Energy Storage Enhancements
Revised Straw Proposal

March 21, 2022

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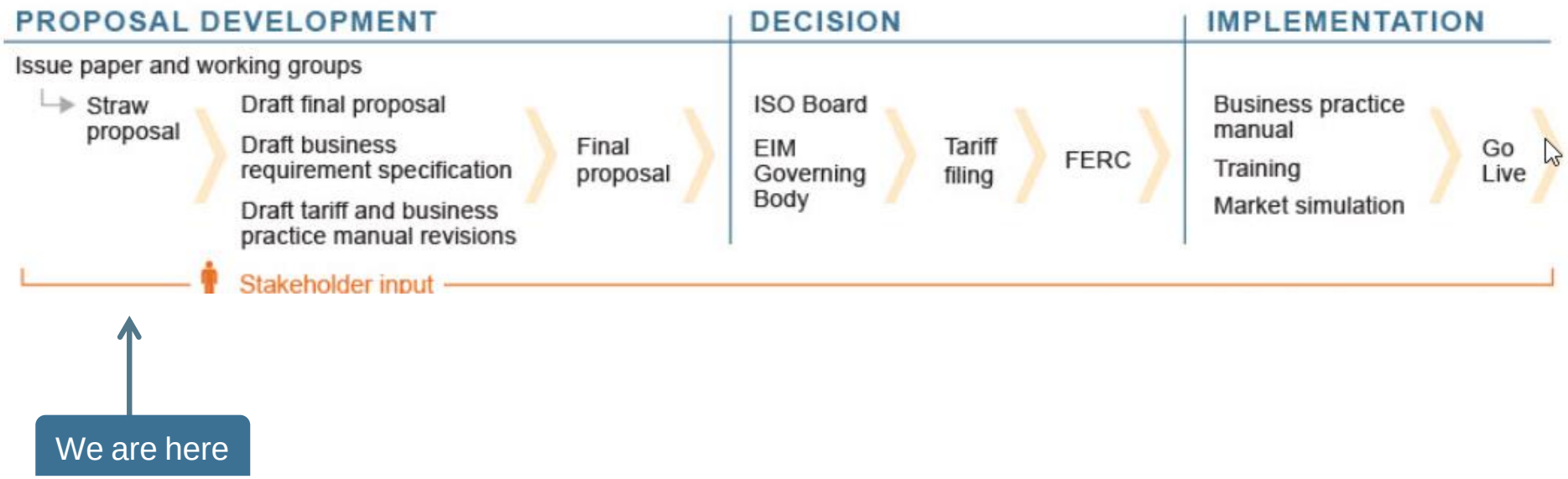
Gabe Murtaugh, Storage Sector Manager

Agenda

Time	Item	Speaker
1:00-1:10	Introductions and Stakeholder Process	Brenda Corona
1:10-1:15	Changes from the Straw Proposal	Gabe Murtaugh
1:15-2:00	Energy Storage Resource Model	George Angelidis Gabe Murtaugh
2:00-2:40	ESR – Market Power Mitigation	Gabe Murtaugh
2:40-3:20	Reliability Enhancements	Gabe Murtaugh
3:20-3:55	Co-Located Enhancements	Gabe Murtaugh
3:55-4:00	Next Steps	Brenda Corona

ISO Policy Initiative Stakeholder Process



Energy Storage Enhancements Timeline

Tues 3/21:	Stakeholder Meeting
Wed 4/4:	Comments Due
May:	Draft Final Proposal/Meeting
July:	Final Proposal/Meeting
(Likely) Sept 2022:	Board of Governors Meeting

The ISO responded to feedback to clarify some of the proposals outlined in the straw proposal

- Expanded the examples to clarify bidding and dispatch for the energy storage resource model
- Added details for market power mitigation for energy storage resources
- Added details and an example for how compensation will work for exceptional dispatches to hold a specific state of charge
- Enhanced and clarified the rules around treatment of co-located storage resources that have investment tax credit or property tax implications
  - ISO continues to advocate for storage modeling of **physical** capabilities
  - Will allow for special treatment of storage for a 5 year period
  - This will not be applicable to new storage coming onto the system

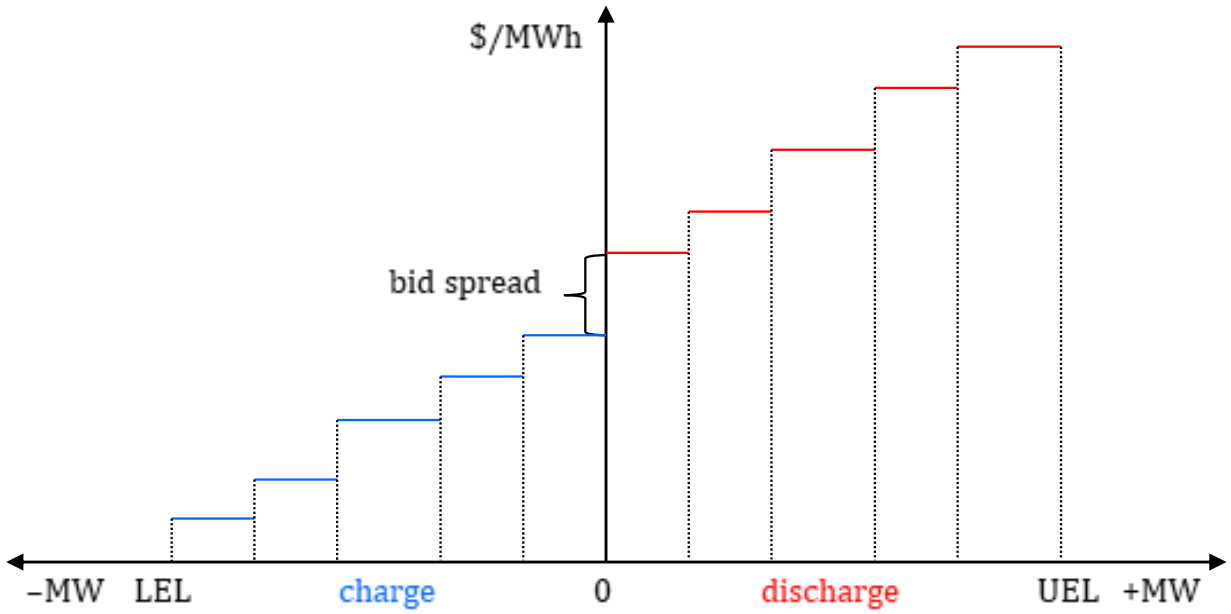
ENERGY STORAGE RESOURCE MODEL

The ISO has a model in place currently for storage resources

- The ISO currently uses the non-generator resource model for energy storage resources
  - Allows for energy storage resource participation in the energy and ancillary service markets
  - Supports charging (round-trip) efficiency
  - Supports state of charge (SOC) constraints
  - Supports regulation energy management (REM)

- Bid curves for these resources are submitted similar to traditional resources
  - Bids are submitted from Pmin (charging) to Pmax (discharging)
  - ISO dispatches a resource to a specific output (MW) target
  - Dispatch is awarded based on locational prices and bids

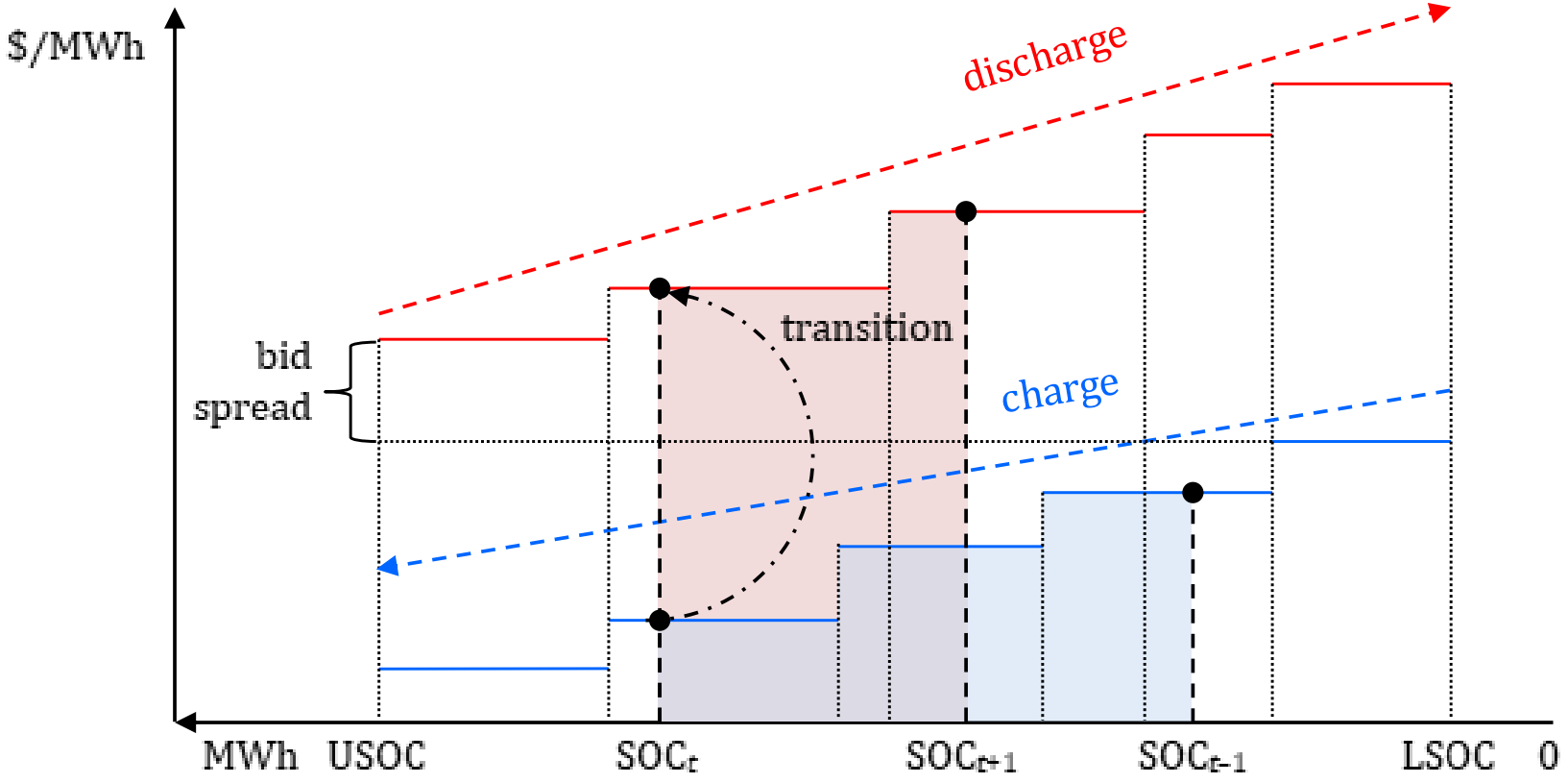
Existing LESR model energy bid



The proposed energy storage resource model will dispatch resources based on state of charge

- Incremental energy bids are submitted in terms of SOC
  - Separate hourly bid sets for charging and discharging
  - Update: A maximum of 10 segments (total) will be allowed
- Upper/lower capacity limits defined by state of charge
  - Registered step function in master file
  - Ramp rate can be limited on the upper and lower operating range
- Ramp rate will depend on state of charge
- Supports charge/discharge transition constraints and costs
  - Daily transition bid costs for changing operating mode
  - Registered transition times and daily transition limit
  - Transition cost included in bid cost recovery

Proposed energy storage resource model: energy bids



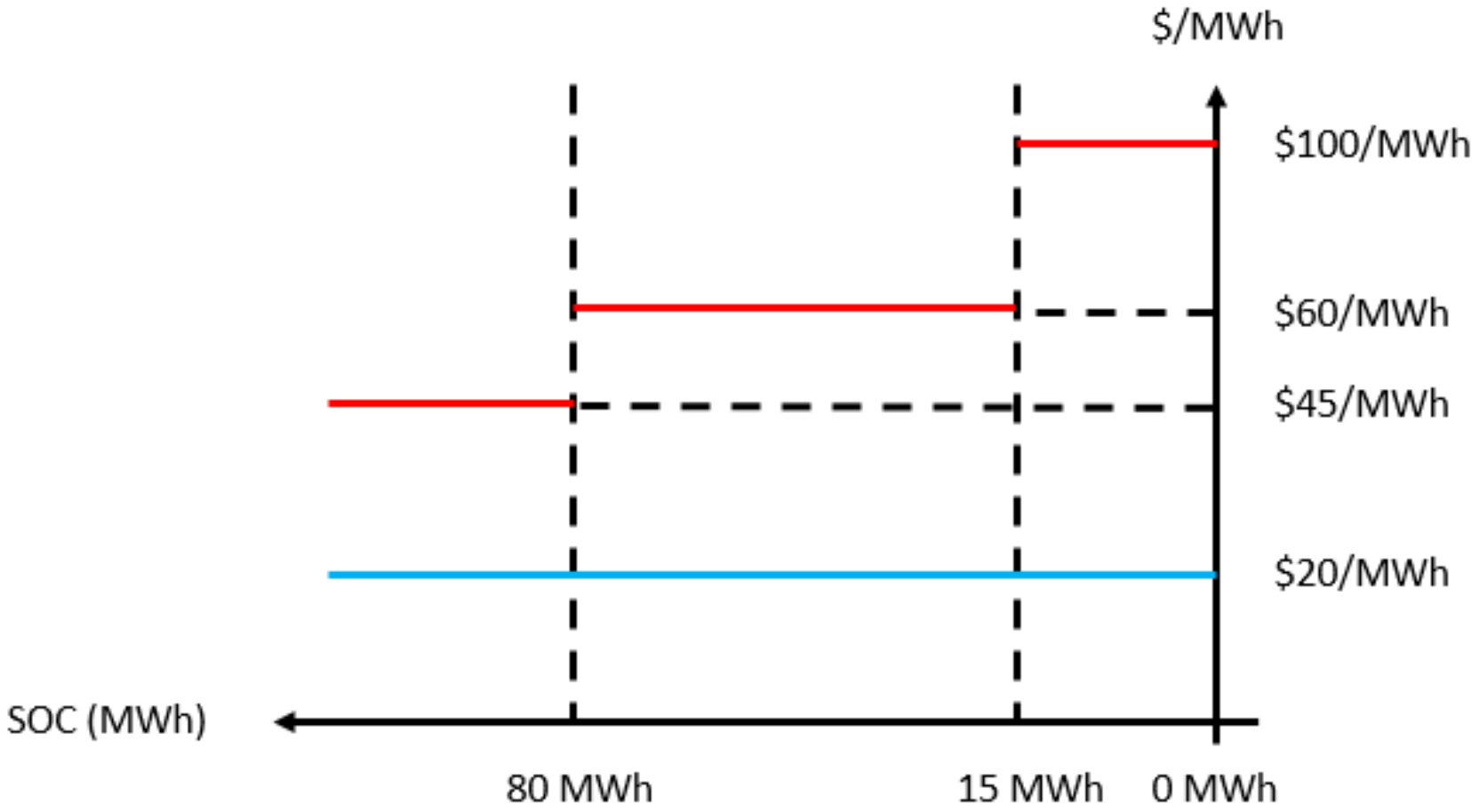
A simplified example for energy storage resource bidding

- Assume a hypothetical energy storage resource
  - Pmin: -25 MW; Pmax: +25 MW
  - SOC Min: 0 MWh; SOC Max: 100 MWh
  - One bid for charging energy, step function for energy discharge

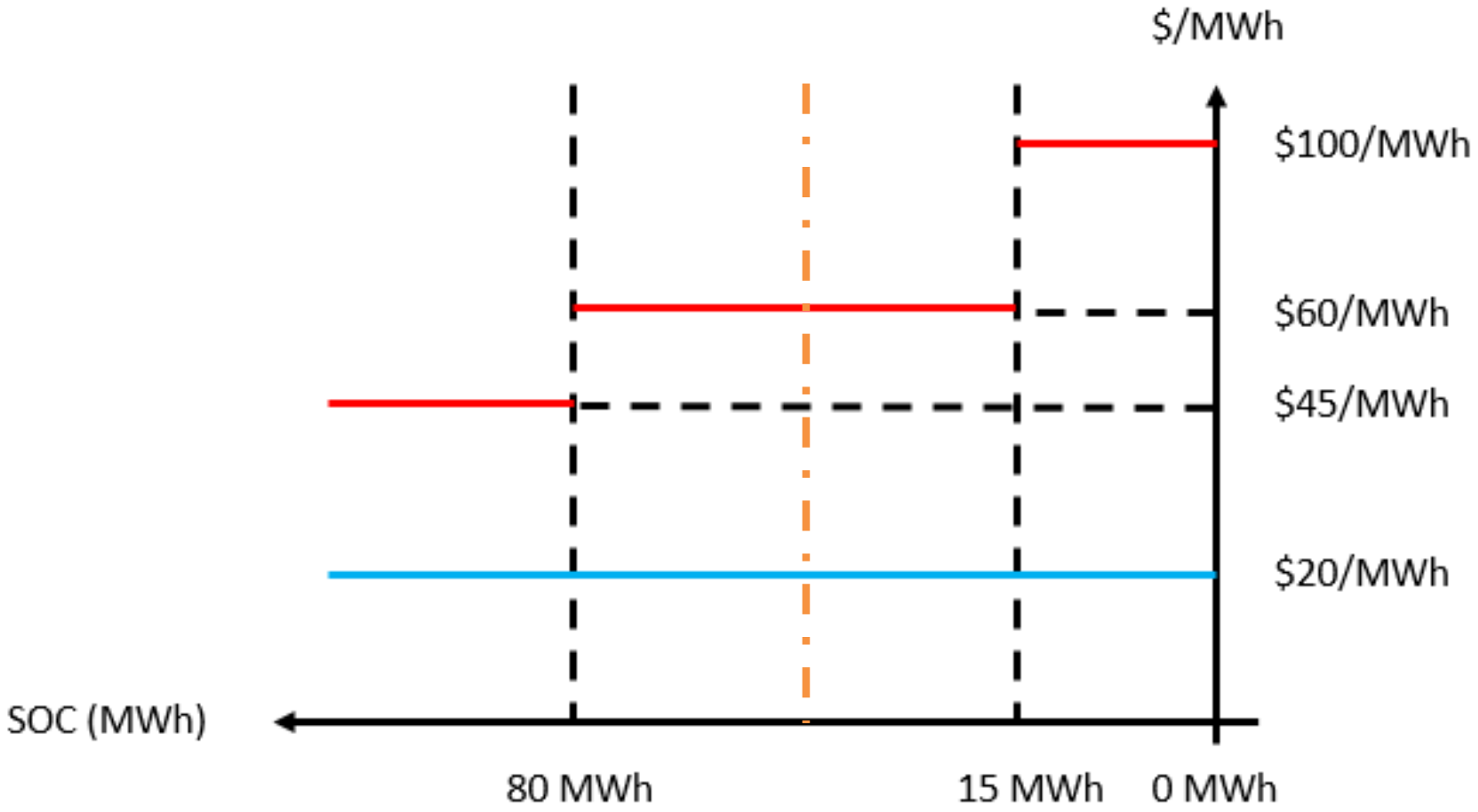
Examples:

1. Medium state of charge
2. Low state of charge
3. High state of charge
4. Transitional state of charge

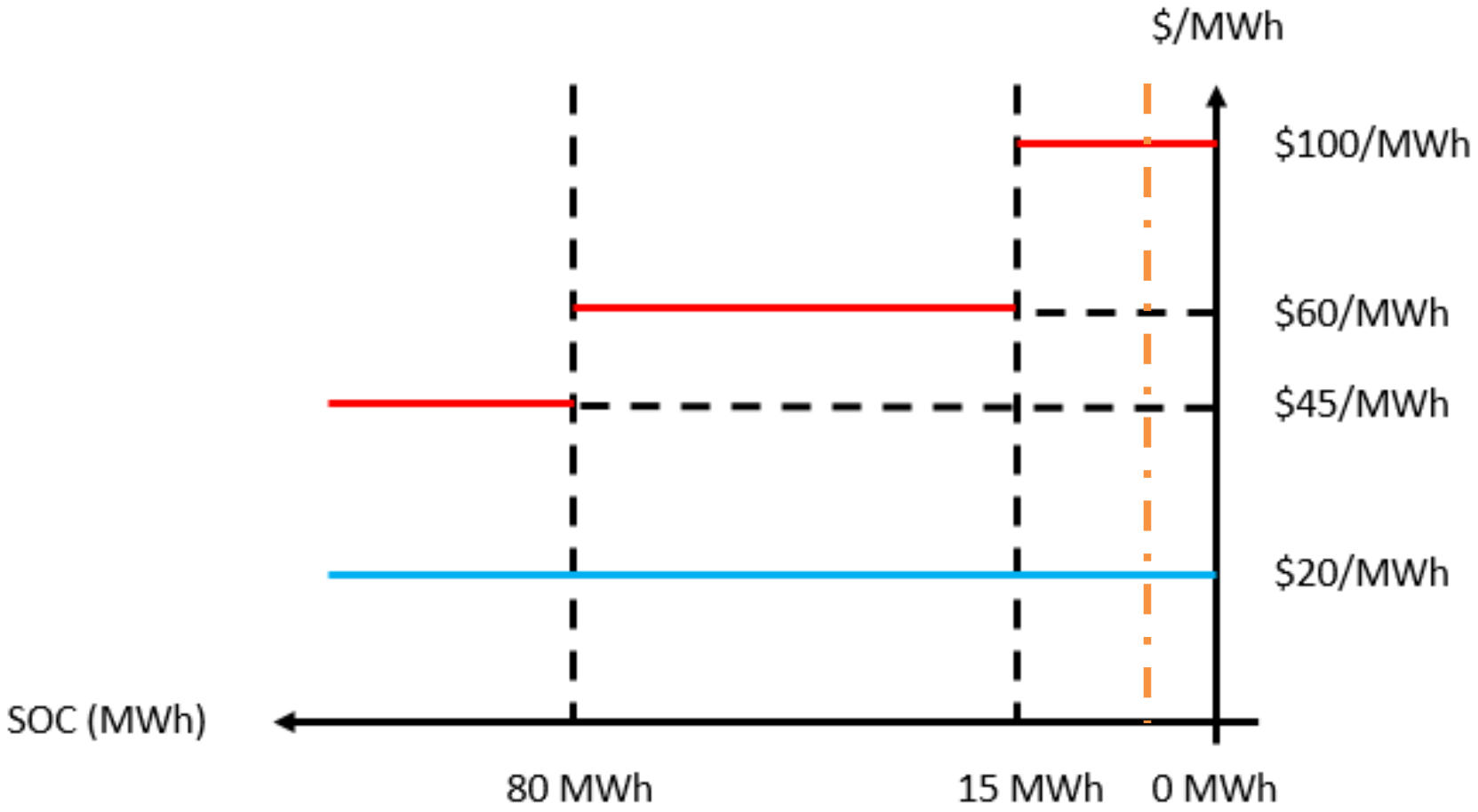
The example resource bids a step function to discharge energy



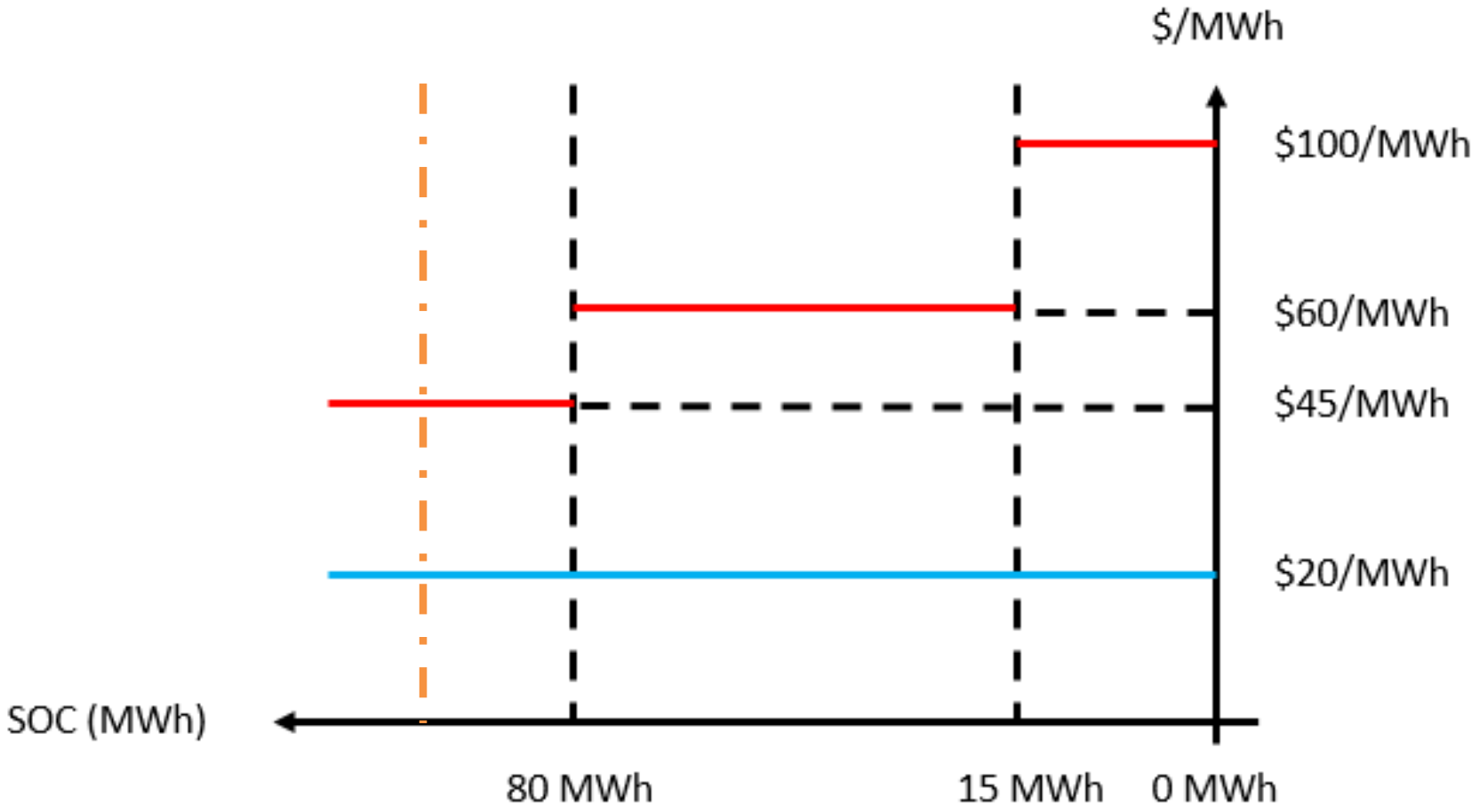
The storage resource will discharge when prices are above $60/MWh, at medium states of charge



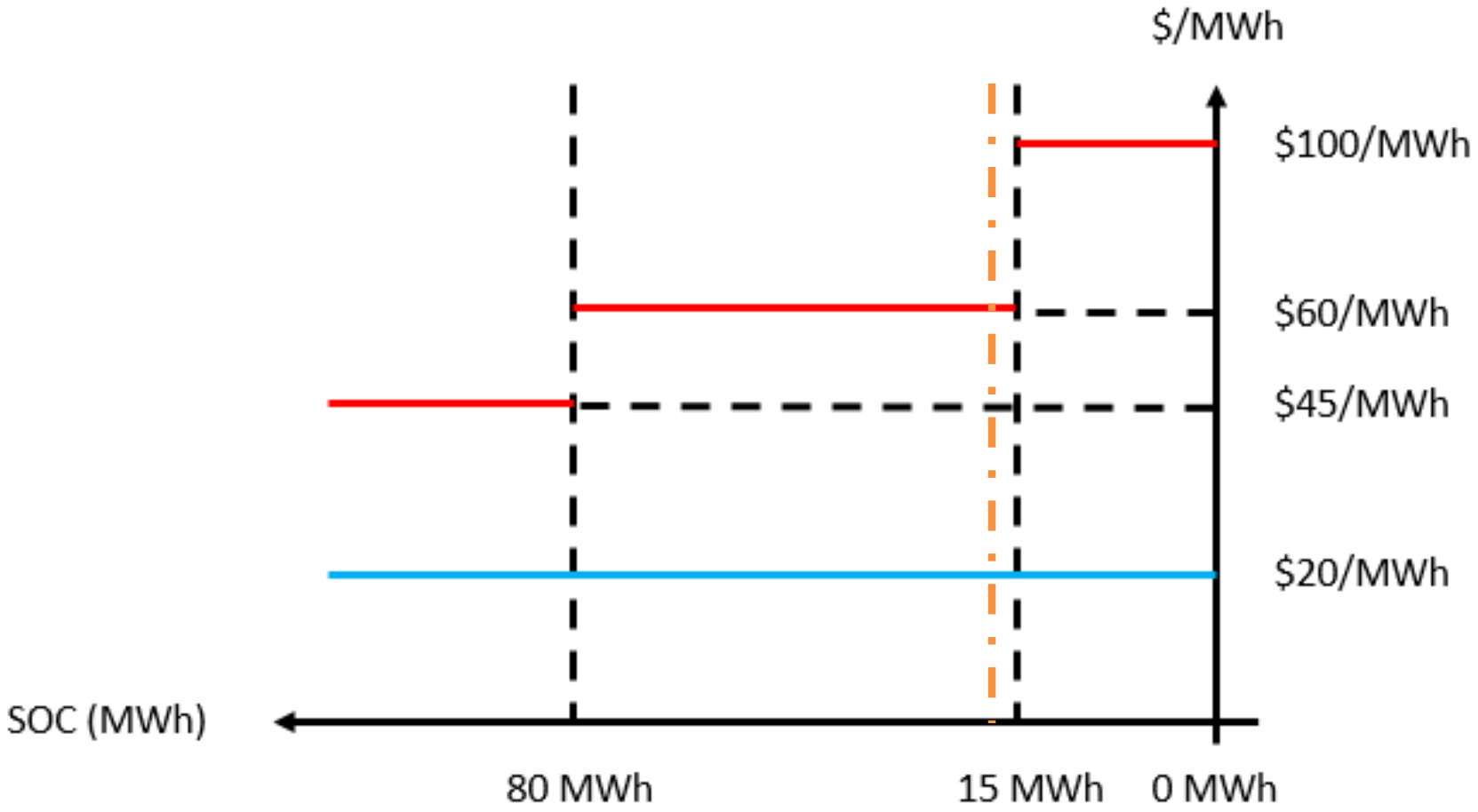
The storage resource will discharge when prices are above $100/MWh, at low states of charge



The storage resource will discharge when prices are above $45/MWh, at high states of charge



Sometimes the resource will be transitioning from one bid curve to another while charging or discharging



MARKET POWER MITIGATION

In ESDER 4 the ISO developed a mechanism for generating default energy bids for storage resources

- Storage resources using the NGR model are subject to market power mitigation
  - Energy storage resources will also be subject to mitigation
- The default energy bid for NGRs includes:
  1. Cost for resources to buy energy
     - Estimate expected costs to charge resource
     - Based on duration of the resource
  2. Cycling costs
     - Because cycling costs can vary, use an upper bound of costs
     - Costs are submitted and verified by the ISO
  3. Opportunity cost (real-time)
     - Ensure that resources are not discharged too early

The ISO is proposing to keep the same general construct for the energy storage resource model

- The same three components will be used to determine the default energy bid for energy storage resources
  - The default energy bid be applied for storage resources participating in the day-ahead market with opportunity costs in the real-time market

- The real-time default energy bid for the energy storage resource model will also include a new ‘sloped’ feature
  - This feature is not necessary in the day-ahead market

The ISO proposes calculating a sloped default energy bid for the discharge bids for energy storage resources

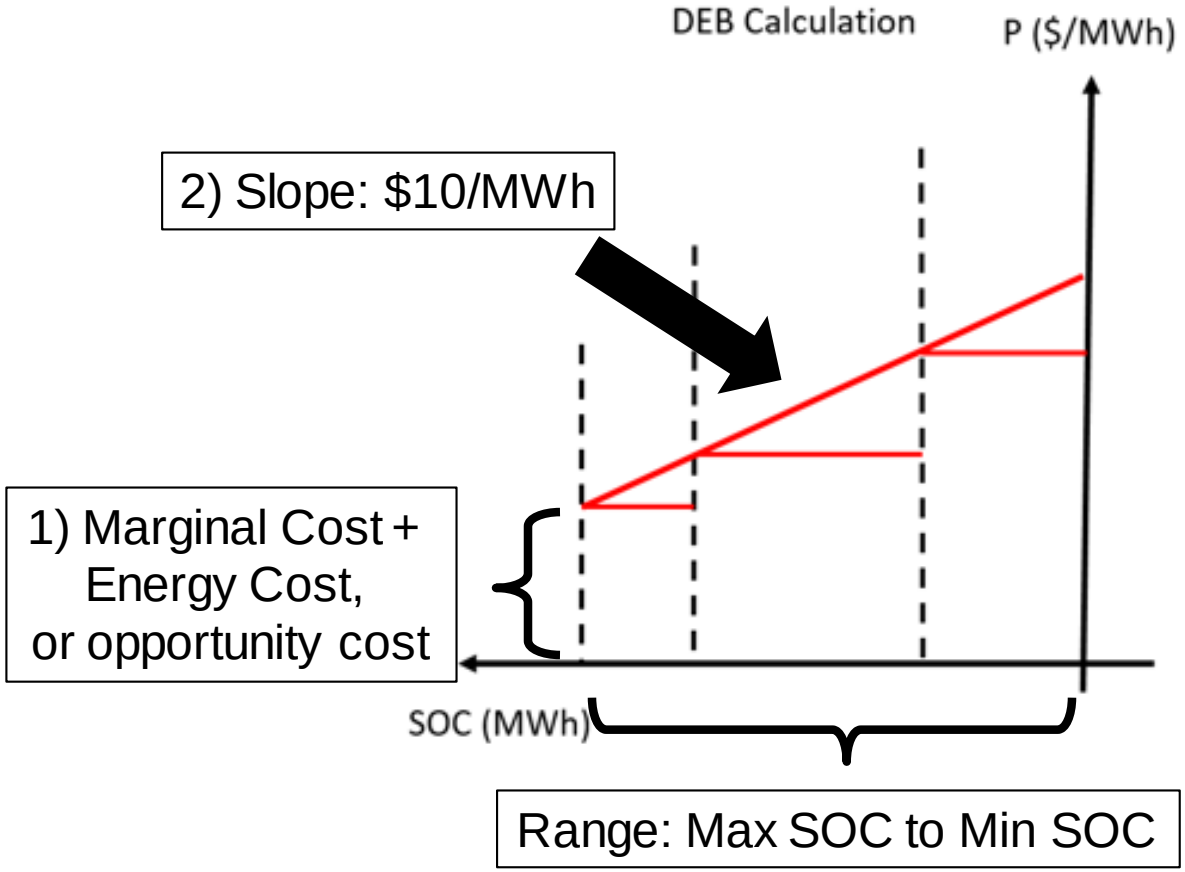
1. Use cost information from the resource to determine the lower bound of the default energy bid for discharging energy, at the maximum state of charge
   - Cost to buy energy + marginal cycling cost, or opportunity cost
2. Determine slope by using the average of the highest priced hours corresponding to the duration of the storage resource
   - The ISO will use the highest 4 hours of LMPs to determine the slope of the default energy bid for a four hour duration storage resource

Example:

Highest continuous prices: $60/MWh, $70/MWh, $80/MWh, $100/MWh

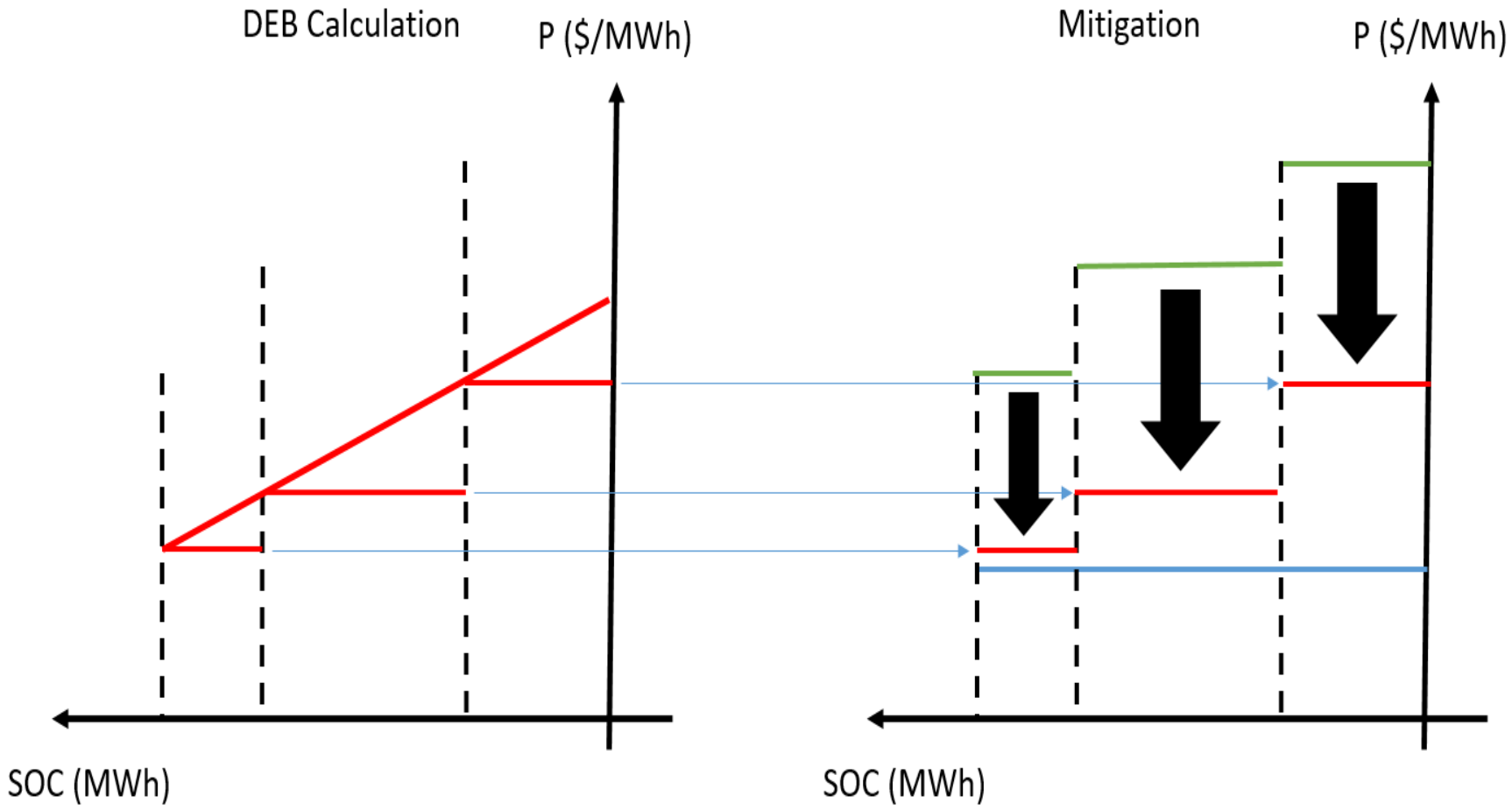
- Slope = ($100/MWh - $60/MWh) / 4 hour = $10/MWh

The default energy bid curve will be sloped, allowing



1) Red diagonal line: Sloped curve to inform default energy bids
2) Black vertical lines: Bid segments for resource
3) Red horizontal lines: Default energy bids

Mitigation may reduce some or all segments of the bid curve for energy storage resources



RELIABILITY ENHANCEMENTS

Day-ahead market results may not perfectly match real-time outcomes for use storage with AS awards

- The ISO is carefully reviewing differences in day-ahead market outcomes and real-time outcomes with storage resources that receive ancillary service awards
  - The day-ahead market assumes no impact to state of charge for ancillary service awards (award is for capacity)
  - Actual amount of energy depleted is unknown
- ISO does re-optimize ancillary services in the real-time market, to ensure that real-time awards are deliverable
  - Re-optimization is performed in the 15-minute market
- ISO may further include additional policy within this proposal to potentially include estimates of impacts to state of charge for ancillary service awards in the day-ahead market

The ISO proposes to change the current rules for storage resources providing ancillary services

- Operators noted storage resources can run out of SOC, resulting in an inability to provide ancillary services
  - Storage schedules with ancillary services may be/become infeasible
  - Storage providing ancillary service is subject to real-time state of charge requirements, but these are evaluated in the RTPD market
- ISO proposes that storage resources must have an energy bid with an accompanying range of dispatch to provide ancillary services
- E.g. A +/- 100 MW storage resource, when awarded 100 MW of regulation up, will be required to also bid 100 MW of charging range, i.e. -100 MW to 0 MW
  - This would preclude a simultaneous award for regulation down
  - This allows the ISO market to charge the resource, if necessary

The ISO proposes enhancements to internal tools for use to ensure local reliability

- ISO local studies show how storage could be used in the planning horizon for local areas to meet reliability needs
  - Specify total amount of (4-hour) storage that can be in one local area
  - Includes requirements for charging energy and transmission capabilities
- In the operations timeframe the ISO ensures that gas resources are available for dispatch when contingencies might occur
  - This could mean starting resources in anticipation of a contingency
- Storage resources may be used to mitigate contingencies as well as gas resources
  - Storage is always on-line, but may not be economic to charge and hold state of charge
- ISO will enhance internal tools so that trade-offs for retaining storage resources are priced in the market

The ISO is expanding the exceptional dispatch authority to include holding state of charge

- Traditional exceptional dispatch for generation is to move to a specific MW target
  - Compensation is at the higher of prevailing prices or bids
- Operators may desire to exceptionally dispatch storage to charge and then have them hold that state of charge
  - E.g. This could be for use later (expected high loads) or it could be to stand-by in the event a contingency occurs in a local area
- ISO will develop a new form of exceptional dispatch to handle this explicitly
  - Storage resources may either be exceptionally dispatched to a specific MW target or to hold a specific state of charge, but not both
  - Compensation for an exceptional dispatch to hold a specific state of charge will be compensated differently than traditional exceptional dispatches

Exceptional dispatch to hold state of charge will be compensated at the opportunity cost

- Stakeholders raised concerns about requiring a storage resources to hold state of charge
  - Preventing discharge for a certain period of time precludes storage from participating in markets and earning revenues there

- ISO proposes an opportunity cost based payment for storage resources that are exceptionally dispatched to hold state of charge

The ISO enhanced the proposal for the compensation methodology for exceptional dispatches to hold SOC

- The ISO proposes to run two very simple counterfactuals to determine payment to storage resources:
  1. Profit maximizing energy schedule without ED
  2. Profit maximizing energy schedule with ED
- Counterfactuals will be based on actual prices realized at the location of the resource
  - The ISO is electing to not update prices
- The timeframe used to construct counterfactuals will include the period of the exceptional dispatch plus an additional period equal to the duration of the battery
  - I.e. If a 4-hour storage resource was exceptionally dispatched for 8 hours, the counterfactual includes a 12 hour period
- These simplifying assumptions enable bulk calculations

A simplified example for compensation for exceptional dispatch to hold state of charge

- Assume a hypothetical energy storage resource
  - Pmin: -25 MW; Pmax: +25 MW
  - SOC Min: 0 MWh; SOC Max: 100 MWh

Examples:

- (Input) Resource initially has 80 MWh of state of charge at the start of the exceptional dispatch
- The resource is dispatched to hold 75 MWh of state of charge for 1.5 hours
- Resource would optimally discharge when prices are high, early in the exceptional dispatch, but is prevented from doing so by the exceptional dispatch

Example: A storage resource that would receive an additional payment for exceptional dispatch

		Counterfactual #1				Counterfactual #2			
Hour	Prices	SOC	Ideal MW	SOC_T+1	Rev	SOC	Const MW	SOC_T+1	Rev
0.5	95	80	25	67.5	$ 1,188	80	0	80	$ -
1	300	67.5	25	55	$ 3,750	80	10	75	$ 1,500
1.5	300	55	25	42.5	$ 3,750	75	0	75	$ -
2	75	42.5	-25	55	$ (938)	75	0	75	$ -
2.5	85	55	25	42.5	$ 1,063	75	25	62.5	$ 1,063
3	100	42.5	25	30	$ 1,250	62.5	25	50	$ 1,250
3.5	125	30	25	17.5	$ 1,563	50	25	37.5	$ 1,563
4	150	17.5	25	5	$ 1,875	37.5	25	25	$ 1,875
4.5	45	5	-25	17.5	$ (563)	25	0	25	$ -
5	90	17.5	25	5	$ 1,125	25	25	12.5	$ 1,125
5.5	82	5	10	0	$ 410	12.5	25	0	$ 1,025
					$ 14,473				$ 9,400

CO-LOCATED ENHANCEMENTS

Additional options for co-located resources that may have rules in place to prevent 'grid charging'

- ITC and property taxes resulted in developers striking contracts with LSEs that strictly prohibit charging storage more than the energy coming off of on-site renewables
  - Contracts that restrict operation of any resource limits the ISO's ability to manage the grid because full resource capability is not available
  - ISO supports contracts that include costs for certain actions, but that do not explicitly restrict resource operation
  - ISO is concerned that ITC rules do not incentivize full participation of storage resources
- ISO realizes that rules for operating some resources may have been struck years ago, and may need some short-term accommodations
  - The ISO proposes updating the co-located model to observe these constraints in limited circumstances
  - Will apply only to legacy (not new) resources

The ISO proposes enhancements to the co-located model for resources with these arrangements

- Co-located resources may elect to impose constraints that will prevent on-site storage from receiving dispatch instructions in excess of co-located renewable output
  - Documentation must be provided to the ISO to qualify for this model
  - Resources are only eligible for this for a 5-year period from joining the grid
- Resources joining the system after this policy is implemented, will not be eligible for this treatment
  - ISO requires that physical characteristics - rather than contractual terms - are modeled in our markets
  - ISO requires that resources respond to dispatch instructions
- Similar to all policy, these rules must be approved by FERC

The ISO will allow these storage resources to observe contractual limitations

- The market model will prevent these storage resources from receiving a dispatch instruction to charge above output from renewable components
- Storage resources may deviate down when dispatch instructions are above actual renewable output
  - Storage must be registered with this alternate co-located model
  - ISO is not responsible for ensuring that actual output levels between co-located storage and solar are aligned, this likely must be done through facility level controls
  - Storage cannot deviate beyond the difference between actual and forecast renewable output
  - Storage resources that deviate will not receive unique settlement treatment and will still be subject to uninstructed deviation charges
  - There will be no additional ISO settlement measures between the co-located resources

Stakeholders requested additional functionality for pseudo tie resources

- Today pseudo tie resources must show transmission capacity for full rating of resource
  - The ISO received requests for new treatment for co-located resources
- ISO proposes to allow co-located resources with transmission less than sum of Pmax values to qualify for pseudo tied resource modeling
  - Resources must be located in the same balancing authority area
  - Aggregate capability constraint would limit combined dispatch to the resources to a value less than or equal to transmission to the ISO

NEXT STEPS

Next Steps

- All related information for the Energy Storage Enhancements initiative is available at: https://stakeholdercenter.caiso.com/StakeholderInitiatives/Energy-storage-enhancements
- Please submit stakeholder written comments on today's discussion and the storage enhancements issue paper by April 4, 2022, through the ISO's commenting tool
  - The commenting tool is located on the Stakeholder Initiatives landing page (click on the "commenting tool" icon): https://stakeholdercenter.caiso.com/StakeholderInitiatives

- The ISO is pleased to be hosting the Stakeholder Symposium in-person at the Safe Credit Union Convention Center in downtown Sacramento on Nov. 9 – 10, 2022
- Registration will be open in May
  - Public notice will be issued once the site is available
- Additional information is available on the Stakeholder Symposium page on ISO's website at: http://www.caiso.com/informed/Pages/MeetingsEvents/StakeholderSymposium/Default.aspx
- Please direct questions to symposiumreg@caiso.com