REPORT

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Program Year 2019 Southern California Edison Summer Discount Plan Impact Evaluation

Prepared for: Southern California Edison

By: Demand Side Analytics

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

ACKNOWLEDGEMENTS

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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 220,000 residential customers enrolled and includes nearly 260,000 control devices and nearly 950,000 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 9,000 customers enrolled with over 80,000 control devices and over 400,000 tons of air conditioner load. Approximately 65% of customers, accounting for 60% of the total commercial air conditioner load, elect the higher incentive. During the system peak day, the SDP program reduced demand by 248 MW on the first event hour, and by an average of 211 MW across all three event hours. During normal (1-in-2) August peak day planning conditions, participants can reduce demand by 187 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.

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1 EXECUTIVE SUMMARY

This report presents the results of the program year 2019 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 2019 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 220,000 customers enrolled and includes nearly 260,000 control devices and nearly 950,000 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 600 MW, and participants can curtail demand by 166 MW during the 4-9 PM peak window. During extreme planning conditions, participant loads peak at 670 MW, and participants can reduce demand by 197 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 2019. For events before the official end of summer, average impacts were consistently greater than 0.50 kW per participant, and percent impacts were generally around 30%. For the events on September 24th and October 16th, impacts and percent impacts were lower, likely due to a reduced cooling load.

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

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

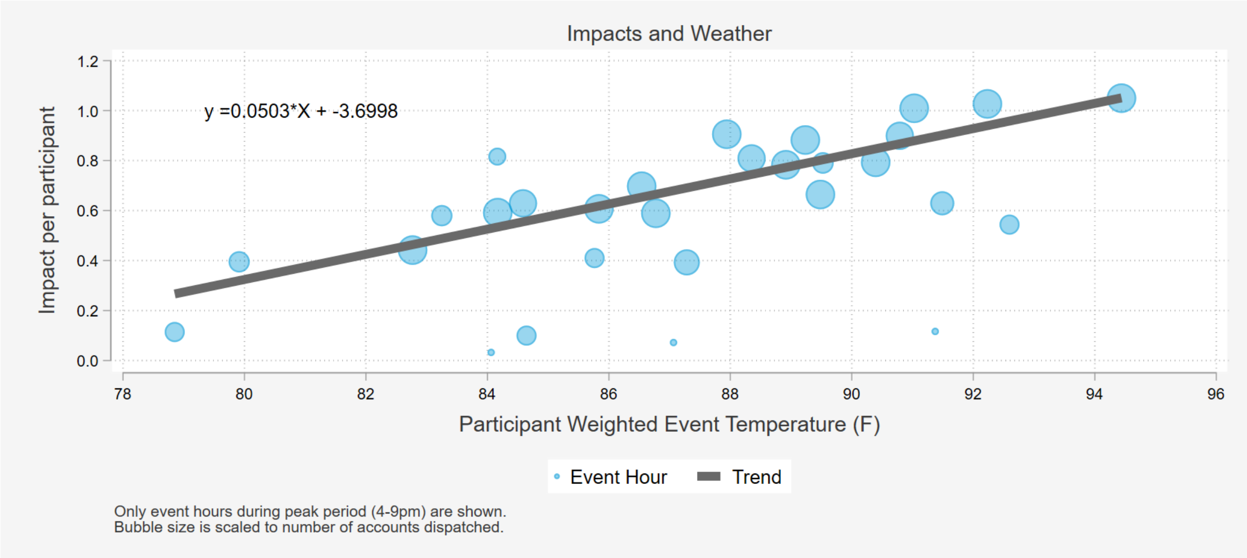


Table 1: SDP-Residential Event Summary, 2019

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		
7/24	4:00 PM	7:00 PM	217,619	214.7	207.1	222.3	0.99	0.85	0.23	34.6%	92.0
8/13	5:00 PM	8:00 PM	217,762	123.1	116.1	130.1	0.57	0.48	0.13	25.7%	86.3
8/14	6:00 PM	8:00 PM	217,459	152.3	144.9	159.7	0.70	0.60	0.16	28.2%	88.1
8/15	6:00 PM	8:00 PM	217,440	149.5	141.9	157.2	0.69	0.59	0.16	28.5%	86.5
9/4	5:00 PM	8:00 PM	217,516	189.4	182.5	196.4	0.87	0.75	0.20	30.9%	88.5
9/5	5:00 PM	8:00 PM	178,310	138.9	133.0	144.9	0.78	0.67	0.18	29.4%	87.9
9/6	6:00 PM	7:00 PM	23,171	18.9	16.5	21.4	0.82	0.73	0.20	32.8%	84.2
9/6	6:00 PM	8:00 PM	51,296	25.0	21.6	28.4	0.49	0.44	0.12	22.4%	81.6
9/6	7:00 PM	8:00 PM	53,904	42.6	39.0	46.3	0.79	0.66	0.18	29.9%	89.5
9/13	6:00 PM	7:00 PM	89,025	56.0	52.0	60.1	0.63	0.53	0.15	26.5%	91.5
9/24	1:00 PM	3:00 PM	217,192	50.9	45.1	56.7	0.23	0.20	0.06	24.2%	88.5
9/24	6:00 PM	7:00 PM	126,641	49.8	45.3	54.2	0.39	0.33	0.09	21.6%	87.3
9/24	6:00 PM	8:00 PM	39,331	18.8	16.0	21.5	0.48	0.40	0.11	23.6%	89.2
10/16	5:00 PM	7:00 PM	39,113	4.2	2.1	6.3	0.11	0.09	0.02	9.3%	81.7
10/16	5:00 PM	8:00 PM	264	0.0	0.0	0.1	0.07	0.07	0.02	6.0%	87.5
Avg. Event	5:00 PM	8:00 PM	204,529	150.7	146.5	154.9	0.74	0.63	0.17	28.9%	87.6

A few other key findings are worth highlighting:

- During the system peak day (September 4, 2019), SDP-R participants reduced demand by an average of 189 MW between 5:00 PM and 8:00 PM. The demand reductions per customer, per device, and per ton for this event were 0.87 kW, 0.75 kW, and 0.20 kW respectively. Temperatures on the peak day reached 98˚F in downtown Los Angeles.
- On the average 2019 event day, the SDP-R program produced 150.7 MW of demand reductions.
- Given current enrollments, the resource can deliver reductions of 166 MW during the peak period under 1-in-2 weather planning conditions and 197 MW under 1-in-10 weather planning conditions (August monthly peak day).
- The per-participant demand reductions for customers signed up for the 100% cycling are more than three times larger than 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 isn't enough cooling load to curtail.
- At similar temperature conditions, 2018 and 2019 ex post per customer and percent impacts were very similar – 28.6% in 2018 and 28.1% in 2019.
- Overall, 2019 weather in Southern California was cooler than in prior years. Due to milder weather conditions, system-wide SCE peaks were lower in 2019 than they were in previous years.
- SCE called several test events in late September and October (technically outside of the official summer). Loads and load reduction outside of the summer tend to be lower, even after accounting for weather, in part because some thermostats may no longer be on cooling mode.

1.2 SDP COMMERCIAL KEY FINDINGS

The SDP Commercial (SDP-C) program has approximately 9,000 customers enrolled and includes over 80,000 control devices and over 400,000 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 480 MW, and participants can curtail demand by 21 MW during the 4-9 PM peak window. During extreme planning conditions (1-in-10 weather conditions), participant loads peak at 500 MW, and participants can reduce demand by 24 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. The relationship between SDP-C demand reductions and outdoor air temperature is visualized in Figure 20 and includes all hours in the peak period, from 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.

Table 2 summarizes the reductions attained during each event in 2019. Impacts per device were generally in the neighborhood of 0.25 kW with a few exceptions. The most notable exception is the early afternoon event on September 24th. Although it is outside the 4:00-9:00 PM peak, the timing of this event better aligns with when SDP-C cooling loads peak, so the per-device impacts were higher, 0.54 kW.

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

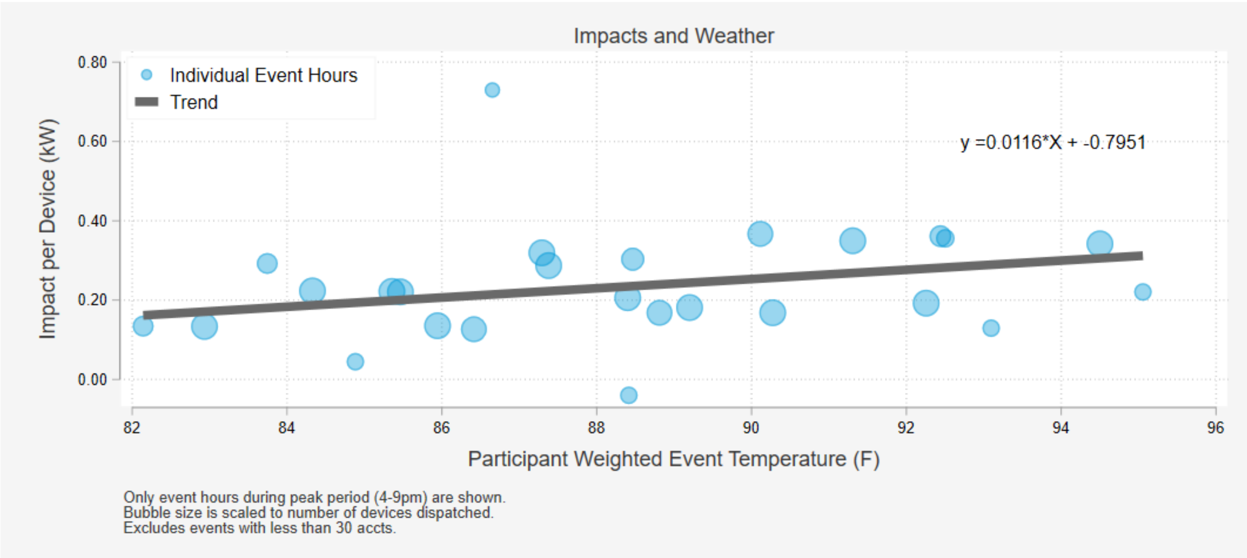


Table 2: SDP-Commercial Event Summary, 2019

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		
7/24	4:00 PM	7:00 PM	9,026	18.9	12.5	25.3	2.09	0.23	0.05	8.90	92.3
8/13	5:00 PM	8:00 PM	9,007	17.3	12.4	22.2	1.92	0.21	0.04	8.41	85.2
8/14	6:00 PM	8:00 PM	8,988	12.8	5.9	19.7	1.42	0.16	0.03	5.98	87.6
8/15	6:00 PM	8:00 PM	8,989	21.9	9.5	34.2	2.43	0.27	0.05	10.02	85.8
9/4	5:00 PM	8:00 PM	8,974	20.9	11.9	29.8	2.33	0.26	0.05	8.12	88.4
9/5	5:00 PM	8:00 PM	8,105	15.2	8.5	22.0	1.88	0.22	0.04	6.79	88.5
9/6	6:00 PM	7:00 PM	1,042	4.6	2.6	6.5	4.38	0.73	0.14	19.14	86.7
9/6	6:00 PM	8:00 PM	3,472	5.6	1.5	9.7	1.62	0.21	0.05	7.01	82.9
9/6	7:00 PM	8:00 PM	1,619	5.5	2.0	9.1	3.40	0.36	0.07	14.16	92.5
9/13	6:00 PM	7:00 PM	2,832	11.8	6.1	17.4	4.15	0.36	0.07	13.89	92.4
9/24	1:00 PM	3:00 PM	8,936	43.6	34.7	52.6	4.88	0.54	0.11	11.96	85.1
9/24	6:00 PM	7:00 PM	4,597	12.9	7.4	18.3	2.80	0.30	0.06	11.13	88.5

				Aggregate Impact (MW)			Impact per… (kW)				
Date	**Event start**	**Event end**	**Accts**	**Impact**	**90% Lower Bound**	**90% Upper Bound**	**Acct**	**Device**	**Ton**	**% Impact**	**Wght. Temp (F)**
9/24	6:00 PM	8:00 PM	881	2.0	0.0	4.1	2.32	0.18	0.03	8.28	94.1
10/16	5:00 PM	7:00 PM	863	0.0	-3.4	3.4	0.03	0.00	0.00	0.12	86.7
10/16	5:00 PM	8:00 PM	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Avg. Event	**5:00 PM**	**8:00 PM**	**8,695**	**17.8**	**13.9**	**21.6**	**2.04**	**0.23**	**0.05**	**7.76%**	**87.3**

A few other key findings are worth highlighting:

- During the system peak day (September 4, 2019), SDP-C participants reduced demand by an average of 20.9 MW between 5:00 PM and 8:00 PM. The demand reductions per customer, per device, and per ton for this event were 2.33 kW, 0.26 kW, and 0.05 kW respectively. Temperatures on the peak day reached 98˚F in downtown Los Angeles.
- On the average 2019 event day, we estimate the SDP-C program produced 17.8 MW of demand reductions.
- 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 will be tied to whether or not schools are in session.
- [redacted]
- Overall, percent impacts tended to be larger in 2019 than in 2018 due to the hotter event conditions.

2 INTRODUCTION

This report presents the results of the program year 2019 Summer Discount Plan (SDP) impact evaluation. SDP is a voluntary demand response program that provides incentives to residential 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 2019 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 2019 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 - related 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?

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. All 2019 events 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 2019 summer. The 2019 system peak, which occurred on September 4th, was 21,961 MW. A DR event was dispatched from 5:00 PM through 8:00 PM on the peak day – the effect of this event is visible in the solid blue line in Figure 4. September 4th was not the only high load day in September, as September 3rd, 5th, and 6th were also some of the highest system load days in 2019 (Figure 4).

Figure 3: System Load Duration Curves

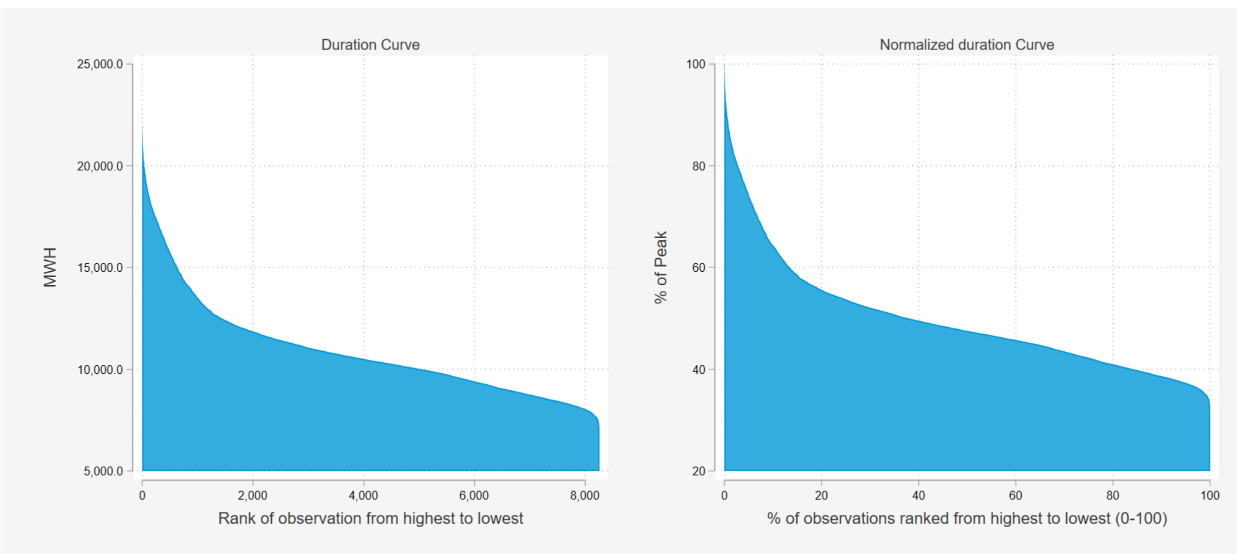


Figure 4: Top Ten System Load Days, 2019

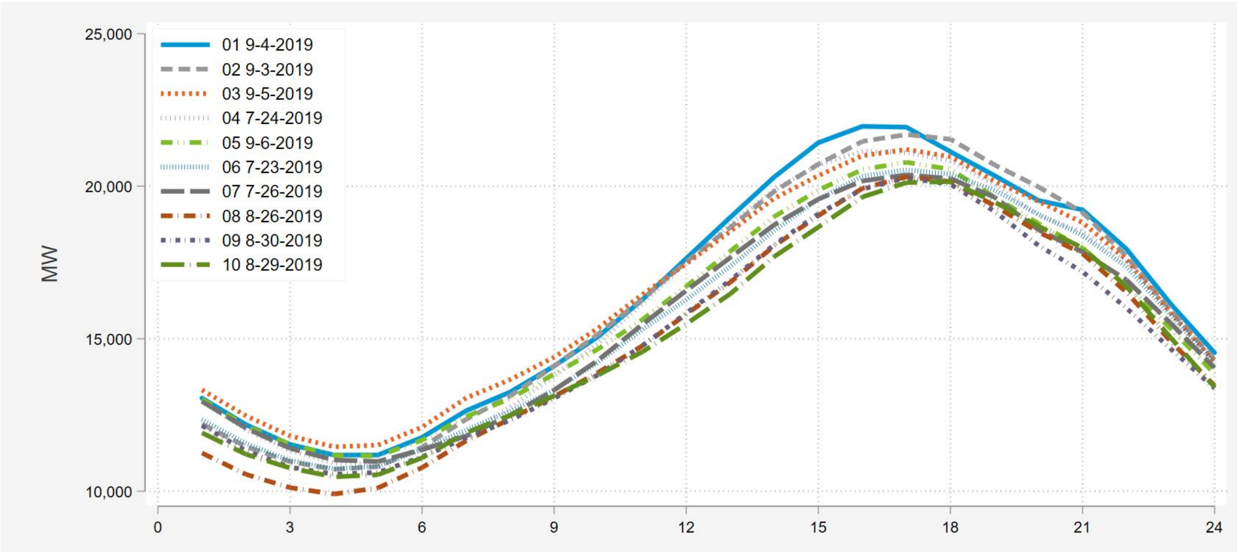


Figure 5 compares system-wide daily peaks over the past four years. Relative to prior years, system peaks in 2019 were low – nearly 2,000 MW lower than the 2017 and 2018 peaks. The lower peak demand level can largely be attributed to a milder summer in 2019. Figure 6 shows the distribution of temperatures over the past three 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 2019 median, as well as the 2019 maximum, was lower than the 2017 and 2018 medians, indicating the 2019 summer was milder in Southern California compared to earlier years.

Figure 5: System Peaks by Year

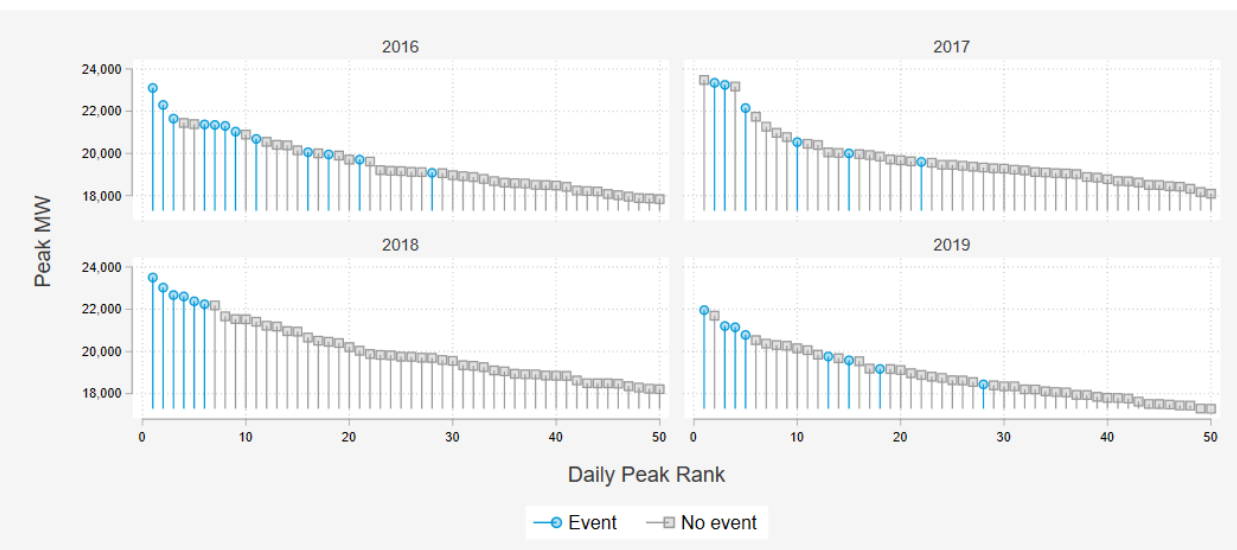
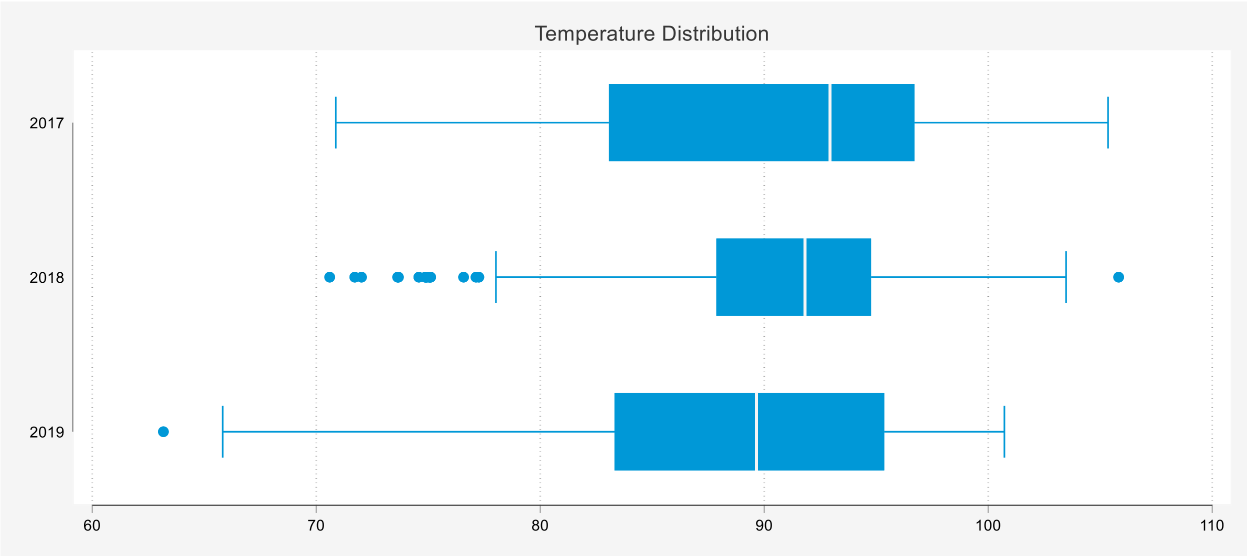
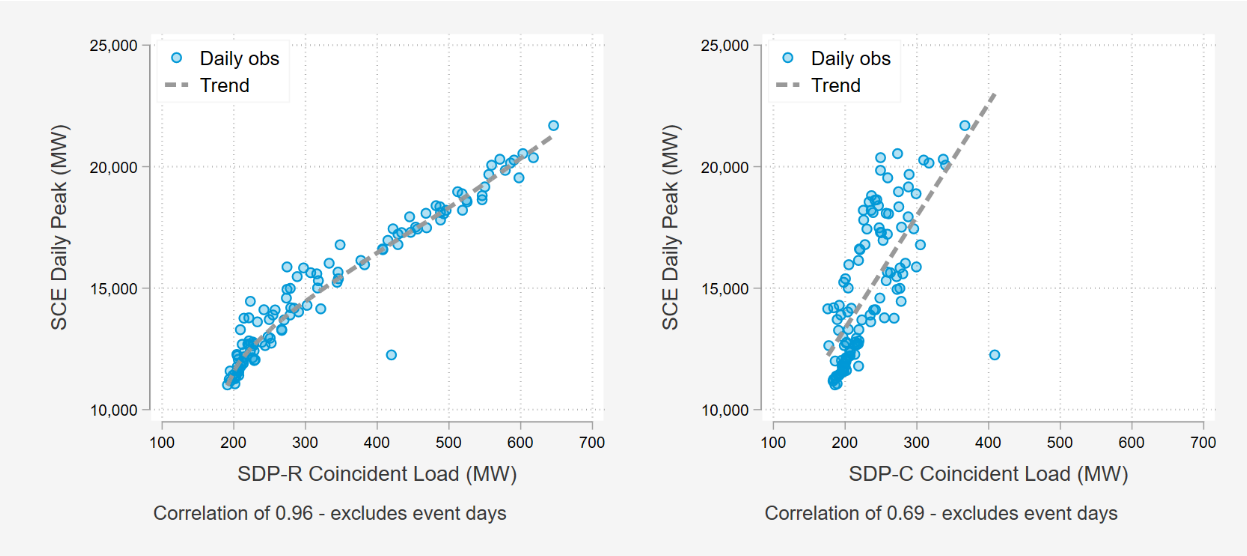


Figure 6: Distribution of Maximum Daily Temperatures, Summer 2017-2019



There is a strong correlation between SDP resources and system-wide peaks. Excluding event days, there was a correlation of 0.96 between system peaks and SDP-R coincident loads – indicative of a very strong linear correlation (left pane in Figure 7). 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 7).

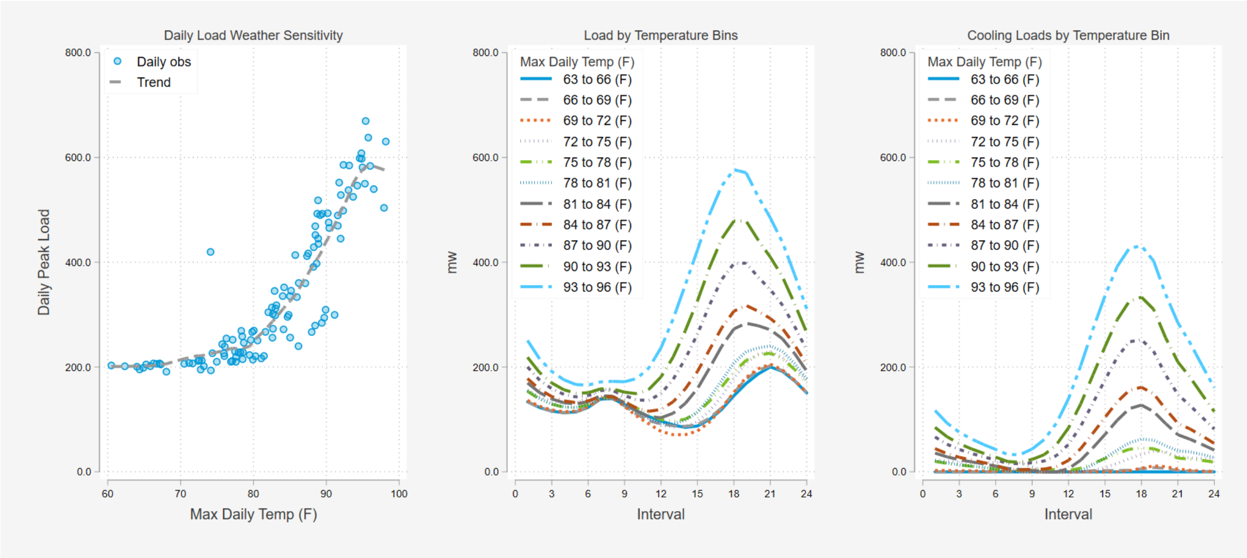
Figure 7: SCE Daily Peaks against SDP Coincident Load



2.4 RESIDENTIAL PARTICIPANT CHARACTERISTICS

A total of 223,003 SCE residential customers participated in at least one SDP demand response event during the 2019 summer. On aggregate, these 223,003 customers have over 400 MW of cooling load when temperatures are hot – 93°F or higher (right pane in Figure 8). At milder temperatures in the mid-to-high 80s, these customers have closer to 200 MW of cooling load. Approximately 11% of SDP-R participants have solar power.

Figure 8: 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 3 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-C resources include:

- The majority of SDP-R participants are on 100% cycling (86%);
- SCE dispatched 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 (0.12%), 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 23% of participants, representing 20% 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 3: 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%	32,090	14.39	35,772	13.76	128,606	13.59
	100%	190,913	85.61	224,195	86.24	818,013	86.41
Load Control Group	Missing	1,074	0.48	1,230	0.47	4,111	0.43
	SDP-Central-1	40,072	17.97	48,367	18.61	173,295	18.31
	SDP-Central-2	23,647	10.60	26,249	10.10	97,942	10.35
	SDP-Central-3	10,908	4.89	14,750	5.67	54,053	5.71
	SDP-Central-4	44,160	19.80	51,518	19.82	188,023	19.86
	SDP-High Desert	13,872	6.22	15,611	6.00	56,013	5.92
	SDP-Low Desert	266	0.12	281	0.11	1,066	0.11
	SDP-North	27,484	12.32	32,405	12.47	114,799	12.13
	SDP-Northwest	9,342	4.19	11,580	4.45	43,048	4.55
	SDP-West-1	28,060	12.58	31,898	12.27	118,052	12.47
	SDP-West-2	24,118	10.82	26,078	10.03	96,215	10.16
Load Control Area	Big Creek/Ventura	37,125	16.65	44,327	17.05	159,047	16.80
	LA Basin	171,786	77.03	199,804	76.86	730,752	77.20
	Outside LA Basin	14,092	6.32	15,836	6.09	56,819	6.00
CARE/FERA Status	Non-CARE/FERA	172,545	77.37	205,393	79.01	758,340	80.11
	CARE/FERA	50,458	22.63	54,574	20.99	188,278	19.89
Zone	South Orange County	17,630	7.91	19,808	7.62	72,072	7.61
	South of Lugo	82,215	36.87	94,336	36.29	347,964	36.76
	Remainder of System	123,158	55.23	145,823	56.09	526,582	55.63
Overall Total		**223,003**	**100**	**259,967**	**100**	**946,618**	**100**

2.5 NON-RESIDENTIAL PARTICIPANT CHARACTERISTICS

A total of 9,062 SCE residential customers participated in at least one SDP demand response event during the 2019 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 9). What this means is that a handful of customers drive the load reduction results.

Figure 9: Tonnage Ranks against Cumulative Tonnage Shares

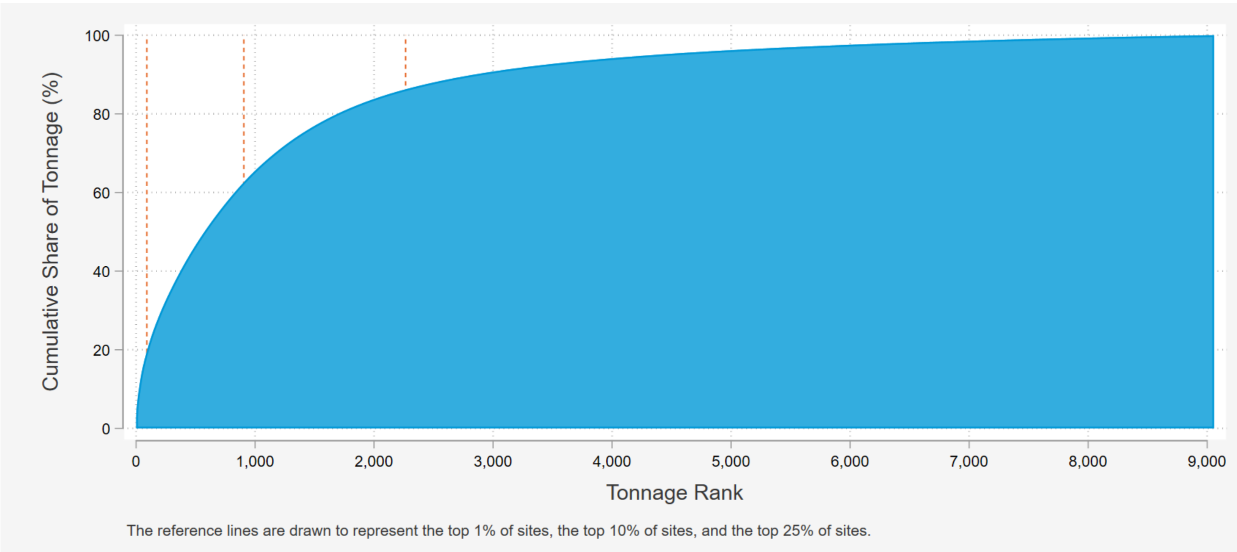
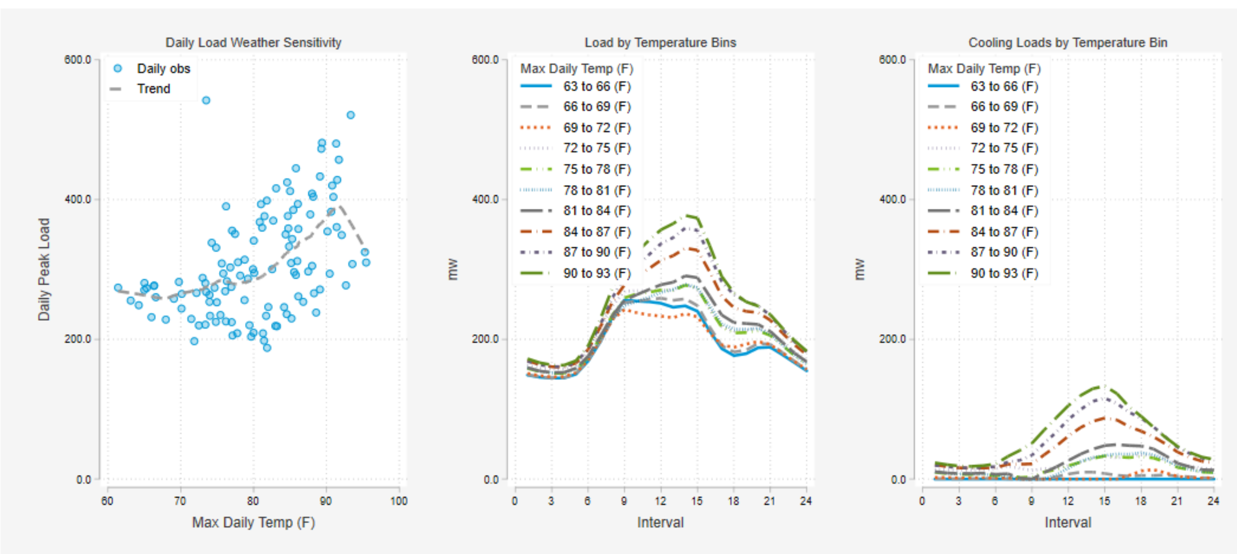


Figure 10: SDP-C Participant Load Summary



On aggregate, the 9,062 SDP-C customers have approximately 150 MW of cooling load when temperatures are hot – 93°F or higher (right pane in Figure 10). 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 more than 60% of the total SDP-C AC tonnage. The drop in the load between 3:00 PM and 6:00 PM is related to the end of the school day (middle pane in Figure 10). Though there certainly is some correlation between the maximum daily temperature and the daily peak load (left pane in Figure 10), the relationship isn't nearly as strong as it is for the residential component of SDP (left pane in Figure 8). Because loads from schools dominate, the magnitude of loads is highly dependent on whether schools are in session or vacation – that is, school loads have a seasonal component.

Table 4 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 (60%);
- The low desert region has the smallest share of tonnage (0.06%), and the other load control groups have somewhere between 5% and 20% of the tonnage each;
- Most SDP-C resources are in the LA Basin load control 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 67% 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 22 illustrates how the scaling was accomplished, and Table 23 shows the percentage of accounts, devices, and total tonnage that remained in the analysis file.

Table 4: 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%	696	7.68	3,285	4.07	18,279	4.49
	50%	2,444	26.97	29,976	37.10	143,140	35.16
	100%	5,922	65.35	47,539	58.84	245,739	60.35
Load Control Group	Missing	1	0.01	3	0.00	7	0.00
	SDP-Central-1	870	9.60	11,669	14.44	61,881	15.20
	SDP-Central-2	1,050	11.59	6,266	7.75	31,655	7.77
	SDP-Central-3	220	2.43	754	0.93	4,284	1.05
	SDP-Central-4	1,423	15.70	14,768	18.28	77,705	19.08
	SDP-High Desert	376	4.15	6,443	7.97	31,616	7.77
	SDP-Low Desert	18	0.20	39	0.05	225	0.06
	SDP-North	975	10.76	9,242	11.44	48,463	11.90
	SDP-Northwest	623	6.87	5,244	6.49	26,736	6.57
	SDP-West-1	1,274	14.06	9,302	11.51	45,556	11.19
	SDP-West-2	2,232	24.63	17,070	21.13	79,030	19.41
Load Control Area	Big Creek/Ventura	1,598	17.63	14,486	17.93	75,199	18.47
	LA Basin	7,069	78.01	59,829	74.05	300,111	73.71
	Outside LA Basin	395	4.36	6,485	8.03	31,848	7.82
Zone	South Orange County	806	8.89	5,434	6.73	27,168	6.67
	South of Lugo	2,948	32.53	27,545	34.09	143,868	35.33
	Remainder of System	5,308	58.57	47,821	59.18	236,123	57.99

Category	Subcategory	Number of Accounts	Share of Accounts	Number of Devices	Share of Devices	Total Tonnage	Share of Tonnage
Industry	Agriculture, Mining, Construction	237	2.62	541	0.67	2,329	0.57
	Institutional/Government	775	8.55	6,382	7.90	30,185	7.41
	Manufacturing	581	6.41	1,597	1.98	8,510	2.09
	Offices, Hotels, Finance, Services	2,166	23.90	4,149	5.13	17,914	4.40
	Retail Stores	1,504	16.60	2,819	3.49	14,793	3.63
	Schools	1,797	19.83	54,731	67.74	273,739	67.23
	Wholesale, Transport, Other Utilities	741	8.18	2,166	2.68	10,202	2.51
	Unknown/Other	31	0.34	50	0.06	206	0.05
	Religious organizations	1,230	13.57	8,365	10.35	49,281	12.10
Tonnage Bin	3 or less	1,277	14.09	1,281	1.59	3,133	0.77
	3 to 4	1,120	12.36	1,149	1.42	3,863	0.95
	4 to 5	769	8.49	870	1.08	3,448	0.85
	5 to 10	1,815	20.03	3,073	3.80	12,572	3.09
	10-100	2,909	32.10	20,326	25.16	98,639	24.23
	100-500	1,105	12.19	42,573	52.69	216,356	53.14
	500+	67	0.74	11,528	14.27	69,147	16.98
Overall Total		**9,062**	**100**	**80,800**	**100**	**407,159**	**100**

2.6 2019 EVENT CONDITIONS

Figure 11 visualizes the timing of the fifteen SDP events during the 2019 summer. Events varied in timing and length, but most started and ended somewhere between 5:00 PM and 8:00 PM.

Figure 11: Timing of SDP Summer Events, 2019

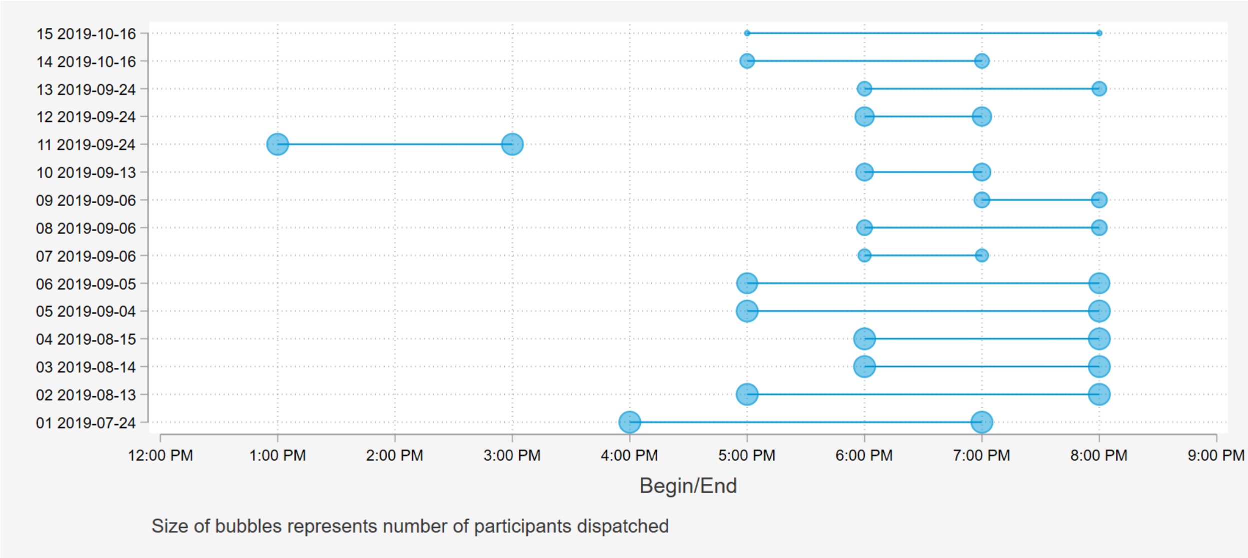


Table 5 shows the dates, start times, and end times for all fifteen of the SDP DR events in 2019, as well as the number of dispatched accounts, devices, and tonnage for the SDP-R and SDP-C segments. The last row in the table shows characteristics for the "average" 2019 event, defined as the average load impacts for the events on August 13, September 4, and September 5 – all system wide events from 5:00 to 8:00 PM. Some highlights from the table:

- For the average SDP-R event, there were just over 200,000 participants and approximately 869,000 total tons of AC load.
- For the average SDP-C event, there were 8,695 participants and approximately 386,000 total tons of AC load.
- The average temperature for the average SDP-R event day was 87.6° F, but average event temperatures ranged from 81.6° F to 92.0° F. For SDP-C, the average temperature on the average event day was nearly three degrees lower than the SDP-R average.
- There were four territory-wide events (7/24, 8/13, 9/4, and 9/24) and a couple of others that dispatched all load control groups except for one.
- Most of the events started in the late afternoon – 5:00 or 6:00 PM – and ended by 8:00 PM. There was also one early afternoon event in 2019.
- SCE called multiple events on 9/6, 9/24, and 10/16. On 9/6, which was one of the highest system load days in 2019, there were three distinct DR events.

Table 5: 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)
7/24	All	4:00 PM	7:00 PM	217,619	253,991	926,419	92.0	9,026	80,723	406,829	89.9
8/13	All	5:00 PM	8:00 PM	217,762	254,068	926,417	86.3	9,007	80,686	406,639	82.5
8/14	C-1, C-2, C-3, C-4, N, W-1, W-2, HD, NW	6:00 PM	8:00 PM	217,459	253,734	925,153	88.1	8,988	80,646	406,409	83.7
8/15	C-1, C-2, C-3, C-4, N, W-1, W-2, HD, NW	6:00 PM	8:00 PM	217,440	253,701	925,010	86.5	8,989	80,652	406,448	82.1
9/4	All	5:00 PM	8:00 PM	217,516	253,681	924,701	88.5	8,974	80,614	406,330	86.1
9/5	C-2, C-3, C-4, N, W-1, W-2, HD, LD, NW	5:00 PM	8:00 PM	178,310	206,344	754,981	87.9	8,105	68,970	344,568	86.0
9/6	C-2	6:00 PM	7:00 PM	23,171	25,734	96,085	84.2	1,042	6,256	31,615	83.9
9/6	W-1, W-2	6:00 PM	8:00 PM	51,296	57,024	210,860	81.6	3,472	26,302	124,294	80.6
9/6	C-3, C-4	7:00 PM	8:00 PM	53,904	64,903	237,259	89.5	1,619	15,481	81,807	88.9
9/13	C-1, N, HD, LD, NW	6:00 PM	7:00 PM	89,025	105,870	379,850	91.5	2,832	32,557	168,468	89.5
9/24	All	1:00 PM	3:00 PM	217,192	253,253	922,903	88.5	8,936	80,383	405,138	86.1
9/24	C-2, C-3, C-4, N, HD, NW	6:00 PM	7:00 PM	126,641	148,886	542,343	87.3	4,597	42,432	219,002	85.4
9/24	C-1, LD	6:00 PM	8:00 PM	39,331	47,436	170,075	89.2	881	11,675	61,955	90.1
10/16	C-1	5:00 PM	7:00 PM	39,113	47,206	169,147	81.7	863	11,638	61,735	82.3
10/16	LD	5:00 PM	8:00 PM	264	279	1,057	87.5	[redacted]			
Avg. Event		**5:00 PM**	**8:00 PM**	**204,529**	**238,031**	**868,699**	**87.6**	**8,695**	**76,757**	**385,846**	**84.8**

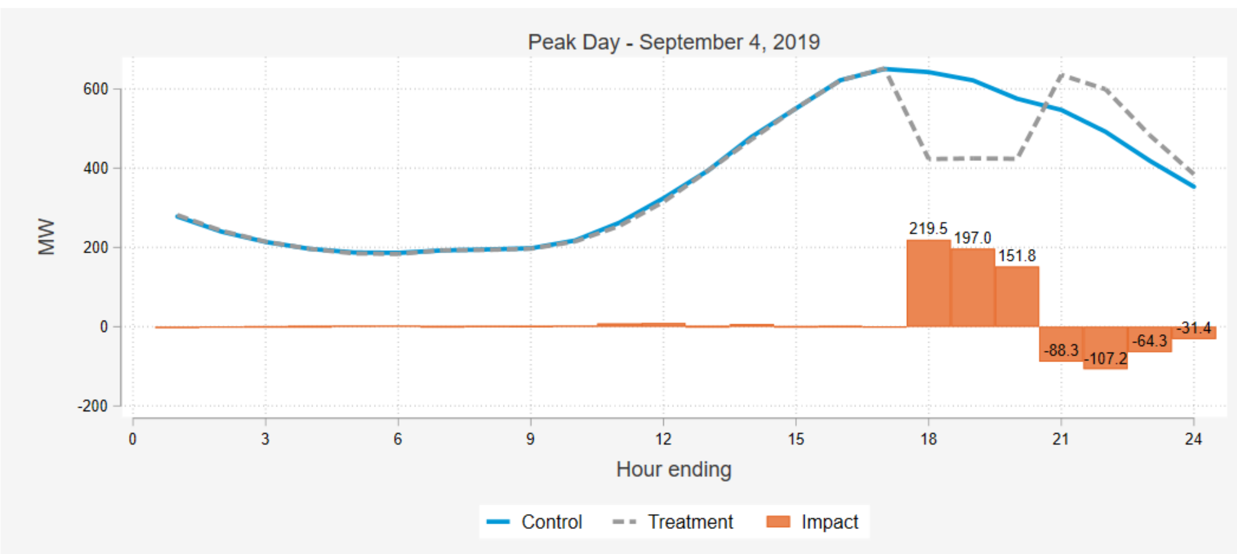
3 RESIDENTIAL EX POST RESULTS

This section focuses on the magnitude of demand reductions delivered by SDP-R during 2019 event days. The magnitude of demand reductions is a function of several factors – outdoor temperature, the hours when SCE dispatched the resource, and geo-targeted dispatch of resources. The historical event performance is employed to develop estimates of the magnitude of program resources under planning (ex ante) conditions.

3.1 SYSTEM PEAK DAY REDUCTIONS

The 2019 system peak was 21,961 MW and occurred on September 4th. On the peak day, SDP-R resources were dispatched from 5:00 PM through 8:00 PM due to wholesale energy market prices. In total, SCE sent instructions to curtail demand to 217,516 SDP-R accounts with 253,681 control devices. Figure 12 shows the hourly load profile for the control group and SDP-R participants on the system peak day. During the first event hour, the demand reduction by SDP-R participants was nearly 220 MW. The demand reductions in later hours were lower mainly because air conditioner loads were lower in later evening hours. Across the three event hours, the average impact was about 190 MW, and the average percent impact was 30.9%.

Figure 12: SDP-R Reductions on System Peak Day



3.2 INDIVIDUAL EVENT DAY REDUCTIONS

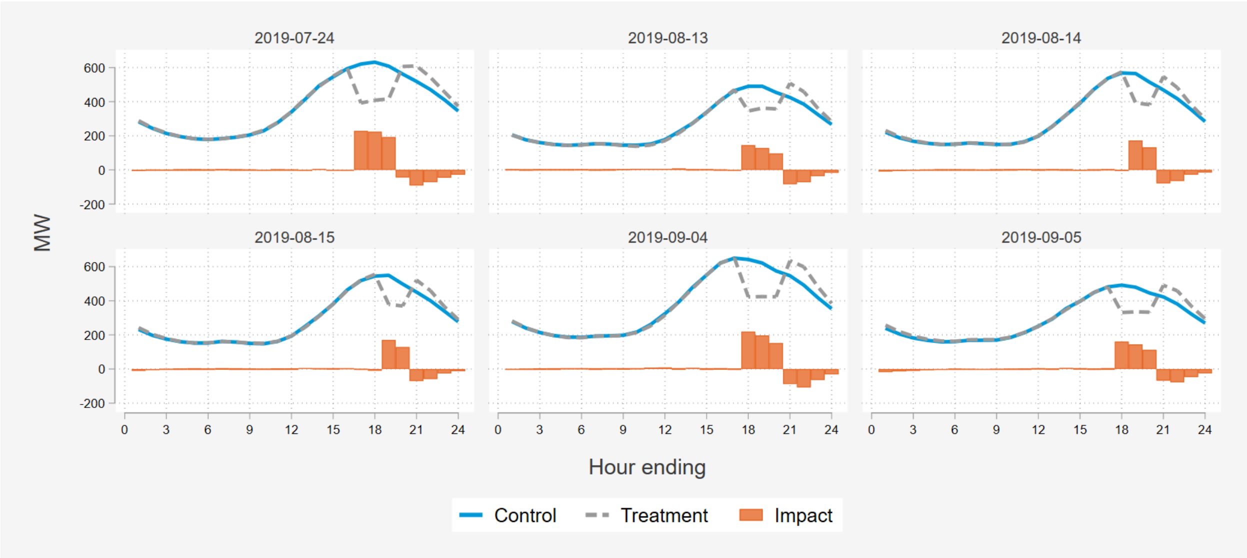
Table 6 shows reference loads, observed loads, impacts, and percent impacts for each of the fifteen SDP-R summer 2019 DR events. The "average" event is the average across the three events from 5:00-8:00 PM that were dispatched for all or most of the territory (8/13, 9/4, and 9/5). For the average event, the percent impact was 28.9% and the average aggregate hourly impact was 150.7 MW. This percent impact is quite similar to the percent impact from the average 2018 SDP-R event, which was 28.8%. Ignoring the October events, percent impacts for the 2019 SDP-R events ranged from 21.6% to 34.6%.

Table 6: SDP-R Event Results, 2019

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		
7/24	All	4:00 PM	7:00 PM	217,619	620.5	405.8	214.7	207.1	222.3	0.99	0.85	0.23	34.6%	92.0
8/13	All	5:00 PM	8:00 PM	217,762	478.4	355.3	123.1	116.1	130.1	0.57	0.48	0.13	25.7%	86.3
8/14	C-1, C-2, C-3, C-4, N, W-1, W-2, HD, NW	6:00 PM	8:00 PM	217,459	540.0	387.7	152.3	144.9	159.7	0.70	0.60	0.16	28.2%	88.1
8/15	C-1, C-2, C-3, C-4, N, W-1, W-2, HD, NW	6:00 PM	8:00 PM	217,440	524.2	374.6	149.5	141.9	157.2	0.69	0.59	0.16	28.5%	86.5
9/4	All	5:00 PM	8:00 PM	217,516	613.3	423.8	189.4	182.5	196.4	0.87	0.75	0.20	30.9%	88.5
9/5	C-2, C-3, C-4, N, W-1, W-2, HD, LD, NW	5:00 PM	8:00 PM	178,310	472.5	333.5	138.9	133.0	144.9	0.78	0.67	0.18	29.4%	87.9
9/6	C-2	6:00 PM	7:00 PM	23,171	57.6	38.7	18.9	16.5	21.4	0.82	0.73	0.20	32.8%	84.2
9/6	W-1, W-2	6:00 PM	8:00 PM	51,296	111.8	86.8	25.0	21.6	28.4	0.49	0.44	0.12	22.4%	81.6
9/6	C-3, C-4	7:00 PM	8:00 PM	53,904	142.4	99.7	42.6	39.0	46.3	0.79	0.66	0.18	29.9%	89.5
9/13	C-1, N, HD, LD, NW	6:00 PM	7:00 PM	89,025	211.8	155.8	56.0	52.0	60.1	0.63	0.53	0.15	26.5%	91.5
9/24	All	1:00 PM	3:00 PM	217,192	210.8	159.9	50.9	45.1	56.7	0.23	0.20	0.06	24.2%	88.5
9/24	C-2, C-3, C-4, N, HD, NW	6:00 PM	7:00 PM	126,641	231.0	181.2	49.8	45.3	54.2	0.39	0.33	0.09	21.6%	87.3
9/24	C-1, LD	6:00 PM	8:00 PM	39,331	79.4	60.6	18.8	16.0	21.5	0.48	0.40	0.11	23.6%	89.2
10/16	C-1	5:00 PM	7:00 PM	39,113	45.2	41.0	4.2	2.1	6.3	0.11	0.09	0.02	9.3%	81.7
10/16	LD	5:00 PM	8:00 PM	264	0.3	0.3	0.0	0.0	0.1	0.07	0.07	0.02	6.0%	87.5
Avg. Event		5:00 PM	8:00 PM	204,529	521.6	370.9	150.7	146.5	154.9	0.74	0.63	0.17	28.9%	87.6

Figure 13 visualizes aggregate impacts for the four territory-wide events (7/24, 8/13, 9/4, 9/24) and two others that were dispatched for nearly the full territory (8/14 and 9/5). Because roughly 85% of sites elect to have their AC unit fully curtailed, the decrease in the magnitude of reduction is most likely due to decreasing air conditioner loads in the later evening hours.

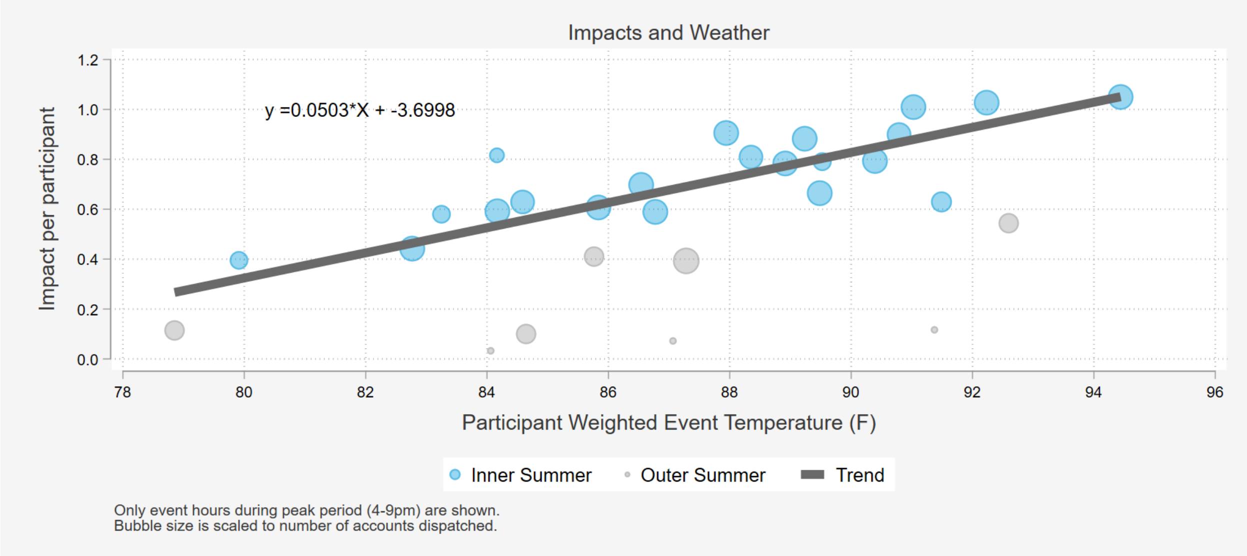
Figure 13: SDP-R Reductions on Select Event Days



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 14 visualizes the relationship between 2019 SDP-R DR reductions and outdoor temperature. The slope of the line in the figure is 0.05, which suggests that the average impact per participant increases by 0.05 kW for each one-degree increase in outdoor temperature. The gray bubbles represent impacts for events that occurred in early fall (9/24 and 10/16). Fewer thermostats were probably on cooling mode during those events, which helps explains why the impacts are lower outside of the official summer.

Figure 14: Relationship between SDP-R Demand Reductions and Weather



3.4 COMPARISON TO PRIOR YEAR

Figure 15 shows the relationship between SDP-R reductions and outdoor temperature for 2018 and 2019. Figure 16 shows the relationship between percent reductions (rather than load reductions) and outdoor temperature. There are several key takeaways from the figures:

- The number of event hours in 2018 far exceeded the number of events hours in 2019 (52 to 31). Many of the 2018 events targeted specific load control groups, while most of the 2019 events dispatched the majority of load control groups at the same time.
- There was a greater range in temperature conditions in 2018. Participant weighted temperatures ranged from the mid-60s to over 100 degrees during 2018 events. During 2019 events, the range of participant weighted temperatures was considerably narrower – from about 80 degrees to 95 degrees.
- Though not readily apparent in the figure, the slope of the linear trend was slightly steeper in 2019 than in 2018. The slope was 0.050 kW per degree in 2019 and 0.046 kW per degree in 2018. The confidence intervals for these two slope values overlap, so we cannot conclude that there is a statistically significant difference between 2018 and 2019.
- Percent impacts are nearly identical between the two program years. In 2018, the average percent impact was 27.2% (weighted by the number of accounts curtailed). When just looking at 2018 percent impacts for weather conditions similar to 2019 events, the average percent impact was 28.6%. The average for 2019 events was 28.1%.

Figure 15: SDP-R Reductions against Temperature, 2018-2019

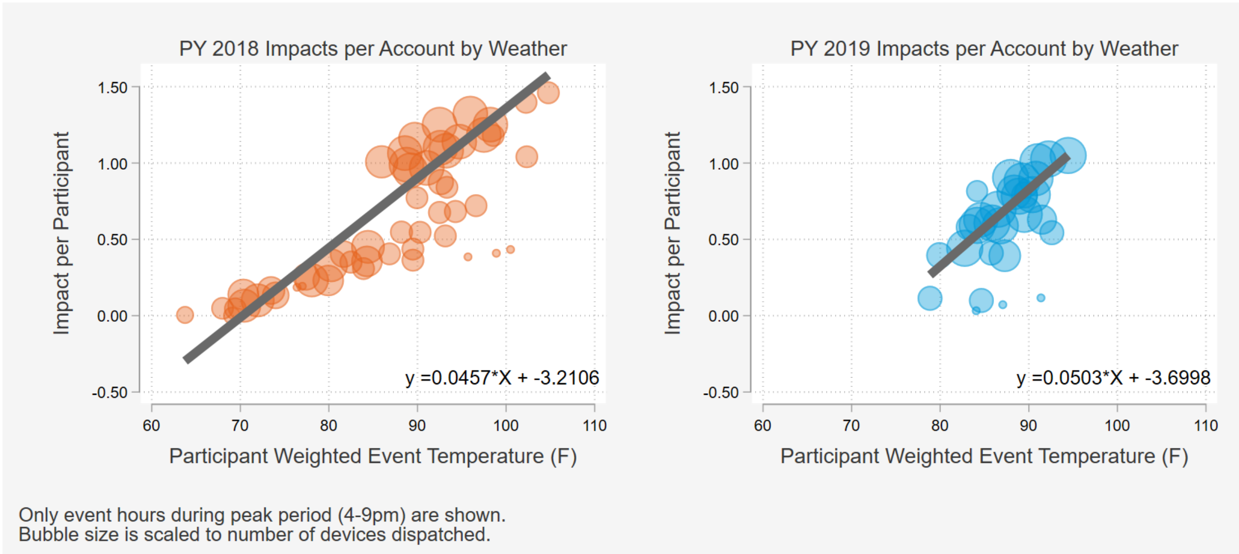
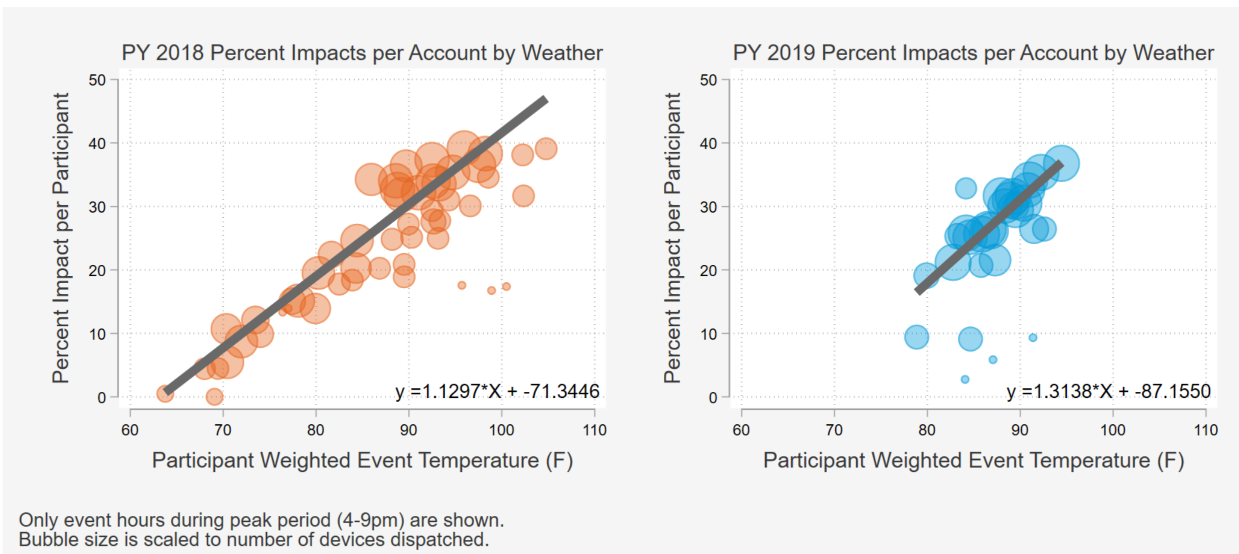


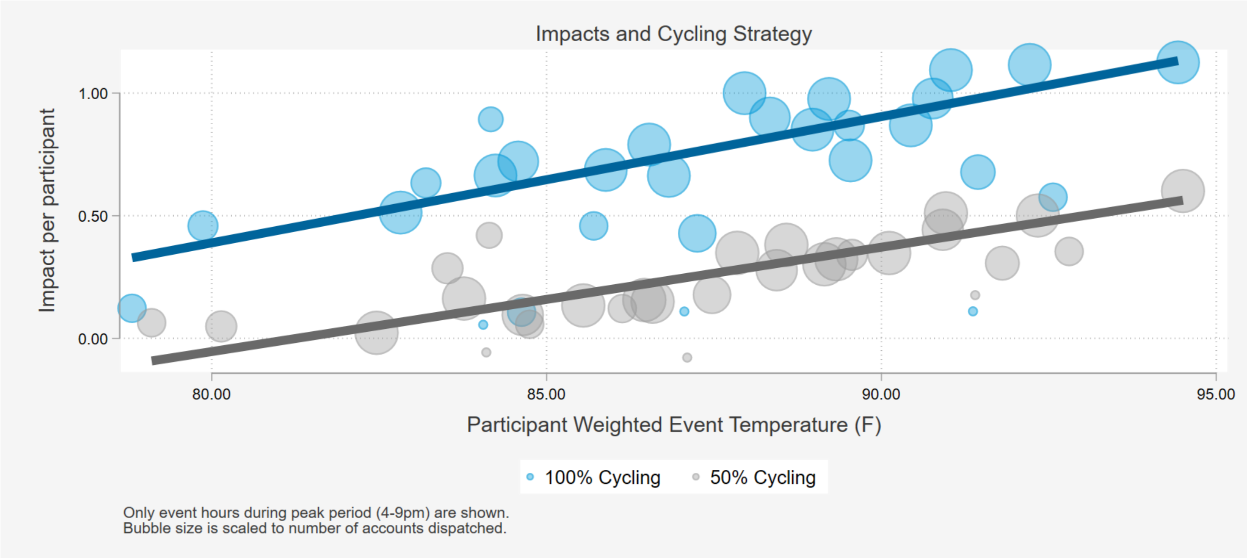
Figure 16: SDP-R Percent Reductions against Temperature, 2018-2019



3.5 IMPACTS BY CYCLING STRATEGY

Figure 17 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 – 0.050 in the 100% cycling group and 0.041 in the 50% cycling group. Recall that these slopes represent the expected increase in the impact for every one degree increase in temperature. Like in other figures, the size of the bubbles is proportional to the number of accounts in the DR event.

Figure 17: SDP-R Impacts by Cycling Strategy



3.6 IMPACTS FOR KEY CUSTOMER SEGMENTS

Table 7 shows the impacts of key customer segments for the average 2019 SDP-R event day. Because of the wide variation in event dispatch times and targeted dispatched, for purposes of this study, the three events that ran from 5:00-8:00 PM and were dispatched to all or nearly all of the territory are considered as the average event. Highlights include:

- On average, impacts in the 100% cycling strategy group are about three times larger than impacts in the 50% cycling strategy group;
- Percent impacts are similar across most load control groups with one notable exception – SDP-NW, which is along the coast;
- The largest average load impacts occurred in load control groups SDP-C-1 and SDP-C-4 at 0.93 kW and 0.92 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, 32.0%, for CARE/FERA homes. By comparison, non-low income homes reduced demand by 28.1%.

Table 7: SDP-R Impacts by Key Customer Segments, Average 2019 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%	29,462	2.69	2.43	0.26	9.6%	7.6
	100%	175,067	2.53	1.71	0.82	32.4%	143.1
Load Control Group	SDP-Central-1	39,245	2.87	1.94	0.93	32.4%	36.4
	SDP-Central-2	23,144	2.38	1.65	0.73	30.6%	16.9
	SDP-Central-3	10,722	2.84	2.14	0.70	24.8%	7.5
	SDP-Central-4	43,246	2.79	1.87	0.92	33.1%	39.9
	SDP-High Desert	13,556	2.38	1.61	0.77	32.2%	10.4
	SDP-Low Desert	261	3.07	2.48	0.59	19.3%	0.2
	SDP-North	26,952	2.79	2.05	0.74	26.5%	19.9
	SDP-Northwest	9,211	2.19	1.98	0.20	9.3%	1.9
	SDP-West-1	27,566	2.15	1.57	0.58	27.0%	16.0
	SDP-West-2	23,708	2.21	1.64	0.57	25.7%	13.5
Load Control Area	Big Creek/Ventura	36,295	2.63	2.03	0.60	22.8%	21.8
	LA Basin	154,548	2.54	1.78	0.77	30.1%	118.4
	Outside LA Basin	13,686	2.40	1.63	0.77	32.1%	10.5
CARE/FERA Status	Non-CARE/FERA	159,284	2.59	1.86	0.73	28.1%	115.8
	CARE/FERA	45,245	2.41	1.64	0.77	32.0%	34.9
Zone	South Orange County	17,171	1.95	1.43	0.52	26.8%	9.0
	South of Lugo	77,710	2.65	1.82	0.84	31.6%	65.2
	Remainder of System	109,649	2.57	1.87	0.70	27.2%	76.5
All Customers		**204,529**	**2.55**	**1.81**	**0.74**	**28.9%**	**150.7**

3.7 KEY FINDINGS

The SDP Residential (SDP-R) program has approximately 220,000 customers enrolled and includes nearly 260,000 control devices and nearly 950,000 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 increase by an average of 0.048 kW for each one-degree increase in outdoor temperature. Across 220,000 customers, this translates to 11 MW in incremental demand reductions for each one-degree increase in outdoor temperature.

For events before the official end of summer, average impacts were consistently greater than 0.50 kW per participant, and percent impacts were generally around 30%. For the events on September 24th and October 16th, impacts and percent impacts were lower, likely due to reduced cooling loads in the early fall.

A few other key findings are worth highlighting:

- During the system peak day (September 4, 2019), SDP-R participants reduced demand by an average of 189 MW between 5:00 PM and 8:00 PM. The demand reductions per customer, per device, and per ton for this event were 0.87 kW, 0.75 kW, and 0.20 kW respectively. Temperatures on the peak day reached 98 ˚F in downtown Los Angeles.
- On the average 2019 event day, the SDP-R program produced 150.7 MW of demand reductions.
- The per-participant demand reductions for customers signed up for the 100% cycling are more than three times larger than 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.
- At similar temperature conditions, 2018 and 2019 ex post percent impacts were very similar – 28.6% in 2018 and 28.1% in 2019.

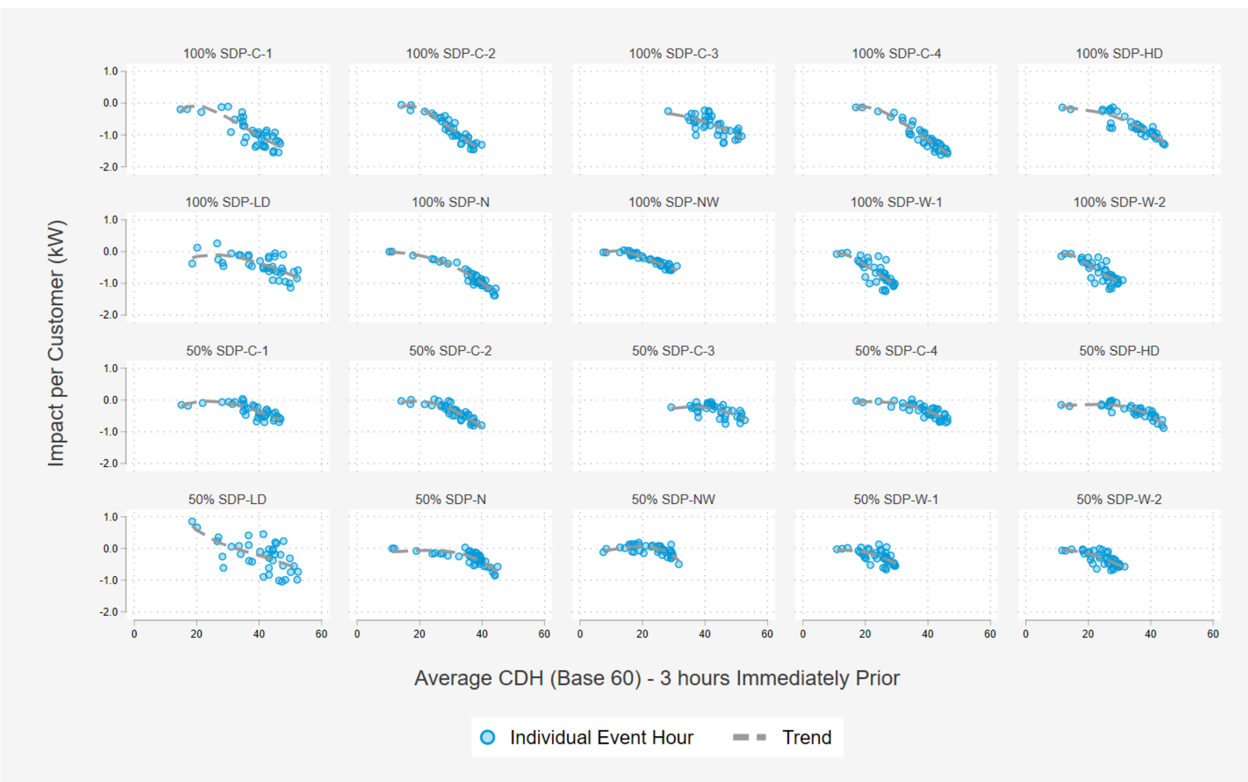
4 RESIDENTIAL EX ANTE RESULTS

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 two years of historical performance data (2018-2019) 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 2018 and 2019 for customers currently in the program. 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 18 shows the relationship between weather and demand reductions for each of the building blocks. Because the afternoon event on 9/24 does not fall in the peak window (4-9 PM), it was not included in the figure below or the ex ante modeling.

Figure 18: 2018-2019 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. 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 temperatures on the 3 hours immediately prior.

4.2 OVERALL RESULTS

For the monthly peak day, Table 8 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 2019 peak day was 0.87 kW, and the average impact per participant on the average 2019 event day was 0.74 kW.

Table 8: 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	0.20	0.67	0.23	0.67
June	0.37	0.94	0.36	0.96
July	0.71	1.14	0.70	0.85
August	0.80	0.95	0.80	0.90
September	0.82	0.99	0.85	0.96

Table 9 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). Per participant ex ante impacts are static through the forecast window as are the ex ante weather conditions.

Table 9: 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
2020	207,072	166	197	165	185
2021	187,929	150	179	150	168
2022	177,512	142	169	141	159
2023	169,151	135	161	135	151
2024	161,464	129	154	128	145
2025	154,381	124	147	123	138
2026	147,838	118	141	118	132
2027	141,778	113	135	113	127
2028	136,151	109	130	108	122
2029	130,908	105	125	104	117
2030	126,010	101	120	100	113

Figure 19 and Figure 20 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 19 shows profiles under 1-in-2 weather conditions, and Figure 20 shows profiles for 1-in-10.

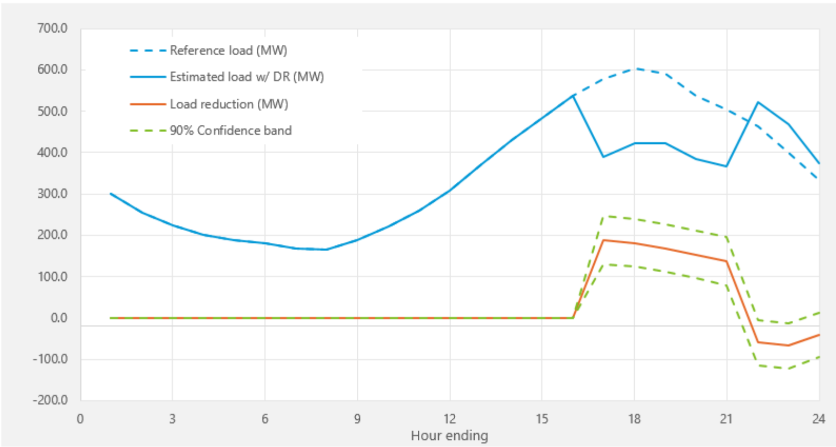
Figure 19: SDP-R Aggregate Ex Ante Impact for 1-in-2 Weather Conditions, August Peak Day

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	2020

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	207,072
Total devices	241,571
Total AC tonnage	880,868
Event window temperature (F)	91.4
Event window load reduction (MW)	165.67
% Load reduction (Event window)	29.4%



Hour ending	Reference load (MW)	Estimated load w/ DR (MW)	Load reduction (MW)	% Load reduction	Avg temp (F, site weighted)	Confidence Band		Std. error	T-statistic
						5th	95th		
1	301.34	301.34	0.00	0.0%	80.12	0.00	0.00	0.00	0.00
2	254.99	254.99	0.00	0.0%	78.73	0.00	0.00	0.00	0.00
3	223.96	223.96	0.00	0.0%	77.70	0.00	0.00	0.00	0.00
4	201.78	201.78	0.00	0.0%	76.67	0.00	0.00	0.00	0.00
5	187.21	187.21	0.00	0.0%	75.75	0.00	0.00	0.00	0.00
6	179.75	179.75	0.00	0.0%	75.10	0.00	0.00	0.00	0.00
7	168.55	168.55	0.00	0.0%	74.43	0.00	0.00	0.00	0.00
8	165.29	165.29	0.00	0.0%	74.34	0.00	0.00	0.00	0.00
9	188.39	188.39	0.00	0.0%	76.69	0.00	0.00	0.00	0.00
10	220.21	220.21	0.00	0.0%	81.14	0.00	0.00	0.00	0.00
11	258.57	258.57	0.00	0.0%	85.59	0.00	0.00	0.00	0.00
12	307.76	307.76	0.00	0.0%	89.26	0.00	0.00	0.00	0.00
13	369.16	369.16	0.00	0.0%	91.78	0.00	0.00	0.00	0.00
14	429.69	429.69	0.00	0.0%	93.99	0.00	0.00	0.00	0.00
15	483.54	483.54	0.00	0.0%	95.49	0.00	0.00	0.00	0.00
16	538.04	538.04	0.00	0.0%	95.60	0.00	0.00	0.00	0.00
17	578.74	390.52	188.22	32.5%	95.13	130.52	245.92	35.08	5.37
18	604.46	423.45	181.01	29.9%	93.48	123.36	238.66	35.05	5.16
19	591.33	422.60	168.73	28.5%	91.69	111.02	226.43	35.08	4.81
20	538.42	384.81	153.61	28.5%	90.04	95.76	211.47	35.17	4.37
21	504.37	367.61	136.76	27.1%	86.74	78.65	194.87	35.33	3.87
22	462.88	523.03	-60.14	-13.0%	83.50	-114.30	-5.99	32.93	-1.83
23	400.79	468.60	-67.81	-16.9%	81.29	-121.99	-13.62	32.94	-2.06
24	334.19	375.34	-41.15	-12.3%	79.59	-95.32	13.03	32.94	-1.25
Daily	Reference load (MWh)	Estimated load w/ DR (MWh)	Energy savings (MWh)	% Change	Avg. Daily Weighted temp (F)	Uncertainty adjusted impact - 5th	95th	Std. error	T-statistic
Daily kWh	8493.42	7834.19	659.23	8.4%	84.33	499.51	818.95	97.10	6.79

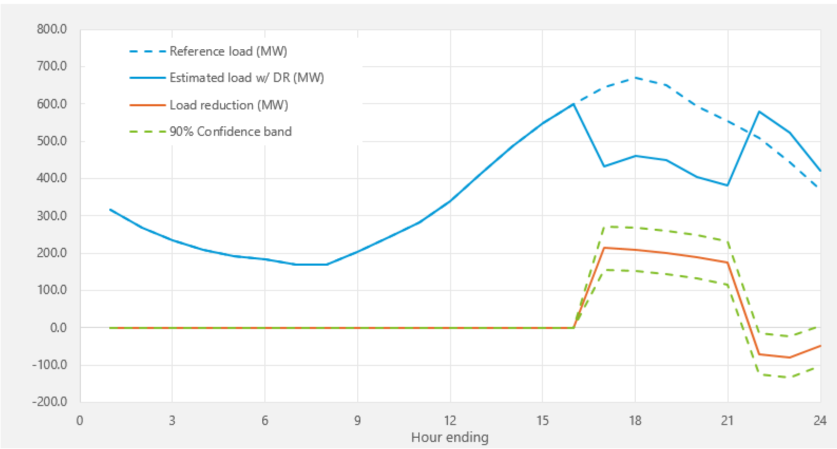
Figure 20: SDP-R Aggregate Ex Ante Impact for 1-in-10 Weather Conditions, August Peak Day

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	2020

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	207,072
Total devices	241,571
Total AC tonnage	880,868
Event window temperature (F)	96.4
Event window load reduction (MW)	197.33
% Load reduction (Event window)	31.7%



Hour ending	Reference load (MW)	Estimated load w/ DR (MW)	Load reduction (MW)	% Load reduction	Avg temp (F, site weighted)	Confidence Band		Std. error	T-statistic
						5th	95th		
1	316.83	316.83	0.00	0.0%	81.56	0.00	0.00	0.00	0.00
2	267.06	267.06	0.00	0.0%	80.01	0.00	0.00	0.00	0.00
3	233.11	233.11	0.00	0.0%	78.70	0.00	0.00	0.00	0.00
4	208.08	208.08	0.00	0.0%	77.29	0.00	0.00	0.00	0.00
5	191.95	191.95	0.00	0.0%	76.15	0.00	0.00	0.00	0.00
6	181.94	181.94	0.00	0.0%	75.22	0.00	0.00	0.00	0.00
7	167.82	167.82	0.00	0.0%	74.17	0.00	0.00	0.00	0.00
8	168.34	168.34	0.00	0.0%	74.16	0.00	0.00	0.00	0.00
9	203.05	203.05	0.00	0.0%	77.03	0.00	0.00	0.00	0.00
10	242.75	242.75	0.00	0.0%	82.44	0.00	0.00	0.00	0.00
11	283.31	283.31	0.00	0.0%	88.39	0.00	0.00	0.00	0.00
12	339.13	339.13	0.00	0.0%	92.69	0.00	0.00	0.00	0.00
13	412.86	412.86	0.00	0.0%	95.15	0.00	0.00	0.00	0.00
14	486.15	486.15	0.00	0.0%	97.00	0.00	0.00	0.00	0.00
15	547.06	547.06	0.00	0.0%	98.54	0.00	0.00	0.00	0.00
16	600.46	600.46	0.00	0.0%	99.64	0.00	0.00	0.00	0.00
17	644.95	431.18	213.77	33.1%	99.03	155.95	271.59	35.15	6.08
18	669.99	461.13	208.85	31.2%	98.86	151.00	266.70	35.17	5.94
19	651.19	450.13	201.07	30.9%	97.82	143.09	259.04	35.25	5.70
20	594.02	404.64	189.39	31.9%	94.97	131.22	247.55	35.36	5.36
21	554.05	380.47	173.58	31.3%	91.14	115.19	231.96	35.50	4.89
22	508.81	579.29	-70.48	-13.9%	87.84	-125.15	-15.81	33.24	-2.12
23	442.45	521.98	-79.52	-18.0%	85.26	-134.22	-24.82	33.26	-2.39
24	371.03	419.61	-48.58	-13.1%	83.60	-103.30	6.14	33.27	-1.46
Daily	Reference load (MWh)	Estimated load w/ DR (MWh)	Energy savings (MWh)	% Change	Avg. Daily Weighted temp (F)	Uncertainty adjusted impact - 5th	95th	Std. error	T-statistic
Daily kWh	9286.40	8498.33	788.07	9.3%	86.94	627.39	948.75	97.69	8.07

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 10 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 10: 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	0.54	1.23	1.13	0.40	0.99	0.91
SDP-Central-2	0.52	1.13	1.03	0.46	1.01	0.92
SDP-Central-3	0.45	0.87	0.81	0.36	0.74	0.69
SDP-Central-4	0.51	1.37	1.24	0.34	1.09	0.97
SDP-High Desert	0.46	0.89	0.86	0.34	0.70	0.67
SDP-Low Desert	0.52	0.73	0.70	0.42	0.61	0.58
SDP-North	0.36	0.90	0.82	0.33	0.82	0.75
SDP-Northwest	0.16	0.47	0.43	0.06	0.30	0.27
SDP-West-1	0.32	0.83	0.74	0.30	0.78	0.70
SDP-West-2	0.40	0.80	0.74	0.36	0.73	0.67
Average	**0.44**	**1.04**	**0.95**	**0.35**	**0.88**	**0.80**

4.4 COMPARISON TO PRIOR YEAR

Table 11 shows a comparison of 2018 and 2019 ex ante impacts for the two different weather scenarios. All impacts represent monthly peak impact estimates, and SCE weather conditions are used. In magnitude and direction, the 2018 and 2019 impacts are similar. Though not shown in the table, the confidence intervals for the 2018 results and 2019 results overlap, suggesting the differences are not statistically significant.

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

Table 11: Comparison of SDP-R Ex Ante Impacts

Month	2018 Ex Ante Impacts (kW)		2019 Ex Ante Impacts (kW)	
	1-in-2	1-in-10	1-in-2	1-in-10
June	0.55	0.77	0.37	0.94
July	0.72	0.91	0.71	1.14
August	0.85	0.99	0.80	0.95
September	0.69	0.95	0.82	0.99

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 are triggered by wholesale market price conditions in specific load pockets, the reductions do not always reflect the magnitude of resources available.

During the 2019 summer, three events – September 4th (system peak day) September 5th, and July 24th – included nearly all customers and were called under similar conditions as ex ante conditions. Participant impacts on these days provide a good point of comparison against the peak day ex ante impact estimates. Table 12 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. In practice, however, the ex ante load impacts were also informed by 2018 and 2019 historical event performance, and 2018 had several hotter event days.

Of course, it's also important to keep in mind that no 2019 SDP-R events were longer than three hours in duration. The event window for ex ante impacts is five hours in duration, which muddies the comparison between ex post and ex ante impacts (as does the weather-normalization).

[2] Like the prior evaluation, our ex post evaluation relied on a difference-in-differences framework. The 2018 ex post model relied mainly on pre-event load variables. The 2019 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 in the 2019 ex ante reference load approach was the inclusion of a temperature spline. This was included to capture the effect of temperature on load 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).

Table 12: 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	8:00-9:00 PM	8:00-9:00 PM
Aggregate Impacts MW	2019-07-24	217,619	253,991	98.6	85.1	228.48	223.51	192.05	-	-
	2019-09-04	217,516	253,681	98.6	85.0	-	219.55	196.99	151.79	-
	2019-09-05	178,310	206,344	93.9	83.9	-	160.36	144.25	112.19	-
	SCE Ex ante 1-in-10 August Peak Day	207,072	241,571	99.6	86.9	213.77	208.85	201.07	189.39	173.58
	SCE Ex ante 1-in-2 August Peak Day	207,072	241,571	95.6	84.3	188.22	181.01	168.73	153.61	136.76
Impacts per Account (kW)	2019-07-24	217,619	253,991	98.6	85.1	1.05	1.03	0.88	-	-
	2019-09-04	217,516	253,681	98.6	85.0	-	1.01	0.91	0.70	-
	2019-09-05	178,310	206,344	93.9	83.9	-	0.90	0.81	0.63	-
	SCE Ex ante 1-in-10 August Peak Day	207,072	241,571	99.6	86.9	1.03	1.01	0.97	0.91	0.84
	SCE Ex ante 1-in-2 August Peak Day	207,072	241,571	95.6	84.3	0.91	0.87	0.81	0.74	0.66
Impacts per Device	2019-07-24	217,619	253,991	98.6	85.1	0.90	0.88	0.76	-	-
	2019-09-04	217,516	253,681	98.6	85.0	-	0.87	0.78	0.60	-
	2019-09-05	178,310	206,344	93.9	83.9	-	0.78	0.70	0.54	-
	SCE Ex ante 1-in-10 August Peak Day	207,072	241,571	99.6	86.9	0.88	0.86	0.83	0.78	0.72
	SCE Ex ante 1-in-2 August Peak Day	207,072	241,571	95.6	84.3	0.78	0.75	0.70	0.64	0.57

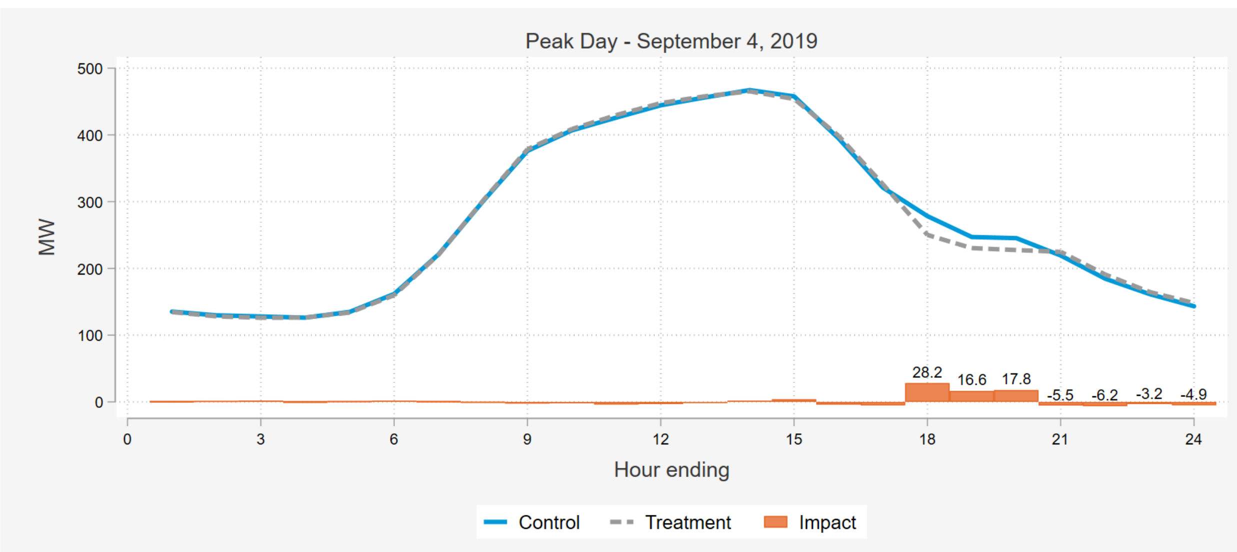
5 NON-RESIDENTIAL EX POST RESULTS

This section focuses on the magnitude of demand reductions delivered by SDP-C during 2019 event days and reflects the impacts delivered given the weather conditions, hours of dispatch, industry and participants mix, and amount of resources dispatched.

5.1 SYSTEM PEAK DAY REDUCTIONS

The system peak occurred on September 4th (21,961 MW during hour ending 4:00 PM). There was an SDP-C event dispatched on the system peak day from 5:00 PM through 8:00 PM due to wholesale market conditions. In total, 8,974 SDP-C accounts were curtailed. Figure 21 shows the hourly load profile for the control and participant groups for the system peak day. During the first event hour, the impact was approximately 28 MW. Across the three event hours, the average impact was nearly 21 MW, and the average percent impact was 8.0%. For commercial customers, AC usage represents a smaller share of load than for residential customers. Commercial AC loads and building occupancy tend to occur mid-day, with less load in the evening hours. In post-event hours, there was 19.9 MWh of snapback. Netting out the snapback, there was approximately 42.6 MWh in energy savings on the peak day.

Figure 21: SDP-C Reductions on System Peak Day



5.2 INDIVIDUAL EVENT DAY REDUCTIONS

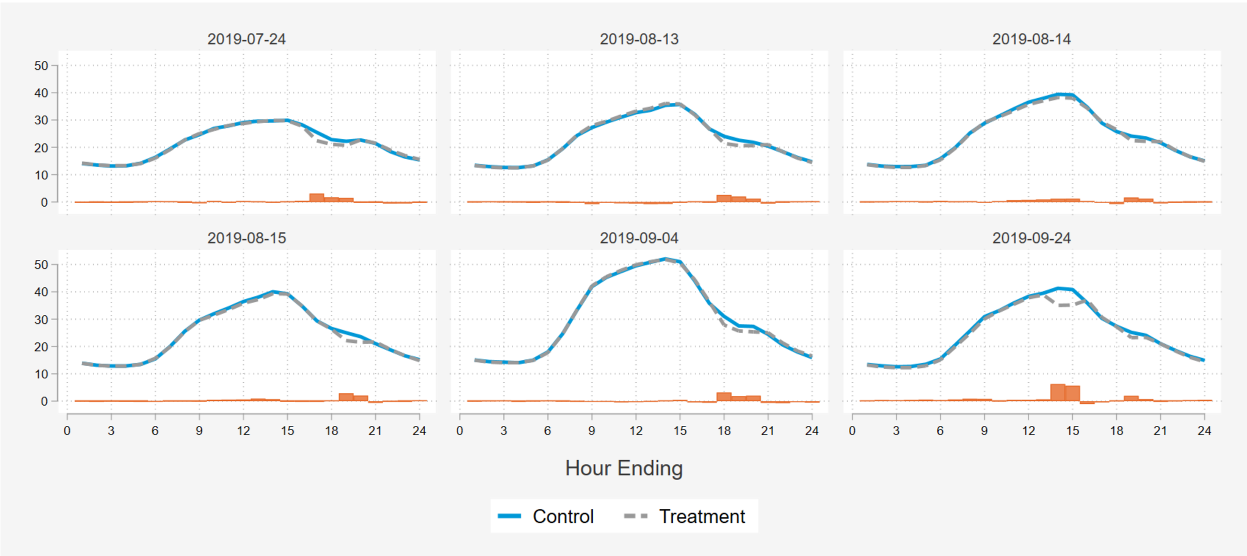
Table 13 shows reference loads, observed loads, impacts, and percent impacts for each of the fifteen SDP-C DR events during the 2019 summer. The table also shows performance metrics for the average event, which is defined as the average of the events on 8/13, 9/4, and 9/5. For the average event, the percent impact was 7.8%, the average aggregate hourly impact was 17.8 MW, and the average per-device impact was 0.23 kW. Ignoring the October events, percent impacts for the 2019 SDP-C events ranged from about 6% to about 19%.

Table 13: SDP-C Event Results, 2019

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		
7/24	All	4:00 PM	7:00 PM	9,026	212.4	193.4	18.9	12.5	25.3	2.09	0.23	0.05	8.90	92.3
8/13	All	5:00 PM	8:00 PM	9,007	205.7	188.4	17.3	12.4	22.2	1.92	0.21	0.04	8.41	85.2
8/14	C-1, C-2, C-3, C-4, N, W-1, W-2, HD, NW	6:00 PM	8:00 PM	8,988	213.7	200.9	12.8	5.9	19.7	1.42	0.16	0.03	5.98	87.6
8/15	C-1, C-2, C-3, C-4, N, W-1, W-2, HD, NW	6:00 PM	8:00 PM	8,989	218.4	196.5	21.9	9.5	34.2	2.43	0.27	0.05	10.02	85.8
9/4	All	5:00 PM	8:00 PM	8,974	257.0	236.1	20.9	11.9	29.8	2.33	0.26	0.05	8.12	88.4
9/5	C-2, C-3, C-4, N, W-1, W-2, HD, LD, NW	5:00 PM	8:00 PM	8,105	224.2	209.0	15.2	8.5	22.0	1.88	0.22	0.04	6.79	88.5
9/6	C-2	6:00 PM	7:00 PM	1,042	23.9	19.3	4.6	2.6	6.5	4.38	0.73	0.14	19.14	86.7
9/6	W-1, W-2	6:00 PM	8:00 PM	3,472	80.1	74.5	5.6	1.5	9.7	1.62	0.21	0.05	7.01	82.9
9/6	C-3, C-4	7:00 PM	8:00 PM	1,619	38.9	33.4	5.5	2.0	9.1	3.40	0.36	0.07	14.16	92.5
9/13	C-1, N, HD, LD, NW	6:00 PM	7:00 PM	2,832	84.7	72.9	11.8	6.1	17.4	4.15	0.36	0.07	13.89	92.4
9/24	All	1:00 PM	3:00 PM	8,936	364.8	321.2	43.6	34.7	52.6	4.88	0.54	0.11	11.96	85.1
9/24	C-2, C-3, C-4, N, HD, NW	6:00 PM	7:00 PM	4,597	115.7	102.8	12.9	7.4	18.3	2.80	0.30	0.06	11.13	88.5
9/24	C-1, LD	6:00 PM	8:00 PM	881	24.7	22.6	2.0	0.0	4.1	2.32	0.18	0.03	8.28	94.1
10/16	C-1	5:00 PM	7:00 PM	863	23.6	23.6	0.0	-3.4	3.4	0.03	0.00	0.00	0.12	86.7
10/16	LD	5:00 PM	8:00 PM	[redacted]										
Avg. Event		**5:00 PM**	**8:00 PM**	**8,695**	**229.2**	**211.4**	**17.8**	**13.9**	**21.6**	**2.04**	**0.23**	**0.05**	**7.76%**	**87.3**

Figure 22 shows aggregate reference loads, observed loads, impacts for the four territory-wide events (7/24, 8/13, 9/4, 9/24) and two others that were dispatched for nearly the full territory (8/14 and 9/5). The counterfactual is visually lower in the earlier events – this can be attributed to the school season, which ramps back up in mid-August. (Recall that a majority of the SDP-C participant tonnage is in schools.) The largest impact occurred during one of the 9/24 events – specifically, the early afternoon event (1:00 – 3:00 PM) – which is coincident with when SDP-C loads peak.

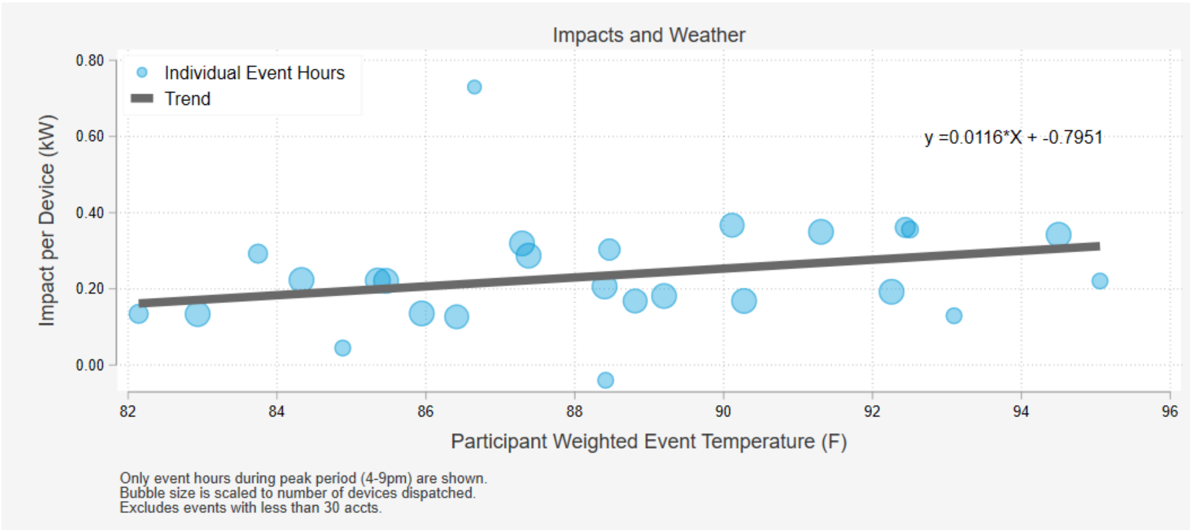
Figure 22: SDP-C Reductions on Select Event Days



5.3 WEATHER SENSITIVITY OF LOAD IMPACTS

The relationship between SDP-C demand reductions and outdoor air temperature is visualized in Figure 23 and includes all hours in the peak period, from 4-9 PM. Due to the large variability in customer size, the plot shows the impact per device. The plot excludes the September 24 event (1-3 PM), even though the SDP-C delivered the largest impacts on that day. It is outside of the 4-9 PM peak window, and the relationship between air conditioner load, impacts, and weather varies based occupancy and hour of the day. 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 0.0116 per degree. This implies that each one-degree increase in temperature is associated with a 0.0116 kW increase in the per-device demand reduction.

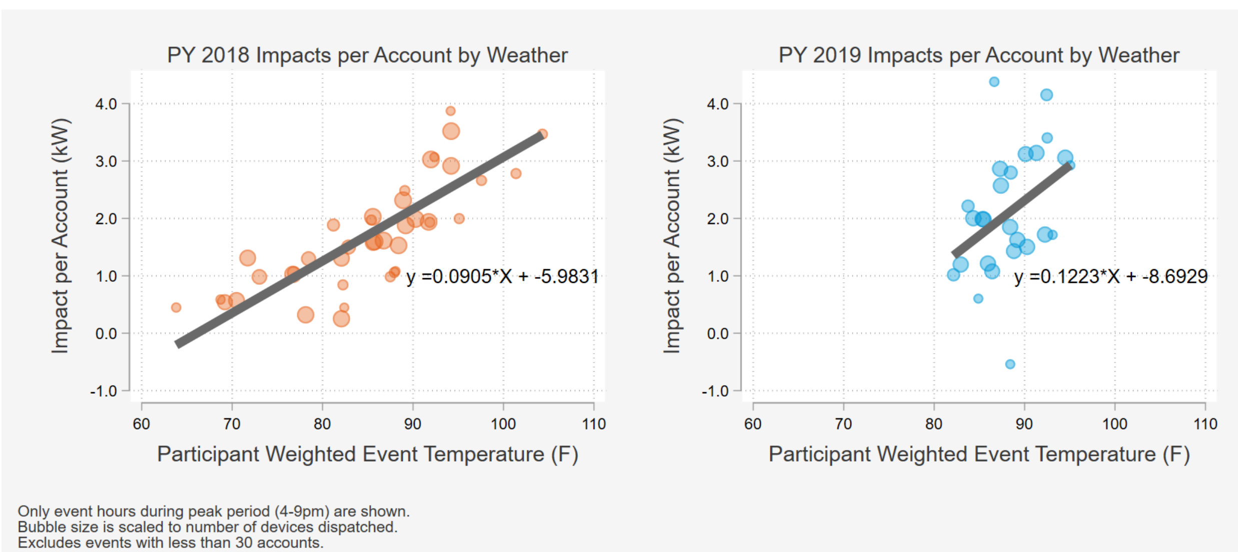
Figure 23: Relationship between SDP-C Demand Reductions and Weather



5.4 COMPARISON TO PRIOR YEAR

Figure 24 shows the relationship between SDP-C reductions and outdoor temperature for 2018 and 2019. Other SDP-C figures summarize impacts at the device level, but this figure summarizes impacts at the participant level as per device impacts were not in the 2018 ex post data set.

Figure 24: SDP-C Reductions against Temperature, 2018-2019



The key takeaways are similar to the SDP-R takeaways:

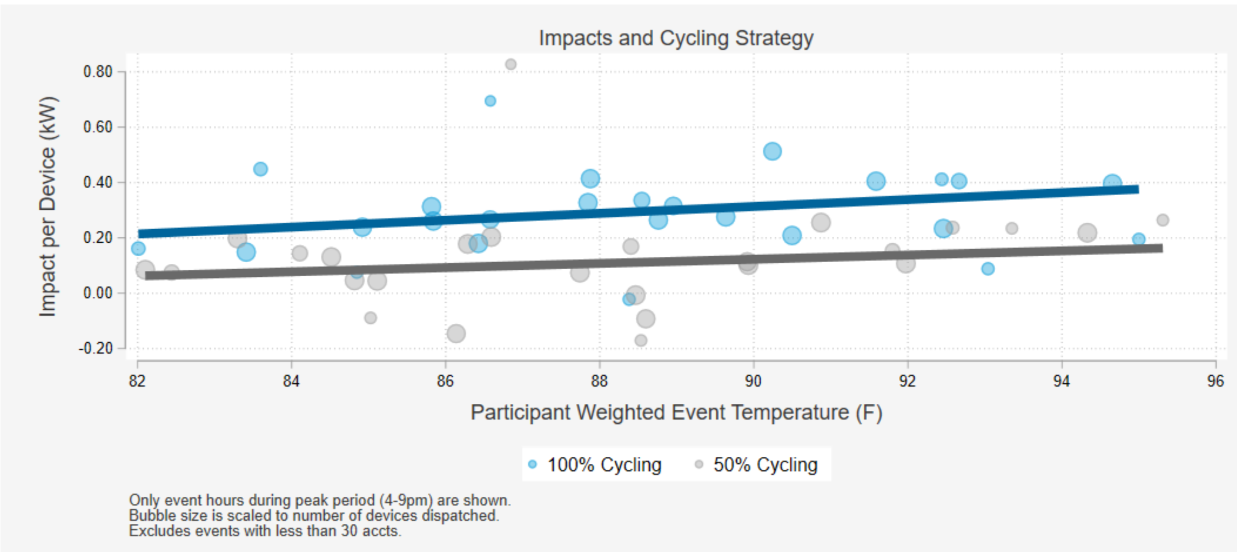
- There were considerably more events in 2018.
- There was a broader range in temperature conditions during 2018 SDP-C DR events.
- The relationship between load impacts and weather (represented by the trend lines) was stronger in 2019 than in 2018. The slope was 0.09 in 2019 and 0.12 in 2018. (Recall that these

slopes represent the expected increase in the per-participant reduction for every one-degree increase in temperature.) The confidence intervals for these two slope values overlap, so we cannot conclude that there is a statistically significant difference between the 2018 and 2019 slopes.

5.5 IMPACTS BY CYCLING STRATEGY

Figure 25 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 4% 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 hotter temperatures.

Figure 25: SDP-C Impacts by Cycling Strategy



5.6 IMPACTS FOR KEY CUSTOMER SEGMENTS

Table 14 shows per-device impacts by key customer segments for the average 2019 SDP-C event day. Highlights include:

- On average, [redacted];
- [redacted];
- Schools account for more than half of the aggregate demand reductions on the average event day and drive the results for SDP-C;
- Percent impacts are larger for customers with more air conditioner tonnage, but per-device impacts are lower.

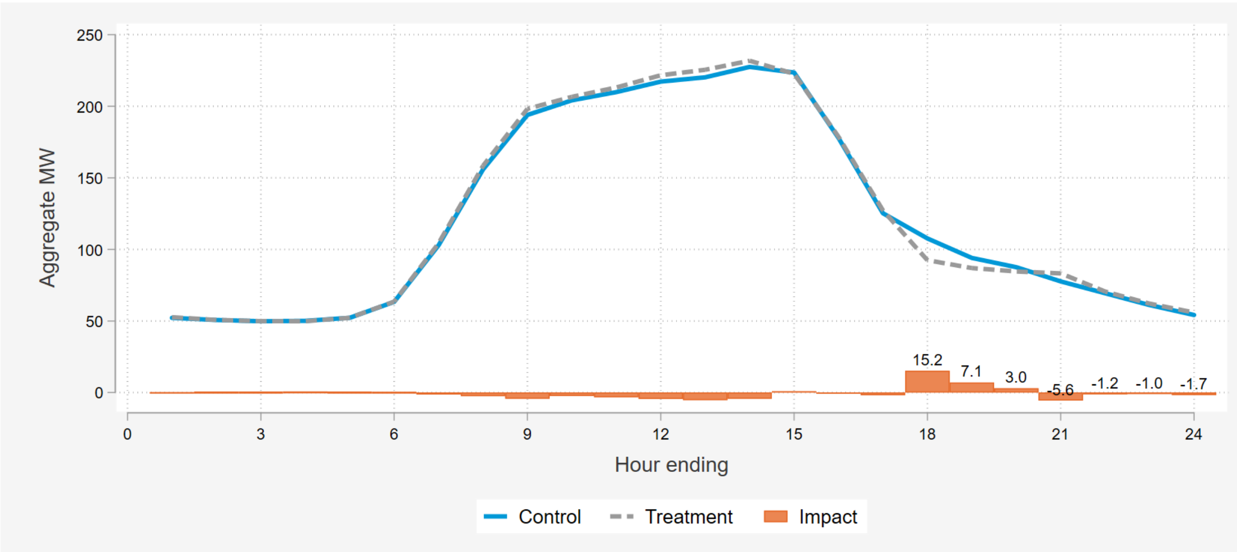
Table 14: SDP-C Impacts by Key Customer Segments, Average 2019 Event Day

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%	5,663	44,814	231,568	127.6	113.7	13.9	10.92%	0.31
Load Control Group	SDP-Central-1	866	11,650	61,796	26.1	24.6	1.5	5.69%	0.13
	SDP-Central-2	1,042	6,251	31,587	22.5	20.0	2.5	11.06%	0.40
	SDP-Central-3	219	753	4,282	3.2	3.0	0.2	6.46%	0.28
	SDP-Central-4	1,404	14,734	77,549	40.0	34.5	5.5	13.81%	0.37
	SDP-High Desert	[redacted]							
	SDP-Low Desert	[redacted]							
	SDP-North	[redacted]							
	SDP-Northwest	615	5,226	26,631	14.0	13.4	0.6	4.16%	0.11
	SDP-West-1	1,266	9,286	45,499	29.4	28.8	0.6	1.92%	0.06
	SDP-West-2	2,212	17,030	78,854	53.1	51.1	2.1	3.92%	0.12
Load Control Area	Big Creek/Ventura	[redacted]							
	LA Basin	6,721	55,820	278,969	169.0	157.8	11.2	6.60%	0.20
	Outside LA Basin	[redacted]							
Zone	South Orange County	800	5,419	27,116	19.0	18.6	0.3	1.82%	0.06
	South of Lugo	2,820	26,184	136,443	77.2	69.1	8.1	10.53%	0.31
	Remainder of System	5,075	45,153	222,287	132.1	122.2	9.9	7.50%	0.22

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	2,078	3,974	17,138	19.5	17.8	1.7	8.84%	0.43
	Retail Stores	1,433	2,679	14,041	33.1	31.5	1.6	4.81%	0.59
	Schools	1,723	51,631	257,427	96.4	88.0	8.4	8.72%	0.16
	Wholesale, Transport, Other Utilities	723	2,119	9,979	10.8	10.1	0.7	6.76%	0.35
	Unknown/Other	[redacted]							
	Religious organizations	1,178	7,954	46,801	14.2	12.3	1.9	13.31%	0.24
Tonnage Bin	3 or less	1,234	1,238	3,031	6.1	5.6	0.4	6.95%	0.34
	3 to 4	1,075	1,104	3,710	6.9	6.4	0.4	6.39%	0.40
	4 to 5	739	835	3,310	5.3	5.0	0.3	5.30%	0.33
	5 to 10	1,746	2,954	12,103	23.6	22.6	1.1	4.60%	0.37
	10-100	[redacted]							
	100-500	1,048	40,169	203,980	66.8	58.8	8.0	11.91%	0.20
	500+	[redacted]							
All Customers		**8,695**	**76,757**	**385,846**	**229.2**	**211.4**	**17.8**	**7.76%**	**0.23**

Aggregate demand reductions for schools on the average 2019 event day are shown in Figure 26. Note that aggregate demand peaks four hours before the average event starts at about 225 MW. By the time the average event begins, the aggregate counterfactual load is approximately 100 MW – much closer to the overnight baseline of 50 MW than the peak. As has been discussed, cooling loads in schools are higher earlier in the day, as are occupancy levels. Per-device impacts in schools – and other industries, too – are constrained by occupancy patterns.

Figure 26: Average Aggregate Demand Reductions for Schools, Average 2019 Event Day



5.7 KEY FINDINGS

The SDP Commercial (SDP-C) program has approximately 9,000 customers enrolled and includes over 80,000 control devices and over 400,000 tons of air conditioner load. Approximately 65% of customers, accounting for 60% of the total SDP-C tons of air conditioner load, elect the higher incentive option, which allows SCE to fully curtail air conditioner demand (100% cycling) during SDP-C DR events. During normal peaking conditions (1-in-2 weather conditions), participant loads peak around 480 MW, and participants can curtail demand by 21 MW during the 4-9 PM peak window. During extreme planning conditions (1-in-10 weather conditions), participant loads peak at 500 MW, and participants can reduce demand by 24 MW during the 4-9 PM peak window

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 0.25 kW with a few exceptions. The most notable exception is the early afternoon event on September 24th. The timing of this event better aligned with when SDP-C cooling loads are peaking, so the per-device impacts were higher, 0.54 kW.

A few other key findings are worth highlighting:

- During the system peak day (September 4, 2019), SDP-C participants reduced demand by an average of 20.9 MW between 5:00 PM and 8:00 PM. The demand reductions per customer, per device, and per ton for this event were 2.33 kW, 0.26 kW, and 0.05 kW respectively. Temperatures on the peak day reached 98˚F in downtown Los Angeles.

- On the average 2019 event day, we estimate the SDP-C program produced 17.8 MW of demand reductions.
- 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.
- Overall, the reductions per account in 2018 and 2019 were similar, after accounting for weather differences. However, more events and hotter weather conditioned were experienced in 2018.

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.

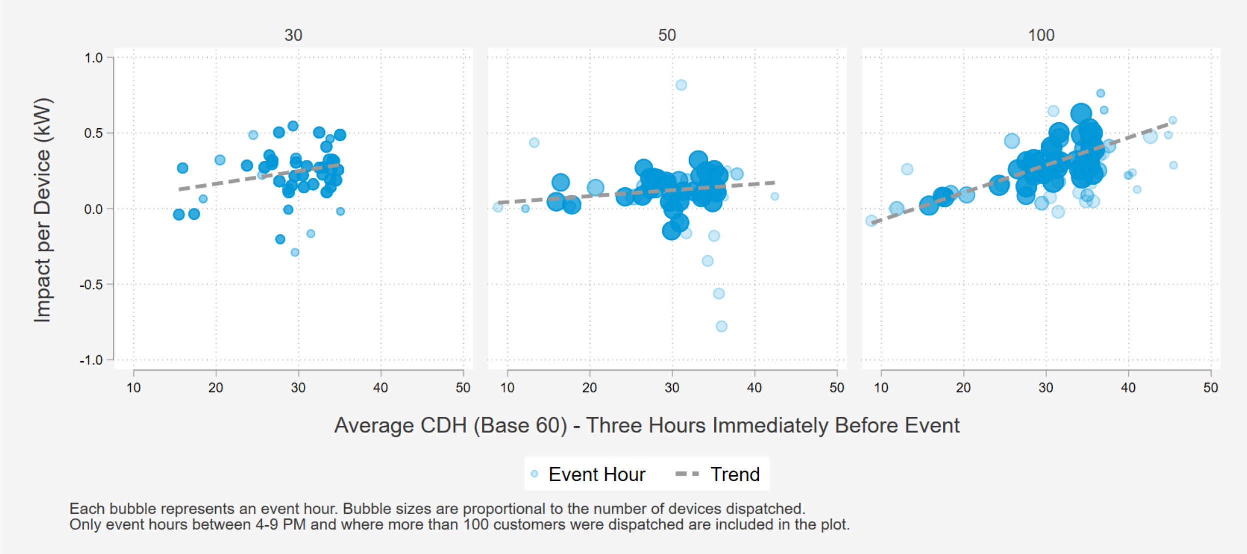
6.1 DEVELOPMENT OF EX ANTE IMPACTS

The ex ante impacts were developed by estimating the relationship between weather and demand reductions during 2018 and 2019 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 27 shows the relationship between weather and demand reductions for the three cycling strategies across the two years. Along with cycling strategy, the key variable used in the ex ante impact model was average cooling degree hours (CDH) in the three hours before the event hour. Figure 27 shows the trend between impacts (per device) and the CDH variable for the three cycling strategies.

Figure 27: Impacts against CDH60 by Cycling Strategy



The pattern of reductions across events and segments was analyzed using a multivariate regression model. Appendix E includes the output from the model. Because the last hour of the RA window (hour ending 21) was not an event hour in 2018 or 2019, we assumed percent impacts in that hour would equal percent impacts in the prior hour (within 30 unique load control and cycling strategy groups).

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 temperatures during the three hours immediately prior.

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.

6.2 OVERALL RESULTS

For the monthly peak day, Table 15 shows average device-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 higher 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 2019 peak day was 0.26 kW, and the average impact per device on the average 2019 event day was 0.23 kW. These values are slightly below the ex ante impacts for July-September, but this makes sense as 2019 was a mild temperature year.

Table 15: 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	0.19	0.28	0.19	0.28
June	0.20	0.31	0.20	0.32
July	0.26	0.37	0.26	0.28
August	0.27	0.30	0.26	0.30
September	0.28	0.32	0.28	0.31

Table 16 shows aggregate ex ante demand reduction forecasts for an August peak event day. Forecasts are shown under the four scenarios identified above. The demand reductions decrease throughout the forecast due to the projected decline in the enrollment forecast. Per device ex ante impacts are static through the forecast window as are the ex ante weather conditions.

Table 16: 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
2020	8,092	78,738	20.9	23.9	20.8	23.7
2021	7,182	69,883	18.6	21.2	18.5	21.0
2022	6,376	62,041	16.5	18.8	16.4	18.7
2023	5,667	55,142	14.6	16.7	14.6	16.6
2024	5,043	49,070	13.0	14.9	13.0	14.8

Forecast Year	Enrollment Forecast	Total Devices	SCE		CAISO	
			1-in-2	1-in-10	1-in-2	1-in-10
2025	4,493	43,718	11.6	13.3	11.5	13.2
2026	4,008	38,999	10.4	11.8	10.3	11.7
2027	3,580	34,835	9.2	10.6	9.2	10.5
2028	3,201	31,147	8.3	9.4	8.2	9.4
2029	2,866	27,887	7.4	8.5	7.4	8.4
2030	2,569	24,997	6.6	7.6	6.6	7.5

Figure 28 and Figure 29 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 28 shows profiles under 1-in-2 weather conditions, and Figure 29 shows profiles for 1-in-10.

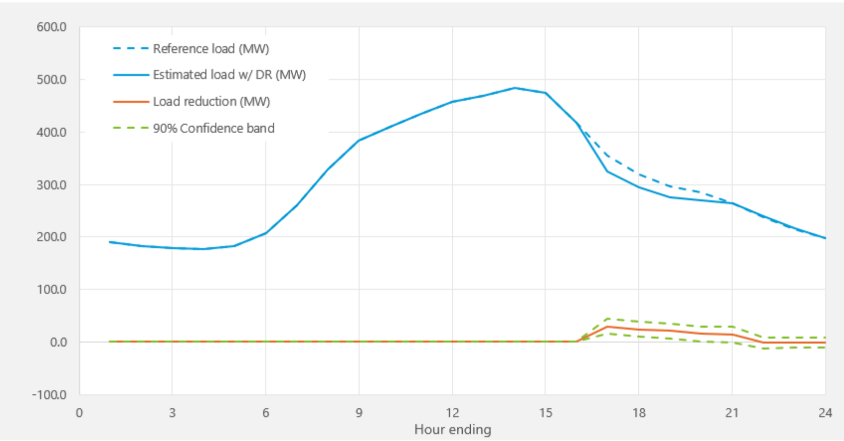
Figure 28: SDP-C Aggregate Ex Ante Impact for 1-in-2 Weather Conditions, August Peak Day

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	2020

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	8,092
Total devices	78,738
Total AC tonnage	397,372
Event window temperature (F)	89.1
Event window load reduction (MW)	20.90
% Load reduction (Event window)	6.9%



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	189.63	189.63	0.00	0.0%	77.74	0.00	0.00	0.00	0.00
2	182.52	182.52	0.00	0.0%	76.60	0.00	0.00	0.00	0.00
3	178.30	178.30	0.00	0.0%	75.68	0.00	0.00	0.00	0.00
4	177.37	177.37	0.00	0.0%	74.74	0.00	0.00	0.00	0.00
5	183.26	183.26	0.00	0.0%	74.03	0.00	0.00	0.00	0.00
6	208.04	208.04	0.00	0.0%	73.48	0.00	0.00	0.00	0.00
7	259.98	259.98	0.00	0.0%	72.88	0.00	0.00	0.00	0.00
8	328.70	328.70	0.00	0.0%	72.91	0.00	0.00	0.00	0.00
9	383.35	383.35	0.00	0.0%	75.12	0.00	0.00	0.00	0.00
10	410.42	410.42	0.00	0.0%	79.24	0.00	0.00	0.00	0.00
11	434.04	434.04	0.00	0.0%	83.44	0.00	0.00	0.00	0.00
12	457.11	457.11	0.00	0.0%	86.95	0.00	0.00	0.00	0.00
13	469.36	469.36	0.00	0.0%	89.40	0.00	0.00	0.00	0.00
14	483.46	483.46	0.00	0.0%	91.49	0.00	0.00	0.00	0.00
15	474.93	474.93	0.00	0.0%	92.86	0.00	0.00	0.00	0.00
16	418.50	418.50	0.00	0.0%	92.88	0.00	0.00	0.00	0.00
17	354.36	324.29	30.07	8.5%	92.34	15.55	44.59	8.83	3.41
18	319.11	295.07	24.05	7.5%	91.05	9.73	38.37	8.71	2.76
19	297.37	276.30	21.07	7.1%	89.64	6.80	35.34	8.67	2.43
20	285.43	269.99	15.44	5.4%	87.81	1.17	29.72	8.68	1.78
21	265.03	265.03	13.90	5.2%	84.47	-0.61	28.41	8.82	1.58
22	238.47	240.38	-1.91	-0.8%	81.16	-11.78	7.96	6.00	-0.32
23	215.50	216.09	-0.59	-0.3%	79.07	-10.46	9.28	6.00	-0.10
24	197.48	198.02	-0.54	-0.3%	77.48	-10.41	9.33	6.00	-0.09
Daily	**Reference load (MWh)**	**Estimated load w/ DR (MWh)**	**Energy savings (MWh)**	**% Change**	**Avg. Daily Weighted temp (F)**	**Uncertainty adjusted impact - 5th**	**95th**	**Std. error**	**T-statistic**
Daily kWh	7411.71	7324.13	101.48	1.4%	82.19	65.07	137.90	22.14	4.58

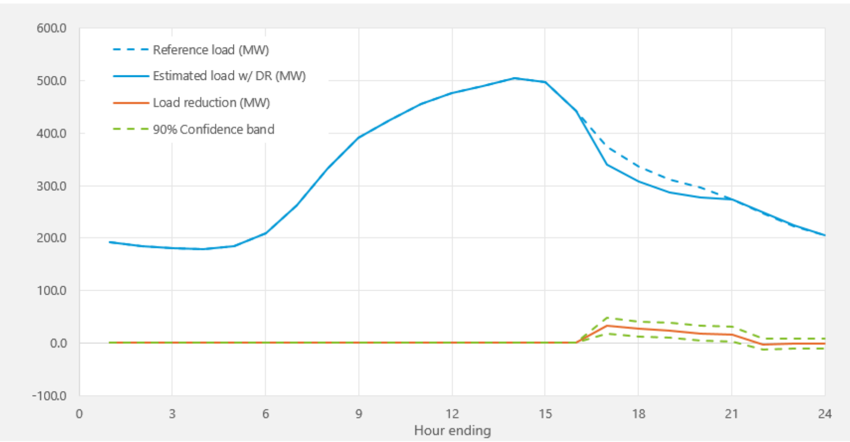
Figure 29: SDP-C Aggregate Ex Ante Impact for 1-in-10 Weather Conditions, August Peak Day

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	2020

Table 2: Event day information

Event start	4:00 PM
Event end	9:00 PM
Total sites	8,092
Total devices	78,738
Total AC tonnage	397,372
Event window temperature (F)	93.3
Event window load reduction (MW)	23.88
% Load reduction (Event window)	7.5%



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	191.68	191.68	0.00	0.0%	79.02	0.00	0.00	0.00	0.00
2	184.74	184.74	0.00	0.0%	77.73	0.00	0.00	0.00	0.00
3	180.32	180.32	0.00	0.0%	76.55	0.00	0.00	0.00	0.00
4	178.91	178.91	0.00	0.0%	75.35	0.00	0.00	0.00	0.00
5	184.60	184.60	0.00	0.0%	74.33	0.00	0.00	0.00	0.00
6	209.13	209.13	0.00	0.0%	73.57	0.00	0.00	0.00	0.00
7	261.68	261.68	0.00	0.0%	72.78	0.00	0.00	0.00	0.00
8	332.67	332.67	0.00	0.0%	72.79	0.00	0.00	0.00	0.00
9	390.90	390.90	0.00	0.0%	75.42	0.00	0.00	0.00	0.00
10	425.93	425.93	0.00	0.0%	80.46	0.00	0.00	0.00	0.00
11	455.23	455.23	0.00	0.0%	86.08	0.00	0.00	0.00	0.00
12	476.82	476.82	0.00	0.0%	89.71	0.00	0.00	0.00	0.00
13	489.28	489.28	0.00	0.0%	91.48	0.00	0.00	0.00	0.00
14	504.70	504.70	0.00	0.0%	93.13	0.00	0.00	0.00	0.00
15	498.22	498.22	0.00	0.0%	94.66	0.00	0.00	0.00	0.00
16	441.78	441.78	0.00	0.0%	96.08	0.00	0.00	0.00	0.00
17	373.96	340.87	33.09	8.8%	96.29	18.48	47.71	8.89	3.72
18	335.71	308.76	26.95	8.0%	95.79	12.58	41.32	8.74	3.09
19	310.75	286.44	24.32	7.8%	94.54	10.01	38.63	8.70	2.80
20	296.04	277.59	18.45	6.2%	91.74	4.12	32.77	8.71	2.12
21	274.17	274.17	16.58	6.0%	88.15	2.08	31.09	8.82	1.88
22	246.55	248.77	-2.22	-0.9%	84.96	-12.10	7.66	6.01	-0.37
23	223.02	223.71	-0.69	-0.3%	82.58	-10.57	9.20	6.01	-0.11
24	204.62	205.26	-0.64	-0.3%	81.08	-10.52	9.25	6.01	-0.11
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	7671.39	7572.13	115.85	1.5%	84.34	79.33	152.37	22.20	5.22

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 17 shows ex ante impact estimates (per device) 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). [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 17: 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]		0.41	0.35	[redacted]		0.49	0.42
SDP-Central-2	[redacted]		0.34	0.29	[redacted]		0.38	0.31
SDP-Central-3	[redacted]		0.44	0.38	[redacted]		0.49	0.43
SDP-Central-4	[redacted]		0.41	0.34	[redacted]		0.49	0.41
SDP-High Desert	[redacted]							
SDP-Low Desert	[redacted]							
SDP-North	[redacted]							
SDP-Northwest	[redacted]		0.22	0.18	[redacted]		0.26	0.21
SDP-West-1	[redacted]		0.26	0.21	[redacted]		0.28	0.22
SDP-West-2	[redacted]		0.25	0.20	[redacted]		0.27	0.22
Average	[redacted]		**0.33**	**0.27**	[redacted]		**0.37**	**0.31**

6.4 COMPARISON TO PRIOR YEAR

Table 18 shows a comparison of 2018 and 2019 ex ante impacts for the two different weather scenarios. The impacts are shown at the participant level rather than at the device level because the 2018 ex ante tables did not include per device impacts. All impacts represent monthly peak impact estimates, and SCE weather conditions are used. In magnitude, the 2019 impacts are larger. Though not shown in the table, the confidence intervals for the 2018 results and 2019 results overlap, suggesting the differences are not statistically significant.

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 18: Comparison of SDP-C Ex Ante Impacts

Month	2018 Ex Ante Impacts (kW)		2019 Ex Ante Impacts (kW)	
	1-in-2	1-in-10	1-in-2	1-in-10
June	1.40	1.75	1.90	2.99
July	1.67	1.99	2.56	3.56
August	1.93	2.13	2.58	2.95
September	1.66	2.12	2.76	3.12

6.5 EX POST TO EX ANTE COMPARISON

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

During the 2019 summer, three events – September 4th (system peak day) September 5th, and July 24th – included nearly all customers and were called under similar conditions as ex ante conditions. Participant impacts on these days provide a good point of comparison against the peak day ex ante impact estimates. Table 19 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. In practice, however, the ex ante load impacts were also informed by 2018 and 2019 historical event performance, and 2018 had several hotter event days.

None of the 2019 SDP-C events were longer than three hours in duration, and none of the events included dispatch for the 8:00-9:00 PM hours. Thus, producing ex ante impact estimates required extending the ex post impacts to an event duration that was not experienced and applying the assumption that impacts for the 8:00-9:00 PM hour are similar, on a percentage basis, to impacts experienced in the 7:00-8:00 PM hour.

Table 19: 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	8:00-9:00 PM	8:00-9:00 PM
Aggregate Impacts MW	2019-07-24	9,026	80,723	96.2	83.2	27.61	15.53	13.58	-	-
	2019-09-04	8,974	80,614	95.9	83.2	-	28.19	16.61	17.80	-
	2019-09-05	8,105	68,970	91.7	82.3	-	25.31	11.60	8.74	-
	SCE Ex ante 1-in-10 August Peak Day	8,092	78,738	96.3	84.3	33.09	26.95	24.32	18.45	16.58
	SCE Ex ante 1-in-2 August Peak Day	8,092	78,738	92.9	82.2	30.07	24.05	21.07	15.44	13.90
Impacts per Account (kW)	2019-07-24	9,026	80,723	96.2	83.2	3.06	1.72	1.50	-	-
	2019-09-04	8,974	80,614	95.9	83.2	-	3.14	1.85	1.98	-
	2019-09-05	8,105	68,970	91.7	82.3	-	3.12	1.43	1.08	-
	SCE Ex ante 1-in-10 August Peak Day	8,092	78,738	96.3	84.3	4.09	3.33	3.01	2.28	2.05
	SCE Ex ante 1-in-2 August Peak Day	8,092	78,738	92.9	82.2	3.72	2.97	2.60	1.91	1.72
Impacts per Device	2019-07-24	9,026	80,723	96.2	83.2	0.34	0.19	0.17	-	-
	2019-09-04	8,974	80,614	95.9	83.2	-	0.35	0.21	0.22	-
	2019-09-05	8,105	68,970	91.7	82.3	-	0.37	0.17	0.13	-
	SCE Ex ante 1-in-10 August Peak Day	8,092	78,738	96.3	84.3	0.42	0.34	0.31	0.23	0.21
	SCE Ex ante 1-in-2 August Peak Day	8,092	78,738	92.9	82.2	0.38	0.31	0.27	0.20	0.18

7 RECOMMENDATIONS

The Summer Discount Program remains a significant component of the SCE Demand Response portfolio. It currently includes roughly 220,000 residential customers, 9,000 non-residential customers, approximately 340,000 air conditioner units, and over 1.3 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. However, the magnitude of SDP resources has been declining and will continue to do so as resources shift from load control devices to smart thermostats.

Based on the 2019 ex post and ex ante load impact evaluation results, we recommend the following:

- We recommend developing estimates of peak period (4-9 PM) weather sensitivity for each participant using all summer non-event days. The approach enables SCE to quantify AC loads for each customer as a function of the weather, which helps both with program operations and in ensuring participants have air conditioner loads during peaking conditions.
- For SDP-R, explore withholding a randomized control group, by CAISO grid area (sublap), for both evaluation and settlement with CAISO. The CAISO baseline settlement rules now allow the use of control groups, which enables better alignment between evaluation and settlement impact estimates. In specific, we recommend randomly assigning 1,000 customers to act as a control group in each grid area, with two exceptions. For the SDP-Central area we recommend a control group of 2,000 customers. We also do not recommend a control group for customers in the SCE-Low Desert area since it is not practical given the small numbers of customers in the area. While the recommended randomized control groups require withholding approximately 3% of resources from economic dispatch, the improved precision of load impact estimates and the better alignment between evaluation and settlement results make it well worth it, in our assessment. In the case of reliability-based events (which are rare), we recommend dispatching all available resources.
- Revisit incentive levels for SDP-C, especially for customers on 50% or 30% cycling. Because the peak period has shifted to 4:00-9:00 PM, the air conditioner loads and impacts for non-residential customers are substantially lower than for hours earlier in the day.
- To the extent possible, avoid dispatching customers on 30% and 50% cycling when participant-weighted temperatures are below 85 °F. At lower temperatures, 30% and 50% cycling do not deliver meaningful demand reductions that can be measured accurately.
- To better define ex ante impacts, ensure the program is dispatched across all ex ante peak hours (4:00 – 9:00 PM). We are not recommending calling a 5-hour event (unless needed for reliability) but support ensuring all the ex ante event hours are included across all the events in a program

year. To achieve this, it may be necessary to supplement events called by CAISO with Measurement and Evaluation events.

- 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.
- Use the full non-residential population of medium and large customers and sample of smaller customers to identify control customers for SDP-C. SDP-C has several extremely large customers and is dominated by schools and religious institutions. For PY2019, after discussion with SCE, we included a sample of non-residential and residential customers in the match control group pool to minimize data risk. Use of stratified sample worked well for the SDP-R. However, the SDP-C population varies too much in customer size and has unique mix of customers. As a result, the use of a sample in the matching process led to less precise, though valid, impact estimates.

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 20: 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 all PY2019 data.
3. Use of control groups	A matched control group was employed for residential and commercial customers. Control customers were pulled from a stratified random sample. From the control sample, the control group is selected using non-event day load patterns, geographic location, and other customer characteristics (e.g., industry) to develop propensity scores within each stratum. For each participant, the nearest neighbor based on propensity scores is identified. Several different propensity score models were tested. For each model, we produce standard metrics for bias and goodness of fit – these metrics measure the error between "nearest neighbor" loads and treatment home loads. Of the three models that produce the lowest percent bias, the model that minimizes mean absolute prediction error is selected as the best model. The control group picked by the best model is used as the control group in the ex post analysis.
4. Load impact Regression	The load impacts were estimated by using a difference-in-differences model with fixed effect and time effect. For each event day, the corresponding proxy event day was used to net out differences between the treatment and control group that were not due to the intervention.
5. Segmentation of impact results	The results are segmented by: ▪ Customer class (residential/non-residential) and NAICS code for non-residential customers, ▪ Zone, LCA, and dispatch group ▪ Cycling strategy, and ▪ AC tonnage size. The main segment categories are building blocks. They are designed to ensure segment-level results add up to the total, to enable production of ex ante impacts, and to allow for busbar level analysis.

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

For SDP-R and SDP-C, the evaluation team, in conjunction with SCE, decided to proceed with a matched control group relying on a stratified random sample of subsets of non-participants to act as the control pool. This eliminates the need to develop a two-stage matched control group, streamlining analysis. Essentially, instead of relying on information from all possible non-participants, we instead construct a control group from a targeted subset of control candidates that have been pre-screened to belong to sampling cells of influential variables. By oversampling large and/or NEM customers, and by allowing non-participants to be matched multiple times to different participants, we can improve the quality of matching compared to a random sample, while also removing the need to do two-stage matching on all non-participants in SCE's territory. For reference, the sample cells are summarized in Table 21.

Table 21: 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, our team ran into one key issue: certain industry segments were not well-represented in the control candidate pool, making it difficult to find matches for some participants. For schools and religious organizations institutions in particular, the number of participants exceeds the number of control candidates by a large margin. There were also a handful of very large customers in the Institutional/Government group for which matching was not successful. As a workaround, SCE provided our team with additional control customers to use in the matching algorithm. Still, we did not find good matches for each customer.

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 results (counterfactual estimates, observed load, impact estimates, standard errors, confidence intervals) based on the tonnage of the sites that were removed from the analysis. Table 22 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 752 curtailed sites that are not in the analysis will be similar to the percent impacts for the 8,274 sites that are in the analysis.

Table 22: Scaling Example

Level	Accounts	Tonnage	Tonnage per Account	Scaling Ratio
In Ex Post Analysis Data	8,274	290,583	35.12	1.28
Curtailed	9,026	406,829	45.07	

Table 23 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 23: Distribution of Accounts by Analysis Status

Analyzed?	Accounts		Devices		Tonnage	
	#	%	#	%	#	%
Yes	8,317	91.8%	59,550	73.7%	291,329	71.6%
No	745	8.2%	21,250	26.3%	115,830	28.4%
Total	**9,062**	**100%**	**80,800**	**100%**	**407,159**	**100%**

APPENDIX B: EX ANTE METHODOLOGY

Figure 30 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 30: Difference between Ex Post and Ex Ante

Ex Post Impacts

- What were the reductions delivered?
- Varies based on:
  - ✓ Temperature
  - ✓ Magnitude of resources dispatched
  - ✓ Hours of dispatch
  - ✓ Length of dispatch
  - ✓ Program/rate changes
  - ✓ Participant mix

Adjustments

- Standardize weather
- Assume full dispatch of resources available
- Standardize hours and length of dispatch
- Incorporate program/rate changes
- Adjust for project enrollment changes

Ex Ante Impacts

- What is the magnitude of program resources available under planning conditions defined by weather?
- SCE and CAISO weather conditions
- 1-in-2 (normal) versus 1-in-10 (extreme) weather conditions
- Different day-types
  - ➢ Monthly peak day
  - ➢ Average month day
- By month

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 24.

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 24: 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 two years of historical performance data for relevant customers. ▪ Decide on an adequate segmentation to reflect changes in the customer. Segments used were load control group and cycling

Methodology Component	Approach
	strategy. These segments reflect that events are dispatched geographically and that impacts in the 100% cycling strategy group are known to be larger in magnitude than impacts in the 50% cycling strategy group. ▪ Estimate the relationship between reference loads and weather using non-event days. This is done separately for each segment in both SDP-R and SDP-C. ▪ Use the models to predict reference loads for 1-in-2 and 1-in-10 weather year conditions. ▪ Estimate the relationship between weather and demand response impacts. Like the reference load estimation, this is done separately by segment. For SDP-C, cycling strategy was the only segment used here, as there simply isn't enough data to estimate impacts for each unique combination of load control group and cycling strategy (ten load control groups and three cycling strategies yields 30 segments). ▪ Estimate the relationship between weather and post-event snapback. ▪ Predict the reductions and snapback for 1-in-2 and 1-in-10 weather year conditions. ▪ Incorporate the enrollment forecast.
3. Accounting for changes in the participant mix	Customers that were no longer active in the program as of October 2019 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.

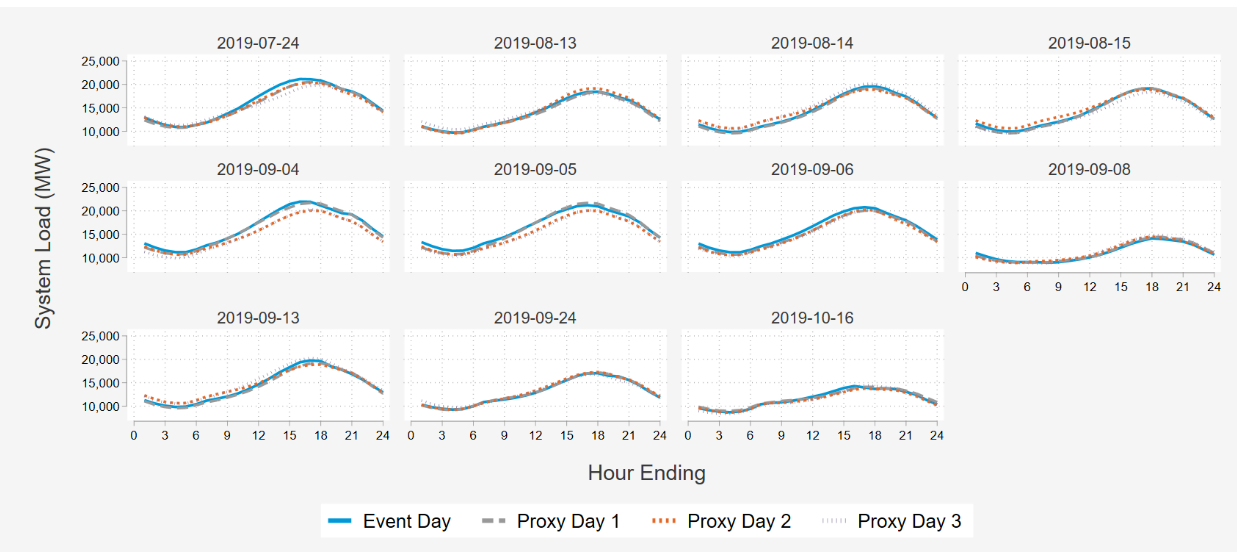
APPENDIX C: PROXY EVENT DAYS

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 2019 event day, Figure 31 shows event day loads and proxy event day loads. The proxy event days track the event day load well.

Figure 31: 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 2019 SDP-R ex post evaluation. Figure 32 shows the average control group load and the average treatment group load for each 2019 summer event day. Other than the event 9/24, control group load tracks treatment group load very well on every event day. The afternoon discrepancy on 9/24 is simple to explain – this was one of the three days on which multiple events were dispatched (9/6, 9/24, and 10/16). The three distinct events on 9/6 were timed similarly, which is why there is only one notch in the treatment group load.

Figure 32: Control Group and Treatment Group Event Day Loads, SDP-R

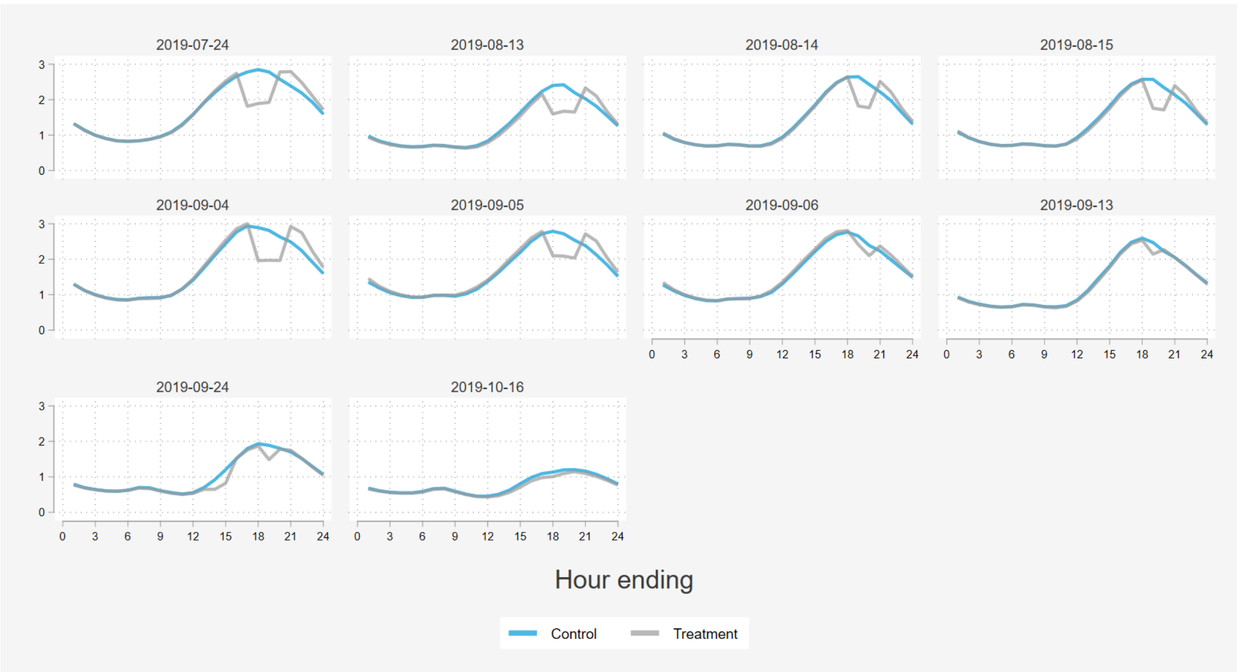
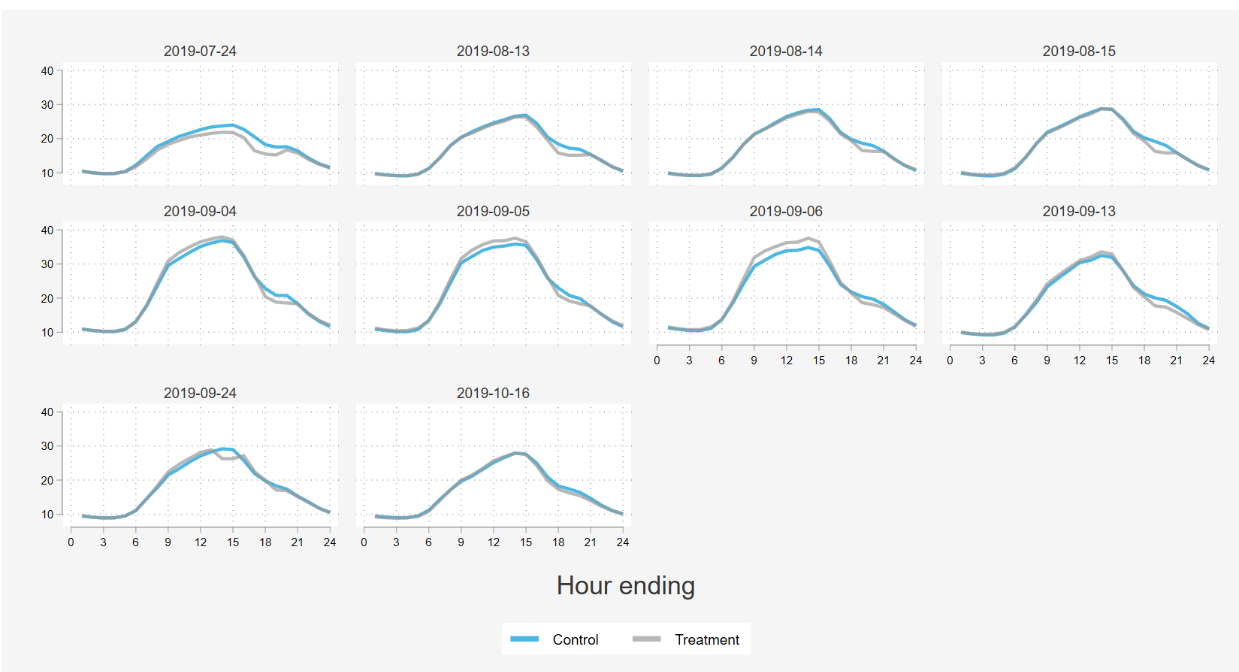


Figure 33 shows how SDP-R control load and treatment load compare on the proxy days used in the 2019 analysis. The takeaway remains the same: average control group load represents average treatment group load very well.

Figure 33: Control Group and Treatment Group Proxy Day Loads, SDP-R

Finally, Figure 34 compares average control group load and average treatment group load for the summer 2019 SDP-C events. On average, control group load represents treatment group load well. The ex post analysis method (difference-in-differences) nets out any differences between the two groups.

Figure 34: Control Group and Treatment Group Event Day Loads, SDP-C



APPENDIX E: EX ANTE MODEL OUTPUT

SDP-R Impacts as a Function of Weather, LCG, and Cycling Group

Source	SS	df	MS			
				Number of obs	=	760
				F(23, 736)	=	188.96
Model	120.819804	23	5.25303496	Prob > F	=	0.0000
Residual	20.4605348	736	.02779964	R-squared	=	0.8552
				Adj R-squared	=	0.8507
Total	141.280339	759	.186140104	Root MSE	=	.16673

impact	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
groupname#c.lag3cdh						
100% SDP-C-1	-.0230533	.0016719	-13.79	0.000	-.0263356	-.019771
100% SDP-C-2	-.0305455	.0019508	-15.66	0.000	-.0343752	-.0267158
100% SDP-C-3	-.009639	.0018669	-5.16	0.000	-.0133042	-.0059739
100% SDP-C-4	-.0246055	.0017481	-14.08	0.000	-.0280372	-.0211737
100% SDP-HD	-.0200271	.0018956	-10.57	0.000	-.0237485	-.0163056
100% SDP-LD	-.0054693	.0047866	-1.14	0.254	-.0148664	.0039277
100% SDP-N	-.021455	.0017544	-12.23	0.000	-.0248993	-.0180108
100% SDP-NW	-.024175	.0025209	-9.59	0.000	-.029124	-.019226
100% SDP-W-1	-.0346528	.0023803	-14.56	0.000	-.0393257	-.0299799
100% SDP-W-2	-.0330243	.0023561	-14.02	0.000	-.0376498	-.0283988
50% SDP-C-1	-.0072411	.0019095	-3.79	0.000	-.0109899	-.0034923
50% SDP-C-2	-.0140409	.002359	-5.95	0.000	-.0186722	-.0094097
50% SDP-C-3	-.0000893	.0024267	-0.04	0.971	-.0048535	.0046748
50% SDP-C-4	-.00524	.0019343	-2.71	0.007	-.0090375	-.0014426
50% SDP-HD	-.0091279	.0029957	-3.05	0.002	-.0150089	-.0032468
50% SDP-LD	-.0012299	.0109494	-0.11	0.911	-.0227256	.0202658
50% SDP-N	-.0083343	.002105	-3.96	0.000	-.0124669	-.0042017
50% SDP-NW	-.0130138	.0041067	-3.17	0.002	-.021076	-.0049517
50% SDP-W-1	-.0163208	.0028339	-5.76	0.000	-.0218843	-.0107574
50% SDP-W-2	-.0186553	.0029075	-6.42	0.000	-.0243633	-.0129473
1.innersummer	-.075668	.0246911	-3.06	0.002	-.1241414	-.0271946
mean17	-.0319251	.002137	-14.94	0.000	-.0361204	-.0277299
eventhour	.0425025	.0079951	5.32	0.000	.0268067	.0581984
_cons	2.583029	.1325812	19.48	0.000	2.322747	2.843311

SDP-C Impacts as a Function of Weather, Hour, and Cycling Group

Source	SS	df	MS
Model	16.2407108	12	1.35339257
Residual	9.49313047	1,127	.008423363
Total	25.7338413	1,139	.022593364

Number of obs	=	1,140
F(12, 1127)	=	160.67
Prob > F	=	0.0000
R-squared	=	0.6311
Adj R-squared	=	0.6272
Root MSE	=	.09178

impact_perdevice	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
cycling#hour#c.lag3cdh						
30 17	-.0161789	.0016782	-9.64	0.000	-.0194717	-.0128861
30 18	-.0105177	.0011061	-9.51	0.000	-.0126879	-.0083475
30 19	-.0098847	.00093	-10.63	0.000	-.0117094	-.00806
30 20	-.0089004	.0009935	-8.96	0.000	-.0108497	-.0069511
50 17	-.0091288	.0007865	-11.61	0.000	-.0106721	-.0075856
50 18	-.0070189	.0006671	-10.52	0.000	-.0083278	-.0057101
50 19	-.0056473	.0006583	-8.58	0.000	-.0069389	-.0043556
50 20	-.0047911	.000701	-6.83	0.000	-.0061666	-.0034156
100 17	-.0155552	.0006775	-22.96	0.000	-.0168844	-.0142259
100 18	-.0131619	.0006187	-21.27	0.000	-.0143757	-.011948
100 19	-.0124509	.0006226	-20.00	0.000	-.0136725	-.0112293
100 20	-.0098772	.0006589	-14.99	0.000	-.01117	-.0085844
_cons	.0578031	.0192888	3.00	0.003	.0199572	.095649