CAISO Energy Storage Enhancements

LS Power Proposals

See full comments [here]

July 26, 2021

LS Power Recommendations

Ensure efficient and reliable dispatch, and represent marginal costs for NGRs

- Remove or limit multi-interval optimization (MIO) for storage
- Make spread bidding optional for storage
- Make storage whole for gross and opportunity costs of MIO

Adapt bid cost recovery (BCR) to work for energy storage

- Calculate BCR based on non-generator resource (NGR) bids, not thermal generator model

Mitigate effects of exceptional dispatch (ED)

- Align ED with day-ahead schedules
- Make NGRs whole for gross and opportunity costs of ED

Update the NGR model to capture variable charging rates

- Use real-time telemetry or operator-provided piecewise parameter to limit power as a function of state of charge

MIO and spread bidding create potential financial and reliability risk

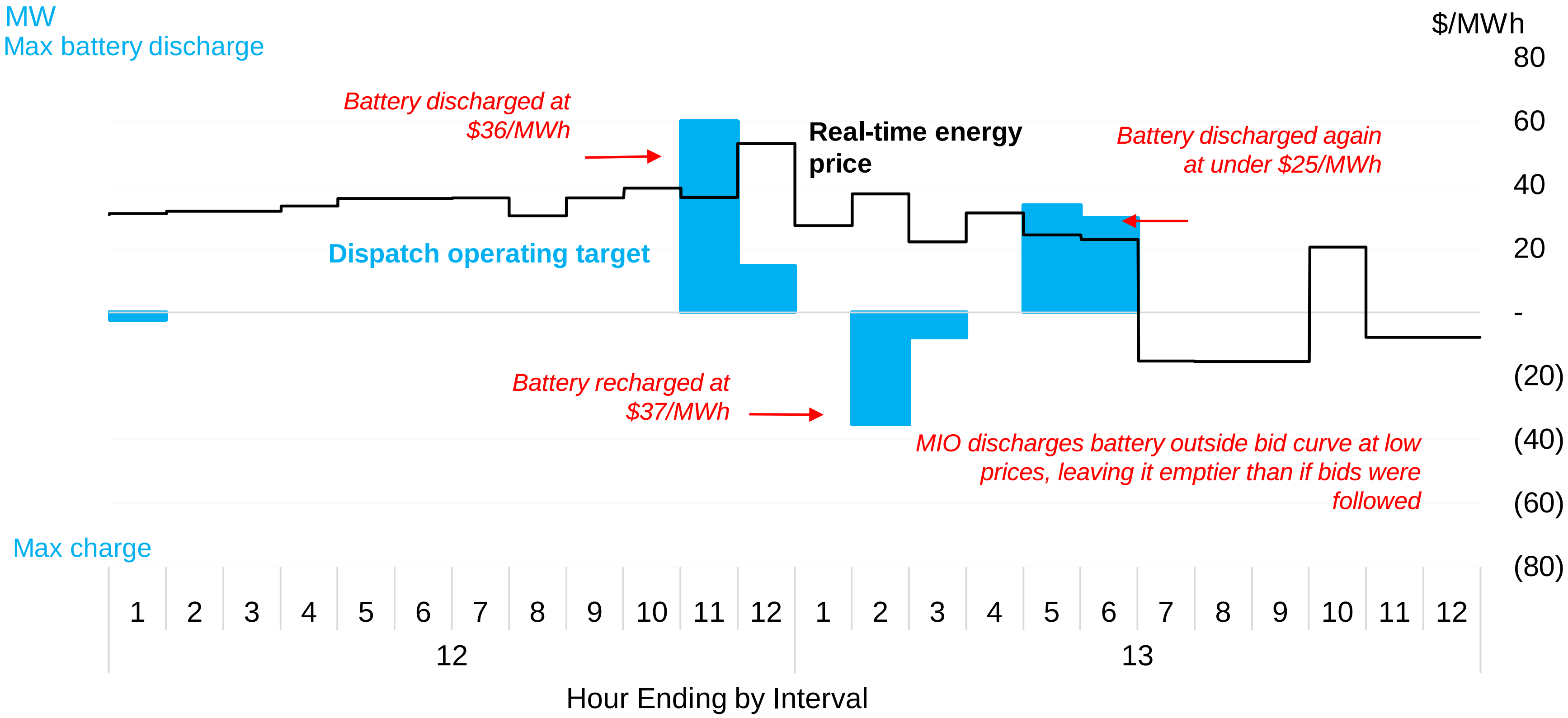
- **Storage resources are not strictly dispatched according to either their bids or to binding energy prices**.
  - Instead, real-time dispatch is optimized over a horizon of advisory prices through multi-interval optimization (MIO). When volatility is highest, bid curves are also converted to 'spread' curves based on the distance between bid prices.
- **Together, these mechanisms can produce undesirable dispatch that can lead to financial losses for resources and potential reliability risk for CAISO.** Specifically, we are concerned by:
  - **Resources discharged early, prior to evening peak** where bids would otherwise have preserved more charge and enabled delivery of day-ahead energy awards.
  - **Resources not discharged when energy is needed most**. We have seen resources held back at prices $100s/MWh above our bid curve because the system saw higher advisory prices ahead that never materialized.
  - **In tandem with the above scenarios, increased reliance on out-of-market measures** like exceptional dispatches, which are inefficient and undesirable to both resources and CAISO.

MIO and spread bidding create potential financial and reliability risk

Typical MIO example at an LS battery

Battery dispatch instructions and locational marginal prices

Note: first charge and discharge bid tiers at ~$50/MWh and ~$100/MWh



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Challenges of MIO

- **MIO can lock in losses at binding prices in anticipation of advisory prices that never materialize.**
  - Resources can be discharged to make room for projected price dips that never materialize, and held back or charged for projected price spikes that never occur.
- **MIO performs poorly when system supply conditions are tight**.
  - MIO relies on advisory prices which, based on dispatch results, appear to be least accurate during extreme volatility when reliable dispatch is most important.
- **Resources are physically dispatched on prices that are often inaccurate and entirely opaque**.
  - CAISO does not publish advisory prices used to optimize dispatch in MIO.
- **No bid cost recovery**.
  - There is currently no compensation for losses incurred due to MIO relative to if dispatch had been determined by bids and on binding interval prices.

Challenges of spread bidding

- **Spread bidding distorts resource bids into fungible spreads that disregard actual resource costs**.
  - A resource with bids to buy at prices under $50/MWh and sell at prices over $150/MWh has a $100/MWh bid spread.
  - If real-time prices then bounce between $500-600/MWh over the same period, spread bidding as we understand it would see the $500/MWh prices at the low end of that spread as opportunities to *charge*, when in reality they represent prices $350/MWh above where the resource wishes to *discharge*.
- **Spread bidding can create even more reliability and financial risk when resources carry day-ahead obligations**.
  - Consider the same example above, but where a resource has a day-ahead energy award sold at the day-ahead price of $200/MWh.
  - Every charge at $500/MWh resulting from spread bidding would not only incur the $500/MWh cost to charge but also result in a -$300/MWh loss from the undelivered day-ahead award ($200/MWh day-ahead award bought back at a $500/MWh real-time price).
- **Implementation of spread bidding is opaque.**
  - According to our understanding, spread bidding is a parameter that CAISO activates with no warning to market participants. Resource owners therefore don't know when CAISO will choose to use bids or convert them to spreads.

Improving NGR dispatch and cost representation

Recommendations

- **Dispatch storage resources on only binding interval prices**, or at least fewer intervals of advisory prices (e.g., 2 or 3 intervals). This would reduce ‘phantom’ arbitrage that locks resources into binding losses based on advisory prices that often do not materialize.
- **Allow resources to opt out of spread bidding.** Risks to resource operators and reliability are such that we would forgo any potential “spread” in order to preserve state of charge, accurately represent marginal costs, and ensure the resource is able to deliver on its obligations.
- **Provide bid cost recovery** where MIO and spread bidding produces losses relative to if submitted resource bids had been followed on binding prices.
- **Publish advisory prices and comprehensive documentation of spread bidding and MIO** so that resource owners can make more informed decisions.
- **LS Power agrees with CAISO that the extending real-time market lookout horizon is not a desirable solution, even if it were technically feasible.** Uncertainty and inaccuracy increase the further out advisory prices extend into the future.

Bid cost recovery should evolve for NGRs

Challenges of bid cost recovery (BCR) for NGRs

- **BCR currently compensates NGRs only for net revenue losses over an entire day**.
  - This prevents storage from being compensated unless ED and other dispatch outside of bids are large enough to wipe out the entirety of a day's net revenues.
- **BCR rules need to be rewritten in a way that accounts for the specific characteristics of storage**.
  - BCR works well for traditional generators that only have positive levels of output and whose operational costs have a different relationship to their bid curve, but does not work for NGRs that charge and discharge, and spend much of the day fully charged.
  - Examples:
    - **There is currently no compensation for opportunity costs when NGRs are exceptionally dispatched down**
      - For either the immediate interval of ED or for later effects that ripple throughout the day. There is no compensation other than the LMP or bid price when units are exceptionally dispatched up, with no BCR value placed on the ED use of scarce charge.
    - **BCR does not recognize that a full battery cannot charge**.
      - If a resource is always willing to charge at any price below $50/MWh, and in a given interval the LMP is $49/MWh but the resource is not able to charge because it is full, BCR treats the resource as though it made a profit of $49/MWh by not charging in that interval.

Bid cost recovery should evolve for NGRs

Recommendation

- **<u>Compensate resources based on settlements that would have resulted had resources been dispatched on actual bids and binding prices</u>**, ‘undoing’ any financial damage from MIO or exceptional dispatch or minimum state of charge requirement, inclusive of day-ahead, fifteen-minute, and real-time market runs and awards. This would make resources whole for both the immediate and ripple effects of issues like MIO and ED throughout the day.
- Alternatively, compensate resources based on the volumes and prices by which bids were violated in each interval.

Comments on Issue Paper Proposals

- Compensating storage only if there are net revenue losses over narrower (e.g., 8 hour) windows rather than a full day will work only for resources following the simplest day-ahead energy-only schedules, for the same reason that looking at net revenue losses over an entire 24-hour period fails to make storage whole now.
- Compensating storage based on if a ‘cycling spread’ has been met also forgoes the opportunity cost of net revenues had bids been followed. A cycle also becomes difficult to clearly define when resources are participating in real-time and ancillary service markets.

Mitigate effects of exceptional dispatch

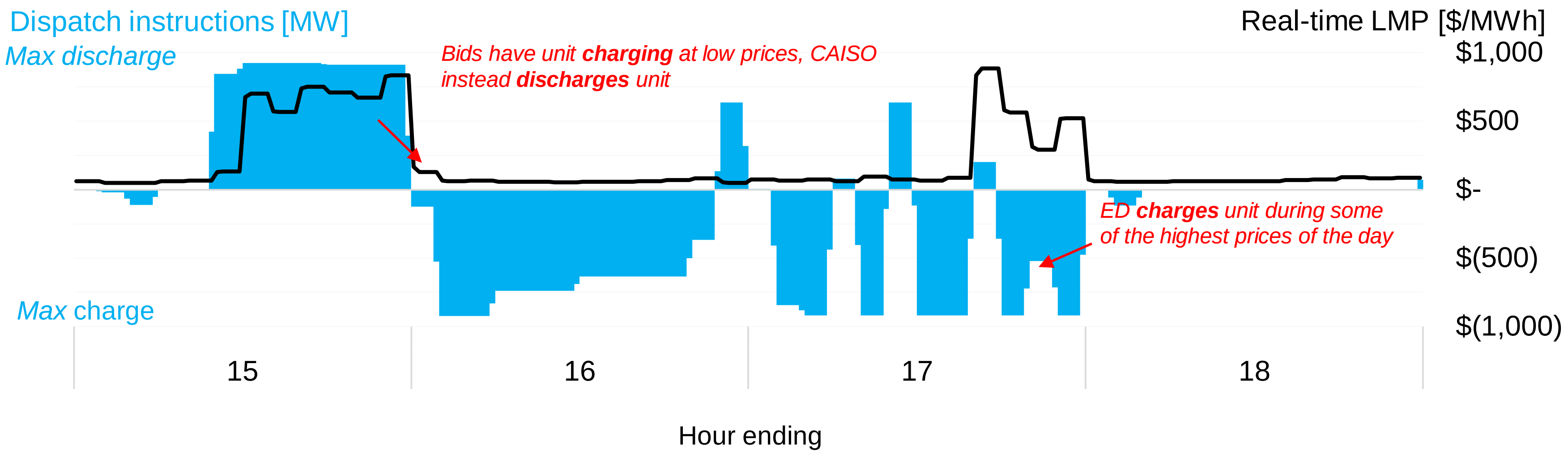
- **CAISO often does not compensate storage for exceptional dispatch**, which removes storage from the market and produces large gross and opportunity costs.
- On several occasions, exceptional dispatch has disrupted and even prevented resources from delivering day-ahead awards.
- In the example to the left, CAISO's current BCR methodology would see that the battery did not lose money *over the entire day* and that no BCR would be necessary.

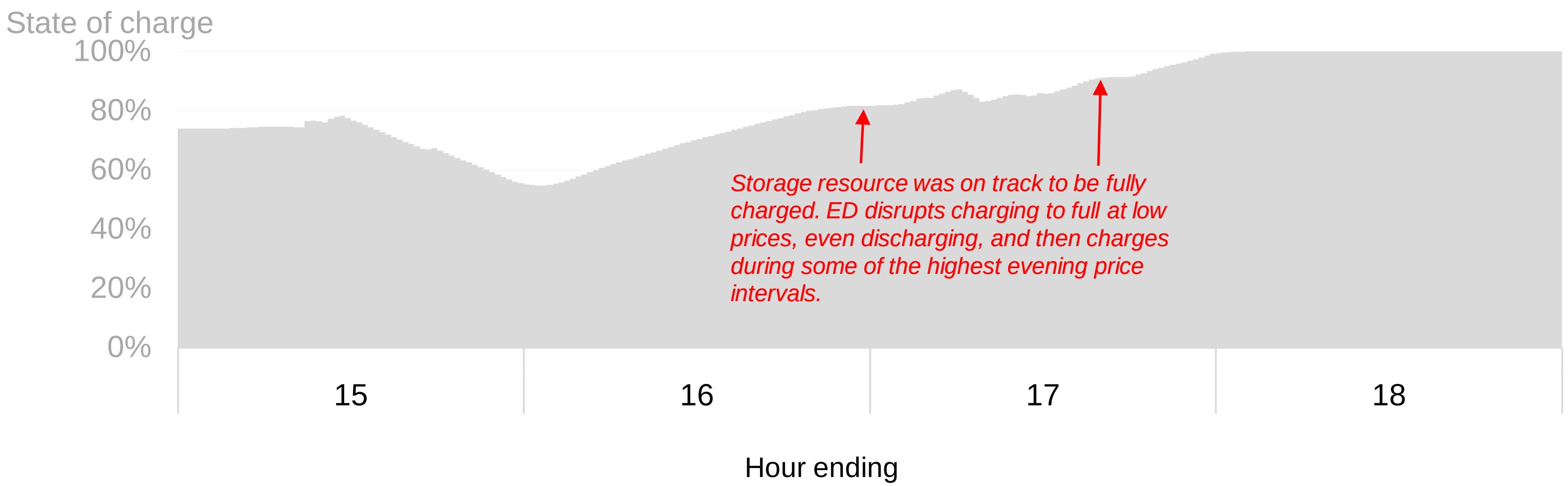
Recommendations

- **Implement NGR-specific bid cost recovery** so that resources are compensated for exceptional dispatches.
- **Exceptional dispatches should seek to align the unit with its day-ahead schedule.** CAISO operations desk personnel should have more information about resource schedules and bids. This would mitigate the risk that EDs disrupt ability to deliver day-ahead awards.
- **Target MWh rather than MW with exceptional dispatch** to avoid unnecessary discharges.

Mitigate effects of exceptional dispatch

Example of exceptional dispatch from July 2021





Use SOC to limit infeasible dispatches

- **Available power declines as a function of state of charge for all lithium-ion batteries**. Storage resources can charge rapidly across most of their usable SOC, but not near the extremes.
- The last few MWh are charged slower and take longer. However, this constraint is not reflected in the NGR model and produces infeasible dispatches, which bring consternation for CAISO operators and risk for resource owners.
- Oversizing all batteries to achieve constant rates of charge would result in in excess ratepayer costs and significant wasted MWhs of unused capacity.

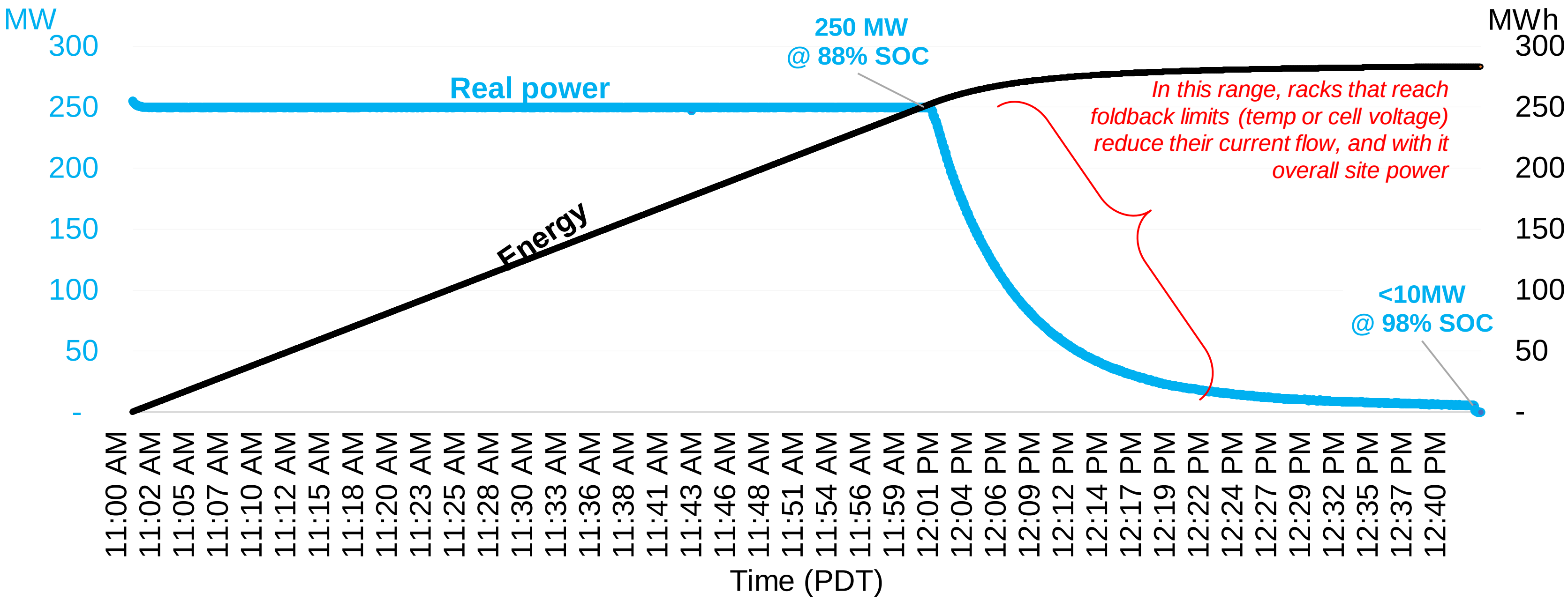
Recommendations

- **Use real-time state of charge and AGC telemetry in real-time dispatch** to create an additional constraint on the power limits at which the resource can be charged or discharged.
- **Allow storage operators to submit a piecewise MW vs SOC curve** as part of the master file or bidding parameters that limits power as function of a SOC.

Variable charging rates

CAISO can use SOC to limit infeasible dispatches

Charge rate and energy at a battery (time series)



Charge rate and state of charge at a battery (scatter plot)