Opinion on
Storage Bid Cost Recovery

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1. Introduction

The Market Surveillance Committee (MSC) of the California Independent System Operator (CAISO) has been asked to comment on the CAISO's proposal[2] for revision of the procedures for calculating real-time (RT) bid cost recovery (BCR) for storage resources. The topic of storage management and compensation has been a major focus of a recent MSC public meeting on July 30, 2024.[3] The MSC has also previously written opinions commenting on Order 831 rules concerning storage bidding above the soft bid cap (which affect incentives to preserve state-of-charge for evening peaks),[4] as well as the ISO's energy storage and distributed resources initiatives and the energy storage enhancements initiative.[5] In this opinion, we focus on a specific

[1] The participation of Dr. Bushnell, Dr. Harvey, and Dr. Hobbs in this Opinion were as compensated members of the MSC, acting as advisors to the California ISO and Western Energy Market governing bodies. All opinions expressed and implied in this document are solely those of the authors and do not represent or reflect the views of their employers.

[2] California ISO, "Revised Draft Final Proposal - Storage Bid Cost Recovery and Default Energy Bids Enhancements", Oct. 10, 2024, https://stakeholdercenter.caiso.com/InitiativeDocuments/Revised-Draft-Final-Proposal-Storage-Bid-Cost-Recovery-and-Default-Energy-Bids-Enhancements-Oct-10-2024.pdf; "Addendum - Draft Final Proposal - Storage Bid Cost Recovery and Default Energy Bids Enhancements," Oct. 15, 2024, https://stakeholdercenter.caiso.com/InitiativeDocuments/Addendum-Draft-Final-Proposal-Storage-Bid-Cost-Recovery-and-Default-Energy-Bids-Enhancements-Oct-15-2024.pdf.

[3] www.caiso.com/informed/Pages/BoardCommittees/MarketSurveillanceCommittee/Default.aspx.

[4] J. Bushnell, S.M. Harvey, and B.F. Hobbs, "Opinion on Order 831 Rules for Bidding above the Soft Offer Cap," Market Surveillance Committee of the California ISO, May 15, 2024, https://www.caiso.com/documents/mscfinalopinion-rulesforbiddingabovethesoftoffercap-priceformationenhancements-may2024.pdf.

[5] Respectively, J. Bushnell, S.M. Harvey, and B.F. Hobbs, "Opinion on Energy Storage and Distributed Energy Resources Phase 4," Market Surveillance Committee of the California ISO, Sept. 9, 2020, www.caiso.com/Documents/MSC-OpiniononEnergyStorageandDistributedResourcesPhase4-Sep8_2020.pdf.; and J. Bushnell, S.M. Harvey, and B.F. Hobbs, "Opinion on Energy Storage Enhancements Proposal," Market Surveillance Committee of the California ISO, Dec. 6, 2022, www.caiso.com/Documents/MSCOpiniononEnergyStorageEnhancements.pdf. Within these opinions, we addressed several specific issues related to storage management and markets, including bidding rules, market power mitigation (focusing on calculation of storage default energy bids), state-of-charge scheduling, state-of-charge management for resources that are procured for ancillary services, and exceptional dispatch.

topic concerning financial settlements of battery storage management and their larger market implications, which is the calculation of RT bid cost recovery payments that are made when batteries are deemed to have incurred certain types of losses in the RT markets, as explained in detail later in this Opinion.

1.1 Summary of Recommendations

To summarize our recommendations, we agree with the ISO and the Department of Market Monitoring that there exist important incentive problems that could result in significant unearned transfers and market inefficiencies. The storage BCR initiative has highlighted these issues, reviewed a number of proposed approaches to reduce the resulting inefficiencies unearned transfers, and recommends implementation of an interim revision to storage real-time BCR procedures. As the role of short-duration storage resources continues to grow, addressing these problems becomes more urgent. As we discuss in the opinion, there are several potential bidding strategies that can significantly inflate BCR payments at little risk to the storage resource engaging in the behavior. A long-term goal should be to eliminate what can be called "BCR on phantom losses" that result from including resource charging bids and discharge offers in the BCR calculation. We believe that this goal is likely to be partially but not completely accomplished by implementation of the ISO's proposal.

In addition, the current BCR mechanism, even when it does not inflate BCR payments, reduces the incentive of the storage operator to use its bids and offers to manage state-of-charge over the day so the resource can cover its day-ahead market schedules. The real-time market design, given its limited look-ahead time frame, relies upon the bids and offers of storage resources to reflect the value of energy stored for later hours of the day. Given that the current BCR design reduces the cost to storage resources of losses incurred when they prematurely deplete their state-of-charge or prematurely fill their charging capacity, the link between near-term storage bidding and operations and later value of energy is weakened. This increases the likelihood of inefficient operations from the system's point of view. Therefore, another long-term goal should be to ensure that any BCR system does not interfere with incentives to manage storage in response to real-time price signals so that stored energy is managed in a way that storage discharge occurs when that energy is most needed by the system.

We support the concept of taking a first step of modifying the BCR calculation to eliminate BCR on phantom losses to the extent that is workable in the near term. However, we are unsure at this point whether BCR on phantom losses is material enough, as well to whether the current CAISO proposal would reduce it enough, to justify the resources required to implement the CAISO design. If BCR payments on phantom losses associated with high bids and low offer prices are, or potentially would be, material, then we support implementation of the CAISO proposal despite its limitations.

The CAISO proposal does not address the problem of incentives for inefficient storage operations created by the current BCR design. The CAISO has not published data on how much BCR would be eliminated by their proposal, nor how much BCR is attributable to phantom losses, as opposed to BCR arising simply from the buy-back costs from premature depletion of state-of-charge or charging capability. DMM calculations discussed in Section 5 suggest to us that at least in the May to July 2024 period, BCR payments on phantom losses are currently small or non-existent.

However, the DMM analysis also indicates that BCR on phantom losses driven by bids was more material prior to the beginning of this stakeholder process. The DMM analysis is also at a very high level; given the complexity of BCR drivers, its implications for the effectiveness of the CAISO design may be more complex than we have inferred. It is reasonable given where we are in the stakeholder process, and the lack of clarity regarding some of the drivers of BCR payments, to implement the CAISO proposal in the near term, at least as a check to ensure there a reversion in bidding behavior does not lead to an increase in BCR paid on phantom losses.

Regardless of whether the current proposal is adopted, further changes in the BCR design based on an a more complete empirical analysis of the actual drivers of BCR payments, are needed, perhaps urgently. Moreover, elimination of BCR on phantom losses should precede any increase in bidding flexibility for storage resources. Therefore, the CAISO should almost immediately continue this process into a Phase II that can continue reforms that we believe will ultimately need to greatly reduce the scope of storage BCR to a few isolated conditions.

1.2 Scope

The opinion is organized as follows. In the next section (Section 2), we provide an in-depth discussion of four issues concerning how BCR is calculated for battery storage resources, and their market implications, including phantom losses and their contribution to inflating BCR; resulting incentives to inefficiently manage state-of-charge; BCR payments for phantom losses from managing regulation-up and -down; and inappropriate payment of BCR to cover costs of keeping regulation capacity charged. In Section 3, we discuss three general reasons for paying BCR to storage. These include losses due to exceptional dispatch leading to depletion of SOC; losses resulting from dispatch at mitigated offer prices in a way that depletes SOC, and multiple interval optimization in the RT market resulting in losses due to mistaken price forecasts or any other reason over the day.

Section 4 turns its focus from the interaction of the DA and RT markets in the CAISO balancing authority and their implications for BCR calculations to other balancing authorities in the larger Western Energy Market (WEM). While we conclude that there is less potential for phantom losses and inflated BCR payments in the WEM than in the CAISO, it would still be desirable to make appropriate changes in the BCR calculation to eliminate the potential for phantom BCR losses and inflated BCR payments.

In Section 5, we summarize five distinct approaches to mitigating the risk of inappropriate payment of BCR to cover the phantom losses or ancillary services energy expenses discussed in Section 3. Simple numerical examples are used to illustrate each approach, and their potential effectiveness to reduce or eliminate inappropriate BCR. These five approaches include:

1. the CAISO's original proposal (which would only have applied in a subset of intervals in which storage output was constrained by SOC considerations);

2. use of the default energy bid (DEB) to calculate deemed profit for the purpose of calculating BCR Payments;
3. the Joint Stakeholder Proposal which calculates as-bid or as-offered costs considering RT and DA locational prices, RT offers, and DEBs in a way that reduces although doesn't eliminate the possibility of phantom losses that would result in BCR;
4. the CAISO's draft final Proposal; and
5. a variation of the CAISO design that would calculate bid cost using the lower of the DEB or DA price in hours with positive deviations from day-ahead market schedule and would instead use the higher of the DEB or the DA price in hours with negative deviations from day-ahead market schedules.

2. What is the Problem?

We agree with the ISO and the Department of Market Monitoring[6] that there are several major issues with the current BCR system for storage that can result in unjustified profits, as well as adversely affecting market efficiency and reliability. Below we provide simple examples and general proofs that we hope will clearly establish the nature of these issues and the need for change. We address four issues. The first of the issues (Section 2.1) is the creation of a "money machine": that is, an opportunity to earn profits that depends only on offers without regard to market power mitigation, and are not related to the efficiency benefits that storage provides to the market. This issue involves the payment of BCR on phantom losses. BCR payments exceed actual economic losses.[7] The second issue (Section 2.2) is that the current BCR design reduces an incentive for storage operators to manage their state-of-charge (SOC) to avoid discharging storage earlier than would be optimal either for the resource owner (given market prices) or for system efficiency. This issue involves the payment of BCR on actual economic losses, but the losses are due to the failure of the storage operator to manage state-of-charge. A third issue (Section 2.3) is that under the current design, regulation charging or discharging can result in BCR paid to cover phantom losses. The fourth issue (Section 2.4) with the current BCR design is that it appears that not all BCR due to the ancillary services constraint is identified by the ancillary

[6] See California ISO, "Storage Bid Cost Recovery and Default Energy Bid Enhancements," Initial Workshop, July 8, 2024, California ISO, "Issue Paper & Straw Proposal for Track 1," July 26, 2024; California ISO, Department of Market Monitoring, "Comments on Storage Bid Recovery and Default Energy Bids," July 8, 2024 workshop, July 18, 2024, https://stakeholdercenter.caiso.com/StakeholderInitiatives/storage-bid-cost-recovery-and-default-energy-bids-enhancements,

[7] As explained more fully below, actual profits or losses for a storage resource in the real-time (RT) market are based on cash flows from incremental RT energy revenues/payments and ancillary services revenues (increment relative to day-ahead (DA) levels), minus variable O&M expenses and marginal battery degradation costs associated with incremental RT schedules, plus any adjustment for increase or decrease in end-of-day state-of-charge (SOC) relative to the DA end-of-day SOC. Phantom RT profits or losses consist of the difference between profits/losses calculated for BCR estimation purposes and actual profits/losses. This difference is primarily or entirely due to deduction of the opportunity cost portions of discharge offer costs, and the addition of opportunity cost portion of charging bid costs to the RT profit/loss calculation. Discharge offers and charging bids are the sum of the opportunity cost portion and any of the aforementioned variable O&M expenses and marginal battery degradation costs. As explained in a later footnote, the opportunity cost portions of RT incremental discharge offer costs and charging bid costs, when added up is the phantom profit or loss (plus an amount that is incurred in order to increase or decrease the end-of-day SOC relative to its DA value).

services state-of-charge (ASSOC) design, so that some amount of BCR continues to be inappropriately paid to cover costs of energy required to satisfy the ancillary services state-of-charge constraint.

2.1 A Money Machine Is Created by the Current BCR Design Based on Offer Prices

The current real-time BCR design for storage considers a storage resource's real-time profit over the day as calculated by adding (a) real-time discharge energy revenues minus discharge price offers, (b) real-time charging energy bids minus payments for charging energy, and (c) any additional net revenues from real-time adjustments to ancillary services supplied. Disregarding ancillary service net revenues for the moment (we return to this topic in Section 2.3), we focus in this section on net real-time energy revenues from the FMM and RTD markets, as estimated for the purpose of calculating BCR. The key feature is the basing of this profit on as-offered discharge prices and as-bid charging prices, even when the actual dispatch is not based on those offer prices because of inadequate state-of-charge or charging capacity. We call this estimated profit the "deemed profit for real-time BCR purposes" (the "BCR profit," or its negative which can be called the "BCR loss").

As a result of this design, a resource's *actual* net margin from the real-time market may be very different from the deemed profit used to calculate BCR payments. This is both because short-term opportunity costs are reflected in resource revenues over the day and because those offers and bids do not necessarily reflect even actual short-term opportunity costs when the resource lacks adequate state-of-charge or charging capability to support those offers.[8] For example, a unit's lost opportunity from not selling energy is not equal to its offer, or the market price, if it

[8]Thus, BCR payments may be based on a low offer implying a low opportunity cost, when the resource actually has high opportunity costs because its state-of-charge is too low to support that dispatch. Examples 1 and 2 illustrate this situation in which a depleted SOC makes it impossible to meet a DA discharge schedule, so the real-time discharge is reduced to zero (i.e., incremental RT deviation from the day-ahead market schedules is negative, offsetting the discharge scheduled in the day-ahead market). In that situation, based on the resource's bids and offers, the BCR algorithm deems the resource as having a low bid to buy back the DA schedule, which becomes the basis of the calculation of a large loss for BCR purposes. The loss occurs because the storage resource pays a high RT price for the RT incremental charging energy but apparently (based on its fictitiously low bid for BCR purposes) has a low opportunity cost-based value for that acquired energy. In reality, however, its actual opportunity cost for the energy is much higher than is deemed for BCR purposes, because it would not be able to have an incremental RT discharge at any price due to its depleted SOC.

This situation is analogous to the situation of a thermal resource that submits a low offer price but cannot be dispatched to that level because of a forced outage or derating. Section 4.1 of the CAISO's July 26, 2024 "Issue Paper and Straw Proposal-Storage Bid Cost Recovery and Default Energy Bids Enhancements" (https://stakeholder-center.caiso.com/InitiativeDocuments/Issue-Paper-and-Straw-Proposal-Storage-Bid-Cost-Recovery-and-Default-Energy-Bids-Enhancements-Jul-26-2024.pdf) proposed to address the problem of inflated BCR payments due to lack of state-of-charge by identifying the intervals in which the resource was effectively out of service due to lack of state-of-charge or charging capacity. While that concept has proved unworkable from an implementation standpoint (see California ISO, "Revised Straw Proposal for Track 1," September 4, 2024, https://stakeholder-center.caiso.com/InitiativeDocuments/Revised-Straw-Proposal-Storage-Bid-Cost-Recovery-and-Default-Energy-Bids-Enhancements-Sep-04-2024.pdf), this is a relevant standard to apply in assessing whether BCR payments are warranted.

has no actual charged energy to sell. Hence, the deemed profits used to calculate BCR may diverge greatly from actual economic costs and benefits (including actual changes in energy revenues and payments in the real-time market, variable O&M and degradation costs, and the opportunity cost associated with changes in the final state-of-charge at the end of the day relative to the day-ahead ending SOC[9]).

The RT *actual* net margin is the change in real-time energy revenues and payments (relative to day-ahead market schedules, in the case of CAISO resources, or relative to base schedules, in the case of WEM resources) summed over the day (minus O&M and degradation expenses and adjusted for changes in the final interval's ending state-of charge). If the sum of as-bid charging benefits minus as-offered discharge costs (net of O&M/degradation expenses and adjusted for changes in end-of-day state-of-charge) is non-zero, the actual RT net margin will differ from the deemed profit for RT BCR calculation purposes by an amount we call "phantom profit" (or "phantom losses" if negative). If this phantom profit is negative, it can increase any BCR payment that would be made above and beyond the BCR payment needed to cover any actual real-time market losses. The profit arising from BCR payments for phantom losses does not reflect actual intra-day opportunity costs (which are automatically accounted for by summing up real-time energy revenues net of energy payments across the day, plus the value of any change in end-of-day state-of-charge).

The inclusion of phantom losses in the deemed profit for real-time BCR purposes has important implications for the amount of BCR which can be earned by storage resources. It also can distort offering /bidding incentives of these resources, and the resulting offers/bids could result in inflated BCR payments, even if storage earns positive actual profits. A key feature of phantom losses, as shown below, is that they arise from the bids and offers of the storage resource, not from CAISO operator actions.

In this subsection, we focus on a specific general result of the current BCR design. In particular, we focus on the case in which the discharge offer prices made by a battery storage resource in real-time are lower in the hours in which it has day-ahead market schedules than in hours in which it has no day-ahead market schedules, yet the resource cannot be dispatched based on those low discharge offers to cover its day-ahead market schedule because it has inadequate state-of-charge as a result of being dispatched in prior hours when it did not have a day-ahead market schedule. In that situation, unless there are real-time profits from other sources, the current BCR design will result in deemed real-time losses and thus BCR payments to that resource when its state-of-charge constraints result in the buy-back of day-ahead discharge market schedules at high real-time prices, even if there are no actual losses. Hence, there are BCR payments for phantom losses. We believe that an important goal for an initial BCR design change would be to drastically decrease or eliminate the opportunity to earn such BCR payments for phantom losses.

[9] It is possible that the SOC at the end of hour 24 of the day will be higher (or lower) than scheduled in the day-ahead market. That delta in SOC will, in general, have a value (if positive) or opportunity cost (if negative) in the next day's energy market, and payments for real-time charging (or revenues for real-time discharging) will have been incurred in hour 24 or before to result in such a change in state-of-charge over the day.

We provide below several simple examples to illustrate how these phantom losses and resulting BCR payments can happen.

Example 1. This example shows a case in which premature dispatch is actually profitable in the real-time energy market, but the storage resource is nevertheless deemed to incur a real-time (phantom) loss and receives real-time BCR payments.

We illustrate this with a six period example to keep it simple. We also assume for simplicity that the FMM and RTD dispatch are identical and there are no charging losses, and that RT schedules are the same across all RT intervals within an hour, so that DA and RT "periods" in the examples are each 1 hour long. There is no net change in state-of-charge over the day in this example or the other examples of Section 2.1 (Examples 1 through 5).

Table 1. Current BCR Design Example 1, Premature Dispatch with Positive Actual Real-Time Margin and Positive BCR

Period	DAM Schedule (MW) A	Real-Time Dispatch (MW) B	Real-Time Deviation (MW) C	Start SOC (MW) D	DAM Price ($/MWh) E	Real-Time Price ($/MWh) F	Real-Time Bid ($/MWh) G	Real-Time Offer ($/MWh) H	Real-Time Revenues ($) I	Bid Cost ($) J	BCR today ($) J
1	-10	-10	0	0	20	-5	15	500	0	0	0
2	-5	-5	0	10	10	10	15	500	0	0	0
3	-5	-5	0	15	10	10	15	500	0	0	0
4	0	10	10	20	20	600	15	500	6000	5000	-1000
5	10	10	0	10	100	500	40	50	0	0	0
6	10	0	-10	0	200	500	40	50	-5000	-500	4500
Total	0	0	0						1000	4500	3500

Table Notes: Here and in other tables, positive MW of RT Deviation (Column C) represent discharging, negative MW represent charging energy. Periods are each 1 hour in length. "BCR today" in Column J is the BCR loss (which is the negative of deemed profit for BCR calculation purposes) used to determine BCR payments under the current BCR design.

The actual real-time energy market margin is (sum of column I):

$$+\$1000 = 10MW * \$600/MW - 10MW * \$500/MW$$

The BCR calculation, however, results in a $3500 BCR payment. The deemed profit for real-time BCR purposes (which is also called the "BCR" loss") is negative (sum over last column), so there is a BCR payment:

$$-\$3500 = +10MW * (\$600-\$500) - 10MW * (\$500-\$50) = 10MW * (\$100/MW - \$450/MW)$$

Thus, adding the BCR payment of $3500 to cover phantom losses increases the total real-time margin from $1000 to $4500.[10]

Example 2. In this example, the actual real-time margin is negative in the absence of a BCR payment, but the BCR payment is so large that the resource not only avoids losses but makes money.

Table 2. Current BCR Design Example 2, Energy market losses, Resource gets BCR sufficient to earn positive margin

	DAM Schedule (MW)	Real-Time Dispatch (MW)	Real-Time Deviation (MW)	Start SOC (MW)	DAM Price ($/MWh)	Real-Time Price ($/MWh)	Real-Time Bid ($/MWh)	Real-Time Offer ($/MWh)	Real-Time Revenues ($)	Bid Cost ($)	BCR today ($)
Period	A	B	C	D	E	F	G	H	I	J	K
1	-10	-10	0	0	20	-5	15	500	0	0	0
2	-5	-5	0	10	10	10	15	500	0	0	0
3	-5	-5	0	15	10	10	15	500	0	0	0
4	0	10	10	20	20	600	15	500	6000	5000	-1000
5	10	10	0	10	100	1000	40	50	0	0	0
6	10	0	-10	0	200	1000	40	50	-10000	-500	9500
Total	0	0	0						-4000	4500	8500

The actual energy market margin is -$4000 =10MW *$600/MW – 10MW *$1000/MW (column I).

The BCR calculation, however, results in a $8500 BCR payment to make up for deemed losses of $8500 (last column). This amount is more than twice the actual losses:

Deemed profit for RT BCR Purposes = -$8500
= +10MW * ($600-$500)/MW -10MW * ($1000-$50)/MW[11]

Thus, the BCR payment flips the actual profit outcome from a $4000 loss (Real-time revenues column I) to a $4500 actual profit (when an $8500 BCR payment is added, i.e., when columns I and K are summed).

While it normally makes sense to calculate foregone revenues relative to bids and offers, a core element of Examples 1 and 2 is that the resource's offer in interval 6 is meaningless because the resource's state-of-charge, not the offer, determines the dispatch. In Examples 1 and 2, the offer to discharge in interval 6 is effectively $501/MWh, not the submitted offer of $50/MWh. The current design allows resources to submit low offer prices that do not impact their dispatch because the state-of-charge is zero and the dispatch is determined by the state-of-charge. Yet that low offer price is used to calculate opportunity costs and BCR.

[10] Note that the bid cost in Column J, Period 6 is based on the discharge offer ($50/MWh), not on the charge bid (whose magnitude is lower, at $40/MWh), because the real-time deviation is from the resource's discharge schedule. This is also the situation in Example 2 (Table 2).

[11] The discharge offer ($50/MWh) is used rather than the charge bid ($40/MWh) for the reason explained in the previous footnote.

Example 3. In fact, the offer price-based BCR design has the consequence that if a storage operator submits offer prices in hours with no DAM schedule that exceed its offer prices in hours with DAM discharge schedules, it cannot lose money as a result of depleting its state-of-charge due to those RT offers and then being unable later to cover its day-ahead market schedules in real-time. This is the case no matter how large the losses from buying back its day-ahead market schedules. If the storage resource depletes its state-of-charge as a result of being dispatched in hours in which it does not have a day-ahead market schedule and has to buy back its day-ahead market schedule at real-time prices, it will always make money by doing so as long as its RT offer prices in hours with no DAM discharge schedule exceed its RT offer prices in hours with DAM discharge schedules. A general demonstration of this result is shown below.

We show this result by generalizing the examples above, with the price in intervals 4 and 6 being Offer4 and Offer6, respectively, and similarly generalizing the RT prices in intervals 4 and 6 to Price4 and Price6. For simplicity, we assume that the RT deviation is 10 MW (discharge in interval 4, and charge in interval 6).

The actual energy market margin is therefore the following, and doesn't depend on the offers/bids:

[1] Energy Margin = 10 MW*(Price4- Price6)

The deemed profit for BCR calculation purposes ("BCR Profit" or negative of "BCR Loss," the equivalent of Column K in the previous tables) is:

[2] Deemed profit for BCR = 10 MW*[(Price4 – Offer4) – (Price6 – Offer6)]

Assuming this quantity is negative (a deemed loss occurs) and is the negative of the BCR payment, the sum of the actual energy market margin and BCR payment is therefore the total profit:

[3] Total Profit = 10 MW*[(Price4 – Price6) – [(Price4 – Offer4) – (Price6 – Offer6)]]

This simplifies to

[4] Total Profit = 10 MW*(Offer4 - Offer6)

There is no explicit dependence on RT prices in equation [4], although there is an implicit dependence because the RT redispatch will depend on the relationship of those prices to the offers. If Offer4 is very high, the spread would be larger but the resource would rarely be dispatched in hour 4 and rarely receive BCR on phantom losses. However, a resource operator can set its offers so that Offer4 exceeds Offer6, but is not so high that the resource would not be dispatched from time to time—and as a result have the opportunity to earn BCR on phantom losses whenever the resource is dispatched.

Hence, expression [4] shows that premature dispatch is always profitable if the offer price in the interval in which the resource is dispatched above its day-ahead market schedule (Offer4) exceeds its offer price in the interval in which it buys back its day-ahead market schedule (Offer6). Moreover, this offer price relationship is completely within the control of the storage resource operator. There is no explicit dependence on RT prices, although there is an implicit dependence because the RT dispatch in the intervals in which the resource does not have a day-ahead market schedule will depend on the relationship of those prices to the offers. Even if the offer prices of the resource could potentially be subject to market power mitigation, the storage operator can ensure that Offer4 > Offer 6 by submitting an offer for hour 4 that is greater than or equal to the real-time DEB (which might be mitigated to the DEB) and an offer for hour 6 that is strictly below the real-time DEB used in hour 4. The offers in hours 5 and 6 in Examples 1 and 2 are moderate, which limits the phantom losses. However, the storage operator can potentially earn large amounts of BCR on phantom losses under the current BCR system by reducing its offers in the hours in which it has day-ahead market discharge schedules (hours 5 and 6 in the example) to the offer floor.

An important point to draw from Example 3 is that it is not just the offers in the hour with DA market offers that are important from the standpoint of BCR calculations. The offers in the hours in which the resource has no DA schedule also matter because higher offers in those hours reduce the profits used to calculate BCR if the resource is dispatched at those times.

Example 4. Conversely, the current BCR design also provides BCR payments for phantom losses when resources cannot charge to meet their day-ahead market charging schedules due to lack of storage capacity as a consequence of premature charging. Example 4 covers the case in which this premature charging is profitable, yet the storage resource still receives a BCR payment, thereby inflating profits and ratepayer costs.

Table 3. Current BCR Design Example 4, Premature charging resulting in phantom losses and BCR payment when actual profits are positive

Period	DAM Schedule (MW) A	Real-Time Dispatch (MW) B	Real-Time Deviation (MW) C	Start SOC (MW) D	DAM Price ($/MWh) E	Real-Time Price ($/MWh) F	Real-Time Bid ($/MWh) G	Real-Time Offer ($/MWh) H	Real-Time Revenues ($) I	Bid Cost ($) J	BCR today ($) K
1	0	-10	-10	0	20	-5	50	500	50	-500	-550
2	-10	-10	0	10	10	10	50	500	0	0	0
3	-10	0	10	20	10	10	90	500	100	900	800
4	0	0	0	20	20	400	90	500	0	0	0
5	10	10	0	20	100	1000	40	50	0	0	0
6	10	10	0	10	200	1000	40	50	0	0	0
Total	0	0	0						150	400	250

Here, the actual RT net margin is an increase of $150 in net revenue as shown in column I.

Actual real-time profit = -10MW *-$5/MW +10MW *$10/MW =+$150.

The BCR calculation, however, results in a $250 BCR payment because the total deemed RT profit for BCR purposes (shown in column K) is -$250:

Deemed Profit for BCR Purposes
= -10 MW *(-$5-$50)/MWh +10 MW *($10-$90)/MWh =10 MW * ($55 - $80)/MWh
=10 MW*-$25/MWh = -$250

Thus, a BCR payment of +$250 is needed to cover phantom losses, which increases the actual margin from a profit of +$150 (column I) to +$400 (sum of columns I + K).

Example 5. This example differs from Example 4 in that the premature filling of storage results in market losses. Nevertheless, the depletion of storage is profitable when combined with the BCR payments.

Table 4: Current BCR Design Example 5, Premature charging resulting in phantom losses and BCR that are sufficient to flip actual profit from negative to positive

	DAM Schedule (MW)	Real-Time Dispatch (MW)	Real-Time Deviation (MW)	Start SOC (MW)	DAM Price ($/MWh)	Real-Time Price ($/MWh)	Real-Time Bid ($/MWh)	Real-Time Offer ($/MWh)	Real-Time Revenues ($)	Bid Cost ($)	BCR today ($)
Period	A	B	C	D	E	F	G	H	I	J	K
1	0	-10	-10	0	20	25	50	500	-250	-500	-250
2	-10	-10	0	10	10	10	50	500	0	0	0
3	-10	0	10	20	10	-100	90	500	-1000	900	1900
4	0	0	0	20	20	400	90	500	0	0	0
5	10	10	0	20	100	1000	40	50	0	0	0
6	10	10	0	10	200	1000	40	50	0	0	0
Total	0	0	0						-1250	400	1650

The actual RT margin is a loss of -$1250: -10 MW*$25/MWh + 10MW*-$100/MWh = -$1250 (column I).

The BCR calculation, however results in a $1650 BCR payment (column K):

Deemed Profit for BCR Purposes (negative of column K)
= -10MW *($25-$50)/MWh +10MW *(-$10-$90)/MWh
= 10MW * ($25/MW - $190/MW) = 10MW * -$165/MWh =-$1650

Thus, the $1650 BCR payment to cover phantom losses increases the actual margin from a loss of $150 to a profit of $1500 (sum of columns I+K).

Once again we note that, while it normally makes sense to calculate foregone revenues relative to bids and offers, a core element of Examples 4 and 5 is that the resource bid in interval 3 is meaningless because the resource's charging capacity, not the bid, determines the dispatch. In Examples 4 and 5 the bid in interval 3 is effectively -$101/MWh, not the submitted bid. The current design allows resources to submit high bid prices that do not impact their dispatch because the available charging capacity is zero and the dispatch is determined by the lack of charging capacity not the bid. Yet that meaningless high bid is used to calculate opportunity costs and BCR.

Example 6. The current BCR design creates a money machine in which storage resources can submit bids that result in BCR payments that produce profits without regard to actual net profits.

We show this by generalizing the examples above, with the bid price for charging in intervals 1 and 3 being Bid1 and Bid3, and similarly generalizing the RT prices in intervals 1 and 3 to Price1 and Price3.

The energy market margin is therefore:

[5] Energy Margin = -10MW *(Price1- Price3)

The BCR loss is:

[6] BCR Loss = - 10MW *[(Price1 – Bid1) – (Price3 – Bid3)]

The sum of the energy market margin and BCR payments is therefore:

[7] Total Margin = - 10MW *[(Price 1 – Price 3) + [(Price1 – Bid1) – (Price3 – Bid3)]]

This simplifies to:

[8] Total Margin = 10 MW*[Bid3 – (Bid1)]

Hence, as long as the bid to charge is higher in the hour in which energy is sold back (here, hour 3) than in the hour in which energy is purchased (hour 1 here), the premature filling of storage will be profitable without regard to real-time prices. We have used moderate values for the bid prices in Examples 4 and 5. However, higher bid prices could be submitted, which would result in larger phantom losses.

It is noteworthy that if the value of $0 is used instead of Offer4 and Offer6 in equation [2], and instead of Bid1 and Bid3 in equation [6], then there are no phantom BCR losses, and BCR payments are equal to actual market losses. This is also the case if Offer4 and Offer6 are replaced by the DAM-based default energy bid in equation [2] and Bid1 and Bid3 are replaced in equation [5].[12] The current design for ED BCR effectively uses $0 instead of Offer4 and Offer6 in calculating BCR. Several of the proposals considered in this initiative would substitute the DAM-based DEB for Offer4 and Offer6 in equation [2] and similarly for Bid1 and Bid3 in equation [5] in some or all circumstances, thereby reducing or eliminating BCR on phantom losses in these scenarios.

In summary, the present BCR design creates a situation in which phantom losses can increase BCR, even if actual profits are positive without BCR payments, resulting in total profits that depend only on offers. Without any restraint on charging bids, in theory a storage resource has no restraint (except for the price cap) on its phantom losses and thus total profit.

[12] This result assumes that RT incremental charges and discharges over the day balance so that the net change in SOC as a result of the RT schedule is zero at the end of the day.

We now turn to a second major problem of the current BCR design, which is that it creates an incentive to discharge earlier than optimally, which can increase profits and even harm system reliability, if energy is more valuable or needed for later hours than earlier hours.

2.2 The Current BCR Design Undermines Incentives to Maintain State-of-Charge

The current BCR design has the consequence that if a storage resource loses money in real-time as a result of prematurely depleting its state-of-charge, and as a result has to buy back its day-ahead market schedules, those losses will be covered by BCR payments.

This BCR design potentially incents resources to gamble on being able to profitably deplete their state-of-charge prior to the net load peak hours because it is, at worst, a "heads the storage resource operator wins, tails it does not lose" proposition. If the storage resource operator sells RT power early in the day and RT prices are low during the later hours when they have a DAM schedules, they make money. If instead RT prices are high during those later hours when they have to buy back their DA schedule, they receive BCR and at worst break even. This is the incentive problem described by the CAISO in its proposal and the Department of Market Monitoring in its comments.

The poor incentives created by the current design can be illustrated using Examples 1 and 2 (Tables 1 and 2 respectively). If the outcome in Example 1 had a 75% probability, and the outcome in Example 2 had a 25% probability, the expected actual profit (excluding any BCR) from discharging the resource in hour 4 when the price was $600 would be -$250.[13] Thus, premature discharge in hour 4 would be unprofitable. However, if the BCR payment covered revenue losses when they occurred , discharging power in hour 4 at a price of $600 would have a positive expected value of $750, because the $4000 loss in the Example 2 outcome would be offset by an equal BCR payment whose expense would be borne by other transmission customers.[14]

Because of the money machine described in Section 2.1, the incentive problem is even worse. The "costs" used in the BCR calculations today are based on the resource owner's bids and offers which can be structured to create phantom losses that turn an actual profit in the energy market into an apparent loss, which would be "compensated" by BCR. Under the current BCR design there would be BCR payments for phantom losses as also shown in Examples 1 and 2. As a result, the net revenues from discharging power during hour 4 and buying back the day-ahead market schedule during hour 6 would be a positive $4500, due to expected BCR payments of $4750.[15] Hence, today it is "heads the storage operator wins in the market, tails it *wins* with BCR payments." It is even better than a break-even proposition for storage operators, it is actually a win-win situation. If the storage resource operator offers its supply at low, zero or negative prices in the hours in which it has day-ahead market schedules, it can receive BCR payments for

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[13] Expected Net Revenues =0.75*$1000 (=actual profit, Table 1, Column I) + 0.25*(-$4000) (=actual profit, Table 2, Column I)

[14] Expected Net Revenues= 0.75*$1000 + 0.25*$0

[15] Expected BCR = $4750 = 0.75*$3500 (=Example 1 BCR) + 0.25*$8500 (=Example 2 BCR). See Column K of Tables 1 and 2, supra.

phantom losses even if it is dispatched at relatively low prices in the hours in which it does not have day-ahead market schedules.

Hence, it is hard to assess how material the impact of the incentives for early discharge would be absent the BCR money machine, because the reality has been that battery operators would actually make money in the situation in which premature dispatch results in actual market losses. This is because the BCR payments are calculated based on offer prices. This may be a major factor. Some of the calculations in the Appendix of the Draft Final Proposal[16] indicate that around 80% of the BCR payments could be from phantom losses, but we do not know whether these ratios are representative. DMM calculations, discussed in section V, suggest that BCR payments on phantom losses may have historically contributed to the lack of incentive to maintain state-of-charge but are not a material factors in recent months (May to July 2024).

Despite this ambiguity as to the current magnitude of BCR payments on phantom losses, we believe that an important goal for interim changes to the BCR calculation for storage resources is that the changes at least materially reduce, if not eliminate, BCR payments for phantom losses and thereby put an end to the money machine.

2.3 Regulation Charging or Discharging

Another scenario that can give rise to BCR payments under the current rules is if a resource deviates from its day-ahead schedules because of net charging or discharging over the day resulting from its regulation schedules that differs from the amount accounted for in the day-ahead market attenuation factors. For example, a storage resource might lack charging capacity to fulfill its day-ahead market charging schedules because of net charging associated with providing regulation-down in prior intervals. A lack of charging capability could also be due to a higher initial state of charge than modeled in the day-ahead market. In these scenarios, total deviations from day-ahead market schedules might reflect net discharges.

Example 7. This is illustrated in Example 7, in Table 5 below. In summary, the resource is assumed to have charged 15 MWh in hours 2 and 3 as uninstructed deviations (with charging shown as positive quantities in column D). For example, this could occur as a result of providing regulation–down .[17] In addition, there are instructed incremental RT energy schedules (e.g., resource-submitted incremental RT energy schedules) that also total 15 MWh in hours 3 and 4 (column C). Table 5 shows the implications for BCR calculations under the current system, in which only the instructed incremental RT energy costs and revenues are considered in BCR calculations, and not revenue and bid costs associated with uninstructed deviations.[18] The instructed RT deviations from DAM schedules result in net revenues of $150 from selling back day-ahead market schedules, as shown in column J. Despite the reduced charging actually being

[16] California ISO, "Draft Final Proposal for Track 1," Appendix A, op. cit., Table 1.

[17] Or as noted above, this could be due to an initial state of charge of 15 MW in real-time that was not modeled in the day-ahead market.

[18] There are also complexities in how regulation charging costs and discharging revenues are accounted for in BCR calculations that we do not go into in this example to allow us to focus on certain issues.

profitable based on FMM prices and charging offers, the resource would receive small BCR payments of $75 based on the offers in Column L, inflating its actual profit from $150 to $225.

The example is complicated by the fact that the resource would have been buying power at the real-time price to the extent that its regulation was resulting in net charging. Furthermore, this net charging would in part be driven by the amount of load conformance used by CAISO operators in RTD, which is outside the control of the storage operator, other than by reducing the amount of regulation-down it offers to provide in the DA market.

Table 5. Current BCR Design Example 7, Regulation-up charging resulting in phantom losses and BCR

	DAM Schedule (MW)	Real-Time Dispatch (MW)	Real-Time Deviation (MW)	Reg charging (MW)	Start SOC (MWh)	DAM Price ($/MWh)	Real-Time Price ($/MWh)	Real-Time Bid ($/MWh)	Real-Time Offer ($/MWh)	Real-Time Revenues ($)	Bid Cost ($)	BCR today ($)
Period	A	B	C	D	E	F	G	H	I	J	K	L
1	0	0	0	0	0	20	20	15	100	0	0	0
2	0	0	0	10	0	20	20	15	100	0	0	0
3	-10	-5	5	5	10	10	10	15	100	50	75	25
4	-10	0	10	0	20	10	10	15	400	100	150	50
5	10	10	0	0	20	100	100	40	50	0	0	0
6	10	10	0	0	10	200	200	40	50	0	0	0
Total	0	15	15	15						150	225	75

Table notes:

1. RT actual revenues (col. J) include revenues from just RT scheduled deviations (scheduled energy discharge) (col. C). For simplicity, this excludes energy market payments for UIE used to charge regulation (col. D).
2. Bid cost for BCR calculations (col K) includes only bid cost associated with RT scheduled deviation (col C, which is multiplied by the RT bid cost H), and not bid cost associated with Reg charging UIE (col D).
3. Deemed losses for BCR calculation purposes (col. L) equals the -1 times the quantity: (i) RT revenues just from RT scheduled deviations (col. C, which is multiplied by the RT price (col. G)) minus (ii) bid cost for BCR calculation purposes (col. K).

However, BCR payments could be much higher in this situation than $75. If instead the resource operator foresaw partway through hour 2 that its resource would be fully charged by the end of interval 3 and submitted a $300 bid for interval 4 (as shown in column H of Table 6), BCR payments would increase substantially from $75 to $2925, despite the resource actually receiving positive real-time revenues of $150 from the instructed energy schedule (Tables 5 and 6, column J). This increases total actual RT profit received by the resource from +$150 (column J) to +$3075 (sum of columns J and L).

Table 6. Current BCR Design Example 8, Regulation-up charging resulting in phantom losses and higher BCR due to inflated RT offer in hour 4

Period	DAM Schedule (MW) A	Real-Time Dispatch (MW) B	Real-Time Deviation (MW) C	Reg charging (MW) D	Start SOC (MWh) E	DAM Price ($/MWh) F	Real-Time Price ($/MWh) G	Real-Time Bid ($/MWh) H	Real-Time Offer ($/MWh) I	Real-Time Revenues ($) J	Bid Cost ($) K	BCR today ($) L
1	0	0	0	0	0	20	20	15	100	0	0	0
2	0	0	0	10	0	20	20	15	100	0	0	0
3	-10	-5	5	5	10	10	10	15	100	50	75	25
4	-10	0	10	0	20	10	10	300	400	100	3000	2900
5	10	10	0	0	20	100	100	40	50	0	0	0
6	10	10	0	0	10	200	200	40	50	0	0	0
Total	0	15	15	15						150	3075	2925

Table notes:

1. RT actual revenues (col. J) calculated in same way as Table 5, Note 1.
2. Bid cost for BCR calculations (col K) calculated same way as Table 5, Note 2. Amount is $3000 in hour 5 due to high RT bid in that hour ($300, col. H).
3. Deemed losses for BCR calculation purposes (col. L) calculated same way as Table 5, Note 3. Its total of $2925 is much larger than the Table 5 total due to the much higher bid cost in col. K.

We have focused above on BCR associated with sell-back of DA market charging schedules due to regulation charging. There could also be BCR associated with buy-backs of DA market discharge schedules due to regulation discharges. The potential for these losses would be reduced to the extent that the regulation charging and discharges are accounted for in the attenuation factors used in the day-ahead market but this would only be true on average. There does not appear to be a simple way to fully eliminate BCR payments for phantom losses in these regulation charging cases but we are unclear as to how material this source of BCR payments is in practice. However, this appears to be a major source of BCR payments on phantom losses in 8 cases provided to the MSC by the CAISO. Some design changes that would eliminate BCR for phantom losses in situations like those portrayed in Examples 1, 2, 4, and 5 would increase BCR payments in the scenarios described in this section.

2.4 BCR Due to the Ancillary Services State-of-Charge Constraint

Several years ago, the DMM and California ISO identified a flaw in the BCR design that resulted in excess BCR payments when the ancillary services state-of-charge constraint resulted in uneconomic charging or uneconomic discharges. This problem was intended to be addressed with the tariff changes proposed in Docket ER22-2881. The implementation of this design involves some of the same type of complexities relating to the identification of binding state-of-charge constraints for the CAISO's original BCR design with RTD's multiple interval optimization.

The Market Surveillance Committee does not have access to data on ancillary services state-of-charge (ASSOC) implementation or BCR payments. However, in reviewing eight numerical examples provided to us by the CAISO based on actual resources that were used to test the impact of the alternative BCR design changes, we saw indications that a material portion of the BCR paid to some resources may be attributable to out-of-merit dispatches to maintain regulation-down charging capacity, yet that BCR was not identified as due to the ancillary services constraint.[19]

Hence, there may be a fourth issue, in addition to those discussed in Sections 2.1-2.3, that the changes implemented in Docket ER22-2881 with the intent of eliminating BCR payments due to the ASSOC constraint may not be completely effective in achieving this goal.[20] Hence some of the current BCR payments may be a result of the complexities in implementing the Docket ER22-2881 design. Further changes to the BCR design may be needed to eliminate these unwarranted BCR payments.

We have reviewed a number of examples of actual resource dispatch and BCR data in which the BCR appears to largely driven by a combination of regulation charging (or initial state of charge) and discharges due to a binding ancillary services state of charge constraint. However, because the CAISO data does not include data on interval by interval state of charge or regulation charging, we cannot be sure of the cause of the uneconomic failure to charge. Some CAISO staff have suggested that the failure to charge might be due to the operation of multiple interval optimization, although we view that as implausible in the intervals with the largest BCR costs. However, the cause does not really matter. The point of example 8, and what we see in the CAISO examples, is that when there is an out of merit failure to charge in hours with day-ahead market charging schedules, then regardless of the reason for the out-of-merit dispatch, BCR costs can be inflated by the submission of high charging bids.

We will see in the discussion in Section 5 that none of the BCR design changes proposed by market participants or the CAISO will fully eliminate BCR payments due to limitations of the ASSOC design or these other factors, but designs using the DEB to cap the bid used to calculate BCR (such as the CAISO proposal) will cap inflated BCR payments based on phantom losses, whatever the reason for the deviation.

3. Is There a Need for Storage BCR At All?

There are only three potential reasons that we believe justify the receipt of BCR payments for storage resources. These include losses due to exceptional dispatch leading to depletion of state-of-charge, losses due to dispatch at mitigated offer prices (or failure to charge due to mitigated bid prices) resulting in depleted state-of-charge, and multiple interval optimization resulting in losses for any reason over the day. We will discuss each of these in Subsections 3.1-3.3, respectively. We also discuss the ability of storage operators to manage their state-of-charge with existing tools (Section 3.4).

[19] The MSC has seen some indications of this in non-public examples that the CAISO has provided to the MSC. However, we have not reviewed all of the relevant data and it is possible that these uneconomic dispatches were due to other factors such as anomalies in the multiple interval optimization or bugs in the CAISO RTD software that we are unaware of.

[20] The Market Surveillance Committee does not have access to the detailed data that would be necessary to understand the cause of BCR payments so we are limited to making assessments based on the information provided by market participants, the CAISO and the DMM.

3.1 Exceptional dispatch

Exceptional dispatch can result in a storage resource prematurely depleting its state-of-charge and being dispatched in lower priced intervals. The CAISO has addressed this problem with a special BCR-type settlement for exceptional dispatch implemented in ER23-1533. A noteworthy feature of the exceptional dispatch BCR design is that the calculation of BCR is in this case not based on offer prices (unlike Section 2.1), but on storage resource real-time net revenue impacts calculated based on "but for" dispatches.

3.2 Local Market Power Mitigation

There is a potential for the application of offer price mitigation in RTD to result in premature dispatch of a storage resource at mitigated offer prices, with the consequence that the resource is unable to cover its day-ahead market schedules later in the day due to insufficient state-of-charge. While, as discussed below, mitigation does not appear to have been a significant contributor to instances of early depletion of SOC over the past year, it appears to occur in some situations for particular resources. Such premature dispatch would constitute a situation where some BCR would be warranted. We believe such compensation could be implemented similar to the exceptional dispatch methodology without creating the potential for BCR payments on phantom losses. Therefore, the potential for mitigation due to early depletion does not justify the continuation of BCR policies in the way they are currently implemented.

Both the Department of Market Monitoring and the CAISO have empirically examined the magnitude of premature dispatch due to mitigation and the CAISO has also related the level of mitigated dispatch to the lack of state-of-charge.

The Department of Market Monitoring calculated the impact of mitigation on storage resource dispatch in RTD on 9 restricted maintenance operation days in 2023. This analysis indicates that there were very small amounts of dispatch based on mitigated offer prices in RTD in hours 12-17 on these days, and an average of less than 100-200 MW of dispatch in RTD as a result of mitigation in hour 18.[21] Moreover, we understand from the Department of Market Monitoring that these mitigation rates include the dispatch of resources electing to use a cost-based DEB which is less than $1. Mitigated dispatch based on the cost-based DEB is not the fault of the mitigation design, it could have been avoided by opting to use the normal DEB which, in most situations, would be much higher.

The Department of Market Monitoring also estimated the level of mitigated dispatch that would have occurred if battery resources had instead offered at $1000/MWh on those days and been mitigated based on the normal DEB. This analysis shows there would have been zero mitigated dispatch in hours 12 to 17 over the same 9 restricted maintenance operations days, indicating that based on the DMM analysis, all of the actual mitigated dispatch in hours 12-17 was of resources

[21] See California ISO, Department of Market Monitoring, "Storage Bid Cost Recovery and Default Energy Bids Enhancements," Presentation, Meeting on Revised Straw Proposal, September 11, 2024, Slide 8.

electing to use the cost-based DEB. Also, this analysis appears to show about 200 MW of mitigated dispatch based on normal DEBs and $1000/MWh offer prices in hour 18 for these 9 restricted maintenance operation days [22]

We focus our assessment of the impact of mitigated dispatch over hours 12-17, because it is dispatch in these hours that has the greatest potential to result in inadequate state-of-charge in the net load peak hours. While mitigated dispatch in the net peak load hours could result in a non-optimal dispatch of the remaining state-of-charge, this would generally only be an issue if the resource has depleted its state-of-charge in prior hours and is a secondary concern with respect to the impact of mitigation.

Overall, for resources buying back day-ahead market schedules, the MW of mitigated dispatch calculated by the CAISO is very small relative to the total amount of premature dispatch, accounting for only about 3% of day-ahead market buy-backs[23] and $560,700 of BCR over the 12 months from September 2023 through August 2024. This can be compared to the $18.5 million BCR in total paid to storage resources over the same period, so mitigated storage dispatch accounted for around 3% of the total BCR payments.[24] This mitigation impact is at least somewhat overstated because it includes mitigation of resources using the cost-based DEB.

Thus, in total, roughly $560,000 of BCR was due to premature dispatch associated with mitigation over this 12 month period. This BCR was not spread evenly over all resource days. The ISO noted that there were only 10 resource days with an imputed BCR impact of $10,000 or more.[25] However, one of these resource days accounted for BCR payments well over $50,000 for the day. This illustrates the reality that the impact of mitigation on state-of-charge can be uneven over resources.

It is important to note that these figures for BCR associated with mitigated dispatch do not measure the actual market losses to storage resources due to mitigation absent BCR payments, they only measure the amount of BCR payments associated with mitigated dispatch. As explained in Section 2.1, premature dispatch due to mitigation can result in inflated BCR payments that exceed actual losses because the calculation of BCR is based on offer prices. Hence, changes to the BCR design that put a floor under the offer prices used to calculate BCR on buybacks and put a cap on the bid prices used to calculate BCR on sellbacks (such as the CAISO proposal) would reduce BCR on phantom losses associated with mitigated dispatch or charging.

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[22] California ISO, Department of Market Monitoring, "Storage Bid Cost Recovery and Default Energy Bids Enhancements," op. cit., Slide 11. The estimate for hour 18 is an eyeball estimate based on the figure.

[23] See California ISO, "Storage Bid Cost Recovery (BCR) and Default Energy Bid (DEB) Enhancements," Presentation, Oct. 9, 2024, https://stakeholdercenter.caiso.com/InitiativeDocuments/Presentation-Storage-Bid-Cost-Recovery-and-Default-Energy-Bids-Enhancements-Oct-09-2024.pdf, Slide 42.

[24] CAISO calculations for the Market Surveillance Committee

[25] See California ISO, "Storage Bid Cost Recovery (BCR) and Default Energy Bid (DEB) Enhancements," Presentation, op. cit.

Hence, if actual economic losses to the resource are on average only 25% of BCR payments, then the total economic losses due to mitigation might be only around $140,000.[26] Conversely, if BCR paid on phantom losses has been small, then most of the BCR associated with mitigated dispatch would reflect actual economic losses.

3.3 Multiple Interval Optimization

It is conceivable that multiple interval optimization could result in real-time losses due to uneconomic charging or uneconomic discharges within the hour horizon of RTD. Analysis of the importance of this phenomenon is hindered by a lack of data on instances in which out-of-market MIO dispatch turns out to be non-optimal after the fact, which is complex to assess. The analysis of MIO dispatch back in late 2021 portrayed a number of instances in which out-of-merit dispatch was consistent with resource offers for ancillary services, future period self-schedules, and state-of-charge constraints. There can also be dispatches that appear non-optimal after the fact because of changes in intermittent resource output or the modeling of constraints. In one instance highlighted by stakeholders, the apparently non-optimal dispatch was driven by operator changes to limits that created the potential for windfall profits from premature dispatch, but the MIO dispatch was actually optimal.[27]

It does not appear to us that BCR coverage of actual MIO losses should be a material concern. First, under the CAISO proposal for calculating BCR (see discussion of solutions in Section 5 of this Opinion), storage operators would still receive full BCR coverage for actual market losses, they just would collect fewer BCR payments for phantom losses.

Second, it may not be reasonable that storage operators should be entitled to BCR for a lack of perfect foresight on the part of the CAISO, as the storage operators do not have perfect foresight either. If the MIO is correct after the fact 80% of the time and wrong after the fact 20% of the time, it does not appear reasonable that storage operators should be entitled to keep the profits the 80% of the time the MIO makes the after-the-fact profit-maximizing choice and get BCR the 20% of the time market conditions change and the MIO dispatch is not optimal after the fact.

As noted above, we have had discussions with some CAISO staff of whether the uneconomic deviations from day-ahead market schedules observed in CAISO data are due to regulation charging, initial state of charge, discharges due to the ancillary service state of charge constraint or to issues with the MIO. We are somewhat skeptical that the out of merit dispatch in these cases is due to the operation of the MIO, but this does not really matter. The key issue from the standpoint of BCR is the calculation of BCR on phantom losses driven by artificially high bid prices or low offer prices, regardless of the driver of the out-of- merit dispatch. The use of the DEB as

[26] It is also conceivable that some of the mitigation that lead to dispatch was appropriate and did not reduce net resource revenues. It is possible for example that some of the mitigated dispatch was profitable and the BCR is due to phantom losses.

[27] R. Kalaskar and G. Baustista-Alderete, "Real-time Dispatch Multi-Interval Optimization," Presentation, Market Surveillance Committee Meeting, October 1, 2021, www.caiso.com/documents/energystorageenhancementsmio-presentation-oct1_2021.pdf.

a cap on bids and a floor on offers (such as the CAISO proposal) will tend to reduce BCR payments for phantom losses regardless of the cause of the out-of-merit dispatch.

If the ISO could show through analysis of historical data that MIO dispatch on average has consistently increased actual storage profits (exclusive of BCR) over an extensive period of time compared to a counterfactual in which only binding interval offers/bids were considered without considering consequences in advisory intervals, the willingness of resource owners to accept this policy would be increased. Increasing the transparency of advisory interval prices and their impacts on dispatch and profits would help the ISO make the case that MIO is on balance profit increasing for storage.

Third, for a 4 hour battery, the optimization over a single hour of advisory intervals in the MIO only affects the dispatch outcome when the state-of-charge is more than 75% full or 75% empty, so that the dispatch could result in the storage bounds being limiting within the hour. If the MIO does not perfectly optimize in hour 19 because the resource only has 30 minutes of state-of-charge left, the problem is not really with the MIO, it is with the storage operator that prematurely depleted resource state-of-charge. Similarly, if the resource is 85% charged by noon and the MIO does not perfectly optimize filling the remaining 15% over the rest of the afternoon, the problem is not really with the MIO.

3.4 Limitations of Tools Available to Manage State-of-Charge

Another consideration with respect to BCR payments to storage resources concerns the limitations of the tools currently available to battery resource operators to manage their state-of-charge over the day. As we discussed in Sections 4.2, 5.2.1 and 7.2 of our May 15 opinion on Order 831 changes,[28] the current CAISO market design imposes a number of limitations on the ability of storage resource operators to manage state-of-charge.

These include the adverse impacts from using the end-of-hour state-of-charge constraint to manage resource state-of-charge, the lack of state-of-charge dependent offer prices and the long time lag for changes in offer prices or upper limits. In addition, market participants lack the ability to specify the expected energy discharge or charging associated with day-ahead market regulation-up or regulation-down schedules. Instead, these attenuation factors are specified by the CAISO based on data for each hour of the day averaged over all storage resources over all days within a season, which however may not reflect the expected energy use for a particular resource on particular types of days.[29]

However, we believe that none of these limitations is a reason to pay BCR on phantom losses.

Moreover, the limitations of the current CAISO design for managing state-of-charge does not mean that battery operators should incur no losses when they fail to use offer prices and ancillary

[28] Note 4, infra.

[29] California ISO, Market Performance and Planning Forum, March 11, 2024, www.caiso.com/documents/presentation-market-performance-planning-forum-mar-11-2024.pdf.

service schedules to manage their resource's state-of-charge. The lack of losses would simply reduce the incentive of storage operators to try to use offer prices and schedules to efficiently manage state-of-charge. In fact, without fundamental changes to the current BCR design, storage operators lack incentive to use increased offer flexibility to manage state-of-charge, and are instead incented to use that flexibility to further inflate BCR payments.

4. Storage in the Western Energy Market and BCR

The CAISO discussion has focused on BCR paid to storage resources in CAISO that have day-ahead market schedules. In this section we turn to a discussion of the impacts of the current design within the Western Energy Market.

Storage resource operators located in the WEM have the same ability as resources located within the CAISO to manipulate offer prices over the day in order to create and inflate phantom losses and BCR payments, as described in the discussion of Examples 3 and 6. However, it appears to us that the use of base schedules, rather than day-ahead market schedules, to settle imbalances has some significant implications for the magnitude of phantom losses and BCR profits in the WEM.

A critical difference in the WEM is the different roles of base schedules and DA market schedules. Day-ahead market schedules are financially binding but they do not reflect real-time operating conditions. Hence, as discussed in Section 2.1 above, day-ahead market schedules can be completely inconsistent with the operating capability of the resource.

In contrast, base schedules are set 75 minutes prior to the operating hour, not the day before as is the case with day-ahead market schedules. Moreover, base schedules are intended to be physical as well as financial. Base schedules are used to apply the resource sufficiency evaluation. If a WEM entity resource has little or no state-of-charge at t-75 beyond that needed to cover its base schedules from t-75 to t, we presume the utility would not include a storage resource projected to have little or no state-of-charge in the base schedules used to pass the resource sufficiency evaluation for the period t to t+60.

Our understanding is that BCR for WEM entities is calculated based on deviations from base schedules over the day. Hence, a fundamental difference for WEM resources relative to CAISO resources is that the base schedules for the net load peak hours are determined shortly before those hours and would reflect the state-of-charge expected to be available to draw on or add to over that hour. Hence, real-time imbalances due to lack of state-of-charge should be uncommon in the WEM, and BCR payments due to such real-time imbalances should be small. This difference also impacts WEM utility incentives. If they prematurely deplete their state-of-charge relative to their operating plan for the day, they would need to substitute other resources, or perhaps contract for imports, in order to show sufficient resources to pass the resource sufficiency evaluation, at the same time receiving no BCR payment. Storage resource operators in the CAISO, on the other hand, incur no losses when they are unable to cover their day-ahead market schedules, and it is instead the CAISO that bears the cost of procuring replacement resources to pass the resource sufficiency evaluation and meet real-time load.

Consistent with this conclusion is the fact that the DMM 2023 market performance report reports that 2023 battery BCR in the WEM was only $12,943. This was less than 1/2000 the amount of battery BCR in CAISO.[30]

While there is less potential for phantom losses and inflated BCR payments in the WEM than in the CAISO, it would still be desirable to make appropriate changes in the BCR calculation to eliminate the potential for phantom BCR losses and inflated BCR payments.

Developing alternative BCR designs for the WEM is complicated by the fact that there are no day-ahead market prices and the real-time DEBs are not based on day-ahead market prices. In addition, when there is south-to-north congestion in the WEM, the net load peak hours in the Pacific Northwest and Rockies may be different than the net load peak hours in California and the Southwest. Nevertheless, a BCR design based on a real-time DEB that is constant over the day should eliminate the potential for inflated BCR payments while continuing to allow BCR payments that cover actual losses. As in the CAISO, it would be desirable in the long run for the WEM to apply a BCR design that strengthens protections against the BCR money machine provides; in particular, we recommend a modified BCR design based on DEBs that applies in all intervals.

5. BCR Reform Proposals

Quite a few proposals for changes to the BCR design have been put forward during the ISO's stakeholder process. We summarize a few below and explain how they would operate for the scenarios described in Examples 1, 2, 4, 5, 7, and 8, above. A core problem with the discussion of options in the stakeholder process is that complex options have been presented, but there has been no discussion of the principled basis for the individual components of the equations such as the DEB, the DAM price, and the RT price. One reason for including a fixed DEB based on day-ahead market prices in these formulas is to cap extreme values of bid prices and put a floor under offer prices, in order to reduce the magnitude of phantom losses due to extreme bid and offer prices. A second advantage of a design based on a fixed DEBs is that if the same DEB is used over the day to calculate profits and losses this will eliminate BCR on phantom losses when sales and buy back schedules are balanced. However, a DEB-based design may not reduce phantom BCR when applied to unbalanced sales and buy-backs or purchases and sell-backs over the day.[31]

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[30] See California ISO, Department of Market Monitoring, "2023 Annual Report on Market Issues & Performance," July 29, 2024, Table 2.4, p. 109.

[31] Strictly speaking, there are several conditions for phantom real-time profits based on the DEB approach to be zero. First, the DEBs for discharge offers and charge bids must differ in a way that appropriately accounts for variable O&M costs (other than energy opportunity costs), battery degradation, and the effect of round-trip efficiency on opportunity costs of charging versus discharging. Second, real-time schedules must result in no change in the end-of-day state-of-charge compared to the DA SOC.

Under these assumptions, the opportunity cost component of the DEB bids and offers will cancel out, and the only effect on deemed profit for the purpose of calculating BCR will be the variable O&M costs and degradation terms, which are in fact appropriate to include in BCR. If charging and discharging do not balance out in a way that

The inclusion of a DAM price in the formula in combination with the DEB will tend to reduce BCR on buy-backs and sales because the DAM price will be lower than the DEB in the hours in which the resource does not have day-ahead market sales schedule. Such a design could result in BCR payments which are only a portion of actual economic losses, which could have some positive impacts on the incentive to maintain state-of-charge.

The inclusion of the real-time price in the Joint Stakeholder and CAISO formulas, on the other hand, appears to us to lack any principled basis. In the CAISO design, the inclusion of the RT price in the formulas appears to result in offer prices being used rather than default energy bids in some situations, allowing larger BCR payments on phantom losses.

The bottom line is that the original CAISO state of charge based proposal would appear to eliminate all phantom BCR, and would also eliminate all BCR on actual economic losses, even if the losses were due to mitigation. The current CAISO proposal will not eliminate all BCR for phantom losses. In fact, for the cases in examples 1, 2, 4, and 5 above, it would only partially reduce BCR for phantom losses relative to the current design. However, even though BCR for phantom losses will not be eliminated, the CAISO design could materially reduce BCR based on extremely large phantom losses due to extreme bid and offer values. The CAISO design has evolved to be largely the same in its impacts as the Joint Stakeholder design. It appears to us that the CAISO (and Joint Stakeholder) designs would pay full BCR on actual economic losses, whether they are due to dispatch based on mitigated prices, non-optimal dispatch, or failure to manage state-of-charge.

A static day-ahead market DEB-based design was also discussed in the stakeholder process. A static DEB-based design would completely eliminate payments on phantom losses in Examples 1, 2, 4, and 5 of Section 2.1, while continuing to pay BCR on all actual economic losses. However, this design could perform worse than the CAISO and Joint Stakeholder designs, and worse than the current BCR designs in scenarios such as Examples 7 and 8.

5.1 CAISO Original Proposal

The original CAISO proposal described in Section 4.1 of the CAISO's July 26, 2024 Issue Paper and Straw Proposal was to identify when a resource could not charge or discharge as a result of a state-of-charge constraint, and eliminate BCR payments in those intervals.

This would be an elegant solution to the problems identified in Sections 2.1, 2.2 and 2.3. We will see in the discussion below of the other options that if this solution could be accurately implemented, it would address some sources of BCR better than the options considered in this stakeholder process.

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leaves the end-of-day SOC unchanged from the DA value, then the change in energy in storage should have an imputed value that might logically be based on discharge DEB. If, for instance, SOC is in fact increased by the RT schedule, then the imputed value of the change in SOC will partially or fully offset the fact that relatively more charging has taken place, so that the accumulated opportunity cost portion of the discharge offer costs will exceed the accumulated opportunity cost portion of charge bid costs.

However, as discussed above, the CAISO has determined that this option is not currently workable from an implementation standpoint due to a need to consider the impact of binding constraints in advisory intervals on the binding interval schedules.[32] This is likely the same type of implementation complexity that appears to have resulted in imperfect implementation of the AS-SOC constraint.

Furthermore, the original design would also have addressed the issue raised in Section 2.2 concerning the dampening of incentives to avoid inefficient premature discharge of storage. It is not apparent that there is a way within this design to continue to allow BCR payments due to premature depletion of state-of-charge, including depletion due to the impact of market power mitigation and possibly the impact of multiple interval optimization.

A significant problem with this design is that while it is easy to illustrate in a made up example, we understand it has proved very complex for the CAISO to implement in actual settlements calculations.

5.2 Static Day-Ahead Market DEB-Based BCR Payments

Another approach that is useful to use as a benchmark for BCR design performance is a design that uses the DAM price-based RT DEB as the bid and offer for calculating BCR payments, and uses the sa.me value in all intervals. This design would have the effect of eliminating the money machine arising from phantom losses described in Section 2.1 because (using the notation of Example 3) Offer4=Offer6 and (in the notation of Example 6) Bid1=Bid3.

This design would not eliminate BCR compensating for actual losses such as in Examples 2, 5, and 8 but would in many scenarios largely or completely eliminate BCR for phantom losses. This is shown in Examples 2-DEB and 5-DEB (where such BCR is eliminated) and Example 8-DEB (where such BCR is decreased by roughly half), shown in the Appendix (Tables A.1, A.2, A.4). (Example 2-DEB illustrates, for instance, that using DEBs as the basis for offers and bids in deemed profit calculations for BCR periods can result in zero net bid-cost, and so BCR equals the actual loss of $400, rather than the inflated value of $8500 in Table 2. Example 8-DEB Table A.4 in the appendix shows that the high real-time bid in hour 4 of $300/MWh has a much reduced effect on BCR under a DEB-based system, because BCR is instead driven by the DEB of $100/MWh. As a result, BCR is reduced by more than half compared to the current system (Table 6).

However, a core limitation of this design is that while it would tend to put a cap on BCR payments arising from premature charging or discharging as a result of providing regulation in some scenarios involving regulation charging, it would also likely continue to allow potentially substantial BCR payments for profitable deviations from day-ahead market schedules (reducing

[32] California ISO, Revised Straw Proposal for Track 1, September 4, 2024, https://stakeholdercenter.caiso.com/InitiativeDocuments/Revised-Straw-Proposal-Storage-Bid-Cost-Recovery-and-Default-Energy-Bids-Enhancements-Sep-04-2024.pdf.

market efficiency and in some circumstances adversely impact reliability by encouraging premature discharge of SOC) and inflated BCR payments for unprofitable deviations. (See Section 2.2 for how this inefficiency would occur.)

An illustration is as follows. There are some scenarios, such as Example 7-DEB (in the Appendix, Table A.3, infra), in which a BCR design based solely on the DEB would result in higher BCR than under the current design (compare to Example 7, Table 5, above) and than under the CAISO proposal.

5.3 CESA/Joint Stakeholder Proposal

The "Joint Stakeholder" proposal, an evolution of the California Energy Storage Association proposals supported by the Western Power Trading Forum, Vistra and PG&E would only apply a non-bid-based BCR payment design in hours with buy backs of day-ahead market discharge schedules, or sell-backs of day-ahead market charging schedules.[33]

Thus, for a buy back of a discharge schedule:[34]

BCR = (RT dispatch – DA schedule)
*{[Max (RT Discharge Offer, Min (DA LMP, Discharge RT DEB, RT LMP))] – RT LMP}

For a sell back of a charge schedule:

BCR = (RT dispatch – DA schedule)
*{[Min (RT Charge Bid, Max (DA LMP, Charge RT DEB, RT LMP))] – RT LMP}

A core weakness of this design is that because it continues to base the calculation of BCR profits for buy-backs in the hour in which the resource is dispatched above its day-ahead market schedule on the resource offer, there is a continuing potential for BCR payments on phantom losses anytime the resource is dispatched at an offer price that is higher than the RT DEB.

This is illustrated in Examples 1 and 2. The RT discharge bid based on the 4th highest DAM price would be less than or equal to the DA LMP in the hours with day-ahead market schedules. The DEB would also generally be lower than the RT LMP during hours in which there are DAM schedules and the resource has to buy back at a loss. Thus, the Joint Stakeholder design effectively replaces the bid with the RT DEB in the buy-back intervals. This will eliminate some phantom BCR from RT offer prices that are less than the RT DEB, but will not completely eliminate BCR on phantom losses.

Because the RT offers in those examples in hour 4 are materially above the DEB, there are large BCR payments for phantom losses in Examples 1 and 2 under the Joint Stakeholder design. In these examples, that design would only slightly reduce BCR payments for phantom losses by raising the offer in hour 6 from $50 to the $100 DEB. However, the impact of the Joint Stakeholder design could be larger if resource submitted lower offers in hour 6. Thus, if the resource

[33] See CESA comments 9/23/24, Section 8, https://stakeholdercenter.caiso.com/Comments/AllComments/04a134b1-3874-498a-ab08-e075048095e5.

[34] Our formula involves a slight correction of a missing right parenthesis in the Final Draft Proposal, p. 6.

operator offered supply at -$150 in hour 6, the Joint Stakeholder design would raise the offer to the DEB for the purpose of calculating BCR, reducing BCR payments. Of course, resources are less likely to be prematurely discharged in RT if their offers exceed the DEB, but when this happens under the Joint Stakeholder design, then the resources will receive BCR payments on phantom losses (the difference between the offer in the hour in which the resource is dispatched above its day-ahead market schedule and the DEB). We believe that there is no rationale for these BCR payments on phantom losses.

Similarly, the Joint Stakeholder design would use the resource offer in the calculation of BCR profits for sell-backs in the hour in which the resource is dispatched above its day-ahead market schedule. There is therefore a continuing potential for BCR payments on phantom losses anytime the resource charges based on a bid price that is lower than the RT DEB. BCR on phantom losses is more likely than in Examples 1 and 2 because bid prices are likely to be lower than the RT DEB, which is based on the 4th highest DAM price.

This is illustrated in Examples 4 and 5. The real-time DEB for CAISO resources would be set based on the 4th highest DAM price, which would certainly exceed the DAM price in the charging hours. Also, we conjecture that the DEB would likely be higher than the real-time price in any hours in it would be economic to charge in real-time. Hence the Joint Stakeholder formula will continue to use bid prices to calculate charging BCR unless the bid prices are above the DEB. While the Joint Stakeholder design would eliminate extreme BCR payments based on very high charging bids, the BCR in Examples 4 and 5 would remain exactly the same as under the current design. Once again, we believe there is no basis for BCR payments to cover phantom losses resulting from such bidding behavior.

5.4 Draft Final CAISO Proposal

The current CAISO proposal differs from the Joint Stakeholder proposal in that the CAISO proposal would be applied to all hours of the day, and would adjust the price used to calculate BCR in hours in which resources do not have day-ahead market schedules, but are dispatched to discharge or charge in real-time. The discharge offer cost and charging bid cost in this proposal can be stated as follows.[35]

- For intervals with day-ahead market schedules:
  - If(FMM schedule-Day-ahead market schedule > 0, then:
    - FMM Bid Costs: = (FMM schedule – Day-ahead markets schedule) * ([Min(FMM Bid, Max(DA LMP, Real-time DEB, FMM LMP))] – FMM LMP), 0)
  - If(FMM schedule-Day-ahead market schedule <= 0, then:
    - FMM Bid Costs: = (FMM schedule – Day-ahead market schedule) * ([Max(FMM Bid, Min(DA LMP, Real-time DEB, FMM LMP))] – FMM LMP), 0)

[35] With minor clarifications of notation and corrections of the formulae on p. 6 of Appendix A of the draft final proposal, op. cit..

If(RTD Dispatch-FMM schedule > 0, then:
RTD Bid Costs:= (RTD Dispatch – FMM schedule) *
([Min(RTD Bid,Max(DA LMP, Real-time DEB, RTD LMP))]–RTD LMP), 0)

If(RTD Dispatch-FMM schedule <= 0, then:
RTD Bid Costs:= (RTD Dispatch – FMM schedule) *
([Max(RTD Bid,Min(DA LMP, Real-time DEB,RTD LMP))] –RTD LMP), 0)

- For intervals with no day-ahead market schedules

If(FMM Dispatch > 0, then:
FMM Bid Costs:= (FMM Dispatch – DA schedule) *
([Min(FMM Bid, Max(Real-time DEB, FMM LMP))] – FMM LMP), 0)

If(FMM Dispatch <= 0, then
FMM Bid Costs:= (FMM dispatch – DA schedule) *
([Max(FMM Bid, Min(Real-time DEB, FMM LMP))] – FMM LMP), 0)

If(RTD Dispatch-FMM schedule > 0, then
RTD Bid Costs:= (RTD Dispatch – FMM Schedule) *
([Min(RTD Bid, Max(Real-time DEB, RTD LMP))] – RTD LMP), 0)

If(RTD Dispatch-FMM schedule <= 0,
RTD Bid Costs:= (RTD Dispatch – FMM Schedule) *
([Max(RTD Bid, Min(Real-time DEB, RTD LMP))] – RTD LMP), 0)

In practice, the CAISO design will apparently only result in lower BCR than the Joint Stakeholder design in intervals in which a storage resource is dispatched to discharge when it does not have a day-ahead market schedule and the real-time price is less than the DEB. But there will generally be no BCR on phantom losses when this is the case. The limited impact of the calculation of BCR over all hours appears to largely be due to the inclusion of the RT price in the CAISO BCR formula, which causes the RT bid or offer to be used in cases in which the BCR profit calculation for hours without a day-ahead market schedule would otherwise be based on the DEB. However, in intervals in which the real-time price and offer exceed the DEB, the CAISO design will produce the same BCR value as the Joint Stakeholder proposal and there will continue to be BCR paid on phantom losses. The difference relative to the current design is that BCR will not be paid on buy-back bid prices that are lower than the DEB, nor sell-back offer prices that are higher than the DEB. The CAISO design, like the Joint Stakeholder design, will eliminate extreme inflation of phantom losses through extreme bids and offers.

However, in intervals in which a resource is dispatched to charge with no day-ahead market schedule, the CAISO design will produce the same BCR values as the Joint Stakeholder proposal and the current design because the bid price will generally be lower than the DEB. There will continue to be some BCR paid on phantom losses. This is the case in Examples 4 and 5 in Section 2.1.

On the other hand, the CAISO design might perform better in terms of less BCR on phantom losses than the current design, as well as better than a DEB-based design in cases in which there are not balanced real-time charging and discharging imbalances. However, depending on the offer prices, the CAISO design may also perform the same as the current design and the Joint Stakeholder design as would be the case in in Example 7 with moderate bid prices. Further empirical analysis of actual payments of BCR on phantom losses would be needed to assess the overall performance of the CAISO design.

As discussed in sections 2.3, 2.4 and 3.3, the cap on bid prices and floor on offer prices provided by the CAISO design would reduce BCR on phantom losses associated with buybacks and sell backs of day-ahead market schedules calculated using inflated bid prices and artificially low offer prices, regardless of the cause of the buybacks or sellbacks. This is a desirable outcome.

Our assessment of CAISO proposal is that it will always pay BCR that is greater than or equal to actual economic losses except possibly in case of a resource that has net discharges over the day. Further analysis of a range of cases will confirm whether or not this is the case. We also believe that losses due to mitigated dispatch and MIO will at least be covered by BCR payments and often will be more than covered.

It is impossible for the MSC to fully assess the benefits from the CAISO design because we do not have an empirical knowledge of the characteristics of the periods in which resources currently receive BCR, including BCR on phantom losses. If relatively little of the BCR is paid on phantom losses but is simply paid on actual economic losses due to premature discharge, then the CAISO design's effect on the level of BCR payments will be small or zero, and will do little to correct the incentives for premature storage discharge.

We agree with stakeholders that the examples the CAISO has posted are complex and difficult to understand without more detailed explanation. In addition, the CAISO has not provided examples showing the operation of its rules over the hours of the day, in particular the impact of alternative rules on BCR paid on phantom losses. On the other hand, it is a challenge for the CAISO, and the MSC, to evaluate and explain the operation of alternative rules over all possible BCR scenarios. Also, the CAISO has confidentiality problems in presenting examples based on individual storage resources.

A core problem in evaluating the value of the CAISO proposal is that the CAISO has not provided calculations over a period of time, a week, a month or longer, showing the BCR that would be paid under at least the CAISO proposal and the current design. This makes it impossible to assess whether the CAISO proposal fixes 10% of the problem of phantom BCR or 90% of the problem, and it is also impossible for us to evaluate whether phantom BCR is 5% of the problem or 80% of the problem based on data the CAISO has provided.

Slide 3 in the DMM September 11, 2024 presentation bears on this question.[36] We have confirmed with DMM that the "Revenue" data in this figure portray the difference between imbalance buy-back charges and net imbalance sales. Hence, the data in this figure indicate that the premature dispatch is on average substantially unprofitable on the days in which resources received BCR. Similarly, we understand that the "Bid Cost" data is the difference between the bid/offer in the hours with buy-backs and in the hours with sales. This difference was negative in the January through April period, implying that "Bid Costs" were on average lower in the buy-back hours, which is consistent with bids benefitting BCR payments on phantom losses. However, the amount of BCR payments due to the differences in bid costs was a relatively small proportion of the overall BCR payments in these months, so the main source of BCR costs was uneconomic premature dispatch. These data suggest that the BCR calculation changes proposed by the CAISO might result in a relatively small decrease in BCR payments.

Moreover, the data in the Figure on slide 3 of that presentation also shows that the pattern of bid costs has changed over the May to July period. By July "Bid Costs" were on average higher in the buy-back hours, so BCR payments were on average lower than the actual economic loss, so on average there were no BCR payments for phantom losses. While it may be that the averages conceal whether some resources have continued to submit bids and offers that result in BCR payments on phantom losses, the July data clearly indicate that inflated BCR payments due to phantom losses were not a material issue by July 2024. In fact, by July differences in bid prices apparently were causing a reduction in BCR due to phantom profits. The July data further indicate that the BCR changes proposed by the CAISO are likely to have very little impact on the level of BCR payments.

We of course caveat these observations by noting that the DMM analysis is an overall analysis and the CAISO may be aware of specific resources, bidding strategies, or market conditions for which there is a pattern that differs from the averages. The CAISO has not provided any overall analysis showing that the proposed changes will have a material impact on BCR payments. While the CAISO changes are in a positive direction in terms of reducing the potential for inflated BCR payments on phantom losses, it is not clear that is a material problem.
On the other hand, it is complex to work through the implications of DMM's high level analysis for all of the potential causes of out-of-merit dispatch triggering BCR payments and there may be cases for which this high level analysis is misleading. The CAISO has provided us with 8 examples, which may be special, but are still examples in which a DEB based bid cap and offer floor would have dramatically reduced BCR while covering actual BCR losses. In addition, the change in bidding behavior since the beginning of this initiative which has reduced the BCR due to bids in the DMM analysis, may not continue. Hence, given where we are in this stakeholder process it appears best to continue and implement the proposed CAISO changes, but this should not be a stopping point.

[36] See California ISO Department of Market Monitoring, "Storage Bid Cost Recovery and Default Energy Bids Enhancements," Presentation, Meeting on Revised Straw Proposal, September 11, 2024, https://stakeholder-center.caiso.com/InitiativeDocuments/Presentation-Battery-Bid-Cost-Recovery-and-Mitigation-Data-DMM-Sep-11-2024.pdf, Slide 3.

Appendix

This Appendix presents three cases of the impact of the DEB-based BCR system on phantom losses and inflated BCR payments. We consider Examples 2, 5, and 8 from Section 2 whose results under the current BCR system are shown in Tables 2, 4, and 6, above. We find that phantom losses are eliminated, and only that BCR which is justified by actual profits is paid under the DEB-based BCR proposal.

Example 2-DEB. This is an example of how BCR calculations using offers and bids on DEBs (Section 5.2) would affect the phantom profits and BCR earned in Example 2 (Table 2 of Section 2.1, above).

Table A.1. DEB-Based Design Example 2, Energy market losses, Resource gets BCR sufficient to earn positive margin

	DAM Schedule (MW)	Real-Time Dispatch (MW)	Real-Time Deviation (MW)	Start SOC (MW)	DAM Price ($/MWh)	Real-Time Price ($/MWh)	Real-Time Bid ($/MWh)	Real-Time Offer ($/MWh)	Real-Time Revenues ($)	DEB ($/MWh)	DEB Bid Cost ($)	DEB based BCR ($)
Period	A	B	C	D	E	F	G	H	I	J	K	L
1	-10	-10	0	0	20	-5	15	500	0	100	0	0
2	-5	-5	0	10	10	10	15	500	0	100	0	0
3	-5	-5	0	15	10	10	15	500	0	100	0	0
4	0	10	10	20	20	600	15	500	6000	100	1000	-5000
5	10	10	0	10	100	1000	40	50	0	100	0	0
6	10	0	-10	0	200	1000	40	50	-10000	100	-1000	9000
Total	0	0	0						-4000		0	4000

Example 5-DEB. This illustrates how BCR calculations using offers and bids on DEBs (Section 5.2) would affect the phantom profits and BCR earned in Example 5 (Table 4 of Section 2.1, above).

Table A.2. DEB-based BCR Design Example 5: Unlike current BCR system, premature charging does not result in phantom losses

	DAM Schedule (MW)	Real-Time Dispatch (MW)	Real-Time Deviation (MW)	Start SOC (MW)	DAM Price ($/MWh)	Real-Time Price ($/MWh)	Real-Time Bid ($/MWh)	Real-Time Offer ($/MWh)	Real-Time Revenues ($)	DEB ($/MWh)	DEB Bid Cost ($)	DEB based BCR ($)
Period	A	B	C	D	E	F	G	H	I	J	K	L
1	0	-10	-10	0	20	25	50	500	-250	100	-1000	-750
2	-10	-10	0	10	10	10	50	500	0	100	0	0
3	-10	0	10	20	10	-100	90	500	-1000	100	1000	2000
4	0	0	0	20	20	400	90	500	0	100	0	0
5	10	10	0	20	100	1000	40	50	0	100	0	0
6	10	10	0	10	200	1000	40	50	0	100	0	0
Total	0	0	0						-1250		0	1250

Examples 7-DEB and 8-DEB. Here, the use of DEB-based bids results in phantom profits and excess BCR earned in both Examples 7-DEB and 8-DEB (regulation-up charging case, Table 6, Section 2.1). In the case of Example 7-DEB, phantom profits and BCR are increased relative to the original Example 7 (Table 5, supra) because a (higher) DEB is substituted for the low RT bid in the DEB-based proposal. Whereas in Example 8-DEB, BCR (which is the same as in Example 7, are much reduced relative to Example 8 (Table 6, supra) but not eliminated by the DEB-based BCR proposal.

Table A.3. DEB-based BCR Design Example 7, Regulation-up charging results in phantom losses and higher BCR due to DEB higher than RT Bid offer in hour 4; BCR is more than in current system

Period	DAM Schedule (MW) A	RT 15 (MW) B	Real-Time Deviation (MW) C	Reg Charging UIE (MW) D	Start SOC ($/MWh) E	DAM Price ($/MWh) F	RT Price ($/MWh) G	RT Bid ($/MWh) H	RT Offer ($/MWh) I	RT Revenues ($) J	DEB ($/MWh) K	DEB Bid Cost ($) L	DEB based BCR ($) M
1	0	0	0	0	0	20	20	15	100	0	100	0	0
2	0	0	0	10	0	20	20	15	100	0	100	0	0
3	-10	-5	5	5	10	10	10	15	100	50	100	500	450
4	-10	0	10	0	20	10	10	40	400	100	100	1000	900
5	10	10	0	0	20	100	100	40	50	0	100	0	0
6	10	10	0	0	10	200	200	0	50	0	100	0	0
Total	0	15	15	15						150		1500	1350

Table A.4. DEB-based BCR Design Example 8, Regulation-up charging results in phantom losses and higher BCR due to inflated RT offer in hour 4; BCR is less than in current system

Period	DAM Schedule (MW) A	RT 25 (MW) B	Real-Time Deviation (MW) C	Reg charging UIE (MW) D	Start SOC ($/MWh) E	DAM Price ($/MWh) F	RT Price ($/MWh) G	RT Bid ($/MWh) H	RT Offer ($/MWh) I	RT Revenues ($) J	DEB ($/MWh) K	DEB Bid Cost ($) L	DEB based BCR ($) M
1	0	0	0	0	0	20	20	15	100	0	100	0	0
2	0	0	0	10	0	20	20	15	100	0	100	0	0
3	-10	-5	5	5	10	10	10	15	100	50	100	500	450
4	-10	0	10	0	20	10	10	300	400	100	100	1000	900
5	10	10	0	0	20	100	100	40	50	0	100	0	0
6	10	10	0	0	10	200	200	40	50	0	100	0	0
Total	0	15	15	15						150		1500	1350