Energy Storage and Distributed Energy Resources (ESDER) Phase 4

Training Session: Market Simulation Readiness

August 31, 2021

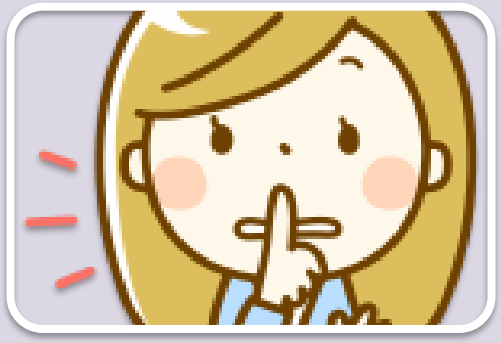
Radha Madrigal

Customer Readiness

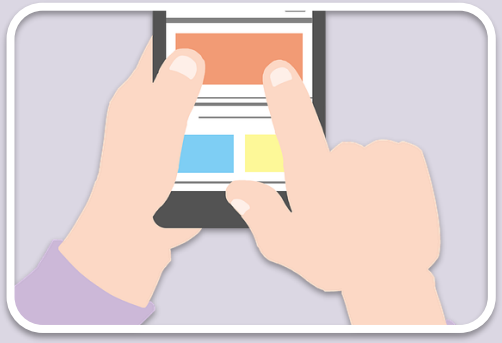
Updates made to slides 32 & 43

Updated: 10/21/2021

Housekeeping



Keep yourself muted to minimize background noise



Unmute to ask verbal questions or write questions in the chat pod

Raise your hand using WebEx interactivity tools

Objectives: Energy storage and distributed energy resources – Phase 4

- Parameters to better reflect demand response resource operational characteristics
- Optional end-of-hour state of charge parameter for storage resources
- Default energy bid cost methodology for storage resources
- Streamlined market participation agreements for non-generator resource participants

Agenda

This training will cover the following topics:

- High-level review of changes
- Description of changes by participation model
- Application-specific details
- Market simulation activities

Acronyms

Abbreviation	Term
BAA	Balancing Authority Area
BCR	Bid Cost Recovery
CIDI	Customer Inquiry, Dispute and Information
CMRI	Customer Market Results Interface
DA / DAM	Day-Ahead / Day-Ahead Market
DEB	Default Energy Bid
DR	Demand Response
EIM	Energy Imbalance Market
EOH	End-of-Hour
ESL	Energy Storage Limit
FERC	Federal Energy Regulatory Commission

Acronyms

Abbreviation	Term
GRDT	Generator Resource Data Template
IFM	Integrated Forward Market
LESR	Limited Energy Storage Resource
LMP	Locational Marginal Price
MDRT	Maximum Daily Run Time
MEAF	Metering Energy Adjustment Factors
MPM	Market Power Mitigation
NGR	Non-Generating Resource
Non-REM	Non Regulation Energy Management
OASIS	Open Access Same-time Information System
PDR	Proxy Demand Resource

Acronyms

Abbreviation	Term
PDR-LSR	Proxy Demand Resource – Load Shift Resource
PMAX	Maximum Generation Capacity
PMIN	Minimum Generation Capacity
RDRR	Reliability Demand Response Resource
REM	Regulation Energy Management
RT/RTM	Real-Time / Real-Time Market
RUC	Residual Unit Commitment
SC	Scheduling Coordinator
SIBR	Scheduling Infrastructure and Business Rules
SOC	State Of Charge

Background

Application-Specific Details

Market Simulation

ENERGY STORAGE AND DISTRIBUTED ENERGY RESOURCES – PHASE 4

Implementation timeline

- Tariff amendment filed with FERC: March 19, 2021
  - (re: simplification of NGR agreements)
- FERC approval obtained: May 14, 2021
- Tariff amendment filed with FERC: August 27, 2021
  - (re: ESDER 4 implementation)
  - FERC approval requested by October 28, 2021
- Market simulation: August 30, 2021 – October 1, 2021
- Production activation: November 1, 2021

BACKGROUND: HIGH-LEVEL REVIEW OF CHANGES

Parameters to better reflect demand response resource operational characteristics

- Some demand response (DR) programs have a limited number of activations and a set number of hours available for dispatch within a day

- New parameters provide DR resources a new daily max run time constraint
  - Max daily run time constraint allows DR resources to identify the max number of hours per day the resource could be “curtailed”
  - Optional Master File parameter
  - Minimum 1 MW curtailment size threshold to mitigate system performance impact

Optional end-of-hour state of charge parameter for storage resources

- End-of-hour (EOH) state of charge (SOC) bid parameter is submitted as a minimum and maximum MWh range
  - Must respect ancillary service (AS) awards and physical minimum and maximum charge constraints
  - Market optimization will protect AS awards if there is a conflict with the EOH SOC bid parameter

- Both self-scheduling and the end-of-hour state of charge parameter impact bid cost recovery (BCR) settlement

Default energy bid cost methodology for storage resources

- The default energy bid methodology approximates storage resource costs according to the following components:
  - Energy procurement costs
  - Marginal costs to charge and discharge (i.e. cycling costs)
  - Opportunity costs

- Storage resources may elect to use this default energy bid, or any other existing default energy bid types for which they are eligible
- Storage resources less than 5MW are exempt from local market power mitigation

Streamlined market participation agreements for non-generator resource (NGR) participants

- Currently, NGRs must execute a participating load agreement and a participating generator agreement

- Streamlined process allows NGRs to participate with a single agreement
  - NGRs that operate as a storage device or choose to operate only as a generator will execute the participating generator agreement
  - NGRs operating as dispatchable demand response will execute the participating load agreement

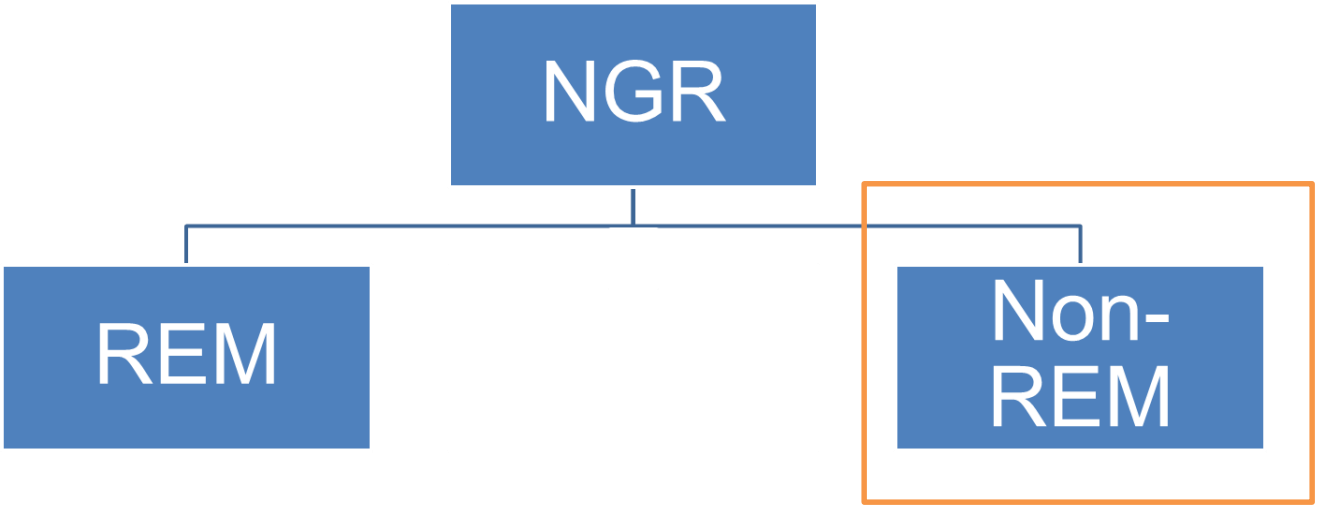
- NGRs operating under existing agreements not required to execute new agreements

Non-REM LESR

PDR, PDR-LSR Curtailment, RDRR

DESCRIPTION OF CHANGES BY PARTICIPATION MODEL

Batteries (Non-Generating Resources – NGR) have two participation models:



ESDER 4 Changes

- Regulation Energy Management (REM):
  - Can be awarded for regulating energy up/regulating energy down only
- Non-REM:
  - Can be awarded for energy or ancillary services, including regulation awards

Participation model: Non-REM Limited Energy Storage Resource (LESR)

- Non-REM LESRs will have:
  - Access to a set of biddable parameters for maximum and minimum end-of-hour (EOH) state of charge (SOC)
  - A modification of bid cost recovery (BCR) calculation when submitting:
    - End-of-hour state of charge bids
    - Self-scheduling

Participation model: Non-REM LESR

- Non-REM LESRs will be subject to market power mitigation and have access to:
  - A new default energy bid (DEB) formulated for storage that include:
    - Energy costs
    - Variable costs
      - Including ‘cell degradation’ or ‘cycling’ costs
    - Opportunity costs
      - Applicable to real-time default energy bids

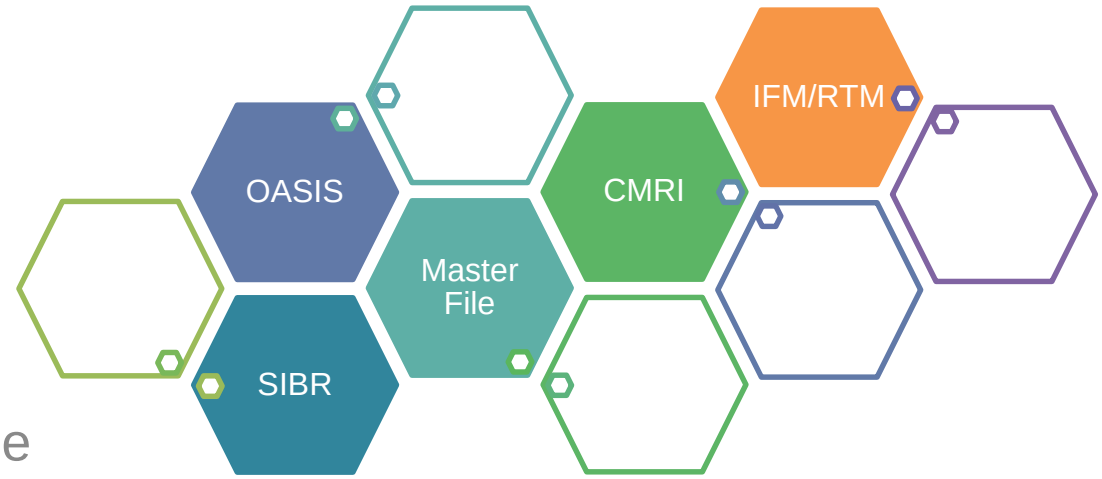
Participation model: Non-REM LESR

- Storage resources that are not net-suppliers and are smaller than 5 MW will be considered in a “safe harbor” and will be exempt from local market power mitigation

Participation model: PDR, PDR-LSR Curtailment, RDRR

- For PDR, PDR-LSR curtailment and RDRR resources:
  - Optional Maximum Daily Run Time (MDRT) parameter will be added to the market optimization

Questions



Master File

SIBR

IFM/RTM

CMRI

OASIS

REVIEW APPLICATION-SPECIFIC DETAILS

Registering Storage-Based Variable Cost for LESRs

Master File

- SC's of LESR resources will have the ability to register the following optional parameter with an effective start and end date:
  - Storage-based variable cost
- Parameter represents the cost the resource incurs while producing energy
  - For most resources, the bulk of these costs will include cell degradation costs
  - Other costs related to charging or discharging may be included in this component

Registering Storage-Based Variable Cost for LESRs

Master File

- Storage-based variable cost submission applies to non-REM LESRs
  - Optional parameter
  - Includes cycling cost (also called cell degradation cost)
  - Unit of parameter is in $/MWh (e.g. $30/MWh)

Registering Storage-Based Variable Cost for LESRs

Master File

- Registration by SC's shall follow lead time similar to other resource registration parameters
- Resource's SC shall submit manufacturer warranty, available data, and supporting documentations to justify their requested cost
- If no storage-based variable cost is submitted by LESR's SC, system shall set it to $0/MWh
- Resource's SC shall have the capability to view the submitted storage-based variable cost

Registering Storage-Based Variable Cost for LESRs

Master File

- Implementation:
  - Storage-based variable cost parameter shall be submitted via CIDI ticket
  - Resource's SC will have read-only access to the submitted parameter via the generator resource data template (GRDT)

New **storage** default energy bid option for CAISO BAA's non-REM LESRs

Master File

- A new **storage** default energy bid (DEB) option has been added for CAISO BAA's non-REM LESRs
- Modifiable resource attribute that can be submitted via the GRDT
- Other DEB options for these resources are:
  - Variable Cost
  - LMP
  - Negotiated Rate

New **storage** default energy bid option for CAISO BAA's non-REM LESRs

Master File

- SCs of non-REM LESRs shall rank the **storage** DEB option as the first option in order to activate it
  - If no rank is specified for a non-REM LESR, system shall set the default ranking as follows:
    1) Variable Cost
    2) LMP
- Storage DEB option will not apply to EIM BAA's non-REM LESRs as there are no IFM LMP prices available for EIM resources
  - EIM non-REM LESRS may utilize the negotiated DEB or other existing DEB options

Safe Harbor Designations for Small non-REM LESRs

Master File

- System shall designate resources that satisfy all of these conditions as “Safe Harbor” resources and shall exempt them from market power mitigation and DEB ranking submission:
  - Resource type is non-REM LESR
  - Resource Registered Pmax capacity ≤ 5 MW
  - Resource’s ultimate parent company is not a net-supplier

Registering Max Daily Run Time (MDRT) for PDR, PDR-LSR Curtailment and RDRR Resources

Master File

- Max daily run time (MDRT) is an optional new parameter with an effective start and end date for resources that satisfy all of the following criteria:
  - Resource type is either PDR, PDR-LSR Curtailment or RDRR
  - Curtailment Capability (Registered Pmax) ≥ 1 MW

- MDRT represents maximum daily number of hours the resource can be committed and/or dispatched
- Valid values for MDRT are either NULL or integers from 1 to 23 hours

Registering Max Daily Run Time (MDRT) for PDR, PDR-LSR Curtailment and RDRR Resources

Master File

- MDRT is an optional Master File parameter
  - If MDRT is not entered, system shall store it as NULL
- Registration in Master File shall follow lead time and process similar to other resource registration parameters

RTM optional hourly bid parameters by non-REM LESR's SC

SIBR

- Only non-REM LESRs can submit optional hourly bid parameters in the real-time market:
  - Min End-Of-Hour (EOH) State Of Charge (SOC) (in MWh)
  - Max End-Of-Hour (EOH) State Of Charge (SOC) (in MWh)

- Non-REM LESR's SCs shall not use the EOH SOC bidding parameters in such a way to undermine their must offer obligation or use them to withhold additional RA capacity that is not scheduled in IFM or RUC

- There are no EOH SOC bid parameters for DAM

Note: Min and Max EOH SOC bidding parameters should be submitted as a pair.

SIBR Validation Rules

SIBR

- EOH SOC Bid Parameters
  - Automatically validate submitted EOH SOC bid parameters using all of the following rules:
    - Submitting Resource is not REM LESR type
    - Min EOH SOC ≤ Max EOH SOC
    - Min EOH SOC ≥ Biddable Min ESL
    - Min EOH SOC ≥ Registered Min ESL
    - Max EOH SOC ≤ Biddable Max ESL
    - Max EOH SOC ≤ Registered Max ESL

How RT biddable parameters are handled in the context of RUC-generated binding Min EOH SOC

IFM/ RTM

- For non-REM LESRs and for any RTM intervals where there is overlap between:
  - RUC-generated binding Min EOH SOC requirement
  - Biddable hourly RT Min and/or Max EOH SOC parameters
  - And/or Biddable daily Min and/or Max ESL
- The market will give precedence to the binding RUC-generated reliability Min EOH SOC requirement

Default Energy Bid (DEB) for **storage** option covers entire operating range for non-REM LESRs

IFM/ RTM

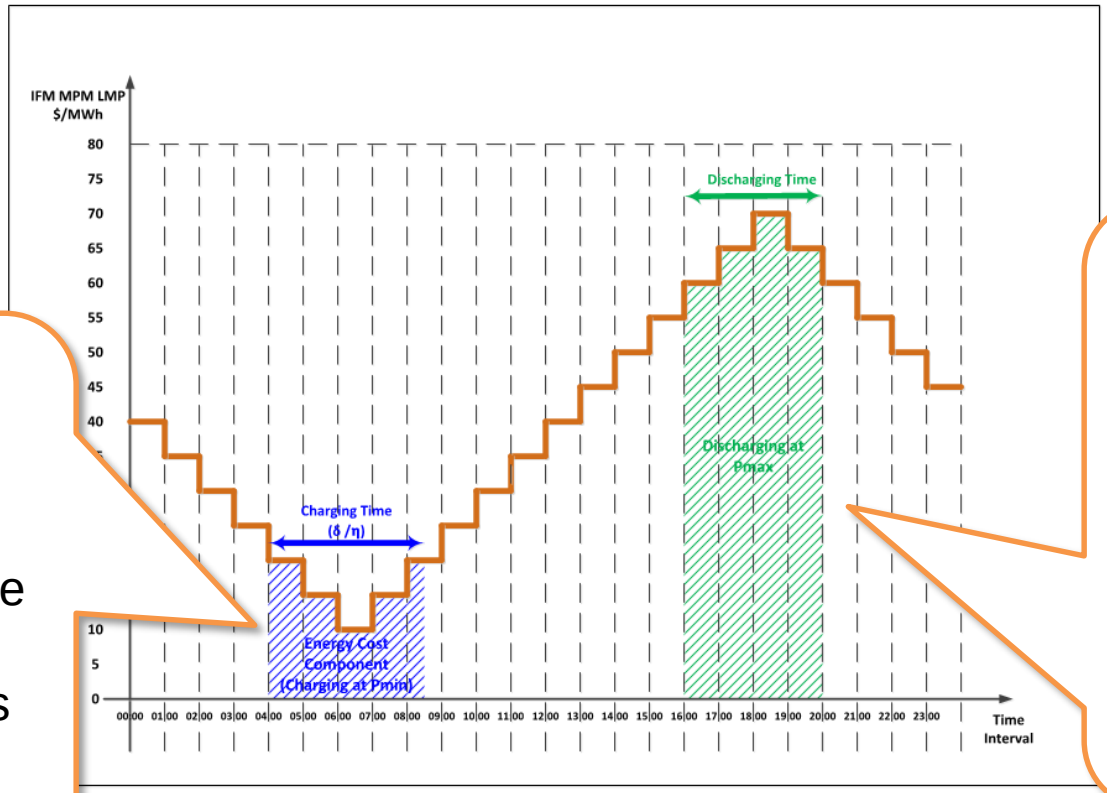
- DAM and RTM DEBs for storage option cover their entire operating range (charging as well as discharging) from registered Pmin to registered Pmax

- Separate DAM and RTM daily DEBs will account for:
  - Energy Cost (cost to purchase energy, while charging, including accounting for round-trip efficiency)
  - Storage-Based Variable Cost (including Cell degradation cost [also called Cycling Cost])
  - Price-Based Opportunity Cost (only for RTM DEB)

- Soft bid cap of $1,000 will apply to calculated DEBs

DAM DEB calculation with sample DA MPM LMP price curve

IFM/ RTM



This section indicates the resource will charge at the least expensive continuous block of LMPs at a value of 4.44 hours (adjusted energy charging duration).

This section indicates that the resource will discharge at the most expensive continuous block of LMPs at Pmax.

Calculate the energy charging duration, then adjust for round-trip efficiency

IFM/ RTM

Parameter	Value
Pmin	-10 MW
Pmax	10 MW
Registered Min Continuous Energy Limit	0 MWh
Registered Max Continuous Energy Limit	40 MWh
Round-Trip Efficiency (η)	0.9
Storage-Based Variable Cost (ρ)	$30/MWh

Energy Charging Duration (δ) =
(40 MWh – 0 MWh) / abs(-10 MW) = 4 hours

Adjusted Energy Charging Duration (δ/η) =
4 hours / 0.9 = 4.44 hours

Since the adjusted Energy Charging Duration is calculated at 4.44 hours, the calculation will select the lowest continuous block of LMPs across 4.44 hours to calculate the Energy Cost. The lowest continuous block of DA LMP prices occurs in HE 5-9. The Energy Cost is calculated as:

$\mathrm{En}_{\delta/\eta}$ = [($20/MWh * 1) + ($15/MWh * 1) + ($10/MWh * 1) + ($15/MWh * 1) + ($20/MWh * 0.44)] / 4.44

= $15.5/MWh

Calculate DAM DEB

IFM/
RTM

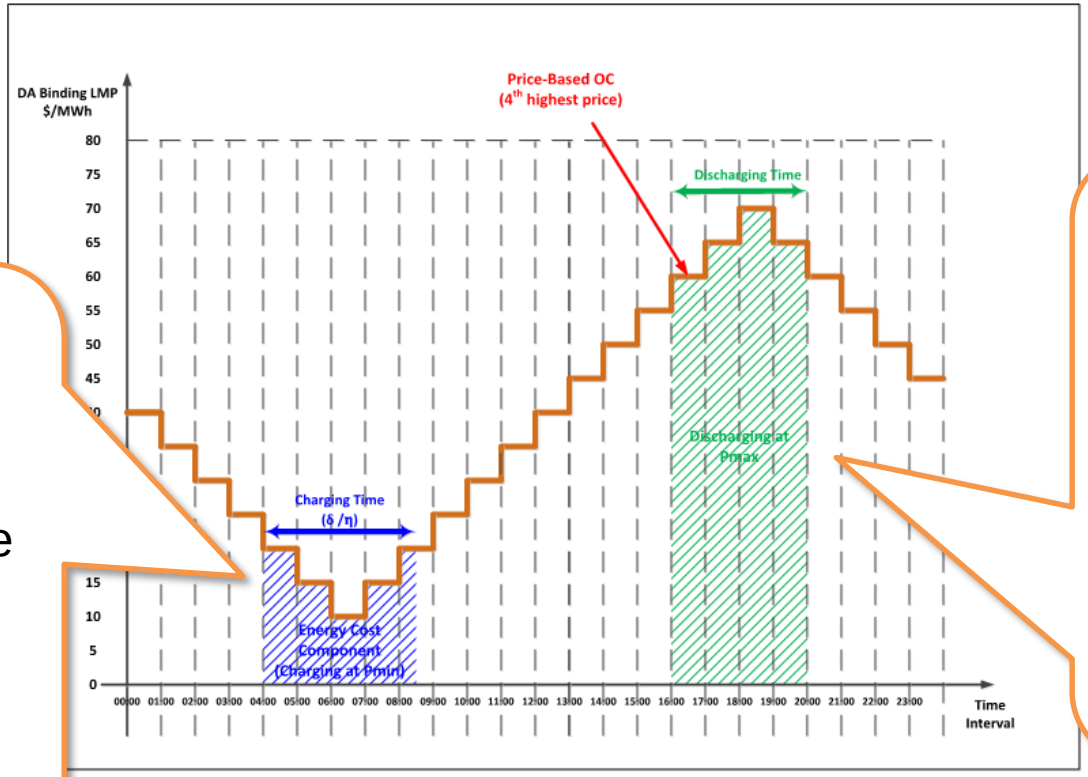
The calculation varies slightly between the charging and discharging segments, because the charging portion should not include the Variable Operations cost. Recall that the price-based Opportunity Cost component is not included in the DAM calculation:

$$\text{DAM DEB}_{\text{-10 MW to 0 MW}} = \{\$15.5 + 0\} * 1.1 = \$17.05/\text{MWh}$$

$$\text{DAM DEB}_{\text{0 MW to 10 MW}} = \{\$15.5 + \$30\} * 1.1 = \$50.05/\text{MWh}$$

RTM DEB calculation with sample DA LMP price curve

IFM/ RTM



This section indicates the resource will charge at the least expensive continuous block of LMPs at a value of 4.44 hours (adjusted energy charging duration).

This section indicates that the resource will discharge at the most expensive continuous block of LMPs at a value of 4 hours.

Calculate the energy charging duration, then adjust for round-trip efficiency

IFM/ RTM

Parameter	Value
Pmin	-10 MW
Pmax	10 MW
Registered Min Continuous Energy Limit	0 MWh
Registered Max Continuous Energy Limit	40 MWh
Round-Trip Efficiency (η)	0.9
Storage-Based Variable Cost (ρ)	$30/MWh

Energy Charging Duration (δ) =
(40 MWh – 0 MWh) / abs(-10 MW) = 4 hours

Adjusted Energy Charging Duration (δ/η) =
4 hours / 0.9 = 4.44 hours

Since the adjusted Energy Charging Duration is calculated at 4.44 hours, the calculation will select the lowest continuous block of LMPs across 4.44 hours to calculate the Energy Cost. The lowest continuous block of DA LMP prices occurs in HE 5-9. The Energy Cost is calculated as:

$\mathrm{En}_{\delta/\eta}$ = [($20/MWh * 1) + ($15/MWh * 1) + ($10/MWh * 1) + ($15/MWh * 1) + ($20/MWh * 0.44)] / 4.44

= $15.5/MWh

Calculate the energy discharging duration, then round down to the nearest integer

IFM/ RTM

Parameter	Value
Pmin	-10 MW
Pmax	10 MW
Registered Min Continuous Energy Limit	0 MWh
Registered Max Continuous Energy Limit	40 MWh
Round-Trip Efficiency (η)	0.9
Storage-Based Variable Cost (ρ)	$30/MWh

Energy Discharging Duration (γ) =
(40 MWh – 0 MWh) / 10 MW = 4 hours

Adjusted Energy Discharging Duration (r) =
min{24, max[1, RoundDown(4 hours)]} =
4 hours

Based on the value of the adjusted Energy Discharging duration, choose the 4th highest DA LMP to set the price-based Opportunity Cost.

According to the price curve in the example, the 4th highest DA LMP is $60/MWh in HE 17.

Calculate RTM DEB

IFM/ RTM

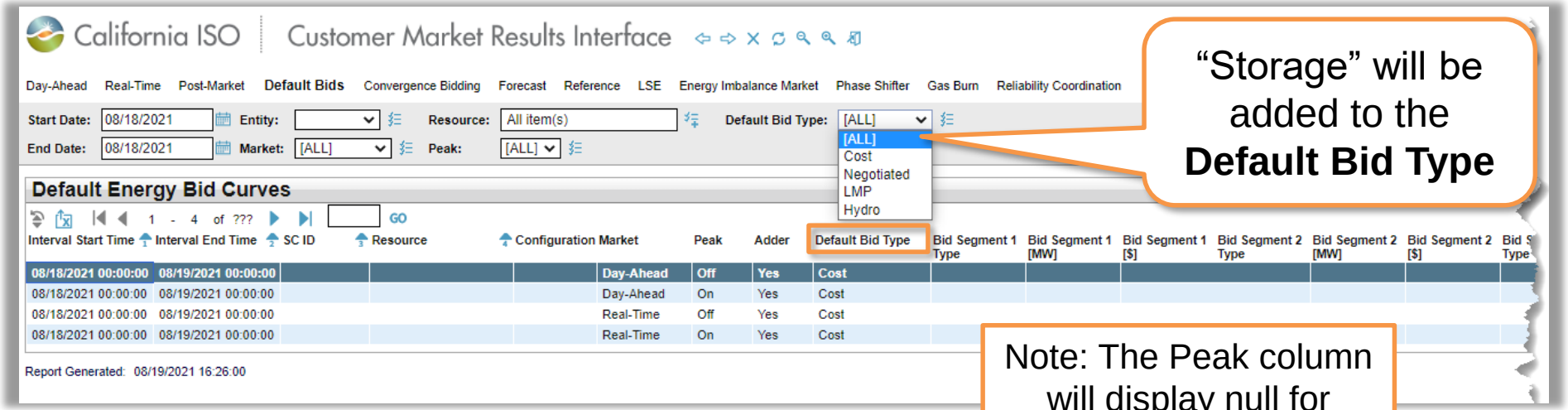
- The calculation varies slightly between the charging and discharging segments, because the charging portion should not include the Variable Operations cost:
  - RTM $DEB_{\text{-10 MW to 0 MW}}$ = Max{ [$15.5 + $0], $60 } * 1.1 = $66/MWh
  - RTM $DEB_{\text{0 MW to 10 MW}}$ = Max{ [$15.5 + $30], $60 } * 1.1 = $66/MWh

- When the DEB is the same price in both segments, it will be consolidated to a single segment before it is used by the market or published downstream
  - In this example, it would be -10 MW to +10 MW @ $66/MWh

CMRI Report: Default Energy Bid Curves

CMRI

- The **Default Energy Bid Curves** report will contain:
  - DAM DEBs with all existing Default Bid Types as well as new "Storage" Default Bid Type for T+1 trade date
  - RTM DEBs with all existing Default Bid Types as well as new "Storage" Default Bid Type for the trade date
- Report structure will be the same, but the **Default Bid Type** will have a new value of **"Storage"**



Expected timing of DEB publishing in CMRI

CMRI

	DAM	RTM
Current	Storage resources N/A not published Other resources ~8:45AM (day prior to trading day)	Storage resources N/A not published Other resources ~9:40PM (day prior to trading day)
Future	Storage resources Published with DAM results (approx. 1PM PT, day prior to trading day) Other resources ~8:45AM (day prior to trading day)	Storage resources Published with DAM results (approx. 1PM PT, day prior to trading day) Other resources ~9:40PM (day prior to trading day)

OASIS Report: Public Bids

- Two new columns containing the RTM optional hourly bid parameters for non-REM LESRs will be published to the masked **Public Bids** report:
  - (optional) Min EOH SOC
  - (optional) Max EOH SOC

- Report is published 90 days after the trade date
- Download report in XML or CSV

CHANGES TO SETTLEMENTS

Affected charge codes/settlements calculations

- CC 6620 – RUC and RTM Bid Cost Recovery Settlement
- CC 66200 – RTM Bid Cost Recovery EIM Settlement
- Pre-calc – RTM Net Amount

Impact to Bid Cost Recovery (new functionality)

Resources will be disqualified from receiving RTM bid cost shortfall in the following situations:

- Resource has accepted RTM EOH SOC bids in an hour – disqualify for that hour and the previous hour (flagged hours)
  - This can span trade dates
- Any hour where both RUC-generated Min EOH SOC requirement and biddable hourly RT Min or Max EOH SOC parameters overlap for non-REM LESR
- For RTM self-schedules in an hour, disqualify the resource for the previous hour (flagged hour)
  - This can span trade dates

Impact to Bid Cost Recovery (existing functionality)

- The RTM bid cost/revenue shortfall assessment shall be evaluated at each 5-minute interval of the flagged hours
- Apply RTM BCR to Entire Operating Range
- No Change to Existing DAM BCR
- No Change to DA Metering Energy Adjustment Factors (MEAF), RTM Performance Metric and Persistent Deviation Rules

Questions

MARKET SIMULATION

Market Simulation Activities

- Market simulation structured scenarios provide customers with the ability to preview and test bid-to-bill scenarios

- Deadline to register for market simulation via the MarketSim@caiso.com mailbox was August 24, 2021

Market Simulation Activities

- Link to market sim structured scenarios included in the reference section
- Users must be provisioned for access in order to participate in market simulation
- Attend the Market Simulation calls to stay informed on the timing of activities for this and other Fall 2021 release initiatives

Market simulation structured scenario

Scenario Number	Scenario Execution Trade Date: TBD	
1	Description	Submit Combinations of Competitive RT Bids with EOH SOC Parameters and Self-Schedules by non-REM LESRs' SCs that Overlap with RUC-Generated Binding Min EOH SOC Requirements (Bid-to-Bill Scenario)
	ISO Actions	RUC under-gen infeasibility is triggered for at least 1 hour in a trade day.
	EIM Market Participant Actions	N/A
	ISO Market Participant Actions	SCs of the non-REM LESR resource submit combination of competitive RT bids that includes EOH SOC parameters and self-schedules (bid-to-bill scenario) that overlap for some hours with the RUC-generated binding Min EOH SOC requirements
	Expected Outcome	OASIS: Masked RT EOH SOC bid parameters will be published for non-REM LESRs in Public Bid report. Note: CAISO will provide a sample of the report to participants since the report is published T+90 days. ADS/ BAOOP/CMRI: RT market results of non-REM LESRs reflects system setting precedence to satisfying binding RUC-generated reliability Min EOH SOC requirement
	Anticipated Settlement Outcome	RTM BCR accounts for EOH SOC parameters and self-schedules for non-REM LESRs irrespective of overlap with RUC-generated reliability Min EOH SOC requirement.
	Expected Settlement Outcome	RTM BCR accounts for EOH SOC parameters and self-schedules for non-REM LESRs in Settlements

Market simulation structured scenario

Scenario Number	Scenario Execution Trade Date: TBD	
2	Description	Submit Combinations of DA and RT Bids subject to Market Power Mitigation by non-REM LESRs' SCs (Bid-to-Bill Scenario)
	ISO Actions	CAISO will facilitate congestion to trigger mitigation for some of the registered LES resources if their submitted bids are high enough.
	EIM Market Participant Actions	N/A
	ISO Market Participant Actions	SC's of Non-REM LESR resource submit DA and RT bids that are subject to market power mitigation (bid-to-bill scenario).
	Expected Outcome	Verify that DA and RT MPM market results of non-REM LESRs considers bid mitigation. Verify DAM and RTM DEBs are published for non-REM LESRs.
	Anticipated Settlement Outcome	N/A
	Expected Settlement Outcome	N/A

Final Questions

Thank you for your participation!

For more detailed information on anything presented, please visit our website at:
www.caiso.com

Or send an email to:
CustomerReadiness@caiso.com

REFERENCE MATERIAL

Reference Material

- Business Practice Manual changes:
  - BPM Change Management
    - Energy Imbalance Market, Market Instruments, Market Operations, Settlements and Billing (configuration guides)

- Business Requirements Specification:
  - http://www.caiso.com/Documents/BusinessRequirementsSpecification-EnergyStorageandDistributedEnergyResourcesPhase4.pdf

- Draft settlement technical documents:
  - http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=68131471-83EE-4370-82B7-622E25E9A735

Reference Material

- Initiative webpage:
  - https://stakeholdercenter.caiso.com/StakeholderInitiatives/Energy-storage-and-distributed-energy-resources

- Market Simulation Structured Scenarios:
  - http://www.caiso.com/Documents/MarketSimulationStructuredScenarios-EnergyStorageandDistributedEnergyResourcesPhase4.pdf

Reference Material

- Tariff filings
  - March 19, 2021 – Tariff amendment – non-generator resource participation agreements:
    - http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=4A2F6975-C219-415F-B80B-8E21BB053838
  - August 27, 2021 – Tariff amendment – ESDER 4
    - http://www.caiso.com/Pages/documentsbygroup.aspx?GroupID=82FE02A1-C9E8-4E26-BC77-9BF3D2D0D7C8

- Technical Specifications – located on the ISO's Developer Site which provide detailed descriptions of the system changes for:
  - CMRI
  - Master File
  - OASIS
  - SIBR