# 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 right corner 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.

# 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 – 11:15 | Overview of Storage Constraints | Sergio Dueñas Melendez |
| 11:15 – 11:45 | Overview of Outage Management and Nonlinearity issues | Sergio Dueñas Melendez |
| 11:45 – 12:00 | Open discussion | |
| 12:00 – 1:00 | Break | |
| 1:00 – 1:45 | Overview of Storage DEBs | Sergio Dueñas Melendez |
| 1:45 – 2:15 | Overview of SOC Management and Capacity Awards | Sergio Dueñas Melendez |
| 2:15 – 3:00 | Stakeholder presentations | Various stakeholders |
| 3:00 – 3:55 | Open discussion | |
| 3:55 – 4:00 | Next Steps | Brenda Marquez |

# CAISO Policy Initiative Stakeholder Process


We are here

# 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 and implement solutions in a staggered manner
- The working groups process will result in the development of a straw proposal for Topic Group 1 and an Issue Paper for Topic Groups 2 and 3
- 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 their proposed guiding principles and 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 existing SOC constraints, outage management, DEBs, and SOC and capacity awards today
- The ISO welcomes discussion of the guiding principles and straw proposals across all topics as part of the working group process

# Updated Tentative Topic Groups

# 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

| Date | Milestone |
|---|---|
| 01/23/25 | Stakeholder meeting on Topic Group 1 and Working Group on Topic Group 2 |
| 02/20/25 | Stakeholder meeting on Topic Group 1 and Working Group on Topic Group 3 |
| 03/05/25 | Comments due |
| 03/19/25 | Topic Group 1 Straw Proposal Posting |
| 03/24/25 | Stakeholder meeting on Topic Group 1 and Working Group on Topic Group 2 |
| 04/16/25 | Stakeholder meeting on Topic Group 1 and Working Group on Topic Group 3 |
| 05/07/25 | Comments due |

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

# Revised timeline

| Date | Milestone |
|---|---|
| 05/21/25 | Topic Group 1 Revised Straw Proposal Posting & Topic Groups 2 and 3 Issue Paper Posting |
| 05/28/25 | Stakeholder meeting on Topic Group 1 and Working Group on Topic Group 2 |
| 06/25/25 | Stakeholder meeting on Topic Group 1 and Working Group on Topic Group 3 |
| 07/16/25 | Comments due |
| 07/31/25 | Topic Group 1 Draft Final Proposal Posting |

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

# 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

# Glossary of variables related to SOC constraints

| | |
|---|---|
| $i$ | Resource index |
| $t$ | Time interval index |
| $E^{(+)}$ | Discharging energy schedule (positive, 0 if not discharging) |
| $\eta$ | Round trip efficiency |
| $E^{(-)}$ | Charging energy schedule (negative, 0 if not charging) |
| $RU$ | Regulation up award |
| $mRU$ | Multiplier applied to regulation up (between 0 and 1) |
| $RD$ | Regulation down award |
| $mRD$ | Multiplier applied to regulation down (between 0 and 1) |
| $u$ | Resource index |
| $\bar{P}$ | Maximum discharge capability |
| $\underline{P}$ | Minimum charge capability (negative) |
| $E$ | Energy schedule |
| $SR$ | Spinning reserve award |
| $NR$ | Non-spinning reserve award |

# Glossary of variables related to SOC constraints

| | |
|---|---|
| $soc$ | State of charge |
| $soc^{AT}$ | State of charge including attenuation factors |
| $\underline{soc}$ | Minimum state of charge |
| $\overline{soc}$ | Maximum state of charge |
| $\Delta T$ | Duration of real-time interval (15 or 5 minutes) |
| $T$ | One hour |
| *FRU* | Upward flexible ramping product award |
| *FRD* | Downward flexible ramping product award |
| *mAS* | Multiplier applied to ancillary service capacity awards (between 0 and 1) |
| UEL | Upper economic limit |
| LEL | Lower economic limit |
| $S_{LESR}$ | Set of limited energy storage resources (LESR). |

# 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

# Day-Ahead Stored Energy Management

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

$$
\left.
\begin{aligned}
SOC_{i,t} &= SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)}\right)\frac{\Delta T}{T_{60}} \\
\underline{SOC_{i,t}} &\leq SOC_{i,t} \leq \overline{SOC_{i,t}} \\
SOC_{i,t}^{AT} = SOC_{i,t-1}^{AT} &- \left(EN_{i,t}^{(+)} + \eta EN_{i,t}^{(-)} + ATRU_t RU_{i,t} - ATRD_t \eta_i RD_{i,t}\right)\frac{\Delta T}{T_{60}} \\
\underline{SOC_{i,t}^{AT}} &\leq SOC_{i,t}^{AT} \leq \overline{SOC_{i,t}^{AT}} \\
0 &\leq EN_{i,t}^{(+)} \leq u_{i,t} UEL'_{i,t} \\
(1 - u_{i,t}) LEL'_{i,t} &\leq EN_{i,t}^{(-)} \leq 0 \\
EN_{i,t,} &= EN_{i,t}^{(+)} + EN_{i,t}^{(-)} \\
u_{i,t} &= \{0,1\}
\end{aligned}
\right\}, \forall i \in S_{LESR} \wedge t
$$

# 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

$$\left.\begin{aligned}
SOC_{i,t} &= SOC_{i,t-1} - \left(EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)}\right)\frac{\Delta T}{T_{60}} \\
\underline{SOC_{i,t}} &\leq SOC_{i,t} \leq \overline{SOC_{i,t}} \\
SOC_{i,t}^{AT} = SOC_{i,t-1}^{AT} &- \left(EN_{i,t}^{(+)} + \eta EN_{i,t}^{(-)} + ATRU_t RU_{i,t} - ATRD_t \eta_i RD_{i,t}\right)\frac{\Delta T}{T_{60}} \\
\underline{SOC_{i,t}^{AT}} &\leq SOC_{i,t}^{AT} \leq \overline{SOC_{i,t}^{AT}} \\
0 &\leq EN_{i,t}^{(+)} \leq u_{i,t} UEL'_{i,t} \\
(1 - u_{i,t}) LEL'_{i,t} &\leq EN_{i,t}^{(-)} \leq 0 \\
EN_{i,t,} &= EN_{i,t}^{(+)} + EN_{i,t}^{(-)} \\
u_{i,t} &= \{0,1\}
\end{aligned}\right\}, \forall i \in S_{LESR} \wedge t$$

# 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, and End-of-Hour (EOH) SOC bids limits

# 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:

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

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

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

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

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

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

# 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:

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

- In 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:

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

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

# 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

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

# 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

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

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

# 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 DA Market and at least 30 minutes in the RTM after issuance of the dispatch instruction
- In the RTM, where a storage resource will not have sufficient SOC to meet its AS schedule, the CAISO will dispatch the storage resource to have sufficient SOC to meet its AS schedule
- The CAISO enforces this requirement through the ancillary service state of charge constraint
- For the DA 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

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

- 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

# 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

# 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
    - Importantly, this NoW is exempt from the Resource Adequacy Availability Incentive Mechanism (RAAIM)
  - 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."

# Open Discussion

# Break

# Overview of Storage Default Energy Bids

# CAISO has developed a DEB for storage resources

- Eligible storage resources may rank the Storage DEB as their primary DEB methodology in the Master File at any time, however Scheduling Coordinators for these resources may wish to register a non-zero variable storage operations cost with the CAISO
- If the Scheduling Coordinator does not wish to register a non-zero variable storage operations cost, the CAISO will enter a default value of $0/MWh to the Master File
- EIM storage resources are not able to utilize the Storage DEB option because the Storage DEB calculation relies on day-ahead LMPs, which are not calculated for WEIM participating resources

# Overview of the Storage DEB Calculation

- The Storage DEB includes three main cost components:
  - Energy costs
  - Variable storage operations costs
  - Price-based opportunity costs
- The Storage DEB is calculated as follows:

$$\text{Storage DEB} = \text{Max}\left\{\left[\text{Max}\left(\text{En}_{\delta/\eta}, 0\right) + \rho\right], \text{PB\_OC}_{\gamma}\right\} * \text{DEB Multiplier}$$

Where:

| | |
|---|---|
| En: | Energy Cost |
| $\eta$: | Round-Trip Efficiency |
| $\delta$: | Energy Charging Duration |
| $\gamma$: | Energy Discharge Duration |
| $\rho$: | Variable Storage Operations Cost |
| PB_OC: | Price-Based Opportunity Cost |
| DEB Multiplier | 110% Multiplier |

# Energy Costs

- This component estimates the average cost of energy needed to charge the storage resource, assuming that the energy is purchased by the resource through the CAISO markets
- The calculation of this cost assumes the storage resource performs one cycle of charging/discharging per day, and that the resource will charge during the least expensive continuous block of time during the day
- Adjustments for round-trip efficiency are also included in the calculation
- For the DAM Storage DEB calculation, the energy cost component will source DA LMP prices from the MPM run at the relevant PNode for the same Trading Day
- For the RTM Storage DEB calculation, the energy cost component will source DA LMP prices from the IFM run at the relevant PNode for the same Trading Day

# Efficiency and Duration

- Round-Trip Efficiency:
  - This value is static and is registered in Master File. The Master File parameter is called “Energy Efficiency”
- Energy Charging Duration:
  - The adjusted Energy Charging Duration is used in the calculation of the Energy Cost
- Energy Discharging Duration:
  - The adjusted Energy Discharging Duration is used in the calculation of the price-based opportunity cost component of the Storage DEB

# Variable Storage Operation Costs

- This component represents the costs associated with operation of the resource, including cycling and cell degradation costs
- This cost will be set to zero for the entire charging portion of the DEB, in order to ensure the DEB is monotonically increasing with output
- The $/MWh value will be registered in the Master File and must be approved by the CAISO
- If no value is registered, the variable storage operations cost will be set to the default value of $0/MWh.

# Price-Based Opportunity Cost & DEB Multiplier

- Price-Based Opportunity Costs:
  - This component estimates the market opportunity cost faced by a storage resource when determining whether to discharge stored energy at various hours during the day
  - In the Real-Time Storage DEB calculation, the price-based opportunity cost will be set at the value of the highest Day-Ahead LMP corresponding to the discharge duration of the resource
  - The Day-Ahead DEB calculation will use the advisory prices from the Market Power Mitigation process
- DEB Multiplier:
  - This multiplier is intended to cover variability between the CAISO's calculation of the Storage DEB and the resource's actual marginal costs
  - The DEB Multiplier is currently set to 1.1

# Challenges related to the Storage DEB

- Reliance on DA LMPs
  - Creates challenges with an expanding footprint
  - May overlook the changing conditions in RT relative to DA, eroding SOC management efforts

- Potential to over- or under-estimate opportunity costs
  - Since the energy costs and price-based opportunity costs are based on specific blocks of hours but the DEB is the same throughout the relevant trade date, the costs may be over- or understated in given hours

- Applicability to long-duration energy storage
  - Having a "one cycle a day" assumption may not work for resources with longer balancing horizons

# Previously suggested potential changes to the Storage DEB

- Modify the DEB Multiplier to capture the differences between DA and RT prices
- Modify the price-based opportunity cost proxy to focus on the expected peak price
- Make the DEB an hourly calculation that can vary through the day by continuously updating the energy cost and price-based opportunity costs hour blocks

- In addition, stakeholders have suggested to consider alternative methodologies that capture short-term opportunity pricing at the asset's local hub

# Open Discussion

# Overview of SOC Management and Capacity Awards

# The current SOC formulation does not consider the impact of delivering FRP on SOC

- Today, a large share of FRP is procured from storage resources
- Since the SOC calculation does not consider the impact of providing FRP, these awards could end up being undeliverable due to inadequate SOC
- This issue has price formation and market efficiency implications
  - Since SOC does not limit the amount of FRP that can be awarded to an asset, FRP prices could be artificially suppressed
  - If inadequate SOC results in undeliverable FRP awards, the market will need to procure that additional energy from other resources, putting upward pressure on the bid stack and potentially increasing energy prices

# The current SOC formulation does not consider the impact of delivering FRP on SOC

- In FMM, the market accounts for the SOC impacts of Energy and AS to ensure feasible dispatch instructions (*i.e.,* that these awards can be supported by the SOC for every single interval of the horizon)
- Currently, this constraint does not include FRP awards
- When the market clears for Energy or AS or FRP it does it for all intervals of the horizon
- Since FRP is not included in the constraint, a storage resource may be dispatched for Energy and AS in a manner that exhausts the SOC, while also receiving significant FRP awards later in the horizon
- This results in a material change regarding the energy dispatched

# Open Discussion

# Working Group

# Stakeholder Presentations

# Open Discussion

# Next Steps

# Next steps

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

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

# For reference

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

- If you have any questions, please contact Brenda Marquez at bmarquez@caiso.com or ISOStakeholderaffairs@caiso.com