

Comments on Energy Storage Enhancements State of Charge Formula - Workshop Paper

Department of Market Monitoring

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Summary

The Department of Market Monitoring (DMM) appreciates the opportunity to comment on the *Energy Storage Enhancements – State of Charge Formula* workshop paper.¹ In the Energy Storage Enhancements stakeholder initiative, the ISO introduced changes to state of charge modeling to reflect the estimated impact of regulation deployment on state of charge. These changes were intended to improve the deliverability of ancillary services awarded to storage resources, specifically addressing the issue of storage resources receiving several consecutive hours of regulation awards that may become undeliverable in real-time. While the related software changes were scheduled to be implemented in spring 2023, DMM understands that testing revealed the potential for the proposed approach to produce negative regulation prices, which are incompatible with the CAISO tariff.

DMM supported CAISO's proposal in the Energy Storage Enhancements initiative to estimate the impact of regulation awards on state of charge, and DMM continues to support the inclusion of constraints on state of charge that reflect the impact of regulation awards. While DMM also supports market based tools to improve the performance of regulation provided by storage resources, constraints may be necessary to support reliability and ensure feasible market awards.

While DMM understands that negative regulation prices are not allowed under the current CAISO tariff, the ISO should not rule out the possibility of considering tariff revisions that support this outcome. Negative prices for regulation may be a theoretically compatible outcome for storage resources with intertemporal dependencies that optimize over multiple hours.

Each of the ISO's proposed alternatives will involve tradeoffs, including the need for tariff revisions, potential unintended interference with other upcoming market changes, or allowing the issue of undeliverable storage ancillary service awards to go unaddressed for an extended period of time. DMM recommends that the ISO weigh these tradeoffs carefully, and choose a path forward that ensures reliability in the short run, while continuing to evaluate potential interactions with other market design elements and remaining prepared to revise the approach as necessary.

¹ *Energy Storage Enhancements – State of Charge Formula*, California ISO, July 27, 2023:
<http://www.caiso.com/InitiativeDocuments/Energy-Storage-Enhancements-Workshop-Paper-Jul-31-2023.pdf>

Comments

DMM supports modeling constraints to ensure deliverability of energy storage ancillary service awards

DMM and the ISO have previously noted a number of issues around the availability of ancillary services procured from energy storage resources.² DMM supported the ISO's proposal in the Energy Storage Enhancements initiative to model the estimated impact of regulation awards on state of charge, and DMM continues to support the use of a modeling approach or constraint that reflects the expected impacts of providing regulation on state of charge.

Market based enhancements that would provide stronger incentives for resources to self-manage state of charge to ensure award deliverability would decrease dependence on modeled resource constraints. In some cases, this approach may also lead to more efficient market outcomes. However, more complete modeling of all types of market awards supports reliability by ensuring feasible market awards, regardless of market participant bidding behavior.

Storage resources are optimized over many hours or intervals, with intertemporal dependence on market awards and state of charge. Because regulation awards may impact state of charge and energy schedules in future hours, directly modeling the estimated impact of all types of market awards on state of charge may also support optimization of the state of charge over the operating day.

The ISO should not exclude potential solutions only on the basis that they can produce negative regulation prices

The ISO postponed the modeling enhancements to consider the impact of regulation awards on state of charge on the basis that that the enhancements can result in negative regulation prices. Negative regulation prices are not permissible under the current CAISO tariff.

DMM appreciates the need to delay the proposed enhancements to ensure compliance with the CAISO tariff. However, the outcome of negative prices when state of charge modeling reflects the estimated impacts of regulation awards may not be theoretically inconsistent. In the absence of tariff compliance concerns, the ISO should not exclude potential modeling enhancements only on the basis that the approach can produce negative regulation prices.

Regulation prices should reflect the cost associated with providing regulation service. For a traditional generator, this cost might include opportunity cost of foregone energy revenues when capacity is held as regulation, or the expected real-time settlement cost when the regulation is deployed. For a storage resource, the same general concepts apply. However, because of the intertemporal relationship between storage resource awards, it may be cost minimizing for the market when resources pay to provide regulation in certain circumstances.

² <http://www.caiso.com/Documents/DMM-Comments-Energy-Storage-Enhancements-Final-Proposal-2022-11-15.pdf>

This outcome may also be consistent with the willingness of storage resources to pay for charging energy.

A regulation award has an expected impact on state of charge that could support market awards in future intervals. The ISO's proposal in the Energy Storage Enhancements initiative directly models this expected impact. For example, the expected impact on state of charge associated with a regulation down award could support an energy discharge or additional ancillary service award requiring stored energy in a future interval. Energy discharged in the later interval will be settled at the LMP in that interval. In the simplest example with no round trip efficiency losses or variable maintenance costs, the day-ahead market solution would reflect charging of the resource in an earlier interval at a price no greater than that at which it later discharges. In this simple example, the willingness to pay for charging is determined by the later discharge price.

When a market solution meets all regulation down needs with storage resources that discharge later in the day, negative regulation down prices may result, reflecting the value of the later discharge. From the perspective of the day-ahead market optimization, the use of storage resources to provide regulation down at negative prices may be a cost minimizing solution to meet regulation needs, while also displacing higher cost resources when storage resources discharge in later intervals.

The economics of a regulation award providing the charge needed to support a market award will vary depending on the assumed impact of regulation deployment, as well as energy and ancillary service prices over the day, expected real-time energy settlement impacts, and the costs of production by other resources. However, because of the inter-hour dependence of storage resource market awards, it does not appear theoretically inconsistent that regulation prices may be negative, especially as increasing volumes of regulation are provided by storage resources prices reflect the value of opportunities later in the operating day.

Each of the ISO's proposed alternatives will involve tradeoffs

The ISO's Energy Storage Enhancements workshop paper proposes three potential paths to resolve the issue of modeling the impacts of regulation awards on state of charge. DMM sees advantages and disadvantages to each of the proposed paths, and encourages the ISO to carefully consider tradeoffs of each.

The original proposal approved in the Energy Storage Enhancements initiative provides the most direct modeling of potential impacts of regulation awards on state of charge. This approach was demonstrated in ISO testing to produce negative regulation prices at times, and would require tariff changes to allow this outcome. However, with the use of appropriately chosen multipliers, this approach appears to have the advantage of leading to day-ahead ancillary service awards for energy storage resources that are highly likely to be feasible in real-time.

This approach does also have potential to lead to day-ahead energy awards that may be infeasible when regulation is not deployed in real-time as assumed in the day-ahead multipliers. However, newly developed exceptional dispatch tools for storage resources may help to ensure deliverability of day-ahead energy schedules where needed for more extreme system conditions.

The ISO proposes that as an alternative to the original Energy Storage Enhancements proposal, the envelope equations developed in the Day-Ahead Market Enhancements (DAME) initiative could be used constrain state of charge to reflect the impacts of regulation awards. This approach is a less direct approach that does not explicitly include the impact of regulation awards in state of charge modeling, but bounds state of charge to a range that reflects the potential impacts of regulation awards. Because the feasibility of future market awards is determined by this constrained state of charge, the approach still indirectly models the impacts of regulation awards on state of charge and future market awards. This approach also appears likely to result in feasible ancillary service awards to storage resources.

The envelope equations appear to provide an alternative that would be a less direct constraint on state of charge that may also be less likely to result in negative regulation prices. However, the possibility of negative regulation prices may not be completely eliminated and therefore use of this alternative may still require tariff changes. Further, the envelope equations developed in DAME as an alternative to direct state of charge modeling prevent the estimated impacts of imbalance reserve (IR) awards in opposite directions from offsetting in the day-ahead market. This was an important feature for modeling the state of charge impacts of imbalance reserve awards, but this may not be an appropriate outcome for regulation awards in opposite directions. Finally, the introduction of regulation into the envelope constraints may cause unintended interactions with imbalance reserves market outcomes in the DAME context.

The final option proposed by the ISO is to further delay the implementation of any constraint or modeling that considers the impacts of regulation awards on state of charge. This would allow additional time for stakeholder consideration of a path forward, and to more completely consider all market interactions. This approach has merit in allowing the potential for a more thorough vetting of any proposed solution. However, the additional delay comes at the expense of an ongoing risk that ancillary services may be awarded by the market in a manner that is infeasible and has the potential to contribute to real-time reliability challenges. Support for this approach would likely need to be established by the ISO first quantifying the ongoing magnitude of reliability risks created by infeasible ancillary services awards.