Energy Storage and Distributed Energy Resources Phase 4

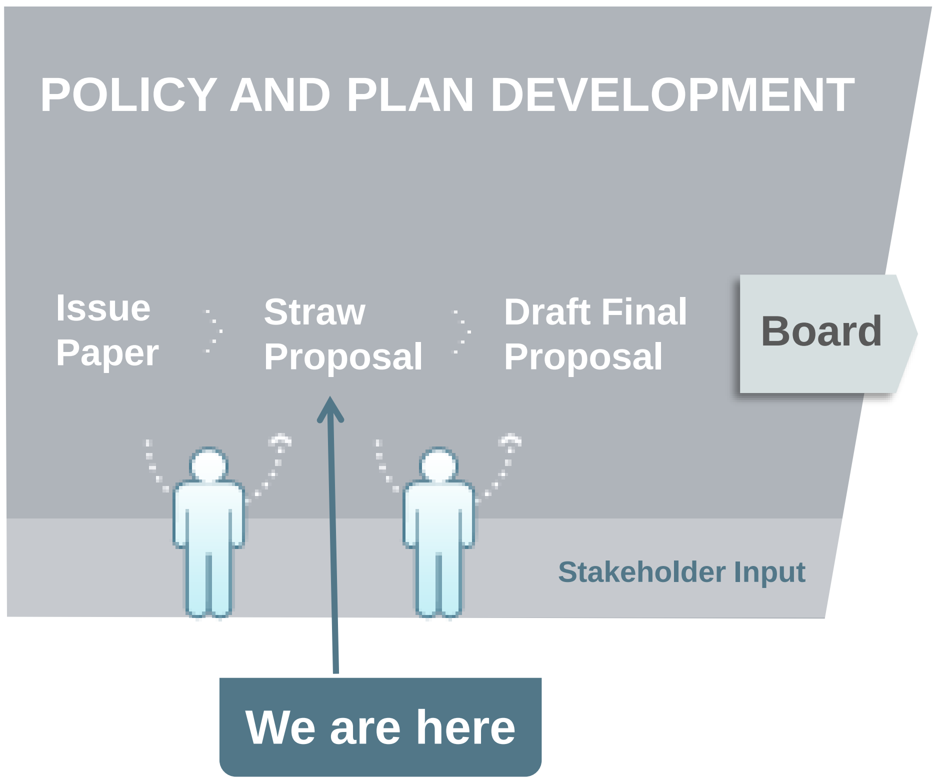
Stakeholder Working Group
August 21, 2019
9:00 a.m. – 12:00 p.m. (Pacific Time)

Agenda

Time	Item	Speaker
9:00 - 9:05	Stakeholder Process and Schedule	James Bishara
9:05 – 9:10	Objectives and Scope	Eric Kim
9:10 – 10:00	Discussion of comments related to non-24x7 settlement of BTM energy storage	Eric Kim
10:00 – 11:00	Storage DEB Proposal	Gabe Murtaugh
11:00 – 11:55	Variable Output Demand Response	Lauren Carr
11:55 – 12:00	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

STAKEHOLDER COMMENTS ON BTM SETTLEMENT

The ISO is continuing the discussion of behind-the-meter participation and settlement

- Certain stakeholders have requested the ISO remove the 24x7 settlement of resources participating under an NGR model.
  - The use case is that BTM resources want to participate under a DER aggregation model and provide services outside of the ISO market.
    - But current rules require the BTM resource to settle all energy, regardless of if it was not instructed by the ISO.

The CAISO asked the following questions for discussion

1. As a BTM resource under NGR, any wholesale market activity will affect the load forecast. How will LSEs account for changes to the load forecast due to real time market participation?
2. How would a Utility Distribution Company (UDC) prevent settling a resource at the retail rate when the BTM device is participating in the wholesale market?
3. If a BTM resource is settled only for wholesale market activity, what would prevent a resource from charging at a wholesale rate and discharging to provide retail or non-wholesale services? How would this accounting work?

Clarification based on stakeholder comments

- The non-24x7 of BTM resource is under the assumption that the resource is participating as a DER aggregation under the ISO's NGR model and <u>not</u> PDR.

- DR resources under a PDR model are not allowed to net export onto the transmission system.
  - This is a rule under CPUC jurisdiction.

The ISO is continuing the discussion of behind-the-meter participation and settlement

- Stakeholders have requested the ISO remove the 24x7 settlement of resources participating under the NGR and DERP models to accommodate multi-use.
  - BTM resources express wanting to provide wholesale services in addition to providing services outside of the ISO market.
    - Current rules require a resource participating under the NGR or DERP models to settle all energy generated from the resource in the wholesale market
      - As Instructed or Un-instructed energy

The CAISO asked the following questions for discussion

1. As a BTM resource under NGR, any wholesale market activity will affect the load forecast. How will LSEs account for changes to the load forecast due to real time market participation?
2. How would a Utility Distribution Company (UDC) prevent settling a resource at the retail rate when the BTM device is participating in the wholesale market?
3. If a BTM resource is settled only for wholesale market activity, what would prevent a resource from charging at a wholesale rate and discharging to provide retail or non-wholesale services? How would this accounting work?

Clarification based on stakeholder comments

- The non-24x7 of BTM resource participation is as the NGR and DERP participation models and <u>not</u> PDR.

- DR resources under PDR are not settled for net export of energy when dispatched for load curtailment.
  – Under CPUC jurisdiction.

Question 1: How will LSEs account for changes to load forecast?

- **CESA –** Points to similar challenges with PDR model and requests input from LSEs on how to separate retail vs. wholesale.
- **Electrify America –** Points to similar challenges with PDR model.
- **PG&E –** Currently no way for an LSE to account for changes in services between retail, distribution, and wholesale. Communication standards needed between DER and LSE for correct load forecast.
- **Public Advocates Office –** ISO and LSEs should use LIP to account for changes in load forecasting due to real time market participation of BTM resources.

Question 2: Settlement of retail vs. wholesale activity

- **CESA –** Lists three options: ex post settlement, reporting to UDCs throughout billing cycle, or estimation methodologies or tools to remove retail settlements.
- **Electrify America –** Data sharing where ISO shares market intervals during dispatches at the NGR sub-meter to the UDC and it would adjust settlements accordingly.
- **PG&E –** No rule in place from CPUC and ISO to prevent settling a BTM resource at retail vs. wholesale.
- **Public Advocates Office –** IOUs should continue to settle at retail rates of any demand reduction in customer load used to supply a wholesale service.

Question 3: Preventing wholesale charging and retail discharging

- **CESA –** Points to FERC Order 841 and PJM have developed accounting methodologies to address this issue.
- **Electrify America -** Establish bidding rules where a resource in the discharge direction bids above the NBT and for charge bids below $0.
- **PG&E –** An LSE will need to assess which electrons were used for which service. There are no current accounting methodologies to determine wholesale vs. retail.
- **Public Advocates Office –** Settlement quality meter that meets ANSI C12 metering standards for monitoring and the accounting methodology.

Other concerns and issues

- Independent Energy Producers (IEP)
  - Concerned with double counting and compensation if the BTM resource is participating as a NEM resource.
- SCE
  - What is the FERC-required interconnection that allows participation of non-24x7 participation for non-RA BTM resources?
  - Concerned with designing a participation model without understanding if there are any double-counting for services between distribution and transmission.

PG&E laid out areas of need and the cross-jurisdictional requirements of a non-24x7 settlement.

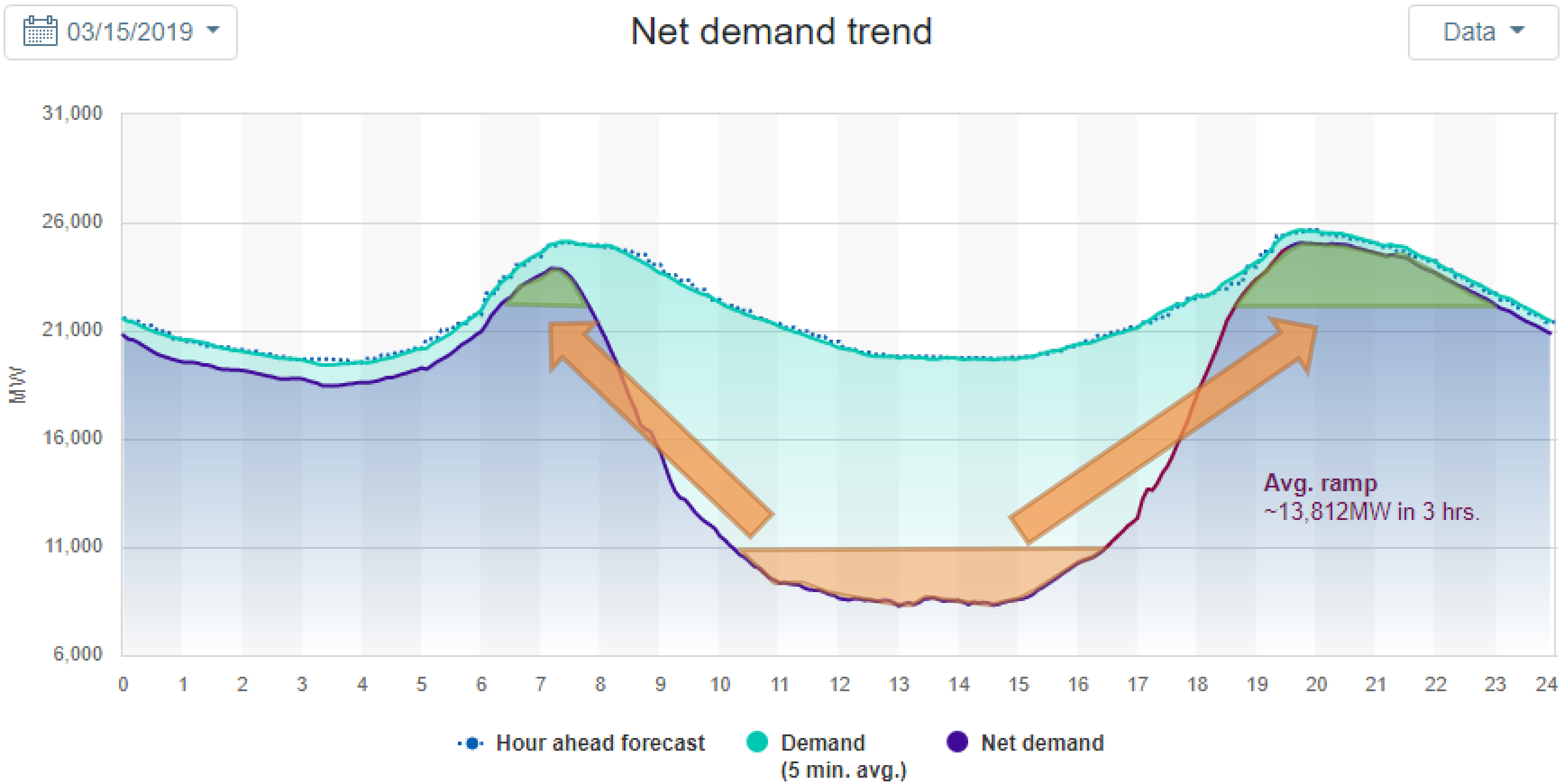
1. **Rules & Standards**
   - UDCs and LSEs need jurisdictional clarity when a CPUC jurisdictional BTM resource participates by exporting into the ISO.
2. **Support Systems**
   - Separate metering is needed to understand wholesale vs. retail.
   - Accounting methodology for when sub-meter is behind a retail meter and service is provided in different intervals.
   - IT and billing systems to support these new proposals
3. **Operations and Communication**
   - Communication protocols or standards for DER providers to inform LSEs of their operational configuration for a given day/season.

MARKET POWER MITIGATION FOR ENERGY STORAGE

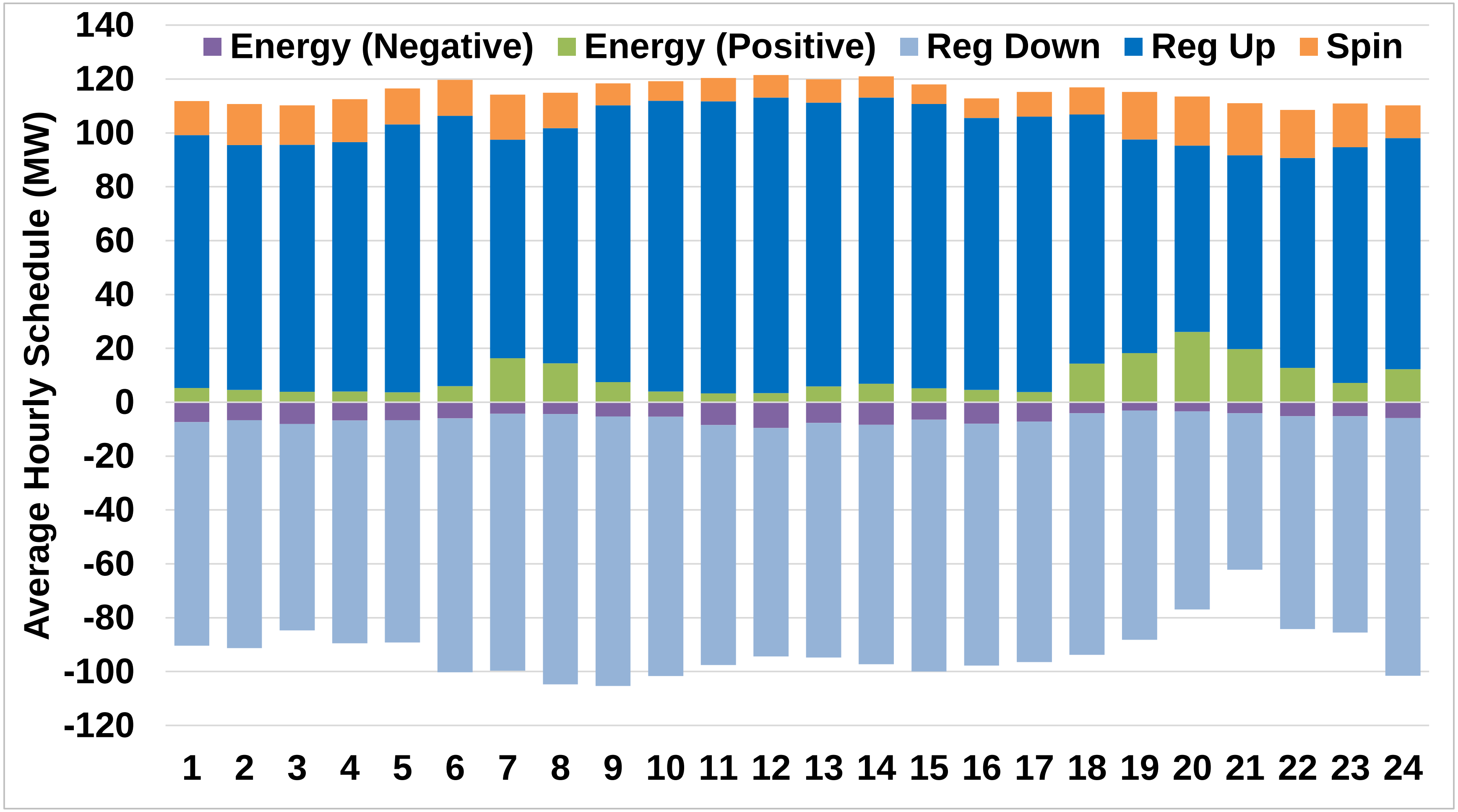
The ISO is proposing a methodology to calculate default energy bids for storage resources in ESDER 4

- 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 'shift' energy from one time of the day to another



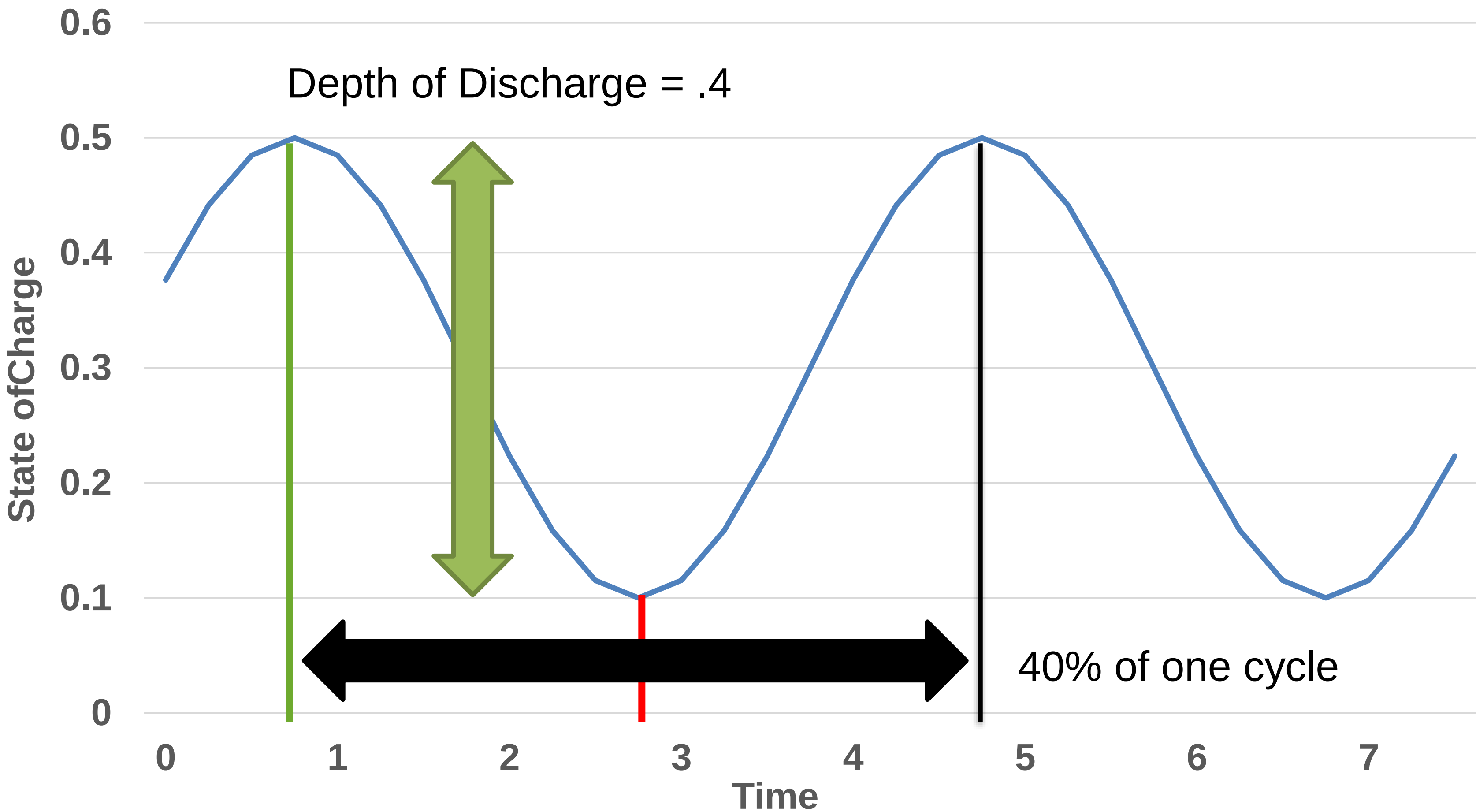
Battery dispatch data shows storage was scheduled for regulation and not energy in 2019H1



Storage definitions used in this paper

- Cycle – Complete (100%) charge-discharge of the battery
- Depth of Discharge (DoD) – Percentage of the state of charge (SOC) that the battery loses while discharging
- 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 ISO 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 faster with “deeper” cycles
  - Cycling costs should be included in the DEBs, as they are directly related to storage resource operation
  - It is expensive for these resources to capture current spreads
- Opportunity costs

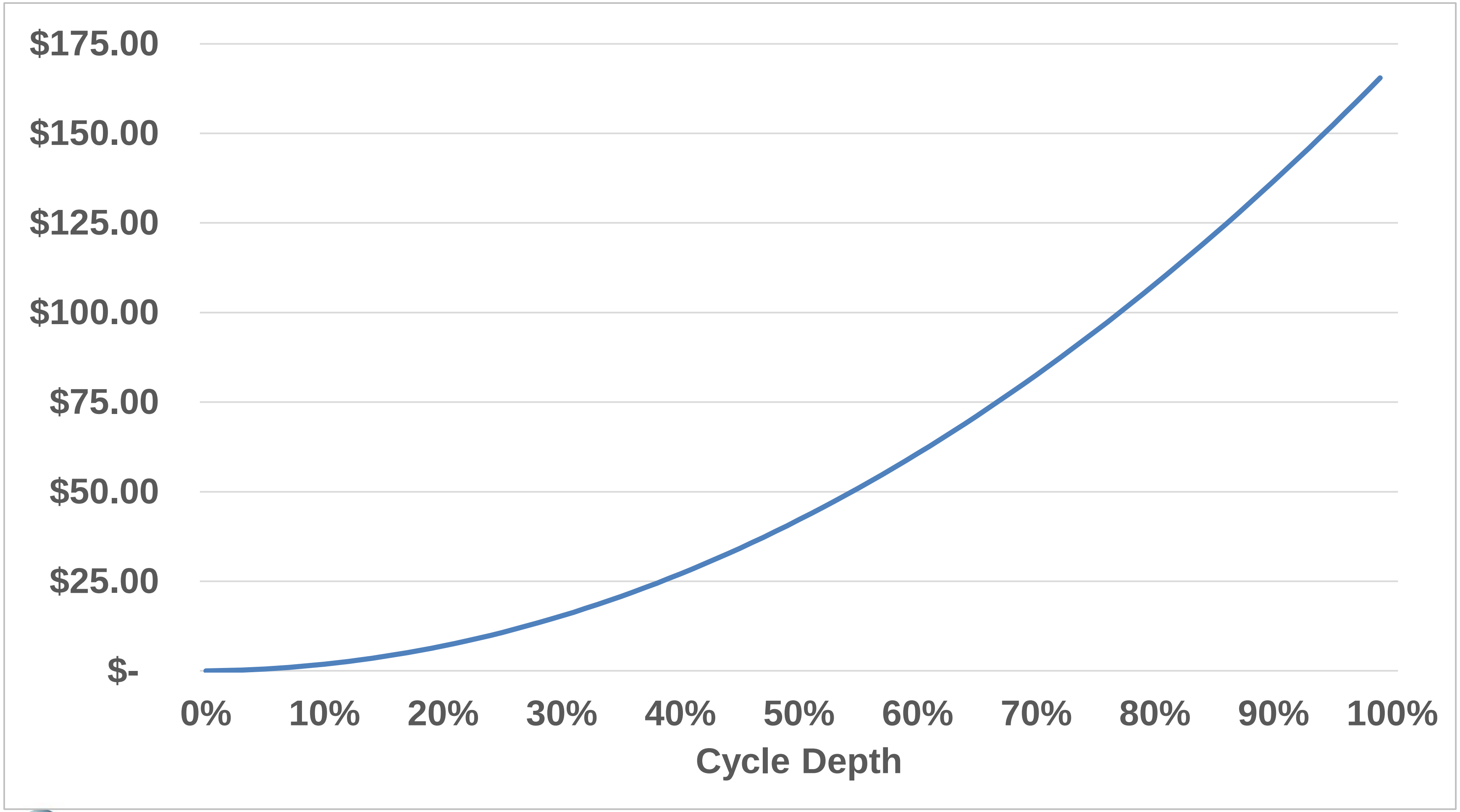
Cycle Aging Cost paper outlines offers a detailed model for battery aging costs

- Identifies cycling costs as primary cost and current rate, over charge/discharge, average state of charge as other drivers
- Include a "rainflow" model to account for cycling costs
  - Models the battery in multiple small segments
- Quantifies the idea that deeper discharges are more expensive

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

- IEEE publication by Bolun et al.

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



A simplified example of the model can illustrate costs

Cycle Depth (CD)	Total Cost ($)	Marginal Cost ($)
10%	1	1
20%	4	3
30%	9	5
40%	16	7
50%	25	9
60%	36	11
70%	49	13

- There is a quadratic relationship between **total cost** and **cycle depth**
- Marginal costs increase linearly as cycle depth increases

The speed of discharge does not impact costs

Hour	P (MW)	SOC (MWh)	SOC (%)	Cost
1	0	7	70%	0
2	4	3	30%	16
3	0	3	30%	0
4	0	3	30%	0
5	0	3	30%	0
6	0	3	30%	0
SUM:				16

Hour	P (MW)	SOC (MWh)	SOC (%)	Cost
1	0	7	70%	0
2	1	6	60%	1
3	1	5	50%	3
4	1	4	40%	5
5	1	3	30%	7
6	0	3	30%	0
				16

Depth of discharge ‘resets’ when the resource charges

Cycle Depth (CD)	Total Cost ($)	Marginal Cost ($)
10%	1	1
20%	4	3
30%	9	5
40%	16	7
50%	25	9
60%	36	11
70%	49	13

Hour	P (MW)	SOC (MWh)	SOC (%)	Cost ($)
1	0	7	70%	0
2	4	3	30%	16
3	-2	5	50%	0
4	2	3	30%	4
5	1	2	20%	**9**
6	1	1	10%	**11**
SUM:				40

- Note the relatively low cost for dispatch in hour 4 and the relatively high cost to dispatch in hour 5
- This example illustrates the ‘rainflow’ model approach to accounting for storage resource cycling costs

Example: Costs can be demonstrated in a relatively simple manner with respect to ***cycle depth***

$$Total\ Cost\ for\ Discharge = (Cycle\ Depth)^2$$

$$Marginal\ Cost\ for\ Discharge = 2 * Cycle\ Depth$$

where Cycle Depth is a value between 0 and 1

Cycle Depth (%)	Total Cost	Marginal Cost
1	0.10	0.2
20	40	4
40	160	8
60	360	12
70	490	14

The ISO has two potential ideas for modelling these costs using existing software

- ISO software is limited by the number binary variables that can be introduced and arrive at a timely solution
  - Precludes inclusion of complete ‘rainflow’ model
  - The ISO makes simplifying assumptions for modelled resources today (i.e. linear fuel costs for gas resources)
- Modelling non-linear discharge costs in DEBs will necessitate that the ISO include this model in bids
- Software dispatches resources based on MW bids, rather than state of charge bids
- Both proposed models have cost adders that will be included in the market optimization for bids and DEBs
  - Will need additional testing to vet best approach to apply
  - Both models use this hypothetical example cost characterization

The first model includes a multiplier applied to the 'distance' dispatch SOC is below maximum SOC

- Model energy with the state of charge

$$CD_{i,t} = v_{i,t}\, \rho_i \left(Max\, SOC\ - SOC_{i,t}\right)$$

where:

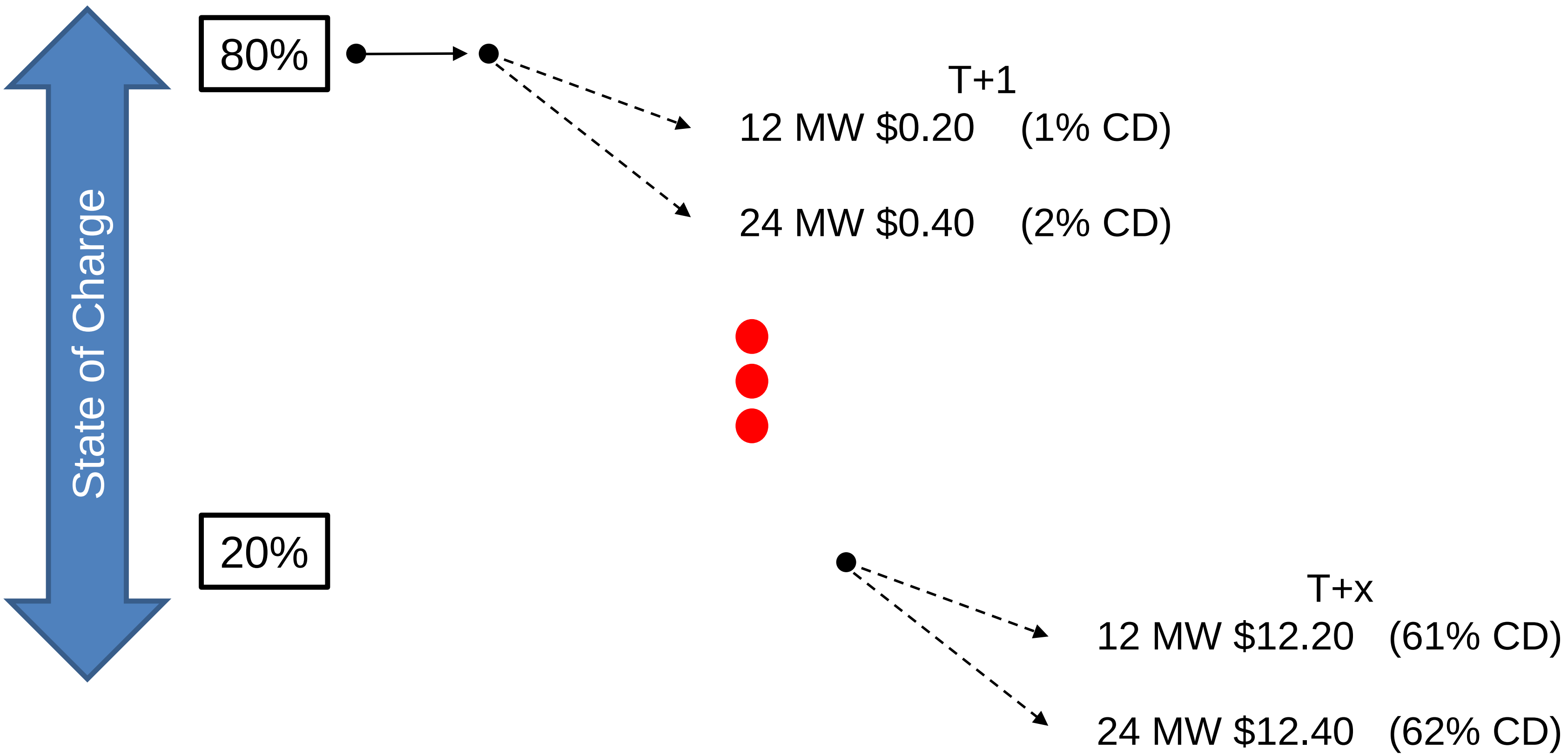
i: Resource
t: Interval

v: Binary = 1 when the state of charge is decreasing
ρ: Constant

Max SOC: Maximum SOC available for dispatch
SOC: State of charge (Market decision variable)

Assume a +/-24 MW storage resource with 100 MWh of capacity and ***ρ* = 20**. Resource is forbidden to operate above 80 MWh or below 10 MWh (Max discharge = 70%).

Proposed DEB including marginal cost adder included in the market optimization to determine dispatch



There are several pros and cons to modelling resources based on maximum cycle depth

Pros

- This model will always be greater than or equal to the cost to operate the battery
  - Aligns with increasing marginal costs
- Price for any discharge increases as state of charge decreases
  - Market outcomes will tend to charge the battery

Cons

- The model may grossly overestimate the cost to produce
  - Assumes costs at maximum cycle depth
  - This happens if the resource charges “mid-discharge”
  - Does not account for ‘rainflow’ methodlogy

The second model includes a multiplier applied to the difference in SOC from one interval to the next

- Model energy with the state of charge

$$CD_{i,t} = u_{i,t}\,\rho_i\left(SOC_{i,t-1} - SOC_{i,t}\right)$$

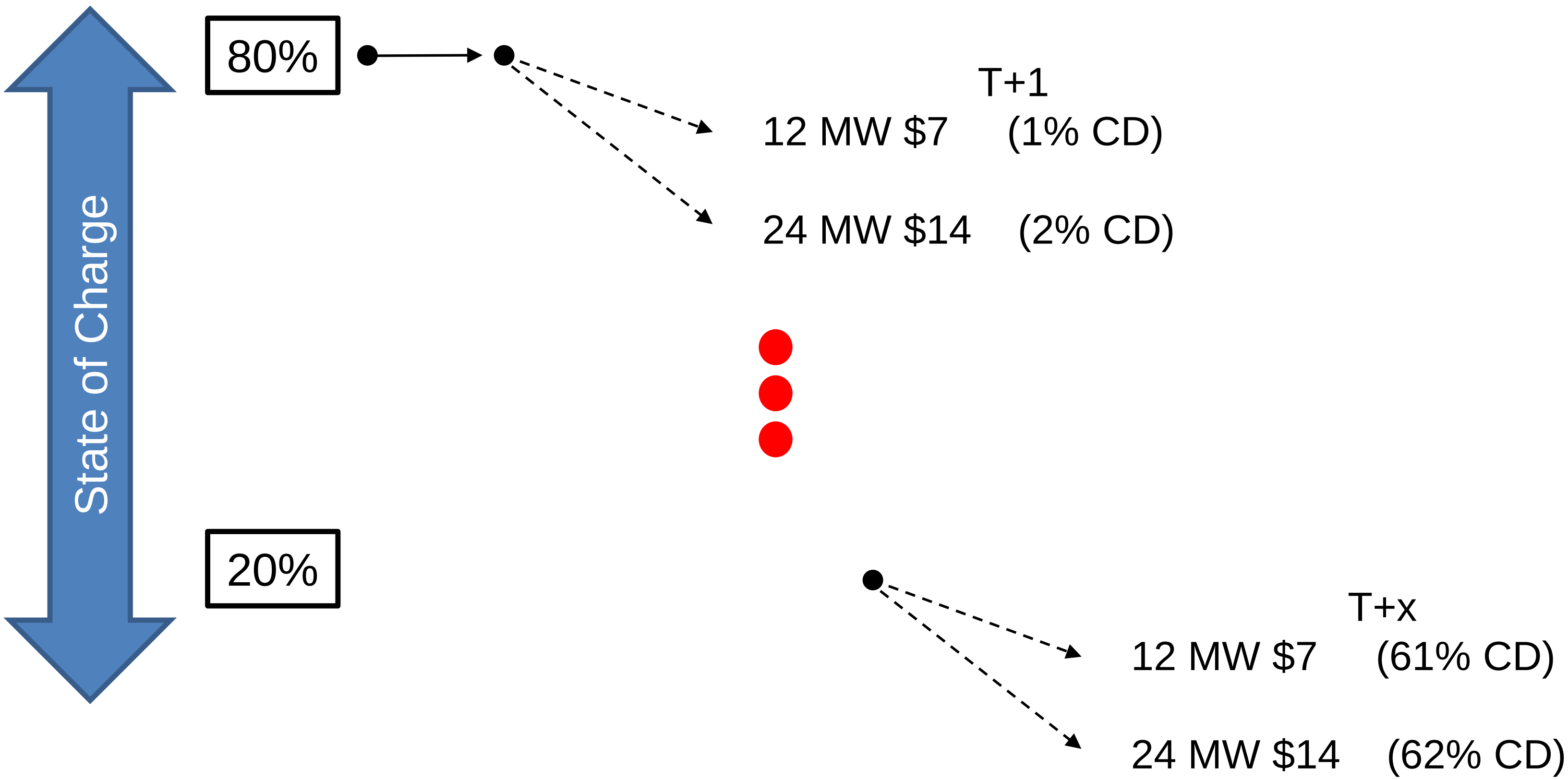
$$= u_{i,t}\,\rho_i\,\frac{P_{i,t-1} + P_{i,t}}{2}\,\frac{\Delta T}{T}$$

where:

P: Dispatch instruction (Market decision variable)

Assume a +/-24 MW storage resource with 100 MWh of capacity and **ρ = 700**

This cost characterization causes all individual interval deeper discharges to be more expensive



There are several pros and cons to modelling resources based on total costs for cycle depth

Pros

- May more efficiently dispatch resources for energy (MWh)
- May more consistently produce the correct price on average

Cons

- – Overestimates costs for large dispatches when cycle depth is thin and under estimates costs for small dispatches when cycle depth is deep

The ISO will need to collect additional information in Master File and storage bids to construct DEBs

- Losses: round trip and parasitic
- Cost estimates for cell augmentation
  - May differ with expected cost date
  - May differ with facility/vendor/market participant
- ISO may use collected values and industry data to develop DEBs
  - ISO does not want bids to force batteries to produce energy through mitigation when not economic to do so
  - At the same time we want a measure to allow for the potential mitigation of market power
- Biddable ‘multiplier’ parameters

Other concerns about batteries have been raised during this initiative

- What tools does the ISO have to ensure that resources are charged during a period
  - 1.75 hour binding RTPD dispatch instructions
  - Exceptional dispatch
- The ISO may consider ‘locking’ day-ahead schedules in real-time markets and allowing storage to bid residual

Variable-Output Demand Response

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

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 their full capability

The CAISO will provide informational ELCC values for demand response resources for stakeholder and LRA consideration

- Analysis will require data inputs that inform DR resources' availability
  - Total Capacity (Pmax)
  - Number of Calls (calls/month, calls/year, number of consecutive days)
  - Maximum call duration
  - Hourly load profile (to reflect variability by hour, season, weather, etc.)

CAISO requests feedback from stakeholders on data inputs and assumptions regarding DR availability

- As a starting point, the CAISO could assume the following:
  - Availability required for a resource to provide resource adequacy
    - 4 hour duration
    - 24 hours per month
    - 3 consecutive days
    - Available during the RA measurement hours (aligned with the Availability Assessment Hours)
  - Bids reflect hourly load profile
- Could be more beneficial to consider programs available beyond minimum availability requirements
  - Much of this information should be available in the Load Impact Protocol reports for utility programs

CAISO could treat variable-output DR similar to VERs for market participation and must offer obligations

- VERs bid the amount they are physically capable of providing as specified through a forecast in order to meet their must offer obligation
- Forecasts are provided every 5 minutes on a rolling basis, looking out at least 2.5 hours
  - Each 15-minute schedule is based on the average of the three relevant 5-minute interval forecasts
  - 5 minute dispatch based on the most recent forecast
- Bids submitted 75 minutes before the operating hour
  - The forecast sets the upper economic limit on bids

CAISO utilizes real-time data to provide forecasts and feasible dispatches for VERs

- VERs submit various real-time production data and meteorological data every 4 seconds for the CAISO to accurately forecast and provide feasible dispatches
- FMM dispatches will be awarded at the FMM price, subject to further modification in RTD
  - FMM:

    Thirty minutes ago the CAISO forecasts a solar resource's output of 50 MW

    ✓ *Solar resource received a 50 MW schedule*
  - RTD:

    Utilizing the most updated information, including telemetry, forecast shows resource can now only produce 45 MW

    ✓ *Solar farm receives a 45 MW dispatch*
    - The 5 MW difference is settled as a real time imbalance energy

Updated forecast and real-time data provides more accurate and feasible RTD results

CAISO requests stakeholder feedback on the feasibility of demand response providers submitting resource capability as real-time data

- SCs for variable-output DR must submit capability
  - CAISO does not have appropriate visibility into individual resource capabilities for DR resources
  - Load Impact Protocols (LIPs) could be leveraged to develop a profile of load impacts to determine resource capability
- Could capability be provided to the CAISO through an automated, real-time process?
- Is it feasible and not cost prohibitive for variable-output demand response to provide resource capability as real-time data?

NEXT STEPS

Next Steps

Milestone	Date
Stakeholder Comments	September 4, 2019
Revised Straw Proposal	September 19, 2019
Stakeholder Web Conference	September 25, 2019

Written stakeholder comments on today's discussion are due by COB September 4 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.