



California ISO

Energy Storage and Distributed Energy Resources Initiative (ESDER4)

Draft Final Proposal

Stakeholder Web Conference

May 27, 2020

New online stakeholder commenting tool coming soon

- Ability to view all comments with a single click.
- Ability to filter comments by question or by entity.
- Login, add your comments directly into the template and submit.
 - You can save and return to your entry anytime during the open comment period.

NOTE

Submitting comments in the new tool will require a one-time registration.

Agenda

Time	Agenda Topic	Presenter
9:00 - 9:05	Welcome and Introduction	James Bishara
9:05 - 9:10	Overview of ESDER4 elements	Jill Powers
9:10 - 9:30	Background	Gabe Murtaugh
9:30 - 10:15	Default energy bid for storage resources	Gabe Murtaugh
10:15 - 11:00	State of charge parameter(s)	Bridget Sparks
11:00 – 11:10	Background on Variable Output DR	Lauren Carr
11:10 - 12:25	ELCC study results	E3
12:25 - 12:30	Next Steps	James Bishara

ISO Policy Initiative Stakeholder Process



ESDER 4 Post Draft Final Proposal Elements

1. Applying market power mitigation to storage resources
2. State-of-charge biddable parameter for storage resources
(end of hour SOC only)
3. Vetting qualification and operational processes for variable-output demand response resources
4. Maximum daily run time parameter for demand response
5. Streamlining market participation agreements for non-generator resource participants

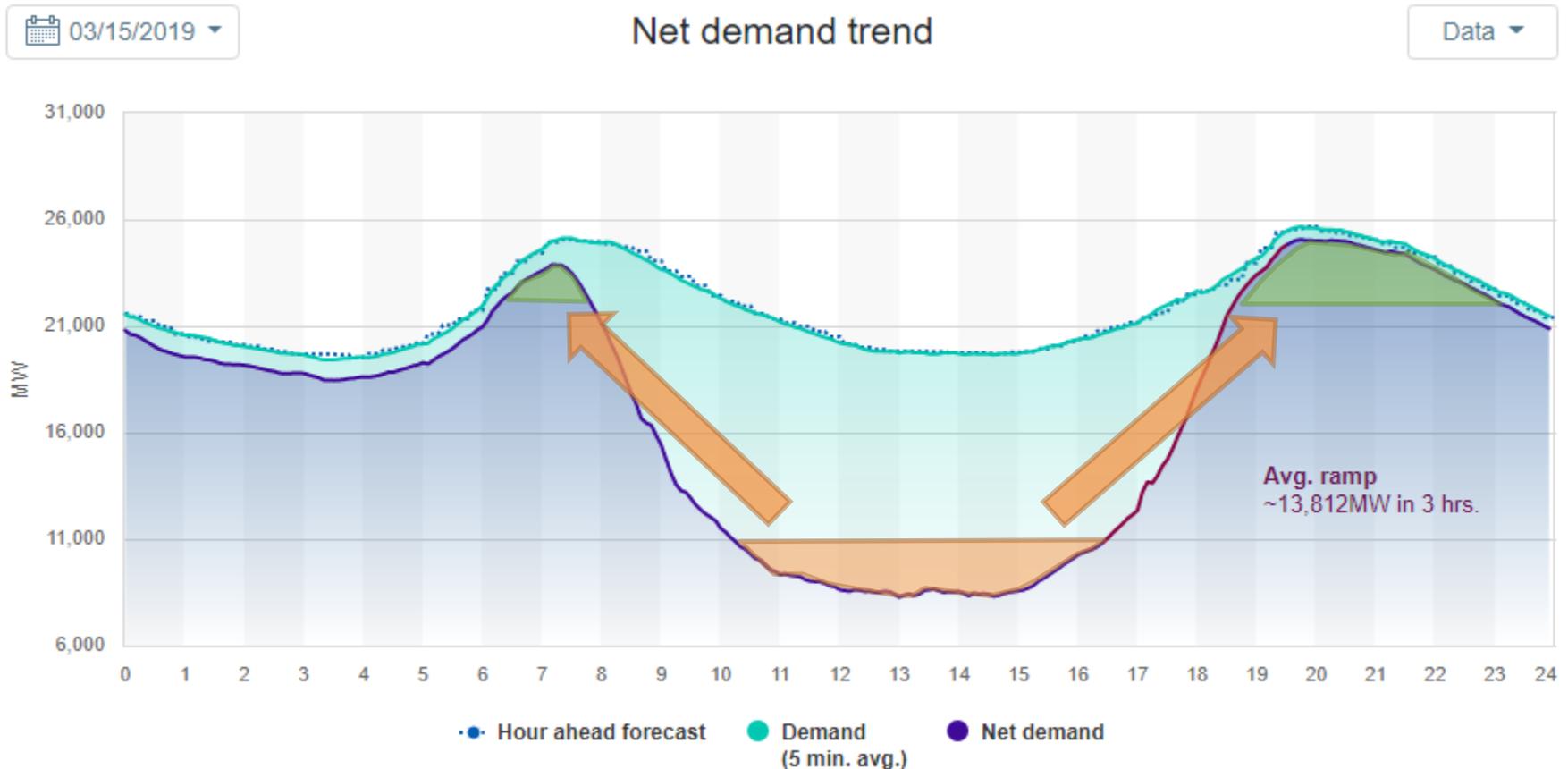
Individual proposals with updates in Draft Final Proposal being discussed today

BACKGROUND

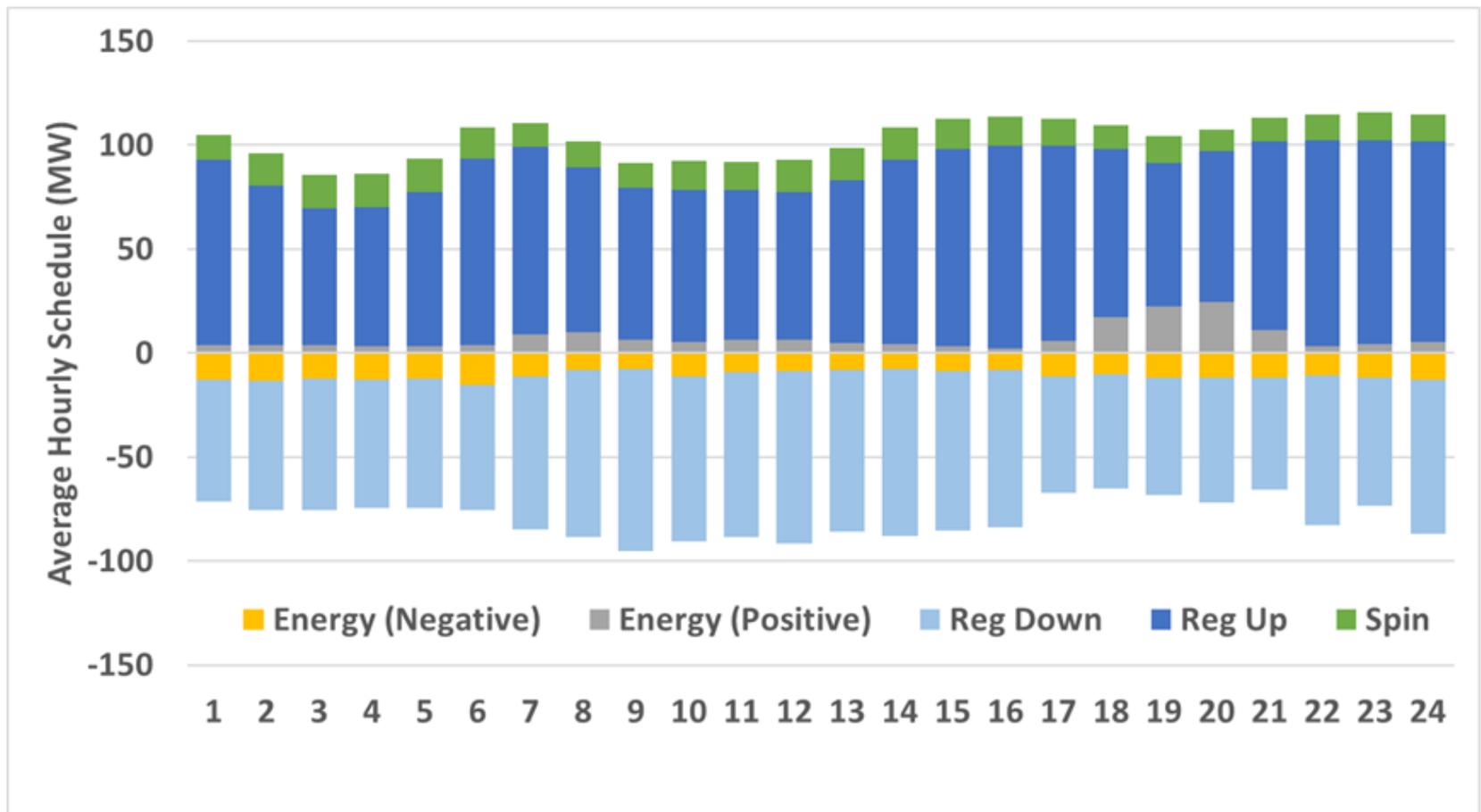
Storage is expected to be integral for California to produce energy with less greenhouse gas emissions

- The CPUC is ordering new resource procurement to replace older steam resources over the next 3 years
 - The retirement of a large nuclear resource in 2024 will likely require additional procurement
- Today there are about 200 MW of storage online, but the ISO will be dispatching thousands of MW in the future
- Much of the new procurement may come in the form of battery storage and hybrid (solar + storage) resources
- These resources bring new integration challenges
 - Market power mitigation is not currently applied to storage resources
 - CAISO does not currently have a tool to compel a storage resource to charge and be “ready” for discharge
 - Storage resources have limited energy

Planning for storage resources has assumed 'arbitrage' of day-ahead energy prices



Today storage resources are not moving significant amounts of energy across different hours of the day

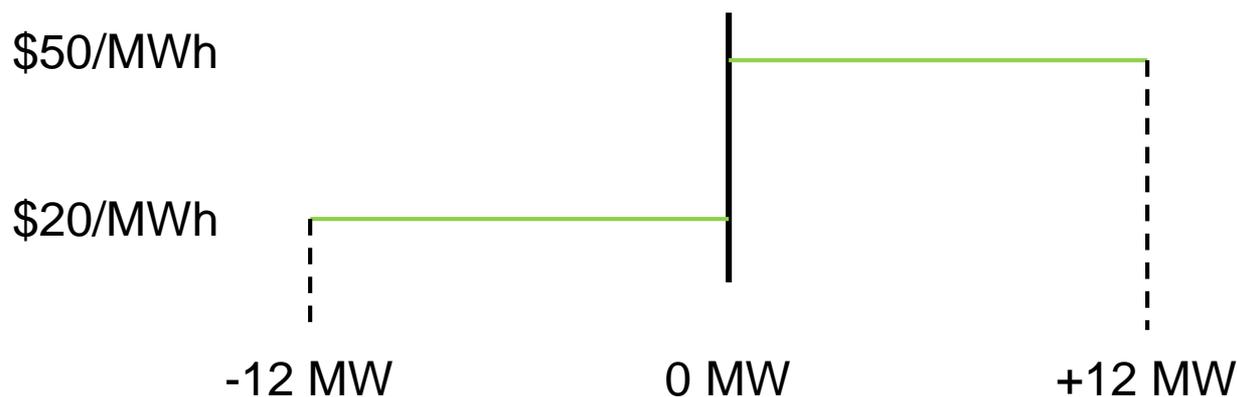


BIDDING FOR STORAGE RESOURCES

Bids for storage resources work similarly to bids for conventional resources

- The day-ahead market may schedule a resource based on: bids to charge, bids to discharge, and 'spread bids'
- Similar to most resources participating in the market, storage resources can bid their capacity from P_{min} to P_{max} , for dispatch at price/quantity pairs

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



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

- The day-ahead market may schedule the example resource to charge if prices are \$50/MWh, however this would only occur if there was another interval where prices were \$80/MWh or greater where the resource was scheduled to discharge
 - In this way, the day-ahead market already observes spreads between positive and negative energy bids
 - This is different than treatment for conventional resources
- The day-ahead market will schedule the resource to charge when prices are below \$20/MWh, and to discharge when prices are above \$50/MWh
- This is possible since the day-ahead solution evaluates all 24 hours at once, where all hours bind

DEFAULT ENERGY BID FOR STORAGE RESOURCES

The ISO identified three primary cost categories for storage resources

- Energy
 - Energy likely procured through the energy market
 - Includes round-trip efficiencies
- 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

$$\text{Storage DEB} = \text{Max} \left[\left(En^{\delta/\lambda} + \rho \right), OC^{\delta} \right] * 1.1$$

- Energy Costs (En) – Cost or expected cost for the resource to purchase energy
- Storage Duration (δ) – Duration of energy storage $\left(\frac{\text{Energy Storage (MWh)}}{P_{max}} \right)$
- Losses (λ) – Round-trip efficiency for lithium-ion storage resources
- Cycle Costs (ρ) – 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
- Bid is calculated daily in the real-time and the day-ahead market, according to the formula, for each resource that selects this default energy bid option

Energy costs are designed to match expected energy prices that resources could buy energy at

- The ISO assumes that storage resources will buy energy during the lowest priced hours of the day
- The previous proposal included a model where a prediction of the lowest prices were calculated using historical output price data
- This proposal includes using data from the market power mitigation (in the DA market) run to inform mitigation in the integrated forward market run of the market
 - Round trip efficiencies will also be factored
- Day-ahead prices would also be used as an estimate energy purchased in the real-time market

Opportunity costs are designed to match the expected peak energy prices resources can sell

$$OC_t^\delta = OC_{t-1}^\delta * \text{Max} \left(\frac{DAB_t}{DAB_{t-1}}, 1 \right)$$

- Opportunity Costs (OC) – Calculated based on relevant bilateral index prices (DAB) from previous day to current day
- Opportunity costs will estimate the expected price that a resource could discharge at, if fully charged
- Storage duration (δ) – Represent the amount of storage a resource has, in hours and will be used to determine the estimated energy price that a resource would pay to charge
- Each resource will be mapped to a single representative bilateral hub, which will scale prior day prices – similar to expectations for energy prices

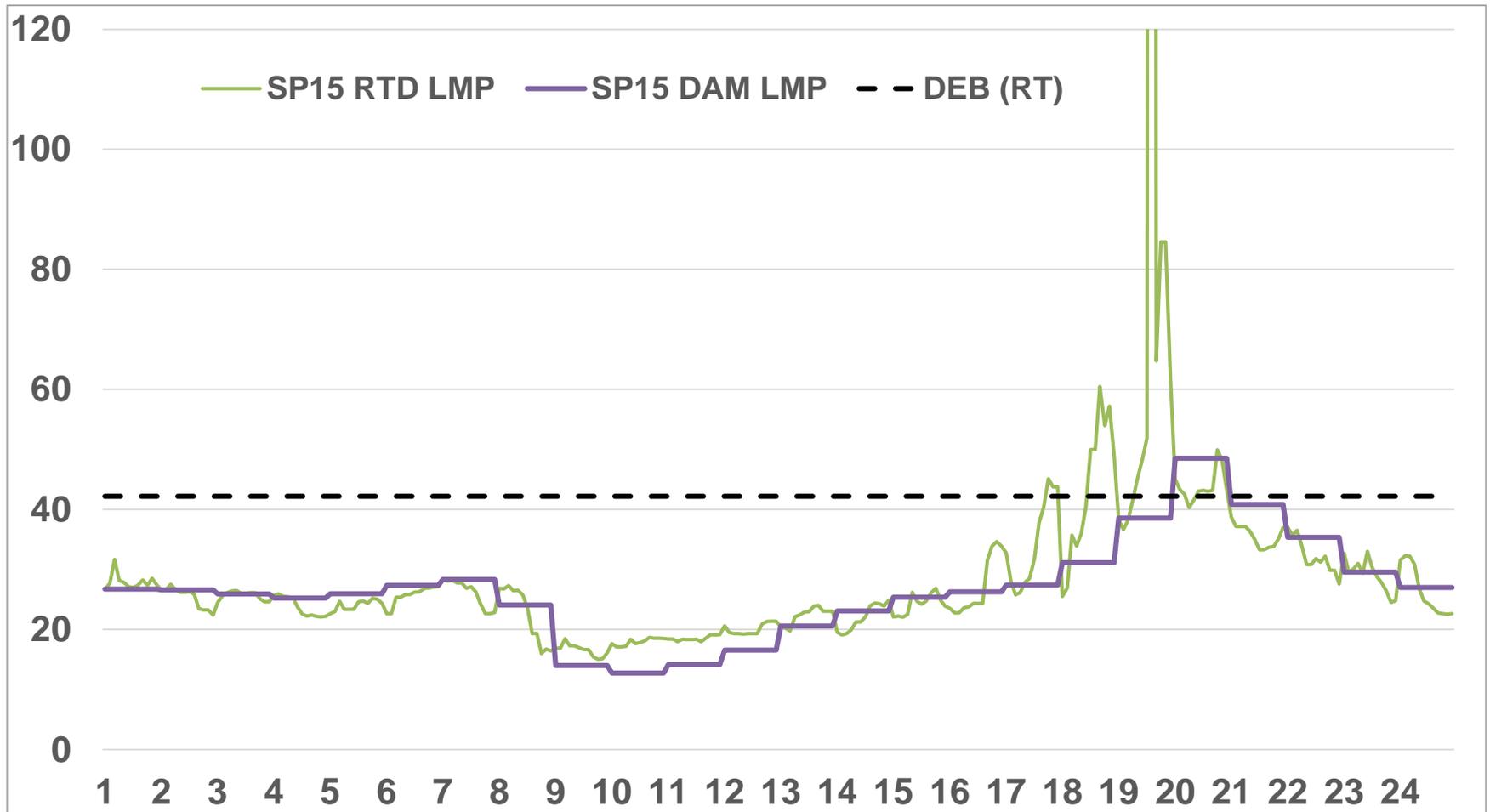
In this version, the ISO continues to use a significantly simpler approach to cycle depth costs

- 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 charge/discharge 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 for how much cell degradation costs will be for running up to that one cycle, and beyond that level
- The ISO intends to solicit documentation from storage resources on both costs, and apply the higher value to the ρ (cycle cost) component of the DEB
 - This may be refined as more resources interconnect

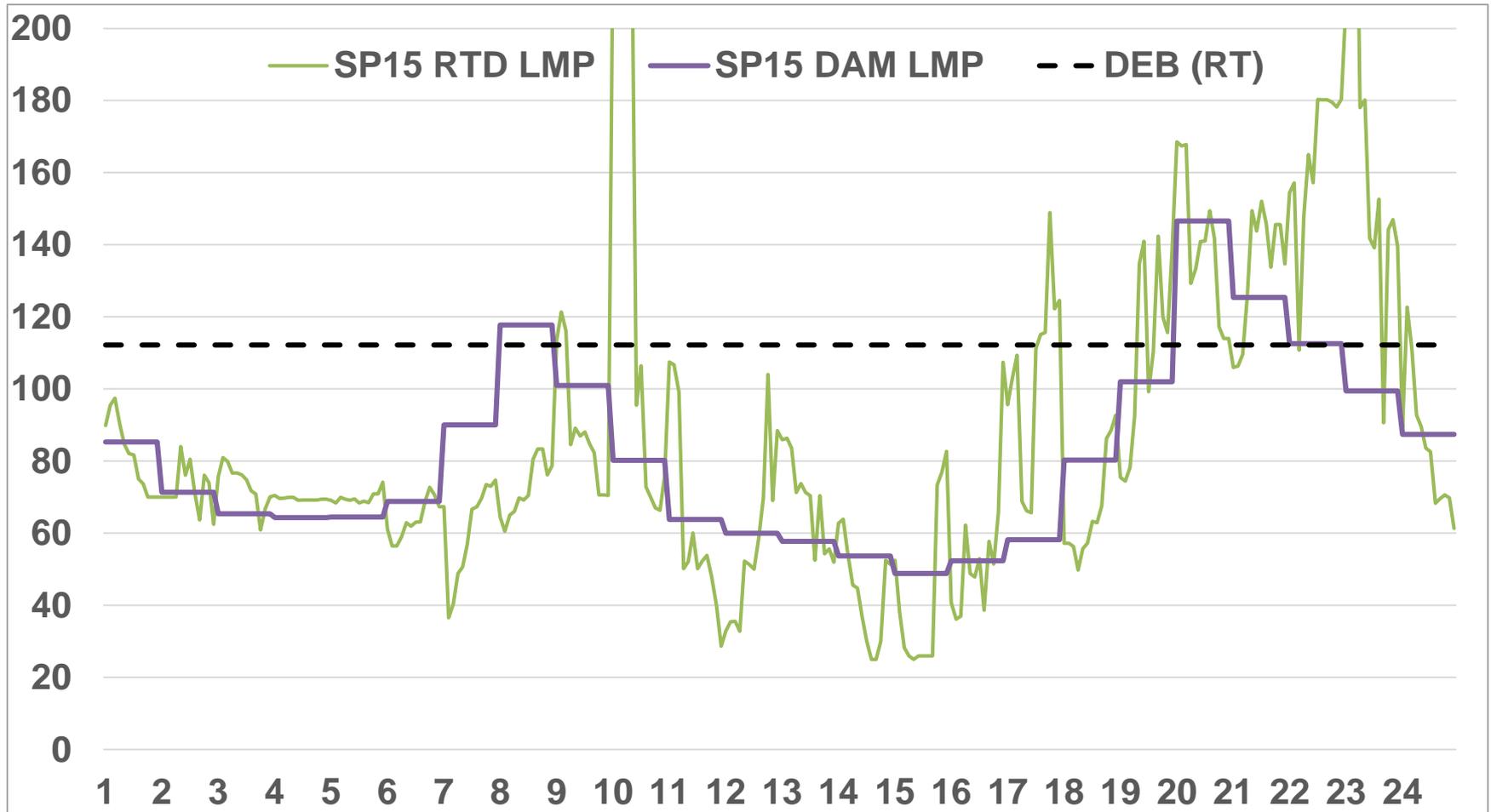
The ISO performed analysis on this default energy bid calculation

Month	Variable Comp.	OC Comp.	DEB	Run Hrs./Day
Jan	\$ 47.71	\$ 49.93	\$ 56.98	1.4
Feb	\$ 59.54	\$ 98.27	\$ 108.64	1.7
March	\$ 32.05	\$ 54.74	\$ 60.21	2.0
April	\$ 26.76	\$ 36.98	\$ 40.91	1.6
May	\$ 25.36	\$ 29.09	\$ 32.03	1.9
June	\$ 31.98	\$ 33.18	\$ 38.29	1.6
July	\$ 41.41	\$ 42.88	\$ 48.86	0.7
Aug	\$ 42.35	\$ 43.68	\$ 49.53	1.5
Sept	\$ 42.32	\$ 45.43	\$ 51.35	1.0
Oct	\$ 39.36	\$ 44.29	\$ 49.04	0.7
Nov	\$ 47.80	\$ 54.12	\$ 60.29	1.2
Dec	\$ 50.49	\$ 49.23	\$ 56.66	1.1

A typical summer day (August 18, 2019)



An high priced shoulder day (February 21, 2019)



The ISO will need to collect information in Master File and storage bids to construct default energy bids

- Round trip efficiency (λ): Estimated round trip efficiency
- Storage Duration (δ): Time the resource is capable of discharging, given energy (MWh) capacity at full output
- Cell degradation costs (ρ): Estimates for cell degradation costs
 - Captures limit of expected cell degradation
 - Will require documentation prior to implementation
 - May be reviewed by actual costs incurred (or anticipated) after a track record of participation is established
 - General values may be applied to the variable energy default energy bids as the ISO gains more experience
- ISO may use collected values and industry data to develop future default energy bids

Other concerns about storage resources have been raised during this initiative

- ISO is balancing the need to derive a default energy bid that does not understate costs with the need to mitigate for market power
 - Understating costs could reduce market participation and competition
 - Market power could have far reaching impacts to rate payers and lead to potential reliability impacts
- Resources will always have the ability to file for a negotiated default energy bid with the ISO

End-of-Hour State of Charge Parameter

End-Of-Hour State-of-Charge Biddable Parameter

Option for storage resources to manage use in real-time market to achieve a desired state-of-charge

- Enhance real-time market to accept state-of-charge values for future hours and constrain the NGR output to meet those values
 - Submitted as a MWh range with min and max SOC
 - Targeted SOC accommodated with min = max
- Allow end-of-hour state-of-charge parameter to take precedence over economic outcomes in the market optimization
 - Exceptional dispatch will override this parameter
- Allow the market to dispatch storage resources economically or uneconomically to achieve a preferred hourly end-of-hour state-of-charge

Resource Constraints Prioritized Above EOH SOC

Constraints that will be respected before the end-of-hour state-of-charge effecting its achievability:

- 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

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

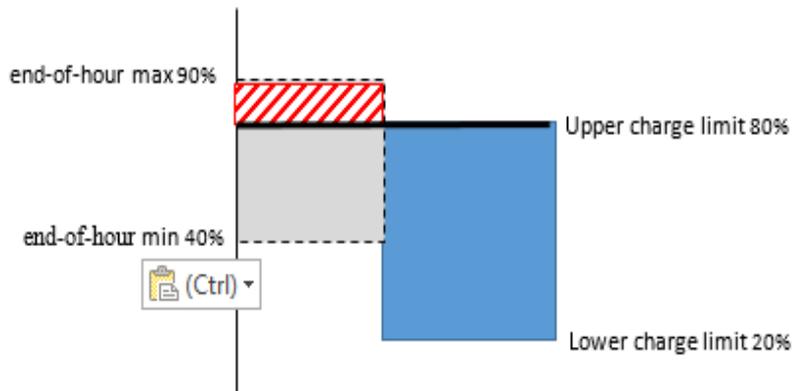
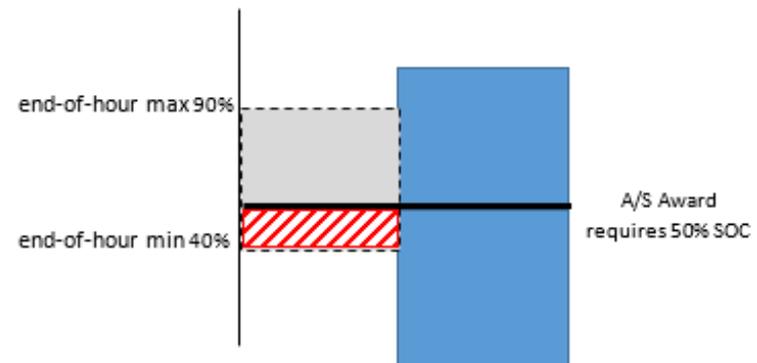


Figure 2: End-of- hour state-of-charge constrained by ancillary service award



Resource Adequacy impacts

Current Paradigm

- The expectation set out in BPM for Reliability Requirements Section 7.1.1 states that a non-generating resource (non-REM) must submit “economic bids or self-schedules... for any remaining RA Capacity from resources scheduled in IFM or RUC”
- A scheduling coordinator should not submit an end-of-hour state-of-charge parameter that is below the resource’s must offer obligation, or use it to withhold additional RA Capacity not scheduled in the IFM or RUC

UCAP Paradigm

- CAISO is moving towards a new unforced capacity valuation methodology (UCAP) which takes into account a resource’s derates and forced outages when determining its capacity value.
- CAISO may consider treating self-schedules and end-of-hour state-of-charge parameters that fall below the resources contracted value as a reduction in availability of the resource. This may be treated as a derate when UCAP values are calculated, which will decrease the capacity value of that resources.
- Follow the Resource Adequacy Enhancements Initiative for more details

Market Application of the end-of-hour SOC bid

- Real-time bidding parameters are submitted to the market 75 minutes prior to the start of the hour.
 - ✓ Applies to when market will see resources submitted end-of-hour state-of-charge minimum and maximum parameters.
- Once received these values will be used to inform dispatch instructions for resources in the successive 15-minute market (RTPD) interval and the corresponding 5-minute interval.

CAISO proposes to align visibility of the end-of hour state-of-charge 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.

Example: RT Market Application for the EOH SOC

Resource submits a min EOH SOC for HE10 due at 07:45

RTPD:

At 07:50 the binding market run begins for 08:30 interval **(First RTPD market run with EOH SOC)**

Binding instructions for 08:30-08:45, Advisory for 08:45-10:00 **(EOH SOC respected for each of the Adv & Bind ints)**

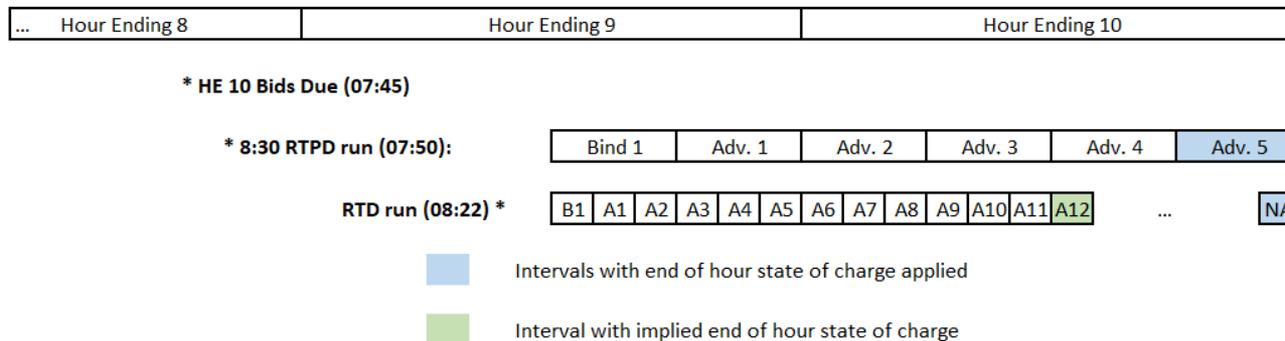
✓ **From this point, as needed, all RTPD intervals will be used to achieve the resources EOH SOC**

RTD: Market runs 7.5 minutes prior to the start of a specific 5-min interval with 65 minute look out 1 binding and 12 advisory 5-minute intervals

At 08:07:30 binding market run begins for 08:15-08:20 **(EOH SOC is in market for RTD run – but will not be considered)**

At 08:57:30 binding market run begins for 09:05-09:10 **(First RTD market run to see EOH SOC)**

✓ **EOH SOC bid is not considered until the last interval of the 5-minute (RTD) run time horizon reaches the end of the hour**



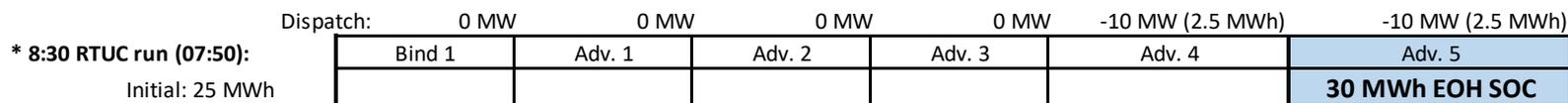
- Due to EOH SOC time horizon visibility differences between RTPD & RTD there may be a sub-optimal situation where RTD could undo planned RTPD actions not dispatching to charge the resource until it is too late.

Example: RT Market Application for the EOH SOC

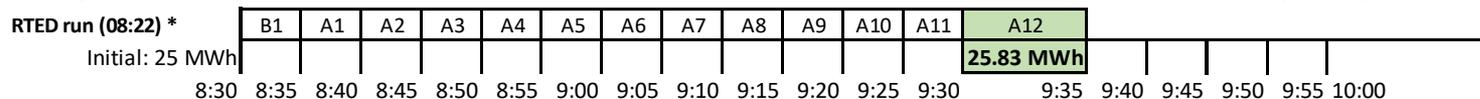
- Propose to align visibility of the end-of hour state-of-charge bid constraint to the same binding intervals for both the RTD and RTPD
- An implied end of hour constraint will be applied at the end of the time horizon for RTD runs for binding intervals (starting 8:30 to 09:35 in this example)
- This 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
- Example:** Suppose 40MWh resource has an initial SOC of 25 MWh (62.5%), and submits an EOH SOC of at least 30 MWh (75%) by HE 10

... Hour Ending 8	Hour Ending 9	Hour Ending 10
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* HE 10 Bids Due (07:45)



Dispatch assuming price convergence with RTUC: 0 MW 10 MW (Assumed 10 MW dispatch beyond horizon)

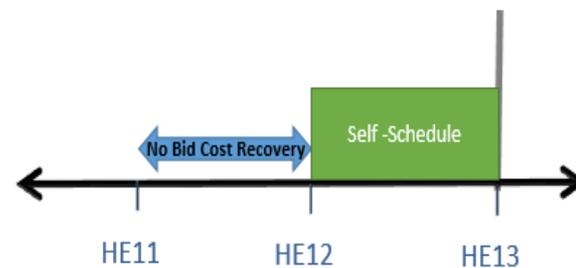
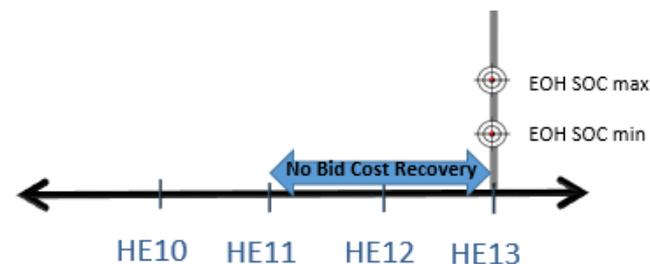


- Interval with end of hour state of charge applied
- Interval with end of horizon state of charge applied

Modifications to Bid Cost Recovery

Proposal modifies a storage resource's bid cost recovery settlement in hours when EOH SOC bid parameter or self-schedule has the potential to create an uneconomic dispatch. Revenue shortfalls will not be counted towards the daily BCR settlement during ineligible hours, but revenue surpluses in these hour(s) will offset 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



BCR Modification Proposal

- The two hour BCR ineligibility flag will cover the entire two hours.
- A secondary indicator will evaluate bid cost and revenue on a 5-minute interval basis:
 - If bid cost $>$ revenue, then interval will be set to 0
 - If bid cost $<$ revenue, then no change to interval
 - This will essentially exclude intervals with an uneconomic dispatch by setting it equal to zero, but will allow any additional revenues to flow through to the daily BCR calculation and could be use to cover BCR shortfall in other periods not effected by the EOH SOC parameter

BCR Modification Example

- Resource A is a 25 MW four-hour duration battery (100 MWhs)
- A scheduling coordinator submits the following parameters:
 - EOH SOC target= 50MWh at HE 14
 - EOH SOC target= 20MWh at HE 20
 - Bids \$0 to charge, and \$10 to discharge energy

BCR Modification Example cont.

5M Interval	164	165	166	167	168	~	235	236	237	238	239	240
EOH SOC target					50							20
SOC	46	48	49	49	50	~	25	24	23	22	21	20
Dispatch (MWh)	-1	-1	-1	0	-1	~	1	1	0	1	1	1
Bid (Chg)	0	0	0	0	0	~	-	-	-	-	-	-
Bid (Gen)	-	-	-	-	-	~	10	10	10	10	10	10
Price	6	-1	0	1	5	~	5	5	5	15	15	15
BCR Eligibility	N	N	N	N	N	~	N	N	N	N	N	N
Cost	6	0	0	-	5	~	10	10	-	10	10	10
Revenue	0	1	0	-	0	~	5	5	-	15	15	15
Included in BCR settlement	0	1	0	-	0	~	0	0	-	5	5	5
BCR Impacted	Y	N	N	N	Y	~	Y	Y	N	N	N	N

Battery would not get BCR when Bid Cost > Revenue

- If we assume revenue neutrality in subsequent intervals, the resource had Daily Bid Cost of \$61 > Revenue of \$56
- Resource would normally be eligible for \$5 BCR payment
- Under new proposal, intervals 164,168,235,236 would be set to \$0, new Daily Bid Cost of \$40 < Revenue of \$56
- Resource would not have a BCR shortfall, and would not receive a payment
 - It is assumed that the Battery performs as expected, therefore Persistent Deviation and Performance Metrics do not apply

End-of-Day State-of-Charge Parameter, no longer under consideration in ESDER 4

- In the 2nd Revised Straw Proposal, the CAISO proposed that scheduling coordinators could submit an end-of-day state-of-charge with a minimum range between 0 and 10% and a maximum between 0 and 100%.
 - Many stakeholders argued there should be no limitations. PG&E asked for the minimum to be raised to 25%.
- CAISO analysis showed potential for capacity shortfalls during critical evening ramp period at minimum EOD SOC of just 5%
- The Day-Ahead Market Enhancement Initiative and Resource Adequacy Enhancements Initiative are proposing significant changes to the design of the day-ahead market and a shift towards a day-ahead must-offer obligation, the CAISO has decided to table the discussion and implementation of an end-of-day state-of-charge parameter until those other policies move forward

Self-Schedule Enhancement

- Due to the different lookout horizons between RTPD and RTD, RTD may schedule a resource to discharge/charge the resource more/less because it cannot see the full self-schedule
- CAISO has identified the need for a new real-time market constraint to preserve a minimum state-of-charge to meet the submitted self-schedule.
- The new enhancement to the non-generating resource model applies a constraint on the ending advisory period in RTD market that would preserve the minimum state-of-charge necessary to meet the full self-schedule

Questions?

VARIABLE-OUTPUT DEMAND RESPONSE

Background on Variable-Output DR

- Supply Side Working Group (2018-2019)
 - Stakeholders requested modifications to treatment of demand response resources with variable load curtailment capabilities
 - CPUC presented on current ELCC approach for wind and solar
 - CAISO proposed ELCC approach for variable-output DR
- ESDER 4 (2019 to Present)
 - Conducted stakeholder process to explore ELCC as a qualifying capacity valuation methodology, as well as modifications to must offer obligation fulfillment
 - **E3 performed ELCC study on existing DR programs to inform stakeholders**
- CPUC RA Proceeding (Present)
 - CAISO proposed commitment in track 2 of the adoption of ELCC by the end of track 4

ELCC STUDY RESULTS

(SEE E3 PRESENTATION)

NEXT STEPS

ESDER 4 Schedule

Date	Milestone
May 27	Stakeholder Meeting (including E3 study results)
June 10	Comments due
June - July	BRS & Tariff development
Early Aug	Call on MSC Opinion (energy storage proposals)
<i>Mid Aug</i>	<i>Post Final Proposal</i>
<i>Late Aug</i>	<i>Comments (final positions) due</i>
Sep	Present to EIM GB and Board
Fall 2021	Implementation (proposed)

Next steps

- All related information for the Energy Storage and Distributed Energy Resources Phase 4 (ESDER4) initiative is available at <http://www.caiso.com/StakeholderProcesses/Energy-storage-and-distributed-energy-resources>
- Please submit stakeholder written comments on today's discussion and the ESDER4 draft final proposal by end of day June 10, 2020
 - Submit to initiativecomments@caiso.com
 - Comments template is available on the ESDER4 initiative webpage under today's meeting header, at <http://www.caiso.com/StakeholderProcesses/Energy-storage-and-distributed-energy-resources>