California ISO

Energy Storage and Distributed Energy Resources (ESDER) Phase 4: Storage Cost Working Group

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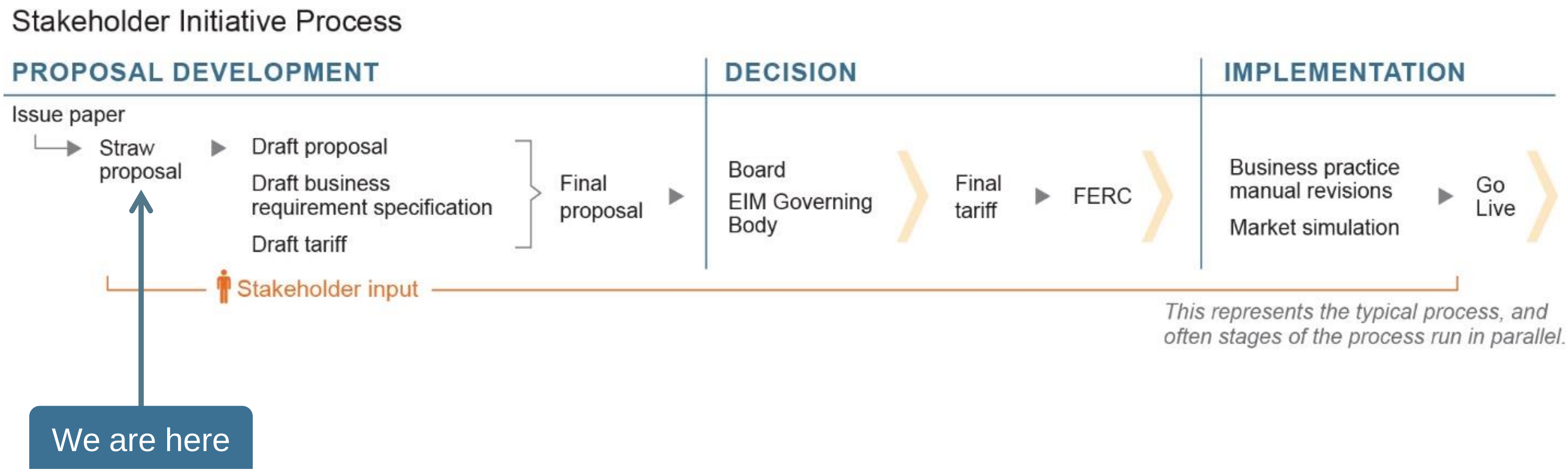
Agenda

Time	Item	Speaker
10:00 – 10:05	Welcome & Stakeholder Process	James Bishara
10:05 – 12:00	Energy Market Framework • ISO energy market framework • Variable operation costs for storage resources • Storage resources within this framework	Gabe Murtaugh
12:00 – 1:00	Break	
1:00 – 2:55	Formulating a Default Energy Bid • Energy and opportunity cost components • Marginal cell degradation component • Applying this methodology to specific resources	Gabe Murtaugh
2:55 – 3:00	Next Steps	James Bishara

ISO Policy Initiative Stakeholder Process



Storage definitions used in this paper

- Cycles* – Complete (100%) charge-discharge of the battery
- 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)

Acronym List

CD – Cycle depth

DEB – Default energy bid

DoD – Depth of discharge

GHG – Green house gas

LMP – Locational marginal price

MC – Marginal cost

O&M – Operations and maintenance

PPA – Power purchase agreement

RA – Resource adequacy

RTM – Real time market

SOC – State of charge

Energy Market Framework

The framework that is ultimately implemented for storage resources is malleable

- Much of the work completed to date in this initiative is based on existing published literature on storage resources
- Significant research and development is occurring and storage technology is evolving
- There are many types of storage being developed with varying chemistries, duration, and storage methods
- The default energy bid framework to represent marginal costs should work with anticipated additions to the fleet over the next few years, but also accommodate future generations of technology
- While there is some installed capacity, we are still learning about the operational characteristics of storage resources

Bids from all resources are combined to create a supply stack

- Bids, reflecting **incremental costs** for resources, are considered when dispatch instructions are determined

MW Bids	Price
75	$0
150	$10
100	$30
25	$45
…	…

→

Supply Stack (MW)	Price
0-75 MW	$0
75-225 MW	$10
225-325 MW	$30
325-330 MW	$45
…	…

- This market design creates efficient resource dispatch instructions
  - A market clearing price incentivizes lower cost resources to generate and higher priced resources to idle
  - Incentivizes resources to bid in at their true incremental cost

Gas resources illustrate why these market principles work

The example on the previous slide is highly simplified, but informative of general market principles. Additional market considerations include:

- Ramping and transmission constraints
- Energy and ancillary service, which are co-optimized
- Resources may have multiple steps in bid curve

Incremental costs for gas resources are highly correlated with the cost of gas and include other costs as well

- Gas prices * resource efficiency (heat rates)
- Other costs include variable O&M, GHG adders, grid management adders

Gas resources illustrate important concepts that can be applied to storage resources

- Bifurcation between fixed costs and variable costs
  - Bidding variable costs does not preclude any resource from earning market rents in the energy market
  - Incremental costs are bid into the energy market and recovered through market revenues
  - Fixed costs generally are recovered through long-term agreements and RA contracts
- Costs bid into the market do not include contractual costs, or contractually imposed usage limitations. They represent actual variable costs for the resource to operate.

Estimates for incremental cost for storage resources can be informed by a similar paradigm

- Storage resources incur cost when the resource is initially built
  - These are fixed costs, and should not be considered in variable costs
  - These costs may be recovered by PPA or RA contracts, and revenues above costs in the energy and AS markets
- Storage resources require augmentation as they cycle
  - As storage resources cycle they require cell augmentation to maintain interconnection capacity
  - Cell augmentation should be included in variable costs
    - These costs may be recovered through energy market revenues
  - Cell augmentation might be a profit maximizing strategy for a resource owner, as this will allow the resource to utilize full capability of the invertor at the battery location
- Additional costs incurred during operations, but not effected by the amount of energy generated, should be considered as fixed costs

The ISO currently has little experience with actual costs associated with storage operation

This example may illustrate these costs

- Assume a $300/kW-year price to build a storage resource
  - Referenced in a recent Lazard (link below) report and in the ISO's TPP
  - Ignoring financing, time value of money, etc. a 1 MW battery with an expected 10 year life may be a total cost of $3 million
  - Assume that the cost of the battery cell component alone is $1.5 million
  - If the approximate battery cells degrade at a rate of about 1% per year, if the resource cycles once per day, then the total cost to cycle the storage resource once is $\frac{1}{365} * \frac{\$1.5\ million}{100} \approx \$41$
  - This may be lower if the storage resource runs for multiple hours.

TPP: http://www.caiso.com/Documents/ISO_BoardApproved-2018-2019_Transmission_Plan.pdf

Lazard: https://www.lazard.com/media/450774/lazards-levelized-cost-of-storage-version-40-vfinal.pdf

Example assuming a storage resource with very straightforward costs and constant cell degradation

Suppose this very simple design for a storage resource:

- No losses
- Energy is free to buy (when charging)
- No opportunity costs
- Resource degrades at $40/MWh

→ When market prices are higher than $40/MWh this resource is profitable to operate; when prices are less than $40/MWh then it is unprofitable

- This example is based on the assumption that a resource may replace cells at any time at a uniform cost
- These costs due to cell degradation may provide perfect replacement capacity and restore a battery to full operability

To establish baseline variable operations and maintenance values the ISO will review these costs

- If this example did illustrate actual costs and degradation curves for a resource these costs would need to be verified by the ISO for the approval of any storage default energy bid or custom default energy
- This is the practice followed by the ISO today, to establish guidelines for variable O&M adders for individual resources currently on the system and fleet averages
  - Average values are reviewed to set default variable operations and maintenance values which may be included in ‘variable cost’ default energy bids

The ISO offers three default energy bid options in the master file, which will be available to storage

- **Variable Cost**
  - Reflects gas costs for gas resources
  - Includes variable operations and maintenance reflecting values for each technology
- **LMP Based**
  - Reflects the lowest quartile of locational prices over the last 90 days when the resource was dispatched
- **Negotiated**
  - Default energy bids are negotiated with the ISO or DMM and built to reflect actual incremntal costs

How should the ISO develop a DEB for storage resources?

- If all storage resources were as straightforward as the example resource with a $40/MWh unchanging variable cost, a default energy bid would be as simple as a single adder for storage in the variable DEB tariff definition
- If such a parameter is a solution for many resources, much of the work in this policy to date, may be unnecessary
- Although the example is illustrative of how costs could work for the simplest resource, the next few slides walk through potential reasons why they may not accurately illustrate costs, and some potential ways these differences may be addressed

Certain factors for batteries make the variable cost calculation more complicated than the example

- A fleet of resources may have varying costs
  - Distributions of these costs can be constructed and a standard value may be set to cover most resources
- Costs may change <u>over time</u> as the battery ages
  - Average costs can be adjusted over time as battery cells change with age with master file values
- Costs may vary with <u>state of charge</u>
  - May consider adders for specific state of charge values
  - These may require additional binary variables in the optimization
- Costs may vary with <u>temperature</u>
  - These factors can be updated seasonally/monthly, with expected averages
  - To what extent does air conditioning at the facilities play a role in operating temperature?

Certain factors for batteries make the variable cost calculation more complicated than the example

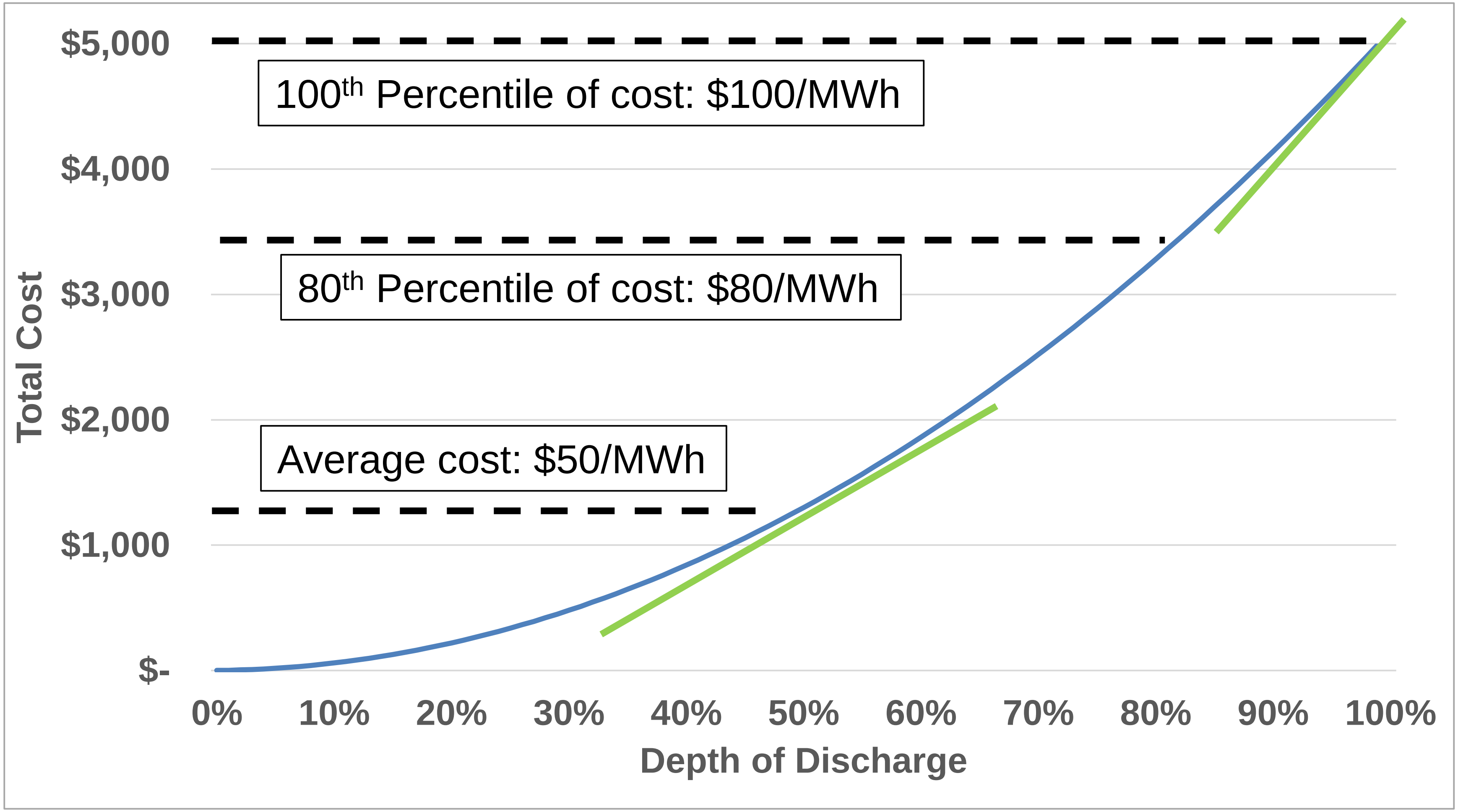
- Costs may vary with the discharge rate
  - Discharge rates are a function of dispatch instructions and can be directly factored into any default energy bid
  - To what extent are discharge rates variable for 4 hour batteries that can only discharge between 0-2% during any given 5-minute interval?
  - For example a 25 MW storage resource with 100 MWh of storage capacity will only ever be dispatched to discharge $\frac{25\ MW}{12} \approx 2MWh$ during any 5-minute interval
  - To what extent are discharge rates of 0.5 MWh different than discharge rates of 1 MWh or 2 MWh?

Certain factors for batteries make the variable cost calculation more complicated than the example

- Storage resources may have non-linear costs
  - This policy has discussed this possibility at length
  - Xu (link below) illustrates that the costs for storage may be quadratic with depth of discharge
  - Non-linear costs are challenging to model because average costs may not cover large portions of the costs incurred to run a resource and values that do cover all/most costs may overstate actual cost of degradation during most intervals
  - Do storage resources really incur these costs in a quadratic fashion? Are the actual costs large enough that a simple flat adder would not cover most costs?

Xu, et al: https://arxiv.org/pdf/1707.04567.pdf

Quadratic total costs imply potentially high DEB values to cover all, or even most incremental costs



Two proposals were outlined to capture potential non-linear costs

- Actually tracking the total depth of discharge is incredibly computationally burdensome
  - May be able to calculate accurately for a single resource on an hourly basis, but many resources on a 5-minute basis is not feasible

- However, current state of charge values can infer the maximum depth of discharge that is feasible, which can be used to create an upper bound for the cost of a resource to discharge

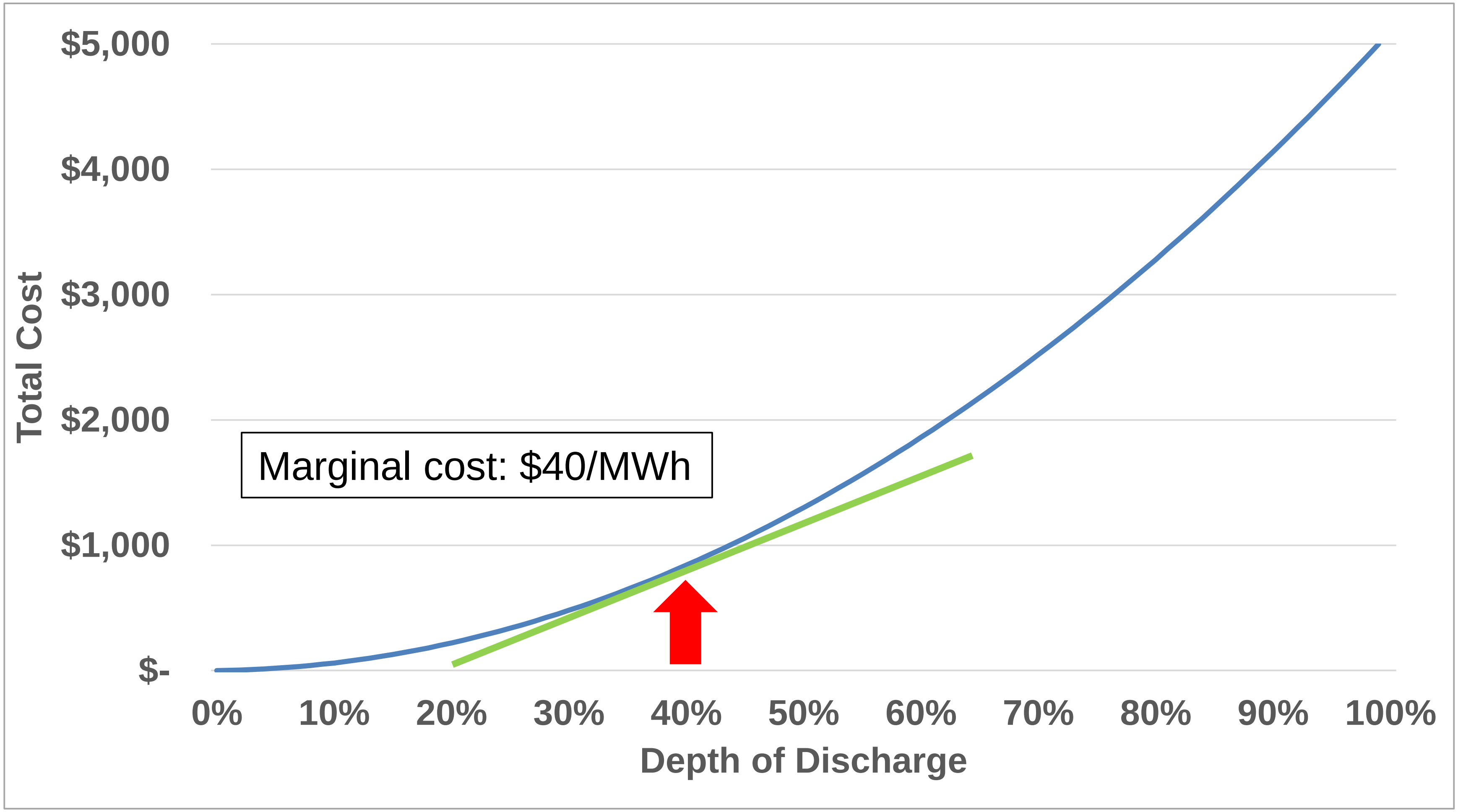
The current state of charge can inform an upper bound on the incremental cost of cell degradation

- In the previous example, if the current state of charge for a resource is 60%, the maximum possible depth of discharge would be 40%

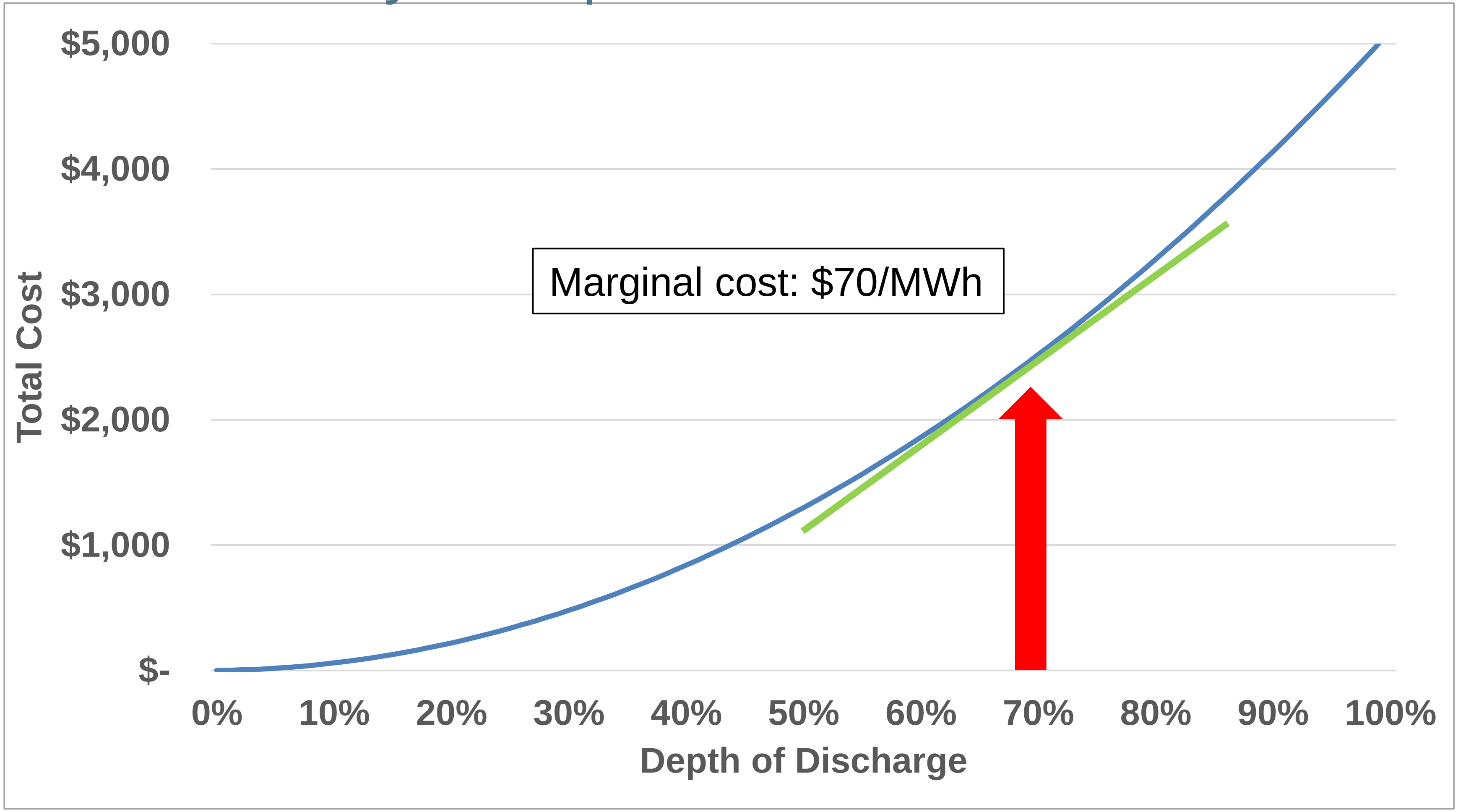
- This value could set a baseline, or an upper extreme value for these resources for calculating a default energy bid

- Similarly, if the current state of charge for the resource is 30% the maximum possible depth of discharge is 70%

A resource at 60% state of charge, could at most, be at a 40% cycle depth, with a cost of $40/MWh



A resource at 30% state of charge, could at most, be at a 70% cycle depth, with a cost of $70/MWh



Formulating a Default Energy Bid

What framework might is needed to capture incremental costs of storage resource

- Consider state of charge as a parameter in cost function
  - Reluctant to introduce unnecessary binary variables in the ISO’s cost minimizing market solution
- Consider additional weight on the dispatch instruction
  - Are these weights linear?
- What other factors that need to be considered?

ISO must maintain non-decreasing (convex) nature of bid curves for all resources with regard to MW values

All cost categories for storage resources should be included in the default energy bid calculation

- 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

The proposed default energy bid for storage resources combines these costs

$$Storage\ DEB = Max\left[\left(\frac{En}{\eta} + CD\right), OC\right] * 1.1$$

- Energy Costs (*En*) – Cost or expected cost for the resource to purchase energy
- Losses (η) – Round-trip efficiency values (calculated from losses) currently impact lithium-ion storage resources. May include parasitic losses in future models
- Cycle Depth Costs (CD) – Cost, in terms of cell degradation represented in $/MWh, to operate the storage resource
- Opportunity Cost (OC) – An adder to ensure that resources with limited energy are not prematurely dispatched, before the highest priced hours of the day

Energy costs are built to measure the expected cost for resources to buy energy

$$En_d^{\delta} = En_{d-1}^{\delta} * Max\left(\frac{DAB_d}{DAB_{d-1}}, 1\right)$$

- Energy Costs (*En*) – Calculated based on relevant bilateral index prices (DAB) from previous day to current day
- Energy costs will estimate the cost for a storage resource to charge
- Storage duration (δ) – Represents the amount of storage a resource is capable of discharging, in hours, and will be used to determine the estimated energy price that a resource would pay to charge
- Day (*d*) – Value for a specific day *d*
- Each resource will be mapped to a single representative bilateral hub, which will scale prior day prices to expected prices
- The ISO is not carrying out any supply and demand analysis to forecast anticipated prices

Example calculation for expected energy costs for a storage resource with 4 hours of capacity

	Bilateral P	4th Lowest P
t	30	$20
t+1	33	$22

	Bilateral P	4th Lowest P
t	30	$20
t+1	25	$20

- Bilateral hubs may include NP-15, SP-15, Palo Verde and Mid-Columbia
- Day-ahead peak futures hub prices generally trade on the Intercontinental Exchange (ICE) for the a block of peak hours for the next trading day (i.e. futures trading on 12/3 is for energy on 12/4)

Opportunity costs are built to match the expected peak prices when resources will be able to sell energy

$$OC_d^{\delta} = OC_{d-1}^{\delta} * Max\left(\frac{DAB_d}{DAB_{d-1}}, 1\right)$$

- Opportunity Costs (*OC*) – Calculated based on relevant bilateral index prices (DAB) from previous day to current day
- Opportunity costs will estimate expected prices that a resource could discharge at, if fully charged
- Storage duration (δ) – Represents the amount of storage a resource has, in hours, and will be used to determine the estimated energy price that a resource would receive while discharging
- Day (*d*) – Value for a specific day *d*
- Each resource will be mapped to a single representative bilateral hub, which will scale prior day prices – similar to expectations for energy prices
- Opportunity costs may be formulated to include flexible ramping product and ancillary services

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

Model for the cycle depth cost of energy using current state of charge:

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

where:

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

Max SOC: Maximum SOC available for dispatch (generally 100%)
SOC: State of charge (Market decision variable)

i: Resource
t: Interval

Example Resource: Assume a +/-24 MW storage resource with 100 MWh of capacity and ***ρ* = 20**. Max SOC = 100%

During any single interval the ISO will calculate a default energy bid based on state of charge

- Suppose a hypothetical resource has η=.85, and the estimated cost for purchasing energy is $10/MWh
- For simplicity, assume opportunity costs are $0/MWh
- When the resource is charged at 100%, the adder will generally be very small

$$DEB_{i,t} = \left(\frac{En}{\eta} + CD\right) * 1.1 = \left(\frac{\$10}{.85} + v_{i,t}\,\rho_i\,\left(1\, - SOC_{i,t}\right)\right) * 1.1$$

- If the optimization chooses 0 MW then $v_{i,t} = 0$ and the DEB will equal $\frac{\$10}{.85}$ * 1.1 = $12.94/MWh
- If the optimization chooses a positive dispatch, then $v_{i,t} = 1$, and the resulting DEB will be dependent on the dispatch instruction
- The formula results in a continuous, increasing, linear function when expressed as a component of the dispatch instruction

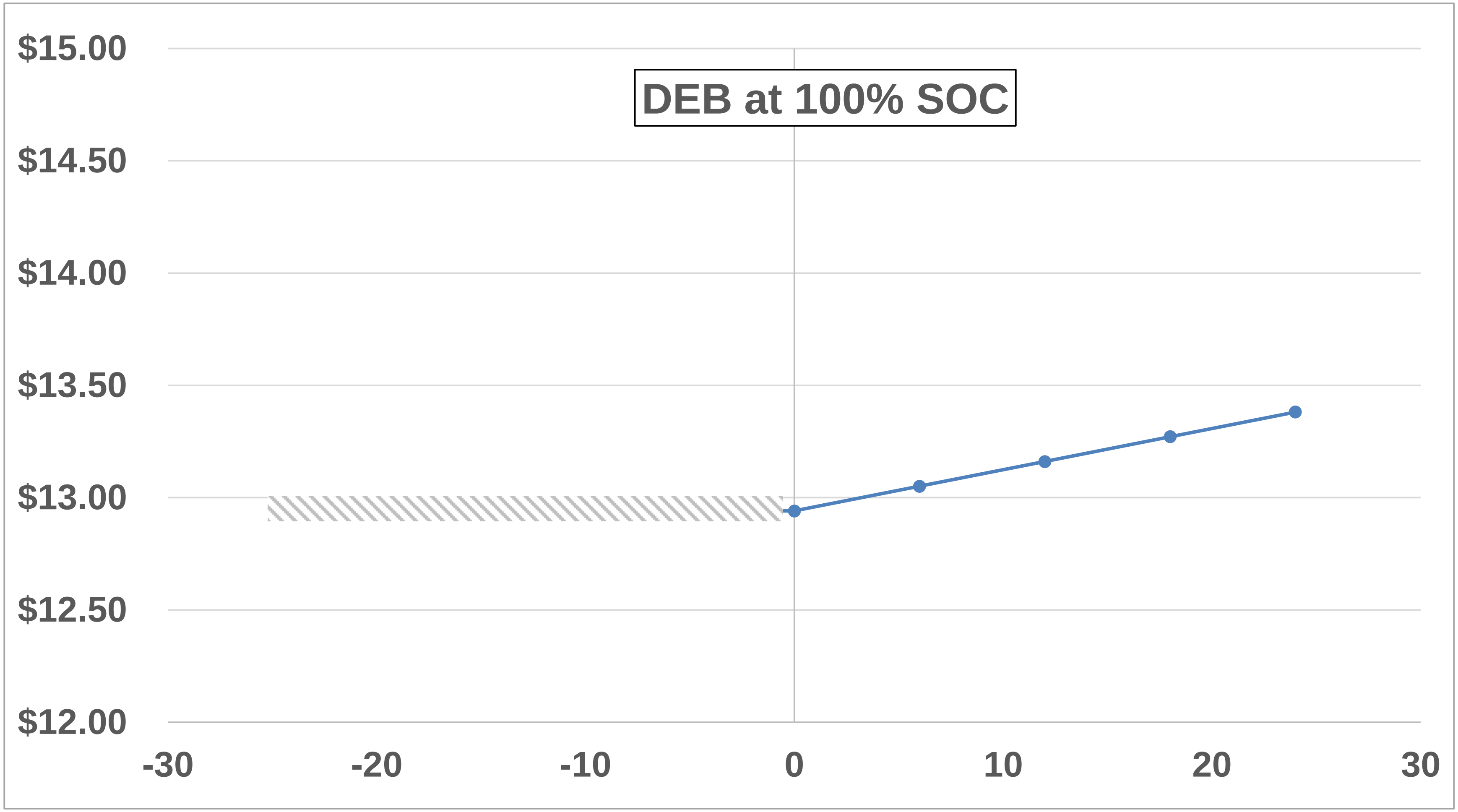
During any single interval the ISO will calculate a default energy bid based on state of charge

- Suppose the resource is a hypothetical resource that can be dispatched between -24 MW to +24 MW, and is capable of storing 100 MWh of energy
- Assume ρ_i = 20

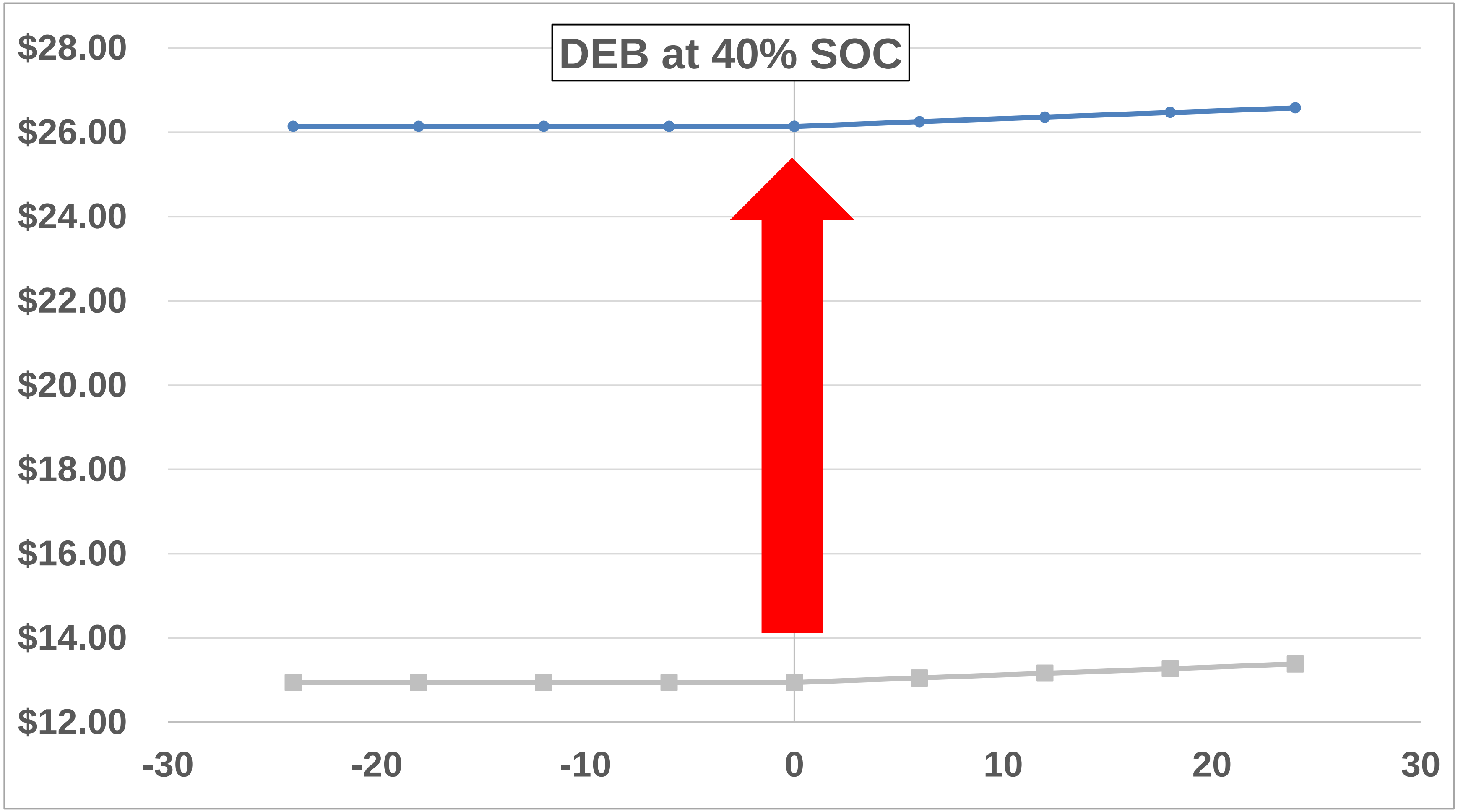
$$DEB_{i,t} = \left(\frac{En}{\eta} + CD\right) * 1.1 = \left(\frac{\$10}{.85} + v_{i,t}\,\rho_i\,\left(1 - SOC_{i,t}\right)\right) * 1.1$$

- If the optimization chooses a positive dispatch, then $v_{i,t} = 1$, and the resulting DEB will be dependent on the dispatch instruction and the resulting state of charge

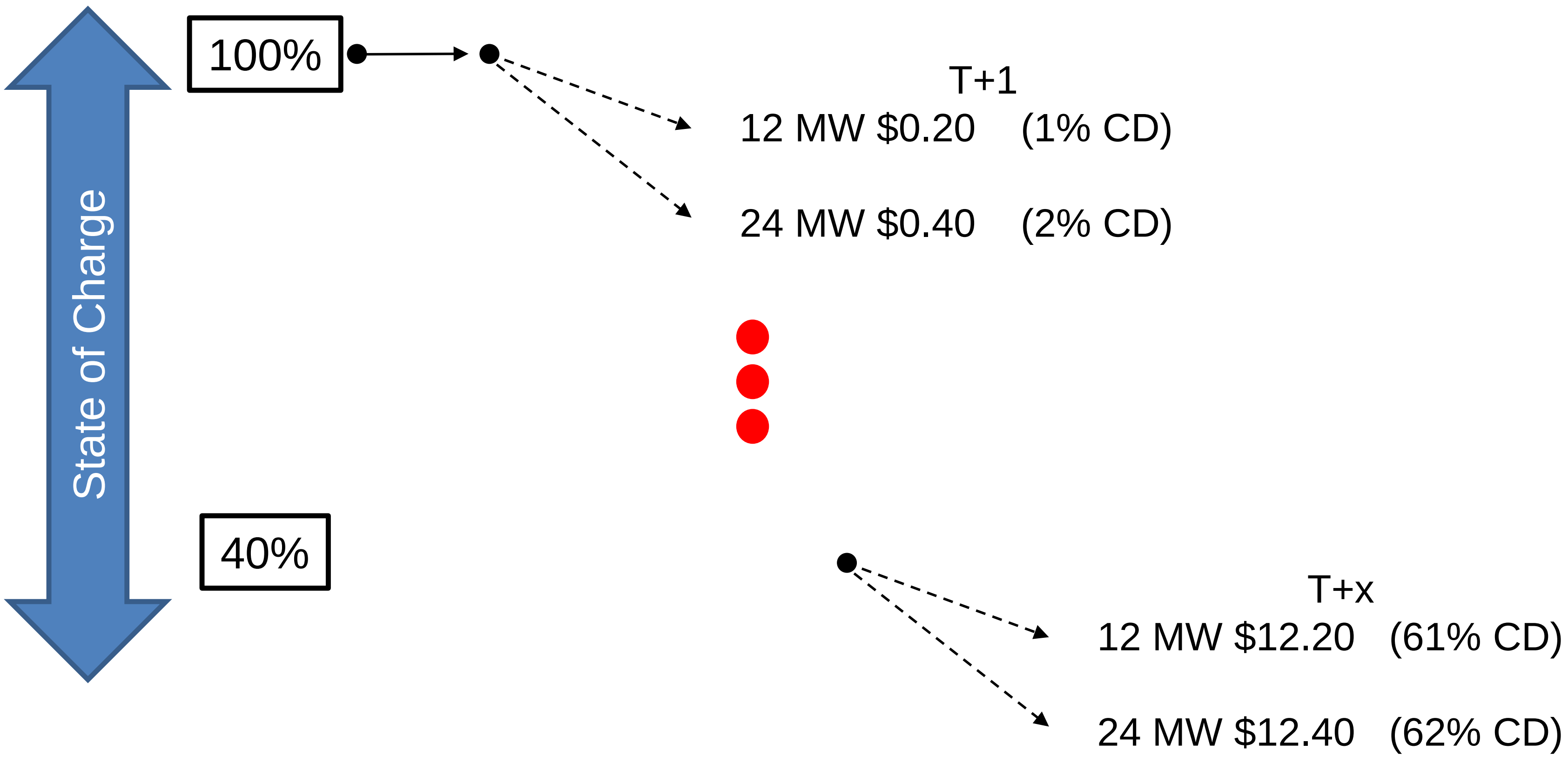
Values for the default energy bid when the resource is fully charged



Default energy bid adders get more significant for the discharge portions as the SOC decreases



Proposed dynamic CD costs reflecting incremental costs of cycle depths in the real-time market



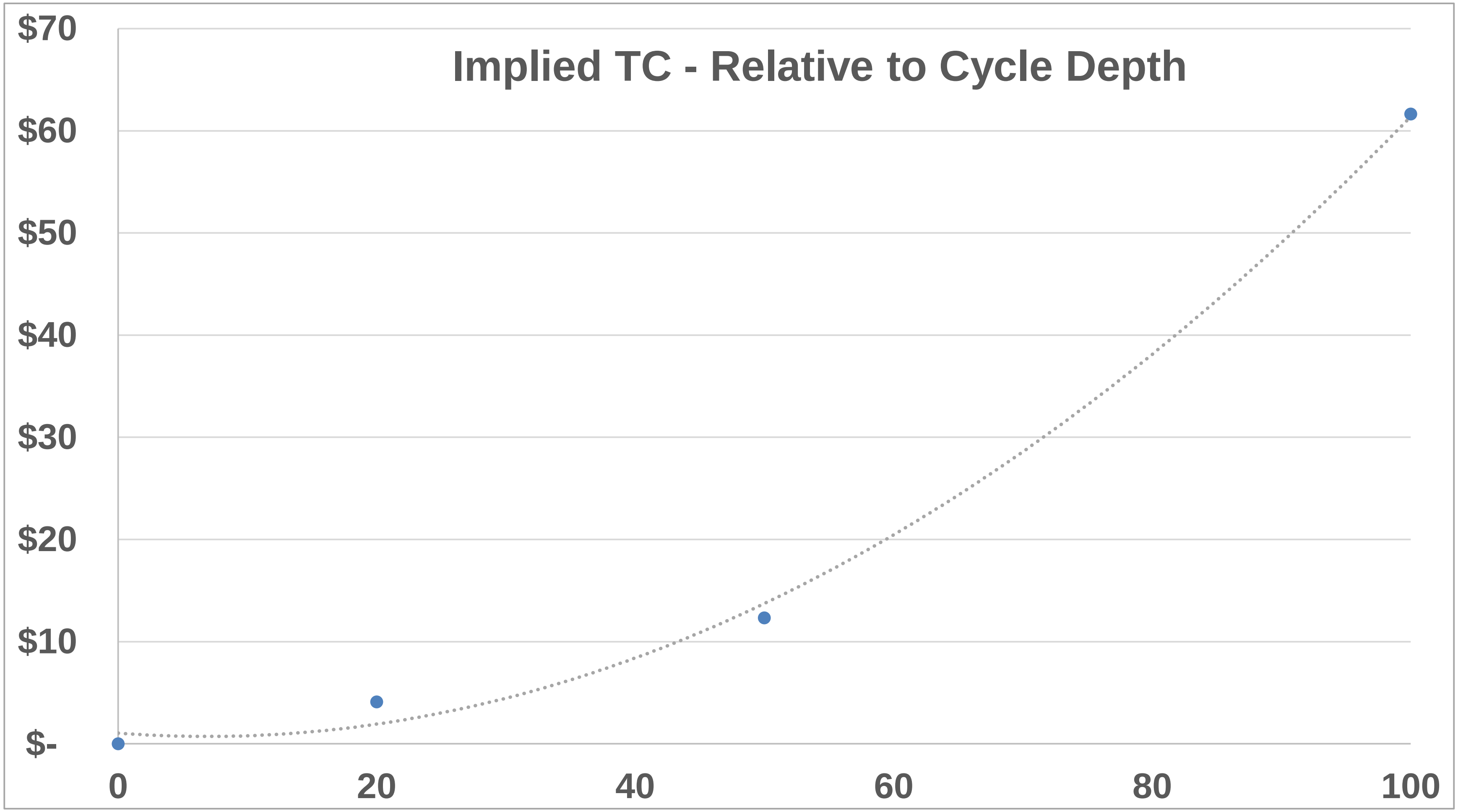
Applying for and establishing a value for ρ will require resource performance estimates

- If the manufacturer provides data highlighted in blue from the chart below it is possible to calculate total costs and implied total costs per cycle

DoD	Days	Exp Degredation (%)	Total Cost ($M)	Degredation ($)	Implied TC
0	365	0.00%	1.5	-	$ -
20	365	0.02%	1.5	300	$ 4
50	365	0.15%	1.5	2,250	$ 12
100	365	1.50%	1.5	22,500	$ 62

- These values can be used to generate approximate total cost curves and associated incremental costs, which could then be used to inform the adders applied to the default energy bids

The sample degradation estimates may be used to identify a value for ρ for use in the DEB



There could be several possible methodologies to set or verify values for ρ

A methodology where the ρ value is set so that calculated incremental costs are greater than or equal to implied incremental cost for a certain percentile of DoDs (i.e. 80%)

A least squares methodology also may be appropriate to validate a value for ρ

$$Min \sum_{k=1}^{n} \left(\int_{0}^{DoD_k} (\rho * DoD_k) - Implied\ TC_k \right)^2$$

- Where *k* is the estimated value for total cost provided from manufacturer estimates for *n* different costs, and the function is minimized over a range of possible values for ρ

This model could be further augmented to reflect the relationship between the dispatch incremental cost

- Several comments asked that the relationship between dispatch (MW) and cost be included in any default energy bid formulation
- These could be costs may be included in this model and could effectively increase the slope of the bid curve
- Similar to depth of discharge values, these would also need to be filed and verified with the ISO

- The default energy bids must continue to respect the optimization rules to ensure a market solution, including that the DEB be non-decreasing
  - Breaking these rules could allow a resource to model additional costs to <u>charge</u> at higher rates, than costs to charge at lower rates

If a dynamic default energy bid is adopted, resources will be able to supply matching bids

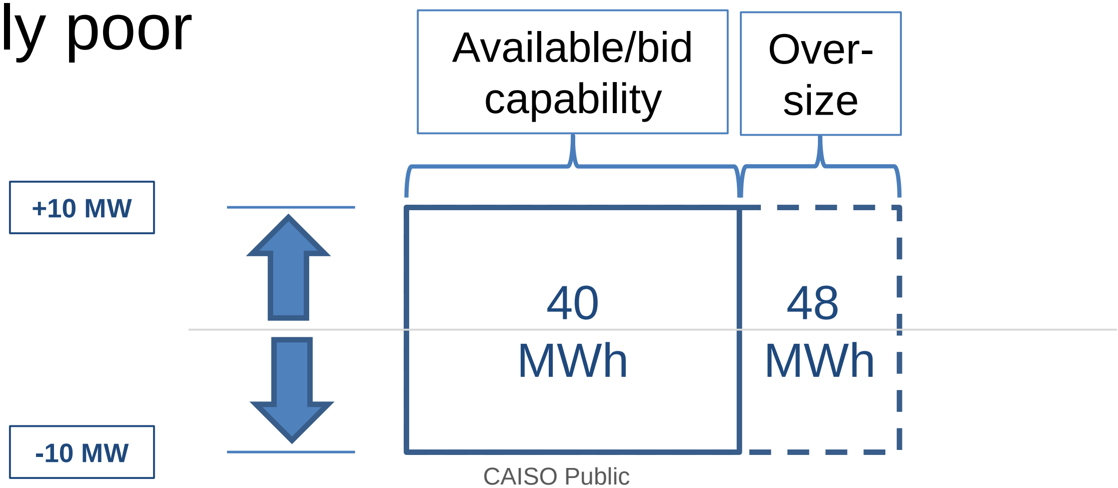
- Resources will have the ability to bid values into the market that match default energy bids
- Current construct for bids include a set of (MW, Price) pairs, but do not allow for bid values to change within the hour
  - Bids are submitted 75 minutes prior to the start of the hour
- Since the outlined default energy bid is dynamic, with the state of charge value, to accommodate bids that can match, resources will be able to offer a multiplier applied to actual state of charge (similar to ρ)
  - This bid value may be updated within standard bidding windows, 75 minutes prior to the start of any real-time hour
  - This bid value would work in conjunction with the current (MW, Price) pairs submitted for consideration in the market
  - This bid value could be set at 0, indicating that no adder would be applied to bids; could be set to the master file ρ value; or some other value

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

- Losses (η): Expected round trip efficiency losses
  - Does this value need to be more granular?
- Storage Duration (δ): Amount of time the resource is capable of discharging for, given energy (MWh) capacity at full output
- Cell degradation cost (ρ): Estimates for cell degradation costs
  - Will differ with discharge cost model ultimately implemented
  - May differ with expected cost date
  - May differ with facility/vendor/market participant
- ISO may use collected values and industry data to develop DEBs

Storage resources may 'oversize' a facility to meet capabilities across its expected calendar life

- Some resources may have additional capability not offered into the ISO markets
- Oversized storage may be built so that the resource can perform at certain levels even after some cell degradation
- Owners may oversize resource so that the resource is not operating in an area where performance or degradation is particularly poor



An oversized storage resource may need compensation under a different paradigm

- An oversized storage facility designed under this paradigm may incur little variable operations and maintenance costs
  - Very low incremental cost to generate energy
  - DEBs should be reflective of these low costs
- For these resources, most of the costs for the facility may be incurred upfront and as a cost to build or routinely maintain the resource, rather than costs incurred while the resource is operating
- For such resources, it is likely that energy rents can earn owners some revenue, but owners may need to seek recovery of initial costs through RA or other arrangements

Storage resources with these limitations may be eligible for opportunity cost adders

- Today the ISO offers resources with physical use limitations ‘opportunity cost adders’ that are applied to variable cost default energy bids
  - Although these resources may have a physical limitation of a particular number of cycles it is unclear if that these cycles are physically limited to a specific period of time (i.e. 10 years is a contractual target)
- The ISO does not base opportunity cost adders on contractual limitations
- Specific rules need to be determined for storage resources related to eligibility for these adders
  - Resources are required to submit applications through the master file and the generator resource data template (GRDT) process today, where all submitted values are verified or vetted by ISO staff

Next Steps

Next Steps

Milestone	Date
Second Revised Straw Proposal	February 10, 2020
Stakeholder Meeting	February 17, 2020

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

APPENDIX – ALTERNATE CYCLE DEPTH MODEL

The second model includes a multiplier applied to the difference in state-of-charge 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:

u: Binary = 1 when the state of charge is decreasing

P: Dispatch instruction (Market decision variable)

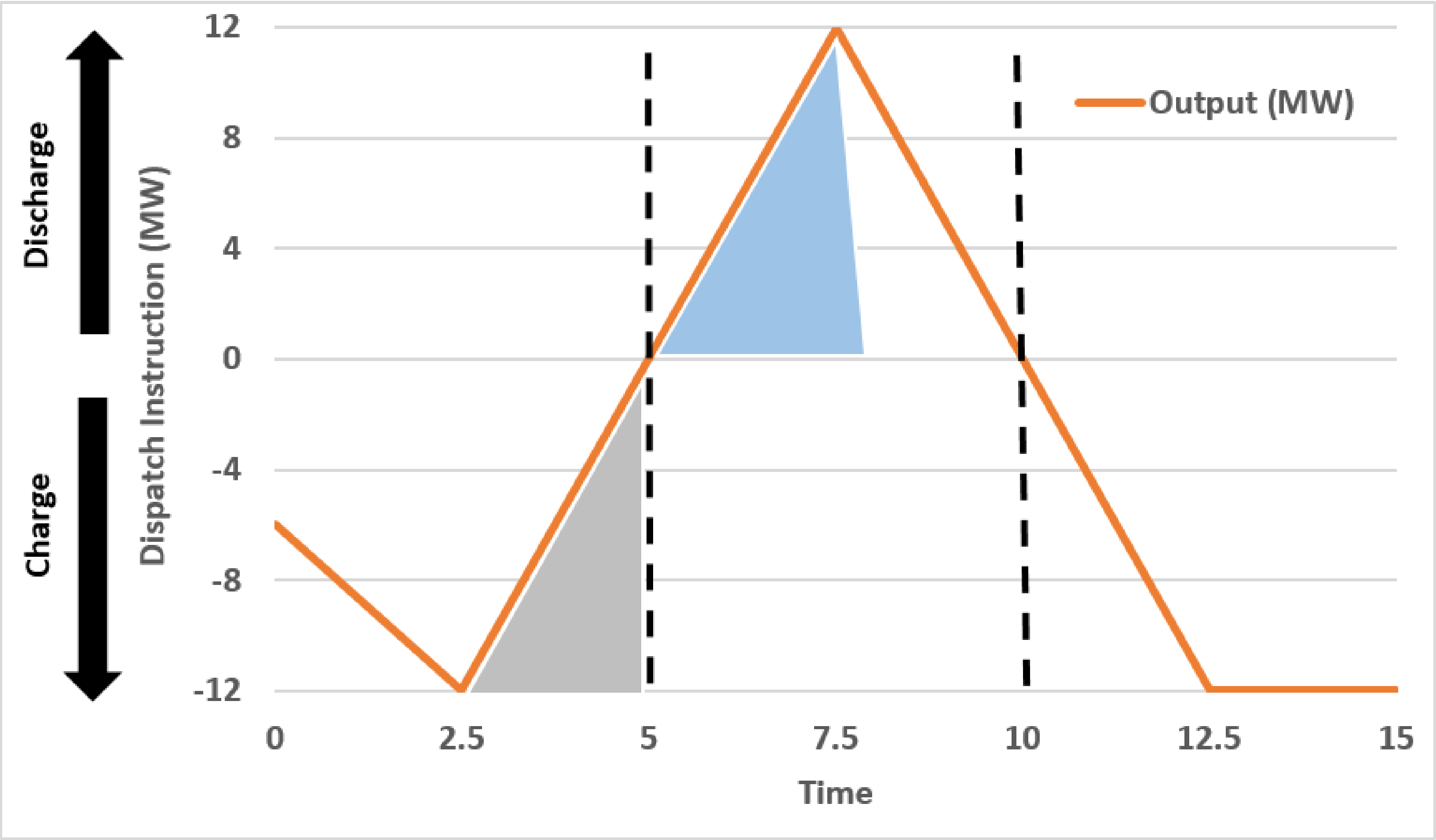
Assume a +/-24 MW storage resource with 100 MWh of capacity and **ρ = 1000**

Because ramps are not instantaneous, the state of charge value may not directly mirror dispatch

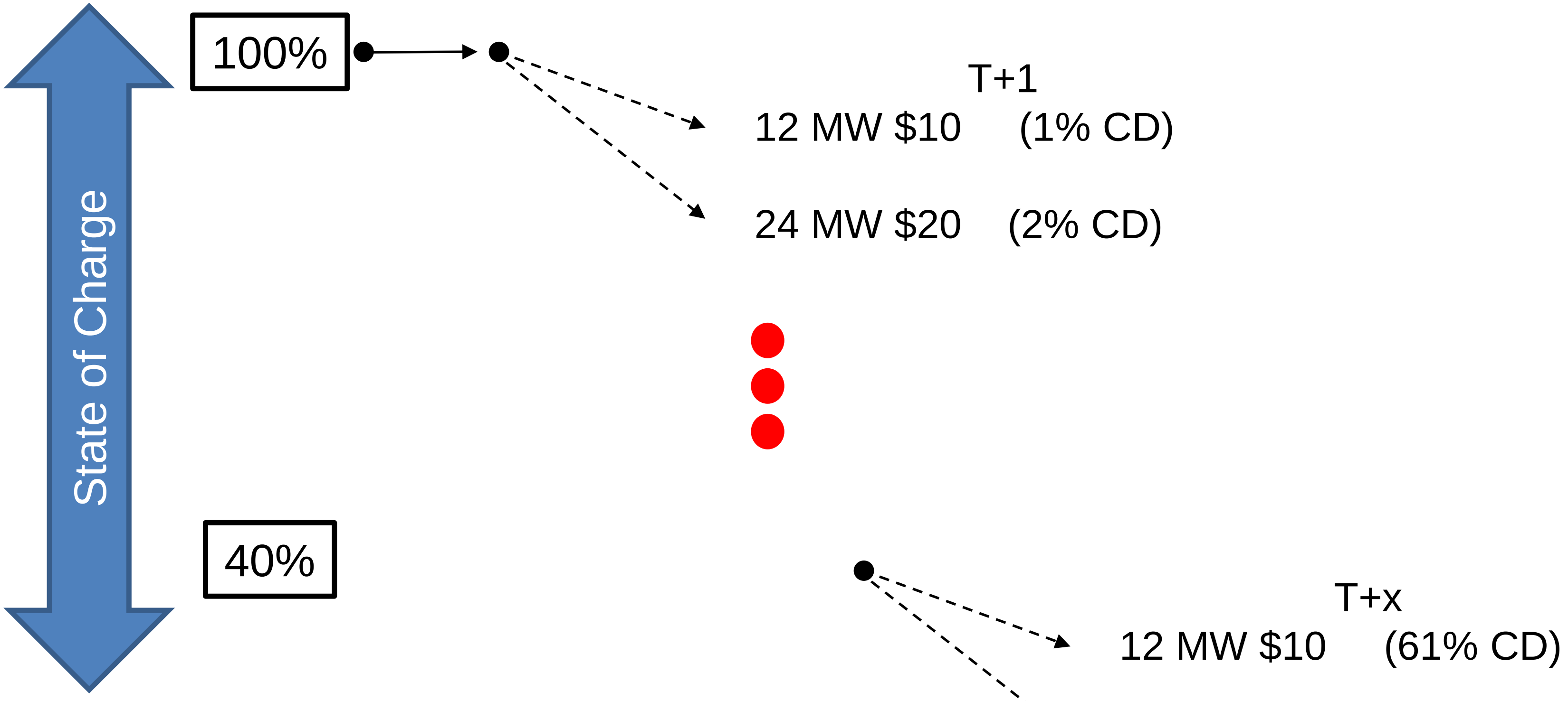
- The resources starts ramping to a new instruction, midway through the previous instruction
- The following example illustrates this:
  - Interval 0: resource is dispatched to 0 MW
  - Interval 1: -12 MW (charge)
  - Interval 2: +12 MW (discharge)
  - Interval 3: -12 MW (charge)
- The resource does not reach -12 MW until minute 2.5, when it immediately transitions to ramping up to meet the instruction for the next interval
- The resource does not remain at 12 MW for any time, and immediately starts to ramp down to meet the next instruction
- The average of the dispatch instructions from interval 1 to interval 2 is used to calculate the change in the state of charge

An example resource following dispatch instructions, and implied state of charge calculations

Figure 1: RTD state of charge calculation



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
- May be more simplistic for implementation/settlement

Cons

- Overestimates costs for large dispatches when cycle depth is thin and under estimates costs for small dispatches when cycle depth is deep
- May cause round-trip efficiency to be underestimated

Appendix: Waterfall Methodology

Cycling costs are an important component of cost for storage resources

- As a storage resource operates, the metal making up the battery cells degrades and eventually requires replacement
  - The cost for battery replacement is directly related to battery operation and should be considered in incremental cost
- Cells degrade more when resources perform 'deeper' cycles

Cycle Cepth (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

- Cells may also degrade faster based on current rate, ambient temperature, over charge/discharge, and average state of charge

Cycling costs may be accrued over a short period of time or a long period of time

- Generally storage resources that discharge at the same depth over a short period of time or long period of time experience about the same amount of cell degradation

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
				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

Modelling depth of discharge can be complicated

- Xu et al. uses a 'rainflow' model to estimate cell degradation and associated costs
- This model effectively tracks when every discharge period starts and ends, and tracks 'nested' discharge periods

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
				40

- This model is difficult to implement in a nodal market because of modelling complexity

Xu, et al. Factoring the Cycle Aging Cost of Batteries Participating in Electricity Markets: https://arxiv.org/pdf/1707.04567.pdf.

The rainflow model tracks charge and cost for a storage resource

- Each portion of the battery has a flag to determine if charged or discharged
  - Cheapest segments are charged first, before more expensive segments

Segment	0.1	0.2	0.3	0.4	0.5	0.6	…
	↓	↓	↓	↓	↓	↓	
Marginal Cost	1	3	5	7	9	11	…
Charge?	0/1	0/1	0/1	0/1	0/1	0/1	…

- Model may accurately tracks costs for resources, but can be computationally intensive to model for many resources
- A model would need many more discrete intervals for RT markets.

Charging and discharging impact the cheapest digits in the rainflow model first

Battery Segments

Segment	1	2	3	4	5	6	7	8	9	10
MC	1	3	5	7	9	11	13	15	17	19

Hour	MW	SOC											TC
1	0	5	0	1	1	0	1	1	1	0	0	0	
2	0	5	0	1	1	0	1	1	1	0	0	0	0
				-1	-1								
3	+2	3	0	0	0	0	1	1	1	0	0	0	8 = 3 + 5
			+1	+1	+1	+1				+1			
4	-5	8	1	1	1	1	1	1	1	1	0	0	0
			-1										
5	+1	7	0	1	1	1	1	1	1	1	0	0	1
				-1	-1	-1							
6	+3	4	0	0	0	0	1	1	1	1	0	0	15 = 3 + 5 + 7

- Costs are only incurred when a segment is discharged
- Multiple segments can be discharged at once, and costs are summed for those segments