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2024 Load Impact Evaluation of Southern California Edison's Demand Response Aggregator Contracts

CALMAC Study ID SCE0495

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ABSTRACT

This report documents the ex-post and ex-ante load impact evaluation of Southern California Edison's ("SCE's") third-party Demand Response Aggregator ("DRA") contracts. The report provides estimates of ex-post load impacts that occurred during events dispatched from October 2023 through September 2024 and an ex-ante forecast of load impacts for 2025 through 2035 that is based on the DRA contract requirements and the ex-post load impacts estimated for the 2024 events.

Three DRAs had active contracts during the analysis period: Hybrid Electric Building Technologies (Hybrid), Stem Energy (Stem), and Swell Energy (Swell). Hybrid and Stem enrolled commercial and industrial customers within SCE's service territory to provide demand response, while Swell enrolled residential customers to fulfill its commitments. The DRAs nominated customers on a monthly basis, SCE dispatched the contracts, and the DRAs were responsible for dispatching their DR resources and ensuring they met their contracted capacity amount.

We conduct the ex-post load impact analysis at the customer level, using each customer's available hourly interval load data from October 2023 through September 2024. We estimate customer-specific regression models applied to the hourly data, which are designed to simulate reference loads for event days accounting for typical monthly, day-of-week, and hourly usage patterns, along with weather conditions. The resulting load impacts are estimated by subtracting the observed loads from the simulated reference loads.

Developing ex-ante load impacts involves combining analyses of ex-post load impacts with expected contract terms over the forecast period. Since Swell's contract has been dissolved, Swell customers are not included in our ex-ante forecasts. Apart from Swell, the forecast contract quantities match those in place during our ex-post events so no adjustment for changes in contract terms is required. Therefore, the ex-ante forecast is based on an application of each contract's most relevant historical performance.

Ex-post impacts relative to contract quantities varied across DRAs. Two performed similarly, with load impacts averaging 94 percent of contract quantity when examining four-hour events beginning in hour-ending 17 or 18. The third DRA performed poorly in comparison, with load impacts averaging 1.3 percent of their contract commitment. [redacted]

EXECUTIVE SUMMARY

This report documents the ex-post and ex-ante load impact evaluation of Southern California Edison's ("SCE's") third-party Demand Response Aggregator ("DRA") contracts. The report provides estimates of ex-post load impacts that occurred during events dispatched from October 2023 through September 2024 and an ex-ante forecast of load impacts for 2025 through 2035 that is based on the DRA contract requirements and the ex-post load impacts estimated for the 2024 events.

The primary goals of this evaluation are the following:

1. Estimate ex-post load impacts for October 2023 through September 2024, as described below, using methods that conform to the Load Impact Protocols;
2. Develop ex-ante load impact forecasts for the period 2025 through 2035; and
3. Provide transparency in the process of developing ex-ante load impacts from historical ex-post load impacts.

ES.1 Resources Covered

Three DRAs had active contracts during the analysis period: Hybrid Electric Building Technologies (Hybrid), Stem Energy (Stem), and Swell Energy (Swell). Hybrid and Stem enrolled commercial and industrial customers within SCE's service territory to provide demand response, while Swell enrolled residential customers to fulfill its commitments. The DRAs nominated customers on a monthly basis, SCE dispatched the contracts, and the DRAs were responsible for dispatching their DR resources and ensuring they met their contracted capacity amount. [redacted] Swell has a second contract that is excluded from this evaluation because it is not bid into the CAISO market.

Table ES-1a and ES-1b summarizes the events dispatched by DRA contract during the analysis period, with ES-1a showing weekday events and ES-1b showing weekend events. The tables include the number of event days, number of dispatchable resources within each contract, the average number of those resources called during events, the average number of customers dispatched, the most common event window, and the average event duration. Contracts are most commonly dispatched for four-hour events from 5 to 9 p.m.

Table ES-1a: Weekday Event Summary by DRA Contract

Contract	# Event Days	Total Dispatchable Resources	Avg. Called Resources per Event	Avg. Customers per Event	Most Common Event Window	Average Event Duration (Hours)
[redacted]						

Table ES-1b: Weekend Event Summary by DRA Contract

Contract	# Event Days	Total Dispatchable Resources	Avg. Called Resources per Event	Avg. Customers per Event	Most Common Event Window	Average Event Duration (Hours)
[redacted]						

ES.2 Evaluation Methodology

We conduct the ex-post load impact analysis at the customer level, using each customer's available hourly interval load data from October 2023 through September 2024. We estimate two separate sets of customer-specific regression models: one for weekday events and another for weekend events. These distinct models account for structural differences in load profiles between weekday and weekend day types, ensuring that variations in consumption patterns and behavioral responses are appropriately captured. The models are designed to simulate reference loads for event days accounting for typical monthly, day-of-week, and hourly usage patterns, along with weather conditions. The resulting load impacts are estimated by subtracting the observed loads from the simulated reference loads. This approach allows us to summarize customer-level results by contract and overall to address all the evaluation objectives listed above.

Developing ex-ante load impacts involves combining analyses of ex-post load impacts with expected contract terms over the forecast period. Since Swell's contract has been dissolved, Swell customers are not included in our ex-ante forecasts. Apart from Swell, the forecast contract quantities match those in place during our ex-post events, so no adjustment for changes in contract terms is required. Therefore, the ex-ante forecast is based on an application of each contract's most relevant historical performance.

ES.3 Ex-post Load Impacts

Tables ES-2a through ES-2d summarize the average load impact for four-hour events for events starting in HE17, HE18, HE19, and weekend HE18 events. Each of these event windows is provided separately due to differences in contract quantities at the hour intervals. [redacted] The associated contract achievement percentage (i.e., the load impact divided by the contract quantity) is in parentheses.

[redacted]

Table ES-2a: Weekday Hourly Load Impacts by DRA Contract During HE17 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
All Hybrid	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Stem	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
Swell	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
All Contracts	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Table ES-2b: Weekday Hourly Load Impacts by DRA Contract During HE18 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]					
All Hybrid	[redacted]				
Stem					
Swell					
All Contracts					

Table ES-2c: Weekday Hourly Load Impacts by DRA Contract During HE19 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]					
All Hybrid	[redacted]				
Stem					
Swell					
All Contracts					

Table ES-2d: Weekend Hourly Load Impacts by DRA Contract During HE18 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]					
All Hybrid	[redacted]				
Stem					
Swell					
All Contracts					

ES.4 Ex-ante Load Impacts

Figure ES-1 shows the average RA-window load impact totaled across all contracts. We show August monthly peak day impacts for the two 1-in-2 weather scenarios in each year. Notice that the load impacts do not vary across weather scenarios, which is a direct result of the methodology we applied (as discussed in Section 5.1). [redacted]

Figure ES-1: Average August RA Window Load Impacts by Weather Scenario and Year, Total for All Contracts

[redacted]

1. INTRODUCTION AND PURPOSE OF THE STUDY

This report documents the ex-post and ex-ante load impact evaluation of Southern California Edison's ("SCE's") third-party Demand Response Aggregator ("DRA") contracts. The report provides estimates of ex-post load impacts that occurred during events dispatched from October 2023 through September 2024 (referred to as "Program Year 2024" or "PY2024") and an ex-ante forecast of load impacts for 2025 through 2035 that is based on the DRA contract requirements and the ex-post load impacts estimated for the PY2024 events.

The evaluation is conducted under the guidance of the Demand Response Measurement & Evaluation Committee (DRMEC), which consists of representatives of the Joint Utilities (SCE, PG&E, and SDG&E), the California Public Utilities Commission (CPUC), and the California Energy Commission (CEC). The evaluation conforms to the Load Impact Protocols adopted by the CPUC in D-04-08-050.

The primary goals of this evaluation are the following:

1. Estimate ex-post load impacts for PY2024, as described below, using methods that conform to the Load Impact Protocols;[1]
2. Develop ex-ante load impact forecasts for the period 2025 through 2035; and
3. Provide transparency in the process of developing ex-ante load impacts from historical ex-post load impacts.

The ex-post analysis estimates hourly *load impacts* for every event dispatched for each DRA contract. We summarize estimated load impacts for each hour of every event day by DRA contract and across all contracts, for the *average* event day, for the average customer, for all customers in aggregate, and for customers in each local capacity area (LCA).[2]

Developing ex-ante load impacts involves combining analyses of ex-post load impacts with expected contract terms over the forecast period. The ex-ante forecast is based on an application of each contract's most relevant historical performance, adjusted for expected changes in contract terms as needed. An important component of the development of ex-ante load impacts involves clearly explaining the process by which ex-post load impacts are translated into ex-ante load impacts and discussing and quantifying factors that affect differences between per-customer ex-post and ex-ante load impacts. Ex-ante load impacts from this evaluation will also be compared to those of the previous evaluation.

The report is organized as follows. Section 2 contains a description of the DRA contracts, the enrolled customers, and the events called; Section 3 describes the methods used in the study; Section 4 contains the detailed ex-post load impact results; Section 5 describes the ex-ante load impact forecast; and Section 6 contains descriptions of

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[1] Methods for estimating ex-post load impacts that conform to the Load Impact Protocols differ from methods used to determine DRA settlements after events. Settlement calculations vary by DRA.

[2] While summaries by LCA are required by the Protocols, all customers in this evaluation reside in a single LCA (LA Basin).

differences in various scenarios of ex-post and ex-ante load impacts. Appendix A contains an assessment of the validity of the study.

2. DESCRIPTION OF RESOURCES COVERED IN THE STUDY

This section provides details on the current DRA contracts, including summaries of contract characteristics and a summary of the events called from October 2023 through September 2024.

2.1 Contract Descriptions

Three DRAs had active contracts during the analysis period: Hybrid Electric Building Technologies (Hybrid), Stem Energy (Stem), and Swell Energy (Swell). Hybrid and Stem enrolled commercial and industrial customers within SCE's service territory to provide demand response, while Swell enrolled residential customers to fulfill its commitments.[3] The DRAs nominated customers on a monthly basis, SCE dispatched the contracts, and the DRAs were responsible for dispatching their DR resources and ensuring they met their contracted capacity amount. [redacted]

The bilateral contracts between SCE and the DRAs define the effective dates, contract commitments, allowed timing of events, and how settlements are determined for each DRA contract. There are a number of similarities between the contracts that each DRA has negotiated with SCE. In previous program years, the [redacted] A description of each DRA contract is provided below.

Hybrid Contracts

[redacted]

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[3] Swell has a second contract that is excluded from this evaluation because it is not bid into the CAISO market.

[redacted]

Table 2-1: Hybrid Contract Capacities and End Months

Contract	Regular Hours Contract Capacity (MW)	Extended Hours Contract Capacity (MW)	Additional Hours Contract Capacity (MW)	Contract End Month
[redacted]				

Stem Contracts

[redacted]

[redacted]

Swell Contracts

Swell has two energy storage contracts with SCE that began in 2022. One contract is a Preferred Resources Pilot (PRP) and the other is an Aliso Canyon Energy Storage (ACES) contract. [redacted]

2.2 Event Summary

Table 2-2 summarizes the maximum contract capacity across the hours of the day for each DRA contract included in the ex-post study.[4] [redacted]

Table 2-2: Maximum Capacity by Hour and DRA Contract

Hours	Total Contract Capacity (MW)			
	Hybrid	Stem	Swell	Total
[redacted]				

Tables 2-3a and 2-3b show a summary of the number of events and dispatchable resources by DRA contract, with 2-3a showing weekday events and 2-3b showing weekend events. [redacted] However, not all resources are called during a particular event, as reflected in the "Avg. Called Resources per Event" column. The tables show the most common event window by contract as well as the average event duration. Variations in event hours and called resources across events complicate the summaries of load impacts.

Table 2-3a: Weekday Event Summary by DRA Contract

Contract	# Event Days	Total Dispatchable Resources	Avg. Called Resources per Event	Avg. Customers per Event	Most Common Event Window	Average Event Duration (Hours)
[redacted]						

4 [redacted]

Table 2-3b: Weekend Event Summary by DRA Contract

Contract	# Event Days	Total Dispatchable Resources	Avg. Called Resources per Event	Avg. Customers per Event	Most Common Event Window	Average Event Duration (Hours)
[redacted]						

3. STUDY METHODOLOGY

3.1 Overview

For the DRA evaluation, two key factors are of interest in the ex-post analysis:

1. the estimated load reductions during events, which is important for assessing the resource value of the resources during emergencies, and
2. the extent to which DRAs successfully reduce load to meet their contract requirements during events.

We conduct the ex-post load impact analysis at the customer level, using each customer's available hourly interval load data from October 2023 through September 2024. We estimate two separate customer-specific regression models: one for weekday events and another for weekend events. These distinct models account for structural differences in load profiles between weekday and weekend day types, ensuring that variations in consumption patterns and behavioral responses are appropriately captured. The models are designed to simulate reference loads for event days accounting for typical monthly, day-of-week, and hourly usage patterns, along with weather conditions. The resulting load impacts are estimated by subtracting the observed loads from the simulated reference loads.

One potential challenge with estimating load impacts for DRAs is the high frequency of events for some DRA contracts. [redacted]. This leaves relatively few non-event weekdays to use as a counterfactual for event-day load profiles to estimate load impacts. As a result, we use all available pre-event hours on event days in addition to the non-event day data to develop the reference load models for each enrolled customer.

Our estimation process proceeds as follows: we apply a common specification to each customer, withholding approximately 15 percent of the customer's data from the estimated model. Each customer's model quality is then assessed by comparing its predicted values to the observed loads on the withheld days. We also examine and summarize the R-squared values for each customer, which represents the proportion of the customer's usage variability that is explained by the model's parameters. We summarize results from our model validation in Appendix A. For customers whose loads are not well-predicted using the standard model, we explore variations that may improve the predictions. The standard model was adapted from the models employed in the previous evaluation and is presented in the next sub-section.

Our review revealed data quality issues for three hybrid customers. The interval data for these customers indicated minimal to no event impacts, whereas the metered generation output (MGO) settlement data showed significant event impacts. Since MGO settlement data is derived from a meter on the battery, it is expected to be highly correlated with customer-level interval data and be a direct comparison to our estimated results. However, issues were identified in how the interval data was reported. Given that MGO data already measures event impacts, it was used as the impact measure for these three customers instead of our estimated impacts.

Using the standard and refined models, we estimate regression models applied to hourly data at the individual customer number level for all DRA contract customer accounts nominated during the analysis period. This approach allows us to summarize results across various characteristics that may be associated with a given contract number to address all the evaluation objectives listed above. For example, to produce total impacts across all contracts, we can add estimated load impacts across all contract numbers. At a more detailed level, we can add estimated load impacts for the customers of a specific DRA contract, or for those that are located within a particular location.

3.2 Description of Methods

Regression Model

In this section we describe the standard model that we estimate for each DRA customer for weekday and weekend events. The regression models only include data for non-event days and pre-event hours on event days.[5] The standard specification includes variables that account for typical customer usage patterns and weather conditions. The models include data beginning in the first month in which we observe the customer being nominated by its DRA. This helps ensure that the estimates don't include load data that precedes the storage installation, which may also be used on non-event days to manage customer bills. The weekday and weekend models are largely similar in how the data is created, with the only difference being that weekday events are constructed using weekday data and weekend events use weekend and holiday data. The covariates are also largely the same, with the main differences being day type variables.

The general form of our weekday regression model is as follows:

$Q_{i,t} = a + b^{Temp} \times Temp_{i,t} + b^{AvgT} \times Avg\_temp_t + b^{PeakT} \times Peak\_temp_t + b^{AvgT\_T} \times$
$Temp_{i,t} \times Avg\_temp_{i,t} + b^{PeakT\_T} \times Temp_{i,t} \times Peak\_temp_{i,t} + b^{Irrad} \times Irrad_{i,t} +$
$b^{NearHoliday} \times NearHoliday_t + \sum_{i=2}^{24}(b_i^{NearHoliday} \times h_{i,t} \times NearHoliday_t) + b^{MornLoad} \times$

[5] For events that end earlier than hour-ending 18, only the event hours and the three hours following the event are excluded from estimation.

$MornLoad_t + \sum_{i=2}^{24}(b_i^{MON} \times h_{i,t} \times MON_t) + \sum_{i=2}^{24}(b_i^{FRI} \times h_{i,t} \times FRI_t) + \sum_{i=2}^{24} b_i^h \times h_{i,t} + \sum_{i=2}^{5} b_i^{DOW} \times DOW_{i,t} + \sum_{i=2}^{12} b_i^{MONTH} \times MONTH_{i,t} + e_{i,t}$

The general form of our weekend regression model is as follows:

$$Q_{i,t} = a + b^{Temp} \times Temp_{i,t} + b^{AvgT} \times Avg\_temp_t + b^{PeakT} \times Peak\_temp_t + b^{AvgT\_T} \times Temp_{i,t} \times Avg\_temp_{i,t} + b^{PeakT\_T} \times Temp_{i,t} \times Peak\_temp_{i,t} + b^{Irrad} \times Irrad_{i,t} + \sum_{i=2}^{24}(b_i^{Holiday} \times h_{i,t} \times Holiday_t) + b^{Sunday} \times Sunday_t + b^{MornLoad} \times MornLoad_t + \sum_{i=2}^{24} b_i^h \times h_{i,t} + + \sum_{i=2}^{12} b_i^{MONTH} \times MONTH_{i,t} + e_{i,t}$$

The variables are explained in Table 3-1.

Table 3-1: Descriptions of Variables included in the Ex-Post Regression Equation

Variable Name / Term	Variable / Term Description
$Q_{i,t}$	The customer's usage in hour *i* of day *t*
a and the various *b*'s	The estimated parameters
h_i	A dummy variable for hour *i*
$Temp_{i,t}$	Temperature during hour *i* and/or day *t*
Avg_temp_t	Average daily temperature on day *t*
$Peak\_temp_t$	Average temperature from HE 17-21 on day *t*
$Irrad_{i,t}$	Irradiance at the customer's weather station during hour *i* of day *t*
$MornLoad_t$	A variable equal to the average of the day's load in HE 1-10
$NearHoliday_t$	A dummy variable for days before and after holidays
MON_t	A dummy variable for Monday
FRI_t	A dummy variable for Friday
$DTHOL_t$	A dummy variable for holidays
$DOW_{i,t}$	A series of dummy variables for each day of the week
$MONTH_{i,t}$	A series of dummy variables for each month
$e_{i,t}$	The error term.

The "morning load" variable is used in the same spirit as the optional day-of adjustment to the 10-in-10 baseline method currently used in some DR programs (e.g., CBP). That is, it is intended to adjust the reference load (the regression-based estimate of the loads that would have occurred in the absence of the event day) for unobserved exogenous factors that may affect a customer's loads on a given day. The use of the morning load variable assumes that variations in the morning load are related to variations in reference loads later in the day; but that the changes in the morning load are not part of the customer's response to the event itself.

The remaining terms in the equation are designed to control for weather and other periodic variation in a customer's load profile (e.g., hour of the day, day of the week, and month of the year). The interaction of the Monday and Friday indicators with the hourly indicators is designed to account for the typically different hourly load profiles of commercial and industrial customers on the first and last days of the workweek.

For each customer we use the estimates from the specification to produce predicted loads for every hour of every event day for which the customer is dispatched. We calculate the estimated load impacts by subtracting the customer's actual observed loads from the predicted reference loads.

Development of Uncertainty-Adjusted Load Impacts

The Load Impact Protocols require the estimation of uncertainty-adjusted load impacts. In the case of ex-post load impacts, the parameters used to predict the customer's reference loads are not estimated with certainty. We base the uncertainty-adjusted load impacts on the variances from the reference load predictions.

Specifically, the uncertainty is based on the standard error of the predicted reference load for each customer. We arrive at the aggregate standard error by summing the variances of each customer's reference load predictions across the customers who are dispatched for each event. These aggregations are performed at either the all-contract level or by DRA contract, as appropriate. The uncertainty-adjusted scenarios are then simulated under the assumption that each hour's load impact is normally distributed with the mean equal to the sum of the estimated load impacts and the standard deviation equal to the square root of the sum of the variances of the errors around the estimates of the load impacts. Results for the 5^{th} and 95^{th} percentile scenarios are generated from these distributions.

In order to develop the uncertainty-adjusted load impacts associated with the average event hour (i.e., the bottom rows in the tables produced by the ex-post table generator), we assume that load impacts are independent across event hours.

4. DETAILED STUDY FINDINGS

The primary objective of the ex-post evaluation is to estimate the aggregate and per-customer event-day load impacts for each DRA contract. In this section we first summarize the aggregate estimated load impacts for each DRA using a metric of estimated *average hourly load impacts* by event and for the average event. We limit the summarized results to four-hour events beginning in HE 17, 18, and 19 which are the majority of the events for each contract and are the most relevant events when developing the ex-ante forecast. The averages are first calculated at the customer level and then added up across customers within a contract.[6] This approach ensures that load

[6] In previous evaluations, we first averaged load impacts at the dispatch ID level rather than the customer level prior to aggregating impacts to the contract level. The change was made to account for missing customer data for some events in the summer of 2024, which reduced the estimated

impacts are not diluted by averaging across resources dispatched for different event hours or different event days.[7] We use percent contract achievement as a measure of contract performance, which is defined as the estimated ex-post load impact divided by the contract amount.

We then present tables of *hourly* load impacts for a representative event day where all resources are dispatched (there is no typical event day due to the variability in resources dispatched as well as the event hours), in the format required by the Load Impact Protocols adopted by the California Public Utilities Commission (CPUC) in Decision (D.) 08-04-050 ("the Protocols"). These results include risk-adjusted load impacts at different probability levels, and figures that illustrate the reference loads, observed loads and estimated load impacts compared to aggregate contract commitments.

4.1 Ex-Post Load Impacts by DRA

Summarizing ex-post impacts is complicated because it is uncommon for all dispatch IDs to be called at the same time and event hours can vary across dates and dispatch IDs. We simplify the summary of ex-post load impacts in two ways. First, we summarize only the most common event windows: four-hour events beginning in hour-ending 17, 18, and 19. The HE17 and HE18 events are the most relevant for the ex-ante study because they occur during the Resource Adequacy (RA) window and thus serve as the basis for our forecasts. Second, we reflect the full capability of each contract by calculating the average load impact at the customer level and summing across the customers within a contract. Therefore, average load impacts reflect what would happen when all dispatch IDs are called during the same hours, even though that rarely (if ever) happens in practice.

Table 4-1a through 4-1d summarize the average load impact for four-hour events for events starting in HE17, HE18, HE19, and weekend HE18 events. Each of these event windows is provided separately due to differences in contract quantities at the hour intervals. [redacted] The associated contract achievement percentage (i.e., the load impact divided by the contract quantity) is in parentheses.

[redacted]

impacts by dispatch ID relative to what we would have estimated with a complete set of customer load data.

[7] Note that it may be difficult to compare the ex-post summaries contained in this report to the results contained in the Excel-based table generator appendix. The focus of the Excel-based table generator is to present the load impacts for every day that had an event, regardless of the extent of the dispatch. (Monthly summaries are included as well, showing the average outcome across the events as they were called.)

[redacted]

Table 4-1a: Weekday Hourly Load Impacts by DRA Contract During HE17 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]					
All Hybrid	[redacted]				
Stem	[redacted]				
Swell	[redacted]				
All Contracts	[redacted]				

Table 4-1b: Weekday Hourly Load Impacts by DRA Contract During HE18 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]					
All Hybrid	[redacted]				
Stem	[redacted]				
Swell	[redacted]				
All Contracts	[redacted]				

Table 4-1c: Weekday Hourly Load Impacts by DRA Contract During HE19 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]					
All Hybrid	[redacted]				
Stem					
Swell					
All Contracts					

Table 4-1d: Weekend Hourly Load Impacts by DRA Contract During HE18 Four-Hour Events (MW), Contract Achievement Percentage in Parentheses

Contract	Hour of Event				Average Event Window
	Hour 1	Hour 2	Hour 3	Hour 4	
[redacted]					
All Hybrid	[redacted]				
Stem					
Swell					
All Contracts					

Figure 4-1 contains the same event data as shown in Tables 4-1a through 4-1d, but provides a more direct way to compare the scale of load impacts. In addition, the Hybrid contracts have been combined to reduce clutter. [redacted]

Figure 4-1: Average Hourly Load Impacts for Four-Hour Events

[redacted]

Table 4-2 summarizes the uncertainty-adjusted hourly load impacts, reference loads, observed loads, and percent load impacts for the event on January 16, 2024.[8] Figure 4-2 illustrates the reference loads (green line), observed loads (blue line), load impacts (orange line), and contract commitments (red line) across all DRA contracts for this event. Nine of the thirteen active resources were called from 4 to 8 p.m. (HE 17 through 20), one resource was called from 2 to 6 p.m. (HE 15 through 18) and the remaining three resources were called from 5 to 9 p.m. (HE 18 through 21).

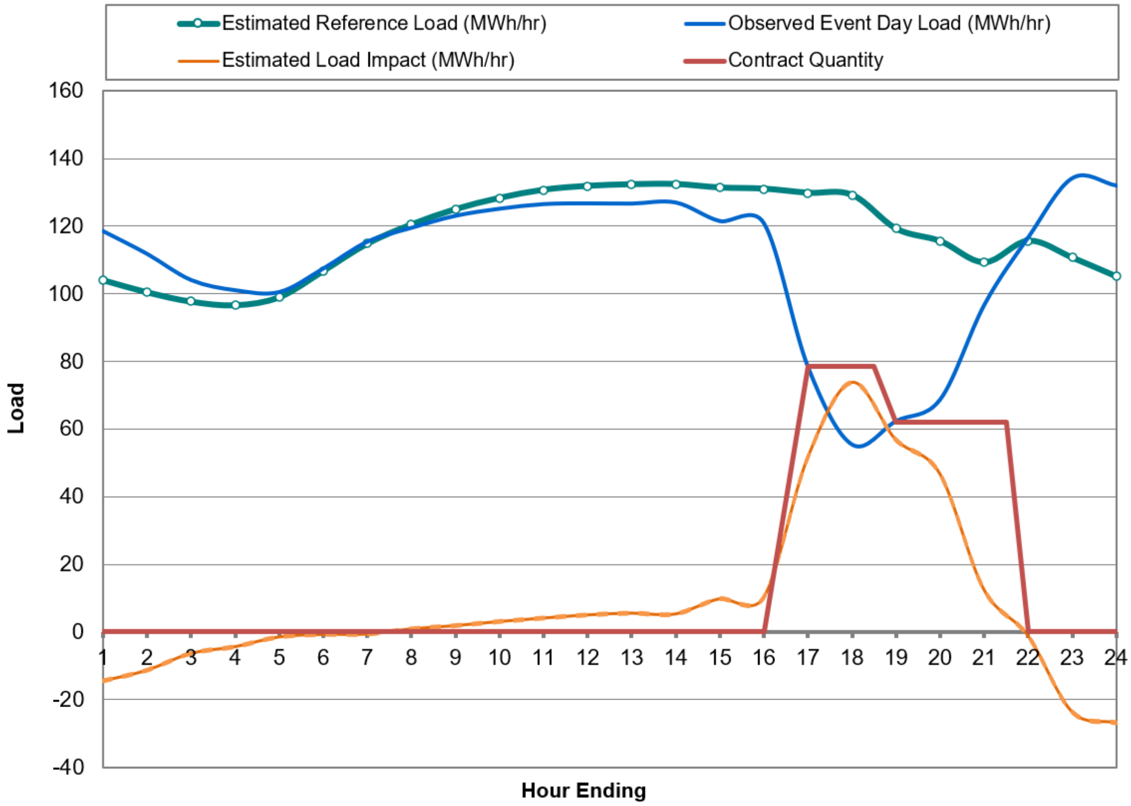
The load impact is highest during HE 18, at 73.8 MW. The total contract quantity during this hour is 78.5 MW [redacted] The aggregate contract commitment drops to 62 MW from HE 19 to HE 21 [redacted]

[8] The selection criteria for a representative ex-post date were threefold: first, ensuring that most, if not all, contracts were called on the selected day; second, event hours were largely similar across the contracts; and third, verifying data quality by excluding dates with enough missing customer data or other quality concerns that may affect the aggregated results.

Table 4-2: Hourly Load Impacts for All Contracts on January 16, 2024

Hour-Ending	Estimated Reference Load (MWh/hr)	Observed Event Day Load (MWh/hr)	Estimated Load Impact (MWh/hr)	Weighted Average Temperature (°F)	Uncertainty Adjusted Impact (MWh/hr) - Percentiles 5th%ile	50th%ile	95th%ile	Standard Error
1	104.0	118.6	-14.6	51.7	-14.85	-14.55	-14.25	0.18
2	100.5	111.9	-11.4	51.1	-11.70	-11.39	-11.09	0.18
3	97.7	104.1	-6.4	50.7	-6.68	-6.38	-6.08	0.18
4	96.7	101.1	-4.4	50.1	-4.72	-4.42	-4.12	0.18
5	99.0	100.6	-1.5	49.2	-1.82	-1.51	-1.21	0.19
6	106.8	107.5	-0.8	48.5	-1.08	-0.77	-0.47	0.19
7	114.8	115.5	-0.7	48.1	-0.98	-0.67	-0.37	0.19
8	120.5	119.6	0.9	47.7	0.56	0.87	1.18	0.19
9	125.0	123.2	1.8	47.7	1.51	1.82	2.14	0.19
10	128.3	125.2	3.0	50.8	2.74	3.05	3.36	0.19
11	130.7	126.6	4.1	55.4	3.77	4.08	4.38	0.18
12	131.8	126.8	5.0	58.9	4.70	5.00	5.30	0.18
13	132.3	126.8	5.5	61.7	5.23	5.54	5.84	0.19
14	132.4	127.1	5.3	63.5	4.98	5.29	5.60	0.19
15	131.3	121.6	9.8	64.7	9.45	9.77	10.08	0.19
16	131.0	120.9	10.1	63.9	9.80	10.11	10.43	0.19
17	129.8	78.3	51.5	61.8	51.19	51.51	51.82	0.19
18	129.2	55.3	73.8	60.5	73.50	73.83	74.16	0.20
19	119.2	62.3	56.9	58.9	56.54	56.88	57.21	0.20
20	115.6	68.8	46.8	57.2	46.46	46.79	47.13	0.20
21	109.3	96.8	12.5	56.1	12.18	12.52	12.85	0.20
22	115.7	116.8	-1.1	55.0	-1.47	-1.14	-0.80	0.20
23	110.7	134.3	-23.6	53.8	-23.98	-23.65	-23.31	0.20
24	105.1	132.1	-26.9	53.2	-27.27	-26.94	-26.60	0.20
By Period:	Estimated Reference Energy Use	Observed Event Day Energy Use (MWh/hr)	Estimated Change in Energy Use	Weighted Average Temperature (°F)	Uncertainty Adjusted Impact (MWh/hr) - Percentiles 5th%ile	50th%ile	95th%ile	Standard Error
Average Event Hour	120.6	72.3	48.3	58.9	47.97	48.30	48.63	0.20

Figure 4-2: Hourly Load Impacts for All Contracts on January 16, 2024



Hybrid Load Impacts

[redacted]

[redacted] A summary of Hybrid's load impacts during each event is presented in the Excel-based table generator designated as Appendix B.

Table 4-3: Hourly Load Impacts for All Hybrid Contracts on January 16, 2024

[redacted]

Figure 4-3: Hourly Load Impacts for All Hybrid Contracts on January 16, 2024

[redacted]

Stem Load Impacts

[redacted] A summary of Stem's load impacts during each event is presented in the Excel-based table generator designated as Appendix B.

Table 4-4: Hourly Load Impacts for the Stem Contract on January 16, 2024

[redacted]

Figure 4-4: Hourly Load Impacts for the Stem Contract on January 16, 2024

[redacted]

Swell Load Impacts

[redacted] A summary of Swell's load impacts during each event is presented in the Excel-based table generator designated as Appendix B.

Table 4-5: Hourly Load Impacts for the Swell Contract on January 16, 2024

[redacted]

Figure 4-5: Hourly Load Impacts for the Swell Contract on January 16, 2024

[redacted]

5. EX-ANTE LOAD IMPACT FORECAST

5.1 Description of Methods

The objectives of the ex-ante portion of the evaluation are to develop ex-ante DRA load impacts for the RA window[9] for the period 2025 through 2035, where the forecasts are provided:

- For a typical event day and for the monthly system peak day for each month;
- For the average customer and all customers in aggregate, and by LCA[10]; and
- For 1-in-2 weather year under both SCE and CAISO-coincident peak conditions.

In this process, three elements are required to develop the ex-ante load impact forecasts:

1. Contract capacity forecasts (e.g., MW commitment by contract, year, and month);
2. Contract-specific reference load profiles; and
3. Estimates of average load impacts by contract.

[9] The RA window is from 4 to 9 p.m. (HE 17 to 21) from June through February and 5 to 10 p.m. (HE 18 to 22) from March through May.
[10] All DRA contracts are limited to the LA Basin LCA.

SCE provided the forecast of monthly capacity commitments by contract, which is summarized in the next sub-section.[11] In a typical demand response study, the utility provides a customer enrollment forecast. However, in this study the DRAs determine the enrollment required to meet their contract obligations. Therefore, the focus of the ex-ante forecast is on the contract obligations rather than customer enrollments, which are reverse engineered as necessary to obtain the forecast capacity values.

Contract-specific reference load profiles are based on simulations from regression models that match those used in the ex-post load impact analyses but removing the morning load variable.[12] Customer-specific models are estimated with the resulting reference loads added up to the contract level. Reference loads are simulated using the appropriate weather data (e.g., 1-in-2 weather-year conditions for SCE and CAISO-coincident peak conditions as provided by SCE) and event-day characteristics.

Ex-ante load impacts are developed from the ex-post load impact estimates. Because the contract capacities in our historical data match those of the forecast period (i.e., the contracts included in this year's evaluation do not have any forecast changes in their contract capacity values), we perform a straightforward adaptation of the ex-post impacts into the ex-ante forecast. There's no need to adjust for changes in the contract capacities.

The ex-ante load impacts are based on each contract's average performance during similar events in the ex-post study, which are four-hour events beginning in HE 17 or 18. Due to gaps in the interval data for some customers, ex-ante impacts are calculated at the customer level before being aggregated to the contract level. Because the contracts can be called for a maximum of four hours, we simulate a four-hour event from HE 18 through 21 in the ex-ante forecast. The HE 17 ex-post load impacts are shifted one hour when calculating the average ex-post impacts (i.e., HE 17 to 20 is treated as HE 18 to 21). Reported average RA window load impacts are calculated over the four hours assumed to be called (i.e., excluding HE 17). Although the RA window is an hour later (HE 18 through 22) from March through May, we do not modify the load impacts to accommodate those hours because only the Hybrid contracts were called later than HE 21.

Snapback effects are included in the ex-ante forecast for the three hours following the event (HE 22 through 24). They are based on the ex-post average load impacts for the three hours following four-hour events beginning in HE 17 or 18. The uncertainty-adjusted load impact scenarios are simulated using the standard deviations of the hour-specific average load impacts described above.

5.2 Contract Quantity Forecasts

In lieu of an enrollment forecast (which is what we receive in the typical DR resource evaluation), SCE provided us with the monthly contract capacity (MW) values for each contract during the forecast period. Customer enrollments are assumed to remain the

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[11] Swell is not included in the ex-ante forecasts due to their contract being dissolved.

[12] The presence of the morning load variable complicates the simulation of ex-ante reference loads because it requires a separate simulation of the morning load.

same, as the contract capacity values do not change in the forecast period. Table 5-1 shows the totals across all contracts by month and year, averaged for the RA window. The hybrid contracts have a lower capacity value during HE 19 through 21 (the "Extended" hours), which is reflected in the table's averages.

Table 5-1: Average RA Window Forecast Contract Quantities for All Contracts (MW)

Month	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035
Jan	[redacted]										
Feb	[redacted]										
Mar	[redacted]										
Apr	[redacted]										
May	[redacted]										
Jun	[redacted]										
Jul	[redacted]										
Aug	[redacted]										
Sep	[redacted]										
Oct	[redacted]										
Nov	[redacted]										
Dec	[redacted]										

The contract end dates are as follows:

[redacted]

5.3 Ex-Ante Load Impacts by DRA

All Contracts Forecast

Figure 5-1 shows the average RA-window load impact totaled across all contracts. We show August monthly peak day impacts by weather scenario for each year. Notice that the load impacts do not vary across weather scenarios, which is a direct result of the methodology discussed in Section 5.1. [redacted]

Figure 5-1: Average August RA Window Load Impacts by Weather Scenario and Year, Total for All Contracts

[redacted]

Table 5-2 shows the monthly average RA window load impact across all contracts for 2025. The average is calculated over the hours assumed to be called: HE 18 through 21. Therefore, while the RA window is shifted one hour later from March through May (HE 18 through 22 versus HE 17 through 21 in all other months), the reported RA window average load impact is the same during all months.

Table 5-2: Average RA Window Forecast Contract Quantities for All Contracts by Month in 2025 (MW)

Month	SCE 1-in-2 Worst Day RA Window Load Impacts
January	[redacted]
February	[redacted]
March	[redacted]
April	[redacted]
May	[redacted]
June	[redacted]
July	[redacted]
August	[redacted]
September	[redacted]
October	[redacted]
November	[redacted]
December	[redacted]

Table 5-3 and Figure 5-2 show the hourly load impacts in August 2025 for the utility-specific 1-in-2 weather scenario. The load impact declines somewhat during the RA window, which reflects two things:

[redacted]

Table 5-3: Hourly Reference Loads and Load Impacts for All LCR Contracts, August 2025 SCE 1-in-2 Weather

[redacted]

Figure 5-2: Hourly Reference Loads and Load Impacts for All LCR Contracts, August 2025 SCE 1-in-2 Weather

[redacted]

Hybrid Forecast

[redacted]

13 [redacted]

Table 5-4: Average RA-Window Load Impacts in August (MWh/hr), All Hybrid Contracts

Year	CAISO 1-in-2	Utility 1-in-2	% Performance
2025	[redacted]		
2026			
2027			
2028			
2029			
2030			
2031			
2032			
2033			
2034			
2035			

Stem Forecast

[redacted]

Table 5-5: Average RA-Window Load Impacts in August (MWh/hr), Stem

Year	CAISO 1-in-2	Utility 1-in-2	% Performance
2025	[redacted]		
2026			
2027			
2028			
2029			
2030			
2031			
2032			
2033			
2034			
2035			

6. COMPARISONS OF RESULTS

In this section, we present several comparisons of load impacts for each contract:

- Ex-post load impacts from the current and previous studies;
- Ex-ante load impacts from the current and previous studies;
- Previous ex-ante and current ex-post load impacts; and
- Current ex-post and ex-ante load impacts.

Above, "current study" refers to this report, which is based on findings from 2024; and "previous study" refers to the report that was developed for 2023. Ex-ante reference loads and load impacts are averaged over the hours assumed to be called within the Resource Adequacy (RA) window.

6.1 Previous versus current ex-post

It is difficult to construct an apples-to-apples comparison of ex-post impacts across evaluations because the contracts can be called over a range of hours and, [redacted]. To alleviate concerns about comparing result across years, we directly compare event windows and the hours within. For instance, HE 17 to 20 events in PY2024 will be directly compared to HE 17 to 20 events in PY2023.

Table 6-1 uses the load impact and contract MW values from the Tables 4-1a through 4-1b, representing events that were four hours in duration starting in HE 17 or 18. We recreated the same values for PY2023 to provide a direct comparison. [redacted]

Table 6-1a: Previous versus Current HE17 Ex-Post Impacts

DRA	Event Hour	Current			Previous		
		Impact MW	Contract MW	% of Contract	Impact MW	Contract MW	% of Contract
[redacted]							

Table 6-1b: Previous versus Current HE18 Ex-Post Impacts

DRA	Event Hour	Current			Previous		
		Impact MW	Contract MW	% of Contract	Impact MW	Contract MW	% of Contract
[redacted]							

6.2 Previous versus current ex-ante

Table 6-2 compares the ex-ante impacts from the current and previous studies for August 2025 using the SCE-specific 1-in-2 weather conditions. [redacted]

Table 6-2: Previous versus Current Ex-Ante Impacts

DRA	Period	Current		Previous	
		Impact MW	Contract MW	Impact MW	Contract MW
[redacted]					
All	All	[redacted]		55.2	57.6

6.3 Previous ex-ante versus current ex-post

Table 6-3 compares the ex-post impacts from the current study to the August 2024 SCE 1-in-2 ex-ante forecast from the previous study. The ex-post impacts are calculated by taking an average of impacts during four-hour events that start in HE17 or HE18. [redacted]

Table 6-3: Previous Ex-Ante versus Current Ex-Post Impacts

DRA	Period	Current Ex-Post		Previous Ex-Ante	
		Impact MW	Contract MW	Impact MW	Contract MW
[redacted]					
All	All	54.3	57.6	55.2	57.6

6.4 Current ex-post versus current ex-ante

Table 6-4 compares ex-post and ex-ante load impacts from the current study. Both types of impacts are based on four-hour events starting in HE 17 or 18, though the hours are combined slightly differently in the two cases. Because the ex-ante impacts are based on averages of the ex-post impacts, we would expect the load impacts to be similar, which is the case here. The ex-ante load impacts reflect the August 2025 impacts.

Table 6-4: Current Ex-Post vs. Current Ex-Ante Impacts

DRA	Period	Current Ex-Post		Current Ex-Ante	
		Impact MW	Contract MW	Impact MW	Contract MW
[redacted]					
All	All	54.3	57.6	[redacted]	

APPENDICES

The following Appendices accompany this report. Appendix A is the validity assessment associated with our ex-post load impact evaluation. The additional appendices are Excel files that can produce the tables required by the Protocols. The Excel file names are listed below.

DRA Study Appendix B:
PY2024_SCE_Third-Party DRA_Ex_Post_Impacts_FINAL_CONFIDENTIAL.xlsx
DRA Study Appendix C:
PY2024_SCE_Third-Party DRA_Ex_Ante_Impacts_FINAL_CONFIDENTIAL.xlsx

APPENDIX A. VALIDITY ASSESSMENT

Our primary method of validating our ex-post regression model is to see how well the model predicts loads for days that are withheld from the estimation (i.e., out-of-sample predictions). We first randomly selected 15 percent of the non-event days to withhold from the testing regression models, which are separately estimated for each customer number.

[redacted][14][redacted]

Figure A-1a: Weekday Observed and Predicted Out-of-Sample Loads, Hybrid

[redacted]

[14] MPE provides an indication of bias while MAPE provides a measure of accuracy.

Figure A-1b: Weekend Observed and Predicted Out-of-Sample Loads, Hybrid

[redacted]

[redacted]

Figure A-2a: Weekday Observed and Predicted Out-of-Sample Loads, Stem

[redacted]

Figure A-2b: Weekday Observed and Predicted Out-of-Sample Loads, Stem

[redacted]

[redacted]

[redacted]

Figure A-3a: Weekday Observed and Predicted Out-of-Sample Loads, Swell

[redacted]

Figure A-3b: Weekend Observed and Predicted Out-of-Sample Loads, Swell

[redacted]

[redacted]

[redacted]

Figure A-4a: Weekday Histogram of Customer-Specific R^2 Values by DRA

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

Figure A-4b: Weekend Histogram of Customer-Specific R^2 Values by DRA

[redacted]

Tables A-1a and A-1b summarize the average of the customer-specific R^2 values by DRA and model [redacted].

Table A-1a: Weekday Average R^2 from Ex-Post Model by Demand Response Aggregator

Aggregator	Average Customer-Level R^2
[redacted]	
All Contracts	0.580

Table A-1b: Weekend Average R^2 from Ex-Post Model by Demand Response Aggregator

Aggregator	Average Customer-Level R^2
[redacted]	
All Contracts	0.533