California ISO | WESTERN ENERGY MARKETS

Memorandum

To: ISO Board of Governors and Western Energy Markets Governing Body

From: Eric Hildebrandt, Executive Director, Market Monitoring

Date: July 15, 2025

Re: **Department of Market Monitoring report**

This memorandum does not require ISO Board of Governors or WEM Governing Body action.

EXECUTIVE SUMMARY

This memo summarizes a report on battery storage resources in the California ISO and Western Energy Imbalance Market (WEIM) in 2024, recently released by the Department of Market Monitoring (DMM).[1] Highlights in the report include the following:

- Battery capacity in the ISO balancing area grew from 500 MW in 2020 to over 13,000 MW. During the peak net load hours, batteries provided about 9 percent of the ISO area's energy in 2024. Battery charging represented about 15 percent of ISO area load during mid-day hours, which helped reduce the need to curtail or export surplus solar energy at very low prices.
- Batteries are also beginning a period of rapid expansion in other WEIM areas outside of the ISO balancing area. Battery capacity in these WEIM areas has nearly doubled from 2,600 MW in 2023 to 5,000 MW in 2024.
- In the next few years, new battery capacity outside of California is projected to be more than double new battery capacity in California. By 2028, 8,200 MW of battery capacity is scheduled to come on-line in California, while over 19,000 MW is projected to come on-line in other WEIM states.[2] Much of the battery capacity in other WEIM states is being installed to meet the renewable energy requirements of load serving entities in California.
- Net market revenue for batteries in the ISO area dropped from $78/kW-yr in 2023 to $53/kW-yr in 2024, driven largely by lower loads and lower peak energy prices.
- Most battery capacity used to meet ISO balancing area resource adequacy requirements is available under the most critical hours, but DMM continues to find

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[1] *2024 Special Report on Battery Storage*, Department of Market Monitoring, May 29, 2025: https://www.caiso.com/documents/2024-special-report-on-battery-storage-may-29-2025.pdf

[2] *Preliminary Monthly Electric Generator Inventory (based on Form EIA-860M as a supplement to Form EIA-860)*, U.S. Energy Information Administration, March 2025.

that some capacity is unavailable due to insufficient state-of-charge, and other resource and modeling limitations.

- DMM recommends that the ISO place a high priority on changing current bid cost recovery rules for batteries, which significantly decrease the incentive for batteries to bid in a manner that ensures their capacity is usually fully available during the most critical net load hours.
- Market power mitigation currently has minimal impact on the dispatch of batteries. However, enhancements should be made to ensure that bid mitigation effectively mitigates locational market power, but does not prevent most batteries from being fully charged during critical net load hours. Most importantly, default energy bids for batteries should vary during different hours of the day to reflect how the opportunity cost of discharging differs over the course of each day.
- DMM recommends that the ISO establish a standard option for setting default energy bids for batteries in WEIM similar to the opportunity cost option used for batteries in the ISO balancing area. This would simply require use of different regional electric and gas market prices, combined with the enhancements recommended for default energy bids for resources in the ISO balancing area.

REPORT HIGHLIGHTS

Battery capacity in the ISO balancing area has grown dramatically from 500 MW in 2020 to over 13,000 MW in 2024. As shown in Figure 1, stand-alone batteries and co-located batteries each comprise 44 percent of this capacity. The remaining 12 percent is comprised of hybrid and hybrid/co-located batteries.

Battery capacity in other WEIM areas has nearly doubled from 2,600 MW in 2023 to 5,000 MW in 2024. As shown in Figure 2, most battery capacity in other WEIM areas is located in the Desert Southwest. Much of the battery capacity outside of California is being installed to meet the renewable energy requirements of load serving entities in California.

Figure 3 compares DMM's calculation of currently installed battery capacity in Western states based on ISO data, to data from the Energy Information Agency (EIA) on installed and planned battery capacity in different Western states. As shown in Figure 3, EIA data are very consistent with DMM's calculations of currently installed capacity.

Figure 4 shows a breakdown of EIA's projection of future battery capacity in each state by 2028. Based on these EIA data, about 30 percent of new battery capacity in Western states over the next four years will be located in California, about 25 percent will be in Arizona, 12 percent will be in Oregon, and about 10 percent in Nevada. Most of this planned capacity is projected to be completed by 2027 or 2028.

Figure 1. Active battery capacity in CAISO balancing area (2019–2024)

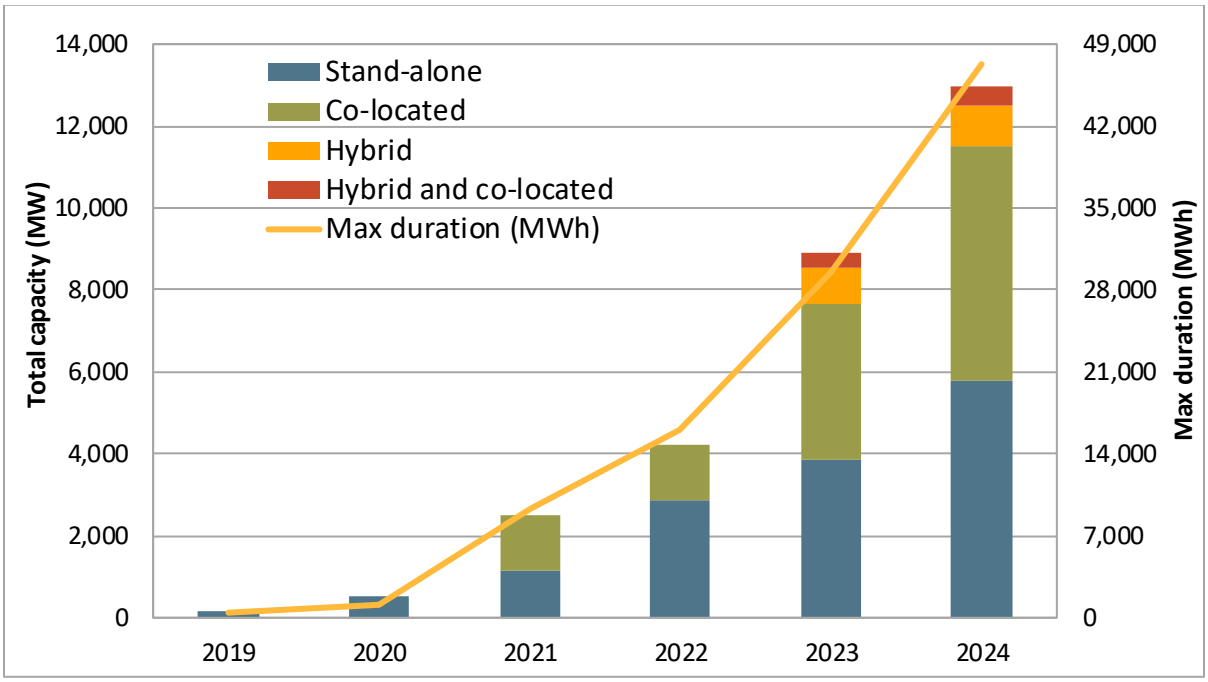


Figure 2. Active battery capacity by WEIM balancing area (2024)

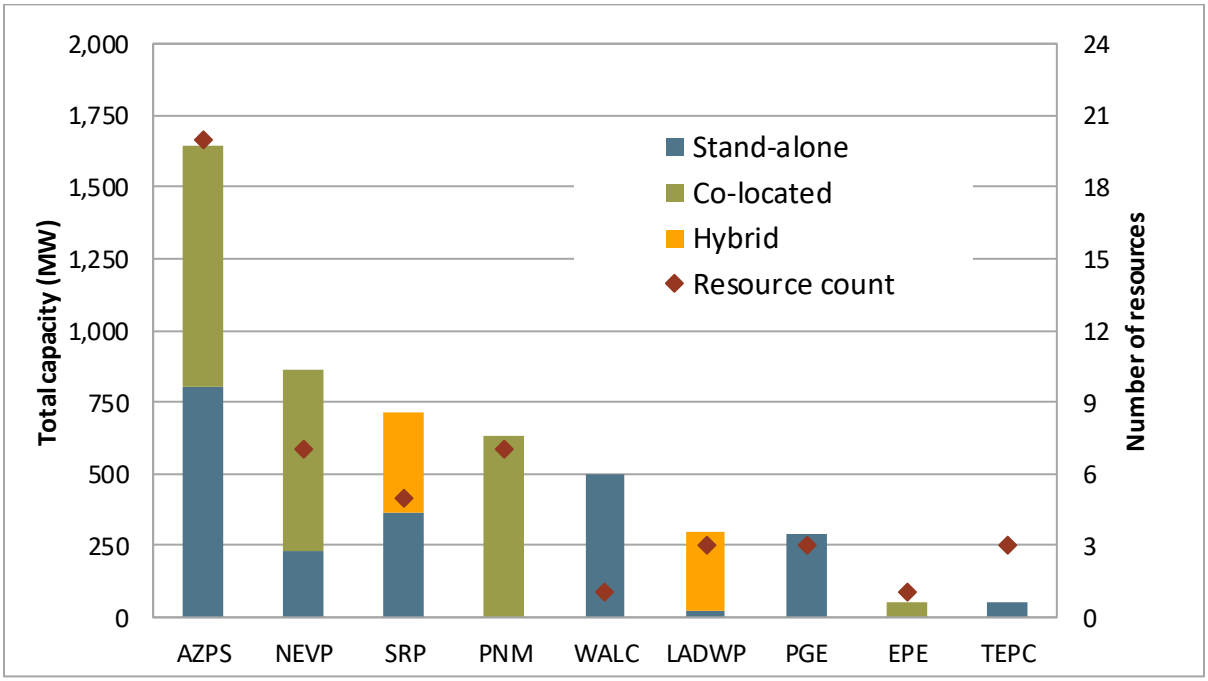


Figure 3. Installed and planned battery capacity in Western states as reported by Energy Information Agency

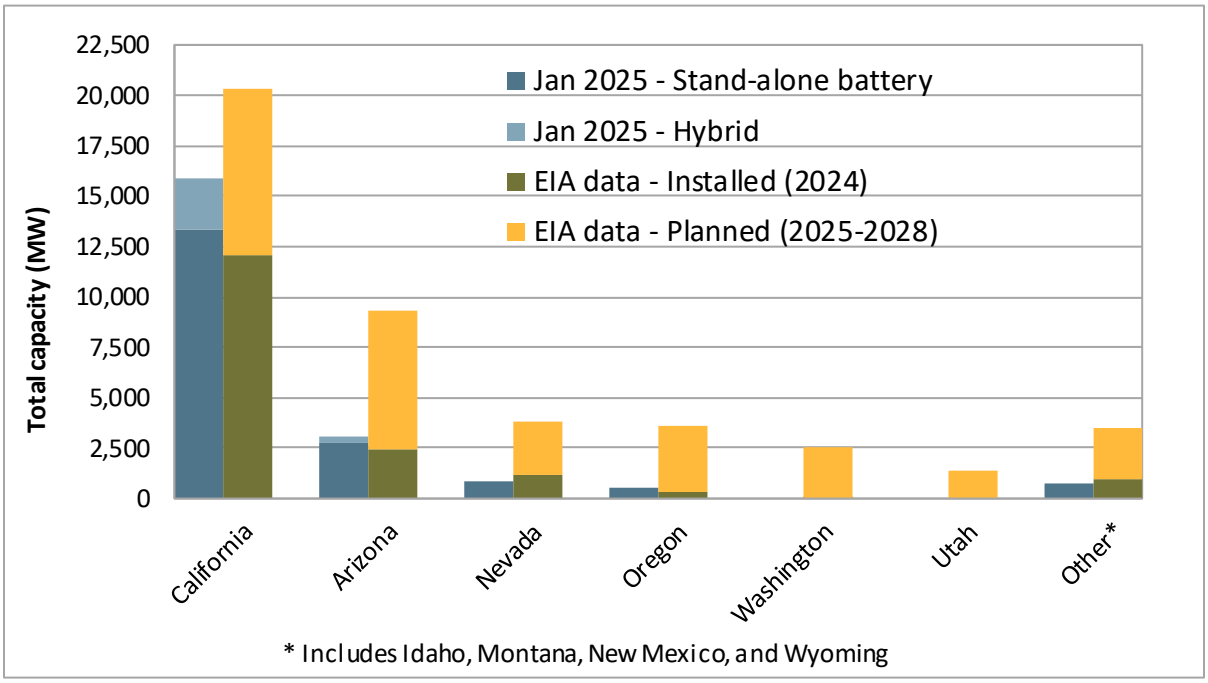
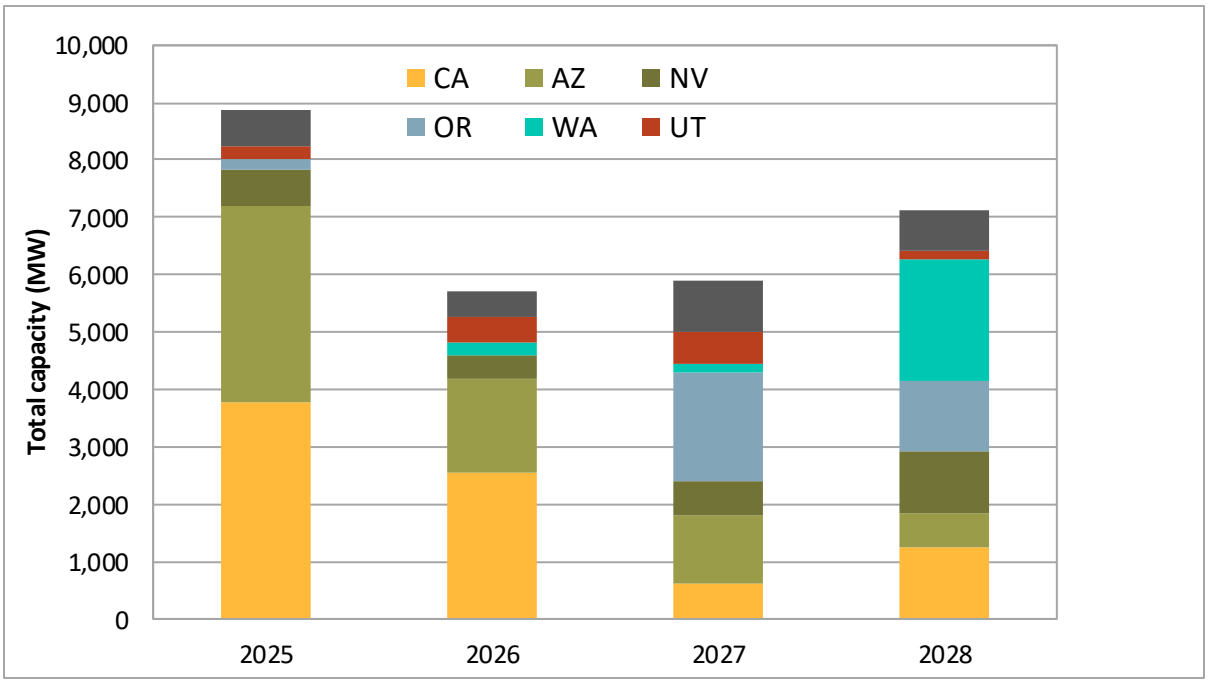


Figure 4. Planned battery capacity in Western states (by 2028) as reported by Energy Information Agency



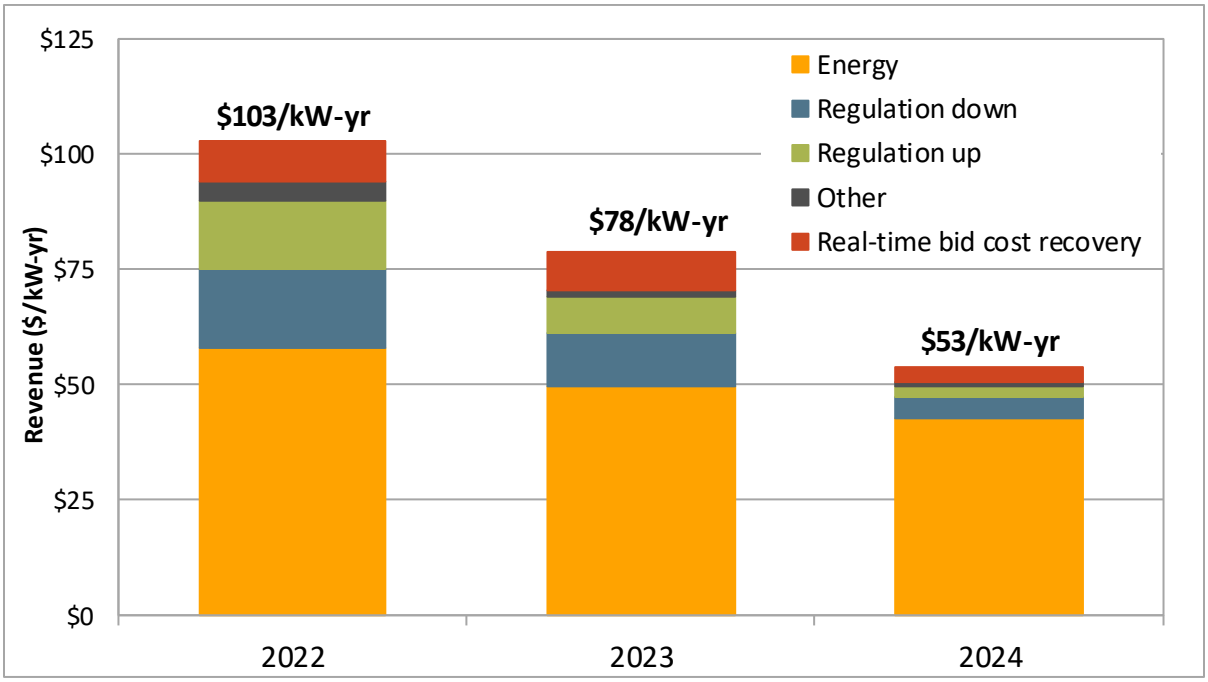
Bid cost recovery

As shown in Figure 5, revenue for batteries in the ISO market dropped from $78/kW-yr in 2023 to $53/kW-yr in 2024, continuing a trend in lower net market revenues. This drop is driven largely by lower peak energy prices. In addition, as the amount of battery capacity has increased, revenues from ancillary services have continued to drop significantly.

Batteries in the ISO area received $18 million of real-time bid cost recovery payments in 2024, which accounts for 11 percent of total bid cost recovery payments and 4 percent of batteries' total net market revenues. While bid cost recovery payments for batteries have not increased, DMM recommends that the ISO modify bid cost recovery rules for batteries.

Current rules significantly decrease the incentive for batteries to bid in a manner that ensures their capacity is usually fully available during the most critical peak net load hours.[3] In addition to increasing bid cost recovery payments and related gaming opportunities, this can result in batteries being discharged prior to the peak net load hours, when battery capacity is needed most.

Figure 5. Average revenue for batteries with a full year of operation



[3] *Opinion on Storage Bid Cost Recovery*, James Bushnell, Scott M. Harvey, Benjamin F. Hobbs; Members of the Market Surveillance Committee, November 1, 2024: https://www.caiso.com/documents/market-surveillance-committee-final-opinion-storage-bid-cost-recovery-nov-01-2024.pdf

Availability of battery capacity

DMM's report provides a detailed assessment of the availability of batteries providing resource adequacy capacity in 2024 during the most critical peak net load hours. Figure 6 shows this analysis for the resource adequacy battery fleet during each of the peak net load hours (17 to 22) on the five days with the highest average daily load in the ISO balancing area.[4] Figure 6 shows the average percentage of the total capacity of the battery fleet providing resource adequacy that falls into the following categories:

- The dark blue and light blue bars show the portion of battery capacity dispatched to provide energy and regulation up, respectively, during the peak net load hours on these five days.
- The dark green and light green bars show the portion of battery capacity scheduled to provide spinning and non-spinning reserves and upward flexible ramping capacity, respectively.
- The solid orange bars show the amount of undispatched energy bids offered at prices greater than the resources' locational marginal prices.[5] It is possible that some of this capacity also may not have been available due to state-of-charge and other constraints, but this cannot be determined.
- The solid yellow bars show the amount of undispatched energy bids offered at prices below the resources' locational marginal prices. Since this capacity was bid at prices below the market price but not dispatched, it still may have been unavailable due to some of the various resource constraints that can limit the actual availability of battery capacity described above.
- The striped yellow and orange portion of each bar shows the portion of the battery fleet unavailable due to a reported outage or de-rate.
- The dashed circle in Figure 6 highlights hours when this analysis indicates the availability of the battery fleet in real-time was significantly lower than the fleet's resource adequacy rating. This includes capacity on outage (striped bars) and energy bids offered at prices below the resources' locational marginal prices that were not dispatched (orange bars).

Key points shown in Figure 6 include the following:

- The bars for each hour in Figure 6 are higher than the dotted black line showing the total aggregate resource adequacy capacity from batteries. This reflects the fact that batteries tend to contract less than their maximum power capacity for resource adequacy, and can therefore theoretically provide more power than their resource adequacy value.

[4] In order from highest to lowest average load, the days are September 6, September 5, July 24, July 23, and July 25.

[5] This figure is most relevant as a metric for resource adequacy performance for units that are required to submit economic bids, e.g., units with flexible resource adequacy capacity.

- The average availability of battery capacity over these five days was quite high, with available capacity meeting the resource adequacy rating of the battery fleet during all hours except hour 22.
- During hour 22, an average of about 88 percent of the fleet's resource adequacy capacity was available after subtracting capacity that was on outage (striped bars) or was bid below the market price but was not dispatched (orange bars),

Figure 7 provides these same metrics for the resource adequacy battery fleet during the seven hours on July 24, when the ISO issued an Energy Emergency Alert Watch (EEA Watch) from hours-ending 18 through 24.[6] Key points shown in Figure 7 include the following:

- Real-time availability of battery resource adequacy capacity on July 24 appears to be very high during hours 18 to 21.
- As shown by the dashed circle in Figure 7, during hours 22 to 24 the availability of the battery fleet in real-time was significantly lower than the fleet's resource adequacy rating after subtracting capacity that was on outage (striped bars), not bid (top red bar), or was bid below the market price but was not dispatched (orange bars).
- During hours 22 to 24 on July 24, the amount of battery capacity available in real-time fell from about 75 percent to about 55 percent of the fleets resource adequacy rating.

These findings show that the overall availability of the battery fleet providing resource adequacy capacity was quite high during these high load days. However, the availability of batteries can drop significantly in the later peak net load hours—when batteries are critical for system reliability—due to insufficient state-of-charge.

[6] The ISO uses Emergency Energy Alerts with 4 levels of urgency, from EEA Watch to EEA 3, to communicate potential energy shortages to market participants: https://www.caiso.com/Documents/Emergency-Notifications-Fact-Sheet.pdf

Figure 6. Average 15-minute resource adequacy battery capacity during 5 highest load days of 2024

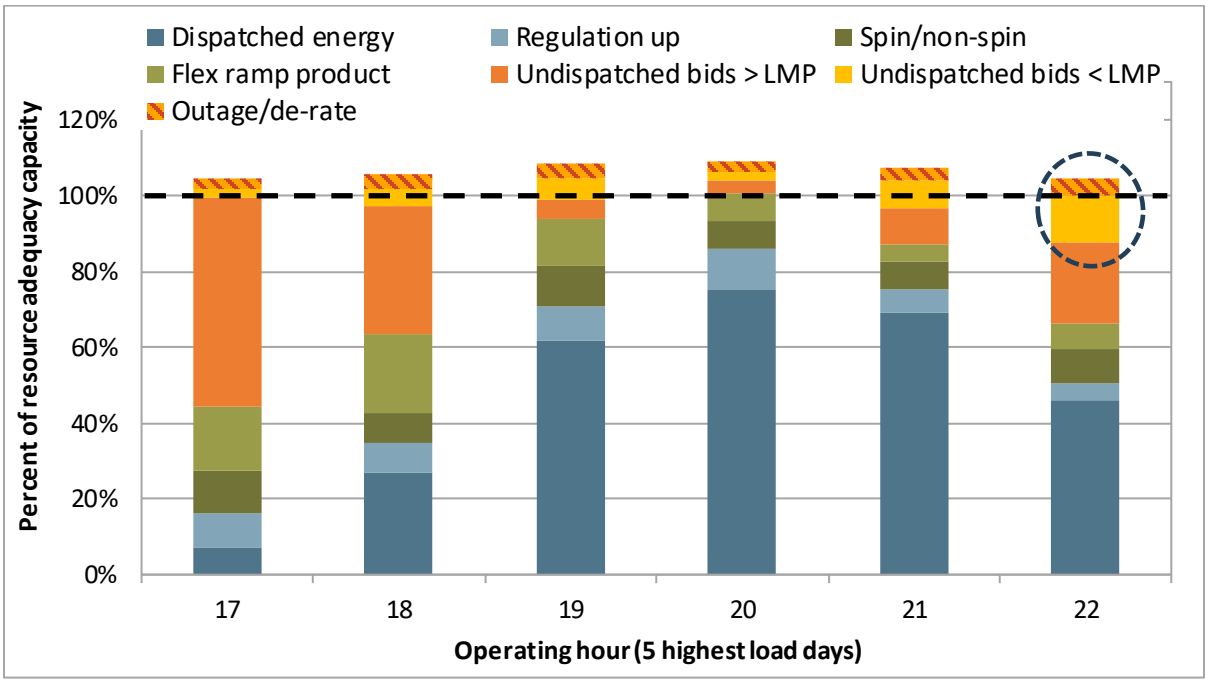
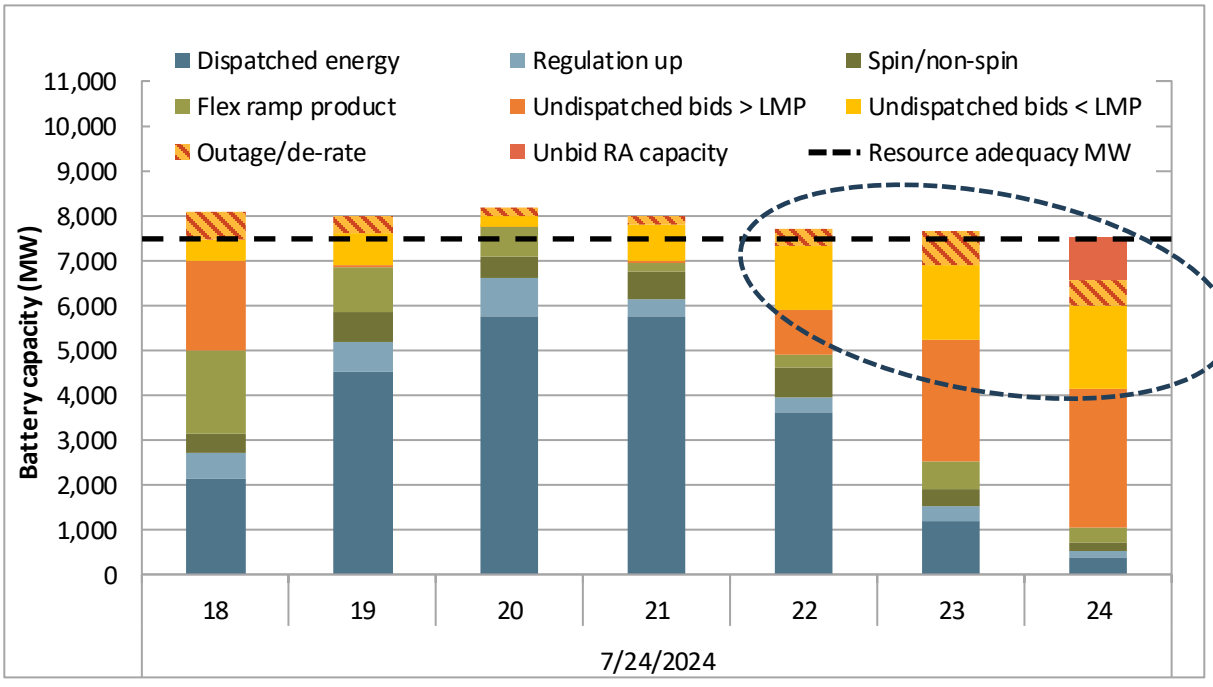


Figure 7. Resource adequacy capacity during EEA hours (July 24, 2024)



Market power mitigation

Analysis by DMM shows that market power mitigation procedures currently have minimal impact on the dispatch of batteries (see Figure 9). However, DMM continues to recommend that enhancements be made to ensure that bid mitigation effectively mitigates locational market power, but does not prevent most batteries from being fully charged during critical net load hours.

Most importantly, default energy bids for batteries should vary during different hours of the day to reflect how the opportunity cost of discharging differs over the course of each day. This could allow default energy bids to be set higher during the mid-day hours when the opportunity cost of discharging is higher and local market power is generally lower. This would also help ensure availability of battery capacity by avoiding any battery capacity from being unnecessarily dispatched prior to the peak net load hours due to mitigation.

DMM also recommends that the ISO establish a standard option for setting default energy bids for batteries in WEIM similar to the opportunity cost option used for batteries in the ISO balancing area. This would simply require use of different regional electric and gas market prices, combined with the enhancements recommended for default energy bids for resources in the ISO area.

Figure 9. Hourly average 15-minute market battery mitigation (2024)