REPORT

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Program Year 2020 Southern California Edison Summer Discount Plan Impact Evaluation

Prepared for: Southern California Edison

By: Demand Side Analytics

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ACKNOWLEDGEMENTS

Research Team

- Josh Bode, M.P.P.
- Steve Morris, M.S.
- Adriana Ciccone, 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 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. Impacts were calculated by comparing the energy use of participants and the control customer during event and hot non-event days. The SDP program has approximately 206,000 residential customers enrolled and includes nearly 240,000 control devices and 872,000 tons of air conditioner load. Approximately 85% of residential customers elect the higher incentive option, which allows SCE to entirely curtail air conditioner demand (100% cycling) during SDP demand response events. On the commercial side, there are approximately 8,300 customers enrolled with over 73,000 control devices and over 369,000 tons of air conditioner load. Approximately 65% of customers, accounting for 62% of the total commercial air conditioner load, elect the higher incentive. During the system peak day, the SDP program reduced demand by 294 MW on the first event hour, and by an average of 259 MW across all five full event hours. California experienced a number of reliability events in 2020, most notably on August 14th and August 15th, when rolling blackouts occurred. On those days, the SDP program exceeded resource adequacy forecasts.

During normal (1-in-2) August peak day planning conditions, participants can reduce demand by 182 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. In the face of widespread heat waves and the COVID-19 pandemic, the 2020 evaluation faced unique challenges.

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1 EXECUTIVE SUMMARY

This report presents the results of the program year 2020 Summer Discount Plan (SDP) impact evaluation. 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 2020 operations and quantify the magnitude of reductions available during peaking conditions used for planning.

1.1 SDP RESIDENTIAL KEY FINDINGS

The SDP Residential (SDP-R) program has approximately 206,000 customers enrolled and includes nearly 240,000 control devices and 872,000 tons of air conditioner load. Approximately 85% 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 551 MW, and participants can curtail demand by 165 MW during the 4-9 PM peak window. During extreme planning conditions, participant loads peak at 611 MW, and participants can reduce demand by 189 MW 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 each event in the evaluation period from May 2020 through September 2020.[2] For full event hours, average impacts were in the neighborhood of 1 kW per participant, and percent impacts were generally around 30%. For three peak days (8/18, 9/5, and 9/6), average participant impacts were around 1.20 kW and percent impacts were around 32%.

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

[2] Two SDP events were called in mid-October 2020 for only 216 participants. The other was dispatched on 9/7/2020 to 5,623 participants.

Figure 1: Relationship between SDP-R Demand Reductions and Weather

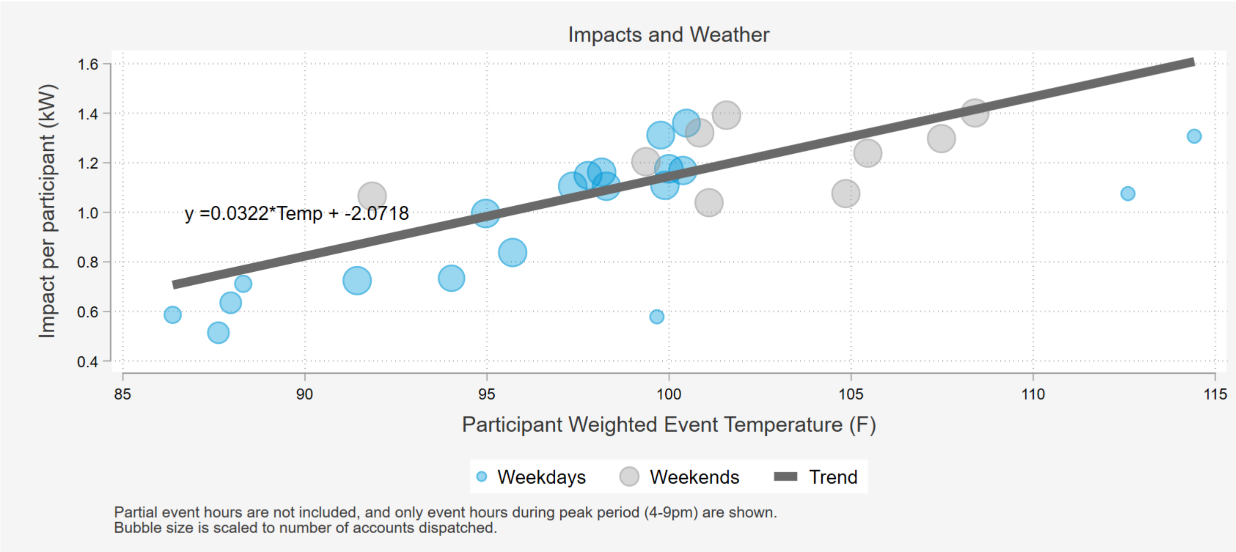


Table 1: SDP-Residential Event Summary, 2020

Date	Event start	Event end	Accts	Aggregate Impacts (MW)			Impact per… (kW)			% Impact	Weighted Temp (F)
				Impact	90% Lower Bound	90% Upper Bound	Account	Device	Ton		
7/31	4:00 PM	5:00 PM	193,745	225.1	214.93	235.34	1.16	1.00	0.28	38.3%	98.1
8/7	4:00 PM	5:00 PM	9,777	5.7	4.93	6.39	0.58	0.43	0.12	24.8%	99.7
8/13	6:00 PM	8:00 PM	60,869	35.0	31.89	38.06	0.57	0.52	0.14	25.4%	87.8
8/13	7:00 PM	8:00 PM	141,933	104.2	96.81	111.52	0.73	0.62	0.17	27.3%	94.0
8/14	4:00 PM	5:00 PM	193,224	225.9	216.05	235.68	1.17	1.01	0.28	35.4%	100.4
8/14	5:00 PM	8:00 PM	193,224	196.6	187.97	205.19	1.02	0.88	0.24	31.6%	98.0
8/14	5:10 PM	8:35 PM	9,570	11.4	10.72	12.08	1.19	0.88	0.24	30.1%	113.5
8/14	8:00 PM	9:12 PM	193,224	140.0	130.00	149.94	0.72	0.63	0.17	25.4%	91.4
8/15	3:00 PM	7:45 PM	202,781	268.9	260.38	277.48	1.33	1.14	0.31	37.0%	100.6
8/16	5:40 PM	7:25 PM	202,781	216.0	205.53	226.40	1.07	0.91	0.25	33.1%	91.8
8/17	3:10 PM	7:40 PM	177,503	226.1	219.14	233.03	1.27	1.08	0.30	36.0%	99.3
8/17	4:21 PM	7:40 PM	22,064	14.3	12.97	15.67	0.65	0.60	0.16	24.4%	87.3
8/18 (Peak Day)	**1:40 PM**	**7:48 PM**	**199,557**	**232.1**	**225.01**	**239.15**	**1.16**	**1.00**	**0.27**	**33.7%**	**99.3**
9/5	5:30 PM	8:25 PM	191,475	227.2	218.12	236.30	1.19	1.02	0.28	32.1%	106.2
9/6	4:40 PM	8:23 PM	191,475	234.8	225.69	243.93	1.23	1.05	0.29	32.2%	105.0
Avg. Event	**3:30 PM**	**7:30 PM**	**195,521**	**216.9**	**211.49**	**222.35**	**1.11**	**0.95**	**0.26**	**29.9%**	**102.8**

Table 2: SDP-Residential Summary of Key Findings

Topic	Findings
How did SDP-R perform on the SCE system peak day (August 18th)?	During the system peak day (August 18, 2020), SDP-R participants reduced demand by an average of 218 MW between 4:00 PM and 7:00 PM. Demand reductions in the first event hour exceeded 250 MW (2:00 PM – 3:00 PM). The average demand reductions per customer, per device, and per ton for this event were 1.16 kW, 1.00 kW, and 0.27 kW respectively. The reductions delivered exceeded the resource adequacy estimates for 1-in-2 and 1-in-10 weather years.
How did SDP-R perform on August 14th and August 15th, when CAISO called for rolling blackouts?	On the CAISO Stage 3 Emergency days (8/14 and 8/15), SDP-R participants delivered demand reductions in excess of 200 MW. During the first two hours of the 8/15 event, SDP-R participants delivered an average of 282 MW in demand reductions. During the first two hours of the 8/14 event, SDP-participants delivered an average of 226 MW. The reductions delivered exceeded the resource adequacy estimates for 1-in-2 and 1-in-10 weather years.
What impact did COVID have on customer loads and demand reductions?	SDP-R customer loads absent demand response were 9% higher under COVID-19 conditions, likely due to shelter-in-place orders and higher home occupancy levels. A substantial share of SCE's customers were either working from home or had children engaged in distance learning. However, the pandemic was not found to have a statistically significant effect – positive or negative – on the magnitude of demand reductions delivered by SDP-R participants. While overall home energy use was higher, there was no detectable change in cooling loads and, by connection, SDP-R demand reductions. Differences between the 2020 load impacts and prior years is explained almost exclusive by differences in weather conditions.
How did SDP-R perform on weekend events?	In response to peaking conditions, there were a number of weekend events dispatched in 2020 which is atypical for SDP. For full event hours, participant-level demand reductions ranged from 1.04 kW to 1.40 on these weekend events. Percent impacts ranged from 29.2% to 39.2%.
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 who are 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.
What is magnitude of demand reduction capability under planning conditions?	Given current enrollments, the resource can deliver reductions of 165 MW during the peak period under 1-in-2 weather planning conditions and 189 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 8,300 customers enrolled and includes over 73,000 control devices and nearly 370,000 tons of air conditioner load. About 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 403 MW, and participants can curtail demand by 17 MW during the 4-9 PM peak window. During extreme planning conditions (1-in-10 weather conditions), participant loads peak at 420 MW, and participants can reduce demand by 21 MW 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 would be 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 2020. Impacts per device were generally in the neighborhood of 0.20 kW with a few exceptions. A number of the events were dispatched on weekends in response to peaking conditions (8/15, 8/16, 9/5, and 9/6), when non-residential loads are lower.

Figure 2: Relationship between SDP-C Demand Reductions and Weather

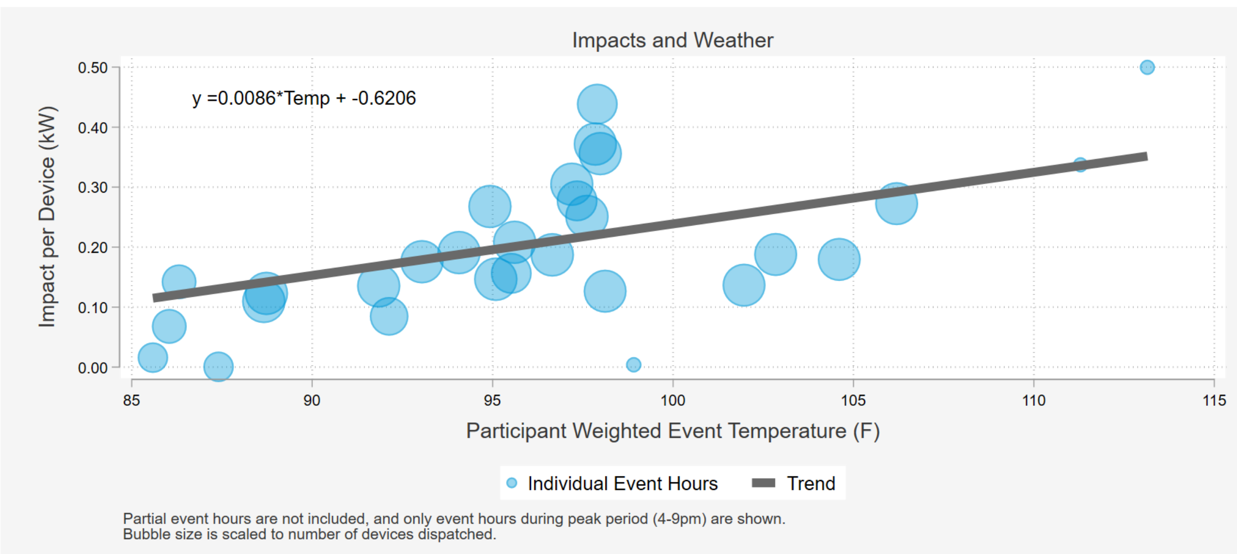


Table 3: SDP-Commercial Event Summary, 2020

Date	Event start	Event end	Accts	Aggregate Impact (MW)			Impact per... (kW)			% Impact	Wght. Temp (F)
				Impact	90% Lower Bound	90% Upper Bound	Acct	Device	Ton		
7/31	4:00 PM	5:00 PM	8,075	13.87	9.44	18.29	1.72	0.19	0.04	6.4%	94.1
8/7	4:00 PM	5:00 PM	210	0.00	-0.57	0.58	0.01	0.00	0.00	0.2%	98.9
8/13	6:00 PM	8:00 PM	[redacted]								
8/13	7:00 PM	8:00 PM	[redacted]								
8/14	4:00 PM	5:00 PM	8,060	27.00	21.45	32.56	3.35	0.37	0.07	10.5%	97.8
8/14	5:00 PM	8:00 PM	8,060	16.67	12.39	20.96	2.07	0.23	0.05	7.1%	95.3
8/14	5:10 PM	8:35 PM	195	0.28	-0.06	0.62	1.44	0.42	0.07	12.1%	112.2
8/14	8:00 PM	9:12 PM	8,060	8.92	5.25	12.59	1.11	0.12	0.02	3.9%	88.7
8/15	3:00 PM	7:45 PM	8,268	15.14	11.60	18.69	1.83	0.21	0.04	7.3%	96.5
8/16	5:40 PM	7:25 PM	8,268	8.05	5.37	10.73	0.97	0.11	0.02	3.9%	88.7
8/17	3:10 PM	7:40 PM	6,129	16.28	12.69	19.86	2.66	0.29	0.06	7.4%	96.9
8/17	4:21 PM	7:40 PM	2,021	0.13	-1.62	1.89	0.07	0.01	0.00	0.4%	86.5
8/18 (Peak Day)	**1:40 PM**	**7:48 PM**	**8,160**	**26.81**	**21.88**	**31.75**	**3.29**	**0.37**	**0.07**	**8.8%**	**97.0**
9/5	5:30 PM	8:25 PM	8,038	11.08	7.64	14.53	1.38	0.16	0.03	5.0%	103.3
9/6	4:40 PM	8:23 PM	8,038	13.71	9.68	17.75	1.71	0.20	0.04	6.1%	102.4
Avg. Event	**3:30 PM**	**7:30 PM**	**8,094**	**14.66**	**11.74**	**17.58**	**1.81**	**0.21**	**0.04**	**6.1%**	**99.9**

Table 4: SDP-Commercial Summary of Key Findings

Topic	Findings
How did SDP-C perform on the SCE system peak day (August 18th)?	During the system peak day (August 18, 2020), SDP-C participants reduced demand by an average of 26 MW between 2:00 PM and 7:00 PM. Demand reductions in the first event hour exceeded 43 MW (2:00 PM – 3:00 PM). The average demand reductions per customer, per device, and per ton for this event were 2.64 kW, 0.30 kW, and 0.06 kW respectively.

Topic	Findings
How did SDP-C perform on August 14th and August 15th, when CAISO called for rolling blackouts?	CAISO Stage 3 Emergencies were declared on 8/14 and 8/15. During the first two full event hours on 8/14, SDP-C participants delivered an average of 25 MW. During the first two full event hours on 8/15, SDP-C participants delivered an average of 18 MW. The gap between demand reductions on the two days is due to the time of day and to differences between SDP-C cooling loads on weekdays versus weekends (8/15 was a Saturday).
What impact did COVID have on customer loads and demand reductions?	SDP-C participant loads were more than 25% lower under COVID-19 conditions and led to lower demand reductions. Schools and religious institution account for over 80% of the enrolled air conditioner tonnage and had occupancy and load patterns disrupted by COVID.
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 over 70% 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 peak hours of 4-9 PM.
How did SDP-C perform on weekend events?	SDP-C loads and demand reductions were lower on weekends than on weekdays due to the reduced occupancy levels on weekends.
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. We caution, however, that it is not feasible to disentangle the role of customer self-selection from the performance of the cycling algorithm.
What is magnitude of demand reduction capability under planning conditions?	Given current enrollments, the resource can deliver reductions of 17 MW during the peak period under 1-in-2 weather planning conditions and 21 MW under 1-in-10 weather planning conditions (August monthly peak day).

2 INTRODUCTION

This report presents the results of the program year 2020 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 2020 operations and quantify the magnitude of reductions available during peaking conditions used for planning.

Historically, utilities operated demand response programs to reduce peak demand and offset the need for additional peaking capacity. While reductions in peak demand to offset capacity remains 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 2020 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?
- 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?

An additional research question in 2020 concerns the COVID-19 pandemic. In specific, how did this pandemic affect reference loads and demand reductions?

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 run time of the unit 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. The majority of the 2020 events were due to adverse reliability conditions, and the others were due to economic dispatch or for measurement and evaluation testing. 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 2020 summer. The 2020 system peak, which occurred on August 18th, was 23,328 MW. A demand response event was dispatched from 1:40 PM through 7:48 PM on the peak day – the effect of this event is visible in the solid blue line in Figure 4. The mid-August heat wave accounts for six of the top ten system load days, and two of the top four system load days were weekend days (Figure 4, Figure 5).

Figure 3: System Load Duration Curves

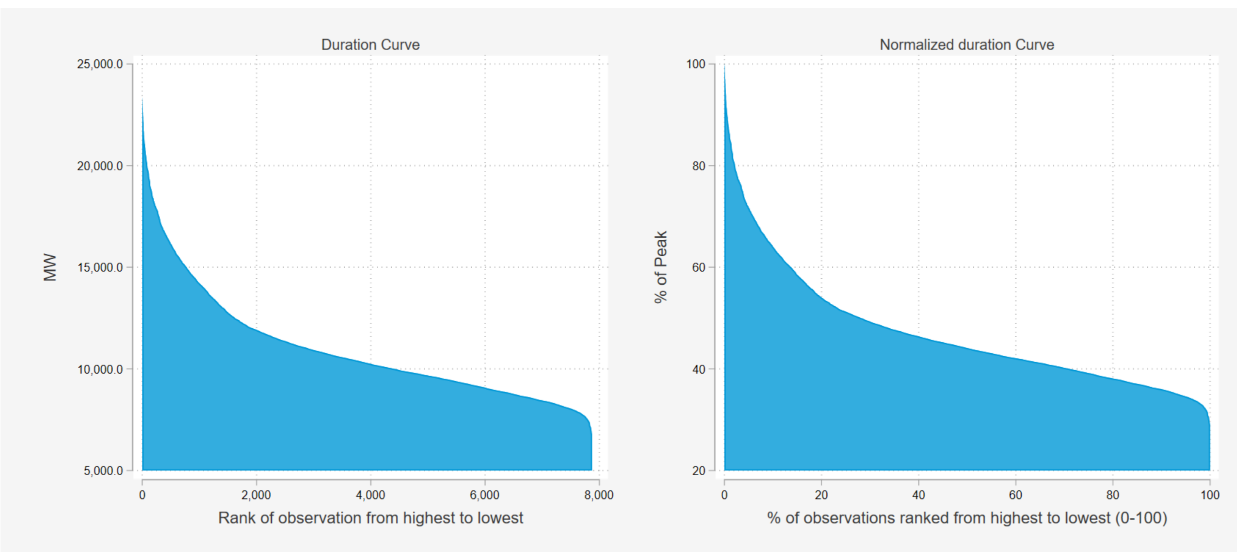


Figure 4: Top Ten System Load Days, 2020

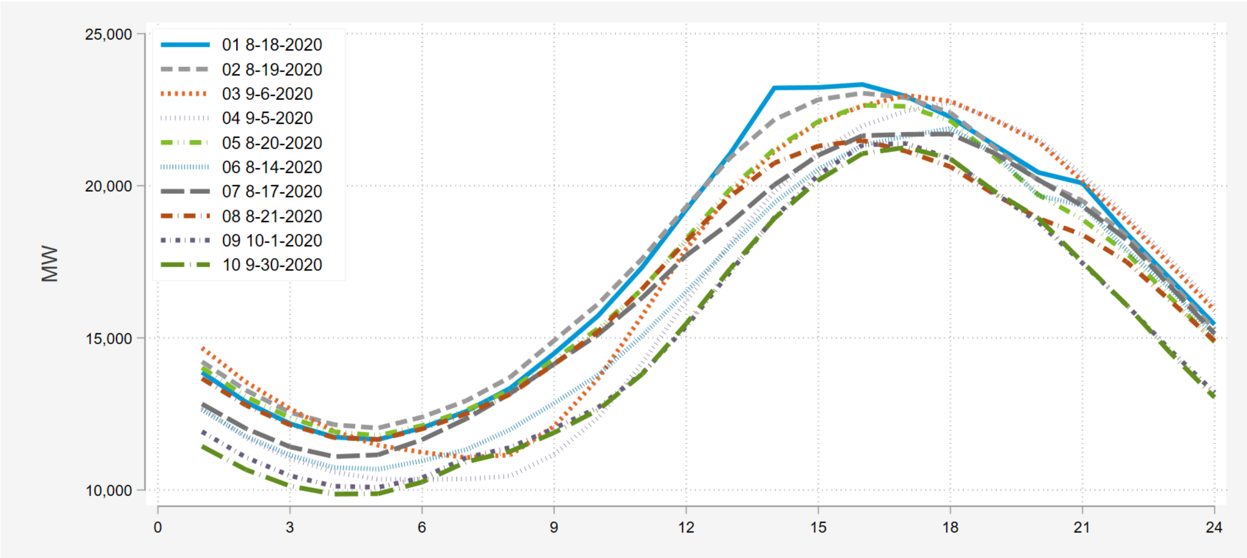


Figure 5: Top Ten System Load Days by Day Type, 2020

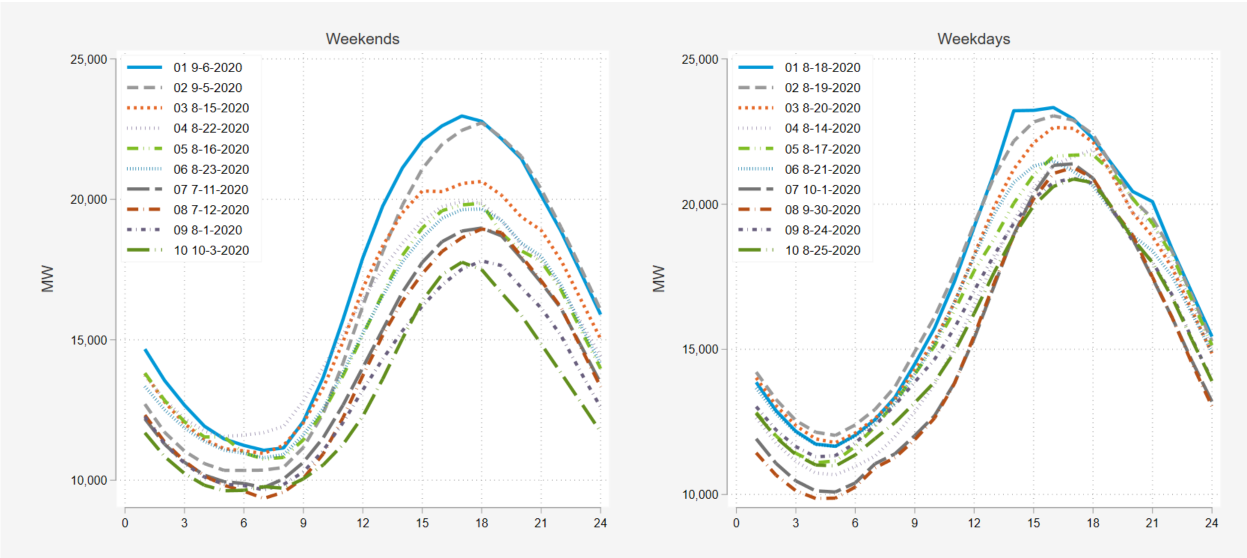


Figure 6 compares system-wide daily peaks over the past five years. System peaks in 2020 were higher than in 2019, which had a mild summer, but in line with 2017 and 2018 peaks. Figure 7 shows the distribution of temperatures over the past four years via box-plot. The further to the right the plot is for a given year, the warmer it was. The white line in the middle of each box represents the median – a measure of central tendency. The 2020 median was greater than the 2017-2019 medians, indicating the 2020 summer was warmer in Southern California compared to earlier years.

Figure 6: System Peaks by Year

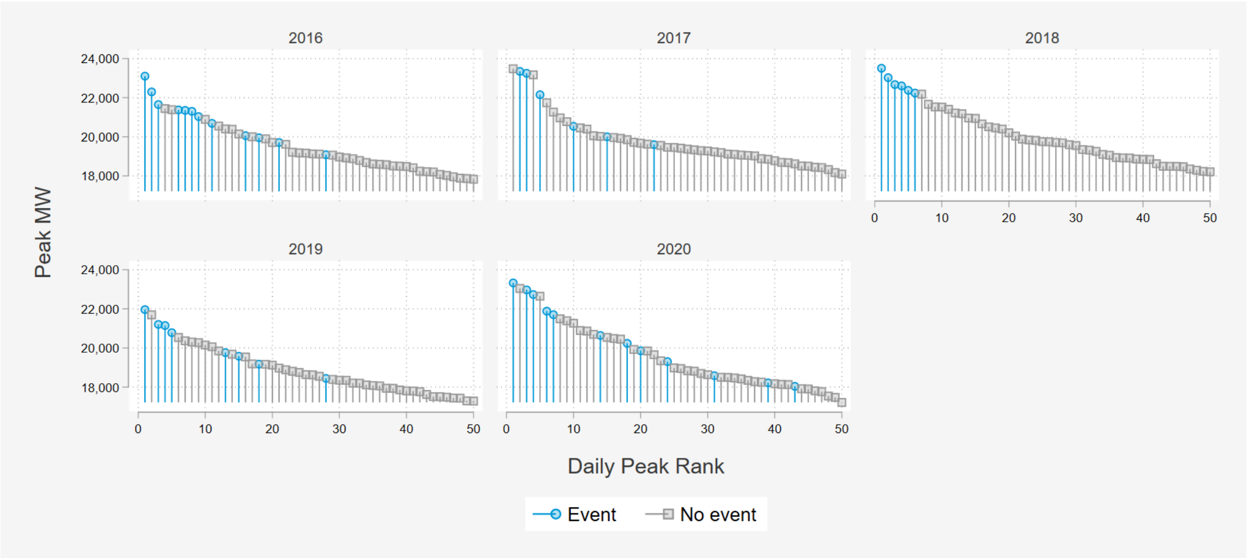
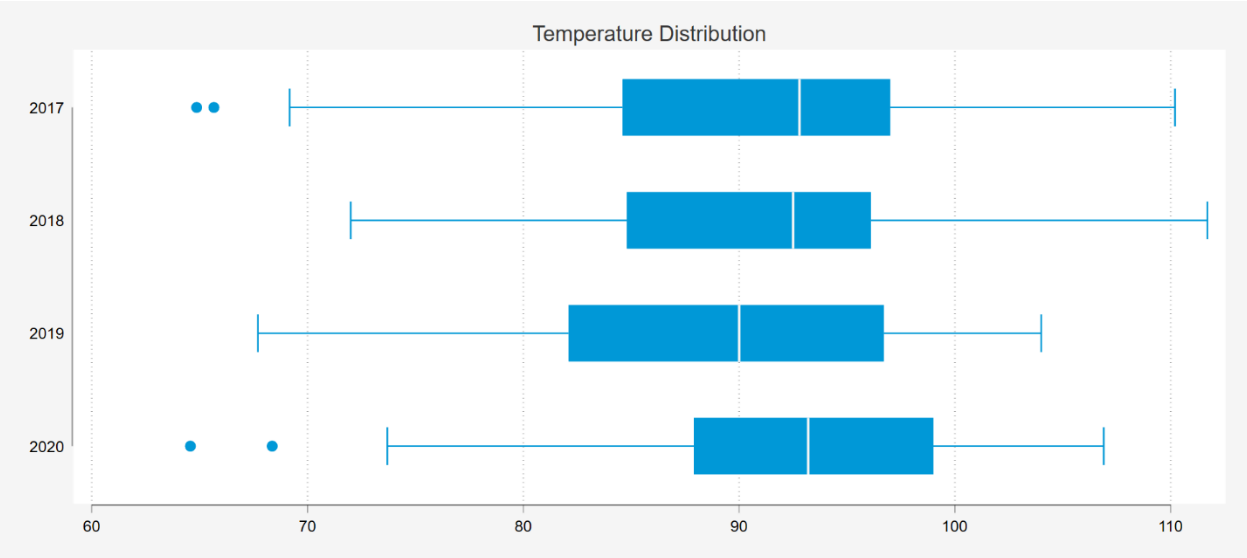
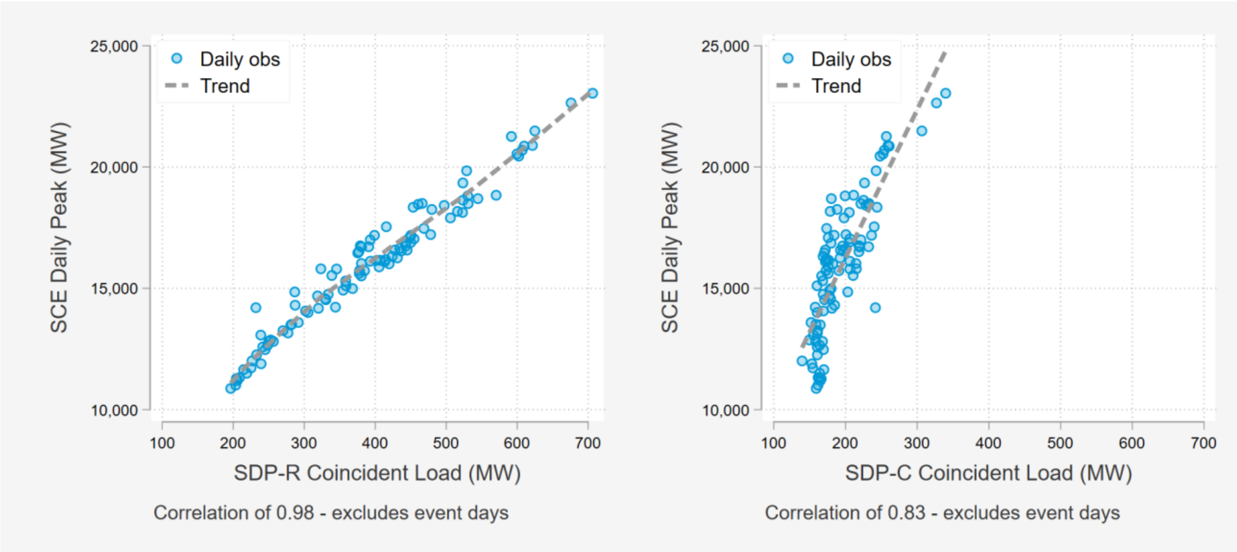


Figure 7: Distribution of Maximum Daily Temperatures, Summer 2017-2020



There is a strong correlation between SDP resources and system-wide peaks. Excluding event days, there was a correlation of 0.98 between system peaks and SDP-R coincident loads – indicative of a very strong linear correlation (left pane in Figure 8). In laymen's terms, this means that for larger SCE daily peaks, coincident load for SDP-R customers tends to be larger as well. The correlation is not as strong for SDP-C customers, but there is still a moderately strong linear relationship (right pane in Figure 8).

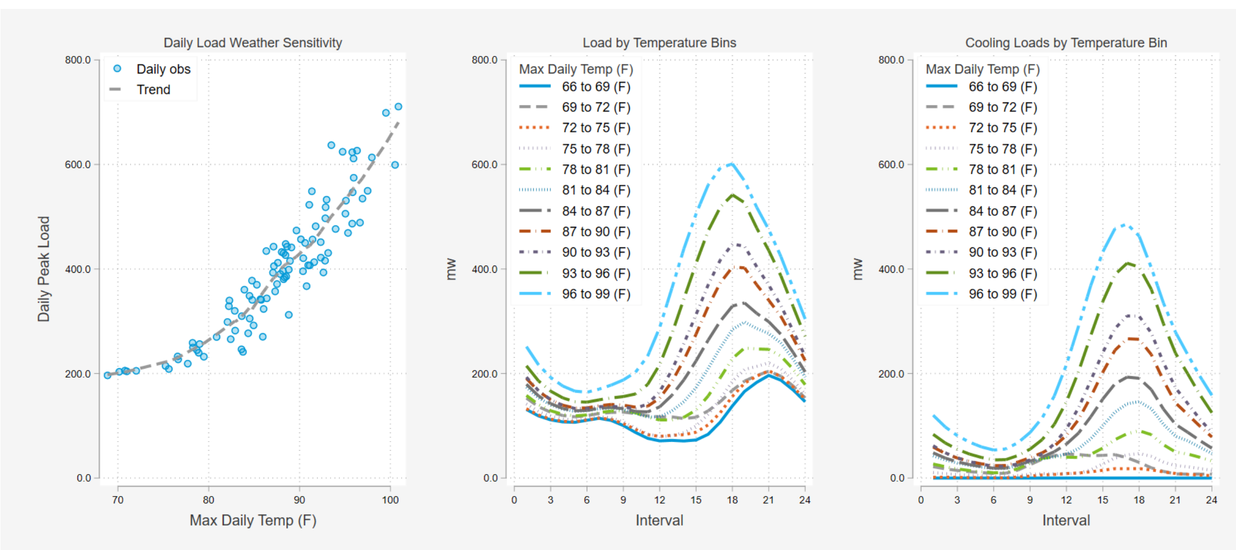
Figure 8: SCE Daily Peaks against SDP Coincident Load



2.4 RESIDENTIAL PARTICIPANT CHARACTERISTICS

A total of 205,706 SCE residential customers participated in at least one SDP demand response event during the 2020 summer. On aggregate, these 205,706 customers have over 400 MW of cooling load when temperatures are hot – 93°F or higher (right pane in Figure 9). At milder temperatures in the mid-to-high 80s, these customers have closer to 200 MW of cooling load. Approximately 12% 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 – over 85% –

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 (86%);
- 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 (0.10%), 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.

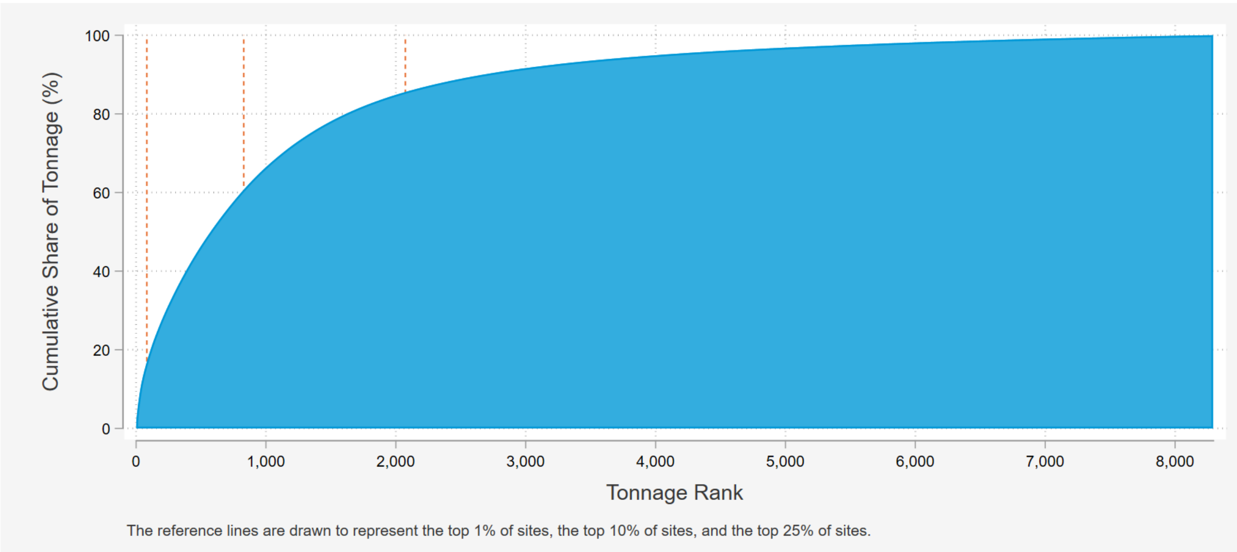
Table 5: SDP-R Participation by Category

Category	Subcategory	Number of Accounts	Share of Accounts	Number of Devices	Share of Devices	Total Tonnage	Share of Tonnage
Cycling	50%	30,207	14.68	33,698	14.04	120,887	13.86
	100%	175,499	85.32	206,257	85.96	751,206	86.14
Load Control Group	SDP-Central-1	37,082	18.03	44,734	18.64	160,044	18.35
	SDP-Central-2	21,962	10.68	24,429	10.18	91,028	10.44
	SDP-Central-3	9,775	4.75	13,225	5.51	48,178	5.52
	SDP-Central-4	40,901	19.88	47,750	19.90	173,887	19.94
	SDP-High Desert	12,741	6.19	14,338	5.98	51,191	5.87
	SDP-Low Desert	215	0.10	232	0.10	860	0.10
	SDP-North	25,472	12.38	30,057	12.53	106,240	12.18
	SDP-Northwest	8,788	4.27	10,943	4.56	40,609	4.66
	SDP-West-1	26,295	12.78	29,912	12.47	110,387	12.66
	SDP-West-2	22,475	10.93	24,335	10.14	89,669	10.28
Local Capacity Area	Big Creek/Ventura	34,262	16.66	41,002	17.09	146,854	16.84
	LA Basin	158,488	77.05	184,383	76.84	673,188	77.19
	Outside LA Basin	12,956	6.30	14,570	6.07	52,051	5.97
CARE/FERA Status	Non-CARE/FERA	150,684	73.25	179,964	75.00	664,142	76.15
	CARE/FERA	55,022	26.75	59,991	25.00	207,951	23.85
Zone	South Orange County	16,409	7.98	18,437	7.68	66,923	7.67
	South of Lugo	75,973	36.93	87,243	36.36	321,203	36.83
	Remainder of System	113,324	55.09	134,275	55.96	483,967	55.49
Overall Total		**205,706**	**100**	**239,955**	**100**	**872,093**	**100**

2.5 NON-RESIDENTIAL PARTICIPANT CHARACTERISTICS

A total of 8,293 SCE non-residential customers participated in at least one SDP demand response event during the 2020 summer. A defining characteristic of the SDP-C customer pool is its top-heaviness in terms of AC tonnage: 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). What this means is that a handful of customers drive the load reduction results.

Figure 10: Tonnage Ranks against Cumulative Tonnage Shares



On aggregate, the 8,293 SDP-C customers have 150-200 MW of cooling load when temperatures are hot – 93°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. The overall load shape for the SDP-C customer pool is driven by schools, as schools account for nearly 70% 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. The case in 2020 was that schools transitioned to distance learning in response to the COVID-19 pandemic.

Figure 11: SDP-C Participant Load Summary

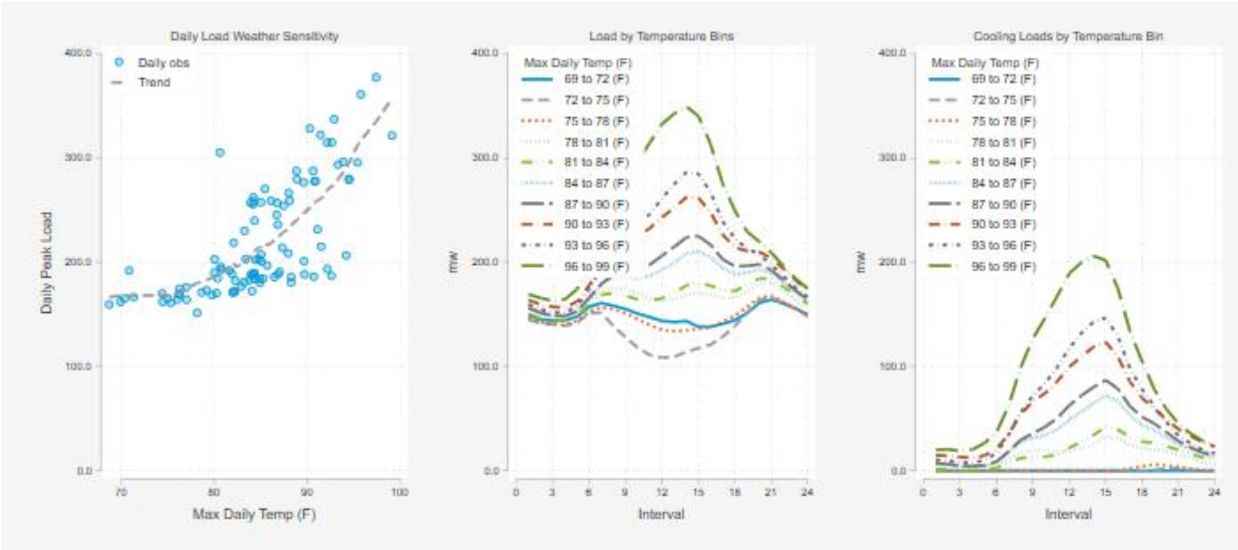


Table 6 shows the distribution of SDP-C participation, devices, and AC tonnage by several key categories and subcategories. Some key highlights of the SDP-C resources include:

- 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 and SDP-Central-4 have the most (each around 20%);
- 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 69% of the participant tonnage.

Our ex post methodology relied on matching participants to similar non-participants in a control pool. 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 26 illustrates how the scaling was accomplished, and Table 27 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%	640	7.72	3,469	4.73	18,591	5.03
	50%	2,253	27.17	24,648	33.59	120,304	32.55
	100%	5,400	65.12	45,262	61.68	230,679	62.42
Load Control Group	SDP-Central-1	810	9.77	11,541	15.73	61,215	16.56
	SDP-Central-2	946	11.41	5,270	7.18	25,555	6.91
	SDP-Central-3	196	2.36	673	0.92	3,868	1.05
	SDP-Central-4	1,280	15.43	13,755	18.75	70,631	19.11
	SDP-High Desert	341	4.11	3,511	4.78	20,055	5.43
	SDP-Low Desert	15	0.18	35	0.05	211	0.06
	SDP-North	922	11.12	9,166	12.49	46,892	12.69
	SDP-Northwest	550	6.63	4,378	5.97	22,324	6.04
	SDP-West-1	1,188	14.33	8,654	11.79	42,556	11.51
	SDP-West-2	2,045	24.66	16,396	22.34	76,268	20.64
Local Capacity Area	Big Creek/Ventura	1,472	17.75	13,544	18.46	69,216	18.73
	LA Basin	6,465	77.96	56,289	76.71	280,093	75.79
	Outside LA Basin	356	4.29	3,546	4.83	20,266	5.48
Zone	South Orange County	754	9.09	5,033	6.86	25,357	6.86
	South of Lugo	2,685	32.38	25,683	35.00	131,637	35.62
	Remainder of System	4,854	58.53	42,663	58.14	212,581	57.52

Category	Subcategory	Number of Accounts	Share of Accounts	Number of Devices	Share of Devices	Total Tonnage	Share of Tonnage
Industry	Agriculture, Mining, Construction	224	2.70	505	0.69	2,144	0.58
	Institutional/Government	715	8.62	3,394	4.63	18,340	4.96
	Manufacturing	531	6.40	1,497	2.04	8,102	2.19
	Offices, Hotels, Finance, Services	1,964	23.68	3,765	5.13	16,347	4.42
	Religious organizations	1,175	14.17	8,074	11.00	47,634	12.89
	Retail Stores	1,276	15.39	2,537	3.46	12,997	3.52
	Schools	1,683	20.29	51,490	70.17	254,140	68.77
	Unknown/Other	39	0.47	62	0.08	247	0.07
	Wholesale, Transport, Other Utilities	686	8.27	2,055	2.80	9,623	2.60
Tonnage Bin	3 or less	1,163	14.02	1,199	1.63	2,850	0.77
	3 to 4	1,006	12.13	1,034	1.41	3,463	0.94
	4 to 5	692	8.34	789	1.08	3,104	0.84
	5 to 10	1,620	19.53	2,777	3.78	11,198	3.03
	10-100	2,705	32.62	19,089	26.01	92,171	24.94
	100-500	1,050	12.66	40,716	55.49	205,836	55.70
	500+	57	0.69	7,775	10.60	50,954	13.79
Overall Total		**8,293**	**100.00**	**73,379**	**100.00**	**369,575**	**100.00**

2.6 2020 EVENT CONDITIONS

California's 2020 summer was marked by wildfires, extreme heat waves, California Independent System Operator (CAISO) emergencies, and rolling blackouts. The heat waves began in mid-August and lasted through early September. Extreme heat leads to increased electrical demand in the form of air conditioning, which in turn led to the CAISO emergencies. CAISO has three emergency stages[3]:

- Stage 1 Emergency: Contingency reserve shortfalls exist or are forecasted to occur. There is a strong need for conservation.
- Stage 2 Emergency: CAISO has taken all mitigating actions and is no longer able to provide its expected energy requirements. This requires CAISO intervention in the market, such as ordering power plants online, and dispatching emergency demand response programs.
- Stage 3 Emergency: The ISO is unable to meet minimum contingency reserve requirements and load interruption is imminent or in progress (i.e., rolling blackouts).

Prior to 2020, the last time a Stage 3 Emergency was declared was in 2001. The last Stage 2 Emergency occurred in 2006, and there has only been one Stage 1 Emergency since 2008 (2017). Flex alerts are often issued when a transmission emergency is declared. These alerts ask consumers to voluntarily conserve energy when demand may exceed supply. From 2011 to 2019, there has been at least one Flex alert issued per year.[4]

In 2020, Stage 3 Emergencies were declared on 8/14 and 8/15. CAISO called for rolling blackouts on a statewide basis on these two days. Stage 2 Emergencies were declared on 8/17, 8/18 (which was the system peak day), 9/5, and 9/6. There were no rolling blackouts on the Stage 2 Emergency days. Flex alerts were issued for 8/14, 8/16, 8/17, 8/18, 8/19, 9/5, 9/6, 9/7, and for a few October days.[5] SDP emergency events were called on all of the CAISO emergency days and for a number of the flex alert days. This is an important departure from prior summers, when SDP events were not coincident with CAISO emergencies (as there have been no such emergencies recently).

Figure 12 visualizes the timing of the SDP events during the 2020 summer. Events varied in timing and length, and many events started or ended mid-hour. There were also a number of weekend events in 2020. Weekend events have not historically been dispatched for SDP. The 2020 weekend events were called in response to CAISO emergencies described above. Notably, the event on the system peak day (8/18) lasted for more than six hours.

[3] https://www.caiso.com/documents/systemalertswarningsandemergenciesfactsheet.pdf
[4] https://www.caiso.com/Documents/FlexAlertNoticesIssuedFrom1998-Present.pdf
[5] https://www.caiso.com/Documents/AWE-Grid-History-Report-1998-Present.pdf

Figure 12: Timing of SDP Summer Events, 2020

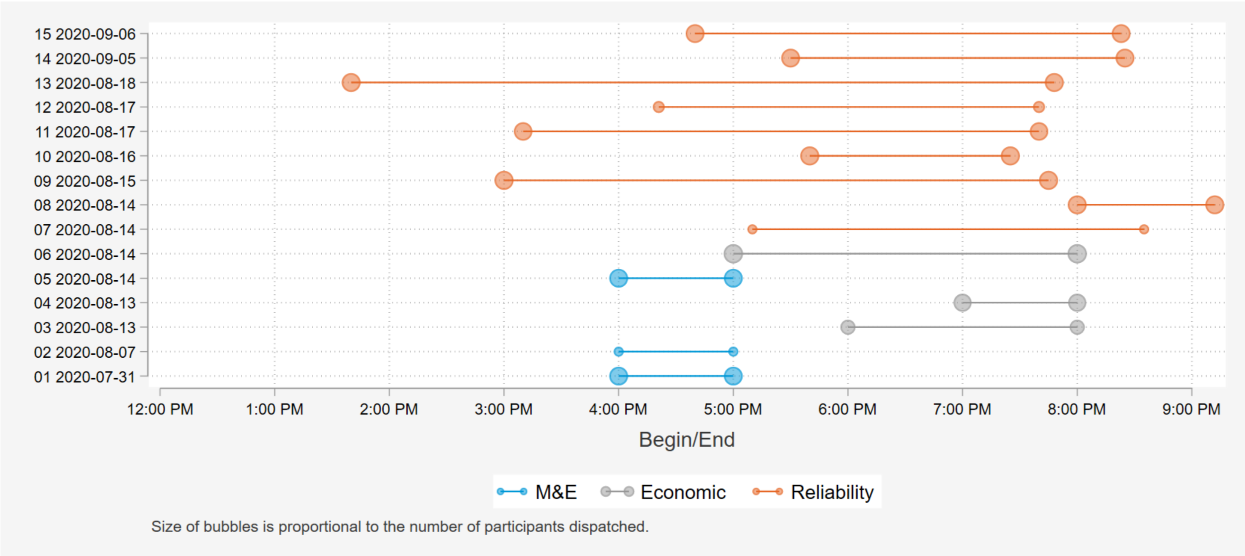


Table 7 shows the dates, start times, and end times for all fifteen of the SDP DR events in 2020, as well as the number of dispatched accounts, devices, and tonnage for the SDP-R and SDP-C segments. The last row in the table shows characteristics for the "average" 2020 event. Due to variation in event timing and the fact that most events started or ended in the middle of an hour, defining an "average" event was not as straightforward in 2020 as it has been in previous years. We defined the average event as the average load impacts on August 17th and September 6th – both system-wide events. One of these events was a weekend day and both events started and ended mid-hour. We would caution readers to take the average results with a grain of salt and refrain from comparing the 2020 average event day to average event days from prior years (when defining an average was more straightforward). Some highlights from the table:

- There were four territory-wide event days (8/17, 8/18, 9/5, and 9/6) and a couple of others that dispatched all load control groups except for one.
- Participant-weighted average temperatures exceeded 100°F for several of the events. SDP-R temperatures tended to be several degrees greater than temperatures experienced by SDP-C participants, on average.
- On the system peak day (8/18), an event was dispatched from 1:40 PM to 7:48 PM.
- Four events were dispatched on weekends, a departure from prior program years.
- There were four events dispatched on 8/14, but three of these events were for the same set of participants and were dispatched back-to-back (4:00 – 5:00 PM, 5:00 – 8:00 PM, and 8:00 – 9:12 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)
7/31	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	193,745	224,164	815,029	97.4	8,075	72,631	365,280	92.9
8/7	C-3, LD	4:00 PM	5:00 PM	9,777	13,167	48,027	98.1	210	704	4,057	97.5
8/13	HD, W-1, W-2	6:00 PM	8:00 PM	60,869	67,860	248,735	89.2	3,562	28,528	138,715	87.6
8/13	C-1, C-2, C-3, C-4, N, NW	7:00 PM	8:00 PM	141,933	168,674	611,366	97.0	4,685	44,679	229,966	95.5
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	193,224	223,564	812,833	99.6	8,060	72,626	365,286	96.7
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	8:00 PM	193,224	223,564	812,833	99.5	8,060	72,626	365,286	96.8
8/14	C-3	5:10 PM	8:35 PM	9,570	12,942	47,181	114.5	195	670	3,848	113.3
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	8:00 PM	9:12 PM	193,224	223,564	812,833	95.7	8,060	72,626	365,286	93.0
8/15	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	3:00 PM	7:45 PM	202,781	236,491	859,990	101.1	8,268	73,408	369,703	97.1
8/16	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	5:40 PM	7:25 PM	202,781	236,490	859,987	94.8	8,268	73,409	369,706	91.6
8/17	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1	3:10 PM	7:40 PM	177,503	208,825	758,200	100.1	6,129	56,003	288,275	97.5
8/17	W-2	4:21 PM	7:40 PM	22,064	23,886	88,066	88.4	2,021	16,249	75,586	87.3
8/18	All	1:40 PM	7:48 PM	199,557	232,734	846,367	100.6	8,160	72,372	364,532	98.3
9/5	All	5:30 PM	8:25 PM	191,475	223,465	812,643	108.3	8,038	70,118	353,748	105.3
9/6	All	4:40 PM	8:23 PM	191,475	223,465	812,643	107.8	8,038	70,118	353,748	105.5
Avg. Event		**3:30 PM**	**7:30 PM**	**195,521**	**228,088**	**829,454**	**102.8**	**8,094**	**71,185**	**358,805**	**99.9**

2.7 COVID-19 PANDEMIC

One unique challenge presented by the 2020 SDP evaluation was the effect of the COVID-19 pandemic. For estimating ex post results, the effect of the pandemic is mitigated by the fact that ex post impacts are derived via comparison with a matched control group. Effects of the pandemic were not unique to SDP participants and control customers experienced the same shelter-in-place rules, facility reopening timelines, social distancing requirements, and work and schooling from home. Residential loads were generally higher over the course of pandemic, and non-residential loads were generally lower. Because SDP controls air conditioning load, the relevant question is the effect of the pandemic on cooling loads. For SDP-C in particular, ex post reference loads were vastly different in 2020 compared to prior years due to the disruptions caused by the pandemic. Naturally, SDP-C ex post impacts were a bit different in 2020 as well. Over 80% of SDP-C air conditioner tonnage is in Schools and Religious Institutions, both of which had their occupancy heavily affected by COVID-19. In the ex post analysis, the impacts are what they are. That said, 2020 reference loads and ex post results factor into ex ante impact estimation. Subsequent sections discuss the impacts the pandemic had on SDP-R and SDP-C reference loads, as well as how COVID-19 was handled in ex ante estimation.

RESIDENTIAL REFERENCE LOADS

To better understand how the pandemic affected energy consumption, our team reviewed 2017-2020 load data. The comparison was limited to the set of customers for which we have four full years of interval data. Figure 13 and Figure 14 illustrate our findings for the residential sector. At similar temperature ranges, residential peaks were approximately 9% higher in 2020 compared to prior years, likely due to shelter-in-place orders that had a portion of the workforce working from home and many schools pivoting to distance learning (Figure 13). Daily energy use shows a similar trend – slightly higher in 2020, especially at higher temperature ranges. It's import to note that 2020 also saw several CAISO emergencies and rolling blackouts (see discussion in Section 2.6). It's possible that such occurrences could alter behaviors on event-like non-event days.

Figure 13: Peak Load Comparison, SDP-R

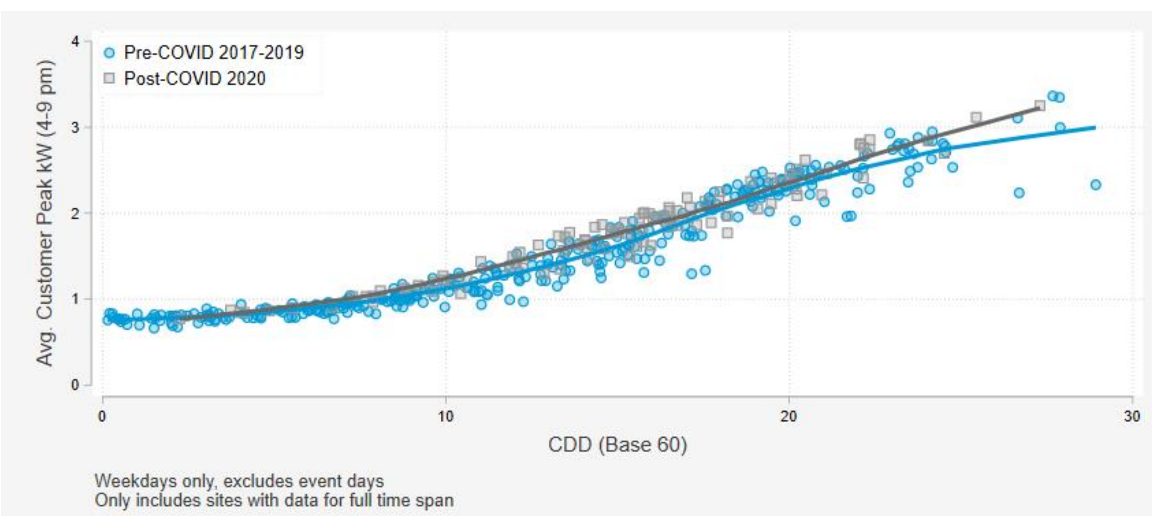
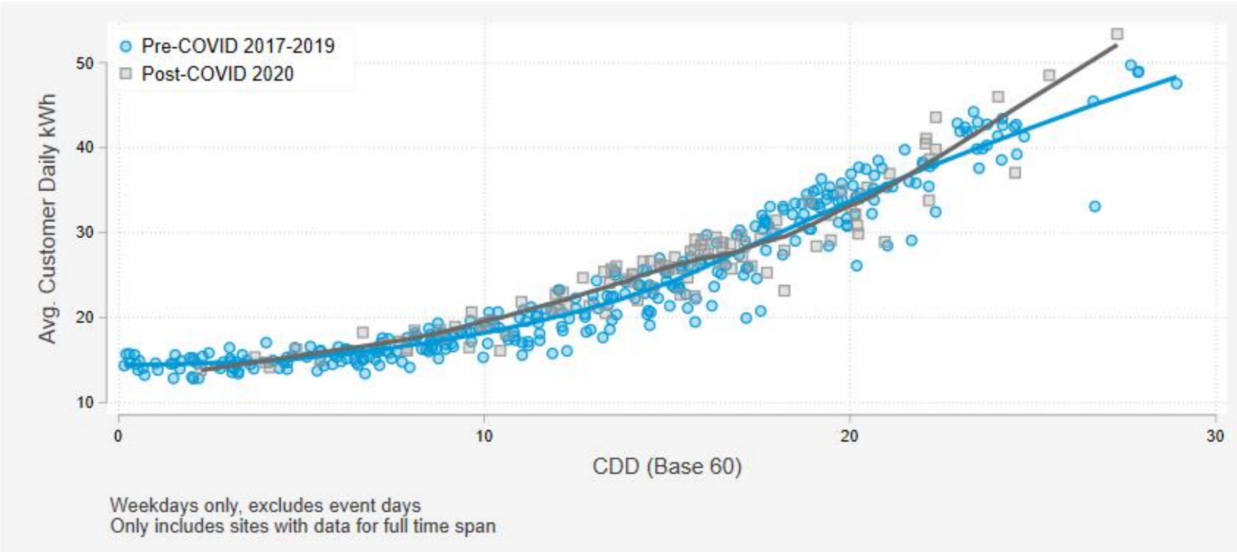


Figure 14: Daily kWh Comparison, SDP-R



Non-Residential Reference Loads

On the commercial side, it is important to keep in mind that the majority of SDP-C devices and tonnage are in schools (Table 6). Perhaps more so than any other industry, COVID-19 disrupted typical load patterns in schools because most school districts pivoted to distance learning. In a distance learning framework, the school buildings themselves are without students. Instead, students log in and follow along from home. As a result, peak SDP-C participant loads were more than 25% lower in 2020 relative to prior years (Figure 15). Daily energy use for SDP-C participants was also down considerably in 2020 relative to pre-COVID years (Figure 16). Recall that this comparison focuses on participants for which we have four years of interval data.

Figure 15: Peak Load Comparison by Day of Year, SDP-C

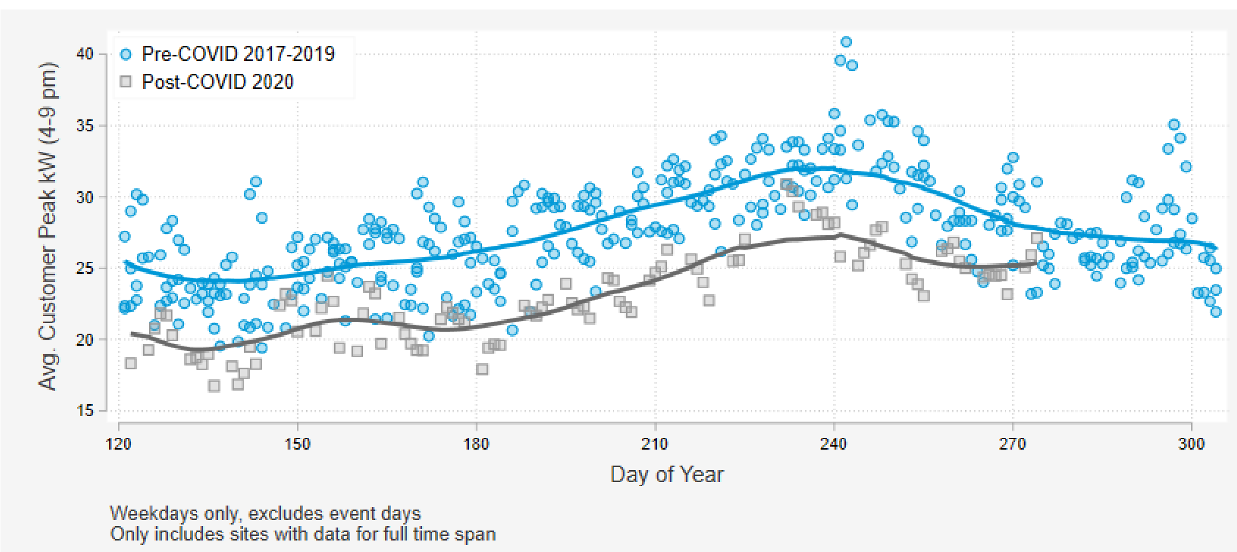
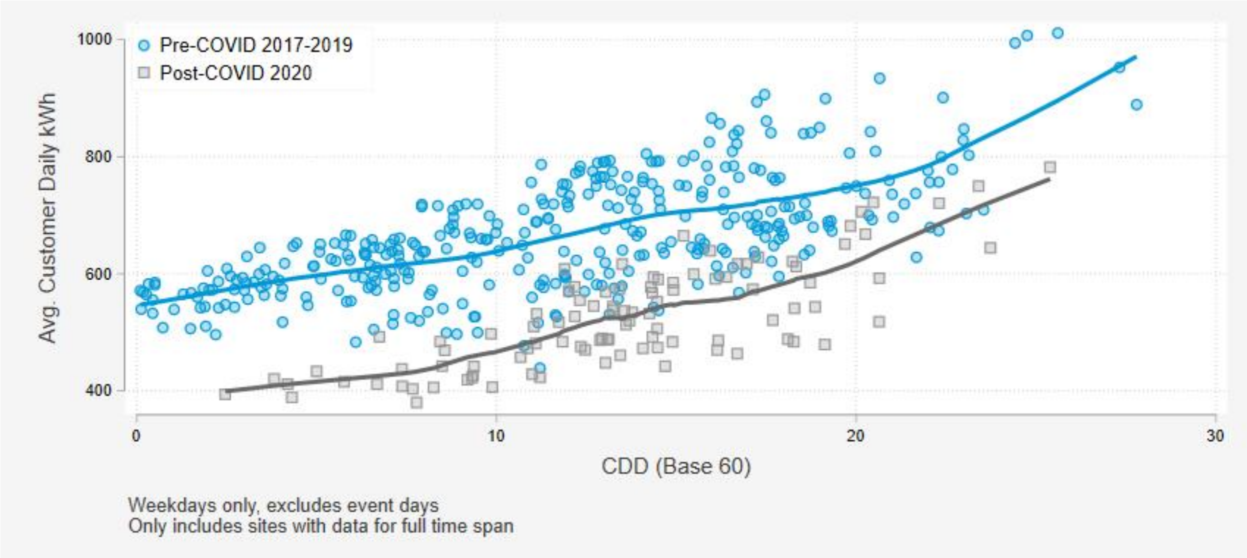


Figure 16: Daily kWh Comparison, SDP-C



COVID-19 INDEX

To summarize the previous two sections, SDP-R loads were slightly higher under COVID-19 conditions and SDP-C loads were more than 25% lower under COVID-19 conditions. To account for the lingering impact of the pandemic in future years, a COVID-19 index was used in the 2020 ex ante analysis (Table 8). In forecast year 2021, the value of the index is 0.50. This means forecast year 2021 is half way between a year without COVID-19 and 2020. In each subsequent year, the index is cut in half. In 2031, the value of the index hits 0, meaning the disruptions caused by the pandemic are a distant memory. A number of the results shown in Sections 4 and 6 are for forecast year 2021.

Table 8: Ex Ante COVID-19 Index

Forecast Year	COVID-19 Index
2021	0.50
2022	0.25
2023	0.125
2024	0.063
2025	0.031
2026	0.016
2027	0.008
2028	0.004
2029	0.002
2030	0.001
2031	0.0

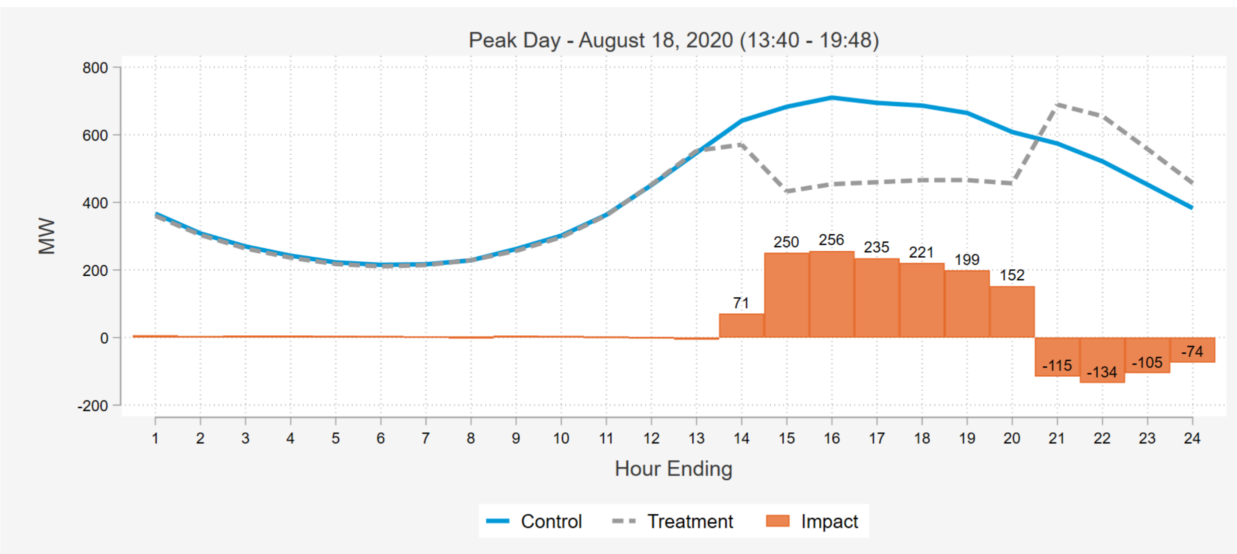
3 RESIDENTIAL EX POST RESULTS

This section focuses on the magnitude of demand reductions delivered by SDP-R during 2020 event days. The magnitude of demand reductions is a function of several factors – temperature, time of day, and geo-targeted dispatch of resources. Note the COVID-19 pandemic impact was not found to have a statistically significant impact on the magnitude of demand reductions delivered by SDP-R participants, and the pandemic's impact on SDP-R reference loads is discussed in Section 2.7.

3.1 SYSTEM PEAK DAY REDUCTIONS

The 2020 system peak was 23,328 MW and occurred on August 18th. On the peak day, SDP-R resources were dispatched from 1:40 PM through 7:48 PM due to grid reliability. In total, SCE sent instructions to curtail demand to 199,557 SDP-R accounts with 232,734 control devices. Figure 17 shows the hourly load profile for the control group and SDP-R participants on the system peak day. During the first two full event hours, the aggregate demand reductions by SDP-R participants were just above 250 MW on average. The demand reductions in later hours were smaller mainly because air conditioner loads are lower in later evening hours. Across the five full event hours (2:00 PM through 7:00 PM), the average impact was 232 MW, and the average percent impact was 33.7%.

Figure 17: SDP-R Reductions on System Peak Day



3.2 INDIVIDUAL EVENT DAY REDUCTIONS

Table 9 shows reference loads, observed loads, impacts, and percent impacts for each of the fifteen SDP-R summer 2020 DR events. Percent impacts were typically in the low 30s. The "average" event is the average across two territory-wide events: 8/17/2020 and 9/6/2020 (the latter of which is a Sunday). Defining an average event in 2020 was difficult, as many events started and/or ended mid-hour and there was variation in event durations and event start times and there were also a number of weekend events in 2020 due to CAISO emergencies.

Table 9: SDP-R Event Results, 2020

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		
7/31	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	193,745	587.7	362.5	225.1	214.93	235.34	1.16	1.00	0.28	38.3%	98.1
8/7	C-3, LD	4:00 PM	5:00 PM	9,777	22.8	17.1	5.7	4.93	6.39	0.58	0.43	0.12	24.8%	99.7
8/13	HD, W-1, W-2	6:00 PM	8:00 PM	60,869	137.9	102.9	35.0	31.89	38.06	0.57	0.52	0.14	25.4%	87.8
8/13	C-1, C-2, C-3, C-4, N, NW	7:00 PM	8:00 PM	141,933	381.3	277.2	104.2	96.81	111.52	0.73	0.62	0.17	27.3%	94.0
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	193,224	638.0	412.1	225.9	216.05	235.68	1.17	1.01	0.28	35.4%	100.4
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	8:00 PM	193,224	623.0	426.5	196.6	187.97	205.19	1.02	0.88	0.24	31.6%	98.0
8/14	C-3	5:10 PM	8:35 PM	9,570	37.9	26.5	11.4	10.72	12.08	1.19	0.88	0.24	30.1%	113.5
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	8:00 PM	9:12 PM	193,224	551.9	411.9	140.0	130.00	149.94	0.72	0.63	0.17	25.4%	91.4
8/15	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	3:00 PM	7:45 PM	202,781	725.9	456.9	268.9	260.38	277.48	1.33	1.14	0.31	37.0%	100.6
8/16	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	5:40 PM	7:25 PM	202,781	653.4	437.4	216.0	205.53	226.40	1.07	0.91	0.25	33.1%	91.8
8/17	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1	3:10 PM	7:40 PM	177,503	628.3	402.2	226.1	219.14	233.03	1.27	1.08	0.30	36.0%	99.3
8/17	W-2	4:21 PM	7:40 PM	22,064	58.6	44.3	14.3	12.97	15.67	0.65	0.60	0.16	24.4%	87.3
8/18	**All**	**1:40 PM**	**7:48 PM**	**199,557**	**687.7**	**455.6**	**232.1**	**225.01**	**239.15**	**1.16**	**1.00**	**0.27**	**33.7%**	**99.3**
9/5	All	5:30 PM	8:25 PM	191,475	708.1	480.9	227.2	218.12	236.30	1.19	1.02	0.28	32.1%	106.2
9/6	All	4:40 PM	8:23 PM	191,475	728.9	494.0	234.8	225.69	243.93	1.23	1.05	0.29	32.2%	105.0
Avg. Event		**3:30 PM**	**7:30 PM**	**195,521**	**724.4**	**507.5**	**216.9**	**211.49**	**222.35**	**1.11**	**0.95**	**0.26**	**29.9%**	**102.8**

Figure 18 and Figure 19 visualize impacts on Friday 8/14 and Saturday 8/15. These days are notable because they were both CAISO Stage 3 Emergency days. These emergencies were declared due to excessive heat driving up electricity use, resulting in strain on the grid. CAISO also issued Flex Alerts for 8/14. These alerts urge consumers to conserve electricity to reduce strain on the grid. In the first few hours of the 8/14 event, aggregate impacts were around 225 MW. For the 8/15 event, aggregate impacts were around 280 MW for the first few event hours. Reference loads and percent impacts were also higher on 8/15, potentially explained by higher temperatures, the 8/14 Flex Alerts, and/or the fact that 8/15 was a Saturday. A small percentage of SDP-R participants were affected by rotating outages on these two days. Importantly, these customers were not included in the estimation of demand reductions for these days and affected control customers were removed from the matching pool.

Figure 18: SDP-R Load Impacts on Friday, 8/14/2020

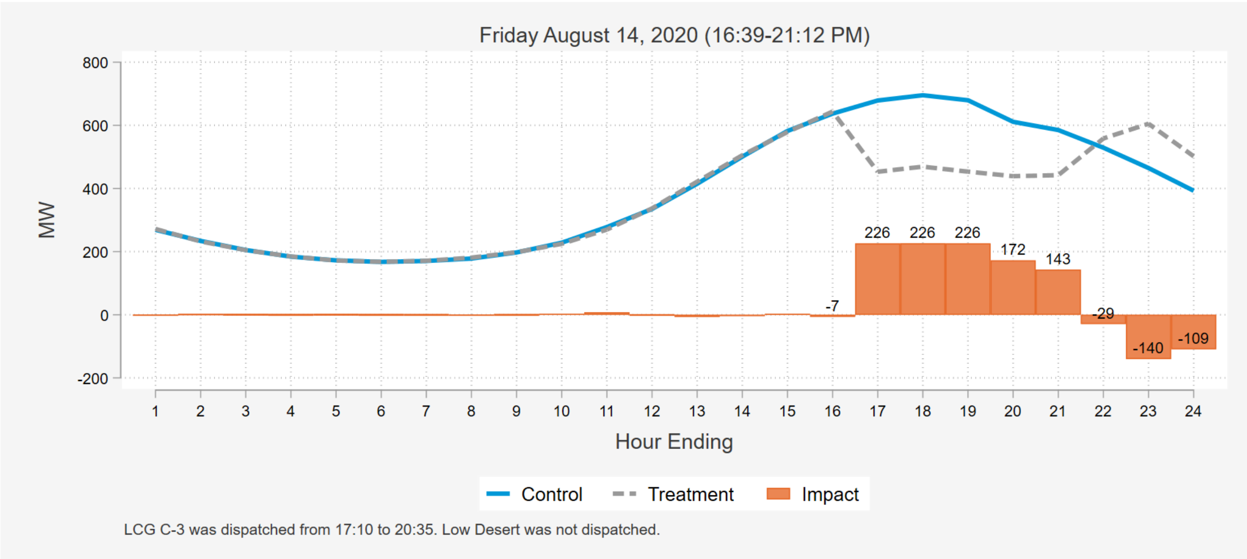


Figure 19: SDP-R Load Impacts on Saturday, 8/15/2020

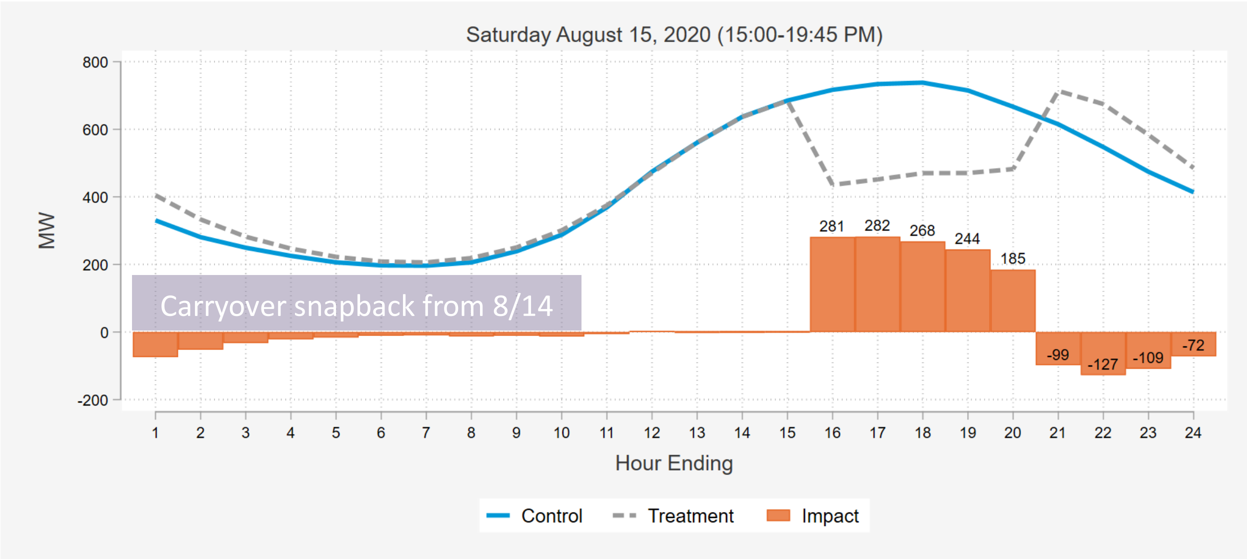
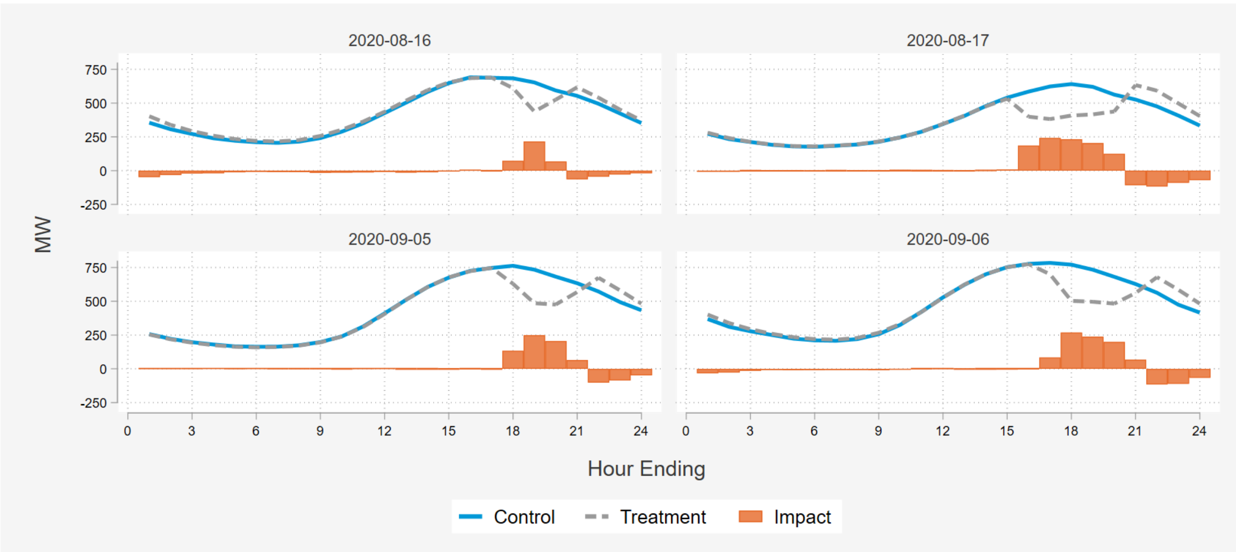


Figure 20 visualizes aggregate impacts for four other events of interest. All four events occurred during the mid-August and early September heat waves, and three of these events coincided with CAISO Stage 2 Emergency declarations (8/17, 9/5, and 9/6). Flex Alerts were issued for all four of these days. The September events both fell on the weekend, and the peak loads for those days ranked third and fourth for SCE during the 2020 summer. Because roughly 85% of sites elect to have their AC unit fully curtailed, the decrease in the magnitude of reduction in the later evening hours is most likely due to decreasing air conditioner loads.

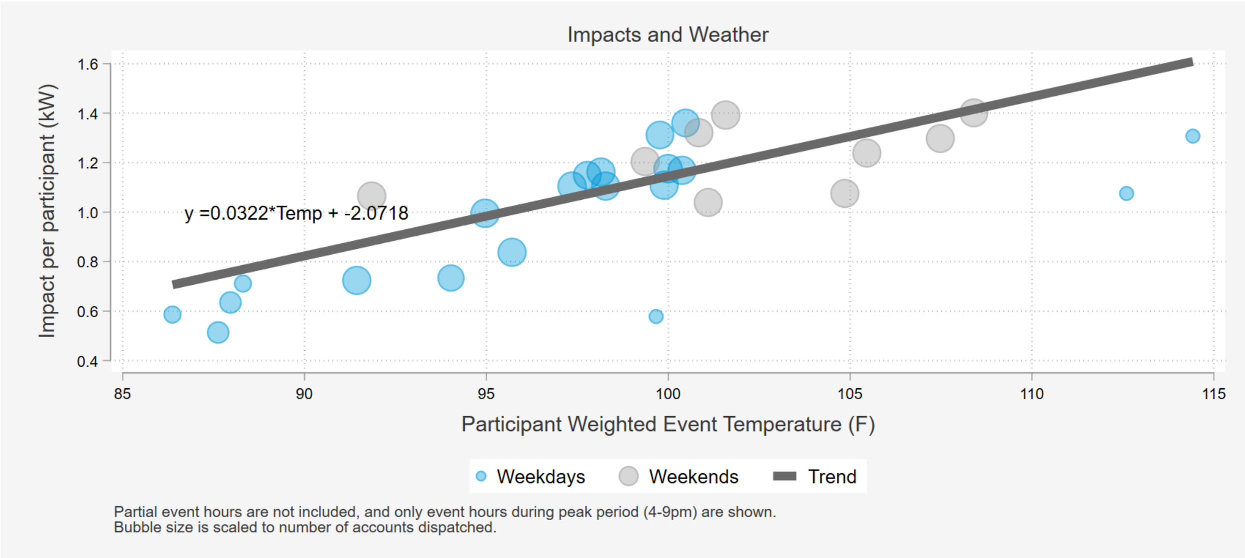
Figure 20: SDP-R Reductions on Select Event Days



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 21 visualizes the relationship between 2020 SDP-R DR reductions and outdoor temperature. The slope of the line in the figure is 0.032, which suggests that the average impact per participant increases by 0.032 kW for each one-degree increase in outdoor temperature. The gray bubbles represent impacts for events that occurred on weekend days. Load curtailments for weekend days were comparable to weekday event reductions.

Figure 21: Relationship between SDP-R Demand Reductions and Weather



3.4 COMPARISON TO PRIOR YEARS

In comparing SDP-R event performance in 2020 to performance in prior years, three key details will act to confound the comparison:

- Several of the 2020 events were dispatched due to CAISO emergencies. This was not the case in 2018 or 2019 as there were no CAISO emergencies.
- Whereas the 2019 summer was mild, the 2020 summer saw extreme heat waves. Cooling loads were elevated due to these heat waves – this spurred the aforementioned CAISO emergencies.
- The COVID-19 pandemic was ongoing during the 2020 summer DR season. SDP-R reference loads were slightly higher due to the pandemic, but we have found that the pandemic did not have a statistically significant effect on the magnitude of 2020 SDP-R impacts. Thus, it should be expected that 2020 ex post percent impacts are slightly lower than percent impacts in prior years.

With these details in mind, Figure 21 shows the relationship between SDP-R reductions and outdoor temperature for the past three years. In the figure, program years 2018 and 2019 are grouped together. There is a significant difference in temperature ranges between the two 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 2018-2019 and 2020 impacts are very similar.

Figure 22: SDP-R Ex Post Reductions against Temperature, 2018-2020

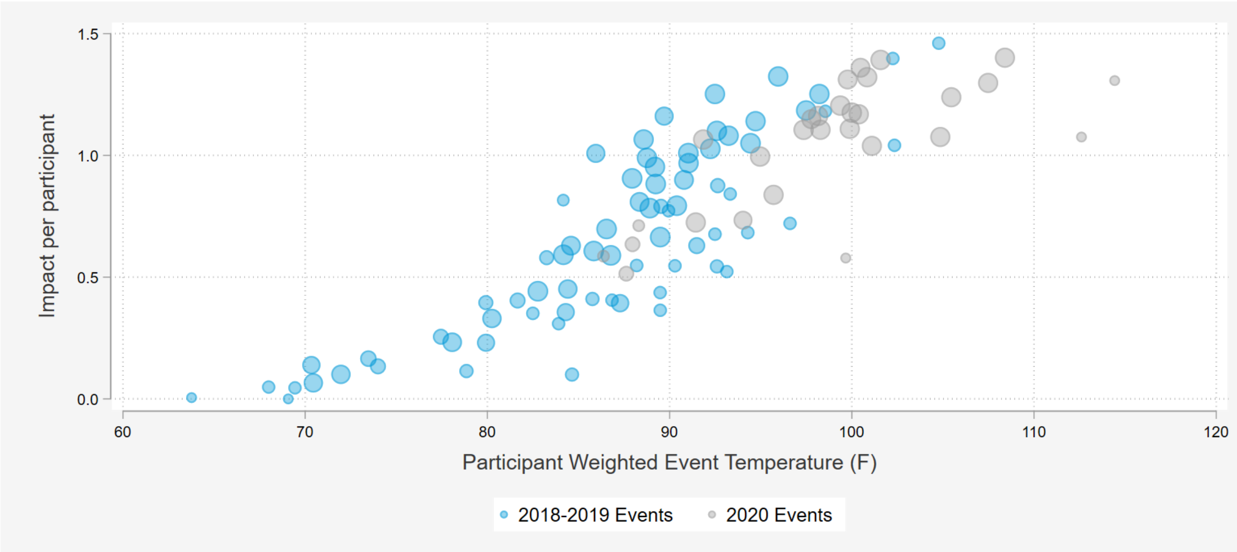
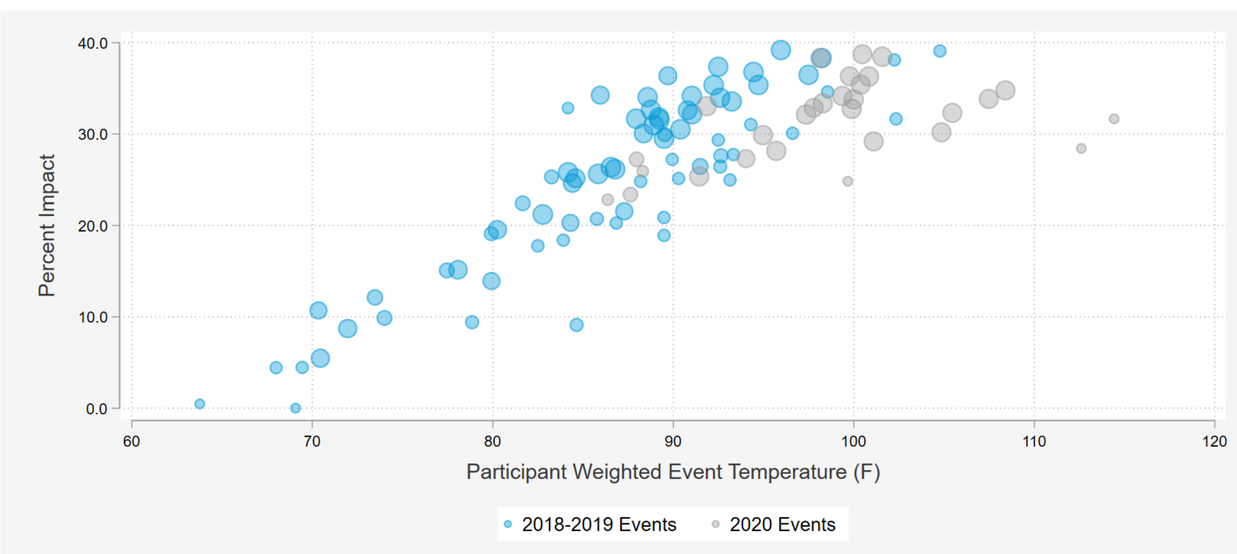


Figure 23 shows the relationship between percent reductions (rather than load reductions) and outdoor temperature. Readers should keep two things in mind when reviewing this figure. First, percent impacts are calculated with whole-premise load in the denominator, not cooling load. This means there is 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, 2020 events were warmer than 2018-2019 events, on average, and the range of temperatures observed in 2020 was narrow compared to 2018-2019. The eye test tells us that at similar temperature ranges, percent impacts are relatively stable across the three years (though slightly lower in 2020 due to pandemic-inflated reference loads) and max out around 40%.

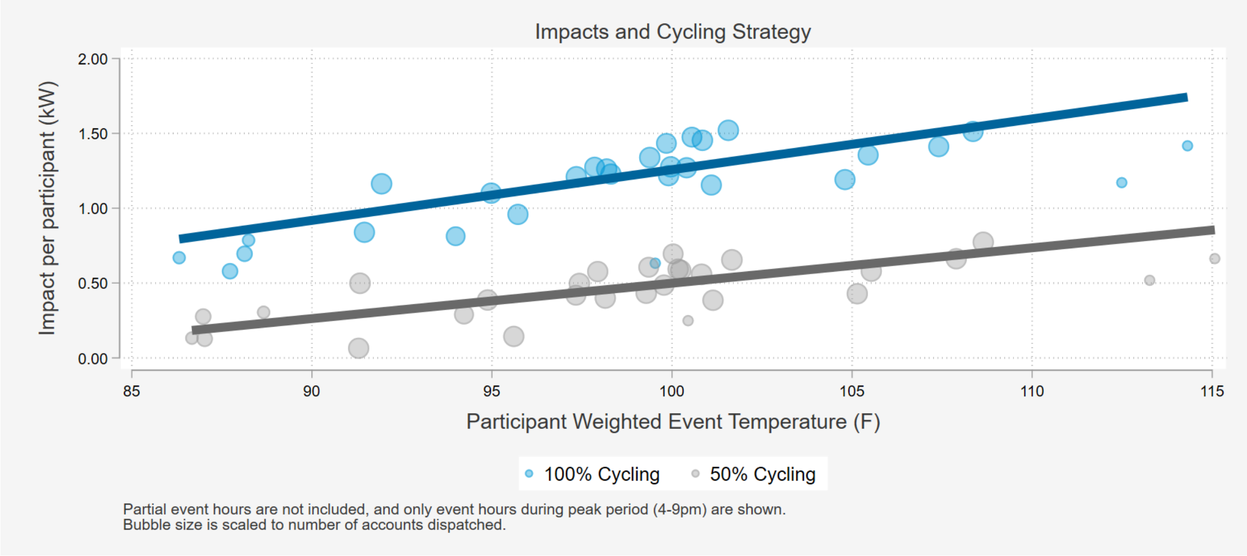
Figure 23: SDP-R Percent Reductions against Temperature, 2018-2020



3.5 IMPACTS BY CYCLING STRATEGY

Figure 24 plots the load impacts against outdoor temperature for the two cycling strategy groups. The size of the bubbles is proportional to the number of accounts dispatched. 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 not identical, but they are very similar – 0.034 in the 100% cycling group and 0.024 in the 50% cycling group. Recall that these slopes represent the expected increase in the impact for every one degree increase in temperature.

Figure 24: SDP-R Impacts by Cycling Strategy



3.6 IMPACTS FOR KEY CUSTOMER SEGMENTS

Table 10 shows the impacts of key customer segments for the average 2020 SDP-R event day (which was the average of two territory-wide events, one of which was a weekend event). As a reminder, we would urge readers to pay less mind to the average event day in 2020 than in prior years, as there was no average or typical event in 2020. Highlights include:

- On average, impacts in the 100% cycling strategy group are approximately 2.3 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 1.37 kW and 1.44 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, 32.3%, for CARE/FERA homes. By comparison, non-low income homes reduced demand by 29.1%.

Table 10: SDP-R Impacts by Key Customer Segments, Average 2020 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%	29,093	3.77	3.25	0.52	13.8%	15.1
	100%	166,428	3.69	2.48	1.21	32.8%	201.8
Load Control Group	SDP-Central-1	35,055	4.12	2.75	1.37	33.2%	47.9
	SDP-Central-2	20,900	3.75	2.55	1.20	32.1%	25.1
	SDP-Central-3	9,319	3.78	2.91	0.87	23.1%	8.1
	SDP-Central-4	38,548	4.08	2.64	1.44	35.4%	55.7
	SDP-High Desert	12,129	3.38	2.19	1.18	35.0%	14.4
	SDP-Low Desert	206	3.94	3.08	0.86	21.9%	0.2
	SDP-North	24,152	3.74	2.67	1.08	28.8%	26.0
	SDP-Northwest	8,448	3.61	3.02	0.59	16.4%	5.0
	SDP-West-1	25,111	3.12	2.34	0.79	25.3%	19.8
	SDP-West-2	21,655	3.14	2.47	0.67	21.4%	14.5
Local Capacity Area	Big Creek/Ventura	[redacted]					
	LA Basin	[redacted]					
	Outside LA Basin	12,335	3.39	2.21	1.18	34.8%	14.5
CARE/FERA Status	Non-CARE/FERA	143,253	3.75	2.66	1.09	29.1%	156.3
	CARE/FERA	52,268	3.59	2.43	1.16	32.3%	60.7
Zone	South Orange County	[redacted]					
	South of Lugo	[redacted]					
	Remainder of System	107,861	3.71	2.65	1.06	28.6%	114.4
All Customers		**195,521**	**3.71**	**2.60**	**1.11**	**29.9%**	**216.9**

By LCG, Figure 25 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 26 shows how participant-level impacts vary across subcategories for several key research categories (cycling strategy, load control group, and CARE status).

Figure 25: Average Aggregate Impacts by Event and LCG, SDP-R

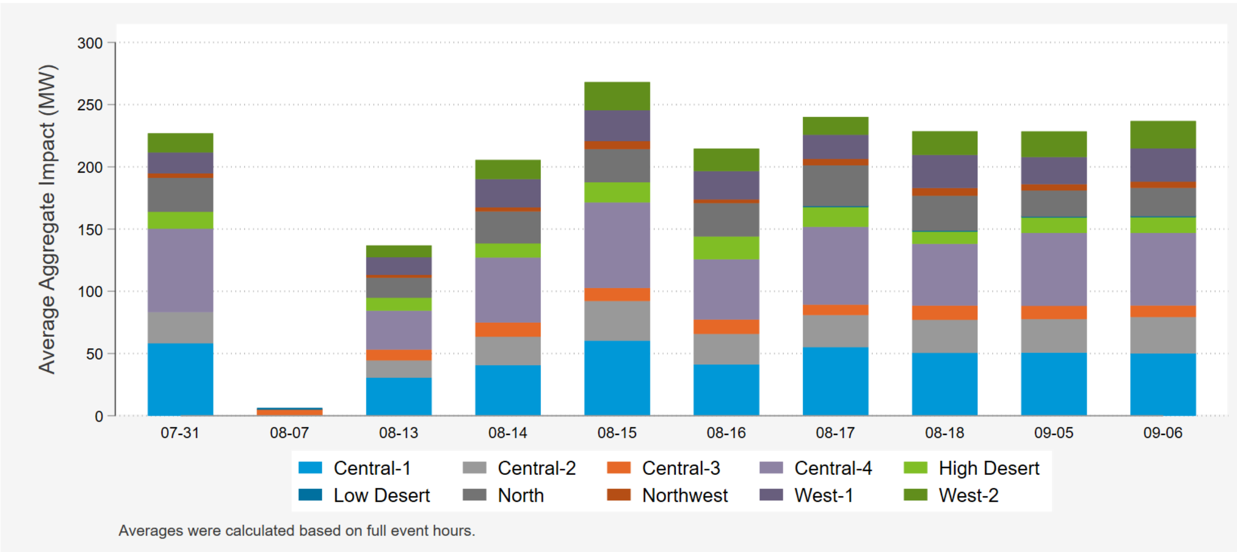
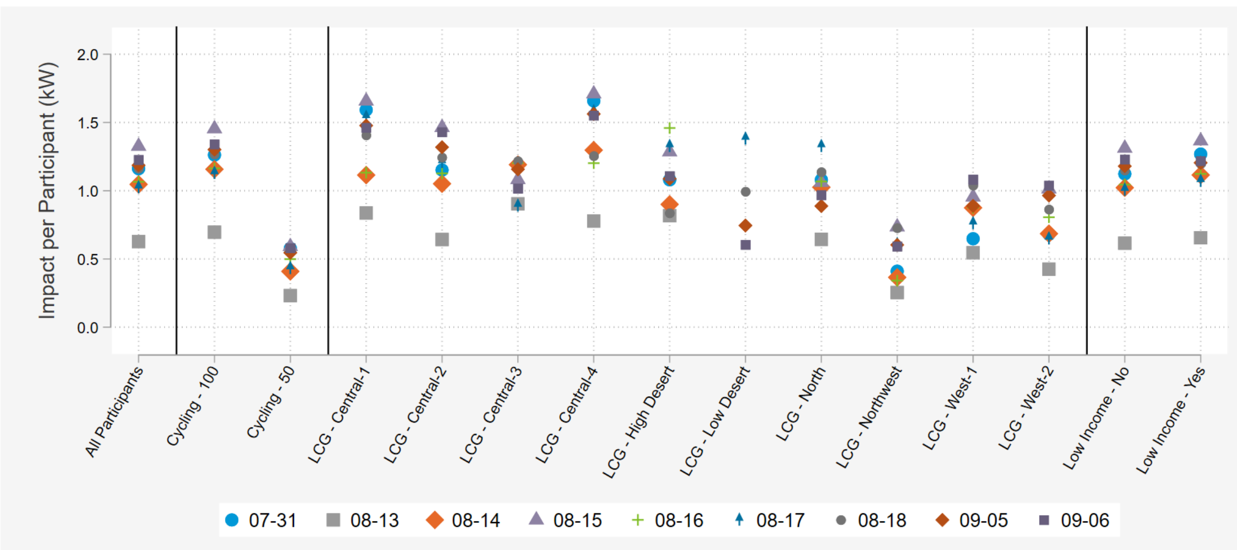


Figure 26: Average Participant Impact by Event and Key Subcategory, SDP-R



3.7 KEY FINDINGS

The SDP Residential (SDP-R) program has approximately 206,000 customers enrolled and includes nearly 240,000 control devices and 872,000 tons of air conditioner load. Approximately 85% 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 0.032 kW for each one-degree increase in outdoor temperature in 2020. Across 206,000 customers, this translates to 6.6 MW in incremental demand reductions for each one-degree increase in outdoor temperature.

For full event hours, average impacts were in the neighborhood of 1 kW per participant, and percent impacts were generally around 30%. For three peak days (8/18, 9/5, and 9/6), average participant impacts were around 1.20 kW and percent impacts were around 32%.

A few other key findings are worth highlighting:

- During the system peak day (August 18, 2020), SDP-R participants reduced demand by an average of 218 MW between 4:00 PM and 7:00 PM. Demand reductions in the first event hour exceeded 250 MW (2:00 PM – 3:00 PM). The demand reductions per customer, per device, and per ton for this event were 1.16 kW, 1.00 kW, and 0.27 kW respectively.
- On CAISO Stage 3 Emergency days (8/14 and 8/15), SDP-R participants delivered demand reductions in excess of 200 MW. During the first two hours of the 8/15 event, SDP-R participants delivered an average of 282 MW in demand reductions. During the first two hours of the 8/14 event, SDP-participants delivered an average of 226 MW.
- SDP-R reference loads were slightly higher under COVID-19 conditions, likely due to shelter-in-place orders that had a portion of the workforce working from home and many schools pivoting to distance learning. The pandemic was not found to have a statistically significant effect on the magnitude of demand reductions delivered by SDP-R participants. The fact that impacts were larger in 2020 than in previous years is explained by the extreme heat.
- The per-participant demand reductions for customers signed up for the 100% cycling are more than twice as large as demand reductions for those on 50% cycling. For customers who are in the 50% cycling group, demand reductions are negligible when temperatures are below 85° F, as there simply isn't enough cooling load to curtail.
- In response to peaking conditions, there were a number of weekend events dispatched in 2020 which is atypical for SDP. For full event hours, participant-level demand reductions ranged from 1.04 kW to 1.40 on these weekend events. Percent impacts ranged from 29.2% to 39.2%.

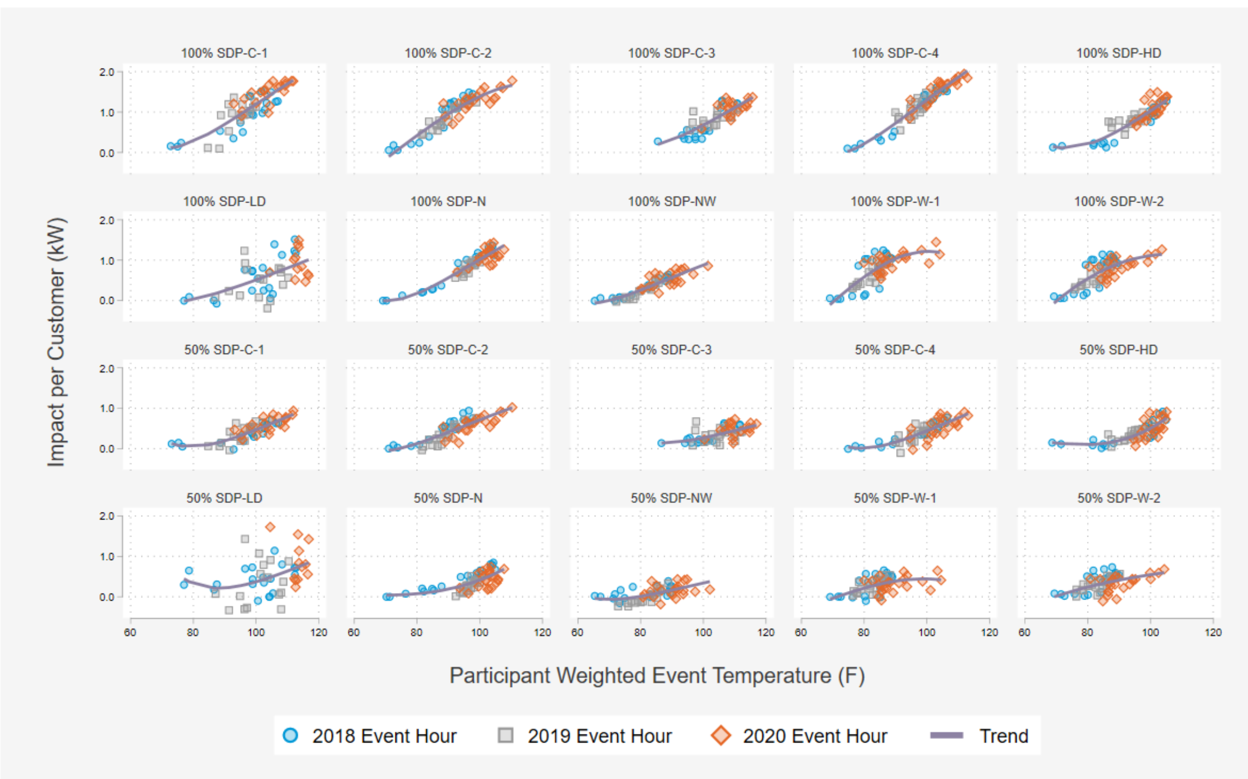
4 RESIDENTIAL EX ANTE RESULTS

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 (2018-2020) 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 2018-2020 for customers currently enrolled in the program. Partial event hours from 2020 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 27 shows the relationship between weather and demand reductions for each of the building blocks.

Figure 27: 2018-2020 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 COVID-19 pandemic, 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 11 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 2020 peak day was 1.16 kW though this includes impacts that occurred outside of the ex ante window (4:00 PM – 9:00 PM). Inside this window, the average impact on the 2020 peak day was 1.09 kW per participant.

Table 11: 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	0.22	0.54	0.23	0.54
June	0.53	0.97	0.53	0.99
July	0.81	1.13	0.79	0.92
August	0.87	1.00	0.86	0.94
September	0.88	1.02	0.90	1.01

Table 12 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 12: Aggregate Peak Event 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
2021	189,795	165	189	164	178
2022	191,614	167	192	166	181
2023	183,372	160	184	159	173
2024	173,446	151	174	150	164
2025	164,345	143	165	142	155
2026	155,979	136	156	135	147
2027	148,270	129	149	128	140
2028	141,145	123	142	122	133
2029	134,541	117	135	117	127
2030	128,402	112	129	111	121
2031	122,677	107	123	106	116

Figure 28 and Figure 29 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 28 shows profiles under 1-in-2 weather conditions, and Figure 29 shows profiles for 1-in-10. Note that the forecast year shown is 2021 and the COVID index is 0.50. However, the pandemic was not found to have a statistically significant impact on SDP-R demand reductions, so the value of the COVID index does not materially affect the demand reductions.

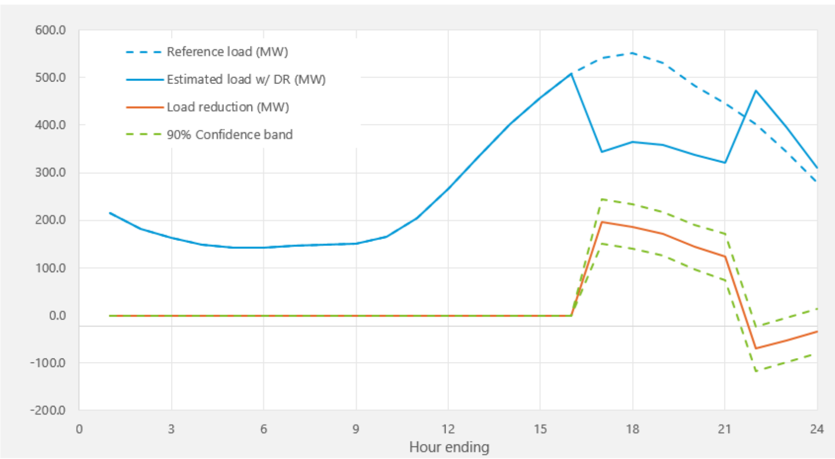
Figure 28: SDP-R Aggregate Ex Ante Impact for 1-in-2 Weather Conditions, August Peak Day

Table 1: Menu options

Program	SDP-R
Type of result	Aggregate
Category	ALL
Subcategory	All
Weather Data	SCE Weather
Weather Year	1-in-2
Day Type	MONTHLY SYSTEM PEAK DAY
Month	8
Forecast Year	2021

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	189,795
Total devices	221,618
Total AC tonnage	808,299
Event window temperature (F)	91.3
Event window load reduction (MW)	164.59
% Load reduction (Event window)	32.3%
COVID Index	0.50



Hour ending	Reference load (MW)	Estimated load w/ DR (MW)	Load reduction (MW)	% Load reduction	Avg temp (F, site weighted)	Confidence Band 5th	Confidence Band 95th	Std. error	T-statistic
1	214.83	214.83	0.00	0.0%	79.99	0.00	0.00	0.00	0.00
2	182.85	182.85	0.00	0.0%	78.61	0.00	0.00	0.00	0.00
3	162.82	162.82	0.00	0.0%	77.59	0.00	0.00	0.00	0.00
4	149.44	149.44	0.00	0.0%	76.55	0.00	0.00	0.00	0.00
5	141.84	141.84	0.00	0.0%	75.65	0.00	0.00	0.00	0.00
6	142.32	142.32	0.00	0.0%	75.00	0.00	0.00	0.00	0.00
7	147.23	147.23	0.00	0.0%	74.34	0.00	0.00	0.00	0.00
8	149.15	149.15	0.00	0.0%	74.24	0.00	0.00	0.00	0.00
9	150.34	150.34	0.00	0.0%	76.59	0.00	0.00	0.00	0.00
10	165.89	165.89	0.00	0.0%	81.03	0.00	0.00	0.00	0.00
11	205.48	205.48	0.00	0.0%	85.48	0.00	0.00	0.00	0.00
12	266.62	266.62	0.00	0.0%	89.14	0.00	0.00	0.00	0.00
13	336.42	336.42	0.00	0.0%	91.65	0.00	0.00	0.00	0.00
14	402.44	402.44	0.00	0.0%	93.85	0.00	0.00	0.00	0.00
15	458.75	458.75	0.00	0.0%	95.32	0.00	0.00	0.00	0.00
16	508.00	508.00	0.00	0.0%	95.43	0.00	0.00	0.00	0.00
17	540.33	342.98	197.35	36.5%	94.95	150.77	243.93	28.32	6.97
18	550.98	364.28	186.70	33.9%	93.33	140.23	233.18	28.25	6.61
19	530.22	358.94	171.27	32.3%	91.58	124.85	217.69	28.22	6.07
20	481.86	337.71	144.15	29.9%	89.92	97.71	190.59	28.23	5.11
21	444.49	321.00	123.48	27.8%	86.62	74.86	172.11	29.56	4.18
22	402.07	472.11	-70.04	-17.4%	83.39	-117.36	-22.72	28.77	-2.43
23	343.04	394.70	-51.66	-15.1%	81.18	-98.94	-4.37	28.75	-1.80
24	278.36	311.50	-33.13	-11.9%	79.48	-80.49	14.23	28.79	-1.15
Daily	Reference load (MWh)	Estimated load w/ DR (MWh)	Energy savings (MWh)	% Change	Avg. Daily Weighted temp (F)	Uncertainty adjusted impact 5th	Uncertainty adjusted impact 95th	Std. error	T-statistic
Daily kWh	7355.77	6687.64	668.13	10.0%	84.20	535.00	801.26	80.94	8.25

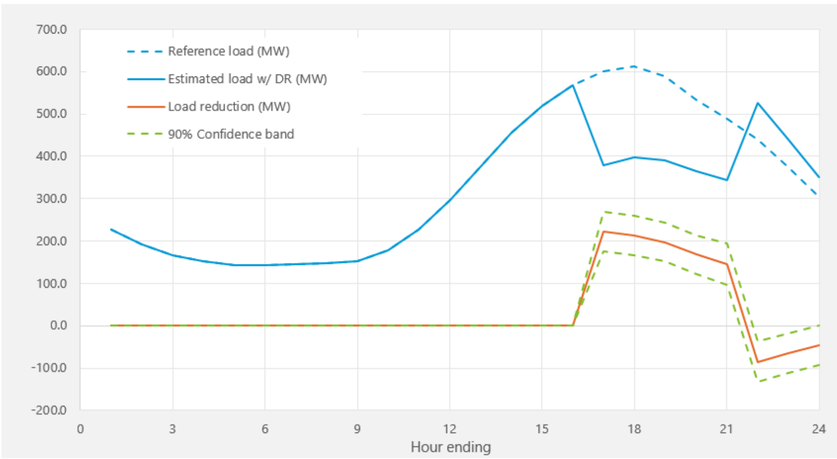
Figure 29: SDP-R Aggregate Ex Ante Impact for 1-in-10 Weather Conditions, August Peak Day

Table 1: Menu options

Program	SDP-R
Type of result	Aggregate
Category	ALL
Subcategory	All
Weather Data	SCE Weather
Weather Year	1-in-10
Day Type	MONTHLY SYSTEM PEAK DAY
Month	8
Forecast Year	2021

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	189,795
Total devices	221,618
Total AC tonnage	808,299
Event window temperature (F)	96.2
Event window load reduction (MW)	189.41
% Load reduction (Event window)	33.5%
COVID Index	0.50

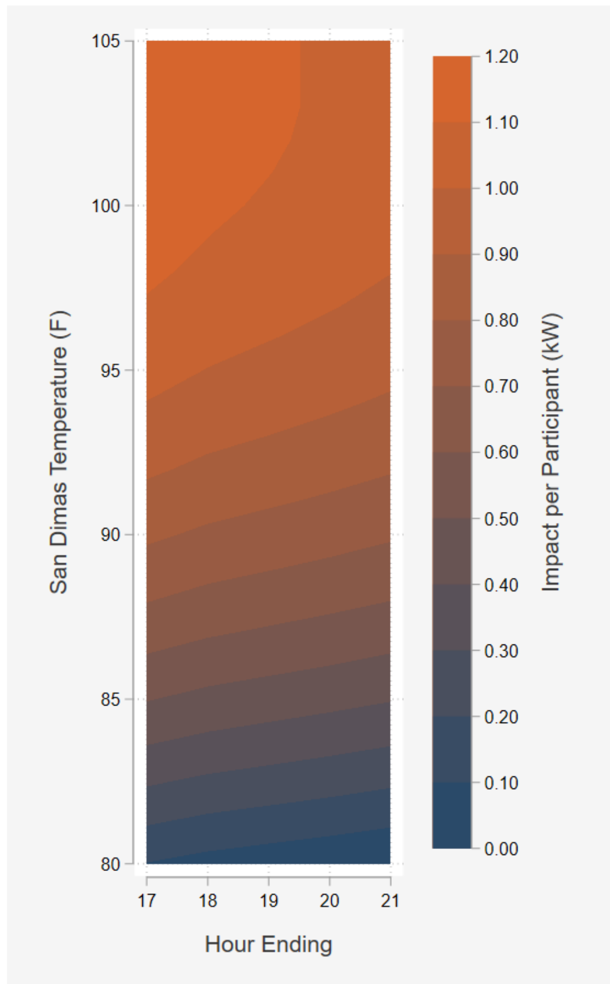


Hour ending	Reference load (MW)	Estimated load w/ DR (MW)	Load reduction (MW)	% Load reduction	Avg temp (F, site weighted)	Confidence Band 5th	Confidence Band 95th	Std. error	T-statistic
1	227.37	227.37	0.00	0.0%	81.41	0.00	0.00	0.00	0.00
2	191.07	191.07	0.00	0.0%	79.87	0.00	0.00	0.00	0.00
3	167.61	167.61	0.00	0.0%	78.56	0.00	0.00	0.00	0.00
4	151.48	151.48	0.00	0.0%	77.15	0.00	0.00	0.00	0.00
5	142.83	142.83	0.00	0.0%	76.02	0.00	0.00	0.00	0.00
6	142.06	142.06	0.00	0.0%	75.10	0.00	0.00	0.00	0.00
7	145.06	145.06	0.00	0.0%	74.06	0.00	0.00	0.00	0.00
8	147.49	147.49	0.00	0.0%	74.05	0.00	0.00	0.00	0.00
9	152.52	152.52	0.00	0.0%	76.91	0.00	0.00	0.00	0.00
10	178.66	178.66	0.00	0.0%	82.29	0.00	0.00	0.00	0.00
11	227.90	227.90	0.00	0.0%	88.22	0.00	0.00	0.00	0.00
12	296.21	296.21	0.00	0.0%	92.48	0.00	0.00	0.00	0.00
13	377.73	377.73	0.00	0.0%	94.90	0.00	0.00	0.00	0.00
14	456.08	456.08	0.00	0.0%	96.75	0.00	0.00	0.00	0.00
15	519.70	519.70	0.00	0.0%	98.29	0.00	0.00	0.00	0.00
16	568.72	568.72	0.00	0.0%	99.41	0.00	0.00	0.00	0.00
17	600.33	378.26	222.07	37.0%	98.85	175.41	268.74	28.37	7.83
18	611.38	398.05	213.33	34.9%	98.67	166.78	259.88	28.30	7.54
19	589.55	391.52	198.03	33.6%	97.63	151.54	244.52	28.26	7.01
20	533.92	366.08	167.84	31.4%	94.78	121.34	214.34	28.27	5.94
21	488.61	342.83	145.79	29.8%	90.97	96.89	194.69	29.73	4.90
22	439.99	524.93	-84.94	-19.3%	87.67	-132.36	-37.51	28.83	-2.95
23	374.63	439.37	-64.74	-17.3%	85.09	-112.11	-17.36	28.80	-2.25
24	304.97	350.65	-45.69	-15.0%	83.43	-93.14	1.77	28.85	-1.58
Daily	**Reference load (MWh)**	**Estimated load w/ DR (MWh)**	**Energy savings (MWh)**	**% Change**	**Avg. Daily Weighted temp (F)**	**Uncertainty adjusted impact 5th**	**Uncertainty adjusted impact 95th**	**Std. error**	**T-statistic**
Daily kWh	8035.86	7284.16	751.70	10.3%	86.77	618.27	885.13	81.12	9.27

Figure 30 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 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 represent the expected participant-level impact for a territory-wide event for the given hour and temperature.

Figure 30: SDP-R Time-Temperature Matrix

Temp	Hour Ending				
	17	18	19	20	21
105	1.18	1.14	1.11	1.09	1.06
104	1.18	1.14	1.11	1.09	1.06
103	1.18	1.14	1.11	1.09	1.06
102	1.17	1.14	1.11	1.08	1.05
101	1.17	1.13	1.10	1.08	1.05
100	1.15	1.12	1.09	1.06	1.04
99	1.14	1.10	1.07	1.05	1.02
98	1.12	1.08	1.05	1.03	1.00
97	1.09	1.06	1.03	1.01	0.98
96	1.06	1.03	1.00	0.98	0.95
95	1.03	1.00	0.97	0.95	0.92
94	1.00	0.96	0.94	0.91	0.89
93	0.96	0.92	0.90	0.88	0.85
92	0.92	0.88	0.86	0.83	0.81
91	0.87	0.83	0.81	0.79	0.76
90	0.82	0.78	0.76	0.74	0.71
89	0.76	0.73	0.71	0.68	0.66
88	0.70	0.67	0.65	0.63	0.60
87	0.64	0.61	0.59	0.56	0.54
86	0.58	0.54	0.52	0.50	0.47
85	0.51	0.47	0.45	0.43	0.41
84	0.43	0.40	0.38	0.36	0.33
83	0.35	0.32	0.30	0.28	0.26
82	0.27	0.24	0.22	0.20	0.18
81	0.19	0.16	0.13	0.11	0.09
80	0.10	0.07	0.05	0.03	0.00



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 13 shows ex ante impact estimates (per participant) for these key segments using SCE 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 13: SDP-R Ex Ante Results by Customer Segment, SCE Weather

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	0.42	1.15	1.04	0.55	1.36	1.24
SDP-Central-2	0.46	1.04	0.94	0.53	1.17	1.06
SDP-Central-3	0.35	0.93	0.84	0.43	1.04	0.95
SDP-Central-4	0.38	1.22	1.09	0.54	1.47	1.32
SDP-High Desert	0.34	0.82	0.78	0.45	0.99	0.95
SDP-Low Desert	0.56	0.83	0.78	0.66	0.95	0.90
SDP-North	0.34	0.90	0.82	0.37	0.98	0.89
SDP-Northwest	0.09	0.34	0.31	0.13	0.46	0.41
SDP-West-1	0.27	0.80	0.71	0.29	0.83	0.74
SDP-West-2	0.31	0.72	0.66	0.34	0.78	0.70
Average	**0.34**	**0.96**	**0.87**	**0.42**	**1.10**	**1.00**

4.4 COMPARISON TO PRIOR YEAR

Table 14 shows a comparison of vintage year 2018, 2019, and 2020 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 2018 and 2019 ex ante impacts, participant-level impacts are static throughout the forecast window. For 2020 ex ante impacts, participant-level impacts from forecast year 2021 are shown (though participant-level impacts for forecast years 2022-2031 are essentially the same as 2021). In magnitude and direction, the 2018-2020 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.[6]

Table 14: Comparison of SDP-R Ex Ante Impacts (kW), 2018-2020

Month	Vintage Year 2018		Vintage Year 2019		Vintage Year 2020	
	1-in-2	1-in-10	1-in-2	1-in-10	1-in-2	1-in-10
June	0.55	0.77	0.37	0.94	0.53	0.97
July	0.72	0.91	0.71	1.14	0.81	1.13
August	0.85	0.99	0.80	0.95	0.87	1.00
September	0.69	0.95	0.82	0.99	0.88	1.02

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. In 2020, however, several of the events were called in response to CAISO emergency declarations.

During the 2020 summer, events were called on three of the top four SCE peak load days – August 18th (system peak day), September 5th, and September 6th. Note the two September events were both weekend events. Given that these were each peak load days, these days provide a good point of comparison against the peak day ex ante impact estimates. It's notable that the temperatures on 9/5 and 9/6 exceeded the 1-in-10 ex ante temperatures by several degrees. Table 15 compares the hour-by-hour ex post load impacts on those days to the ex ante 1-in-2 and 1-in-10 SCE August monthly peak day. In magnitude, the ex post load impacts are very similar to the ex ante impact estimates shown in the table. The ex post impacts on 9/5 and 9/6 actually exceed the ex ante impacts but, as has been noted, temperatures on these days exceeded 1-in-10 ex ante weather conditions.

[6] Like the prior evaluation, our ex post evaluation relied on a difference-in-differences framework. The 2018 ex post model relied mainly on pre-event load variables. The 2019-2020 approach leveraged one pre-event load term, but also a weather variable and time variables. Regarding ex ante model specifications, there were several differences. One key distinction between the 2018 and 2019-2020 approaches was the inclusion of a temperature spline. This 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 ex ante model also accounted for the effects of the COVID-19 pandemic.

Table 15: 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	2020-08-18	199,557	232,734	102.6	87.2	234.6	220.5	198.6	---	---
	2020-09-05	191,475	223,465	109.3	91.1	---	---	248.5	206.0	---
	2020-09-06	191,475	223,465	109.9	94.3	---	268.3	237.2	198.9	---
	SCE Ex ante 1-in-10 August Peak Day	189,795	221,618	99.4	86.8	222.1	213.3	198.0	167.8	145.8
	SCE Ex ante 1-in-2 August Peak Day	189,795	221,618	95.4	84.2	197.4	186.7	171.3	144.2	123.5
Impacts per Account (kW)	2020-08-18	199,557	232,734	102.6	87.2	1.18	1.11	1.00	---	---
	2020-09-05	191,475	223,465	109.3	91.1	---	---	1.30	1.08	---
	2020-09-06	191,475	223,465	109.9	94.3	---	1.40	1.24	1.04	---
	SCE Ex ante 1-in-10 August Peak Day	189,795	221,618	99.4	86.8	1.17	1.12	1.04	0.88	0.77
	SCE Ex ante 1-in-2 August Peak Day	189,795	221,618	95.4	84.2	1.04	0.98	0.90	0.76	0.65
Impacts per Device	2020-08-18	199,557	232,734	102.6	87.2	1.01	0.95	0.85	---	---
	2020-09-05	191,475	223,465	109.3	91.1	---	---	1.11	0.92	---
	2020-09-06	191,475	223,465	109.9	94.3	---	1.20	1.06	0.89	---
	SCE Ex ante 1-in-10 August Peak Day	189,795	221,618	99.4	86.8	1.00	0.96	0.89	0.76	0.66
	SCE Ex ante 1-in-2 August Peak Day	189,795	221,618	95.4	84.2	0.89	0.84	0.77	0.65	0.56

* Table excludes partial event hours.

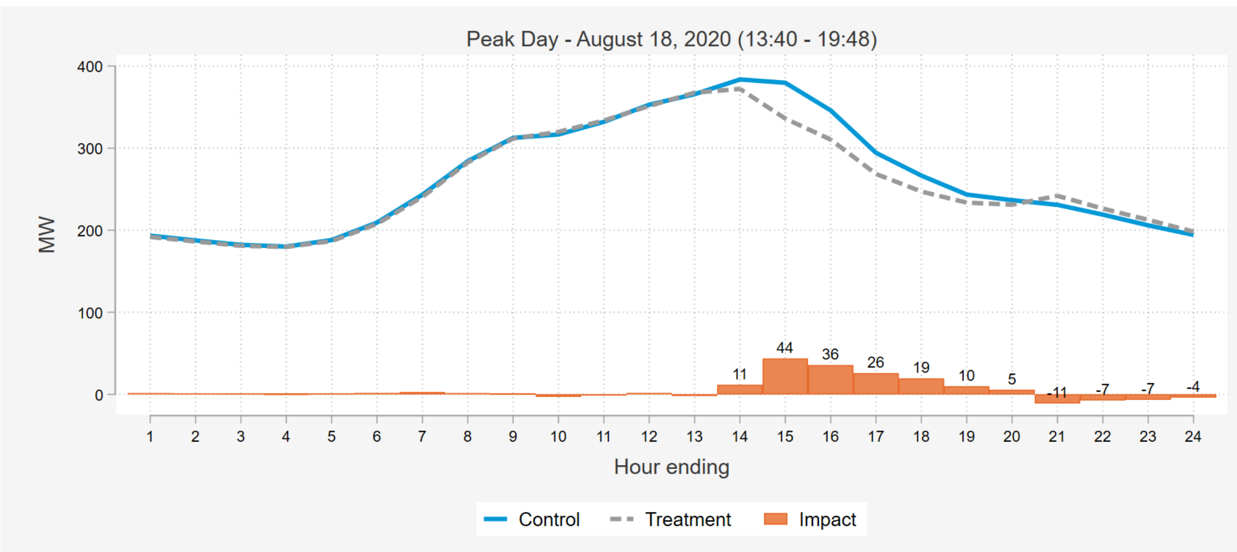
5 NON-RESIDENTIAL EX POST RESULTS

This section focuses on the magnitude of demand reductions delivered by SDP-C during 2020 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 August 18th. On the peak day, SDP-C resources were dispatched from 1:40 PM through 7:48 PM due to grid reliability. In total, SCE sent instructions to curtail demand to 8,160 SDP-C accounts with 72,372 control devices. Figure 31 shows the hourly load profile for the control and participant groups for the system peak day. During the first full event hour, the impact was approximately 44 MW. Across the five full event hours, the average impact was nearly 27 MW, and the average percent impact was approximately 8.8%. 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 29 MWh of snapback. Netting out the snapback, there was approximately 122 MWh in energy savings on the peak day.

Figure 31: SDP-C Reductions on System Peak Day



5.2 INDIVIDUAL EVENT DAY REDUCTIONS

Table 16 shows reference loads, observed loads, impacts, and percent impacts for each of the fifteen SDP-C DR events during the 2020 summer. The table also shows performance metrics for the average event, which is defined as the average of the events on 8/17 and 9/6. We urge readers to pay less attention to the average event day in 2020 than in prior years, as there was no average or typical event in 2020.

Table 16: SDP-C Event Results, 2020

					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)
7/31	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	8,075	217.17	203.30	13.87	9.44	18.29	1.72	0.19	0.04	6.4%	94.1
8/7	C-3, LD	4:00 PM	5:00 PM	210	1.77	1.77	0.00	-0.57	0.58	0.01	0.00	0.00	0.2%	98.9
8/13	HD, W-1, W-2	6:00 PM	8:00 PM	[redacted]										
8/13	C-1, C-2, C-3, C-4, N, NW	7:00 PM	8:00 PM	[redacted]										
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	8,060	257.33	230.32	27.00	21.45	32.56	3.35	0.37	0.07	10.5%	97.8
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	8:00 PM	8,060	235.95	219.28	16.67	12.39	20.96	2.07	0.23	0.05	7.1%	95.3
8/14	C-3	5:10 PM	8:35 PM	195	2.31	2.03	0.28	-0.06	0.62	1.44	0.42	0.07	12.1%	112.2
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	8:00 PM	9:12 PM	8,060	228.14	219.22	8.92	5.25	12.59	1.11	0.12	0.02	3.9%	88.7
8/15	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	3:00 PM	7:45 PM	8,268	207.02	191.88	15.14	11.60	18.69	1.83	0.21	0.04	7.3%	96.5
8/16	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	5:40 PM	7:25 PM	8,268	208.19	200.14	8.05	5.37	10.73	0.97	0.11	0.02	3.9%	88.7
8/17	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1	3:10 PM	7:40 PM	6,129	218.69	202.41	16.28	12.69	19.86	2.66	0.29	0.06	7.4%	96.9
8/17	W-2	4:21 PM	7:40 PM	2,021	36.69	36.56	0.13	-1.62	1.89	0.07	0.01	0.00	0.4%	86.5
8/18	**All**	**1:40 PM**	**7:48 PM**	**8,160**	**305.99**	**279.17**	**26.81**	**21.88**	**31.75**	**3.29**	**0.37**	**0.07**	**8.8%**	**97.0**
9/5	All	5:30 PM	8:25 PM	8,038	220.35	209.26	11.08	7.64	14.53	1.38	0.16	0.03	5.0%	103.3
9/6	All	4:40 PM	8:23 PM	8,038	223.63	209.92	13.71	9.68	17.75	1.71	0.20	0.04	6.1%	102.4
Avg. Event		**3:30 PM**	**7:30 PM**	**8,094**	**239.51**	**224.44**	**14.66**	**11.74**	**17.58**	**1.81**	**0.21**	**0.04**	**6.1%**	**99.9**

Figure 32 and Figure 33 visualize impacts on Friday 8/14 and Saturday 8/15. These days are notable because they were both CAISO Stage 3 Emergency days. These emergencies were declared due to excessive heat driving up electricity use, resulting in strain on the grid. In the first few hours of the 8/14 event, aggregate impacts were around 25 MW and the event average was approximately 17 MW (full event hours only). For the 8/15 event, aggregate impacts were around 18 MW for the first few event hours and 15 MW on average. Reference loads and impacts were higher on 8/14 due to 8/15 being a Saturday – recall that a majority of the participant tonnage in SDP-C is in schools. A small percentage of SDP-C participants were affected by rotating outages on these two days. Importantly, these customers were not included in the estimation of demand reductions for these days and affected control customers were removed from the matching pool.

Figure 32: SDP-C Load Impacts on Friday, 8/14/2020

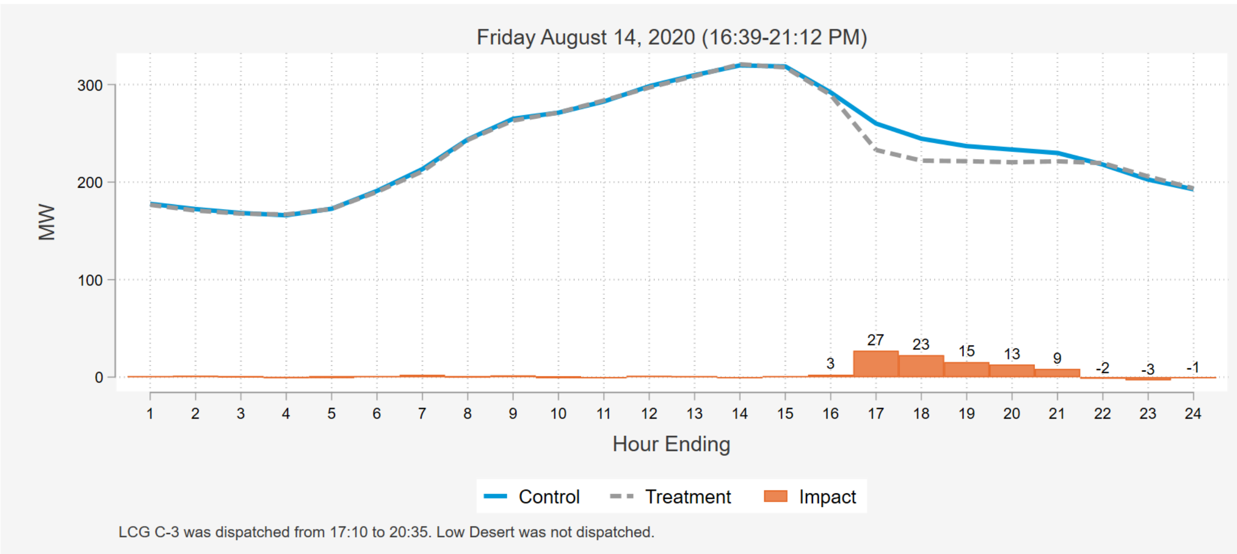


Figure 33: SDP-C Load Impacts on Saturday, 8/15/2020

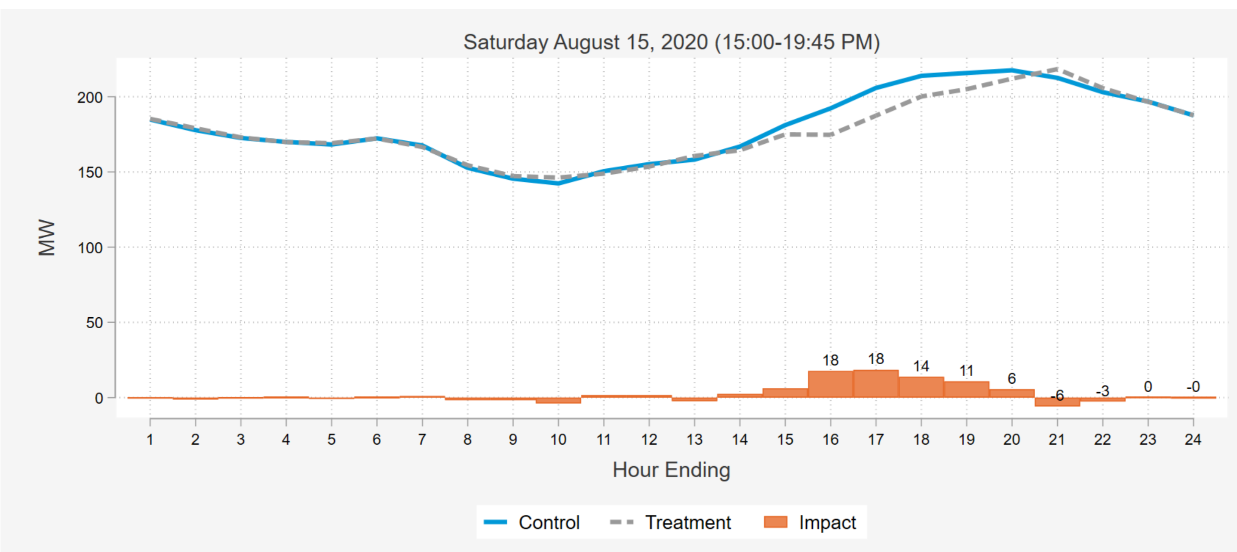
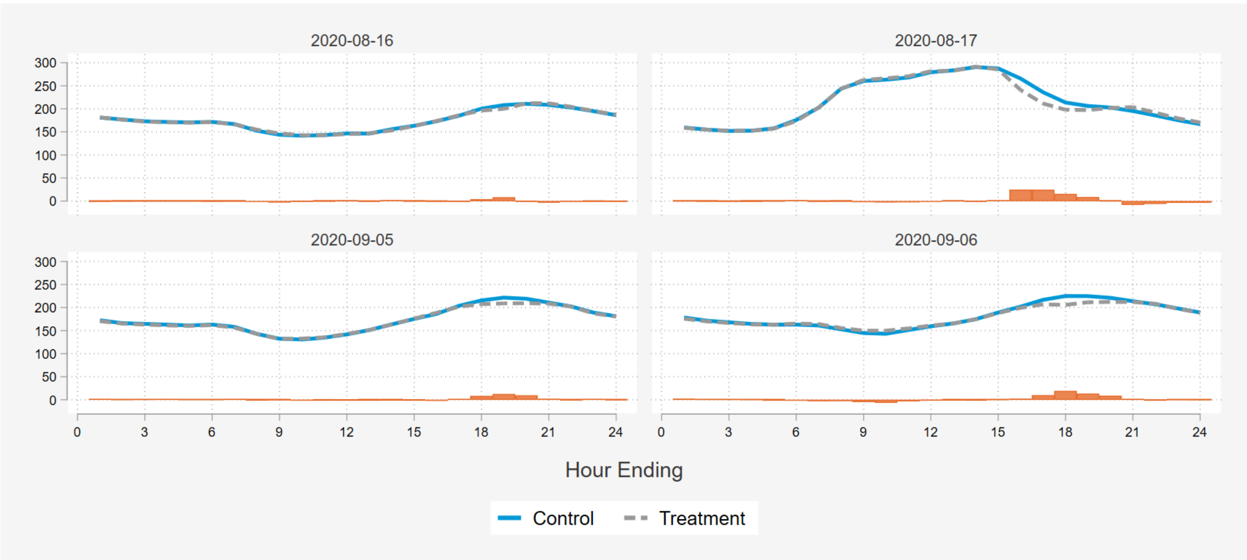


Figure 34 visualizes aggregate impacts for four other events of interest. All four events occurred during the mid-August and early September heat waves, and three of these events coincided with CAISO Stage 2 Emergency declarations (8/17, 9/5, and 9/6). Flex Alerts were issued for all four of these days. Note that three of these days (8/16, 9/5, and 9/6) were weekend days. The difference between weekday and weekend SDP-C reference load shapes stands out in the figure. The average aggregate impact for these three event days was approximately 10 MW. Impacts were higher on 8/17, touching 25 MW in the first full event hour.

Figure 34: SDP-C Reductions on Select Event Days



5.3 WEATHER SENSITIVITY OF LOAD IMPACTS

The relationship between SDP-C demand reductions and outdoor air temperature is visualized in Figure 35 and includes all full event hours in the peak period (4-9 PM). Due to the large variability in customer size, the plot shows the impact per device. 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 0.0086 per degree. This implies that each one-degree increase in temperature is associated with a 0.0086 kW increase in the per-device demand reduction. Figure 36 highlights how the relationship between demand reductions and outdoor temperature is related to the time of day. Impacts clearly tend to be larger earlier in the day. This is because more SDP-C participant cooling load is available for curtailment earlier in the day, leading to greater demand reductions.

Figure 35: Relationship between SDP-C Demand Reductions and Weather

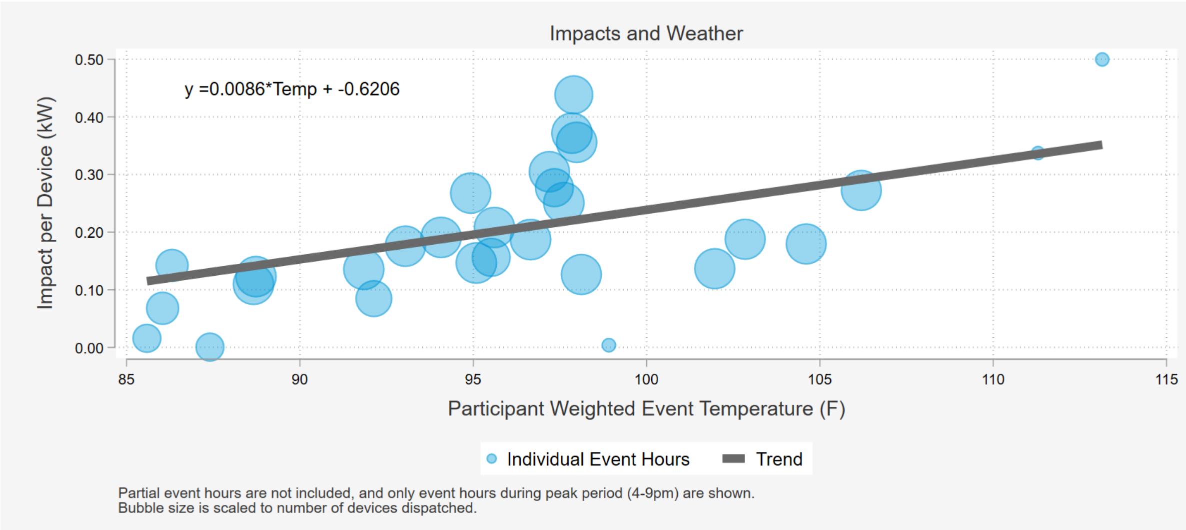
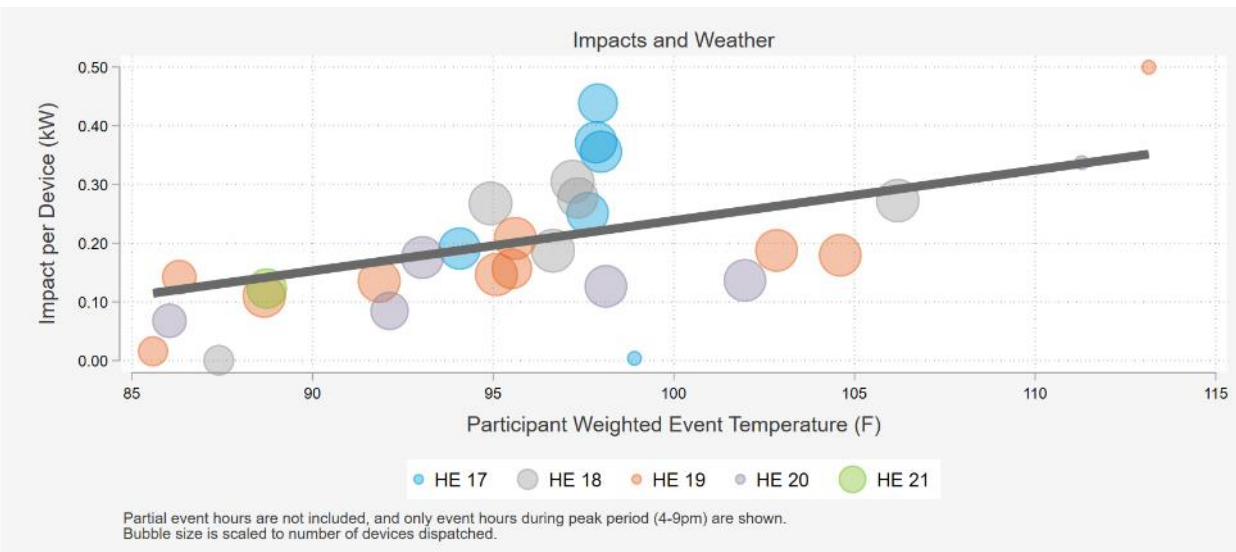


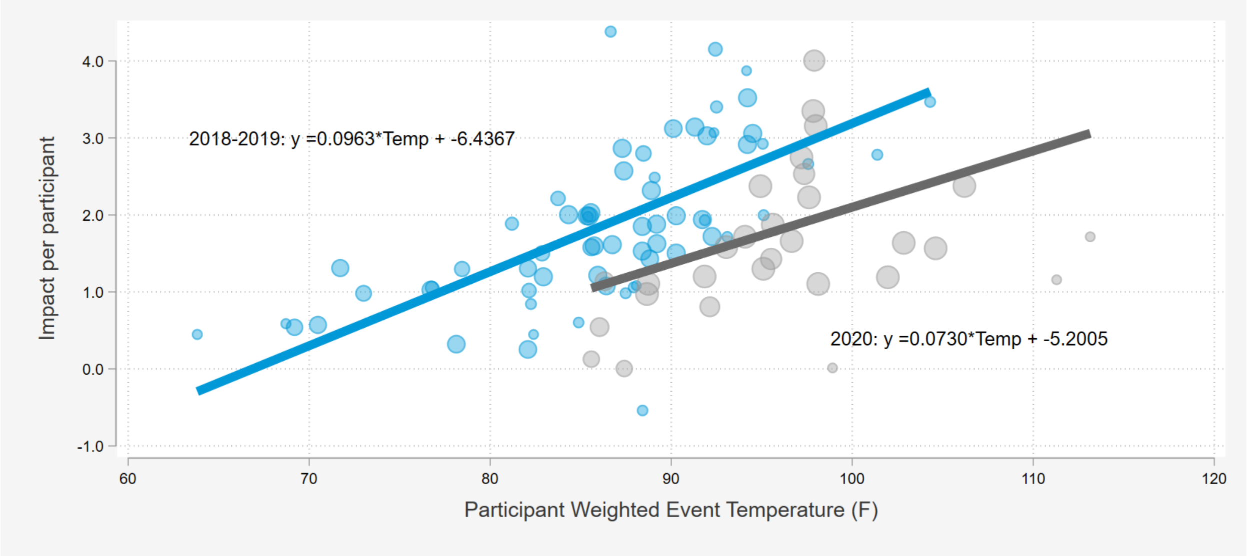
Figure 36: Relationship between SDP-C Demand Reductions and Weather by Hour



5.4 COMPARISON TO PRIOR YEAR

Figure 37 shows the relationship between SDP-C reductions and outdoor temperature for 2018, 2019, and 2020. Other SDP-C figures summarize impacts at the device level, but this figure summarizes impacts at the participant level as per device impacts are not in the 2018 ex post data set. The clear difference in the magnitude of the impacts in 2020 can be explained by the COVID-19 pandemic. Recall that a majority of the SDP-C tonnage is in schools and the pandemic had a significant impact on the load profiles at schools. Distance learning means that cooling loads (and reference loads) were down in 2020, and so it would be expected that SDP-C reductions in 2020 are smaller than they were in prior years. SDP-C peak loads on non-event days were down by more than 25% in 2020 (see discussion in Section 2.7).

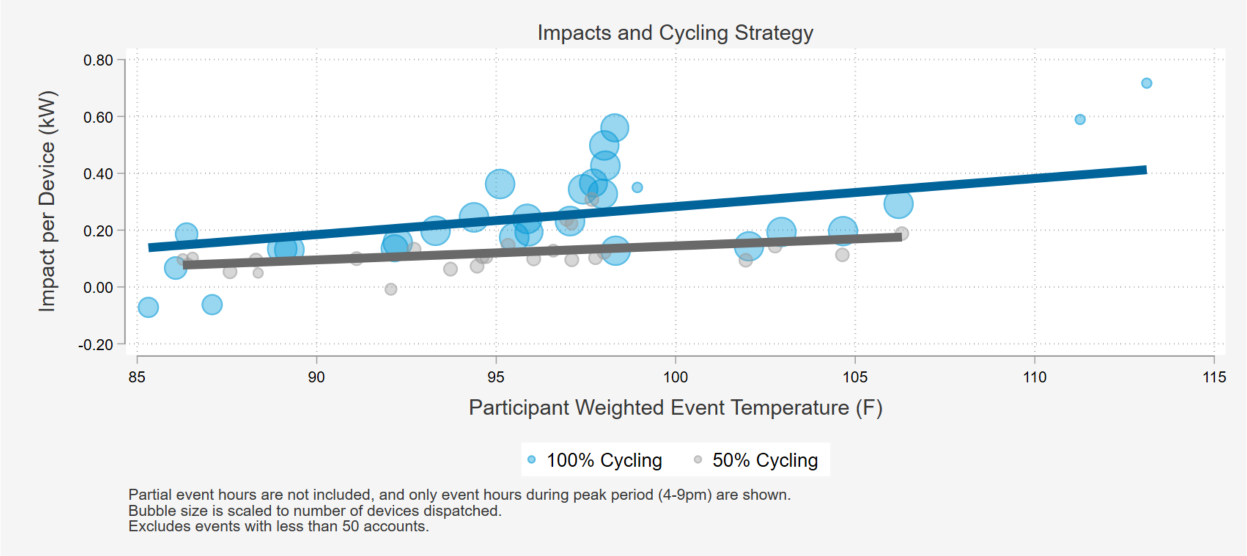
Figure 37: SDP-C Reductions against Temperature, 2018-2019



5.5 IMPACTS BY CYCLING STRATEGY

Figure 38 plots per-device 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. For both groups, the impact per device grows larger with higher temperatures though the trend is subtle compared to the trend for SDP-R participants.

Figure 38: SDP-C Impacts by Cycling Strategy



5.6 IMPACTS FOR KEY CUSTOMER SEGMENTS

Table 17 shows per-device impacts of key customer segments for the average 2020 SDP-C event day (which was the average of two territory-wide events, one of which was a weekend event). As a reminder, we would urge readers to pay less mind to the average event day in 2020 than in prior years, as there was no average or typical event in 2020. Highlights include:

- On average, [redacted];
- [redacted]; and
- Schools account for more nearly half of the aggregate demand reductions on the average event day and drive the results for SDP-C.

Table 17: SDP-C Impacts by Key Customer Segments, Average 2020 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%	5,275	44,023	224,824	93.2	82.4	10.4	7.62%	0.24
Load Control Group	SDP-Central-1	794	11,354	60,237	16.5	14.4	1.6	9.66%	0.14
	SDP-Central-2	925	5,178	25,121	16.3	15.0	1.2	7.33%	0.23
	SDP-Central-3	192	661	3,803	2.3	2.2	0.2	8.25%	0.29
	SDP-Central-4	1,240	13,018	66,734	25.3	21.5	3.4	13.47%	0.26
	SDP-High Desert	[redacted]							
	SDP-Low Desert	[redacted]							
	SDP-North	[redacted]							
	SDP-Northwest	539	4,308	21,967	9.1	8.5	0.8	8.30%	0.18
	SDP-West-1	1,161	8,507	41,838	19.3	18.2	1.6	8.54%	0.19
	SDP-West-2	2,014	16,197	75,354	35.3	33.7	2.6	7.32%	0.16
Local Capacity Area	Big Creek/Ventura	[redacted]							
	LA Basin	6,324	54,916	273,086	115.4	104.9	10.9	6.23%	0.20
	Outside LA Basin	[redacted]							
Zone	South Orange County	737	4,947	24,930	13.6	12.9	1.0	7.58%	0.21
	South of Lugo	2,618	24,763	126,810	49.8	44.0	5.5	7.10%	0.22
	Remainder of System	4,740	41,476	207,065	176.3	167.6	8.2	3.41%	0.20

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	1,919	3,689	16,016	18.1	16.9	1.3	4.81%	0.36
	Retail Stores	1,245	2,482	12,719	26.5	25.5	1.1	2.86%	0.46
	Schools	1,623	49,710	245,492	64.6	56.9	6.8	7.34%	0.14
	Wholesale, Transport, Other Utilities	671	2,004	9,390	10.0	9.1	1.0	6.71%	0.52
	Unknown/Other	[redacted]							
	Religious organizations	1,158	7,956	46,935	9.2	8.2	0.9	7.51%	0.12
Tonnage Bin	3 or less	[redacted]							
	3 to 4	985	1,012	3,391	6.2	5.5	0.6	6.59%	0.61
	4 to 5	[redacted]							
	5 to 10	1,583	2,714	10,933	17.4	17.2	0.4	1.34%	0.13
	10-100	[redacted]							
	100-500	1,013	39,233	198,524	51.9	45.5	5.7	7.72%	0.15
	500+	[redacted]							
All Customers		**8,094**	**71,185**	**358,805**	**239.5**	**224.4**	**14.7**	**4.44%**	**0.21**

By LCG, Figure 39 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. Figure 40 shows how participant-level impacts vary across subcategories for several key research categories (cycling strategy, select industries, and load control group). In particular, one can see how impacts in schools compare to the full SDP-C population.

Figure 39: Average Aggregate Impacts by Event and LCG, SDP-C

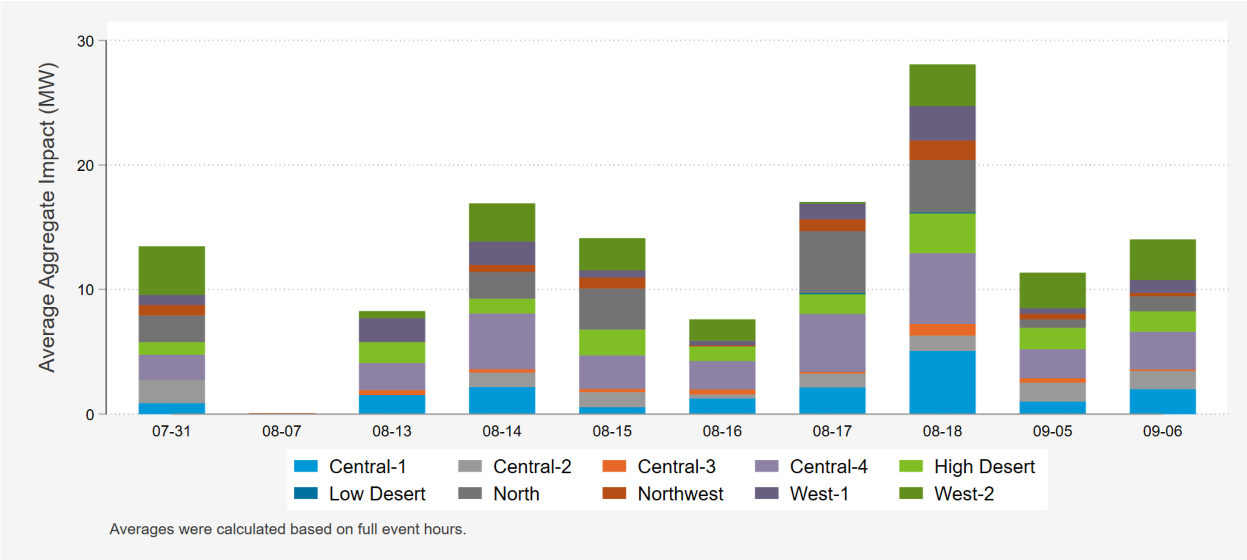
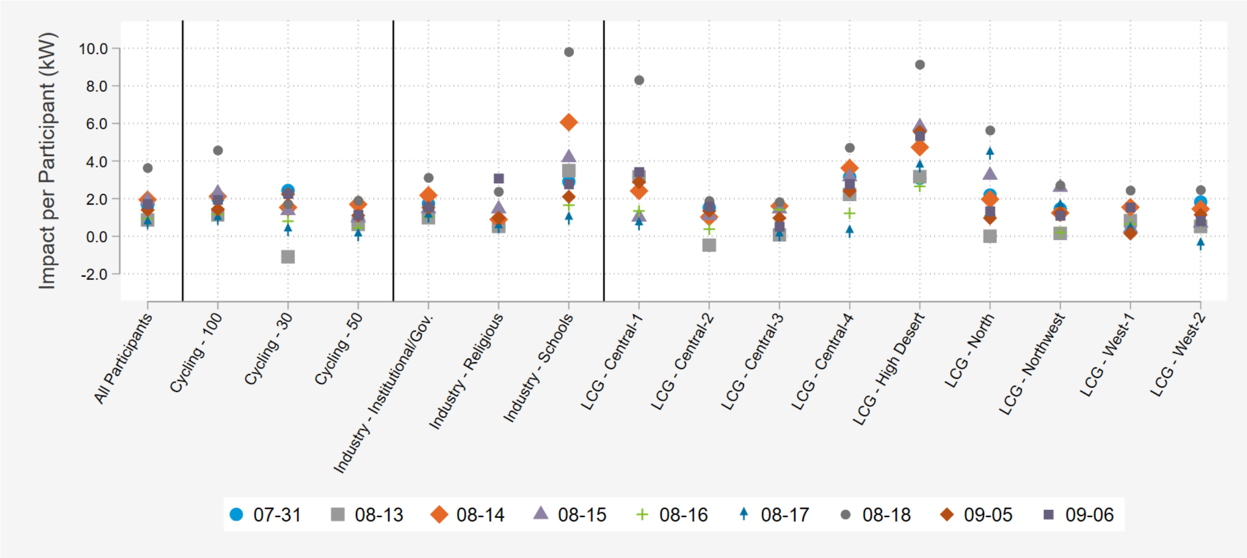


Figure 40: Average Participant Impact by Event and Key Subcategory, SDP-C



5.7 KEY FINDINGS

The SDP Commercial (SDP-C) program has approximately 8,300 customers enrolled and includes over 73,000 control devices and nearly 370,000 tons of air conditioner load. About 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. Weekend event days tended to produce lower impacts than weekday event days due to the nature of SDP-C reference loads (which are lower on weekends).

A few other key findings are worth highlighting:

- During the system peak day (August 18, 2020), SDP-C participants reduced demand by an average of 26 MW between 2:00 PM and 7:00 PM. Demand reductions in the first event hour exceeded 43 MW (2:00 PM – 3:00 PM). The average demand reductions per customer, per device, and per ton for this event were 2.64 kW, 0.30 kW, and 0.06 kW respectively.
- CAISO Stage 3 Emergencies were declared on 8/14 and 8/15. During the first two full event hours on 8/14, SDP-C participants delivered an average of 25 MW. During the first two full event hours on 8/15, SDP-C participants delivered an average of 18 MW. The gap between demand reductions on the two days is partially due to time of day but mostly due to the difference between SDP-C reference and cooling loads on weekdays and weekends (8/15 was a Saturday).
- SDP-C reference loads were significantly lower under COVID-19 conditions, largely due to many schools pivoting to distance learning frameworks which resulted in reduced loads in schools (where nearly 70% of SDP-C participant tonnage is concentrated).
- 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 [redacted]. We caution, however, that it is not feasible to disentangle the role of customer self-selection from the performance of the cycling algorithm.

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 two years of historical performance data (2018-2019) and factored in projected changes in enrollment.

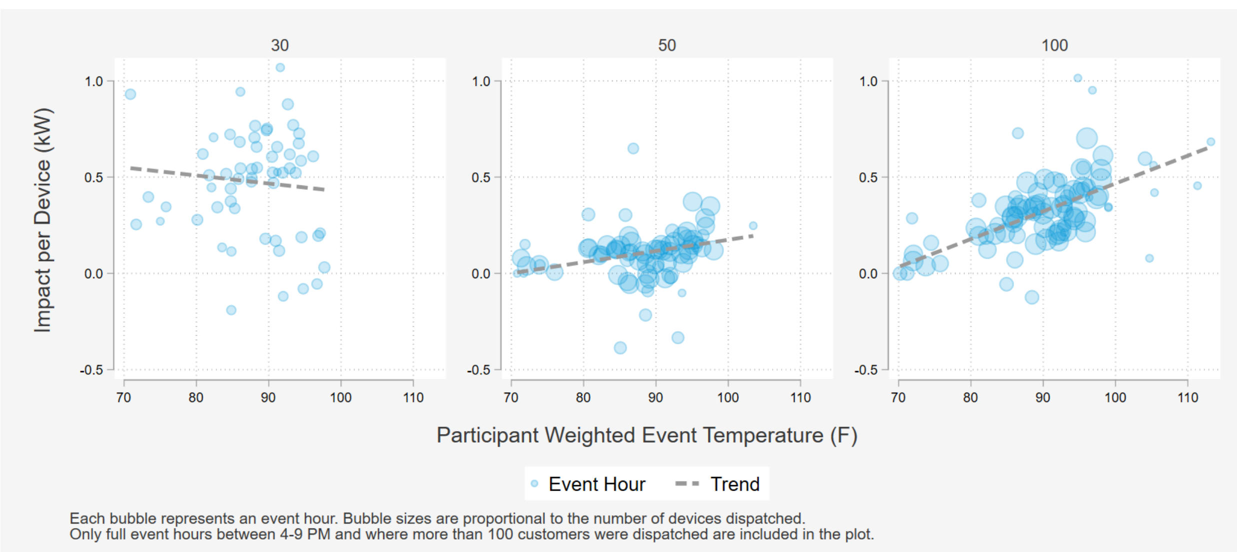
6.1 DEVELOPMENT OF EX ANTE IMPACTS

The ex ante impacts were developed by estimating the relationship between weather and demand reductions from 2018 to 2020 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 41 shows the relationship between outdoor temperature and demand reductions (per device) for the three cycling strategies across the three 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 41: 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 COVID-19 pandemic, hour of day, day of week, and cycling strategy. 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 average temperature between midnight and 5:00 PM ("mean17").

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

Unlike SDP-R, the COVID-19 pandemic had a significant effect on SDP-C reference loads and impacts. While SDP-R reference loads were marginally higher under COVID-19 conditions and demand reductions were not materially different, SDP-C reference load was significantly smaller under COVID-19 conditions and impacts were as well. The ex ante models control for the effects of COVID-19. As discussed in Section 2.7, ex ante estimates were predicted under a COVID glide path where the effects of COVID-19 gradually fade away through the forecast window.

6.2 OVERALL RESULTS

For the monthly peak day, Table 18 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 2020 peak day was 0.37 kW though this includes impacts that occurred outside of the ex ante window (4:00 PM – 9:00 PM). Inside this window, the average impact on the 2020 peak day was 0.25 kW per device.

Table 18: 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	0.21	0.29	0.19	0.29
June	0.22	0.29	0.24	0.31
July	0.28	0.40	0.27	0.28
August	0.26	0.32	0.26	0.31
September	0.31	0.34	0.29	0.33

Table 19 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. Per participant impacts increase throughout the forecast window as the effects of the COVID-19 pandemic fade (see the discussion on the COVID-19 glide path in Section 2.7).

Table 19: Aggregate Peak Event Day Demand Reduction Forecast – SDP-C

Forecast Year	Enrollment Forecast	Total Devices	SCE		CAISO	
			1-in-2	1-in-10	1-in-2	1-in-10
2021	7,457	64,890	17.1	20.9	16.8	19.8
2022	6,776	58,694	17.1	20.6	16.9	19.6
2023	6,163	53,630	16.3	19.5	16.1	18.6
2024	5,611	48,826	15.2	18.1	15.0	17.3
2025	5,113	44,493	14.0	16.6	13.8	15.9
2026	4,664	40,586	12.8	15.2	12.7	14.6
2027	4,259	37,061	11.8	13.9	11.6	13.3
2028	3,892	33,868	10.8	12.8	10.6	12.2
2029	3,559	30,970	9.8	11.7	9.7	11.2
2030	3,258	28,351	9.0	10.7	8.9	10.2
2031	2,985	25,975	8.3	9.8	8.2	9.4

Figure 42 and Figure 43 show the estimated ex ante load profiles for the SDP-C customer pool. Both figures show profiles for the August peak day, and both figures use SCE weather conditions rather than CAISO conditions. Figure 42 shows profiles under 1-in-2 weather conditions, and Figure 43 shows profiles for 1-in-10. Note that the forecast year shown is 2021 and the COVID index is 0.50 (meaning the reference load and impacts are half-way between a year with COVID-19 and a year without COVID-19).

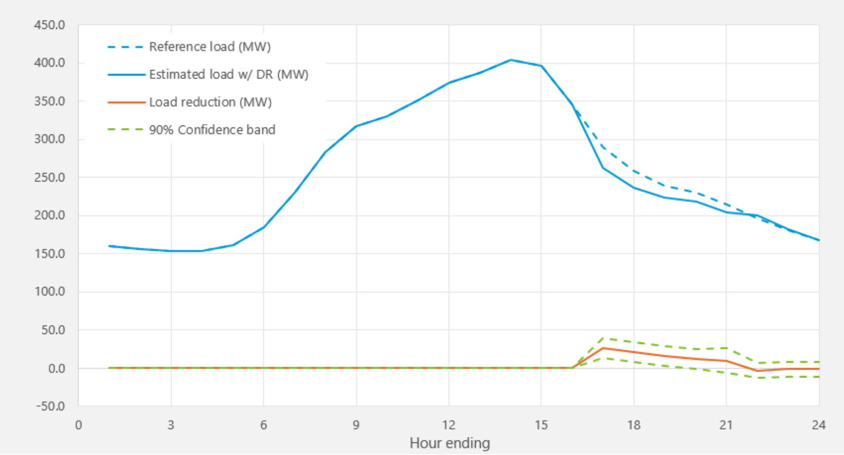
Figure 42: SDP-C Aggregate Ex Ante Impact for 1-in-2 Weather Conditions, August Peak Day

Table 1: Menu options

Program	SDP-C
Type of result	Aggregate
Category	ALL
Subcategory	All
Weather Data	SCE Weather
Weather Year	1-in-2
Day Type	MONTHLY SYSTEM PEAK DAY
Month	8
Forecast Year	2021

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	7,457
Total devices	64,890
Total AC tonnage	327,395
Event window temperature (F)	88.9
Event window load reduction (MW)	17.11
% Load reduction (Event window)	6.9%
COVID Index	0.50



Hour ending	Reference load (MW)	Estimated load w/ DR (MW)	Load reduction (MW)	% Load reduction	Avg temp (F, site weighted)	Confidence Band 5th	Confidence Band 95th	Std. error	T-statistic
1	160.71	160.71	0.00	0.0%	77.59	0.00	0.00	0.00	0.00
2	156.02	156.02	0.00	0.0%	76.46	0.00	0.00	0.00	0.00
3	153.35	153.35	0.00	0.0%	75.56	0.00	0.00	0.00	0.00
4	153.70	153.70	0.00	0.0%	74.62	0.00	0.00	0.00	0.00
5	161.00	161.00	0.00	0.0%	73.92	0.00	0.00	0.00	0.00
6	185.36	185.36	0.00	0.0%	73.38	0.00	0.00	0.00	0.00
7	230.26	230.26	0.00	0.0%	72.78	0.00	0.00	0.00	0.00
8	283.54	283.54	0.00	0.0%	72.82	0.00	0.00	0.00	0.00
9	316.60	316.60	0.00	0.0%	75.01	0.00	0.00	0.00	0.00
10	330.23	330.23	0.00	0.0%	79.12	0.00	0.00	0.00	0.00
11	350.48	350.48	0.00	0.0%	83.33	0.00	0.00	0.00	0.00
12	374.00	374.00	0.00	0.0%	86.83	0.00	0.00	0.00	0.00
13	387.32	387.32	0.00	0.0%	89.27	0.00	0.00	0.00	0.00
14	403.38	403.38	0.00	0.0%	91.35	0.00	0.00	0.00	0.00
15	395.74	395.74	0.00	0.0%	92.71	0.00	0.00	0.00	0.00
16	345.44	345.44	0.00	0.0%	92.71	0.00	0.00	0.00	0.00
17	289.34	263.02	26.32	9.1%	92.15	13.50	39.14	7.79	3.38
18	258.22	237.17	21.05	8.2%	90.87	8.44	33.66	7.67	2.75
19	239.66	223.57	16.09	6.7%	89.48	3.54	28.64	7.63	2.11
20	230.54	218.33	12.21	5.3%	87.65	-0.43	24.85	7.68	1.60
21	214.70	204.84	9.86	4.6%	84.30	-6.42	26.15	9.90	1.00
22	196.86	199.70	-2.84	-1.4%	81.00	-12.50	6.82	5.87	-0.48
23	180.42	181.64	-1.23	-0.7%	78.92	-10.89	8.44	5.88	-0.21
24	167.40	168.46	-1.06	-0.6%	77.33	-10.74	8.63	5.89	-0.18
Daily	Reference load (MWh)	Estimated load w/ DR (MWh)	Energy savings (MWh)	% Change	Avg. Daily Weighted temp (F)	Uncertainty adjusted impact 5th	Uncertainty adjusted impact 95th	Std. error	T-statistic
Daily kWh	6164.29	6083.87	80.41	1.3%	82.05	45.96	114.86	20.94	3.84

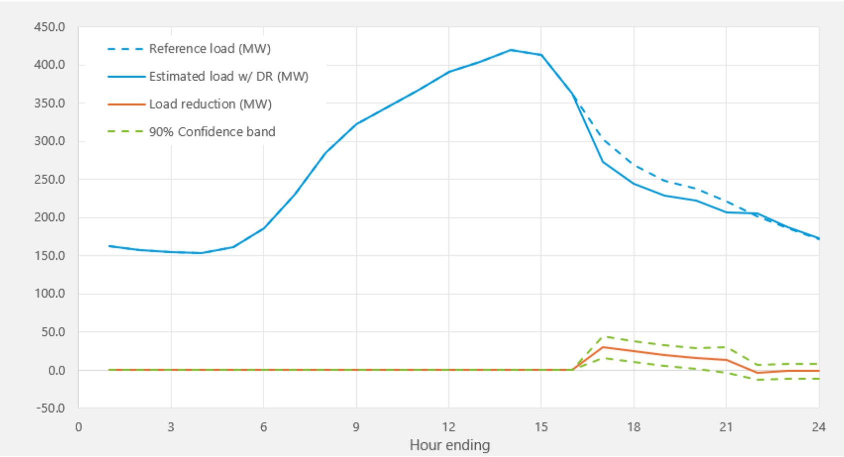
Figure 43: SDP-C Aggregate Ex Ante Impact for 1-in-10 Weather Conditions, August Peak Day

Table 1: Menu options

Program	SDP-C
Type of result	Aggregate
Category	ALL
Subcategory	All
Weather Data	SCE Weather
Weather Year	1-in-10
Day Type	MONTHLY SYSTEM PEAK DAY
Month	8
Forecast Year	2021

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	7,457
Total devices	64,890
Total AC tonnage	327,395
Event window temperature (F)	93.1
Event window load reduction (MW)	20.87
% Load reduction (Event window)	8.2%
COVID Index	0.50



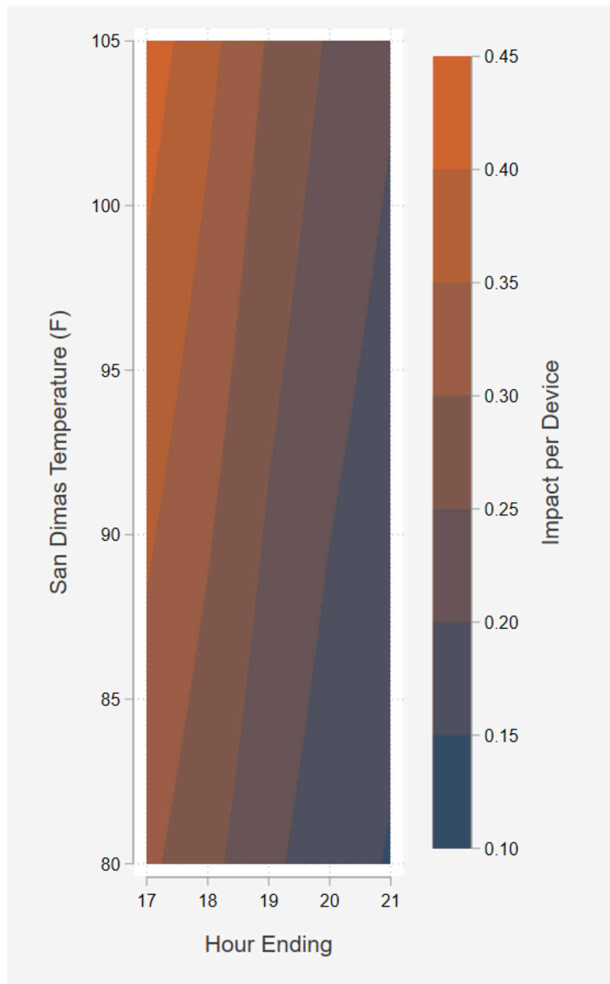
Hour ending	Reference load (MW)	Estimated load w/ DR (MW)	Load reduction (MW)	% Load reduction	Avg temp (F, site weighted)	Confidence Band 5th	Confidence Band 95th	Std. error	T-statistic
1	162.11	162.11	0.00	0.0%	78.84	0.00	0.00	0.00	0.00
2	157.36	157.36	0.00	0.0%	77.57	0.00	0.00	0.00	0.00
3	154.40	154.40	0.00	0.0%	76.40	0.00	0.00	0.00	0.00
4	154.26	154.26	0.00	0.0%	75.19	0.00	0.00	0.00	0.00
5	161.15	161.15	0.00	0.0%	74.18	0.00	0.00	0.00	0.00
6	185.56	185.56	0.00	0.0%	73.43	0.00	0.00	0.00	0.00
7	230.15	230.15	0.00	0.0%	72.66	0.00	0.00	0.00	0.00
8	284.52	284.52	0.00	0.0%	72.67	0.00	0.00	0.00	0.00
9	322.24	322.24	0.00	0.0%	75.28	0.00	0.00	0.00	0.00
10	343.94	343.94	0.00	0.0%	80.31	0.00	0.00	0.00	0.00
11	366.54	366.54	0.00	0.0%	85.91	0.00	0.00	0.00	0.00
12	390.74	390.74	0.00	0.0%	89.53	0.00	0.00	0.00	0.00
13	403.84	403.84	0.00	0.0%	91.27	0.00	0.00	0.00	0.00
14	419.75	419.75	0.00	0.0%	92.91	0.00	0.00	0.00	0.00
15	413.32	413.32	0.00	0.0%	94.44	0.00	0.00	0.00	0.00
16	362.70	362.70	0.00	0.0%	95.88	0.00	0.00	0.00	0.00
17	303.07	272.79	30.28	10.0%	96.11	16.40	44.16	8.44	3.58
18	269.67	244.76	24.90	9.2%	95.61	11.34	38.47	8.25	3.02
19	248.77	228.94	19.83	8.0%	94.34	6.26	33.40	8.25	2.40
20	237.67	221.79	15.88	6.7%	91.54	2.35	29.41	8.23	1.93
21	220.74	207.28	13.46	6.1%	87.96	-3.74	30.65	10.45	1.29
22	202.26	205.16	-2.90	-1.4%	84.76	-12.57	6.77	5.88	-0.49
23	185.45	186.71	-1.25	-0.7%	82.38	-10.93	8.43	5.88	-0.21
24	172.15	173.22	-1.08	-0.6%	80.90	-10.78	8.62	5.90	-0.18

Daily	Reference load (MWh)	Estimated load w/ DR (MWh)	Energy savings (MWh)	% Change	Avg. Daily Weighted temp (F)	Uncertainty adjusted impact 5th	Uncertainty adjusted impact 95th	Std. error	T-statistic
Daily kWh	6352.38	6253.26	99.12	1.6%	84.17	62.78	135.47	22.10	4.49

Figure 44 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 represent the expected device-level impact for a territory-wide event for the given hour and temperature.

Figure 44: SDP-C Time-Temperature Matrix, Impacts per Device

Temp	Hour Ending				
	17	18	19	20	21
105	0.43	0.37	0.29	0.24	0.21
104	0.42	0.36	0.29	0.24	0.20
103	0.42	0.36	0.29	0.24	0.20
102	0.41	0.35	0.28	0.24	0.20
101	0.41	0.35	0.28	0.23	0.20
100	0.40	0.35	0.28	0.23	0.20
99	0.40	0.34	0.27	0.23	0.19
98	0.39	0.34	0.27	0.22	0.19
97	0.39	0.33	0.27	0.22	0.19
96	0.39	0.33	0.26	0.22	0.19
95	0.38	0.33	0.26	0.22	0.18
94	0.38	0.32	0.26	0.21	0.18
93	0.37	0.32	0.25	0.21	0.18
92	0.37	0.31	0.25	0.21	0.18
91	0.36	0.31	0.25	0.20	0.17
90	0.36	0.30	0.24	0.20	0.17
89	0.35	0.30	0.24	0.20	0.17
88	0.35	0.30	0.24	0.19	0.17
87	0.34	0.29	0.23	0.19	0.16
86	0.34	0.29	0.23	0.19	0.16
85	0.33	0.28	0.23	0.19	0.16
84	0.33	0.28	0.22	0.18	0.16
83	0.33	0.28	0.22	0.18	0.15
82	0.32	0.27	0.22	0.18	0.15
81	0.32	0.27	0.21	0.17	0.15
80	0.31	0.26	0.21	0.17	0.15



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 20 shows ex ante impact estimates (per device) for these key segments using SCE weather conditions for forecast year 2021. 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. The lowest impacts are in the SDP-Northwest region, which is along the coast. [redacted]

Table 20: SDP-C Ex Ante Results by Customer Segment, SCE Weather

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]		0.38	0.31	[redacted]		0.48	0.40
SDP-Central-2	[redacted]		0.33	0.25	[redacted]		0.40	0.32
SDP-Central-3	[redacted]		0.51	0.43	[redacted]		0.54	0.45
SDP-Central-4	[redacted]		0.39	0.31	[redacted]		0.48	0.40
SDP-High Desert	[redacted]							
SDP-Low Desert	[redacted]							
SDP-North	[redacted]							
SDP-Northwest	[redacted]		0.16	0.16	[redacted]		0.23	0.20
SDP-West-1	[redacted]		0.26	0.17	[redacted]		0.29	0.19
SDP-West-2	[redacted]		0.25	0.18	[redacted]		0.29	0.22
Average	[redacted]		**0.33**	**0.26**	[redacted]		**0.40**	**0.32**

6.4 COMPARISON TO PRIOR YEAR

Table 21 shows a comparison of vintage year 2018, 2019, and 2020 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 2018 and 2019 ex ante impacts, participant-level impacts are static throughout the forecast window. For 2020 ex ante impacts, participant-level impacts from forecast year 2021 are shown. The COVID-19 index in forecast year 2021 is 0.5, meaning the COVID-19 effect is cut in half.

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 21: Comparison of SDP-C Ex Ante Impacts (kW), 2018-2020

Month	Vintage Year 2018		Vintage Year 2019		Vintage Year 2020	
	1-in-2	1-in-10	1-in-2	1-in-10	1-in-2	1-in-10
June	1.40	1.75	1.90	2.99	1.91	2.52
July	1.67	1.99	2.56	3.56	2.44	3.52
August	1.93	2.13	2.58	2.95	2.29	2.80
September	1.66	2.12	2.76	3.12	2.65	2.96

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 (such as a pandemic, as was the case in 2020). 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. In 2020, however, several of the events were called in response to CAISO emergency declarations.

During the 2020 summer, events were called on three of the four SCE peak load days – August 18th (system peak day), September 5th, and September 6th. However, the two September days were both weekend days. As such, they do not represent a good point of comparison since ex ante impacts are predicted for weekday events. Two other events days (August 14th and August 17th) were within the top 10 SCE load days for 2020 and were dispatched for the entire territory (though some LCGs were dispatched for a separate set of hours). Participant impacts on these days provide a good point of comparison against the peak day ex ante impact estimates. It is important to note that the COVID index for the 2021 ex ante forecast is 0.50, meaning COVID impacts are cut in half. The 2020 ex post results reflect full COVID impacts. Table 22 compares the hour-by-hour ex post load impacts on those days to the ex ante 1-in-2 and 1-in-10 SCE August monthly peak day. In magnitude, the ex post load impacts tend to be slightly smaller than the ex ante impact estimates shown in the table – largely a product of the COVID-19 pandemic.

Table 22: 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	2020-08-14	8,255	73,296	98.2	84.8	27.7	22.5	15.5	13.0	---
	2020-08-17	8,150	72,252	95.2	83.6	---	15.5	9.0	---	---
	2020-08-18	8,160	72,372	100.7	85.1	25.6	19.4	9.8	---	---
	SCE Ex ante 1-in-10 August Peak Day	7,457	64,890	96.1	84.2	30.3	24.9	19.8	15.9	13.5
	SCE Ex ante 1-in-2 August Peak Day	7,457	64,890	92.7	82.1	26.3	21.1	16.1	12.2	9.9
Impacts per Account (kW)	2020-08-14	8,255	73,296	98.2	84.8	3.28	2.73	1.87	1.57	---
	2020-08-17	8,150	72,252	95.2	83.6	---	1.91	1.11	---	---
	2020-08-18	8,160	72,372	100.7	85.1	3.16	2.37	1.20	---	---
	SCE Ex ante 1-in-10 August Peak Day	7,457	64,890	96.1	84.2	4.06	3.34	2.66	2.13	1.80
	SCE Ex ante 1-in-2 August Peak Day	7,457	64,890	92.7	82.1	3.53	2.82	2.16	1.64	1.32
Impacts per Device	2020-08-14	8,255	73,296	98.2	84.8	0.37	0.31	0.21	0.18	---
	2020-08-17	8,150	72,252	95.2	83.6	---	0.21	0.12	---	---
	2020-08-18	8,160	72,372	100.7	85.1	0.36	0.27	0.14	---	---
	SCE Ex ante 1-in-10 August Peak Day	7,457	64,890	96.1	84.2	0.47	0.38	0.31	0.24	0.21
	SCE Ex ante 1-in-2 August Peak Day	7,457	64,890	92.7	82.1	0.41	0.32	0.25	0.19	0.15

* 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 206,000 residential customers, 8,300 non-residential customers, approximately 310,000 air conditioner units, and over 1.2 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. SCE has requested permission from the California Public Utility Commission to increase the incentives from $140 to $175 and to offer a $50 sign up bonus. Table 23 summarizes our recommendations for the program. We recognize that our recommendations do not incorporate costs and may not be funded under current budgets.

Table 23: 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	While 2020 experienced extreme heat and multiple system-wide events, most years are less extreme. 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.

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 24: 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 PY2020 data. Events on 9/7, 10/15, and 10/16 were not included in the analysis due to being dispatched to a small subset of customers.
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 25.

Table 25: 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 26 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 26: 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 27 shows the number of accounts, number devices, and total tonnage for the sites that were in analyzed and for the sites that were not analyzed.

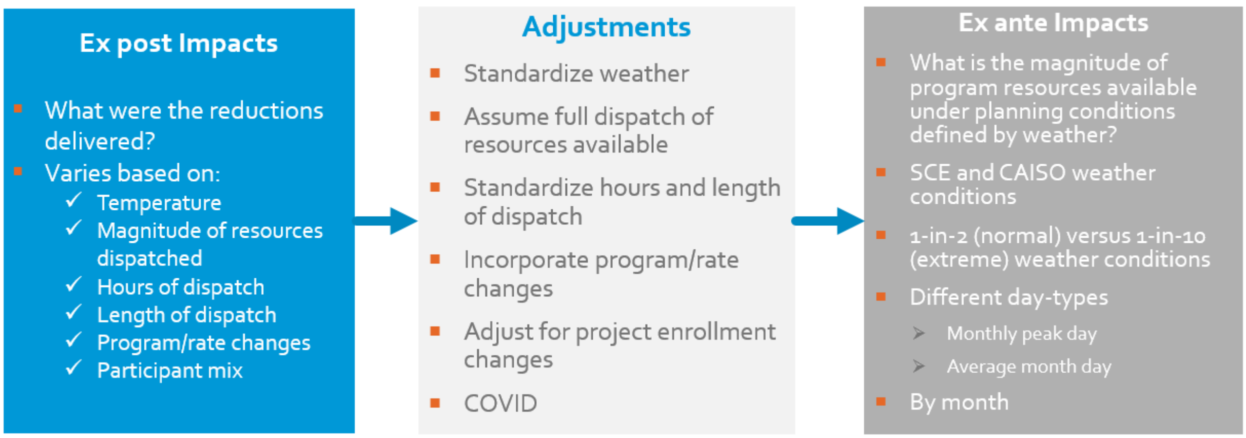
Table 27: Distribution of Accounts by Analysis Status

Analyzed?	Accounts		Devices		Tonnage	
	#	%	#	%	#	%
Yes	7,990	96.3%	62,381	85.0%	304,540	82.4%
No	303	3.7%	10,998	15.0%	65,035	17.6%
Total	**8,293**	**100%**	**73,379**	**100%**	**369,575**	**100%**

APPENDIX B: EX ANTE METHODOLOGY

Figure 45 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 45: 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 28.

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 28: Summer Discount Plan Ex Ante Evaluation Approach

Methodology Component	Approach
1. Years of historical performance	We used two years 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 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 strategy. These segments reflect that events are dispatched geographically and that impacts in the 100% cycling strategy group are

Methodology Component	Approach
	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 and the effects of the COVID-19 pandemic are controlled for. ▪ 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 and the effects of the COVD-19 pandemic are controlled for. 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	Customers that were no longer active in the program as of October 2020 were removed from the ex ante analysis. Additionally, customers scheduled for removal from the program (due to non-performance) were not included. Enrollment forecasts were provided by SCE.

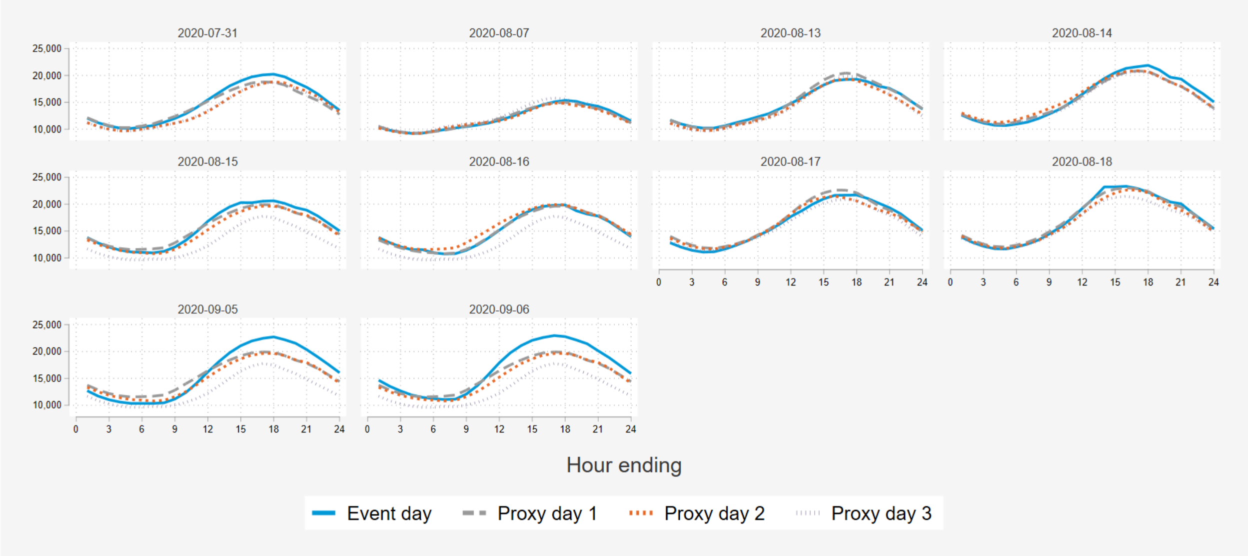
APPENDIX C: PROXY EVENT DAYS

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 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 2020 event day, Figure 46 shows event day loads and proxy event day loads. The proxy event days track the event day load well on each event day other than 9/5 and 9/6. Note these two days were weekend days and two of the three SCE peak load days.

Figure 46: System Load on Event Days and 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 2020 SDP-R ex post evaluation. Figure 47 shows the average control group load and the average treatment group load for each 2020 summer event day. On some days, the treatment and control group loads differ early in the morning. This only occurs when the previous day was also an event day. The gap between the loads is simply carryover snapback.

Figure 47: Control Group and Treatment Group Event Day Loads, SDP-R

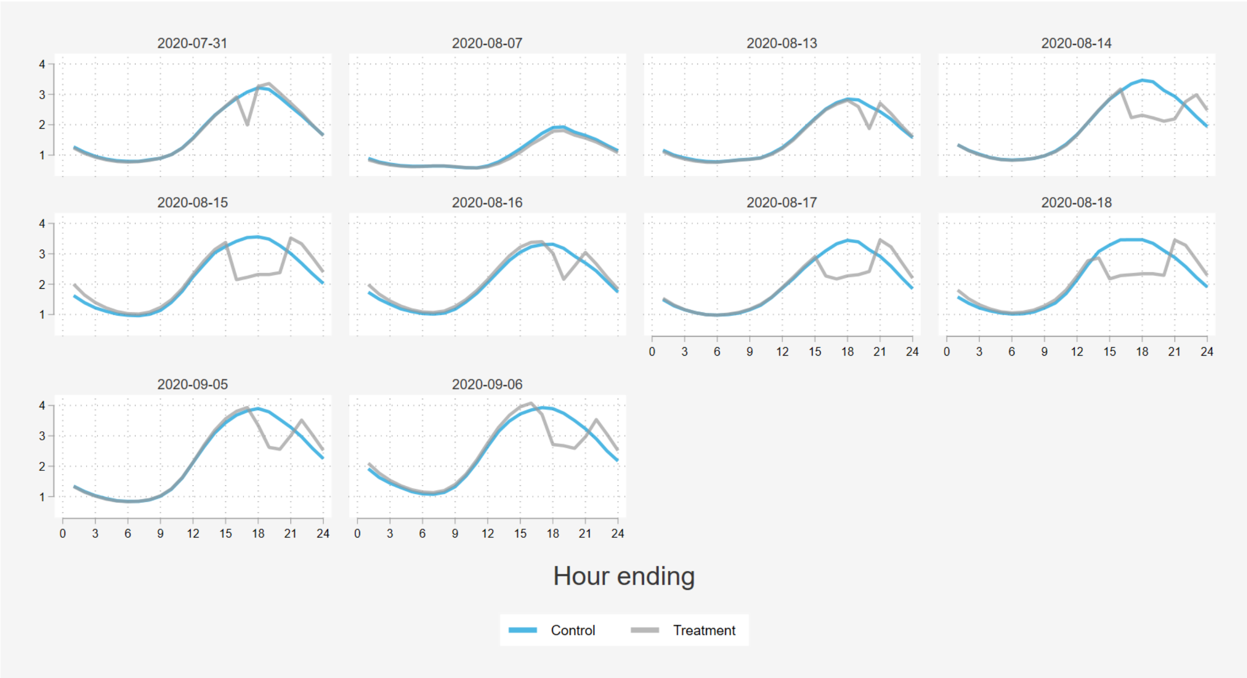


Figure 48 compares average control group load and average treatment group load for the summer 2020 SDP-C events. The control group load does not track the treatment group load as well as SDP-R. The ex post analysis method (difference-in-differences) nets out any differences between the two groups.

Figure 48: 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	102.295708	25	4.09182832	Number of obs	=	577
Residual	12.1793669	551	.022104114	F(25, 551)	=	185.12
				Prob > F	=	0.0000
Total	114.475075	576	.19874145	R-squared	=	0.8936
				Adj R-squared	=	0.8888
				Root MSE	=	.14867

impact	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.0279279	.0045458	-6.14	0.000	-.0368571	-.0189987
avgtemp_2	-.0394105	.0115096	-3.42	0.001	-.0620185	-.0168025
avgtemp_3	.1138112	.0358797	3.17	0.002	.0433335	.1842889
tempf	-.0079189	.0021557	-3.67	0.000	-.0121533	-.0036844
c.covid#c.tempf	-.0000435	.0002137	-0.20	0.839	-.0004631	.0003762
hour#c.tempf						
18	.0003883	.0002398	1.62	0.106	-.0000828	.0008594
19	.0011016	.0002305	4.78	0.000	.0006488	.0015544
20	.0025638	.0002618	9.79	0.000	.0020496	.003078
21	.0034887	.0006159	5.66	0.000	.0022788	.0046985
outersummer#c.tempf						
1	.0032241	.0004025	8.01	0.000	.0024335	.0040147
lcgnum#c.tempf						
SDP-C-2	-.0012513	.0002775	-4.51	0.000	-.0017964	-.0007062
SDP-C-3	.0056826	.0004284	13.27	0.000	.0048412	.0065241
SDP-C-4	-.0004038	.0002148	-1.88	0.061	-.0008258	.0000182
SDP-HD	.0024078	.0002919	8.25	0.000	.0018344	.0029813
SDP-LD	.0069137	.0020594	3.36	0.001	.0028684	.0109591
SDP-N	.0019242	.0002349	8.19	0.000	.0014627	.0023857
SDP-NW	.0022686	.000462	4.91	0.000	.0013611	.0031761
SDP-W-1	-.0012481	.0003465	-3.60	0.000	-.0019287	-.0005675
SDP-W-2	-.0004483	.0003478	-1.29	0.198	-.0011316	.0002349
dow#c.tempf						
1	-.0017779	.0003546	-5.01	0.000	-.0024744	-.0010814
2	-.0006592	.0003491	-1.89	0.060	-.0013451	.0000266
3	-.0002152	.0003906	-0.55	0.582	-.0009825	.0005521
4	.0004325	.0004013	1.08	0.282	-.0003557	.0012207
5	.0001775	.0003615	0.49	0.624	-.0005325	.0008875
6	-.0010843	.0003273	-3.31	0.001	-.0017272	-.0004415
_cons	2.129964	.3031344	7.03	0.000	1.534524	2.725404

SDP-R Impacts – 50% Cycling Group

Source	SS	df	MS
Model	25.913259	25	1.03653036
Residual	9.44704055	551	.017145264
Total	35.3602996	576	.061389409

Number of obs	=	577
F(25, 551)	=	60.46
Prob > F	=	0.0000
R-squared	=	0.7328
Adj R-squared	=	0.7207
Root MSE	=	.13094

impact	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.0105305	.0040244	-2.62	0.009	-.0184356	-.0026255
avgtemp_2	-.024177	.0102603	-2.36	0.019	-.0443311	-.0040229
avgtemp_3	.0496715	.031639	1.57	0.117	-.0124763	.1118192
tempf	-.0064164	.0019079	-3.36	0.001	-.010164	-.0026688
c.covid#c.tempf	.001011	.0001869	5.41	0.000	.0006439	.0013782
hour#c.tempf						
18	.0007991	.0002113	3.78	0.000	.0003841	.0012141
19	.0016905	.0002034	8.31	0.000	.0012909	.00209
20	.0032038	.0002313	13.85	0.000	.0027495	.0036581
21	.0050576	.0005421	9.33	0.000	.0039928	.0061223
outersummer#c.tempf						
1	.0003323	.000353	0.94	0.347	-.0003611	.0010256
lcgnum#c.tempf						
SDP-C-2	-.0017965	.0002379	-7.55	0.000	-.0022639	-.0013291
SDP-C-3	.0032187	.0003896	8.26	0.000	.0024535	.0039839
SDP-C-4	.000617	.0001874	3.29	0.001	.0002489	.0009852
SDP-HD	.000036	.0003295	0.11	0.913	-.0006111	.0006832
SDP-LD	.0012123	.001682	0.72	0.471	-.0020916	.0045162
SDP-N	.0003906	.000213	1.83	0.067	-.0000278	.0008089
SDP-NW	.0008835	.0004263	2.07	0.039	.0000462	.0017208
SDP-W-1	-.0010582	.0002979	-3.55	0.000	-.0016433	-.0004732
SDP-W-2	-.0014742	.0003023	-4.88	0.000	-.002068	-.0008804
dow#c.tempf						
1	-.0007344	.0003158	-2.33	0.020	-.0013548	-.000114
2	-.0000168	.0003102	-0.05	0.957	-.0006261	.0005926
3	.0003496	.0003458	1.01	0.312	-.0003296	.0010287
4	.0003112	.0003565	0.87	0.383	-.0003889	.0010114
5	.0002781	.0003196	0.87	0.385	-.0003497	.000906
6	-.00007	.0002891	-0.24	0.809	-.0006379	.000498
_cons	1.001137	.2723638	3.68	0.000	.4661389	1.536136

SDP-C Impacts – 100% Cycling Group

Source	SS	df	MS			
				Number of obs	=	94
				F(15, 78)	=	11.44
Model	1.2284881	15	.081899206	Prob > F	=	0.0000
Residual	.558394543	78	.007158904	R-squared	=	0.6875
				Adj R-squared	=	0.6274
Total	1.78688264	93	.019213792	Root MSE	=	.08461

impact_perdevice	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.0639451	.0138408	-4.62	0.000	-.0915001	-.0363902
avgtemp_2	.0112246	.0226752	0.50	0.622	-.0339182	.0563674
avgtemp_3	-.0258132	.0854164	-0.30	0.763	-.1958642	.1442378
mean17	.0406747	.0143944	2.83	0.006	.0120178	.0693317
c.covid#c.mean17	.0015413	.0003717	4.15	0.000	.0008012	.0022813
hour#c.mean17						
18	.0012289	.0004068	3.02	0.003	.0004191	.0020387
19	.0023558	.000382	6.17	0.000	.0015952	.0031163
20	.0031468	.0004084	7.70	0.000	.0023337	.0039599
21	.0038331	.0009128	4.20	0.000	.0020159	.0056504
dow#c.mean17						
1	-.0004944	.0008268	-0.60	0.552	-.0021405	.0011517
2	-.0013456	.000748	-1.80	0.076	-.0028348	.0001436
3	-.0004427	.0007868	-0.56	0.575	-.0020092	.0011238
4	-.0017766	.0008114	-2.19	0.032	-.0033919	-.0001613
5	-.0008445	.0008059	-1.05	0.298	-.0024489	.0007599
6	.0004677	.0006962	0.67	0.504	-.0009184	.0018537
_cons	1.458836	.7150194	2.04	0.045	.0353415	2.88233

SDP-C Impacts – 50% Cycling Group

Source	SS	df	MS
Model	.346678146	15	.023111876
Residual	.411346782	67	.006139504
Total	.758024929	82	.009244206

Number of obs	=	83
F(15, 67)	=	3.76
Prob > F	=	0.0001
R-squared	=	0.4573
Adj R-squared	=	0.3359
Root MSE	=	.07835

impact_perdevice	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.0245739	.0141832	-1.73	0.088	-.0528837	.0037359
avgtemp_2	-.0211171	.0246399	-0.86	0.394	-.0702986	.0280644
avgtemp_3	.0418834	.0931296	0.45	0.654	-.1440041	.2277709
mean17	.035031	.0135734	2.58	0.012	.0079384	.0621236
c.covid#c.mean17	.0001758	.0003683	0.48	0.635	-.0005594	.0009109
hour#c.mean17						
18	.0006238	.0004058	1.54	0.129	-.0001861	.0014338
19	.0012722	.0003794	3.35	0.001	.0005149	.0020296
20	.0019101	.0004063	4.70	0.000	.0010991	.002721
21	.0020863	.0009018	2.31	0.024	.0002863	.0038863
dow#c.mean17						
1	.0006238	.0009014	0.69	0.491	-.0011754	.002423
2	-.0003616	.0008141	-0.44	0.658	-.0019866	.0012634
3	.0000784	.0008411	0.09	0.926	-.0016004	.0017571
4	.0000928	.0008698	0.11	0.915	-.0016434	.0018289
5	-.0008016	.0008565	-0.94	0.353	-.0025111	.0009079
6	.0007183	.0007386	0.97	0.334	-.000756	.0021925
_cons	-.944427	.7537589	-1.25	0.215	-2.448936	.5600821

SDP-C Impacts – 30% Cycling Group

Source	SS	df	MS
Model	2.22037553	15	.148025036
Residual	1.94651251	55	.035391137
Total	4.16688805	70	.059526972

Number of obs	=	71
F(15, 55)	=	4.18
Prob > F	=	0.0000
R-squared	=	0.5329
Adj R-squared	=	0.4055
Root MSE	=	.18813

impact_perdevice	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
avgtemp_1	-.0660318	.0386404	-1.71	0.093	-.1434689	.0114053
avgtemp_2	-.1235829	.0679362	-1.82	0.074	-.2597301	.0125643
avgtemp_3	.5089949	.2567168	1.98	0.052	-.0054771	1.023467
mean17	.096071	.0378272	2.54	0.014	.0202636	.1718784
c.covid#c.mean17	.0066647	.000989	6.74	0.000	.0046826	.0086468
hour#c.mean17						
18	.000553	.0010631	0.52	0.605	-.0015775	.0026834
19	.0011044	.0009975	1.11	0.273	-.0008946	.0031035
20	.0018843	.0010733	1.76	0.085	-.0002667	.0040352
21	.0009319	.0023849	0.39	0.697	-.0038475	.0057113
dow#c.mean17						
1	.0068319	.0023104	2.96	0.005	.0022018	.011462
2	.0053877	.0021234	2.54	0.014	.0011324	.009643
3	.0072283	.0021776	3.32	0.002	.0028643	.0115922
4	.0057448	.0022501	2.55	0.013	.0012355	.0102542
5	.0020051	.0022386	0.90	0.374	-.002481	.0064913
6	.0024793	.0019613	1.26	0.212	-.0014513	.0064099
_cons	-3.155676	2.035732	-1.55	0.127	-7.235373	.9240212

APPENDIX F: AGGREGATE HOURLY IMPACTS

Table 29: 2020 SDP-R Aggregate Hourly Impacts, Full Event Hours Only

Date	Load Control Groups	Event Start	Event End	Event Type	Accts	MW Reductions						
						HE 15	HE 16	HE 17	HE 18	HE 19	HE 20	HE 21
7/31	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	M&E	193,745			225.1				
8/7	C-3, LD	4:00 PM	5:00 PM	M&E	9,777			5.7				
8/13	HD, W-1, W-2	6:00 PM	8:00 PM	Economic	60,869					38.7	31.3	
8/13	C-1, C-2, C-3, C-4, N, NW	7:00 PM	8:00 PM	Economic	141,933						104.2	
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	M&E	193,224			225.9				
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	8:00 PM	Economic	193,224				214.3	213.6	161.9	
8/14	C-3	5:10 PM	8:35 PM	Reliability	9,570					12.5	10.3	
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	8:00 PM	9:12 PM	Reliability	193,224							140
8/15	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	3:00 PM	7:45 PM	Reliability	202,781		281.3	282.3	267.9	244.2		
8/16	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	5:40 PM	7:25 PM	Reliability	202,781					216.0		
8/17	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1	3:10 PM	7:40 PM	Reliability	177,503			241.4	232.8	204.0		
8/17	W-2	4:21 PM	7:40 PM	Reliability	22,064				15.7	12.9		
8/18	All	1:40 PM	7:48 PM	Reliability	199,557	250.5	256.2	234.6	220.5	198.6		
9/5	All	5:30 PM	8:25 PM	Reliability	191,475					248.5	206	
9/6	All	4:40 PM	8:23 PM	Reliability	191,475				268.3	237.2	198.9	
2020 August 1-in-2		**4:00 PM**	**9:00 PM**		**189,795**			**197.4**	**186.7**	**171.3**	**144.2**	**123.5**
2020 August 1-in-10		**4:00 PM**	**9:00 PM**		**189,795**			**222.1**	**213.3**	**198.0**	**167.8**	**145.8**

Table 30: 2020 SDP-C Aggregate Hourly Impacts, Full Event Hours Only

Date	Load Control Groups	Event Start	Event End	Event Type	Accts	MW Reductions						
						HE 15	HE 16	HE 17	HE 18	HE 19	HE 20	HE 21
7/31	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	M&E	8,075			13.9				
8/7	C-3, LD	4:00 PM	5:00 PM	M&E	210			0.0				
8/13	HD, W-1, W-2	6:00 PM	8:00 PM	Economic	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8/13	C-1, C-2, C-3, C-4, N, NW	7:00 PM	8:00 PM	Economic	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	4:00 PM	5:00 PM	M&E	8,060			27.0				
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	5:00 PM	8:00 PM	Economic	8,060				22.1	15.1	12.8	
8/14	C-3	5:10 PM	8:35 PM	Reliability	195					0.3	0.2	
8/14	C-1, C-2, C-4, HD, N, NW, W-1, W-2	8:00 PM	9:12 PM	Reliability	8,060							8.9
8/15	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	3:00 PM	7:45 PM	Reliability	8,268		17.6	18.4	13.7	10.8		
8/16	C-1, C-2, C-3, C-4, HD, N, NW, W-1, W-2	5:40 PM	7:25 PM	Reliability	8,268					8.0		
8/17	C-1, C-2, C-3, C-4, HD, LD, N, NW, W-1	3:10 PM	7:40 PM	Reliability	6,129			24.6	15.5	8.8		
8/17	W-2	4:21 PM	7:40 PM	Reliability	2,021				0.0	0.3		
8/18	All	1:40 PM	7:48 PM	Reliability	8,160	43.6	35.5	25.8	19.4	9.8		
9/5	All	5:30 PM	8:25 PM	Reliability	8,038					12.6	9.6	
9/6	All	4:40 PM	8:23 PM	Reliability	8,038				19.1	13.2	8.9	
2020 August 1-in-2		**4:00 PM**	**9:00 PM**		**7,457**			**26.3**	**21.1**	**16.1**	**12.2**	**9.9**
2020 August 1-in-10		**4:00 PM**	**9:00 PM**		**7,457**			**30.3**	**24.9**	**19.8**	**15.9**	**13.5**