Storage Design and Modeling

Working Group on Uplift & Default Energy Bids, and Outage Management

Stakeholder Meeting

May 18, 2026

9 am – 12 pm

Engagement Best Practices

This call is being recorded for informational and convenience purposes only and will be available on the CAISO website. Any related transcriptions should not be reprinted without ISO's permission.

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

The facilitator will provide guidance for comments and questions to ensure a productive flow. Please keep remarks succinct and avoid revisiting points that have already been covered, allowing space for all voices.

Closed Captioning and the Transparency Viewer are available at the bottom of the Webex screen.

Instructions for Raising Your Hand to Ask a Question

Please remember to state your name and affiliation before making your comment. After unmuting, please pause for about two seconds before speaking to ensure your audio connects clearly.

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.

If you are connected on the phone line only and not the Webex, dial *3 to be added to the raise hand queue.

You may send questions via chat to all panelists.

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

CAISO Policy Initiative Stakeholder Process

Initiate
Prioritize objectives and initiatives to develop roadmap

Scope
Define opportunities and scope to reflect diverse goals and objectives

Develop
Stakeholders collaborate to develop solutions and final proposal

Decide
Obtain governance approvals and submit FERC filing as required

Implement
Complete customer readiness, market simulation and go-live

We are here

Learn more in the [Stakeholder Process Guide]

Agenda

Time	Topic	Presenter
9:00 – 9:05	Welcome and today's agenda	Brenda Marquez
9:05 – 9:15	Meeting Goals and Initiative Overview	Sergio Dueñas Meléndez
9:15 – 10:00	Draft Straw Proposal on Storage DEB Enhancements	Sergio Dueñas Meléndez
10:00 – 10:35	Overview of the NGR bidding concept put forth by the Market Surveillance Committee	Sergio Dueñas Meléndez
10:35 – 10:50	Open Discussion	
10:50 – 11:00	Break	
11:00 – 11:45	Overview of Outage Management Second Revised Straw Proposal	Dinesh Das Gupta
11:45 – 12:00	Open Discussion	

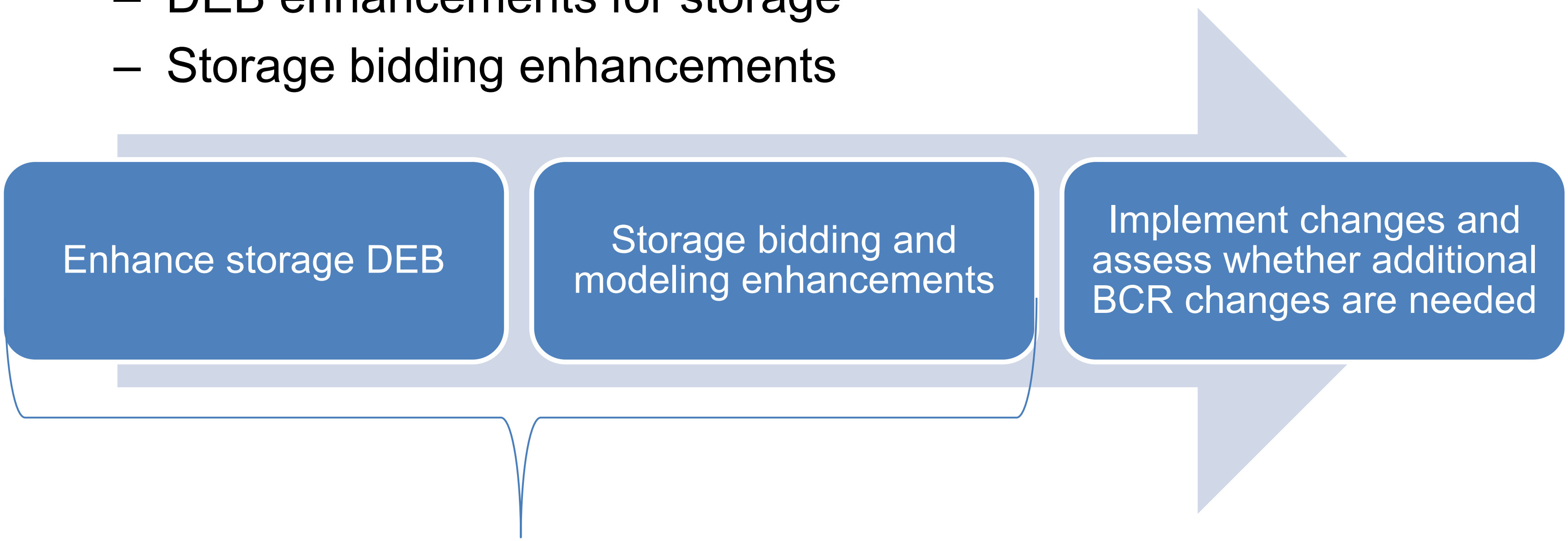
MEETING GOALS AND INITIATIVE OVERVIEW

Meeting Goals

- Share a draft straw proposal to modify the storage default energy bid (DEB) in a manner aligned with MSC and stakeholder feedback
- Share overview of the non-generator resource (NGR) bidding concept put forth by the Market Surveillance Committee (MSC)
- Provide an overview of the Outage Management Second Revised Straw Proposal ahead of the stakeholder comment deadline

Overview of potential proposal timeline *

- Focus straw proposal development on the topics we'll discuss today:
  – DEB enhancements for storage
  – Storage bidding enhancements



Part of the Straw Proposal on Uplift & DEB and SOC Management (expected late June) *

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

Overview of potential proposal timeline *

- **May 18th:** Hybrid meeting
- **June 1st:** Comments due

- **June 30th:** Straw Proposal
- **July 15th:** Hybrid meeting
- **July 29th:** Comments due

- **September 2nd:** Revised Straw Proposal
- **September 16th:** Hybrid meeting
- **September 30th:** Comments due

- **October 30th:** Draft Final Proposal

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

DRAFT STRAW PROPOSAL ON STORAGE DEFAULT ENERGY BID ENHANCEMENTS

In the following slides, the ISO provides an overview of a draft straw proposal to modify the storage default energy bid calculation in a manner aligned with feedback provided by stakeholders and the Market Surveillance Committee (MSC)

- Will have minimal differences between how the storage default energy bid (DEB) is calculated for CAISO/EDAM storage and WEIM-only storage

- Includes elements of the hydro DEB given stakeholder feedback

- Can be readily leveraged under today's bidding and modeling approach

Today, the storage default energy bid accounts for batteries' round-trip efficiency and duration and includes three cost components

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

Where:

En:	Energy Cost
η:	Round-Trip Efficiency
δ:	Energy Charging Duration
γ:	Energy Discharge Duration
ρ:	Variable Storage Operations Cost
PB_OC:	Price-Based Opportunity Cost
DEB Multiplier	110% Multiplier

Today, the storage default energy bid accounts for batteries' round-trip efficiency and duration and includes three cost components

1. Energy costs: estimates the average cost of energy needed to charge the storage resource

   – For the day-ahead default energy bid, the energy costs are sourced from the day-ahead locational marginal price from the market power mitigation run at the relevant pricing node for the same trading day

   – For the real-time default energy bid, the energy costs are sourced from day-ahead locational marginal prices from the integrated forward market run at the relevant pricing node for the same trading day

Today, the storage default energy bid accounts for batteries' round-trip efficiency and duration and includes three cost components

2. Price-based opportunity costs: estimates the market opportunity cost when determining whether to discharge stored energy at various hours during the day

   – For the day-ahead storage default energy bid, the price-based opportunity cost uses advisory prices from the market power mitigation process

   – For real-time storage default energy bid, the price-based opportunity cost is set at the value of the highest day-ahead locational marginal price corresponding to the discharge duration of the resource

Today, the storage default energy bid accounts for batteries' round-trip efficiency and duration and includes three cost components

3. Variable storage operations cost: used to represent cycling and other variable operational costs

   – If a non-zero variable storage operations cost is desired, Scheduling Coordinators should submit an Inquiry ticket via CIDI to register their variable storage operations cost

   – 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

Today, the storage default energy bid accounts for batteries' round-trip efficiency and duration and includes three cost components

- Today, WEIM-only storage resources (those not participating in EDAM) are not able to utilize the Storage DEB option because the Storage DEB calculation relies on day-ahead LMPs, which are not calculated for non-EDAM participating resources
  - Today, such storage resources must pursue the Negotiated DEB option, or pick any of the other DEB options for which they are eligible

Default Energy Bids: Problem Statement

- The storage default energy bid's dependence on outputs from prior market runs creates challenges since:
  - Those values may be "stale" in the market the DEB is used
  - With an expanding footprint, some resources that are not part of the day-ahead market cannot readily leverage the storage default energy bid option

- A static real-time storage default energy bid has the potential to over- or under-estimate opportunity costs at different hours of the day

Default Energy Bids: Guiding Principles

- The storage default energy bid should be designed in a way that allows for the reflection of changing real-time opportunity costs, ensuring the correct placement of storage within the bid stack, even under mitigation

- The storage default energy bid should be calculated in a way that all storage resources, regardless of location, should be able to readily leverage a default energy bid option

- The storage default energy bid should be designed in a way that minimizes the risks of charging-side mitigation

The ISO has been working on a DEB draft straw proposal that would leverage the "time-of-day" concept for both CAISO/EDAM and WEIM-only storage resources

- Stakeholders called for the ISO to prioritize default energy bid improvements ahead of uplift redesign, with significant support for time-of-day (TOD) or hourly concepts
  - CalCCA, Cal Advocates, Portland, PG&E, SCE, Terra-Gen, and others generally leaned towards a multiplier-based TOD approach
  - AES, CalCCA, NV Energy, SCE, and Portland generally support development of a readily available WEIM-only storage DEB
    - In contrast, CESA, Terra-Gen, and Vistra argued that all storage resources should be subject to a single, consistent DEB framework

In their September 2020 opinion, the MSC also offered recommendations to eliminate certain elements of the storage default energy bid's design

- The MSC argues that charging costs are generally unnecessary within DEB calculations because these are implicitly included in the optimization in day-ahead and are sunken costs in real-time

- In contrast, the variable storage operation costs would always be a legitimate part of bids and should therefore be included in the DEB calculations

- Regarding opportunity costs, the MSC argues that, while these may not be necessary to include in the day-ahead timeframe, they are relevant in real-time bids to manage state-of-charge and should be included in the DEB calculation

In addition, some stakeholders have advocated for the incorporation of Hydro DEB elements into the storage DEB

- WPTF and Vistra opposed TOD DEBs and instead support modifying the existing hydro DEB methodology (including short-term and gas-floor components)

- Stakeholders have argued that inclusion of the hydro DEB elements such as the gas floor is essential to ensure storage preserves the correct position in the bid stack, even under mitigation

The “time-of-day” DEB draft straw proposal would have minimal differences between its application for CAISO/EDAM storage and WEIM-only storage

Market	Timeframe	1. Eliminate energy cost, include gas floor	2. Scale price proxies to address “stale” values	3. Calculate initial DEB value, without any multiplier	4. Modify the 1.1 DEB multiplier as needed
CAISO/EDAM	Day-Ahead	Energy costs are sunken costs, the DEB should be determined by forward-looking opportunity costs. The gas floor is included to conform with the hydro DEB and to ensure storage preserves the correct position in the bid stack, even under mitigation.	Scale MPM outputs based on difference relative to the DA LMPs	Use the current formula (minus energy costs and the 1.1 DEB multiplier) to calculate a DEB value	**To conform with the hydro DEB, use 1.1 for the gas floor and the Variable Storage Operations Cost and 1.4 for the Price-based Opportunity Cost across all hours**
	Real-Time		Scale **DA LMPs** based on difference relative to RT LMPs		Use a multiplier **between 0.6 and 1.4 to conform with the hydro DEB and better represent changing opportunity costs.**
WEIM	Real-Time		Scale **DGAP** prices based on difference relative to RT LMPs		

The "time-of-day" DEB draft straw proposal would have minimal differences between its application for CAISO/EDAM storage and WEIM-only storage

Storage DA DEB = Max (Variable Storage Operations Cost * **1.1** , PB_OC * **1.4**, **Gas Floor * 1.1**)

Storage RT DEB =
Max (Variable Storage Operations Cost , PB_OC, **Gas Floor**) * **TOD Multiplier**

Where:

- Variable Storage Operations Cost ($/MWh) = Represents cycling and other operational costs
- PB_OC = Price-based Opportunity Cost ($/MWh)
  - In DA for CAISO/EDAM, calculated by scaling the MPM outputs based on differences relative to DA LMPs
  - In RT for CAISO/EDAM, **calculated by scaling DA LMPs** based on differences relative to RT LMPs
  - In RT for WEIM, **calculated by scaling DGAP** based on differences relative to RT LMPs
- TOD Multiplier = A value between 0.6 and 1.4 that shapes the DEB (only in real-time)
- Gas Floor = 11,068 MMBtu/MWh * Fuel region gas price

- ***The ISO plans to perform analyses to determine if the additional complexity associated with adding hydro DEB elements is valuable***

Example: Current Storage RT DEB Calculation

	LMP
HE1	30
HE2	31
HE3	32
HE4	33
HE5	34
HE6	37
HE7	35
HE8	18
HE9	7
HE10	4
HE11	8
HE12	9
HE13	10
HE14	11
HE15	12
HE16	13
HE17	14
HE18	28
HE19	40
HE20	54
HE21	50
HE22	41
HE23	42
HE24	37

DEB Today	45.1
En	7.3
VSOC	10
PB_OC	41
Duration	4
Efficiency	0.9

RT DEB Calculation today

Max {[Max (7.3, 0) +10], 41} * 1.1

Max {17.3, 41} * 1.1

41*1.1 = 45.1

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

Where:

En:	Energy Cost
η:	Round-Trip Efficiency
δ:	Energy Charging Duration
γ:	Energy Discharge Duration
ρ:	Variable Storage Operations Cost
PB_OC:	Price-Based Opportunity Cost
DEB Multiplier	110% Multiplier

Illustrative Example: TOD CAISO/EDAM RT DEB

	LMP
HE1	30
HE2	31
HE3	32
HE4	33
HE5	34
HE6	37
HE7	35
HE8	18
HE9	7
HE10	4
HE11	8
HE12	9
HE13	10
HE14	11
HE15	12
HE16	13
HE17	14
HE18	28
HE19	40
HE20	54
HE21	50
HE22	41
HE23	42
HE24	37

Scale based the differences relative to RT LMPs
1.05

This value is not final, it is included for illustrative purposes

Scaled LMPs
31.5
32.55
33.6
34.65
35.7
38.85
36.75
18.9
7.35
4.2
8.4
9.45
10.5
11.55
12.6
13.65
14.7
29.4
42
56.7
52.5
43.05
44.1
38.85

DEB without charging costs or multiplier	43.05
VSOC	10
PB_OC	43.05
Duration	4
Efficiency	0.9
Gas floor	18.44

The gas floor is calculated using (11,068 MMBtu/MWh * Fuel region gas price)

The value above assumes a $1.5/MMBtu fuel region price for illustrative purposes

Example: TOD CAISO/EDAM RT DEB

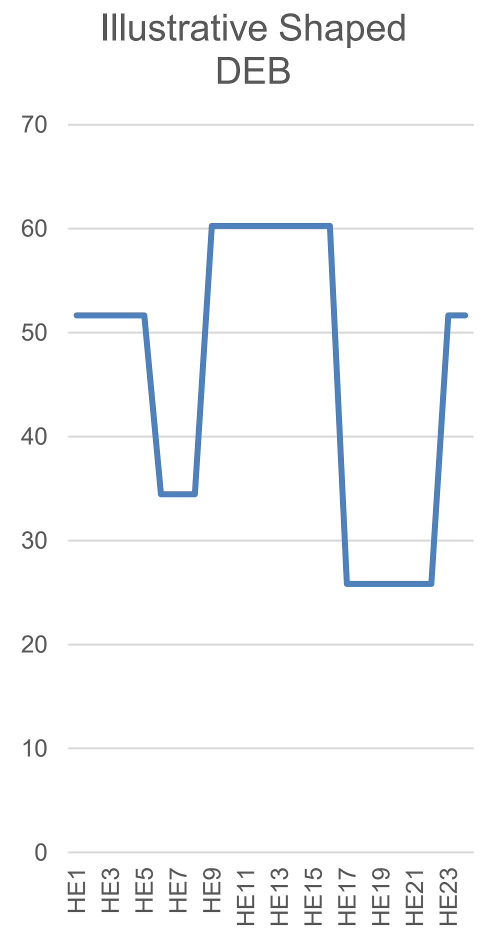
DEB without charging costs or multiplier	43.05
VSOC	10
PB_OC	43.05
Duration	4
Efficiency	0.9
Gas floor	18.44

The gas floor is calculated using (11,068 MMBtu/MWh * Fuel region gas price)

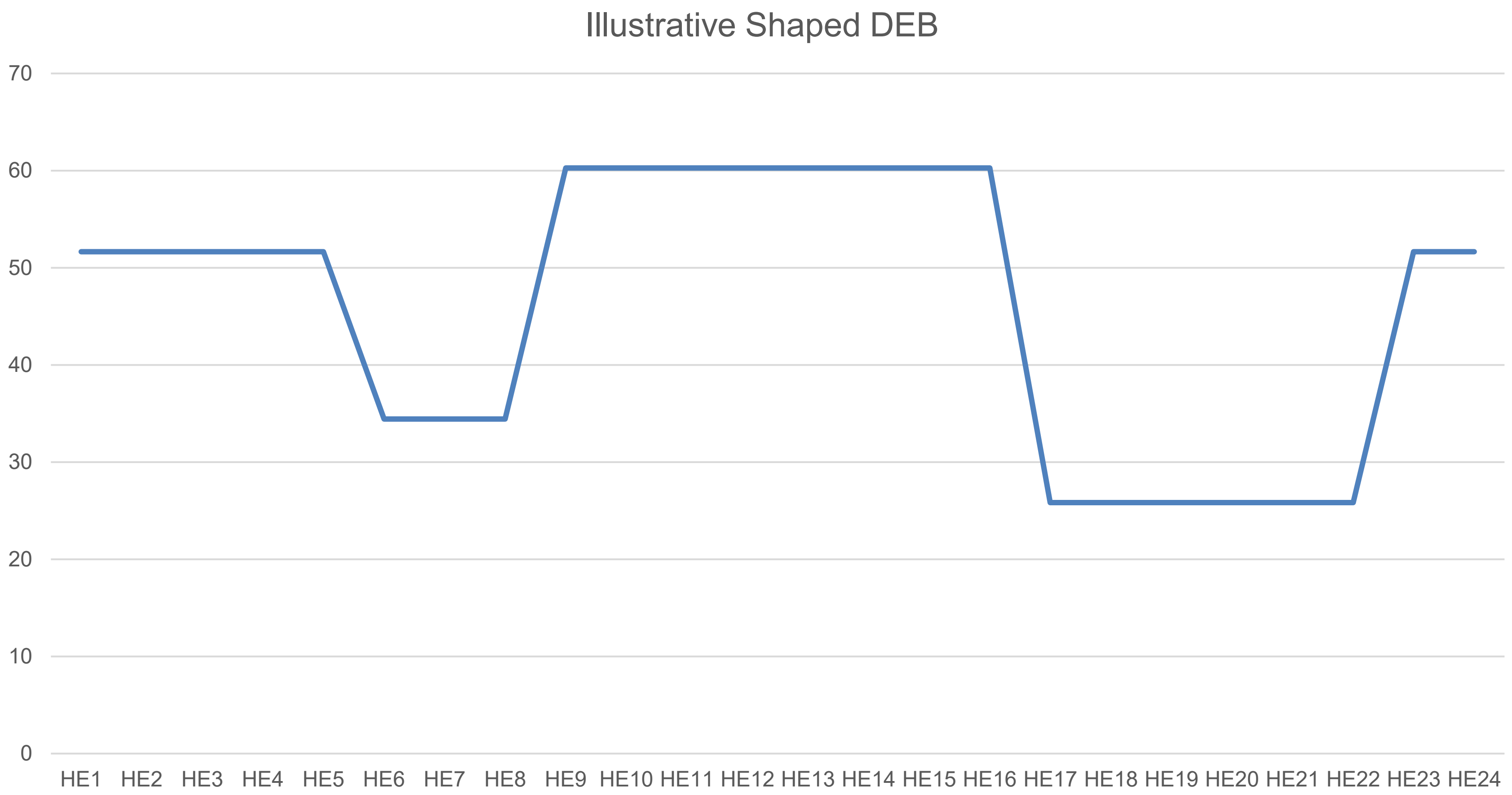
The value above assumes a $1.5/MMBtu fuel region price for illustrative purposes

	Shaping multiplier	Shaped DEB
HE1	1.2	51.66
HE2	1.2	51.66
HE3	1.2	51.66
HE4	1.2	51.66
HE5	1.2	51.66
HE6	0.8	34.44
HE7	0.8	34.44
HE8	0.8	34.44
HE9	1.4	60.27
HE10	1.4	60.27
HE11	1.4	60.27
HE12	1.4	60.27
HE13	1.4	60.27
HE14	1.4	60.27
HE15	1.4	60.27
HE16	1.4	60.27
HE17	0.6	25.83
HE18	0.6	25.83
HE19	0.6	25.83
HE20	0.6	25.83
HE21	0.6	25.83
HE22	0.6	25.83
HE23	1.2	51.66
HE24	1.2	51.66

These values are not final, they are included for illustrative purposes



Example: TOD CAISO/EDAM RT DEB



The draft straw proposal addresses the applicable principles put forth in the Updated Issue Paper on Uplift and DEBs

- Allows for the reflection of changing real-time opportunity costs and ensures the correct placement of storage within the bid stack, even under mitigation

- Addresses the challenges posed by leveraging “stale” values

- Offers a formulation that allows all storage resources, regardless of location, to readily leverage a default energy bid option with minimal differences

- Minimizes the risks of charging-side mitigation

OVERVIEW OF THE NGR BIDDING CONCEPT PUT FORTH BY THE MARKET SURVEILLANCE COMMITTEE

In the 2020 opinion related to non-generator resource default energy bids, the MSC also discussed a bidding paradigm that could alleviate the “end effects” problem

- The “end effects” problem refers to the challenges associated with limited lookaheads within its optimization processes
  - Day-ahead: ~24 hours
  - Real-time: ~1–3 hours

- End effects may undervalue the energy remaining after the horizon, leading to difficulties when managing state-of-charge

- The MSC put forth an NGR bidding concept that could address known challenges of the current NGR model without creating a brand new participation pathway

The MSC underscored that the end-of-hour state-of-charge parameter represents a “primal” approach to address end effects, but recommends exploration of a “dual” approach

- Today’s end-of-hour state-of-charge parameter seeks to address end effects by fixing a state-of-charge level at the end of a given horizon
  - “Save this much energy for later”

- Under a “dual” approach, scheduling coordinators could both
  - Fix a state-of-charge level at the end of a given horizon**; and,**
  - Assign a $/MWh to the energy at the end of that horizon
    - “The stored energy has this future economic value”

The MSC argues that the dual approach would allow for a more effective way to manage deviation form the scheduled state-of-charge

- Deviation from the “natural” market dispatch today comes from adjusting bids and offers, which may be complicated by:
  - Underlying random events (load, renewables)
  - Asymmetrical knowledge of system conditions
  - Endogeneity issues: The prices being forecast by a storage asset need to incorporate the effect of forecasting by other storage assets

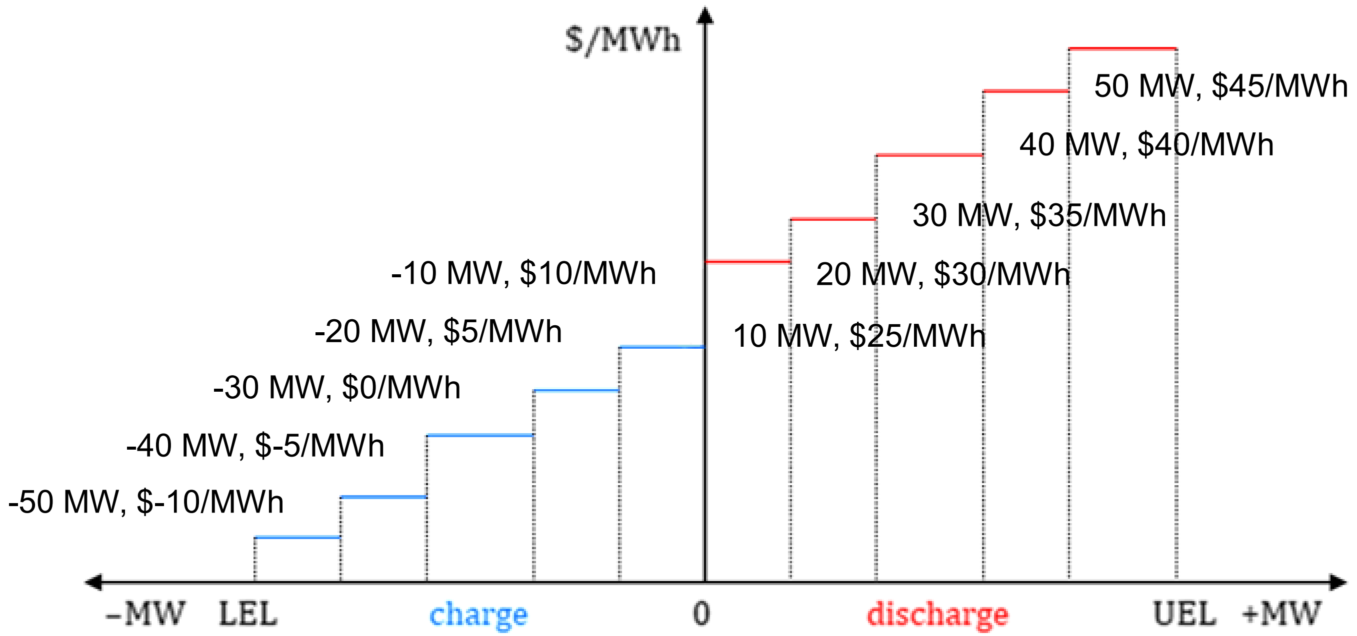
- MSC recommends a bidding paradigm where deviations from the scheduled state-of-charge are handled via the energy value under the “dual” approach
  - This is viable because the market optimization already internalizes charging costs and opportunity costs if state-of-charge and energy value are specified

While the aforementioned DEB concept can be readily leveraged under today's bidding approach, MSC members have suggested a "reframing" of non-generator resource bidding could bolster the design's effectiveness

- Reframe storage bidding to require storage owners to submit a bid/offer for deviating end-of-horizon state-of-charge from its initial level, reflecting the expected value of energy after the market horizon

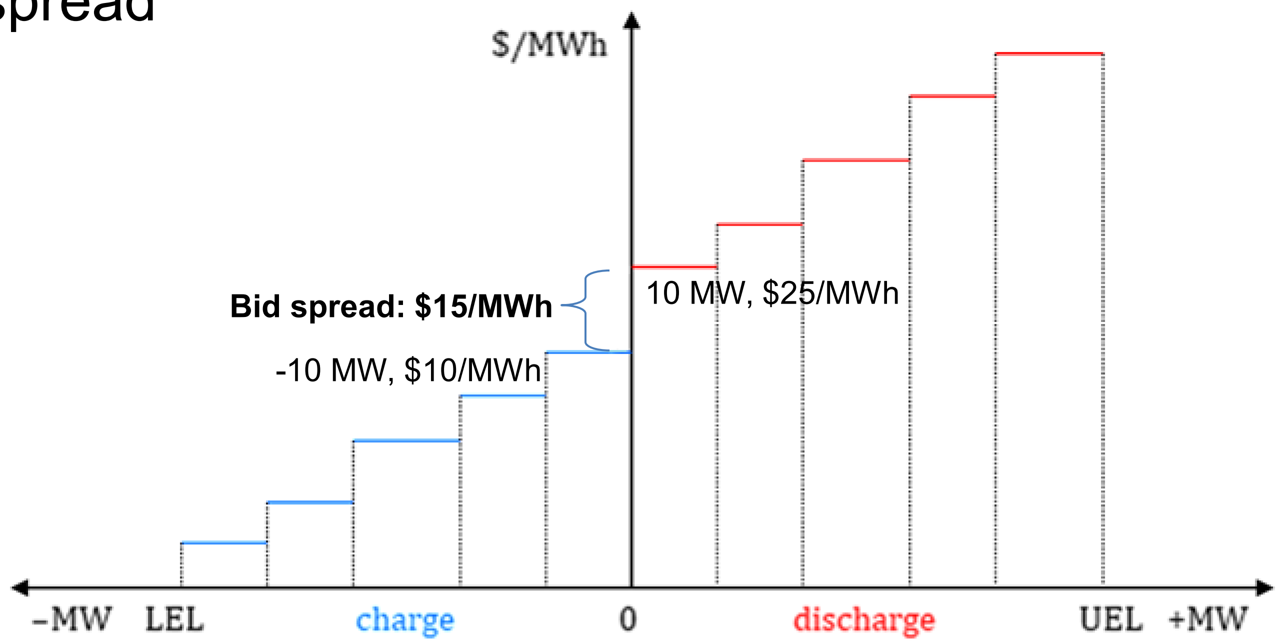
NGR bidding today – High-level overview

- Today, NGRs submit a monotonically nondecreasing bid curve with up to ten MW-$/MWh pairings to indicate their willingness to charge or discharge



Today, the specific $/MWh values are not the sole drivers of dispatch

- Within the optimization horizon, the market is able to schedule storage assets based mainly on the difference between the highest offer to charge and the lowest bid to discharge, AKA the bid spread



Today, the bid spread may inform dispatch within the optimization horizon

- In day-ahead under today's bidding approach, storage resources submit a bid curve and the implied bid spread enables the market to optimally schedule them within the optimization horizon
  - The market will schedule the asset to charge in hours with the lowest prices and discharge in hours with the highest prices, treating the bid spread as the arbitrage minimum bid value

Today, the bid spread may inform dispatch within the optimization horizon

- In real-time, under today's bidding approach, storage submit the whole bid curve and, due to the shorter optimization horizon, the bid spread is only material when the horizon anticipates a state-of-charge constraint
  - This approach relies on price forecasting by the scheduling coordinators, who must submit interval-by-interval bids to charge and discharge, which is complicated by:
    - Underlying random events (load, renewables)
    - Asymmetrical knowledge of system conditions
    - Endogeneity issues: The prices being forecast by a storage asset need to incorporate the effect of forecasting by other storage assets

Storage bids could be reframed as the reflection of the asset's perceived value of the stored MWh ***beyond the optimization horizon***

- Allows for endogenous dispatch optimization within the optimization horizon
- Financially links the end-of-horizon state-of-charge to the initial state-of-charge level, reflecting the expected value of energy after the market horizon
  - Eliminates the need for assets to perform interval-by-interval price forecasts within the optimization horizon and captures the asset's private assessment of future value beyond the horizon, such as next-day prices

The MSC suggested a bidding paradigm where storage owners submit a bid/offer for deviating end-of-horizon state-of-charge from its initial level, reflecting the expected value of energy after the market horizon

- Model the technical characteristics of storage, including round-trip efficiency and state-of-charge (done today)
- Asset submits bid/offer reflecting its willingness to pay to increase its end-of-horizon state-of-charge or its willingness to accept compensation for reducing end-of-horizon state-of-charge
- This bid eliminates the need for assets to perform interval-by-interval price forecasts and captures the asset's private assessment of future value beyond the horizon, such as next-day prices

The MSC suggested a bidding paradigm where storage owners submit a bid/offer for deviating end-of-horizon state-of-charge from its initial level, reflecting the expected value of energy after the market horizon

- Storage is paid and charged only for energy injected or withdrawn, not for state-of-charge itself

- The end-of-horizon state-of-charge bid influences dispatch decisions but does not directly settle

- Prices (LMPs) emerge naturally from this optimization and storage earns arbitrage value without forecasting prices
  - The arbitrage is embedded in centralized optimization

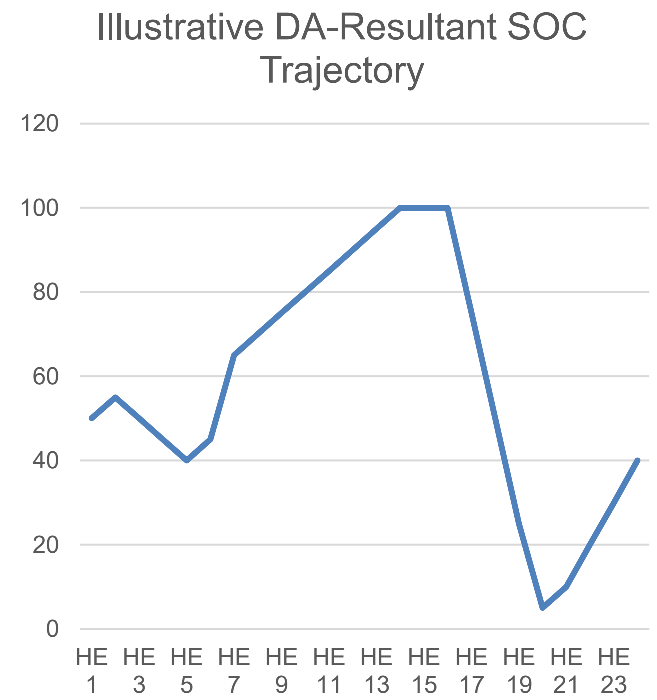
In day-ahead, state-of-charge is explicitly tracked across the full horizon so storage owners can submit a bid/offer that represents the willingness-to-pay (or accept) for deviating end-of-day state-of-charge from initial state-of-charge

- Reflects expectations about prices after the day-ahead horizon (e.g., the next day)

- Reflects long-term operational strategy (wear, fuel substitution, risk appetite)

In day-ahead, state-of-charge is explicitly tracked across the full horizon so storage owners can submit a bid/offer that represents the willingness-to-pay (or accept) for deviating end-of-day state-of-charge from initial state-of-charge

Bid element	Value
Initial DA SOC	50 MWh (50%)
Bid to end day with lower SOC	$25/MWh
Optional: EOH SOC	NA



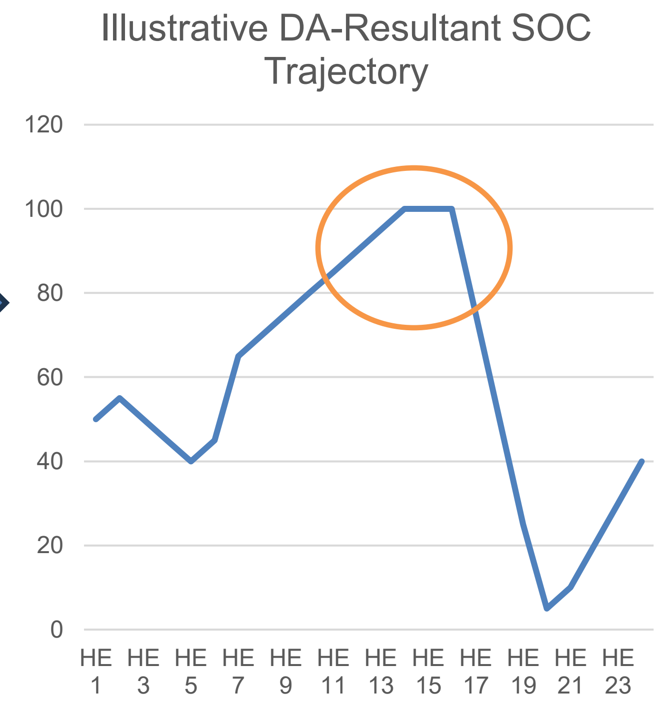
In real-time, due to the short look-ahead horizon, the real-time end-of-horizon state-of-charge is defined relative to the day-ahead state-of-charge trajectory

- If the real-time horizon ends:
  - At a day-ahead boundary → real-time reference state-of-charge = day-ahead state-of-charge at that hour
  - Inside a day-ahead hour → real-time reference state-of-charge is interpolated from the day-ahead state-of-charge trajectory

- Storage submits one real-time deviation bid per interval (hour), which captures the willingness-to-pay (or accept) for deviating real-time end-state-of-charge from the day-ahead-implied state-of-charge

In real-time, due to the short look-ahead horizon, the real-time end-of-horizon state-of-charge is defined relative to the day-ahead state-of-charge trajectory

Bid element (HE 16)	Value
Bid to end **the hour** with lower SOC **relative to DA trajectory**	$50/MWh
Optional: EOH SOC	NA



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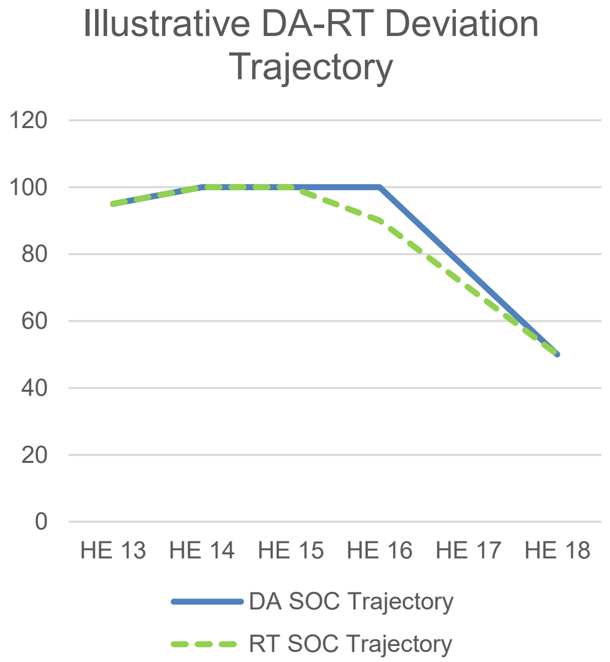
Bid element (HE 16)	Value
Bid to end **the hour** with lower SOC **relative to DA trajectory**	$50/MWh
Optional: EOH SOC	NA



In real-time, due to the short look-ahead horizon, the real-time end-of-horizon state-of-charge is defined relative to the day-ahead state-of-charge trajectory

- Real-time dispatch becomes:
  - Non-myopic (because state-of-charge is tracked)
  - Consistent with day-ahead financial positions
  - Resistant to gaming through frequent rebidding

Today, storage resources can specify an end-of-hour state-of-charge, but cannot specify a bid/offer for deviating their end-horizon state-of-charge from the reference state-of-charge

- Today, the market interprets the implied bid spread as the arbitrage minimum bid, which eases optimization within the horizon but does not place value on the energy beyond the horizon

- To achieve this, bidding could be reframed as capturing the willingness to deviate the end-of-horizon state-of-charge compared to start-of-horizon state-of-charge
  - This becomes the meaning of the bid, and what is subject to the previously discussed DEB

The ISO seeks feedback on the merits of this reframing in the context of DEB and state-of-charge management enhancements

- Mitigates risk of inefficient dispatch from incorrect bids/offers within the optimization horizon because misestimated costs/prices no longer distort market outcomes
- Enhances transparency into cost structures and automatically incorporates physical constraints embedded in optimization rather than approximated in bids
- Financially links state-of-charge trajectory across day-ahead and real-time timeframes

OVERVIEW OF OUTAGE MANAGEMENT SECOND REVISED STRAW PROPOSAL

In the following slides, the ISO provides an overview of the recently published Second Revised Straw Proposal on Outage Management

- Present the Second Revised Straw Proposal for the Outage Management topic group
- Reflect feedback from working group discussions, written stakeholder comments, and ISO implementation assessments
- Discuss OMS enhancements and modeling of storage nonlinearity (foldback)
- Outline next steps and stakeholder timelines

The Second Revised Straw Proposal does not include some elements discussed within the August 2025 Revised Straw Proposal

- The initial Revised Straw Proposal discussed three potential updates to the ISO's Business Practice Manuals (BPMs)
  - Clarify outage reporting for all capability attributes
  - Add storage-related cause descriptions in the nature of work table
  - Clarify the definition of state of charge

- The ISO will submit these three updates as proposed revision requests in the BPM Change Management process, inclusive of the redlines suggested by commenters in response to the initial Revised Straw Proposal
  - Stakeholders seeking to further engage with the BPM changes should refer to the BPM Change Management process

The first section of the paper relates to enhancements to the Outage Management System (OMS)

- OMS manages transmission and generation outages via outage cards
  - It is used to communicate availability, derates, and out-of-service conditions

- Within the Second Revised Straw Proposal, the ISO focuses on five OMS enhancements previously detailed
  - Automatic acceptance of outage change requests
  - Power minimum rerates on test energy cards
  - Improvements to out-of-service checkbox functionality
  - Partial outages for non-generation services
  - Overlapping outage cards

Commenters generally agreed on the need to enhance the OMS to better reflect storage operations

- Generalized support for enhancements to OMS to improve visibility into true outages and temporary derates
- Overall, commenters stated their priorities as (1) enabling overlapping outage cards, (2) adding automation to the acceptance of updates to existing outage cards, and (3) reducing manual reporting burdens
- Most commenters also expressed interest in the identified implementation timeline of no-sooner-than spring 2027, and asked for additional information on the development effort, sequencing, and milestones

ISO is prioritizing phased implementation of OMS enhancements based on stakeholder feedback and competing commitments

- Automation efforts set to be completed by end of 2026 will allow most outage change requests to be accepted immediately upon submission
  - "Acceptance" means the system updates and reflects the change, all outage changes will still undergo full review and approval processes by reliability and operations staff
  - Market participants will be able to make follow-on changes more easily, with updates reflected in near real-time

- By end of 2026, the ISO will also enable power minimum rerates on test energy cards for new/storage resources during implementation
  - Testing will be constrained by Master File limits and ISO-approved testing parameters

ISO is prioritizing phased implementation of OMS enhancements based on stakeholder feedback and competing commitments

- The ISO will continue exploring implementation prioritization for
  - Improving the functionality of the out-of-service checkbox for both charging range and discharging range
  - Allowing for non-null values to be included in non-generation outage cards
- This is due to the relative implementation burden of these projects and the ISO's intention to pursue a modeled nonlinearity solution for non-generator resources no sooner than Spring 2027

ISO is prioritizing phased implementation of OMS enhancements based on stakeholder feedback and competing commitments

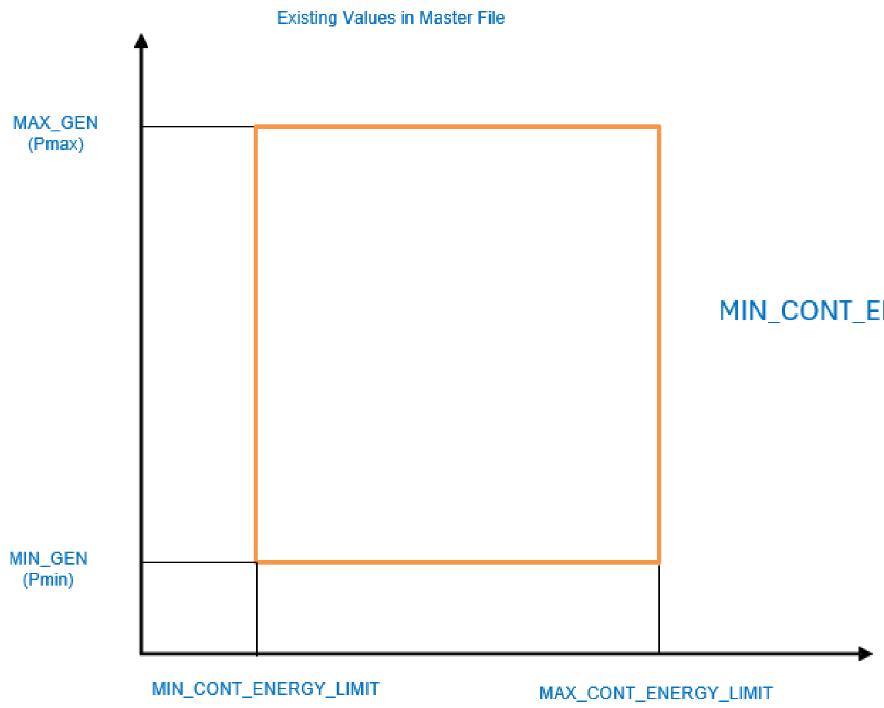
- The ISO performed further analysis on the feasibility of allowing for overlapping outage cards
  - Assessment indicated that such an enhancement to OMS would be cost-prohibitive
  - The ISO will no longer explore this proposal at this time

The second section of the paper relates to storage nonlinearity (foldback)

- Lithium-ion batteries exhibit nonlinear charging/discharging behavior, foldback, as they approach their state-of-charge bounds
  - Near the upper state-of-charge limit, charging capability declines
  - Near the lower state-of-charge limit, discharging capability declines

- Current non-generator resource model does not capture nonlinearity as it assumes a rectangular feasible operating region bounded by Pmax, Pmin, the minimum continuous energy limit, and the maximum continuous energy limit

Current non-generator resource model assumes a rectangular feasible operating region bounded by Pmax, Pmin, the minimum continuous energy limit, and the maximum continuous energy limit



$$Pmin \leq P \leq Pmax$$

$$\text{MIN\_CONT\_ENERGY\_LIMIT} \leq SOC \leq \text{MAX\_CONT\_ENERGY\_LIMIT}$$

The Second Revised Straw Proposal builds on the conversations regarding nonlinearity following the late 2025 stakeholder meetings

- In late 2025, the ISO had proposed a clarification to limit the Master File state-of-charge ranges to the regions that are not affected by nonlinearity, therefore eliminating the need for outage card use ahead of the release of a modeled solution
  - The ISO framed this as an interim solution while developing a longer-term modeled approach

- In late 2025, REV proposed an approach to implement a modeled solution
  - REV suggested these parameters could support real-time updates reflecting actual operating conditions

Many stakeholders strongly opposed excluding the foldback region from the Master File range and instead supported expediting a modeled solution

- In January 2026, the ISO indicated it will no longer pursue the aforementioned clarification and would instead expedite development of a modeled solution as for non-generator resources
  - The ISO reiterated that, under current rules, if foldback behavior prevents a resource from fulfilling its resource adequacy obligations, that underperformance remains generally subject to RAAIM prior to the implementation of a modeled solution
  - The ISO also noted that, given current and anticipated development priorities and system constraints, a modeled solution relying on new Master File data fields could be implemented at the earliest by Spring 2027

In the Second Revised Straw Proposal, the ISO details a modeled solution grounded in Master File data provided by each scheduling coordinator

- The proposed approach enables the market to accurately reflect individual storage resource operating characteristics

- A Master File–based solution is preferred over a dynamic or bid-based approach
  - Reduces implementation complexity compared to solutions using biddable parameters
  - Limits opportunities for misuse or market manipulation associated with attempts to withhold energy or bypass outage reporting
  - Encourages proper maintenance and operational practices (e.g., addressing voltage imbalance) that mitigate foldback over time

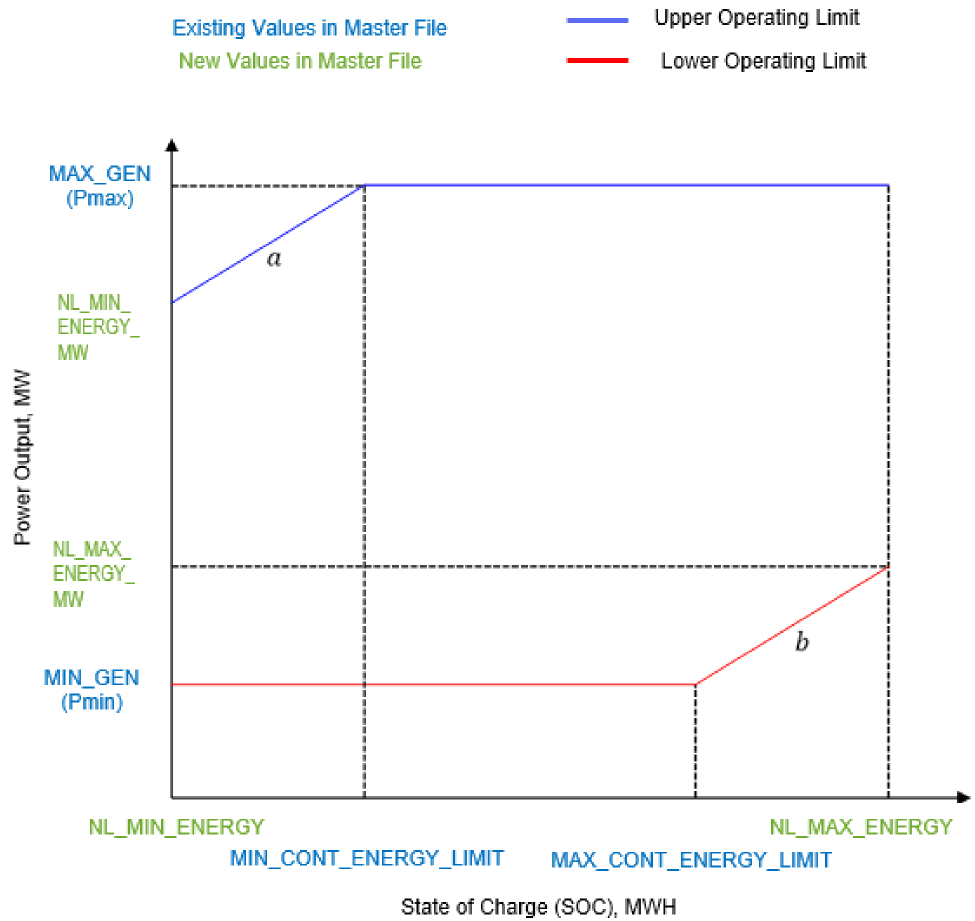
The ISO's proposed modeled solution is largely based on stakeholder feedback and would leverage new Master File fields

- The proposed modeled solution would introduce additional Master File fields and associated constraints to reshape the feasible region from a rectangle into an irregular hexagon

- This enhanced representation would reflect the reduction in minimum power output as the state-of-charge approaches its upper limit, as well as the reduction in maximum power output as the state-of-charge approaches its lower limit

- Largely consistent with the proposal presented by REV at the November 11, 2025 stakeholder meeting

The ISO's proposed modeled solution is largely based on stakeholder feedback and would leverage new Master File fields



To implement these additional constraints, the ISO would request that storage scheduling coordinators submit four new data fields within the Master File

- Minimum and maximum nonlinear energy limits (NL_MIN_ENERGY and NL_MAX_ENERGY) and the diminished power outputs when in the nonlinear regions (NL_MAX_ENERGY_MW and NL_MIN_ENERGY_MW)

- Under the proposed modeled approach, the current minimum and maximum continuous energy limits would bookend the range unaffected by nonlinearity

- Any updates to these new Master File fields would follow the same currently applicable process for Master File modifications

The ISO proposes to incorporate the constraints associated with the modeled solution in both the day-ahead and real-time markets

- The consistent application of the associated constraints across both day-ahead and real-time markets is both viable and desirable
  - The application of the associated constraints in both day-ahead and real-time markets is not expected to pose significantly higher implementation burden compared to incorporating these constraints only in the real-time market
  - Minimizing differences in the variables and constraints leveraged across all markets produces more consistent results across markets and limits financial arbitrage

Ahead of the release of a modeled solution, market participants can limit their risk of entering the nonlinear range and receiving infeasible dispatch instructions by only reflecting the state-of-charge range unaffected by foldback in the Master File

- If market participants do not do so, any unavailability impacts due to nonlinearity on their charge and discharge capabilities should be conveyed via plant trouble outage card submissions to prevent infeasible dispatches prior to the modeled solution implementation
  - Consistent with current policy and the guidance discussed by the ISO during the January 2026 stakeholder meeting
  - If foldback behavior prevents a resource from fulfilling its resource adequacy obligations, that underperformance remains generally subject to RAAIM prior to the implementation of a modeled solution

The proposed modeled solution will significantly reduce the need for outage cards to represent nonlinearity

- This reduction depends on accurate representation of limitations in the model and Master File values
- The optimization engine will limit dispatch to feasible levels based on state-of-charge and nonlinearity
  - The model ensures dispatch instructions remain physically achievable despite nonlinear constraints
  - Resources will continue to be able to meet must-offer obligations even when foldback occurs

The ISO does not expect material interactions between the modeled solution and current RAAIM rules

- Because no outage is needed and bids can be submitted, RAAIM exposure is largely avoided
- The RAAIM framework is currently under review in the RAMPD initiative
  - Future interactions between the modeled solution and a RAAIM successor framework will be addressed in RAMPD

The ISO is seeking stakeholder feedback to refine and finalize the design of the modeled solution

- Target implementation timing is no earlier than Spring 2027
- After implementation, ISO will update BPM language to reflect the changes
  - BPM updates will go through the formal BPM Change Management process
  - Stakeholders can continue engagement via BPM revision requests and discussions.

NEXT STEPS

Next Steps and Key Dates *

- **June 1st:** Comments due for May 18th stakeholder discussion
- **June 30th:** Straw Proposal on Uplift & DEB and SOC Management
- **July 15th:** Hybrid meeting on Straw Proposal

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

Next Steps

- Visit initiative webpage for more information: [Storage Design and Modeling]
- Written comments due on June 1st.

- Any questions please contact Brenda Marquez at bmarquez@caiso.com or ISO Stakeholder Affairs: ISOstakeholderaffairs@caiso.com

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