



PRELIMINARY ANALYSIS OF CALIFORNIA'S RESILIENCY DURING THE SEPTEMBER 2022 HEAT WAVE

SUMMARY

This is a preliminary assessment of the impacts of the September 2022 heat wave that led to all-time record levels of electricity demand not only in the California Independent System Operator (CAISO), but across the western United States. The Public Advocates Office (Cal Advocates) staff will continue to research and analyze the impacts as more data becomes available.

During the heatwave, the CAISO made numerous calls for conservation and issued reliability alerts. Despite the record electricity demand, only sparse load shedding occurred, (presumably due to miscommunication). Supply-side resources faced typical summer-time levels of outages, and while wildfires affected solar production, they did not cause any transmission outages.

Given the CAISO issued Flex Alerts from August 31 to September 9, 2022, we considered this period to be the "heat wave" for the purposes of this analysis. Sources for this analysis include price and load data from the CAISO Open Access Same-time Information System (OASIS)¹ and weekly summer reliability calls the California Public Utilities Commission (Commission) holds with the three large investor-owned utilities (IOUs).

GOAL

With heat waves only expected to be more frequent and more intense with each year due to climate change, it is critical to have up-to-date analysis in order to address these situations in the most informed and cost-effective way possible.

¹ Available at: <http://oasis.caiso.com>

LOAD

The September 2022 heat wave set an all-time record for CAISO electricity demand of 51,426 MW on September 6 at 16:55. CAISO also reported that the Western Interconnection set a new peak demand record on September 6 at 164.6 GW.² The graph below shows CAISO gross demand from August 31 to September 9, with varying levels of Flex and Emergency Alerts highlighted in red.³

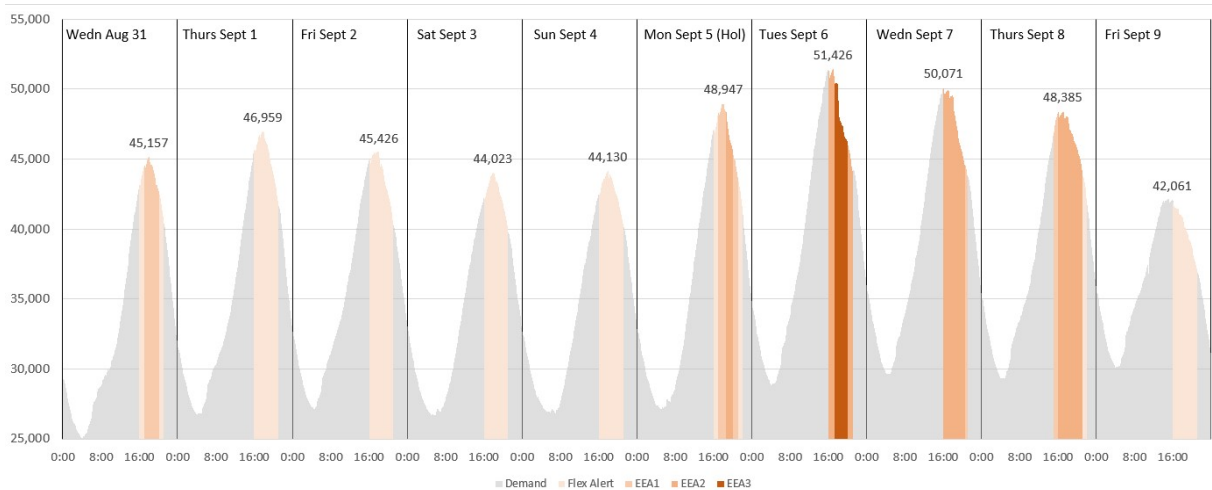


Figure 1. CAISO gross demand from August 31-September 9, 2022.

It was clear to forecasters as early as August 30 that California was going to experience a likely-record-breaking heat wave.⁴ Going into Tuesday, September 6, the demand forecast looked likely to result in outages. Figure 2, found on the next page, shows gross and net forecasts for the day; the black line represents the Resource Adequacy (RA) capacity and credits available to the CAISO. The blue lines represent the day ahead gross and net forecasts, and the grey lines represent the gross and net forecasts with the CAISO's reserve requirement adder.⁵ Demand exceeds supply planning program targets when the grey and blue lines exceed the black line. Outages looked like a

² WECC Daily Status Report, 2022-09-07, available at <https://www.wecc.org/Reliability/WECC%20Daily%20Status%20Report%202022-09-07.xlsx>

³ See CAISO's Emergency Notification Fact Sheet for more information, available at <http://www.caiso.com/Documents/Emergency-Notifications-Fact-Sheet.pdf>

⁴ Daniel Swain, *Weather West*, "Severe, dangerous, and likely record-breaking heatwave over Labor Day weekend," August 30, 2022, available at <https://weatherwest.com/archives/17179>

⁵ The CAISO reserve requirements are the 6% North American Electric Reliability Corporation (NERC)-mandated reserves that they must maintain to ensure the operability of the grid.

certainty, and the CAISO pre-emptively declared an Electric Emergency Alert (EEA) Watch on September 5.

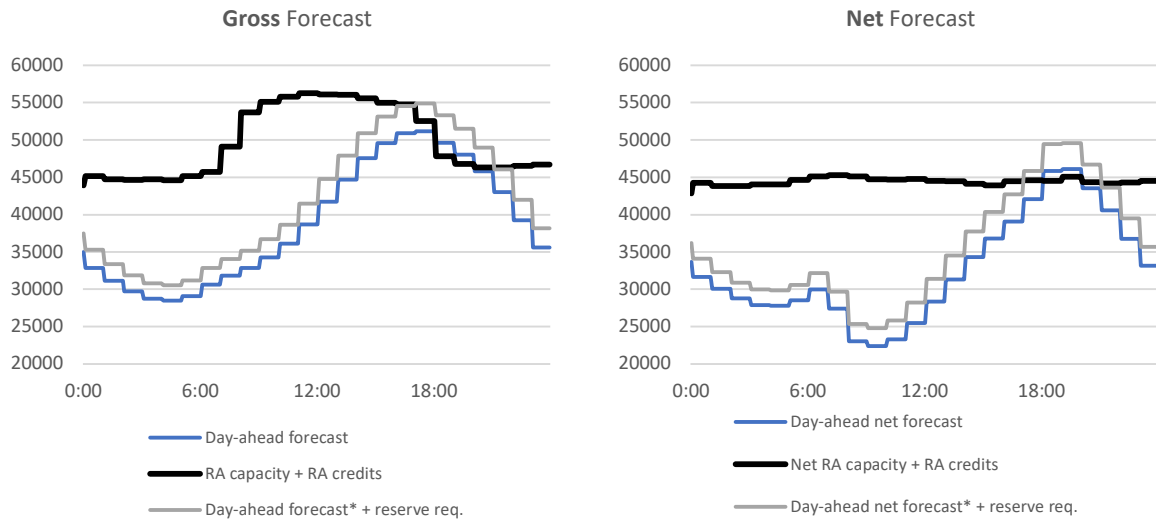


Figure 2. Gross v. net forecasted energy demand.

Figure 3, found on the next page, shows the progression of load throughout September 6. As with the forecast, the black line represents RA capacity and credits available to the CAISO, while the light blue line is gross demand, dark blue is net demand, and the gray line represents the gross demand plus reserve requirements that CAISO must maintain.⁶ The periods in late afternoon when the gray line exceeded the black line are nominally the periods which would have posed the largest risk for load shedding and are mostly correlated with the CAISO's issuance of a EEA 3 alert, which indicates that firm load interruption is imminent or in progress and the CAISO is unable or meet minimum Contingency Reserves.. Nonetheless, CAISO maintained adequate operating reserves throughout the EEA3 with average 9.7% and minimum of 6.2% of load.⁷

⁶ All data obtained from CAISO's Today's Outlook for September 6, 2022. Available at: <https://www.caiso.com/TodaysOutlook/Pages/default.aspx>

⁷ See CAISO's OASIS, under Ancillary Services > Actual Operating Reserves for 09/06/2022, at <http://oasis.caiso.com/mrioasis/logon.do>.

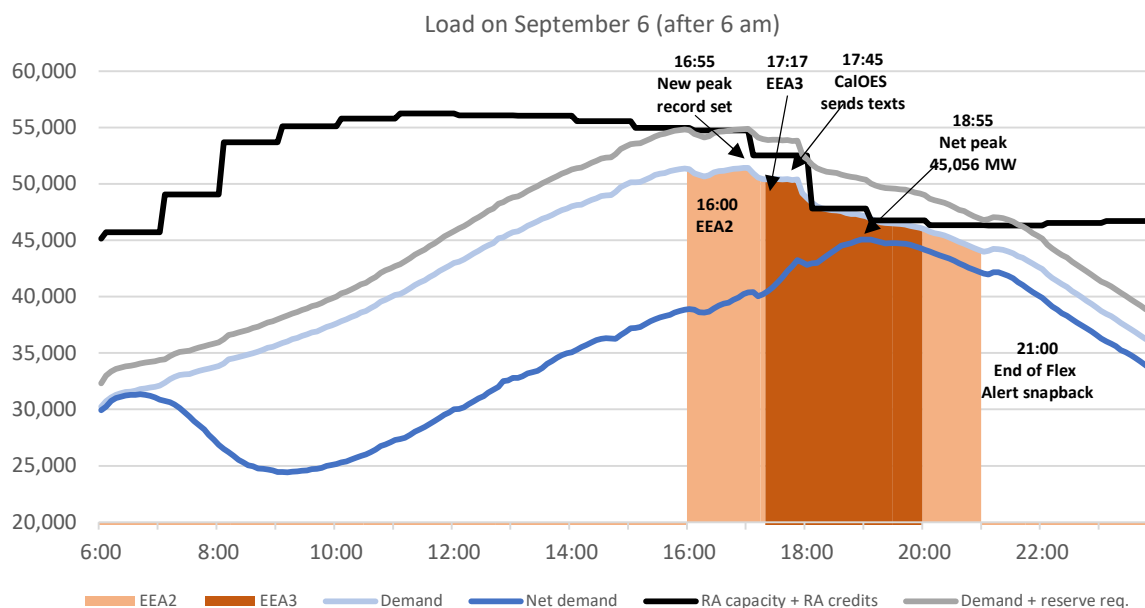


Figure 3. Progression of load on September 6, 2022.

The day started off with poor wind production, and at 10:09 the CAISO pre-emptively declared an EEA1 starting at 16:00.⁸ By 13:55, due to forecasted shortfalls, the CAISO upgraded its scheduled EEA1 to an EEA2 for 16:00-21:00, enabling it to call on demand response and backup generation.⁹ When the EEA2 began at 16:00, CAISO initiated demand response (DR) events and continued to do so until 21:00. CAISO recorded a new gross peak demand record at 16:55 of either 51,426 or 52,061 MW,¹⁰ at the peak of its first DR snapback.¹¹ As the evening solar ramp began, CAISO triggered EEA3 at 17:17.¹² Conditions continued to deteriorate and at 17:45 Governor Newsom authorized the Office of Emergency Services to deploy the Emergency Alert System,¹³ pushing out alerts to mobile phones across the state asking residents to “Turn off or reduce nonessential power if health allows, now until 9pm.” The message was also sent in

⁸ CAISO, Grid Emergencies History Report – 1998 to Present, available at <http://www.caiso.com/informed/Pages/Notifications/NoticeLog.aspx>

⁹ California ISO Media Briefing, September 7, 2022, available at <https://www.youtube.com/watch?v=fTRpiAXCDac>

¹⁰ CAISO’s reported data shows a peak of 51,426 MW, although CAISO President Mainzer has publicly reported the peak was 52,061 MW. The 2006 record was 50,270 MW.

¹¹ “Snapback” refers to a rapid increase in energy consumption that is often observed after a demand response event ends.

¹² The newly deployed “EEA” system differs from CAISO’s previous emergency stages, where a final Stage 3 emergency implies that load shedding is occurring. In an EEA3 emergency, CAISO orders utilities to arm firm load in preparation of shedding, but it still has several steps and tools available prior to load shedding.

¹³ California ISO Media Briefing, September 7, 2022, available at <https://www.youtube.com/watch?v=fTRpiAXCDac>

Spanish. Initial estimates from the CAISO have suggested that this message resulted in a drop of 2000 MW in load over 20-30 minutes.¹⁴ The EEA3 was downgraded to an EEA2 at 20:00 without CAISO ordering load shedding.

LOAD-ADJACENT ISSUES

On September 5-8, the CAISO declared Northern California Transmission Emergencies beginning in early afternoon until 21:00.¹⁵ CAISO staff clarified that these were localized overload situations which were managed using the state's 60 MW backup emergency generators that are part of the Strategic Energy Reserve (SER).¹⁶ During the September 9 Summer Reliability Call,¹⁷ a staff person from one of the IOUs suggested that declaring the Transmission Emergencies was procedurally necessary to release the state's Strategic Emergency Reliability Reserve assets that are located in Sutter county.¹⁸

While CAISO did not order load shed at any point during the heat wave, some load was shed by municipal utilities. The source of the error appears to be confusion surrounding the new EEA emergency system.³ At 17:53, the Northern California Power Agency (NCPA; made up of municipal utilities, BART, the Port of Oakland, etc.) misinterpreted CAISO's EEA3 alert as a load shed request.¹⁹ Due to this misinterpretation, NCPA's dispatcher ordered the Cities of Alameda, Lodi, Santa Clara, Palo Alto, Healdsburg, and Ukiah to shed 46 MW of load, most of which was restored within the hour.

WHOLESALE ELECTRICITY PRICES

Wholesale energy prices have been higher in 2022 than previous years.²⁰ Numerous factors are behind this, driven in part by the elevated price of natural gas which is two to three times higher this summer than in recent years. Last year, the CAISO implemented the Federal Energy Regulatory Commission's (FERC) orders to increase the price cap of

¹⁴ California ISO Media Briefing, September 7, 2022, available at <https://www.youtube.com/watch?v=fTRpiAXCDac>

¹⁵ <http://www.caiso.com/Documents/Grid-Emergencies-History-Report-1998-Present.pdf>

¹⁶ California ISO Media Briefing, September 7, 2022, available at <https://www.youtube.com/watch?v=fTRpiAXCDac>

¹⁷ California's three investor-owned electric utilities hold weekly calls with staff from the California Public Utilities Commission as well as the Public Advocates Office to debrief the past week's electric load and look ahead at forecasts for the following week.

¹⁸ California Energy Commission, "Greenleaf 1 Temporary Power Generators," available at

<https://www.energy.ca.gov/powerplant/simple-cycle/greenleaf-1-temporary-power-generators>

¹⁹ http://www.ncpa.com/wp-content/uploads/2022/09/NCPA_EEA3-Press-Release-Final-090722.pdf

²⁰ CAISO Q1 2022 Report on Market Issues and Performance, September 6, 2022, pp. 15-16. Available at: <https://www.caiso.com/Documents/2022-First-Quarter-Report-on-Market-Issues-and-Performance-Sep-6-2022.pdf>

energy from \$1,000/MWh to \$2,000/MWh, and the market easily reached the new cap during the heat wave.

Figure 4 below shows the average Locational Marginal Price (LMP) of the four price regions in CAISO at the Day-ahead Market (DAM) price and Real-time Market (RTM) five-minute dispatch price.²¹

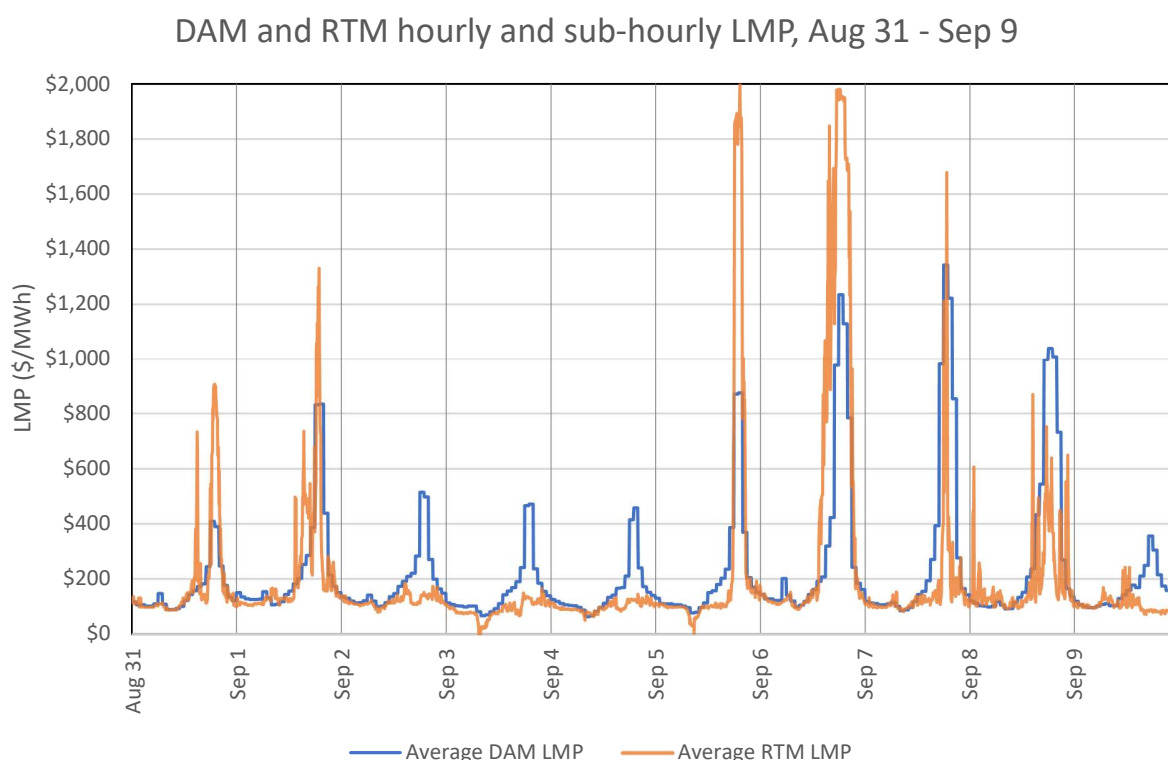


Figure 4. Comparison of average DAM and RTM LMP of four price regions in CAISO.

- Average DAM prices from August 31 to September 9 were \$218.78/MWh, and average RTM prices were \$198.47.
- In 2021, Quarter 3, average DAM LMPs were \$65/MWh and RTM prices were \$58/MWh.
- During the August 14-15, 2020 blackouts and the following days, DAM and RTM prices hovered just below or at \$1,000/MWh (the price cap at the time) in a similar pattern, mostly around 16:00-21:00.

²¹ Prices were generally consistent across all four domestic CAISO Distributed Local Aggregation Points (DLAP, an average of price regions), so the data presents an unweighted average LMP of all 4 DLAPs. The graph uses data from the CAISO OASIS.

- The daily maximum hourly (DAM) and 5-minute interval (RTM) prices are shown below. The highest single Default Load Aggregation Point (DLAP) LMP was in PG&E's service territory on 9/6, 16:50-16:55 at \$2,105.62.²²

Max Price	31-Aug	1-Sep	2-Sep	3-Sep	4-Sep	5-Sep	6-Sep	7-Sep	8-Sep	9-Sep
DAM	\$409	\$835	\$514	\$472	\$458	\$876	\$1,235	\$1,343	\$1,039	\$356
RTM	\$906	\$1,331	\$185	\$164	\$144	\$2,000	\$1,980	\$1,678	\$869	\$241

Table 1. Daily maximum hourly (DAM) and 5-minute interval (RTM) prices.

NATURAL GAS PRICES

Gas prices have an exponential impact on energy prices and have remained two times above average for most of 2022. Natural gas prices are influenced by numerous factors including national and international market trends and supply as well as constraints on the out-of-state and in-state gas transportation/storage systems. No significant infrastructure constraints were reported during this heat wave.

- The average daily price of natural gas on the PG&E and SCE Citygate pipeline systems from August 31 to September 9 was \$11.56/MMBtu.
- In 2021, natural gas prices on the two Citygate lines averaged \$5.98/MMBtu, and in 2020 they averaged \$3.00/MMBtu.

ENERGY STORAGE PERFORMANCE

Energy storage performed well during the heat wave with dispatches peaking at 18:30 on September 5. A moderate amount of charging took place during night-time hours, likely due to lower pricing in those hours making it cheaper to charge storage; prices during the heat wave were lowest from 1:00-5:00 and 9:00-11:00. Figure 5, found on the next page, shows storage dispatches for August 31-September 9, with the average five-minute dispatch in dark blue.²³ Dispatch behavior on September 6 (peak day) is shown in the orange line.

²² The \$2000/MWh price cap applies to the raw price of energy and do not account for congestion and other price adders. The Congestion adder at this time was \$662.98.

²³ Data sourced from CAISO's Today's Outlook dashboard.

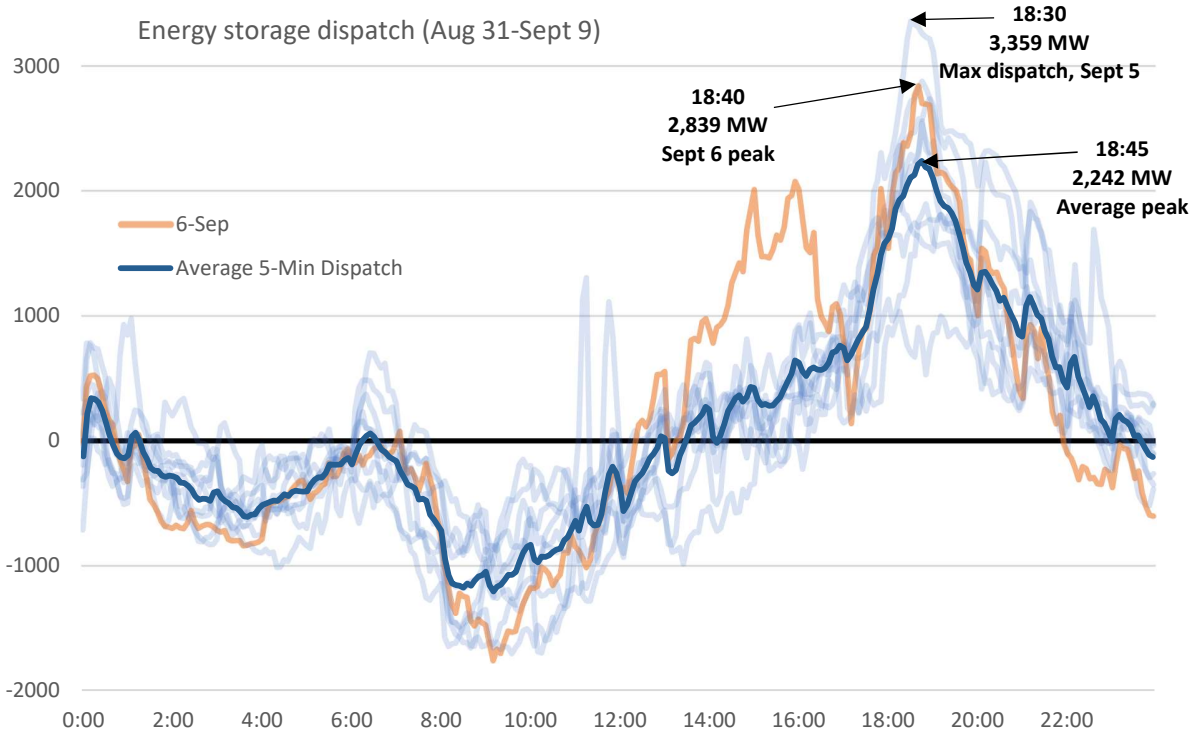


Figure 5. Energy storage dispatches from August 31-September 9, 2022.

On September 6, there were unusually high dispatches of storage from 13:30 to 16:30. Although solar production unexpectedly decreased around that time, it is not enough to explain the discharges. Cal Advocates hypothesizes that the one-hour-look-ahead period used in the CAISO real-time Multi-Interval Optimization (MIO) process was not long enough to limit real-time economic discharge awards between 13:30 and 16:30. This is because the rolling 5-minute real-time dispatch in the MIO does not take system needs beyond one hour into consideration. Dispatches may have been issued to storage in response to high real-time prices, but the awards did not adequately reflect the need to maintain storage state-of-charge to meet system needs beyond one hour. The MIO seems not to have recognized the need until the period between 16:30 and 17:20, the time at which the one-hour lookahead would begin to incorporate peak system load. Operator intervention through Exceptional Dispatch (ED) instructions may also explain the drop in storage discharge to close to 0 MW at 17:20.²⁴ However, prices at the RTM and DAM were quite predictable so storage bids should have been updated by

²⁴ The MIO process is designed to limit dispatch of storage in periods when prices may be high, but the storage capacity is expected to be needed later in the day, namely 4-9pm when reliability needs are high. For more information, see the ongoing Energy Storage Enhancements initiative: <https://stakeholdercenter.caiso.com/StakeholderInitiatives/Energy-storage-enhancements>

generators to reflect the value of discharge at the typical peak load times. The CAISO is currently evaluating the process at the Energy Storage Enhancements initiative.

Up until 2020, energy storage was most frequently dispatched in the CAISO market for ancillary services, primarily regulation up and regulation down to provide rapid responses for voltage regulation and other needs. Between July 2020 and April 2022, California was able to install over 3,111 MW of new battery storage.²⁵ The CAISO and generator stakeholders have observed that by 2022, the Ancillary Services market had become saturated, due to the increasing penetration of energy storage. The quantity of ancillary services offered into the CAISO market is more than sufficient to meet needs, which has resulted in more storage capacity that is available to provide discharge energy instead of ancillary services.

RENEWABLE PRODUCTION

Renewable production was generally robust though solar production decreased by approximately 30% on the afternoon of September 8, possibly due to wildfire smoke or impacts from Tropical Storm Kay in Southern California. The impact of decreased solar production was offset by increased generation from mostly natural gas generation but also energy storage and hydropower.

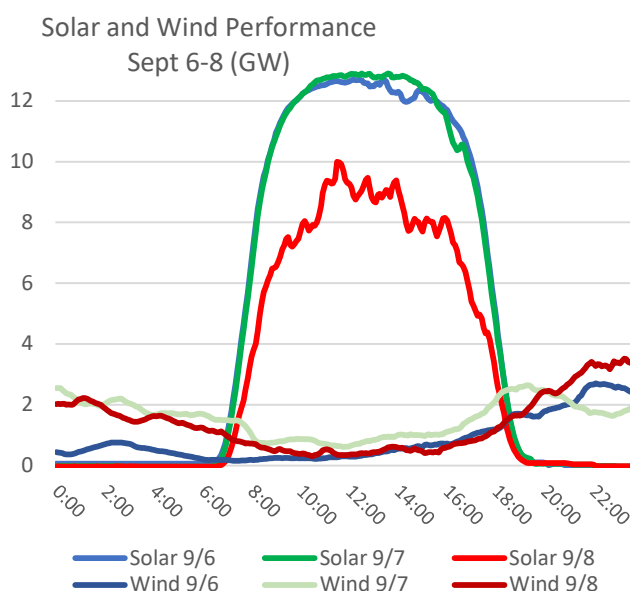


Figure 6. Solar and wind performance Sept. 6-8, 2022.

RESOURCE OUTAGES ON SEPTEMBER 6 – 7

Gross peak occurred at 16:55 on September 6 and 16:00 on September 7. Not including temperature-related efficiency de-rates and transmission-induced curtailments, 3,183

²⁵ Sterkel, Molly. *Tracking Energy Development – Presentation at CEC Staff Workshop*. May 2022, <https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/energy-division/documents/summer-2021-reliability/tracking-energy-development/cec-may-reliability-workshop-tracking-energy-development-may-2022.pdf>. PowerPoint Presentation.

MW of generation was on outage on September 6^h and 3,193 MW on September 7. This value includes some non-CAISO resources such as Oroville Dam and Hoover Dam hydro capacity not contracted for by SCE. The table below shows resources with greater than 100 MW on outage.²⁶

6-Sep	MW Outage	NQC	7-Sep	MW Outage	NQC
Alamitos 5	450	480	Oroville Hydro	597.1	347.75
Oroville Hydro	378.1	347.75	Alamitos 5	450	480
Russell City	277	600.9	San Luis Hydro	236.43	374.43
El Segundo 7/8	234	271.74	Hoover-SCE	264	287.01
Big Creek Hydro	185.3	700	Antelope Solar	127	100
Hoover-SCE	138.01	287.01			
Desert Sunlight	130	171.15			
Antelope Solar	127	100			
Hoover-WECC	100	249			

Table 2. Resources with greater than 100MW outages.

The table below considers the percentage of Once-Thru Cooling (OTC) resources that were on outage for September 6-7, 2022.

	MW on Outage at Gross Peak		% on Outage		NQC
	9/6/2022	9/7/2022	9/6/2022	9/7/2022	
Outages during critical events					
Alamitos 3	96	97	30%	30%	321
Alamitos 4	34	34	10%	10%	335
Alamitos 5	450	480	94%	100%	480
Huntington Beach 2	11	11	5%	5%	225
Moss Landing 6 (1)	15	13	3%	3%	510
Moss Landing 7 (2)	15	1	3%	0%	510
Ormond Beach 1	86	86	12%	12%	741
Ormond Beach 2	70	70	9%	9%	750
Redondo Beach 5	69	69	39%	39%	178
Redondo Beach 6	19	19	11%	11%	175
Redondo Beach 8	35	42	7%	9%	480
Total	900	922	19%	20%	4705

Table 3. Percentage of Once-Thru Cooling resource outages for Sept. 6-7, 2022.

For comparison, OTC resources had about 20% of their capacity on outage during the 2020-2021 peak periods. Aggregate outage levels were typical for OTC resources,

²⁶ Outage data in this section was sourced from the CAISO's Curtailed and Non-Operational Generator Prior Trade Date Reports. Available at: <https://www.caiso.com/market/Pages/OutageManagement/CurtailedandNonOperationalGenerators.aspx>

although this is well above the observed 8% national average outage rate for conventional generation.²⁷ Redondo Beach 8 was also on 100% outage from August 30 to September 3, 2022.

DEMAND RESPONSE ACTIVITY

The IOUs reported ex ante (production estimates) DR dispatches for September 1-7 at weekly Summer Reliability meetings. Peak load DR dispatch ex ante estimates for the three large IOUs totaled approximately 2,000 MW, including Emergency Load Reduction Program (ELRP), but actual dispatch information is not available to Cal Advocates at this time. The IOUs noted concerns about customer fatigue reducing performance due to consecutive DR dispatches over the week. Preliminary DR performance will be reported by the CAISO's Department of Market Monitoring (DMM) in January 2023, with final performance data available later in 2023. Load Impact Protocol reports will also be filed in early 2023 which enables Commission review of dispatch volumes for certain DR programs.

WILDFIRE IMPACTS

Despite the presence of numerous wildfires from the Mexico border on through to Oregon, there do not appear to have been any major impacts on supply due to wildfire. The IOUs reported that 100 MW of SCE's Big Creek hydro system was unavailable due to active fire, and that 2,699 customers were without power due to the Mosquito Fire as of September 6 (822 acres burned at the time, up to 50,000 acres as of Sept 13). Cal Advocates lacks data regarding non-IOU distribution impacts, such as a 5,000-acre wildfire on September 1 near LADWP's Castaic hydro resource.

OTHER HEAT-RELATED IMPACTS

The heat wave impacted distribution-level infrastructure throughout the state, largely manifesting through transformer or sub-station overloads.²⁸ Distribution outages included approximately 50,000 PG&E customers on September 7,²⁹ and 6,500 SDG&E

²⁷ Source: NERC, *General Availability Review Dashboard*. Accessed September 13, 2022, at: <https://www.nerc.com/pa/RAPA/Pages/GeneralAvailabilityReview.aspx>.

²⁸ These outages were not limited to customers of the IOUs, but also extended to publicly owned utilities. See for example, <https://twitter.com/AlamedaMuniPwr/status/1567272874276450306> and <https://twitter.com/SantaClaraPower/status/1567343293993975808>.

²⁹ ABC7 News, "Widespread rolling blackouts averted but PG&E outages still possible due to weather-related issues," September 7, 2022, available at <https://abc7news.com/pg-e-outages-bay-area-power-pge-map-napa-outage/12201419/>

customers on September 5.³⁰ The majority of these distribution outages appear to have been resolved within hours. No Public Safety Power Shutoff (PSPS) events appear to have been called by the IOUs during the heat wave though the IOUs communicated the possibility of PSPS on September 8 and through the weekend. The IOUs report any PSPS events to CPUC during Summer Reliability Calls held each Friday.

CONCLUSION

The heat wave in September 2022 resulted in the all-time highest electricity demand in the CAISO area, and fortunately, this event did not lead to rolling outages. Our analysis is preliminary and we will update it as information becomes available. We will also continue to research the heat wave events and update our analysis if additional information becomes available from the CAISO, IOUs, or other entities.

³⁰ NBC7 News, "Brutal Heat Wave Leads to Power Outages for Thousands of San Diegans, More Blackouts Possible Tuesday," September 6, 2022, available at <https://www.nbcsandiego.com/news/local/brutal-heat-wave-leads-to-power-outages-for-thousands-of-sdge-customers/3040129/>

GLOSSARY

CAISO – California Independent System Operator

DAM – Day-Ahead Market Price

DLAP – Default Load Aggregation Point

DMM – CAISO’s Department of Market Monitoring

DR – Demand Response

ED – Exceptional Dispatch

EEA – Electric Emergency Alert

ELRP – Emergency Load Reduction Program

FERC – Federal Energy Regulatory Commission

IOU – Investor-Owned Utility

LMP – Locational Marginal Price

MIO – Multi-Interval Optimization

OASIS – CAISO’s Open Access Same-time Information System

OTC – Once-Thru Cooling

PSPS – Public Safety Power Shutoff

RTM – Real-Time Market

SER – Strategic Energy Reserve