Energy Storage and Distributed Energy Resources Phase 4

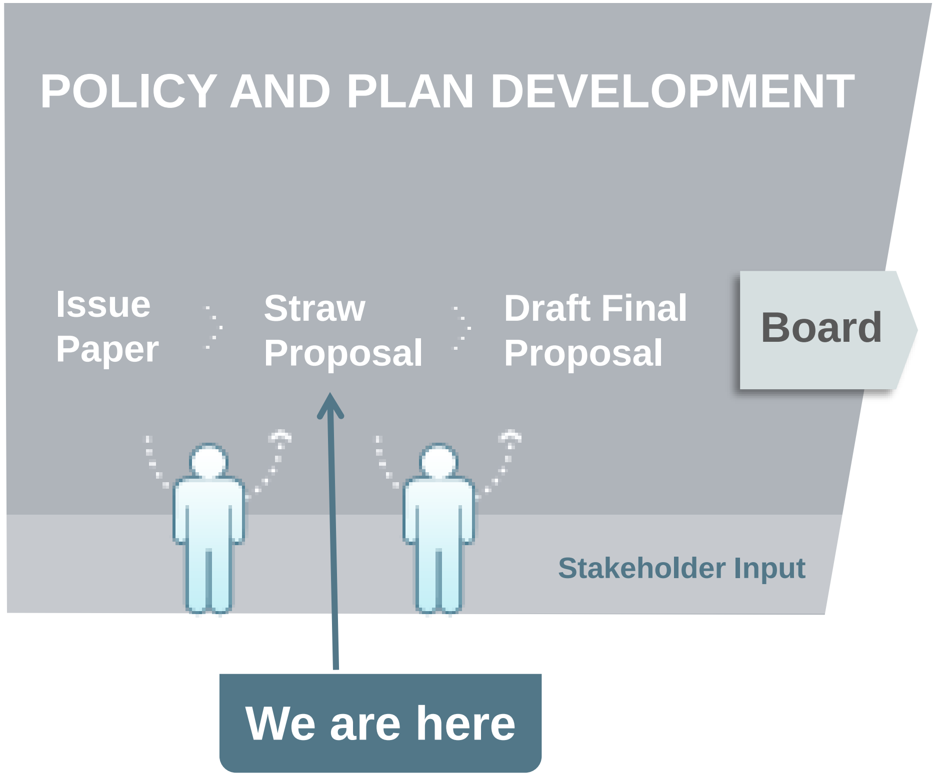
Stakeholder Workshop
June 27, 2019
10:00 a.m. – 4:00 p.m. (Pacific Time)

Agenda

Time	Item	Speaker
10:00 - 10:05	Stakeholder Process and Schedule	James Bishara
10:05 – 10:10	Objectives and Scope	Eric Kim
10:10 – 12:00	Default Energy Bids for Energy Storage	Gabe Murtaugh
1:00 – 2:00	SOC Parameter for NGR	Perry Servedio
2:00 – 3:00	Variable Output Demand Response	Lauren Carr
3:00 – 3:45	Maximum Run Time Parameter for DR	Eric Kim, Jill Powers
3:45 – 4:00	Next Steps	James Bishara

STAKEHOLDER PROCESS

CAISO Policy Initiative Stakeholder Process



OBJECTIVES / SCOPE

Scope

1. NGR state of charge parameter
2. Market power mitigation measures for energy storage resources
3. Streamlining interconnection agreements for NGR participants
4. Demand response maximum run time parameter
5. Operational process for variable-output demand response resources
6. Consideration of the non-24x7 settlement of behind the meter resources utilizing NGR model*

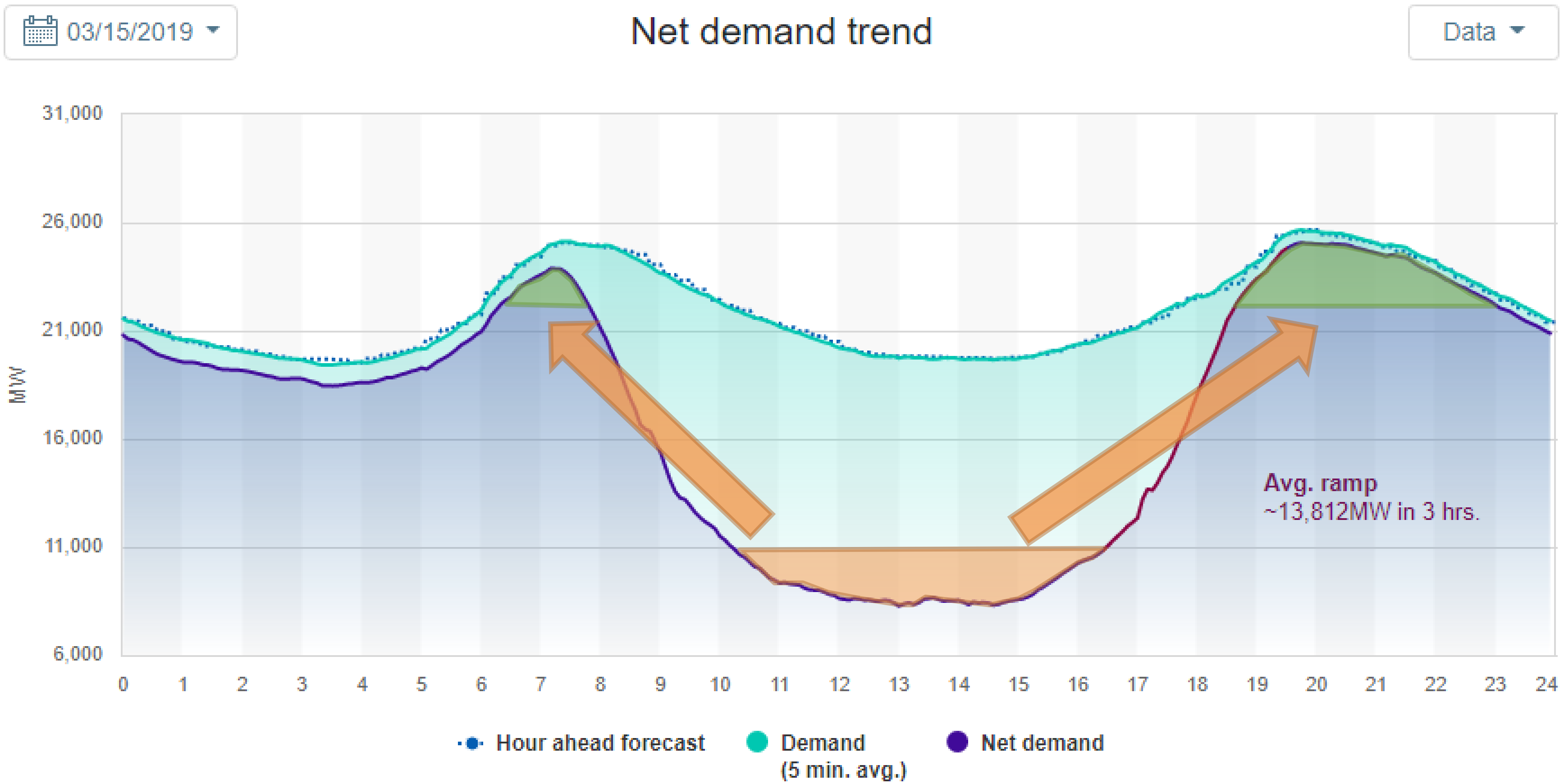
*To be determined based on future discussions

MARKET POWER MITIGATION FOR ENERGY STORAGE

The ISO is proposing a methodology to calculate default energy bids for storage resources in ESDER 4

- The ISO currently does not calculate default energy bids for storage resources
- There is a considerable amount of storage in the new generation queue for the system
- Storage is often suggested as a solution for local issues to mitigate for retirement of essential resources
- Planning models used by the CPUC and the ISO tend to include 4-hour storage ‘moving’ generation from peak solar hours to peak net load hours
  - Generally the existing battery fleet is not doing this

Batteries might be used to ‘move’ energy from one time of the day to another



DMM published data showing that storage was scheduled for energy infrequently in 2018

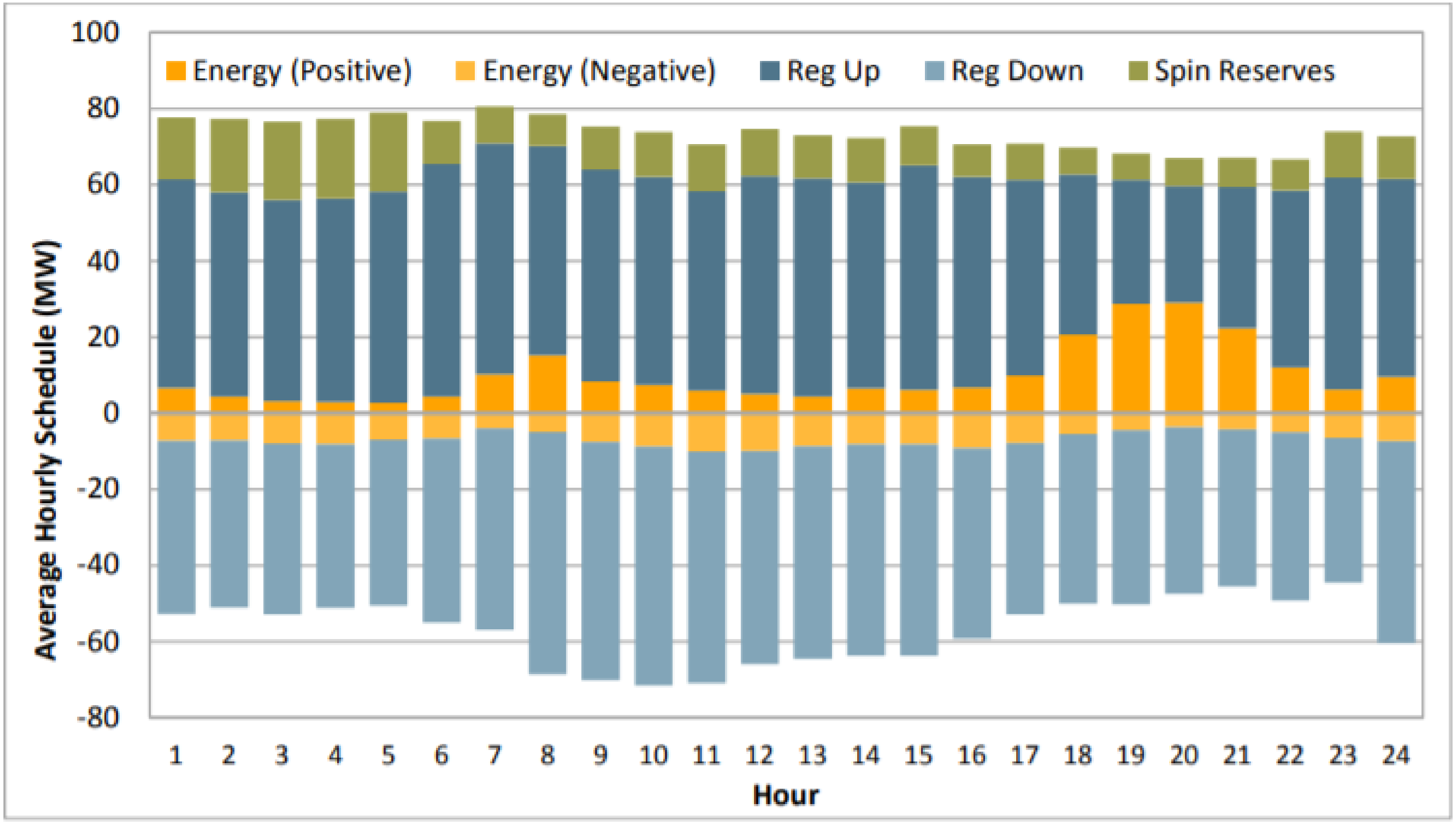


Figure taken from DMM 2018 Annual Report on Market Issues and Performance, Figure 1.11

Objectives of this workshop include continuing to develop understanding of battery costs

Key Questions:

- What are the key contributors to battery marginal costs to operate?
  - In this discussion, were there any key costs that were omitted?
- How does the depth of discharge impact these costs?
- What is the cost for replacing a battery cell and how much do those costs change in the future?
- What is the best framework for the ISO to follow moving forward to create a DEB for storage resources?

STAKEHOLDER PRESENTATIONS: DMM & SCE

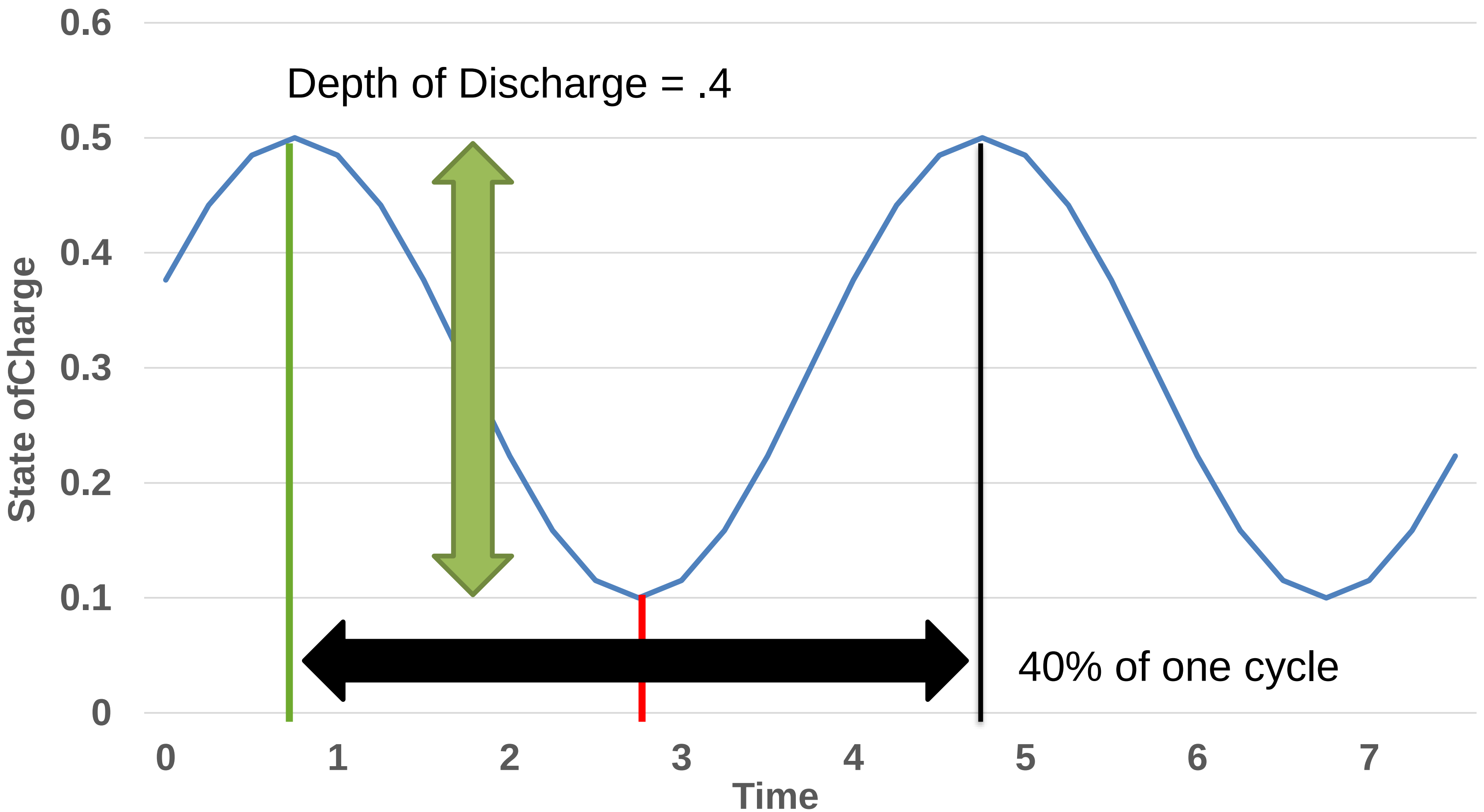
The CAISO identified four primary cost categories for storage resources

- Energy
  - Energy likely procured through the energy market
- Losses
  - Round trip efficiency losses
  - Parasitic losses
- Cycling costs
  - Battery cells degrade with each “cycle” they run
  - Cells may degrade more with “deeper” cycles
  - Unclear if these costs should be included in the DEBs
  - Including these costs may not make it efficient for storage resources to capture small price spreads
- Opportunity costs

Storage definitions used in this paper

- Cycles – Complete (100%) charge-discharge of the battery
- Discharge Period – Period of time when the battery is continuously discharging
- Depth of Discharge (DoD) – Percentage of the state of charge (SOC) that the battery loses during a discharge period
- Calendar Life – Elapsed time before a battery becomes inactive
- Cycle Life – Number of complete cycles a battery can perform before battery degradation (i.e. 80% capacity)

Example of 1 discharge period and .4 cycles



The MSC identified a paper outlining cycling costs for lithium-ion storage resources

- ISO will focus this initiative on lithium-ion technology
  - Majority of resources on system and in the queue are lithium-ion
  - Develop a framework for DEBs that may incorporate other battery types in addition to lithium-ion
- Many factors cause these batteries to fatigue
  - Depth of discharge
  - Extreme levels of charge or discharge (i.e. states of charge >95% and <15%)
  - Ambient temperature
  - Average state of charge
  - Current rate

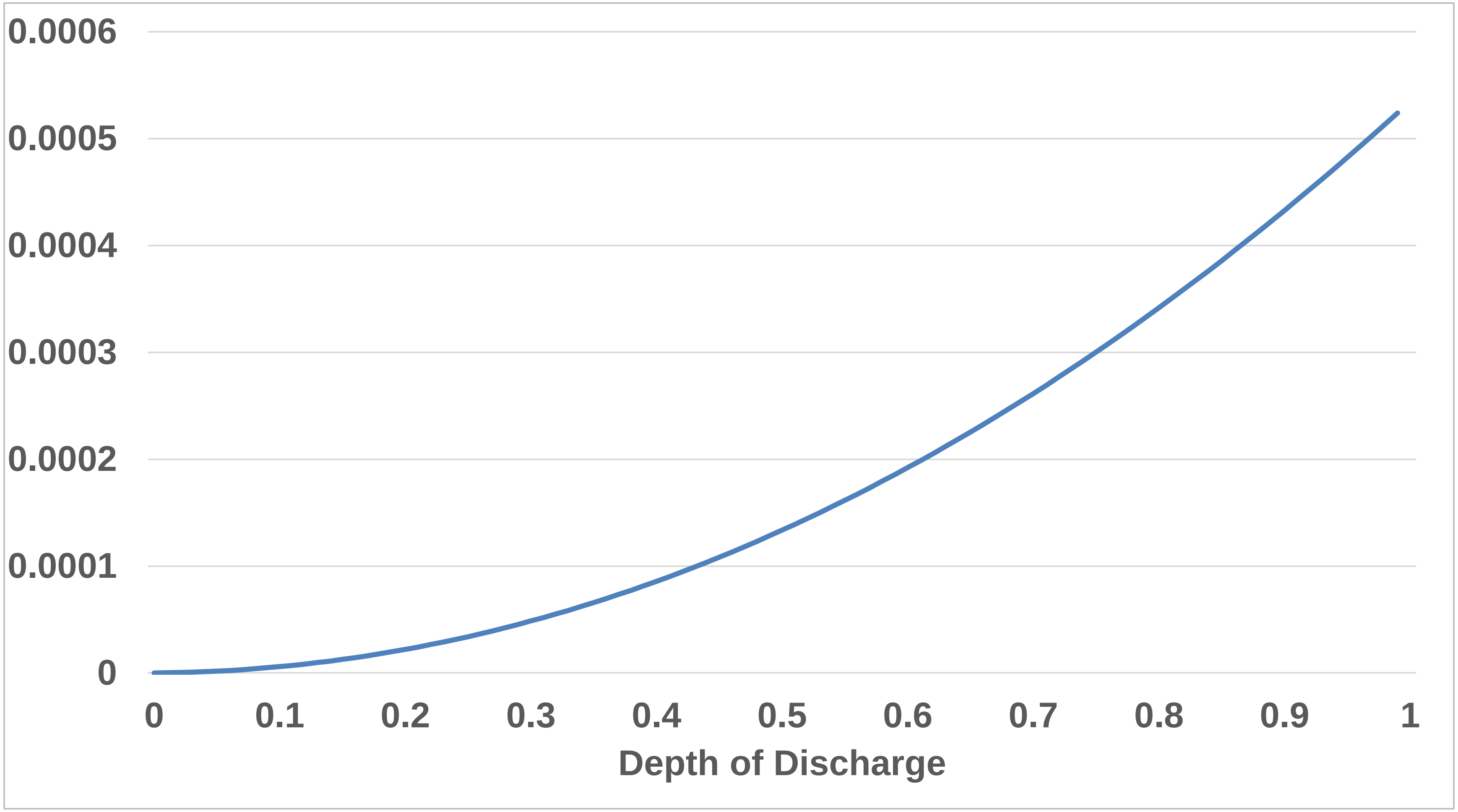
https://arxiv.org/pdf/1707.04567.pdf

Batteries may be able to charge and discharge many more times if the depth of discharge is smaller

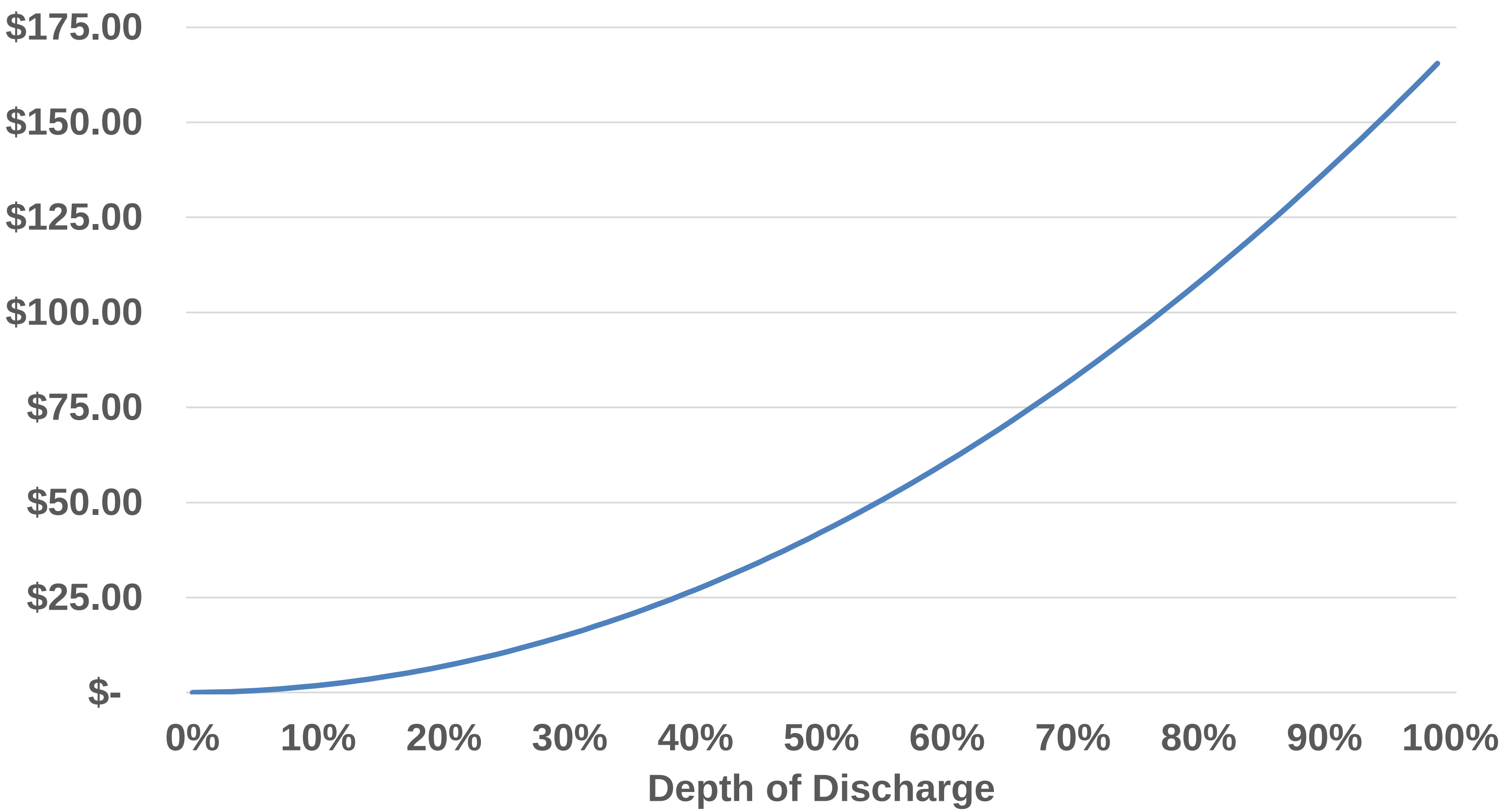
- Batteries have a roughly quadratic relationship between expected degradation rate and depth of discharge during a discharge period
  - Batteries are capable of many small discharges, but few large discharges

DoD	Degradation (x1000)	Degredation/Cycle	Ratio
0.1	0.005	0.049	0.10
0.2	0.018	0.090	0.18
0.5	0.123	0.246	0.48
1	0.513	0.513	1.00

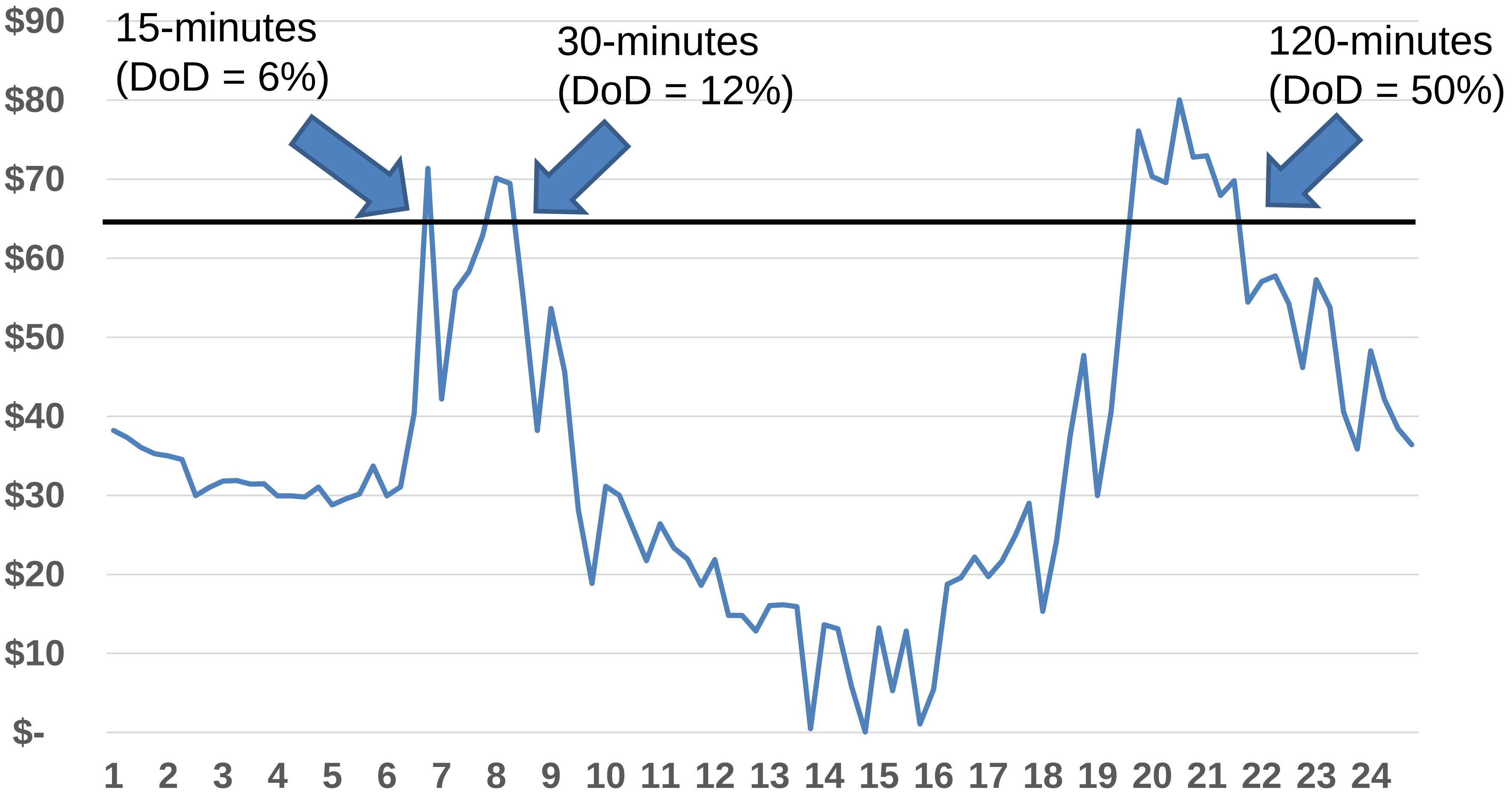
Expected cell degradation for a specific discharge



Estimated Costs for one discharge period with $300,000 replacement cost and 95% efficiency



A single DEB for output may not be sufficient for storage resources (Ex 40MWh, with 10 MW bid)



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NGR STATE-OF-CHARGE PARAMETER

Proposal

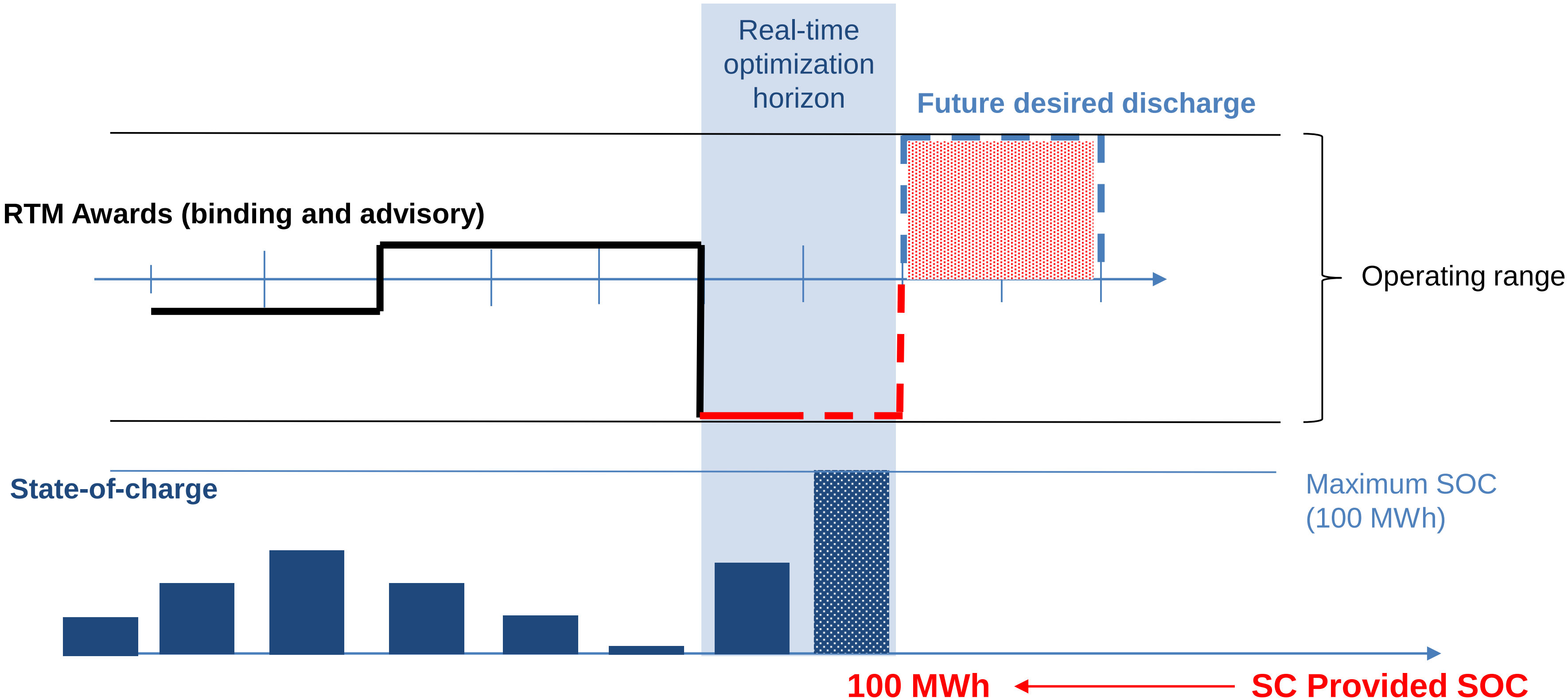
The ISO is exploring an end of hour or end of day SOC parameter to inform policy design of SATA, MUA, and other needs identified by stakeholders.

Real-time state-of-charge management

- Scheduling coordinator to submit end-of-hour SOC
- Bid parameter is optional
- SOC parameter will take precedence over economic outcomes in the market optimization
- Market will respect all resource constraints in addition to the SOC parameter
  - SOC required to fulfill ancillary service awards will be maintained

NGR enhancements: real-time SOC management

- In order to meet future desired discharge, NGR provides desired state of charge of 100 MWh in interval prior to discharge.



NGR will be ineligible to receive bid-cost recovery if dispatched uneconomically due to SOC parameter or self-schedules

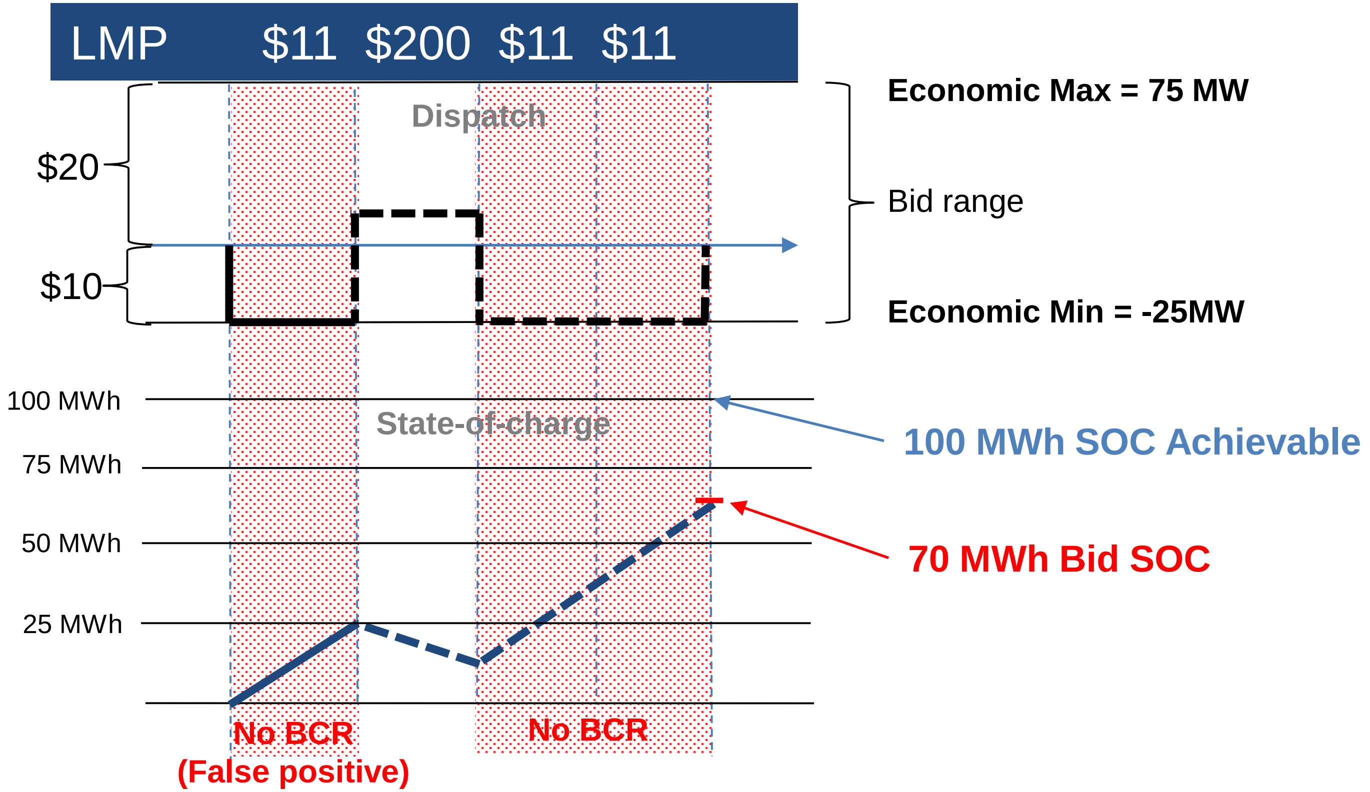
CAISO currently evaluating two approaches

Approach 1 (simple)

- Ineligible for BCR with market award due to SOC bid
  1. Charge or discharge is uneconomic;
  2. SOC bid is greater than the current SOC while the awarded value is at economic minimum; or
  3. SOC bid is less than current SOC while the awarded value is at the economic maximum.

Potential for false positives

- No BCR if out-of-the-money, at economic minimum, and bid SOC is greater than current SOC
- However, optimization sees price spread opportunity between interval 1 and 2
- Bid SOC is otherwise achievable, so the dispatch to economic minimum is not solely to satisfy bid-in SOC



NGR will be ineligible to receive bid-cost recovery if dispatched uneconomically due to SOC parameter or self-schedules

Approach 2 (more complex)

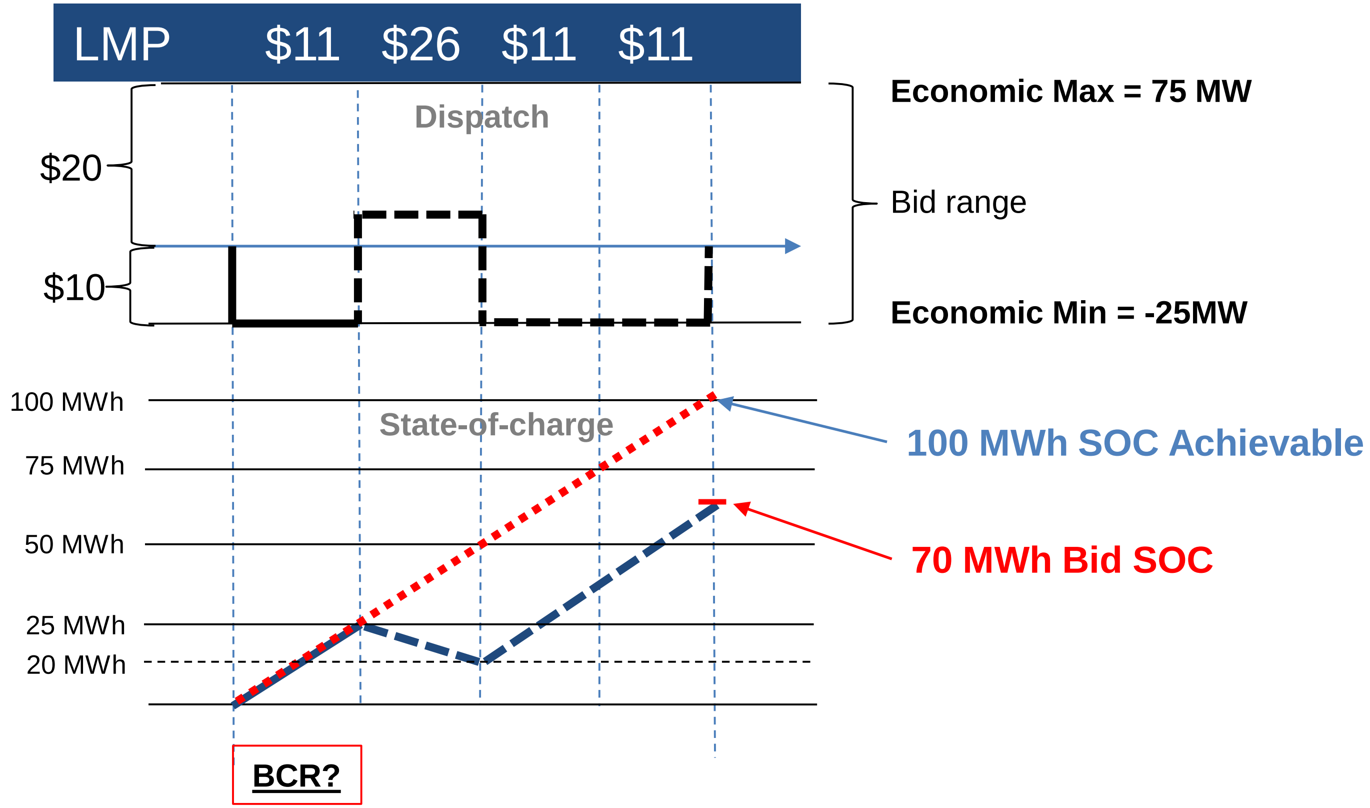
- Ineligible for BCR while charging
  - If dispatched uneconomically in interval t, and
  - If submitted end-of-hour SOC is greater than or equal to achievable end-of-hour SOC as of interval t

$$Achievable\ SOC_t = SOC_t + \sum_{i}^{N}\left(\frac{ECOMIN_i}{4}\right)$$

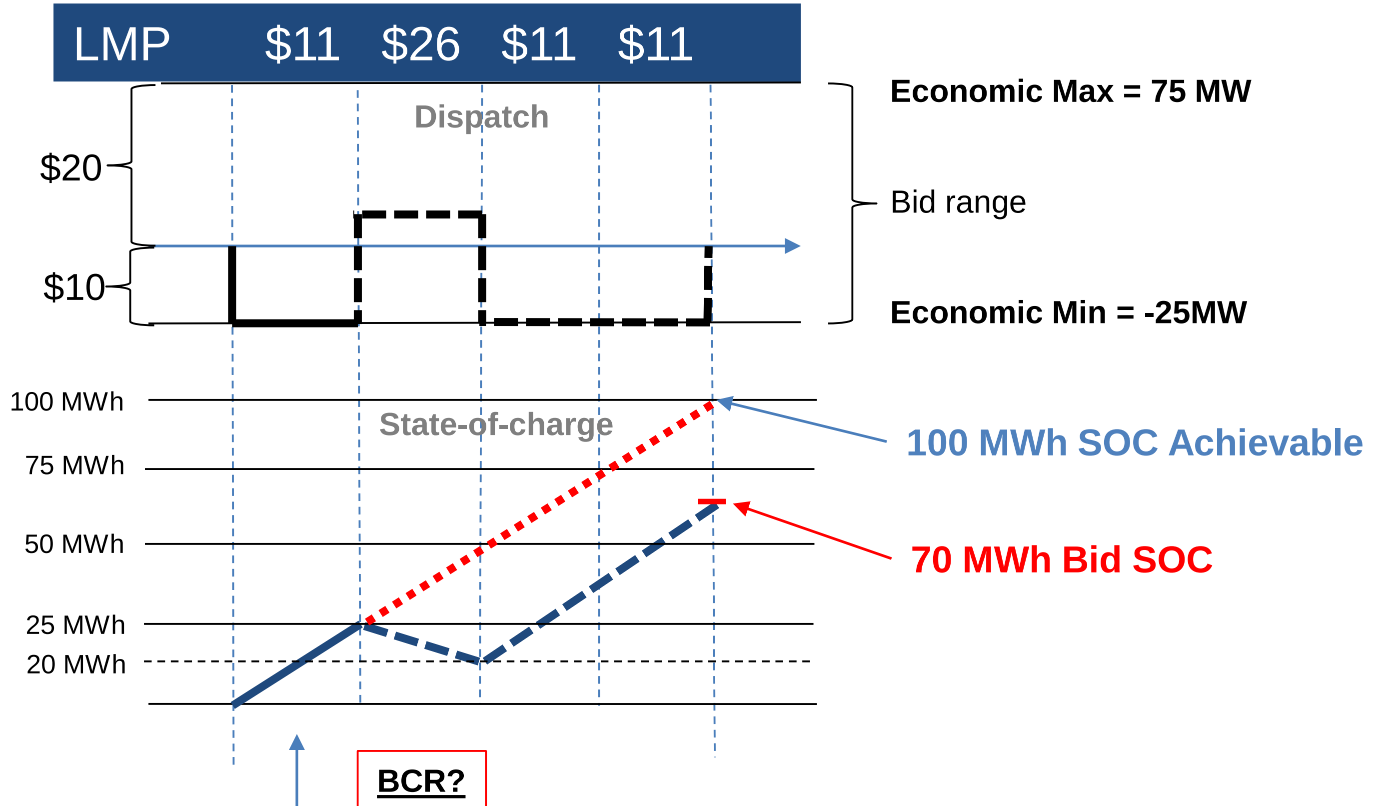
$$N = number\ of\ intervals\ remaining\ in\ hour$$

- Similar calculation for discharging

Bid cost recovery eligibility (Approach 2)

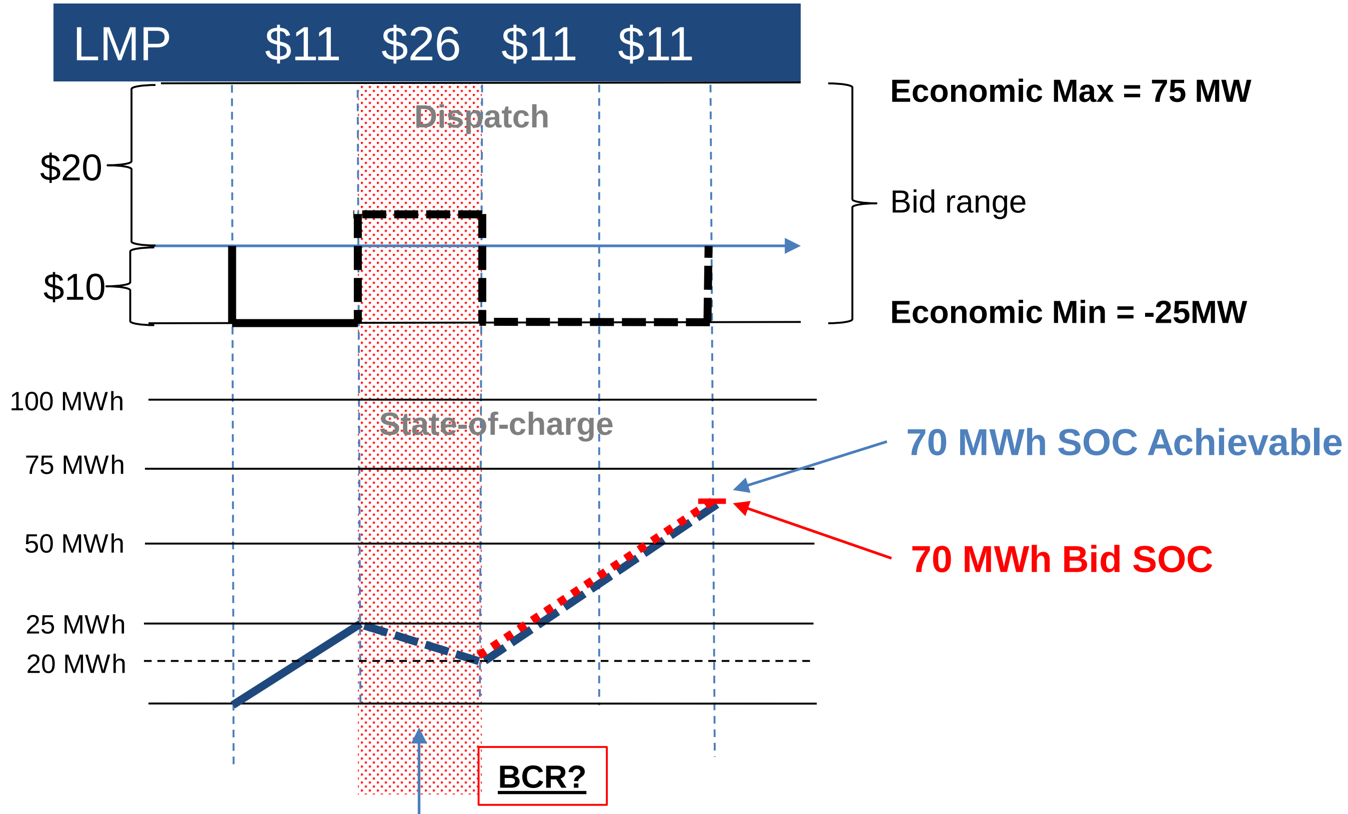


Bid cost recovery eligibility (Approach 2)



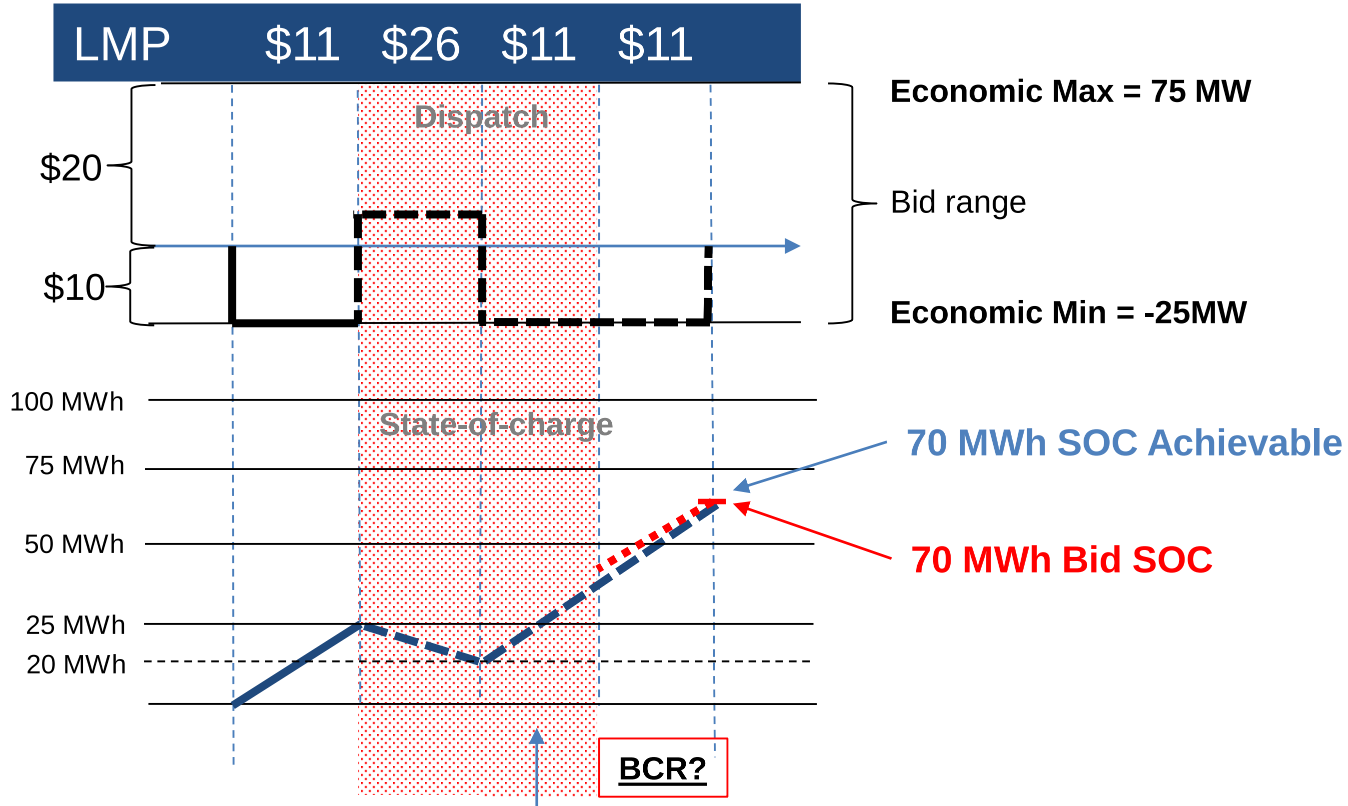
Out-of-the-money but bid-SOC achievable, eligible for BCR

Bid cost recovery eligibility (Approach 2)



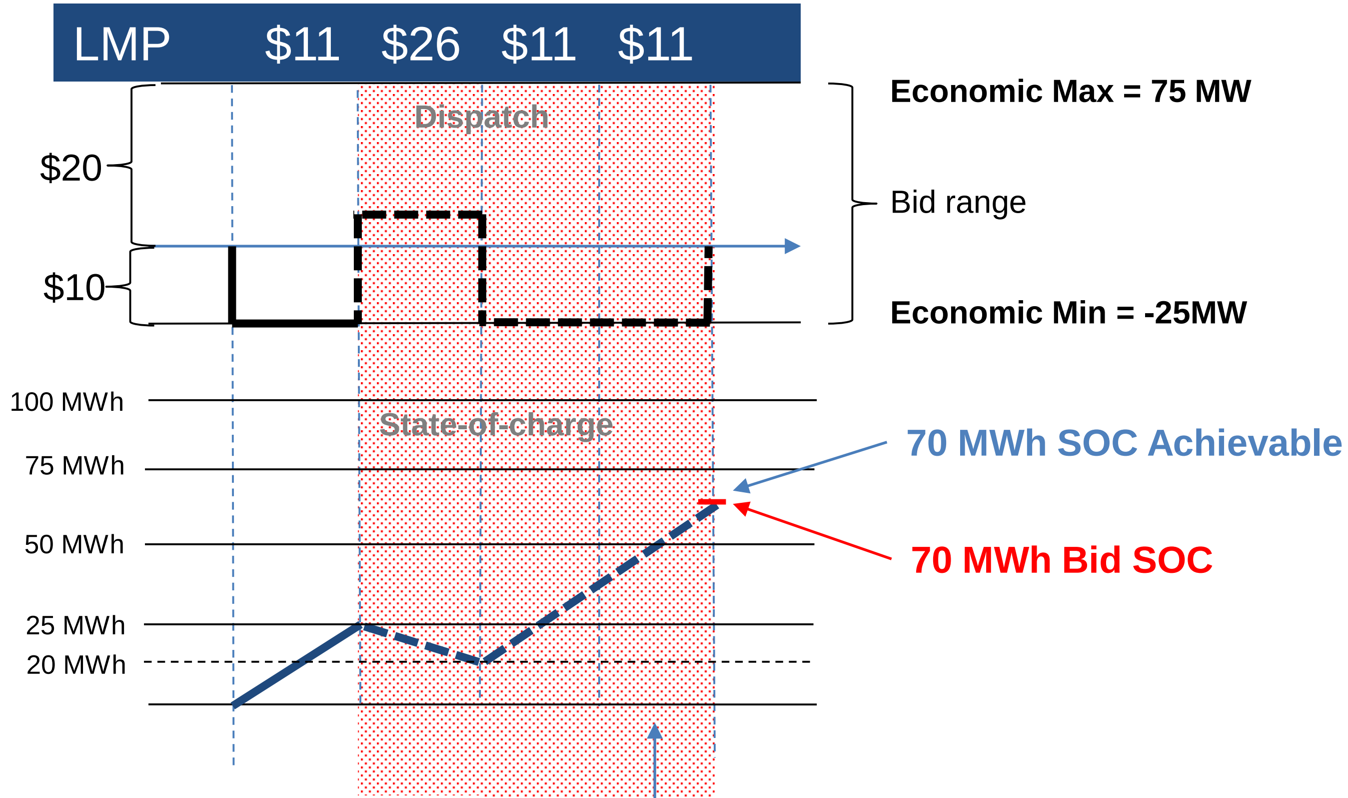
In-the-money, not eligible for BCR

Bid cost recovery eligibility (Approach 2)



Out-of-the-money but charging to meet bid-SOC, not eligible

Bid cost recovery eligibility (Approach 2)



Out-of-the-money but charging to meet bid-SOC, not eligible

STAKEHOLDER PRESENTATIONS: WPTF

Variable-Output Demand Response

The CAISO will advance the variable-output demand response issue following two key principles

1. The qualifying capacity (QC) valuation for DR must consider variable-output DR resources' reliability contribution to system resource adequacy needs.
   - To help inform and advance CPUC/LRA consideration, the CAISO will discuss how to perform a Loss of Load Expectation (LOLE) study and establish an Effective Load Carrying Capability (ELCC) value for variable-output DR.
2. Market participation and MOOs must align with variable-output demand response resource capabilities.
   - The CAISO will explore altering market participation rules for variable-output DR to allow must offer obligation fulfillment by bidding forecasted output.

Objectives for today's workshop

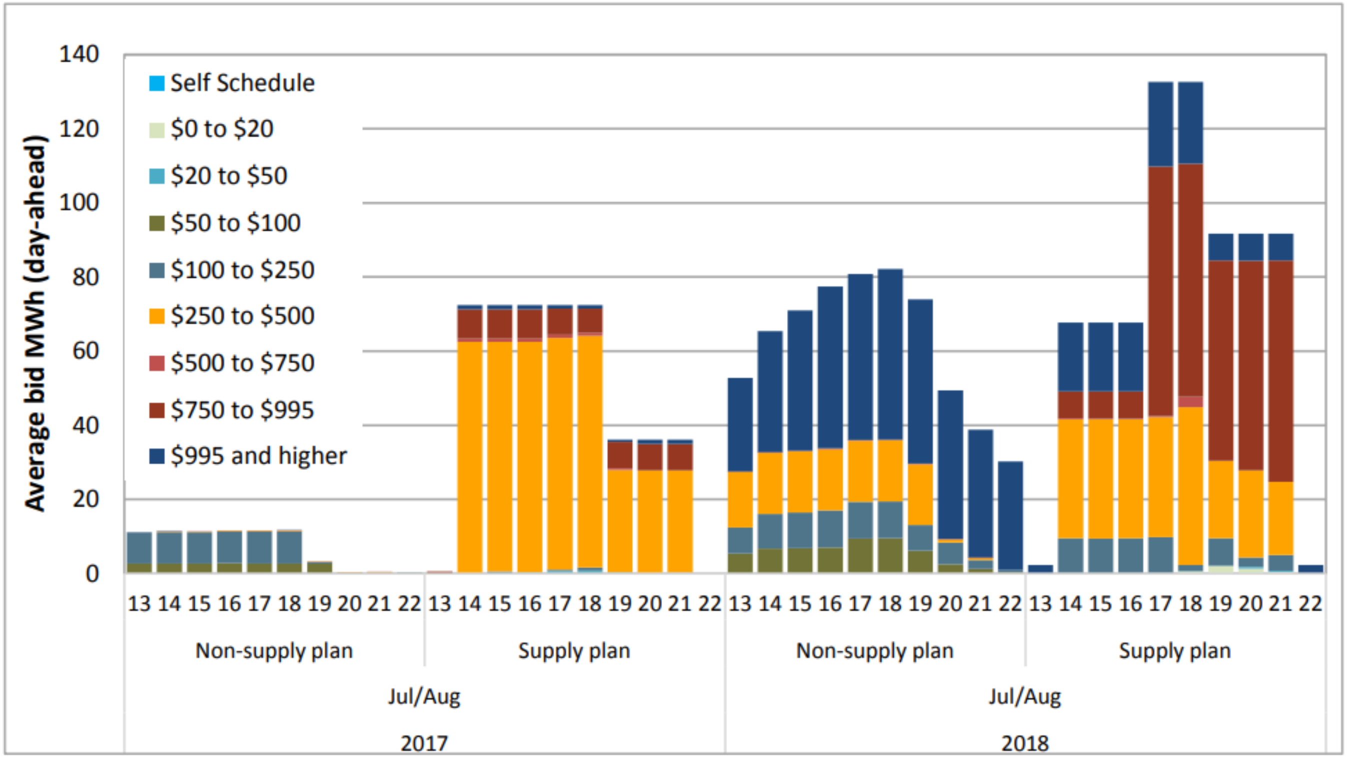
1. Defining Variable-Output DR
2. Understanding the changing RA landscape
3. Exploring the link between QC valuation and Must Offer Obligation rules
4. Clarifying certain ELCC concepts

By definition, variable-output DR may be unable to deliver its full NQC value in real-time due to its variable nature.

- CAISO defines variable output DR as DR whose maximum output of DR resources can vary over the course of a day, month, or season due to production schedules, seasonality, temperature, occupancy, etc.
- The central tenet of the RA program is to ensure sufficient energy is available and deliverable when and where needed.
- If a DR resource cannot bid its full RA capacity and deliver it under its must offer obligation (MOO) due to its variable nature, the resource may be assessed RAAIM penalties.

DMM’s 2018 annual report includes PDR bidding and performance data that suggests variability in underlying load profiles.

Supply plan and non-supply plan day-ahead PDR bid prices July and August



Source: Annual Report on Market Issues and Performance, Department of Market Monitoring, May 2019.

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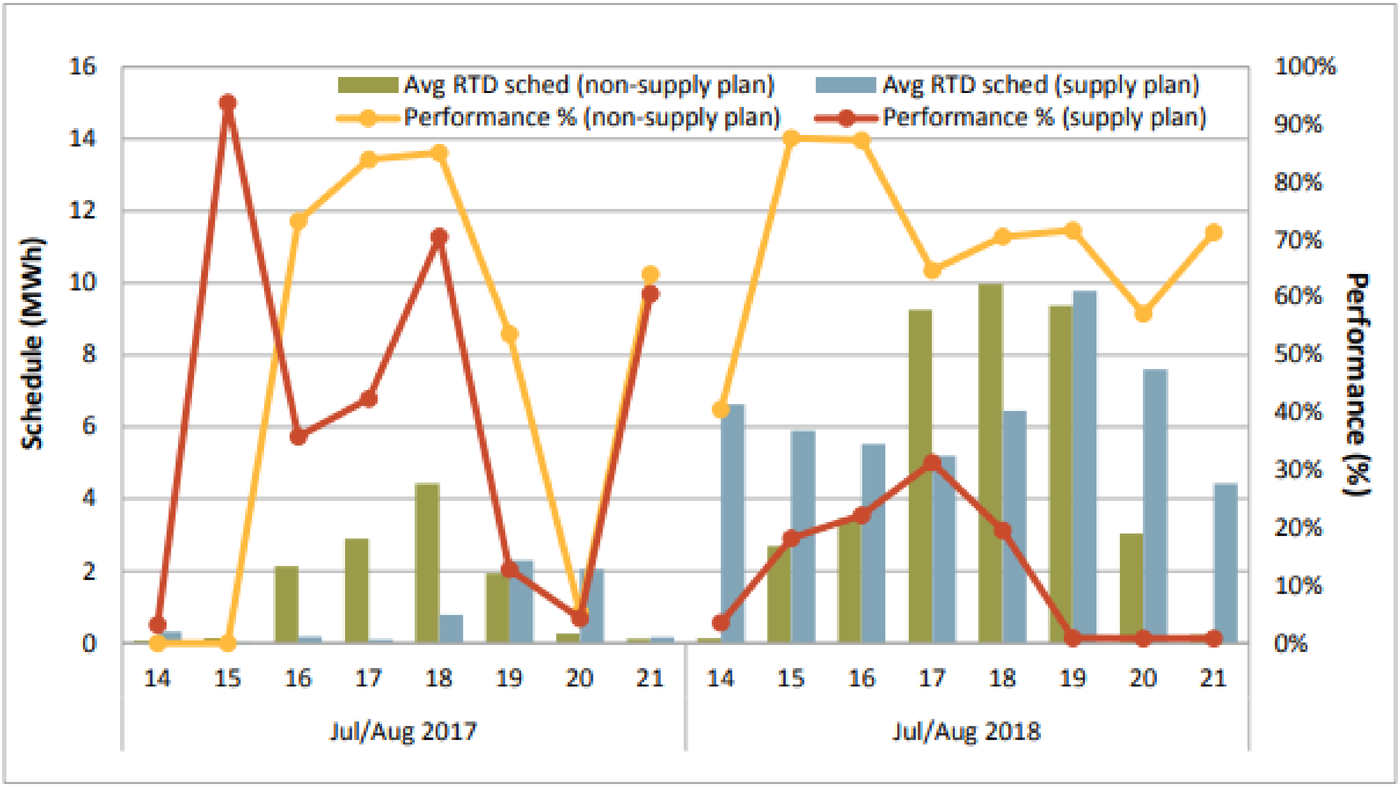
Proxy demand response schedules and performance July and August



Source: Annual Report on Market Issues and Performance, Department of Market Monitoring, May 2019.

Stakeholder Comments- Defining Variable-Output DR

- Several stakeholders encouraged more definition around what classifies a DR resource as "variable-output"
  - **CAISO Response:**
    - CAISO defines variable-output DR as DR whose maximum output can vary, meaning the resource cannot provide a fixed MW amount to the CAISO in every hour of the year, month, or day.
    - CAISO believes most DR programs have some degree of variable output but not all.
    - The CAISO will explore allowing resources that are not variable to continue to receive an NQC and bid that fixed MW amount into CAISO markets to satisfy a must offer obligation.

Variable-Output DR is one piece of the changing RA landscape requiring reform

- Attributes of past resource mix did not necessitate assessment of needs beyond capacity available in the peak hour.
- New resource mix is increasingly variable and availability limited, warranting additional reforms to ensure sufficient energy is available to meet load.
- RA Enhancements initiative is addressing such changes to ensure adequate energy available in all hours of the year.
  - ELCC proposal for DR could align with proposals in RA Enhancements

Needed reforms are in scope of existing definition of California's Resource Adequacy program

- California Public Utilities Code (PUC) § 380 codified the resource adequacy program under the following principle:

  "Each load-serving entity shall maintain physical generating capacity and electrical demand response adequate ***to meet its load requirements***, including, ***but not limited to, peak demand*** and planning and operating reserves. The generating capacity or electrical demand response shall be deliverable to locations and at times as may be necessary to maintain electric service system reliability and local area reliability**."** **(*emphasis added*)**

Stakeholder Comments- Resource Adequacy Landscape

- Some stakeholders suggested the RA program is focused on meeting peak capacity needs and applying ELCC to these resources would be a dramatic shift in the purpose of RA.
  - **CAISO Response:**
    - The presumption that resource adequacy capacity comes with sufficient energy to meet load in all hours may have led to a misunderstanding that resource adequacy is simply ensuring sufficient peak capacity exists on the system.
    - Resource adequacy is fundamentally about meeting load requirements, not just satisfying peak demand.
    - Growing penetrations of variable and availability limited resources necessitates an examination of resources' RA contribution to meeting load when needed.

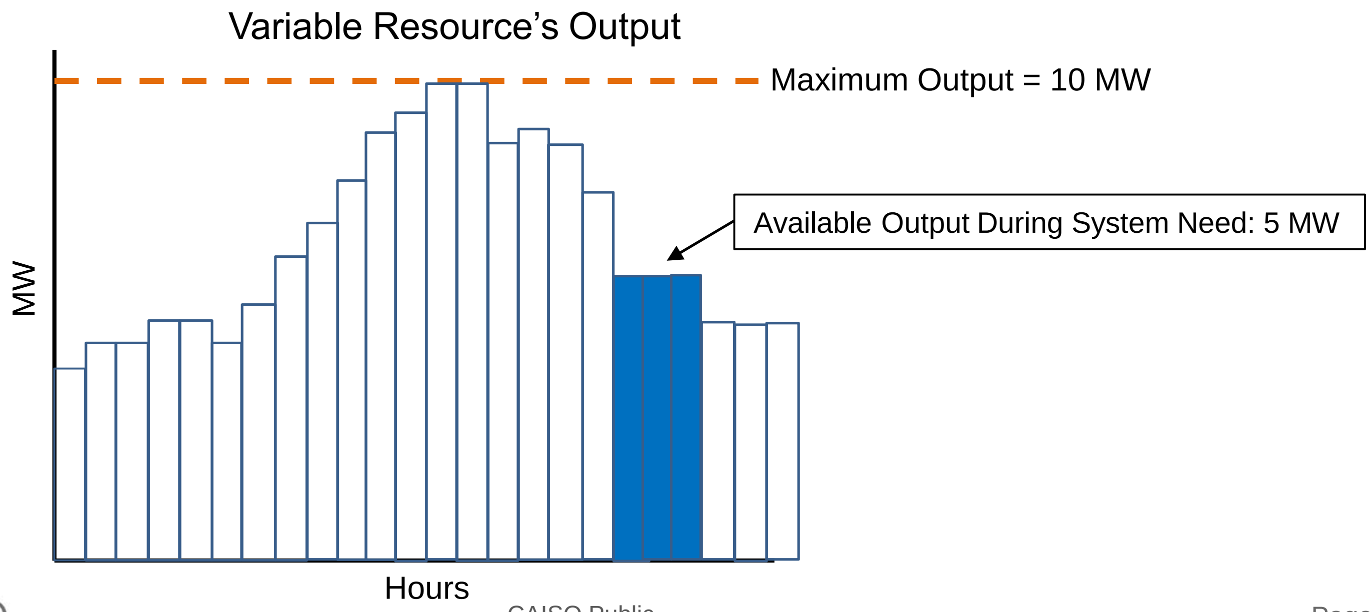
QC valuation and must offer obligations must be consistent

- Allowing resources to bid forecasted output while relying on a peak capacity amount as its RA value would create misalignment between planning and operations.
  - Under this construct, the amount of capacity procured would not be reflective of amount of energy available.
  - CAISO may require energy from RA resources outside of the peak hour.
  - Variable resources cannot deliver peak capacity amount in many hours of the year.
- Variability must be reflected in QC valuation to ensure enough resources are procured to cover energy needs during the operating day.

QC valuation and must offer obligations must be consistent- Example

- Consider a hypothetical resource with the following attributes and a CASIO need of 10 MWs:

Maximum Output During CAISO Peak	CAISO Need	Actual Availability During CAISO Need	Shortage (CAISO Need – Actual Availability)
10 MW	10 MW	5 MW	5 MW



Stakeholder Comments- Link between QC valuation and Must Offer Obligations

- Stakeholders are generally supportive of aligning variable-output DR's must offer obligations with forecasted output.
- Some stakeholders suggest this proposal should be adopted independent of the CAISO's QC valuation proposal.
  - **CAISO Response:** A resource's QC value must be correlated to the MWs the CAISO expects to be available such that load requirements can be met in all hours. CAISO's proposal would align the QC value of DR with its availability, given its variable nature.

ELCC can assess the resource adequacy contribution of a portfolio of *multiple resource types*

- ELCC would enable demand response's reliability contribution to be compared to the reliability contribution of other variable energy and preferred RA resources
- Different resource types are often complimentary such that the combined ELCC of the entire portfolio is greater than the sum of individual contribution of a resource, known as diversity benefits
- Example:
  - Higher portfolio ELCC: A system with solar output during the day and available load drop from DR after sunset
  - Lower portfolio ELCC: A system with solar output and available load drop from DR during the same hours

The planning assumption of 1-in-2 peak load would be maintained under an ELCC methodology

- The California's standard reliability target is 1-in-10 LOLE
  - The expected number of days for which the available generation capacity is insufficient to serve the daily peak demand is 1 day in 10 years
- This assessment can be made under the 1-in-2 peak load conditions currently employed in California's RA program for system RA

Reliability Standard (LOLE)	Peak Load Conditions: 1-in-2	Peak Load Conditions: 1-in-10
1-in-10	• Average weather • 1-in-10 LOLE *California standard in ELCC studies	• Extreme weather • 1-in-10 LOLE • Highest Reliability
1-in-2	• Average weather • 1-in-2 LOLE • Lowest Reliability	• Extreme weather • 1-in-2 LOLE

Stakeholder Comments- ELCC Methodology

- Some stakeholders suggest the maximum output of demand response is difficult to determine, and as such, applying an ELCC to these resources would be inappropriate
  - **CAISO Response:** CASIO acknowledges demand response may not have a traditional “nameplate” capacity value, however, resources should be capable of determining maximum output capability, as is currently done today to establish a Pmax
- Several stakeholders expressed concerns over applying an ELCC value to all DR, given different DR programs have differing degrees of variability
  - **CAISO Response:** CAISO is willing to explore the feasibility of an ELCC methodology that accounts for differing degrees of variability

As the grid transforms, ELCC is being explored by industry experts as a capacity valuation methodology.

- E3: Resource Adequacy in the Pacific Northwest
  - https://www.ethree.com/wp-content/uploads/2019/03/E3_Resource_Adequacy_in_the_Pacific-Northwest_March_2019.pdf
- IEEE: A Methodology for Estimating the Capacity Value of Demand Response
  - https://ieeexplore.ieee.org/document/6939174
- The CAISO is considering leveraging industry experts for the purposes of developing an ELCC approach for California variable-output demand response.

Maximum Run Time Parameter for Demand Response

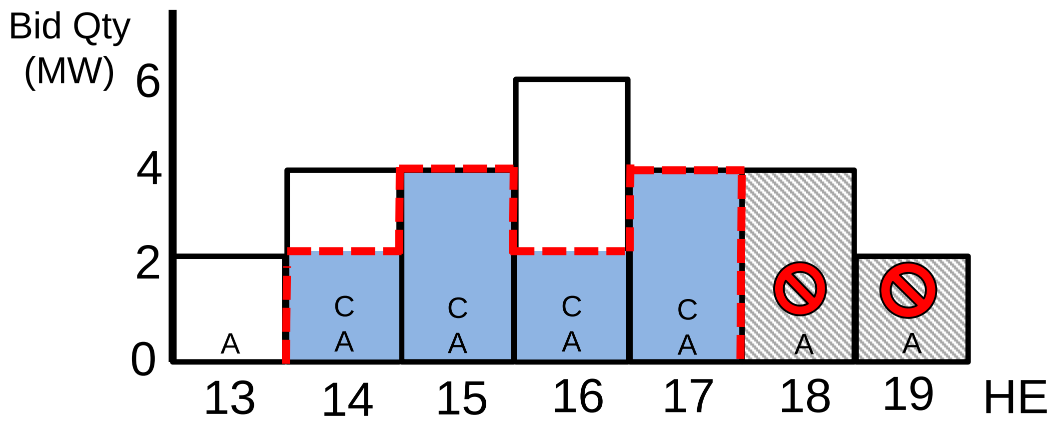
Operational Characteristics of DR Resources

1. DR program has a maximum number of hours
   – If dispatched to curtail the resource has a time limit.
2. Needs continuous dispatch
   – Once dispatched to curtail, the resource must stay on or end curtailment.
   – Unable to respond to dispatch for movement between Pmin and Pmax.
3. No flexibility to represent a Pmin > 0 MW

Maximum Run Time Parameter Definition

- Stakeholders have requested the ISO implement a maximum run time parameter.
- Minimum run time is defined as the minimum amount of time a unit must stay on-line after being started-up.
- Max run time would similarly be defined as the "maximum amount of time a unit can stay on-line after being started-up."
  - "Start-up" is defined as a commitment status transition from Off to On.

Max Run Time Proposal: With Pmin > 0 MW (lowest bid quantity)



Key

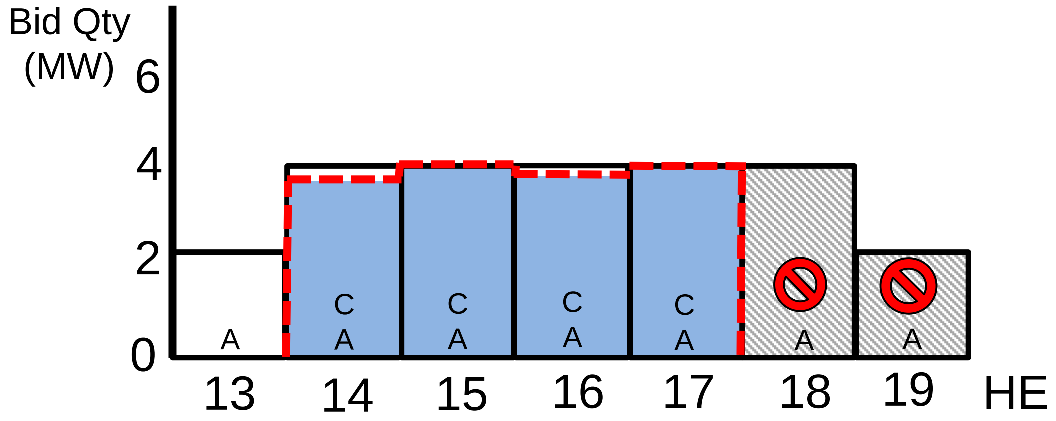
- A = Available
- C = Committed
- = Not available

Characteristics

- Pmin = 2 MW
- Start-up = 1
- Min run = 1 hr
- Max run = 4 hrs

- DR is committed to Pmin in HE 14 and dispatched to 4 MW in HE 15.
- Max run time will not allow resource to be dispatched beyond HE 17.

Max Run Time Proposal: With Pmin > 0 MW (Pmin = Pmax)



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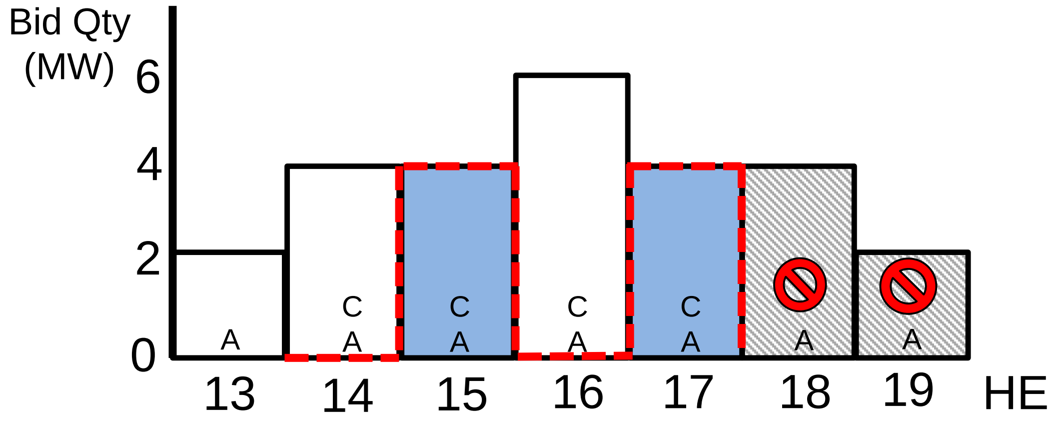
Max Run Time Proposal: With Pmin = 0 MW



Key

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Characteristics

- Pmin = 0 MW
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- Min run = 1 hr
- Max run = 4 hrs

- DR is committed to Pmin in HE 14 and dispatched to 4 MW in HE 15.
- Max run time will not allow resource to be dispatched beyond HE 17.
- Would not resolve continuous dispatch requirement.

Observations on Max Run Time

- Consideration of a max run time is highlighting the limited availability of DR capacity.
  - Once max run time is reached, the resource will no longer be available to the grid.
  - The ISO is concerned with the growing number of availability limited resources.
- Even with a max run time, DR with a Pmin of 0 MW will not receive a continuous dispatch.
  - DR will need to register a non-zero Pmin along with associated start up and minimum load costs.
  - Or, at a minimum, a start-up cost and minimum load cost (Fall 2020) with a Pmin of 0 MW.

Path Forward

- Develop a maximum run time parameter but develop rules to efficiently utilize DR.
  - Maximum run time threshold (4 hours to align with RA requirement)
  - Require registration of start up and minimum load costs
  - Explore solutions for a non-zero Pmin
- Understand interactions with variable output DR proposal.

NEXT STEPS

Next Steps

Milestone	Date
Stakeholder working group	June 27, 2019
Stakeholder comments due	July 11, 2019

Written stakeholder comments on today's discussion are due by COB July 11 to InitiativeComments@caiso.com.

All material for the ESDER initiative is available on the ISO website at: http://www.caiso.com/informed/Pages/StakeholderProcesses/EnergyStorage_DistributedEnergyResources.aspx.