Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

Program Year 2021 Southern California Edison Summer Discount Plan Impact Evaluation

Confidential information is redacted and denoted with black highlighting: [redacted]

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Research Team

- Josh Bode, M.P.P.
- Akhil Jonnalagadda, M.A.
- Savannah Horner, M.S.

Southern California Edison Team

- Emrah Ozkaya
- Yi (Louie) Liu
- Michael Ellison
- Patrick Riley

ABSTRACT

This study analyzes the impact of Southern California Edison's Summer Discount Plan program for a range of weather conditions and dispatch hours. Summer Discount Plan is a voluntary demand response program that provides incentives to residential and non-residential customers who allow SCE to manage the use of their air conditioner when grid conditions require additional resources. The impacts were evaluated using a quasi-experimental design where a matched control customer was identified for each participant. The load impacts were calculated via difference-in-differences by comparing the energy use of participants and the control customer during event and hot non-event days. The SDP program has approximately 180,000 residential customers enrolled and includes nearly 204,000 control devices and 774,000 tons of air conditioner load. Approximately 84% of residential customers elect the higher incentive option, allowing SCE to curtail air conditioner demand (100% cycling) during SDP demand response events. On the commercial side, there are approximately 7,700 customers enrolled with about 69,000 control devices and nearly 350,000 tons of air conditioner load. Roughly 65% of customers elect the higher incentive, accounting for 62% of the total commercial air conditioner load. During the system peak day, the SDP program reduced demand by 166 MW on the first and only event hour. Compared to prior years, 2021 was a substantially cooler year, with lower air conditioner loads, and lower SCE system demand.

During normal (1-in-2) August peak day planning conditions, participants can reduce demand by 166 MW across the five-hour 4:00–9:00 PM peak window. In practice, program resources are dispatched by grid location, with varying event times and under different weather conditions.

TABLE OF CONTENTS

FIGURES

1 EXECUTIVE SUMMARY

This report presents the load impacts of the program year 2021 Summer Discount Plan (SDP). SDP is a voluntary demand response program that provides incentives to customers who allow Southern California Edison to curtail or reduce the use of their central air conditioner on summer days with high energy usage or high energy prices. The report has two primary objectives: estimate the demand reductions that were delivered via 2021 operations and quantify the magnitude of reductions available during peaking conditions used for planning over the next eleven years (2022 – 2032).

1.1 SDP RESIDENTIAL KEY FINDINGS

The SDP Residential (SDP-R) program has approximately 180,000 customers enrolled and includes nearly 204,000 control devices and 774,000 tons of air conditioner load. Approximately 84% of customers elect the higher incentive option, which allows SCE to fully curtail air conditioner demand (100% cycling) during SDP demand response (DR) events. During normal (1-in-2) peaking conditions, participant loads peak at 462 MW, and participants can curtail demand by 150 MW on average during the 4–9 PM peak window. For extreme planning conditions (1-in-10), participant loads peak at 514 MW, and participants can reduce demand by 166 MW on average during the 4–9 PM peak window.[1]

Figure 1 summarizes the per participant demand reductions for each event hour as a function of temperature. Demand reductions grow larger in magnitude when temperatures are hotter and resources are needed most. Table 1 summarizes the reductions attained during full event hours for each event in the evaluation period (from October 2020 through September 2021). For full event hours, average impacts were in the neighborhood of 0.75 kW per participant, and percent impacts were generally around 29%.

[1] August Monthly Peaky Day using SCE Weather for 1-in-2 and 1-in-10 Peaking conditions.

Figure 1: Relationship between SDP-R Demand Reductions and Weather (R^2 = 0.83)

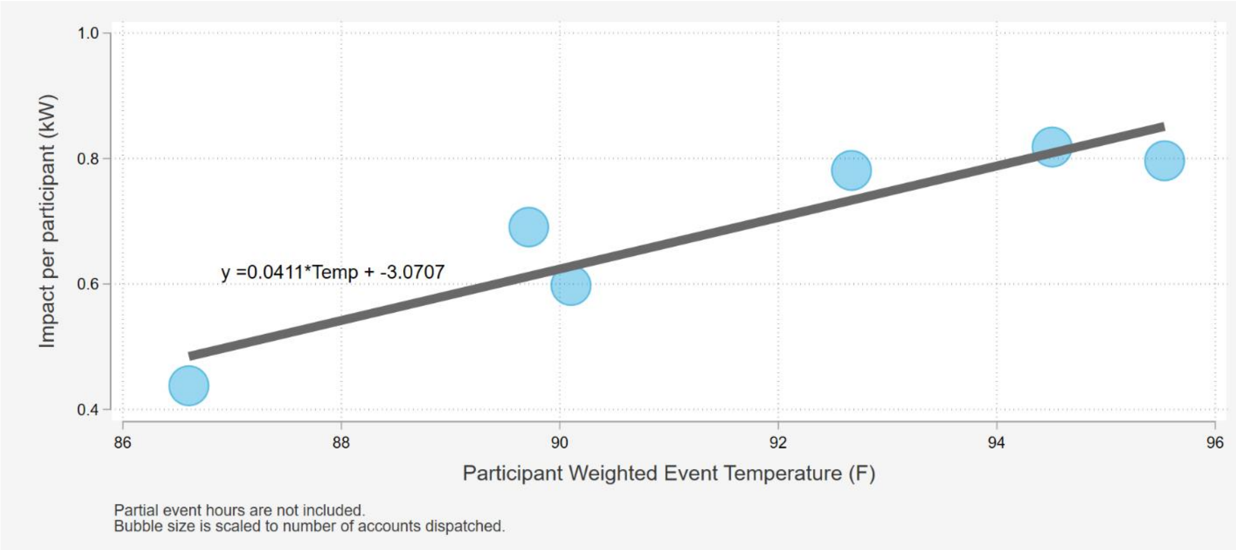


Table 1: SDP-Residential Event Summary, 2021

Date	Event start	Event end	Accts	Aggregate Impacts (MW)			Impact per ... (kW)			% Impact	Wght. Temp (F)
				Impact	90% Lower Bound	90% Upper Bound	Acct	Device	Ton		
10/14/2020	6:00 PM	7:00 PM	202	0.07	0.02	0.12	0.35	0.33	0.09	20.6%	97.8
10/15/2020	6:00 PM	7:00 PM	202	0.04	-0.03	0.11	0.22	0.20	0.05	13.5%	99.6
6/17/2021	5:00 PM	6:00 PM	168,129	116	111	121	0.69	0.60	0.16	29.3%	89.7
7/9/2021*	5:50 PM	8:50 PM	175,532	121	116	126	0.69	0.60	0.16	26.5%	91.4
8/27/2021	6:00 PM	7:00 PM	175,588	140	134	145	0.80	0.69	0.19	29.0%	95.5
9/9/2021*	3:58 PM	5:00 PM	175,962	144	138	150	0.82	0.71	0.19	30.1%	94.5
Avg. Event	**First Event Hour**		**173,803**	**132**	**129**	**135**	**0.76**	**0.66**	**0.18**	**29.0%**	**93.1**

* Only full event hours are included in impacts

Table 2: SDP-Residential Summary of Key Findings

Topic	Findings
How did SDP-R perform on the SCE system peak day (September 9th)?	During the system peak day (September 9th, 2021), SDP-R participants reduced demand by an average of 144 MW between 4:00 PM and 5:00 PM. The average demand reductions per customer, per device, and per ton for this event were 0.82 kW, 0.71 kW, and 0.19 kW, respectively.
Did performance differ for the 100% cycling and 50% cycling options?	The per-participant demand reductions for customers signed up for the 100% cycling were more than twice as large as demand reductions for those on 50% cycling. For customers in the 50% cycling group, demand reductions were negligible when temperatures are below 85° F, as there simply isn't enough cooling load to curtail.
How did 2021 weather influence the magnitude of demand reductions?	Residential air conditioner loads are highly weather-sensitive. As a result, demand reductions are larger in magnitude when temperatures are hotter, and resources are needed most. Compared to prior years, 2021 was a substantially cooler year, with lower air conditioner loads and lower SCE system demand. The range of temperatures was lower in 2021, even on peak days. As a result, the program can expect larger demand reductions with hotter temperatures.
Did the COVID pandemic affect the magnitude of demand reductions?	By the summer of 2021, the typical energy use of residential customers and residential demand reductions aligned with pre-pandemic conditions.
What is the magnitude of demand reduction capability under planning conditions?	Given current enrollments, the resource can deliver reductions of 150 MW during the peak period under 1-in-2 weather planning conditions and 166 MW under 1-in-10 weather planning conditions (August monthly peak day).

1.2 SDP COMMERCIAL KEY FINDINGS

The SDP Commercial (SDP-C) program has approximately 7,700 customers enrolled and includes about 69,000 control devices and nearly 350,000 tons of air conditioner load. Roughly 65% of customers elect the higher incentive option, which allows SCE to entirely curtail air conditioner demand (100% cycling) during SDP-C DR events. During normal peaking conditions (1-in-2 weather conditions), participant loads peak around 381 MW, and participants can curtail demand by 16 MW on average during the 4–9 PM peak window. During extreme planning conditions (1-in-10 weather conditions), participant loads peak at 397 MW, and participants can reduce demand by 19 MW on average during the 4–9 PM peak window.

Figure 2 summarizes the per-device demand reductions for each individual event hour as a function of temperature. This figure includes all full event hours in the peak period (4–9 PM). Impacts are shown per device due to the large variability in customer size. As expected for a load control program, the magnitude of demand reductions is larger when temperatures are hotter.

Table 3 summarizes the reductions attained during each event in 2021. Impacts per device were generally in the neighborhood of 0.20 kW, with a few exceptions.

Figure 2: Relationship between SDP-C Demand Reductions and Weather (R^2 = 0.81)

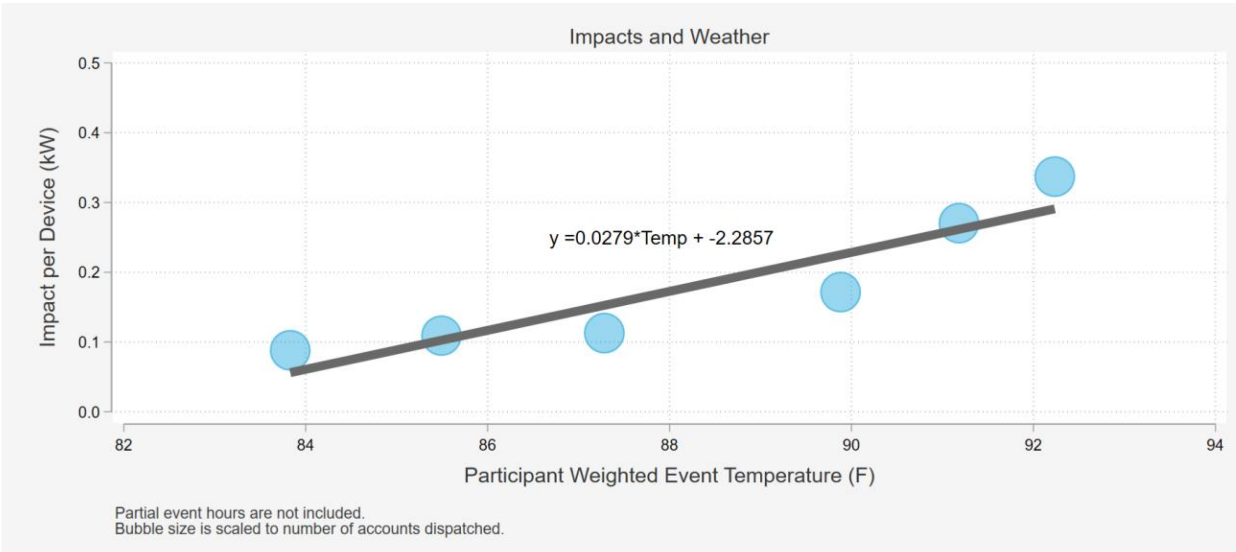


Table 3: SDP-Commercial Event Summary, 2021

Date	Event start	Event end	Accts	Aggregate Impacts (MW)			Impact per ... (kW)			% Impact	Wght. Temp (F)
				Impact	90% Lower Bound	90% Upper Bound	Acct	Device	Ton		
10/14/2020	6:00 PM	7:00 PM	[redacted]								
10/15/2020	6:00 PM	7:00 PM									
6/17/2021	5:00 PM	6:00 PM	7,418	7	3	12	1.00	0.11	0.02	6.6%	85.5
7/9/2021*	5:50 PM	8:50 PM	7,567	10	6	13	1.27	0.14	0.03	8.5%	88.6
8/27/2021	6:00 PM	7:00 PM	7,514	18	13	22	2.36	0.27	0.05	11.6%	91.2
9/9/2021*	3:58 PM	5:00 PM	7,517	22	18	26	2.94	0.34	0.07	11.1%	92.2
Avg. Event	**First Event Hour**		**7,504**	**15**	**13**	**17**	**2.00**	**0.23**	**0.04**	**10.3%**	**89.7**

* Only full hours are included in impacts

Table 4: SDP-Commercial Summary of Key Findings

Topic	Findings
How did SDP-C perform on the SCE system peak day (September 9th)?	During the system peak day (September 9th, 2021), SDP-C participants reduced demand by an average of 22 MW between 4:00 PM and 5:00 PM. The average demand reductions per customer, per device, and per ton for this event were 2.94 kW, 0.34 kW, and 0.07 kW, respectively.
How does the customer mix impact performance?	SDP-C is a very top-heavy program, as 10% of the program participants account for more than 60% of the total AC tonnage. In other words, a small handful of customers account for a majority of the AC tonnage. Schools also account for about 68% of the SDP-C AC tonnage, so demand reductions are tied to whether or not schools are in session and whether AC units are in operation. School whole building and air conditioner loads drop off considerably after 3 PM, leaving limited controllable AC loads during the 4–9 PM peak hours.
Did performance differ for the 100% cycling and 50% cycling options?	On average, percent impacts in the 100% cycling strategy group are more than two times larger than percent impacts in the 50% cycling group.
Did the COVID pandemic affect the magnitude of demand reductions?	Roughly 81.2% of the non-residential load control devices are at schools and religious institutions (often private schools). The pandemic substantially affected schools, leading to remote learning, lower facility use, and lower air conditioner loads. In 2021, the effect of the COVID pandemic largely subsided, since nearly all schools in Southern California returned to in-person learning for the 2021-2022 school year. However, there are several business types that are still experiencing lower energy use compared to pre-pandemic patterns.
What is the magnitude of demand reduction capability under planning conditions?	Given current enrollments, the resource can deliver reductions of 16 MW during the peak period under 1-in-2 weather planning conditions and 19 MW under 1-in-10 weather planning conditions (August monthly peak day).

2 INTRODUCTION

This report presents the results of the program year 2021 Summer Discount Plan (SDP) impact evaluation. SDP is a voluntary demand response program that provides incentives to residential and commercial customers who allow Southern California Edison to curtail or reduce the use of their central air conditioner on summer days with high energy usage or high energy prices. The report has two primary objectives: estimate the demand reductions that were delivered via 2021 operations and quantify the magnitude of reductions available during peaking conditions used for planning over the next eleven years (2022 – 2032).

Historically, utilities operated demand response programs to reduce peak demand and offset the need for additional peaking capacity. While peak demand reductions to offset capacity remain critical, existing programs have had to adjust as operating needs have evolved due to the higher penetration of renewable power. The most immediate changes have been the shift of system peaking conditions to the late afternoon and evening hours and the increased economic dispatch of resources.

2.1 KEY RESEARCH QUESTIONS

The impact evaluation study was designed to address the following research questions:

- What were the demand reductions due to program operations and interventions in 2021 for each event day?
- How do weather and event conditions influence the magnitude of demand response?
- How does the cycling strategy – the degree of control over the air conditioner units – relate to the magnitude of demand reductions?
- How do load impacts vary for different customer sizes, locations, and customer segments?
- Did the COVID pandemic influence the performance of the program?
- What is the magnitude of resources available under planning conditions (1-in-2 and 1-in-10 ex ante weather)?
- What concrete steps can help improve program performance?

2.2 PROGRAM DESCRIPTION

SDP is a voluntary demand response program that provides incentives to customers who allow Southern California Edison to curtail or reduce the use of their central air conditioner on summer days with high energy usage or high energy prices. All SDP participants have a load cycling switch device installed on at least one air conditioner unit. The device enables SCE to cycle the customer's air conditioner off and on to reduce load during an SDP event. SCE initiates events by sending a signal to all participating devices through radio frequency transmission. The signals instruct the switch devices to either fully curtail the use of the air conditioning system or to cycle the air condition on and off, reducing the unit's run time during events, thus reducing demand.

SCE may dispatch SDP any month of the year, but total program dispatch is limited to 180 event hours annually. On a single day, dispatch of SDP is limited to a maximum of 6 hours. In total, four events were dispatched in 2021, with three being a result of self-scheduling in the day-ahead market. While the program is designed to deliver flexible resources under system peaking conditions, SCE may dispatch SDP resources in response to:

- Grid operator warnings or emergencies
- Adverse reliability conditions on SCE's electric system such as high peak demand of loss of key transmission lines;
- High wholesale energy prices (based on CAISO bid awards); and
- Measurement and evaluation (M&E) testing.

2.3 SDP LOADS AND SYSTEM PEAKING CONDITIONS

SCE peak loads remain highly concentrated in a limited number of hours, as shown in Figure 3. System load rarely exceeded 20,000 MW during the 2021 summer. The 2021 system peak, which occurred on September 9th, was 20,750 MW. A demand response event was dispatched from 3:58 PM through 5:00 PM on the peak day – the effect of this event is visible in the solid blue line in Figure 4.

Figure 3: System Load Duration Curves

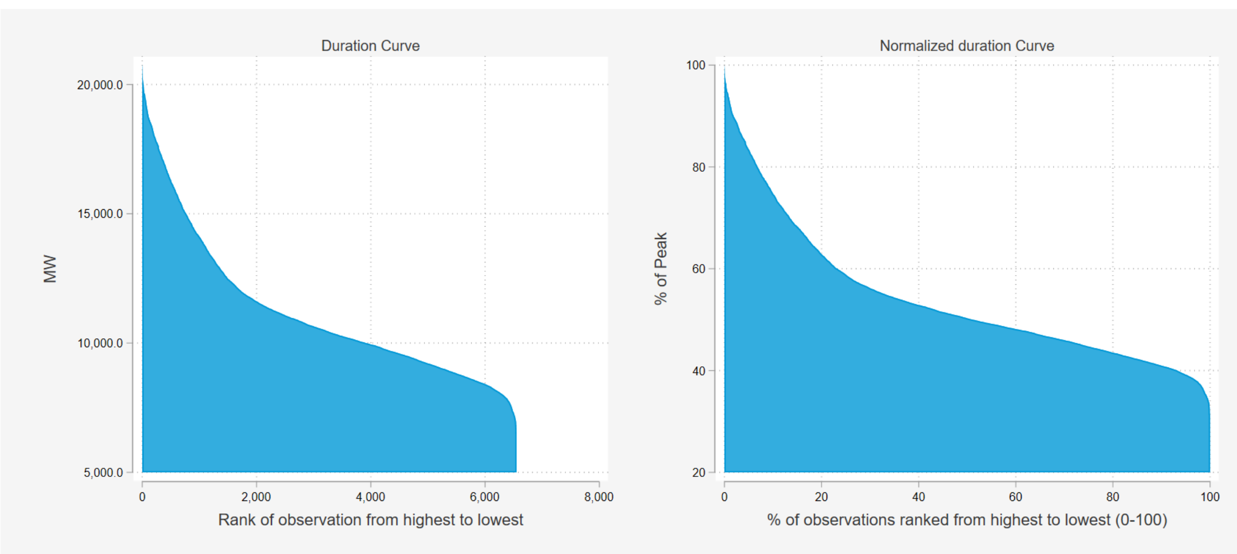


Figure 4: Top Ten System Load Days, 2021

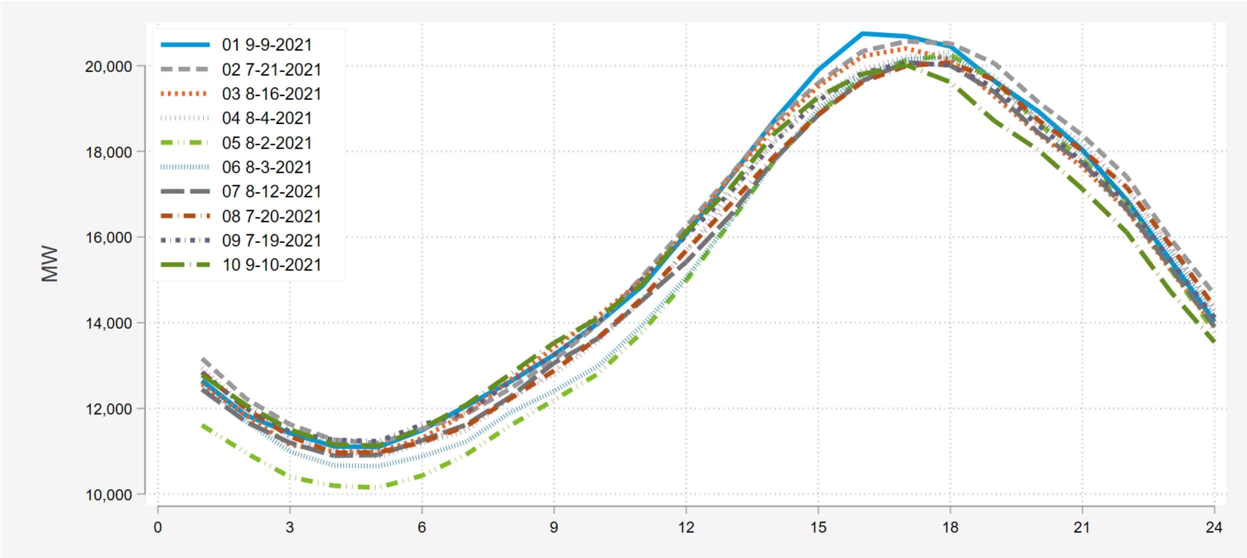


Figure 5: Top Ten System Load Days by Day Type, 2021

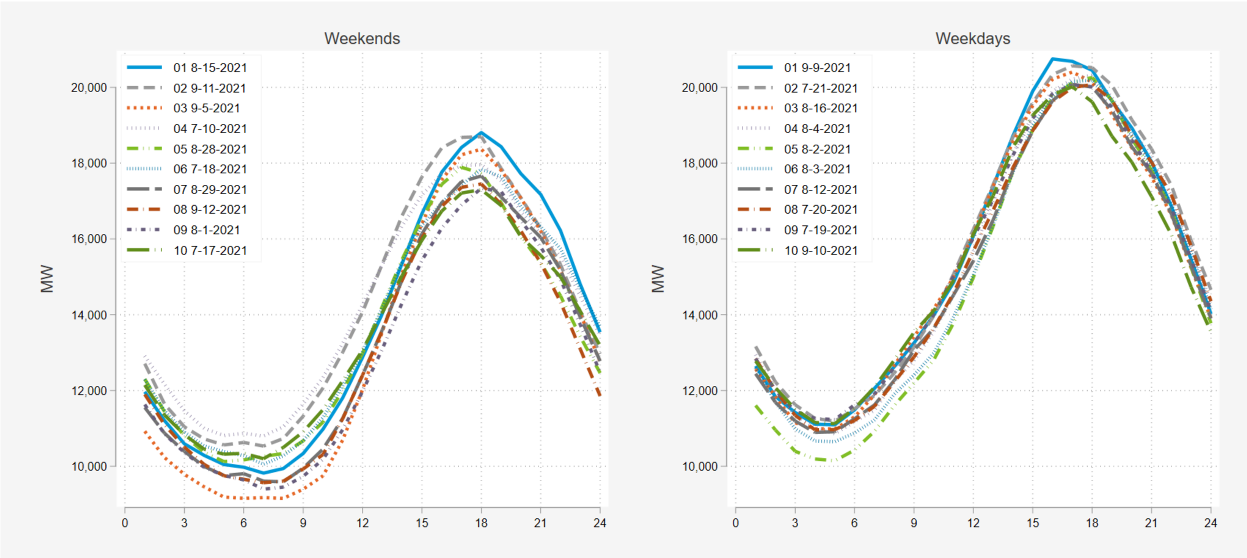
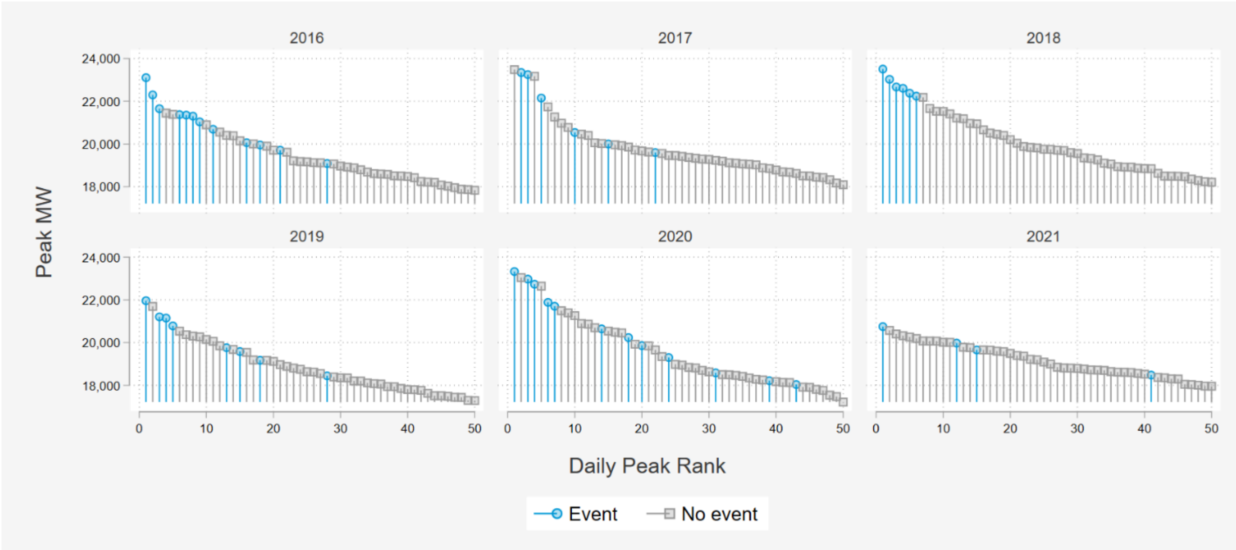


Figure 6 compares system-wide daily peaks over the past six years. System peaks in 2021 were lower than in 2019, which already had a mild summer.

Figure 6: System Peaks by Year



To estimate the program cooling load, we run a regression of whole-home loads as a function of temperature, day of week, hour of day, and month. The regression was used to parse out base load from cooling load for each hour.

The cooling loads of SDP controllable air conditioner resources tend to be larger during the 4–9 PM peak hours when SCE and CAISO system-wide peaks are higher, as shown in Figure 7 and Figure 8. Excluding event days the correlation between coincident residential cooling loads and SCE and CAISO gross peak loads is 0.89 and 0.90, respectively, indicating a very strong linear correlation (Figure 7). However, CAISO net loads are now the primary driver for planning and market prices because of the amount of utility-scale wind and solar. The correlation between residential cooling loads and CAISO net loads varies by hour and is not as strong (0.76). In specific, controllable air conditioner load is lower in later evening hours (7–9 PM) than in earlier hours in the peak period (4–7 PM). For SDP-C customers (Figure 8), there is still a moderately strong linear relationship between coincidental cooling loads and SCE gross (0.90) and CAISO gross (0.83) loads, but the correlation between of CAISO net loads is weaker (0.39).

Figure 7: Relationship Between SDP-R Cooling Loads and Peaking Conditions

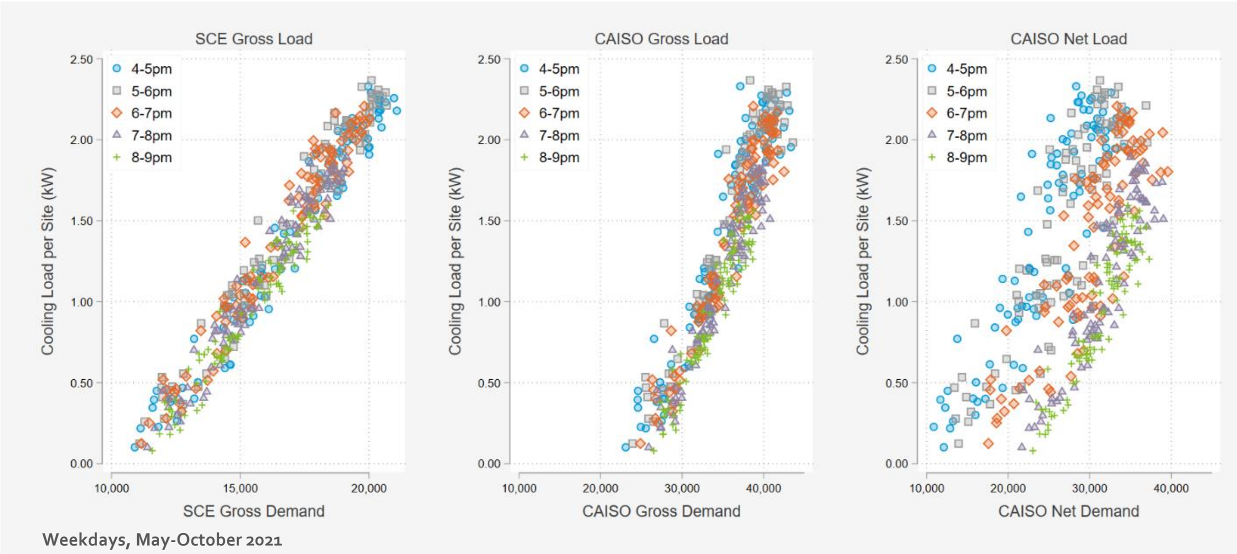
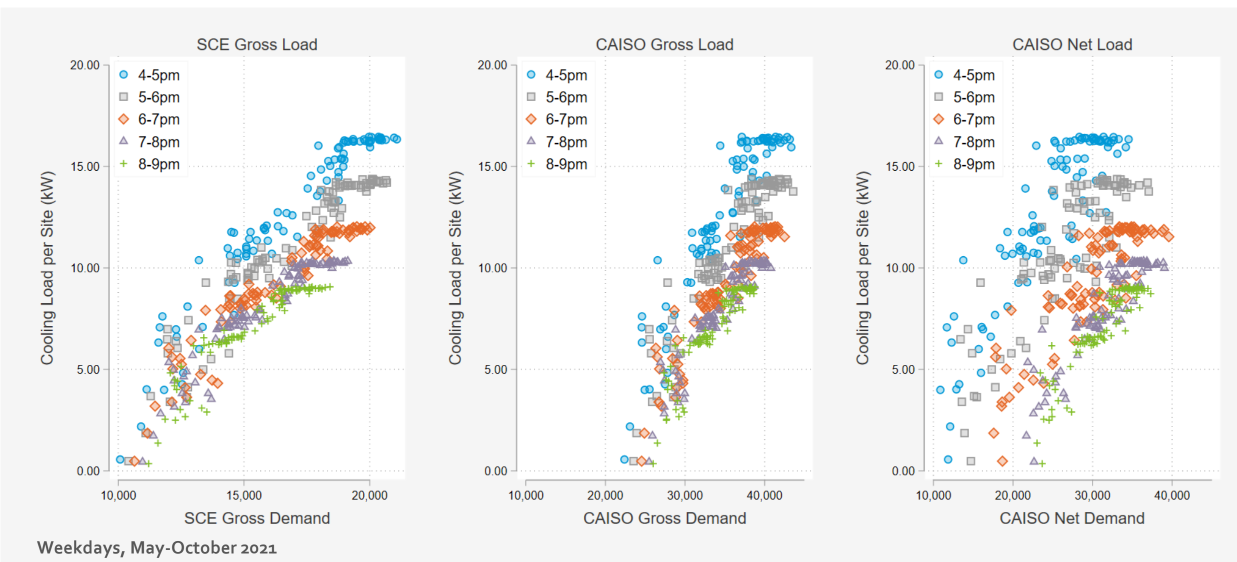


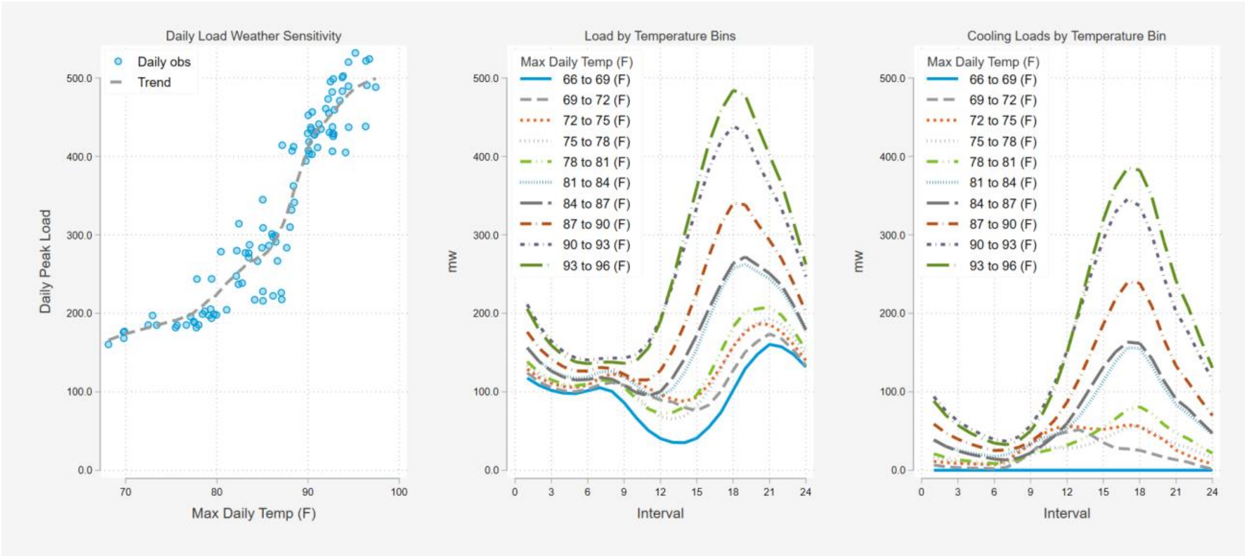
Figure 8: Relationship Between SDP-C Cooling Loads and Peaking Conditions



2.4 RESIDENTIAL PARTICIPANT CHARACTERISTICS

A total of 179,447 SCE residential customers participated in at least one SDP demand response event during the 2021 summer. On aggregate, these 179,447 customers have over 400 MW of cooling load when temperatures are hot – 91°F or higher (left pane in Figure 9). At milder temperatures in the mid-to-high 80s, these customers have closer to 200 MW of cooling load. Approximately 13% of SDP-R participants have solar power.

Figure 9: SDP-R Participant Load Summary



SDP-R customers can opt for one of two cycling strategies: 50% or 100%. For 100% cycling, participant AC units are shut off entirely during the DR event. For 50% cycling, participant AC units are shut off for fifteen minutes out of every half hour during the DR event. The large majority of homes – about 84% – are in the 100% cycling group. Participants can also sign up with an "Override" option that allows them to opt out of up to five events per year.

Table 5 shows the distribution of SDP-R participants, devices, and air conditioner tonnage by cycling strategy and several other key customer segments. Some key highlights of the SDP-R resources include:

- The majority of SDP-R participants are on 100% cycling (84%);
- SCE dispatches SDP resources by geographically defined regional subgroups known as load control groups (LCGs). The low desert load control group has the smallest share of participants (0.11%), and the other nine load control groups have somewhere between 4% and 20% of participants each;
- The majority of participants and controllable air conditioner tonnage (~77%) is in the LA Basin area, which encompasses the four SDP-Central load control groups as well as the two SDP-West load control groups; and
- Approximately 27% of participants, representing 24% of the total tonnage, are enrolled in the California Alternate Rates for Energy (CARE) program or the Family Electric Rate Assistance (FERA). Low-income residential customers enrolled in these programs receive discounts on their electric bills.

Table 5: SDP-R Participation by Category

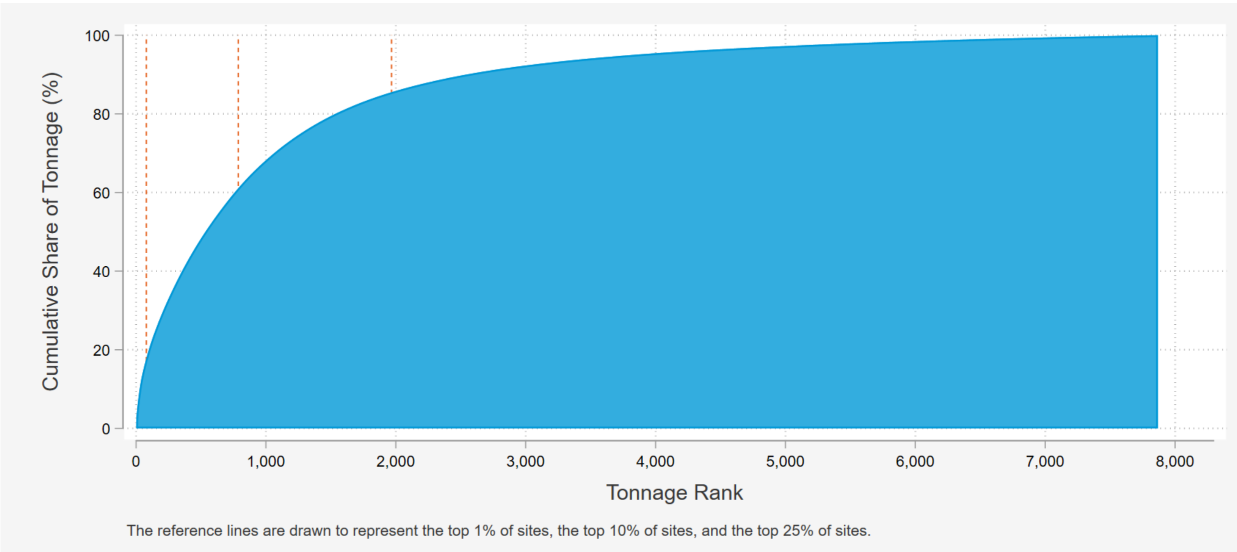
Category	Subcategory	Number of Accounts	Share of Accounts	Number of Devices	Share of Devices	Total Tonnage	Share of Tonnage
Cycling	50%	28,735	16.01%	31,067	15.26%	115,472	14.92%
	100%	150,709	83.99%	172,481	84.74%	658,336	85.08%
Load Control Group	SDP-Central-1	31,415	17.51%	36,961	18.16%	135,565	17.52%
	SDP-Central-2	19,397	10.81%	21,143	10.39%	80,593	10.41%
	SDP-Central-3	8,730	4.86%	11,000	5.40%	43,046	5.56%
	SDP-Central-4	34,469	19.21%	39,368	19.34%	146,597	18.94%
	SDP-High Desert	11,300	6.30%	12,294	6.04%	47,268	6.11%
	SDP-Low Desert	190	0.11%	195	0.10%	754	0.10%
	SDP-North	22,468	12.52%	25,636	12.59%	95,181	12.30%
	SDP-Northwest	8,013	4.47%	9,594	4.71%	36,979	4.78%
	SDP-West-1	23,156	12.90%	25,840	12.69%	101,942	13.17%
	SDP-West-2	20,309	11.32%	21,517	10.57%	85,897	11.10%
Local Capacity Area	Big Creek/Ventura	30,478	16.98%	35,230	17.31%	132,149	17.08%
	LA Basin	137,475	76.61%	155,828	76.56%	593,638	76.72%
	Outside LA Basin	11,494	6.41%	12,490	6.14%	48,035	6.21%
CARE/FERA Status	Non-CARE/FERA	127,280	70.93%	150,919	74.14%	562,414	72.68%
	CARE/FERA	48,722	27.15%	52,629	25.86%	184,934	23.90%
Zone	South Orange County	14,407	8.03%	15,843	7.78%	63,483	8.20%
	South of Lugo	65,545	36.53%	73,556	36.14%	277,058	35.80%
	Remainder of System	99,495	55.45%	114,149	56.08%	433,281	55.99%
Overall Total		**179,447**	**100%**	**203,548**	**100%**	**773,822**	**100%**

* Based on all participants that were enrolled in the program between the first event and last event of the 2021 season.

2.5 NON-RESIDENTIAL PARTICIPANT CHARACTERISTICS

A total of 7,680 SCE non-residential customers participated in at least one SDP demand response event during the 2021 summer. A defining characteristic of the SDP-C customer pool is its top-heaviness in terms of AC tonnage. Overall, 1% of the sites account for approximately 20% of the SDP-C tonnage, 10% of the sites account for nearly 60% of the tonnage, and 25% of the sites account for just over 80% of the tonnage (Figure 10). This means that a handful of customers drive the load reduction results.

Figure 10: Tonnage Ranks against Cumulative Tonnage Shares



On aggregate, the 7,680 SDP-C customers have 125-150 MW of cooling load when temperatures are hot – 90°F or higher (right pane in Figure 11). At milder temperatures in the mid-to-high 80s, these customers have closer to 100 MW of cooling load. However, the non-residential air conditioner load peak earlier in the day than SCE's 4-9 pm peak hours. Cooling load drops substantially in evening hours. The overall load shape for the SDP-C customer pool is driven by schools and religious institutions (often private schools), which account for over 80% of the total SDP-C AC tonnage. Though there certainly is some correlation between the maximum daily temperature and the daily peak load (left pane in Figure 11), the relationship isn't nearly as strong as it is for the residential component of SDP (left pane in Figure 9). Because loads from schools dominate, the magnitude of loads is highly dependent on whether schools are in session or not.

Figure 11: SDP-C Participant Load Summary

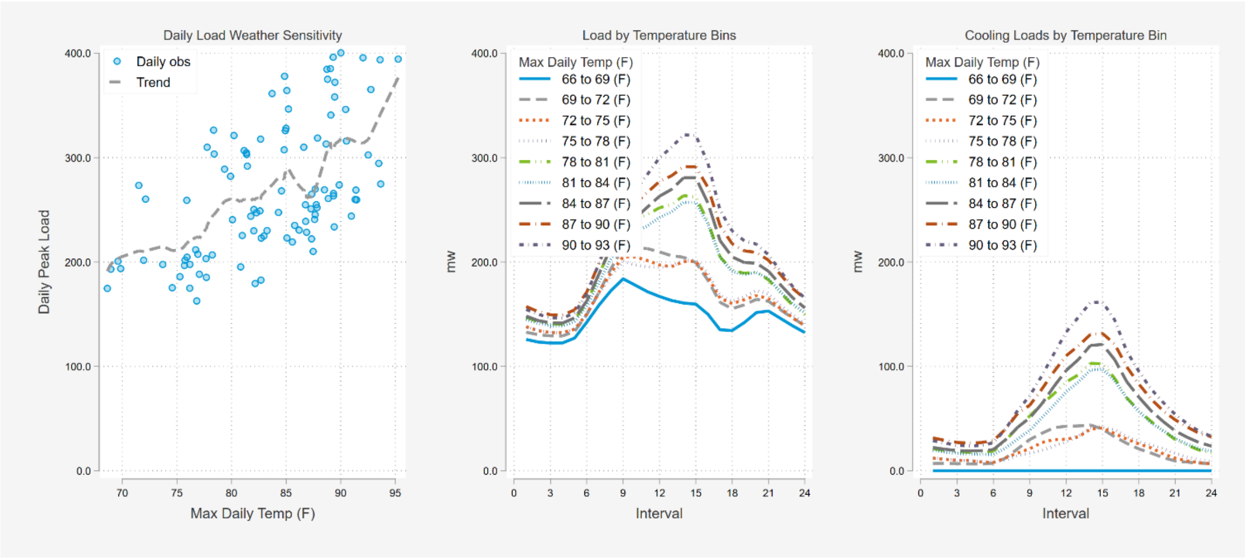


Table 6 shows the distribution of SDP-C participation, devices, and AC tonnage by several key categories and subcategories. Some key highlights of the SDP-C resources include:

- The majority of SDP-C tonnage is on 100% cycling (62%);
- The low desert region has the smallest share of tonnage (0.06%), while SDP-West-2 has the most (21%);
- Most SDP-C resources are in the LA Basin local capacity area; and
- Three key industry segments – Institutional/Government, Schools, and Religious Organizations – account for approximately 87% of the SDP-C tonnage. Schools alone account for 68% of the participant tonnage.

Our ex post methodology relied on matching participants to similar non-participants in a control pool. As noted earlier, some SDP-C participants are large and unique. We withheld some sites from the analysis due to the lack of viable control matches in the control pool. To account for this, ex post impacts were scaled based on tonnage. More details are presented in Appendix A. Specifically, Table 25 illustrates how the scaling was accomplished, and Table 26 shows the percentage of accounts, devices, and total tonnage that remained in the analysis file.

Table 6: SDP-C Participation by Category

Category	Subcategory	Number of Accounts	Share of Accounts	Number of Devices	Share of Devices	Total Tonnage	Share of Tonnage
Cycling	30%	616	8.02%	3,405	4.97%	20,887	5.98%
	50%	2,117	27.57%	23,090	33.69%	112,159	32.12%
	100%	4,947	64.41%	42,037	61.34%	216,158	61.90%
Load Control Group	SDP-Central-1	752	9.79%	11,355	16.57%	60,278	17.26%
	SDP-Central-2	888	11.56%	5,132	7.49%	25,019	7.16%
	SDP-Central-3	180	2.34%	645	0.94%	3,700	1.06%
	SDP-Central-4	1,188	15.47%	12,215	17.82%	62,492	17.90%
	SDP-High Desert	318	4.14%	3,460	5.05%	22,416	6.42%
	SDP-Low Desert	14	0.18%	33	0.05%	205	0.06%
	SDP-North	811	10.56%	7,518	10.97%	39,725	11.38%
	SDP-Northwest	511	6.65%	4,277	6.24%	21,839	6.25%
	SDP-West-1	1,089	14.18%	7,795	11.37%	38,568	11.04%
	SDP-West-2	1,929	25.12%	16,102	23.50%	74,962	21.47%
Local Capacity Area	Big Creek/Ventura	1,322	17.21%	11,795	17.21%	61,564	17.63%
	LA Basin	6,026	78.46%	53,244	77.69%	265,018	75.89%
	Outside LA Basin	332	4.32%	3,493	5.10%	22,622	6.48%
Zone	South Orange County	715	9.31%	4,962	7.24%	25,036	7.17%
	South of Lugo	2,460	32.03%	23,158	33.79%	118,834	34.03%
	Remainder of System	4,505	58.66%	40,412	58.97%	205,334	58.80%

Category	Subcategory	Number of Accounts	Share of Accounts	Number of Devices	Share of Devices	Total Tonnage	Share of Tonnage
Industry	Agriculture, Mining, Construction	205	2.67%	477	0.70%	2,045	0.59%
	Institutional/Government	664	8.65%	3,173	4.63%	19,848	5.68%
	Manufacturing	501	6.52%	1,439	2.10%	7,840	2.25%
	Offices, Hotels, Finance, Services	1,737	22.62%	3,365	4.91%	14,716	4.21%
	Retail Stores	1,163	15.14%	2,356	3.44%	12,142	3.48%
	Religious organizations	1,124	14.64%	7,767	11.33%	46,017	13.18%
	Schools	1,542	20.08%	47,997	70.04%	237,504	68.01%
	Unknown/Other	40	0.52%	59	0.09%	267	0.08%
	Wholesale, Transport, Other Utilities	629	8.19%	1,899	2.77%	8,825	2.53%
Tonnage Bin	3 or less	1,036	13.49%	1,037	1.51%	2,541	0.73%
	3 to 4	910	11.85%	932	1.36%	3,129	0.90%
	4 to 5	614	7.99%	694	1.01%	2,753	0.79%
	5 to 10	1,490	19.40%	2,554	3.73%	10,291	2.95%
	10-100	2,533	32.98%	18,001	26.27%	87,076	24.94%
	100-500	967	12.59%	37,778	55.12%	191,262	54.77%
	500+	55	0.72%	7,536	11.00%	52,152	14.93%
Overall Total		**7,680**	**100%**	**68,532**	**100%**	**349,204**	**100%**

* Based on all participants that were enrolled in the program between the first event and last event of the 2021 season.

2.6 2021 EVENT CONDITIONS

Figure 12 visualizes the timing of the SDP events during the 2021 summer. Events varied in timing and length, and some events started or ended mid-hour. The testing events, which make up the majority of the 2021 events, refer to events that were dispatched by SCE to evaluate the program performance.

Figure 12: Timing of SDP Summer Events, 2021

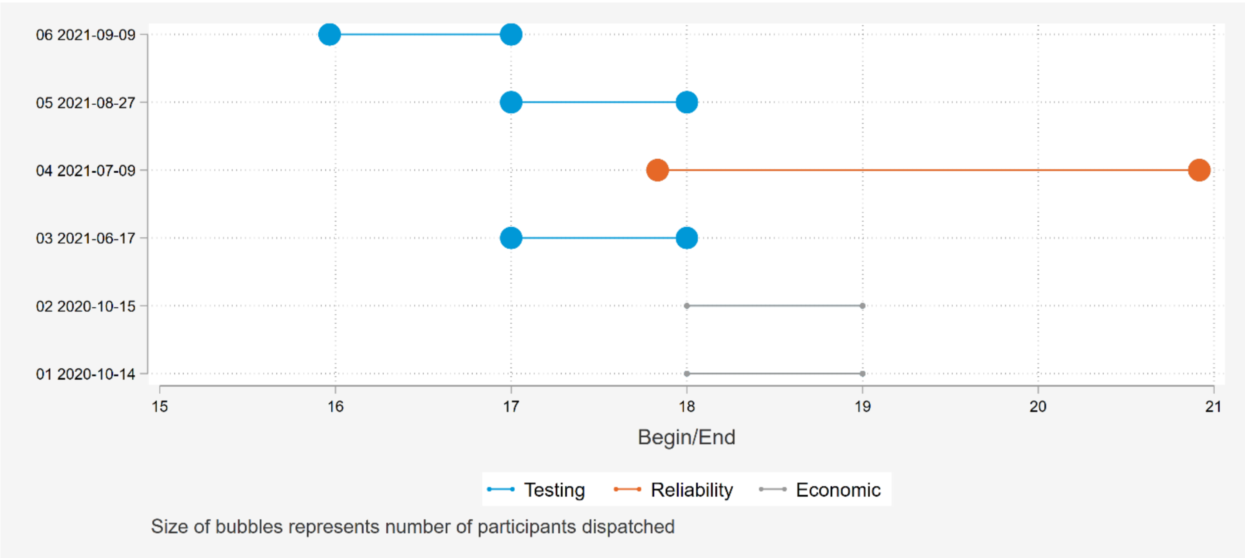


Table 7 shows the dates, start times, and end times for the four SDP DR events in 2021 and the two in 2020. It also shows the number of dispatched accounts, devices, and tonnage for the SDP-R and SDP-C segments. The last row in the table shows characteristics for the "average" 2021 event, defined as the average load impacts for the first event hour of each 2021 event day. Some highlights from the table:

- There were just under 175,000 participants and approximately 737,000 total tons of AC load for the average SDP-R event.
- There were 7,504 participants and approximately 339,000 total tons of AC load for the average SDP-C event.
- The average temperature for the average SDP-R event day was 93.1° F, but average event temperatures ranged from 89.7° F to 95.5° F. For SDP-C, the average temperature on the average event day was nearly three and a half degrees lower (89.7° F) than the SDP-R average.
- There were three territory-wide event days (7/9, 8/27, and 9/9).
- On the system peak day (9/9), an event was dispatched from 3:58 PM to 5:00 PM.

Table 7: Summary of SDP-R and SDP-C Events

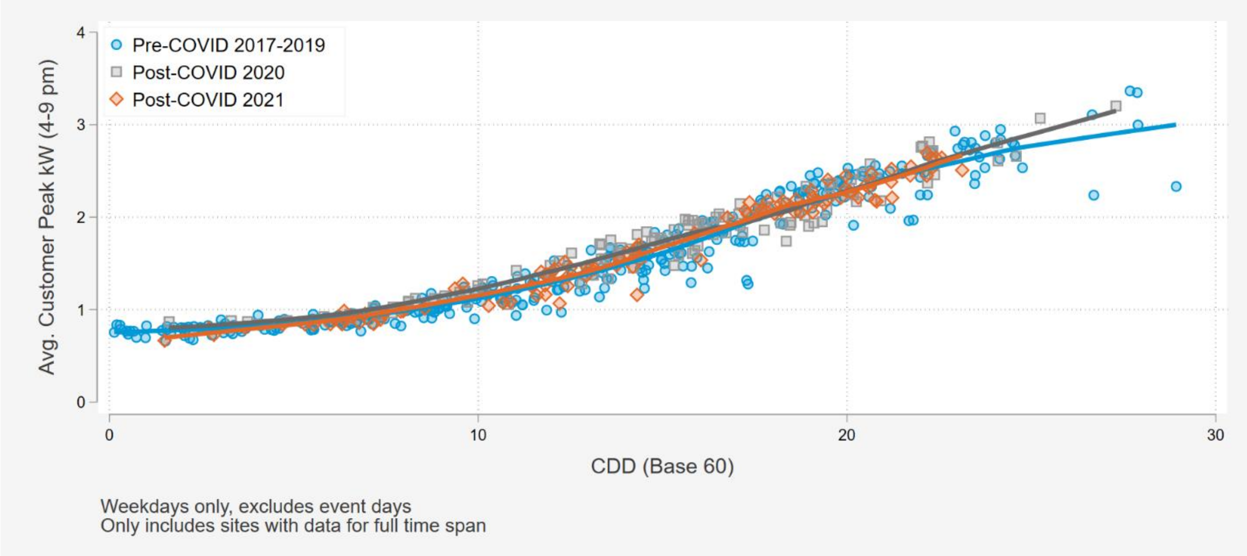
Date	Load Control Groups	Event Start	Event End	SDP-Residential				SDP-Commercial			
				Accounts	Devices	Tonnage	Weighted Temp (F)	Accounts	Devices	Tonnage	Weighted Temp (F)
10/14/2020	LD	6:00 PM	7:00 PM	202	217	810	97.8	[redacted]			
10/15/2020	LD	6:00 PM	7:00 PM	202	217	810	99.6	[redacted]			
6/17/2021	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	6:00 PM	168,129	192,947	708,285	89.7	7,418	67,918	345,625	85.5
7/9/2021	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	5:50 PM	8:50 PM	175,532	202,999	745,416	91.4	7,567	67,726	346,026	88.6
8/27/2021	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	6:00 PM	7:00 PM	175,588	203,051	745,653	95.5	7,514	65,511	332,930	91.2
9/9/2021	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	3:58 PM	5:00 PM	175,962	203,485	747,257	94.5	7,517	65,545	333,102	92.2
Avg. Event		**First Event Hour**		**173,803**	**200,621**	**736,653**	**93.1**	**7,504**	**66,675**	**339,421**	**89.7**

2.7 COVID-19 PANDEMIC

The 2020 SDP evaluation faced a unique challenge of estimating results in the context of the COVID-19 pandemic, which mostly affected the customer loads and had minimal effects on the demand reductions delivered by SDP-R customers. Across the 2020 COVID-19 pandemic, residential loads were generally higher and non-residential loads were generally lower. This was important to note in last year's evaluation since the 2020 reference loads and ex post results were factored into the ex ante impact estimation. The effect of COVID on SDP program performance diminished in 2021.

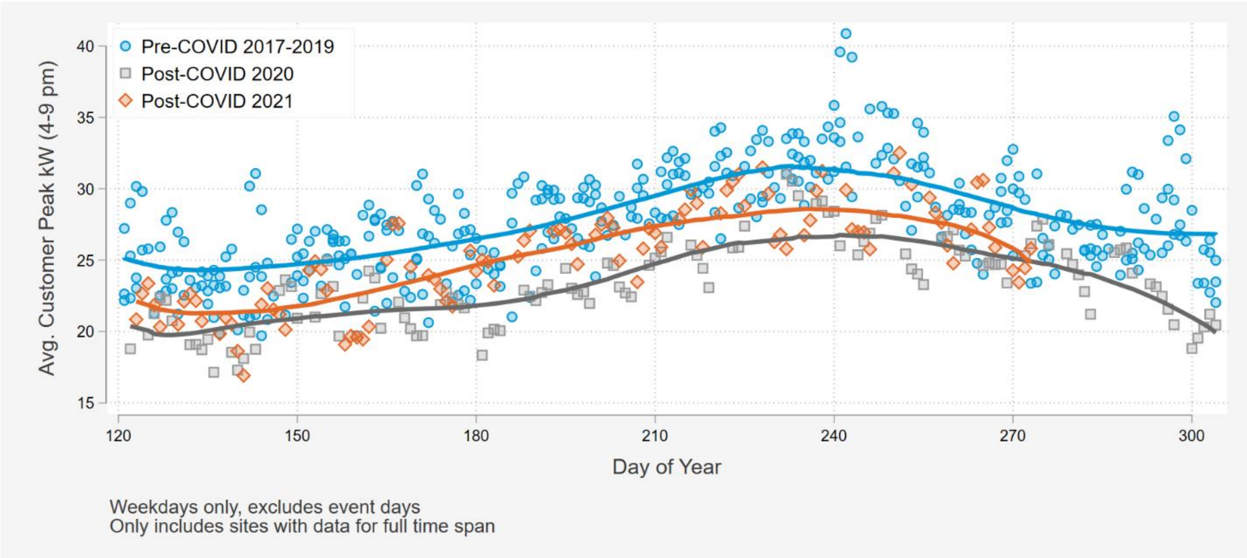
Figure 13 illustrates our findings for the residential sector, where residential peaks in 2021 were more similar to the pre-COVID trend than the 2020 trend. Because of this, we do not factor COVID-19 effects into our ex ante model, but we do exclude the 2020 reference loads in the 2021 ex ante evaluation. Additionally, impacts from 2020 are included since no substantial change was prevalent in the temperature-impact relationship.

Figure 13: Daily 4-9 PM Load Comparison, SDP-R



In 2020, the commercial sector experienced a greater discrepancy between the pre-COVID loads and the post-COVID loads than the residential sector. This was primarily due to over 80% of SDP-C air conditioner tonnage coming from Schools and Religious Institutions, both of which had their occupancy heavily affected by COVID-19. These institutions were not as heavily impacted in 2021, with many schools re-opening for in-person classes. Figure 14 shows how the 2021 commercial peak loads rebounded, but does not account for the lower 2021 temperatures. Separately, DSA conducted a more detailed analysis of how the effect of COVID on various customers segments. The most relevant finding is that schools loads, which make up over 70% of the AC tonnage in the program, largely rebounded when schools returned to in-person learning in August of 2021. As a result, we do not factor COVID-19 effects into our ex ante model, but we do exclude the 2020 reference loads and control for 2020 COVID impacts in developing the ex ante load impacts.

Figure 14: Daily 4-9 PM Load Comparison by Day of Year, SDP-C



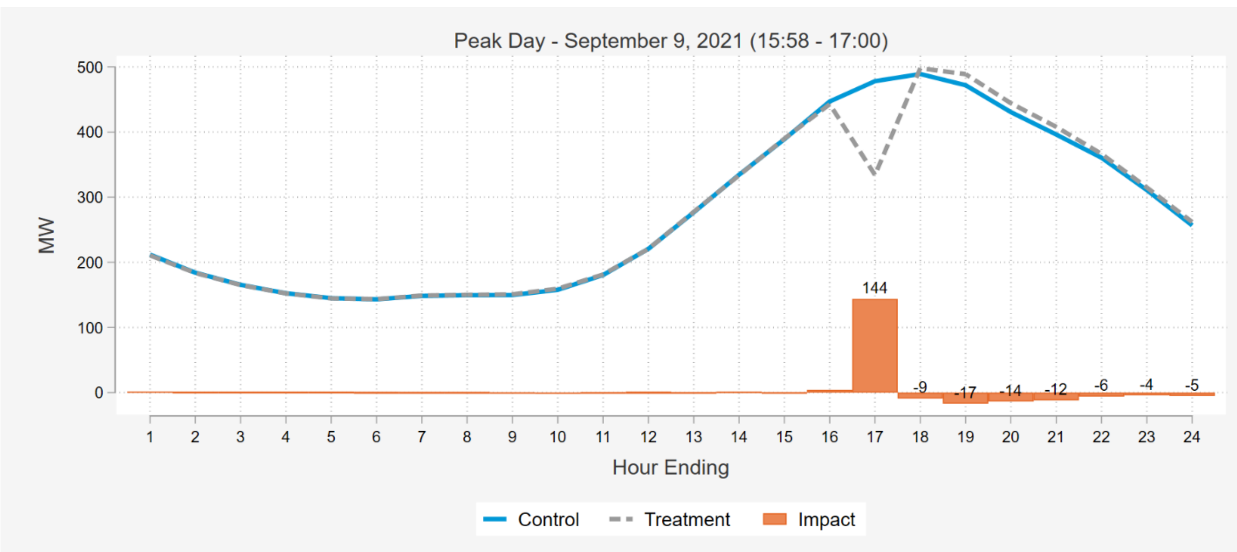
3 RESIDENTIAL EX POST RESULTS

This section focuses on the magnitude of demand reductions delivered by SDP-R during 2021 event days. The magnitude of demand reductions is a function of several factors – temperature, time of day, and geo-targeted dispatch of resources.

3.1 SYSTEM PEAK DAY REDUCTIONS

The 2021 system peak was 20,750 MW and occurred on September 9th. On the peak day, SDP-R resources were dispatched from 3:58 PM through 5:00 PM in the self-scheduled day-ahead market. In total, SCE sent instructions to curtail demand to 175,962 SDP-R accounts with 203,485 control devices. Figure 15 shows the hourly load profile for the control group and SDP-R participants on the system peak day. During the full event hour, the aggregate demand reduction by SDP-R participants was 144 MW, with a percent impact of 30.1%.

Figure 15: SDP-R Reductions on System Peak Day



3.2 INDIVIDUAL EVENT DAY REDUCTIONS

Table 8 shows reference loads, observed loads, impacts, and percent impacts for each of the four SDP-R summer 2021 DR events, as well as the two SDP-R late summer 2020 DR events. Percent impacts were typically in the high 20s. The "average" event is constructed from the first full event hour for each of the 2021 events.

Table 8: SDP-R Event Results, 2021

Date	Load Control Groups	Event start	Event end	Accts	MW Metrics					Impact per ... (kW)			% Impact	Wght. Temp (F)
					Reference Load	Load with DR	Impact	90% Lower Bound	90% Upper Bound	Acct	Device	Ton		
10/14/2020	LD	6:00 PM	7:00 PM	202	0.35	0.28	0.07	0.02	0.12	0.35	0.33	0.09	20.6%	97.8
10/15/2020	LD	6:00 PM	7:00 PM	202	0.33	0.28	0.04	-0.03	0.11	0.22	0.20	0.05	13.5%	99.6
6/17/2021	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	6:00 PM	168,129	396	280	116	111	121	0.69	0.60	0.16	29.3%	89.7
7/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	5:50 PM	8:50 PM	175,532	457	336	121	116	126	0.69	0.60	0.16	26.5%	91.4
8/27/2021	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	6:00 PM	7:00 PM	175,588	481	342	140	134	145	0.80	0.69	0.19	29.0%	95.5
9/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	3:58 PM	5:00 PM	175,962	478	334	144	138	150	0.82	0.71	0.19	30.1%	94.5
Avg. Event		**First Event Hour**		**173,803**	**456**	**324**	**132**	**129**	**135**	**0.76**	**0.66**	**0.18**	**29.0%**	**93.1**

* Only full hours are included in impacts

Figure 16 visualizes impacts on Friday 7/9, which was the only reliability event within the 2021 season. In the two full hours of the event, aggregate impacts were around 121 MW, which accounts for a 26.5% reduction in the reference load.

Figure 16: SDP-R Load Impacts on Friday, 7/9/2021

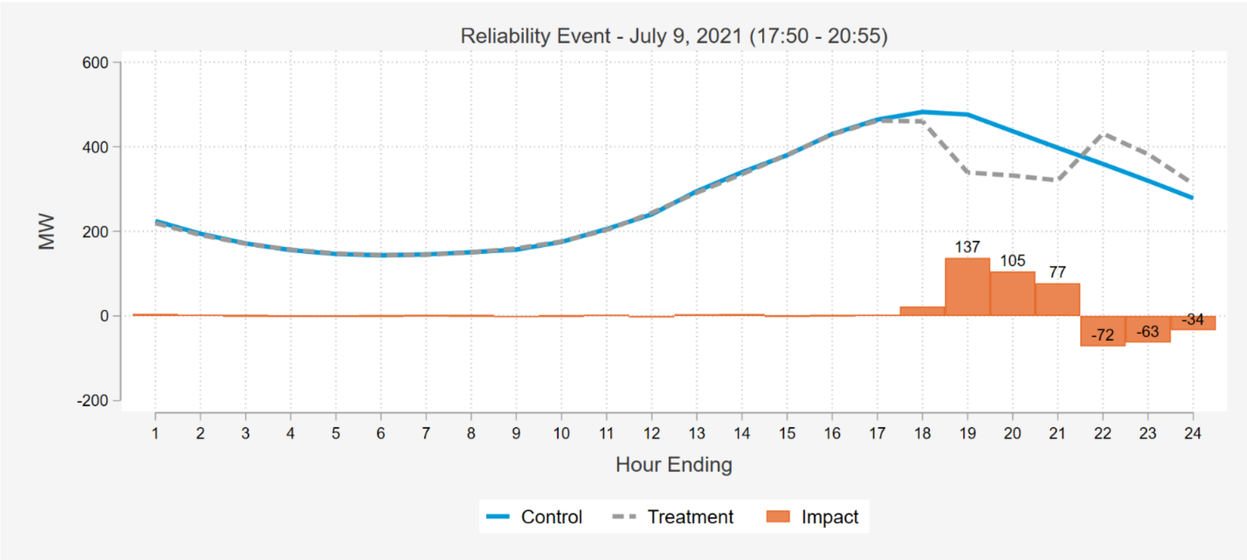
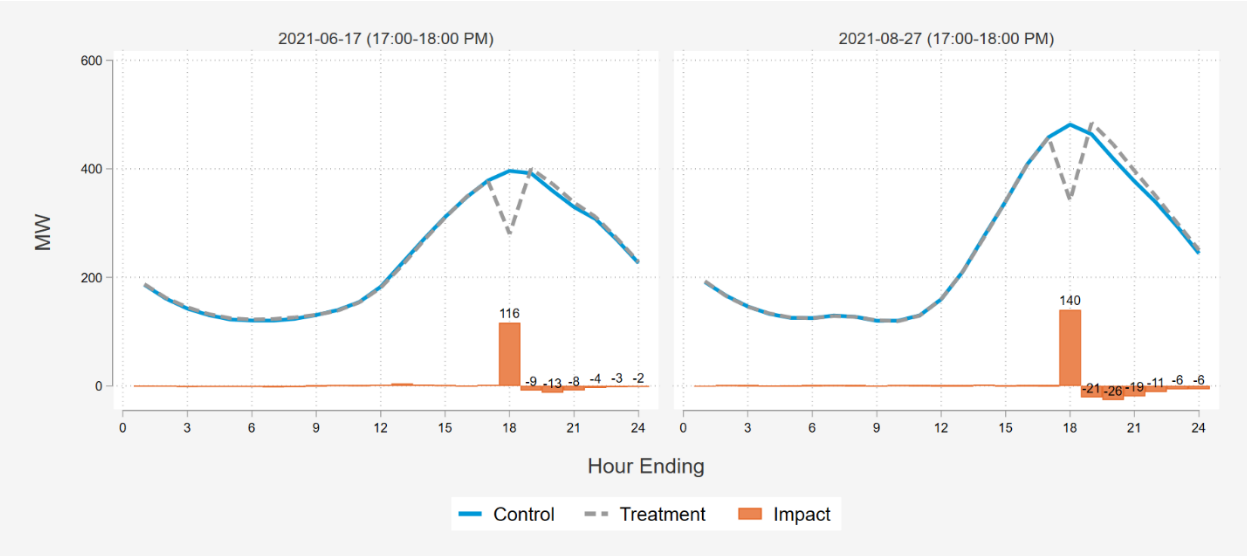


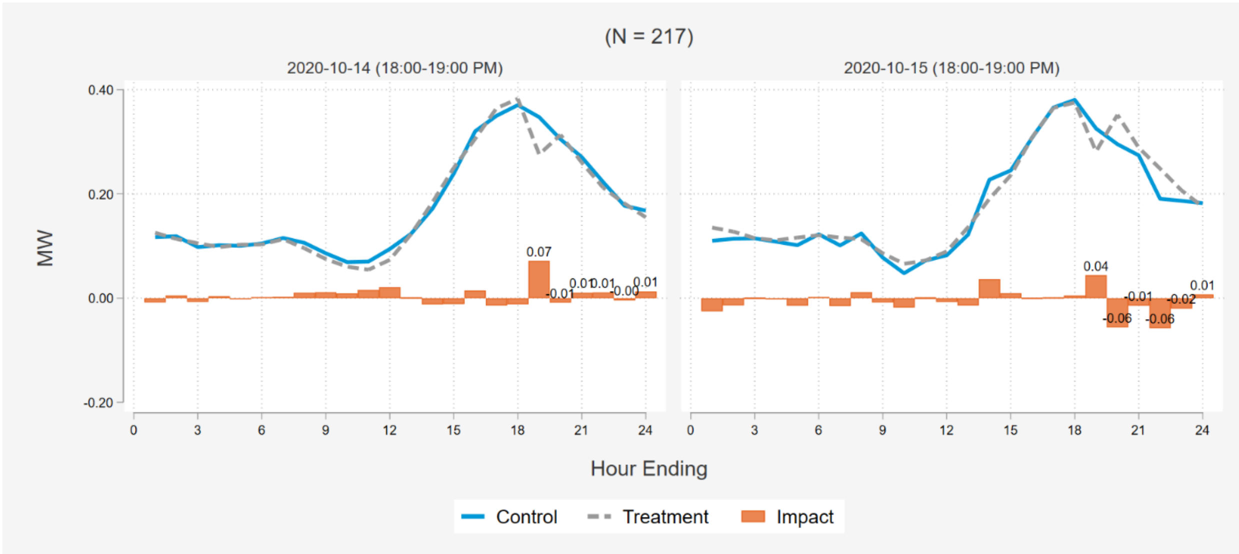
Figure 17 visualizes the aggregate impacts for the two other events in the 2021 DR season, which both begin at 5 PM and end at 6 PM.

Figure 17: SDP-R Reductions on Other 2021 Event Days



We additionally analyzed two October events days from 2020. These two events only dispatched the Low Desert load control group, which accounts for 0.11% of accounts, so the impacts were small and variable.

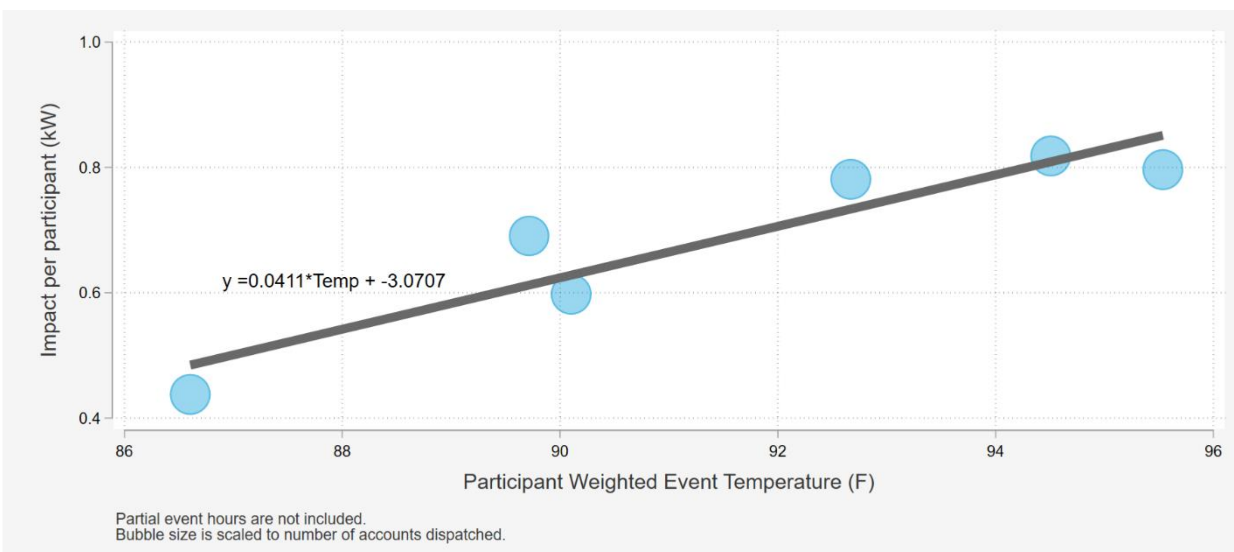
Figure 18: SDP-R Reductions on October 2020 Event Days



3.3 WEATHER SENSITIVITY OF LOAD IMPACTS

As one might expect, residential DR impacts tended to be larger when outdoor temperatures were higher – when temperatures are higher, more controllable air conditioner load is available for reductions. Figure 19 visualizes the relationship between 2021 SDP-R DR reductions and outdoor temperature. The slope of the line in the figure is 0.041, which suggests that the average impact per participant increases by 0.041 kW for each one-degree increase in outdoor temperature.

Figure 19: Relationship between SDP-R Demand Reductions and Weather ($R^2 = 0.83$)



3.4 COMPARISON TO PRIOR YEARS

In comparing SDP-R event performance in 2021 to performance in 2019 and 2020, a few key details will act to confound the comparison:

- The number of event hours in 2019 and 2020 far exceeded the number of events hours in 2021.
- Several of the 2020 events were dispatched due to CAISO emergencies. This was not the case in 2021, as there were no CAISO emergencies.
- Whereas the 2019 and 2021 summers were mild, the 2020 summer saw extreme heat waves. Cooling loads were elevated due to these heat waves – this spurred the aforementioned CAISO emergencies.

With these details in mind, Figure 20 shows the relationship between SDP-R reductions and outdoor temperature for the past three years. There is a significant difference in temperature ranges between these periods. As temperatures get higher and higher, we see diminishing returns – there is only so much cooling load available for curtailment, meaning there is an upper bound on the impact per participant. In other words, a 3-ton system cannot shed more than three tons even if the outdoor temperature is 120°F. When focusing on overlapping temperature ranges, the impacts seem be to fairly similar.

Figure 20: SDP-R Ex Post Reductions against Temperature, 2019-2021

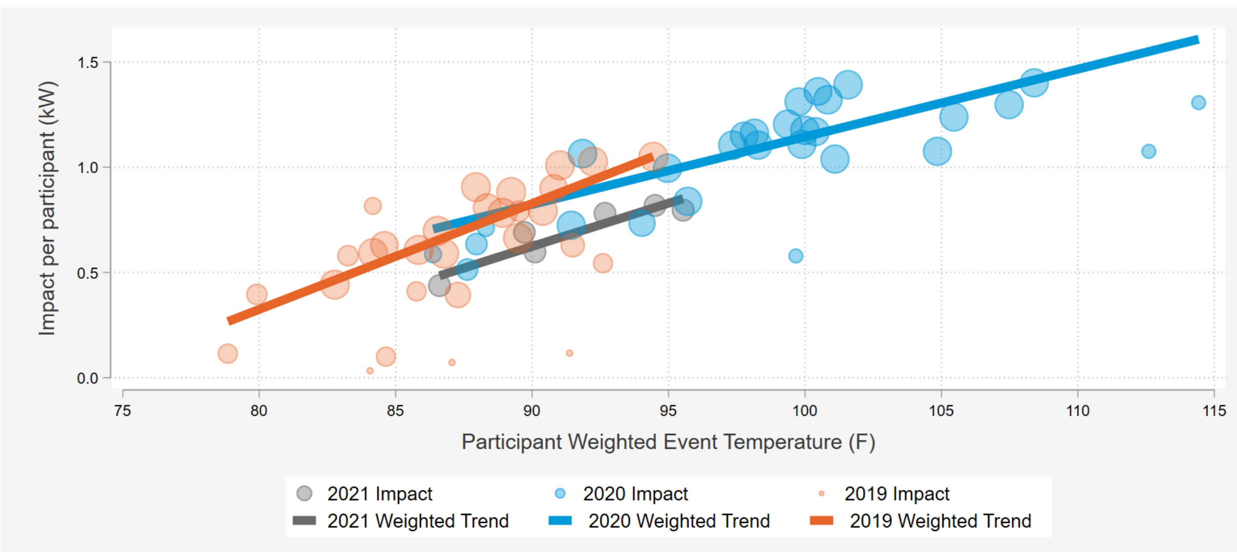
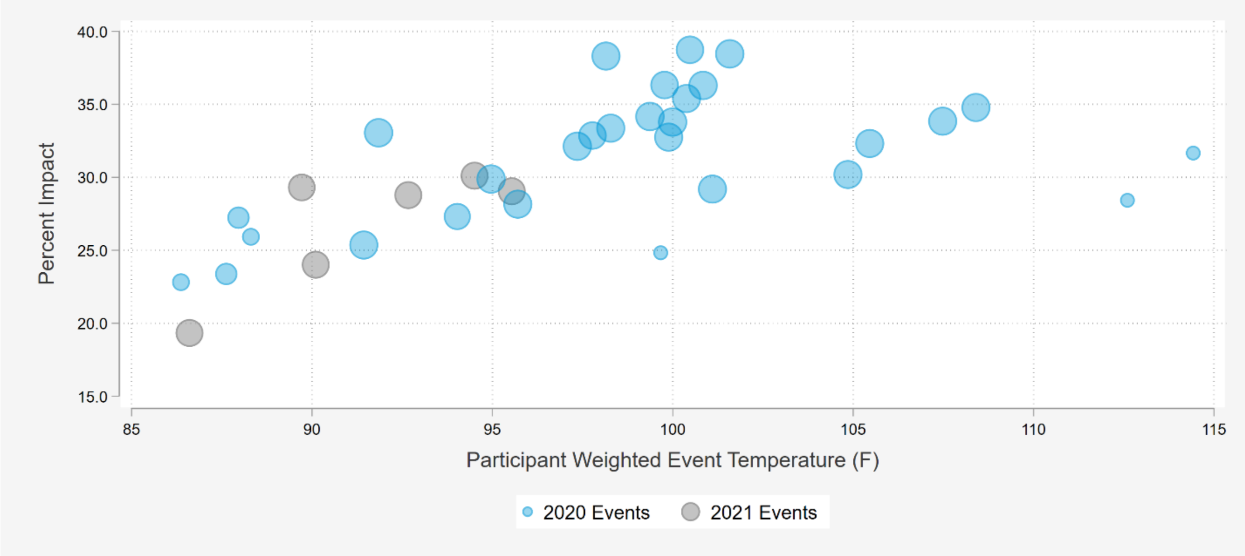


Figure 21 shows the relationship between percent reductions (rather than load reductions) and outdoor temperature. Readers should keep two things in mind when reviewing this figure. First, percent impacts are calculated with whole-premise load in the denominator, not cooling load. This means there is a physical cap on percent impacts since SDP-R only targets cooling load. This is why percent impacts do not continue to climb at higher temperatures. Second, 2021 events were cooler than 2020 events. The eye test tells us that at similar temperature ranges, percent impacts are relatively stable across the two years and max out around 40%.

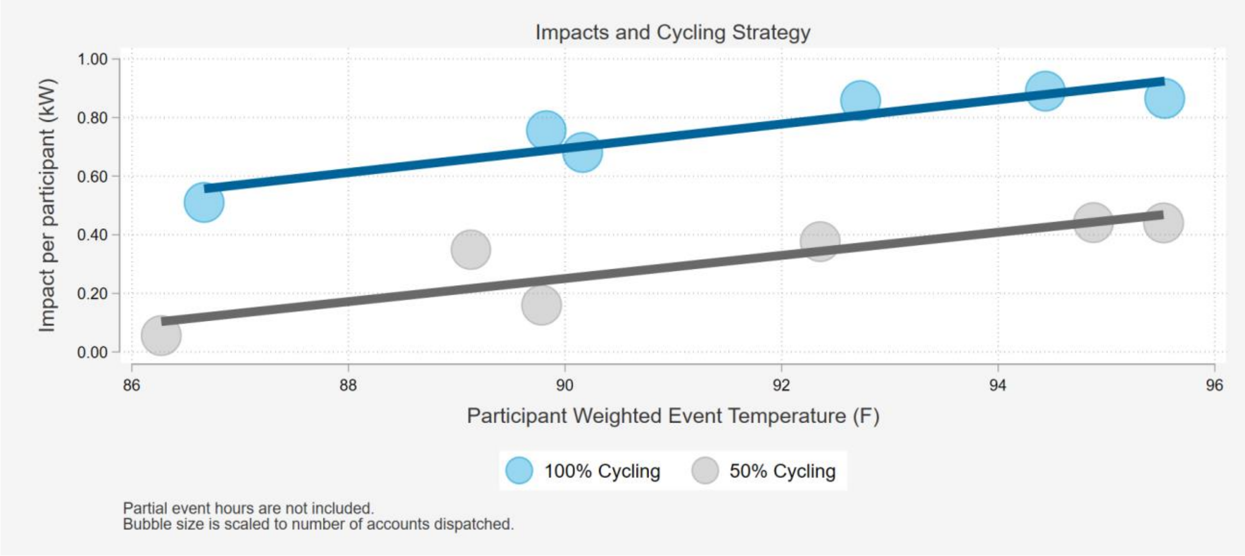
Figure 21: SDP-R Percent Reductions against Temperature, 2020-2021



3.5 IMPACTS BY CYCLING STRATEGY

Figure 22 plots the load impacts against outdoor temperature for the two cycling strategy groups. The impacts of the 100% cycling strategy group are clearly larger. The relationship between impacts and temperature is similar between the two groups (beyond the magnitude difference). The slopes of the lines in the figure are nearly identical– 0.041 in the 100% cycling group and 0.039 in the 50% cycling group. Recall that these slopes represent the expected increase in the impact for every one degree increase in temperature.

Figure 22: SDP-R Impacts by Cycling Strategy



3.6 IMPACTS FOR KEY CUSTOMER SEGMENTS

Table 9 shows the impacts of key customer segments for the average 2021 SDP-R event day, which is composed of the average of the first event hour from the four 2021 events.

- On average, impacts in the 100% cycling strategy group are approximately 2.1 times larger than impacts in the 50% cycling strategy group;
- Percent impacts are similar across most load control groups with one notable exception – SDP-NW, which is along the coast;
- The largest average load impacts occurred in load control groups SDP-C-1 and SDP-C-4 at 0.95 kW and 0.98 kW, respectively. These two load control groups also deliver the highest aggregate load impacts, as they each have 10,000+ more customers than any other load control group; and
- Percent impacts are slightly higher in the low-income group, 30.8%, for CARE/FERA homes. By comparison, non-low income homes reduced demand by 28.2%.

Table 9: SDP-R Impacts by Key Customer Segments, Average 2021 Event Day

Category	Subcategory	Number of Accounts	Average Reference Load (kW)	Average Load w/no DR (kW)	Average Load Impact (kW)	% Load Impact	Aggregate Load Impact (MW)
Cycling	50%	27,810	2.74	2.34	0.40	14.5%	11.0
	100%	145,993	2.60	1.77	0.83	31.9%	120.9
Load Control Group	SDP-Central-1	30,867	3.08	2.12	0.95	31.0%	29.5
	SDP-Central-2	19,072	2.39	1.69	0.70	29.2%	13.3
	SDP-Central-3	8,175	3.46	2.60	0.87	25.0%	7.1
	SDP-Central-4	33,993	2.87	1.90	0.98	34.0%	33.3
	SDP-High Desert	10,984	2.71	1.80	0.91	33.6%	10.0
	SDP-Low Desert	179	3.63	2.79	0.84	23.1%	0.1
	SDP-North	21,845	3.11	2.23	0.89	28.5%	19.4
	SDP-Northwest	7,776	2.07	1.89	0.17	8.4%	1.4
	SDP-West-1	22,892	1.89	1.42	0.47	24.9%	10.8
	SDP-West-2	20,110	1.92	1.47	0.46	23.7%	9.2
Local Capacity Area	Big Creek/Ventura	29,618	2.83	2.14	0.70	24.5%	20.6
	LA Basin	133,063	2.56	1.81	0.76	29.6%	100.8
	Outside LA Basin	11,122	2.72	1.81	0.91	33.4%	10.1
CARE/FERA Status	Non-CARE/FERA	125,592	2.57	1.85	0.73	28.2%	91.1
	CARE/FERA	48,211	2.75	1.90	0.85	30.8%	40.9
Zone	South Orange County	14,233	1.69	1.28	0.42	24.5%	5.9
	South of Lugo	64,545	2.65	1.80	0.85	32.0%	54.8
	Remainder of System	95,026	2.74	1.99	0.75	27.3%	71.2
All Customers		**173,803**	**2.62**	**1.86**	**0.76**	**29.0%**	**132.0**

By LCG, Figure 23 shows the average aggregate impact for each event. Note that only full event hours were included. Central-1 and Central-4 tend to deliver the largest impacts, followed by North and Central-2.

Figure 23: Average Aggregate Impacts by Event and LCG, SDP-R

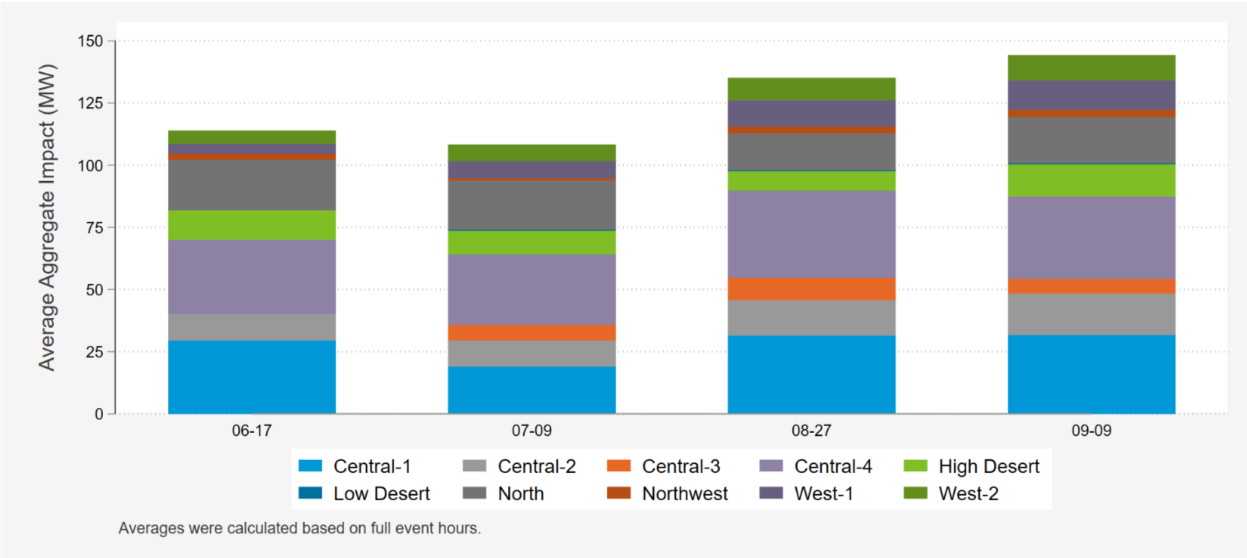
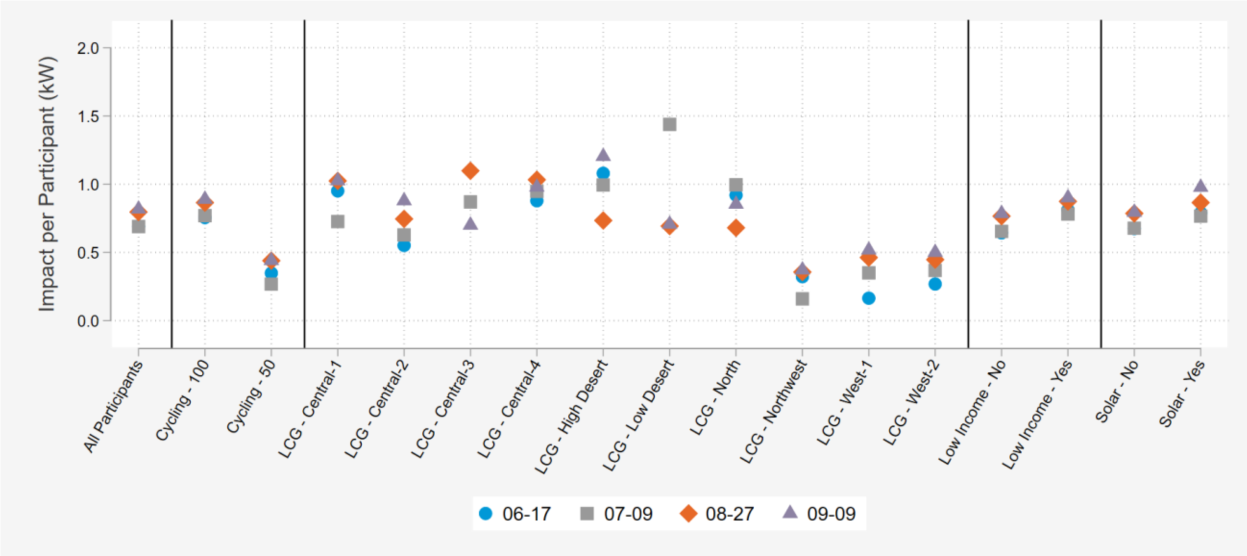


Figure 24 shows how participant-level impacts vary across subcategories for several key research categories (cycling strategy, load control group, and CARE status).

Figure 24: Average Participant Impact by Event and Key Subcategory, SDP-R



3.7 KEY FINDINGS

The SDP Residential (SDP-R) program has approximately 180,000 customers enrolled and includes nearly 204,000 control devices and 774,000 tons of air conditioner load. Approximately 84% of customers elect the higher incentive option, which allows SCE to fully curtail air conditioner demand

(100% cycling) during SDP demand response (DR) events. Demand reductions grow larger in magnitude when temperatures are hotter, and resources are needed most. On a per customer basis, demand reductions increased by an average of 0.041 kW for each one-degree increase in outdoor temperature in 2021. Across 180,000 customers, this translates to 7.4 MW in incremental demand reductions for each one-degree increase in outdoor temperature.

For full event hours, average impacts were in the neighborhood of 0.75 kW per participant, and percent impacts were generally around 29%.

A few other key findings are worth highlighting:

- During the system peak day (September 9th, 2021), SDP-R participants reduced demand by an average of 144 MW between 4:00 PM and 5:00 PM. The demand reductions per customer, per device, and per ton for this event were 0.82 kW, 0.71 kW, and 0.19 kW respectively.
- On the average 2021 event day, the SDP-R program produced 132 MW of demand reductions.
- The per-participant demand reductions for customers signed up for the 100% cycling are more than two times larger than demand reductions for those on 50% cycling.
- At similar temperature conditions, 2020 and 2021 ex post percent impacts were similar – 25.5% at 89ºF in 2020 and 26.5% at 91ºF in 2021.
- Residential air conditioner loads are highly weather-sensitive. As a result, demand reductions are larger in magnitude when temperatures are hotter, and resources are needed most. Compared to prior years, 2021 was a substantially cooler year, with lower air conditioner loads and lower SCE system demand.
- By the summer of 2021, the typical energy use of residential customers and residential demand reductions aligned with pre-pandemic conditions.

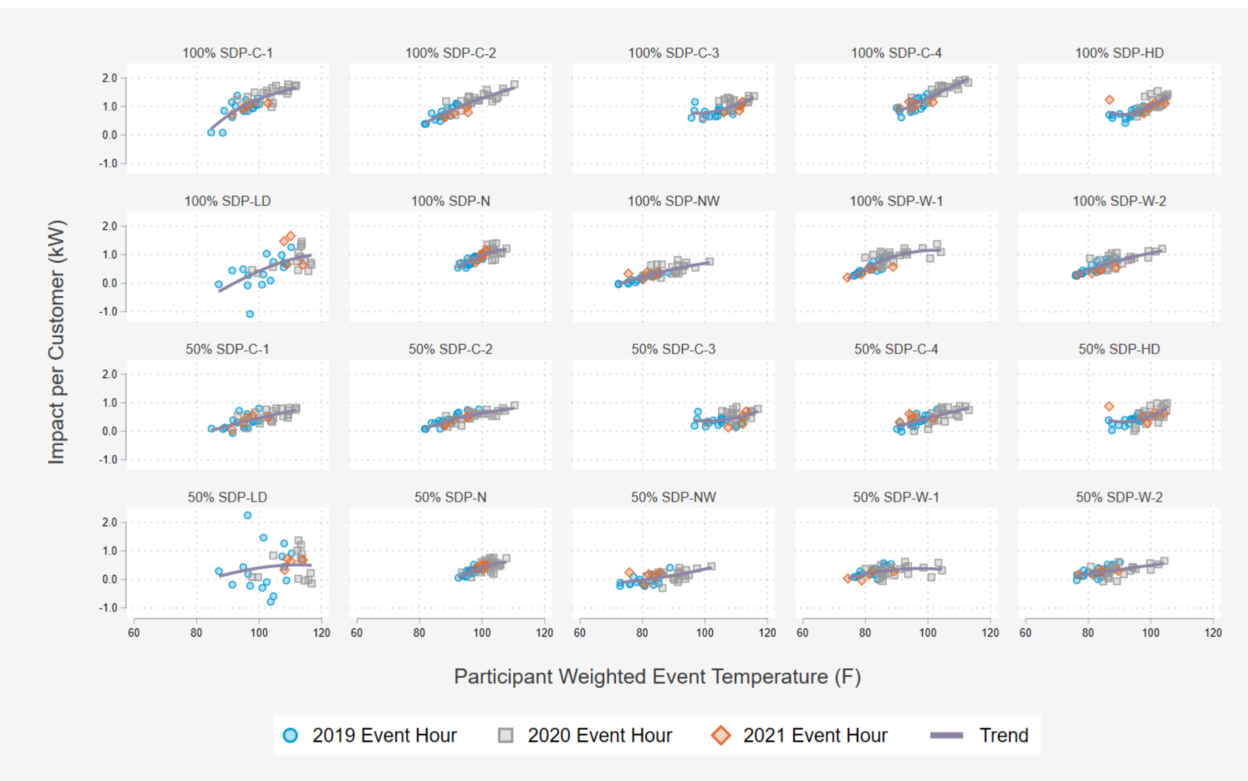
4 RESIDENTIAL EX ANTE RESULTS

Ex ante impacts describe the magnitude of program resources available under planning conditions defined by weather. The ex ante estimates are developed for both SCE and California ISO peak conditions under normal (1-in-2) and extreme (1-in-10) peak planning conditions. We estimated ex ante impacts based on the relationship between demand reductions and weather using three years of historical performance data (2019-2021) and factored in projected changes in enrollment.

4.1 DEVELOPMENT OF EX ANTE IMPACTS

The ex ante impacts were developed by estimating the relationship between weather and demand reductions during from 2019-2021 for customers currently enrolled in the program. Partial event hours were not used in the ex ante analysis. In total, we estimated the relationship between demand reductions and impact for 20 distinct segments – defined by load control group and cycling strategy. The granularity of the analysis was dictated by how SCE dispatches resources (at the load control group level), the geographic diversity of the SCE territory, and the fact that 100% and 50% cycling produce a different magnitude of demand reduction. Figure 25 shows the relationship between weather and demand reductions for each of the building blocks.

Figure 25: 2019-2021 Impacts as a Function of Weather by Load Control Group and Cycling



The pattern of reductions across events and segments was analyzed using a multi-variate regression model. The model accounts for the effects of the hour of day, day of week, cycling strategy, and load control group. Appendix E includes the output from the model. In addition, the historical snapback was analyzed to produce estimates of the post-event increase in loads based on the number of hours since the event finished and daily heat buildup.

4.2 OVERALL RESULTS

For the monthly peak day, Table 10 shows average participant-level ex ante impacts for each of the summer months (and also May). Impacts are shown under four different scenarios – CAISO 1-in-2 and 1-in-10 weather conditions and SCE 1-in-2 and 1-in-10 weather conditions. The estimated reductions are greater under the 1-in-10 weather conditions, as there is more AC load available for curtailment when temperatures are higher. For reference, the average impact per participant on the 2021 peak day was 0.82 kW.

Table 10: Per Participant Peak Day Ex Ante Impacts (kW)

Month	SCE Weather		CAISO Weather	
	1-in-2	1-in-10	1-in-2	1-in-10
May	0.14	0.35	0.16	0.35
June	0.60	0.99	0.58	1.00
July	0.85	1.13	0.85	0.95
August	0.92	1.02	0.92	0.97
September	0.93	1.04	0.95	1.03

Table 11 shows aggregate ex ante demand reduction forecasts for an August peak event day. Forecasts are shown under the four scenarios identified above. The fact that the demand reductions decrease throughout the forecast window can be explained by the decline in the enrollment forecast, which itself can be explained by general customer attrition (customers moving and/or requesting to be removed from the program). Ex ante weather conditions are static through the forecast window. There is a small amount of variation in participant-level impacts through the forecast window (typically in the second or third decimal place).

Table 11: Aggregate August Peak Day Demand Reduction Forecast (MW)

Forecast Year	Enrollment Forecast	SCE Weather		CAISO Weather	
		1-in-2	1-in-10	1-in-2	1-in-10
2022	163,670	150	166	150	159
2023	153,226	140	156	141	149
2024	144,005	132	146	132	140
2025	135,864	124	138	125	132
2026	128,677	118	131	118	125
2027	122,331	112	124	112	119
2028	116,728	107	119	107	114
2029	111,782	102	114	103	109
2030	107,414	98	109	99	105
2031	103,559	95	105	95	101
2032	100,155	92	102	92	98

Figure 26 and Figure 27 show the estimated ex ante load profiles for the SDP-R customer pool. Both figures show profiles for the August peak day, and both figures use SCE weather conditions rather than CAISO conditions. Figure 26 shows profiles under 1-in-2 weather conditions, and Figure 27 shows profiles for 1-in-10. Note that the forecast year shown is 2022.

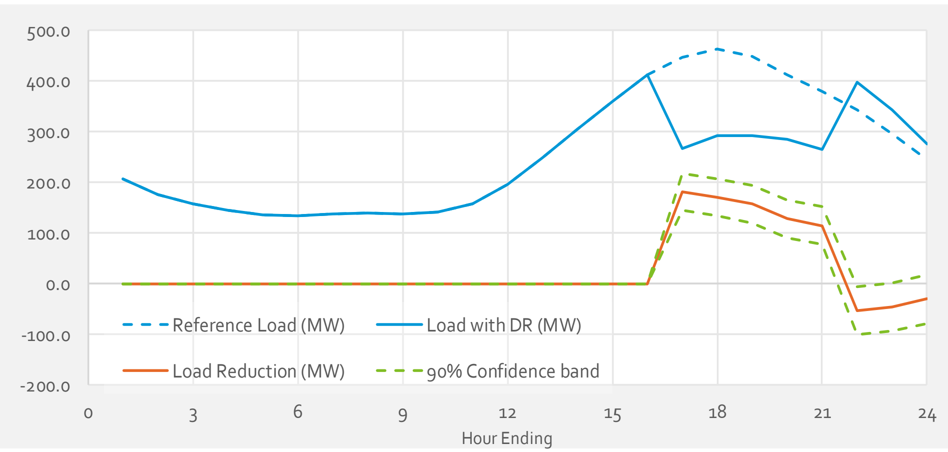
Figure 26: SDP-R Aggregate Ex Ante Impact for 1-in-2 Weather Conditions, August Peak Day 2022

Table 1: Menu options

Type of result	Aggregate
Category	All
Segment	All Customers
Weather Data	SCE
Weather Year	1-in-2
Day Type	August Monthly Peak Day
Forecast Year	2022
Portfolio Level	Program

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	163,670
Total devices	191,082
Total cooling tons	696,554
Event window temperature (F)	91.2
Event window load reduction (MW)	149.89
% Load reduction (Event window)	34.9%
Redaction Information	Public



Hour Ending	Reference Load (MW)	Load with DR (MW)	Load Reduction	% Load Reduction	Avg Temp (°F, Site-Weighted)	Uncertainty- 5th	Uncertainty- 95th	Standard Error	T-Statistic
1	205.83	205.83	0.00	0.00%	79.92	0.00	0.00	0.00	0.00
2	175.99	175.99	0.00	0.00%	78.55	0.00	0.00	0.00	0.00
3	157.69	157.69	0.00	0.00%	77.53	0.00	0.00	0.00	0.00
4	144.48	144.48	0.00	0.00%	76.50	0.00	0.00	0.00	0.00
5	136.07	136.07	0.00	0.00%	75.60	0.00	0.00	0.00	0.00
6	134.26	134.26	0.00	0.00%	74.96	0.00	0.00	0.00	0.00
7	137.59	137.59	0.00	0.00%	74.30	0.00	0.00	0.00	0.00
8	138.12	138.12	0.00	0.00%	74.21	0.00	0.00	0.00	0.00
9	136.38	136.38	0.00	0.00%	76.55	0.00	0.00	0.00	0.00
10	140.69	140.69	0.00	0.00%	80.98	0.00	0.00	0.00	0.00
11	157.55	157.55	0.00	0.00%	85.42	0.00	0.00	0.00	0.00
12	194.71	194.71	0.00	0.00%	89.08	0.00	0.00	0.00	0.00
13	248.04	248.04	0.00	0.00%	91.59	0.00	0.00	0.00	0.00
14	305.24	305.24	0.00	0.00%	93.78	0.00	0.00	0.00	0.00
15	359.21	359.21	0.00	0.00%	95.25	0.00	0.00	0.00	0.00
16	411.52	411.52	0.00	0.00%	95.36	0.00	0.00	0.00	0.00
17	446.20	265.31	180.89	40.54%	94.87	144.05	217.73	22.40	8.08
18	461.54	291.50	170.04	36.84%	93.26	133.12	206.96	22.45	7.58
19	448.28	291.43	156.85	34.99%	91.52	119.87	193.83	22.48	6.98
20	411.29	283.54	127.76	31.06%	89.86	90.80	164.71	22.47	5.69
21	377.98	264.07	113.92	30.14%	86.55	76.44	151.39	22.78	5.00
22	342.91	396.60	-53.68	-15.66%	83.32	-101.07	-6.30	28.81	-1.86
23	294.92	341.87	-46.94	-15.92%	81.11	-94.44	0.55	28.87	-1.63
24	243.83	274.63	-30.80	-12.63%	79.41	-78.41	16.81	28.94	-1.06
Daily	Reference Load (MWh)	Load with DR (MWh)	Energy Savings	% Change	Daily Avg Temp (°F)	Uncertainty 5th	Uncertainty 95th	Standard Error	T-statistic
	6210.34	5592.32	618.03	10.0%	84.14	290.36	945.69	199.21	3.10

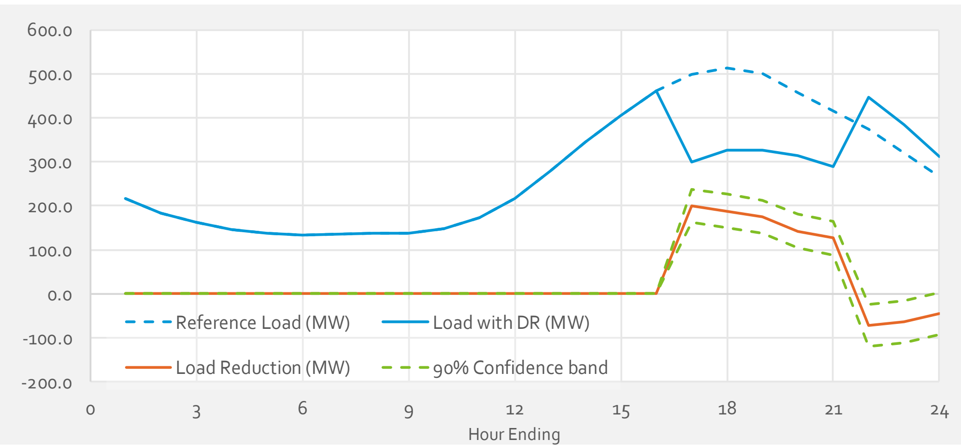
Figure 27: SDP-R Aggregate Ex Ante Impact for 1-in-10 Weather Conditions, August Peak Day 2022

Table 1: Menu options

Type of result	Aggregate
Category	All
Segment	All Customers
Weather Data	SCE
Weather Year	1-in-10
Day Type	August Monthly Peak Day
Forecast Year	2022
Portfolio Level	Program

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	163,670
Total devices	191,082
Total cooling tons	696,554
Event window temperature (F)	96.1
Event window load reduction (MW)	166.41
% Load reduction (Event window)	34.9%
Redaction Information	Public

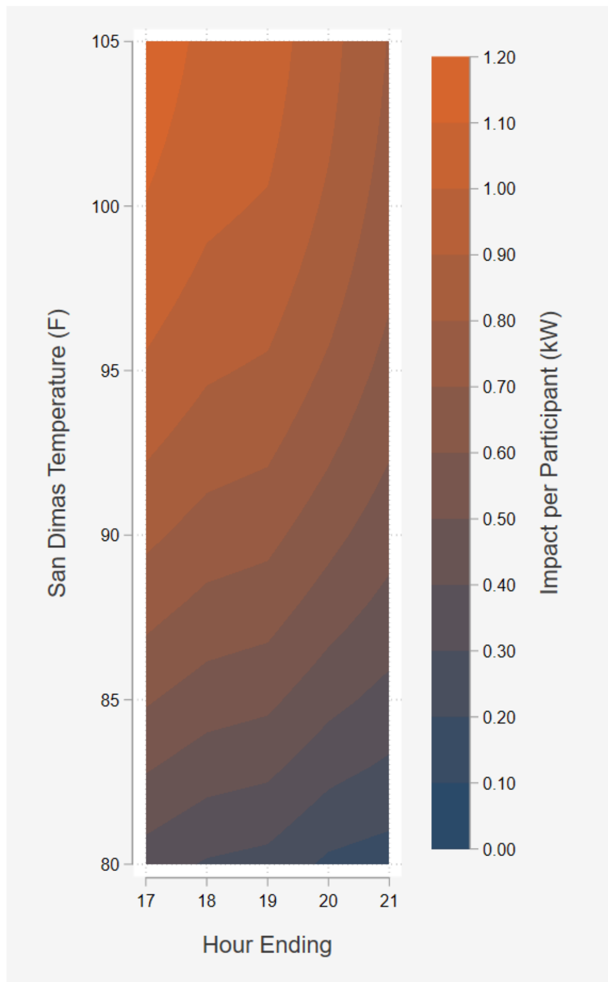


Hour Ending	Reference Load (MW)	Load with DR (MW)	Load Reduction	% Load Reduction	Avg Temp (°F, Site-Weighted)	Uncertainty- 5th	Uncertainty- 95th	Standard Error	T-Statistic
1	215.50	215.50	0.00	0.00%	81.32	0.00	0.00	0.00	0.00
2	183.28	183.28	0.00	0.00%	79.80	0.00	0.00	0.00	0.00
3	161.97	161.97	0.00	0.00%	78.49	0.00	0.00	0.00	0.00
4	146.53	146.53	0.00	0.00%	77.09	0.00	0.00	0.00	0.00
5	137.31	137.31	0.00	0.00%	75.95	0.00	0.00	0.00	0.00
6	134.48	134.48	0.00	0.00%	75.04	0.00	0.00	0.00	0.00
7	135.98	135.98	0.00	0.00%	74.01	0.00	0.00	0.00	0.00
8	136.59	136.59	0.00	0.00%	74.00	0.00	0.00	0.00	0.00
9	136.62	136.62	0.00	0.00%	76.86	0.00	0.00	0.00	0.00
10	148.35	148.35	0.00	0.00%	82.23	0.00	0.00	0.00	0.00
11	173.04	173.04	0.00	0.00%	88.15	0.00	0.00	0.00	0.00
12	216.79	216.79	0.00	0.00%	92.40	0.00	0.00	0.00	0.00
13	279.37	279.37	0.00	0.00%	94.80	0.00	0.00	0.00	0.00
14	345.69	345.69	0.00	0.00%	96.64	0.00	0.00	0.00	0.00
15	405.11	405.11	0.00	0.00%	98.18	0.00	0.00	0.00	0.00
16	460.66	460.66	0.00	0.00%	99.31	0.00	0.00	0.00	0.00
17	498.61	298.76	199.85	40.08%	98.78	162.11	237.59	22.95	8.71
18	514.30	326.04	188.25	36.60%	98.59	150.44	226.07	22.99	8.19
19	502.02	327.21	174.82	34.82%	97.54	136.90	212.73	23.05	7.58
20	456.81	314.33	142.48	31.19%	94.70	104.61	180.35	23.02	6.19
21	415.50	288.85	126.65	30.48%	90.88	88.01	165.30	23.49	5.39
22	375.13	447.29	-72.17	-19.24%	87.58	-119.94	-24.39	29.05	-2.48
23	321.36	385.29	-63.93	-19.89%	85.01	-111.84	-16.02	29.13	-2.19
24	265.52	311.33	-45.80	-17.25%	83.35	-93.89	2.28	29.24	-1.57
Daily	Reference Load (MWh)	Load with DR (MWh)	Energy Savings	% Change	Daily Avg Temp (°F)	Uncertainty 5th	Uncertainty 95th	Standard Error	T-statistic
	6766.52	6116.37	650.15	9.6%	86.70	316.38	983.92	202.92	3.20

Figure 28 shows a time-temperature matrix (TTM) for SDP-R. A TTM quantifies the relationship between demand reductions, temperature conditions, and hour of day. Importantly, the TTM was developed using the same input data as the ex ante forecasts, but the model used to estimate the TTM impacts was simpler out of necessity. The only independent variables used to develop the TTM are temperature (indexed to the San Dimas weather station) and hour of day, while the full ex ante impact model relies on a host of other explanatory variables. Impacts shown in the matrix are static and represent the expected participant-level impact for a territory-wide event for the given hour and temperature.

Figure 28: SDP-R Time-Temperature Matrix

Temp	Hour Ending				
	17	18	19	20	21
105	1.16	1.08	1.05	0.93	0.79
104	1.15	1.07	1.04	0.93	0.79
103	1.14	1.06	1.03	0.92	0.78
102	1.13	1.05	1.02	0.91	0.77
101	1.11	1.04	1.01	0.90	0.76
100	1.09	1.02	0.99	0.88	0.75
99	1.08	1.00	0.97	0.87	0.74
98	1.06	0.98	0.95	0.85	0.72
97	1.03	0.96	0.93	0.83	0.70
96	1.01	0.94	0.91	0.81	0.69
95	0.98	0.91	0.89	0.78	0.66
94	0.96	0.89	0.86	0.76	0.64
93	0.93	0.86	0.83	0.73	0.62
92	0.89	0.82	0.80	0.70	0.59
91	0.86	0.79	0.76	0.67	0.57
90	0.82	0.76	0.73	0.63	0.54
89	0.78	0.72	0.69	0.60	0.51
88	0.74	0.68	0.65	0.56	0.47
87	0.70	0.64	0.61	0.52	0.44
86	0.66	0.59	0.57	0.48	0.40
85	0.61	0.55	0.52	0.43	0.37
84	0.56	0.50	0.48	0.38	0.33
83	0.51	0.45	0.43	0.34	0.29
82	0.46	0.40	0.38	0.29	0.24
81	0.41	0.35	0.32	0.23	0.20
80	0.35	0.29	0.27	0.18	0.15



4.3 RESULTS BY CUSTOMER SEGMENT

The Ex Ante table generator, submitted in tandem with the report, allows users to review ex ante impact estimates across years, weather conditions, and several relevant customer segments. The number of possible combinations is quite large – too large for all combinations to be presented in this report. We believe two of the key grouping variables for SDP-R are cycling strategy and load control group (which bins participants into regional areas). Table 12 shows ex ante impact estimates (per participant) for these key segments using SCE August weather conditions. Impacts are shown for each of the two weather scenarios (1-in-2 and 1-in-10). As would be expected, ex ante estimates are smaller in the 50% cycling group than in the 100% cycling group. Regarding load control groups, trends in the ex ante estimates follow trends in the ex post estimates. Impacts tend to be larger in the SDP-Central region. The lowest impacts are in the SDP-Northwest region, which is along the coast.

Table 12: Per Participant SDP-R Ex Ante Results by Customer Segment, SCE August Weather (kW)

Load Control Group	1-in-2 Weather Conditions			1-in-10 Weather Conditions		
	50% Cycling	100% Cycling	Total	50% Cycling	100% Cycling	Total
SDP-Central-1	0.46	1.22	1.11	0.55	1.41	1.27
SDP-Central-2	0.47	1.07	0.97	0.51	1.16	1.04
SDP-Central-3	0.48	0.96	0.89	0.53	1.04	0.96
SDP-Central-4	0.45	1.28	1.14	0.56	1.5	1.34
SDP-High Desert	0.46	0.94	0.89	0.56	1.06	1.01
SDP-Low Desert	0.51	0.80	0.75	0.56	0.88	0.82
SDP-North	0.39	0.93	0.85	0.42	0.98	0.89
SDP-Northwest	0.09	0.39	0.35	0.12	0.48	0.43
SDP-West-1	0.28	0.86	0.76	0.29	0.88	0.77
SDP-West-2	0.30	0.77	0.69	0.32	0.8	0.72
Average	**0.39**	**1.01**	**0.92**	**0.45**	**1.12**	**1.02**

4.4 COMPARISON TO PRIOR YEAR

Table 13 shows a comparison of vintage year 2019, 2020, and 2021 ex ante impacts for the two different weather scenarios at the participant level. All impacts represent monthly peak impact estimates, and SCE weather conditions are used. For 2019 ex ante impacts, participant-level impacts are static throughout the forecast window. For 2020 and 2021 ex ante impacts, participant-level impacts from forecast years 2021 and 2022 are shown respectively.

In magnitude and direction, the 2019-2021 impacts are similar. Still, differences do exist. The differences can be attributed to a few factors. One of the main factors is the ex ante weather conditions, which were updated in 2019, and the new data is about one degree cooler for the 1-in-2 August monthly peak conditions. Changing the weather conditions should (and does) result in different ex ante impacts. Other key differences include: lower enrollments, differences in the customer mix, differences in which historical ex post impacts are used in developing the ex ante impacts, differences in how ex post impacts are calculated, and differences in ex ante regression model specifications.[2]

Table 13: Comparison of SDP-R Per Participant Ex Ante SCE Weather Impacts (kW), 2019-2021

Month	Vintage Year 2019		Vintage Year 2020		Vintage Year 2021	
	1-in-2	1-in-10	1-in-2	1-in-10	1-in-2	1-in-10
June	0.37	0.94	0.53	0.97	0.60	0.99
July	0.71	1.14	0.81	1.13	0.85	1.13
August	0.80	0.95	0.87	1.00	0.92	1.02
September	0.82	0.99	0.88	1.02	0.93	1.04

4.5 EX POST TO EX ANTE COMPARISON

When comparing ex post and ex ante, it is important to keep the distinction between the two estimates in mind. Ex ante impacts are estimates of the future resources available under standardized planning conditions (defined by weather). Ex post impacts are estimates of what past impacts were given the weather, hours of dispatch, and resources dispatched. Because most events have historically been triggered by wholesale market price conditions in specific load pockets, the reductions do not always reflect the magnitude of resources available.

During the 2021 summer, two events – September 9th (system peak day) and July 9th – included all customers and were called under similar conditions as ex ante conditions. Participant impacts on these days provide a good point of comparison against the peak day ex ante impact estimates. Table 14 compares the hour-by-hour ex post load impacts on those days to the ex ante 1-in-2 SCE August monthly peak day and the ex ante 1-in-2 SCE July monthly peak day developed in PY2021. In magnitude, the ex post load impacts are very similar to the ex ante impact estimates shown in the table. In practice, however, the ex ante load impacts were also informed by 2019 and 2020 historical event performance, and 2020 had several hotter event days.

Of course, it's also important to keep in mind that no 2021 SDP-R events were longer than three hours in duration. The event window for ex ante impacts is five hours in duration, which muddies the comparison between ex post and ex ante impacts (as does the weather-normalization).

[2] Like the prior evaluation, our ex post evaluation relied on a difference-in-differences framework. The 2019-2021 approach leveraged one pre-event load term, but also a weather variable and time variables. A temperature spline was included to capture the effect of temperature on load and demand reductions at different temperature ranges (e.g., increasing the temperature from 65 to 70 does not have the same effect on load as increasing the temperature from 80 to 85). The 2020 and 2021 ex ante models also accounted for the effects of the COVID-19 pandemic.

Table 14: SDP-R Ex Post to Ex Ante Comparison

Units	Date	Accounts	Devices	Max Daily Temp (F)	Average Daily Temp (F)	4:00-5:00 PM	5:00-6:00 PM	6:00-7:00 PM	7:00-8:00 PM	8:00-9:00 PM
Aggregate Impacts (MW)	2021-07-09	175,532	202,999	95.2	82.8	---	---	137.1	104.9	76.8
	2021-09-09	175,962	203,485	95.1	81.7	144.0	---	---	---	---
	2022 SCE Ex ante 1-in-2 July Peak Day	163,670	191,082	95.5	82.3	168.3	159.0	147.1	118.0	103.8
	2022 SCE Ex ante 1-in-2 August Peak Day	163,670	191,082	95.4	84.1	180.9	170.0	156.9	127.8	113.9
Impacts per Account (kW)	2021-07-09	175,532	202,999	95.2	82.8	---	---	0.78	0.60	0.44
	2021-09-09	175,962	203,485	95.1	81.7	0.82	---	---	---	---
	SCE Ex ante 1-in-2 July Peak Day	163,670	191,082	95.5	82.3	1.03	0.97	0.90	0.72	0.63
	SCE Ex ante 1-in-2 August Peak Day	163,670	191,082	95.4	84.1	1.11	1.04	0.96	0.78	0.70
Impacts per Device (kW)	2021-07-09	175,532	202,999	95.2	82.8	---	---	0.68	0.52	0.38
	2021-09-09	175,962	203,485	95.1	81.7	0.71	---	---	---	---
	SCE Ex ante 1-in-2 July Peak Day	163,670	191,082	95.5	82.3	0.88	0.83	0.77	0.62	0.54
	SCE Ex ante 1-in-2 August Peak Day	163,670	191,082	95.4	84.1	0.95	0.89	0.82	0.67	0.60

* Table excludes partial event hours.

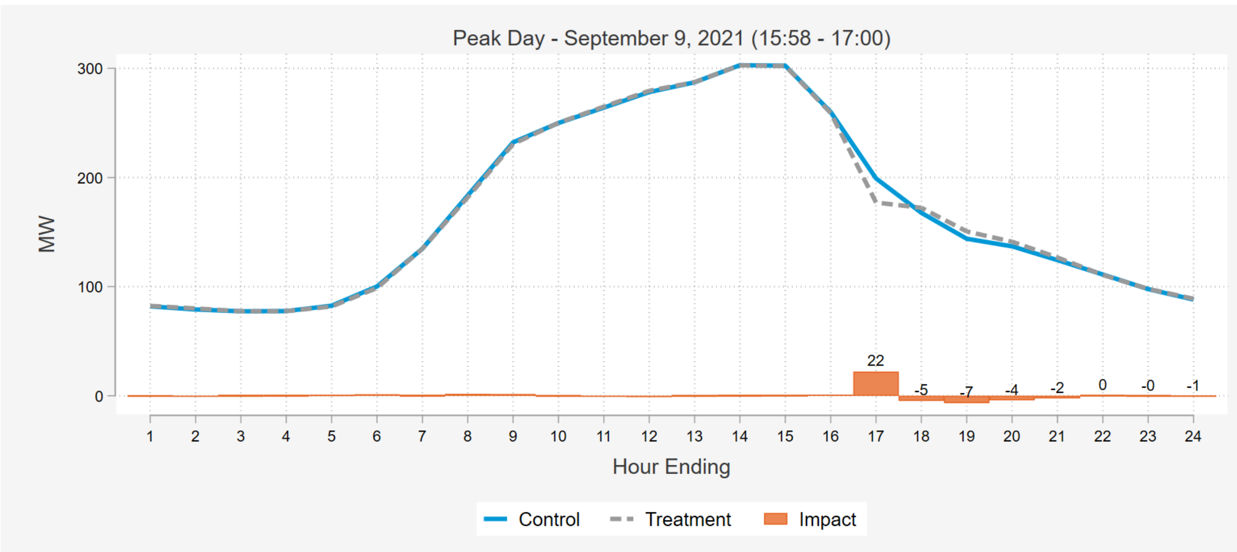
5 NON-RESIDENTIAL EX POST RESULTS

This section focuses on the magnitude of demand reductions delivered by SDP-C during 2021 event days and reflects the impacts delivered given the weather conditions, hours of dispatch, industry and participants mix, and amount of resources dispatched.

5.1 SYSTEM PEAK DAY REDUCTIONS

The system peak occurred on September 9th. On the peak day, SDP-C resources were dispatched from 3:58 PM through 5:00 PM in the self-scheduled day-ahead market. In total, SCE sent instructions to curtail demand 7,517 SDP-C accounts with 65,545 control devices. Figure 29 shows the hourly load profile for the control and participant groups for the system peak day. During the full event hour, the impact was approximately 22 MW and the average percent impact was approximately 11.1%. For commercial customers, AC usage represents a smaller share of load than for residential customers. Commercial AC loads and building occupancy tend to occur mid-day, with less load in the evening hours. In post-event hours, there was 19 MWh of snapback. Netting out the snapback, there was approximately 3.6 MWh in energy savings on the peak day.

Figure 29: SDP-C Reductions on System Peak Day



5.2 INDIVIDUAL EVENT DAY REDUCTIONS

Table 15 shows reference loads, observed loads, impacts, and percent for each of the four SDP-C summer 2021 DR events, as well as the two SDP-C late summer 2020 DR events. The table also shows performance metrics for the average event, which is constructed from the first full event hour for each of the 2021 events.

Table 15: SDP-C Event Results, 2021

					MW Metrics					Impact per ... (kW)				
Date	Load Control Groups	Event start	Event end	Accts	Reference Load	Load with DR	Impact	90% Lower Bound	90% Upper Bound	Acct	Device	Ton	% Impact	Wght. Temp (F)
10/14/2020	LD	6:00 PM	7:00 PM	[redacted]										
10/15/2020	LD	6:00 PM	7:00 PM	[redacted]										
6/17/2021	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	6:00 PM	7,418	113	106	7	3	12	1.00	0.11	0.02	6.6%	85.5
7/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	5:50 PM	8:50 PM	7,567	113	104	10	6	13	1.27	0.14	0.03	8.5%	88.6
8/27/2021	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	6:00 PM	7:00 PM	7,514	153	135	18	13	22	2.36	0.27	0.05	11.6%	91.2
9/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	3:58 PM	5:00 PM	7,517	199	177	22	18	26	2.94	0.34	0.07	11.1%	92.2
Avg. Event		**First Event Hour**		**7,504**	**145**	**130**	**15**	**13**	**17**	**2.00**	**0.23**	**0.04**	**10.3%**	**89.7**

* Only full hours are included in impacts

Figure 30 visualizes impacts on Friday 7/9, which was the only reliability event within the 2021 season. In the two full hours of the event, aggregate impacts were around 10 MW, which accounts for an 8.5% reduction in the reference load.

Figure 30: SDP-C Load Impacts on Friday, 7/9/2021

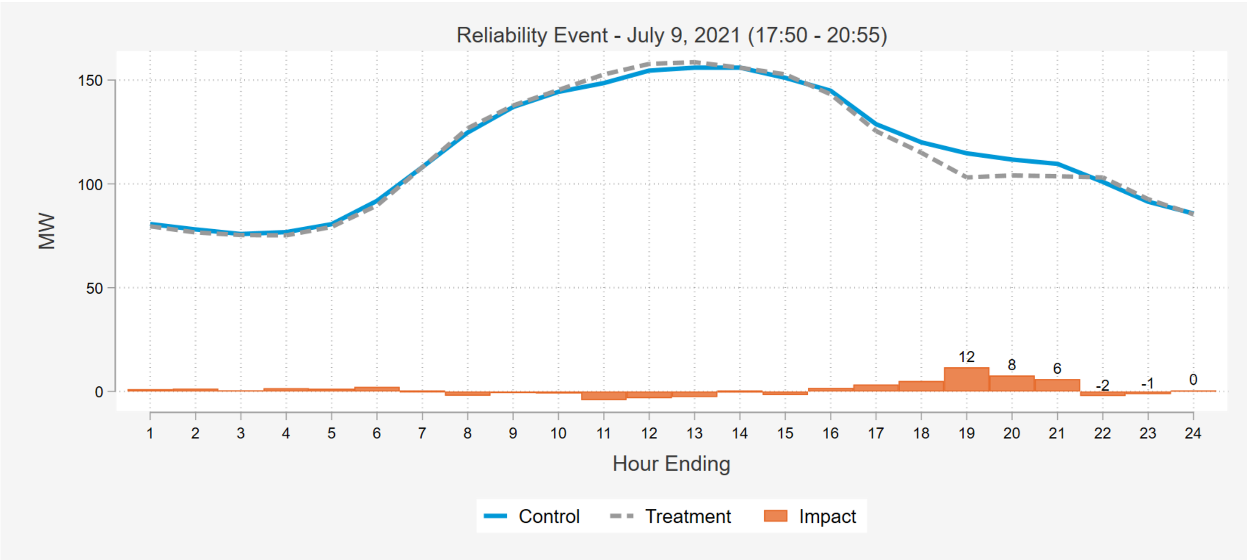
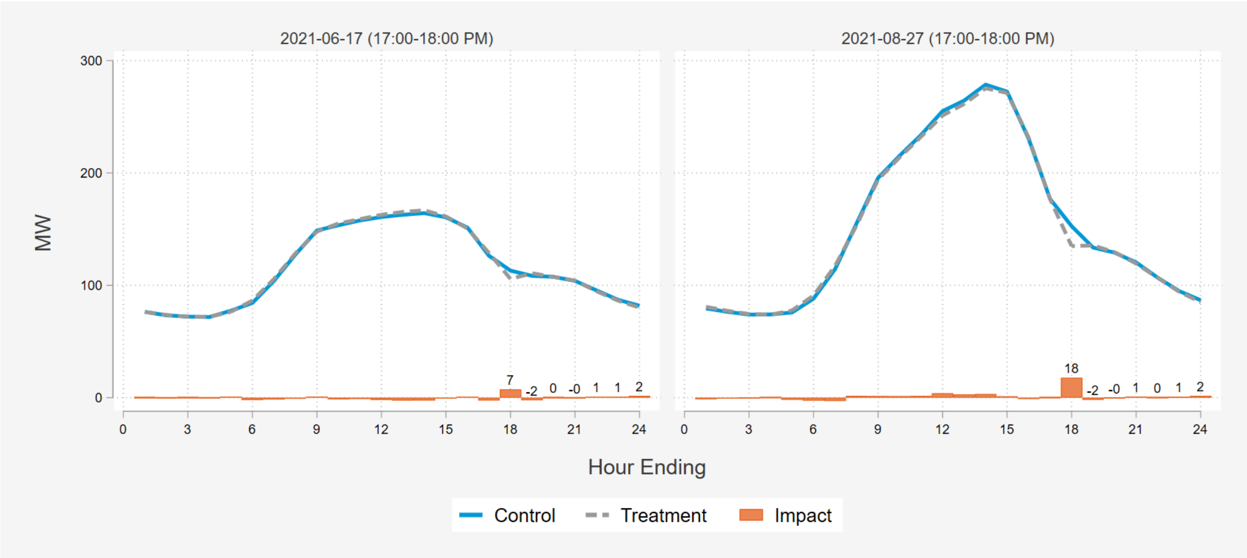


Figure 31 visualizes the aggregate impacts for the two other events in the 2021 DR season, which both begin at 5 PM and end at 6 PM.

Figure 31: SDP-C Reductions on Other 2021 Event Days



We additionally analyzed two October events days from 2020. These two events only dispatched the Low Desert load control group, which accounts for 0.19% of accounts, so the impacts were small and variable.

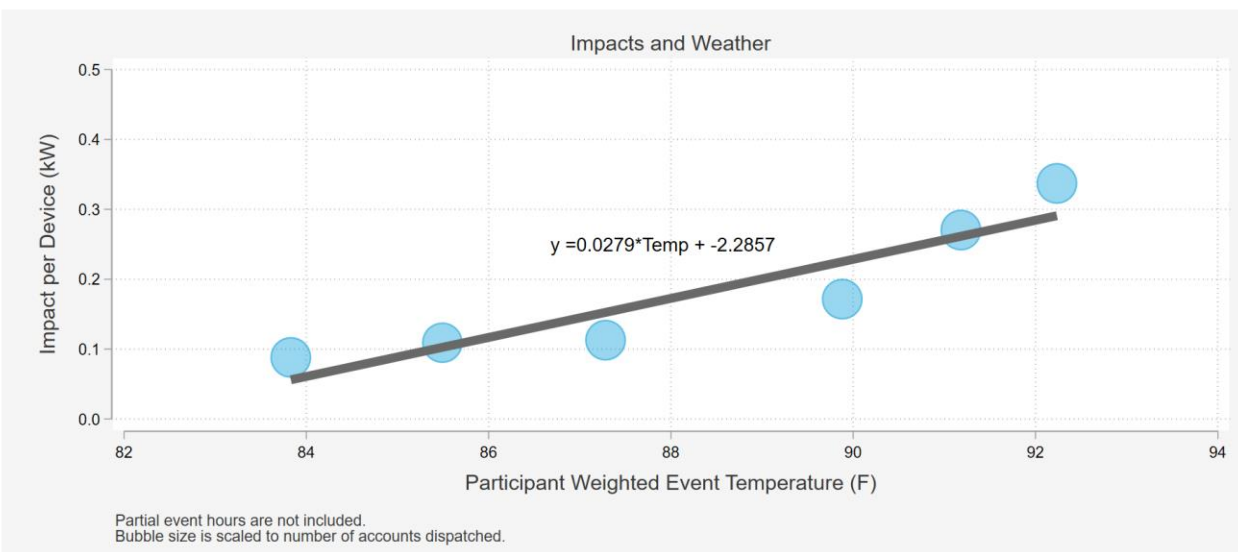
Figure 32: SDP-C Reductions on October 2020 Event Days

[redacted]

5.3 WEATHER SENSITIVITY OF LOAD IMPACTS

The relationship between SDP-C demand reductions and outdoor air temperature is visualized in Figure 33 and includes all full event hours. As would be expected for a load control program, the magnitude of demand reductions is larger when temperatures are hotter. The slope of the trend line is 0.0279 per degree. This implies that each one-degree increase in temperature is associated with a 0.0279 kW increase in the per participant demand reduction.

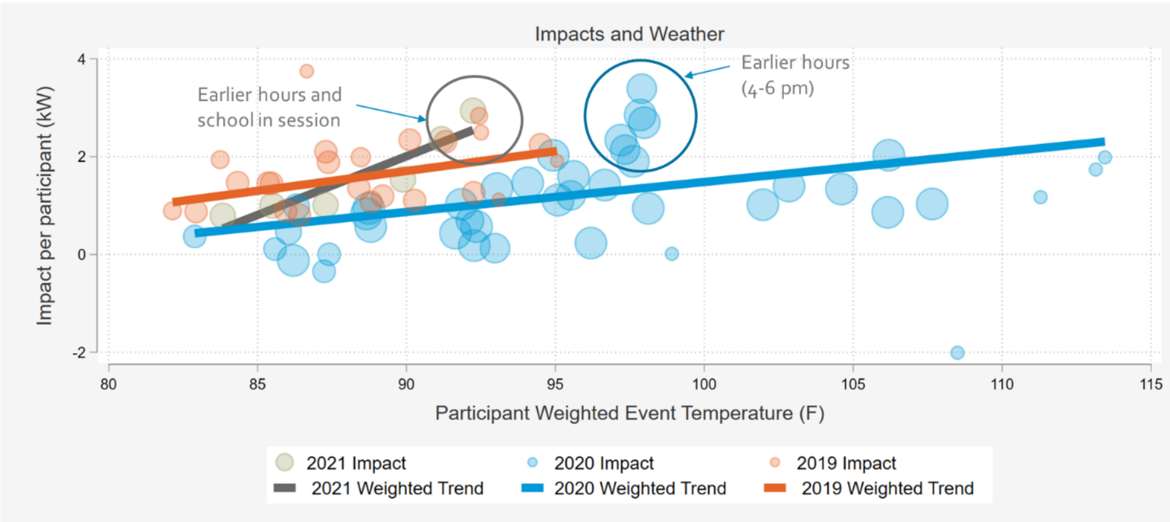
Figure 33: Relationship between SDP-C Demand Reductions and Weather (R^2 = 0.81)



5.4 COMPARISON TO PRIOR YEAR

Figure 34 shows the relationship between SDP-C reductions and outdoor temperature for 2019, 2020, and 2021. The clear difference in the trend of the impacts in 2021 can be explained by a combination of earlier event hours and schools being in session. Recall that a majority of the SDP-C tonnage is in schools. When looking at those data points that are earlier in the day and include schools being in session, the trend between the reductions and weather are more similar.

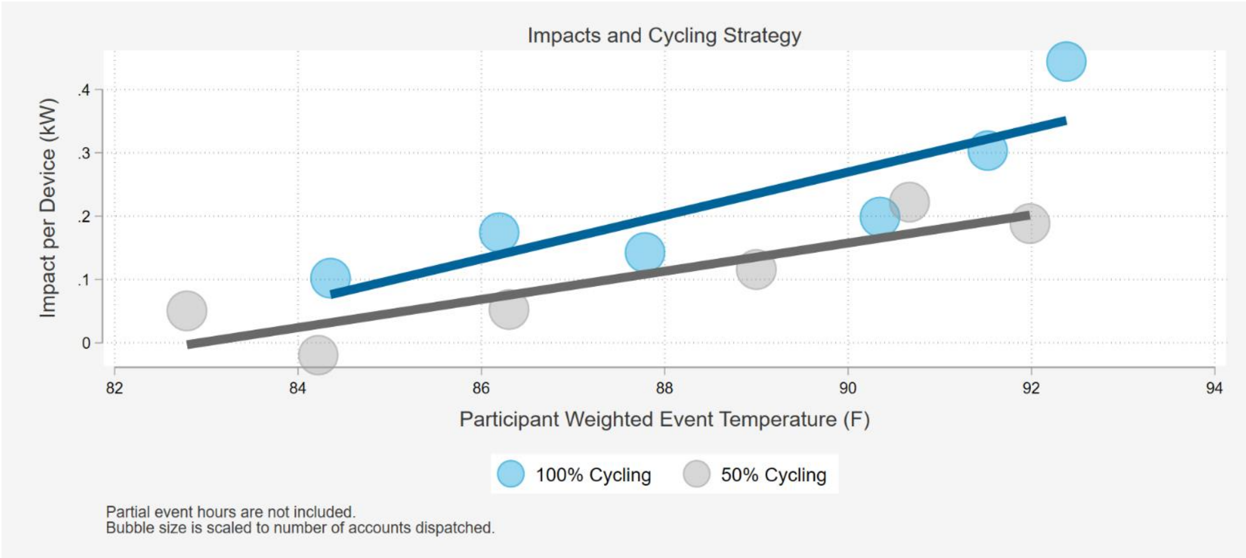
Figure 34: SDP-C Reductions against Temperature, 2019-2021



5.5 IMPACTS BY CYCLING STRATEGY

Figure 35 plots the load impacts against outdoor temperature for the two of the three cycling strategy groups. Impacts for 30% cycling are excluded, as that groups only includes 5% of devices. As expected, the magnitude of impacts for the 100% cycling group is larger than the impacts in the 50% cycling group. The slopes of the lines in the figure are nearly identical– 0.27 in the 100% cycling group and 0.25 in the 50% cycling group. Recall that these slopes represent the expected increase in the impact for every one degree increase in temperature.

Figure 35: SDP-C Impacts by Cycling Strategy



5.6 IMPACTS FOR KEY CUSTOMER SEGMENTS

Table 16 shows per-device impacts of key customer segments for the average 2021 SDP-C event day (which is constructed from the first full event hour for each of the 2021 events).

- On average, percent impacts in the 100% cycling strategy group are more than two times larger than percent impacts in the 50% cycling group;
- Schools account for more nearly half of the aggregate demand reductions on the average event day and drive the results for SDP-C.

Table 16: SDP-C Impacts by Key Customer Segments, Average 2021 Event Day

Category	Subcategory	Number of Accounts	Devices	Tonnage	Ref. Load (MW)	Obs. Load (MW)	Impact (MW)	Percent Impact	Impact per Device (kW)
Cycling	30%	[redacted]							
	50%	[redacted]							
	100%	4,828	40,173	206,352	79.9	68.5	11.4	14.2%	0.28
Load Control Group	SDP-Central-1	745	11,349	60,243	16.9	14.2	2.8	16.3%	0.24
	SDP-Central-2	867	5,139	25,058	14.6	13.3	1.3	8.9%	0.25
	SDP-Central-3	181	650	3,728	2.7	2.6	0.1	5.1%	0.21
	SDP-Central-4	1,085	10,423	53,266	20.8	18.1	2.7	13.0%	0.26
	SDP-High Desert	[redacted]							
	SDP-Low Desert	[redacted]							
	SDP-North	[redacted]							
	SDP-Northwest	509	4,303	21,977	11.0	10.3	0.7	6.2%	0.16
	SDP-West-1	1,091	7,834	38,765	19.8	18.7	1.1	5.7%	0.14
	SDP-West-2	1,931	16,100	74,869	37.0	34.3	2.8	7.5%	0.17
Local Capacity Area	Big Creek/Ventura	[redacted]							
	LA Basin	5,855	51,332	254,998	110.8	100.4	10.5	9.4%	0.20
	Outside LA Basin	[redacted]							
Zone	South Orange County	[redacted]							
	South of Lugo	2,359	21,417	109,875	45.9	40.6	5.3	11.6%	0.25
	Remainder of System	[redacted]							

Category	Subcategory	Number of Accounts	Devices	Tonnage	Ref. Load (MW)	Obs. Load (MW)	Impact (MW)	Percent Impact	Impact per Device (kW)
Industry	Agriculture, Mining, Construction	[redacted]							
	Institutional/Government	[redacted]							
	Manufacturing	[redacted]							
	Offices, Hotels, Finance, Services	1,714	3,323	14,479	16.4	15.0	1.5	8.9%	0.44
	Retail Stores	1,151	2,334	11,936	23.8	22.8	1.1	4.4%	0.45
	Schools	1,516	46,296	228,616	65.9	57.2	8.8	13.3%	0.19
	Wholesale, Transport, Other Utilities	620	1,869	8,651	10.0	9.0	1.0	10.0%	0.53
	Unknown/Other	[redacted]							
	Religious organizations	1,116	7,742	45,880	9.3	8.0	1.3	14.5%	0.17
Tonnage Bin	3 or less	1,022	1,023	2,507	5.1	4.5	0.6	11.8	0.59
	3 to 4	903	924	3,103	6.2	5.7	0.5	8.6	0.57
	4 to 5	605	684	2,710	4.1	3.8	0.3	7.4	0.44
	5 to 10	1,470	2,522	10,159	18.3	17.3	1.0	5.4	0.39
	10-100	[redacted]							
	100-500	943	36,463	184,956	50.6	42.9	7.7	15.3	0.21
	500+	[redacted]							
All Customers		**7,504**	**66,675**	**339,421**	**145.2**	**130.2**	**15.0**	**10.3%**	**0.23**

By LCG, Figure 36 shows the average aggregate impact for each event. Note that only full event hours were included. Central-4 and North tend to deliver the largest aggregate impacts, followed by Central-1 and West-2. Additionally, one can see how impacts are much larger when schools are in session, like in August and September.

Figure 36: Average Aggregate Impacts by Event and LCG, SDP-C

[redacted]

Figure 37 shows how participant-level impacts vary across subcategories for several key research categories (cycling strategy, select industries, and load control group).

Figure 37: Average Participant Impact by Event and Key Subcategory, SDP-C

[redacted]

5.7 KEY FINDINGS

The SDP Commercial (SDP-C) program has approximately 7,700 customers enrolled and includes about 69,000 control devices and nearly 350,000 tons of air conditioner load. Roughly 65% of customers elect the higher incentive option, which allows SCE to entirely curtail air conditioner demand (100% cycling) during SDP-C DR events.

The relationship between per-device DR impacts and outdoor temperature is positive, meaning impacts tend to increase when temperatures are higher. Across all event days, average per-device impacts were generally in the neighborhood of 0.20 kW with some variation.

A few other key findings are worth highlighting:

- During the system peak day (September 9th, 2021), SDP-C participants reduced demand by an average of 22 MW between 4:00 PM and 5:00 PM. The average demand reductions per customer, per device, and per ton for this event were 2.94 kW, 0.34 kW, and 0.07 kW respectively.
- SDP-C is a very top-heavy program, as 10% of the program participants account for more than 60% of the total AC tonnage. In other words, a small handful of customers account for a majority of the AC tonnage. Schools also account for a considerable share of the SDP-C AC tonnage, so demand reductions are tied to whether or not schools are in session. School whole building and air conditioner loads drop off considerably during peak hours.
- On average, percent impacts in the 100% cycling strategy group are more than two times larger than percent impacts in the 50% cycling group.

6 NON-RESIDENTIAL EX ANTE RESULTS

Ex ante impacts describe the magnitude of program resources available under standard planning conditions defined by weather. The ex ante estimates are developed for both SCE and California ISO peak conditions under normal (1-in-2) and extreme (1-in-10) peak planning conditions. The ex ante impacts were estimated based on the relationship between demand reductions and weather using four years of historical performance data (2018-2021) and factored in projected changes in enrollment.

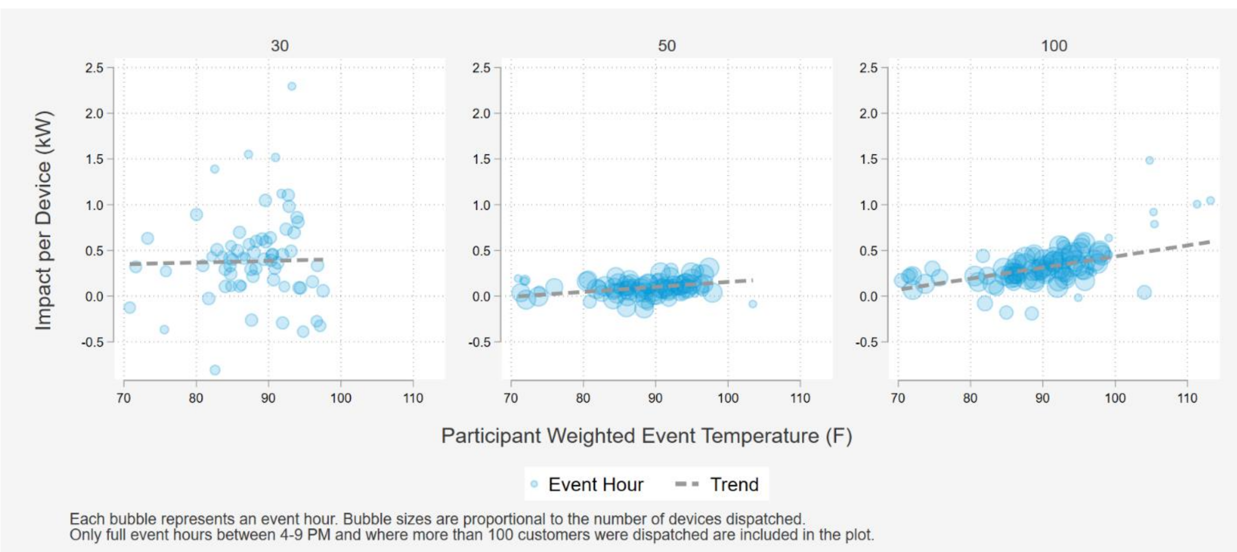
6.1 DEVELOPMENT OF EX ANTE IMPACTS

The ex ante impacts were developed by estimating the relationship between weather and demand reductions from 2018-2021 for customers currently in the program. In total, we estimated the relationship between demand reductions and impact for three distinct segments – each of the three cycling strategies.

One important modeling decision was to only include event hours during the 4:00–9:00 PM peak window. As has been discussed throughout this report, the relationship between air conditioner load, impacts, and weather varies based occupancy and hour of day.

Figure 38 shows the relationship between outdoor temperature and demand reductions (per device) for the three cycling strategies across the four year period. Note that only weekdays are included in the figure. Weekend impacts tend to be smaller due to the makeup of the program (predominantly schools).

Figure 38: Impacts against Temperature by Cycling Strategy



The pattern of reductions across events and segments was analyzed using a multivariate regression model. The model accounts for the effects of the hour of day, day of week, and cycling strategy, as well as includes a dummy variable to flag 2020 as the period containing COVID. All predictions are made on COVID = 0. Appendix E includes the output from the model. In addition, the historical snapback was analyzed to produce estimates of the post-event increase in loads based on the number of hours since the event finished and the daily heat buildup.

The impact models were combined with reference load models that were developed using historical load data and historical weather data (2019 and 2021). The relationship between historical loads and weather was cast across ex ante weather conditions to develop ex ante reference loads.

6.2 OVERALL RESULTS

For the monthly peak day, Table 17 shows average participant-level ex ante impacts for each of the summer months (and also May). Impacts are shown under four different scenarios – CAISO 1-in-2 and 1-in-10 weather conditions and SCE 1-in-2 and 1-in-10 weather conditions. The estimated reductions are greater under the 1-in-10 weather conditions, as there is more AC load available for curtailment when temperatures are higher. For reference, the average impact per device on the 2021 peak day was 0.34 kW.

Table 17: Per Device Peak Day Ex Ante Impacts (kW)

Month	SCE Weather		CAISO Weather	
	1-in-2	1-in-10	1-in-2	1-in-10
May	0.24	0.29	0.22	0.29
June	0.25	0.28	0.27	0.30
July	0.29	0.39	0.28	0.28
August	0.26	0.31	0.26	0.30
September	0.30	0.32	0.29	0.32

Table 18 shows aggregate ex ante demand reduction forecasts for an August peak event day. Forecasts are shown under the four scenarios identified above. The fact that the demand reductions decrease throughout the forecast window can be explained by the decline in the enrollment forecast, which itself can be explained general customer attrition (customers moving and/or requesting to be removed from the program). Ex ante weather conditions are static through the forecast window.

Table 18: Aggregate August Peak Day Demand Reduction Forecast – SDP-C (MW)

Forecast Year	Enrollment Forecast	Total Devices	SCE		CAISO	
			1-in-2	1-in-10	1-in-2	1-in-10
2022	7,062	61,051	16.1	18.8	15.8	18.2
2023	6,643	57,427	15.1	17.7	14.9	17.2
2024	6,267	54,173	14.3	16.7	14.0	16.2
2025	5,929	51,251	13.5	15.8	13.3	15.3
2026	5,625	48,628	12.8	15.0	12.6	14.5
2027	5,353	46,273	12.2	14.2	12.0	13.8
2028	5,108	44,159	11.6	13.6	11.4	13.2
2029	4,889	42,261	11.1	13.0	10.9	12.6

Forecast Year	Enrollment Forecast	Total Devices	SCE		CAISO	
			1-in-2	1-in-10	1-in-2	1-in-10
2030	4,692	40,557	10.7	12.5	10.5	12.1
2031	4,515	39,027	10.3	12.0	10.1	11.7
2032	4,356	37,654	9.9	11.6	9.7	11.2

Figure 39 and Figure 40 show the estimated ex ante load profiles for the SDP-C customer pool in 2022. Both figures show profiles for the August peak day, and both figures use SCE weather conditions rather than CAISO conditions.

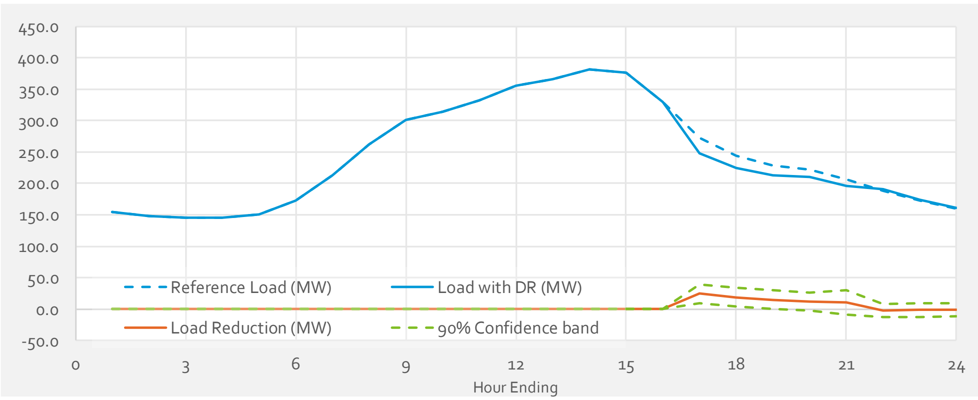
Figure 39: SDP-C Aggregate Ex Ante Impact for 1-in-2 Weather Conditions, August Peak Day 2022

Table 1: Menu options

Type of result	Aggregate
Category	All
Segment	All Customers
Weather Data	SCE
Weather Year	1-in-2
Day Type	August Monthly Peak Day
Forecast Year	2022
Portfolio Level	Program

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	7,062
Total devices	61,051
Total cooling tons	309,774
Event window temperature (F)	88.8
Event window load reduction (MW)	16.06
% Load reduction (Event window)	6.8%
Redaction Information	Public



Hour Ending	Reference Load (MW)	Load with DR (MW)	Load Reduction (MW)	% Load Reduction	Avg Temp (°F, Site-Weighted)	Uncertainty-Adjusted 5th	Uncertainty-Adjusted 95th	Standard Error	T-Statistic
1	154.08	154.08	0.00	0.0%	77.51	0.00	0.00	0.00	0.00
2	148.22	148.22	0.00	0.0%	76.39	0.00	0.00	0.00	0.00
3	145.49	145.49	0.00	0.0%	75.50	0.00	0.00	0.00	0.00
4	145.61	145.61	0.00	0.0%	74.56	0.00	0.00	0.00	0.00
5	150.90	150.90	0.00	0.0%	73.87	0.00	0.00	0.00	0.00
6	172.35	172.35	0.00	0.0%	73.34	0.00	0.00	0.00	0.00
7	212.28	212.28	0.00	0.0%	72.74	0.00	0.00	0.00	0.00
8	262.76	262.76	0.00	0.0%	72.78	0.00	0.00	0.00	0.00
9	301.37	301.37	0.00	0.0%	74.97	0.00	0.00	0.00	0.00
10	314.42	314.42	0.00	0.0%	79.05	0.00	0.00	0.00	0.00
11	332.21	332.21	0.00	0.0%	83.25	0.00	0.00	0.00	0.00
12	355.27	355.27	0.00	0.0%	86.74	0.00	0.00	0.00	0.00
13	366.66	366.66	0.00	0.0%	89.17	0.00	0.00	0.00	0.00
14	381.03	381.03	0.00	0.0%	91.25	0.00	0.00	0.00	0.00
15	375.94	375.94	0.00	0.0%	92.60	0.00	0.00	0.00	0.00
16	329.50	329.50	0.00	0.0%	92.58	0.00	0.00	0.00	0.00
17	272.42	248.11	24.31	8.9%	92.01	9.34	39.28	9.10	2.67
18	243.70	224.90	18.79	7.7%	90.77	4.23	33.36	8.85	2.12
19	227.98	213.07	14.91	6.5%	89.40	0.40	29.43	8.82	1.69
20	221.75	209.80	11.95	5.4%	87.57	-2.60	26.50	8.84	1.35
21	206.81	196.45	10.36	5.0%	84.22	-8.93	29.65	11.73	0.88
22	188.46	191.32	-2.86	-1.5%	80.92	-13.46	7.74	6.44	-0.44
23	172.43	174.28	-1.84	-1.1%	78.84	-12.45	8.76	6.45	-0.29
24	160.19	161.32	-1.14	-0.7%	77.27	-11.76	9.48	6.46	-0.18
Daily	Reference Load (MWh)	Load with DR (MWh)	Energy Savings (MWh)	% Change	Daily Avg Temp (°F)	Uncertainty adjusted 5th	Uncertainty adjusted 95th	Standard Error	T-statistic
	5841.83	5767.34	74.49	1.3%	81.97	-35.22	184.19	66.70	1.12

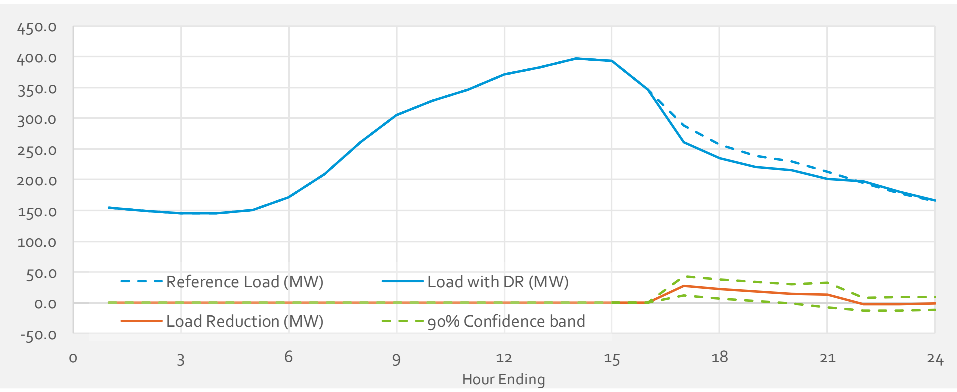
Figure 40: SDP-C Aggregate Ex Ante Impact for 1-in-10 Weather Conditions, August Peak Day 2022

Table 1: Menu options

Type of result	Aggregate
Category	All
Segment	All Customers
Weather Data	SCE
Weather Year	1-in-10
Day Type	August Monthly Peak Day
Forecast Year	2022
Portfolio Level	Program

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	7,062
Total devices	61,051
Total cooling tons	309,774
Event window temperature (F)	93.0
Event window load reduction (MW)	18.77
% Load reduction (Event window)	7.6%
Redaction Information	Public

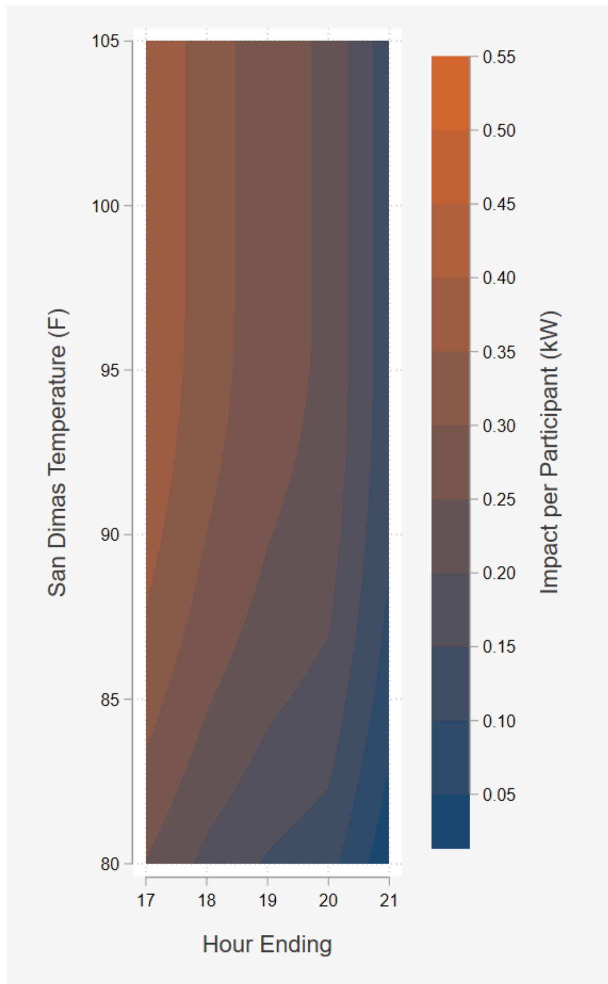


Hour Ending	Reference Load (MW)	Load with DR (MW)	Load Reduction (MW)	% Load Reduction	Avg Temp (°F, Site-Weighted)	Uncertainty-Adjusted 5th	Uncertainty-Adjusted 95th	Standard Error	T-Statistic
1	154.65	154.65	0.00	0.0%	78.76	0.00	0.00	0.00	0.00
2	149.37	149.37	0.00	0.0%	77.50	0.00	0.00	0.00	0.00
3	145.78	145.78	0.00	0.0%	76.34	0.00	0.00	0.00	0.00
4	145.48	145.48	0.00	0.0%	75.15	0.00	0.00	0.00	0.00
5	150.38	150.38	0.00	0.0%	74.15	0.00	0.00	0.00	0.00
6	171.30	171.30	0.00	0.0%	73.40	0.00	0.00	0.00	0.00
7	209.46	209.46	0.00	0.0%	72.64	0.00	0.00	0.00	0.00
8	260.54	260.54	0.00	0.0%	72.65	0.00	0.00	0.00	0.00
9	305.63	305.63	0.00	0.0%	75.25	0.00	0.00	0.00	0.00
10	328.01	328.01	0.00	0.0%	80.25	0.00	0.00	0.00	0.00
11	346.76	346.76	0.00	0.0%	85.83	0.00	0.00	0.00	0.00
12	370.61	370.61	0.00	0.0%	89.41	0.00	0.00	0.00	0.00
13	382.47	382.47	0.00	0.0%	91.12	0.00	0.00	0.00	0.00
14	397.49	397.49	0.00	0.0%	92.76	0.00	0.00	0.00	0.00
15	392.85	392.85	0.00	0.0%	94.28	0.00	0.00	0.00	0.00
16	346.34	346.34	0.00	0.0%	95.74	0.00	0.00	0.00	0.00
17	288.25	260.94	27.31	9.5%	96.01	11.12	43.51	9.84	2.77
18	256.95	235.26	21.69	8.4%	95.48	6.02	37.36	9.53	2.28
19	238.71	220.98	17.74	7.4%	94.21	2.04	33.43	9.54	1.86
20	229.63	215.02	14.61	6.4%	91.42	-0.95	30.18	9.46	1.54
21	213.50	201.00	12.50	5.9%	87.86	-7.81	32.80	12.35	1.01
22	194.99	197.90	-2.92	-1.5%	84.67	-13.53	7.69	6.45	-0.45
23	178.31	180.19	-1.88	-1.1%	82.30	-12.49	8.74	6.45	-0.29
24	165.49	166.64	-1.16	-0.7%	80.82	-11.79	9.47	6.46	-0.18
Daily	**Reference Load (MWh)**	**Load with DR (MWh)**	**Energy Savings (MWh)**	**% Change**	**Daily Avg Temp (°F)**	**Uncertainty adjusted 5th**	**Uncertainty adjusted 95th**	**Standard Error**	**T-statistic**
	6022.92	5935.02	87.90	1.5%	84.08	-27.38	203.18	70.09	1.25

Figure 41 shows a time-temperature matrix (TTM) for SDP-C. A TTM quantifies the relationship between demand reductions, temperature conditions, and hour of day. Importantly, the TTM was developed using the same input data as the ex ante forecasts, but the model used to estimate the TTM impacts was simpler out of necessity. The only independent variables used to develop the TTM are temperature (indexed to San Dimas) and hour of day, while the full ex ante impact model relies on a host of other explanatory variables. Impacts shown in the matrix are static and represent the expected device-level impact for a territory-wide event for the given hour and temperature.

Figure 41: SDP-C Time-Temperature Matrix, Impacts per Device

Temp	Hour Ending				
	17	18	19	20	21
105	0.40	0.32	0.27	0.24	0.12
104	0.40	0.32	0.27	0.24	0.12
103	0.40	0.32	0.27	0.24	0.12
102	0.40	0.32	0.27	0.24	0.12
101	0.40	0.32	0.27	0.24	0.12
100	0.40	0.32	0.27	0.24	0.12
99	0.40	0.32	0.27	0.24	0.12
98	0.40	0.32	0.27	0.24	0.12
97	0.40	0.32	0.27	0.24	0.12
96	0.40	0.32	0.27	0.24	0.12
95	0.39	0.32	0.27	0.24	0.12
94	0.39	0.32	0.27	0.24	0.12
93	0.39	0.32	0.27	0.24	0.11
92	0.38	0.31	0.26	0.23	0.11
91	0.38	0.31	0.26	0.23	0.11
90	0.37	0.30	0.25	0.22	0.11
89	0.36	0.29	0.25	0.22	0.10
88	0.35	0.28	0.24	0.21	0.09
87	0.34	0.28	0.23	0.20	0.09
86	0.33	0.27	0.22	0.19	0.08
85	0.32	0.25	0.21	0.18	0.07
84	0.31	0.24	0.20	0.17	0.06
83	0.29	0.23	0.19	0.16	0.05
82	0.28	0.22	0.17	0.15	0.04
81	0.26	0.20	0.16	0.13	0.03
80	0.25	0.19	0.14	0.12	0.01



6.3 RESULTS BY CUSTOMER SEGMENT

The Ex Ante table generator, submitted in tandem with the report, allows users to review ex ante impact estimates across years, weather conditions, and several relevant customer segments. The number of possible combinations is quite large – too large for all combinations to be presented in this report. We believe two of the key grouping variables for SDP-C are cycling strategy and load control group (which bins participants into regional areas). Table 19 shows ex ante impact estimates (per device) for these key segments using SCE weather conditions for forecast year 2022. Impacts are shown for each of the two weather scenarios (1-in-2 and 1-in-10). [redacted].

Regarding load control groups, trends in the ex ante estimates follow trends in the ex post estimates. Impacts tend to be larger in the SDP-Central region. [redacted].

Table 19: Per Device SDP-C Ex Ante Results by Customer Segment, SCE August Weather (kW)

Load Control Group	1-in-2 Weather Conditions				1-in-10 Weather Conditions			
	30% Cycling	50% Cycling	100% Cycling	Total	30% Cycling	50% Cycling	100% Cycling	Total
SDP-Central-1	[redacted]	[redacted]	0.41	0.30	[redacted]	[redacted]	0.48	0.35
SDP-Central-2	[redacted]	[redacted]	0.36	0.25	[redacted]	[redacted]	0.43	0.32
SDP-Central-3	[redacted]	[redacted]	0.50	0.53	[redacted]	[redacted]	0.52	0.57
SDP-Central-4	[redacted]	[redacted]	0.42	0.27	[redacted]	[redacted]	0.49	0.32
SDP-High Desert	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
SDP-Low Desert	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
SDP-North	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
SDP-Northwest	[redacted]	[redacted]	0.25	0.21	[redacted]	[redacted]	0.28	0.23
SDP-West-1	[redacted]	[redacted]	0.29	0.16	[redacted]	[redacted]	0.31	0.18
SDP-West-2	[redacted]	[redacted]	0.28	0.19	[redacted]	[redacted]	0.31	0.23
Average	[redacted]	[redacted]	**0.37**	**0.26**	[redacted]	[redacted]	**0.41**	**0.31**

6.4 COMPARISON TO PRIOR YEAR

Table 20 shows a comparison of vintage year 2019, 2020, and 2021 ex ante impacts for the two different weather scenarios at the participant level. All impacts represent monthly peak impact estimates, and SCE weather conditions are used. For 2019 ex ante impacts, participant-level impacts are static throughout the forecast window. For 2020 and 2021 ex ante impacts, participant-level impacts from forecast years 2021 and 2022 are shown respectively.

The differences can likely be attributed to a few factors. One of the main factors is the ex ante weather conditions were updated in 2019. Second, additional non-performing sites were removed from the program in 2019. Such a change would necessarily result in higher average impacts per participant. Other key differences include: differences in the customer mix, differences in which historical ex post impacts are used in developing the ex ante impacts, differences in how ex post impacts are calculated, and differences in ex ante regression model specifications.

Table 20: Comparison of SDP-C Per Participant Ex Ante SCE Weather Impacts (kW), 2019-2021

Month	Vintage Year 2019		Vintage Year 2020		Vintage Year 2021	
	1-in-2	1-in-10	1-in-2	1-in-10	1-in-2	1-in-10
June	1.90	2.99	1.91	2.52	2.16	2.45
July	2.56	3.56	2.44	3.52	2.54	3.34
August	2.58	2.95	2.29	2.80	2.27	2.66
September	2.76	3.12	2.65	2.96	2.62	2.80

6.5 EX POST TO EX ANTE COMPARISON

When comparing ex post and ex ante, it is essential to keep the distinction between the two estimates in mind. Ex ante impacts are estimates of the future resources available under standardized planning conditions (defined by weather). Ex post impacts are estimates of what past impacts were given the weather, hours of dispatch, the magnitude of resources dispatched, and other dispatch conditions. Because most events have historically been triggered by wholesale market price conditions in specific load pockets, the reductions do not always reflect the magnitude of resources available.

During the 2021 summer, two events – September 9th (system peak day) and July 9th – included all customers and were called under similar conditions as ex ante conditions. Participant impacts on these days provide a good point of comparison against the peak day ex ante impact estimates. Table 21 compares the hour-by-hour ex post load impacts on those days to the ex ante 1-in-2 SCE August monthly peak day and the ex ante 1-in-2 SCE July monthly peak day developed in PY2021. In magnitude, the ex post load impacts are very similar to the ex ante impact estimates shown in the table. In practice, however, the ex ante load impacts were also informed by 2018-2020 historical event performance, and 2020 had several hotter event days.

Table 21: SDP-C Ex Post to Ex Ante Comparison

Units	Date	Accounts	Devices	Max Daily Temp (F)	Average Daily Temp (F)	4:00-5:00 PM	5:00-6:00 PM	6:00-7:00 PM	7:00-8:00 PM	8:00-9:00 PM
Aggregate Impacts (MW)	7/9/2021 (5:50pm-8:55pm)	7,567	67,726	91.9	80.7	---	---	11.6	7.6	6.0
	9/9/2021 (3:58pm-5:00pm)	7,517	65,545	92.6	79.3	22.1	---	---	---	---
	2022 SCE Ex-ante 1-in-2 July Peak Day	7,062	61,051	91.8	79.5	26.0	20.7	17.0	14.0	11.7
	2022 SCE Ex-ante 1-in-2 August Peak Day	7,062	61,051	92.6	82.0	24.3	18.8	14.9	11.9	10.4
Impacts per Account (kW)	7/9/2021 (5:50pm-8:55pm)	7,567	67,726	91.9	80.7	---	---	1.54	1.01	0.79
	9/9/2021 (3:58pm-5:00pm)	7,517	65,545	92.6	79.3	2.94	---	---	---	---
	SCE Ex-ante 1-in-2 July Peak Day	7,062	61,051	91.8	79.5	3.69	2.93	2.41	1.98	1.66
	SCE Ex-ante 1-in-2 August Peak Day	7,062	61,051	92.6	82.0	3.44	2.66	2.11	1.69	1.47
Impacts per Device (kW)	7/9/2021 (5:50pm-8:55pm)	7,567	67,726	91.9	80.7	---	---	0.17	0.11	0.09
	9/9/2021 (3:58pm-5:00pm)	7,517	65,545	92.6	79.3	0.34	---	---	---	---
	SCE Ex-ante 1-in-2 July Peak Day	7,062	61,051	91.8	79.5	0.43	0.34	0.28	0.23	0.19
	SCE Ex-ante 1-in-2 August Peak Day	7,062	61,051	92.6	82.0	0.40	0.31	0.24	0.20	0.17

* Table excludes partial event hours.

7 RECOMMENDATIONS

The Summer Discount Program remains a significant component of the SCE Demand Response portfolio. It currently includes roughly 180,000 residential customers, 7,700 non-residential customers, approximately 272,000 air conditioner units, and over 1.1 million tons of air conditioning. It has the capability to deliver large magnitudes of flexible loads at very fast ramp rates, is available for a wide range of hours, and can target resources to specific geographic locations. Most importantly, the program delivers larger reductions when the weather is more extreme and resources are needed most. The extreme temperate conditions and emergency events highlight that SDP delivers larger demand reductions when resources are needed most. However, the magnitude of SDP resources has been declining. Increased attrition has coincided with lower incentives and a higher number of events. Table summarizes our recommendations for the program. We recognize that our recommendations do not incorporate costs and may not be funded under current budgets.

Table 22: Evaluator Recommendations

Recommendation	Explanation
Develop a time-temperature matrix to address differences between operations and planning conditions	The load impact protocols were initially developed for long term planning and not for settlement and operations. Increasingly, however, CAISO, planners, and program managers need to understand the magnitude of resources available for different hours, under various temperature conditions. A time-temperature matrix quantifies the relationship between demand reductions, daily temperature conditions, and hour of day. It describes the resources available and bridges the gap between operations and planning conditions. Fundamentally, both rely on observed historical program performance as a function of weather.
Add weekend days to the load impact protocol ex-ante tables and include weekend test events, if needed	Historically, SCE and California as a whole has peaked on weekdays and planned resources to meet weekday demand. The emergency events in 2020 highlighted the need to quantify the magnitude of resources available for weekend conditions. While those do not differ much for residential programs, the weekend DR resources available for non-residential customers differ substantially from weekday resources. To the extent that weekend events are part of future program plans, consider calling more weekend events and developing a "weekend" set of ex ante impacts, particularly for SDP-C where reference loads are smaller on weekends. To allow for better ex ante impact estimation, the weekend events would ideally cover the entire RA window – though not necessarily all in one event.

Recommendation	Explanation
Include "test" event operations to fully assess the load reduction capability	To facilitate comparisons between ex post and ex ante results, we recommend at least one territory-wide event, ideally on the SCE system peak day or another day with high system loads. We also recommend ensuring that the combination of territory-wide actual and test events include each of the peak hour from 4–9 PM. To be clear, we are not recommending five-hour events (unless needed for reliability) but ensuring that at least one of each of the territory-wide events cover the 4–9 PM peak hours. To achieve this, it may be necessary to supplement events called by CAISO with Measurement and Evaluation events.
Make sure to dispatch "test" events that include enough variation to understand program performance	To understand how this program performs, it is imperative to acknowledge the various population groupings (LCG, LCA, etc). For evaluation, we recommend calling different types of events for different sub-populations to better understand performance. This includes variability on the event duration, event start time, and weather conditions. But it does not require calling many events for each customer, instead it encourages calling a couple events across smaller groupings of participants.

APPENDIX A: EX POST METHODOLOGY

The below table summarizes the ex post evaluation approach. The ex post evaluation is direct and relies on simple, transparent methods.

Table 23: Summer Discount Plan Ex Post Evaluation Approach

Methodology Component	Approach
1. Population or sample analyzed	For both residential and commercial customers, analyze the full population of participants and a matched control group.
2. Data included in the analysis	The analysis included nearly all PY2021 data.
3. Use of control groups	A matched control group was employed for residential and commercial customers. Control customers were pulled from a stratified random sample. From the control sample, the control group is selected using non-event day load patterns, geographic location, and other customer characteristics (e.g., industry) to develop propensity scores within each stratum. For each participant, the nearest neighbor based on propensity scores is identified. Several different propensity score models were tested. For each model, we produce standard metrics for bias and goodness of fit – these metrics measure the error between "nearest neighbor" loads and treatment home loads. Of the three models that produce the lowest percent bias, the model that minimizes mean absolute prediction error is selected as the best model. The control group picked by the best model is used as the control group in the ex post analysis.
4. Load impact Regression	The load impacts were estimated by using a difference-in-differences model with fixed effect and time effect. For each event day, the corresponding proxy event day was used to net out differences between the treatment and control group that were not due to the intervention.
5. Segmentation of impact results	The results are segmented by: ▪ Customer class (residential/non-residential) and NAICS code for non-residential customers, ▪ Zone, LCA, and dispatch group ▪ Cycling strategy, and ▪ AC tonnage size. The main segment categories are building blocks. They are designed to ensure segment-level results add up to the total, to enable production of ex ante impacts, and to allow for busbar level analysis.

Because customers enrolled in SDP do not have a natural control group against which to compare loads on event days, one must be constructed. There are many ways to construct a control group, but the evaluation team suggests a blocked propensity score matching process. Propensity score matching is a data pre-processing technique that identifies statistically similar non-participants for each participating customer. It relies on a probit model that relates observed characteristics such as geography, load shapes, industry, and size to whether a given customer has enrolled in a given demand response program – in this case, SDP. The outcome of this model is a propensity score for each participant and non-participant that is the likelihood, given the customer's characteristics, that the customer enrolled in DR. Participants are then "matched" to non-participants with similar propensity scores. Effectively, propensity score matching produces a cohort of non-participants that have the same overall likelihood to have been treated as the participant group – the only customers that did in fact enroll in the program. A blocked propensity score matching process performs this regression and matching procedure for customers in each key strata separately, effectively ensuring that only participants in a given climate zone, for example, will be matched with non-participants in that same climate zone.

For SDP-R and SDP-C, the evaluation team, in conjunction with SCE, decided to proceed with a matched control group relying on a stratified random sample of subsets of non-participants to act as the control pool. This eliminates the need to develop a two-stage matched control group, streamlining analysis. Essentially, instead of relying on information from all possible non-participants, we instead construct a control group from a targeted subset of control candidates that have been pre-screened to belong to sampling cells of influential variables. By oversampling large and/or NEM customers, and by allowing non-participants to be matched multiple times to different participants, we can improve the quality of matching compared to a random sample, while also removing the need to do two-stage matching on all non-participants in SCE's territory. For reference, the sample cells are summarized in Table 24.

Table 24: Summer Discount Plan Non-Participant Sampling Plan

Climate Zone	Customer Class	NEM Status	Annual kWh	Solar Capacity (kW)	Sample
For each CEC Climate Zone	Residential	Non-NEM	0-5000	N/A	1,000
			5k-10k	N/A	1,000
			10k	N/A	1,000
		NEM	N/A	0-6 kW	600
			N/A	6-10 kW	600
			N/A	>10 kW	600

Climate Zone	Customer Class	NEM Status	Peak Demand	Solar Capacity (kW)	Sample
For each CEC Climate Zone	Commercial	Non-NEM	<20kW	N/A	300
			20-200kW	N/A	300
			200kW-1MW	N/A	300
			>1MW	N/A	300
		NEM	<20kW	0-100kW	100
				100-500kW	100
				>500kW	100
			20-200kW	0-100kW	100
				100-500kW	100
				>500kW	100
			200kW-1MW	0-100kW	100
				100-500kW	100
				>500kW	100
			>1MW	0-100kW	100
				100-500kW	100
				>500kW	100

The matched control group for the residential component was successful, as our team found matches for each SDP participant. On the commercial side, however, some SDP participants have very large and unique loads and we were unable to find strong matches for these participants. Rather than leaving the candidates with poor matches in the ex post analysis data set, our team elected to remove them and simply scale the impacts based on the tonnage of the sites that were removed from the analysis. Table 25 lays out an example using a hypothetical event. In the example, the average tonnage per account for sites in the ex post sample is 35.12 tons, and the average tonnage per account for all sites that were curtailed is 45.07. The ratio between these numbers is 1.28. This ratio would be used to scale the estimated counterfactual and the demand reduction estimate (amongst other quantities) for this event. The implicit assumption is that percent impacts for the 400 curtailed sites that are not in the analysis will be similar to the percent impacts for the 7,900 sites that are in the analysis.

Table 25: Scaling Example

Level	Accounts	Tonnage	Tonnage per Account	Scaling Ratio
In Ex Post Analysis Data	7,900	277,448	35.12	1.28
Curtailed	8,300	374,081	45.07	

Table 26 shows the number of accounts, number devices, and total tonnage for the sites that were analyzed and for the sites that were not analyzed.

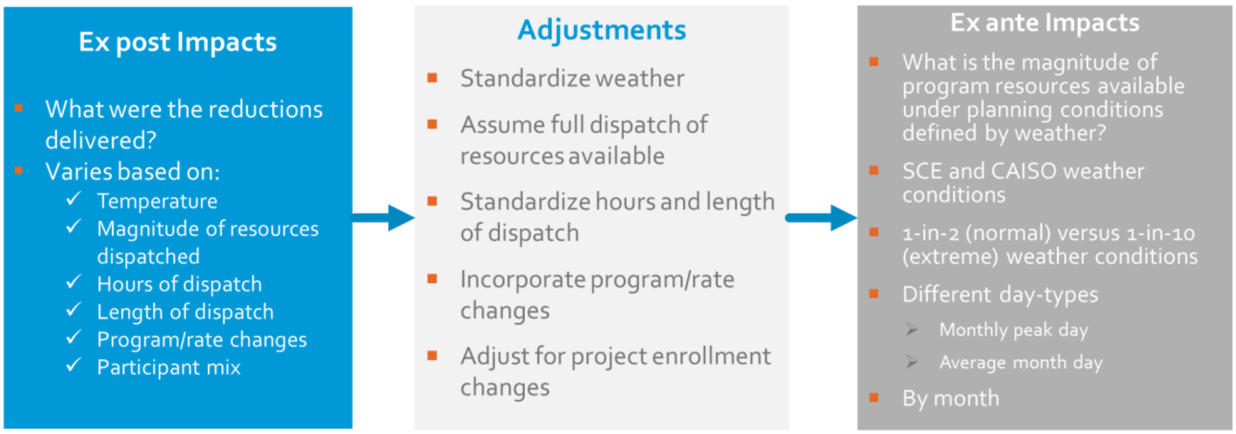
Table 26: Distribution of Accounts by Analysis Status

Analyzed?	Accounts		Devices		Tonnage	
	#	%	#	%	#	%
Yes	7,508	97.8%	60,422	88.2%	295,717	84.7%
No	172	2.2%	8,110	11.8%	53,457	15.3%
Total	**7,680**	**100%**	**68,532**	**100%**	**349,204**	**100%**

APPENDIX B: EX ANTE METHODOLOGY

Figure 42 summarizes some of the key differences between ex post impact estimates and ex ante impact estimates. Perhaps the most important difference is related to weather – ex ante impacts are weather-normalized while ex post impacts reflect historical weather conditions.

Figure 42: Difference between Ex Post and Ex Ante



There are two key steps in developing ex ante impacts. First, historical participant loads are modeled as a function of key weather variables. Using ex ante weather forecasts provided by SCE for both 1-in-2 and 1-in-10 weather years, ex ante reference loads are predicted using the same regression function. Second, a similar process is followed for historical demand response impacts – the impacts are modeled as a function of key weather variables, then the estimated model is used to predict impacts under ex ante weather conditions. Other components of the ex ante methods are discussed in Table 27.

As with ex post impacts, ex ante estimates are produced for key sub-segments of the participant population so that they can be aggregated in different ways to account for changes in future enrollment or program design.

Table 27: Summer Discount Plan Ex Ante Evaluation Approach

Methodology Component	Approach
1. Years of historical performance	We used three/four years (Residential: 2019-2021; Commercial: 2018- 2021) of historical data to estimate how demand reductions vary based on dispatch hours and weather conditions and to estimate the reductions available under planning conditions.
2. Process for producing ex ante impacts	The key steps are: ▪ Use three/four years of historical performance data for relevant customers. ▪ Decide on an adequate segmentation to reflect changes in the customer. Segments used were load control group and cycling

Methodology Component	Approach
	strategy. These segments reflect that events are dispatched geographically and that impacts in the 100% cycling strategy group are known to be larger in magnitude than impacts in the 50% cycling strategy group. ▪ Estimate the relationship between reference loads and weather using non-event days. This is done separately for each segment in both SDP-R and SDP-C. ▪ Use the models to predict reference loads for 1-in-2 and 1-in-10 weather year conditions. ▪ Estimate the relationship between weather and demand response impacts. Like the reference load estimation, this is done separately by segment. For SDP-C, cycling strategy was the only segment used here, as there simply isn't enough data to estimate impacts for each unique combination of load control group and cycling strategy (ten load control groups and three cycling strategies yields 30 segments). ▪ Estimate the relationship between weather and post-event snapback. ▪ Predict the reductions and snapback for 1-in-2 and 1-in-10 weather year conditions. ▪ Incorporate the enrollment forecast.
3. Accounting for changes in the participant mix	Enrollment forecasts were provided by SCE.

APPENDIX C: PROXY EVENT DAYS

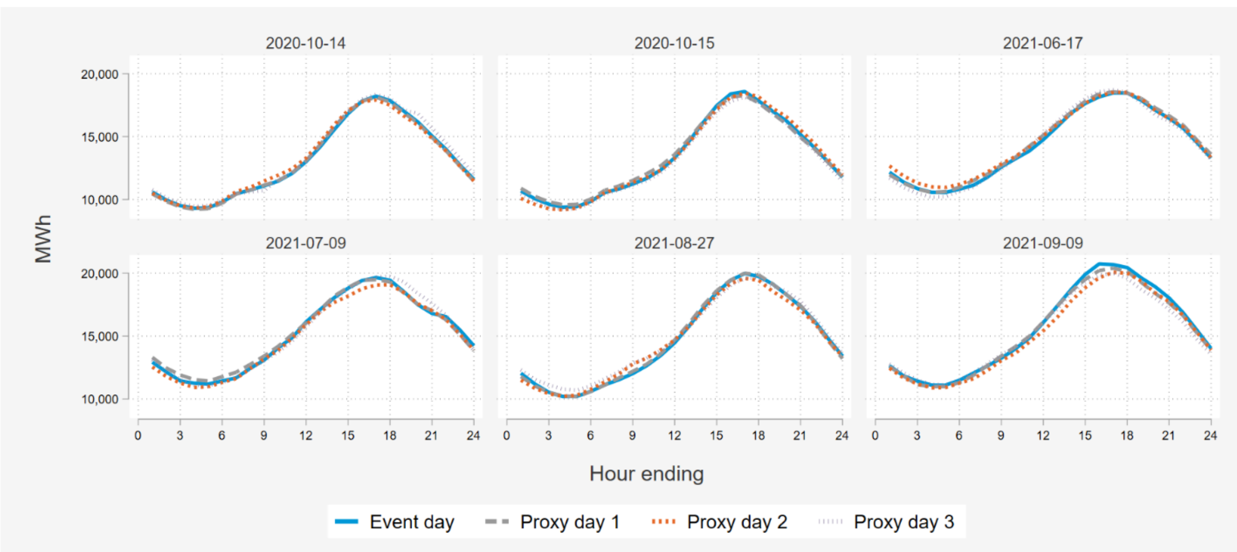
Proxy event days are event-like non-event days. In calculating event day demand reductions, proxy event days are used to net out differences between the treatment and control group that were not due to the intervention. Thus, selecting proxy event days that are similar to actual event days – in terms of total energy used and the hourly load profile – is crucial.

In this analysis, proxy days were selected separately for the residential and commercial customers. Residential proxy days were selected based on SCE loads, while commercial proxy days were selected based on aggregate participant loads.

More generally, proxy days were selected based on a matching algorithm that considers total energy used and how the energy consumption is distributed throughout the day. For the latter component, hourly differences between potential proxy event day loads and event day loads are calculated, then these differences are used to calculate bias and error metrics. For each event day, three proxy event days were selected. Out of all of the candidate days, the proxy event days were selected as follows: keep the nine days with the lowest absolute percent bias; out of those nine, keep the three days with the lowest sum of squared error.

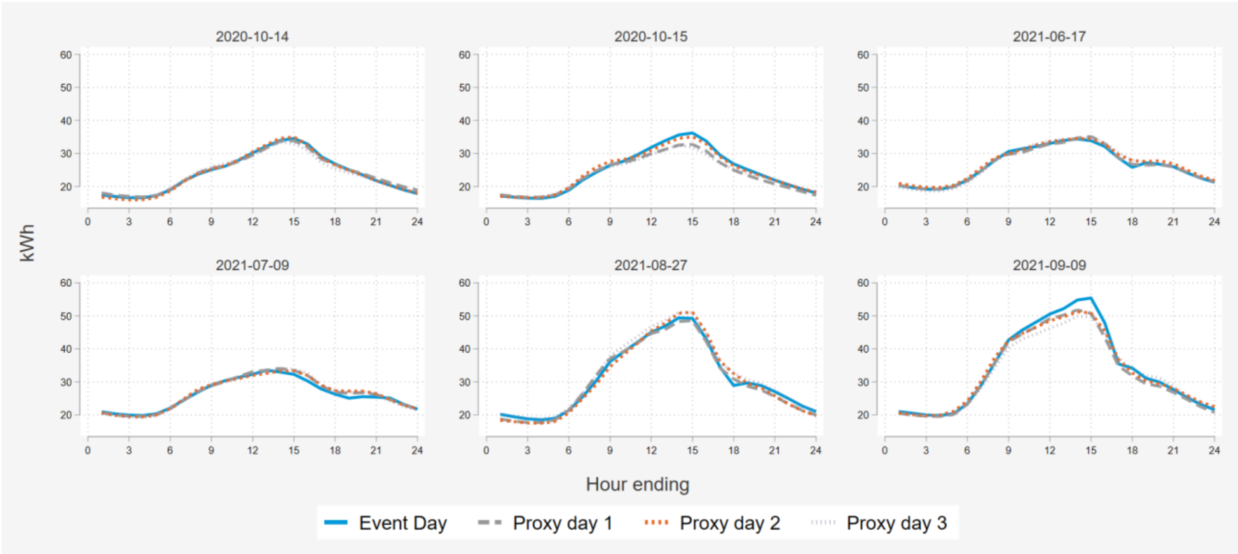
For each 2021 event day, Figure 43 shows system loads on event days and the residential proxy days.

Figure 43: System Load on Event Days and Residential Proxy Days



For each 2021 event day, Figure 44 shows aggregate participant loads on event days and the commercial proxy days.

Figure 44: Aggregate Participant Load on Event Days and Commercial Proxy Days



APPENDIX D: VALIDATION – COMPARISON OF MATCHED CONTROL AND PARTICIPANTS

Ideally, the load profile for a matched control group will mirror the load profile of a treatment group in all hours up until the demand response intervention. This was certainly the case for the 2021 SDP-R ex post evaluation. Figure 45 shows the average control group load and the average treatment group load for each 2021 summer event day.

Figure 45: Control Group and Treatment Group Event Day Loads, SDP-R

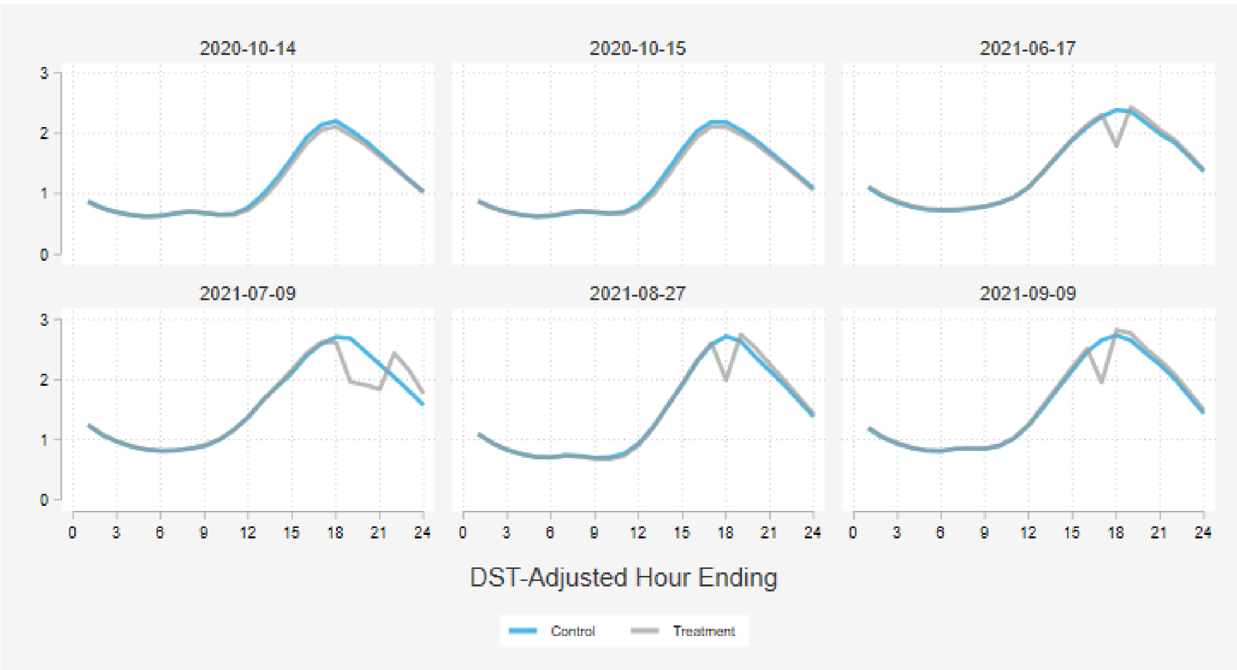
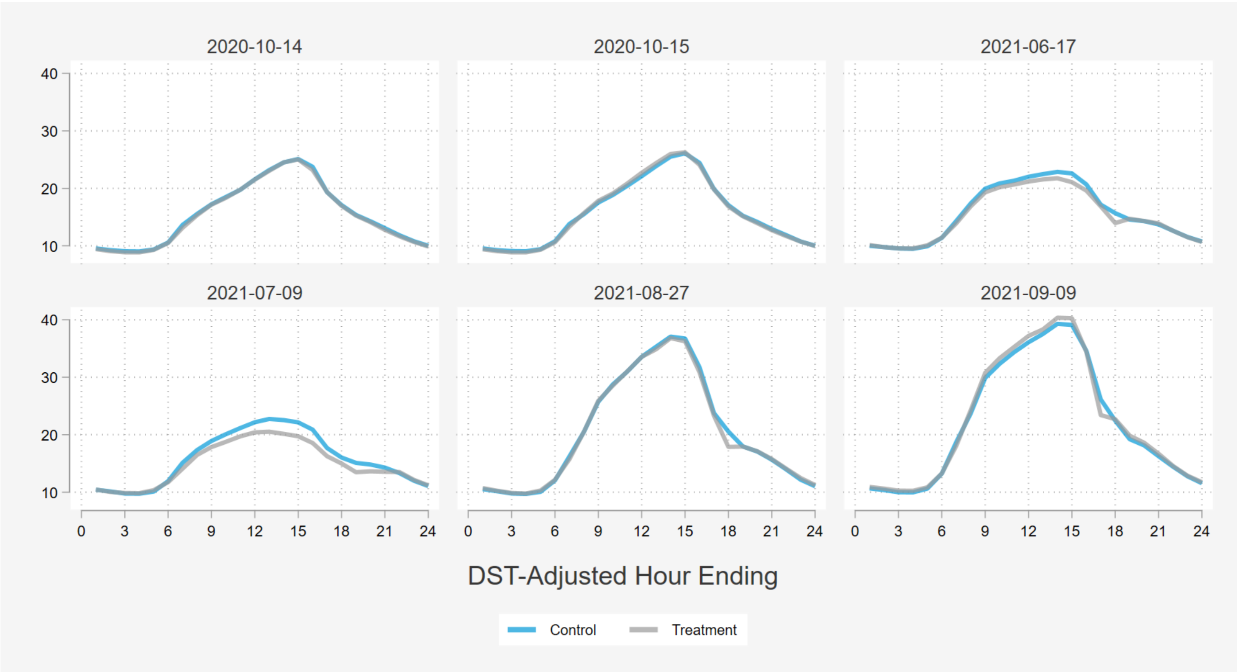


Figure 46 compares average control group load and average treatment group load for the summer 2021 SDP-C events. The control group load does not track the treatment group load as well as SDP-R, but the ex post analysis method (difference-in-differences) nets out any differences between the two groups.

Figure 46: Control Group and Treatment Group Event Day Loads, SDP-C



APPENDIX E: EX ANTE MODEL OUTPUT

SDP-R Impacts –100% Cycling Group

Source	SS	df	MS
Model	472.416052	24	19.6840022
Residual	5.04246292	405	.012450526
Total	477.458515	429	1.11295691

Number of obs	=	429
F(24, 405)	=	1580.98
Prob > F	=	0.0000
R-squared	=	0.9894
Adj R-squared	=	0.9888
Root MSE	=	.11158

impact	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.002137	.0007512	-2.84	0.005	-.0036138	-.0006603
avgtemp_2	-.062542	.0066249	-9.44	0.000	-.0755655	-.0495186
avgtemp_3	.2245193	.0327859	6.85	0.000	.1600675	.2889711
lag3cdh	-.0209337	.0020053	-10.44	0.000	-.0248759	-.0169916
hour#c.lag3cdh						
18	.0020734	.0004608	4.50	0.000	.0011676	.0029793
19	.0040438	.0004429	9.13	0.000	.0031731	.0049144
20	.0090724	.000479	18.94	0.000	.0081307	.010014
21	.0111114	.0010558	10.52	0.000	.009036	.0131869
outersummer#c.lag3cdh						
1	.0192523	.0020872	9.22	0.000	.0151493	.0233554
lcgnum#c.lag3cdh						
SDP-C-2	-.0011234	.0005675	-1.98	0.048	-.002239	-7.77e-06
SDP-C-3	.0115608	.0009522	12.14	0.000	.0096889	.0134327
SDP-C-4	-.0011921	.0004336	-2.75	0.006	-.0020444	-.0003398
SDP-HD	.0048654	.0006409	7.59	0.000	.0036054	.0061254
SDP-LD	.0154434	.0041877	3.69	0.000	.0072111	.0236758
SDP-N	.0058494	.0004905	11.93	0.000	.0048852	.0068136
SDP-NW	.0117671	.0010609	11.09	0.000	.0096816	.0138526
SDP-W-1	-.0015919	.0007689	-2.07	0.039	-.0031035	-.0000803
SDP-W-2	.0017059	.0007641	2.23	0.026	.0002039	.0032079
dow#c.lag3cdh						
1	-.0050076	.0007671	-6.53	0.000	-.0065155	-.0034997
2	.0011904	.0007148	1.67	0.097	-.0002149	.0025956
3	.0006328	.0007157	0.88	0.377	-.0007741	.0020398
4	.0012057	.0007646	1.58	0.116	-.0002974	.0027089
5	.0000843	.0006605	0.13	0.899	-.0012142	.0013828
6	-.0021767	.0005551	-3.92	0.000	-.003268	-.0010855

SDP-R Impacts – 50% Cycling Group

Source	SS	df	MS			
				Number of obs	=	429
				F(24, 405)	=	306.99
Model	85.1021482	24	3.54592284	Prob > F	=	0.0000
Residual	4.6780103	405	.011550643	R-squared	=	0.9479
				Adj R-squared	=	0.9448
Total	89.7801585	429	.209277759	Root MSE	=	.10747

impact	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	.0002603	.0007239	0.36	0.719	-.0011629	.0016834
avgtemp_2	-.0112017	.006363	-1.76	0.079	-.0237104	.001307
avgtemp_3	.0192043	.0310289	0.62	0.536	-.0417935	.080202
lag3cdh	-.0153878	.0019589	-7.86	0.000	-.0192386	-.011537
hour#c.lag3cdh						
18	.0024637	.0004433	5.56	0.000	.0015923	.0033351
19	.0054978	.000426	12.90	0.000	.0046603	.0063353
20	.0104156	.0004603	22.63	0.000	.0095109	.0113204
21	.0142938	.0010161	14.07	0.000	.0122963	.0162913
outersummer#c.lag3cdh						
1	.0072268	.0020378	3.55	0.000	.0032208	.0112328
lcgnum#c.lag3cdh						
SDP-C-2	-.0030213	.0005317	-5.68	0.000	-.0040665	-.0019761
SDP-C-3	.0026242	.0009452	2.78	0.006	.0007661	.0044822
SDP-C-4	.0002416	.0004112	0.59	0.557	-.0005667	.00105
SDP-HD	-.0023231	.0007745	-3.00	0.003	-.0038456	-.0008005
SDP-LD	.0021538	.0037129	0.58	0.562	-.0051452	.0094529
SDP-N	.000496	.0004836	1.03	0.306	-.0004546	.0014466
SDP-NW	.0062987	.001078	5.84	0.000	.0041796	.0084179
SDP-W-1	-.00052	.0007102	-0.73	0.464	-.0019161	.0008761
SDP-W-2	-.0011003	.0007193	-1.53	0.127	-.0025144	.0003138
dow#c.lag3cdh						
1	-.001388	.0007546	-1.84	0.067	-.0028715	.0000954
2	.0029727	.000693	4.29	0.000	.0016105	.004335
3	.0006408	.0006906	0.93	0.354	-.0007168	.0019984
4	.0011157	.0007439	1.50	0.134	-.0003468	.0025782
5	.0010577	.000644	1.64	0.101	-.0002082	.0023236
6	-.0000835	.0005337	-0.16	0.876	-.0011327	.0009656

SDP-C Impacts – 100% Cycling Group

Source	SS	df	MS			
				Number of obs	=	99
				F(15, 83)	=	7.82
Model	.959452862	15	.063963524	Prob > F	=	0.0000
Residual	.679277183	83	.008184062	R-squared	=	0.5855
				Adj R-squared	=	0.5106
Total	1.63873004	98	.016721735	Root MSE	=	.09047

impact_perde~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.0446014	.0148759	-3.00	0.004	-.0741891	-.0150138
avgtemp_2	-.0142733	.0214253	-0.67	0.507	-.0568874	.0283408
avgtemp_3	.0868317	.1173222	0.74	0.461	-.1465174	.3201809
mean17	.0357773	.0152831	2.34	0.022	.0053797	.0661748
covid#c.mean17						
1	.0015574	.0003937	3.96	0.000	.0007745	.0023404
hour#c.mean17						
18	.0013336	.000411	3.24	0.002	.0005161	.002151
19	.0023428	.0003889	6.02	0.000	.0015692	.0031164
20	.0029911	.0004121	7.26	0.000	.0021714	.0038109
21	.003185	.0009792	3.25	0.002	.0012373	.0051326
dow#c.mean17						
1	-.0006374	.0008953	-0.71	0.479	-.0024181	.0011434
2	-.0005774	.000818	-0.71	0.482	-.0022044	.0010496
3	-.0001013	.0008494	-0.12	0.905	-.0017908	.0015882
4	-.0008437	.0008651	-0.98	0.332	-.0025643	.0008769
5	-.0000476	.0008514	-0.06	0.956	-.0017411	.0016459
6	.0006059	.000761	0.80	0.428	-.0009077	.0021194
_cons	.3231988	.6398488	0.51	0.615	-.9494347	1.595832

SDP-C Impacts – 50% Cycling Group

Source	SS	df	MS			
				Number of obs	=	88
				F(15, 72)	=	7.87
Model	.353098054	15	.02353987	Prob > F	=	0.0000
Residual	.215390672	72	.002991537	R-squared	=	0.6211
				Adj R-squared	=	0.5422
Total	.568488726	87	.006534353	Root MSE	=	.05469

impact_perde~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.0406136	.0097167	-4.18	0.000	-.0599836	-.0212436
avgtemp_2	-.0198311	.015021	-1.32	0.191	-.0497749	.0101127
avgtemp_3	.0965133	.083417	1.16	0.251	-.0697755	.2628021
mean17	.0524332	.0094073	5.57	0.000	.0336802	.0711863
covid#c.mean17						
1	.0000653	.0002611	0.25	0.803	-.0004552	.0005857
hour#c.mean17						
18	.0005957	.0002671	2.23	0.029	.0000632	.0011282
19	.0012226	.0002512	4.87	0.000	.0007218	.0017233
20	.0016535	.0002667	6.20	0.000	.0011219	.0021851
21	.0021784	.0006333	3.44	0.001	.0009159	.0034409
dow#c.mean17						
1	.0008887	.0006432	1.38	0.171	-.0003935	.0021709
2	.0009367	.0005876	1.59	0.115	-.0002346	.002108
3	.000622	.000602	1.03	0.305	-.0005782	.0018221
4	.0014628	.0006126	2.39	0.020	.0002416	.0026841
5	7.62e-06	.0005989	0.01	0.990	-.0011863	.0012015
6	.0010563	.0005314	1.99	0.051	-3.05e-06	.0021156
_cons	-1.08876	.4243551	-2.57	0.012	-1.934697	-.2428238

SDP-C Impacts – 30% Cycling Group

Source	SS	df	MS
Model	4.51458413	15	.300972275
Residual	4.89155892	60	.081525982
Total	9.40614305	75	.125415241

Number of obs	=	76
F(15, 60)	=	3.69
Prob > F	=	0.0001
R-squared	=	0.4800
Adj R-squared	=	0.3500
Root MSE	=	.28553

impact_perde~e	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.1484847	.0570344	-2.60	0.012	-.2625704	-.0343989
avgtemp_2	.0925916	.0891956	1.04	0.303	-.0858262	.2710094
avgtemp_3	-.5057531	.4952519	-1.02	0.311	-1.496404	.4848982
mean17	.0772109	.056484	1.37	0.177	-.0357739	.1901957
covid#c.mean17						
1	.0071973	.0015332	4.69	0.000	.0041305	.0102642
hour#c.mean17						
18	.0020361	.0015099	1.35	0.183	-.0009842	.0050564
19	.0012658	.0014212	0.89	0.377	-.001577	.0041086
20	.0029143	.0015185	1.92	0.060	-.0001231	.0059517
21	.0065037	.0036073	1.80	0.076	-.0007119	.0137193
dow#c.mean17						
1	.0065057	.0035353	1.84	0.071	-.000566	.0135774
2	.0037498	.0032768	1.14	0.257	-.0028048	.0103044
3	.0051083	.0033521	1.52	0.133	-.0015969	.0118136
4	.0020871	.0034045	0.61	0.542	-.0047228	.0088971
5	.0032843	.003359	0.98	0.332	-.0034348	.0100034
6	.0008986	.0030215	0.30	0.767	-.0051453	.0069426
_cons	4.629038	2.463361	1.88	0.065	-.2984171	9.556493

APPENDIX F: AGGREGATE HOURLY IMPACTS

Table 28: 2021 SDP-R Aggregate Hourly Impacts, Full Event Hours Only

Date	Load Control Groups	Event Start	Event End	Event Type	Accts	MW Reductions				
						HE 17	HE 18	HE 19	HE 20	HE 21
10/14/2020	LD	6:00 PM	7:00 PM	Economic	202			0.07		
10/15/2020	LD	6:00 PM	7:00 PM	Economic	202			0.04		
6/17/2021	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	6:00 PM	Testing	168,129		116.1			
7/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	5:50 PM	8:50 PM	Reliability	175,532			137.1	104.9	
8/27/2021	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	6:00 PM	7:00 PM	Testing	175,588		139.8			
9/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	3:58 PM	5:00 PM	Testing	175,962	144.0				
2022 SCE August 1-in-2		**4:00 PM**	**9:00 PM**		**163,670**	**180.9**	**170.0**	**156.9**	**127.8**	**113.9**
2022 SCE August 1-in-10		**4:00 PM**	**9:00 PM**		**163,670**	**199.9**	**188.3**	**174.8**	**142.5**	**126.7**

* Only full hours are included in impacts

Table 29: 2021 SDP-C Aggregate Hourly Impacts, Full Event Hours Only

Date	Load Control Groups	Event Start	Event End	Event Type	Accts	MW Reductions				
						HE 17	HE 18	HE 19	HE 20	HE 21
10/14/2020	LD	6:00 PM	7:00 PM	Economic	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
10/15/2020	LD	6:00 PM	7:00 PM	Economic	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
6/17/2021	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	6:00 PM	Testing	7,418		7.4			
7/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	5:50 PM	8:50 PM	Reliability	7,567			11.6	7.7	
8/27/2021	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	6:00 PM	7:00 PM	Testing	7,514		17.7			
9/9/2021*	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1, W-2	3:58 PM	5:00 PM	Testing	7,517	22.1				
2022 SCE August 1-in-2		**4:00 PM**	**9:00 PM**		**7,062**	**24.3**	**18.8**	**14.9**	**11.9**	**10.4**
2022 SCE August 1-in-10		**4:00 PM**	**9:00 PM**		**7,062**	**27.3**	**21.7**	**17.7**	**14.6**	**12.5**

* Only full hours are included in impacts