Opinion on
Resource Adequacy Enhancements Phase I:
Minimum State of Charge Requirements

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1. Introduction and Summary

The Market Surveillance Committee has been asked to comment on one of three elements of the Resource Adequacy (RA) Enhancements Phase 1 initiative.[2] This Opinion is one of three opinions to be written by the MSC during March and April 2021 to address particular proposals that the ISO has made to prepare for the summer of 2021. The other two opinions concern the market enhancements for Summer 2021 readiness initiative. One of those opinions (adopted March 8, 2021[3]) presents our analysis of the scarcity pricing, resource sufficiency test, and block import pricing components, while the other (in preparation) is planned to address the export, load, and wheeling priorities component.

This element of the resource adequacy enhancements initiative defines a minimum state-of-charge (MSOC) requirement on certain short-term energy storage facilities that are under contract to provide resource adequacy in the CAISO market. The requirement would be imposed only under certain specified conditions indicative of system stress. A MSOC requirement was proposed as early as 2019 as part of the Resource Adequacy Enhancements initiative,[4] and was subject to considerable stakeholder discussion in 2020.[5] This element remains part of the Resource Adequacy Enhancements initiative, but has been advanced to support the summer 2021 Readiness efforts, which are scheduled for implementation on June 1, 2021 in order to help ensure grid reliability during the upcoming summer high load period.[6] During the stakeholder

[1] The opinions in this document reflect the personal views of the members of the committee and do not necessarily represent or reflect the views of any institutions with which they are affiliated.

[2] Final proposal, www.caiso.com/InitiativeDocuments/ResourceAdequacyEnhancements-Phase1FinalProposal.pdf

[3] J. Bushnell, S. Harvey, and B.F. Hobbs, Opinion on Market Enhancements for 2021 Summer Readiness, Market Surveillance Committee of the CAISO, Adopted March 8, 2021, www.caiso.com/Documents/MSCOpinionon MarketEnhancementsfor2021SummerReadiness-Mar8_2021.pdf

[4] www.caiso.com/InitiativeDocuments/SecondRevisedStrawProposal-ResourceAdequacyEnhancements.pdf, p. 83 et seq.

[5] See for instance the June 2020 comments at https://stakeholdercenter.caiso.com/StakeholderInitiatives/Resource-adequacy-enhancements

[6] See https://stakeholdercenter.caiso.com/StakeholderInitiatives/Market-enhancements-for-summer-2021-readiness

process for the summer readiness initiative, the MSOC proposal was also discussed and the subject of stakeholder comments in February and March 2021.[7]

To prepare for this Opinion, the MSC has held several public meetings whose agenda included items addressing the integration of short-term storage in the ISO markets. These include a session on hybrid energy resources on May 29, 2020, and several meetings addressing the Energy Storage and Distributed Energy Resources Phase 4 (ESDER4) initiative on June 7 and Aug. 19, 2019, and May 8, and July 30, 2020. We adopted an Opinion on the ESDER4 initiative on Sept. 8, 2020.[8] The reliability enhancements initiative was a focus of MSC meetings held on Dec. 6, 2019, and Nov. 13 and Dec. 11, 2020, including the meeting of Oct. 9, 2020 in which the MSC specifically addressed the question of MSOC requirements. Meanwhile, the heat wave events of August 2020 were the subject of meetings on Oct. 9 and Nov. 13, 2020 and Feb. 11, 2021; at the latter meeting, the MSOC requirement was discussed as well.

In the next section of this opinion, we provide some background on the challenges presented to storage management by real-time market processes that have a short time horizon, and the proposal by the ISO that a MSOC requirement be imposed under certain conditions on battery storage that is under contract to provide resource adequacy. Then in Section 3, we provide an analysis of the proposal. We conclude that that imposing a SOC constraint in the (hopefully rare) conditions when the day-ahead residual unit commitment process indicates that capacity is inadequate is a reasonable precaution to take, at least until the end-of-hour state-of-charge parameter feature is enabled and tested in operation. We advise against implementation of rigid proscriptions of possibly counterproductive charging behavior in intervals prior to or after periods in which the MSOC constraint is applied. We discuss the issue of compensating for opportunity costs that may result from the constraint; we conclude that if experience early in the summer of 2021 indicates that significant losses arise from discharge revenues failing to cover the cost of charging needed to reach the MSOC, then the ISO should consider instituting make whole payments. Finally, we enumerate several challenging issues that will need to be considered in the planned energy storage enhancements initiative, which is intended to institute a market-based process to meet an overall system-wide stored energy (state-of-charge) target in its real-time markets.

2. Background and ISO Proposal

Background. As identified in the 2020 ESDER4 proposal[9] and the Opinion we provided on that proposal,[10] the ISO's present real-time management of battery storage has too short of a time horizon to appropriately tradeoff the value of discharging energy (or cost of charging) in the next few hours against the value of that energy for use in intervals beyond the time horizon of the

[7] https://stakeholdercenter.caiso.com/StakeholderInitiatives/Resource-adequacy-enhancements

[8] J. Bushnell, S. Harvey, and B.F. Hobbs, Opinion on Energy Storage and Distributed Energy Resources Phase 4 Initiative, Market Surveillance Committee of the CAISO, Adopted Sept. 8, 2020, http://www.caiso.com/Documents/MSC-OpiniononEnergyStorageandDistributedResourcesPhase4-Sep8_2020.pdf

[9] https://stakeholdercenter.caiso.com/StakeholderInitiatives/Energy-storage-and-distributed-energy-resources

[10] Op. Cit.

software. In contrast, the day-ahead market can consider these tradeoffs over the operating day, but its schedules may be rendered highly suboptimal by rapidly changing real-time conditions.[11] A particular concern during tight system conditions is that stored energy might be discharged in response to possible high prices that occur early in the day rather than being saved for the evening net peak. Such discharge is suboptimal if expected evening prices are significantly higher than the earlier prices, and if that early discharge means that energy was unavailable for use in the evening net load peak hours.

This can occur for any of several reasons. One is that the logic of the ISO's real-time scheduling software could dispatch batteries to avoid the need to dispatch high-cost generation during mid-day price spikes and then fail to conserve energy to meet load at even higher prices later in the day beyond the time horizon of the optimization.

Another reason is that storage owners might choose to set offer prices that result in discharging energy early in the day either because of overly low forecasts of evening prices or because the current penalty prices prevent evening prices from reflecting the true value of stored energy during shortage conditions. Importantly, corrections to forecasts and offer prices are subject to delays. In particular, the significant time lag for updating bid and offer prices can result in a resource's storage capacity being depleted before the operator can update its offer price to reflect changes in market conditions or unanticipated variations in intermittent resource output that have caused the resource to be dispatched more than expected at its offer price.[12]

An additional reason is that it is also possible that if a large storage facility were owned by a large thermal generator, the generator might attempt to exercise market power by tightening market supply during the net peak period by uneconomically discharging energy early in the day.

To at least partially mitigate the inherent short-sightedness of the limited time horizon scheduling software and lags in updating bid and offer parameters, the ESDER4 initiative proposed an end-of-hour state-of-charge constraint that could be specified by battery owners, and used to reserve energy for use beyond the time horizon of the real-time market software.[13] This will be a useful tool for self-management of the resource, but this design will not be implemented until after summer 2021 and it will be even longer before the CAISO and stakeholders are able to observe how well it is performing in practice.

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[11] In our ESDER4 opinion (ibid.), we also note that both the day-ahead and real-time scheduling processes do not appropriately quantify the option value that arises due to real-time price volatility. This volatility provides short-run arbitrage opportunities in which discharging could take place in 5 minute intervals with high prices, while recharging in intervals with low prices. The price profiles over multiple intervals produced by the market models tend to be too smooth to value those opportunities. We do not discuss this issue further here.

[12] For example if a sustained drop in intermittent resource output began any time after 3:45 p.m. (or even somewhat before) and lead to unexpectedly high prices and a sustained dispatch of a storage resource, the resource operator would not be able to adjust its offer price until 4:45 p.m., which would not affect scheduling until 6 p.m..

[13] L. Carr, G. Murtaugh, J. Powers, and B. Sparks, Final Proposal, ESDER4, Version of Aug. 21,2021, www.caiso.com/InitiativeDocuments/FinalProposal-EnergyStorage-DistributedEnergyResourcesPhase4.pdf

ISO MSOC Proposal. Therefore, as part of the original Summer 2021 readiness initiative,[14] the ISO had proposed imposing a requirement that batteries that are contracted for RA attain a level of charge specified by the ISO prior to the evening peak.[15] We understand that a core driver for proposing this MSOC requirement for this summer, to be followed by the Fall 2021 implementation of the end-of-hour state-of-charge bid parameter, was a concern that, in the absence of scarcity pricing, the low prices that may occur even during tight system conditions will not incent efficient decision by storage resource operators. This concern is reasonable, but we need to recognize that the long run solution is to set prices that send an efficient signal for the decentralized operation of storage, as well as other resources. This will become particularly important as the number of small distributed energy resources rises.

Recently, the ISO announced that elements in Phase 1 of its RA enhancements initiative would be proposed for implementation on June 1, 2021 in order to have its elements in place for the summer peak season. In general, a MSOC requirement has been controversial among storage owners, who would prefer to be given more flexibility to manage storage based on their assessment of system conditions and expected market prices. Numerous comments were received in response to an earlier version of a MSOC requirement, many criticizing the inflexibility of a fixed requirement that in its original form was proposed to be imposed prior to the evening ramp in all days. Several stakeholders viewed this as antithetical to a philosophy of electricity markets that would give discretion to resource owners to operate their resource as they saw fit in response to market incentives; however, other stakeholders believed that because of the inadequate time horizons of real time markets and the primacy of the reliability objective, some sort of requirement for RA-contracted storage to be fully charged prior to the evening's net load peak intervals would be reasonable.

In response to these concerns, the ISO has recently announced that it will start an initiative for developing a competitive process in its spot markets for meeting overall storage targets, as opposed to a requirement for each RA storage facility to meet a prespecified state-of-charge target.[16] However, such an initiative cannot be completed prior to this summer, and might not prove to be either workable or desirable after a full review.

In the coming summer, it is anticipated that nearly an order-of-magnitude more battery storage will be on the ISO system than was available last summer (approximately 1800 MW of RA capacity in 2021 versus about 200 MW in 2020). The ISO believes that is necessary to ensure that the portion of this storage that is under RA contracts will be operated in such a way that the batteries will have energy to meet evening net load peaks without regard to whether this operating plan would be consistent with real-time prices. For this reason, this initiative is proposing imposition of a minimum state-of-charge on a facility-by-facility basis just for 2021 and 2022 until the end-of-hour state of charge parameter has been put into place and perhaps until a more flexible and permanent market-based system to meet system state-of-charge

[14] Op. cit.

[15] This proposal is a modification of an earlier proposal within an early version of the RA enhancements initiative to impose a MSOC for all batteries providing RA in all days, regardless of system conditions.

[16] Proposal, p. 38.

requirements is implemented. Unlike the original 2020 resource adequacy proposal, which would have imposed the requirement on all days, this requirement will be imposed on batteries providing RA only on days in which the day-ahead residual unit commitment (RUC) process (including RA batter resources) shows a deficiency in a given hour. This is a condition that occurred in 25 days over the last three years. However, since 23 of these days occurred in 2020, the requirement may be used frequently if there is another hot summer or fall.[17] Under such conditions, the ISO operators will also have discretion to relax the requirement in real-time if they judge that conditions are such that the energy is not needed. On the other hand, during days when the day-ahead RUC criterion is not met, but it turns out that conditions in real-time indicate that more storage is needed, operators will have the discretion to impose the MSOC requirement.

Some other salient features of the proposal are as follows:[18]

- When the MSOC constraint is triggered due to meeting the day-ahead RUC criterion, then the MSOC requirement will be set at the level of charge needed to support the amount of energy that a RA battery was scheduled to discharge in the DA market solution. This MSOC is only a lower bound, and resources have the flexibility to implement SOC trajectories that are above the lower bound.
- The ISO states that it plans to only apply the requirement in just the hours immediately prior to hours with day-ahead discharge schedules, imposing a schedule that ramps up the required storage over those preceding hours so that the required energy is in storage at the end of the last hour before the discharging hours. The stated intention is that the requirement will be in place for as few intervals as possible, avoiding holding storage resources at very high state of charge values for prolonged periods. The goal is to provide flexibility to meet the MSOC at a minimum cost.
- The ISO shares concerns that stakeholders have expressed (see infra.) about charging storage resources during the peak ramping periods just before the evening net-load peak. The ISO plans to develop a parameter that will spread the charge over additional time.

An alternative to imposing this state-of-charge requirement would be to rely on the present system, in which the ISO depends on storage owners to rationally and accurately forecast and compare near-term versus early evening prices, and developing offers or self-schedules that would yield optimal allocation of charge and discharge over the day. As pointed out above, however, the current rules would introduce long lags into the ability of resource operators to change their offer prices in response to new information, even when they foresaw the change in market conditions as soon as the CAISO did. However, if CAISO operators believe that system conditions warrant an override of the schedules resulting from storage offer prices, the operators in theory always have the option of using exceptional dispatch (ED).[19] But monitoring the status of many small storage facilities and generating ED instructions to each would be a significant

[17] California ISO, Market Enhancements for Summer 2021 Readiness, Draft Final Proposal, February 18, 2021, p. 38.

[18] Resource Adequacy Enhancements Phase I final proposal, op. cit.

[19] See Vistra Corp., Comments submitted March 9, 2021 https://stakeholdercenter.caiso.com/StakeholderInitiatives/AllComments/efcddc86-0919-475b-813a-21c137ae95e8

and likely unwelcome burden on operators during times of system stress, so the ISO prefers that a relatively simple MSOC tool be implemented that does not require an increasing number of operator actions in order to manage the rising number of storage resources to ensure availability of stored energy from all RA storage during the evening peak period during the targeted system conditions.

However, effective use of storage ED requires monitoring and control capabilities in the control room that do not presently exist. Thus, the ISO proposes to develop, by this summer, tools to monitor battery storage status and send ED instructions to batteries. Whether or not the ISO implements a minimum state-of-charge requirement as part of this initiative, the availability of these tools to operators will be essential to managing and monitoring the contribution of the ISO's rapidly growing battery resource to system adequacy.

3. Analysis

General Conclusion. We believe that having the capability to ED battery resources could be important for the ISO to do its job of managing the grid reliably and economically during the next two years. Once, batteries were a fringe resource whose operation had very small impact on either market prices or reliability. No longer. Indeed, they will be the major source of new RA capacity in California the next few years.

It is indeed the case that a rigid minimum SOC constraint for RA batteries has the potential for inefficient and unintended outcomes and that, all else being equal, giving operational flexibility to resource owners is desirable as long as market prices send an efficient price signal to guide the decentralized operation of generation, dispatchable loads, and storage. However, the events of last summer in California and those in Texas this month remind us that reliability is the first responsibility of the ISO.

Therefore, we believe that imposing a SOC constraint in the (hopefully rare) conditions when RUC indicates that capacity is inadequate is a reasonable precaution to take, at least until the end-of-hour state-of-charge parameter feature is enabled and tested in operation. Implementation of a more comprehensive and market-oriented solution to managing state of charge along with a scarcity pricing system that sends an efficient price signal for decentralized operation of batteries could also help eliminate the need for such as constraint. Indeed, imposing a minimum SOC constraint only in the stressed situations envisioned in the proposal should not restrict battery operations significantly, since in the absence of such a constraint under those circumstances, the operators would attempt to exceptionally dispatch batteries to achieve the same effect. However, the experiences of last August that have been pointed out with respect to uneconomic charging are a reminder that operators will have too many things to manage during these conditions to micromanage the operation of a large number of storage resources. The explicit state of charge constraint, and an explicit criterion for triggering it, is more transparent than relying entirely on exceptional dispatch, especially given the challenges that would likely be faced in exceptionally dispatching many individual storage units under stressful system conditions. A possible disadvantage is that even under the restrictive definition of the trigger for the SOC constraint proposed by the ISO, the SOC constraint might automatically be imposed more often than

necessary and result in unanticipated consequences. Conceivably, exceptional dispatch might be invoked only when needed, perhaps lessening the chance of such consequences.

Preventing Counterproductive Charging Behavior Before or After the MSOC Interval. A concern that several stakeholders expressed about the MSOC proposal when it was part of the Summer 2021 readiness initiative was that imposition of the MSOC constraint for a particular hour might result in unintended consequences that could be detrimental to system reliability.[20] One such effect could be concentration of charging activities by 1800 MW of RA batteries in the intervals immediately prior to the interval when the MSOC constraint must be met, regardless of system conditions at that time, or similar rapid charges immediately after the MSOC constraint is lifted later in the evening. The stakeholders highlighted battery charging behavior during the August 2020 events and subsequently in September[21] in which batteries were charging during periods when the ISO issued a Warning, and even during a Stage 3 emergency when rotating outages were instituted. If such conditions occur prior to the interval in which the MSOC requirement is in effect, then such counterproductive charging could occur again, exacerbating reliability problems rather than helping.

Stakeholders offered alternatives to the MSOC for managing the need to provide stored energy for the evening peaks, including a "safety protocol" that would limit real-time charging dispatches to exceptional dispatches by the ISO operators.[22] Such a protocol could also be designed prevent early-in-the day real-time discharges that would result from the real-time software accepting discharge offers without recognizing the (possibly) higher value of that stored energy in intervals after the time horizon of the optimization.[23] The ISO has not proposed such a safety protocol in its MSOC proposal.

We believe that such a protocol would be unwise for at least three reasons. First, there is a high likelihood that it would be suboptimal, since the charging restriction would be imposed regardless of system conditions during the intervals in which is applied, obviating completely the balancing features of storage at those times. There is a distinct possibility that adverse economic and reliability consequences resulting from such inflexible operation would be greater than the benefits of such a charging restriction. Second, this protocol would require significantly more operator attention and effort to manage in real-time than the MSOC constraint, exacerbating the

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[20] See https://stakeholdercenter.caiso.com/StakeholderInitiatives/AllComments/a1105b73-c668-4ba5-9858-9e183a2cd852, especially comments by Pacific Gas & Electric (PG&E) and the California Large Energy Consumers Association (CLECA). See also March 9, 2021 comments on the RA Enhancements Phase 1 initiative by PG&E, https://stakeholdercenter.caiso.com/StakeholderInitiatives/AllComments/efcddc86-0919-475b-813a-21c137ae95e8.

[21] See comments by CLECA, ibid., where they cited charging behaviors described in the Root Causes and DMM reports (CAISO, California Public Utilities Commission, and California Energy Commission, Root Cause Analysis, Mid-August 2020 Extreme Heat Wave, Final, January 13, 2021, www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf; CAISO Department of Market Monitoring, Report on system and market conditions, issues and performance: August and September 2020, Nov. 24, 2020, www.caiso.com/Documents/ReportonMarketConditionsIssuesandPerformanceAugustandSeptember2020-Nov242020.pdf.)

[22] Proposed by CLECA and, implicitly, by PG&E, op. cit.

[23] PG&E in effect proposes this in order to preserve state-of-charge earlier in the day, ibid.

demands on operators rather than helping them. Third, implementation of such a protocol will be more complex; we note that many stakeholders have expressed concern in their comments on the Summer 2021 Readiness initiative over the complexities involved in implementing several changes on a very tight schedule, and implementation of a safety protocol would be more complex than a simpler MSOC requirement. Since the ISO operators always have the option of imposing exceptional dispatch restrictions on charging behavior at any time during the operating day, we do not see a great advantage to attempting prior to June 1 to formalize such restrictions as a safety protocol that are automatically implemented under certain enumerated conditions. If it turns out that operating experience in the Summer of 2021 indicates that such restrictions are useful and predictable, then development of such a protocol could be justifiable for the Summer of 2022, which is the second year of the two-year duration of the MSOC proposal.

We note that in the final proposal,[24] the ISO proposes the use of a parameter to spread out possible charging behavior over intervals immediately preceding the evening net load peak hours which could at least partially help avoid the problems that the stakeholder-proposed safety protocol would attempt to address. Choosing the parameters will require consideration of a balance between the need for flexibility and need to avoid the risk of high charge rates during intervals prior to the evening discharge periods when prices may be very high or the system is otherwise stressed.

Returning to the counter-intuitive charging of storage during system Warning and Emergency conditions noted by the stakeholders, this is indeed a serious concern. It was due to the inappropriate market pricing in which low real-time prices occurred due to the release of generation providing reserves for dispatch when it was replaced by arming load, when the system was actually highly stressed and approaching load shedding. As recognized by the Summer 2021 Readiness initiative, such prices are highly inappropriate and inconsistent with system conditions; therefore, the ISO has included in that initiative measures to prevent this from happening when load is being armed for shedding. These short-term scarcity prices should ensure that market prices would be set at more appropriate levels were the CAISO again to need to arm load to meet its WECC reserves requirements. It is very unlikely that the unintuitive charging behavior that has been noted would have occurred had RTD prices been $1000 instead of $100 or so. As we point out in our Opinion on that initiative,[25] and as the ISO fully recognizes in initiating a comprehensive scarcity pricing initiative, a thorough revisiting of price formation during times of system stress is needed so that prices reflect the probability and costs of load curtailment during times of scarcity. The ISO initiative to develop scarcity pricing reforms together with a separate initiative to develop a more market-oriented process for securing required state-of-charge from the market should together go a long way towards not only avoiding the illogical storage charging patterns observed in August and September, but also provide improved storage incentives and tools to respond to those incentives throughout the day.

[24] Op. cit.

[25] Op. cit.

Compensation for Opportunity Costs. Some stakeholders have argued for the reimbursement of opportunity costs resulting from imposition of the MSOC constraint.[26] As discussed in our Opinion on the ESDER4 initiative,[27] there are large difficulties in quantifying the opportunity cost associated with storage charge, discharge, and state-of-charge. These difficulties arise for several reasons. Some examples of these reasons include:

- the uncertainty of future prices (the opportunity costs should ideally reflect the probability distribution of prices, which have a subjective element and which may be disagreed upon by the resource owner and the ISO);
- the difficulty of estimating counterfactual operating schedules and foregone opportunities;
- the complexities involved in calculating the option value associated with 5 minute price volatility; and
- difficulties involved in quantifying the cost of cycling batteries, considering impacts on battery lifetime.

We believe that any attempt by the ISO estimate the full opportunity cost associated with imposing the MSOC constraint would involve many arbitrary and difficult to verify assumptions, and would take significant time to develop and implement.

It is, however, reasonable to assess whether batteries lose money over the day because of the possibility of charging to reach the MSOC and then discharging at lower-than-expected evening prices, resulting in discharge revenues being less than charging costs. This calculation would have to be based on a counterfactual schedule that would have been followed in the absence of a MSOC constraint. Furthermore, losses in one day due to over-prediction of evening prices might be made up by higher profits on other days when evening prices are under-predicted, suggesting that losses should be averaged over some longer period than one day. The ISO is not able to consider alternative ways to make this calculation and implement them by this summer. The only realistic possibility would be to compare costs of charging in intervals immediately prior to imposing the MSOC with the revenues received from discharging in the evening, and compensating any loss, perhaps if above some deadband. It would be useful for the ISO to estimate and report losses and gains from enforcing the MSOC constraint. Although compensation for such losses might be appreciably less the full opportunity costs, it would provide some assurance that the MSOC will not result in negative profits.

We anticipate that if the CAISO does not modify the proposed design, then during stressful system conditions that it is unlikely that the opportunity costs of the MSOC constraint would frequently and on average significantly exceed the additional revenues that would be gained by storage from discharging more energy during the evening peak when prices are likely to be at their highest. If the MSOC operates as intended, then if there is no market power and if prices

[26] See for instance comments by Boston Energy Trading and Marketing and Vistra Corporation on Summer 2021 Readiness Initiative, Feb. 3, 2021, https://stakeholdercenter.caiso.com/StakeholderInitiatives/AllComments/bbc85fdd-01b0-4901-b544-81791ba65481

[27] Op. cit.

do not hit the price ceiling prior to the intervals in which the MSOC constraint is active, then we anticipate that correcting for the short-sightedness of the real-time market should increase storage profits, on average.[28] However, we encourage the ISO to consider implementation of such a make-whole payment scheme if experience in the early months of summer 2021 shows that such losses can be material. We also encourage the ISO to monitor storage operations and net revenues to understand whether the MSOC might result in significant uncompensated opportunity costs.

There is also the opportunity for storage owners to eventually earn compensating revenues through their RA contracts, although that is not applicable for opportunity costs that would be incurred this summer or coming winter. Since batteries enter into RA contracts voluntarily, they could choose, as the ISO notes in its proposal, not to sign such a contract, and thereby avoid the opportunity costs. RA contracts could also include some compensation for such opportunity costs, although at this late date, the opportunity to negotiate such compensation for the summer of 2021 or even the winter of 2021/2022 has likely passed.

Issues for Consideration in Developing an Auction for State-of-Charge. As mentioned above, the ISO has announced that it will consider designing an auction process in its real-time markets to acquire enough SOC to meet a daily target that might be adjusted in real-time based on improved information. Such design would involve several challenging conceptual and practical issues that we look forward to examining during the upcoming initiative. Some include: understanding the relationship of the payments to procured SOC to the compensation already provided to energy and capacity in the day-ahead and real-time markets; specifying the frequency and timing of any SOC auction, and the amount of SOC to be acquired, conditioned on system conditions; nondiscrimination between storage and non-storage resources, such that the value provided by each is equitably and efficiently rewarded; specification of the nature of the physical and financial option that the ISO will essentially be acquiring through a SOC auction; avoiding the risk of double payment to storage (paying once for SOC, which will partially reflect the value of the stored energy in terms of later energy sales revenue, and then allowing storage to receive energy revenues from discharging that energy); and possibly for some large resources owned by thermal generators, market power mitigation and estimation of opportunity costs. We look forward to interacting with stakeholders and ISO staff on this important initiative.

[28] If storage can exercise market power, then by preventing use of a possible strategy to prematurely discharge of batteries in order to raise peak period prices, storage profits may be reduced even though overall market efficiency would likely be enhanced. Or if prices hit the price cap prior to when the MSOC constraint applies, then restricting discharge or requiring charging to reach the MSOC target could lower profits because prices during the MSOC period could not be higher than that level, even if shortfalls are more severe during the latter period. In this situation, capped prices or malfunctioning scarcity pricing might result in the price signal incorrectly signaling that complying with the MSOC target is suboptimal.