Storage Design and Modeling

Outage Management, Uplift, & DEB and SOC Management Working Group

Stakeholder Meeting

January 23, 2025

9 am – 4 pm

Reminders

- This call is being recorded for informational and convenience purposes only. Any related transcriptions should not be reprinted without ISO's permission.

- The meeting is structured to stimulate dialogue and engage different perspectives.

- Please keep comments professional and respectful.

- Please try to be brief and refrain from repeating what has already been said so that we can manage this time efficiently.

Instructions for raising your hand to ask a question

- Open the Participant and Chat panels from the bottom right.

- If you are connected to audio through your computer or used the "call me" option, select the raise hand icon located on the bottom of your screen.
  - **Note**: *3 only works if you dialed into the meeting.

- Please remember to state your name and affiliation before making your comment.

- You may also send your question via chat to either **Brenda Marquez** or to all panelists.

- If you need technical assistance during the meeting, please send a chat to the event producer.

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Agenda

Time	Topic	Presenter
9:00 – 9:05	Welcome and today's agenda	Brenda Marquez
9:05 – 9:45	Overview of comments and updated tentative topic groups	Sergio Dueñas Melendez
9:45 – 10:30	Overview of Outage Management and Nonlinearity issues	Sergio Dueñas Melendez
10:30 – 11:45	Overview of Storage Constraints	Sergio Dueñas Melendez
11:45 – 12:00	Open discussion	
12:00 – 1:00	Break	
1:00 – 3:00	Stakeholder presentations on SOC Management topics	Various stakeholders
3:00 – 3:55	Open discussion	
3:55 – 4:00	Next Steps	Brenda Marquez

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CAISO Policy Initiative Stakeholder Process

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Overview of Stakeholder Comments

Background on the Working Group Process

- This initiative will tackle a wide array of topics pursuant to energy storage in different configurations

- To ensure adequate and productive discussions, staff recommends categorizing topics in a manner that allows for parallel development while respecting stakeholders' time

- Staff believes that grouping topics will allow for organized discussions, holistic consideration of issues, and the potential to resolve matters in a staggered manner

- The topic groups presented in the following slide were shared to stimulate conversation and were subject to stakeholder feedback

Initial overview of scope and topic groups

BCR, DEB, & OMS Topics

Uplift redesign (BCR)

DEB enhancements

OMS enhancements

SOC Management Topics

System SOC mechanism

Biddable SOC participation pathway

SOC definition and calculation

Nonlinearity at high and low SOC

SOC management for capacity awards

Distribution-level & Paired Resources Topics

Distribution-level Storage

Co-located resource settlement enhancements

DEB for hybrid resources

Overview of stakeholder comments

- Most stakeholders agree with the overall pace of the initiative, with only a couple of comments suggesting shorter and more frequent meetings

- Most stakeholders agree that the issues related to storage outage management and nonlinearity at high and low SOC should be prioritized, although some stakeholders note that storage BCR reform should take precedence

- Several stakeholders agree that each topic should kick off with a holistic review of the issue at hand so as to establish a common understanding and develop guiding principles

Overview of stakeholder comments

- Several stakeholders urged the ISO to focus on known and urgent issues (such as storage outage management issues, nonlinearity, BCR, and SOC definitions) before considering the development of new products or participation pathways

- Some stakeholders recommended modifications to the initially proposed tentative topic groups in order to ensure interrelated topics are discussed jointly

- Some stakeholders shared detailed guiding principles and straw proposals on issues related to DEBs, storage outage management issues, nonlinearity, BCR, and SOC definitions

Overview of stakeholder comments

- The initiative will move forward with the schedule shared in the prior stakeholder meeting, with minor modifications related to the reorganization of topic groups

- The initiative's topic groups will be modified to:
  - Allow for the prioritization of issues that do not require tariff modifications
  - Ensure that interrelated topics are addressed jointly

- Each topic will be introduced with an educational overview followed by a description of the issues, starting with outage management and existing SOC constraints today

- The ISO welcomes discussion of the guiding principles and straw proposals across all topics as part of the working group process

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Updated Tentative Topic Groups

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Revised overview of scope and topic groups

Outage Management, Uplift, and DEB Topics

- Outage reporting and nonlinearity issues
- SOC definition and calculation
- Storage uplift redesign
- Storage DEB modifications

SOC Management Topics

- SOC management for capacity awards
- System SOC mechanism
- Biddable SOC concepts

Distribution-level & Paired Resources Topics

- Co-located resource settlement enhancements
- Distribution-level storage
- DEB for hybrid resources
- Additional hybrid topics

Revised timeline

Dec. 11, 2024

Meeting 1: 9am-12pm
Initial discussion
Outage Management, Uplift, & DEB: Working group

Jan. 23, 2025

Meeting 2: 9am-4pm
Outage Management, Uplift, & DEB: Discussion
SOC Management: Working group

Feb. 20, 2025

Meeting 3: 9am-4pm
Outage Management, Uplift, & DEB: Discussion
Distribution-level & Paired Resources: Working group

March, 2025

Outage Management, Uplift, & DEB straw proposal posting

Mar. 24, 2025

Meeting 4: 9am-4pm
Outage Management, Uplift, & DEB: Straw proposal discussion
SOC Management: Working group

*All dates are tentative until confirmed through a notice in the ISO's Daily Briefing.

Revised timeline

Apr 16, 2025

Meeting 5: 9am-4pm
Outage Management, Uplift, & DEB: Revised straw proposal preparation
Distribution-level & Paired Resources: Working group

May, 2025

Outage Management, Uplift, & DEB Revised straw proposal posting

May 28, 2025

Meeting 6: 9am-4pm
Outage Management, Uplift, & DEB: Revised straw proposal discussion
SOC Management: Issue paper development

Jun. 25, 2025

Meeting 7: 9am-4pm
Outage Management, Uplift, & DEB: Draft final proposal preparation
Distribution-level & Paired Resources: Issue paper development

July, 2025

Draft final proposal posting on Outage Management, Uplift, & DEB

Issue paper posting on SOC Management and Distributed & Paired Resources

*All dates are tentative until confirmed through a notice in the ISO's Daily Briefing.

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Open discussion

Overview of Outage Reporting and Nonlinearity Issues

Background on Outage Reporting and Nonlinearity Issues

- The challenges related to storage outage management and reporting relate to both operational characteristics that are unique to energy storage assets, and limitations of the current outage management system (OMS), which was developed with conventional resources in mind

- Storage resources face limitations and outage types not currently covered in outage management system (OMS) that are unique to these assets, such as the need to rerate negative Pmin and the potential for SOC limitations

- In addition, storage resources face nonlinearity impacts and high/low SOC, an issue referred to as foldback which can impact resource responsiveness and dispatch

Challenges related to the Outage Management System

- The ISO and stakeholders have identified the following challenges related to the Outage Management System (OMS)
  - OMS does not automatically accept updates to existing forced outage cards
  - OMS does not allow existing or new overlapping outage cards that can adjust Availability, Load Max, Max Energy and Min Energy values within a single card
  - OMS does not allow non-NULL values in addition to NULL for other card(s)
  - OMS does not retain outage card values when existing outages are extended

Proposed means to reflect nonlinearity (foldback)

- Allowing an outage card to represent foldback
  - Some stakeholders requested the ISO to authorize the use of the "Technical Limitations not in Market Model" Nature of Work (NoW) category for this purpose
  - Some stakeholders see this as an interim measure and advocate the ISO eventually represent these challenges through resource-specific Master File fields
- Include foldback into resource characteristics through Master File
- Extending the dynamic limit tool to storage resources in order to manage nonlinearity
- Allowing scheduling coordinators to bid their SOC, as opposed to capacity

Other comments regarding outage management

- Vistra commented that the ISO should revise its BPM to clarify outage reporting for all capability attributes (e.g., Pmax, Pmin, and Minimum and Maximum Energy), to state:
  - "…reducing the maximum output or minimum output by ten (10) MW or more or the maximum continuous energy limit or minimum continuous energy limit by 40 MWh from the value most recently recorded in the CAISO's outage management system pursuant to Section 9"
  - "within sixty (60) minutes after discovering any change in the maximum output or minimum output capability of at least ten (10) MW or five percent (5%) of the maximum or minimum output values registered in the Master File, whichever is greater, or the maximum continuous energy limit or minimum continuous energy limit of at least forty (40) MWh or five percent (5%) of the maximum or minimum continuous energy limits registered in the Master File, whichever is greater, from the value registered in the CAISO's outage management system pursuant to Section 9 that lasts for fifteen (15) minutes or longer."

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Open discussion

Overview of Existing Storage Constraints

Background on the NGR participation pathway

- NGR is a resource that can operate continuously by either consuming energy or providing energy, and it can seamlessly switch between generating and consuming energy

- The ISO can use its NGR functionality to model a Limited Energy Storage Resource (LESR) or any resource that can operate seamlessly from the negative to the positive range

- For an NGR, the energy limits (MWh) is the maximum or minimum energy the device can store

- Based on an initial stored energy (state of charge (SOC)), the continuous energy consumption or generation is constrained by the maximum or minimum stored energy limit (specified in the Master File), accounting for inherent losses while charging and discharging

Background on the NGR participation pathway

- For non-REM NGRs, the day ahead and real-time markets observe the energy limits in the energy and ancillary service optimizations

- For REM NGRs energy limits are observed in real-time economic dispatch only

- The energy limits for NGRs are not required for the resource if the resource does not have that physical limitation; nevertheless, if the NGR resource has a stored energy limit, it must register the limit value with the ISO so that the ISO can observe the limit in the market

- When resource energy limits are not provided, the ISO assumes that the NGR does not have these constraints

- The resource owner and Scheduling Coordinator must manage any resource energy constraints in order to comply with ISO dispatch instructions in the ISO Market

Background on the NGR participation pathway

- The algebraic power output of a NGR is limited between a minimum and a maximum capacity measured in MW

- NGRs have distinct ramp rates for operating in a consuming mode (charging) or in a generating mode (discharging), but is limited to one segment for each mode

- NGRs can provide energy and ancillary services (AS)

- The dispatch of a NGR providing AS must employ a stored energy management scheme to manage the state of charge and ensure that there is sufficient stored energy in the device to dispatch to satisfy the AS when they are called upon

- NGRs can provide regulation from anywhere within their regulation range

Ancillary service constraints for storage resources

- The ISO implements a series of constraints related to the impact of ancillary service awards on state of charge on storage resources

- Storage resources that provide ancillary services must have sufficient state of charge to assure that ancillary service awards are deliverable

- This can result in optimal energy schedules that include charging in the day-ahead market in preparation for ancillary service awards, or charging in the real-time market during intervals when a storage resource has ancillary service awards

- A storage resource also may be required to charge in advance of hours with awards for ancillary services to ensure sufficient state of charge to meet the ancillary service state of charge constraints

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Day-Ahead Stored Energy Management

- The state of charge of a storage resource is governed by the equations below

$$SOC_{i,t} = SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)}\right)\frac{\Delta T}{T_{60}}$$

$$\underline{SOC_{i,t}} \leq SOC_{i,t} \leq \overline{SOC_{i,t}}$$

$$SOC_{i,t}^{AT} = SOC_{i,t-1}^{AT} - \left(EN_{i,t}^{(+)} + \eta EN_{i,t}^{(-)} + ATRU_t RU_{i,t} - ATRD_t \eta_i RD_{i,t}\right)\frac{\Delta T}{T_{60}}$$

$$\underline{SOC_{i,t}^{AT}} \leq SOC_{i,t}^{AT} \leq \overline{SOC_{i,t}^{AT}}$$

$$0 \leq EN_{i,t}^{(+)} \leq u_{i,t} UEL'_{i,t}$$

$$(1 - u_{i,t})LEL'_{i,t} \leq EN_{i,t}^{(-)} \leq 0$$

$$EN_{i,t,} = EN_{i,t}^{(+)} + EN_{i,t}^{(-)}$$

$$u_{i,t} = \{0,1\}$$

$$\Bigg\}, \forall i \in S_{LESR} \wedge t$$

Day-Ahead Stored Energy Management

- Both constraints detailed below are enforced and must be simultaneously feasible within any market solution, along with the ancillary service state of charge constraint

- The influence of regulation on the projected state of charge (SOC) is modeled through the regulation awards and the multipliers projecting the typical impacts of regulation up and regulation down on SOC (the attenuation factors), which are estimated quarterly and posted publicly

$$SOC_{i,t} = SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)} \right) \frac{\Delta T}{T_{60}}$$

$$\underline{SOC_{i,t}} \leq SOC_{i,t} \leq \overline{SOC_{i,t}}$$

$$SOC_{i,t}^{AT} = SOC_{i,t-1}^{AT} - \left(EN_{i,t}^{(+)} + \eta EN_{i,t}^{(-)} + ATRU_t RU_{i,t} - ATRD_t \eta_i RD_{i,t} \right) \frac{\Delta T}{T_{60}}$$

$$\underline{SOC_{i,t}^{AT}} \leq SOC_{i,t}^{AT} \leq \overline{SOC_{i,t}^{AT}}$$

$$0 \leq EN_{i,t}^{(+)} \leq u_{i,t} UEL'_{i,t}$$

$$(1 - u_{i,t}) LEL'_{i,t} \leq EN_{i,t}^{(-)} \leq 0$$

$$EN_{i,t} = EN_{i,t}^{(+)} + EN_{i,t}^{(-)}$$

$$u_{i,t} = \{0,1\}$$

$$\Bigg\}, \forall i \in S_{LESR} \wedge t$$

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Real-Time Stored Energy Management

- The ancillary service awards are fixed in RTD; however, the SOC constraints are still enforced in RTD to constrain the energy dispatch so that the sustained energy requirement is satisfied, and to ensure future awards and self-schedules can be met

- SOC constraints are applied to both the binding and non-binding intervals in FMM and RTD based on their Master File parameters, Lower and Upper Charge Limit bids, End-of-Hour (EOH) SOC bids limits, and, if applicable, the reliability-induced Minimum SOC

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Real-Time Stored Energy Management

- To model state of charge for storage resources during each interval the real-time market uses telemetered values for state of charge from storage resources to calculate an initial value

- From these initial conditions state of charge is updated from energy and regulation awards throughout the look-ahead periods considered by the real-time market

- The state of charge is calculated for each interval in real-time markets as follows:

$$SOC_{i,t} = SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)} \right) \frac{\Delta T}{T_{60}}$$

$$\left(1 - u_{i,t} \right) LEL'_{i,t} \leq EN_{i,t}^{(-)} \leq 0$$

$$\underline{SOC_{i,t}} \leq SOC_{i,t} \leq \overline{SOC_{i,t}}$$

$$EN_{i,t,} = EN_{i,t}^{(+)} + EN_{i,t}^{(-)}$$

$$0 \leq EN_{i,t}^{(+)} \leq u_{i,t} UEL'_{i,t}$$

$$u_{i,t} = \{0,1\}$$

Real-Time Stored Energy Management

- Just as in the day-ahead market, the state of charge equation is simultaneously enforced with the ancillary service impact and the ancillary service state of charge constraint

- In addition, ancillary service awards are constrained as follows:

$$\underline{SOC}_{i,t} + \left(SR_{i,t} + RU_{i,t} + NR_{i,t}\right)\frac{30'}{T} + FRU_{i,t-1}\frac{\Delta T}{T} \leq SOC_{i,t} \leq \overline{SOC}_{i,t} - \eta_i RD_{i,t}\frac{30'}{T} - \eta_i FRD_{i,t-1}\frac{\Delta T}{T}$$

- In RTD, the SOC remaining at the end of the RTD time horizon is constrained to ensure the LESR is able to meet its self-schedules in intervals beyond the scope of the RTD time horizon, as follows:

$$SOC_{i,t_e} \geq \underline{SOC}_{i,t_e} + \max\left(0, SSEn_{i,t_e}, P_{i,t_e} + SSRd_{i,t_e}\right)\frac{RM}{T}$$

$$SOC_{i,t_e} \leq \overline{SOC}_{i,t_e} + \eta_i \min\left(0, SSEn_{i,t_e}, \overline{P}_{i,t_e} - SSRu_{i,t_e} - SSSr_{i,t_e} - SSNr_{i,t_e}\right)\frac{RM}{T}$$

Additional Constraints – Ancillary service award constraints

- Storage resources providing ancillary services in positive direction are required to bid energy in the opposite direction (charging energy)

- This also requires storage resources provide bids for discharging energy while awarded ancillary services in the negative direction

- To enforce the requirement, SIBR will auto-populate this real-time bid where a scheduling coordinator fails to do so

$$-\underline{P}_{i,t} - RD_{i,t} \geq mAS \left(RU_{i,t} + SR_{i,t} + NR_{i,t} \right)$$

$$\overline{P}_{i,t} - RU_{i,t} - SR_{i,t} - NR_{i,t} \geq mAS \left(RD_{i,t} \right)$$

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Additional Constraints – Ancillary service award constraints

- The first equation ensures that the negative (charging) capacity, excluding capacity already set aside for regulation down, is greater than some fraction of the regulating services in the upward direction

- The second equation sets the same requirement in the opposite direction

$$-\underline{P}_{i,t} - RD_{i,t} \geq mAS \left(RU_{i,t} + SR_{i,t} + NR_{i,t} \right)$$
$$\bar{P}_{i,t} - RU_{i,t} - SR_{i,t} - NR_{i,t} \geq mAS \left(RD_{i,t} \right)$$

Additional Constraints – Ancillary service award constraints

- Ancillary services awards are also constrained to reserve a portion for charging and discharging the LESR to achieve the SOC level needed to meet the real time ancillary services awards in case there are SOC deviations

- This is achieved using the equations below, where mAS is the ancillary service multiplier and is equal to 0.5 given the tariff requirement that storage resources must be able to provide ancillary service at least thirty (30) minutes in the Real-Time Market after issuance of the Dispatch Instruction

$$mAS\left(RU_{i,t} + SR_{i,t} + NR_{i,t}\right) \leq -\underline{P}_{i,t} - RD_{i,t}$$

$$mAS\left(RU_{i,t} + SR_{i,t} + NR_{i,t}\right) \leq \max\left(0, -LEL_{i,t}\right)$$

$$mAS\,RD_{i,t} \leq \overline{P}_{i,t} - RU_{i,t} - SR_{i,t} - NR_{i,t}$$

$$mAS\,RD_{i,t} \leq \max\left(0, UEL_{i,t}\right)$$

Additional Constraints – Ancillary Service State of Charge Constraint

- Section 8.4.1.1(g) of the tariff requires that Regulation capacity offered must be dispatchable on a continuous basis for at least 60 minutes in the Day-Ahead Market and at least 30 minutes in the Real-Time Market after issuance of the Dispatch Instruction

- In the Real-Time Market, where a storage resource will not have sufficient State of Charge to meet its Ancillary Services Schedule, the CAISO will dispatch the storage resource to have sufficient State of Charge to meet its Ancillary Services Schedule

- The CAISO enforces this requirement through the ancillary service state of charge constraint

- For the day-ahead market, the following equation reflects the ancillary service state of charge constraint:

$$\underline{SOC_{i,t}} + \left(RU_{i,t} + SR_{i,t} + NR_{i,t} \right) \leq SOC_{i,t} \leq \overline{SOC_{i,t}} - \eta_i \left(RD_{i,t} \right)$$

Additional Constraints – Ancillary Service State of Charge Constraint

- In the real-time market the ancillary service state of charge constraint ensures that storage resources have at least 30 minutes of state of charge while providing ancillary services, and 15-minutes or 5-minutes of state of charge while providing flexible ramping capability through the following equations

$$SOC_{i,t} + \frac{1}{2}\left(SR_{i,t} + RU_{i,t} + NR_{i,t}\right) + \frac{\Delta T}{T}FRU_{i,t} \leq SOC_{i,t} \leq \overline{SOC}_{i,t} - \eta_i\frac{1}{2}RD_{i,t} - \eta_i\frac{\Delta T}{T}FRD_{i,t}$$

- In the real-time market, these constraints can result in charging awards or discharging awards for storage resources
- When these constraints bind, and result in energy awards, storage resources are not eligible for bid cost recovery

Additional Constraints – Ancillary Service State of Charge Constraint

- In Real-Time Contingency Dispatch (RTCD) and in Real-Time Disturbance Dispatch (RTDD) the market application will release the state of charge to deliver Spin and Non-Spin capacity for 10 minutes but continue to reserve the state of charge to ensure deliverability of Spin and Non-Spin capacity for future RTCD and RTDD

- In subsequent RTCD and RTDD market runs, the application will release all state of charge to deliver Spin and Non-Spin capacity

- In all RTCD and RTDD market runs, the market application will reserve the state of charge for 30 minutes to support deliverability of Regulation Up and Regulation Down capacity

- The state of charge equation with ancillary service impact and the ancillary service state of charge constraint are simultaneously enforced along with the state of charge equation in the day ahead and real time market

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Additional Constraints – End-of-hour SOC Bid Parameter

- The end-of-hour (EOC) state-of-charge (SOC) bid parameter is an optional, real-time only bid parameter for NGR resources to allow for easier management of the SOC in real-time

- The EOH SOC is an hourly value submitted as a range with an upper and lower state of charge limit

- The market will dispatch the resource so that the SOC ends the hour within the submitted range, while respecting Master File and minimum and maximum energy bid limits

- Ancillary service awards will be protected above the EOH SOC bids; however, a resource may receive uneconomic energy dispatches if necessary to achieve the EOH SOC submitted by the scheduling coordinator

Additional Constraints – Minimum State of Charge

- The minimum state of charge (MSOC) was developed as a tool for storage management to ensure that, in the real-time market, storage resources are charged to a level that will allow them to deliver their day-ahead discharge schedules

- This tool is only be triggered on days when the residual unit commitment process results in an under-generation infeasibility at any trading hour

- The MSOC is enforced in the real-time market only during a specified window of critical hours, and any hours leading to that window if the storage resource needs to charge to attain the required SOC

- There is no additional market compensation beyond the regular energy settlement and applicable bid cost recovery to storage resources that may be subject to the minimum state of charge

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Additional Constraints – Interactions between MSOC and EOH SOC Bid Parameter

- The Minimum State-of-Charge (MSOC) constraint is a form of EOH SOC constraint

- If the MSOC constraint is not active, the minimum and maximum EOH SOC limits submitted as part of bids will be used in the optimization

- If MSOC requirements exist and are active, they will take priority over the bid EOH SOC and daily SOC limits during critical hours

- During non-critical hours, the most restrictive between MSOC, minimum bid EOH SOC, and daily minimum SOC limits will be used

- If necessary, the maximum bid EOH SOC and the daily maximum SOC limits shall be set to the MSOC when in conflict

Open Discussion

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Break

Working Group on SOC Management

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Stakeholder Presentations

Open Discussion

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Next Steps

Next steps

- Upcoming milestones:*
  - 2/20: Upcoming SDM stakeholder meeting and working group
  - 3/05: Stakeholder comments due

*All dates are tentative until confirmed through a notice in the ISO's Daily Briefing.

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For reference

- Visit initiative webpage for more information:
  https://stakeholdercenter.caiso.com/StakeholderInitiatives/Storage-design-modeling

- If you have any questions, please contact
  ISOStakeholderaffairs@caiso.com

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