Demand Side Analytics
DATA DRIVEN RESEARCH AND INSIGHTS

REPORT

2021 Smart Energy Program Load Impact Evaluation

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

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Prepared for Southern California Edison

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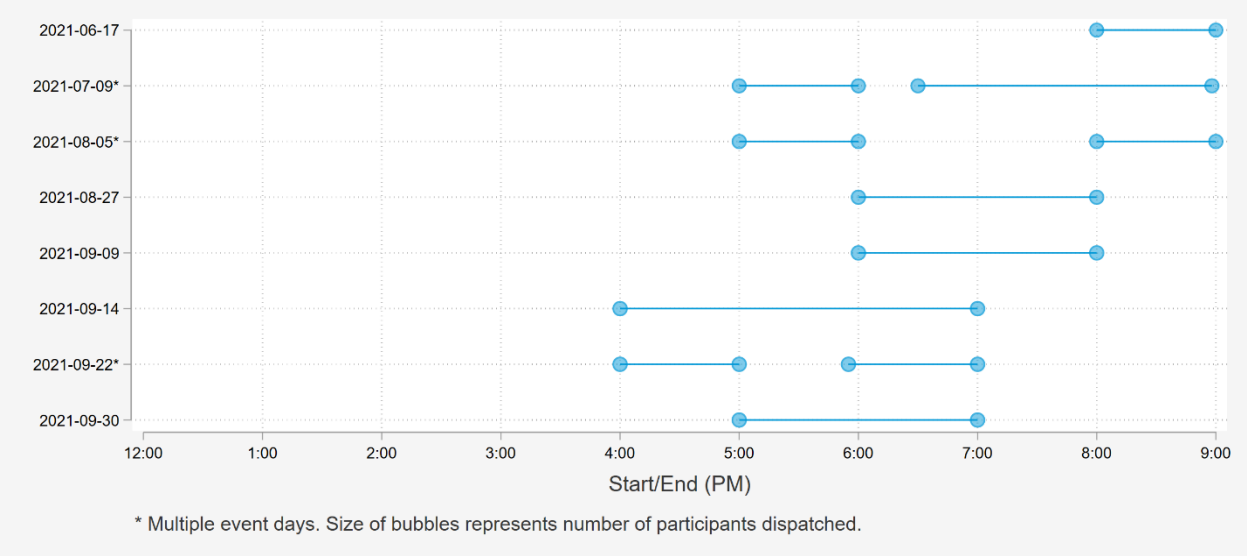
1 EXECUTIVE SUMMARY

This report documents the 2021 load impact evaluation of Southern California Edison's (SCE) Smart Energy Program (SEP). SEP is a residential demand response (DR) program that utilizes Wi-Fi connected smart thermostats to reduce air conditioning load in participating households during peak hours. SCE retained Demand Side Analytics (DSA) to conduct the SEP load impact evaluation for 2021. The primary objectives of this report are to:

- Document the findings of an ex post (after the fact) load impact study for 2021 events
- Provide ex ante (forward looking) estimates of SEP's demand reduction capability over the next eleven years (2022 to 2032) under various weather conditions.

When SCE initiates SEP events, the two participating DR thermostat providers adjust cooling set points upward by as much as four degrees (F) to limit air conditioning usage and reduce electric demand. SCE can call SEP events for emergency (reliability) reasons, economic purposes, or as part of measurement and evaluation. SCE dispatched SEP on eight days during PY2021 between June and September. On three of these days, there were multiple events called, usually in response to need later in the day. In total, there were eleven events with ten being a result of self-scheduling in the day-ahead market and one for reliability purposes. SCE cited both types of dispatch triggers for the 9/9/2021 event. Figure 1 shows the eleven 2021 events along with the start and end time.

Figure 1: SEP 2021 Event Start and End Times (Pacific Daylight)



SEP enrollments decreased between the end of the summer 2020 DR season and the beginning of the summer 2021 season for two primary reasons.

- SCE removed participants who were not available for dispatch because they did not agree to updated terms and conditions with one of the thermostat manufacturers.

- New enrollments during this time were offset by other types of customer attrition such as service turn offs and CCA migrations.

In 2019, SCE integrated SEP into the CAISO wholesale energy market where it is offered as a dispatchable resource based on energy prices. As a result of integrating into the CAISO market, 2019, 2020, and 2021 events were generally called later in the day compared to previous years when the program was dispatched based on other triggers, such as peak demand forecast. In 2017 and 2018, SCE generally called SEP events from 2pm to 6pm. During 2019, 2020, and 2021, SEP events have occurred primarily between 4pm and 9pm, which corresponds to the Resource Adequacy (RA) window established by the CAISO.

1.1 SUMMARY OF EX POST LOAD IMPACTS

There were eleven distinct SEP events in 2021 between June and September. SEP events may be dispatched by Sub-Load Aggregation Point (SubLAP), but are most often called for the entire SCE territory. In 2021, all events were called territory-wide and each SubLAP started and ended dispatch at the same time.

Weather conditions were milder in 2021 than 2020 when California faced extreme heat waves and capacity shortfalls. In 2020 SCE called SEP events on six consecutive days starting on 8/13/2020 as well as four weekend events. In 2021, there were no back-to-back event days and no weekend events.

Demand Side Analytics utilized a matched control group with regression analysis to estimate the impacts of each event across the full participant group and a variety of segments. Table 1 shows the event details and average hourly impacts for all 2021 events and an "Average Event Day" profile.

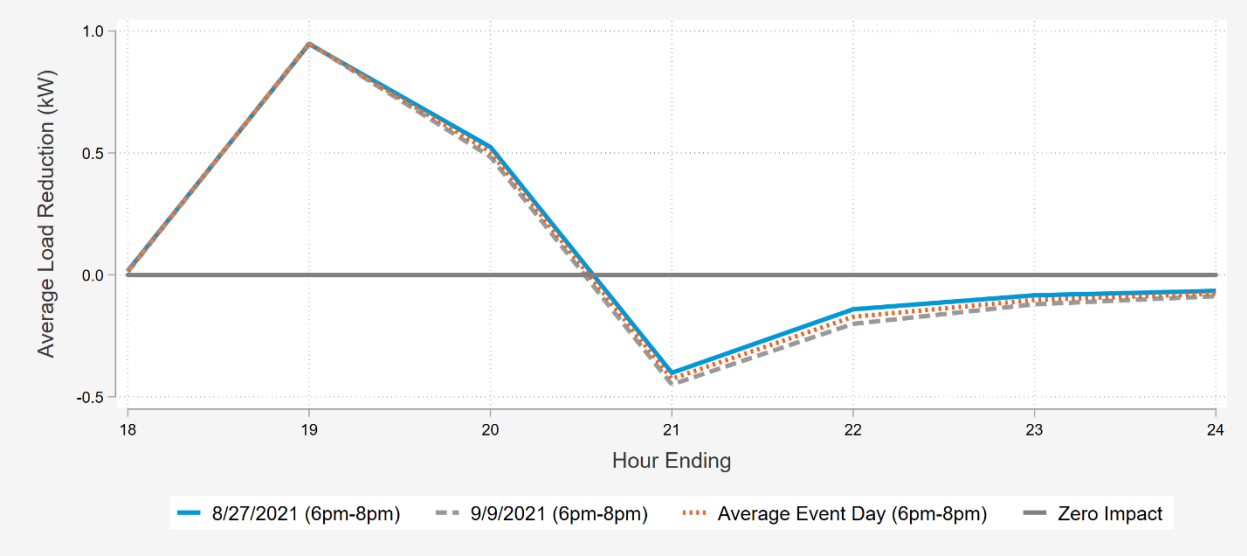
Table 1: 2021 Ex Post Event Impacts

Event Date	Dispatch Region	Participants	Average Event Temp (F)	Daily Max Temp (F)	Average Full Hour Impact (kW Reduction per Participant)	Average Aggregate Full Hour Impact (MW Reduction)
6/17/2021 (8pm-9pm)	Territory Wide	43,847	77.9	87.7	0.63	27.6
*7/9/2021 (5pm-6pm & 6:30pm-8:58pm)	Territory Wide	45,957	87.2	91.7	0.86	39.7
8/5/2021 (5pm-6pm & 8pm-9pm)	Territory Wide	47,389	85.2	88.9	0.78	36.9
8/27/2021 (6pm-8pm)	Territory Wide	47,185	89.0	94.2	0.74	34.7
**9/9/2021 (6pm-8pm)	Territory Wide	49,743	87.2	93.2	0.72	35.7
9/14/2021 (4pm-7pm)	Territory Wide	49,825	83.3	85.6	0.43	21.5
*9/22/2021 (4pm-5pm & 5:55pm-7pm)	Territory Wide	50,160	89.5	93.3	0.84	42.4
9/30/2021 (5pm-7pm)	Territory Wide	49,929	86.7	87.2	0.33	16.6
Average Event Day (6pm-8pm)	Territory Wide	48,498	88.0	93.7	0.73	35.2

* Only full hours are included in impacts
** 2021 System Peak Day

DSA defines an "Average Event Day" for 2021 as the weighted average of the two territory-wide events that began at 6pm and ended at 8pm (two-hour duration). Figure 2 shows the average along with its contributing dates. The impacts are consistent across events. By far the most important predictor of load impact is event hour, or whether a given hour is the first, second, etc. hour of dispatch. The first hour of the "Average Event Day" provides a reduction of approximately 0.95 kW per household, while the second hour had a reduction of 0.50 kW per household. Savings estimates presented in Table 1 show the average hourly impacts. It is important to note that events with longer durations will have lower average hourly impacts because of this tapering trend, thus lowering the average event impact with each additional hour of dispatch.

Figure 2: Hourly Load Reductions for 2021 Average Event Day



The "Average Event Day" had an average per customer hourly reduction of 0.73 kW and aggregate hourly reduction of 35.21 MW. The system peak day in 2021 was September 9thth. The two-hour event on that day had an average per customer hourly reduction of 0.72 kW and an average aggregate hourly savings of 35.67 MW.

1.2 SUMMARY OF EX ANTE LOAD IMPACTS

Historically, ex ante load impact evaluations assume the same average customer impact for each year of the forecast. In 2020 due to the COVID pandemic, we adjusted the methodology to include a COVID effect and gradually withdrew the COVID effect over the forecast horizon. For the 2021 load impact evaluations, the IOUs and Evaluation Contractors decided to treat 2021 as the "new normal" in regards to residential energy usage and load impacts. This means that the declining effect of COVID is no longer present in our models. We also removed March 2020 – December 2020 data from the models used to estimate per-household reference loads.

SCE and CAISO can call SEP reliability events anytime during the year. SEP economic events are restricted to non-holiday weekdays from 11am to 9pm. In the ex ante impacts, SEP events are assumed

to span the Resource Adequacy (RA) window, beginning at 4pm and lasting until 9pm. This event profile prevents any post-event snapback from occurring during the RA window. However, the estimated load reduction capability of SEP during the later hours of the RA window is lower than the initial event hours. Figure 3 illustrates this trend for monthly system peak days using SCE and CAISO 1-in-2 weather conditions. The impacts during hour 20 are only slightly larger than the impacts in hour 21, shown in purple and green respectively in Figure 3. Although SEP is *available* year-round, it is a weather sensitive program with little or no impact when air conditioning is not being used. Using 1-in-2 weather for monthly system peak days, we estimate non-zero SEP capability in March through November for both SCE and CAISO weather conditions.

Figure 3: Average Customer Ex Ante Impacts on 2022 Monthly System Peak Days: 1-in-2 Conditions

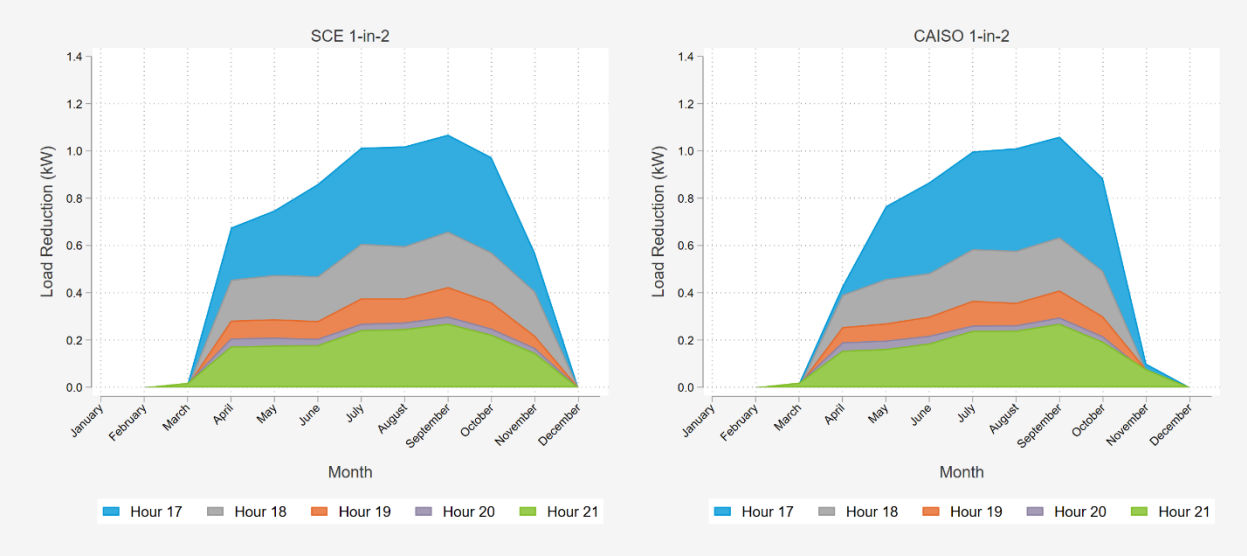
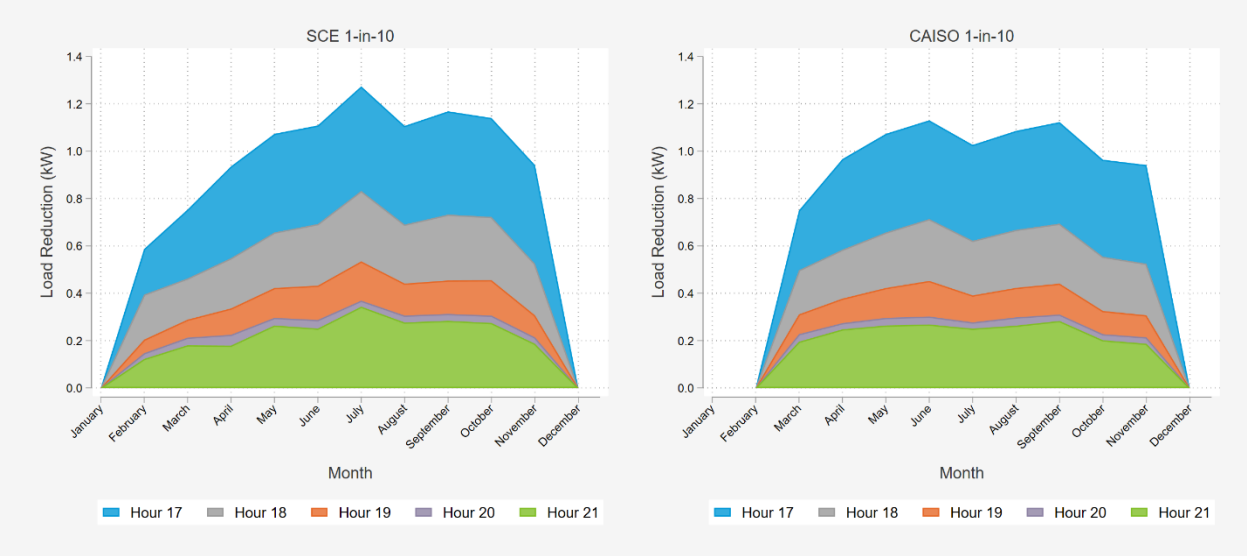


Figure 4 shows the same set of results for 1-in-10 weather conditions, which are hotter than 1-in-2 conditions.

Figure 4: Average Customer Ex Ante Impacts on 2022 Monthly System Peak Days: 1-in-10 Conditions



The weighted average maximum daily temperature on a July system peak day using SCE 1-in-10 weather is 104.35°F and the estimated average load impact per customer is 1.27 kW during the first hour of dispatch. For comparison, the weighted average maximum daily temperature for a July system peak day using CAISO 1-in-10 weather is 94.05°F and the estimated load impact is 1.03 kW during the first hour of dispatch.

- **For SCE 1-in-10 weather conditions**: SEP is projected to have load impact capability in all calendar months except January and December.
- **For CAISO 1-in-10 weather conditions**: SEP is projected to have load impact capability on all monthly system peak days except January, February, and December.

Table 2 shows the SEP aggregate ex ante load impacts for an August Monthly Peak Day in 2022. Current forecasts expect enrollment to increase to 63,114 customers by that time. The estimated load impact of SEP in 2022 ranges from 63.8 MW to 69.8 MW during hour ending 17. Estimated impacts decline across the RA window and range from 15.1 MW to 17.4 MW in hour ending 21. Average impacts for the five-hour RA window range from 30.9 MW to 35.6 MW.

Table 2: SEP Aggregate Ex Ante Impacts (MW) During RA Window: 2022 August Monthly Peak Day

Hour Ending	SCE 1-in-2	CAISO 1-in-2	SCE 1-in-10	CAISO 1-in-10
17	64.3	63.8	69.8	68.5
18	37.7	36.5	43.6	42.1
19	23.7	22.5	27.8	26.7
20	17.3	16.6	19.3	18.8
21	15.6	15.1	17.4	16.6
RA Window	**31.7**	**30.9**	**35.6**	**34.5**

SCE forecasts that SEP enrollments will exceed 161,000 households by 2032. Using the SCE enrollment forecast and the ex ante average customer impacts, we estimate an average aggregate load impact across the five RA window hours of 81.2 MW for SCE 1-in-2 weather conditions on an August system peak day and 91.0 MW for SCE 1-in-10 conditions on an August system peak day in 2032. Using CAISO peaking conditions, we estimate an aggregate impact of 79.1 MW for 1-in-2 conditions and 88.4 MW for 1-in-10 conditions on an August system peak day.

1.3 KEY FINDINGS AND RECOMMENDATIONS

Based on the findings of the PY2021 load impact evaluation, Demand Side Analytics makes the following program and evaluation recommendations for SEP.

- [redacted]

- DSA estimated 2021 ex post impacts using both net and delivered loads to quantify the implications of settlement methods limited to delivered loads. During the first hour of the RA window (4-5pm) analysis of delivered loads reduces the MW performance of the program by 10% overall and 31% for NEM customers.

    - ✓ Later in the evening, once solar production fades, the delivered load bias goes away and impact estimates using net and delivered loads converge.

    - ✓ CAISO's use of delivered loads in day-ahead market settlement calculations negatively affects SEP's valuation. Reduced valuation might discourage SCE from enrolling NEM customers into SEP or offering it for economic dispatch before 6-7pm in the evening, when NEM customers are exporting to the grid.

- Since PY2021 was such a mild weather year, the value of using multiple years of data was vital for predicting the capability of the DR program under more extreme weather conditions. We

recommend continuing the usage of several years of events in order to get the most accurate estimates of ex ante capabilities possible.

- The most important predictor of SEP load impact is not time of day or weather, but the position of an hour within an event. Impacts are largest during the first event hour and decline sharply in each subsequent hour. Consequently, shorter events show larger average load impacts than longer events.

- DSA added a new ex post reporting category for 2021 that segments participant households by the number of Wi-Fi thermostats under program control. Homes with two thermostats showed approximately 50% larger load reductions during 2021 events than homes with a single thermostat. Currently customer bill credits do not take into account the number of thermostats controlled.

    - ✓ Based on the 2021 ex post evaluation results, SCE may want to consider larger bill credits for homes with multiple thermostats. However, we do not recommend giving homes with two thermostats twice the bill credit because they do not provide twice the load reduction, on average.

- Rollout of default TOU pricing for residential customers is underway in SCE territory. As shown in Table 4, nearly 32% of SEP participants faced time-varying pricing during PY2021. Since a majority of customers will be on TOU rates by summer 2022, it will be important to continue to monitor the effect of TOU on SEP participant reference loads and load impacts.

- The COVID-19 pandemic affected all aspects of life in 2020. With the availability of vaccines in early 2021, California gradually re-opened and residential energy consumption patterns stabilized. In the 2020 load impact evaluation, we used a glide path that assumed the effects of COVID would slowly dissipate over several years. For this evaluation, we elected to model 2021 as the "new normal" and remove the COVID glide path from our ex ante analysis. When estimating reference loads, we did not include data from March 2020 – December 2020.

- In PY2021, three of the eight event days were double event days, meaning that SCE dispatched an event, that event ended, and then SCE called another event later in the day. Two of those double events also either began or ended mid-hour. The double events and irregular start/end times resulted in evaluation challenges and reporting modifications. Partial event hours, at either the start or end of an event, result in diluted impacts for those hours. As a result, when reporting impacts in this report, we only report on full event hours. To the extent that SCE has control over timing, events should start and end on the hour to obtain the most accurate impact estimates.

- SCE received approval to use pre-cooling during economic dispatch for summer 2022 events. Pre-cooling may reduce participant opt-outs and deliver more sustained load impacts during the later hours of events. It will be important to consider the time-varying prices faced by participants when initiating pre-cooling. We recommend SCE and its vendors pre-cool during off-peak hours, where possible. For participants on the TOU 5-8pm plan, pre-cooling from 4pm-

5pm would be ideal. For participants on the TOU4-9pm plan, pre-cooling from 3-4pm would be ideal.