Day-Ahead Market Enhancements – Impacts to Storage

Stakeholder Workshop

April 17, 2023

Reminders

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

Instructions for raising your hand to ask a question

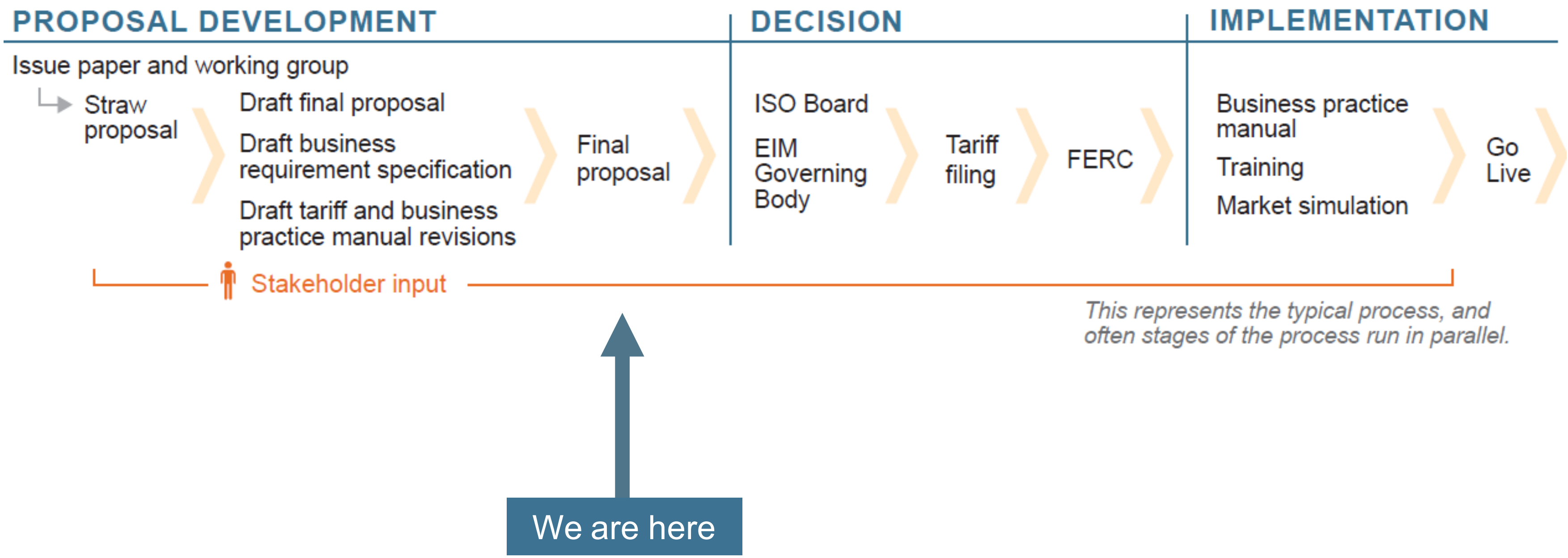
- If you are connected to audio through your computer or used the “call me” option, select the raise hand icon located on the bottom of your screen.
  Note: #2 only works if you dialed into the meeting.
  - Please remember to state your name and affiliation before making your comment.

- You may also send your question via chat to either Isabella Nicosia or to all panelists.

Agenda

Time	Topic	Presenters
1:00 – 1:10	Welcome and introductions	Isabella Nicosia
1:10 – 1:30	Tie-in to final proposal	James Friedrich
1:30 – 1:50	RUC Participation	Gabe Murtaugh
1:50 – 2:20	Model for envelope equations	Gabe Murtaugh
2:20 – 3:00	Setting the envelope multipliers	Gabe Murtaugh
3:00 – 3:45	CESA presentation	Sergio Dueñas
3:45 – 4:00	Next steps	Isabella Nicosia

Stakeholder Process



Day-Ahead Market Enhancements

TIE-IN TO THE FINAL PROPOSAL

Schedule

- Revised Final Proposal – April 6
- Stakeholder Meeting – April 7
- Storage workshop – April 17
- SH Comments – April 20
- Final Proposal – April 28
- **May Board Meeting – May 17**

DAME Final Proposal seeks to balance trade-offs

- Proposal elements intend to balance trade-offs between reliability and cost of new market products
- Design is intended to maximize flexibility to find the “sweet spot” after operational experience
- Changing grid conditions and new day-ahead market participants will require constant re-evaluation of trade offs
- Storage resources expected to be competitive for these new products

Day-Ahead Market Enhancements

STORAGE RESOURCES - RUC PARTICIPATION

Some stakeholders raised concerns about how storage participates in the RUC process today

- The day-ahead market uses the residual unit commitment (RUC) market run to ensure that sufficient capacity is committed to meet CAISO load forecast
  - Resources may not be committed in the integrated forward market run, because of virtual supply and demand
- Residual capacity process for commitment decisions
  - Bids specified in $/MW, and include incremental + decremental energy
  - Integrated forward market schedules are respected
- Today integrated forward market results are used, without flexibility, in the residual unit commitment run for storage
  - Bids from storage resources are not considered in RUC

The current process could introduce inefficiencies and increase overall costs to operate the system

- Typical day-ahead schedules for storage resources may be fairly good representations of actual operation

- Barring storage resources from the residual unit commitment process could result in less than optimal commitments
  - Higher commitments could increase overall costs, and lower efficiency

This proposal allows for storage resource participation in the residual unit commitment process

- Today most resource adequacy resources are required to bid RA capacity into RUC at $0/MW
  - Non-resource adequacy capacity may submit bids into the RUC process

- RUC awards impose bidding obligations in real-time

- Propose to require storage resource participation in RUC
  - Storage resources both shown and not shown for resource adequacy may specify a bid for residual unit commitment, this bid will not be required to be $0/MW

Storage resources are dissimilar from others and cannot provide RUC capacity without state of charge

- RUC awards will not impact state of charge

$$SOC_{i,t} = SOC_{i,t-1} - EN_{i,t}^{(+)} + \eta_i EN_{i,t}^{(-)} + aRU_t RU_{i,t} - \eta_i RD_{i,t}$$

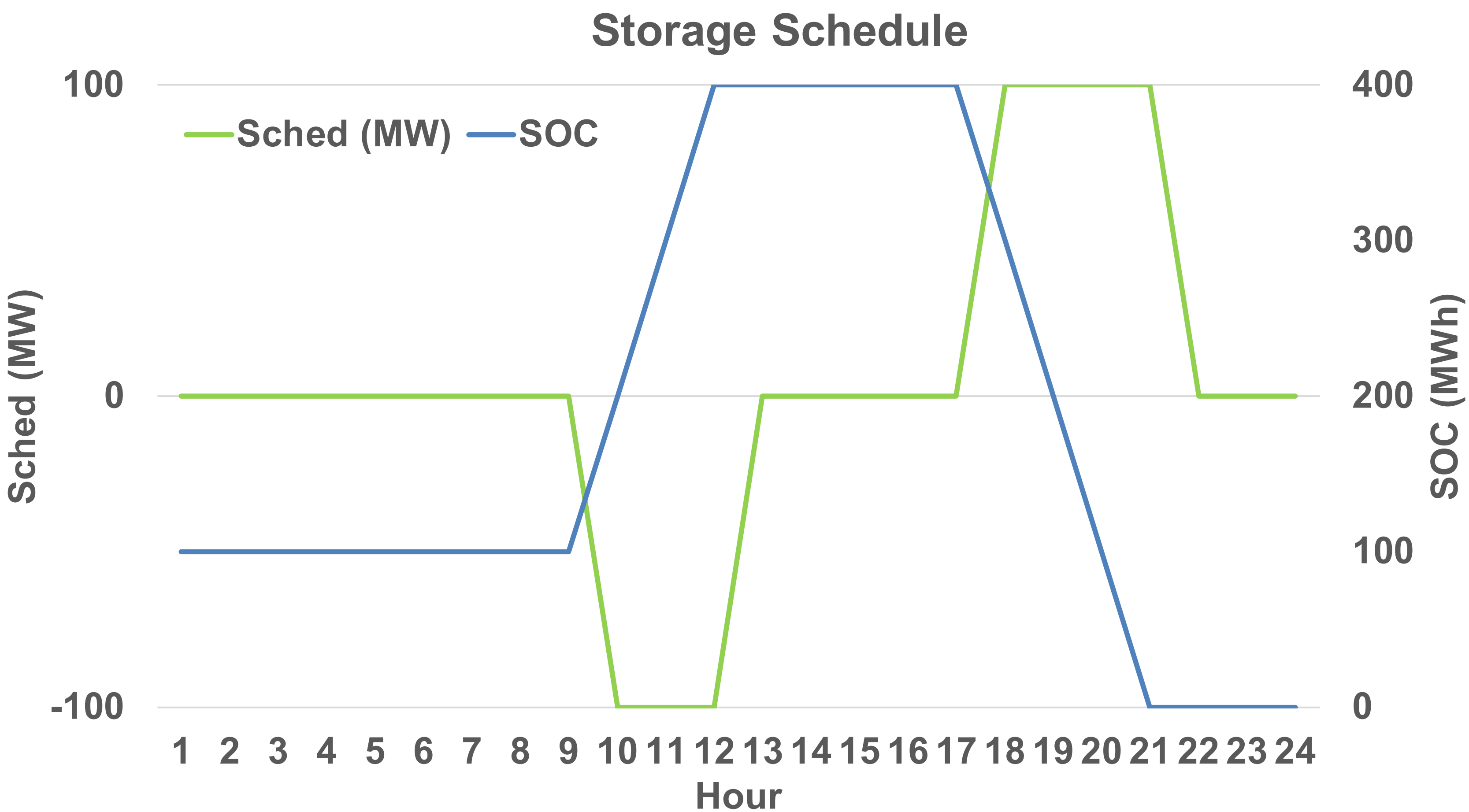
- The ancillary service state of charge constraint ensures that there is sufficient state of charge in an hour with a upward RUC capacity award

$$SOC_{i,t} - RU_{i,t} - SR_{i,t} - NR_{i,t} - IRU_{i,t} - RCU_{i,t} \geq \underline{SOC}_{i,t}$$

- RUC awards will have intertemporal impacts on the state of charge envelope constraints

$$SOC_{i,t}^{(l)} = SOC_{i,t-1}^{(l)} - EN_{i,t}^{(+)} - \eta_i\, EN_{i,t}^{(-)} - AIRU_t\, IRU_{i,t} - ARCU_t\, RCU_{i,t} \geq \underline{SOC}_{i,t}$$

Ex 1: Some situations will **not** allow for additional capacity awards for storage resources in RUC

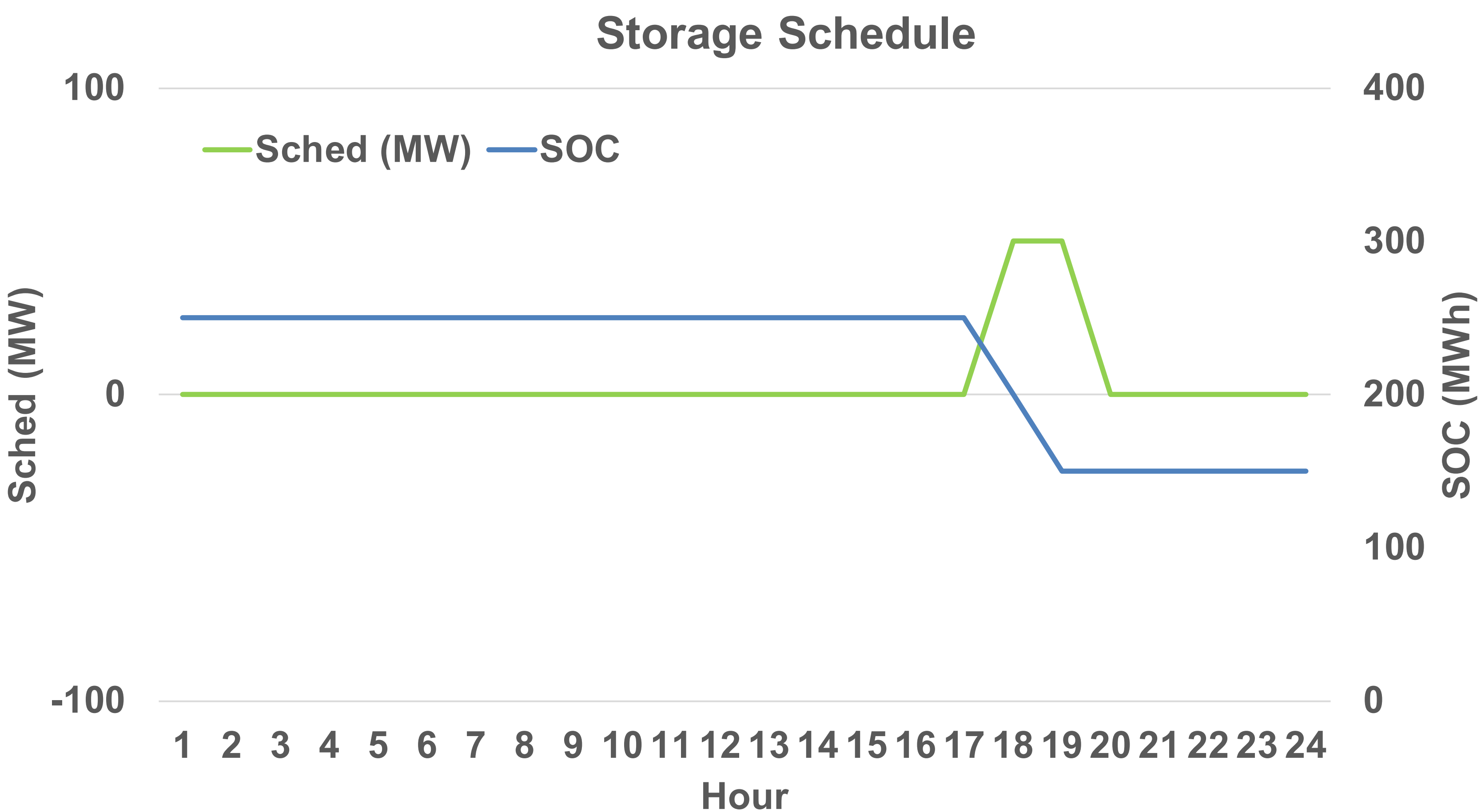


Ex 1: Some situations will **not** allow for capacity awards for storage resources in RUC

HE	16	17	18	19	20	21
Sched (IFM)	0	0	100	100	100	100
SOC	400	400	300	200	100	0
RUC	0	100	0	0	0	0
SOC_L	400	300	200	100	0	-100

- The resource would have sufficient state of charge to provide RUC capacity in HE 17
  - Actual state of charge is 400 MWh > 100 MWh ASSOC requirement
- However, the envelope equations will prevent this award
  - The lower envelope values are intertemporal connected and would be less than 0 MWh with this award

Ex 2: Some situations will allow for additional capacity awards for storage resources in RUC



Ex 2: Some situations will allow for additional capacity awards for storage resources in RUC

HE	16	17	18	19	20	21
Sched (IFM)	0	0	50	50	0	0
SOC	250	250	200	150	150	150
RUC	0	100	0	0	0	0
SOC_L	250	150	100	50	50	50

- The resource would have sufficient state of charge to provide RUC capacity in HE 17
  - Actual state of charge is 250 MWh > 100 MWh ASSOC requirement
- The envelope equations will allow this award
  - The lower envelope values are not below 0 MWh in this example

This proposal allows for storage resource participation in the residual unit commitment process

- Storage resources may receive few awards in RUC if scheduled at extreme values of state of charge in the integrated forward market
  - The residual unit commitment market run will not impact state of charge
  - The ASSOC constraint will prevent a resource from receiving a RUC award during any period when there is not one hour of state of charge
  - The envelope equations will prevent a resource from receiving a RUC award if the actual state of charge **or** the envelope equation is at extreme values

- Storage resources with state of charge, or resources that are not fully depleted, may receive RUC awards

Day-Ahead Market Enhancements

STORAGE RESOURCES – MODEL FOR ENVELOPE EQUATIONS

Imbalance reserves are different than traditional products and may require new tools for management

- Resources may receive imbalance reserve in both directions during any specific hour
  - The real-time outcome will only result in energy realized one direction or the other

- When the system is relying heavily on imbalance reserves, it will consume most of the reserves in the direction of the actual imbalance
  - If storage resources are not available and are relied on for these reserves, it could result in reliability issues
  - Need adequate tools to protect against an outcome like this

The envelope equations are meant to model a hypothetical upper and lower bound for storage

$$SOC^{(u)}_{i,t} = SOC^{(u)}_{i,t-1} - EN^{(+)}_{i,t} - \eta_i \, EN^{(-)}_{i,t} + \eta_i \, AIRD_t \, IRD_{i,t} \leq \overline{SOC}_{i,t}$$
$$SOC^{(l)}_{i,t} = SOC^{(l)}_{i,t-1} - EN^{(+)}_{i,t} - \eta_i \, EN^{(-)}_{i,t} - AIRU_t \, IRU_{i,t} \geq \underline{SOC}_{i,t}$$

- The upper envelope is impacted by downward imbalance reserves, which can increase state of charge
- The lower envelope is impacted by upward imbalance reserves, which can decrease state of charge
- Both values must stay with the operating limits of the resource
- Multipliers are attached to each of the imbalance terms

Example Assumption: A storage resource and calculated state of charge values

Assume that a storage resource can:

- Operate between -100 MW (charging) to +100 MW (discharge)
- Provide four hours of service
  - Energy limits from 0 MWh to 400 MWh
- Has 100% round trip efficiencies
- Begins the day half charged, at 200 MWh

Assume we are using values of 1.0 for the multipliers in the state of charge envelope equation

Example: Example resource with a 0.2 multiplier on both multipliers

Awards over multiple hours, with a 0.2 multiplier

Hour	En	IRU	IRD	SOC_U	SOC	SOC_L
0				100	100	100
1	20	50	0	80	80	70
2	0	80	100	100	80	54
3	-100	0	100	220	180	154
4	0	100	100	240	180	134
5	0	100	100	260	180	114

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STORAGE RESOURCES – ENVELOPE MULTIPLIERS

Setting the correct values for the multipliers will be crucial to ensure participation and availability

- This current proposal suggests multipliers at 0.2 for all hours for upward and downward imbalance reserves
  - The policy intends that multipliers will be updated with operational experience for imbalance reserves
  - The final version of the policy may specify values high than the current proposal, based on analysis

- The business practice manuals will document:
  - What the multipliers are set to (for each hour)
  - The methodology used to set the multipliers

What are the key issues surrounding storage providing imbalance reserves?

PROBLEM STATEMENT: Ensure that storage resources are available to provide imbalance reserves in real-time when **<u>critically</u>** needed

- How does an award for imbalance reserves impact state of charge?

Two foundational problems:

1. How much IRU is actually converted to energy?
   - Some days/periods the system may need more IRU than others
   - This may be a function of IRU and "headroom"
2. How much IRU is converted to energy <u>for storage</u>?
   - Storage may have higher opportunity costs than other resources, if deployed

For the purposes of this slide deck I make the following assumptions

- Only consider upward imbalance reserves, but not corollary for downward reserves
- Assume a +/-100 MW 4-hour (0-400 MWh) storage resource
  - Assume 100% round-trip efficiencies

State of charge and the multipliers impact imbalance reserves awards for a storage resource

- The lower envelope equation allows a fully charged 4-hour duration storage resource to provide different amounts of imbalance reserve based on the multiplier
  - A multiplier of 1 will allow 4 hours of IRU
  - A multiplier of .2 will allow 20 hours of IRU

Multiplier	IRU Hours
1	4
.5	8
.25	16
.2	20
.1	24

- The optimization will charge a resource if IRU looks financially attractive during hours of the day
  - This could drive awards for storage resources

This table expands the previous table, for storage resources with different starting SOC and no charging

Multiplier / SOC	400 MWh	200 MWh	100 MWh
1.0	4	2	1
.5	8	4	2
.25	16	8	4
.2	20	10	5
.1	24	20	10

- Even storage resources with ‘low’ state of charge values can receive significant imbalance reserve awards if multipliers are closer to 1.0
  - This could drive awards for storage resources

The following assumptions apply for this analysis

- ***Question***: What is the probability of a storage resource procured for state of charge not being able to deliver energy (i.e. out of state of charge) if awarded 4-hours of upward imbalance reserve?
  - This could inform how effective a specific multiplier is
  - A number of assumptions are necessary to answer the question
- Assume imbalance reserve procurement is converted into energy on a pro-rata (equal ratio of energy awarded to all resources with IRU) basis
  - On occasions load deviations exceed IRU procured, assume resource provides 100 MW
  - Storage may be priced higher than other IRU resources
  - Not considering other residual units that could be dispatched
  - Not considering other energy awards deviating from DA schedules

The probability of SOC unavailability for a 4-hour award for imbalance reserves can be significant

Multiplier / SOC	400 MWh	340 MWh	300 MWh	250 MWh	200 MWh
1.0	0				
.85		.1			
.75			.17		
.625				.27	
.5					.44

- A multiplier of 0.5 implies a storage resource could receive a 4-hour award for IRU with 200 MWh SOC
  - The resource will be depleted if it received this award on 44% of days
- A storage resource with a multiplier of .85, could receive the same award with 340 MWh of state of charge
  - This resource will be depleted on 10% of days

Additional challenges may make imbalance products for storage more challenging

- Schedules for state of charge in the day-ahead market may not reflect state of charge in the real-time market

- Starting state of charge may not reflect actual state of charge at the beginning of the day

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NEXT STEPS

Next Steps

Milestone	Date
Stakeholder Workshop	April 17, 2023
Comments Due – Draft Revised Final Proposal	April 20, 2023
Revised Final Proposal	April 28, 2023
Joint ISO Board of Governors and WEIM Governing Body meeting	May 17, 2023
Implementation	Fall 2024

Initiative webpage:
https://stakeholdercenter.caiso.com/StakeholderInitiatives/Day-ahead-market-enhancements

Please contact inicosia@caiso.com or isostakeholderaffairs@caiso.com if you have any questions.