Energy Storage and Distributed Energy Resources Phase 4 (ESDER 4) Second Revised Straw Proposal

Comments by Department of Market Monitoring
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Summary

DMM appreciates the opportunity to comment on the ISO's *Energy Storage and Distributed Energy Resources Phase 4 (ESDER 4) Second Revised Straw Proposal*.[1] In these comments, DMM provides input on the ISO's proposed default energy bid (DEB) for storage resource, the end-of-hour state-of-charge (EOH SOC) parameter, and the proposed minimum charge requirement for storage resources.

The DEB proposal in the Second Revised Straw is largely unchanged from the ISO's Revised Straw Proposal. While the latest DEB proposal remains a significant improvement from the original straw proposal, the proposed approach does not allow for any change in DEB value over the day. This reflects how the proposed DEB approach still does not account for variations in opportunity costs at different points in a day and fails to account for storage resources' capability to charge and discharge potentially multiple times over a day.

The proposed approach also necessitates the use of a more blunt and conservative estimate of maintenance costs that may be varying with battery usage over the day. To more accurately capture the dynamic nature of energy storage resource costs, the approach could be refined to allow for different DEBs in different hours of the day and include better opportunity cost calculations.

The ISO should also consider revising its methodology for estimating the future prices used in the DEB calculation to reflect the fact that prices can fall day-over-day. The current proposal considers only the possibility of flat or increasing prices day-over-day. This could overstate opportunity cost estimates on days where prices fall significantly over the previous day.

DMM appreciates that the ISO is considering mechanisms to address the discrepancy in the impacts that the EOH SOC parameter may have on 15-minute and 5-minute market awards. DMM recommends that the ISO provide more examples and formulations to allow stakeholders to fully evaluate the ISO's proposed solution.

DMM also appreciates that the ISO is considering BCR eligibility rules when EOH SOC parameters or self-schedules are used to manage storage schedules in real-time. As part of this effort, DMM recommends that the ISO review how existing RIE rules will impact storage resources submitting EOH SOC constraints or self-schedules and to consider appropriate

[1] *Energy Storage and Distributed Energy Resources Phase 4 Second Revised Straw Proposal*, California ISO, February 24, 2020: http://www.caiso.com/InitiativeDocuments/SecondRevisedStrawProposal-EnergyStorage-DistributedEnergyResourcesPhase4.pdf

enhancements to the RIE rules. DMM also reiterates its comments on the Revised Straw Proposal regarding interactions with resource adequacy rules and how the EOH SOC parameter might be used to exceptionally dispatch storage resources.[2]

More detailed comments on DEBs for storage resources, the end-of-hour SOC parameter, and the minimum charge requirement are provided below.

I. Default Energy Bid for Energy Storage Resources

The Second Revised Straw Proposal includes cycling costs and opportunity costs as two of four cost categories for energy storage resources. DMM supports the inclusion of each of these cost components in a DEB for energy storage resources.

A DEB that can change by hour could allow more accurate estimation of cycling costs

In earlier versions of the ESDER 4 proposal, the ISO sought to estimate the cost per MWh of cycling a storage resource, varying throughout the day based on resource operation over that day. While the approach was focused on cycling costs of lithium-ion batteries, the general approach appeared promising as an approach to accurately estimate costs of storage resources at a point in time. Key components of this general approach include tracking characteristics such as state-of-charge and number of cycles over the day, and allowing cycling costs reflected in DEBs to vary accordingly.

In the current proposal, the ISO proposes a static DEB value over the day. Because the DEB value will not be allowed to change throughout the day, DMM understands that the ISO proposes to use an estimate of cycling costs that will capture the highest-cost cycling scenario that a resource could face in the day. While such an approach may be necessary with a static DEB value for the day, this creates the potential to significantly overestimate costs in some hours and highlights the need for a DEB value that can change through the day.

Opportunity costs are dynamic and should reflect opportunities to recharge

DMM highlighted the role of opportunity costs for energy storage resources in earlier comments and appreciates that the ISO has included this cost in the proposed default energy bid methodology. Specifically, it is appropriate to include opportunity costs from foregone future profit opportunities. Such opportunity costs may be incurred if an energy storage resource charges or discharges at a time that is not profit maximizing over the day or other time period. For example, when a higher priced discharge opportunity is expected in future intervals, or when a lower cost charging opportunity is expected before reaching a high value discharge opportunity. Like the cycling costs considered by the ISO, these costs are also

[2] *DMM Comments on ESDER 4 Revised Straw Proposal*, DMM, November 25, 2019, pp. 5-8: http://www.caiso.com/InitiativeDocuments/DMMComments-EnergyStorage-DistributedEnergyResourcesPhase4-RevisedStrawProposal.pdf

dynamic and change over the day. Opportunity costs will vary over the day with respect to expected prices in upcoming charging and discharging opportunities.

In an effort to capture the type of opportunity costs described above, the ISO proposes to estimate the next day's prices, construct a price duration curve of expected prices sorted in descending order, and then calculate the strike price on that curve corresponding to the discharge duration capability of the storage resource at maximum output. This approach may be appropriate for resources that have no ability to recharge within a day once discharged, as resources subject to these limitations would face static opportunity costs at the highest valued discharge opportunities expected in the day.

However, this approach does not reflect the actual physical characteristics of energy storage resources that may be capable of charging and discharging multiple times over the course of a day. The use of a simple strike price approach for these resources could overstate the opportunity cost for all but the intervals where recharging is not physically possible before reaching the highest valued discharging opportunities.

Example of opportunity costs for resources capable of charging and discharging multiple times per day

To illustrate how using a simple strike price could overstate the opportunity costs of resources capable of charging and discharging multiple times per day, consider the following highly simplified example of storage resources with the following characteristics:

- Storage capacity of 1-hour duration (can completely charge and discharge in one hour)
- Maximum output and charging capability of 1 MW
- No roundtrip efficiency losses
- Variable maintenance costs of $0/MWh
- Optimizing over 4 hours
- Beginning state-of-charge of 0 percent.

Expected hourly prices (P) over the 4-hour optimization period are:

$$P_t = \$3,\ P_{t+1} = \$45,\ P_{t+2} = \$47 \text{ and } P_{t+3} = \$150$$

In this example, if prices were realized as expected, the storage resource would maximize profit by charging in the first hour *t* at the lowest price ($3) , and discharging in the last interval *t+3* at the highest price ($150) for a profit of $147:

$$\pi = \$150*1 - \$3*1 = \$147$$

Now, consider actual realized market prices as:

$$P_t = \$3,\ P_{t+1} = \$100,\ P_{t+2} = \$47 \text{ and } P_{t+3} = \$150$$

Given these actual prices, the resource would instead maximize profit by completing two cycles, charging in the first and third hours (t and $t+2$), and discharging in the second and fourth hours ($t+1$ and $t+3$). This would yield profit of $200:

$$\pi = (\$100*1 - \$3*1) + (\$150*1 - \$47*1) = \$97 + \$103 = \$200$$

If the resource operator submitted a bid indicating that the opportunity cost of discharging in the second hour is the full revenue expected in the fourth hour, not accounting for the potential to recharge in the third hour, the bid would be $150 given the assumptions of the example. This bid would not clear against the realized market prices until the fourth hour is reached, and the additional profit opportunity from discharging in the second hour at $100 and recharging in the third hour at $47 is foregone.

Because the resource has an opportunity to recharge in the third hour before reaching the highest priced hour, the bid of $150 may overstate the opportunity cost of discharging in the second hour, the outcome is not profit maximizing for the resource, and energy may be able to be economically withheld from the market.

When the resource charges in the first interval, the expected profit from selling in the highest price hour is $147 as noted above. However, if the resource instead were to discharge in the second hour the energy purchased for $3 in the first hour, it could replace the energy at an expected cost of $47 in the third hour before reaching the final hour with an expected price of $150. The change in expected profit from discharging in the highest price hour when the $3 charging energy is replaced with $47 charging energy is:

$$= (\$150*1 - \$47*1) - (\$150*1 - \$3*1) = -\$44.$$

This represents the opportunity cost of foregone profit for discharging in the second hour. Coupled with the cost of charging energy at $3, this implies a total marginal cost to discharge in the second hour of $47:

$$\text{(charging energy cost)} + \text{(opportunity cost of foregone profit)} + \text{(maintenance cost)}$$

$$= \$3 + \$44 + \$0$$

$$= \$47$$

This value is considerably less than the estimate of marginal cost implied by the proposed DEB methodology[3]:

$$\text{Proposed DEB} = \max[\ (\$3/1 + \$0)\ ,\ \$150\ ]*1.1$$

$$= \$150*1.1$$

[3] *ESDER4 Revised Straw Proposal*, California ISO, October 21, 2019, p. 14: http://www.caiso.com/Documents/RevisedStrawProposal-EnergyStorage-DistributedEnergyResourcesPhase4.pdf

$$= \$165$$

Note that this is simply the expected cost of replacing the charging energy at the next best opportunity before reaching the expected future high priced hour. In the simplified example, this is the expected price in the next hour.

The reasonableness of the principle illustrated by the example above was recently confirmed in the October 17, 2019 FERC Order on Southwest Power Pool's (SPP) compliance filing for Order 841[4]. In the October 17 Order, FERC notes that a commenter on SPP's Order 841 compliance filing proposed to base a mitigated offer on an expected high value discharge price several intervals into the future. After considering an answer to the comment, FERC ultimately ruled against the commenter:

> *... to base opportunity cost on the expected forgone profit for an unspecified interval several hours into the future … does not account for the opportunity to recharge before the next price peak several hours ahead*.[5]

The concept shown in the example above, and reinforced by this FERC Order, is generalizable to a resource of any duration that may face a wide variety of costs—it need not be limited to the simplified case of a one-hour resource as shown here.

DMM's comments on the ESDER 4 Straw Proposal outline a generalized approach that more fully accounts for opportunity and other costs at different points in the optimization period.[6] This general approach accounts for the dynamic nature of energy storage opportunity costs at different points over a day, and accounts for the ability to charge and discharge multiple times over a day to maximize profit.

Even in the case that the ISO elects to implement a simplified approach for energy storage DEBs rather than a more general approach like that presented in DMM's earlier comments, DMM encourages the ISO to consider an enhancement to estimated opportunity costs to account for the ability of energy storage resources to recharge throughout the day.

Price estimation methods for opportunity cost calculations should allow for possibility of falling prices day-over-day

The DEB approach presented in the Second Revised Straw Proposal uses an expectation of prices over the trade day as an input. Expected prices are used to determine estimated charging costs, as well as the opportunity cost component of the DEB. The approach of using expected prices as an input to the DEB is reasonable, as it may be expected that an energy

[4] *Order on Compliance Filing and Instituting Section 206 Proceeding*, 169 FERC ¶ 61,048

[5] *Ibid*, at p. 14.

[6] *Comments on ESDER 4 Straw Proposal*, Department of Market Monitoring, May 21, 2019: http://www.caiso.com/InitiativeDocuments/DMM_Comments-EneryStorageandDistribuedEnergyResoucesPhase4-StrawProposal.pdf.

storage resource operator would optimize the operation of the resource by considering price expectations over the day.

The ISO's proposed approach to estimating daily prices for use in the next day's DEB uses the current day's prices scaled by a ratio of bilateral prices for the next day and current day. However, the approach does not allow for a ratio of less than one as would occur when prices are expected to fall. The use of a price estimation approach that does not allow for the possibility of prices falling on the next day could overstate costs reflected in the DEB on days when prices fall significantly from the previous day. The ISO may be able to improve its proposed price estimation approach by allowing for the possibility of both rising and falling prices across days when calculating the DEB.

II. End-of-hour state-of-charge parameter

End-of-hour SOC interaction between 15 and 5-minute markets

DMM appreciates the ISO's consideration of impacts that the end-of-hour state-of-charge (EOH SOC) parameter could have between 15-minute and 5-minute markets, given the difference in look-ahead horizons.[7] To address concerns that the 5-minute market could unwind schedules set in the 15-minute market to meet an EOH SOC target, the CAISO proposes to apply EOH SOC targets within corresponding 5-minute market runs. The ISO explains, "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."[8]

DMM would appreciate the ISO providing more examples and formulations in order for stakeholders to fully evaluate the ISO's proposed solution. The ISO's example is based on a slow-ramping battery (0.2MW/min)[9] – in actuality, the CAISO battery fleet is much faster ramping than the resource used in the ISO's example.

For example, if the resource in the ISO's example (100 MWh resource) instead had a ramp rate of 25 MW/Min, the ISO's proposal may still not address potential swings between RTPD and RTD. Similar to the ISO's example, suppose a resource owner sets a target EOH SOC in HE18 at 80% and must be charged to meet the target SOC. Suppose the resource's SOC at 16:30 is 60%. The first RTPD run that sees the EOH SOC constraint would likely charge the resource in earlier intervals of the net load ramp where LMPs tend to be lower (i.e. in HE17). However, based on its ramp rate, the resource could feasibly charge to meet the target SOC if it started charging in hour 18. Binding awards from the first RTPD run that saw the EOH SOC constraint may still be unwound in corresponding HE17 RTD runs that do not see the EOH SOC constraint.

[7] *DMM Comments on ESDER 4 Revised Straw Proposal*, DMM, November 25, 2019, p. 7: http://www.caiso.com/InitiativeDocuments/DMMComments-EnergyStorage-DistributedEnergyResourcesPhase4-RevisedStrawProposal.pdf

[8] *ESDER4 Second Revised Straw Proposal*, p. 7

[9] *Ibid.*, p. 7-8

BCR, RIE, and settlement issues

DMM appreciates the ISO's consideration of BCR eligibility rules when EOH SOC parameters or self-schedules are used to manage storage schedules in real-time.

Because the ISO 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" the impact of the EOH SOC constraint could extend beyond the hour adjacent to the EOH SOC constraint. The ISO's proposed BCR rules for the EOH constraint could limit potential gaming opportunities in hours preceding the hour with the EOH SOC constraint.

However, as mentioned in prior comments, the ISO's proposal could result in excluding hours from BCR calculations where the end-of-hour SOC constraint did not impact a resource's dispatch.[10] For example, the SOC constraint may have no impact on the resource's real-time schedule, but the resource may still be dispatched uneconomically to meet system conditions predicted in advisory intervals. Under this scenario, it seems the hour associated with the SOC parameter should not be excluded from BCR calculations.

The ISO has complicated residual imbalance energy (RIE) rules for determining when to compensate resources based on bids from prior or future hours rather than including the current hour's bid in BCR calculations.   A resource is compensated according to RIE rules when the RIE logic determines that the bids from a prior or future hour, rather than current hour bids, cause a resource to ramp up or down. DMM recommends that the ISO review how existing RIE rules will impact storage resources submitting EOH SOC constraints or self-schedules and to consider appropriate enhancements to the RIE rules that may help to address the BCR concerns.

DMM is also interested to understand whether the ISO could extract shadow prices from target SOC constraints. In addition to evaluating RIE rules, the ISO should also consider how the existence of a positive SOC constraint shadow price could be utilized in BCR/RIE enhancements targeted towards addressing BCR/RIE issues created by the proposed EOH SOC constraint.

Interaction with Resource Adequacy

Under current CPUC Qualified Capacity (QC) counting rules, a battery must be able to provide its resource adequacy (RA) value for 4 consecutive hours. DMM has observed that batteries' state-of-charge are often below the level required to produce the resources' RA value for 4 consecutive hours across the peak net load period. Under these conditions, battery resources can still meet must-offer obligations and avoid RAAIM penalties by submitting bids up to RA values. However, scheduling resources at these levels may be infeasible given resources' actual states-of-charge.

[10] *DMM November 25 Comments on ESDER 4 Revised Straw Proposal*, pp. 7-8.

The ISO's proposed EOH SOC feature would give SCs control over setting resources' target SOCs and could allow SCs to submit target SOCs that fall below 4-hour RA values. The ISO should consider whether a battery submitting a max EOH SOC less than a resource's 4-hour RA value in availability assessment hours (or at the start of the assessment hour window) should constitute a type of outage or de-rate. Alternatively, since a resource may still be able to reach its RA value or Pmax for less than 4 hours, instead of a de-rate reflected in the market, the ISO could consider an ex-post settlement process for batteries that is linked to RAAIM.

DMM understands that RAAIM and must offer obligations may change under the ISO's RA Enhancements Initiative. However, it will become increasingly important to reflect the actual availability of battery resources in capacity values as they begin to comprise a greater portion of the RA fleet. Determining battery availability based on energy bids or forced outages may no longer be sufficient if these resources can use other bid parameters such as the EOH SOC feature to limit availability.

III. Minimum Charge Requirement

The ISO proposes to enforce a minimum charge requirement (MCR) for storage resources in real-time to ensure storage capacity will be available to at least meet day-ahead awards.

The ISO's proposal would likely result in storage resources becoming much less flexible in real-time. For example if a resource's minimum SOC must be set high after its last charging interval earlier in the day in order to maintain day-ahead discharge schedules starting hour 19, the minimum SOC constraint could prevent the resource from discharging and recharging in order to capture additional real-time revenue opportunities before hour 19. Additionally, if conditions in real-time are such that the storage resource's day-ahead energy awards starting hour 19 are no longer needed or would otherwise be uneconomic, it would be unnecessary to maintain a minimum SOC on the resource to meet day-ahead schedules.

DMM also has concerns about the ISO's suggestion that, "Aggressive bidding strategies in the day-ahead market may result in no schedule awarded," and that this behavior may be used as a means to avoid being subject to the minimum charge requirement in real-time.[11] DMM does not support the ISO's suggestion that resources bid such that they are priced out of the day-ahead market in order to avoid minimum charge constraints.

The ISO initially introduced the minimum charge requirement in the RA Enhancements initiative. DMM suggested in RA Enhancements comments that if the ISO is ultimately concerned about RA storage resources remaining available at RA values when the ISO needs

[11] *Energy Storage and Distributed Energy Resources Initiative Second Revised Straw Proposal Day 2*, California ISO, March 3, 2020, Slide 47: http://www.caiso.com/InitiativeDocuments/Presentation-Day2-EnergyStorage-DistributedEnergyResourcesPhase4-SecondRevisedStrawProposal.pdf

capacity the most, the ISO could instead factor storage availability into UCAP calculations proposed under the RA Enhancements initiative.[12]

Additionally, if the ISO needs storage resources to be available for reliability purposes, (particularly RA resources) the ISO should be able to exceptionally dispatch storage resources. DMM previously commented that the ISO should detail how the EOH SOC parameter could be used to exceptionally dispatch storage resources and how settlements might work for these resources.[13] Exceptional dispatches of storage resources using the EOH SOC parameter has not been discussed yet in stakeholder meetings, but is relevant given the EOH SOC parameter and storage DEBs are both within the scope of ESDER 4.

[12] *DMM Comments on RA Enhancements Third Revised Straw Proposal*, DMM, January 30, 2020, p. 8: http://www.caiso.com/InitiativeDocuments/DMMComments-ResourceAdequacyEnhancements-ThirdRevisedStrawProposal.pdf

[13] *DMM Comments on ESDER 4 Revised Straw Proposal*, p. 8.