Energy Storage and Distributed Energy Resources Phase 4 (ESDER 4) 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 (ESDER4) Revised Straw Proposal*. In these comments, DMM provides input on the Revised Straw Proposal for a default energy bid (DEB) and an end-of-hour state-of-charge parameter for energy storage.

The Revised Straw Proposal DEB for energy storage resources represents significant progress toward the goal of accurately representing marginal costs of energy storage resources for use in market power mitigation. Most notably, the Revised Straw Proposal makes significant advances in capturing maintenance costs associated with cycling of lithium-ion batteries, and includes an attempt to capture charging costs and opportunity costs associated with potentially foregone profit opportunities later in a day.

While these features represent significant improvements in the estimation of marginal cost for energy storage resources, the proposed DEB approach does not account for variations in opportunity costs at different points in a day. Further, the approach may overstate opportunity costs by failing to account for the fact that energy storage resources are capable of charging and discharging potentially multiple times over a day. Additional refinement of opportunity cost calculations could more accurately capture the dynamic nature of opportunity costs for energy storage resources.

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 also believes certain aspects of the end-of-hour state of charge parameter could benefit from further discussion. This includes interactions with resource adequacy must-offer rules, treatment of the SOC parameter between the 15 and 5-minute markets, and BCR and settlement rules under market and exceptional dispatches. Detailed comments on DEBs for storage resources and the end-of-hour SOC parameter are provided below.

I. Default Energy Bid for Energy Storage Resources

Opportunity costs are dynamic and should reflect opportunities to recharge

The Revised Straw Proposal includes opportunity costs as one of four cost categories for energy storage resources. DMM highlighted the role of opportunity costs for energy storage resources in earlier comments and appreciates the ISO's inclusion of this cost in the proposed default energy bid methodology.[1] 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. These costs are dynamic and change over the day with respect to 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.

To illustrate this concept, 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

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[1] *Discussion on default energy bids for energy storage resources*, Department of Market Monitoring, Presentation at ESDER 4 Working Group Meeting, June 27, 2019: http://www.caiso.com/InitiativeDocuments/DMMPresentation-EnergyStorage-DistributedEnergyResourcesPhase4-Jun27-2019.pdf

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

- 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 discharge 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[2]:

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

$$= \$150*1.1$$

$$= \$165$$

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[3]. 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*.[4]

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 Straw Proposal outline a generalized approach that more fully accounts for opportunity and other costs at different points in the optimization period.[5] This general approach accounts for the dynamic nature of energy storage opportunity costs at

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

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

[4] Ibid, at p. 14.

[5] DMM May 21 Comments on ESDER 4 Straw Proposal.

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 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 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

The ISO proposes to allow NGR resources to submit end-of-hour *state-of-charge* (SOC) target ranges in real-time. The real-time market would honor target SOC constraints, potentially resulting in the NGR resource being dispatched uneconomically to either charge or discharge to meet end-of hour constraints.

The ISO explains that this parameter is justified for a couple reasons. First, resources may be fully discharged early in the day which "could prevent the optimal use of the resource later in the day given the limited outlook of the real-time market horizon."[6] Second, the ISO states that "[a] scheduling coordinator may want to manage a non-generator resource's state-of-charge throughout the day so that the device has enough energy to meet its day-ahead schedules or its obligations as a transmission asset later in the day."[7]

DMM understands the ISO's second set of concerns given that the ISO may need a mechanism to ensure a NGR resource can be available to meet reliability-based schedules, either as a market-participating

[6] Revised Straw Proposal, p.4
[7] Revised Straw Proposal, p.4.

resource or a transmission asset in the future. However, DMM still has questions about the severity of the first issue as described in the Revised Straw Proposal, i.e. that discharge of a resource could prevent optimal use of the resource later in the day given the limited outlook of the real-time market horizon

If resources' bids adequately reflect short-run marginal costs which includes opportunity costs based on estimates of foregone future profit opportunities, resources should not be disadvantaged by schedules received throughout the day. Scheduling resources according to target SOC may actually result in sub-optimal operation of the NGR resource across the day compared to being scheduled based on economic bids.

In previous stakeholder meetings, the need for a target SOC biddable parameter was discussed in the context of supporting multi-use applications (MUA).[8] In order to formulate our opinion on this aspect of the ESDER 4 proposal, DMM would appreciate stakeholders or the ISO describing the actual MUA use cases that might warrant use of the SOC feature and what benefit this functionality would provide the wholesale market. DMM recommends that the ISO vet the hypothetical benefits to the wholesale market more rigorously before introducing a new parameter that would allow SCs to manage NGR dispatch away from the optimal real-time market solutions.

Interaction with Resource Adequacy

Under current CPUC Qualified Capacity (QC) counting rules, a battery resource 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, the market schedules of battery resources at these levels may be infeasible given resources' actual states-of-charge.

The ISO's proposed end-of-hour SOC feature would give SCs control over setting resources' target SOC and could allow SCs to submit target SOCs that fall below resources' 4 hour RA values. NGR resources could continue to meet must-offer obligations through energy bids and avoid RAAIM penalties, even if these resources cannot feasibly be scheduled up to RA values for four consecutive hours. The ISO should consider whether a battery submitting a max end-of-hour 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. Batteries providing RA should be exposed to the same availability penalties/incentives as other RA resources, creating an incentive for these resources to be available at their RA values.

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

[8] ESDER 4 Straw Proposal Stakeholder Web Conference, May 7, 2019, Slide 8: http://www.caiso.com/InitiativeDocuments/Presentation-EnergyStorageandDistributedEnergyResourcesPhase4-May72019.pdf

of battery resources in capacity values and payments 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 target SOC feature to limit availability.

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

The ISO should clarify how the end-of-hour SOC parameter will function between the 15-minute market (RTPD) and 5-minute market (RTD). Specifically, it is not clear whether the ISO intends to lock 15-minute market (RTPD) schedules in the 5-minute market (RTD).

If RTPD schedules are not held through RTD, RTPD schedules driven by a SOC constraint could be unwound in corresponding RTD market runs that do not look out far enough to capture the end-of-hour SOC constraint that was considered by RTPD. If the SOC parameter is used extensively, significant changes in NGR schedules between certain RTPD and corresponding RTD market runs could occur.

In order to inform appropriate settlement rules when the SOC parameter is used, DMM believes it is important for the ISO to first clarify how the end-of-hour SOC parameter will be treated between RTPD and RTD.

BCR and settlement issues

DMM agrees with the ISO that BCR eligibility rules should be considered if SCs are allowed to submit a target SOC parameter. The ISO proposes to exclude the hour leading up to the end-of-hour SOC target or the hour preceding a self-schedule from real-time BCR calculations. The efficacy of the ISO's proposal will depend on how schedules under the SOC constraint are treated in real-time. Therefore, as discussed above, the ISO should first clarify how the end-of-hour SOC parameter will be considered between RTPD and RTD.

DMM also raises the following points/questions regarding BCR and settlements related to use of the end-of-hour SOC parameter:

- If RTPD schedules are re-optimized and can potentially be unwound in RTD, the ISO's proposal may be sufficient to mitigate potential BCR gaming opportunities. Uneconomic movement of a battery to meet an end-of-hour SOC target would primarily be limited to RTD market runs, and generally limited to an hour timeframe. However, if RTPD schedules will be locked in RTD, then the impact of the target SOC constraint may extend beyond the adjacent hour.
- DMM observes that 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. For example, a resource may set a wide target SOC range. 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.
- DMM is interested to understand whether the ISO could extract shadow prices from target SOC constraints. Whether a set of real-time intervals should be excluded from the real-time BCR calculation could depend on whether the SOC constraint exhibited a positive shadow price.

- If RTPD schedules are locked in RTD, the ISO should also consider whether the resource's energy while ramping across hours would be considered Residual Imbalance Energy (RIE) which could introduce additional settlement concerns.

Additional considerations

- In addition to self-schedules of energy, NGR resources can self-provide ancillary services in real-time. The ISO enforces that a NGR resource's state-of-charge must allow resources to deliver full ancillary services awards over a 30 minute period. Self-provision of AS could therefore drive the same uneconomic dispatches to meet minimum SOC levels as energy self-schedules.
- The ISO should detail how the end-of-hour SOC parameter will be used to exceptionally dispatch NGR resources and how settlements might work for these resources. Exceptional dispatches of NGR using the SOC parameter has not been discussed yet in stakeholder meetings.