Memorandum

To: ISO Board of Governors

From: Benjamin F. Hobbs, Chair, ISO Market Surveillance Committee

Date: October 28, 2021

Re: **Briefing on MSC activities from Sept. 14, 2021 to October 28, 2021**

This memorandum does not require Board action.

During this time period, the MSC held a general session meeting on Oct. 1, 2021. The topic addressed during this meeting was the interaction of the ISO's multi-interval optimization in the real-time market with the dispatch of energy storage.[1] This topic is directly relevant to the ISO's on-going energy storage enhancements initiative.[2]

The session began with a presentation by Brian Bartholomew, Cody Hill, and Renae Steichen of LS Power/Rev Renewables concerning their experience with the ISO's multi-interval optimization scheduling of that company's battery resources. The presentation described a number of their concerns with how the ISO schedules storage in real-time by optimizing it over multiple intervals, including the initial "binding" interval (yielding schedules for that interval that are subject to binding financial settlement and, if not followed, possible deviation penalties) and a series of subsequent advisory intervals. As explained in the ISO staff presentation that followed (summarized below), the purpose of multi-interval optimization is to improve the efficiency of schedules by recognizing the value of energy and capacity in subsequent intervals, which can yield so-called "out-of-merit" schedules in the binding interval.

There are several concerns that the LS Power speakers expressed, based on their experience with how their storage assets have been scheduled and financially settled. One is a perceived lack of transparency, because advisory interval prices and schedules are not publicly available. As a result, it is difficult for resource owners to verify that their resources have been scheduled consistent with the full set of energy and ancillary service prices across the binding and advisory intervals. Consequently, resource owners cannot diagnose why they were dispatched out-of-merit, resulting in what they view as schedules that do not maximize their profits.

Second, the speakers expressed a lack of confidence in advisory interval prices, and another stakeholder agreed, suggesting that the impact of advisory interval prices on binding interval shadow prices is very sensitive to assumptions. Under certain mathematical conditions, as a MSC member pointed out, if the binding interval plus advisory interval prices together were used to settle the multi-interval schedule, the overall profits of storage would indeed be maximized despite any

[1] All staff and MSC member presentations at the general session meeting are available at www.caiso.com/informed/Pages/BoardCommittees/MarketSurveillanceCommittee/Default.aspx

[2] https://stakeholdercenter.caiso.com/StakeholderInitiatives/Energy-storage-enhancements

out-of-merit dispatch in the binding interval. However, when asked, the speakers expressed skepticism that advisory prices (which are not visible to resource owners) are actually trustworthy projections of what actual prices would be realized in later market runs, especially when real-time prices are highly volatile. MSC members suggested that a comparison of advisory interval prices and the actual real-time prices for those intervals would be highly informative and perhaps confidence building. Comparisons could, in theory, be made of profits from following the ISO's schedule versus following a dispatch consistent with binding interval bids, although the speaker expressed skepticism that the necessary counterfactuals could be calculated.

The LS Power presenters proposed that reliable real-time dispatch requires that storage (but not other resources with interdependencies over multiple intervals) be dispatched in the binding interval consistent with binding interval bids. MSC members expressed skepticism as to why this should be true for storage but not for other resources (such as resources subject to ramp limits or unit commitment constraints). The speaker acknowledged that the minimum state-of-charge feature to be implemented for storage (under the ISO's energy storage and distributed resources phase 4 initiative) will help with the perceived problems of multi-interval optimization, but would not completely solve them.

Vigorous discussion among the LS Power representatives and other stakeholders then followed, including a California Public Utilities Commission representative who argued that it is resource adequacy contracts that are driving much of storage bidding and are resulting in inefficient utilization of batteries.

The LS Power presentation then summarized short examples of inefficient storage utilization, apparently arising when conditions in advisory intervals turned out quite different than anticipated by the market software. A MSC member pointed out that the same issues arise with, for instance, natural gas units that might be ramped inefficiently because of the uncertainty. Another stakeholder pointed out that there seemed to be particular problems at the end of the day or hour that might have their root in how the market software handles those transitions.

The LS Power presentation concluded with their recommendations, including that storage be allowed to opt-out of multi-interval optimization, that storage be provided bid cost recovery for lost profits relative to schedules based just on binding interval offers, and that the ISO publish documentation of advisory interval prices and multi-interval optimization performance.

Next was a presentation by Rahul Kalaskar, Manager for Market Analysis at the ISO, and Dr. Guillermo Bautista-Alderete, Director of Market Analysis and Forecasting at the ISO. They reviewed the increasing role of battery-storage in the ISO markets over the last six months, and how battery bidding behavior in the day-ahead and real-time markets has been evolving. The presentation then summarized the multi-interval optimization used in the ISO's real-time markets, in which an interval whose schedules are financially binding on participants is followed by several advisory intervals. The purpose of advisory intervals is to allow the market to "see ahead" the net loads in future periods so that the market can logically consider tradeoffs between the value of energy in the binding interval and its value in later intervals when making decisions about commitment, positioning of units for ramping, the charging and discharging of storage facilities, and other intertemporal decisions. This consideration can result in generation and storage resources

being committed and dispatched in the binding interval "out-of-merit." (For instance, this can consist of selling power when prices are less than price offers, or not selling when the reverse is the case. Or in the charging situation, charging could occur when prices exceed bid prices, or charging does not occur when prices are below bid prices.) Such out-of-merit scheduling occur, for example, because limited stored energy in batteries is more valuable in advisory intervals than in the binding interval, or because flexible generators are held back so they can provide needed ramp in later intervals.

The presentation described the multi-interval optimization model and various ways that it can produce these outcomes. The presentation noted that out-of-merit dispatches of storage tended to occur in 10%-20% of all intervals in the Aug. 2020-July 2021 period. The presentation then described five sets of scenarios in which apparently out-of-merit operation of storage could occur, inspired by actual schedules in the recent past. These scenarios covered complications such as (I) interactions with regulation awards, which might require apparently uneconomic storage dispatch in order to be feasible; (II) advisory interval self-schedules that would not be feasible without uneconomic dispatch in the binding interval; (III) impacts of future state-of-charge limits on binding interval dispatch; (IV) impacts of future economic conditions (higher or lower prices of energy) on binding interval dispatch of storage; and (V) exception dispatch instructions that result in unexpected binding interval discharge due to software issues. MSC members noted that the careful explanation of each case and how it yields unexpected binding interval results was helpful in understanding the reasons for those results.