's total tonnage. In the commercial customer class, there were 2,098 participants and 19,096 cooling tons enrolled. Among residential participants, 31% selected the highest cycling option (100% cycling); among commercial participants, 77% selected the 50% cycling option over the 30% option.

A total of 15 regular program events were called in 2023 with event hours ranging between 5 PM and 9 PM. There were six events called on weekend days. Event hours varied but the most common event period was 7 to 9 PM, which comprised 8 of the 15 events. To align with previous evaluations, the event period from 6 to 8 PM is used for reporting Average Event Day load impacts, which has historically been the most common event period. Load impacts were estimated using a statistically matched control group for both the residential and commercial customers. Table 1-1 shows the

[1] See CPUC Decision (D.) 23-12-005, "Decision Directing Certain Investor-Owned Utilities' Demand Response Programs, Pilots, and Budgets for the Years 2024-2027"

overall 2023 AC Saver Day Of residential ex post load impacts and maximum event window temperatures. The blue-colored rows indicate events that occurred on weekdays from 6 to 8 PM and were used to estimate the average event impacts. The orange-colored rows indicate events that occurred on weekends. The aggregate demand reduction for residential customers on average event days totaled 0.59 MW, or 0.08 kW per premise. Thirteen out of the 15 individual residential event impacts were statistically significant. The largest aggregate load reduction was 0.95 MW on the event on August 28, 2023.

Table 1-1: 2023 AC Saver Day Of Average Residential Ex Post Load Impacts

Date	Impact				Max Event Window Temperature (°F)
	Per Ton (kW)	Per Device (kW)	Per Premise (kW)	Aggregate (MW)	
7/2/2023	0.00	0.01	0.01	0.06	70
7/14/2023	0.01*	0.03*	0.04*	0.29*	78
7/15/2023	0.01*	0.02*	0.02*	0.18*	72
7/16/2023	0.00	0.02	0.02	0.13	76
7/20/2023	0.02*	0.07*	0.09*	0.62*	79
7/21/2023	0.02*	0.05*	0.06*	0.42*	75
7/22/2023	0.01*	0.03*	0.03*	0.23*	73
7/25/2023	0.03*	0.09*	0.11*	0.78*	80
8/14/2023	0.01*	0.04*	0.05*	0.37*	74
8/15/2023	0.02*	0.06*	0.07*	0.52*	79
8/16/2023	0.02*	0.07*	0.08*	0.62*	85
8/28/2023	0.04*	0.11*	0.13*	0.95*	87
8/30/2023	0.02*	0.05*	0.06*	0.45*	84
9/9/2023	0.03*	0.08*	0.09*	0.69*	82
9/10/2023	0.03*	0.09*	0.10*	0.73*	81
Average**	**0.02***	**0.07***	**0.08***	**0.59***	**82**

* Indicates statistically significant impacts
** Reflects the average 6 PM to 8 PM weekday 2023 AC Saver Day of event

Table 1-2 shows the 2023 AC Saver Day Of ex post load impacts for the commercial segment. The aggregate load reduction for commercial customers on average event days was roughly 0.09 MW, or 0.04 kW per premise. Individual impacts for six of the events were statistically significant.

Table 1-2: 2023 AC Saver Day Of Average Commercial Ex Post Load Impacts

Date	Impact				Max Event Window Temperature (°F)
	Per Ton (kW)	Per Device (kW)	Per Premise (kW)	Aggregate (MW)	
7/2/2023	0.03*	0.10*	0.23*	0.49*	69
7/14/2023	0.00	0.01	0.01	0.03	77
7/15/2023	0.00	-0.01	-0.03	-0.06	71
7/16/2023	0.00	0.00	-0.01	-0.01	75
7/20/2023	-0.01*	-0.04*	-0.09*	-0.19*	78
7/21/2023	0.00	0.01	0.02	0.04	74
7/22/2023	-0.02*	-0.06*	-0.14*	-0.30*	72
7/25/2023	0.02*	0.07*	0.18*	0.37*	78
8/14/2023	-0.01	-0.04	-0.11	-0.23	73
8/15/2023	0.00	-0.01	-0.03	-0.06	76
8/16/2023	0.02*	0.07*	0.16*	0.35*	83
8/28/2023	0.02*	0.07*	0.18*	0.38*	85
8/30/2023	0.01	0.02	0.05	0.11	82
9/9/2023	0.01	0.02	0.05	0.11	81
9/10/2023	0.00	0.00	0.01	0.02	81
Average*	**0.00**	**0.02**	**0.04**	**0.09**	**80**

* Indicates statistically significant impacts
** Reflects the average 6 PM to 8 PM weekday 2023 AC Saver Day of event

2. Introduction and Program Summary

San Diego Gas & Electric Company's (SDG&E) AC Saver Day Of program is a demand response resource based on central air conditioner (CAC) load control that is implemented through an agreement between SDG&E and Itron, Inc.[2] This report provides 2023 ex post load impact estimates as required by the California Public Utilities Commission (CPUC) Load Impact Protocols.[3] Because the program is sunsetting in 2023[4], ex ante impacts are not included in this report.

The AC Saver Day Of program is classified as a day-of demand response program and is available to both residential and commercial customers. AC Saver Day Of events may only be called during the months of April through October. Under the current program framework, events can be triggered up to 80 hours per year, 24 hours per month, and three consecutive days at maximum with a total of no more than 20 events per year. Load control events can occur on weekends but not on holidays and cannot be called more than three days in any calendar week. These program rules apply to both residential and commercial customers alike.

Under program design changes that took place in 2017, event triggers vary by month. During the program's operational season, an AC Saver Day Of event can be triggered by any of the following criteria:

- Generator heat rates reaching or exceeding 35,000 Btu[5] per kWh in April, May, June, or October; or 25,000 Btu per kWh in July, August, or September;
- Imminent statewide or local emergencies, extreme conditions, and/or local distribution needs; or
- Upon the award of a bid into the California Independent System Operator (CAISO) wholesale market.

AC Saver Day Of events may be called between 12 PM and 9 PM, and each event may last from a minimum of two to a maximum of four hours in duration.

There are two enrollment options for both residential and commercial participants. Residential customers can choose to have their CAC units cycled 50% or 100% of the time during an event. The incentive paid for each option varies: the 50% cycling option pays $10.35 per ton per year of CAC capacity and the 100% cycling option pays $27 per ton per year.

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[2] AC Saver Day Of was previously marketed to SDG&E customers as the Summer Saver program. The program name changed to AC Saver Day Of in 2018.

[3] See CPUC Rulemaking 07-01-041 Decision (D.) 08-04-050, "Adopting Protocols for Estimating Demand Response Load Impacts" and Attachment A, "Protocols."

[4] See CPUC Decision (D.) 23-12-005, "Decision Directing Certain Investor-Owned Utilities' Demand Response Programs, Pilots, and Budgets for the Years 2024-2027"

[5] British thermal unit, defined as the amount of heat required to raise the temperature of one pound of water by one degree Fahrenheit.

For example, a residential customer with a four-ton CAC unit would be paid the following in the form of an annual credit on their SDG&E bill:

- $41.40 for 50% cycling; or
- $108 for 100% cycling.

Commercial customers have the option of choosing 30% or 50% cycling. The incentive payment for 30% cycling is $4.50 per ton per year and $7.50 per ton per year for the 50% cycling option.

For instance, a commercial customer with five tons of air conditioning would be paid the following in the form of an annual credit on their SDG&E bill:

- $22.50 for 30% cycling; or
- $37.50 for 50% cycling.

Customer enrollment in the AC Saver Day Of program is summarized in Table 2-1. The table includes all customers who were enrolled throughout the 2023 season. There were 9,458 customers enrolled in the program, representing 45,786 tons of CAC capacity in aggregate. For the 2023 program year, residential customers represented approximately 78% of AC Saver Day Of participants and accounted for about 58% of the program's total cooling tons. About 69% of residential customers selected the 50% cycling option and approximately 77% of commercial customers chose the 50% cycling option, which represents the higher of the two cycling strategies offered to those customer segments. Total enrollment—as measured by the number of customers, number of devices, and CAC capacity (in tons)—has generally decreased for residential and commercial customers since 2017 due to minimal marketing to attract new participants to the program.

Table 2-1: 2023 AC Saver Day Of Enrollment

Customer Type	Cycling Option	Enrolled Customers	Enrolled Control Devices	Enrolled Tons
Residential	50%	5,087	5,777	17,450
	100%	2,273	2,696	9,241
	Total	7,360	8,473	26,691
Commercial	30%	491	1,510	5,644
	50%	1,607	3,654	13,452
	Total	2,098	5,164	19,096
Grand Total		**9,458**	**13,637**	**45,786**

Participants in the AC Saver Day Of program can opt into event notifications, which can be received via thermostat display, customer portal, email, and/or text message. The percentage of customers in

each cycling group who are notified via text or email are summarized in Table 2-2. In the 2023 program year, the majority of customers in each customer group and cycling option opted into event notifications. The table includes all customers who received notifications throughout the 2023 season, except for events on July 14, July 15, and July 16, which did not have available notification data.

Table 2-2: Percentage of Customers Receiving Event Notifications

Group	Cycling Option	Notification Method			Cycling Option Total	Number of Customers
		Only Text	Only Email	Both Text and Email		
Residential	50%	3%	8%	82%	94%	4,774
	100%	4%	18%	68%	89%	2,030
	Total	**3%**	**11%**	**78%**	**92%**	**6,804**
Commercial	30%	3%	33%	36%	72%	353
	50%	2%	36%	44%	81%	1,307
	Total	**2%**	**35%**	**42%**	**79%**	**1,660**

On December 14, 2023, Decision (D.) 23-12-005 OP28 ordered SDG&E to terminate the AC Saver program at the end of 2023. Therefore, the program year 2023 AC Saver Day Of Load Impact Evaluation Report does not include ex-ante analysis.

2.1. Evaluation Objectives

The primary objectives of the 2023 AC Saver Day Of load impact evaluation are to:

- Estimate hourly ex post load impacts for the residential and small/medium business (SMB) program segments, for each cycling strategy, climate zone, NEM status, and dual-enrollment status in other DR programs; and
- Estimate hourly ex post load impacts and average daily load impacts for the SMB program segment for each industry group and demand category.

2.2. Report Structure

The remainder of this report is organized as follows: Section 3 summarizes the data and methods that were used to develop ex post load impact estimates and the validation tests that were applied to assess their accuracy. Section 4 contains the 2023 ex post load impact estimates. Section 5 presents the key findings and recommendations from this evaluation.

3. Data and Methodology

This section describes the datasets and analysis methods used to estimate load impacts for each event in 2023. The residential and commercial ex post load impacts were estimated using a matched control group research design.

3.1. Data

A total of 15 AC Saver Day Of events were called in 2023. Table 3-1 shows the date, day of week, start time, end time, and temperature metrics for each event. The key temperature metrics of interest for each event include mean17 (the average temperature during the event day from midnight to 5 PM), and the maximum temperature during the event window. The event hours varied from 5 PM to 9 PM across the events in 2023. Additionally, there were six events called on weekend days. In 2023, SDG&E's system peaking day was on August 28 at 5:38 PM. Thus, SDG&E called a 6 PM to 8 PM event on this date.

Table 3-1: Summary of 2023 AC Saver Day Of Events

Date	Day of Week	Start Time	End Time	Mean17 Temperature (°F)	Max. Event Window Temperature (°F)
7/2/2023	Sunday	7:00 PM	9:00 PM	69	70
7/14/2023	Friday	7:00 PM	9:00 PM	74	78
7/15/2023	Saturday	7:00 PM	9:00 PM	72	72
7/16/2023	Sunday	7:00 PM	9:00 PM	72	76
7/20/2023	Thursday	7:00 PM	9:00 PM	75	79
7/21/2023	Friday	7:00 PM	9:00 PM	71	75
7/22/2023	Saturday	7:00 PM	9:00 PM	70	73
7/25/2023	Tuesday	7:00 PM	9:00 PM	74	80
8/14/2023	Monday	6:00 PM	8:00 PM	71	74
8/15/2023	Tuesday	5:00 PM	9:00 PM	72	79
8/16/2023	Wednesday	5:00 PM	9:00 PM	75	85
8/28/2023	Monday	6:00 PM	8:00 PM	77	87
8/30/2023	Wednesday	6:00 PM	8:00 PM	75	84
9/9/2023	Saturday	6:00 PM	8:00 PM	77	82
9/10/2023	Sunday	6:00 PM	8:00 PM	76	81

Table 3-2 shows the distribution of CAC tonnage by cycling option and climate zone for the residential participant population as of October 2023. Due to the small populations of participants in the Mountain and Desert Climate Zones, they are combined into the Coastal and Inland Climate Zones, respectively, in the ex post analysis.

Table 3-2: Distribution of CAC Tonnage by Program Option and Climate Zone

Group	Cycling Option	Group	Climate Zone				Total
			Coastal	Inland	Mountain	Desert	
Residential	50%	Population	8.1%	56.3%	0.9%	0.1%	65.4%
	100%	Population	9.4%	25.0%	0.2%	0.0%	34.6%
	Total	**Population**	**17.5%**	**81.3%**	**1.1%**	**0.1%**	**100.0%**
Commercial	30%	Population	15.5%	13.9%	0.2%	0.0%	29.7%
	50%	Population	35.5%	34.8%	0.1%	0.0%	70.3%
	Total	**Population**	**50.9%**	**48.7%**	**0.3%**	**0.0%**	**100.0%**

3.2. Methodology

The primary task in developing ex post load impacts is to estimate the reference load for each event. The reference load represents the counterfactual (a measure of what participant demand would have been in the absence of CAC cycling during an event). In previous years, a randomized controlled trial (RCT) framework was utilized to estimate ex post reference loads for the residential segment. However, the implementation of this framework was associated with technical challenges and sampling error due to changes in customer load between the two control groups from one season to the next. Further, the RCT framework requires a percentage of the enrolled residential population be held back during events to serve as a control group, reducing the total load impacts of the program. Beginning in the 2021 evaluation, Resource Innovations has utilized a statistical matching framework for the residential sector.

3.2.1. Ex Post Methodology

3.2.1.1. Statistical Matching Framework

For the 2023 AC Saver Day Of load impact evaluation, a matched control group framework was used for both the residential and commercial segments. In this framework, one nonparticipant was selected as a match for each participant on each event. Interval data for approximately 165,000 randomly selected residential non-participants, and the entire SDG&E small and medium business (SMB) non-participant population (approximately 150,000 customers) were made available for the

statistical matching analysis.[6] From these candidate customers, one match was selected for each treatment customer. Each matched residential and commercial customer was chosen because they most closely resembled their matched participant in terms of the dissimilarity statistic described in Equation 3-1 and Equation 3-2, respectively. The dissimilarity statistic measures how similar each match candidate is to any given participant customer based on how well (or not) their energy usage characteristics match those of the participant on both the event day and other hot non-event days in 2023, called proxy days. After considering a variety of potential forms, different expressions for the dissimilarity statistic were found to be suited for residential and commercial customers.

The characteristics used in the residential dissimilarity statistic are:

- Hourly demand from midnight to one hour before the event period on the event day; and
- Hourly demand during the event window hours on the average proxy day.

Equation 3-1: Dissimilarity Statistic for Residential Customer Matching

$$Dissimilarity_i = \sum_{k=0}^{E_s-1} \left(EventDayHour_{k,i} - EventDayHour_{k,j}\right)^2 + \sum_{k=E_s}^{E_e} \left(ProxyDayHour_{k,i} - ProxyDayHour_{k,j}\right)^2$$

Variable	Definition
$\boldsymbol{EventDayHour_k}$	Hourly demand of the k^{th} hour of the event day
$\boldsymbol{ProxyDayHour_k}$	Hourly demand of the k^{th} hour of the proxy day
$\boldsymbol{E_s}$	Event start hour
$\boldsymbol{E_e}$	Event end hour
$\boldsymbol{j}$	AC Saver Day Of participant to be matched
$\boldsymbol{i}$	Index of the pool of control customers

The characteristics used in the commercial dissimilarity statistic are:

- Hourly demand from 7 AM to two hours before the event period on the event day; and
- Hourly demand from two hours before the event period begins to the end of the event window on the average proxy day

[6] A random sample of the residential segment was provided as candidate matches as SDG&E was only able to provide interval data for a maximum of 350,000 customers.

Equation 3-2: Dissimilarity Statistic for Commercial Customer Matching

$$Dissimilarity_i = \sum_{k=7}^{E_s-2} \left(EventDayHour_{k,i} - EventDayHour_{k,j}\right)^2 + \sum_{k=E_s-2}^{E_e} \left(ProxyDayHour_{k,i} - ProxyDayHour_{k,j}\right)^2$$

Variable	Definition
$\boldsymbol{EventDayHour_k}$	Hourly demand of the k^{th} hour of the event day
$\boldsymbol{ProxyDayHour_k}$	Hourly demand of the k^{th} hour of the proxy day
$\boldsymbol{E_s}$	Event start hour
$\boldsymbol{E_e}$	Event end hour
$\boldsymbol{j}$	AC Saver Day Of participant to be matched
$\boldsymbol{i}$	Index of the pool of control customers

These dissimilarity statistics were chosen as the optimal metrics for matching among numerous alternately specified metrics. The best metrics were chosen based on pre-treatment balance measures. Meaning, the final dissimilarity metrics used most closely matched the usage between treatment and control customers during the period before the event start time.

Matches were chosen such that only customers in the same industry (for commercial customers) and climate zone would be matched to one another. Likewise, NEM customers were only matched to other NEM customers. This approach minimizes the differences between participants and matched nonparticipants while allowing for good estimates for program subsegments of interest.

The matching process proceeds, one participant at a time, by selecting the non-participant within the same industry (commercial only), climate zone, and NEM status with the smallest dissimilarity statistic. Individual non-participants may be selected more than once as a matched control customer.

3.2.1.2. Load Impact Estimation

Ex post event impacts were estimated for a broad collection of program segments including customer class, cycling strategy, NEM status, climate zone, industry, and status of dual enrollment in other pricing and demand response programs at SDG&E.

Since a statistical matching framework was used for both segments in this evaluation, a difference-in-differences (DiD) regression methodology was employed to better control for inherent differences that likely exist between the treatment and control customers. This methodology assumes that the

program impact is equal to the difference in usage between the treatment and the control groups during the event window period, minus any pre-existing difference between the two groups. When using a DiD methodology, the matched control group does not need to perfectly match the treatment group on non-event days. Subtracting any difference between treatment and control customers on non-event days adjusts for any difference between the two groups that might occur due to random chance. Therefore, any further change between the groups in the post-treatment period can be measured as the impact of treatment.

The regression specification for estimating load impacts is shown in Equation 3-3.

Equation 3-3: Difference-in-Differences Model for Estimating Impacts

$$kWh_{i,t} = \alpha_i + \delta \text{treat}_i + \gamma \text{post}_t + \beta(\text{treat*post})_{i,t} + u_t + v_i + \varepsilon_{i,t}$$

Variable	Definition
i, t	Indicate observations for each individual i, date t, and event number *n*
α	The model constant
δ	Pre-existing difference between treatment and control customers
γ	The difference between event and proxy days common to both treatment and control group members[7]
β	The net difference between treatment and control group customers during event days– this parameter represents the difference-in-differences
u	Time effects for each date that control for unobserved factors that are common to all treatment and control customers but unique to the date
v	Customer fixed effects that control for unobserved factors that are time-invariant and unique to each customer
ε	The error for each individual customer and time period
treat	A binary indicator or whether or not the customer is part of the treatment or control group (in practice this is absorbed by the individual customer fixed effects)
post	A binary indicator that equals 0 in the pre-treatment period and 1 in the post-treatment period (in practice this is absorbed by the individual date fixed effects)
*treat*post*	A binary indicator of whether an event occurred that day–impacts are only observed if the customer is on PTS (*Treatment* = 1) and it was an event day

Hourly impact estimates for the entire residential AC Saver Day Of population were calculated by taking a weighted average of the impact estimates for each cycling option, with weights determined

[7] In practice, this term is absorbed by the time effects, but it is useful for representing the model logic.

by the number of tons enrolled on each cycling option and enrolled within each climate zone for each cycling option.

3.2.2. Ex Post Validation Analysis

Even though statistical matching should produce research groups with similar characteristics, it is still important to compare the treatment groups to the matched control groups based on electricity consumption when AC Saver Day Of events are not in effect. Specifically, it is necessary to ensure that the treatment and matched control groups follow similar usage patterns on proxy days, days similar to events in weather where an event was not called.

Figure 3-1 compares the average load profile of residential treatment customers to their matched control counterparts during 2023 proxy days. This figure indicates similar usage behavior among residential participants and their matched control counterparts. Visually, we can see that the treatment and matched control customers are very similar in usage.

Figure 3-1: Residential Matched Control and Treatment Group Comparison Average Load across All 2023 Proxy Days- All Customers

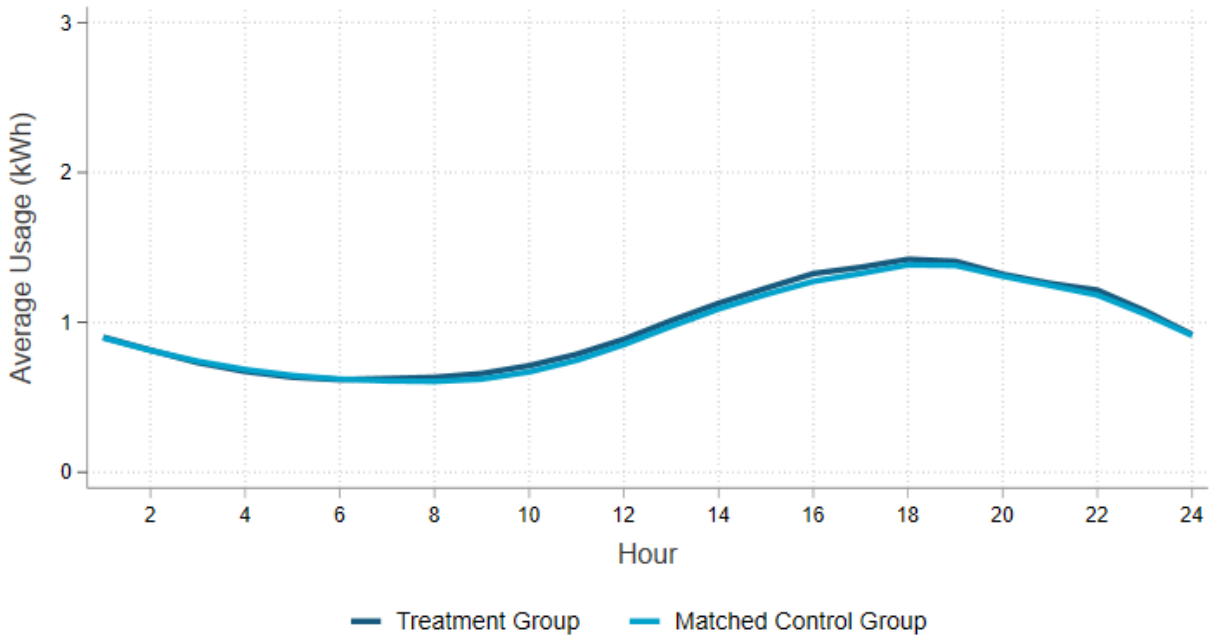
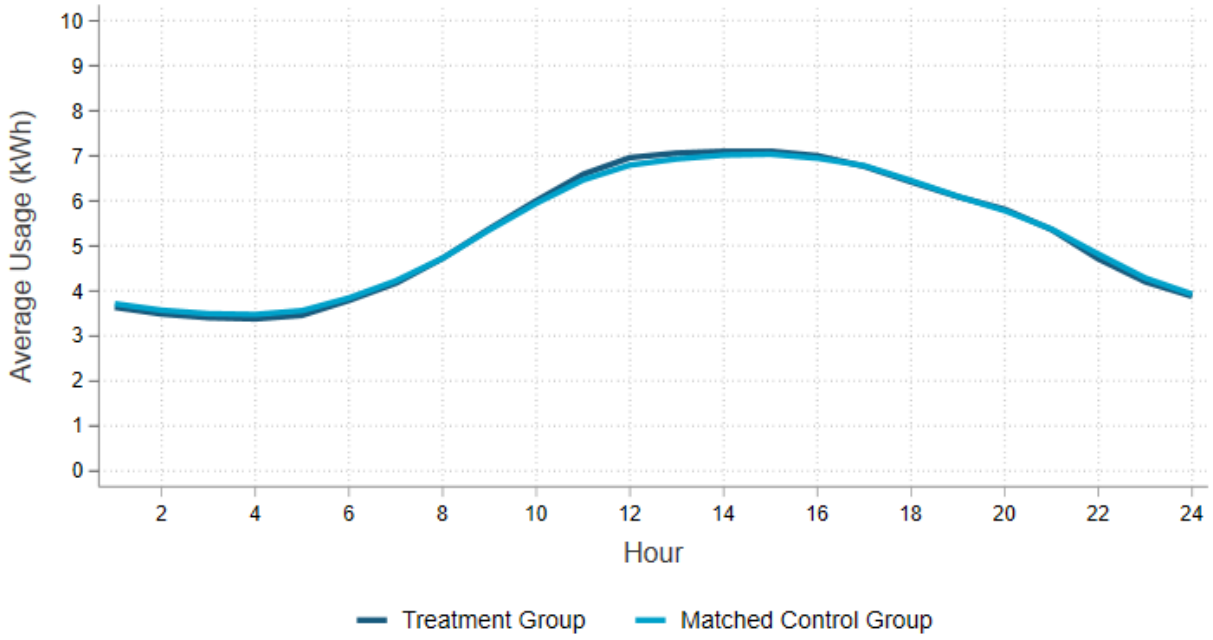


Figure 3-2 compares the average load profile of commercial treatment customers to their matched control counterparts during 2023 proxy days. Like the residential segment, commercial treatment customers exhibit very similar usage patterns to their matched control counterparts during proxy days.

Figure 3-2: Commercial Matched Control and Treatment Group Comparison Average Load across All 2023 Proxy Days



4. Ex Post Load Impact Estimates

This section contains the ex post load impact estimates for program year 2023. Residential load impacts are presented first, followed by commercial load impacts.

4.1. Residential Ex Post Load Impact Estimates

Table 4-1 presents ex post load impacts for the residential program segment for each event in program year 2023. The rows highlighted in blue represent events from 6 to 8 PM that are used in the calculation of the Average Event Day while the rows highlighted in orange represent weekend events. Thirteen of the 15 events were statistically significant at the 90% confidence level.

Aggregate residential load impacts ranged from a low of 0.06 MW on July 2, 2023 to a high of 0.95 MW on August 28, 2023. This low result on July 2 can be explained by the relatively cold weather patterns seen on that day. Temperatures during the early morning of July 2 were low with a mean17 temperature of 69°F and the highest temperature during the event period, 7-9 PM, was only 70°F. This cooler temperature during the event hours likely led to lower cooling loads and therefore load impacts, relative to other event days. The highest event impacts occurred during the event on August 28. This day had a relatively high event window temperature of 87°F and mean17 temperatures of 77°F.

For this ex post evaluation, “Average Event Day” load impacts are calculated using only events with the same event duration, at the same time of day, and only for weekday events. These criteria were selected because load impacts for the direct load control of residential CAC units may be sensitive to the hour in which the event was dispatched, so events with different event times should not be directly compared. Historically, the 6 to 8 PM event period has been the most common event period and has been used to calculate the Average Event Day. In this case, the average event day load impacts are calculated using the events August 14, August 28, and August 30. All three of these events were dispatched from 6 to 8 PM. The three 2023 AC Saver Day 0f events included in the Average Event Day estimate yield an average aggregate load reduction of 0.59 MW.

Table 4-1: AC Saver Day Of 2023 Residential Ex Post Load Impact Estimates

Event Date	Number of Customers	Impact		Mean17 (°F)	Max Event Window Temperature (°F)	Event Hours	Statistically Significant at 90% Level
		Per Site (kW)	Aggregate (MW)				
7/2/2023	7,348	0.01	0.06	69	70	7pm - 9pm	No
7/14/2023	7,348	0.04	0.29	74	78	7pm - 9pm	Yes
7/15/2023	7,348	0.02	0.18	72	72	7pm - 9pm	No
7/16/2023	7,348	0.02	0.13	72	76	7pm - 9pm	No
7/20/2023	7,349	0.09	0.62	75	79	7pm - 9pm	Yes
7/21/2023	7,349	0.06	0.42	71	75	7pm - 9pm	Yes
7/22/2023	7,349	0.03	0.23	70	73	7pm - 9pm	Yes
7/25/2023	7,351	0.11	0.78	74	80	7pm - 9pm	Yes
8/14/2023	7,355	0.05	0.37	71	74	6pm - 8pm	Yes
8/15/2023	7,355	0.07	0.52	72	79	5pm - 9pm	Yes
8/16/2023	7,356	0.08	0.62	75	85	5pm - 9pm	Yes
8/28/2023	7,360	0.13	0.95	77	87	6pm - 8pm	Yes
8/30/2023	7,361	0.06	0.45	75	84	6pm - 8pm	Yes
9/9/2023	7,361	0.09	0.69	77	82	6pm - 8pm	Yes
9/10/2023	7,361	0.10	0.73	76	81	6pm - 8pm	Yes
Average*	**7,359**	**0.08**	**0.59**	**74**	**82**	**6pm - 8pm**	**Yes**

* Blue rows indicate the weekday 6-8 PM events used in the average event calculation
** Orange rows indicate weekend and holiday events

The residential Average Event Day load impacts per premise in 2021, 2022 and 2023 were 0.06 kW, 0.20 kW, and 0.08 kW, respectively. These averages were calculated using events with similarly timed event windows (6 to 8 PM) but with varying average mean17 temperatures (73°F in 2021, 76°F in 2022, and 74°F in 2023) and average event window temperatures (81°F in 2021, 86°F in 2022, and 79°F in 2023). Figure 4-1 shows the relationship between mean17 and impact for the events in 2021, 2022, and 2023.

Figure 4-1: Residential 2021, 2022 and 2023 Ex Post Load Impacts vs. Temperature

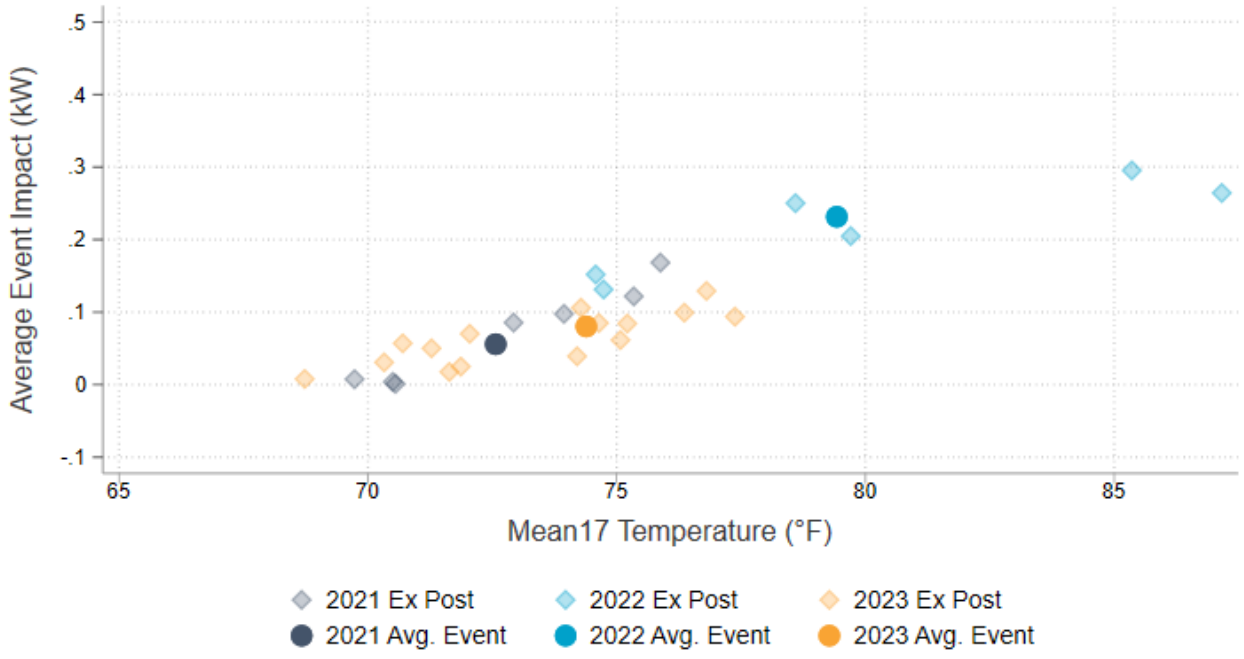


Table 4-2 shows the average per-premise reference loads, load impacts, and percent impacts for residential customers by cycling option. On the average event day, the reference load for the 50% cycling group was approximately 33% higher than the reference load for the 100% cycling group, with reference loads of 1.82 and 1.36 kW per premise, respectively. However, when comparing average percent impacts across event days, the 100% cycling customers provide larger percentage impacts, with average percentage impacts of 15% for the 100% cycling group and 1% for the 50% cycling group.

Table 4-2: AC Saver Day Of 2023 Residential Average Per-Premise Reference Load, Impacts, and Percent Impacts by Cycling Option

Event Date	Average Reference Load per Site (kW)		Average Load Impact per Site (kW)		Average Percent Impact	
	50%	100%	50%	100%	50%	100%
7/2/2023	1.05	0.80	0.00	0.02	0%	3%
7/14/2023	1.49	1.11	0.02	0.08	1%	7%
7/15/2023	1.26	0.93	0.03	0.02	2%	3%
7/16/2023	1.43	1.05	0.01	0.03	1%	3%
7/20/2023	1.67	1.19	0.09	0.07	5%	6%
7/21/2023	1.41	1.05	0.04	0.09	3%	9%
7/22/2023	1.17	0.91	0.01	0.07	1%	7%
7/25/2023	1.73	1.24	0.09	0.15	5%	12%
8/14/2023	1.44	1.03	0.03	0.08	2%	8%
8/15/2023	1.58	1.13	0.06	0.10	4%	8%
8/16/2023	1.76	1.29	0.03	0.20	2%	15%
8/28/2023	2.15	1.63	0.05	0.32	2%	19%
8/30/2023	1.87	1.44	-0.01	0.23	-1%	16%
9/9/2023	1.72	1.28	0.06	0.17	4%	13%
9/10/2023	1.75	1.29	0.07	0.16	4%	12%
Average*	**1.82**	**1.36**	**0.02**	**0.21**	**1%**	**15%**

* Blue rows indicate the weekday 6-8 PM events used in the average event calculation

** Orange rows indicate weekend and holiday events

Aggregate ex post load impacts for the residential portion of AC Saver Day Of are presented in Table 4-3 for each event day, segmented by cycling option. On the average event day, the 50% cycling participants deliver an estimated 0.12 MW of aggregate load reduction while the 100% cycling participants contribute approximately 0.47 MW.

Table 4-3: AC Saver Day Of 2023 Residential Average Per-Premise and Aggregate Load Impacts by Cycling Option

Event Date	Average Load Impact per Site (kW)		Aggregate Load Impact (MW)	
	50%	100%	50%	100%
7/2/2023	0.00	0.02	0.01	0.05
7/14/2023	0.02	0.08	0.10	0.19
7/15/2023	0.03	0.02	0.13	0.05
7/16/2023	0.01	0.03	0.07	0.06
7/20/2023	0.09	0.07	0.46	0.16
7/21/2023	0.04	0.09	0.22	0.20
7/22/2023	0.01	0.07	0.08	0.15
7/25/2023	0.09	0.15	0.44	0.34
8/14/2023	0.03	0.08	0.18	0.19
8/15/2023	0.06	0.10	0.30	0.22
8/16/2023	0.03	0.20	0.18	0.45
8/28/2023	0.05	0.32	0.23	0.72
8/30/2023	-0.01	0.23	-0.06	0.52
9/9/2023	0.06	0.17	0.31	0.38
9/10/2023	0.07	0.16	0.37	0.36
Average*	**0.02**	**0.21**	**0.12**	**0.47**

*Reflects the average 6 to 8 PM weekday 2023 AC Saver Day Of event

Table 4-4 shows estimated event impacts for residential customers segmented by usage quintiles, and Table 4-5 shows the same but segmented by usage deciles. Each customer was placed into 1 of 5 quintiles (or 1 of 10 deciles, in the case of Table 4-5) based on their average usage during the peak hours from 4 PM to 9 PM on all proxy event days in 2023. Impact estimates were calculated separately for each quintile and decile for the average event hour of the 2023 Average Event Day to determine reference loads and load impacts. Load impacts by quintile largely increase with electricity usage, however given the smaller sample sizes associated with each individual quintile, there are relatively large standard errors, as compared to the impacts, associated with these estimates. In the case of the largest quintiles, per-premise load impacts top out at 0.15 kW for 50% cycling and 0.30 kW for 100% cycling. For the largest decile, 50% cycling load impacts peak at 0.20 kW and 100% cycling load impacts peak at 0.39 kW.

Table 4-4: Residential Average Per-Premise Load Impacts by Usage Quintile and Cycling Option

Quintile	50% Cycling		100% Cycling	
	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)
1	-0.01	0.01	0.01	0.01
2	0.00	0.01	0.03	0.01
3	0.02	0.01	0.06	0.01
4	0.02	0.01	0.11	0.01
5	0.15	0.02	0.30	0.02

*Reflects the average 6 to 8 PM weekday 2023 AC Saver Day Of event

Table 4-5: Residential Average Per-Premise Load Impacts by Usage Decile and Cycling Option

Decile	50% Cycling		100% Cycling	
	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)
1	-0.01	0.01	0.01	0.01
2	0.00	0.01	0.01	0.01
3	-0.01	0.01	0.03	0.01
4	0.01	0.01	0.03	0.01
5	0.01	0.01	0.05	0.01
6	0.03	0.01	0.06	0.02
7	0.03	0.02	0.06	0.02
8	0.02	0.02	0.16	0.02
9	0.09	0.02	0.20	0.02
10	0.20	0.02	0.39	0.03

*Reflects the average 6 to 8 PM weekday 2023 AC Saver Day Of event

4.2. Commercial Ex Post Load Impact Estimates

Table 4-6 presents the ex post load impact estimates for commercial customers for each 2023 event day and the Average Event Day. Here again, the Average Event Day load impacts are calculated using the August 14, August 28, and August 30 event days. The rows highlighted in blue represent events from 6 to 8 PM that are used in the calculation of the Average Event Day while the rows highlighted in orange represent weekend events.

Weekday commercial aggregate impact estimates vary from a low of -0.30 MW on July 22 to a high of 0.49 MW on July 2. Event day temperature was generally not correlated with higher load impacts for commercial customers. The event that yielded the largest load impacts, July 2, had one of the lower mean17 and max event window temperatures. This is likely due to the fact that commercial customers in general are less responsive to changes in weather than residential customers. Note that six of the individual event impacts are negative, however four of these impacts are not statistically significant. These four negative impacts are likely due to statistical uncertainty rather than actual load increases for treatment customers. The remaining two events with negative impacts are statistically significant at the 90% confidence level.

Table 4-6: AC Saver Day Of 2023 Commercial Ex Post Load Impact Estimates

Event Date	Number of Customers	Impact		Mean17 (°F)	Max Event Window Temperature (°F)	Event Hours	Statistically Significant at 90% Level
		Per Site (kW)	Aggregate (MW)				
7/2/2023	2,099	0.23	0.49	68	69	7pm - 9pm	Yes
7/14/2023	2,099	0.01	0.03	73	77	7pm - 9pm	No
7/15/2023	2,099	-0.03	-0.06	71	71	7pm - 9pm	No
7/16/2023	2,099	-0.01	-0.01	71	75	7pm - 9pm	No
7/20/2023	2,099	-0.09	-0.19	74	78	7pm - 9pm	Yes
7/21/2023	2,099	0.02	0.04	70	74	7pm - 9pm	No
7/22/2023	2,099	-0.14	-0.30	70	72	7pm - 9pm	Yes
7/25/2023	2,099	0.18	0.37	73	78	7pm - 9pm	Yes
8/14/2023	2,099	-0.11	-0.23	71	73	6pm - 8pm	No
8/15/2023	2,099	-0.03	-0.06	72	76	5pm - 9pm	No
8/16/2023	2,099	0.16	0.35	74	83	5pm - 9pm	Yes
8/28/2023	2,098	0.18	0.38	76	85	6pm - 8pm	Yes
8/30/2023	2,098	0.05	0.11	74	82	6pm - 8pm	No
9/9/2023	2,098	0.05	0.11	77	81	6pm - 8pm	No
9/10/2023	2,098	0.01	0.02	76	81	6pm - 8pm	No
Average*	2,098	**0.04**	**0.09**	**74**	**80**	**6pm - 8pm**	**No**

*Light blue rows indicate the weekday 6-8 PM events used in the average event calculation
** Orange rows indicate weekend and holiday events

Figure 4-2 shows the relationship between mean17 and impact for all commercial events in 2021, 2022 and 2023. The dark circles show the average event mean17 between the three program years. The commercial Average Event Day (6 to 8 PM events) load impacts per premise in 2021, 2022 and 2023 were 0.09 kW, 0.10 kW, and 0.04 kW, respectively. As displayed in Figure 4-2, the mean17 temperature in 2023 was in the range of temperatures seen in the previous two years. However, as mentioned previously, commercial impacts remain relatively consistent regardless of the temperature.

Figure 4-2: Commercial 2021, 2022 and 2023 Ex Post Load Impacts vs. Temperature

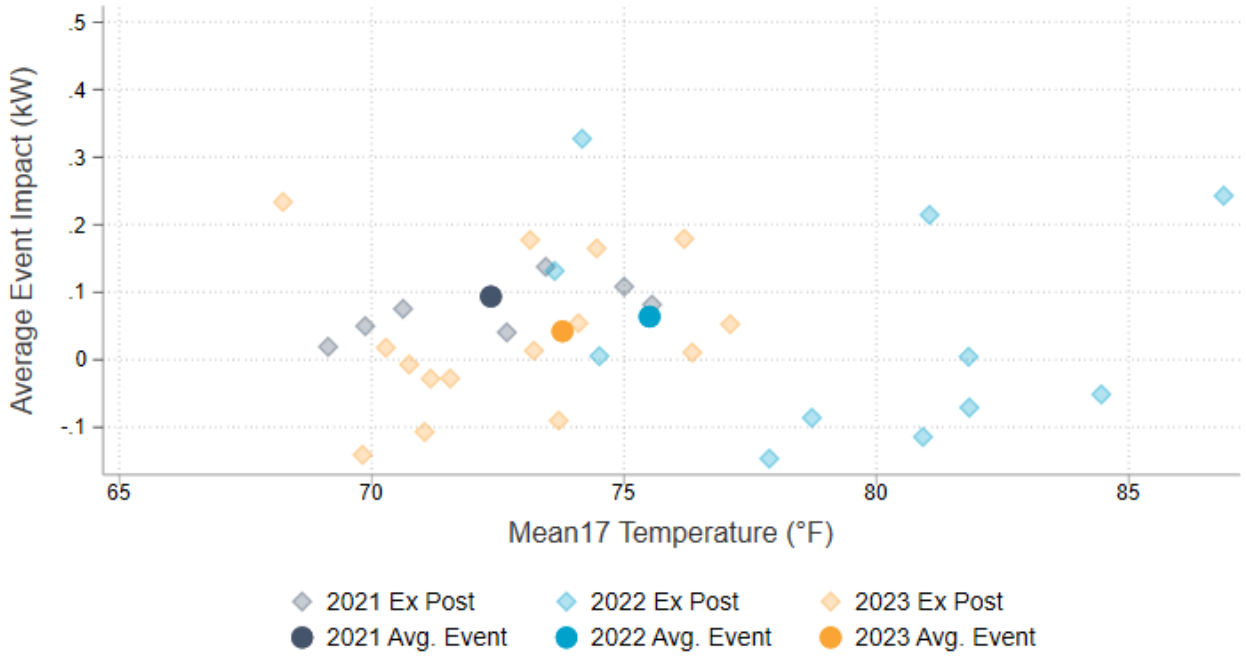


Table 4-7 presents the per-premise and aggregate load impacts for commercial participants on each event day, segmented by cycling strategy. On a per-premise basis, load impacts for the 50% cycling option range from -0.12 kW on July 22 to 0.28 kW on July 2. Per-premise load impacts for the 30% cycling option are more broadly distributed, ranging from -0.30 kW to 0.36 kW. Although the distributions of impacts vary between the groups, on the Average Event Day, load impacts for the 50% cycling group are 0.08 kW, while the 30% group has an average of -0.09 kW. The difference in aggregate impacts reflects the differences in customer enrollment between the two cycling strategies. There were 491 premises in the 30% cycling group and 1,607 in the 50% cycling group at the end of the 2023 event season.

Table 4-7: Commercial Average Per-Premise and Aggregate Load Impacts by Cycling Option

Event Date	Average Load Impact per Site (kW)		Aggregate Load Impact (MW)	
	30%	50%	30%	50%
7/2/2023	0.09	0.28	0.04	0.45
7/14/2023	0.02	0.01	0.01	0.02
7/15/2023	0.03	-0.04	0.01	-0.07
7/16/2023	-0.09	0.02	-0.05	0.03
7/20/2023	-0.23	-0.05	-0.12	-0.07
7/21/2023	-0.20	0.09	-0.10	0.14
7/22/2023	-0.21	-0.12	-0.10	-0.19
7/25/2023	0.36	0.12	0.18	0.19
8/14/2023	-0.16	-0.09	-0.08	-0.15
8/15/2023	0.00	-0.03	0.00	-0.06
8/16/2023	0.23	0.14	0.12	0.23
8/28/2023	-0.06	0.25	-0.03	0.40
8/30/2023	-0.06	0.09	-0.03	0.15
9/9/2023	-0.07	0.09	-0.03	0.14
9/10/2023	-0.30	0.11	-0.15	0.17
Average*	**-0.09**	**0.08**	**-0.05**	**0.13**

*Reflects the average 6 to 8 PM weekday 2023 AC Saver Day Of event

Table 4-8 shows estimated event impacts for commercial customers segmented by usage quintiles, and Table 4-9 shows the same but segmented by usage deciles. Each customer was placed into 1 of 5 quintiles (or 1 of 10 deciles, in the case of Table 4-9) based on their average usage during the peak hours from 4 PM to 9 PM on all proxy event days in 2023. Impact estimates were calculated separately for each quintile and decile for the average event hour of the Average Event Day to determine reference loads and load impacts.

Load impacts by quintile and decile are largely not correlated with electricity usage for 30% and 50% cycling customers. However, these impacts come with a significant amount of statistical uncertainty.

There were 491 commercial 30% cycling customers in total and dividing this group further produces a limited amount of data to evaluate. Given the smaller sample sizes associated with each individual decile for 30% cycling, there are relatively large standard errors associated with these estimates. For example, in the 1st decile of usage for 30% cycling there is a per-premise load impact of --0.33 kW with a standard error of 0.15.

Table 4-8: Commercial Average Per-Premise Load Impacts by Usage Quintile and Cycle Option

Quintile	30% Cycling		50% Cycling	
	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)
1	-0.15	0.08	0.01	0.02
2	0.05	0.02	0.01	0.01
3	-0.04	0.04	0.03	0.04
4	-0.06	0.10	0.10	0.04
5	-0.12	0.18	0.01	0.13

*Reflects the average 6 to 8 PM 2023 AC Saver Day Of Weekday event

Table 4-9: Commercial Average Per-Premise Load Impacts by Usage Decile and Cycle Option

Decile	30% Cycling		50% Cycling	
	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)	Average* Per Premise Load Impact (kW)	Load Impact Standard Error (kW)
1	-0.33	0.15	0.01	0.03
2	0.02	0.02	0.02	0.01
3	0.07	0.02	-0.01	0.02
4	0.04	0.04	0.03	0.02
5	-0.01	0.05	0.10	0.07
6	-0.08	0.07	-0.03	0.04
7	0.04	0.10	0.09	0.05
8	-0.17	0.17	0.11	0.06
9	0.15	0.21	0.05	0.08
10	-0.38	0.29	-0.04	0.26

*Reflects the average 6 to 8 PM 2023 AC Saver Day Of Weekday event

4.3. Ex Post Load Impact Comparison between 2021, 2022 and 2023

This section illustrates the differences in impacts between 2021, 2022, and 2023. Varying weather conditions in 2021, 2022, and 2023 contributed to a change in load impacts across program years. Figure 4-3, Figure 4-4, and Figure 4-5 show the daily mean17 temperature (average daily temperature between midnight and 5 PM) from May 1 through October 31 for 2021, 2022 and 2023, respectively. Each graph has a horizontal line at 75°F and red circles to represent each event day that season. In 2021, 2 of the 7 events called were on days with a mean17 over 75°F. Comparatively, in 2022, 8 of the 11 events were called with a mean17 over 75°F. In 2023, 3 of the 15 events were called with a mean17 over 75°F.

Figure 4-3: 2021 AC Saver Day Of Event Days and Mean17 Temperatures

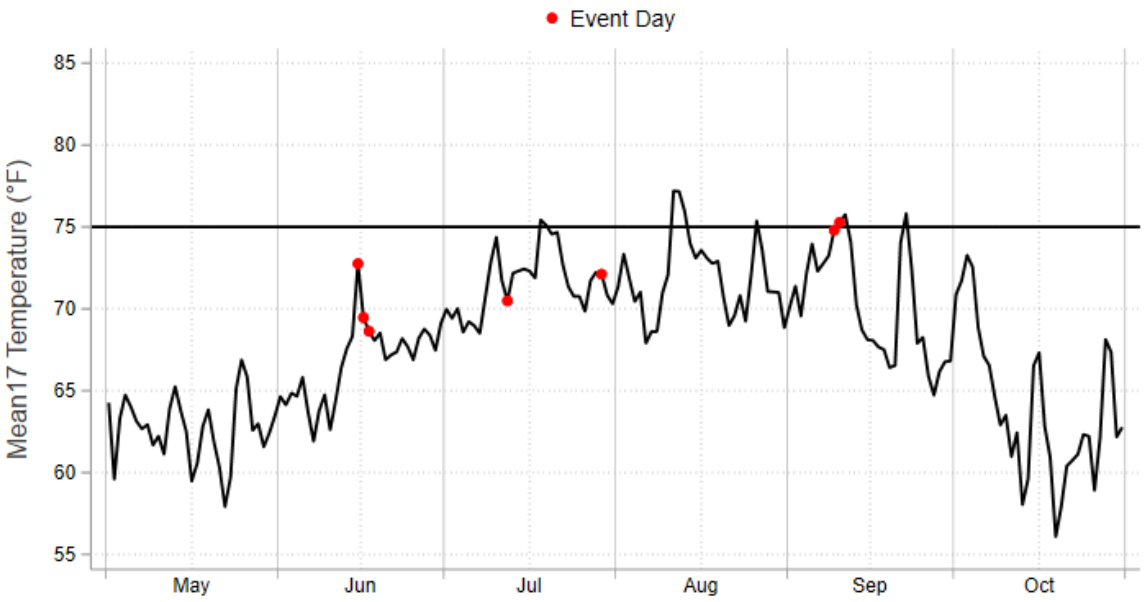


Figure 4-4: 2022 AC Saver Day Of Event Days and Mean17 Temperatures

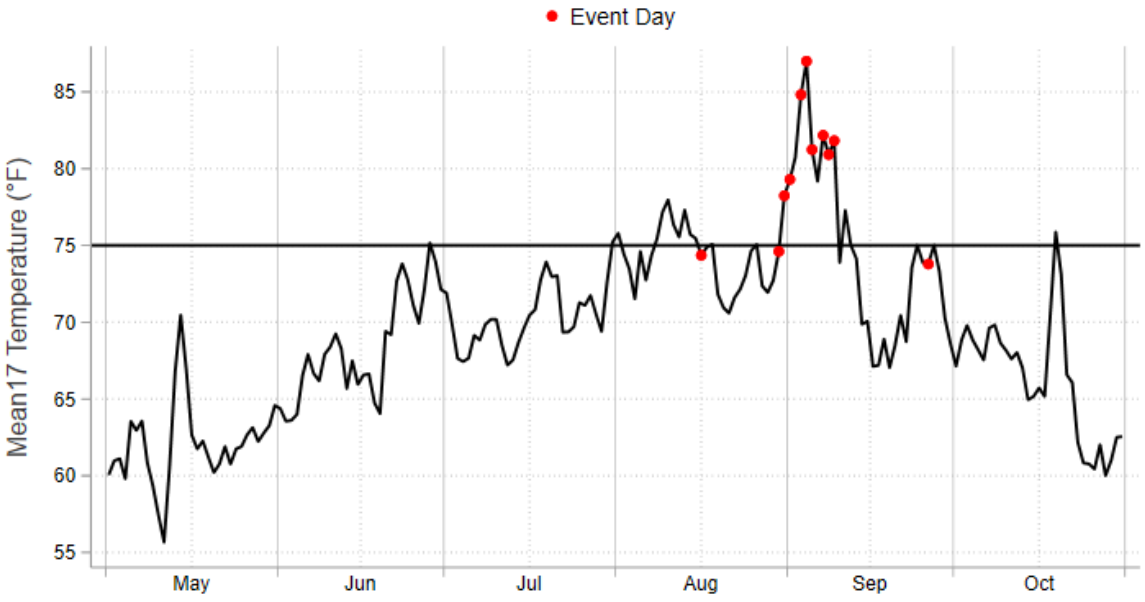


Figure 4-5: 2023 AC Saver Day Of Event Days and Mean17 Temperatures

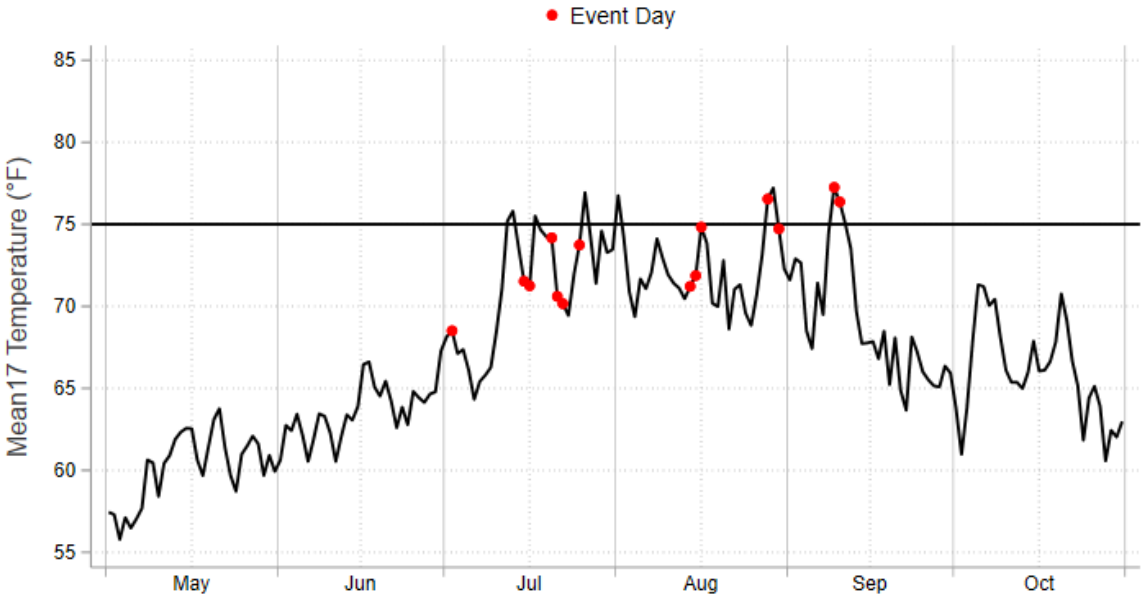


Table 4-10 shows the residential Average Event Day (6 PM to 8 PM) impacts for 2021, 2022 and 2023. Impacts were higher in 2022 in both absolute and percentage terms compared to the other two years. This is likely due to 2022 generally having higher temperatures than the other years. Furthermore, 2021 and 2023 had very similar impacts which is likely due to these being relatively cool seasons.

Table 4-10: Residential 2021, 2022, and 2023 Ex Post Impacts

Year	Avg. Event Hours	Customers Called	Mean17 Avg. Temp. (°F)	Avg. Reference Load (kW)	Avg. Load w/DR (kW)	Impact (kW)	Impact (%)	Snapback (kW)	Aggregate Impact (MW)
2021 Average Event Day	6PM - 8PM	7,798	73	1.37	1.31	0.06	4.1%	-0.04	0.44
2022 Average Event Day	6PM - 8PM	7,996	76	2.15	1.95	0.20	9.4%	-0.07	1.62
2023 Average Event Day	6PM - 8PM	7,348	74	1.68	1.61	0.08	4.8%	-0.08	0.59

Table 4-11 shows the commercial Average Event Day (6 PM to 8 PM) impacts for 2021, 2022, and 2023. Generally, impacts in the commercial segment are not as sensitive to changes in temperature as the residential segment. Thus, the 2022 program year did not have a larger percent impact than the other two program years. However, the percent impact has decreased over time, presumably due to factors such as device age and inadvertent removal.

Table 4-11: Commercial 2021, 2022, and 2023 Ex Post Impacts

Year	Avg. Event Hours	Customers Called	Mean17 Avg. Temp. (°F)	Avg. Reference Load (kW)	Avg. Load w/DR (kW)	Impact (kW)	Impact (%)	Snapback (kW)	Aggregate Impact (MW)
2021 Average Event Day	6PM - 8PM	2,312	72	5.85	5.75	0.09	1.6%	0.03	0.22
2022 Average Event Day	6PM - 8PM	2,265	76	7.83	7.76	0.10	1.2%	0.07	0.22
2023 Average Event Day	6PM - 8PM	2,099	74	6.39	6.36	0.04	0.7%	0.05	0.09

5. Findings and Recommendations

Note that the recommendations provided in this section are hypothetical, assuming that the devices will be used in some form in the future. Given the planned sunsetting and decommissioning of the program, these recommendations may not apply.

Finding 1

Commercial customers produced inconsistent impacts in 2023 when compared to residential customers. Of the 15 events called in 2023, impacts for only six events were statistically significant. Further, the commercial load impacts in 2023 were less correlated with the timing of events or the temperature during the event day. This inconsistency in commercial responsiveness to the program may be due to device operability issues, as some of the installed devices are over 15 years old. Devices that have been installed for a long time could be nonfunctional or have been inadvertently disconnected during CAC upgrades or maintenance.

Recommendation 1

To ensure that the program's direct load control devices are dispatching during events and producing load reductions, a field study should be conducted that examines the fleet of devices for functionality, prioritizing devices for commercial customers. Alternatively, a data-based analysis could be designed that uses clustering or similar techniques to identify specific devices that do not exhibit evidence of cycling during program events.

Finding 2

Most residential and commercial customers received event notifications via either text or email. The lowest rate of notification occurred in the commercial 30% cycling group, which still had 72% of customers opting into alerts. Residential customers generally opt into both text and email while commercial customers opt into receiving just emails at a similar rate as they opt into receiving both emails and texts. Despite notification methods being both widespread and varied between cycling groups, the current analysis does not explore the effect of notifications on load impacts.

Recommendation 2

To better understand the effect of notifications on load impacts, additional data-based analysis can be conducted. The event day usage of customers who receive notifications can be compared to those who do not receive notifications. This analysis will investigate how notifications affect a participant's usage. For instance, notifications may cause customers to preemptively run their AC before the event or lower the temperature of cycling AC during event hours.

Finding 3

In 2023, the majority of events yielded statistically significant impacts in the residential segment. Indeed, 12 out of the 15 events called were significant at a 90% confidence level. The three non-significant events all occurred between the hours of 7 PM to 9 PM on cooler weekends. Historically,

the AC Saver Day Of program has not called many events on weekends or from 7 PM to 9 PM. Given that later nighttime hours are associated with a drop in load for residential customers as the outside temperature decreases, it could be the program impacts are also diminished.

Recommendation 3

The choice of event hours may contribute to the impact of an event. Therefore, to better understand the role of event hours an additional study could be conducted that includes measuring the impact of customer groups experiencing different event times on the same day. Alternatively, a data-based analysis could be designed that uses the cumulative data from previous events to understand the role of event times.

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