Comments on Storage Design and Modeling Working Group Presentation - May 18, 2026

Department of Market Monitoring

June 5, 2026

Summary

The Department of Market Monitoring (DMM) appreciates the opportunity to comment on the *Storage Design and Modeling* working group presentation held on May 18, 2026.[1]

DMM supports the ISO's proposal to incorporate a time-of-day multiplier into the storage default energy bid (DEB) to reflect how opportunity costs vary throughout the day. DMM has long argued that a theoretically sound storage DEB should vary for different hours of the day, since opportunity costs for storage resources change throughout the day based on upcoming prices and their ability to charge and discharge.

While DMM has shown that the current storage DEB performs well as an input to local market power mitigation, DMM agrees that it could be improved to more accurately reflect varying intraday opportunity costs for storage resources. DMM appreciates the ISO's progress in proposing a DEB multiplier that more accurately reflects the hours with higher and lower opportunity costs, and DMM's recent analysis shows that a simple time-of-day multiplier like the ISO is proposing could yield notable benefits.

DMM questions whether the inclusion of the gas floor component is appropriate as an input to estimate the marginal costs of storage resources. DMM believes the current storage DEB's utilization of locational prices from previous market runs more directly reflects estimated opportunity costs and would likely incorporate the cost of gas-fired resources when applicable. DMM requests the ISO provide further justification for why the gas floor should be incorporated into the storage DEB formulation.

DMM generally supports other proposed enhancements to storage outage management and storage resource modeling as discussed in the ISO's May 18 presentation. However, DMM continues to note that such enhancements should not be developed and pursued at the expense of comprehensive bid cost recovery (BCR) design enhancements for storage resources. The ISO's May 18 presentation appears to suggest that other enhancements will be pursued before continuing work on storage BCR design, and that the ISO will "assess whether additional BCR changes are needed" after implementing such enhancements.[2] DMM disagrees with this approach and recommends the ISO continue to prioritize BCR design for storage resources independent and ahead of other storage market design changes.

[1] *Storage Design and Modeling: Working Group on Uplift and Default Energy Bids, and Outage Management* presentation, California ISO, May 18, 2026: https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Storage-Design-Modeling-May-18-2026.pdf

[2] Ibid, slide 8.

Comments

A simple refinement to allow the storage DEB to vary across the day could yield significant benefits

DMM supports the ISO's proposal to incorporate a time-of-day multiplier into the storage DEB formulation in order to more accurately reflect intraday opportunity costs. DMM has previously found that the current storage DEB framework performs well as an input to mitigation, and does not result in significant inefficient real-time dispatch when storage resources are mitigated.[3] However, DMM has long argued that a theoretically sound storage DEB should calculate marginal costs on an hourly basis, since opportunity costs change throughout the day based on upcoming prices and the resource's ability to charge or discharge.[4] While an ideal storage DEB would vary hourly, DMM's recent analysis indicates that even a simple time-of-day multiplier that raises and lowers the DEB during certain hours can yield significant improvements.[5] DMM recommends the ISO continue to develop refinements to the current storage DEB with a simple time-of-day multiplier that takes on values reflecting hours with higher and lower opportunity costs, rather than introducing more complex storage DEB design changes.

The time-of-day multiplier should be based on empirical analysis of how opportunity costs are higher and lower at different times of the day

DMM supports a time-of-day multiplier similar to the illustrative example provided by the ISO, but recommends a multiplier grounded in a more empirical basis. DMM's previous analysis shows that the hour in which the higher DEB multiplier switches to the lower DEB multiplier can significantly impact the efficiency of battery schedules when batteries are subject to mitigation.[6] The determination of which hours have higher or lower multipliers should be based on empirical analysis to ensure the multipliers result in DEBs that accurately reflect the opportunity costs throughout the day without understating or overstating those costs, particularly in pivotal hours. DMM continues to recommend flexibility in the assignment of multiplier values across different hours as it is likely that the highest priced hours will change seasonally and there may be changes in long-term trends as well.[7]

The design of the time-of-day multiplier should ensure storage DEB values are high enough during some hours to prevent inefficient dispatch under mitigation when opportunity costs are higher, while still protecting against potential exercise of market power during high-priced hours when opportunity costs are lower and market conditions may be tight. Intraday opportunity costs are higher leading up to the highest-priced hours and lower during these highest-priced hours. When prices are highest, the opportunity cost of

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[3] *2024 Special Report on Battery Storage,* Department of Market Monitoring, May 28, 2025: https://www.caiso.com/documents/2024-special-report-on-battery-storage-may-29-2025.pdf

[4] *Comments on Energy Storage and Distributed Energy Resources Storage Default Energy Bid Draft Final Proposal,* Department of Market Monitoring, October 9, 2020: https://www.caiso.com/documents/dmmcomments-esder4storagedefaultenergybiddraftfinalproposal-oct92020.pdf

[5] *Comments on Storage Design and Modeling Working Group Presentation on March 16, 2026,* Department of Market Monitoring, April 3, 2026: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-mar-16-2026-working-group-presentation-apr-03-2026.pdf

[6] *Comments on Storage Design and Modeling Working Group Presentation on March 16, 2026,* Department of Market Monitoring, April 3, 2026, pp 10-11.: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-mar-16-2026-working-group-presentation-apr-03-2026.pdf

[7] *Comments on Storage Design and Modeling Updated Discussion and Issue Paper on Uplift and Default Energy Bid,* Department of Market Monitoring, January 8, 2026: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-updated-discussion-and-issue-paper-on-uplift-and-default-energy-bid-jan-8-2026.pdf

being available in future hours is low as the highest prices have already materialized and there is time for the battery to recharge prior to the next set of high-priced hours. While DMM's preliminary analysis focused on the highest prices of the evening peak, having high and low multiplier periods leading up to and during the evening peak, DMM supports the ISO's illustrative proposal to include high and low multiplier periods based on the morning peak as well.

The current storage DEB formulation uses the N^{th} highest price of the day to estimate opportunity cost within the day.[8] Because this is a static value that does not account for multiple charging and discharging opportunities throughout the day, this value overstates the opportunity costs in many hours, and may underestimate the opportunity cost in others.

DMM recommends the storage DEB multiplier take on values both greater than and less than one to ensure that opportunity costs are not under- or over-estimated during particular hours of the day. DMM acknowledges the importance of protecting storage resources from being mitigated to DEB values that understate the opportunity cost and could lead to inefficient dispatch in the real-time. DMM agrees there may be instances when the N^{th} highest day-ahead price may be too low to protect against such occurrences and therefore supports a multiplier that takes on values larger than one in hours where the opportunity costs are highest. However, values less than one are also necessary in some hours to reflect that opportunity costs are lower than the N^{th} highest price during certain hours of the day, particularly in net peak hours when opportunity costs are lowest and the potential for market power may be higher.

DMM recommends the ISO incorporate the time-of-day multiplier into the day-ahead storage DEB as well. It is unclear to DMM why the same multiplier cannot be applied to day-ahead storage DEBs and why the ISO instead proposes to use the upper-bound of the multiplier throughout the entire day. DMM supports aligning the storage DEB structure across the day-ahead and real-time markets to support convergence between the two markets.

Inclusion of the gas floor as an input into the storage DEB does not seem appropriate as it is not directly related to the marginal cost of battery resources

As stated previously, DMM has shown that the storage DEB performs well overall as an input to local market power mitigation and does not result in significant inefficient real-time dispatch caused by mitigation. While DMM believes there are improvements that can be made to allow the storage DEB to more accurately reflect real-time conditions and variable intraday opportunity costs, DMM does not see how inclusion of the gas floor addresses either of these issues.

The gas floor is a value used in the short-term component of the hydro DEB, and it is one of several inputs used to estimate real-time prices at the resource's location.[9] The current storage DEB estimates the opportunity cost of storage by using the prices at that resource's node from previous market runs. DMM argues that this approach more accurately reflects expected prices at that resource's location in upcoming hours than gas prices. This is especially true if the storage DEB includes additional multipliers as proposed to better account for intraday opportunity cost, or if the storage DEB were to include a scaling approach to more directly account for differences between

[8] The price-based opportunity cost will be set at the value of the highest price corresponding to the discharge duration of the resource; for example, if a storage resource has a four-hour discharge duration, the price-based opportunity cost will be the fourth-highest price. See *Market Instruments BPM - Attachment D*.

[9] *Local Market Power Mitigation Enhancements Draft Final Proposal (Updated),* California ISO, January 31, 2019: https://stakeholdercenter.caiso.com/InitiativeDocuments/DraftFinalProposal-LocalMarketPowerMitigationEnhancements-UpdatedJan31_2019.pdf

day-ahead and real-time prices. Therefore, DMM questions whether inclusion of the gas floor is necessary or appropriate. While gas prices and electricity prices may be correlated, it is likely that the prices from previous market runs with appropriate scalar adjustments where appropriate will reflect gas prices when applicable.

DMM does not see a theoretically justified reason for including the gas floor in the storage DEB, and requests the ISO provide further justification for why the gas floor should be included in an estimate of the marginal cost of a storage resource.

DMM supports non-generator resource (NGR) outage management and nonlinearity modeling improvements, but these are not substitutes for storage BCR design changes

As discussed in the ISO's May 18 presentation and the Second Revised Straw Proposal on Outage Management Topic Group, the ISO is proposing to add new functionality to the Outage Management System (OMS) and to create a modeled solution to represent the nonlinearity of lithium-ion batteries.[10,11] DMM continues to support both improvements to increase the efficiency and transparency of the CAISO system.[12,13] However, DMM notes that such enhancements should not be viewed as a substitute for comprehensive bid cost recovery (BCR) design enhancements for storage resources.

The ISO's May 18 presentation appears to suggest that other enhancements will be pursued before continuing work on storage BCR design, and that the ISO will "assess whether additional BCR changes are needed" after implementing such enhancements. DMM disagrees with this approach and recommends the ISO continue to prioritize BCR design for storage resources independent and ahead of other storage market design changes that may further delay work on storage BCR design.

DMM supports Master File changes and outage reporting processes that improve transparency

In the ISO's May 2025 *Issue Paper and Straw Proposal on Outage Management, Nonlinearity, and SOC Clarification,* the ISO proposed to introduce new outage card types and clarifications unique to storage resources. Related changes were also introduced into the Business Practice Manual (BPM) Change Management process. The ISO has since removed all of these proposed changes from both the market design proposal and the BPM Change Management process.

In comments on the May 2025 Issue Paper and Straw Proposal, DMM focused on the updates to new OMS outage types unique to storage resources, and clarifications to resource management in the BPM Change

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[10] *Storage Design and Modeling: Working Group on Uplift and Default Energy Bids, and Outage Management* presentation, California ISO, May 18, 2026: https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Storage-Design-Modeling-May-18-2026.pdf

[11] *Storage Design and Modeling: Second Revised Straw Proposal on Outage Management Topic Group,* California ISO, May 7, 2026: https://stakeholdercenter.caiso.com/InitiativeDocuments/Second-Straw-Proposal-Outage-Management-Topic-Storage-Design-Modeling-May07-2026.pdf

[12] *Comments on Storage Design and Modeling Working Group Presentation on January 22, 2026,* Department of Market Monitoring, February 17, 2026: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-jan-22-2026-working-group-presentation-feb-17-2026.pdf

[13] *Comments on Storage Design and Modeling Issue Paper and Straw Proposal on Outage Management, Nonlinearity, and SOC Clarification,* Department of Market Monitoring, May 23, 2025: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-issue-paper-and-straw-proposal-on-outage-management-nonlinearity-and-soc-clarification-may-23-2025.pdf

Management process. The focus of the comments was on outage type usage to avoid RAAIM, and improved transparency for distribution connected resources.[14,15] As noted in these earlier comments, DMM continues to recommend the ISO increase transparency around distribution-level resources by creating a flag in Master File to facilitate monitoring of these resources. DMM also continues to support OMS enhancements where added transparency may be needed.

The proposed OMS enhancements outlined in the May 7 Second Revised Straw Proposal would allow for automated acceptance of an outage change request into the system following submission, and power minimum rerates on test energy cards during new resource implementation. DMM understands this will increase the efficiency of OMS for operations purposes. However, DMM finds the scope of improvements limited when a goal was to increase the transparency of storage resource outages. The Master File modeling of nonlinearities will reduce the need for some outages, but there are additional limitations experienced by storage resources that would benefit from additional outage card types to increase the transparency of their physical limitations.

One leading factor for storage resource outages (or derates) are power nonlinearities when the storage resource is near the minimum or maximum SOC. DMM continues to support the development of a Master File solution to approximate and incorporate the nonlinearities into the market model. The proposed solution to modeling nonlinearity uses additional Master File parameters that will scale the charging and discharging capabilities of the resource linearly with SOC in the extreme ranges of SOC. The solution creates an envelope for the operational range of storage resources to ensure feasible dispatches and allow for full access to the stored energy of the resource. DMM requests the ISO provide the mathematical formulation of the modeled approach, such as whether the envelope will be a hard constraint or have a penalty price.

Modeling nonlinearities through Master File will reduce the frequency of OMS use to reflect these limitations. However, there may still be cases when a storage resource will experience a power derate due to nonlinearities beyond the modeled approach that may need to be reflected to the market. Since these limitations will still exist and need to be included in the market through OMS, DMM continues to recommend the ISO create additional outage types specific to storage resource limitations.

Changes to storage resource modeling will impact other areas of the market

DMM has cautioned that any changes to storage capacity modeling, such as the Master File update for nonlinearities, need to contemplate the interrelated policies around resource adequacy and RAAIM. Any power output limitation on resource adequacy capacity, even if modeled in Master File, should be subject to RAAIM. The ISO has indicated that RAAIM will be addressed in the Resource Adequacy Program and Modeling Design (RAMPD) initiative. DMM will continue to be an active stakeholder in that process.

Further, DMM recommends the ISO clearly articulate how power limitations arising from this modeling approach will interact with interrelated market products, such as ancillary services, and the Day-Ahead Market Enhancement products of imbalance reserves and reliability capacity. The 24-hour optimization of day-ahead products should allow for more straightforward incorporation of modeled nonlinearities. However, the real-time products may run into limitations such as ancillary service deliverability. DMM recommends the ISO detail the interactions of the ancillary service SOC constraint and how changes in power limits from the new model will ensure real-time deliverability.

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[14] *Ibid.*

[15] *Comments on Storage Design and Modeling Working Group Presentation on September 29, 2025,* Department of Market Monitoring, October 14, 2025: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-sep-29-2025-working-group-presentation-oct-14-2025.pdf

NGR bidding enhancements could improve storage modeling, but DMM recommends the ISO continue to prioritize BCR design for storage resources

In January 2026, the ISO presented a potential new non-generator resource (NGR) bidding model for storage resources that would allow the resources to bid state-of-charge, instead of power output.[16] The ISO introduced another alternative approach to a new NGR bidding model in the May 18, 2026 stakeholder meeting.[17]

The NGR bidding approach presented in May appears to be a simplification of the January proposal. As an initial point, DMM asks the ISO to clarify whether the May proposal is a replacement for the January proposal, an interim step, or a first step to developing a more complete biddable SOC model.

The NGR bidding proposal introduced in May would allow storage resources to bid a single-value end-of-horizon state-of-charge (EOH SOC) parameter. In the day-ahead, the EOH bid will provide a parameter for the market software to optimize storage schedules given the financial willingness of a resource to deviate between its initial and end-of-day SOC. This would indicate to the market the shadow value of the stored energy at the end of the day, which the current market model does not consider explicitly. In the real-time, the EOH bid will be a willingness to deviate from the day-ahead SOC trajectory, which similarly will allow the market to assign a value to the SOC outside of the optimization horizon.

DMM notes that in addition to the EOH SOC parameter, both the day-ahead and real-time model would also need to allow an intra-horizon bid parameter that reflects the minimum spread needed to cover variable O&M costs incurred by operating within the optimization horizon. This value would be reflected today in energy bids to charge and discharge. If such bids were eliminated in their current form, it is unclear from the May 18 presentation if such a parameter would be included.

DMM continues to view these types of enhancements as a significant improvement for storage resources in the NGR model, as it will allow them to better represent their costs and operational characteristics to the market.[18] However, the development and implementation of a new NGR bidding model for storage is a large undertaking that seems likely to require significant resources by the ISO and stakeholders. As noted earlier in these comments, DMM recommends the ISO continue to prioritize BCR design for storage resources ahead of other storage market design changes that may further delay work on storage BCR design.

The NGR bidding concept does not address issues with the BCR design for storage resources

The ISO indicated in the presentation that this proposed improvement "mitigate[s] the risk of inefficient dispatch from incorrect bids/offers within the optimization horizon because misestimated costs/prices no longer distort market outcomes." An EOH SOC opportunity value may mitigate inefficient dispatch by allowing the market model to optimize within the optimization horizon, accounting for the opportunity

[16] *Storage Design and Modeling: Working Group on Uplift & DEB, Outage Management, and State-of-Charge Management* presentation, California ISO, January 22, 2026: https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Storage-Design-Modeling-Jan-22-2026.pdf

[17] *Storage Design and Modeling: Working Group on Uplift and Default Energy Bids, and Outage Management Presentation,* California ISO, May 18, 2026: https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Storage-Design-Modeling-May-18-2026.pdf

[18] *Comments on Storage Design and Modeling Working Group Presentation on January 22, 2026,* Department of Market Monitoring, February 17, 2026: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-jan-22-2026-working-group-presentation-feb-17-2026.pdf

value of the SOC beyond the optimization horizon. However, it does not solve DMM's core concern that the current BCR design doesn't incentivize efficient real-time bidding. The EOH SOC value will still necessarily be determined by a forecast of real-time prices later in the day as storage energy bids are today, and the current BCR design does not incentivize resources to submit bids that reflect real-time conditions because the current BCR design for storage resources does not leave the resources exposed to real-time prices.[19]

DMM supports exploring SOC-based bidding, but emphasizes the need for clarity and consideration of market power mitigation impacts

In principle, DMM is supportive of an SOC-based bidding construct for storage resources, and requests the ISO to more generally elaborate on their intended direction with SOC bidding. Further, as SOC bidding functionality is explored, it will be important to consider market power mitigation in these frameworks. Unlike cost-based bids, the reference levels of SOC bids are not as readily observable and have the possibility of leading to new gaming strategies. As a result, SOC bidding frameworks will need to be jointly evaluated with future DEB enhancements.

[19] *Comments on Storage Design and Modeling Working Group Presentation on January 22, 2026,* Department of Market Monitoring, February 17, 2026: https://www.caiso.com/documents/dmm-comments-on-storage-design-and-modeling-jan-22-2026-working-group-presentation-feb-17-2026.pdf