Energy Storage Enhancements

Second Revised Straw Proposal

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Market & Infrastructure Policy

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1 Introduction

Storage developers are rapidly deploying new utility-scale resources onto the California grid to provide replacement capacity for retiring resources and to meet procurement mandates authorized by the California Public Utilities Commission. These storage resources will help the state meet its clean energy and climate goals. Ultimately, storage resources will be available to meet energy needs during most periods when renewable resources are not available to generate. Today, there is just over 3,500 MW of storage capacity available for dispatch in the ISO market. The ISO observes these resources primarily charging during the lowest priced periods of the day (when solar is abundant) and discharging during the highest priced periods of the day. Today the ISO relies on storage resources for the critical operation of one local capacity area. The ISO anticipates that storage resources will be necessary for the reliable operations in many other local capacity areas in the future. In the ISO's annual local capacity area technical studies, the ISO proactively estimates the amount of energy storage that can be added to each local capacity area based on charging restrictions due to anticipated load and other local generation capability required to meet mandatory standards and transmission capability under applicable contingency conditions.[1]

The ISO market models are evolving to address storage requirements. The fourth phase of the energy storage and distributed energy resources (ESDER) initiative, which was recently implemented, included development of market power mitigation for storage resources and tools to help scheduling coordinators manage state of charge.

The ISO acknowledges concerns regarding investment tax credits and property taxes and proposes changes to the existing co-located model that can be used by these resources for a limited period of time. These changes will completely prevent co-located resources from charging when beyond generation levels for on-site resources. These proposed changes are outlined in Section 4.2.

1.1 Changes from the Revised Straw Proposal

In response to stakeholder feedback the ISO has made changes to items contained within the scope of this initiative.

[1] These studies assume storage is fully charged exactly when needed based on area specific load profiles, and will operate precisely as required to meet those needs.

Many stakeholders commented that the ISO should prioritize changes to the co-located model and reliability tools, in order to develop them as quickly as possible. Comments also indicated that taking more time to carefully consider options for the proposed energy storage resource model and potential changes to the existing non-generator resource model would also be beneficial. In response to these comments the ISO plans to move aspects of the proposal concerning development of a new market model for storage resources to a new initiative, likely called storage modeling enhancements. This new initiative will run concurrently with the energy storage enhancements initiative and will build on work already completed in this energy storage enhancements policy. This will allow time for additional workshops and feedback on storage modeling in general. The ISO's goal is to deliver the highest value changes soon through this initiative, and allow for a more through discussions and deep dives into potential modeling changes for storage resources.

The ISO formally proposes an update to the formula that governs state of charge. This formula will include awards for regulation up and regulation down weighted by a multiplier that approximates energy discharged and energy charged by the resource providing these services, respectively. The ISO also continues to caution that conditions exist where storage resources are scheduled to provide regulating services but cannot provide these services because of state of charge concerns. The ISO continues to advocate for a solution where storage resources are required to provide energy bids alongside ancillary service awards. However, the ISO updated the required energy bids from 100% of the ancillary award to 50% of the ancillary service award. This will continue to allow flexibility to charge or discharge a resource, to compensate for depleted or charged energy from an ancillary service award, but will be less burdensome than the previous proposal.

In response to comments the ISO changed two components of the compensation methodology for storage resources that receive exceptional dispatch instructions from the ISO. First, when determining counterfactual schedules, the ISO will only generate dispatch instructions to discharge when bids are below locational marginal prices. Second, instead of using a time horizon equal to the duration of the storage resource, the ISO will use a horizon that extends through the end of the day.

The ISO offers a new very simple example of how the local tools could work with a storage resource and a gas resource located in a local area.

Finally, due to a very high volume of stakeholder comments the ISO proposes an alternate co-located model for storage, that would not require charging in excess of on-site renewables, for any storage resource that would like to adopt it. The

ISO notes, that all resources on the grid are subject to operator or exceptional dispatch instructions that could fall anywhere within the registered operating range of the resource. Exceptional dispatch authority is a critical tool to maintain grid reliability.

2 Policy Summary

As a quick reference and summary, this policy includes the following proposals:

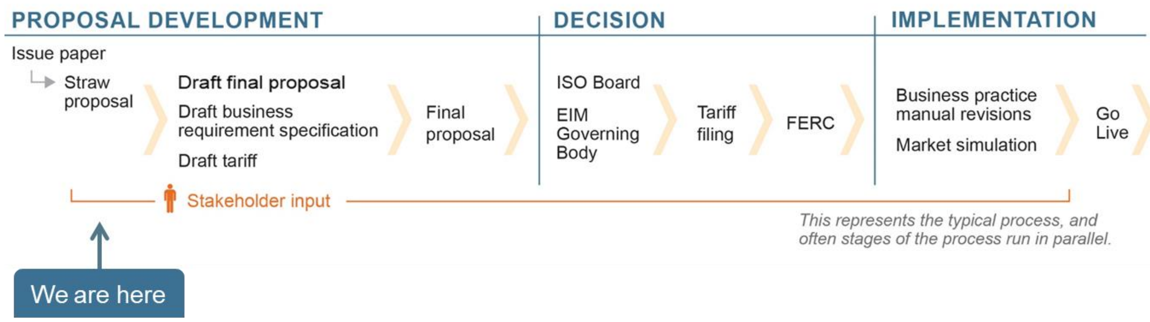
- (4.1.1) State of charge will include expected impacts from regulation
- (4.1.1) Storage must bid energy in the opposite direction of AS awards
  - A resource providing reg up/reg down must have energy bids to charge/discharge
- (4.1.2) Storage resources may be issued EDs to hold state of charge
  - Storage may receive a traditional ED or an SOC ED, but not both
- (4.1.3) Compensation will include lost opportunity from not generating
  - ISO will calculate counterfactual energy revenues with and without the exceptional dispatch in place
  - If prices are below bids counterfactuals will not include discharges
  - The ISO will not generate counterfactual LMPs, actuals will be used
  - Time horizon will include the ED period through the end of the day
- (4.1.4) The ISO may procure state of charge for day-ahead contingencies
  - These procurements will be priced in the market
- (4.2.1) Develop an electable co-located model
  - Available to all storage resources
  - Storage schedules will never exceed renewable schedules
  - Storage may deviate down to match solar, when solar is producing less than schedules in real-time
  - Deviations will be subject to imbalance energy charges
  - Storage must submit outages when depleted and unable to charge
  - All resources are required to respond to operator and exceptional dispatch instructions within physical bounds of operation
  - ISO continues to offer the hybrid model
- (4.2.2) Allow for co-located pseudo-tie resources to apply ACC
  - Resources under an ACC must be pseudo-tied from the same BAA

3 Stakeholder Process

The ISO is at the "straw proposal" stage in the energy storage enhancement (ESE) stakeholder process. Figure 1 below shows the status of the overall energy storage enhancements stakeholder process.

The purpose of the straw proposal is to include detailed solutions for resolving issues related to the integration, modeling, and participation of energy storage in the ISO market. The ISO will publish a number of straw proposals, and solicit stakeholder feedback after each iteration. The ISO will publish a draft final proposal, solicit stakeholder feedback and then conclude with a final proposal. As appropriate, the ISO may organize focused working groups to address complex issues or issues that have cross-jurisdictional concerns as we move through the initiative process.

Figure 1: Stakeholder Process for ESE Stakeholder Initiative



4 Proposal

The ISO introduced the non-generator resource (NGR) model in 2012 to allow for wholesale market participation of energy storage resources. Although the ISO believes the non-generator resource model effectively integrates energy storage resources today, the increasing number of storage devices participating in the wholesale market warrants consideration of further market model enhancements to ensure storage resources are appropriately compensated and the market can accommodate the unique features of storage resources. Stakeholders identified a number of potential enhancements for the ISO to consider to help better model storage resources. While the ISO's day-ahead market optimizes all resources over a 24-hour period, the real-time market has a shorter optimization horizon, which can make it more difficult to capture periods when it is critical that the storage resources have state of charge for several hours to meet system needs. The goal of this initiative is to explore enhancements that could help storage scheduling coordinators better manage resource state of charge and continue to ensure efficient market outcomes.

4.1 Reliability Enhancements

4.1.1 Ancillary Services

Today the ISO requires all supply resources that provide ancillary services to have sufficient energy if called upon by the market. Specifically, the ISO requires that storage resources retain energy equal to 1 hour of regulation awards in the day-ahead market and 30 minutes in the real-time market. This means that a storage resource with a 10 MW award for regulation up, must have at least 10 MWh of state of charge in the day-ahead market going into the hour with the award. In the real-time market, the same resource must carry at least 5 MWh of state of charge going into each 15-minute period during the hour that the resource receives the regulation award.

A number of issues have been identified around the ability of storage resources to provide ancillary services to the market and the feasibility of awards from the day-ahead market into the real-time market. Today, the real-time market requires a state of charge sufficient so that storage is capable of delivering at least 30 minutes of sustained energy delivery for each ancillary service award. If a storage resource has insufficient state of charge, the real-time market will force a buy back of an ancillary services award and rescind a day ahead ancillary services payment. This can result in incremental ancillary services procurement in the 15-minute market, which may create unnecessary operational challenges.

To help prevent these concerns, the ISO proposes two changes to rules currently in place. First, the ISO proposes an enhancement to the equation that governs state of charge so that ancillary service awards will impact state of charge. This is meant to help anticipate the energy that will be lost or gained by a storage resource that provides ancillary services. This will be tracked by the model and incorporated in state of charge. The second change requires that storage resources have availability of economic bids while providing regulation up or regulation down.

Modeling State of Charge

Today, state of charge for a storage resource is governed by the following formula:

$$SOC_{i,t} = SOC_{i,t-1} - \left(P_{i,t}^{(+)} + \eta_i P_{i,t}^{(-)}\right)$$

Where

$SOC_{i,t}$	State of charge for resource *i* at time *t*
$P_{i,t}^{()}$	Charging (+) or discharging (-) instruction for resource *i* at time *t*

η_i	Round trip efficiency for resource *i*

This equation states that state of charge changes as the resource receives dispatch instructions. For example, if the resource receives an award to discharge 60 MW during a specific hour in the day-ahead market, the state of charge for that resource will be 60 MWh less at the end of the hour compared to the start of the hour. Further, if the storage resource is awarded a charging schedule for 60 MW during a specific hour, that resource will have 60 MWh * η_i of additional state of charge at the end of the hour. A typical round trip efficiency might be around 85%, making the increase in state of charge 51 MWh, or 60 MWh * .85. This equation does not take ancillary service awards into account. For example, if a resource is awarded 60 MW of regulation up for a specific hour without an energy award, this equation assumes that the resource will have the same state of charge at the beginning and end of the hour. In practice this will not be true. In the real-time market, resources that receive regulation awards receive 4-second automatic generator control (AGC) instructions from the ISO. In aggregate in real-time, the resource will certainly have less state of charge than at the start of the hour. However, the exact amount of state of charge is uncertain and will depend on real-time system conditions.

The proposal will also help to ensure that charging or discharging schedules do not exceed physical limits of the storage resource while determining the state of charge during any particular interval.[2] The model governing state of charge will be updated to the following formula:

$$SOC_{i,t} = SOC_{i,t-1} - \left(P_{i,t}^{(+)} + \eta_i P_{i,t}^{(-)} + \mu_1 RU_{i,t} - \mu_2 \eta_i RD_{i,t}\right)$$

Where

$RU_{i,t}$	Regulation up awarded to resource *i* at time *t*
$RD_{i,t}$	Regulation down awarded to resource *i* at time *t*
μ	Multiplier

This formula illustrates that state of charge, in any interval, is a function of the state of charge in the previous interval, the energy dispatch instructions during the previous interval and a fraction of the regulation awards in the previous interval. The ISO notes that only the fraction μ of the full amount of regulation will factor into the state of charge for the next interval. This multiplier will be

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[2] Business Practice Manual for Market Operations, p 239: https://bpmcm.caiso.com/Pages/BPMDetails.aspx?BPM=Market%20Operations.

specified in a business practice manual and may be updated as the ISO updates analysis of actual regulation awards and impacts to state of charge. The ISO performed some preliminary analysis on these values and may propose that μ_1 and μ_2 be set to .08 and .19, respectively.[3]

Energy Bids

Day-ahead ancillary service awards over multiple consecutive hours may not be feasible in the real-time market because the state of charge could be potentially depleted by use of the resource providing these services. The ISO operations team observed multi-week periods when large storage resources were completely committed for ancillary services for multiple consecutive hours. During this period these conditions resulted in periods where the ISO had significantly less access to ancillary services than what was initially procured for reliable grid operation in the real-time market. Resources that provide ancillary services must be accessible by the ISO and must not be exposed to conditions that can lead to persistent resource unavailability.

To prevent these concerns, the ISO proposes that in the future all ancillary service awards for storage resources be accompanied with bids for energy. Previously the ISO proposed that a 10 MW award for regulation must be accompanied by a 10 MW of bids to charge the resource. The rules previously proposed would allow a resource +/- 12 MW resource to provide up to 6 MW of regulation up and 6 MW of regulation down at the same time, with accompanying bids for a 6 MW range of energy to charge and a 6 MW range of energy to discharge.

The ISO relaxes the previous proposal and only require energy bids equal to 50% of the ancillary service award. Under this proposal, a +/- 12 MW storage resource providing 12 MW of regulation up would be required to bid a 6 MW range of charging capability. This same resource would be permitted to provide up to 8 MW of regulation up and 8 MW of regulation down at the same time, while bidding a 4 MW range to charge and discharge energy.

4.1.2 Exceptional Dispatch

ISO operators can exceptionally dispatch resources on the grid to ensure reliability. For storage resources, this includes dispatch instructions to discharge energy and dispatch instructions to charge. If a resource is dispatched to

3 An hourly summary of this analysis is provided in the Appendix.

discharge energy to the grid, then the resource will receive compensation at the higher of their bid or the prevailing price for the dispatched (MW) amount.

The ISO proposes new functionality that will allow the ISO operators to dispatch storage resources to hold a certain state of charge (MWh), in addition to the traditional (MW) exceptional dispatch.[4] The ISO operators will have a tool that allows for dispatch of storage resources to charge to and hold a specific level of state of charge for a specific duration of time. For example, a specific exceptional dispatch may require a storage resource to charge to 75 MWh and hold that state of charge through the end of hour ending 20. When that energy may be needed later in the day, operators may subsequently issue a dispatch for the resource to provide energy through a typical exceptional dispatch, or simply release the resource from the exceptional dispatch with a state of charge target so that they can discharge economically. The ISO always seeks to avoid exceptional dispatch, and only uses these tools when reliability or grid stability is threatened.

Because so much use-limited storage is interconnecting at the same time that the ISO is capacity constrained in peak hours, the ISO believes it is prudent to develop these tools. They can help ISO operators manage energy across the storage fleet as well as overall generating capability for critical times of the day. The ISO also notes this tool is consistent with current functionality to issue exceptional dispatches today, but has included a discussion here for transparency, and introduction of unique settlement for storage resources.

Compensation for traditional exceptional dispatch is based on the 'bid or better' paradigm where resources receive compensation for energy delivered in response to exceptional dispatch instructions at the higher of bid prices or prevailing market prices. This ensures that resources receive compensation at least as great as marginal costs to provide energy. Today, if the ISO operators want a resource to hold state of charge, they could issue an exceptional dispatch at or near 0 MW, but this would result in almost no compensation for the exceptional dispatch. At the same time, the storage could potentially miss opportunities to participate in the real-time market during these periods and potentially earn significant market revenues.

[4] Actual signals for exceptional dispatch to resources will continue to be transmitted to storage scheduling coordinators via a dispatch instruction in terms of MW. While exceptional dispatches are issued to storage resources to hold state of charge, these instructions will likely be for storage resources to not exceed 0 MW of output, if the resource has just met the target MWh. Actual details for instructions will be developed with the business requirements for this initiative.

Resources below target state of charge levels, when exceptionally dispatched to a certain state of charge, will be required to charge up to the target levels. These exceptional dispatch instructions will be issued from the ISO similar to traditional exceptional dispatch instructions today. For example, if a storage resource is exceptionally dispatched to hold 75 MWh of state of charge, but is currently only at 50 MWh, the resource will receive traditional exceptional dispatch instructions to charge while moving from 50 MWh to 75 MWh. Once at 75 MWh the resource will receive exceptional dispatch instructions to hold that state of charge.

4.1.3 Compensation for Exceptional Dispatch to Hold State of Charge

Storage resources receiving exceptional dispatch instructions to hold state of charge will be compensated using a different methodology than traditional exceptional dispatch. This compensation will be based on an opportunity cost methodology and will capture the revenues that the resource would have received had it been optimally participating in the market, during the exceptional dispatch and for a period of time after the exceptional dispatch.

The ISO received some stakeholder comments expressing concerns about the hypothetical calculations including intervals hypothetical instances for charging when prices are below bids from resources. The ISO proposes to augment the counterfactual dispatch instructions so that they only occur when locational marginal prices exceed bids.

The ISO also received comments about the duration of the timeframe considered for the counterfactuals. The concern was raised about the potential window considered being too short. The ISO updates this proposal to include a window that extends through the end of the operating day of the exceptional dispatch, instead of a window equal to the duration of the storage resource. The ISO is not proposing a longer timeframe, as extending this into another operational day may be more burdensome in the settlements process, because of additional needs to include data across multiple days.

Comments also asked about compensation for lost opportunities to provide ancillary services resulting from ISO issued exceptional dispatch instructions. Today, when an exceptional dispatch instruction prevents any resource from being able to provide scheduled ancillary service awards, that resource is compensated for losing that opportunity. This same functionality will be applied to storage resources that may be dispatched to hold state of charge, and because of those dispatches lose the ability to provide ancillary services.

Compensation Calculation

For each exceptional dispatch issued to a storage resource to hold state of charge, the ISO will compute two counterfactual values. The first will be the revenue maximizing energy dispatch the resource would have received if there was no exceptional dispatch in place, and the second is the revenue maximizing energy dispatch that the resource would have received if the exceptional dispatch was still in place.[5]

As noted above, the ISO recognizes that storage resources that are issued exceptional dispatch instructions to hold state of charge can impact prices, particularly in local areas where there is little other generation that can serve load. However, the ISO is unable to update these values and will use realized locational marginal prices to complete this analysis.

The time horizon for these counterfactuals will start from the first interval where the exceptional dispatch to hold state of charge is in place. The time horizon will include the entire horizon of the exceptional dispatch and will include additional periods through the end of the operating day. For example, if the exceptional dispatch began at 18:30 and was in place for 1.5 hours – through 8pm - then both counterfactuals would include intervals between 18:30 through midnight.

After calculation of both counterfactual values, the ISO will compare them. If the resource would have been able to make additional revenue if the exceptional dispatch was not in place, then the resource would be awarded the difference between the counterfactual revenue earned without the exceptional dispatch in place and with the exceptional dispatch in place, as an additional uplift payment for the day. Counterfactuals in the real-time market will be based on imbalances from day-ahead schedules, similar to typical real-time settlement practices.

Example

This highly simplified example illustrates how this calculation could be completed. It uses the same hypothetical resource discussed above with a -25 MW lower operating limit, +25 MW upper operating limit, 0 MWh minimum state of charge, and a 100 MWh maximum state of charge. At 18:30 the resource is issued a dispatch instruction to hold state of charge at or above 75 MWh and this exceptional dispatch is in place through 20:00. Further, for simplicity, we assume

[5] This methodology will only include counterfactual schedules to discharge energy when storage resources have bids that are below actual locational marginal prices.

that the resource does not have any cycling costs associated with operating. These values will be included in the revenue calculations, when provided.

For simplicity, this example does not include 5-minute prices, but instead includes prices during half hour blocks. These are meant to reference segments of 6 5-minute prices. For this example, we assume that each of the 5-minute prices within the illustrated interval results in an identical price, specified in Table 1.

Table 1: Exceptional Dispatch Compensation

Hour	Prices	SOC	Ideal MW	SOC_T+1	Rev	SOC	Const MW	SOC_T+1	Rev
18:30	95	80	25	67.5	$ 1,188	80	0	80	$ -
19:00	**300**	67.5	25	55	$ 3,750	80	10	75	$1,500
19:30	**300**	55	25	42.5	$ 3,750	75	0	75	$ -
20:00	75	42.5	-25	55	$ (938)	75	0	75	$ -
20:30	85	55	25	42.5	$ 1,063	75	25	62.5	$1,063
21:00	100	42.5	25	30	$ 1,250	62.5	25	50	$1,250
21:30	125	30	25	17.5	$ 1,563	50	25	37.5	$1,563
22:00	150	17.5	25	5	$ 1,875	37.5	25	25	$1,875
22:30	45	5	-25	17.5	$ (563)	25	0	25	$ -
23:00	90	17.5	25	5	$ 1,125	25	25	12.5	$1,125
23:30	82	5	10	0	$ 410	12.5	25	0	$1,025
					$14,473				$9,400

The first column of this sheet represents the times with specific intervals, in half hour increments. The second column represents actual realized locational marginal prices. For simplicity, we assume that the storage resource bids to discharge anytime prices are greater than $50/MWh. Columns 3-6 and columns 7-10 represent the counterfactual ideal dispatch instructions for profit maximization if no exceptional dispatch is in place and the ideal dispatch instructions with the exceptional dispatch in place, respectively. Specifically, these sets of columns include information on current state of charge, counterfactual energy dispatch instruction, state of charge resulting from the dispatch instruction and the total revenue realized from the dispatch instruction.

First, note that the time frame included in this example includes 5.5 hours of data. This corresponds to the initial exceptional dispatch, between 18:30 and 20:00, followed by 4 additional hours of data through midnight. Second, prices between 19:00 and 19:30 actually materialized at $300/MWh. Third, for this analysis the ISO does not generate counterfactual prices for intervals after the exceptional dispatch is in place.

Columns 3-6 represent the revenue maximizing, or ideal, dispatch for the resource had there been no exceptional dispatch, with corresponding state of charge values and revenues. In this scenario, the resource would have discharged energy during the high priced periods when the exceptional dispatch was in place (hours 18:30 through 20:00), then recharged for one half hour (hour 20:00 through 20:30), then discharged for most of the remainder of the period, excluding hour 22:30 when prices were low. This would have resulted in a hypothetical revenue of $14,473.

Columns 7-10 represent the revenue maximizing, or ideal, dispatch for the resource while observing the exceptional dispatch. In this scenario, the resource would have been limited by how much energy could have been discharged before 20:00. This allows for a relatively full state of charge at the conclusion of the exceptional dispatch, and results in discharging the resource anytime prices are above $50/MWh later in the day. Operating following this pattern would have resulted in a hypothetical revenue of $9,400.

In this instance the resource would be made an additional payment of $5,073 ($14,473 - $9,400) as an opportunity cost payment for incurring this specific exceptional dispatch instruction.

4.1.4 Tools for Local Areas

Local areas can require additional work to ensure reliable operation. Today, the ISO uses tools to ensure that there is sufficient resources commitment in local areas during periods when conditions are particularly tight. In the future, as storage becomes more prevalent, the ISO will rely on storage resources even more to ensure reliable local operation. To do this the ISO may need to ensure state of charge availability from storage resources in local areas. The ISO proposes the ability to automatically secure state of charge for local needs in addition to system needs through the day-ahead market process.

Today, the ISO takes a number of steps to ensure local reliability prior to running the day-ahead market. Not only does the ISO ensure that the model of the grid matches real conditions as closely as possible, but also that reliability can be maintained in local areas even with the loss of the certain critical elements. For example, the loss of the most critical electrical element, or an N-1 condition, could be included in the day-ahead market run. These conditions imposed in the market ensure voltage stability and prevent thermal overloads should the grid actually lose these critical elements. When the day-ahead model solution is generated, it includes these conditions and includes prices generated with congestion from including these contingencies.

Further, the ISO also has the ability to impose second tier constraints, known as minimum on-line commitment constraints, in the market to ensure against further losses, which do not impact prices or congestion. For example, these could include the loss of the second most critical element, or an N-1-1 condition, in a local area. These additional constraints can result only in commitment of resources, and will not result in energy schedules. Once committed these resources are required to be available in the real-time market, and will serve as a safeguard against key element losses in the local area.

Constraints that are priced in the market do result in energy schedules, and ensure that the market would operate reliably even in the absence of the key electric element, which is usually in service in the actual real-time market. Today, this might imply a start-up instruction and energy schedule for a gas resource in a local area, even though that gas resource may not be strictly needed – if the electric element is on-line in the market. Similar to gas resources, storage resources may also be used to meet these constraints. They may be scheduled earlier in the day to charge, and provide energy later in the day to meet local demands that no or few other resources can satisfy when the outage is modeled.

Second tier constraints do not result in additional energy schedules, but may result in resource commitment. Essentially, these constraints ensure there is enough capacity in the local area to manage the contingency, but are not necessarily scheduling energy to meet it. For natural gas fired resources that are effective at managing the second tier outage, this could imply dispatch instructions to start units, which will also ensure availability in the real-time market. The market treats storage resources differently. They are always on-line, and therefore automatically qualify to meet second tier 'capacity' requirements. However, even though the storage resources may be on-line they may not have sufficient state of charge to provide energy to maintain reliability, should an outage occur.

The ISO proposes to enhance the logic for second tier constraints to ensure that capacity is available from traditional resources and that energy is available from storage resources to maintain reliability in the event a key grid element is lost to meet local reliability needs. These requirements will be imposed as constraints in the day-ahead market, and any results will include an efficient procurement of resources that is factored into market prices.

EXAMPLE

This highly simplified example illustrates how a situation where a concern in a local area could be resolved. First, suppose there is a local area with only two resources located within the area: a gas resource and a storage resource. Also, suppose there is a certain situation where, on a particular day, the ISO anticipates a need of 50 MW of generation during a three hour window in the local area. This is illustrated in Table 2.

Table 2: Local Example

Hour Ending	Local Need
17	50 MW
18	50 MW
19	50 MW

In this scenario if the gas resource is on-line in hour ending 17, 18 and 19 it can potentially provide the 50 MW of generation necessary for the local area. Additionally, if the storage resource has 150 MWh of state of charge entering hour ending 17, it can also provide the 50 MW of generation necessary during all three hours. There could also be situations where the gas resource is on for part of the period and the storage resource is required for other times. The ISO will include these requirements in the optimization and will determine the most efficient way for the grid to maintain reliability in the local area.

4.2 Co-located Enhancements

Many stakeholders commented that current investment tax credit (ITC) rules impact the financial incentives for storage resources. The investment tax credit rules also can impact contracting for storage resources. Some contracts expressly prohibit ‘grid charging’ for storage resources because grid charging can reduce the revenue stream for a storage or co-located projects. At the July 26 ISO workshop stakeholders suggested that the ISO introduce a new mechanism for co-located resources that ensures revenue recovery if a storage resource seeking the investment tax credit were to incur costs due to grid charging. Such a mechanism may reduce qualifications in future contracts that prohibit grid charging and may allow storage resources seeking to bid charging capacity into the market to do so more freely.

In response to these requests, the ISO proposes enhancements to ensure any co-located storage resource model. These changes, discussed further below, will be optional functionality that may be elected by co-located storage resources and will prevent dispatched above scheduled output from on-site renewable resources. As with all policy, the ISO may review behaviors of resources using this functionality and may choose to adapt or remove these provisions in the future. The ISO will monitor for problematic situations that arise from this functionality, particularly those that threaten reliability.

Finally, the ISO notes that any resource interconnected to the grid is subject to exceptional dispatch from the ISO operations team. These exceptional dispatches may be anywhere within the registered operational limits of the resource. The ISO operations team only uses exceptional dispatch authority when reliability is threatened and actions are often time sensitive, which is why compliance with these instructions is critical. To completely avoid situations where energy flows from the grid to a generating facility the ISO will continue to offer the hybrid model, which can have a lower operational bound for a resource at 0 MW.

4.2.1 Enhanced Co-Located Functionality

Co-located storage resources are able to and – when shown for resource adequacy – may be required to bid economically or self-schedule into the market. Either could result in a certain schedule to charge during a real-time interval. Storage resources, like all non-variable resources, are obligated by the ISO tariff to follow dispatch instructions that result from market awards.[6]

Even if a storage resource is scheduled to charge at a level commensurate with forecasted production by a co-located renewable resource, if the co-located renewable resource is unable to generate at its schedule, then an onsite storage resource may be required to charge from the grid. This could occur for a variety of reasons, such as renewable resource intermittency or the renewable resource being backed down economically by market dispatch.

The ISO proposes new functionality for co-located storage resources in the day-ahead and real-time markets to help address some of the concerns voiced by stakeholders. The ISO proposes an electable functionality to limit dispatch instructions for co-located storage resources to charge to be no greater than the dispatch operating target of their co-located renewable resources.[7] This functionality will be electable and offered to any co-located storage resource and will prevent 'grid charging.' This functionality will include two components: 1) market rules that ensures that storage charging schedules do not exceed solar

[6] Phase 4 for the energy storage and distributed energy resource policy implemented an exception to this rule when on-site renewables are generating above forecast levels.

[7] This functionality could allow for the maximum charging rate for a single storage resource to be determined by the output of a single or multiple renewable resources.

generation schedules, and 2) allowances that ensure that actual real-time charging does not exceed actual real-time co-located renewable generation.

Charging Schedules will not Exceed Renewable Schedules

The ISO will implement functionality that will prevent storage resources from receiving instructions to charge in excess of the dispatch operating target of the co-located renewable resource(s). Generally, the dispatch operating target of a renewable resource equals its forecasted output. This functionality will apply whether the renewable-resource output was limited by fuel limitations or a supplemental negative dispatch instruction to operate below forecast.

If a co-located storage resource would like to elect this functionality, or has this functionality elected and would like it removed, they must go through the generator resource data template update process.

Allow Storage to Charge at Output from Solar

The ISO proposes that storage resources be allowed to deviate down from their real-time dispatch instructions for charging during intervals when co-located renewables are unable to produce the forecast energy. For example, assume a solar resource is forecast and dispatched at 30 MW during one interval in real-time, and the associated co-located storage resource is scheduled to charge at -30 MW. While actually operating during the period, the solar resource is only able to produce 25 MW. In this case, the storage resource would be allowed to simultaneously only charge at -25 MW, even though the dispatch instruction to the resource was for -30 MW.

This prevents the storage resource from charging from the grid when it receives a charging schedule that exceeds the total energy awarded to the solar resource, during intervals when the solar resource is unable to generate at that award. The storage resource may not deviate beyond the difference in scheduled and actual energy from the variable resource and is required to charge at the level of output from the solar resource when deviating from dispatch instructions.

The ISO is not proposing any changes to the settlement system to accommodate these proposed rule changes. Storage resources that elect this alternate co-located model, and do not fully meet dispatch awards to charge will be subject to associated imbalance energy charges for those differences.

Storage Unavailability

Storage resources that are unable to charge because of insufficient on-site generation are required to submit outage cards to the ISO. ISO operators rely on outage cards to understand what generation is available and what generation is unavailable. Co-located storage resources that cannot charge in excess of on-site renewables are required to submit outage cards if they have a depleted state of charge and there is no ability to charge the resource. This can happen because the on-site solar resource is not generating during nighttime hours. Outage cards submitted because the resource cannot generate due to a lack of state of charge and no ability to charge would be subject to the ISO's resource adequacy availability incentive mechanism (RAAIM).

4.2.2 Pseudo-Tie Resource Functionality

During the stakeholder meetings on July 26, stakeholders requested enhanced functionality for modeling pseudo-tie resources. They suggested it would be beneficial for additional participation of resources outside of the ISO footprint. Today, the ISO allows co-located resources to have interconnection limits below the aggregate maximum output of on-site generation. This functionality is useful for facilities with solar and storage resources, as the two generally are not producing at full output during the same time.

Today pseudo-tie resources are required to show firm capacity from the resource interconnection to a delivery point on the ISO transmission grid for their full generating capability. Stakeholders requested that the ISO relax this requirement for co-located pseudo-tie resources, and that the firm transmission need only be demonstrated for the amount of interconnection capacity that the co-located resources have, rather than the maximum generating capability of the entire facility. With these requirements in place the ISO could then use the aggregate capability constraint (ACC) to ensure that dispatch for the combination of the resources under the constraint does not exceed the interconnection limits and firm transmission dedicated to the project. The ISO proposes implementing this change, but only for co-located resources that can be modeled by an aggregate capability constrain and where all resources are pseudo-tied from the same balancing authority area to the ISO. Also, the host balancing authority must agree that firm transmission for the maximum capability is not required. Co-located resources pseudo-tied to the ISO seeking to utilize an aggregate capability constraint would need the prior written approval of their host balancing authority to utilize this functionality and verify that they have physical controls in place that prevent the co-located resources' exceeding the interconnection service capacity at their point of interconnection to the host balancing authority.

5 WEIM Classification

This initiative proposes to introduce a new market model, the energy storage resource model, for use by storage resources in the real-time market, as well as other changes to the existing non-generator resource model that will be applied to the markets. CAISO staff believes that the WEIM Governing Body has joint authority with the Board of Governors over the changes proposed in this paper.

The role of the WEIM Governing Body with respect to policy initiatives changed on September 23, 2021, when the Board of Governors adopted revisions to the corporate bylaws and the Charter for EIM Governance to implement the Governance Review Committee's Part Two Proposal. Under the new rules, the Board and the EIM Governing Body have joint authority over any, "proposal to change or establish any CAISO tariff rule(s) applicable to the EIM Entity balancing authority areas, EIM Entities, or other market participants within the EIM Entity balancing authority areas, in their capacity as participants in EIM. This scope excludes from joint authority, without limitation, any proposals to change or establish tariff rule(s) applicable only to the CAISO balancing authority area or to the CAISO-controlled grid." Charter for EIM Governance § 2.2.1.

The tariff changes to implement this initiative would be "applicable to EIM Entity balancing authority areas, EIM Entities, or other market participants within EIM Entity balancing authority areas, in their capacity as participants in EIM." If established, EIM balancing authority areas may use the energy storage resource model. Accordingly, the proposed changes outlined in this proposal fall within the scope of joint authority.

This proposed classification reflects the current state the initiative and could change as the stakeholder process moves ahead.

6 Next Steps

The ISO requests additional feedback from stakeholders on the solutions included in this revised straw proposal. The ISO will host a stakeholder call on July 7, 2022 to review the second revised straw proposal, and encourages all stakeholders to submit comments on the issue paper. Comments are due on July 20, 2022.

7 Appendix

The ISO reviewed hourly records from three months of data for specific storage resources in the fleet from March 1, 2022 to May 31, 2022. This resulted in about 35,000 records where storage received either regulation up or regulation down awards. This data was paired with observed real-time information on changes in state of charge between the beginning of the award to the end of the award. These state of charge values were modified to remove any impact from energy schedules during the same time period. The ISO then conducted a simple linear regression where regulation up and regulation down were descriptive variables for the associated change in state of charge. This analysis was performed on the entire set of data and subsets of data for each hour. From the results, it is clear that regulation awards in different hours have different impacts on state of charge. At this point the ISO is not prepared to change the state of charge equation to accommodate for these differences, but it may be something the ISO considers in the future.

The table below shows the coefficients attached to the descriptive variables regulation up and regulation down and how they relate to state of charge. The first row indicates that typically an award of 100 MW of regulation up will result in a reduction of state of charge of about 8 MWh. It also indicates that an award 100 MW of regulation down will typically result in a 19 MWh increase in state of charge. Further, we might expect that a typical resource with an award of 100 MW of regulation up and 100 MW of regulation down would typically charge about 11 MWh (19 MWh – 8 MWh) without knowing what specific hour the award occurs.

	Reg Up	Reg Down
ALL	8%	19%
Hour	**Reg Up**	**Reg Down**
1	6%	12%
2	2%	10%
3	2%	13%
4	7%	18%
5	6%	11%
6	8%	13%
7	12%	24%
8	6%	22%
9	3%	13%
10	8%	13%
11	4%	13%
12	6%	18%
13	7%	20%
14	11%	21%
15	8%	21%
16	9%	21%
17	16%	25%
18	16%	35%
19	12%	21%
20	7%	35%
21	6%	37%
22	8%	23%
23	3%	26%
24	5%	25%