Energy Storage and Distributed Energy Resources Phase 4 discussion

Gabe Murtaugh
Jill Powers
Lauren Carr
Bridget Sparks
Infrastructure and Regulatory Policy

Market Surveillance Committee Meeting
General Session
May 8, 2020

ESDER 4 includes proposals enhancing energy storage and demand response resource market participation

1. Applying market power mitigation to energy storage resources *
2. End-of-hour State-of-charge parameter for the non-generator resource model *
3. Establishing parameters to better reflect demand response resource operational characteristics *
4. Vetting qualification and operational processes for variable-output demand response resources
5. Streamlining market participation agreements for non-generator resource participants

*These three proposal elements will be discussed today

ESDER4 proposals emphasize developing tools to enhance energy storage provisions in the market

- ISO and CPUC call for procurement of 3,300 MW of additional resource adequacy resources by 2023 to make up for gas retirements
- Most of the resources in the interconnection queue are energy storage
  - Lithium-ion 4-hour batteries
  - There will be hundreds of MW of interconnected storage capacity this year, and several thousand MW of capacity added in the next few years
- Markets were designed around gas resources, and may not have features that best accommodate the unique attributes of storage
- The ISO currently does not apply market power mitigation to storage

STORAGE AND THE ISO MARKETS

Gabe Murtaugh

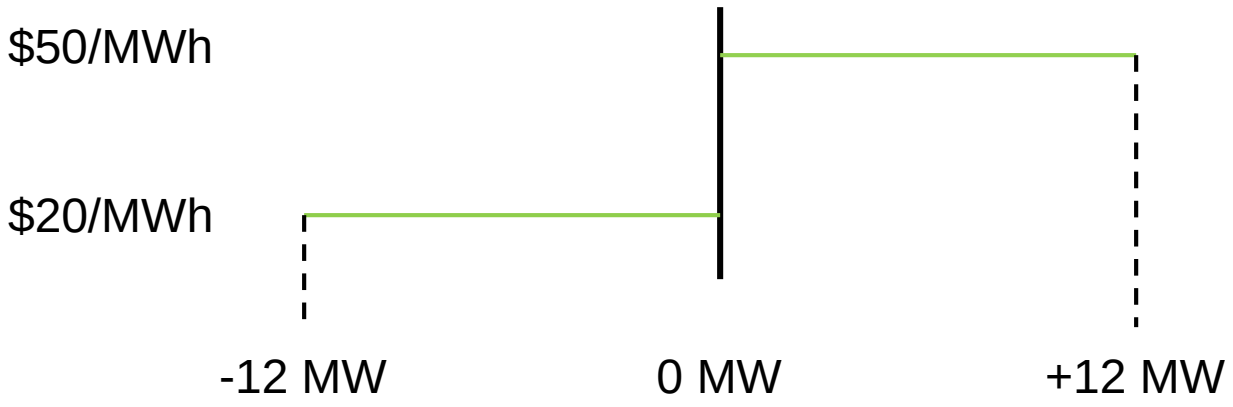
Initiative described how energy storage bids are used in the DA and RT market optimization

- Energy markets were designed around gas resources and may not accommodate the unique features of energy storage resources such as:
  - "True spread bidding"- price difference between charge and discharge
  - Bids that can increase with battery cycle
  - Bids that move inversely with state of charge
- The ISO wants reliable and efficient real-time market outcomes
  - Without longer real-time market horizons, batteries can be discharged early when prices are high leaving insufficient energy available to cover the late net-load peak after sunset
- ESDER4 is not making fundamental market reforms, such as bidding and commitment horizons
  - ISO is still in the early stages of its operational learning curve
  - Future development will depend on participant feedback and actual operating experience in the future

Bids for storage resources work similarly to bids for conventional resources

- Bids to charge, discharge, and 'spread bids' are used in the day-ahead market to schedule energy storage resources
- Storage resources can bid their capacity from Pmin to Pmax, for dispatch at price/quantity pairs for each hour
- Day-ahead market will also track state-of-charge (SOC) and round trip (RT) efficiency for storage

<u>Example bid curve for a +/- 12 MW resource:</u>



In the day-ahead market, storage resources can receive schedules based on spread bids

- Using the prior bid curve example

  The day-ahead market may schedule the resource to charge if prices are $50/MWh, however, this would only occur if there was another hour where prices were >= $80/MWh where the resource was scheduled to discharge

  - In this way the day-ahead market already observes spreads between positive and negative energy bids ($30/MWh in this example)
  - This is different than the treatment of conventional (gas) resources

- The day-ahead market generally profit maximizes for the storage resource

  - Storage is charged during the least expensive hours and discharged during the most expensive hours

- In the day-ahead market, this result is for all 24 hours and the market awards are financially binding

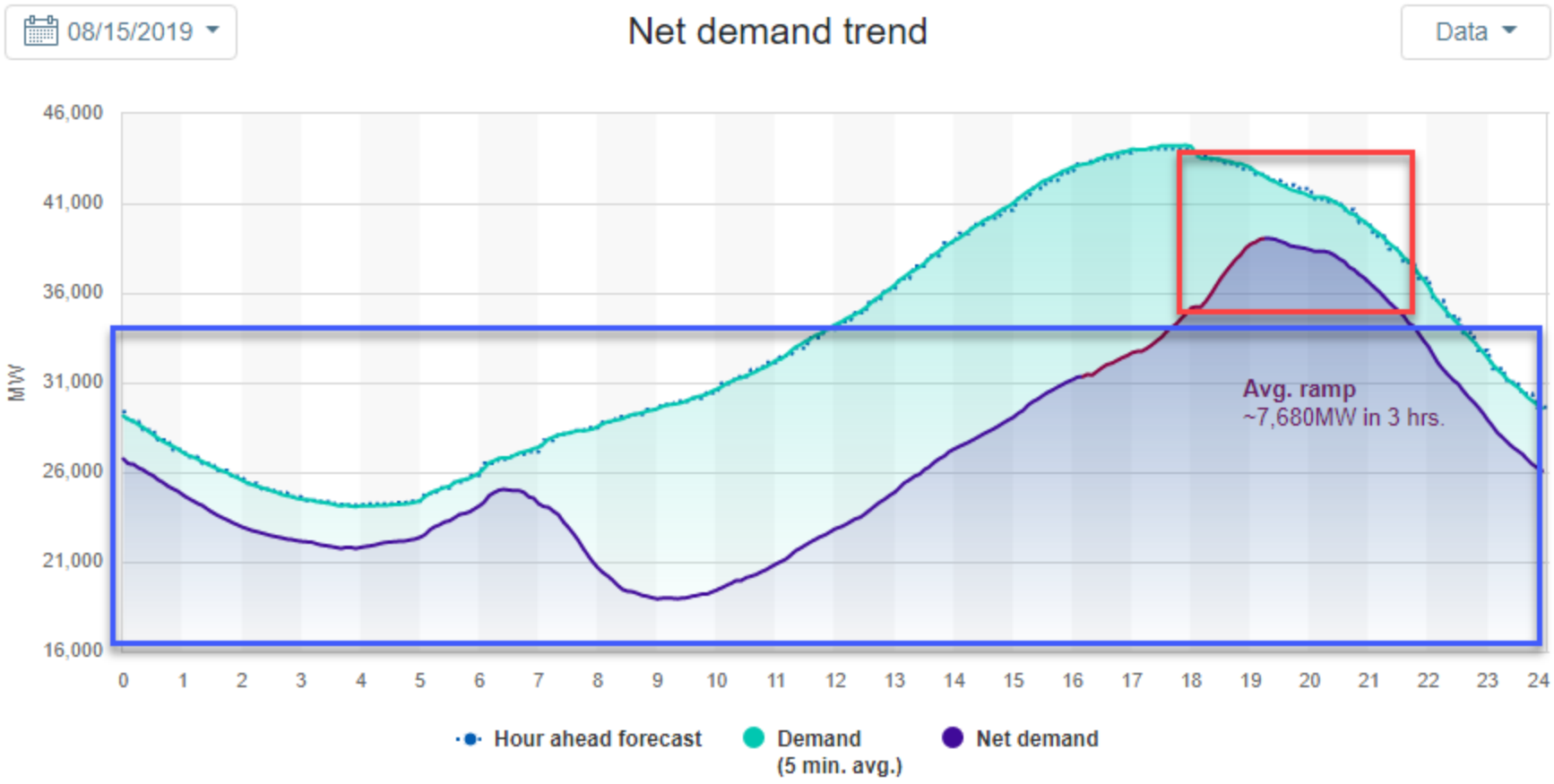
The real-time market works differently

- Real-time dispatch instructions are independent of day-ahead instructions
  - Day-ahead and real-time awards are financially binding
- The optimization in each 5-minute interval in the real-time market is optimized with twelve advisory intervals
- The real-time observes spread bids, but because the time horizon is so short the actual dispatch is much closer to a dispatch based only on bid prices
- Spreads in future advisory intervals can influence RT output
  - High advisory prices can result in charge instructions for the binding interval
  - Low advisory prices can result in discharge instructions in the binding interval
  - Prices in the binding intervals are not necessarily realized even though dispatch is based on these expected prices

Additional notes on market functionality for energy storage resources

- Dispatch includes calculation of losses
- Resources are co-optimized between energy and ancillary services
- Bids and spreads can change from hour to hour (within one RTD solution set) complicating the market solution
- ISO is concerned about storage awarded in the day-ahead market being unavailable for real-time operations
  - This could be addressed by a longer real-time look ahead window
  - Addressing this issue in the resource adequacy enhancements initiative
- STUC has an indirect influence on dispatch instructions for storage resources
  - STUC is only used to commit resources and not for dispatch

Energy limited resources may be critical for reliability on the system as gas resources retire



DEFAULT ENERGY BIDS FOR STORAGE RESOURCES

Gabe Murtaugh

The ISO identified four primary cost categories for storage resources

- Energy
  - Energy likely procured through the energy market
- Losses
  - Round trip efficiency losses
  - Parasitic losses
- Cycling costs
  - Battery cells degrade with each “cycle” they run
  - Cells may degrade faster with “deeper” cycles
  - Cycling costs should be included in the DEBs, as they are directly related to storage resource operation
  - It is expensive for these resources to capture current spreads
- Opportunity costs

Several factors contribute to the proposed default energy bid for storage resources

$$Storage\ DEB = Max\left[\left(\frac{En}{\lambda} + CD\right), OC\right] * 1.1$$

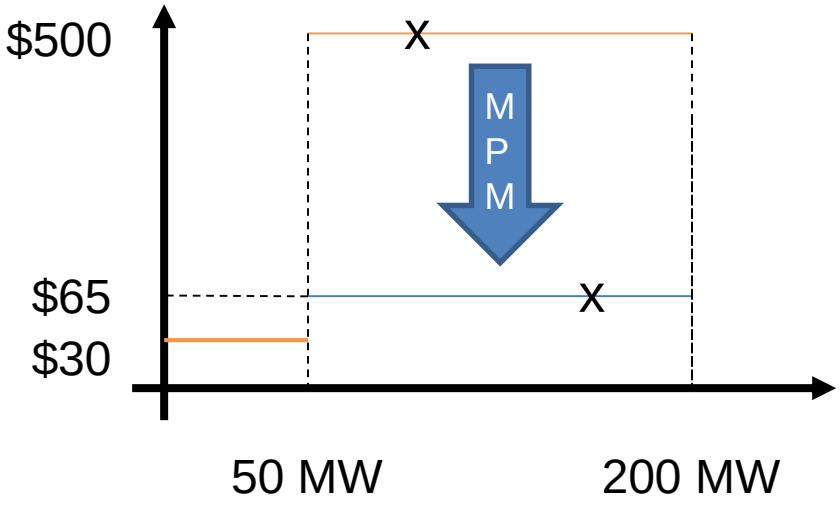
- Energy Costs (*En*) – Cost or expected cost for the resource to purchase energy
- Losses (λ) – Round-trip efficiency losses currently impact lithium-ion storage resources. May include parasitic losses in the model in the future
- Cycle Costs (CD) – Cost, in terms of cell degradation represented in $/MWh, to operate the storage resource
- Opportunity Cost (OC) – An adder to ensure that resources with limited energy are not prematurely dispatched, before the highest priced hours of the day

The ISO proposal includes a simpler approach to cycle depth costs than was initially proposed

- Generally storage resources are designed and built to a specification for average working conditions
  - Actual resources entering the market anticipate the ability to provide one cycle per day (and operate for a four hour duration)
  - These resources may operate beyond these specifications, but costs may be significantly higher
- These resources have an estimate from manufacturers about how much cell degradation costs will be for running up to that specification, and beyond that level
- The ISO intends to solicit documentation from storage resources on both costs, and apply the higher value to the ‘CD’ component of the DEB
  - Refinement anticipated as more resources interconnect in the future

When a gas resource is mitigated, its bid curve is reduced to the default energy bid

- Mitigation is applied for one specific hour of the day
  - Market Run Schedule: 100 MW @ $500/MWh
  - IFM run could increase schedule to: 150 MW @ $65/MWh



The proposed DEB framework may not be perfect, but is a good first step to preventing the exercise of market power

- Market power mitigation will not decrease schedules and will not mitigate hours when ‘downward’ market power may be exerted
- Market power mitigation does not mitigate to a “spread”
  - Actual energy purchase prices are not considered
- Additional output in the day-ahead market may imply additional charging earlier in the day

End-of-Hour State of Charge Parameter

Bridget Sparks

End-Of-Hour State-of-Charge (EOH SOC) Biddable Parameter

Optional parameter for storage using the non-generator resource (NGR) model to manage its state-of-charge in real-time

- Enhance real-time market to accept state-of-charge values for future hours and constrain the storage output to meet those values
  - Submitted as a MWh range with min and max SOC
  - Targeted SOC accommodated with min = max
- Allow EOH SOC parameter to take precedence over economic outcomes in the market optimization
- Allow the market to dispatch storage economically or uneconomically to achieve a preferred hourly EOH SOC
- Provide more flexibility than the use of self-schedules to manage SOC
- Resource will be ineligible for BCR for the EOH SOC applicable operating hour and the hour prior

Resource Constraints Prioritized Above EOH SOC

- Certain constraints will be respected before respecting the EOH SOC constraint
  - The max/min continuous energy limits in the Masterfile or upper/lower charge limit that are bid in
  - A state-of-charge needed to meet an ancillary service award
  - A state-of-charge needed to meet an exceptional dispatch, if the resource is exceptionally dispatched, the resource will be eligible for BCR

Figure 1: End-of- hour state-of-charge constrained by upper and lower charge limits

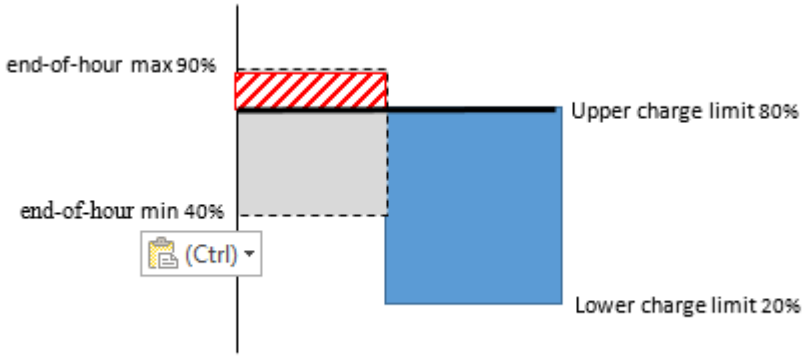
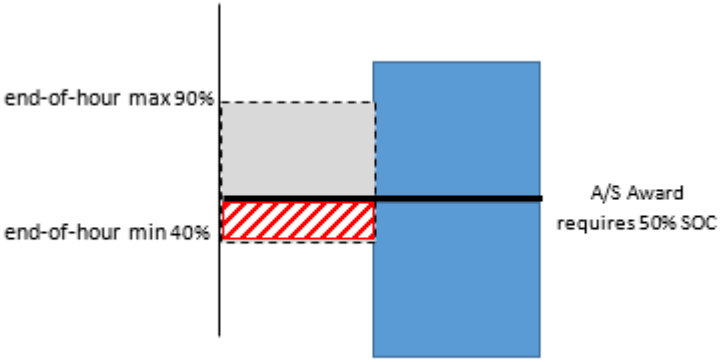


Figure 2: End-of- hour state-of-charge constrained by ancillary service award



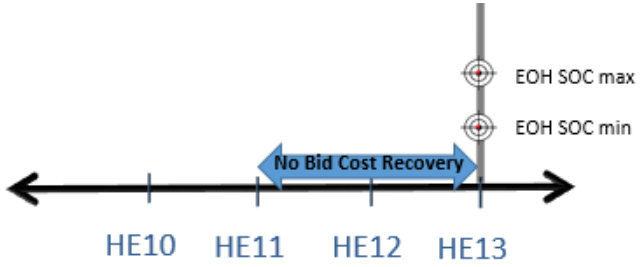
Market Application of the end-of-hour SOC bid

- EOH SOC will be submitted into the market 75 minutes prior to the start of the hour
  - Informs dispatch instructions in the successive 15-minute market (RTPD) interval and the corresponding 5-minute interval (RTD)
- Due to the different time horizons across the two real-time markets, the CAISO proposes to align visibility of the EOH SOC bid constraint to the same binding intervals for both the 5-minute (RTD) and 15-minute real-time (RTPD) markets.
  - An implied end of hour constraint will be applied at the end of the time horizon for 5-minute (RTD) runs.
  - The end of horizon constraint will be set to the end of hour constraint, adjusted for the resources full charging capability between the end of horizon and end of hour.

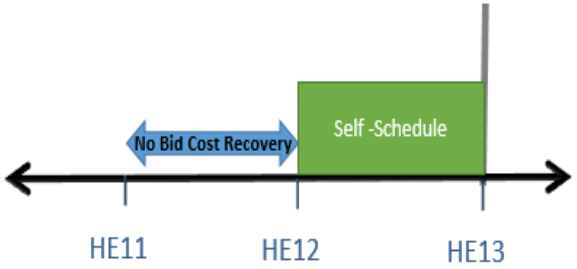
Modifications to Bid Cost Recovery

Proposal modifies a non-generator resource's bid cost recovery settlement in hours when EOH SOC bid parameter or self-schedule has the potential to create an uneconomic dispatch. Net costs will not be counted towards the daily BCR settlement during ineligible hours, but net revenues in these hour(s) will be counted towards offsetting shortfalls accrued during other intervals during the day.

- Ineligible to receive bid-cost recovery for shortfalls in both the hour preceding AND for the hour in which an end-of-hour state-of-charge is bid



- Ineligible to receive bid-cost recovery for shortfalls in the hour preceding the self-scheduled hour



Demand Response
-Max Daily Run Time Parameter

Jill Powers

Maximum Daily Run Time constraint allows a demand response resource to identify the maximum number of hours the resource could be “on” over the course of a day

- Demand response resource characteristic representing the maximum number of hours a DR resource can be committed and/or dispatched in one day
- Optional master file parameter, not a requirement
- Minimum 1 MW curtailment capability with registered Pmax >= 1 MW
- Applicable for both PDR and RDRR.

Example: Interaction between day-ahead and real-time market awards with Max Daily Run Time