Summer Market Performance Report June 2022

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Prepared by

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3 Acronyms

AZPS	Arizona Public Service
BAA	Balancing Authority Area
BANC	Balancing Authority of Northern California
CAISO	California Independent System Operator
CCA	Community Choice Aggregator
CEC	California Energy Commission
CMRI	Customer Market Results Interface
CPUC	California Public Utilities Commission
DAM	Day ahead market
DLAP	Default Load Aggregated Point
EIM	Energy Imbalance Market
ELCC	Effective Load Carrying Capacity
ESP	Energy Service Provider
ETC	Existing Transmission Contract
F	Fahrenheit
FMM	Fifteen Minute Market
HASP	Hour Ahead Scheduling Process
HE	Hour Ending
IEPR	Integrated Energy Policy Report
IFM	Integrated Forward Market
IOU	Investor-Owned Utility
IPCO	Idaho Power Company
LADWP	Los Angeles Department of Water and Power
LMP	Locational Marginal Price
LMPM	Local Market Power Mitigation
LPT	Low priority export. This is a scheduling priority assigned to price-taker exports that do not have a non-RA supporting resource
LSE	Load Serving Entity
MSG	Multi-Stage Generator
MW	Megawatt
MWh	Megawatt-hour
NEVP	NV Energy
NGR	Non-Generating Resource
NOB	Nevada-Oregon Border
NSI	Net Scheduled Interchange
NWMT	Northwestern Energy
OASIS	Open Access Same-Time Information System
OR	Operating Reserves
PACE	PacifiCorp East
PACW	PacifiCorp West
PGE	Portland General Electric
PNM	Public Service Company of New Mexico
PRM	Planning Reserve Margin
PSEI	Puget Sound Energy

PST	Pacific Standard Time
PTO	Participating Transmission Owner
PTK	High priority assigned to a schedule. Exports are assigned this priority when they can have a non-RA resource supporting its export.
QC	Qualifying Capacity
RA	Resource Adequacy
RDRR	Reliability Demand Response Resource
RTM	Real-Time Market
RUC	Residual Unit Commitment
SCL	Seattle City Light
SMEC	System Marginal Energy Component
SOC	State of Charge
SRP	Salt River Project
TIDC	Turlock Irrigation District
TOR	Transmission Ownership Right

4 Executive Summary

The California ISO regularly reports on the performance of its markets to provide timely and relevant information. This is the first in a series of customized monthly reports focusing on the CAISO's market performance and system conditions during the 2022 summer months from June through September, when system conditions are particularly constrained in California and the Western Interconnection. These monthly reports will also provide a performance assessment of specific market enhancements implemented as part of the CAISO's summer readiness market rules changes.[1]

Overall, June observed mild conditions with relatively mild demand levels which did not strain the supply in the system.

June 2022 Highlights

The CAISO extended the summer 2021 readiness initiative for the period of June 1, 2022 through May 31, 2023. This allows to continue to use the functionality for the scheduling priorities for load, exports and wheel-through transactions. There are also a series of summer 2021 enhancements that remained in place, including enhanced real-time pricing signals, management of storage resources, resource sufficiency evaluation enhancements.

Although June experienced above-average and record warmest mean temperature in California, on average the peak loads in June came at about 34,445 MW, lower than the 37,837 MW observed in June 2021. The highest load in the month was observed on June 27 when CAISO area experienced 6 F degree above normal.

System continued to see reduced levels of hydroelectric production due to driest period on record for California. Reservoir conditions for California and the West continued to be significantly below normal. Storage in major reservoirs statewide was 57 percent of average for this time of the year and 39 percent of capacity overall.[2] Hydro production in June 2022 was slightly above the level observed June 2021 production.

The CAISO did not call for Flex Alerts in the month of June.

[1] This report is targeted in providing timely information regarding the CAISO's market's performance for the month of June. Several metrics provided in this report are preliminary and based on data still subject to change. It is also important to note that the data and analysis in this report are provided for informational purposes only and should not be considered or relied on as market advice or guidance on market participation.
[2] https://cdec.water.ca.gov/reportapp/javareports?name=STORSUM

The CAISO's load peak in June happened on June 27 at about 41, 363 MW. This load level was below the June 2022 monthly showings forecast of 47,266 MW used in resource adequacy (RA) programs. RA capacity made available in the day-ahead timeframe was sufficient to cover the net load peak.

Monthly RA capacity was at 47,266 MW and was above the level of actual load needs, which is demand plus operating reserves. RA capacity from hydro resources for June 2022 saw a reduction of 131 MW. RA Imports saw a steep decline of about 50 percent relative to 2021 reaching a level of 1,144MW. RA capacity from storage resources increased by 1,796 MW.

CAISO's prices showed moderated convergence across markets during June, and on daily average remained below $100/MWh. With no emergencies triggered in June, summer enhancements for improving real-time pricing did not trigger. The energy prices have been higher than historical prices due to higher gas prices.

The residual unit commitment (RUC) process was able to meet the adjusted load forecast in all hours of the month. There were very infrequent and minor reduction of low-priority and economic exports reduced in the RUC process.

Hourly average of net imports was about 6,600 MW for peak hours (17-21) in June. Net imports reached their minimum levels on June 10, 11 and 27 when CAISO experienced the largest volume of exports from the system for the month. The larger volume of exports was generally observed prior to the peak hours.

Western EIM transfers into the CAISO area were consistently over 1,000 MW in. Transfers into CAISO's were from multiple areas, including adjacent areas and also from farther reaching areas. Overall, EIM transfers reflect the economic and operational benefits that EIM offers to participating entities by maximizing supply diversity.

All RA imports bid at $0/MWh or lower prices in both the day-ahead market and real-time markets. This is assessed for static RA imports related to CPUC-jurisdictional load serving entities and for hours ending 17 through 21 on weekdays.

Up to 455 MW out of the 742 MW of registered wheels in June were used in the market. A maximum of 200 MW high priority self-schedule wheels in the day-ahead were scheduled from Malin to Mead230 locations. For low priority wheels, the maximum transaction was 214 MW from Malin to Paloverde locations.

Reliability demand response resources were not activated in the real-time market in the month of June, while proxy demand response and reliability demand response was dispatched up to 266 MW and 108 MW, respectively.

Storage resources continue to increase the level of capacity provided to the market. The total storage in June was about 10,900 MWh, with bid-in capacity consistently over 2,000MW. The maximum state of charge in real-time was about 9,000 MWh while real-time dispatches reached about 2,000MW.

On average, the CAISO's daily average market costs were $54.6 million in June. The highest daily cost accrued on June 10 at about $93 million. These cost levels are consistent with summer conditions when increasing loads and services settled at higher energy prices.

5 Background

In mid-August 2020, a historical heat wave affected the Western United States, resulting in energy supply shortages that required two rotating power outages in the CAISO balancing authority area (BAA) on August 14 and 15, 2020. The heat wave extended through August 19. CAISO declared Stage emergencies for August 17 and 18 but avoided rotating outages. Over the 2020 Labor Day weekend, California experienced another heat wave and again the CAISO avoided rotating outages.

In a joint effort, the California Public Utilities Commission, the California Energy Commission and the California ISO initiated an analysis of the causes for the rotating outages. The findings were documented in the Final Root Cause Analysis report.[3]

The Final Root Cause Analysis found three major causal factors contributing to the rotating outages of August 14 and 15, 2020,

1. The extreme heat wave experienced in mid-August 2020 was a 1-in-30 year weather event in California and resulted in higher loads that exceeded resource adequacy and planning targets. This weather event extended across the Western United States, impacting loads in other balancing areas and straining supply across the West.

2. In transitioning to a reliable, clean, and affordable resource mix, resource planning targets have not kept pace to ensure sufficient resources that can be relied upon to meet demand for both the gross and net load (gross peak of demand less solar and wind production) peaks.

3. Some existing practices in the day-ahead energy market at that time exacerbated the supply challenges under highly stressed conditions.

Effective September 5, 2020, while still facing high-load conditions, the CAISO identified one area of improvement to existing market practices regarding the treatment of export priorities. The CAISO made an emergency business practice manual change to address this issue. The first part of the change was to use the intertie schedules derived from the scheduling run, instead of the pricing run, in the reliability unit commitment (RUC) process to more accurately reflect the feasible export schedules coming from the day-ahead market. These schedules serve as a reference for E-tagging. The second part of the change was to use the RUC schedules, instead of the integrated forward market (IFM) schedules, in determining the day-ahead priority utilized in the real-time market for exports being self-scheduled. Prior to this change, any export cleared in the IFM market received a day-ahead priority in the real-time market up to the cleared IFM schedule. With the change, exports cleared in the day-ahead market receive a day-ahead priority up to the cleared schedule in the RUC process. After the implementation of the export priorities in August 2021, the practice of using RUC schedules as the reference for feasible export schedules remains in place.

[3] California Independent System Operator, California Public Utilities Commission, and California Energy Commission. Final Root Cause Analysis Mid-August 2020 Extreme Heat Wave. January 13, 2021. http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf

Following the publication of the Final Joint Root Cause Analysis, the CAISO initiated an effort to identify, discuss with market participants, and propose enhancements across different areas of the market practices. This effort was initiated with educational workshops to level the understanding of existing market practices and their implications. This was followed by the formal launch of the Market Enhancements for Summer 2021 Readiness initiative[4].

The summer 2021 enhancements included:

1. Load, Export and wheeling priorities
2. Import market incentives during tight system conditions
3. Real-time scarcity pricing enhancements
4. Reliability demand response dispatch and real-time price impacts
5. Additional publication of intertie schedules
6. Addition of uncertainty component to the EIM resource capacity test
7. Management of storage resources during tight system conditions
8. Interconnection process enhancements
9. New displays in Today's outlook for projected conditions seven days in advance

These enhancements were implemented at different times during summer 2021.

For the summer 2022, the following enhancements continue to be in place:

1. Import market incentives during tight system conditions
2. Real-time scarcity pricing enhancements
3. Reliability demand response dispatch and real-time price impacts
4. Additional publication of intertie schedules
5. Management of storage resources during tight system conditions
6. Interconnection process enhancements
7. New displays in Today's outlook for projected conditions seven days in advance

After the assessment of the performance of the capacity test, the enhancement to include the uncertainty requirement in the capacity test was disabled from the production system effective February 15, 2022[5].

Furthermore, as early as July 2021 CAISO started the second phase of the Transmission service and market scheduling priorities with the aim at developing a long-term, holistic, framework for establishing scheduling priorities in the ISO market. Given the limited time available to develop this policy and how soon they could be implemented to be ready for summer 2022, CAISO filed at FERC to extend the

[4] The policy initiative material can be found at https://stakeholdercenter.caiso.com/StakeholderInitiatives/Market-enhancements-for-summer-2021-readiness

[5] Market notice about the suspension of the net load uncertainty adder can be found at http://www.caiso.com/Documents/Update-WEIM-Resource-Sufficiency-Evaluation-Suspension-Net-Load-Uncertainty-Adder-from-Capacity-Test-Effect-021522.html

scheduling priorities phase 1 policy for 2022 and 2023 while still working on finalizing the second phase of the policy initiative.

Finally, CAISO implemented several additional enhancements in preparation for summer 2022; these include:

1. Enhancements to the resource sufficiency test. These include changes to the logic of the capacity test to improve the accounting of the supply available in real-time. This also include the consideration of the supply infeasibilities projected in the real-time market into the flexible ramping test.
2. Further visibility to non-RA capacity for resources supporting exports. This includes notifications when high priority exports schedule exceeds the non-RA capacity of the supporting resource.
3. Enhancements to ensure variable energy resources (VER) supporting high-priority exports are based on the most recent forecast ahead of the real-time. Therefore, when the forecast changes, the exports needs to bid accordingly.
4. There were also additional transparency improvements to post on OASIS data related to load forecast adjustments across the applicable markets, as well as export reductions in the RUC and HASP markets.

Table 1 summarizes the different enhancements in place in summer 2022.

Table 1: Summary of enhancements in place for Summer 2022

Summer enhancement	Date Implemented	Trigger	Dates Triggered
EIM resource sufficiency test	1-Jun-2022	Permanent feature	All the time
Import market incentives during tight system conditions	15-Jun-2021	Warning or Emergency	Not triggered
Intertie schedules information on OASIS	26-Jul-2021	Permanent feature	All the time
Enhanced real-time pricing signals during tight supply conditions	15-Jun-2021	Warning or Emergency	Not triggered
Management of storage resources during tight system conditions	30-Jun-2021	RUC undersupply	Not triggered
Reliability demand response dispatch and real-time price impacts	4-Aug-2021	Activation of RDRR	Not triggered
Load, export and wheeling priorities	4-Aug-2021	Permanent feature[6]	All the time
CAISO's public communication protocols	29-May-2021	System Event driven	Not triggered
Today's Outlook displays	Aug 18-2021	Permanent feature	All the time
Resource sufficiency test	Jun 1, 2022	Permanent feature	All time
Enhancements to supporting resources for exports	June, 2022	Permanent feature	All time
Further visibility for supporting resources	June, 2022	Permanent feature	All time
Additional transparency for load conformance	June, 2022	Permanent feature	All time

[6] The wheeling through priorities the CAISO placed into effect are interim with an original sunset date of May 31, 2022. CAISO filed at FERC to extend these provision from June 1, 2022 through May 31, 2023 while it develops a long term policy for Forward Scheduling.

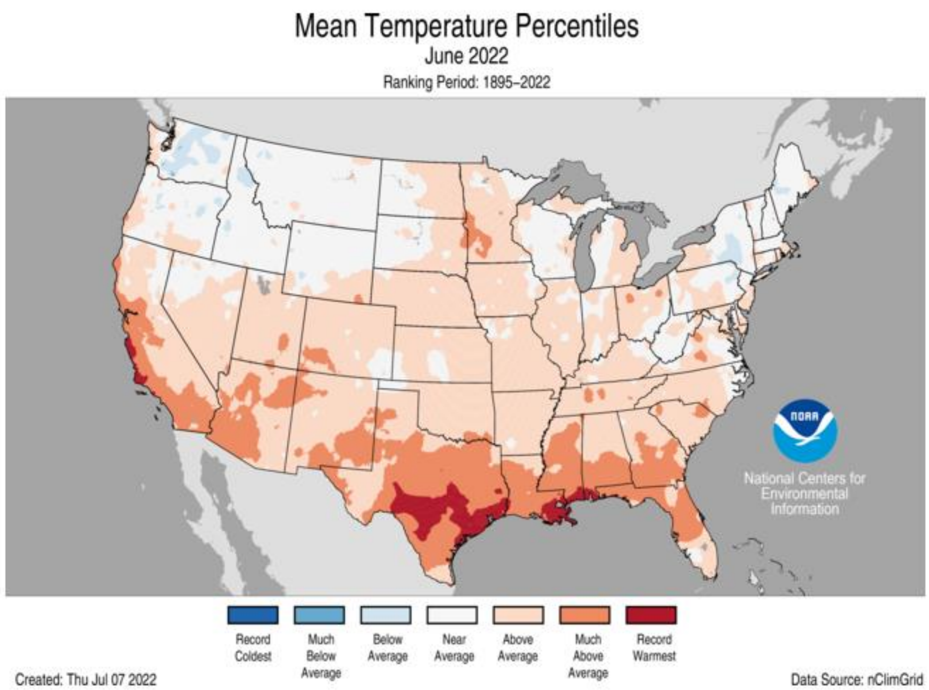
6 Weather and Demand Conditions

Weather such as temperatures and hydro conditions play a key role in the variables affecting the market and system operations, including hydro production, renewable production and load levels.

6.1 Temperature

Above average, much above average, and record warmest mean temperature percentiles were observed for California and the southwestern US while the north western United States observed near or below normal temperatures. This is shown in Figure 1 and Figure 2.

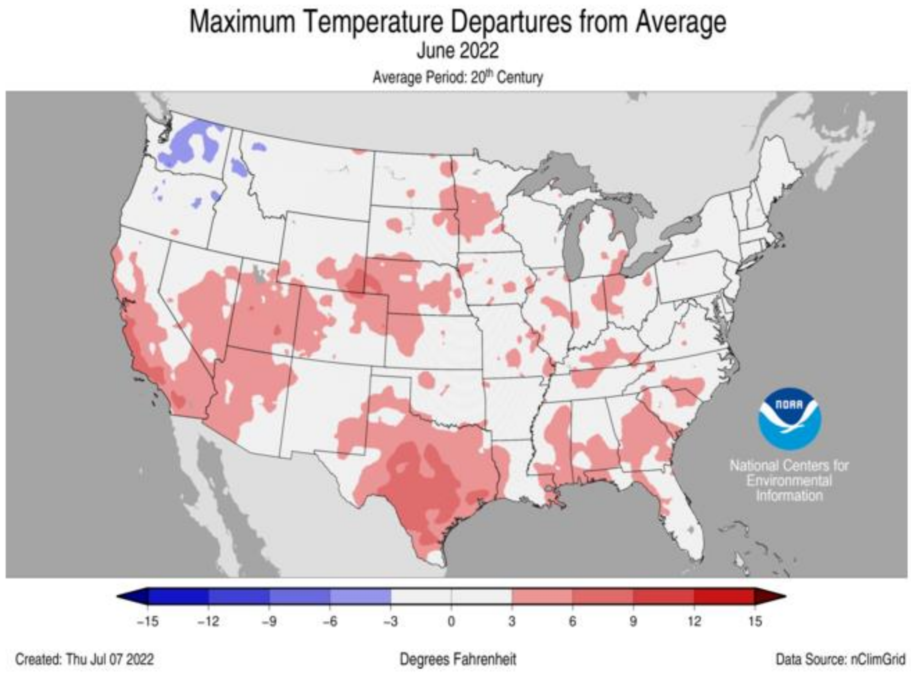
Figure 1: Mean temperature percentiles for June 2022[7]

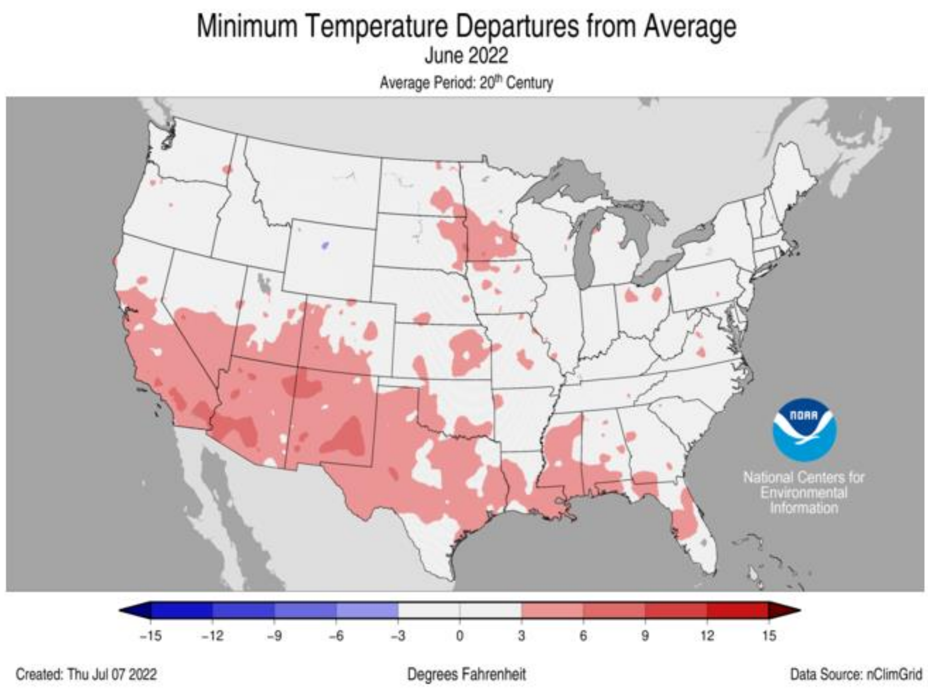


There were more widespread minimum temperature departures from normal versus maximum across California and the Desert Southwest, as shown in Figure 2. This is largely due to an increase in the monsoonal cloud coverage and moisture across this region, which acted to keep overnight temperatures warm. Certain regions of Washington, Oregon, Idaho and Montana observed monthly maximum temperature below normal for June, which was the only region in the country to have temperatures below normal for the month.

[7] https://www.ncdc.noaa.gov/temp-and-precip/us-maps/

Figure 2: Maximum and minimum CONUS temperature departures from normal[8]





Looking at the Desert Southwest EIMs more closely in

[8] https://www.ncdc.noaa.gov/temp-and-precip/us-maps/

Figure 3, the first half of the month experienced the warmest conditions. Phoenix had high temperatures 105+ for 12 consecutive days from the 6th through the 17th. Temperatures during the second half of the month dropped significantly due to an increase in monsoon storms and cloud cover impacts, cooling over 20 degrees compared to the start of the month, especially for New Mexico. Throughout CAISO, above normal temperatures were also observed during the second week of the month, but not as extreme as New Mexico and Arizona. The CAISO high temperature departures from normal are shown in Figure 4. These periods of above normal temperatures were balanced out by prolonged periods of below normal temperatures, with the month ending overall with an average high temperature of 1.6 degrees above normal. For CAISO, the warmest period of June was the 9-11, where temperatures across the Valley and deserts were 100+.

Figure 3: Desert Southwest EIM Entity high temperature departure from normal

Public Service Company of New Mexico (PNM)

High temperature departure from normal

June 2022

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
			1 0	2 -1	3 1	4 0
5 2	6 4	7 6	8 4	9 3	10 9	11 7
12 4	13 4	14 2	15 3	16 6	17 -4	18 -8
19 -10	20 -10	21 -14	22 -20	23 -8	24 -7	25 -10
26 -20	27 -18	28 -10	29 -8	30 -5		
				days < normal 16	days > normal 14	Deg +/- normal -3

above normal	below normal	Normals: 1990-2020

Arizona Public Service (APS)

High temperature departure from normal

June 2022

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
			1 -1	2 0.6	3 0.1	4 -2
5 -0.3	6 2	7 4	8 5	9 5	10 8	11 10
12 8	13 3	14 -0.1	15 1	16 6	17 4	18 -9
19 -5	20 -3	21 0.3	22 -3	23 -2	24 -1	25 -2
26 -3	27 -5	28 -0.5	29 -0.8	30 -3		
				days < normal 16	days > normal 14	Deg +/- normal + 0.5

above normal	below normal	Normals: 1990-2020

Figure 4: CAISO high temperature departure from normal

California ISO (CAISO)

High temperature departure from normal

June 2022

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
			1: 5	2: 2	3: -2	4: -5
5: -2	6: 1	7: 3	8: 2	9: 6	10: 9	11: 7
12: 0.3	13: -3	14: 0.6	15: 3	16: 0	17: -9	18: -9
19: -3	20: 5	21: 7	22: 2	23: 5	24: 5	25: 5
26: 4	27: 6	28: 5	29: 1	30: -2		
				days < normal	days > normal	Deg +/- normal
				8	22	+ 1.6

above normal | below normal | Normals: 1990-2020

The Pacific Northwest experienced some large temperature swings throughout June. Much like the Desert Southwest and CAISO, the period of warmest temperatures for the month came during the second week, followed by a large drop in temperature for the third week of the month. High temperature departures from normal for PacifiCorp East and Portland Gas and Electric are shown in Figure 5 below.

Figure 5: High temperature departure from normal for Northwestern EIM entities

PacifiCorp East

High temperature departure from normal

June 2022

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
			1: -6	2: 4	3: 5	4: 4
5: -1	6: -1	7: -1	8: 7	9: 8	10: 13	11: 13
12: 13	13: -13	14: -17	15: -8	16: 14	17: 15	18: 6
19: -4	20: -14	21: -2	22: 2	23: 4	24: 1	25: -2
26: 3	27: 7	28: 7	29: 3	30: 3		
				days < normal	days > normal	Deg +/- normal
				11	19	+ 2

above normal | below normal | Normals: 1990-2020

Portland Gas and Electric (PGE)

High temperature departure from normal

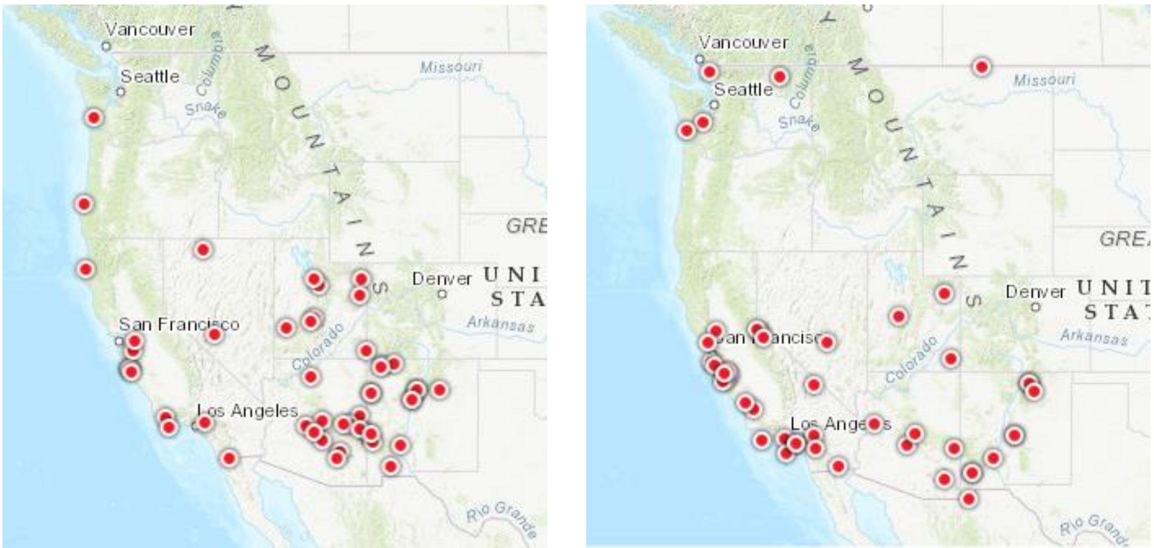
June 2022

Sun	Mon	Tues	Wed	Thurs	Fri	Sat
			1: 7	2: 8	3: -6	4: -7
5: -2	6: -6	7: 3	8: 4	9: -3	10: -4	11: -7
12: -14	13: -15	14: -8	15: -5	16: -4	17: -15	18: -11
19: -9	20: -4	21: 7	22: 3	23: 0	24: 8	25: 16
26: 21	27: 17	28: -4	29: -1	30: 3		
				days < normal	days > normal	Deg +/- normal
				18	12	-.9

above normal | below normal | Normals: 1990-2020

Looking at the entire Western United States high temperature records in Figure 6, there were 709 maximum temperature records which were tied or broken during the month of June and 1,359 minimum temperature records which were tied or broken. This is largely due to the increase in monsoon moisture and cloud cover across much of the southwest, which act to keep daytime temperatures cooler but overnight limit the amount of cooling that can occur, and keep low temperatures above normal.

Figure 6: Maximum temperature records broken or tied (left) and minimum temperature records tied or broken (right) in June 2022[9]



Excessive heat, depending on the day of week, has the potential to bring load to the electrical system that may higher than those anticipated during long-term planning and forecasts about the supply expected to be necessary to meet demand. In addition, during excessive heat events, supply resources (thermal and renewable) typically operate less efficiently, creating de-rates on the maximum energy that can be produced depending on the temperature and other characteristics, such as air flow.

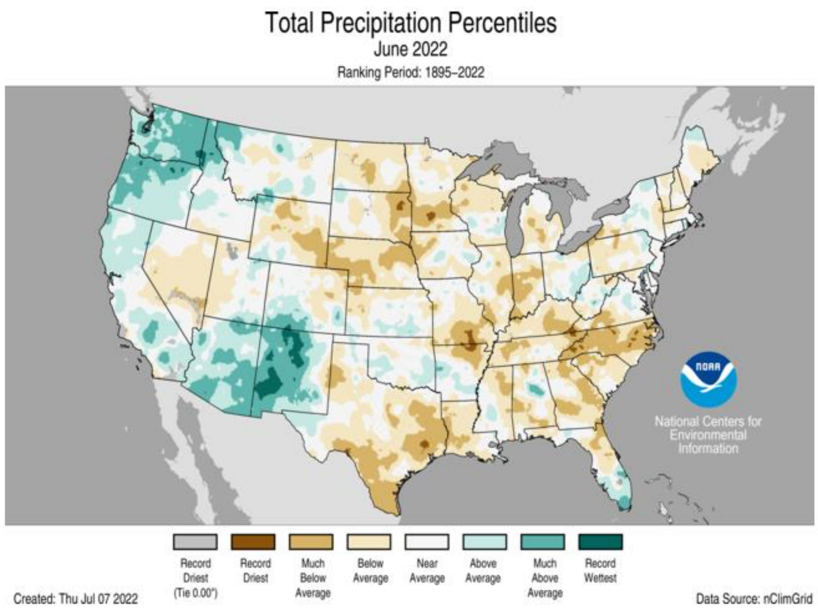
6.2 Hydro conditions

The Western United States, including California, experienced some of the driest January – June conditions on record. The January – June 2022 timeframe was the driest on record for California, 2nd driest on record for Nevada and 3rd driest on record for Utah. [10] Although June saw above average, to even record wettest conditions for much of the western US, as shown in Figure 7, due to below normal winter rainfall for California and the Desert Southwest, drought conditions persist. During the month of June, precipitation was above average throughout much of the western US, which is quite unusual for summer months.

[9] https://www.ncdc.noaa.gov/cdo-web/datatools/records

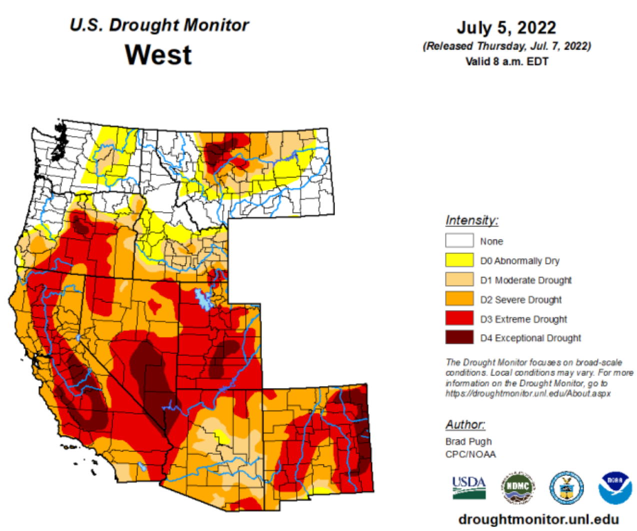
[10] https://www.ncdc.noaa.gov/temp-and-precip/us-maps/12/202109?products[]=statewidepcpnrank

Figure 7: The United States total precipitation percentiles for June 2022 [11]



Due to the lack of total precipitation throughout this water year for California and the Desert Southwest, the majority of the Western United States remains in drought conditions, extending from abnormally dry to exceptionally dry. Parts of the Pacific Northwest are no longer in drought, thanks to near-to-above average rainfall during the fall and winter months. Despite Oregon seeing its wettest April – June on record in 2022, much of the state is still in drought, indicative of how severe the drought across the west is. The extent of the drought coverage is shown in Figure 8 below.

Figure 8: The Western United States drought monitor as of July 5, 2022 [12]

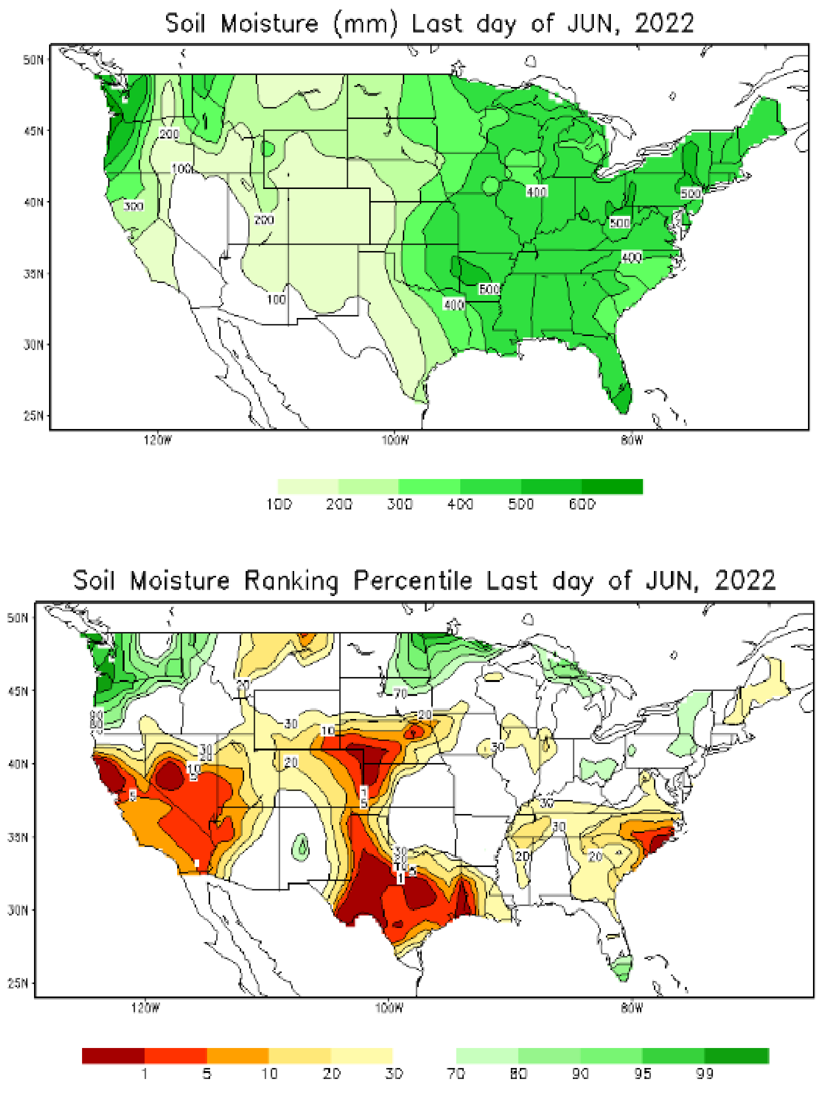


[11] https://www.ncdc.noaa.gov/temp-and-precip/us-maps/

[12] https://droughtmonitor.unl.edu/CurrentMap/StateDroughtMonitor.aspx?West

In Figure 9 below, the bottom image shows that nearly all of California is currently in the bottom 10% of soil moisture, with some coastal Northern California locations in the bottom 1%. Heading into the summer months where little-to-no precipitation is normally received, this will put most of the state into an unfavorable setup of elevated fire risk heading into the rest of summer and fall months.

Figure 9: The United States soil moisture for June 2022 (top) and the soil moisture rank (bottom)[13]

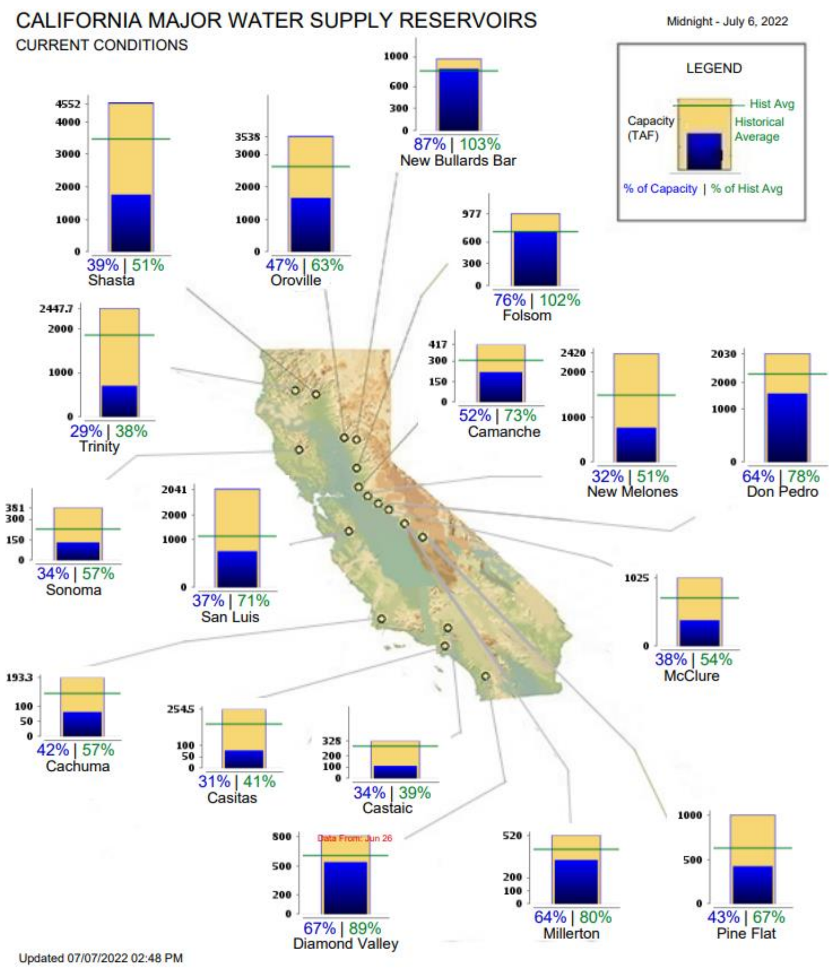


Based on all the factors discussed above related to temperatures, precipitation, drought conditions, and soil moisture levels, many reservoir conditions for California and the west are significantly below normal,

[13] https://www.cpc.ncep.noaa.gov/products/Soilmst_Monitoring/US/Soilmst/Soilmst.shtml#

as shown in Figure 9. The statewide storage in major reservoirs is currently 57% of average and at 39% of capacity[14]. This is compared to 55% of average and 41% of capacity at the end of June 2021.

Figure 10: California's reservoir conditions as of July 7, 2022[15]

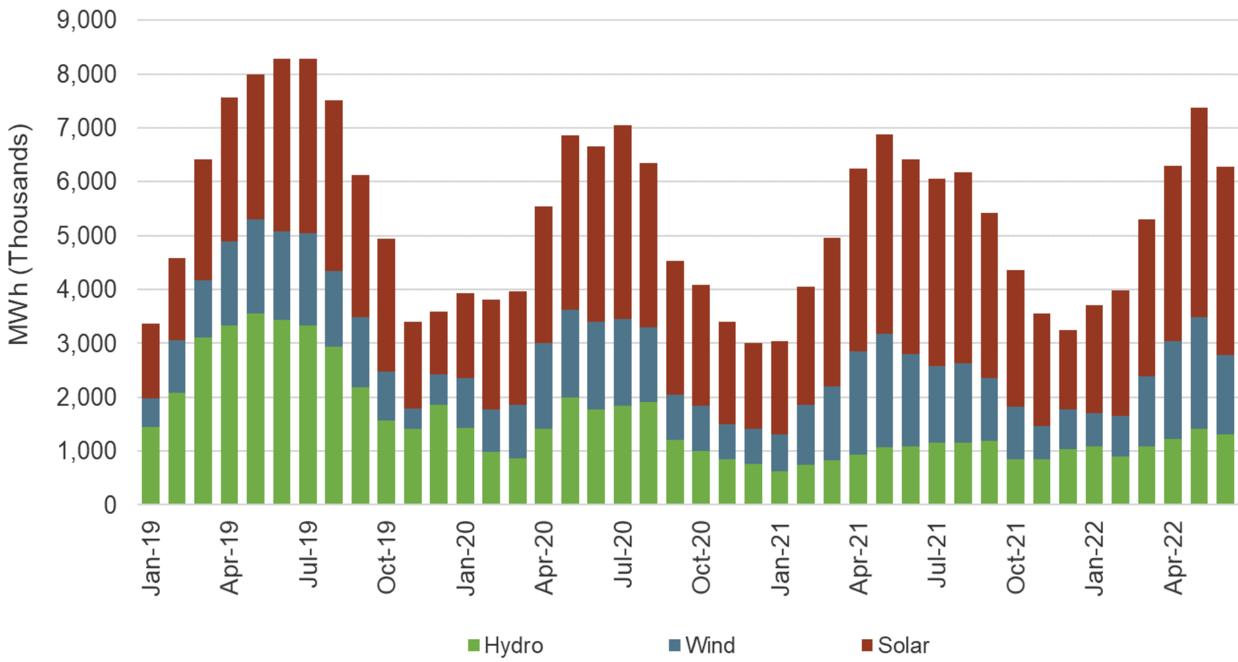


The CAISO's electrical system utilizes hydro production throughout the year to meet the CAISO demand needs. Due to the significant reduction in available water capacity currently observed in the reservoirs, the CAISO continues to see reduced capacity in hydro production this year. Figure 11 below shows the historical trend of total energy produced from hydro resources, as well as renewable resources, in which hydro production for 2022 so far has been similar to 2021. Hydro production in June 2022 is about 20 percent higher than the production observed in June 2021. Although drought conditions continue to reduce the overall available energy available over the summer, hydro resource operators typically strive

[14] https://cdec.water.ca.gov/reportapp/javareports?name=STORSUM
[15] https://cdec.water.ca.gov/resapp/RescondMain

to conserve their more limited water to provide peaking energy, which helps mitigate the adverse impact of limited hydro.

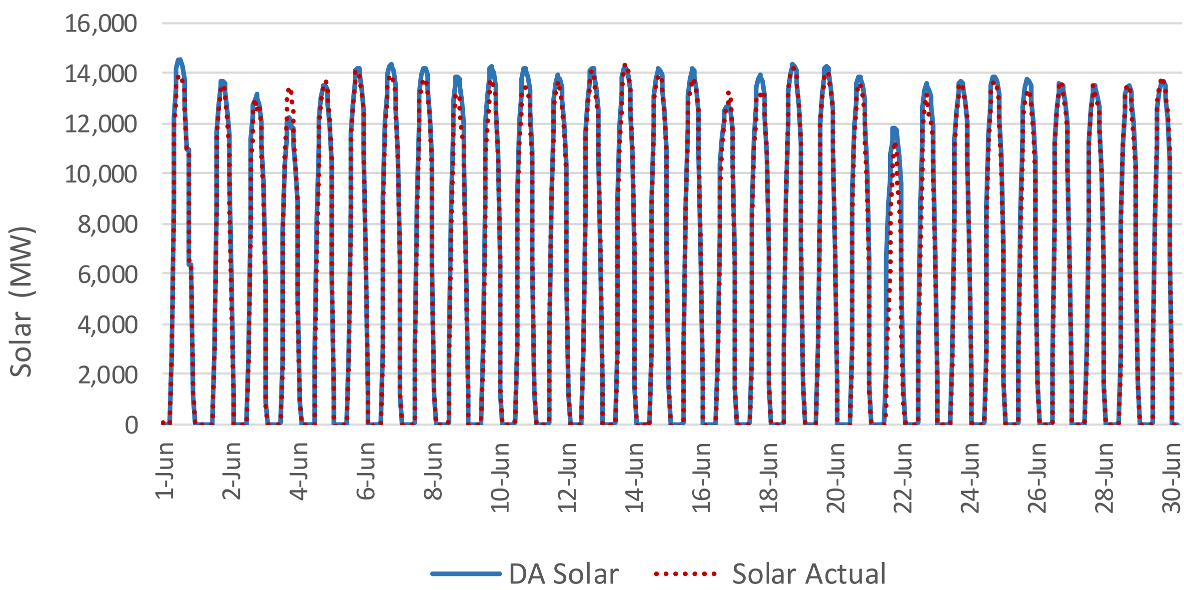
Figure 11: Historical trend of hydro and renewable production



6.3 Renewable forecasts

June 2022 saw periods of increased cloud cover and even times of showers and storms for the state due to increased monsoonal moisture in the region. Figures 12 and 13 below show the solar and wind day-ahead renewable forecasts compared to actual plus supplemental dispatch. Supplemental dispatch reflects the market's downward dispatch relative to the resource's forecast based on their bids. This allows the CAISO to measure the performance of the full-fuel forecast that is utilized in RUC and the real-time market optimization.

Figure 12: Day-ahead solar forecasts for CAISO's area



The period around June 4-6 saw unusual summertime showers across northern California. This led to a forecasted reduction in the solar output, and an increase in solar variability for the sites in northern California. This trend of impacts from cloud cover continued through the 10th, then again from the 22-24 where there was increased forecast uncertainty also due to an influx of monsoonal moisture.

The average error[16] for the day-ahead solar forecast in June was 2.41 percent. The average error observed in June 2022 is lower the day-ahead solar forecast error observed for the month of June in 2020 and 2021[17].

[16] Accuracy error is measured with the Mean Absolute Percentage Error (MAPE); ((Forecast-Actual)/Nameplate Capacity).

[17] http://www.caiso.com/Documents/Presentation-MarketPerformancePlanningForum-Jun162022.pdf

Figure 13: Day-ahead wind forecasts for CAISO's area

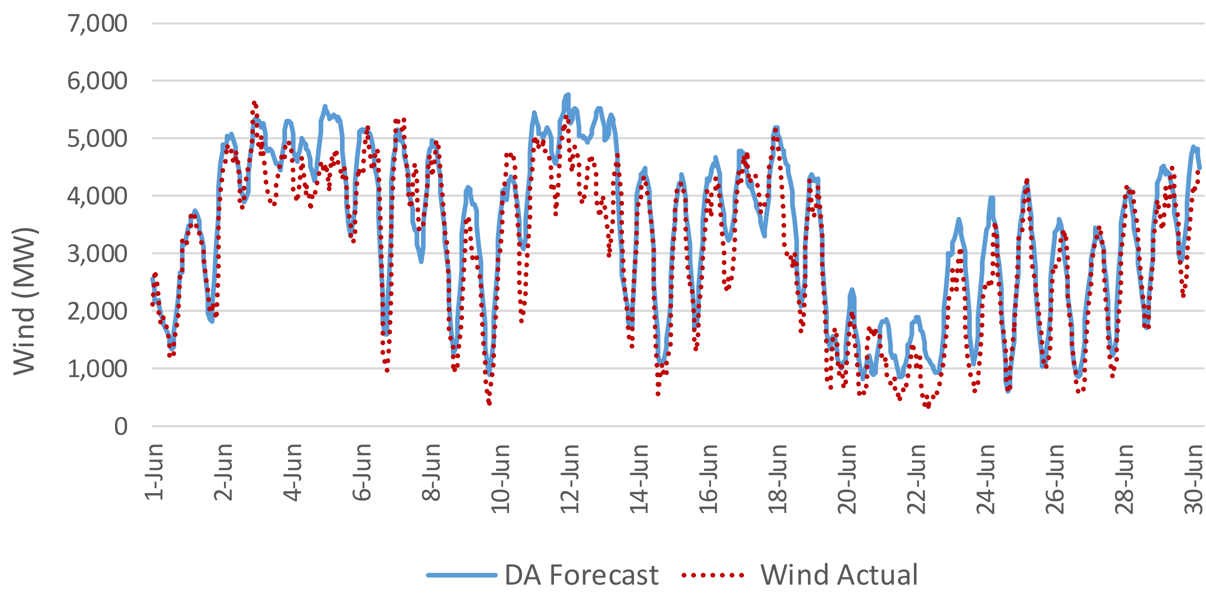


Figure 13 shows the day-ahead wind forecast compared to the actuals plus curtailments throughout the month of June for wind in the CAISO's system. The average error[18] for the day-ahead wind forecast in June was 5.79 percent. The average error observed in June 2022 is comparable to the day-ahead wind forecast error observed for the month of June in 2020 and greater than the day-ahead wind forecast error observed for June 2021.[19]

6.4 Demand forecasts

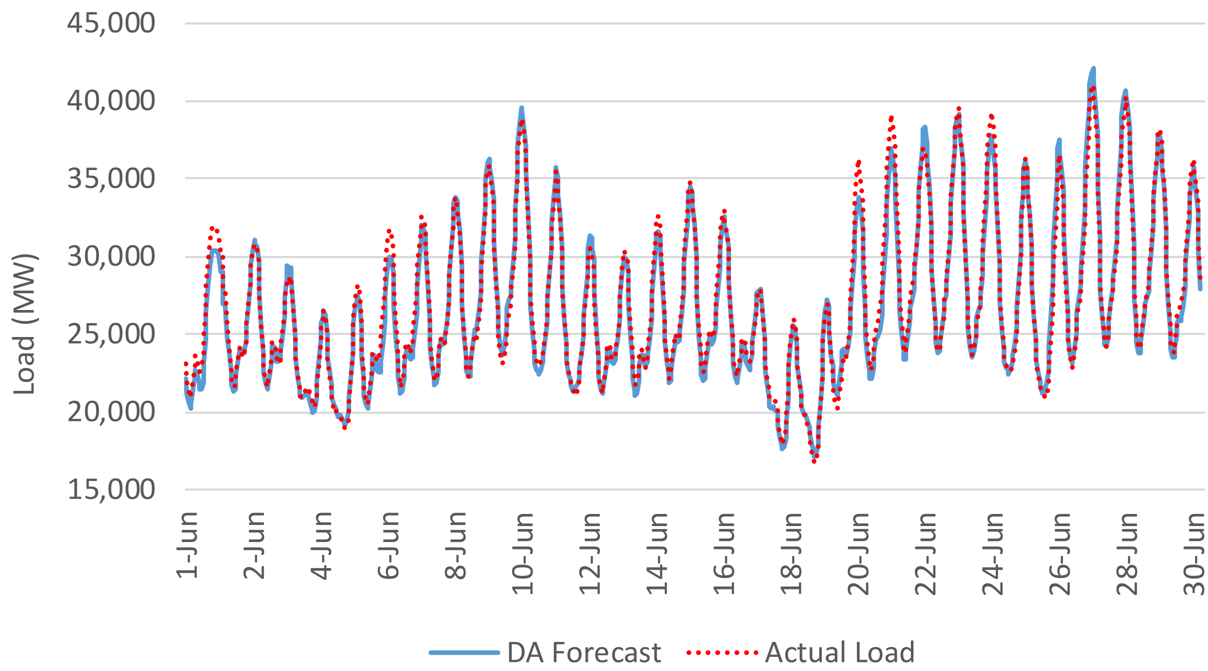
The CAISO produces load forecasts for the day-ahead and real-time markets for all areas participating in the CAISO markets.

6.4.1 CAISO's demand forecasts

The CAISO demand during the month of June 2022 was very responsive to the temperature changes observed throughout the month. Figure 14 shows the trend of the CAISO's load. The highest hourly average June load of 41,365MW was observed on June 27, 2022 when the CAISO footprint was running 6 degrees F above normal for maximum temperatures. The maximum hourly average load observed within a single hour in June 2021 was 3,555 MW under the CEC month ahead forecast for June Peak of 44,920 MW.

[18] Accuracy error is measured with the Mean Absolute Percentage Error (MAPE); ((Forecast-Actual)/Nameplate Capacity).
[19] http://www.caiso.com/Documents/Presentation-MarketPerformancePlanningForum-Jun162022.pdf

Figure 14: Day-ahead demand forecast for CAISO's area



The average accuracy error[20] for the day-ahead demand forecast in June was 1.93 percent, while the error for peak hours was 2.07 percent. The average error observed in 2022 is less than the day-ahead demand forecast error observed for June 2020 and comparable to the day-ahead demand forecast error observed in 2021.

6.5 Energy Conservation

6.5.1 June's impact of energy conservation

During the month of June the CAISO did not issue any Flex Alerts to assist in meeting the net load peak on tight supply conditions. Consequently, there is no energy conservation estimates to report for June.

7 Demand and Supply

7.1 Resource adequacy

The CAISO manages the resource adequacy (RA) program established by the CPUC for its jurisdictional load serving entities (LSEs), which include Investor Owned Utilities (IOUs), Community Choice Aggregators

(CCAs) and Energy Service Providers (ESPs). Collectively, these LSEs cover about 90 percent of CAISO's load. The RA program ensures through contractual obligations that there is sufficient supply capacity to meet the system's needs and to operate the grid reliably. The CPUC RA program sets and enforces the program's rules within the jurisdictional LSE's footprint. This program also includes setting the monthly obligations based on an electric load forecast and planning reserve margin (PRM). The California Energy Commission estimates the electric load forecast used by the CPUC in its RA program. Non-CPUC jurisdictional LSEs can set their own RA program. RA capacity from both CPUC and non-CPUC jurisdictional LSEs is shown to the CAISO annually and monthly following a process established by the CAISO.

Through the RA program, there are three types of capacity: System, Local and Flexible. All three products serve a purpose in ensuring a reliable operation of the system. The events of August 2020 were primarily a result of insufficient system RA since it was a condition of insufficient supply to meet the overall system demand. For system capacity, the RA requirement ensures the contracted capacity is sufficient to cover the 1-in-2-year (average) peak load plus a 15 percent PRM.[21] This PRM is to cover the 6 percent of operating reserves while the rest is a contingent headroom to account for higher-than-expected load forecast and resource outages.

The monthly RA showing for June 2022 was 47,266 MW, which is higher than June's 2021 monthly showing of 46,130 MW.[22] Figure 15 compares the total monthly RA capacity in June between 2021 and 2022 by fuel type. Although the total RA capacity in June's 2022 is about 1,136 MW higher than that of 2021, there are some marked variations in the RA composition. RA capacity increased by 1,796 MW in storage resource which fully offsets the reduction of 1,031 MW of static imports. The hydro RA saw a minor reduction of 131 MW, which is expected given the extended drought conditions in 2022.

Static RA imports decreased from 2,176 MW in June 2021 to 1,144 MW in June 2022.[23] The composition by intertie varied between years as shown in Figure 16. RA imports through Malin decreased from 1,119 MW to just 270 MW from June 2021 to June 2022, while imports through NOB decreased from 412 MW to 261 MW across the same timeframe. Imports on Malin and NOB account for about 46 percent of all static RA imports in June 2022, down from the 70 percent share observed in June 2021.

[21] The official planning reserve margin is 15 percent for the CPUC jurisdictional entities. Per Decision 21-03-056, the CPUC increased the "effective" planning reserve margin to 17.5 percent for 2021 and 2022 but this is met with both RA and above RA resources that may also not be in the wholesale market.
[22] These values are based on the monthly showings estimates available at the time of preparing this report. These monthly showings are provided through the supply plans to meet the final RA obligation. The final RA obligation is composed of the forecast plus PRM and then all credits, including DR, are deducted. The total RA values can change through the month, with weekend showing typically a significant reduction. For simplicity in the reporting and comparison, the simple average through the month is used as a reference in this report. Also, the total RA values represented in this report include any CPM and RMR capacity.
[23] Dynamic and pseudo tie resources are grouped into the corresponding fuel type instead of the generic import group. Generic imports are referred as Static imports in this report.

Figure 15: June's 2022 RA organized by fuel type

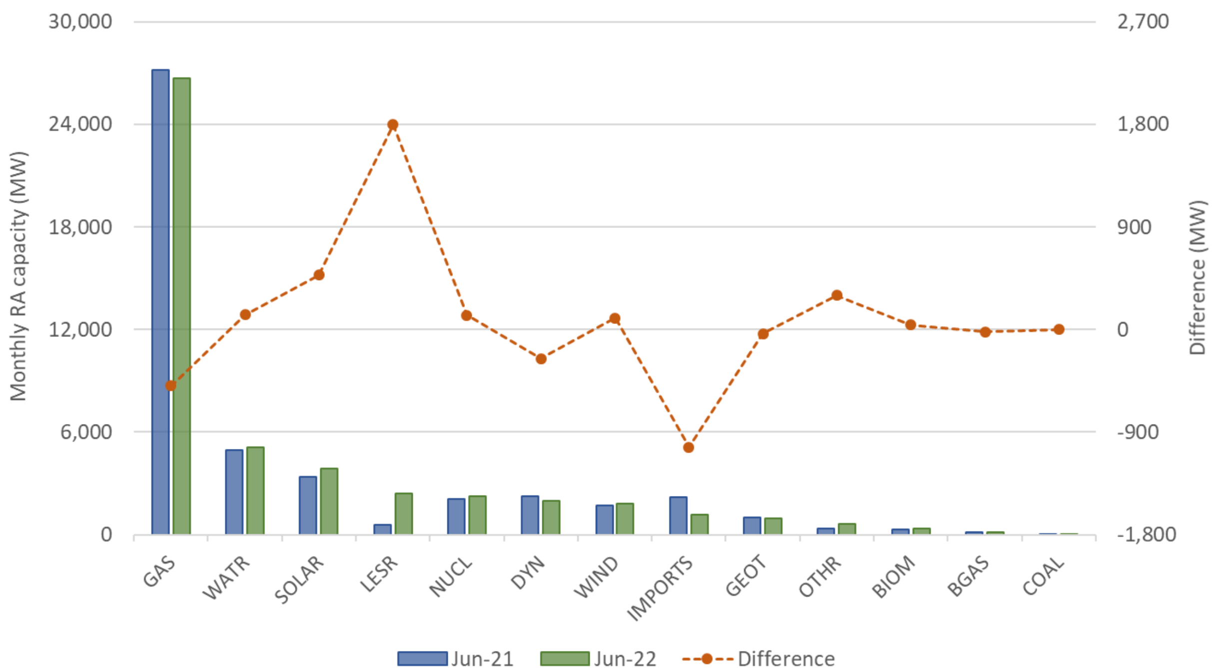
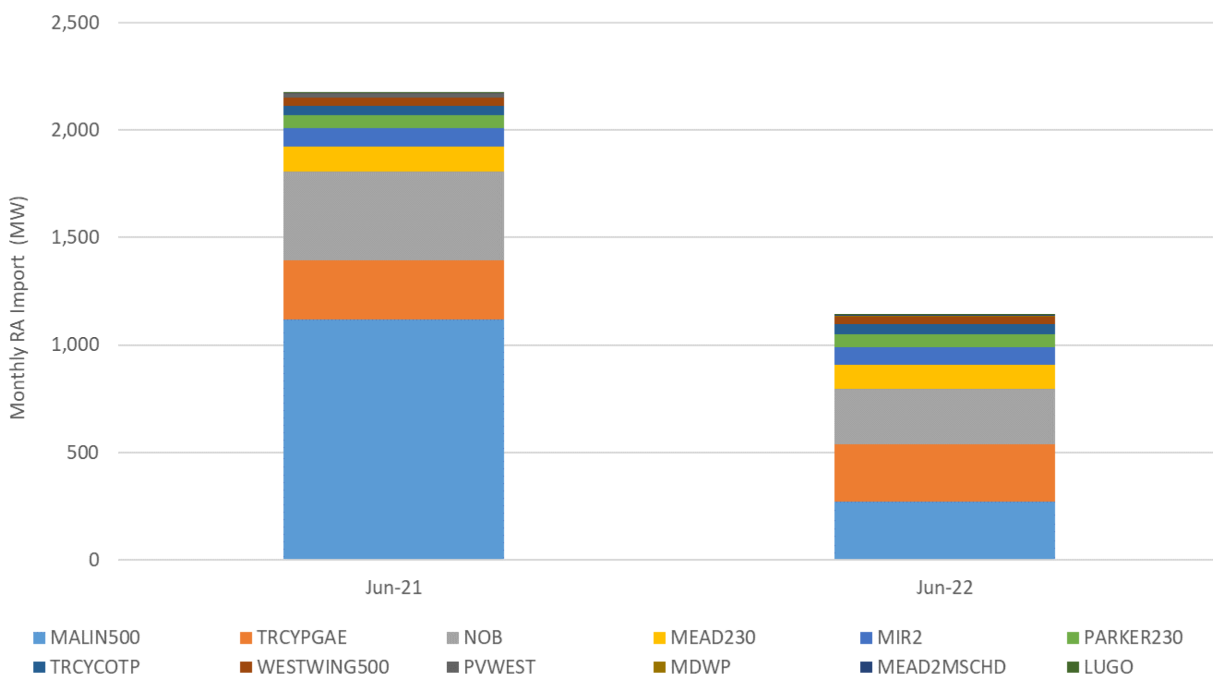


Figure 16: Monthly RA organized by tie



RA imports declined in June 2022 to 1,144 MW relative to 2,176 MW in June 2021. Overall, RA and RA imports tend to increase through summer. These trends are shown in Figure 17 and Figure 18.

Figure 17: Monthly RA showings

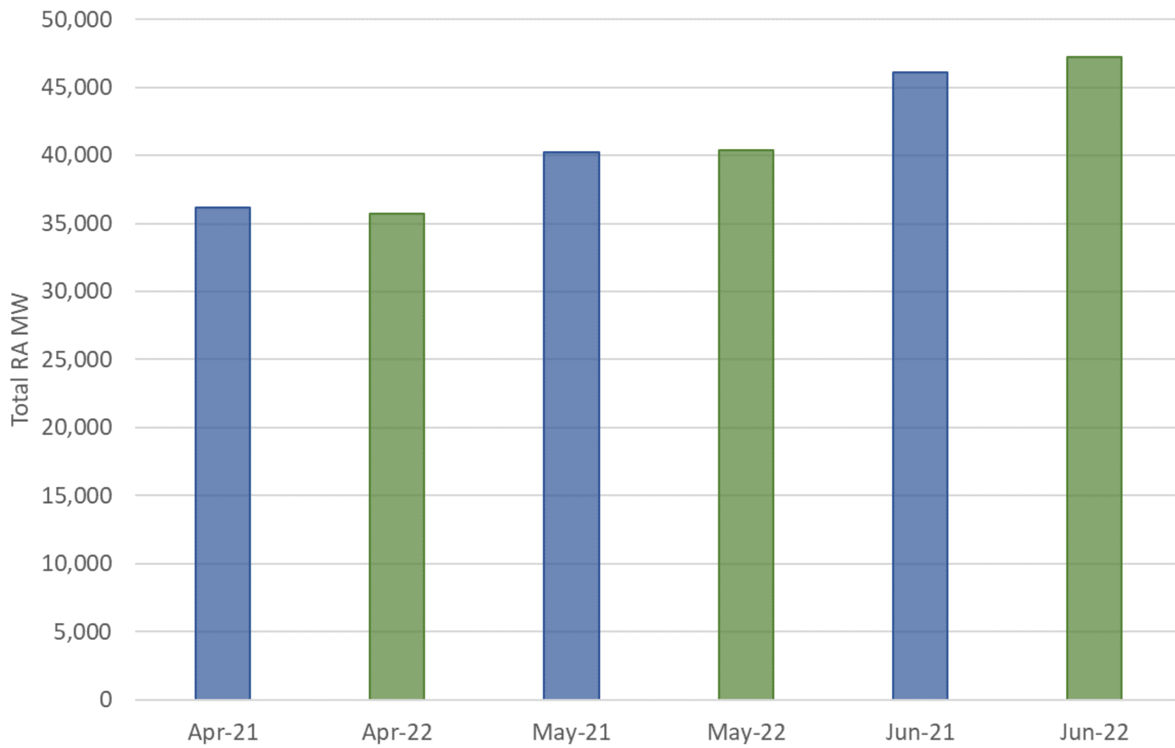
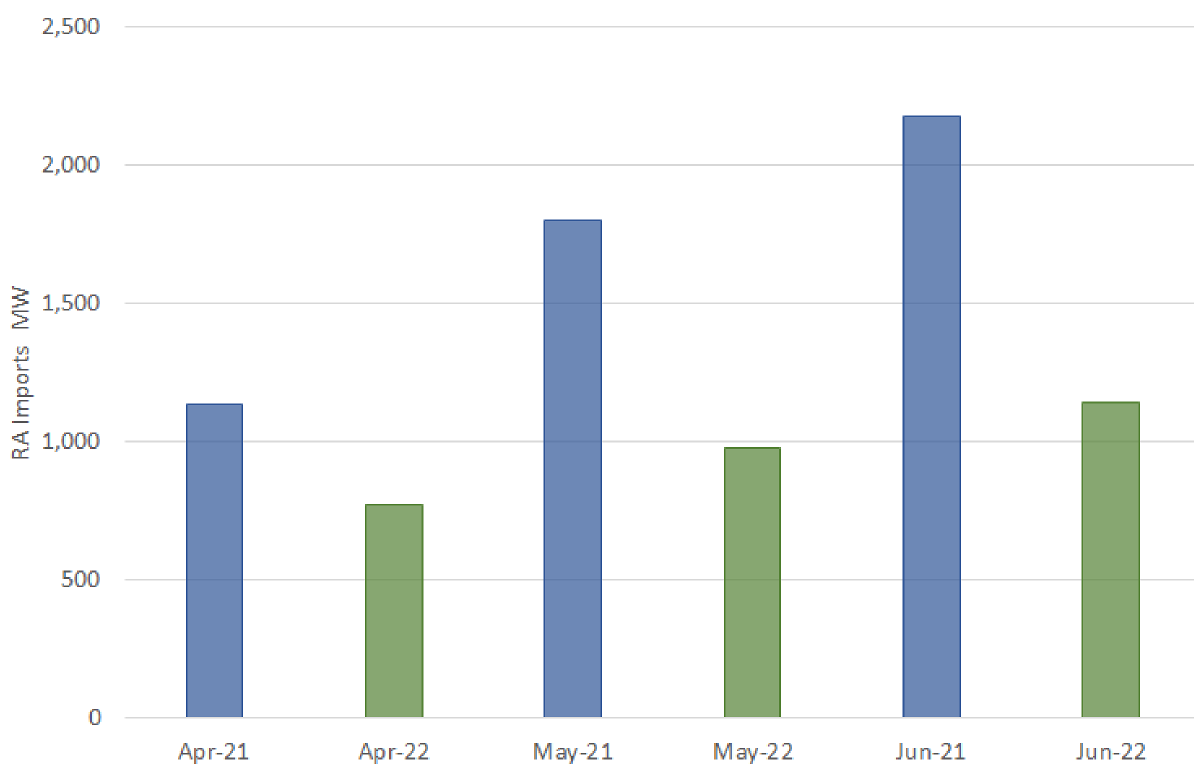


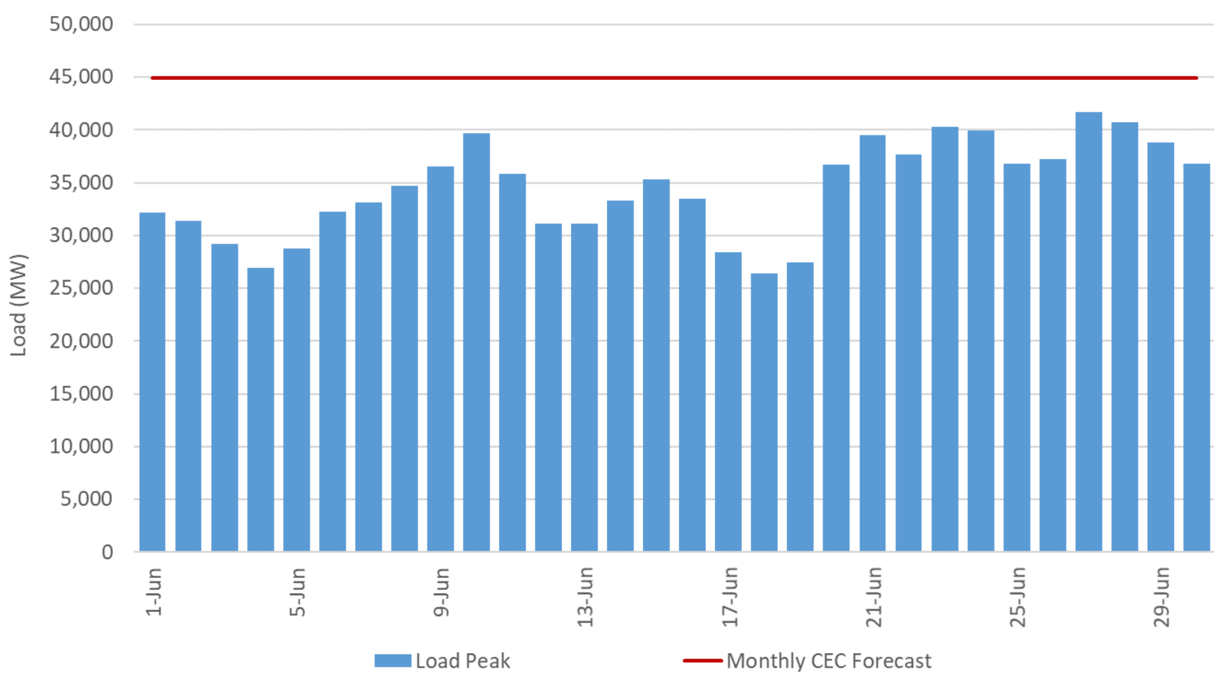
Figure 18: Monthly trend of static RA Imports



7.2 Peak loads

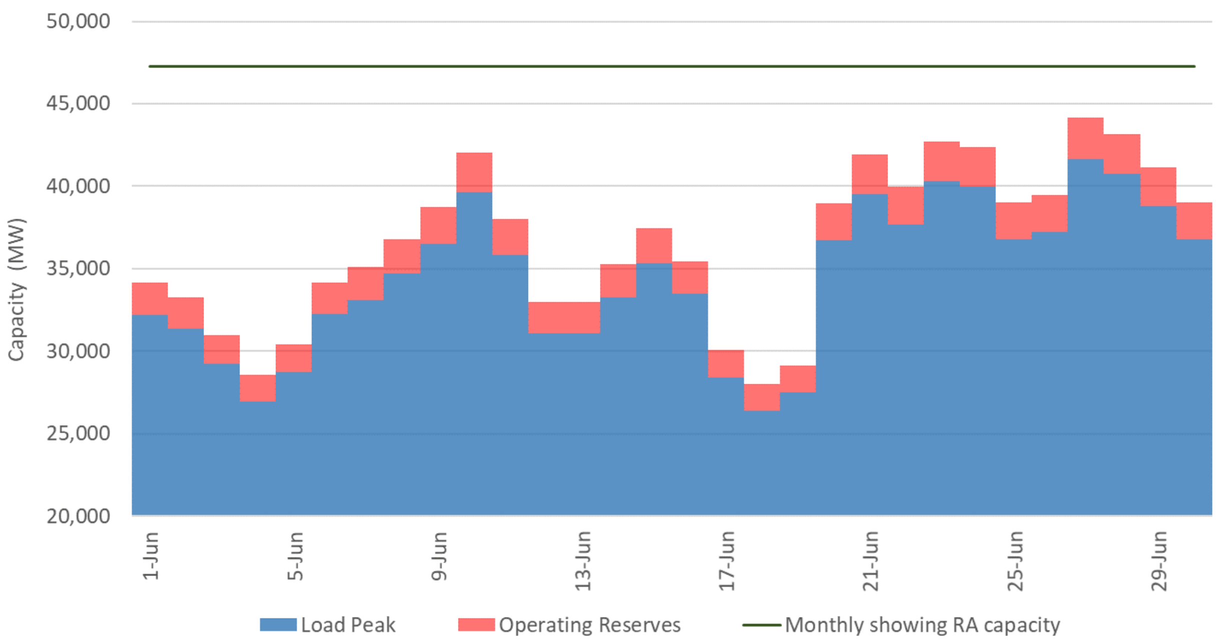
Peak loads in June 2022 exceeded 40,000 MW in three days. The average peak load in June was about 34,445, fairly lower than the 37,837 MW observed in June 2021. Figure 19 shows the 5-minute daily load peak for the June relative to the CEC month ahead forecast used to assess the resource adequacy requirements. The highest peak load in the month happened on June 27 at 41,664 MW and was below the CEC month-ahead forecast of 44,920 MW.

Figure 19: Daily peaks of actual load in June 2022



The actual load did not exceed the monthly RA showings for the month of June 2022 as a whole, as illustrated in Figure 20. The green line indicates nominal monthly RA showings. As discussed later in this report, the actual capacity made available into the CAISO's market (accounting for outages and other factors) can vary from day to day. In subsequent sections, the actual RA capacity made available in the market is represented as a trend over for the month on an hourly basis, which more accurately represents RA capacity available to meet demand.

Figure 20: Daily peaks and RA capacity for June through June 2022



7.3 Market prices

Market prices naturally reflect supply and demand conditions; as the market supply tightens, prices rise. Locations marginal prices have three components: the marginal cost of energy on the system, the marginal cost of congestion reflecting constraints, and the marginal cost of losses. The marginal energy component reflects the impact of supply and demand conditions. Congestion conditions may also create local or regional price separations. Figure 21 compares the average prices across CAISO's markets.[24] In the month of June, prices were generally under $100/MWh with some exceptions in IFM and FMM at a few points within the month. Figure 22 shows average daily prices across CAISO's markets; price divergence is most significant in the peak hours, however price divergence occurs at varying degrees for all hours.

[24] Default Load Aggregation Point (DLAP) prices are a good indicator of overall prices. However, congestion may create price separation among DLAPs. The metrics presented here are based on a weighted average price of the DLAPs within the CAISO area.

Figure 21: Average daily prices across markets, June 2022

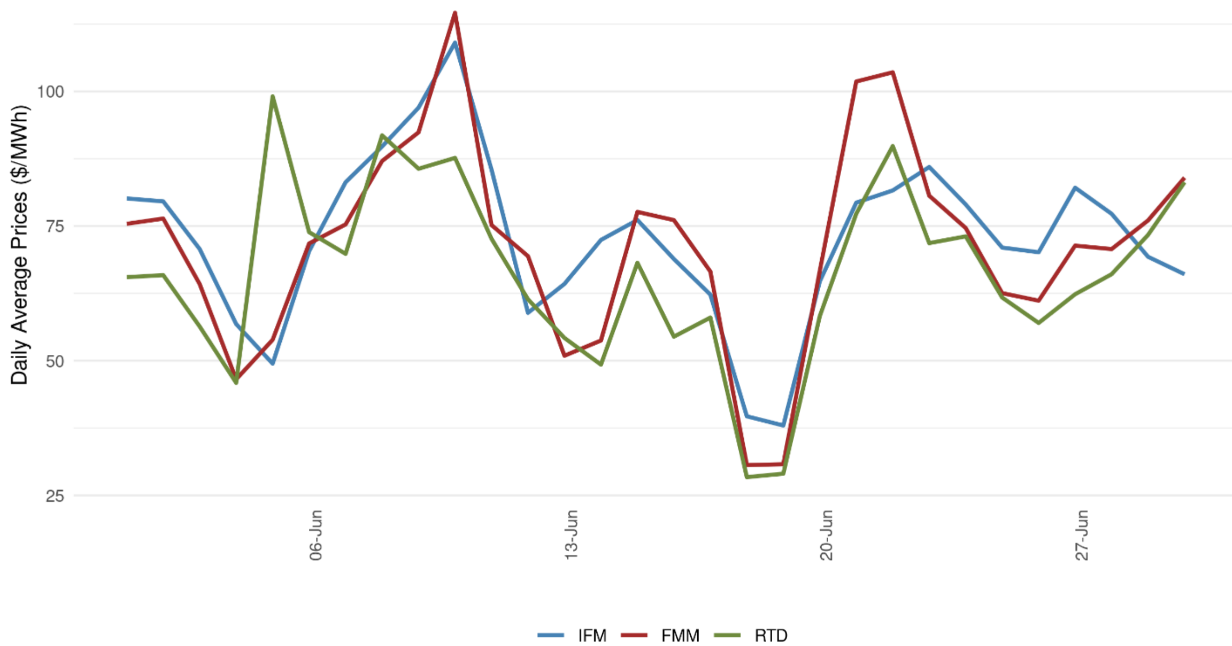


Figure 22: Average hourly prices across markets, June 2022

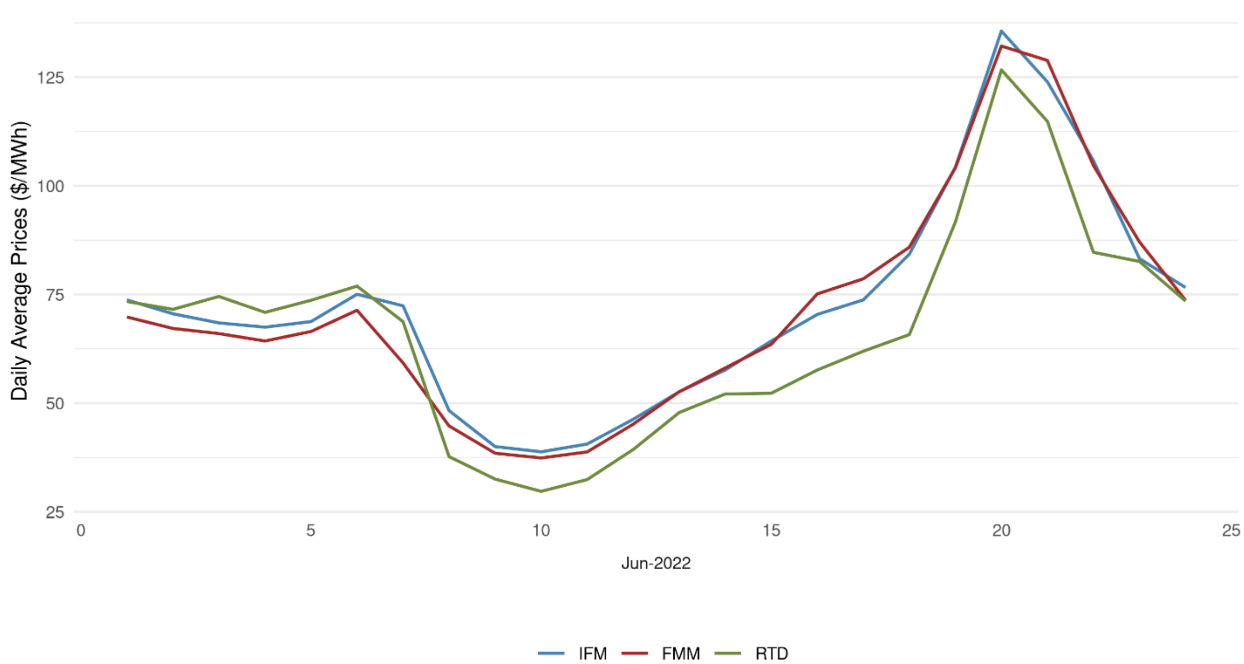


Figure 23 and Figure 24 show the daily and hourly distribution of day-ahead prices with box-whisker plots. The whiskers represent the maximum and minimum prices in a given day or hour, while the boxes represent the 10th and 90th percentile of the prices. The red dots represent the average prices for the day. These plots better illustrate the full distribution of prices observed throughout the month. Day-ahead prices in June were typically below \$200/MWh although the maximum price occurred on June 10 at \$270/MWh.

Figure 23: Daily distribution of IFM prices, June 2022

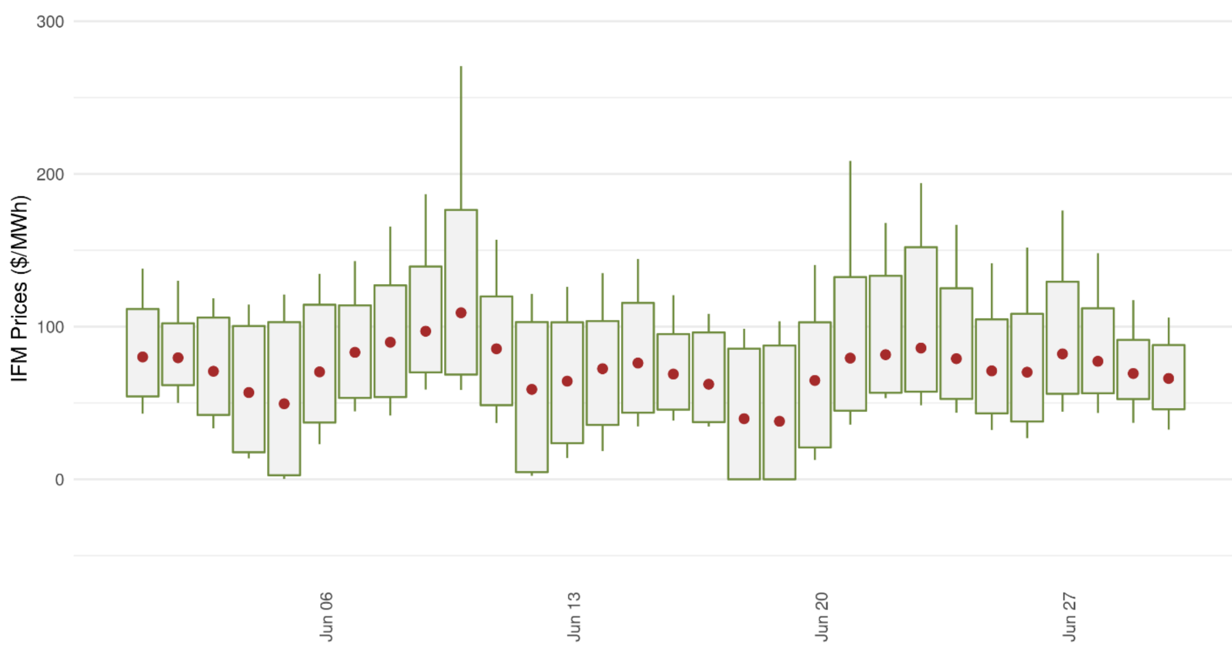
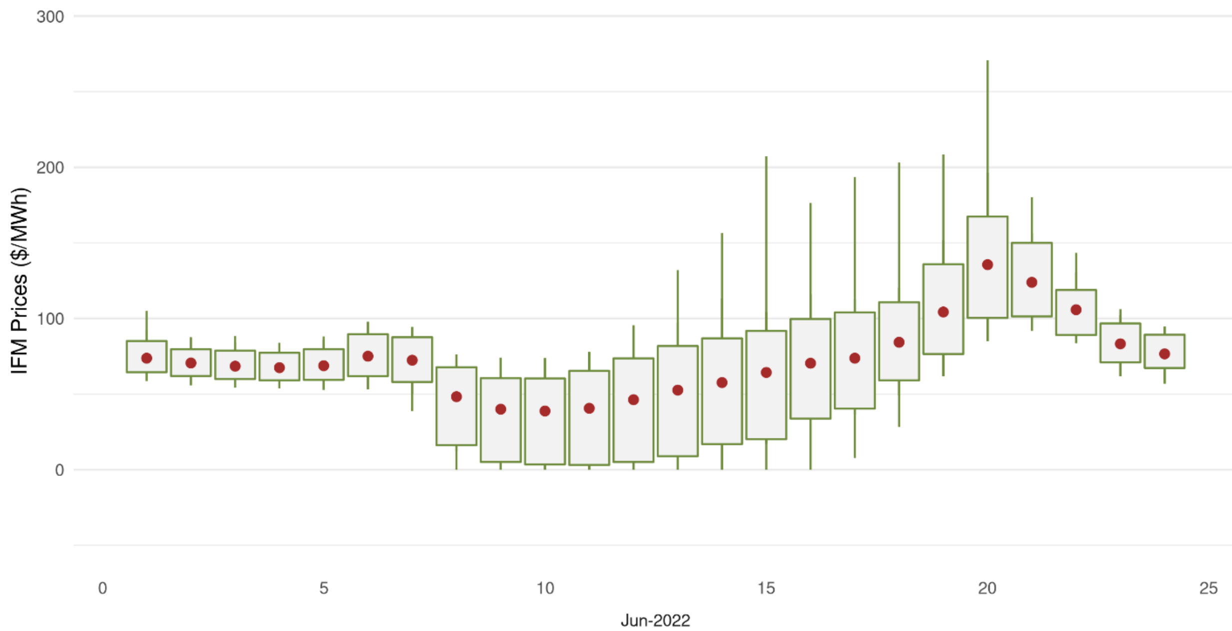


Figure 24: Hourly distribution of IFM prices, June 2022



Similarly,

Figure 25 and Figure 26 show distributions of fifteen-minute market (FMM) prices throughout the month. The day-ahead prices generally exhibit a larger spread throughout the month while in contrast, FMM prices are more narrowly distributed under $100/MWh with a few outliers. Given the dynamic conditions of real-time, such price excursions are expected to happen even though they are short in duration.

Figure 25: Daily distribution of FMM prices, June 2022

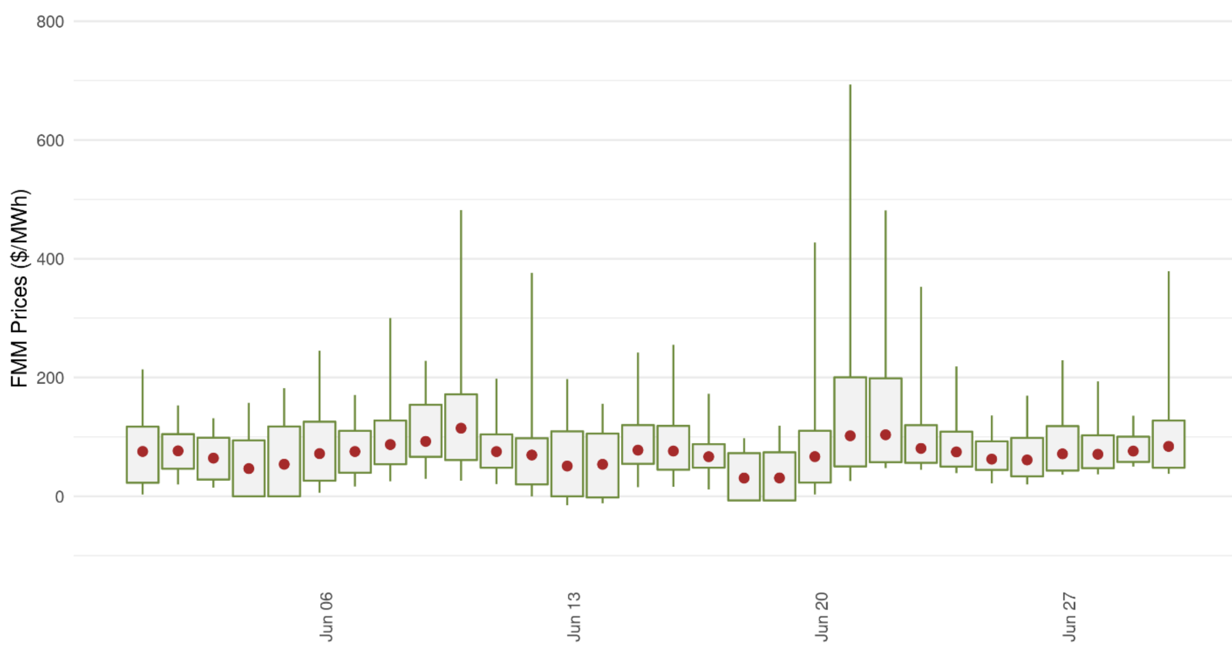
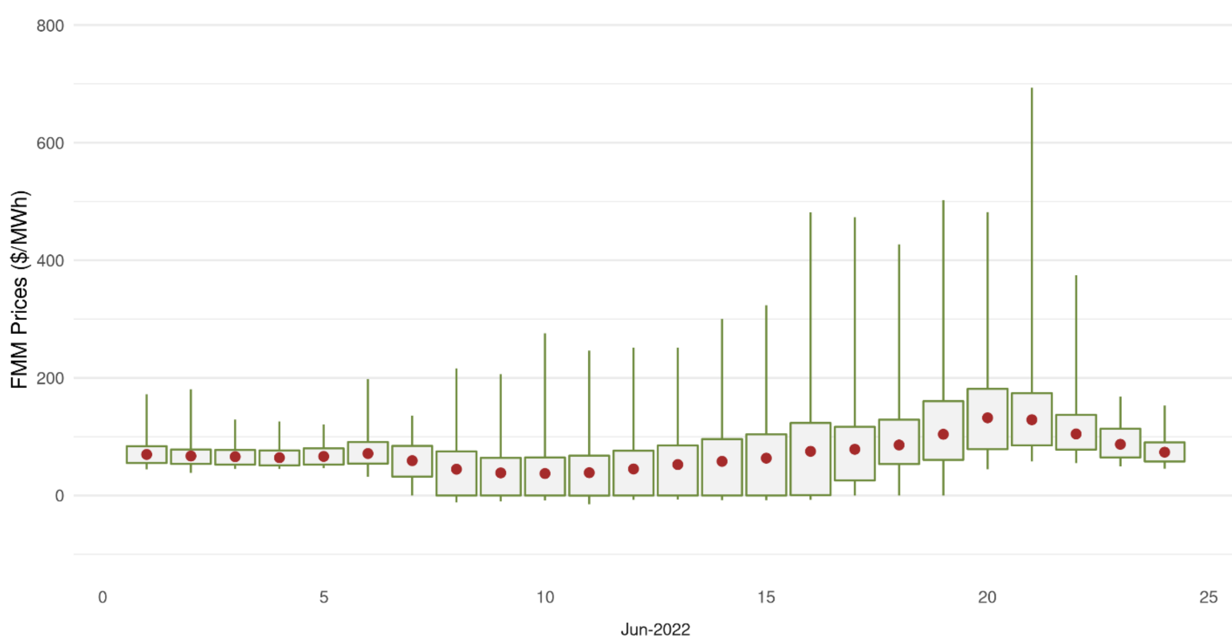


Figure 26: Hourly distribution of FMM prices, June 2022



With the CAISO's generation fleet consisting of a meaningful share of gas resources, dynamics from the gas market and system can typically have an impact on the electric market. Electricity prices generally track gas prices. Figure 27 shows the average prices (bars in red), and the maximum and minimum prices (whiskers in black), for the two main gas hubs in California. Gas prices have trended consistently higher throughout June 2022 as compared to June 2021 with averages of $8.77/MMBtu and $8.17/MMBtu for PG&E Citygate and SoCal Citygate, respectively.

Figure 27: Gas prices at the two main California hubs, June 2022

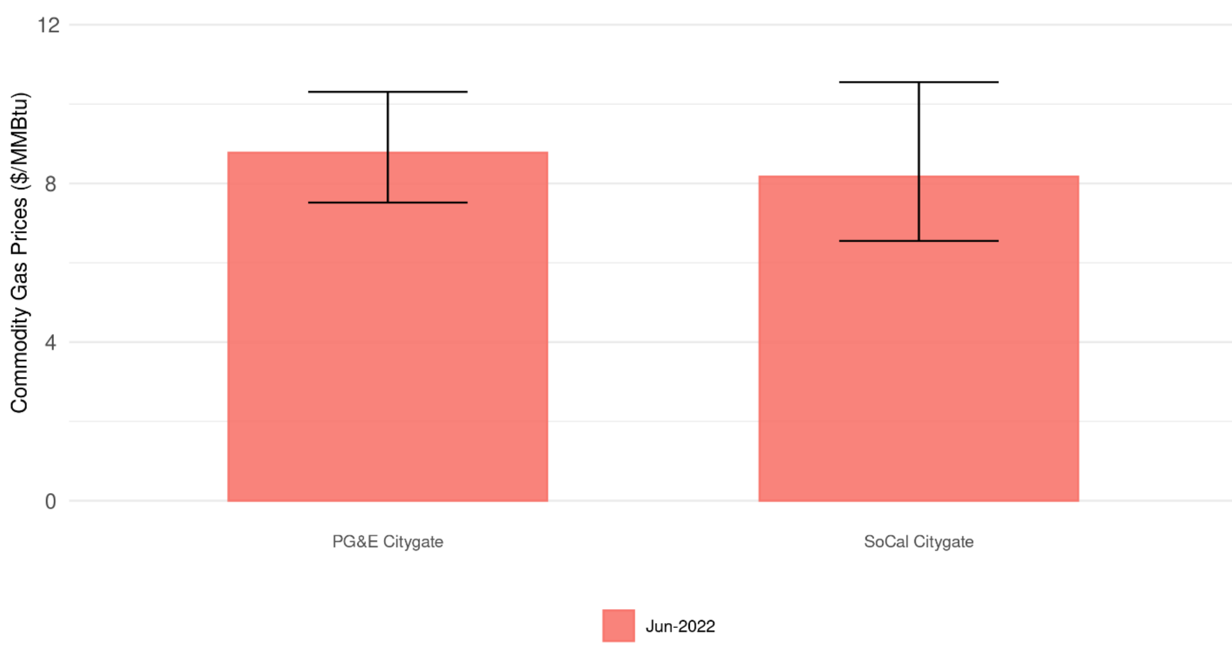


Figure 28 shows daily average electricity prices from the CAISO day-ahead market (y-axis) relative to next-day gas prices at SoCal Citygate (x-axis) and the peak load (color gradient from blue to pink) on a daily basis.

Figure 29 shows the same metric using next-day gas prices at PG&E Citygate. Peak loads ranged widely and this comparison exhibits a good degree of correlation between electricity and gas prices. In addition, it can be observed that electricity prices generally rise when load levels are higher.

Figure 28: Correlation between electricity prices, SoCal Citygate gas prices and peak load level

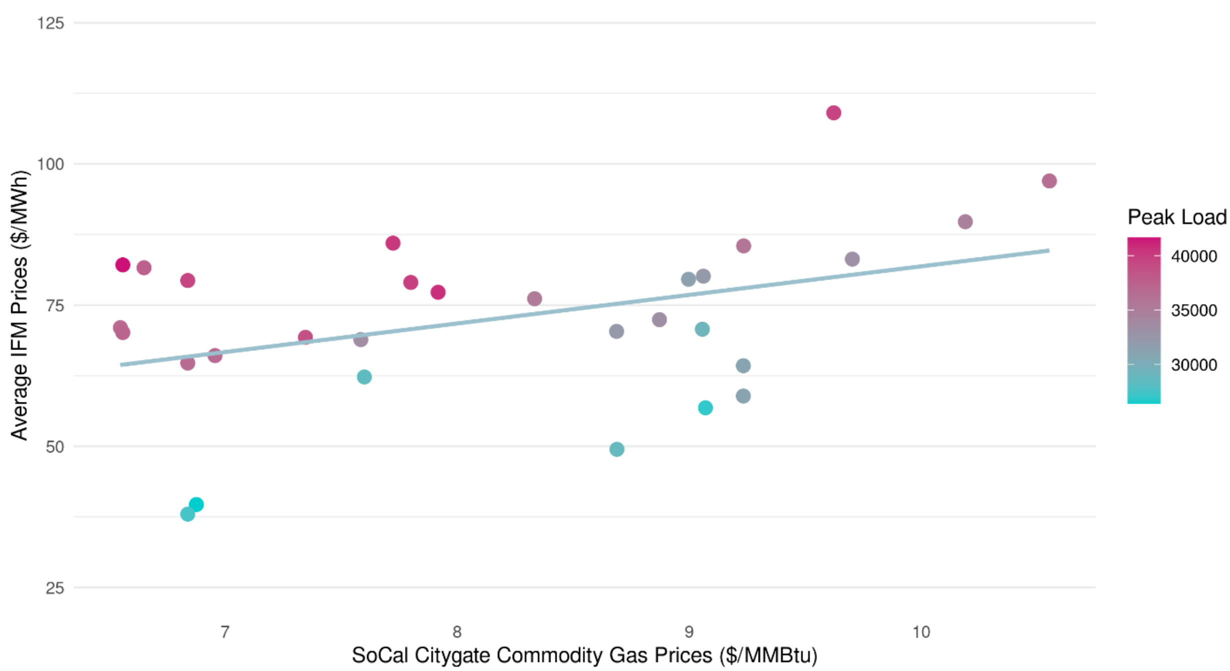
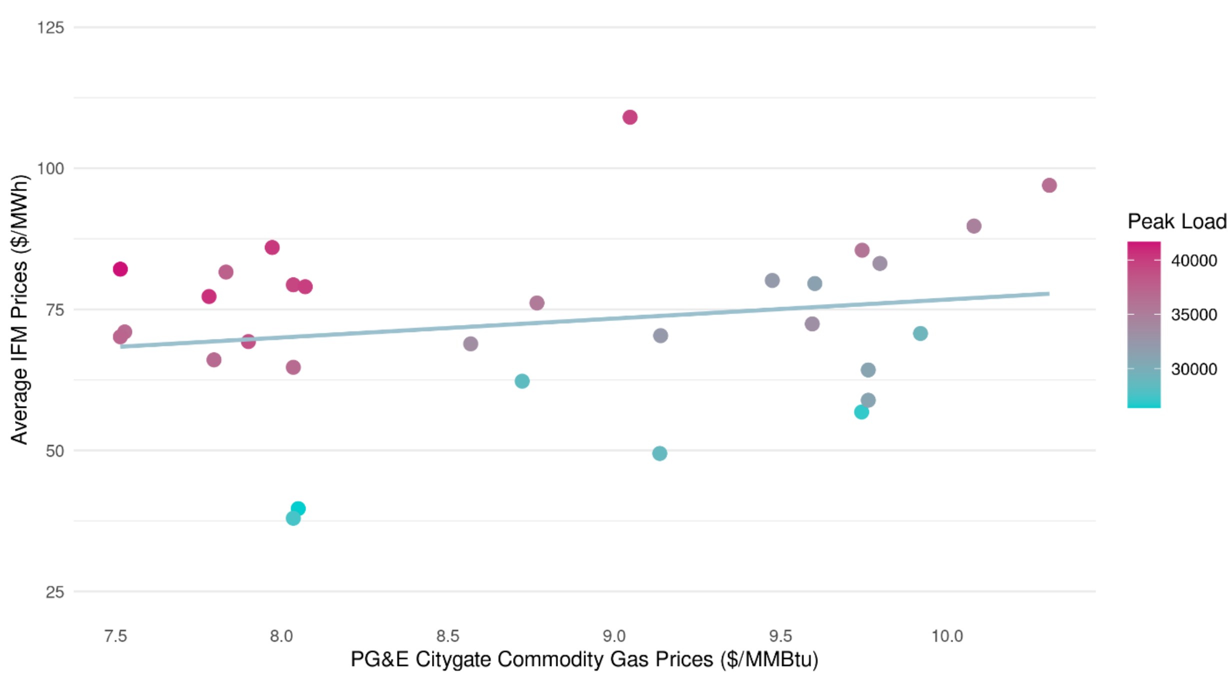


Figure 29: Correlation between electricity prices, PG&E Citygate gas prices and peak load level



8 Bid-In Supply

The CAISO's markets rely on supply made available from different resources, including internal supply of various technologies and imports. Supply capacity is bid into the market with three components: startup costs, minimum load costs and incremental energy costs. The bid-in capacity is adjusted for any outages and derates on an hourly basis to reflect the actual available supply. That available bid-in capacity is then considered in the market optimization along with the resource's characteristics and system constraints. In addition to supply capacity from RA resources, the market also considers bid-in supply from above RA resources. This supply does not have an RA obligation but economically and voluntarily participates in the CAISO's markets. Based on the submitted bids, the market will optimally determine the least-cost dispatch of all resources to meet the bid-in demand in IFM or the load forecast in RUC. It is not unusual that above RA capacity be dispatched before all the RA capacity is exhausted since resource dispatches are based entirely on prices and resource characteristics and system conditions, and there is no merit order based on whether they are RA or not.

In the RA program, there are certain qualifiers for a resource's capacity to be eligible to count towards meeting the RA requirements. The CPUC developed a Qualifying Capacity (QC) requirement based on what a resource can produce during peak load hours. For conventional resources such as gas and hydro, the QC value is based on maximum output of the resource. For wind and solar resources, the QC values are based on a statistical methodology known as effective load carrying capability (ELCC). This approach will estimate QC values for wind and solar significantly below their maximum output. Resources are then assessed for deliverability to determine their net qualifying capacity, which is ultimately what is used to determine their RA capacity.

8.1 Supply and RA Capacity

Since the summer 2020 events, the CAISO has been tracking whether RA capacity available in the CAISO's markets could be sufficient to meet the needs of both load and operating reserves. To assess this condition, all supply capacity is classified accordingly relative to its monthly RA value. For any wind or solar resource that has any RA capacity assigned in the month, the entire supply available in the market from that resource is considered RA. For instance, if a solar or wind resource has a supply available in the day-ahead market for 100 MW in a given hour and its RA capacity is 30 MW, the full 100 MW are considered RA capacity. For any other type of resource such as gas, hydro or imports, RA capacity is determined up to the RA monthly value; any capacity above the RA value is considered or above RA.

Figure 30 shows the breakdown of the day-ahead supply capacity[25] as RA capacity and above RA capacity. The purple line represents the day-ahead load forecast plus the capacity required to meet operating reserves (OR), which is typically about 6 percent of the load value. The dashed line represents the adjusted load forecast plus OR plus high-priority export self-schedules, which represents the overall need to be met

[25] This capacity is assessed based on the supply bid in the market and reflects any outages or derates of resources as long as they are known and recorded before the market is run.

in the day-ahead market. Figure 31 has the same capacity breakdown but the comparison is relative to the net load (gross load minus VER forecast). Since this figure represents net load, the supply side is also reduced by subtracting all VER contributions. Tracking the available capacity for the net load peak hour is as important as tracking available capacity for the gross peak hour.

Figure 30: Supply capacity available relative to load forecast in the day-ahead market

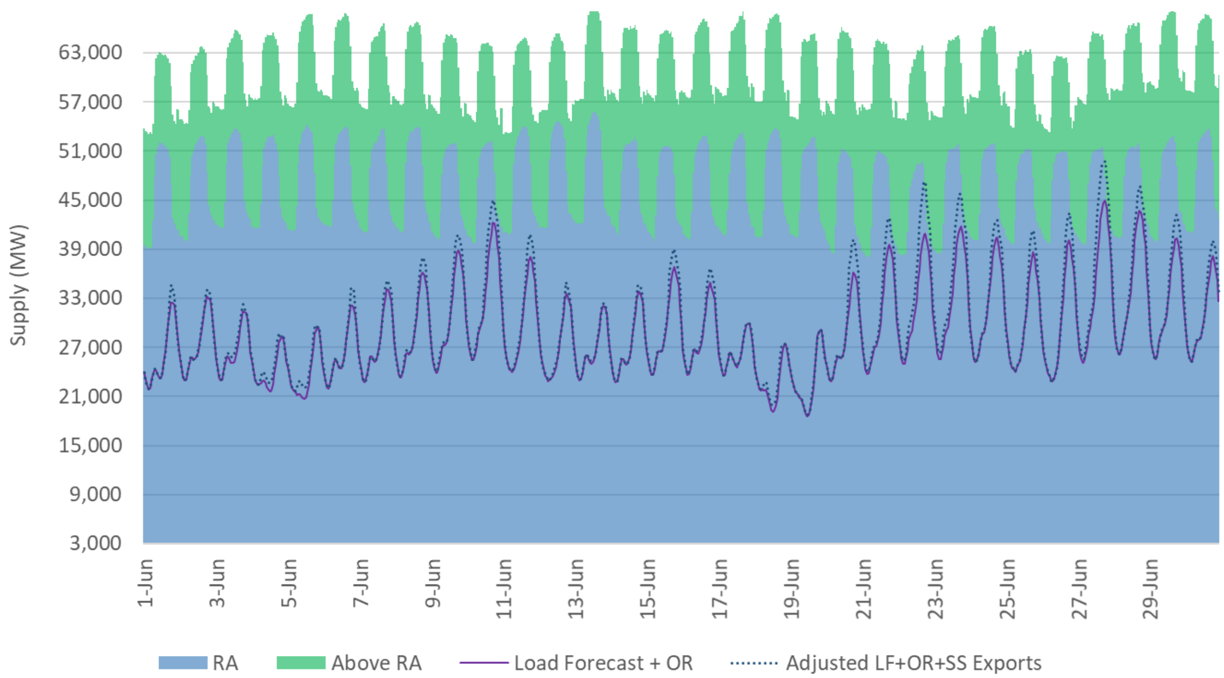
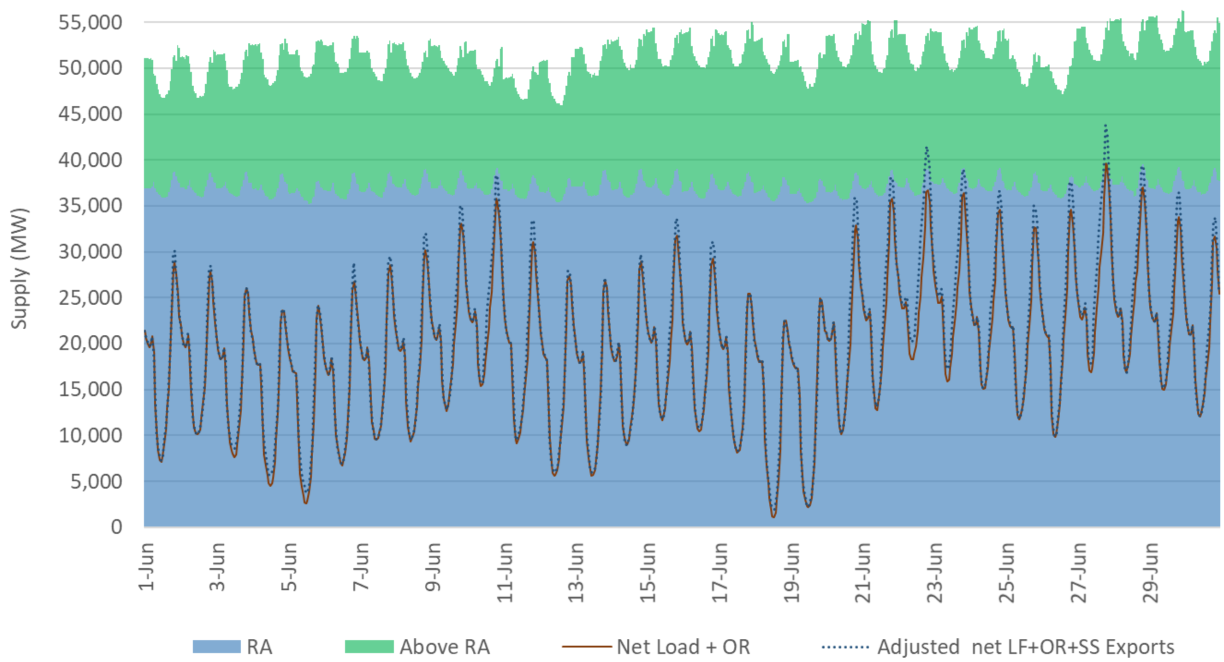


Figure 31: Supply capacity available relative to net load forecast in the day-ahead market



In both trends, the load peaked on June 28. A more granular view of the supply-demand conditions are provided for this period in Figure 32 and Figure 33. The RA capacity was sufficient relative to the standard day-ahead load, but below the level to meet the adjusted load forecast during the net load peak.

Figure 32: Supply capacity available relative to load forecast in the day-ahead market –June 26-28

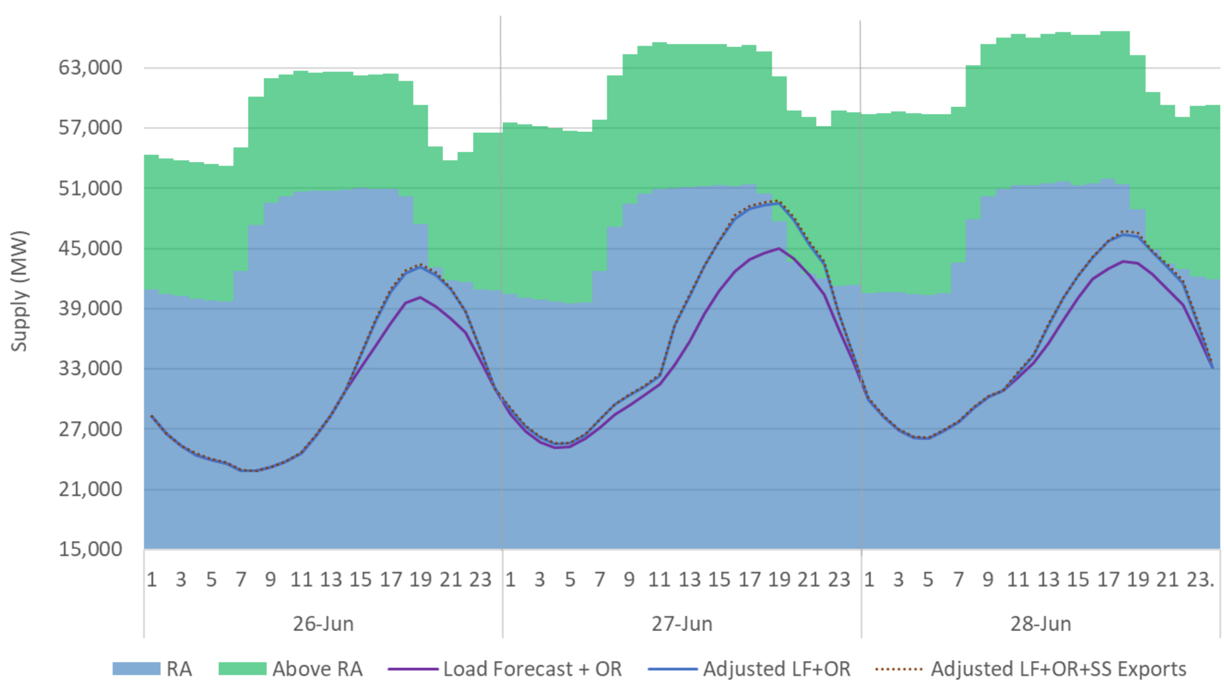
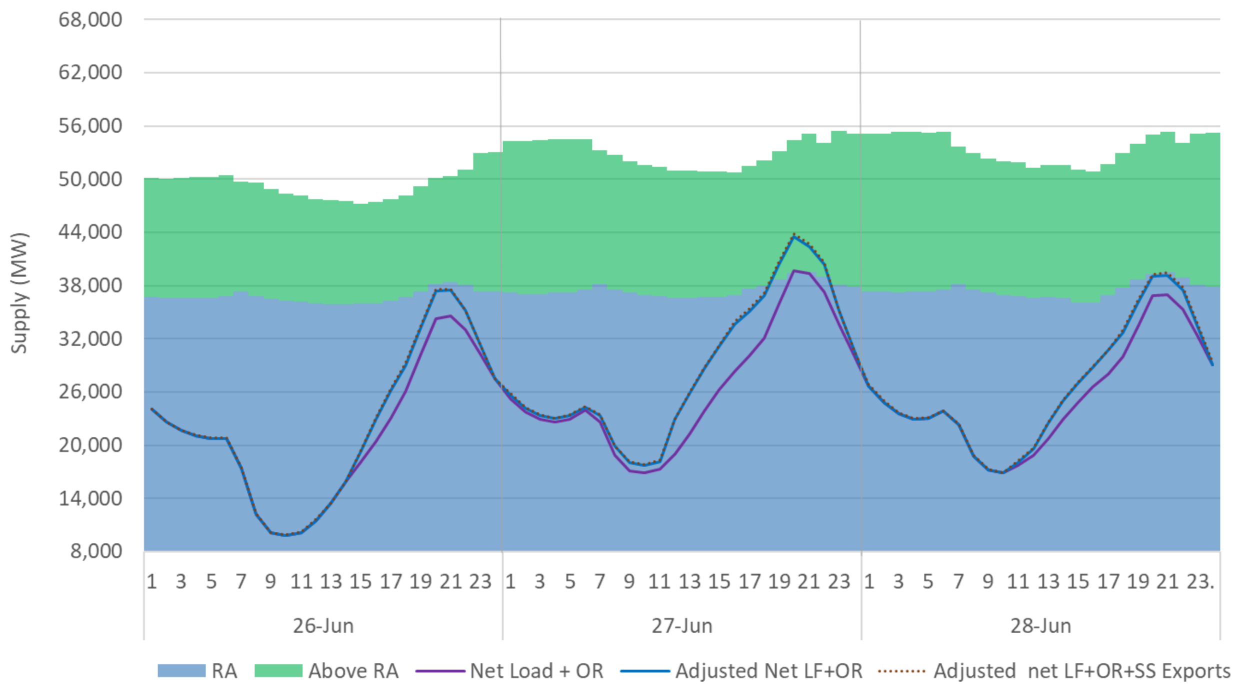


Figure 33: Supply capacity available relative to net load forecast in the day-ahead market – June 26-28

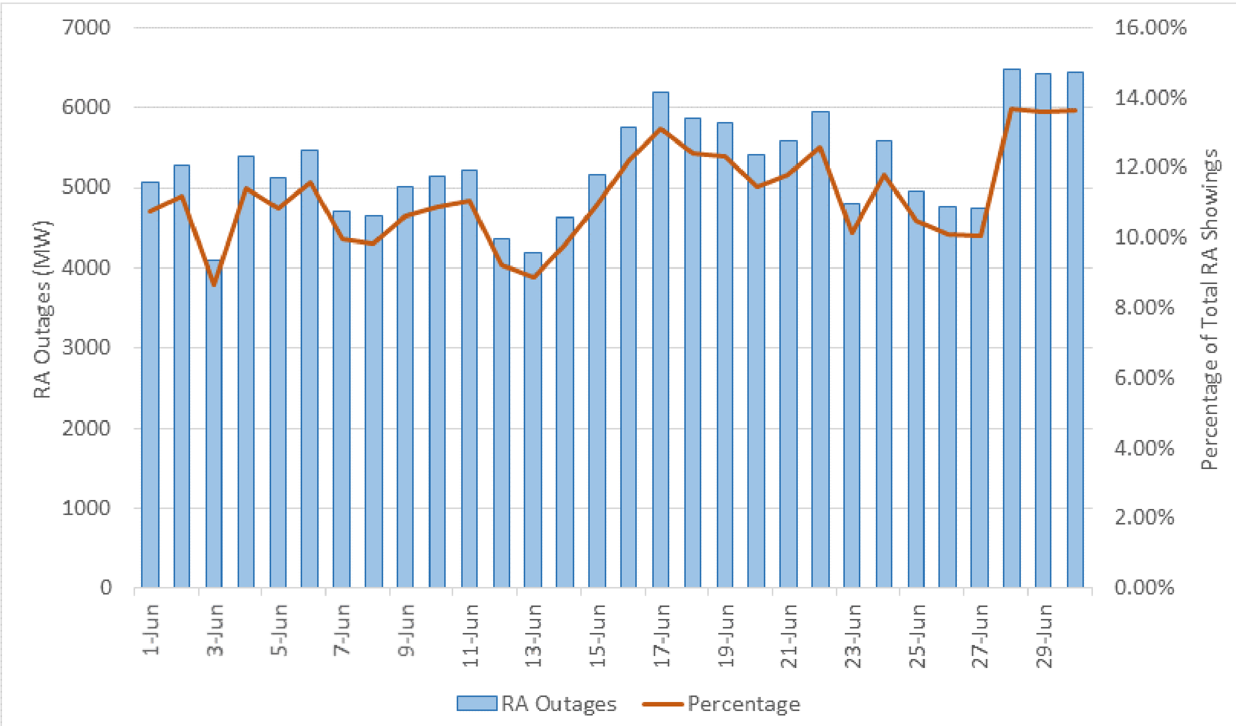


For instances in which the load needs exceed the available RA capacity, the market will utilize any other above RA available capacity. For the month of June, above RA capacity was consistently bid into the market.

8.2 Unavailable RA capacity

Generating units can face operating conditions that required them to be derated or be offline. CAISO tracks these outages through the outage system and these outages are reflected in the capacity made available in the market. The market consumes the outages and impose these limitations on the units, making them unavailable or derating their capacity accordingly. Some outages may be planned while others may be forced. Figure 34 provides the trend of RA capacity on outage during the month of June. On average, the daily capacity on outage is about 5,000 MW.

Figure 34: Volume of RA capacity on outage in June



8.3 Demand and supply cleared in the markets

The day-ahead market is composed of three different passes: local market power mitigation (LMPM), IFM and RUC. Each of these market runs has a purpose and each of them is solved based on a cost-minimization optimization problem. The first pass of the day-ahead market, LMPM, identifies structural conditions for the potential exercise of local market power enabled by transmission constraints. The outcome is the identification of uncompetitive constraints and potentially results in the mitigation of specific resource bids. These mitigated bids are then used, together with the rest of non-mitigated bids, in the IFM process to solve the financially binding market where bid-in demand is cleared against bid-in supply. This IFM clears both physical and convergence bid supply against bid-in demand, convergence bid demand and exports, and produces awards and prices that are financially binding for all resources. The RUC process uses the IFM solution as a starting point to further refine the supply schedules that can meet the day-ahead load forecast. Operators may adjust the day-ahead forecast to factor in other foreseeable conditions such as load uncertainty. The RUC process will clear supply against the final adjusted load forecast. Figure 35 compares the IFM schedules for physical resources versus the day-ahead load forecast and the adjusted load forecast eventually used in the RUC process. Day-ahead load forecast varied through the month, going from high-load days in June 10 and June 27 to other days with very mild loads in the weekend of June 18.

Figure 35: Day-ahead demand trend in June

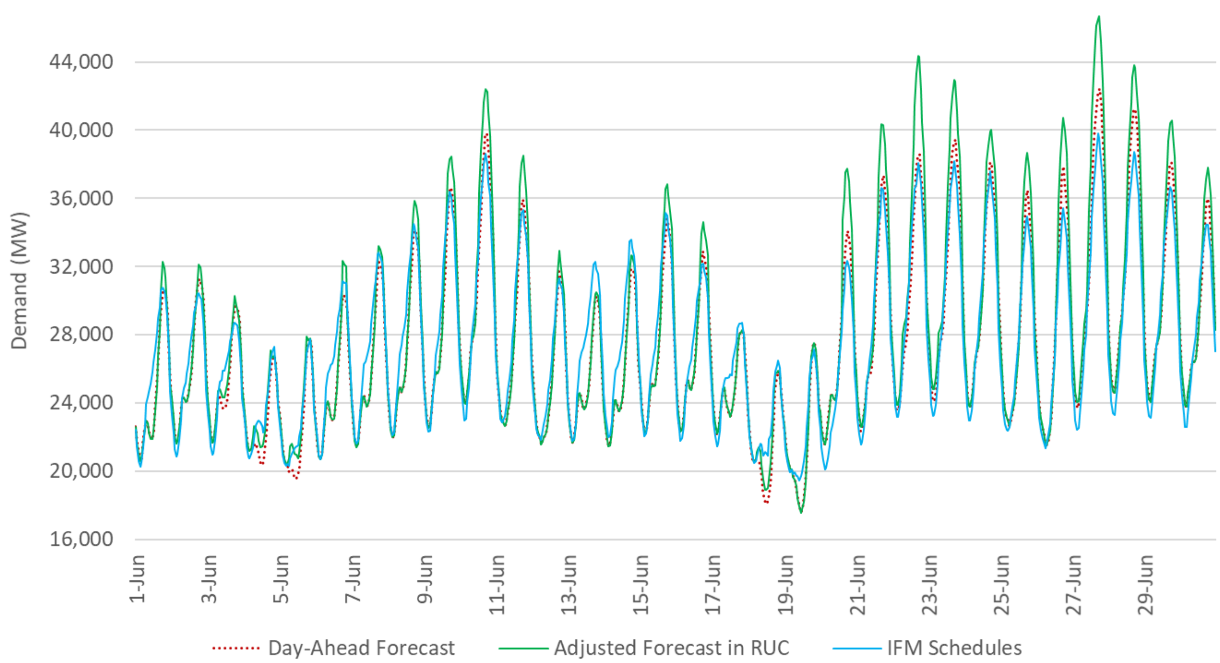
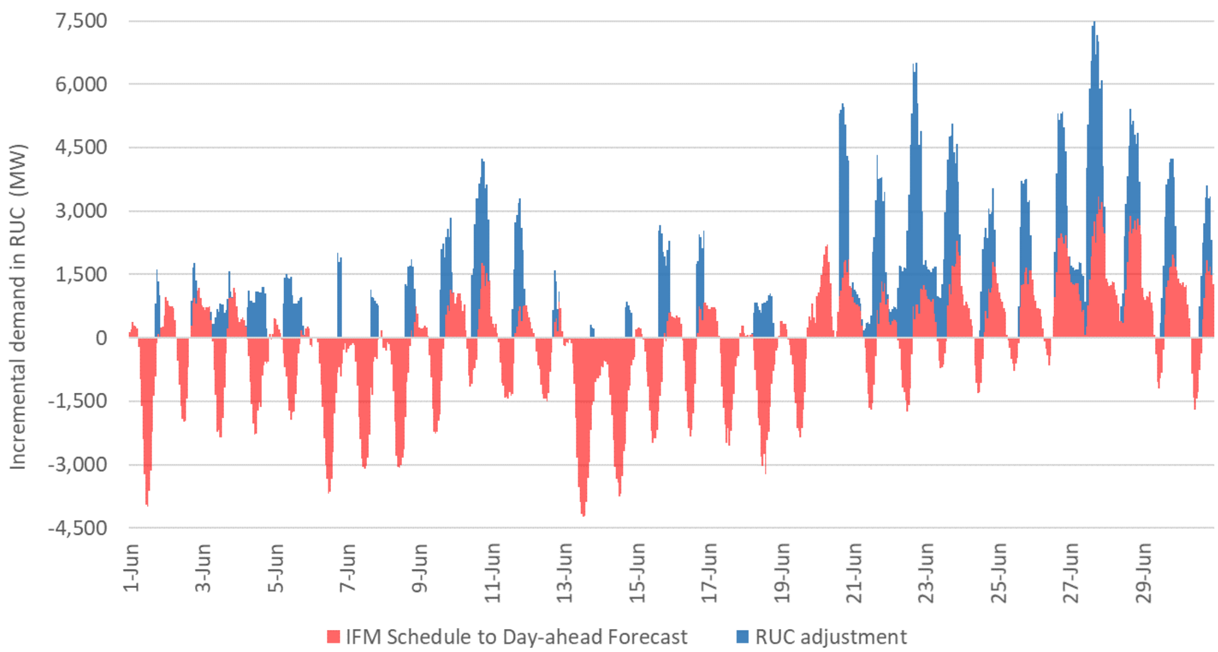


Figure 37 shows the differences between the IFM schedules for physical resources versus the nominal day-ahead load forecast. This is the additional capacity relative to the IFM solution that RUC determines is needed to meet the day-ahead load forecast. Effectively, this is either the shortfall or surplus capacity from IFM that RUC has to meet. The delta is driven by the difference between cleared bid-in demand and the load forecast, as well as any displacement driven by convergence bids. The area in blue is the RUC adjustment to the day-ahead load forecast. In cases when RUC is infeasible, some of this additional capacity will not be met. For most of the first 20 days of the month and with milder loads, IFM was already clearing naturally above the day-ahead forecast. As loads increase towards the end of the month, RUC has to clear additional supply to meet the day-ahead forecast, while RUC adjustments done by operators were adding to this requirement.

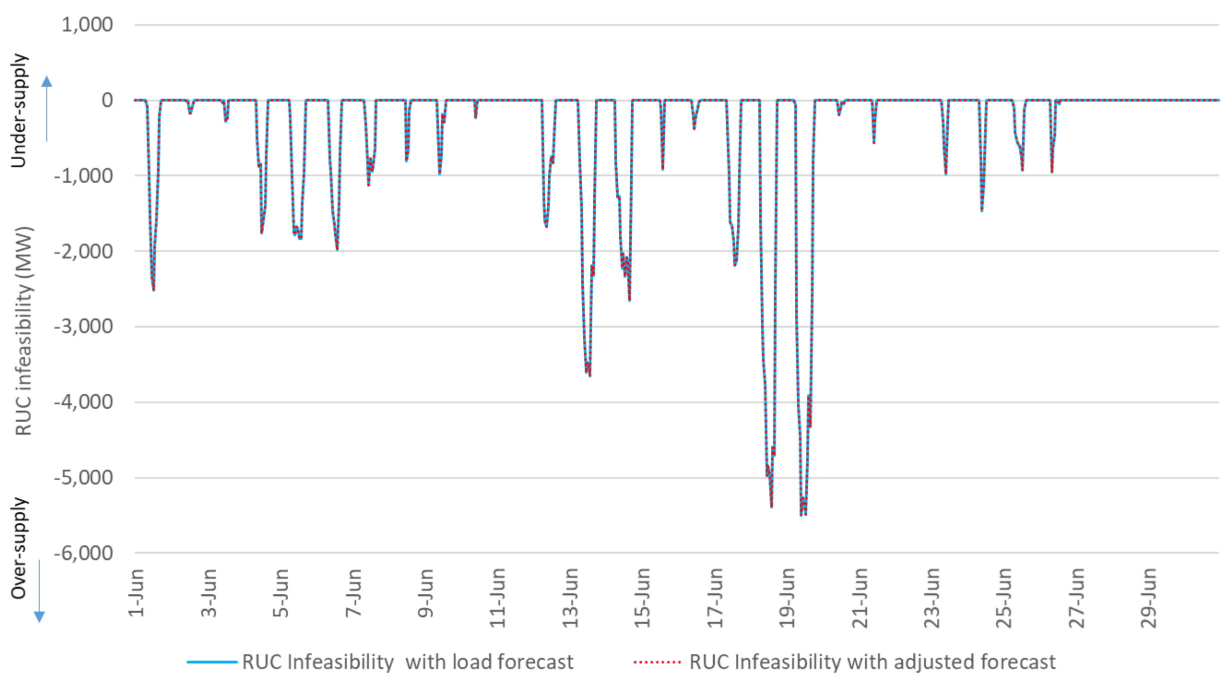
Figure 36: Incremental demand required in RUC in June



The RUC forecast adjustment is typically guided by a reference of an upper confidence bound and is estimated by the CAISO with consideration to weather and load model and renewables uncertainty. In some cases, there may be other factors to consider by operators to determine the final adjustments. With summer conditions under development in the second part June, IFM schedules and RUC adjustments were predominantly positive, meaning that RUC had to clear higher physical supply than IFM. However, given the milder loads observed in June.

Since RUC clears against a load forecast which is not price sensitive, under certain conditions RUC may relax the power balance constraint due to a surplus or shortfall of supply capacity. A relaxation signals that there is an imbalance between the load requirements and the supply available. An infeasible power balance can be in either direction. In hours with low levels of load and minimum downward capability, RUC may observe an oversupply condition, resulting in a negative infeasibility. Conversely, in hours where there is insufficient supply to meet the load requirement, RUC may have an undersupply condition, resulting in a positive infeasibility. Negative RUC infeasibilities occur because RUC can only dispatch a resource down to its minimum load and cannot actually de-commit a resource or set up additional exports. Conversely, positive RUC infeasibilities occur because all incremental RUC bids have been exhausted and RUC has curtailed all the economic and LPT exports,[26] which leaves just the power balance constraint to be relaxed and reducing PTK (high priority) exports, to allow RUC to clear. Figure 37 shows the RUC infeasibility against two reference points: one infeasibility is relative to the final adjusted forecast in RUC, while the other is relative to the raw day-ahead forecast. For the whole month of June, there were no RUC under-supply infeasibilities relative to the standard load forecast. There were only over-supply infeasibilities various days of the month. The marked over-supply in June occurred during the weekend of June 18 when loads came in significantly low in comparison to adjacent days.

Figure 37: RUC infeasibilities in June



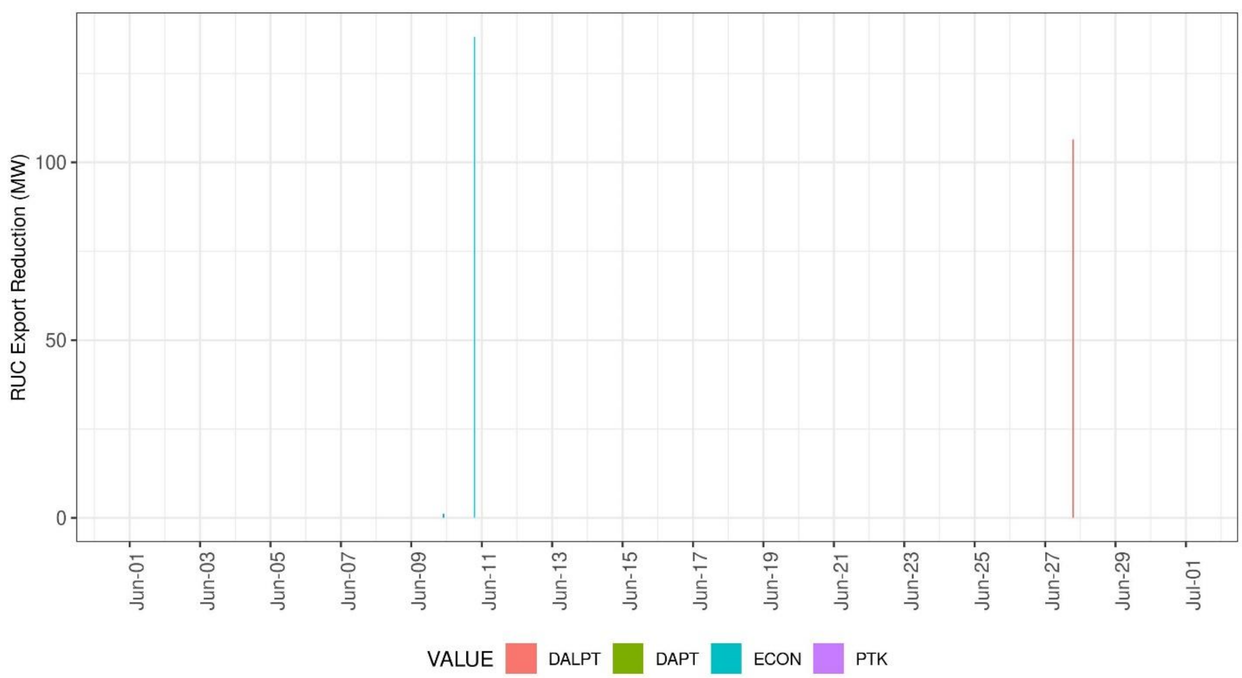
In addition to relaxing the power balance constraint, the RUC process utilized other scheduling priorities to enforce the power balance. Indeed, before relaxing the power balance (and based on current scheduling priorities), RUC will first reduce economic exports (exports bid-in at a given price) and lower

[26] There are different type of exports participation. They can be based on economic bids with prices between the bid floor and the bid cap; they can be price takers, also referred to as low priority exports and labeled as LPT. Exports can also be high priority self-schedule labeled as PTK (i.e., not backed by capacity that may be committed to CAISO load under its resource adequacy program). If the market clearing process encounters constraints, the CAISO will treat PTK exports similar to internal loads, but treats LPT exports as recallable and the market will curtail LPT exports before relaxing the power balance constraint.

priority price-taker exports. Only when RUC has exhausted these LPT exports, PT exports may be reduced concurrently to relaxing the power balance constraint.[27]

Figure 38 shows the volume of hourly export reduction in the RUC process, which only happened on June 10 and 27 for very small volumes for either economic or low priority since they have the lowest priority and are reduced first.

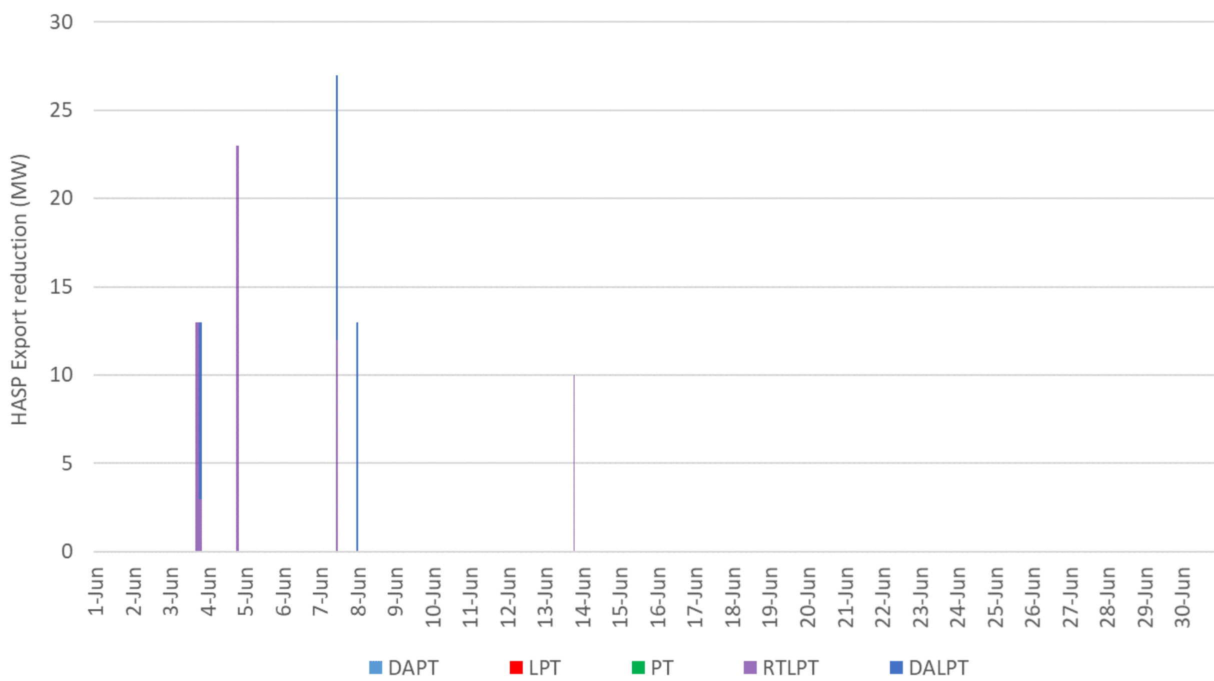
Figure 38: Exports reduction in RUC



Exports can still participate in the real-time market by rebidding relative to the DAM solution, or directly into real-time market with either high or low priority, as well as with economical bids. Market participants can self-schedule exports cleared in the day-ahead into the real-time market. Under the new market rules and scheduling priorities post August 4, these cleared day-ahead schedules are treated in the real-time market as having a day-ahead priority, which is above the priority of LPT and PT exports submitted in the real-time. Thus, exports cleared in the day-ahead are less likely to be cut in the real-time. Participants can also submit PT or LPT self-schedules in the real-time market, which are more at risk of curtailments in the hour-ahead scheduling process (HASP) process. In June, the real-time market saw very minor curtailments given the milder load conditions..

[27] Under the current setup of scheduling priorities, PT exports and the RUC power balance constraint have the same priority reflected with the same penalty price utilized in the market optimization. What level of curtailment relative to the level of power balance relaxation is achieved will depend on many other conditions in the optimization process, such as the location of the exports that may look more or less attractive for reduction in comparison to the power balance. Thus, typically, both export reduction and power balance infeasibilities can be observed in an RUC solution under tight supply conditions.

Figure 39: Exports reductions in HASP



9 Intertie Transactions

The CAISO's system relies on imports that arrive into the balancing authority area through various interties, including Malin and NOB from the Northwest and Paloverde and Mead from the Southwest, among others. Interties are generally grouped into static imports and exports, or dynamic and pseudo tie resources, which are generally resource-specific. Similar to internal supply resources, interties can participate in both the day-ahead and real-time markets through bids and self-schedules. Additionally, the CAISO's markets offer the flexibility to organize pair-wise imports and export to define a wheel. This transaction defines a static import and export at given intertie scheduling points which are paired into the system to ensure both parts of the transaction will always clear at the same level. Wheel transactions must be balanced, thus, do not add or subtract supply to the overall CAISO system, regardless of the cleared level. However, they utilize scheduling capacity on interties and transmission capacity on CAISO's internal transmission system. All intertie transactions will compete for scheduling and transmission capacity via scheduling priority and economic bids to utilize the scarce capacity on the transmission system.

Economic bids for imports are treated similarly to internal supply bids, while exports are treated similarly to demand bids, or fixed load through the load forecast feeds. These bids are bounded between the bid floor (-$150/MWh) and bid cap ($1,000/MWh or $2,000/MWh). Each part of a wheel is also treated accordingly as supply or demand but its net bid position is defined as the spread between its import and export legs.

Intertie transactions also have the flexibility to self-schedule. The CAISO's market utilizes a series of self-schedules which define higher priorities than economic bids based on the attributes applicable to such resources. Participants with such entitlements can submit intertie self-schedules using transmission ownership rights (TORs) or Existing Transmission Contracts (ETCs), as well as PTK and LPT.

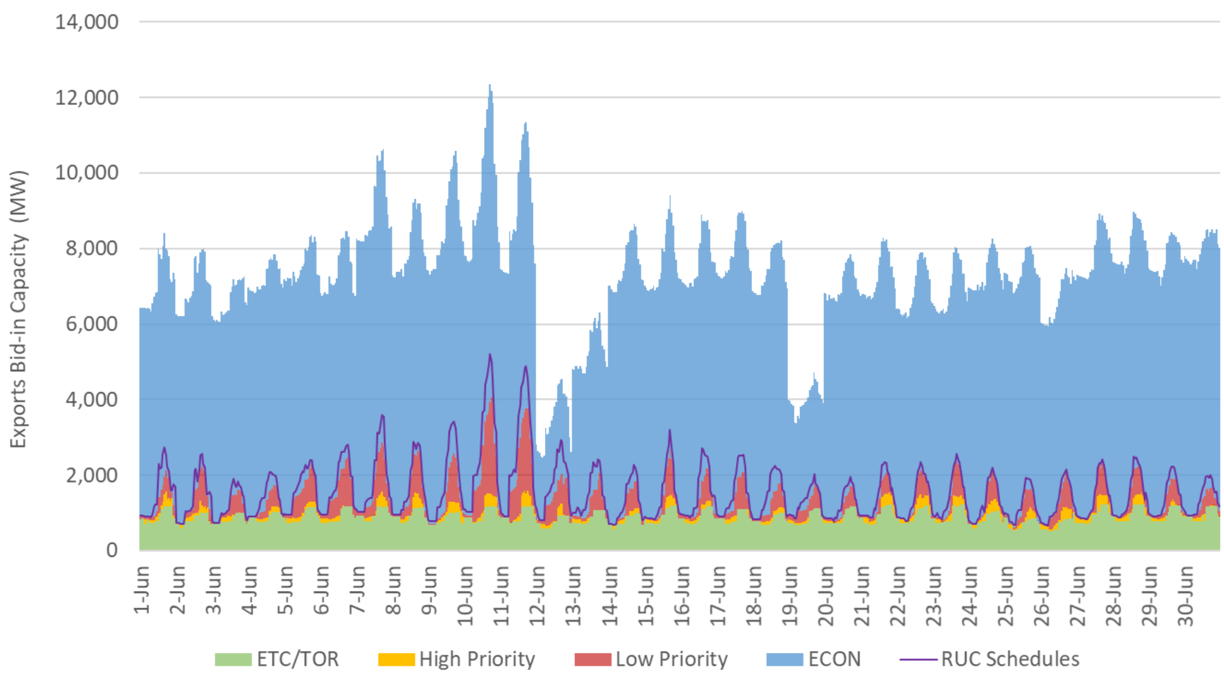
The CAISO's markets will clear intertie transactions utilizing its least-cost optimization process in each of its market runs. Bids and self-schedules are considered in a merit order to determine the clearing schedules, and all resource bids and characteristics, and system conditions, are taken into account. In the upward direction, when supply capacity is limited, imports with self-schedules clear first, followed by economic bids from cheapest to most expensive, up to the level of the market clearing price. Conversely, exports will clear first for ETC/TORs, then PTK exports, followed by LPT exports and lastly economic bids from most expensive to cheapest. Wheel transactions have a higher priority in the clearing process defined as the relative spread of penalty prices between the import and export sides.

9.1 Intertie supply

Figure 40 shows the capacity from static export-based transactions in the day-ahead market for the month June 2022 organized by the various types of exports. This capacity does not include export capacity associated with wheel transactions of any type because wheels are in balance on a net basis and, thus, the export side of wheels does not reduce supply to the CAISO supply stack.

This figure also illustrates the clearing schedules from the RUC process with the line in purple. The RUC schedules are used as reference, instead of the IFM schedules, because they are the relevant schedules for clearing interties in the day-ahead market. As defined in Section 31.8 of the CAISO tariff, in the day-ahead market, the CAISO enforces a net physical intertie scheduling limit in the RUC process and enforces a net physical and virtual intertie schedules limit in the IFM process of the day-ahead market. This is to ensure that intertie schedules cleared in the day-ahead market are physically feasible and not encumbered by virtual intertie schedules. Prior to May 1, 2014, the CAISO enforced a net physical intertie scheduling limit in the IFM. As a result of this change where physical-based flows from the RUC process are the most reliable reference of feasible schedules on interties, the CAISO operators use the RUC schedules to evaluate E-tags submitted in the pre-scheduling timeframe.

Figure 40: Bid-in and RUC cleared export capacity



The RUC schedule represents the expected delivery and E-tags that market participants should submit in the pre-scheduling timeframe, and not the IFM schedule. While not required to submit their E-tags in the day-ahead timeframe, market participants are encouraged to do so and in such cases should base their E-tag on the RUC schedule. If not, E-tags greater than RUC schedules may be curtailed by the CAISO. This applies to all dynamic and static intertie schedules.

Export bid capacity in the day-ahead market varies by hour and typically follows a daily profile. About 81 percent, 12 percent, 5 percent and 2 percent of the export capacity were for economic bids, ETC/TOR, LPT and PTK, respectively. With milder load conditions in June, there was naturally less need for exports as reflected by the relatively low volume of self-schedule versus economical bids.

Figure 41: Bid-in and RUC cleared import capacity

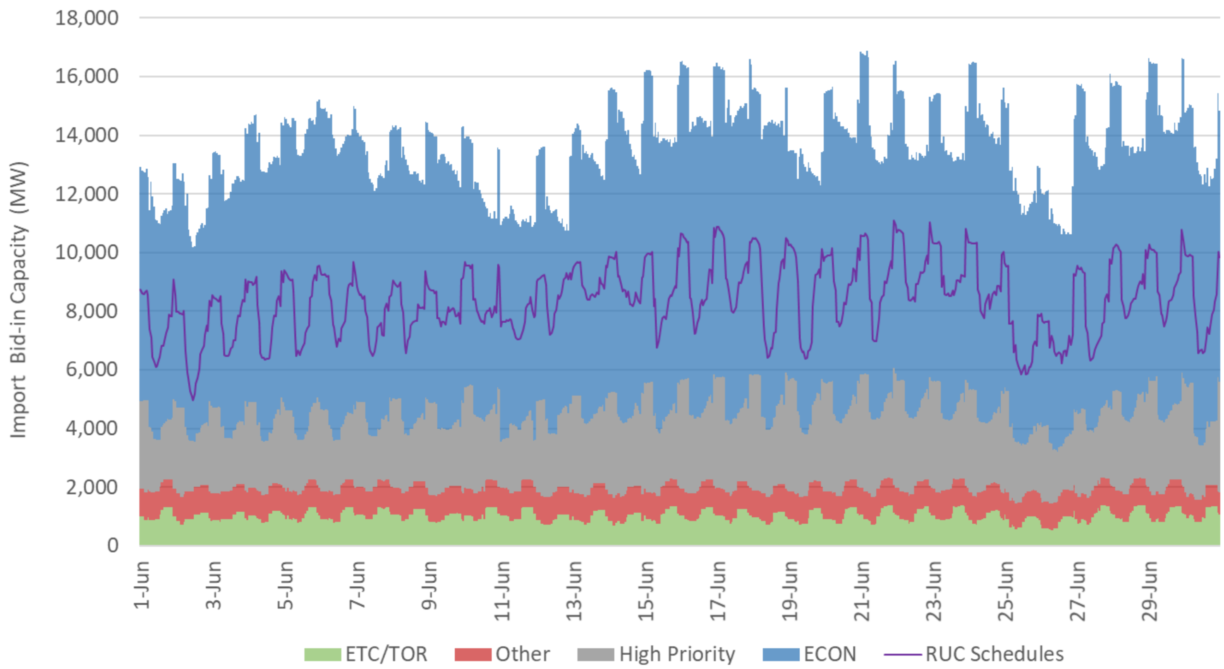
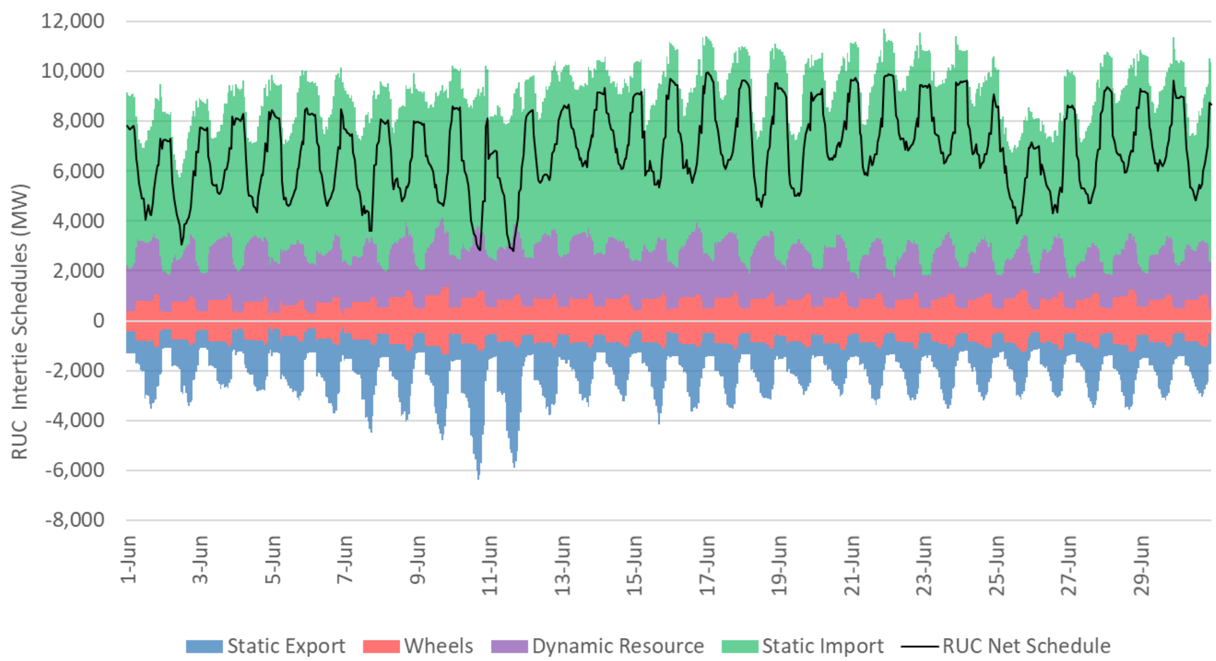


Figure 42 shows the same illustration for imports. These volumes include both static imports and dynamic resources. Both ETC/TOR remained relatively stable through the month, while hourly economic imports continued to see a high volume over 5000MW. The "Other" group includes regulatory must run priority capacity and the portion of Pmin for dynamic resources with a Pmin above 0 MW.

Figure 43 shows the overall intertie schedules organized by type of schedule, as well as the net interchange based on the RUC solution. The net interchange projected in the RUC process was over 2,000 MW for all hours in June given milder loads and lower level of exports.

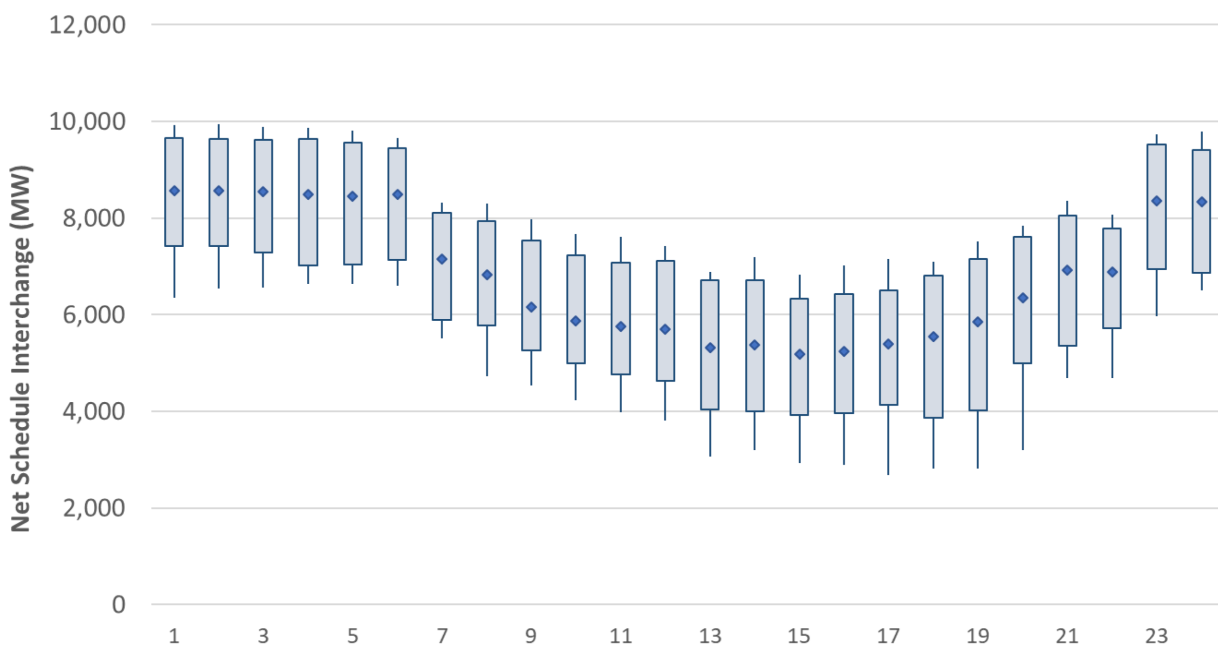
Figure 42: Breakdown of RUC cleared schedules



The hourly net schedule interchange were consistently over 2,000 MW with minimum levels above 5,000 MW by the end of the month.

Figure 43 illustrates the hourly net schedule interchange distribution by hour in the summer months. This trend is useful to visualize the hourly profile of schedules and shows that net schedules reduce in midday hours when solar production comes in and start to increase as the solar production fades away in the evening hours. It also shows two well-defined blocks of On- and Off-peak schedules. The lowest net interchange values are attained in hours prior to the gross peak when solar supply is still plentiful.

Figure 43: Hourly RUC net schedule interchange



An area of interest since summer 2020 is the trend of exports in the CAISO's system. Export levels were generally low in June with milder loads.

Figure 45 illustrates the hourly distribution of RUC schedules for exports, and that the highest volume occurred during midday hours when CAISO's system has excess solar supply; exports were in high demand during the afternoon hours at the beginning of the month.

Figure 44: Hourly RUC exports

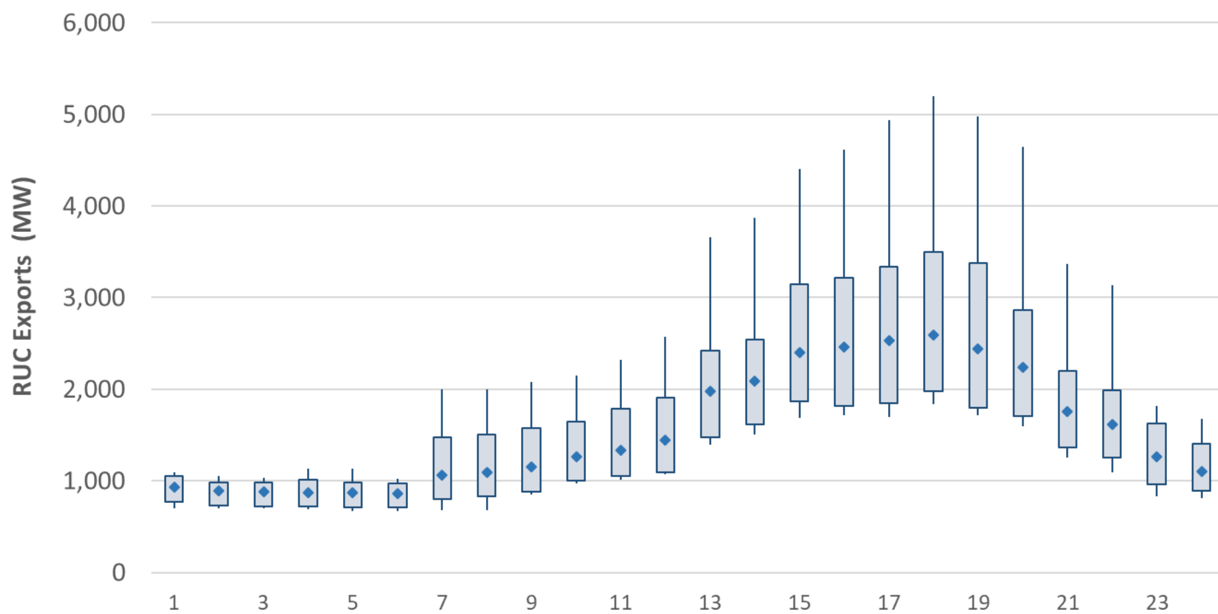
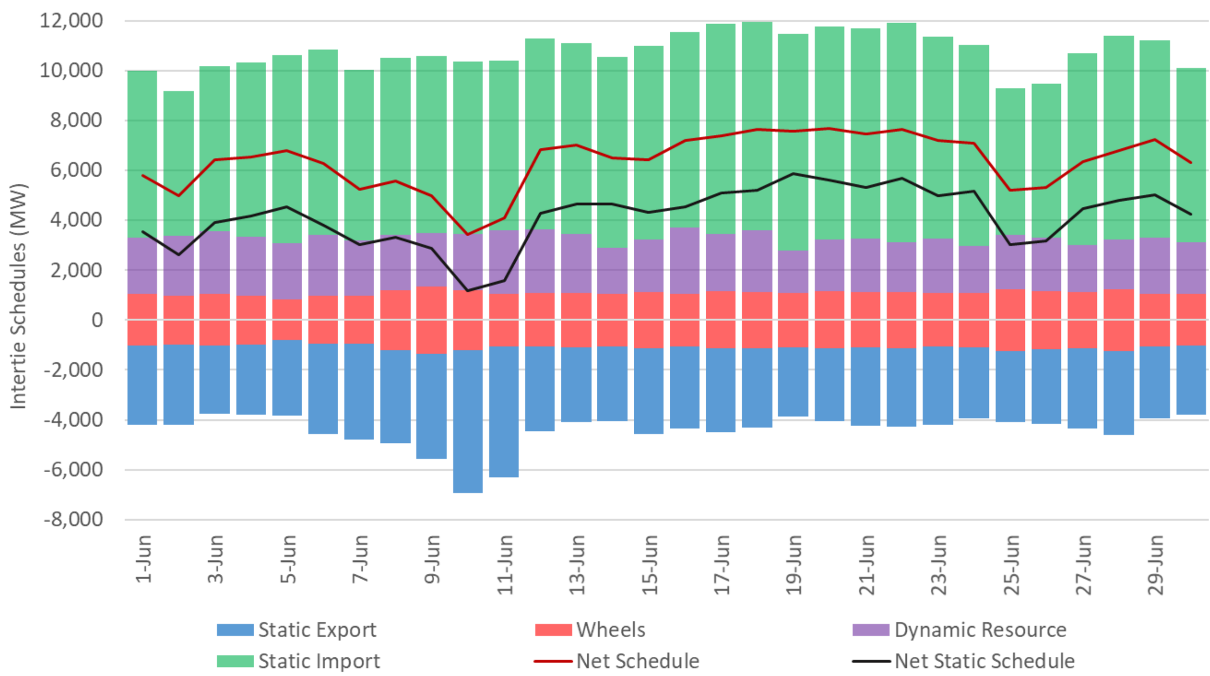


Figure 45 shows the intertie capacity available in the day-ahead market for hour ending 20 to highlight the conditions around peak time, when the CAISO's system faces the highest supply needs.

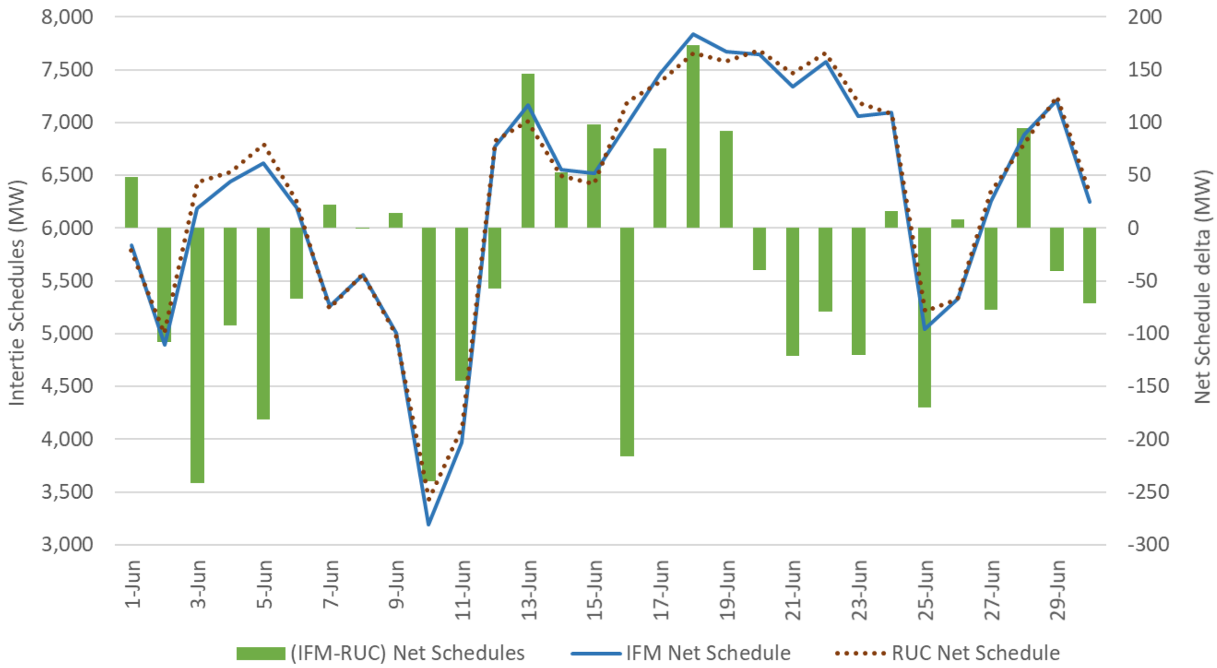
Figure 45: RUC schedules for interties for hour ending 20



This balance does not include any imports or exports associated with explicit wheeling transactions. Including wheels will increase the volume of imports and exports by the same amount such that the net schedule remains the same. The red line represents the net schedules cleared in RUC (imports plus dynamics less exports), while the blue line represents the net schedule in RUC when considering only static imports and exports.

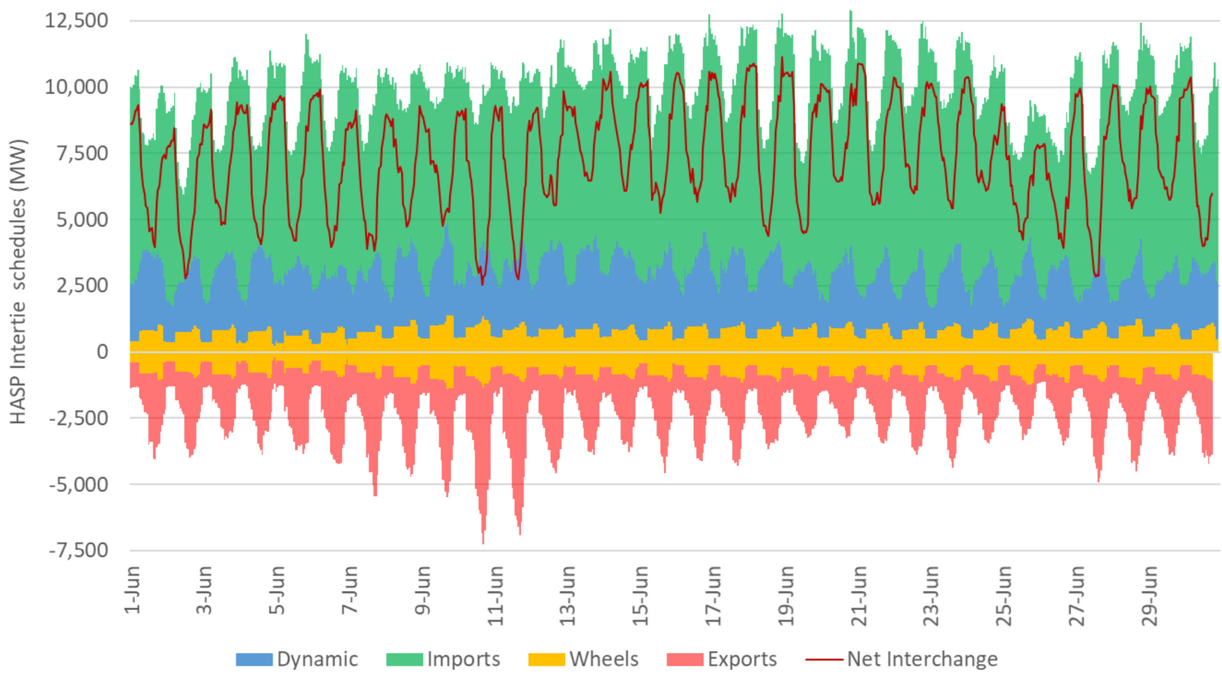
The RUC process may schedule additional supply to meet the load forecast, above what was scheduled in the IFM. Under tight supply conditions, the RUC process may also identify that export schedules cleared in the IFM process are not feasible, and signals to the participant that their exports is not feasible in the real-time. Therefore, for interties, the RUC schedules are the relevant schedules for assessing what is feasible to flow into real-time, and they are what should be tagged if participants submit a day-ahead tag for their export. IFM schedules are still financially binding. Figure 46 compares the net schedule cleared in both IFM and RUC for hour ending 20, and provides the relative change of schedules between the two processes as shown with the bars in green. These changes can happen for any type of resources and it is not always limited to a reduction of exports. IFM schedules for exports were reduced in the RUC process mainly for June 10 and 27.

Figure 46: IFM and RUC schedule interchange for hour ending 20



Intertie positions are largely set from the day-ahead market. Import or exports cleared in the day-ahead may tend to self-schedule into the real-time to preserve the day-ahead award. There may still be incremental participation in the real-time market through the HASP process, which allows resources to bid-in economically to buy back their day-ahead position, or also enables the procurement or clearing of additional capacity in the real-time market. Figure 47 shows the cleared schedules in real time for interties of different groups, and the net intertie schedules cleared, referred as Net Schedule Interchange. The net schedule interchange is at its lowest value in June 10 due to the highest level of exports cleared on that day prior to the evening peak. The real-time market largely follows the trend observed in the day-ahead market. On average, for June the net schedule in HASP was about 6,630 MW for peak hours.

Figure 47: HASP cleared schedules for interties in June



The HASP market presents an opportunity for interties to clear through the market clearing process after the DAM is complete. Interties cleared in the day-ahead market can submit self-schedules into. Clearing the RUC process indicates that these exports were feasible to flow based on the projected system conditions in RUC.[28] Additionally, exports can participate directly into the real-time market with either self-schedules or economic bids.

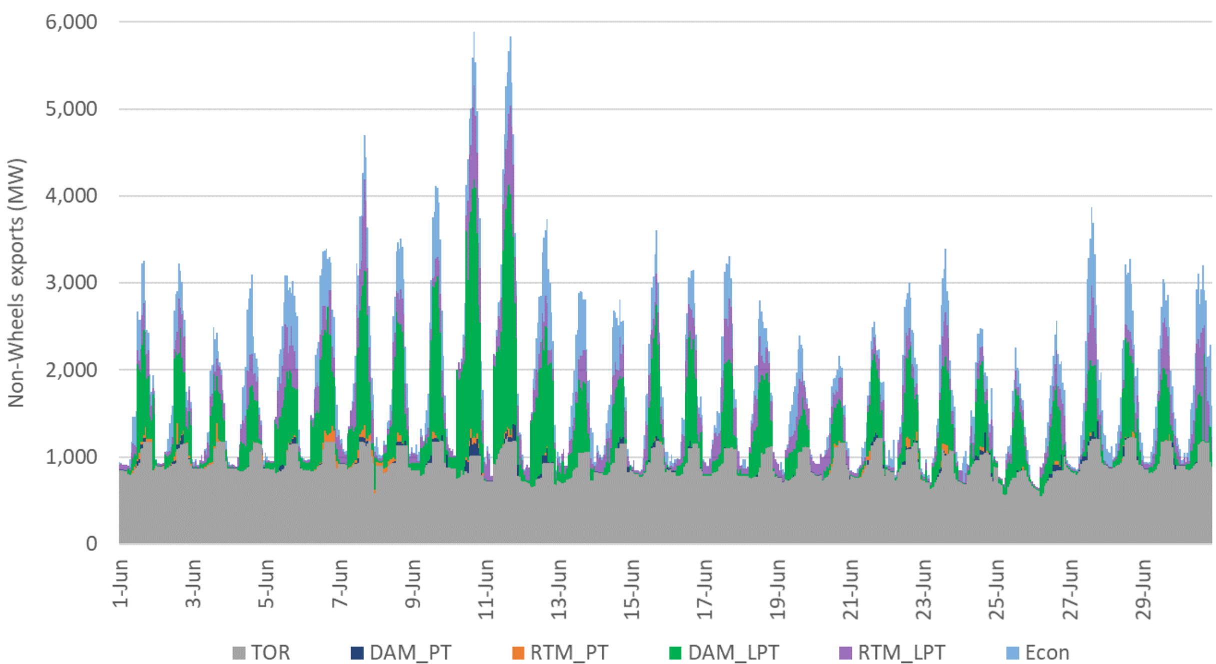
Each market, RUC or HASP, can assess reduction of exports based on the overall system conditions and economics. Export reductions in RUC cannot self-schedule into real-time with day-ahead priority but they are able to be rebid into the real-time market and be fully assessed based on real-time conditions. LPT or economic exports cuts in the RUC process are most likely to be cut again in HASP since they will have the lowest priority in the presence of tight supply conditions. Figure 48 shows all the exports cleared in the HASP process and identifies the nature of such exports. TOR is for export with scheduling priorities associated with transmission rights. The groups of DA_PTK or DA_LPT stand for day-ahead exports coming into real-time as self-schedules with high or low priorities. Similar classification is followed for those high and low priority exports coming into real-time directly (RT_PTK and RT_LPT). ECON stands for economic exports. The group of wheels stands for all type of wheels observed in the real-time market (low- or high-

[28] Based on these rules implemented on August 4, through the summer enhancements described earlier and now in place, the CAISO will no longer provide exports a higher priority than load in the real-time, and will only provide them equal in priority to load if the participant demonstrates that they continue to be supported by resources contracted to serve external load.
Details are available at http://www.caiso.com/Documents/Jun25-2021-OrderAcceptingTariffRevisionsSubjecttoFurtherCompliance-SummerReadiness-ER21-1790.pdf

priority). With different framework of priorities before August 4, this classification is an approximation to the new framework post-August 4 that is applicable for the first 4 days of August. Given the many different groups for exports, wheels are shown in this metric explicitly. These exports are only for non-wheel transactions. A granular breakdown of wheels is provided in a subsequent section of wheels.

The volume of exports cleared in real time follows the pattern of loads with a fair increase in June 9-11. On June 10, up to 2945 MW of day-ahead low priority cleared in real-time, which represented about 45 percent of the overall exports.

Figure 48: Exports schedules in HASP



Imports and exports were scheduled over multiple intertie scheduling points in June, with Malin, Paloverde and NOB seeing the highest volume of transactions. Figure 49 through Figure 51 illustrate the trend of import and export schedules cleared in HASP for the top three intertie points. Although schedules in the import direction are the predominant schedules, exports cleared at different levels on these major interties when supply was tight.[29] Exports in Palo Verde were higher on June 9-11; exports on Malin and NOB were minimal.

[29] The breakdown of imports and exports at the system or tie level may be subject to different levels of aggregation. For instance, wheels are in balance and the import side of a wheel nets out with the export side of the wheel. There are some transactions like TORs that behave like wheels although they are not explicit wheels in the market clearing process; i.e., the market can clear the import at a value different than the export's value. Generally they may clear in balance and thus the export side may not add demand needs to the system, like stand-alone exports, even though it is counted in the total volume of exports for a specific tie.

Figure 49: HASP schedules at Malin intertie

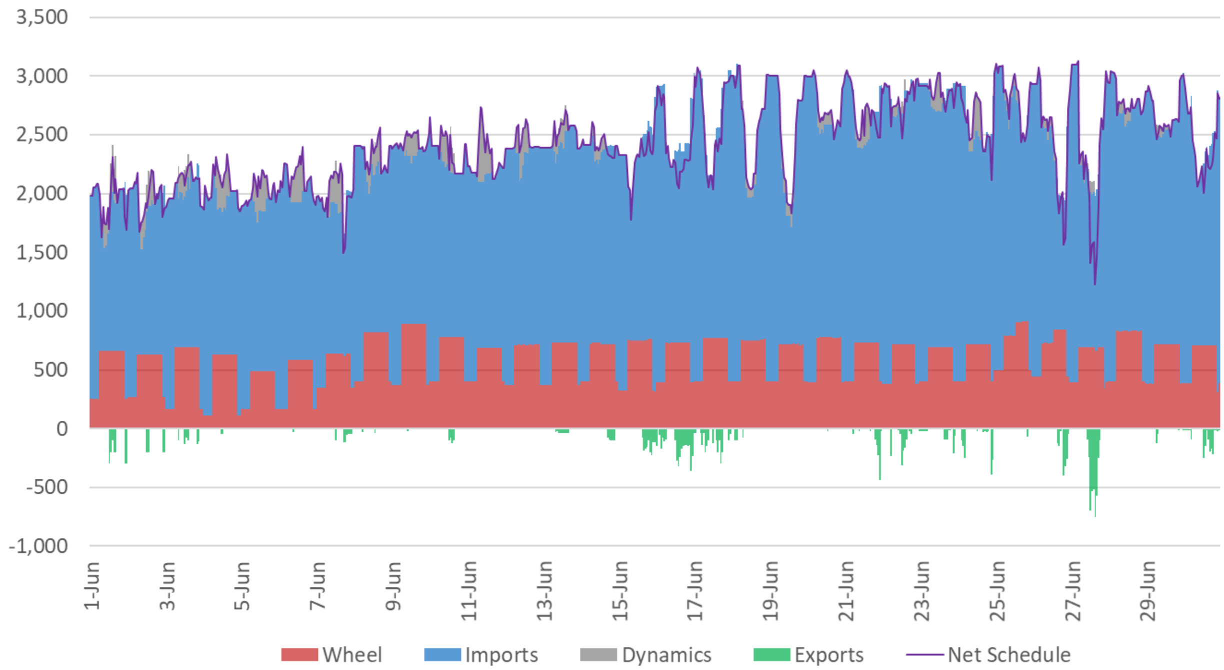


Figure 50: HASP schedules at PaloVerde intertie

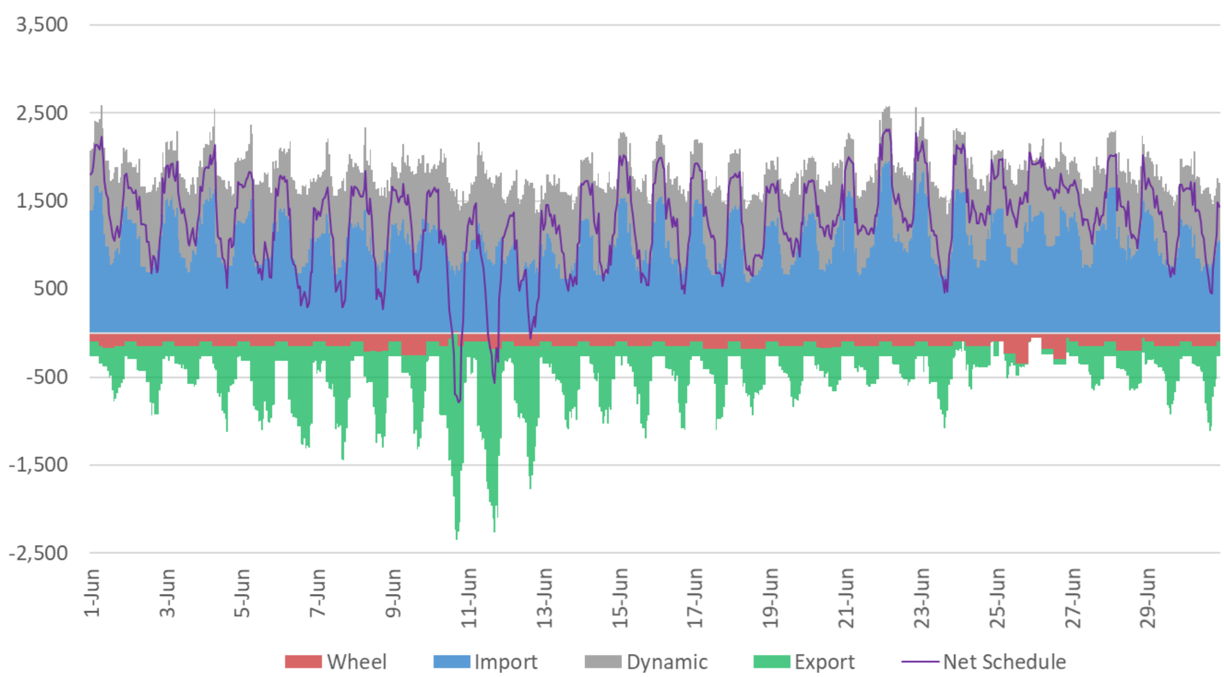
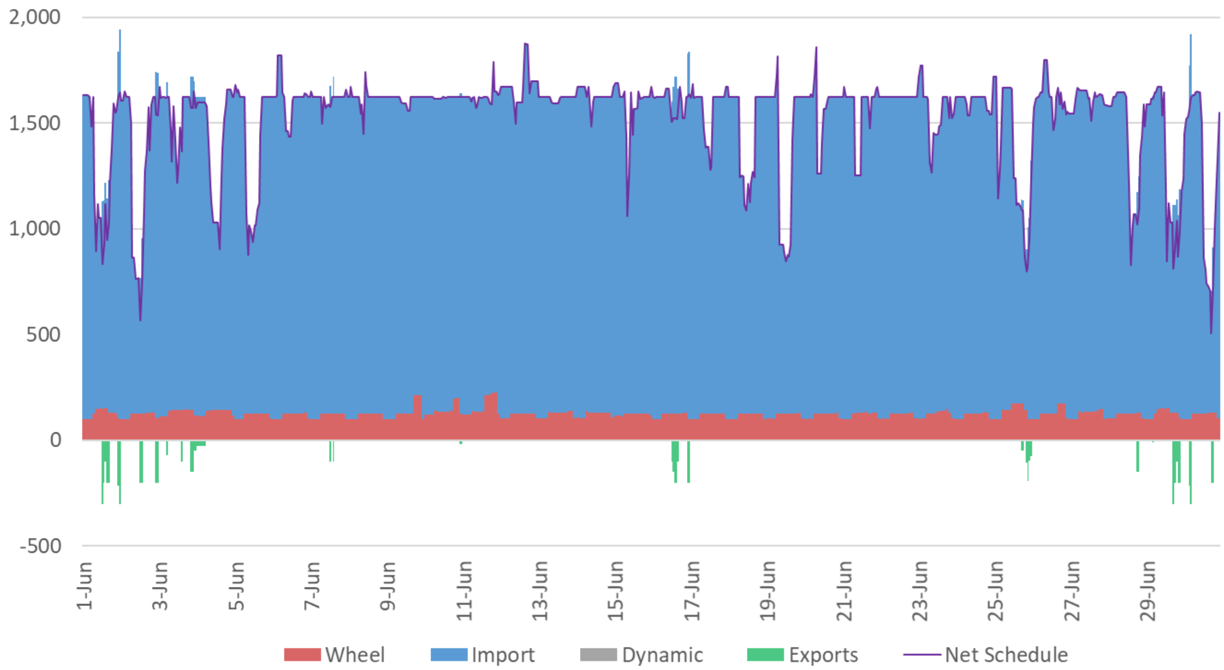


Figure 51: HASP schedules at NOB intertie



9.2 Resource adequacy imports

Imports can be used to meet Resource Adequacy (RA) requirements and they can be resource-specific or non-resource specific. For simplicity, this analysis relies on static imports as a proxy for non-specific resources. The other type of imports are dynamic or pseudo tie resources, which typically will be resource-specific. The total amount of RA supported by static imports in June was about 554 MW related to LSEs under CPUC jurisdiction.

Under RA rules, non-resource specific RA imports for LSEs under CPUC jurisdiction must self-schedule or bid with economics bids between -$150/MWH and $0/MWh at least for the availability assessment hours. Figure 52 is an approximation of the supply bid in the day-ahead market by static RA imports associated with LSEs under CPUC jurisdiction and for hours ending 17 through 21 of weekdays only. This supply is organized by price range, including self-schedules and also differentiates between RA capacity and above RA capacity. Based on this subset, basically all RA import capacity was bid with either self-schedules or economic bid at or below $0/MWh in June. Some RA imports bid in above their RA level with either self-schedules or economical bids. These volumes are also shown in the figure. Additionally, this plot also shows the cleared imports, which largely utilized all the bid-in volume for RA and Above RA.

Figure 53 shows the same information for the real-time market using the HASP bids. The majority of RA imports come in as self-schedules in the real-time market, with only a small fraction of imports coming with an economic bid. In the day-ahead market, 8.8 percent in August came with an economic bid. The majority of RA imports were bidding at least up to the RA level, while a few RA imports indeed bid-in above their RA level.

Figure 52: Day-Ahead RA import for hour endings 17 through 21 for weekdays

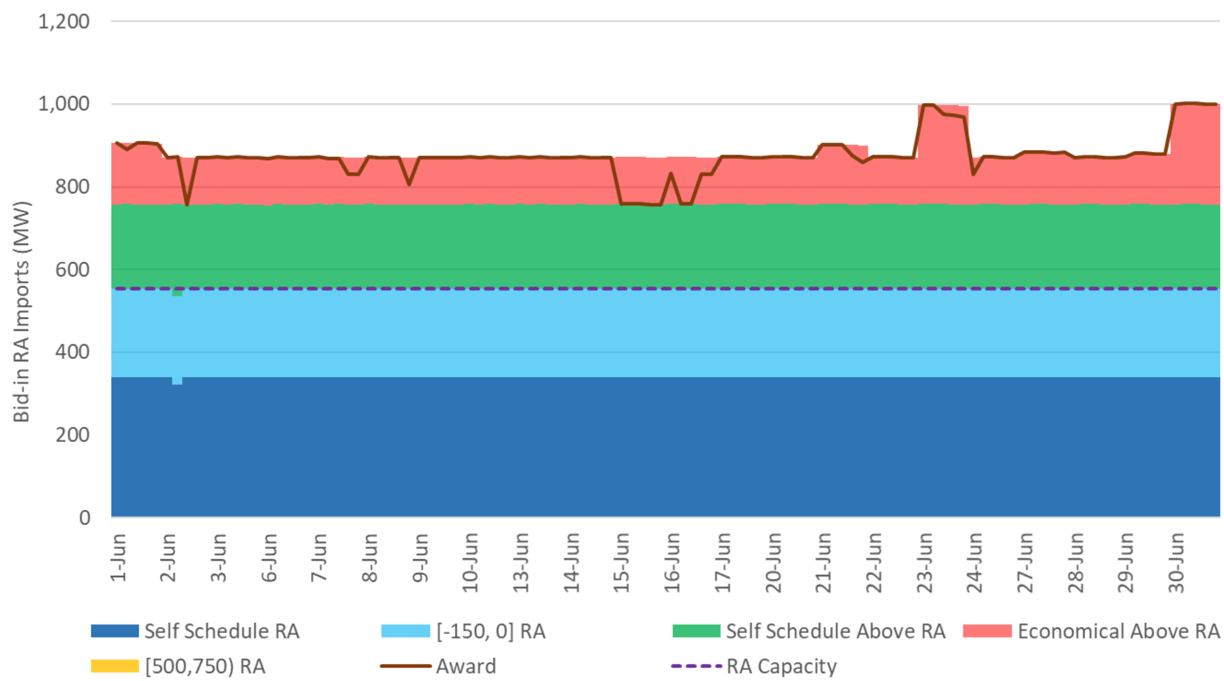
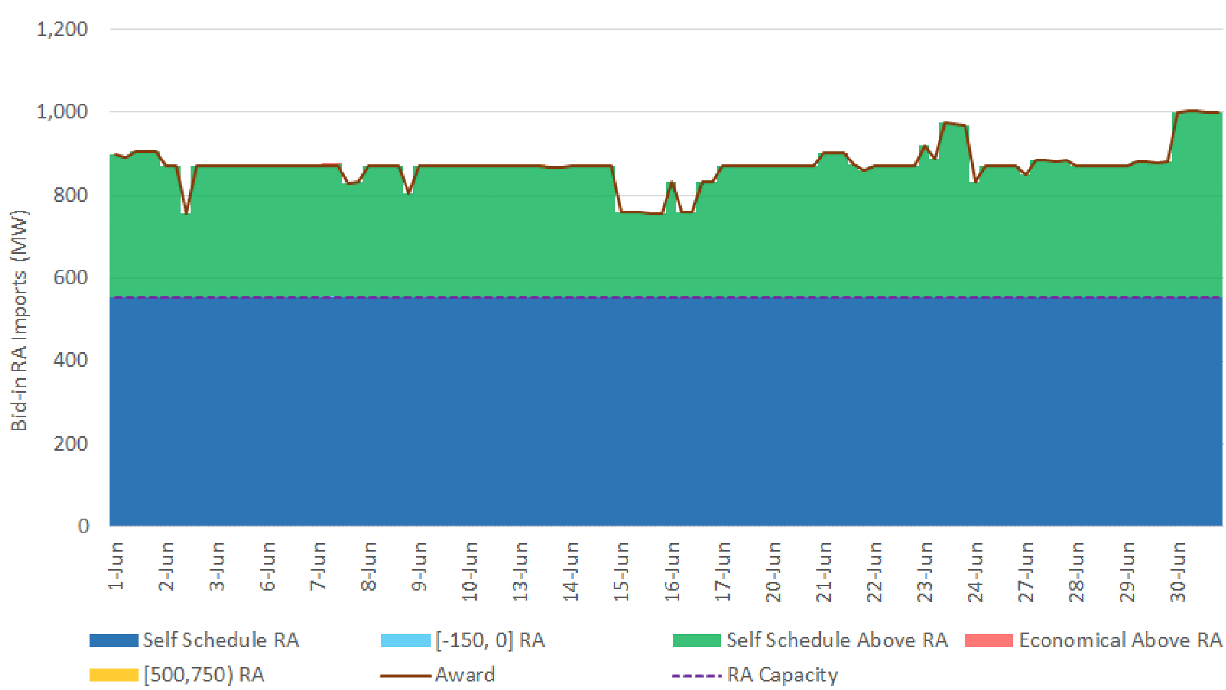


Figure 53: HASP RA import for hour endings 17 through 21 for weekdays



9.3 Wheel transactions

With the summer enhancements for Exports, Loads and wheels scheduling priorities extended for summer 2022, wheels seeking a high scheduling priority in the market equal to ISO load are required to register in advance their wheel transactions by meeting specific requirements up to 45 days prior to the start of month.[30] If the requirements are not met and the wheel transaction is not registered, the transaction receives low scheduling priority. For the month of June, the CAISO received registration requests for a total of 742 MW from six different scheduling coordinators. Table 2 shows all the wheel-through paths registered by all scheduling coordinators.[31]

Table 2: Wheel-through transaction registered for June

Source	Sink	MW
CFETIJ	MEAD230	50
CFEROA	MEAD230	50
MALIN500	MEAD230	200
MIR2	RANCHOSECO	30
NOB	MIR2	25
NOB	MEAD230	56
MALIN500	MCCULLOUG500	100
MALIN500	PVWEST	100
MALIN500	PVWEST	100
NOB	MEAD230	6
NOB	WESTWING500	25
	Total	742

Once these transactions are registered, they can be scheduled in the CAISO's markets and receive a high scheduling priority. Scheduling coordinators can opt to utilize these wheels on an hourly basis through the month. Figure 54 shows the hourly wheels cleared in the RUC process throughout the month. Wheels participating in the day-ahead market in the month of June were ETC/TOR, high- and low-scheduling priority, peaking at 1,366 MW on June 9, with 620 of TORs, 400MW of high priority and 346 of low priority wheels. There were no wheels with economic bids. The volume of explicit wheels associated with ETC/TOR was stable throughout the month with higher values in peak hours.

[30] Market Operations Business Practice Manual, section 2.5.5 (2021).

[31] Some request for wheels provided both Malin and NOB as possible sources. For simplicity in the aggregation, some sources were assigned to Malin and others to NOB trying to assign the wheels evenly between the two potential sources.

Figure 56 provides an hourly breakdown of high- and low-priority wheels, with the maximum hourly cleared RUC volumes of 455 MW of high priority wheels on June 28; this is about a 61 percent utilization of the volume of high priority wheels registered for June.

For June, high priority wheels exhibit an on-peak block with largely the same MW value across the block. Low-priority wheels were in the market all hours of the day but exhibited a pattern for the off- and on-peak blocks as shown in Figure 56; i.e., the submitted self-schedules were at the same MW value for blocks of multiple hours that define off-peak (hours ending 1 through 6 and hours ending 23 through 24) and on-peak hours (hours ending 7 through hour ending 22).

In comparing the high priority wheels registered in advance for the month of June with the wheel records that were actually bid in the day-ahead market, Figure 57 shows that up to 455 MW out of the 742 MW of registered wheels in June were used in the market.

Figure 54: Hourly volume of wheel transactions used in the day-ahead market by type of self-schedule

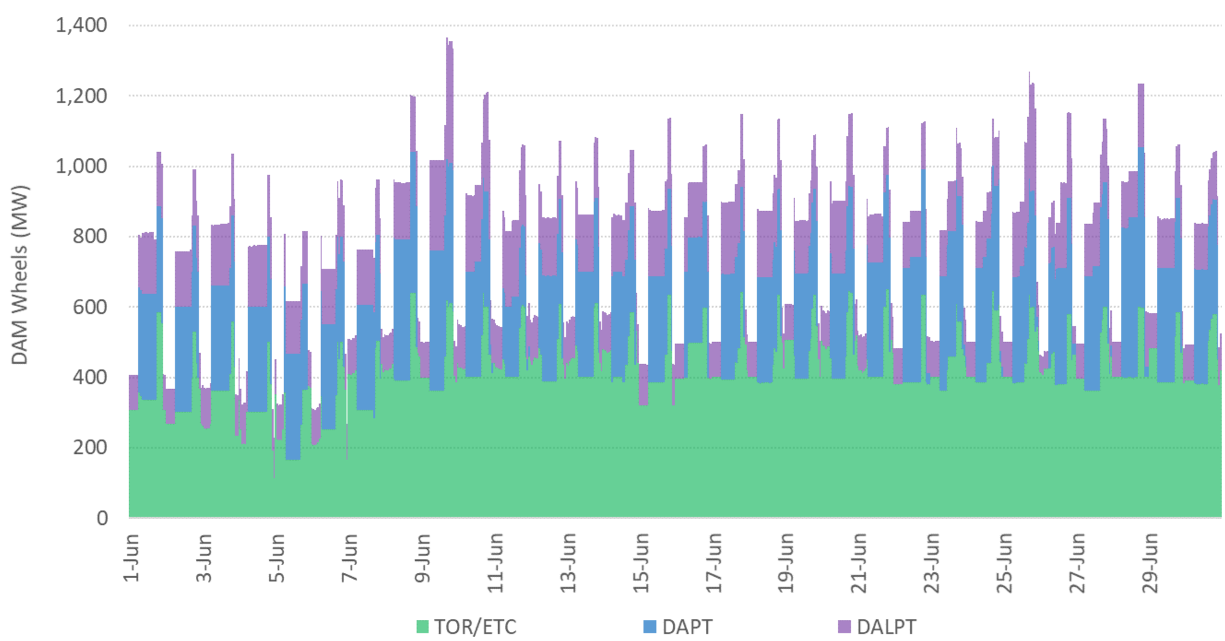


Figure 55: Hourly volume high- and low-priority wheels cleared in RUC

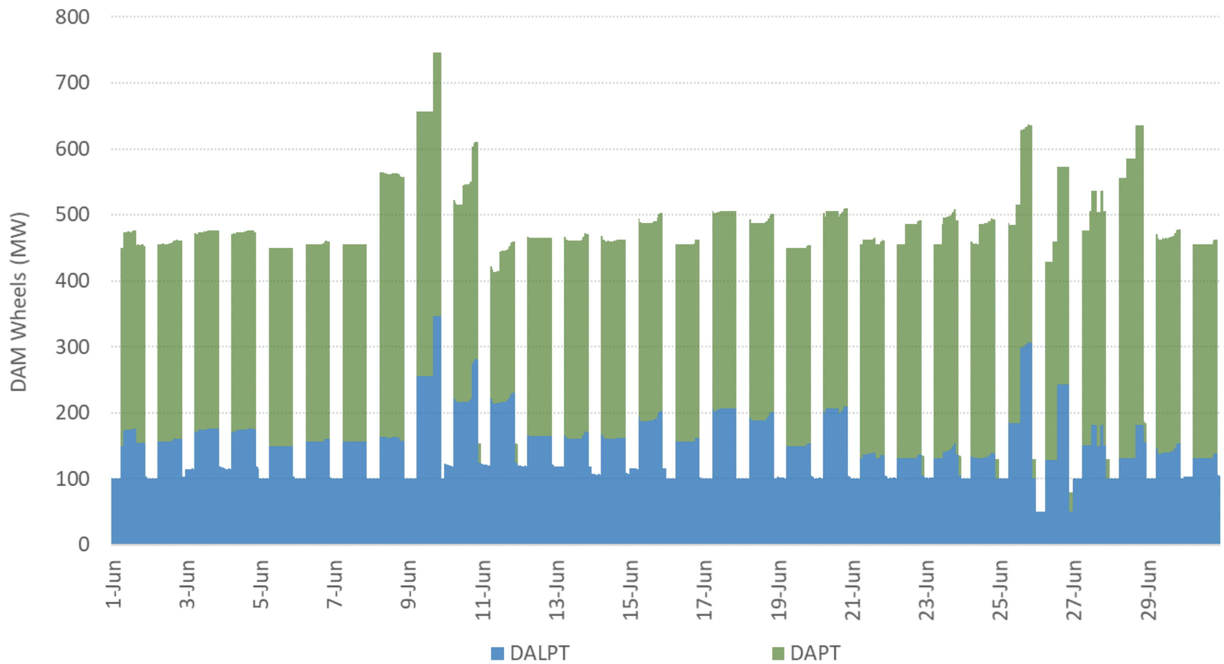
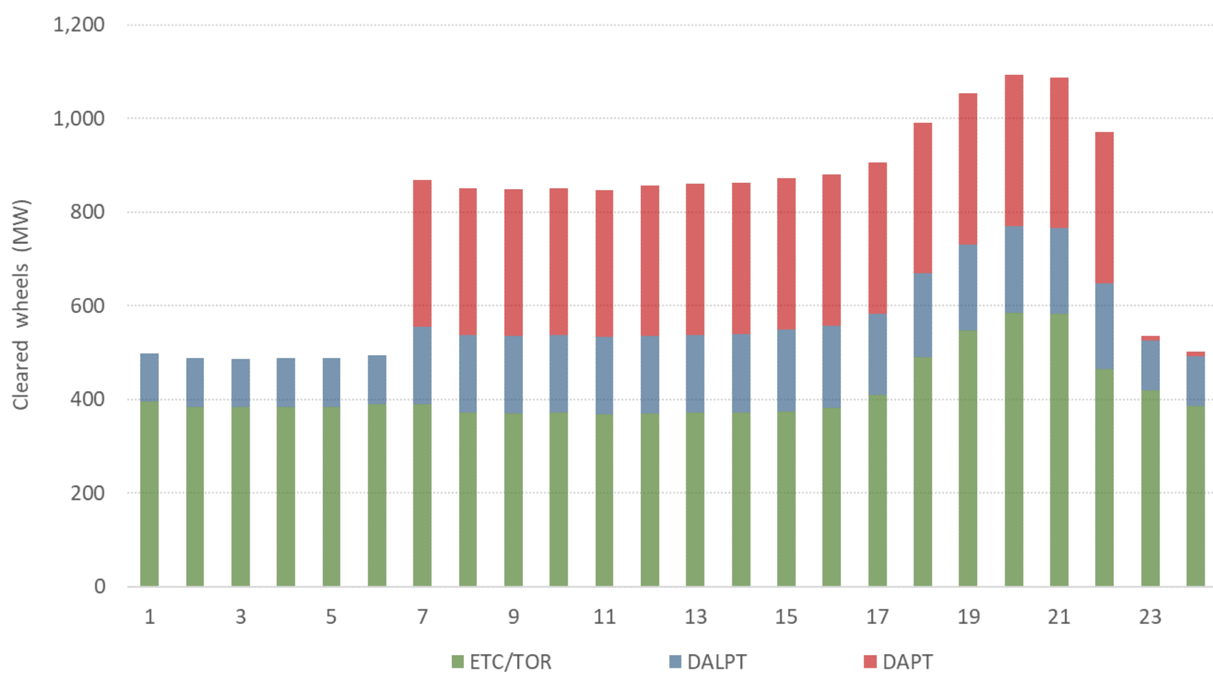


Figure 56: Day-ahead hourly profile of wheels in June



Wheels are defined with a source and sink location in the CAISO's markets to factor in their contribution to the flows on either intertie constraints or internal transmission constraints. Figure 57 summarizes the hourly average of wheels organized by source and sink combinations. An empty entry reflects that no wheels were present for that given source-to-sink combination in June. *Source* refers to the import scheduling point while *sink* refers to the export scheduling point. The path with the largest volume of wheels in June in the day-ahead market was from Malin to MEAD230, followed by wheels from NOB to Palo Verde.

Figure 57: Hourly average volume (MWh) of wheels by path in June

		Sink							
Type	Source	PVWEST	MEAD230	WESTWING500	MCCULLOUG500	MDWP	MEAD2MSCHD	MIR2	RANCHOSECO
DALPT	CRAG	3.5							
DALPT	MALIN500	10.3	8.8	15.5					
DALPT	MDWP			0.7					
DALPT	MEAD230	0.1							
DALPT	NOB	93.6	2.8	1.2	1.3	0.8	0.6	10.6	
DALPT	PVWEST				0.1				
DAPT	CFEROA		0.0						
DAPT	MALIN500	35.6	133.3		35.6				
DAPT	MIR2								4.8
DAPT	NOB							4.4	

Figure 58 summarizes the maximum hourly wheels cleared in any hour in June in the day-ahead market by source-to-sink combination. The maximum volume of wheels in a given path occurred from Malin to Palo Verde.

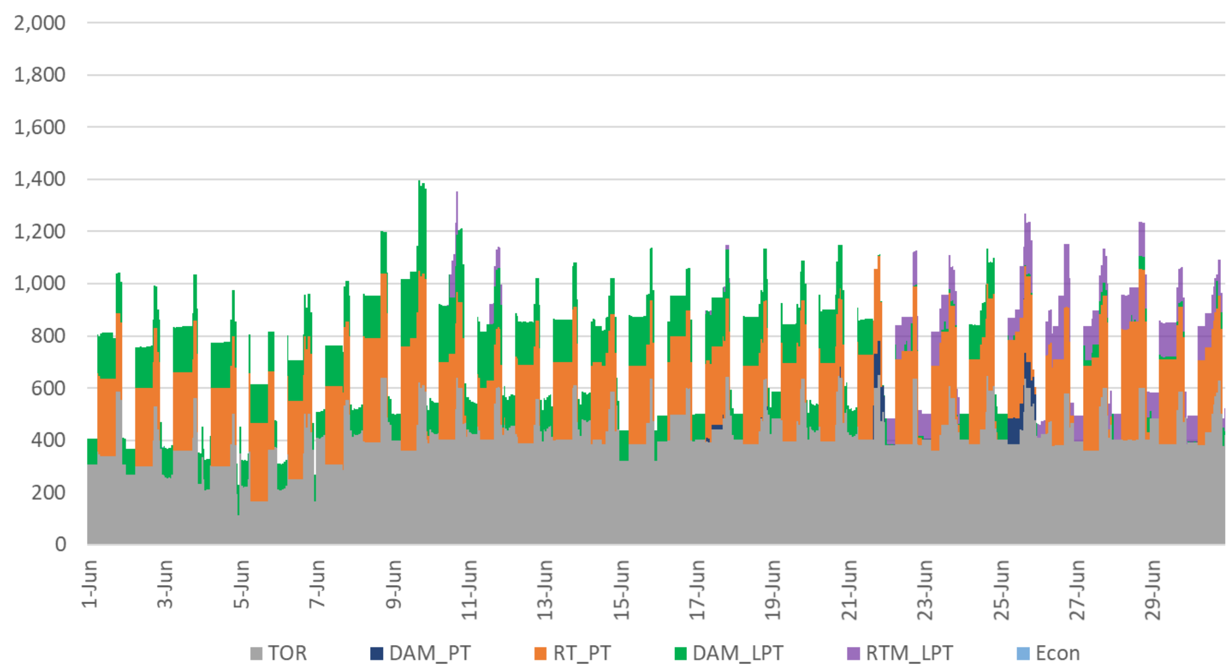
Figure 58: Maximum hourly volume (MW) of wheels by path in June

		Sink							
Type	Source	PVWEST	MEAD230	WESTWING500	MCCULLOUG500	MDWP	MEAD2MSCHD	MIR2	RANCHOSECO
DALPT	CRAG	79							
DALPT	MALIN500	214	56	25					
DALPT	MDWP			15					
DALPT	MEAD230	8							
DALPT	NOB	123	26	15	90	50	25	25	
DALPT	PVWEST				50				
DAPT	CFEROA		1						
DAPT	MALIN500	100	200		100				
DAPT	MIR2								30
DAPT	NOB							25	

Although wheels do not add or subtract capacity to the overall power balance of the CAISO market, they compete for limited scheduling and transmission capacity. With self-schedule wheels having higher priority than stand-alone imports or exports, wheels can clear before other imports on paths with limited capacity available.

Wheels cleared in the day-ahead market can be carried over into the real-time market with a day-ahead priority or be directly self-scheduled in HASP process. Figure 59 shows the volume of wheels cleared eventually in the real-time market, organized by the various types of priority and relative changes.

Figure 59: Wheels cleared in real-time market



The *TOR* groups represent the wheels with priority of transmission rights. These groups include those wheels that explicitly bid as wheels in either day-ahead. The majority of TOR wheels scheduled in the day-ahead market carried over to real-time.

The *DAM_*PT is for wheels with high priority that cleared in the day-ahead market and they rebid into real-time. RT_PT is high priority that came in directly into real-time market. DAM_LPT is for wheels with low priority cleared in day-ahead and rebid into real-time. Similarly. RT_LPT is for wheels bid in directly into real time. Econ is for economical wheels (which there was none in June).

10 Demand Response

The CAISO markets consider demand response programs designed to reduce demand based on system needs, and trigger demand response programs through market dispatches. In the CAISO's markets, there are two main programs for demand response: economic (proxy) and emergency demand response. These programs use supply-type resources that can be dispatched similar to conventional generating resources.

Figure 61 shows the dispatch for proxy demand resources (PDR) in both the day-ahead and real-time markets. PDRs are dispatched economically in either market based on their bid-in prices. During the month of June, PDR resources were consistently dispatched in both the day-ahead and real-time markets. The largest volume of PDR dispatches in real-time occurred on June 14 at about 266 MW.

Figure 60: PDR Dispatches in day-ahead and real-time markets in June

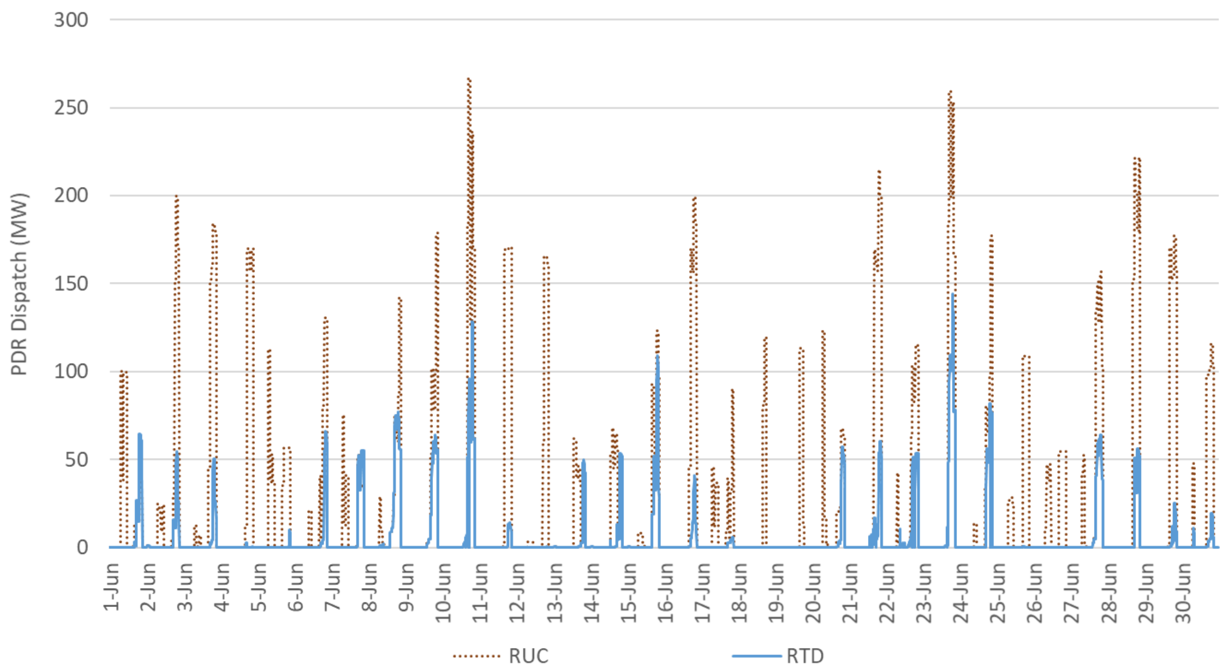
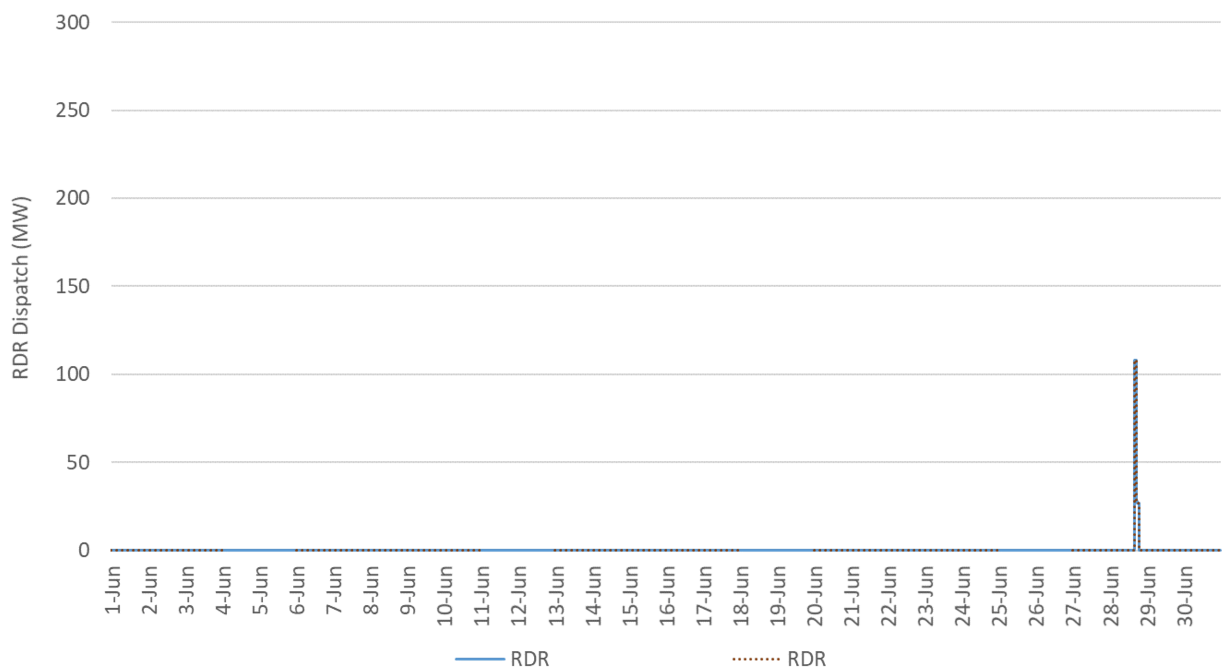


Figure 61 shows the dispatches for reliability demand response resources (RDRRs) in both the day-ahead and real-time markets. In the day-ahead market, these types of resources can be dispatched based on economics. The real-time market will consider these DAM dispatches as self-schedules. Therefore, these RDRRs will be dispatched in the real-time market even when there is no energy emergency declaration. Although most RDRRs are only deployed in the real-time when the CAISO has declared at least a CAISO Warning, some RDRRs may bid-in economically into the CAISO day-ahead market. In that case, any cleared RDRRs will come into the real-time market as a self-schedule and be dispatched generally at the same level of the day-ahead market award. RDRRs were dispatched in the real-time market only on June 28 up to 108 MW.

Figure 61: RDRR dispatches in day-ahead and real-time markets for June



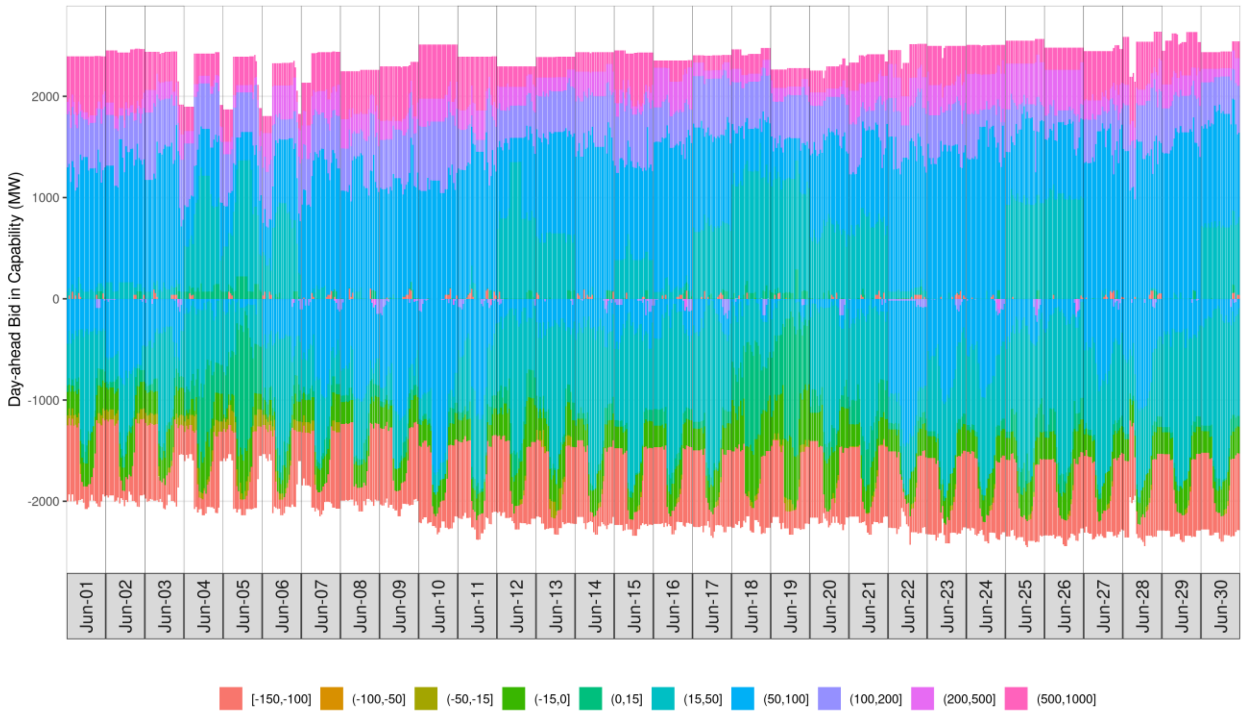
At the time this report was prepared, there were no estimates yet of the demand response performance. Estimates become available about two months after the trade date based on settlement data submitted by the scheduling coordinators and are used to measure the performance of demand response resources relative to a baseline. The CAISO will report on their performance when the data becomes available.

11 Storage Resources

The CAISO's markets use the Non-Generating Resource (NGR) model to accommodate energy constrained storage resources that can consume and produce energy. The NGR model allows storage resources to participate in the regulation market only, or participate in both energy and ancillary service markets. In June 2022, there were 49 storage resources actively participating in the CAISO markets. All storage resources participated in both the energy and ancillary service market. Storage resources can arbitrage the energy price by consuming energy (storing charge) when prices are low, then subsequently delivering energy (discharging) during market intervals with high prices. Each storage resource has a maximum storage capability that reflects the physical ability of the resource to store energy.

The total storage from all the active resources participating in the market was 10,899 MWh. In terms of the capacity made available to the markets, Figure 62 shows the bid-in capacity for storage resources in the day-ahead market.

Figure 62: Bid-in capacity for batteries in the day-ahead market



The negative area represents charging while the positive area represents discharging. On June 4th to June 7th, the overall capacity was reduced by up to 567MW for 6 to 8 hours due to outages. The bid-in capacity is organized by \$/MWh price ranges. There were consistent patterns of batteries bidding to charge at negative prices, and to discharge only at prices above \$200/MWh. There was a fair amount of capacity willing to charge when prices were lower than \$50/MWh. Conversely, they were always willing to discharge at higher prices. The bright pink shows bids close to or at the bid cap and shows that there was certain volume of storage capacity that is expecting to discharge only at these high prices. Figure 63 shows the bid-in capacity for the real-time market. The majority of bids were \$50/MWh or above on the discharging side, and \$50/MWh or below on the charging side. In the late morning to early afternoon hours before the evening peak, batteries were willing to charge even at prices higher than \$50/MWh.

Figure 63: Bid-in capacity for batteries in the real-time market

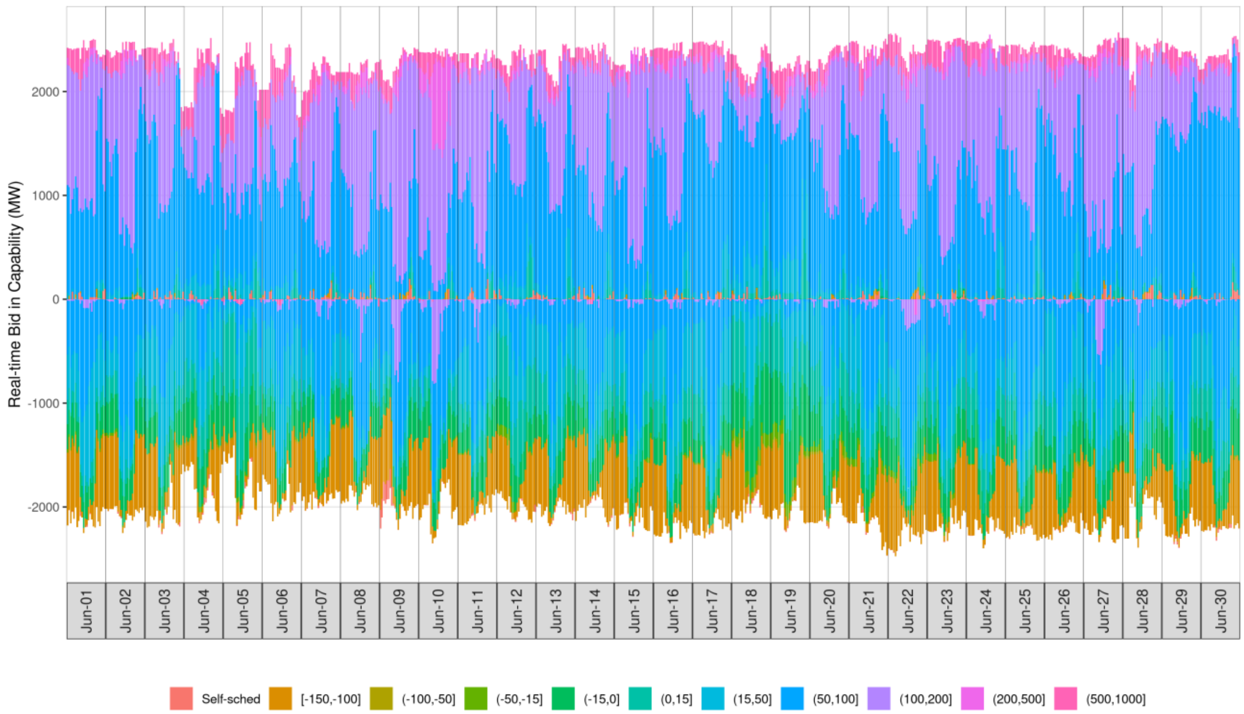


Figure 64 IFM distribution of state of charge for June 2022

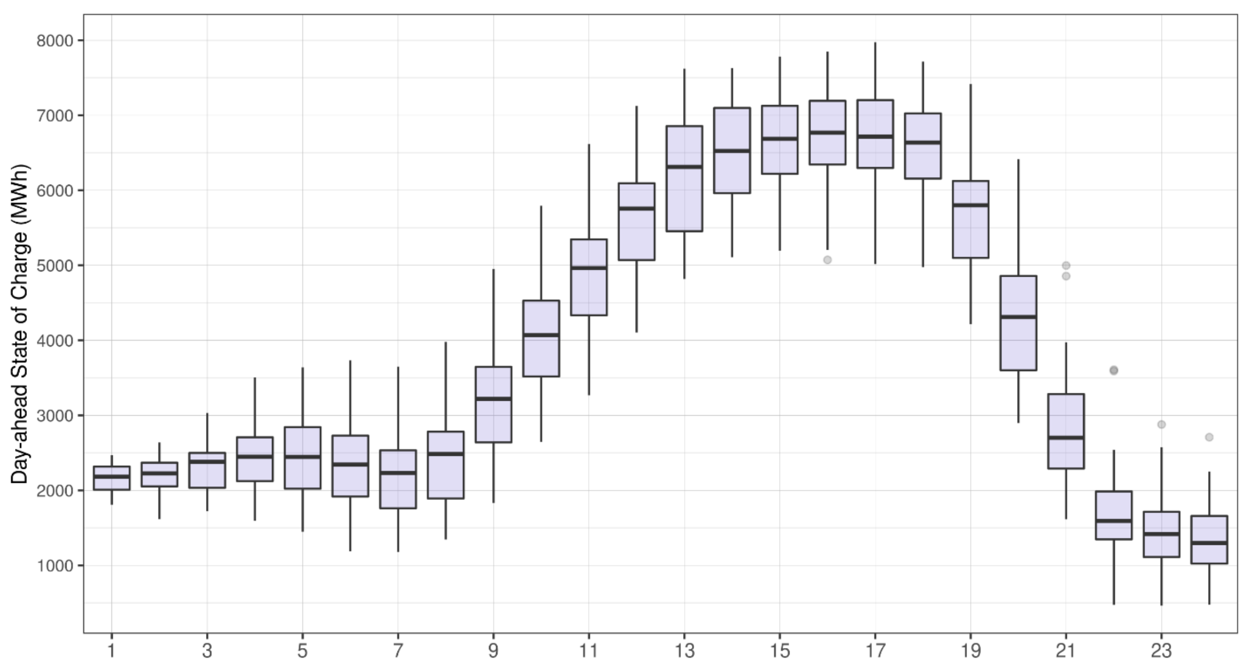
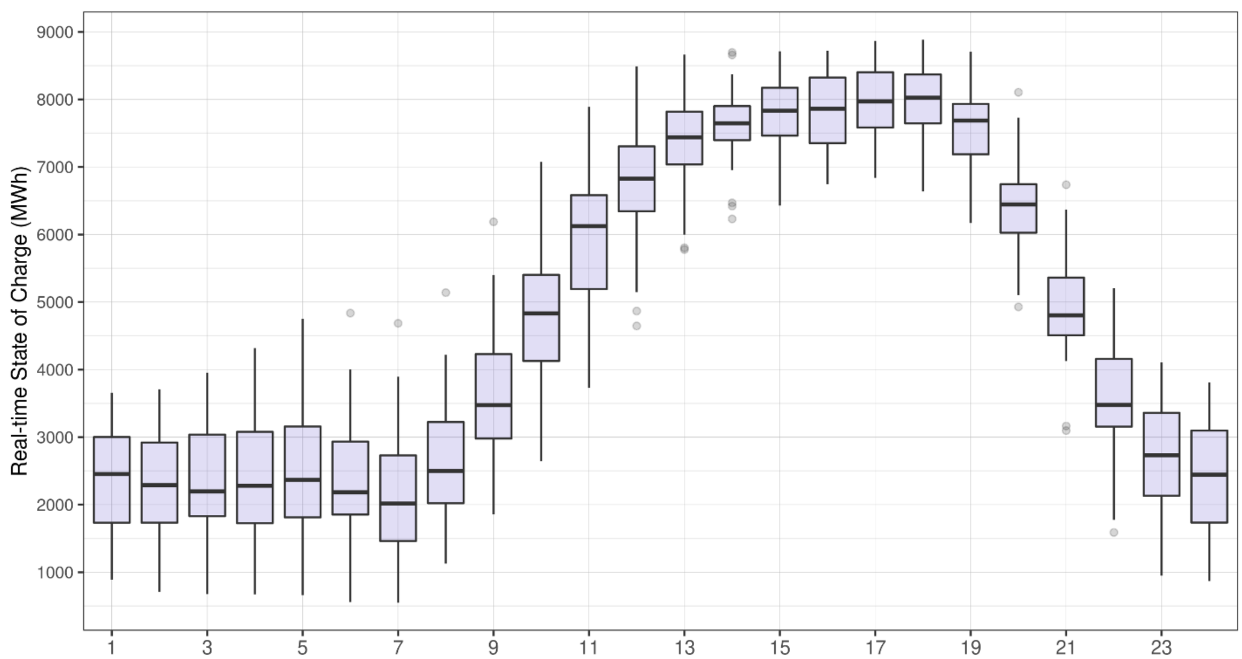


Figure 64 shows the hourly distribution of the storage capacity of resources participating in IFM for June 2022. The box plot shows the median, 25th percentile, 75th percentile, and outliers for the total state of charge in IFM. Storage resources charge in hours when there is abundantly cheap energy from solar resources in the daytime, between hour ending 8 and 17. The system reached maximum stored energy by hour ending 17, followed by a period of steady discharge from hours ending 18 through 24. In June, the highest median system state of charge was 6,768 MWh, which occurred in the hour ending 16.

Figure 66 shows the distribution of state of charge for the real-time market for June 2022. The peak hourly state of charge in the real-time market was slightly higher than the day-ahead peak state of change.

Figure 65 Real-Time Market distribution of state of charge for June 2022



Most of the storage resources in the CAISO market are four-hour batteries, which implies that if a resource is fully charged, it will take four hours to discharge this resource completely. To arbitrage prices, it is expected that the resource would be charged to full capacity just prior to the hours with high energy prices. With the need for more supply as solar production diminishes, it is expected that storage resources would be discharging during net load peak hours. Figure 71 shows the average hourly system marginal energy component (SMEC) of the locational marginal price in IFM for June 2022. Figure 72 shows the distributions of energy awards in IFM, and Figure 73 shows the distributions of energy awards in real-time. Figure 72 and 73 highlight hours ending 18 through 22 in a different color than the other hours, to show that the storage resources are being discharged in intervals with the highest energy prices.

Figure 71: IFM hourly average system marginal energy price in June 2022

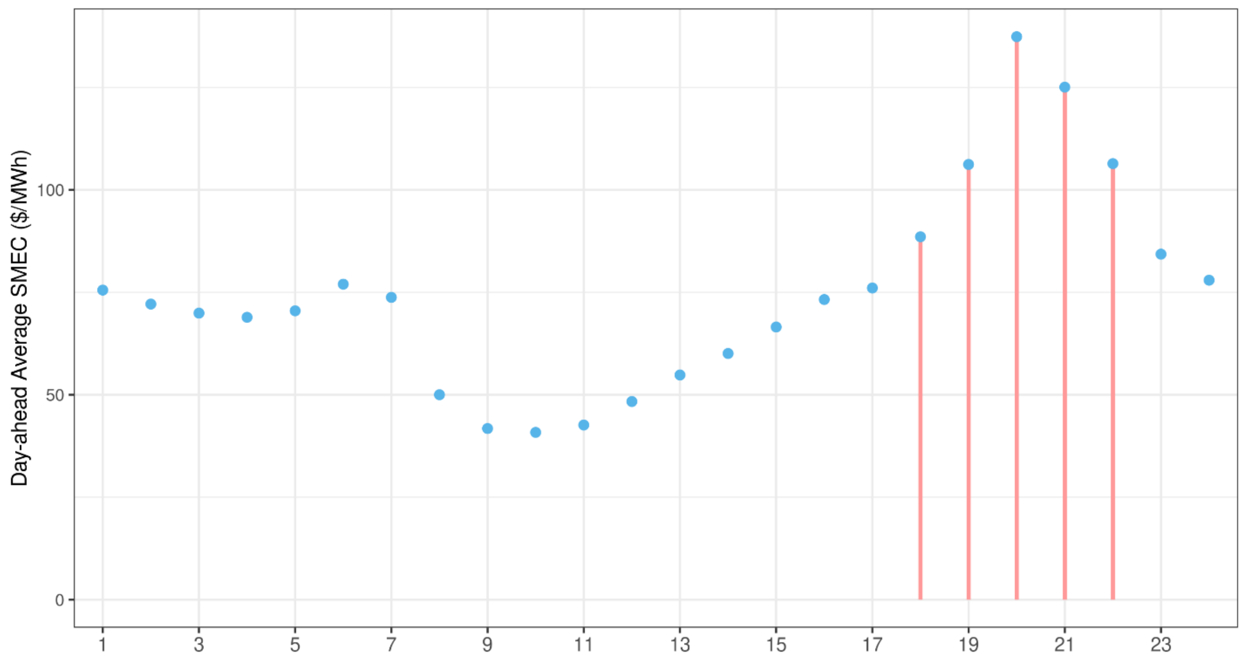


Figure 72: Hourly distribution of IFM energy awards for batteries in June 2022

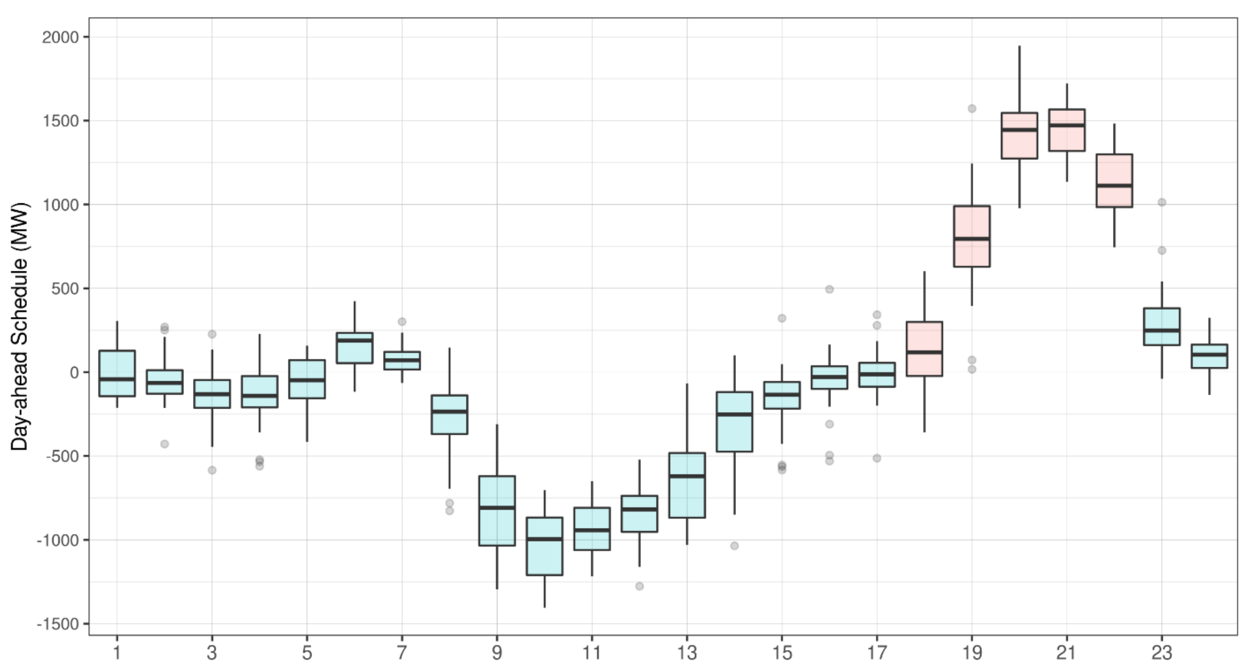


Figure 73: Hourly Distribution of real-time dispatch for batteries in June 2022

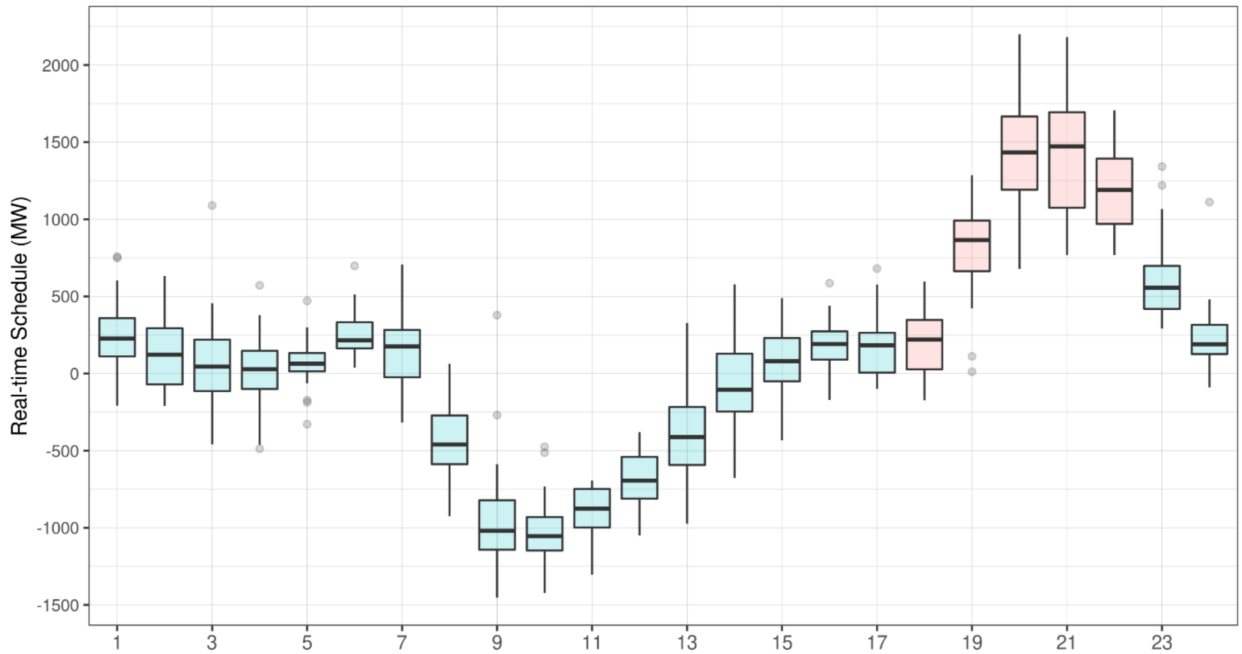
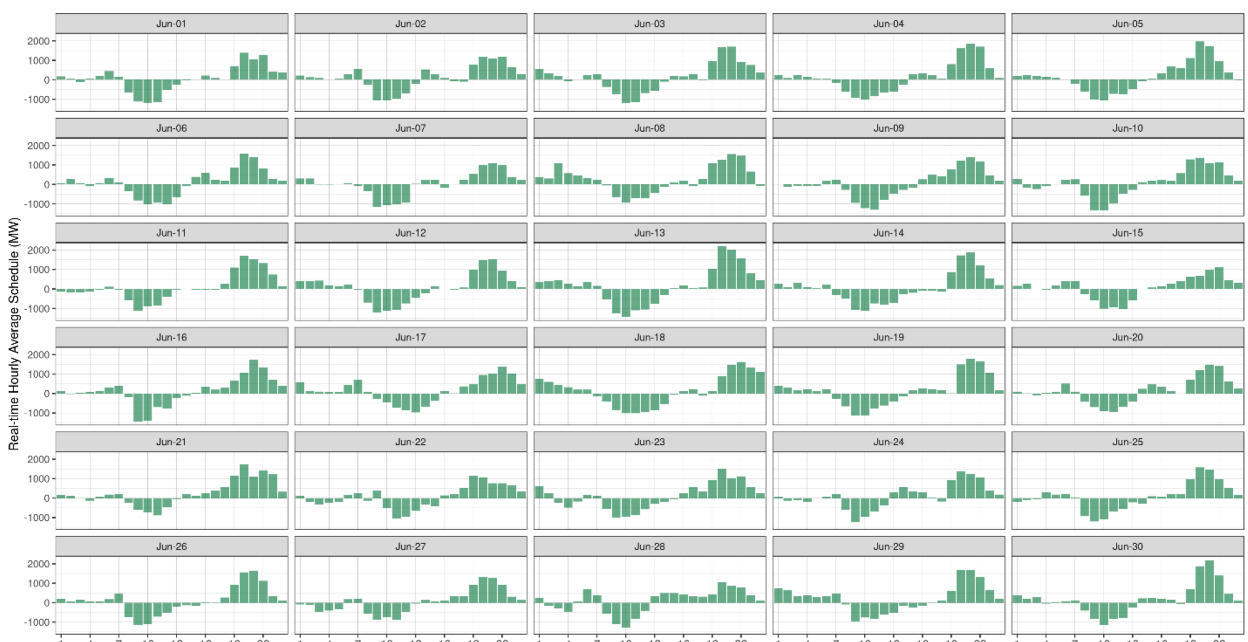


Figure 66 Hourly average real-time dispatch in June 2022



12 Energy Imbalance Market

12.1 EIM transfers

The Energy Imbalance Market, or EIM, provides an opportunity for participating balancing authority areas to serve their load while realizing the benefits of increased resource diversity. The CAISO estimates EIM's gross economic benefits on a quarterly basis.[32] One main benefit of the EIM is the realized economic transfers among areas. These transfers are the realization of a least-cost dispatch by reducing more expensive generation in an area and replacing it with cheaper generation from other areas. In a given interval, one area may have an import transfer with another area while concurrently having an export transfer with another area. Figure 67 shows the distribution of five-minute EIM transfers for the CAISO area. A negative value represents an export from the CAISO area to other EIM areas. This trend shows that in June, the CAISO area had a predominant EIM import.

Figure 67: Daily distribution of EIM transfers for CAISO area

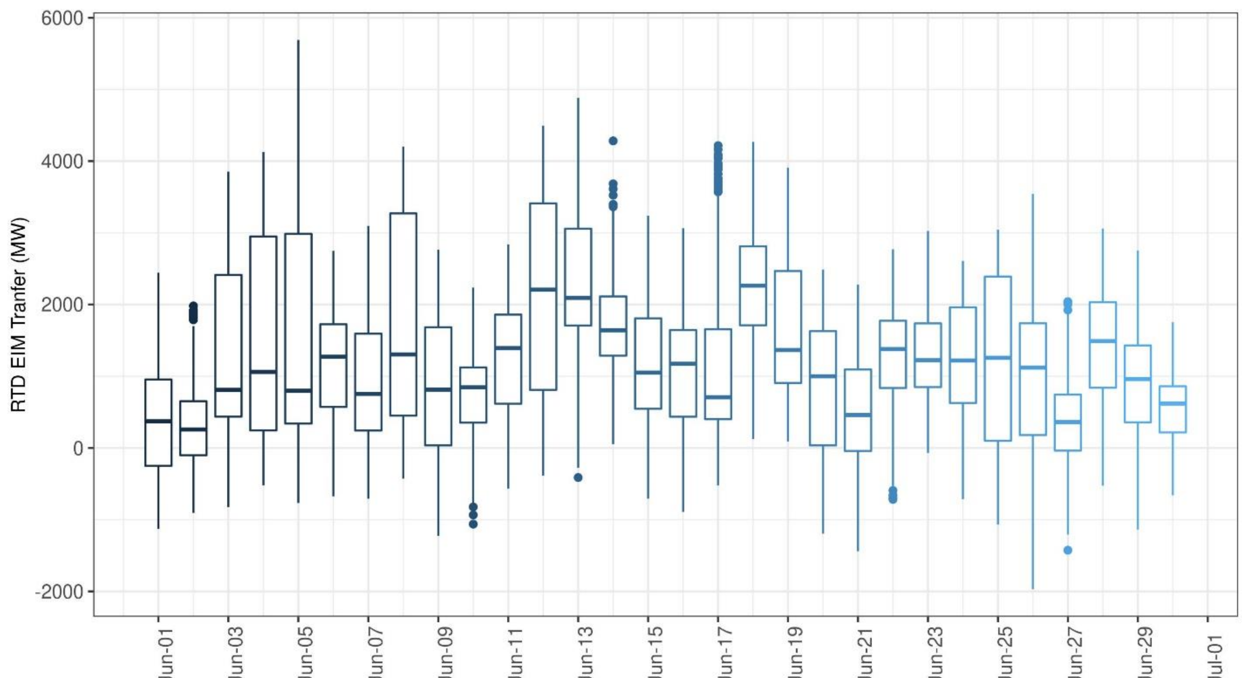
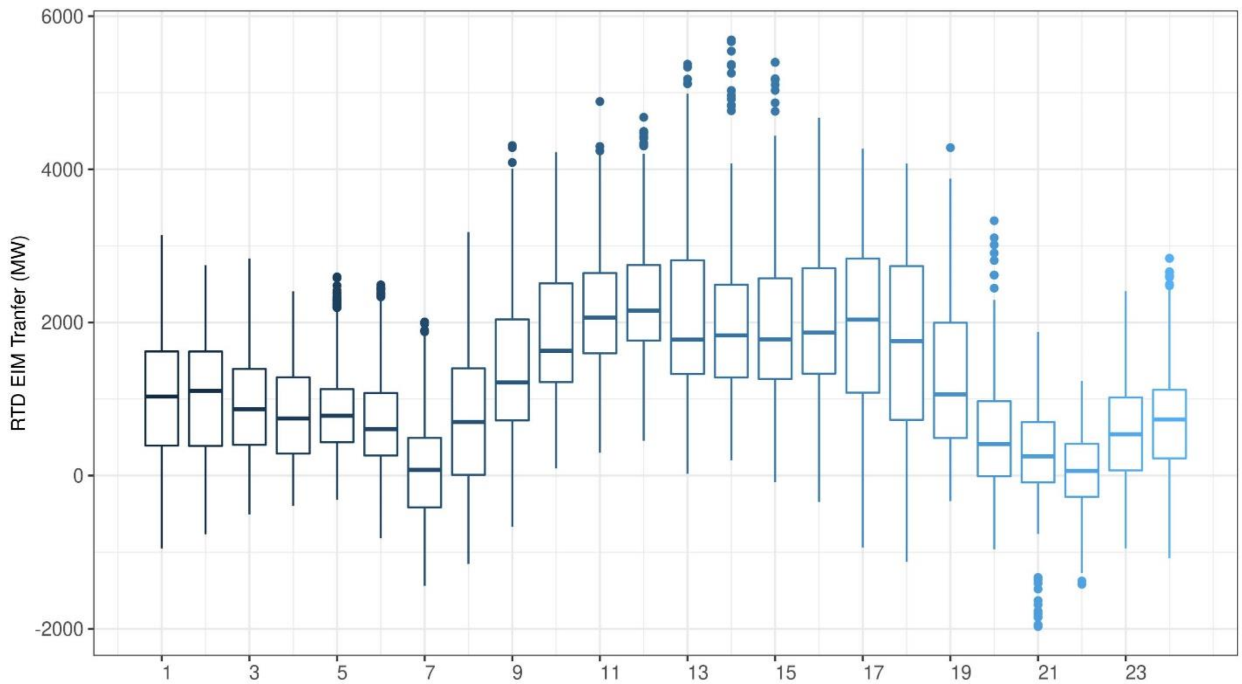


Figure 68 shows the EIM transfers in an hourly distribution, which highlights the typical profile of the CAISO transfers which are generally export transfers during periods of solar production. During the evening ramp as the evening peak approaches, the transfers become a net import to the CAISO area. This trend is typical across summer months.

Figure 68: Hourly distribution of 5-minute EIM transfers for CAISO area

[32] The EIM quarterly reports are available at https://www.westerneim.com/pages/default.aspx

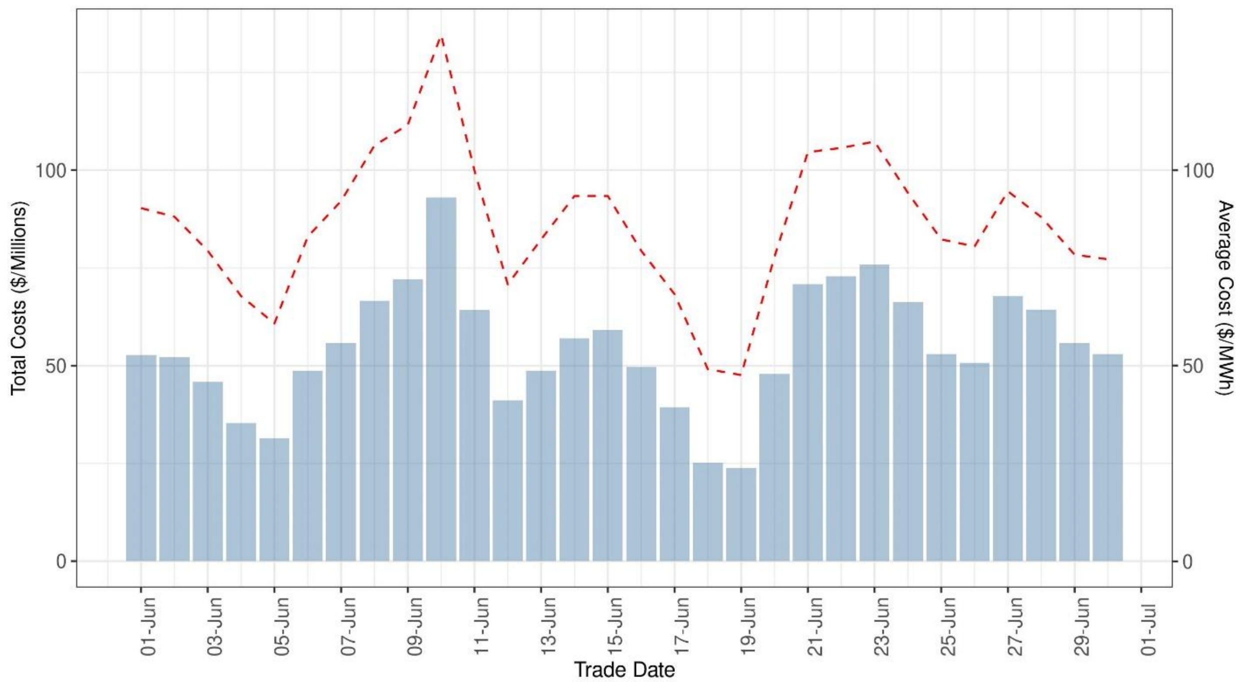


13 Market Costs

The CAISO markets are settled based on awards and prices derived from the markets through specific settlement charge codes; these include day-ahead and real-time energy, and ancillary services, among others. The majority of the overall costs accrue on the day-ahead settlements.

Figure 70 shows the daily overall settlements costs for the CAISO balancing area; this does not include EIM settlements. As demand and prices rise, the overall settlements are is expected to increase. This trend shows the increase in the overall costs during June during the mid-month heat wave, reaching a maximum daily value of about $93 million on June 10. When considering the overall costs relative to the volume of demand transacted, the dotted red line provides a reference of an average cost per MWh.

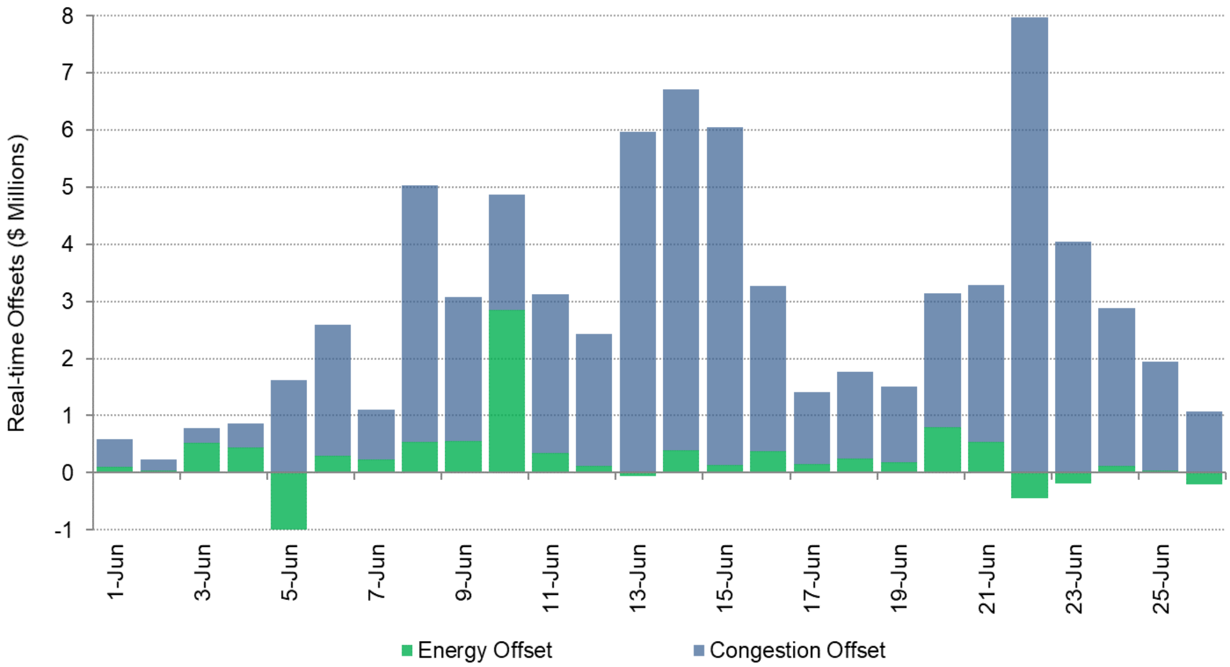
Figure 69: CAISO's market costs in summer months of 2022



The average daily cost in June was $54.66 million (or an average daily price of $86.29/MWh).

Two components of this overall cost are the real-time energy and congestion offsets. These costs reflect the settlements of differences between the day ahead and real-time markets for energy and congestion. These costs typically track system conditions. The congestion offset was about 90 percent of the overall real-time offset totaling about 68 million, which was driven by the significant volume of congestion observed in June. The daily trend is shown in

Figure 70: Real-time energy and congestion offsets in June



14 Minimum-State-of-Charge Constraint

The minimum State-Of-Charge (SOC) requirement is a new tool to ensure that Limited Energy Storage (LES) resources with RA capacity obligations maintain sufficient SOC to provide energy during tight system conditions. This requirement was implemented as part of the market enhancements for the summer readiness 2021 stakeholder initiative and has a two-year sunset provision.

The minimum SOC constraint is only applied on days when system needs are critical. The constraint is activated when there are one or more hours with under-gen infeasibilities in RUC, which occurs infrequently but indicates tight system conditions. When activated, the constraint ensures that all LES resources with an RA obligation maintain sufficient SOC to cover energy schedules cleared in RUC over a set of critical hours. These critical hours are defined by the operators prior to running RUC, and remain consistent from RUC into the real-time markets.

The goal of the constraint is to ensure that each LES resource with an RA obligation will have enough SOC to meet its positive RUC schedules in the real-time markets in each critical hour. This means each resource needs to have enough SOC at the beginning of each critical hour to meet the RUC schedules in that hour plus all future critical hours, taking into account the resource’s charging efficiency and operating limits. The minimum SOC constraint is defined as an end-of-hour constraint. In practice, this often means the minimum SOC will build up in the hours preceding the critical hours, and peak at the sum of the positive RUC schedules in the hour preceding the start of the critical hours.

Since there were no RUC undersupply infeasibilities in June, the MOSC constraint was not enforced in June.

15 Scarcity Pricing Enhancements

When the CAISO meets its real-time demand requirement with generation it has originally reserved to meet its contingency reserve requirement, the market may produce lower energy price at a time when it should be signaling very tight supply conditions with high prices. When the CAISO is in a Stage 2 Energy Emergency, it is allowed to use generators providing contingency reserves to serve demand and meet its contingency reserve requirement by arming load. CAISO generally enters into Stage 2 Energy Emergency with the intent to begin “arming load” to meet reserve requirements. “Arming load” is a process where the CAISO system operators inform load-serving entities to make all preparations necessary to be able to drop load in a controlled manner. With the summer enhancement implemented on June 15, when arming load to meet contingency reserve requirements, the CAISO will release both the contingency and non-contingency operating reserves at the bid cap price. This will set prices at the offer cap when there is insufficient generation supply to meet both energy and contingency reserve requirements and the released operating reserves are dispatched for energy.

There were no energy emergencies for the month of June and consequently the scarcity pricing logic did not trigger in June.

16 Market Issues

Through the analysis of the market outcomes and performance, there was one market issue related to summer readiness conditions identified during the month of June 2022:

1. Approved high priority wheels lost their priority in the bidding process.
   Under certain scenarios, some approved high priority exports lost their priority incorrectly during the bid submission process, defaulting to lower priority. This issue was related to a software defect which was corrected on July 13, 2022.