Comments on Storage Design and Modeling Working Group Session 1

Department of Market Monitoring

January 8, 2025

Overview

The Department of Market Monitoring (DMM) appreciates the opportunity to comment on the *Storage Design and Modeling Working Group Session 1* held December 11, 2024.[1] DMM supports further storage policy design and modeling enhancements as the amount of storage resources increases and the California ISO gains additional experience with these resources. The proposed scope of this initiative addresses many of the outstanding storage market design issues DMM and others have raised.

While DMM supports many items in the proposed scope of this initiative, DMM highly encourages the ISO to address the storage bid cost recovery (BCR) concerns as the top priority, before undertaking additional storage design enhancements. In these comments, DMM provides comments on the proposed storage design and modeling (SDM) initiative. DMM includes comments on the following seven issues:

- **Storage bid cost recovery (BCR).** DMM recommends the ISO complete a comprehensive review of BCR rules for batteries, and address the previously identified efficiency, gaming, and underlying bidding incentives issues. This should be the top priority in this initiative, and should be complete before undertaking other storage market design enhancements that may be complex and time consuming to develop and implement.
- **Storage default energy bids (DEB).** Storage DEBs should be hourly, and change to reflect changing intraday opportunity costs. This may result in some hours with higher DEBs, and some hours with lower DEBs than would be produced under the current methodology. Additionally, the ISO should develop DEBs for storage resources in the Western Energy Imbalance Market (WEIM).
- **Hybrid resource DEBs.** Hybrid resources are not currently subject to local market power mitigation (LMPM), but could potentially exercise market power in uncompetitive conditions. These resources should be subject to LMPM, and the ISO should develop an appropriate DEB to reflect the resources' marginal costs.
- **Improved state-of-charge (SOC) definitions and biddable SOC functionality.** DMM recommends the ISO develop enhanced tariff and business practice manual (BPM) definitions for telemetered SOC and the day-ahead initial SOC (DA-ISOC). DMM supports the ability for storage resources to bid based on SOC to better reflect marginal costs and improve storage resource availability and operations.

[1] *Storage Design and Modeling Working Group Session 1*, CAISO, December 11, 2024: https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Storage-Design-and-Modeling-Dec-11-2024.pdf

- **Improved outage reporting.** DMM recommends improving the outage management system to more accurately reflect limitations that are specific to storage resources, while also considering interdependent policies such as resource adequacy availability incentive mechanism (RAAIM) and unforced capacity (UCAP).
- **Co-located resources and settlement enhancements.** DMM recommends the ISO work to improve the settlement design for co-located resources with urgency, but not at the expense of first addressing the BCR design for storage resources.
- **Modeled flexible ramp product (FRP) awards.** DMM recommends the ISO further demonstrate the issue being identified and the importance of the need to address this issue.

Comments

Storage BCR design should be the top priority in this initiative

DMM and the Market Surveillance Committee (MSC) have identified efficiency, gaming, and bidding incentive issues with the current BCR design for batteries. While the recent Storage BCR and DEB Enhancements Track 1 initiative and related filing at FERC limits the gaming issues, these design changes do not directly address the core efficiency issues caused by the current storage BCR design.[2,3,4] Addressing these core efficiency issues should be a priority ahead of the rest of this initiative.

This initiative should thoroughly assess drivers of storage BCR under the current design, and clearly determine where BCR payments are warranted for storage resources to support efficient dispatch, and develop rules targeted at paying BCR to storage resources only in those cases.[5] Currently, storage BCR rules operate from a presumption of eligibility with specific cases removed as they are identified as problematic. DMM recommends the converse, to assume no BCR eligibility for batteries and add eligibility where deemed appropriate.

The majority of real-time BCR currently paid to batteries is the result of binding state-of-charge (SOC) constraints that prevent delivery of day-ahead schedules. This BCR removes exposure to real-time opportunity costs, and creates efficiency, gaming, and reliability concerns. A primary purpose of BCR is to incentivize resources to submit bids that accurately reflect actual costs so that the market optimization achieves efficient market outcomes. The current BCR design for storage resources does the

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[2] *Tariff Amendment to Prevent Unwarranted Bid Cost Recovery Payments to Storage Resources, and Request for Effective Date on Shortened Notice*, CAISO, November 26, 2024: https://www.caiso.com/documents/nov-26-2024-tariff-amendment-bid-cost-recovery-to-storage-resources-er25-576.pdf

[3] *Opinion on Storage Bid Cost Recovery*, James Bushnell, Scott M. Harvey, Benjamin F. Hobbs; Members of the Market Surveillance Committee, November 1, 2024: https://www.caiso.com/documents/market-surveillance-committee-final-opinion-storage-bid-cost-recovery-nov-01-2024.pdf

[4] *Comments of the Department of Market Monitoring of the California Independent System Operator Corporation*, CAISO DMM, ER25-576-000, December 17, 2024: https://www.caiso.com/documents/dmm-comments-on-er25-576-storage-bcr-dec-17-2024.pdf

[5] *Comments on Storage Bid Cost Recovery and Default Energy Bids July 8, 2024 Workshop*, CAISO DMM, July 18, 2024: https://stakeholdercenter.caiso.com/Common/DownloadFile/6a07fe60-f791-489c-8100-64e2f7b55118

opposite, and instead creates incentives to bid inconsistent with real-time opportunity costs in hours preceding day-ahead schedules.

The SDM initiative should review all potential drivers of storage BCR to determine instances in which these payments may be warranted. However, DMM believes that eliminating real-time BCR eligibility for batteries when SOC constraints bind would be a significant step toward addressing the core efficiency issues with the current storage BCR design.

In the recently completed Storage BCR and DEB Enhancements Track 1 initiative, the ISO initially proposed to solve the core problem in this way, by removing BCR eligibility in cases where the market was not choosing the awards due to binding SOC constraints. DMM encourages the ISO to continue exploring methods of identifying SOC insufficiency, so that eliminating BCR eligibility in such instances could be a viable solution to the core problem in the BCR design, creating incentives for storage resources to submit bids reflecting expected real-time intraday opportunity costs. If the ISO determines through the SDM stakeholder process that BCR may be warranted in some instances that SOC constraints are binding, such cases should be allowed only as an explicit exception to a more general rule that storage resources are not eligible for BCR resulting from binding SOC constraints.

DMM believes most day-ahead storage BCR is not warranted. DMM finds the vast majority of day-ahead BCR for storage resources arises from scheduling coordinator parameter submissions forcing uneconomic schedules for the resource. Since storage does not have commitment costs, nor relevant ramping constraints, and the day-ahead market optimizes over the full 24-hour horizon, there should be little to no day-ahead BCR for batteries. DMM notes, however, that BCR may be warranted in the day-ahead market in limited instances such as exceptional dispatches. However, such instances should be explicitly determined in the SDM stakeholder process, and should be exceptions to a general assumption that there should not be any day-ahead BCR for storage resources.

In general, DMM recommends that through the SDM initiative, the ISO clearly identify where storage BCR is warranted, and where it is not, in both the real-time and day-ahead markets. The resulting BCR design should address the core efficiency issues created by the current BCR design.

Mitigation plays a minimal role in storage BCR on average

In the Storage BCR and DEB Enhancements Track 1, the ISO proposed to eliminate BCR eligibility during intervals where the SOC was insufficient to meet a day-ahead schedule in real-time. The stakeholder process raised the issue of whether the ISO's current local market power mitigation (LMPM) procedures might undermine or offset the efficiency and reliability benefits that would result from the BCR modifications initially proposed by the ISO, such that it would not be worth undertaking these BCR changes without changes to the current storage DEBs.

To address this issue, DMM analyzed the actual and potential impacts of bid mitigation on the dispatch of batteries using market data from Restricted Maintenance Operations (RMO) days in summer 2023 and 2024. Based on this analysis, DMM does not believe that mitigation using the current default energy bids for storage resources would significantly limit the efficiency and reliability benefits of the ISO's

initial proposal to eliminate BCR eligibility when SOC is insufficient to meet a day-ahead schedule.[6] Therefore, DMM continues to recommend the ISO thoroughly address the efficiency, gaming, and bidding incentives that arise from BCR before addressing any further storage enhancements.

Mitigation may still result in financial losses to a battery due to SOC insufficiency in some intervals. While DMM's analysis suggests such losses would be relatively limited overall, such losses might be more significant for certain resources. Therefore, additional settlement provisions may be needed to prevent revenue losses when a storage resource's bids are mitigated, causing them to have insufficient SOC to meet day-ahead schedules. As noted by the Market Surveillance Committee (MSC), such provisions could be based on current settlement provisions that were developed to compensate batteries for any lost revenues due to exceptional dispatches issued to hold state-of-charge.[7]

Storage DEBs should vary hourly to incorporate changing intraday opportunity costs

DMM continues to recommend that the ISO improve storage default energy bids (DEBs) to vary across different hours of the day and better reflect real-time opportunity costs.[8] Currently, batteries can opt to have default energy bids that include an opportunity cost component based on the fourth highest resource LMP from the day-ahead market, plus a 10 percent adder.[9]

The option may be effective and efficient in many instances. However, in real-time, these DEBs may be insufficient to capture intraday opportunity costs associated with potentially higher real-time prices based on changing real-time conditions. Further, the current DEB design is a static value over all hours of the operating day and does not consider changing intraday opportunity costs throughout the day. This implicitly indicates that the storage resource can only discharge up to one cycle per day, with no ability to recharge. This formulation can lead to a DEB that is too high in some hours, and too low in other hours. DMM recommends the ISO develop DEBs that vary with changing intraday opportunity costs, where the DEBs could be higher in the intervals leading up to the peak pricing hours, and lower in later intervals as intraday opportunity costs fall, or earlier intervals where recharge opportunities exist before reaching peak pricing hours.

DMM believes it is important to focus on the opportunity cost component of the DEB calculation. The rationale for using opportunity costs to estimate short run marginal costs (or the opportunity cost DEB) of energy storage resources is that dispatch in one interval may only be possible by forgoing profit opportunities in a future interval. If the storage resource operator maximizes profit over some period of time (such as a day), then an appropriate estimate of short run marginal cost is one that covers the marginal opportunity cost of a dispatch that deviates from the expected profit maximizing dispatch over

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[6] *Comments on Storage BCR and DEB Enhancements Revised Draft Proposal for Track 1*, CAISO DMM, October 23, 2024: https://stakeholdercenter.caiso.com/Common/DownloadFile/f70571ef-5b73-4db3-b1d2-22cc489098ba

[7] *Opinion on Storage Bid Cost Recovery*, James Bushnell, Scott M. Harvey, Benjamin F. Hobbs; Members of the Market Surveillance Committee, November 1, 2024: https://www.caiso.com/documents/market-surveillance-committee-final-opinion-storage-bid-cost-recovery-nov-01-2024.pdf

[8] *Comments on Storage Bid Cost Recovery and Default Energy Bids July 8, 2024 Workshop*, CAISO DMM, July 18, 2024: https://stakeholdercenter.caiso.com/Common/DownloadFile/6a07fe60-f791-489c-8100-64e2f7b55118

[9] For a four hours energy storage resource. For an N hour energy storage resource, it would be the Nth highest day-ahead LMP. See Appendix D, Market Operations Business Practice Manual, p 310: https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market%20Instruments

the day. DMM recommends framing the storage DEB formulation as an estimate of the marginal opportunity cost of the storage resource in a particular interval (or hour).

For a real-time storage DEB, DMM recommends the ISO work with stakeholders to develop a method to calculate an intraday opportunity cost following the principles discussed above. To more accurately capture intraday opportunity costs for batteries in the real-time market will require the ISO to develop a DEB using an enhanced framework to estimate opportunity costs outside the market optimization horizon. Crucial to the enhanced framework would be to ensure that the model accurately accounts for opportunity costs by considering the ability of storage resources to discharge and recharge before reaching future intervals.

DMM further recommends the ISO consider the need to estimate the enhanced storage DEB for resources with different storage duration parameters, as the duration of the storage resource will alter the opportunity cost of the resource's stored energy and charging ability.

The ISO should develop DEBs for batteries in other WEIM areas

DMM notes that the current storage DEB is not available to storage resources in the WEIM other than those in the CAISO, and there is no other standard DEB available for these WEIM storage resources. This necessitates the use of negotiated default energy bids to estimate marginal costs for these resources. DMM recommends that in the near term, the ISO make the current storage DEB available to all WEIM resources, using alternative price inputs as needed where binding day-ahead prices are unavailable. DMM further recommends the ISO extend any enhanced real-time storage DEB developed in this initiative to WEIM storage resources, adapting as necessary to meet the specific needs of those resources.

The ISO should develop DEBs for hybrid resources, and subject these resources to local market power mitigation

DMM believes hybrid resource DEB development should be a high priority for the ISO. Currently, hybrid resources are not subject to local market power mitigation, and do not have a functional DEB. DMM analysis found that in 2023, on average up to 70 megawatts of hybrid resources could have been subject to mitigation but were not because of the hybrid resource mitigation rules.[10] To ensure competitiveness on the system, the ISO should develop a hybrid DEB and include hybrid resources in the LMPM market process.

Hybrid resources are multiple generators modeled as a single resource. The ISO collects data on the individual generation components of hybrid resources, and DMM recommends the ISO implement a DEB that is consistent with these individual components. A DEB cannot be applied individually to each generation component of a hybrid resource.

One potential simple approach to calculating a single DEB for a hybrid resource would be to use the maximum of the DEBs that would apply to each of the generation components that make up the hybrid resource. In cases where there are variable energy resources (VERs) paired with storage, the DEB would often be the opportunity cost of the storage component. In a case of a non-VER and storage, the DEB

[10] *2023 Special Report on Battery Storage,* DMM, July 16, 2024, p 36: https://www.caiso.com/documents/2023-special-report-on-battery-storage-jul-16-2024.pdf

could take the maximum of the piecewise DEB, and in a case where the storage DEB is greater, limit the DEB to the horizon of the SOC from the storage resource. While this type of approach may overestimate the marginal costs of hybrid resources in some hours, a simplified approach that is easy to implement would be preferable to a continued total lack of mitigation of hybrid resources. Hybrid resource DEBs should then continue to be enhanced in future initiatives as appropriate to more accurately reflect the costs of hybrid resources.

Often, hybrid resources are a combination of a non-storage resource and a storage resource. Therefore, prior to hybrid resource DEB implementation, the ISO should complete refinements to the enhanced storage DEB to more accurately consider changing intraday opportunity costs. Upon completing refinements to the storage DEB, the ISO can and should analyze the impact of the piecewise hybrid DEB configuration for further stakeholder discussion.

Improved SOC definitions and biddable SOC functionality

The tariff and BPMs need enhanced definitions of telemetered SOC and day-ahead initial SOC

DMM recommends the ISO improve tariff and BPM definitions for telemetered SOC and the day-ahead initial SOC (DA-ISOC) parameters. These two parameters are important inputs in the market model, and DMM has observed instances of values that are inaccurate or infeasible, impacting market outcomes and settlements.

Telemetered SOC is defined in Appendix A of the CAISO tariff as "The Energy available to CAISO Markets from a Non-Generator Resource or storage device." DMM has identified cases in which the telemetered SOC may reflect energy that is stored in cells of the resource, but is not accessible at the time the SOC is calculated. Further, DMM understands there are multiple potential ways to calculate SOC for a battery resource, and the tariff and BPMs are not prescriptive on which approach should be used.

DMM recommends the ISO establish and document a consistent methodology to be used in calculating SOC, and define an appropriate timeframe within which the stored energy must be available to the market. For instance, the ISO may specify that the reported telemetry value should only reflect stored energy that is accessible at the time of the SOC calculation. An enhanced definition of telemetered SOC will improve system reliability, and the efficient provision of energy, ancillary services, and flexible ramping product.

The DA-ISOC is a parameter scheduling coordinators may submit prior to the day-ahead market run. This parameter serves as the initial condition for the resource in the day-ahead market. The CAISO tariff indicates that this parameter should be the "…forecasted starting physical position of the Non-Generator Resource."[11] However, DMM has observed data suggesting that there may be some ambiguity around the current tariff definition, and what limitations should be reflected in the DA-ISOC when a given level of SOC is likely to be unachievable at the beginning of the real-time market.

DMM recommends the ISO enhance tariff and BPM definitions for the DA-ISOC parameter, clarifying what constitutes a "forecasted starting physical position", and outlining specific expected SOC limitations that should be considered in the submitted DA-ISOC value.

[11] *CAISO Tariff*, Section 30.5.6.1

The ISO should also reconsider if the default value of zero MWh is the appropriate value to use if no value is submitted, as this can further exaggerate differences between day-ahead and real-time initial SOC. Large differences between the DA-ISOC and the real-time initial SOC may lead to infeasible day-ahead schedules in real-time, which can contribute to unwarranted BCR under current rules.

Biddable SOC functionality would improve the market model for storage

DMM supports the ISO's development of a new energy storage model that considers variation in cost and operational characteristics by state of charge (SOC). DMM views this model as a significant improvement in the ability of storage resources to accurately reflect costs and resource limitations applicable to a particular market interval.

DMM understands that costs for storage resources can vary based on SOC, so that the cost of producing at a given megawatt output level can vary depending on SOC. This can be true for O&M and cycling costs, as well as for opportunity costs associated with expected market opportunities in future intervals.

Storage resources are expected to bid their opportunity costs based on an assumption of the resource's SOC in the current and future intervals. However, the final period to update bids is T-75 minutes before the hour, and bids will be static over that hour regardless of whether the resource is dispatched between the T-75 minutes submission and dispatch. As a result, the SOC could end up being significantly different between the energy bid submission and dispatch.

Accepting bids in relation to SOC, rather than megawatt operating level, resolves the static energy bid curves relationship with bid submission timing. DMM's understanding is that the market model would be able to take the SOC bids and translate them into the standard market model bid curve with price-quantity pairs for a given period. The translation would then accurately reflect costs at the time of dispatch conditional on the resource's SOC. These improvements would allow storage resources to mitigate issues such as foldback, and more accurately bid their intraday marginal costs. However, the translation to the price-quantity pairs for a bid curve must ensure the bid curve reflects marginal costs, and not average costs, to ensure consistent price formation across all resource types.[12]

If the ISO develops this new energy storage model, DMM recommends close attention be paid to LMPM, particularly in the real-time dispatch (RTD) market. Supposing bids for SOC are translated to a standard bid curve and price-quantity pairs, the LMPM runs will need to modify mitigation as SOC changes. However, in RTD, a bid could be mitigated in an advisory interval and flow through to the binding RTD interval. With the SOC changing between advisory and binding intervals, so could the bid curve. A more appropriate mitigated bid in this instance would consider the mitigated SOC bid applicable to the SOC at the start of that interval, rather than the previous advisory intervals. This would ensure that the market clearing solution in the binding interval accurately reflects the cost of the mitigated energy storage resource at the SOC in that interval of binding schedules, but would require significant changes to the RTD LMPM process.[13]

[12] *Comments on Energy Storage Enhancements Revised Straw Proposal*, CAISO DMM, April 7, 2022: https://www.caiso.com/documents/dmm-comments-on-energy-storage-enhancements-revised-straw-proposal-apr-7-2022.pdf

[13] Ibid.

Finally, DMM notes that the proposed storage model using biddable SOC has an interdependency with the resource adequacy availability incentive mechanism (RAAIM). The SOC bidding model, and foldback issues, will limit the full Pmin and Pmax of a resource in the regions where there are limited abilities to charge or discharge. If a generic or flexible resource adequacy (RA) resource cannot bid their full RA showing, this impacts the resource's availability. And changes in availability will then lead to storage resources incurring RAAIM penalties, which would disincentivize resources in reaching the zones in which foldback occurs. DMM recommends this interdependency be raised in the stakeholder process for further discussion.

Improved outage reporting would assist in operations and monitoring

Storage resources face limitations and outage types not currently covered in outage management system (OMS) that are unique to storage resources, such as negative Pmin and energy (SOC) limitations. DMM agrees there needs to be improvements made to the definition of the outage options in the OMS, and requirements around the timing requirement of outage submission for storage resources. The timing requirements for storage outages should also apply to SOC limitations, in addition to Pmin and Pmax rerates and derates.

Furthermore, when resources have SOC limitations, it is often due to a physical outage. For example, the physical outage may be an inverter that is not functioning correctly, which could be correlated with limitations on Pmax or Pmin for the resource. DMM recommends the ISO work with stakeholders to include these outages into OMS to ensure efficient and reliable market function. Improved outage reporting will assist market operators and monitors in ensuring the system is operating reliably and efficiently.

DMM understands that a common limitation for storage resources are issues of *foldback*, or varying ramp rates at the upper and lower ends of a resource's SOC range. Allowing scheduling coordinators to bid their SOC, versus capacity, would alleviate some of the issues of foldback. Allowing an outage card to represent foldback would further aid in an accurate representation of a storage resource to the market. Additionally, DMM recommends the ISO include foldback into resource characteristics through Master File.

DMM notes there are interdependencies between storage outage reporting and the ISO's policy initiative on Resource Adequacy Modeling and Program Design (RAMPD) that should be considered. Within the RAMPD initiative, resources that go on forced outage could potentially lose resource adequacy capacity, or net qualifying capacity (NQC), through the unforced capacity (UCAP) mechanism. Currently, UCAP is considering outages that are at the control of the scheduling coordinator. The ISO should develop new storage outage reporting to be interoperable with the RAMPD initiative, taking UCAP into consideration.

Lastly, there was a suggestion that dynamic limits could be used to manage storage resources in place of OMS. DMM recommends against this because the ISO has full visibility of storage resource operations that it lacks for hybrid resources, and storage outages are physical limitations that are more appropriately reflected in OMS. Storage resources do not have the same non-physical operating considerations that hybrid resources may reflect through dynamic limits (e.g., a desire to charge onsite storage). Further, OMS provides a much greater degree of visibility for the ISO and DMM, which is important for monitoring purposes and consideration of overlapping policies, such as RAAIM and

forthcoming UCAP. DMM recommends the limitations are accurately captured in OMS to ensure the overlapping policies are appropriately applied to the resource availability and performance incentives.

Co-located resources and settlement design

Co-located resources are becoming increasingly developed in the CAISO system, making up over half of the installed storage capacity (as of June 1, 2024).[14] Given the scale of co-located resources, and some recently observed market outcomes involving co-located resources, DMM recommends the ISO work to improve the settlement design for co-located resources with urgency. However, DMM views this as a secondary priority to addressing the BCR design for storage resources.

Modeled flexible ramp product (FRP) awards in SOC calculation needs further investigation

DMM recommends that during the development of the Issue Paper, the ISO should further demonstrate the need to incorporate SOC management into capacity awards, or FRP. It is understood there could be a theoretical consideration where SOC modeling requires the incorporation of the FRP. However, it appears FRP schedules are incorporated into the envelope equation in section 7.8.2.5 of the Market Operations BPM and the Energy Storage Enhancements Track 1 Business Requirements Specification.[15]

[14] *2023 Special Report on Battery Storage,* CAISO DMM, July 16, 2024: https://www.caiso.com/documents/2023-special-report-on-battery-storage-jul-16-2024.pdf

[15] *Energy Storage Enhancements Track 1 Business Requirements Specification,* CAISO, February 7, 2023, section 4.2.1, ESE-BRQ036: https://www.caiso.com/documents/businessrequirementsspecificationenergystorageenhancementstrack1.pdf