



Business Requirements Specification

Energy Storage and Distributed Energy Resources (ESDER) Phase 4

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Revision History

Date	Version	Description
2/2/2021	1.0	Initial Document Release.
8/4/2021	1.1	Updated for the following: <ul style="list-style-type: none"> • Section 5.1 (BPM): <ul style="list-style-type: none"> ○ Changed Demand Response BPM impact to N/A ○ Clarified Settlements impact to be on configuration guides BPM impact. • ESDER4-BRQ-01020: <ul style="list-style-type: none"> ○ Added a requirement for resource’s SC ability to view the submitted Storage-Based Variable Cost and added implementation notes for it to be submitted via CIDI and viewed via GRDT. ○ Added GRDT to Potential Application(s) Impacted. • ESDER4-BRQ-01040: <ul style="list-style-type: none"> ○ Updated to restrict Storage DEB option ranking to first option only for CISO BAA’s non-REM LESRs. • ESDER4-BRQ-01050: <ul style="list-style-type: none"> ○ Added to validate that Storage DEB option ranking is not submitted by EIM BAA’s non-REM LESRs. • ESDER4-BRQ-01060: <ul style="list-style-type: none"> ○ Updated to remove Storage and Negotiated Rate DEB default option rankings. • ESDER4-BRQ-01520: <ul style="list-style-type: none"> ○ Added for RIMS support of consolidated PGA for storage resources using NGR model. • ESDER4-BRQ-01540: <ul style="list-style-type: none"> ○ Added for RIMS support of consolidated PLA only for participating loads using NGR model. • ESDER4-BRQ-02120: <ul style="list-style-type: none"> ○ Replace “calculate” with “process” for NDEB. • ESDER4-BRQ-04260, ESDER4-BRQ-04300: <ul style="list-style-type: none"> ○ Replaced “Energy Storage Duration” with “Energy Charging Duration”. • ESDER4-BRQ-04350:

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		<ul style="list-style-type: none"> ○ Added for Applying Bid Cap Limit to Calculated “Storage” DEBs. ● ESDER4-BRQ-04410: <ul style="list-style-type: none"> ○ Added for Overlapping between RUC-Generated Binding Min EOH SOC Requirement and RTM Biddable Min and Max EOH SOC Parameters and/or Biddable Daily Min and Max ESL. ● ESDER4-BRQ-06080: <ul style="list-style-type: none"> ○ Clarified it. ● ESDER4-BRQ-06140: <ul style="list-style-type: none"> ○ Clarified it. ● ESDER4-BRQ-07040: <ul style="list-style-type: none"> ○ Corrected typo to replace JOU Parent and Child Data with New/Modified Data. ○ Updated to add Storage-Based Variable Cost to the list of data. ● ESDER4-BRQ-08050: <ul style="list-style-type: none"> ○ Added for Overlapping between RUC-Generated Binding Min EOH SOC Requirement and Biddable Hourly RT Min and Max EOH SOC Parameters. ● ESDER4-MSIM-09060: <ul style="list-style-type: none"> ○ Added for overlap between EOH SOC bidding parameters and RUC-generated Min EOH SOC requirements. ● ESDER4-MSIM-09080: <ul style="list-style-type: none"> ○ Added for DA and RT market power mitigation of non-REM LESRs. ● Appendix-B: <ul style="list-style-type: none"> ○ Fixed typo to displace x-axis of Example-1, 2, 3 and 4 one hour earlier. ○ Example-4: Corrected PBOC typo to 60 instead of 55.
10/11/2021	1.2	Updated for the following: <ul style="list-style-type: none"> ● ESDER4-BRQ-01025 <ul style="list-style-type: none"> ○ Added for MF data that are needed in this project because of dependency with Hybrid Resources Phase-2 initiative. ● ESDER4-BRQ-01520 <ul style="list-style-type: none"> ○ Removed RIMS requirement for support of consolidated PGA for storage resources using NGR model. ● ESDER4-BRQ-01540

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		<ul style="list-style-type: none"> ○ Removed RIMS requirement for support of consolidated PLA only for participating loads using NGR model. ● ESDER4-BRQ-02120 <ul style="list-style-type: none"> ○ Updated the note to still apply the DEB to all NGRs that elect Negotiated DEB option. ● ESDER4-BRQ-04100 <ul style="list-style-type: none"> ○ Clarified that optional Min and Max EOH SOC bidding parameters should be submitted as pair. ● ESDER4-BRQ-04340 <ul style="list-style-type: none"> ○ Replaced “24” with “NHD” (Number of Hours per Trade Day). ● ESDER4-BRQ-04410 <ul style="list-style-type: none"> ○ Updated to apply the previous functionality to critical hours only and add another functionality for non-critical hours to use most restrictive constraint amongst the RUC-generated and biddable Min EOH SOC constraints and updated functionality that sets Max EOH SOC in both critical and non-critical hours when there is overlap with RUC-generated Min EOH SOC constraint. ● ESDER4-BRQ-06060 <ul style="list-style-type: none"> ○ Added implementation note that CMRI will display Null for Peak column for Storage DEBs.
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Implementation Note: Changes in this version of the BRS are pending internal CAISO change request approval.

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1 Introduction

1.1 Purpose

The purpose of this document is to capture and record a description of what the Users and Business Stakeholders of the project wish to obtain, by providing high level business requirements. This document establishes the basis for the agreement between the initiators and implementers of the project. The information in this document serves as input to determine the scope of projects and all Business Process Modeling and System Requirements Specifications efforts.

Business requirements are what must be delivered to provide value for the Users and Business Stakeholders. Systems, software, and processes are the ways (how) to deliver, satisfy or meet the business requirements (what).

The purpose of this project is to cover enhancements related to the fourth phase of the ESDER initiative to continuously improve and enhance its interaction and participation models for both storage and distributed energy resources in the CAISO's market.

1.2 Conventions

- None

1.3 Scope

- For non-REM LESRs:
 - Allowing End-Of-Hour (EOH) State-of-charge (SOC) biddable parameter in RTM.
 - Modification of Settlements RTM Bid Cost Recovery (BCR) to account for:
 - EOH SOC
 - Self-scheduling
 - Enhanced Default Energy Bids (DEB) calculations for storage resources for DAM and RTM that take into account:
 - Energy Costs
 - Storage-Based Variable Costs (including Cell Degradation Cost [also called Cycling Cost])
 - Price-Based Opportunity Costs (applicable to RTM DEB but not DA DEB)
 - Applying Market Power Mitigation (MPM). **Note:** Sufficiently small “Safe Harbor” resources that do not have market power will be exempted from bid mitigation in DAM and RTM.
- For PDR, PDR-LSR curtailment and RDRR resources:
 - Considering Maximum Daily Run Time (MDRT) parameter.

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2 Intellectual Property Ownership

Intellectual Property covers a broad array of information and materials, including written works, computer programs, software, business manuals, processes, symbols, logos and other work products. Determining ownership of Intellectual Property is very important in preserving the rights of the California ISO, and helps to avoid Intellectual Property infringement issues. In considering the business requirements or service requirements to be performed, the business owner of the project must determine Intellectual Property Ownership.

2.1 Checklist

The ISO retains intellectual property ownership of the following:

- Related Business Practice Manuals
- All rights reserved for works included within this BRS document

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3 Acronym and Terms Definitions

Refer to **Appendix-A – Acronym Definition**

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4 Details of Business Need/Problem

4.1 Description

- Number and diversity of non-REM LESRs continue to grow and represent an important part of the future grid.
- Lower barriers and enhance the ability of these resources to participate in the CAISO's market.

Business Opportunity/Problem Statement:	
What:	Enhance the ability of Energy Storage and Distributed Resources to participate in the ISO market.
When:	<ul style="list-style-type: none"> • Stakeholder Initiative • 10/1/2021 Release
Why do we have this opportunity/problem:	<ul style="list-style-type: none"> • There is an increase in these types of resources
Who does this opportunity/problem impact:	<ul style="list-style-type: none"> • CISO Participants • EIM Participants

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5 Business Impacts

5.1 Business Practice Manual (BPM)

BPM	Description of Impact(s)
Demand Response	N/A
Energy Imbalance Market (EIM)	Document: <ul style="list-style-type: none"> Relevant changes on IFM, RTM and SIBR systems that are related to EIM.
Market Instruments	Document: <ul style="list-style-type: none"> Relevant changes on CMRI, OASIS, and SIBR. Relevant Storage DEB calculation and examples.
Market Operations	Document: <ul style="list-style-type: none"> Relevant changes in IFM and RTM systems.
Settlements and Billing	Document: <ul style="list-style-type: none"> Relevant changes in Settlements system. Impact on configuration guide BPMs only.

5.2 Other

Impact:	Description: (optional)
Market Simulation	<ul style="list-style-type: none"> Yes
Market Participant Impact	<ul style="list-style-type: none"> Submission of MF parameters with manufacturer warranty, available data, and supporting documentations. Submission of SOC EOH bid component. Settlements CC impact.

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Impact:	Description: (optional)
External Training	<ul style="list-style-type: none"> • Yes
Policy Initiative	<ul style="list-style-type: none"> • Yes
Tariff Modifications	<ul style="list-style-type: none"> • Yes

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6 Business Requirements

The sections below describe the Business processes and the associated business requirements involved in the project. These may represent high-level functional, non-functional, reporting, and/or infrastructure requirements. These business requirements directly relate to the high-level scope items determined for the project.

6.1 Business Process: Resource Management

6.1.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDER4-BRQ-01020	<p>Registering Storage-Based Variable Cost for LESRs</p> <ul style="list-style-type: none"> • System shall support SC's of LESR resource to register the following optional parameter with an effective start and end dates: <ul style="list-style-type: none"> ○ Storage-Based Variable Cost • 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, following similar process as use-limited business process. • System shall support MCI user's ability to validate, accept or reject the submitted Storage-Based Variable Cost parameters, similar to the process for hydro DEB validation. • If no Storage-Based Variable Cost is submitted by LESR's SC, system shall set it to zero. • Resource's SC shall have the capability to view the submitted Storage-Based Variable Cost. <p>Notes:</p> <ul style="list-style-type: none"> • Storage-Based Variable cost submission applies to both REM and non-REM LESRs. • Storage-Based Variable Cost is optional parameter. • Storage-Based Variable Cost parameter includes Cycling Cost (also called Cell Degradation Cost) • Unit of Storage-Based Variable Cost parameter is in \$/MWh (e.g. \$30/MWh) 	Core	<ul style="list-style-type: none"> • MF • GRDT

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • The Storage-Based Variable Cost parameter represent the cost the resource incurs while producing energy. For most storage resources, the bulk of these costs will include cell degradation costs, or the wear and tear the cells of the battery cells experience as the resources charges and discharges. However, other costs related to the LESR resource charging or discharging may be included in this component. • Implementation <ul style="list-style-type: none"> ○ Storage-Based Variable Cost parameter shall be submitted via CIDI ticket, following similar process as use-limited business process. ○ Resource’s SC shall have the capability to read-only the submitted Storage-Based Variable Cost in GRDT. 		
ESDER4-BRQ-01025 (part of HRp2-BRQ246)	<p>Updating GRDT for Hybrid-Resources Related Data The generator resource data template (GRDT) shall be updated to include the following resource attributes:</p> <ul style="list-style-type: none"> • VER NGR flag • Co-Located flag <p>Note:</p> <ul style="list-style-type: none"> • Implementation: This is needed for dependency between this initiative and Hybrid Resources Phase-2 initiative. 	Core	<ul style="list-style-type: none"> • MF • GRDT
ESDER4-BRQ-01040	<p>Add “Storage” DEB Option Ranking for CISO BAA’s non-REM LESRs</p> <ul style="list-style-type: none"> • System shall support “Storage” as DEB option ranking as one of the DEB Options Ranking which CISO BAA’s non-REM LESR’s SC can submit in addition to supporting these existing options: <ul style="list-style-type: none"> ○ Variable Cost ○ LMP ○ Negotiated Rate • System shall provide SCs of a CISO BAA’s non-REM LESRs with the capability to rank “Storage” DEB option as first option in order to activate it. 	Core	<ul style="list-style-type: none"> • MF



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> System shall not provide SCs of a CISO BAA's non-REM LESRs with the capability to rank "Storage" DEB option as any other rank (i.e. cannot rank it as 2nd, 3rd or 4th rank). System shall not provide SCs of EIM BAA's non-REM LESRs with the capability to rank "Storage" as DEB option since no IFM LMP prices are available for EIM resources. <p>Notes:</p> <ul style="list-style-type: none"> Implementation: Storage DEB Option Ranking parameter is new parameter that is submitted via GRDT as modifiable resource attribute. 		
ESDER4-BRQ-01050	<p>Validate that "Storage" DEB Option Ranking is not Chosen for EIM BAA's non-REM LESRs</p> <p>System shall validate that no "Storage" DEB option ranking is submitted by any EIM BAA's non-REM LESRs' SCs and reject submitted parameters that fail the validation.</p>	Core	• MF
ESDER4-BRQ-01060	<p>Default DEB Option Ranking for non-REM LESRs</p> <ul style="list-style-type: none"> If no rank is specified for a non-REM LESR, system shall set the default ranking as: <ol style="list-style-type: none"> Variable Cost LMP 	Core	• MF
ESDER4-BRQ-01080	<p>Safe Harbor Designations for Small non-REM LESRs</p> <p>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:</p> <ul style="list-style-type: none"> Resource type is non-REM LESR. Resource Registered Pmax capacity ≤ 5 MW (configurable). Resource's ultimate parent company is not a net-supplier. 	Core	• MF
ESDER4-BRQ-01100	<p>Registering Max Daily Run Time (MDRT) for PDR, PDR-LSR Curtailment and RDRR Resources</p> <ul style="list-style-type: none"> System shall support resources' SC to register Max Daily Run Time (MDRT) optional new parameter with an effective start and end dates for resources that satisfy all of the following: <ul style="list-style-type: none"> Resource type is either PDR, PDR-LSR Curtailment or RDRR. 	Core	• MF

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> ○ Curtailment Capability (Registered Pmax) ≥ 1 MW • If MDRT is not entered by resource's SC, system shall store it as NULL. • Registration by SCs shall follow lead time similar to other resource registration parameters. • Registration by SCs shall follow similar submission/update process as Maximum Daily Energy parameter. <p>Note:</p> <ul style="list-style-type: none"> • Valid values for MDRT are either NULL or integers from 1 to 23 hours. • MDRT represents maximum daily number of hours the resource can be committed and/or dispatched. 		

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6.2 Business Process: Calculate & Monitor Energy Costs & Indices

6.2.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDER4-BRQ-02120	<p>“Negotiated” DEB (NDEB) System shall support SC of a non-REM LESR to negotiate its separate NDEB if the applicable DEB option is “Negotiated”, following existing established process as non-LESRs.</p> <p>Note:</p> <ul style="list-style-type: none"> For all NGRs with Negotiated applicable DEB ranking option, System still need to process them based on ranking. 	Core	<ul style="list-style-type: none"> Internal ISO System

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6.3 Business Process: Manage DAM & RTM

- **Manage Day Ahead Market and Operations**
- **Manage Real Time Operations**

6.3.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDE R4- BRQ- 04040	<p>Model Max Daily Run Time (MDRT) System shall have the capability to include the following constraint in the Opportunity Cost Calculator (OCC) optimization model similar to MUT, MDT for PDR, PDR-LSR Curtailment resources:</p> <ul style="list-style-type: none"> • (optional) MDRT <p>Note:</p> <ul style="list-style-type: none"> • Null value of MDRT shall designate no constraint. 	Core	<ul style="list-style-type: none"> • Internal ISO System
ESDE R4- BRQ- 04100	<p>EOH SOC Bid Parameters Submission System shall have the capability to support submission of the following RTM optional hourly bid parameters by non-REM LESR's SC:</p> <ul style="list-style-type: none"> • Min End-Of-Hour (EOH) State Of Charge (SOC) (in MWh) • Max End-Of-Hour (EOH) State Of Charge (SOC) (in MWh) <p>Note:</p> <ul style="list-style-type: none"> • There are no EOH SOC bid parameters for DAM. • If a non-REM LESR opts to submit EOH SOC bidding parameters for a trade hour, it shall submit them as pair (both Min and Max EOH SOC). <p>Market Participants Note:</p> <ul style="list-style-type: none"> • Non-REM LESR's SCs shall not use the EOH SOC bidding parameters in such a way to undermine their Must Offer Obligation (MOO) or use them to withhold additional RA capacity that is not scheduled in IFM or RUC. 	Core	<ul style="list-style-type: none"> • SIBR



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDE R4-BRQ-04120	<p>EOH SOC Bid Parameters Validation</p> <ul style="list-style-type: none"> • System shall have the capability to automatically validate submitted EOH SOC bid parameters using all of the following rules: <ul style="list-style-type: none"> ○ 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 • System shall have the capability to automatically reject the submitted Min and Max EOH SOC bid parameter if above validation failed. <p>Note:</p> <ul style="list-style-type: none"> • Only non-REM LESRs can submit EOH SOC bid parameters. 	Core	• SIBR
ESDE R4-BRQ-04140	<p>Broadcast EOH SOC Bid Parameter Data</p> <p>Along with existing RTM bidding parameters and upon close of RTM bidding window, system shall have the capability to automatically broadcast the following RTM optional hourly bid parameters for non-REM LESRs to downstream systems:</p> <ul style="list-style-type: none"> • Min EOH SOC • Max EOH SOC 	Core	• SIBR
ESDE R4-BRQ-04160	<p>Do not Broadcast EOH SOC Bid Parameter Data to STUC for Advisory Hours</p> <p>System shall not broadcast Min and Max EOH SOC parameters to STUC for advisory hours (STUC bids).</p>	Core	• SIBR
ESDE R4-BRQ-04240	<p>DEB for “Storage” Ranking Option Covers Entire Operating Range for Non-REM LESRs</p> <p>System shall have the capability to calculate DAM and RTM DEBs for “Storage” ranking option for non-REM LESRs that covers their entire operating range (charging as well as discharging) from registered Pmin to registered Pmax.</p>	Core	• IFM
ESDE R4-BRQ-04260	<p>“Storage” DEB Calculations</p> <p>System shall have the capability to automatically calculate separate DAM and RTM daily DEBs for non-REM LESRs only if the applicable DEB option is “Storage”, to account for:</p>	Core	• IFM

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	<ul style="list-style-type: none"> • 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) <p>The Storage DEB calculation shall follow the following formulas:</p> <ul style="list-style-type: none"> • Storage DEB Formula: <ul style="list-style-type: none"> ○ DAM Storage DEB = $\{ \text{Max} (E_{\delta/\eta}, 0) + \rho \} * DS$ ○ RTM Storage DEB = $\text{Max} \{ [\text{Max} (E_{\delta/\eta}, 0) + \rho], PBOC_{\delta} \} * DS$ <p>Where:</p> <ul style="list-style-type: none"> • E_n: Estimated Cost to Buy Energy (e.g. \$60/MWh) • δ: Energy Charging Duration (e.g. 4 hours) • η: Round-Trip Efficiency (e.g. 0.9) • ρ: Storage-Based Variable Costs (including Cell degradation cost [also called Cycling Cost]) (e.g. \$30/MWh) • PBOC: Price-Based Opportunity Cost (e.g. \$100/MWh) • DS: DEB Scalar (e.g. 1.1) <p>Note:</p> <ul style="list-style-type: none"> • Refer to Appendix-B –Storage DEB Calculations Examples. 		
ESDER4-	Energy Charging Duration (δ) Calculation System shall have the capability to automatically calculate the following for non-REM LESRs if the applicable DEB option is “Storage” option:	Core	• IFM



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
BRQ-04280	<ul style="list-style-type: none"> Energy Charging Duration (δ) (hour) = $\frac{[\text{Registered Max ESL (MWh)} - \text{Registered Min ESL (MWh)}]}{ABS[\text{Pmin (MW)}]}$ 		
ESDE R4-BRQ-04290	<p>Energy Discharging Duration (γ) Calculation System shall have the capability to automatically calculate the following for non-REM LESRs if the applicable DEB option is "Storage" option:</p> <ul style="list-style-type: none"> Energy Discharging Duration (γ) (hour) = $\frac{[\text{Registered Max ESL (MWh)} - \text{Registered Min ESL (MWh)}]}{P_{\text{max}} \text{ (MW)}}$ 	Core	• IFM
ESDE R4-BRQ-04300	<p>Storage DEB's Energy Cost ($E_{n_{\delta/\eta}}$) Component Calculation System shall have the capability to automatically calculate the following component of DAM and RTM Storage DEBs for non-REM LESRs if the applicable DEB option is "Storage" option:</p> <ul style="list-style-type: none"> Energy Cost Component ($E_{n_{\delta/\eta}}$) in \$/MWh: Estimated cost to buy energy (while charging) for the adjusted energy charging duration following these rules: <ul style="list-style-type: none"> One cycle of charge/discharge per day. Charging during least expensive continuous LMP prices (valley). Charging at full Pmin MW. Accounting for round-trip efficiency (η) in the Adjusted Energy Charging Duration as follows: <ul style="list-style-type: none"> Adjusted Energy Charging Duration (hour) = δ / η For DAM Storage DEB: <ul style="list-style-type: none"> Use DA LMP from IFM-MPM pass. For RTM Storage DEB: <ul style="list-style-type: none"> Use actual binding DA LMP from same trade day IFM run. 	Core	• IFM
ESDE R4-	<p>Storage DEB's Storage-Based Variable Cost (ρ) Component</p>	Core	• IFM

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BRQ-04320	<p>System shall have the capability to automatically set the Storage-Based Variable Cost (ρ) component of DAM and RTM Storage DEBs for non-REM LESRs if the applicable DEB option is “Storage” option as follows:</p> <ul style="list-style-type: none"> • Entire Charging Operating Range: <ul style="list-style-type: none"> ○ Storage-Based Variable Cost (ρ) = 0 • Entire Discharging Operating Range: <ul style="list-style-type: none"> ○ Storage-Based Variable Cost (ρ) = MF Storage-Based Variable Cost <p>Notes:</p> <ul style="list-style-type: none"> • The setting of zero Storage-Based Variable Cost for the charging range of the resource is needed to guarantee that the Storage DEB is monotonically increasing with output, where in that case the Storage DEB will be constant value for entire charging portion of the resource’s operating range. 		
ESDE R4-BRQ-04340	<p>RTM Storage DEB’s Price-Based Opportunity Cost (PBOC) Component</p> <p>System shall have the capability to automatically calculate the Price-Based Opportunity Cost (PBOC) component of RTM Storage DEBs for non-REM LESRs if the applicable DEB option is “Storage” option as follows:</p> <ul style="list-style-type: none"> • Price-Based Opportunity Cost (PBOC) = the r^{th} highest hourly DA LMP price of the same trade day of IFM. • Where “r” is the Energy Discharging Duration (γ), rounded to nearest lower integer and bounded by values of 1 and NH: <ul style="list-style-type: none"> ○ $r = \text{Min} \{ \text{NH} , \text{Max} [1 , \text{RoundDown} (\gamma)] \}$ • Where NHD is the number of hours per trade day (typically 24 hours, but is 23 hours for short days and 25 hours for long days) <p>Examples:</p> <ul style="list-style-type: none"> • If $\gamma = 4.3$ hours, $r = 4$ • If $\gamma = 4.6$ hours, $r = 4$ 	Core	• IFM

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	<ul style="list-style-type: none"> • If $\gamma = 0.6$ hours, $r = 1$ • If $\gamma = 0.3$ hours, $r = 1$ • If $\gamma = 25.6$ hours, $r = 24$ <p>Notes:</p> <ul style="list-style-type: none"> • There is no Price-Based Opportunity Cost component of DAM Storage DEB. 		
ESDE R4-BRQ-04350	<p>Applying Bid Cap Limit to Calculated “Storage” DEBs</p> <p>System shall apply the configurable bid cap limit to the calculated DAM and RTM daily DEBs for non-REM LESRs, if the applicable DEB option is “Storage”.</p> <p>Note:</p> <ul style="list-style-type: none"> • The configurable bid cap limit will be defaulted to \$1,000/MWh. 	Core	• IFM
ESDE R4-BRQ-04360	<p>Model Max Daily Run Time (MDRT)</p> <p>System shall have the capability to include the following constraint in the market optimization model similar to MUT, MDT for PDR, PDR-LSR Curtailment or RDRR resources:</p> <ul style="list-style-type: none"> • (optional) MDRT <p>Note:</p> <ul style="list-style-type: none"> • Null value of MDRT shall designate no constraint. 	Core	• IFM • RTM
ESDE R4-BRQ-04380	<p>Model EOH SOC Bid Parameters as Constraints in Market Optimization</p> <ul style="list-style-type: none"> • System shall have the capability to include the following constraints in the market optimization model similar to biddable Min and Max ESLs for non-REM LESRs: <ul style="list-style-type: none"> ○ (optional) Min EOH SOC ○ (optional) Max EOH SOC • System shall have the capability to automatically dispatch resources economically or uneconomically to satisfy the EOH SOC. • System shall have the capability to apply EOH constraint to the last market interval of the hour (e.g. last 15-min for FMM [00:45-01:00] and last 5-min for RTD [00:55-01:00]). 	Core	• RTM

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	Note: <ul style="list-style-type: none"> N/A to DAM 		
ESDE R4- BRQ- 04400	EOH SOC Constraints Priority System shall have the capability to model EOH SOC constraints priority via the following: <ul style="list-style-type: none"> Satisfying EOH SOC constraint shall take precedence over economic outcome of the optimization, including but not limited to energy bid curve and ancillary services bid. Respecting ancillary services awards, schedules, and obligations (from same market or lower markets) shall take precedence over satisfying EOH SOC constraints. ED or MD shall take precedence over meeting EOH SOC constraints. Note: <ul style="list-style-type: none"> N/A to DAM 	Core	<ul style="list-style-type: none"> RTM
ESDE R4- BRQ- 04410	Overlapping between RUC-Generated Binding Min EOH SOC Requirement and Biddable Hourly RT Min and Max EOH SOC Parameters and/or Biddable Daily Min and Max ESL For non-REM LESRs and for any RTM market intervals that have overlapping between RUC-generated binding Min EOH SOC requirement and biddable hourly RT Min and/or Max EOH SOC parameters and/or Biddable daily Min and/or Max ESL, <ul style="list-style-type: none"> For critical hours, System shall set precedence to satisfying binding RUC-generated reliability Min EOH SOC requirement. For non-critical hours, System shall satisfy the most restrictive among binding RUC-generated reliability Min EOH SOC requirement and biddable hourly RT Min EOH SOC parameters and/or Biddable daily Min ESL. For critical as well as non-critical hours, System shall set Max EOH SOC and daily Max ESL to be equal to the binding RUC-generated reliability Min EOH SOC requirement if it is in conflict with the latter for the conflicting hours only. Example-1:	Core	<ul style="list-style-type: none"> RTM

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	<ul style="list-style-type: none"> • For a given RTM market interval (within critical hours) and a non-REM LESR with the following parameters: <ul style="list-style-type: none"> ○ No Biddable Daily Min ESL ○ No Biddable Daily Max ESL ○ Biddable Min EOH SOC = 30 MWh ○ Biddable Max EOH SOC = 70 MWh • If binding RUC-gen Min EOH SOC = 25 MWh, binding EOH SOC constraints shall be: <ul style="list-style-type: none"> ○ Min EOH SOC = 25 MWh (from RUC) ○ Max EOH SOC = 70 MWh (from Bid) • If binding RUC-gen Min EOH SOC = 50 MWh, binding EOH SOC constraints shall be: <ul style="list-style-type: none"> ○ Min EOH SOC = 50 MWh (from RUC) ○ Max EOH SOC = 70 MWh (from Bid) • If binding RUC-gen Min EOH SOC = 80 MWh, binding EOH SOC constraints shall be: <ul style="list-style-type: none"> ○ Min EOH SOC = 80 MWh (from RUC) ○ Max EOH SOC = 80 MWh (from RUC) (biddable Max EOH SOC limit interferes with RUC-generated Min EOH SOC limit). <p>Example-2:</p> <ul style="list-style-type: none"> • For a given RTM market interval (within non-critical hours) and a non-REM LESR with the following parameters: <ul style="list-style-type: none"> ○ No Biddable Daily Min ESL ○ No Biddable Daily Max ESL ○ Biddable Min EOH SOC = 30 MWh ○ Biddable Max EOH SOC = 70 MWh • If binding RUC-gen Min EOH SOC = 25 MWh, binding EOH SOC constraints shall be: <ul style="list-style-type: none"> ○ Min EOH SOC = 30 MWh (from RUC) ○ Max EOH SOC = 70 MWh (from Bid) • If binding RUC-gen Min EOH SOC = 50 MWh, binding EOH SOC constraints shall be: <ul style="list-style-type: none"> ○ Min EOH SOC = 50 MWh (from RUC) ○ Max EOH SOC = 70 MWh (from Bid) • If binding RUC-gen Min EOH SOC = 80 MWh, binding EOH SOC constraints shall be: <ul style="list-style-type: none"> ○ Min EOH SOC = 80 MWh (from RUC) ○ Max EOH SOC = 80 MWh (from RUC) (biddable Max EOH SOC limit interferes 		



ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
	with RUC-generated Min EOH SOC limit)		
ESDE R4-BRQ-04420	<p>EOH SOC Constraints Alignment between RTUC/FMM & RTED System shall have the capability to create implied End of Horizon SOC constraints in RTED to align EOH constraint between RTUC/FMM and RTED, using the EOH SOC and the schedule MW from RTUC/FMM, if following condition is met:</p> <ul style="list-style-type: none"> • RTED end of horizon is earlier than the last interval of the hour where EOH SOC exist. <p>Note:</p> <ul style="list-style-type: none"> • N/A to DAM • Refer to Appendix-C –Alignment of EOH SOC Constraints between RTUC/FMM & RTED 	Core	• RTM
ESDE R4-BRQ-04440	<p>Display EOH SOC Parameters System shall have the capability to display the EOH SOC parameters to system users/operators, via UI, similar to existing functionality that displays energy bids and biddable energy storage limits.</p>	Core	• RTM
ESDE R4-BRQ-04450	<p>Calculate & Display Effective SOC Limits</p> <ul style="list-style-type: none"> • System shall have the capability to calculate effective SOC limits as follows: <ul style="list-style-type: none"> ○ Effective SOC Lower Limit: Effective Min SOC limit that is used by market application. It shall include the effect of any bid parameters or any outages derates in SOC. ○ Effective SOC Upper Limit: Effective Max SOC limit that is used by market application. It shall include the effect of any bid parameters or any outages derates in SOC. • System shall have the capability to display the following parameters to system users/operators, via UI: <ul style="list-style-type: none"> ○ SOC Lower Limit ○ SOC Upper Limit 	Core	• RTM
ESDE R4-	<p>Apply MPM to Entire Operating Range for non-REM LESRs System shall have the capability to apply MPM to entire operating range (charging as well as discharging) for</p>	Core	• IFM • RTM

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BRQ-04460	non-REM LESRs except for resources that are designated as "Safe Harbor".		

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6.4 Business Process: Manage Market Reporting

- **Manage Day Ahead Market and Operations**
- **Manage Real Time Operations**

6.4.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDE R4- BRQ- 06050	<p>Monitoring DAM & RTM DEBs for non-REM LESRs</p> <p>System shall have the capability to monitor and support alerts if any of the following conditions occur: for non-REM LESRs:</p> <ul style="list-style-type: none"> • Mismatch between received DAM and RTM DEBs and the number of non-REM LESRs in MF. 	Core	• CMRI
ESDE R4- BRQ- 06060	<p>Publish DAM & RTM DEBs for non-REM LESRs</p> <p>Upon receipt from upstream systems, system shall have the capability to automatically publish the following DEBs for non-REM LESRs for the “Default Energy Bid Curves” report:</p> <ul style="list-style-type: none"> • 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 T+1 trade date <p>Note:</p> <ul style="list-style-type: none"> • The CMRI report structure will be the same, but the “Default Bid Type” will have a new possible value of “Storage”; and “Peak” will have a new possible value of Null. • System shall continue not to publish Reasonableness Threshold nor Default Commitment Costs or their related parameters for non-REM LESRs. • Implementation: <ul style="list-style-type: none"> ○ CMRI will display Null for the “Peak” column for DEBs with “Storage” default bid types. 	Core	• CMRI
ESDE R4-	<p>Effective Dates for Publishing Modified Reports</p> <p>System shall have the capability to publish the applicable report upon production activation.</p>	Core	• CMRI

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
BRQ-06080			
ESDE R4-BRQ-06120	Publish EOH SOC Bid Parameters and to Public Bids System shall have the capability to include the following RTM optional hourly bid parameters for non-REM LESRs to the masked " <i>Public Bids</i> " report: <ul style="list-style-type: none"> • (optional) Min EOH SOC • (optional) Max EOH SOC 	Core	• OASIS
ESDE R4-BRQ-06140	Effective Dates for Publishing Modified Reports System shall have the capability to publish the modified report upon production activation.	Core	• OASIS

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6.5 Business Process: Manage FERC Reporting

- **Manage Day Ahead Market and Operations**
- **Manage Real Time Operations**

6.5.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDE R4- BRQ- 07040	<p>Store and Publish to FERC Modified/New Data System shall have the capability to automatically store and publish the following data to FERC for non-REM LESRs. This shall include:</p> <ul style="list-style-type: none"> ○ For non-REM LESRs: <ul style="list-style-type: none"> ▪ Storage-Based Variable Cost ▪ (optional) Min EOH SOC RTM hourly bid parameters ▪ (optional) Max EOH SOC RTM hourly bid parameters ▪ DEBs ▪ Default Bid Type (new bid type for “Storage”) ▪ “Safe Harbor” designation flag (existing LMPM flag is used). ○ For PDR, PDR-LSR curtailment and RDRR resources: <ul style="list-style-type: none"> ▪ (optional) Max Daily Run Time (MDRT) 	Core	<ul style="list-style-type: none"> • Internal ISO System

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6.6 Business Process: Manage Market Billing and Settlements

6.6.1 Business Requirements

ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDER4-BRQ-08040	<p>Disqualification of RTM Bid Cost Shortfall Due to RTM EOH SOC Bids (Flagged Hours) For an accepted RTM Min and Max EOH SOC bid parameters in an hour for non-REM LESRs:</p> <ul style="list-style-type: none"> System shall have the capability to automatically disqualify the resource from receiving RTM Bid Cost shortfall for that hour and the previous hour (flagged hours) per the rules in ESDER4-BRQ-08080. 	Core	<ul style="list-style-type: none"> Settlements
ESDER4-BRQ-08050	<p>Bid Cost Recovery Treatment for Overlap between RUC-Generated Binding Min EOH SOC Requirement and Biddable Hourly RT Min and Max EOH SOC Parameters For 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, System shall disqualify that resource from RTM BCR according to the below referenced business requirement.</p> <p>Notes:</p> <ul style="list-style-type: none"> Refer to ESDER4-BRQ-08040 	Core	<ul style="list-style-type: none"> Settlements
ESDER4-BRQ-08060	<p>Disqualification of RTM Bid Cost Shortfall Due to RTM Self-Schedules (Flagged Hours) For an accepted RTM self-schedules in an hour for non-REM LESRs:</p> <ul style="list-style-type: none"> System shall have the capability to automatically disqualify the resource from receiving RTM Bid Cost shortfall for the previous hour (flagged hour) per the rules in ESDER4-BRQ-08080. <p>Note:</p> <ul style="list-style-type: none"> Disqualification of RTM and DA BCR due to self-schedules for the same hour is an existing functionality. 	Core	<ul style="list-style-type: none"> Settlements
ESDER4-	<p>RTM Bid Cost Shortfall/Surplus Assessment for the Flagged Hours System shall have the capability to automatically evaluate RTM Bid Cost Shortfall/Surplus for the</p>	Core	<ul style="list-style-type: none"> Settlements

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
BRQ-08080	<p>flagged hours at each 5-minute interval of the for non-REM LESRs, as follows:</p> <ul style="list-style-type: none"> • If RTM Bid Cost is > RTM Market Revenue (shortfall): <ul style="list-style-type: none"> ○ this interval shall be set to 0 in the daily BCR settlements; • If RTM Bid Cost is ≤ RTM Market Revenue (surplus): <ul style="list-style-type: none"> ○ there shall be no change in this interval ○ These surpluses shall be included in the daily BCR settlements and used to cover shortfalls that may have been generated in other periods in the day. <p>Notes:</p> <ul style="list-style-type: none"> • Refer to ESDER4-BRQ-08040, ESDER4-BRQ-08060 for flagged hours identifications. • RTM Bid Cost: <ul style="list-style-type: none"> ○ The total of a resource’s RTM SUC, RTM MLC, RTM pump SDC, RTM MSG STC, RTM Pumping Cost (PC), RTM Energy Bid Cost, and RTM AS Bid Cost. • RTM Market Revenue: <ul style="list-style-type: none"> ○ The amount received by BCR-eligible resource from energy scheduled and AS awarded in the RTM for the purposes of BCR. • RTM Bid Cost Shortfall: <ul style="list-style-type: none"> ○ The negative amount resulting from the difference between its RTM Bid Cost and its RTM Market Revenue, for each settlement interval, for any BCR-eligible resource. • RTM Bid Cost Surplus: <ul style="list-style-type: none"> ○ The positive amount, if any, resulting from the difference between its RTM Bid Cost and its RTM Market Revenue, for each settlement interval, for any BCR-eligible resource. 		

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ID#	Business Feature	Requirement Type	Potential Application(s) Impacted
ESDER4-BRQ-08100	Apply RTM BCR to Entire Operating Range System shall have the capability to automatically apply RTM BCR rules to entire operating range (discharging and charging) for non-REM LESRs.	Existing System Functionality	<ul style="list-style-type: none"> • Settlements
ESDER4-BRQ-08140	No Change to Existing DAM BCR System shall not modify existing settlements rules of DAM BCR as a result of EOH constraint or self-schedules for non-REM LESRs.	Existing System Functionality	<ul style="list-style-type: none"> • Settlements
ESDER4-BRQ-08160	No Change to DA MEAF, RTM Performance Metric and Persistent Deviation Rules System shall not modify existing settlements rules of DA Metering Energy Adjustment Factors (MEAF), RTM Performance Metric and Persistent Deviation as a result of EOH constraint or self-schedules for non-REM LESRs.	Existing System Functionality	<ul style="list-style-type: none"> • Settlements

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6.7 Business Process: <Market/Business Simulation>

This section shall provide a basis for the development of the Market/Business Simulation Scenarios. These requirements will provide guidance on the market participant impacts, inputs into the Scenarios, endpoints to the Scenarios and reasons for potential Scenarios. The guidance on market participant impacts shall be gathered from the requirements that impact rules, interfaces, applications/reports, new system processes, new/modified data models and new user roles. The source and sink systems shall be determined through the development of the system context diagram and the web service requirements. The Reason for the Potential Scenario column will be to offer guidance regarding what potential Scenarios, and their context, may be needed for this project. This section applies to all policy development projects, market enhancements, technology enhancements, operation enhancements, Energy Imbalance Market (EIM) implementations and Reliability Coordination (RC) service implementations.

In the Reason for Potential Scenario column, the Business Analyst must select one or more of the following reasons:

1. **Rule Impacts:** Generalized changes in market rules, bidding rules, settlements rules, market design changes, or other business rules.
2. **Interface changes:** Changes that impact templates (e.g. the Resource Adequacy {RA} supply plan), user interface (UI), and application programming interface (API) (e.g. retrievals of new shadow settlement data).
3. **New application/report:** Changes that cause addition/modification of market software or reports, especially when market data input is required by the market participant.
4. **New system process:** Modification of data flow in systems, especially if the new process requires the market participant to demonstrate proficiency prior to production.
5. **New/Modified model data:** Addition or substantial modification of model data as a market solution provided by the ISO.
6. **New user role:** The addition or modification of access permissions for a user role applied to specific business units within an EIM entity or market participant organization (e.g. Load Serving Entity (LSE) as a Local Regulatory Authority (LRA) role). Scenarios are beneficial for market participants taking on a new function or process within their organization.

6.7.1 Business Requirements

ID#	Guidance on Market Participant Impacts	Source System	Sink System	Reason for Potential Scenario
ESDER4-MSIM-09020	<p>Submit Combinations of Competitive RT Bids with EOH SOC Parameters and Self-Schedules by non-REM LESRs' SCs (Bid-to-Bill Scenario)</p> <ul style="list-style-type: none"> • Set up a scenario where: 	<ul style="list-style-type: none"> • SIBR 	<ul style="list-style-type: none"> • ADS • BAAOP • CMRI • OASIS 	1. Rule Impact 5. New/Modified model data

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ID#	Guidance on Market Participant Impacts	Source System	Sink System	Reason for Potential Scenario
	<ul style="list-style-type: none"> ○ 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). ● Follow the results in the sink systems. Specifically: <ul style="list-style-type: none"> ○ ADS, BAAOP, CMRI: <ul style="list-style-type: none"> ▪ Verify that RT market results of non-REM LESRs considers EOH SOC bid parameters. ○ CMRI: <ul style="list-style-type: none"> ▪ Verify DAM and RTM DEBs are published for non-REM LESRs. ○ OASIS: <ul style="list-style-type: none"> ▪ Verify that masked RT EOH SOC bid parameters are 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. ○ Settlements: <ul style="list-style-type: none"> ▪ Verify that RTM BCR accounts for EOH SOC parameters and self-schedules for non-REM LESRs. 		<ul style="list-style-type: none"> ● MRI-S [Settlements] 	
ESDER4-MSIM-09040	<p>Submit Combinations of Competitive DA and RT Bids and Self-Schedules by PDRs, PDR-LSRs curtailment or RDRRs' SCs</p> <ul style="list-style-type: none"> ● Set up a scenario where: <ul style="list-style-type: none"> ○ SCs of the PDR, PDR-LSR curtailment or RDRR resource submit combination of competitive bids and self-schedules with or without Max Daily Run Time (MDRT) constraint. 	<ul style="list-style-type: none"> ● SIBR 	<ul style="list-style-type: none"> ● ADS ● BAAOP ● CMRI 	1. Rule Impact 5. New/Modified model data

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ID#	Guidance on Market Participant Impacts	Source System	Sink System	Reason for Potential Scenario
	<ul style="list-style-type: none"> • Follow the results in the sink systems. Specifically: <ul style="list-style-type: none"> ○ ADS, BAAOP, CMRI: <ul style="list-style-type: none"> ▪ Verify that DA and RT market results of PDRs, PDR-LSRs curtailment or RDRRs considers MDRT parameter. 			
ESDER4-MSIM-09060	<p>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)</p> <ul style="list-style-type: none"> • Set up a scenario where: <ul style="list-style-type: none"> ○ <i>RUC under-gen infeasibility is triggered for at least 1 hour in a trade day.</i> ○ 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. • Follow the results in the sink systems. Specifically: <ul style="list-style-type: none"> ○ ADS, BAAOP, CMRI: <ul style="list-style-type: none"> ▪ Verify that RT market results of non-REM LESRs reflects system setting precedence to satisfying binding RUC-generated reliability Min EOH SOC requirement. ○ OASIS: <ul style="list-style-type: none"> ▪ Verify that masked RT EOH SOC bid parameters are published for non-REM LESRs in Public Bid report. Note: CAISO will provide a sample of the report to participants since 	<ul style="list-style-type: none"> • SIBR 	<ul style="list-style-type: none"> • ADS • BAAOP • CMRI • OASIS • MRI-S [Settlements] 	1. Rule Impact 5. New/Modified model data

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ID#	Guidance on Market Participant Impacts	Source System	Sink System	Reason for Potential Scenario
	<p style="text-align: center;">the report is published T+90 days.</p> <ul style="list-style-type: none"> ○ Settlements: <ul style="list-style-type: none"> ▪ Verify that 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. 			
ESDER4-MSIM-09080	<p>Submit Combinations of DA and RT Bids subject to Market Power Mitigation by non-REM LESRs' SCs (Bid-to-Bill Scenario)</p> <ul style="list-style-type: none"> • Set up a scenario where: <ul style="list-style-type: none"> ○ SCs of the non-REM LESR resource submit DA and RT bids that are subject to market power mitigation (bid-to-bill scenario). • Follow the results in the sink systems. Specifically: <ul style="list-style-type: none"> ○ CMRI: <ul style="list-style-type: none"> ▪ 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. ○ Settlements: <ul style="list-style-type: none"> ▪ Verify that DA and RT settlements statements account for mitigated bids for non-REM LESRs. 	<ul style="list-style-type: none"> • SIBR 	<ul style="list-style-type: none"> • CMRI • MRI-S [Settlements] 	1. Rule Impact 5. New/Modified model data

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7 Appendices

7.1 Appendix-A – Acronym Definition

Acronym	Definition
A2A	Application-to-Application
ABC	Available Balancing Capacity
ABS	Absolute
ACL	Access Control List
AD	Architecture Definition
ADS	Automatic Dispatch System
AGC	Automatic Generation Control
AIM	Access and Identity Management
ALFS	Automated Load Forecast System
Anode	Aggregate Node
API	Application Program Interface
Apnode	Aggregate Pricing Node
AS	Ancillary Services
AUX	Auxiliary
B2B	Business-to-Business
BA	Business Analyst
BAA	Balancing Authority Area
BAAOP	Balancing Authority Area Operations Portal
BCR	Bid Cost Recovery
BOG	Board Of Governors

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Acronym	Definition
BPM	Business Process Manual
BRS	Business Requirement Specifications
BSAP	Base Schedule Aggregation Portal
BSC	Base Schedule Coordinator
CAISO	California Independent System Operator
CB	Convergence Bidding
CCDEBE	Commitment Costs and Default Energy Bid Enhancements
CDN	Conformed Dispatch Notice
CIDI	Customer Inquiry, Dispute and Information
CIM	Common Information Model
CIP	Critical Infrastructure Protection
CIRA	Customer Interface for Resource Adequacy
CISO	California Independent System Operator
CMRI	Customer Market Results Interface
Cnode	Connectivity Node
COG	Constrained-Output Generator
CPM	Capacity Procurement Mechanism
CRN	Contract Reference Number
CRR	Congestion Revenue Rights
CRRS	Congestion Revenue Rights Settlements (aka CRR Clawback system)
CSS	Critical Systems Support

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Acronym	Definition
DA	Day-Ahead
DACA	Day-Ahead Contingency Analysis
DAM	Day-Ahead Market
DART	Day-Ahead Reliability Tool (an internal CAISO system/application)
DB	Database
DCPA	Dynamic Competitive Path Assessment
DEB	Default Energy Bid
DGAP	Default Generation Aggregation Point
DMM	Department of Market Monitoring
DOP	Dispatch Operating Point
DOT	Dispatch Operating Target
DS	DEB Scalar
DSA	Dynamic Stability Analysis
ECIC	Energy Costs and Index Calculator (an internal CAISO system/application)
ED	Exceptional Dispatch
EDAM	Extended Day-Ahead Market
EDR	Enterprise Data Repository (an internal CAISO system/application)
EE	Expected Energy
EEA	Expected Energy Allocation
EFC	Effective Flexible Capacity
EIM	Energy Imbalance Market

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Acronym	Definition
EIMNPR	Energy Imbalance Market Non-Participating Resource
EIMPR	Energy Imbalance Market Participating Resource
EMM	Enterprise Model Management
EMMS	Enterprise Model Management System (an internal CAISO system/application)
EMNA	Energy Management Network Application (an internal CAISO system/application)
EMS	Energy Management System (an internal CAISO system/application)
EOH	End Of Hour
EPI	Electricity Price Index
ESDER	Energy Storage and Distributed Energy Resources
ESL	Energy Storage Limit
ESP	Electronic Security Perimeter
ETC	Existing Transmission Contract
ETSR	Energy Transfer System Resources
FERC	Federal Energy Regulatory Commission
FMCA	Fifteen-Minute Contingency Analysis
FMM	Fifteen-Minute Market
FNM	Full Network Model
FODD	FERC Outgoing Data Depository (an internal CAISO system/application)
FRD	Flexible Ramp Down
FRU	Flexible Ramp Up
GDF	Generation Distribution Factor

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Acronym	Definition
GHG	Green House Gas
GIP	Generator Interconnection Procedure
GMC	Grid Management Charge
GPI	Gas Price Index
GRDT	Generator Resource Data Template
GUI	Graphical User Interface
HASP	Hour-Ahead Scheduling Process
HR	Heat Rate
HAVGC	Heat Average Cost (for non-gas resources)
IAIQ	IT Architecture, Integration and QA
ICE	InterContinental Exchange
ICM	Infrastructure Contracts and Management
ID	Identifier
IFM	Integrated Forward Market (an internal CAISO system/application)
ISL	Intertie Scheduling Limit
ISO	California Independent System Operator
IOOC	Integrated Optimal Outage Coordination (an internal CAISO system/application)
IT	Information Technology
ITC	Inter-Tie Constraint
ITPD	Information Technology Product Development
ITPM	Information Technology Product Management

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Acronym	Definition
ITS	Interchange Transaction Scheduler
LACA	Look-Ahead Contingency Analysis (an internal CAISO system/application)
LEL	Lower Economic Limit
LESR	Limited Energy Storage Resource
LF	Load Forecast
LMP	Locational Marginal Price
LMPM	Locational Market Power Mitigation
LOL	Lower Operating Limit
LRA	Local Regulatory Authority
LSE	Load Serving Entity
LSR	Load Shift Resource
LTCA	Long-Term Contingency Analysis (an internal CAISO system/application)
MA&F	Market Analysis & Forecasting
MAX (or Max)	Maximum
MCI	Model and Contract Implementation
MD	Manual Dispatch
MDT	Minimum Down Time
MDRT	Maximum Daily Run Time
MDS	Maximum Daily Startups
MEAF	Metering Energy Adjustment Factors
MF	Master File (an internal CAISO system/application)

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Acronym	Definition
MFRD	Master File Reference Data
MIN (or Min)	Minimum
MLC	Minimum Load Cost
MMA	Major Maintenance Adder
MMG	Manage Markets & Grid
MMR	Manage Market & Reliability
MOO	Must-Offer Obligation
MOS	Manage Operations Support & Settlements
MPM	Market Power Mitigation
MQS	Market Quality System (an internal CAISO system/application)
MRID	Master Resource IDentifier
MRI-S	Market Results Interface – Settlements
MSSA	Metered Sub System Agreement
MSG	Multi-Stage Generator
MUT	Minimum Up Time
MV	Materialized View
MV&A	Market Validation & Analysis
MVT	Market Validation Tool
MW	Mega Watt
MWh	Mega Watt Hour
N/A	Not Applicable

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Acronym	Definition
NA	Network Application
NDEB	Negotiated Default Energy Bid
NGR	Non-Generating Resource
NM	Network Model
NQC	Net Qualifying Capacity
OASIS	Open Access Same-time information System
OATI	Open Access Technology International
OC	Opportunity Cost
OCC	Opportunity Cost Calculator (an internal CAISO system/application)
ODCP	On Demand Capacity Procurement
OES	Operations Engineering Services
OMS	Outage Management System (aka WebOMS)
OTS	Operations Training Simulator (an internal CAISO system/application)
PAM	Program and Application Management
PBC	Power Balance Constraint
PBOC	Price-Based Opportunity Cost
PC	Pumping Cost
PC	Pre-Calculation
PCA	Price Correction Admin (an internal CAISO system/application)
PCT	Price Correction Tools (an internal CAISO system/application)
PDR	Proxy Demand Resource

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Acronym	Definition
PGA	Participating Generator Agreement
PI	Plant Information
PL	Participating Load
PLA	Participating Load Agreement
Pmax	Maximum Generation Capacity
Pmin	Minimum Generation Capacity
PMO	Program Management Office
Pnode	Pricing Node
POC	Point Of Contact
PRSC	Participating Resource Scheduling Coordinator
PSH	Pump Storage Hydro
PSTD	Power Systems Technology Development
PSTO	Power Systems Technology Operations
PTO	Participating Transmission Owner
QRB	Quality Review Board
RA	Resource Adequacy
RC	Reliability Coordinator
RC-BSAP	Reliability Coordinator - Base Schedule Aggregation Portal
RCD	Reliability Capacity Down
RCSA	Reliability Coordinator Service Agreement
RCU	Reliability Capacity Up

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Acronym	Definition
RDRR	Reliability Demand Response Resource
RDT	Resource Data Template
REM	Regulation Energy Management
RIG	Remote Intelligent Gateway
RIMS	Resource Interconnection Management System
RMR	Reliability Must Run
RR	Ramp Rate
RT	Real-Time
RTBS	Real-Time Base Scheduler (an internal CAISO system/application)
RTCA	Real-Time Contingency Analysis (an internal CAISO system/application)
RTD	Real-Time Dispatch (used alternatively with RTED)
RTED	Real-Time Energy Dispatch (used alternatively with RTD)
RTPD	Real-Time Pre-Dispatch
RTM	Real-Time Market (an internal CAISO system/application)
RTUC	Real-Time Unit Commitment
RUC	Residual Unit Commitment
SADS	System And Design Specifications
SAMQ	Security, Architecture, Model Management & Quality
SC	Scheduling Coordinator
SCME	Scheduling Coordinator Meter Entity
SDC	Shut Down Cost

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Acronym	Definition
SE	State Estimator
SIBR	Scheduling Infrastructure and Business Rules
SME	Subject Matter Expert
SOA	Service-Oriented Architecture
SOC	State Of Charge
SQMD	Settlements Quality Meter Data
SRS	System Requirement Specifications
STC	State Transition Cost
STF	Short-Term Forecast
STC	State Transition Cost
STT	State Transition Time
STUC	Short-Term Unit Commitment
SUC	Start Up Cost
SUT	Start Up Time
T	Trading Hour
TBD	To Be Determined
TG	Tie Generator
TNA	Transmission Network Application
TOP	Transmission Operator Provider
TOR	Transmission Ownership Contract
UAT	User Acceptance Testing

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Acronym	Definition
UEL	Upper Economic Limit
UI	User Interface
UIE	Uninstructed Energy Imbalance
UL	User Limited
UOL	Upper Operating Limit
VER	Variable Energy Resource
VOM	Variable Operations & Maintenance
VOMC	Variable Operations & Maintenance Cost
WebOMS	Web-based Outage Management System (aka OMS)
XML	Extensible Markup Language
XSD	XML Schema Definition

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7.2 Appendix-B –Storage DEB Calculations Examples

7.2.1 Non-REM LESR Parameters

Parameter	Value
Pmin	-10 MW
Pmax	10 MW
Registered Min ESL	0 MWh
Registered Max ESL	40 MWh
Round-Trip Efficiency (η)	0.9
Storage-Based Variable Cost (ρ)	30 \$/MWh
DEB Scalar (DS)	1.1

7.2.2 Common Calculations for All Examples

- Energy Charging Duration (δ) (hour)

$$= (\text{Registered Max ESL} - \text{Registered Min ESL}) / \text{ABS}(P_{\text{min}})$$

$$= (40-0) / 10$$

$$= 4 \text{ hours}$$
- Adjusted Energy Charging Duration (hour)

$$= \delta / \eta$$

$$= 4 / 0.9$$

$$= 4.44 \text{ hours}$$
- Energy Discharging Duration (γ) (hour)

$$= (\text{Registered Max ESL} - \text{Registered Min ESL}) / P_{\text{max}}$$

$$= (40-0) / 10$$

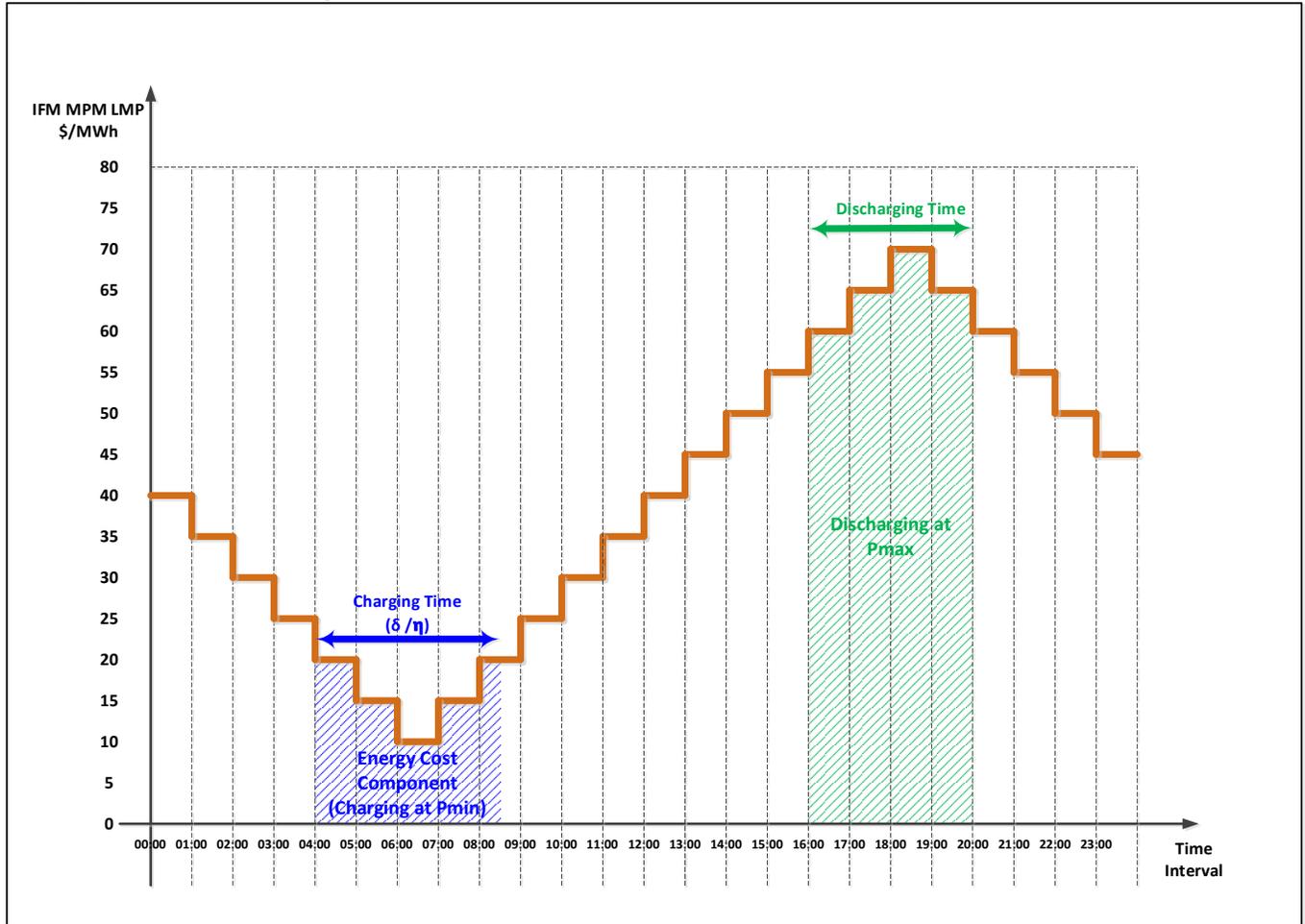
$$= 4 \text{ hours}$$
- r

$$= \text{Max} \{ 24, \text{Min} [1, \text{RoundDown}(\gamma)] \}$$

$$= 4$$
- Storage-Based Variable Cost (ρ) (from Pmin to 0 [-10 to 0 MW]) = 0 \$/MWh
- Storage-Based Variable Cost (ρ) (from 0 to Pmax [0 to 10 MW]) = 30 \$/MWh



7.2.3 Example-1 – DAM Storage DEB Calculations

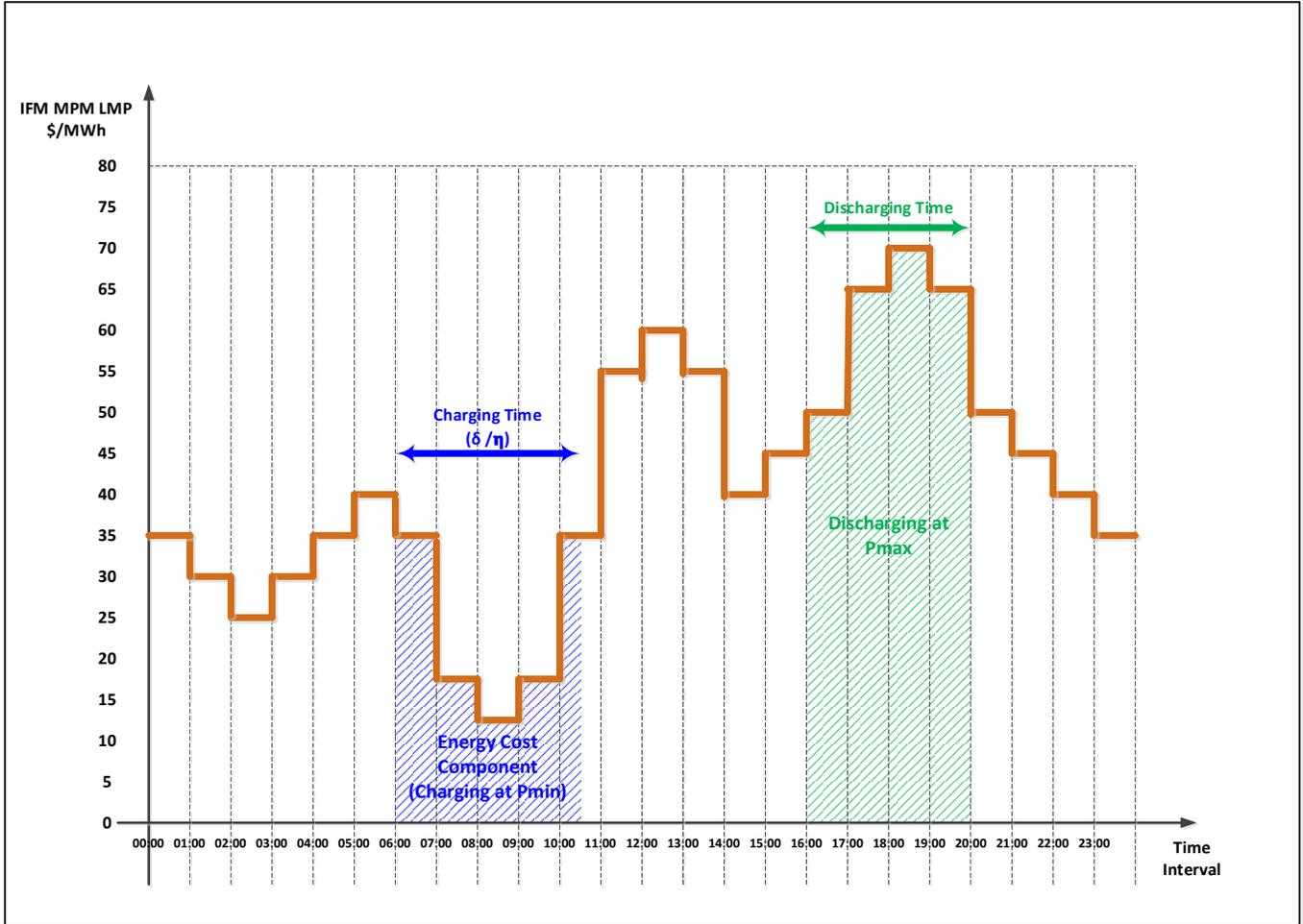


- $$En_{\delta/\eta} = [(20*1) + (15*1) + (10*1) + (15*1) + (20*0.44)]/4.44 = 15.5 \text{ \$/MWh}$$

MW Segment Range	DAM Storage DEB: $\{\text{Max}(En_{\delta/\eta}, 0) + \rho\} * DS$
Pmin to 0 (-10 to 0)	$\{15.5 + 0\} * 1.1 = 17.05 \text{ \$/MWh}$
0 to Pmax (0 to 10)	$\{15.5 + 30\} * 1.1 = 50.05 \text{ \$/MWh}$



7.2.4 Example-2 – DAM Storage DEB Calculations

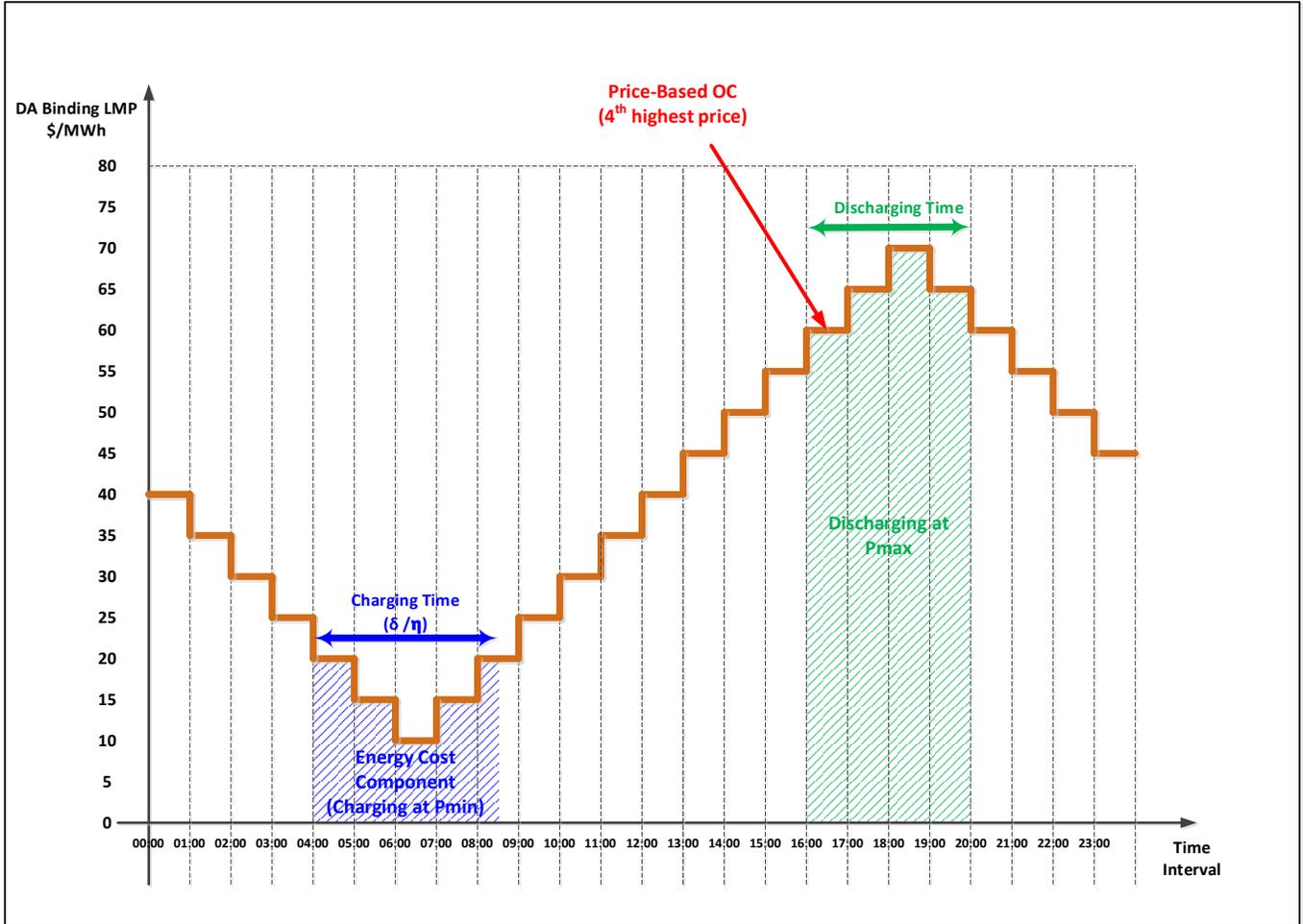


- $$En_{\delta/\eta} = [(35*1) + (15*1) + (10*1) + (15*1) + (35*0.44)]/4.44 = 20.375 \text{ \$/MWh}$$

MW Segment Range	DAM Storage DEB: $\{\text{Max}(En_{\delta/\eta}, 0) + \rho\} * DS$
Pmin to 0 (-10 to 0)	$\{20.375 + 0\} * 1.1 = 22.41 \text{ \$/MWh}$
0 to Pmax (0 to 10)	$\{20.375 + 30\} * 1.1 = 55.41 \text{ \$/MWh}$



7.2.5 Example-3 – RTM Storage DEB Calculations

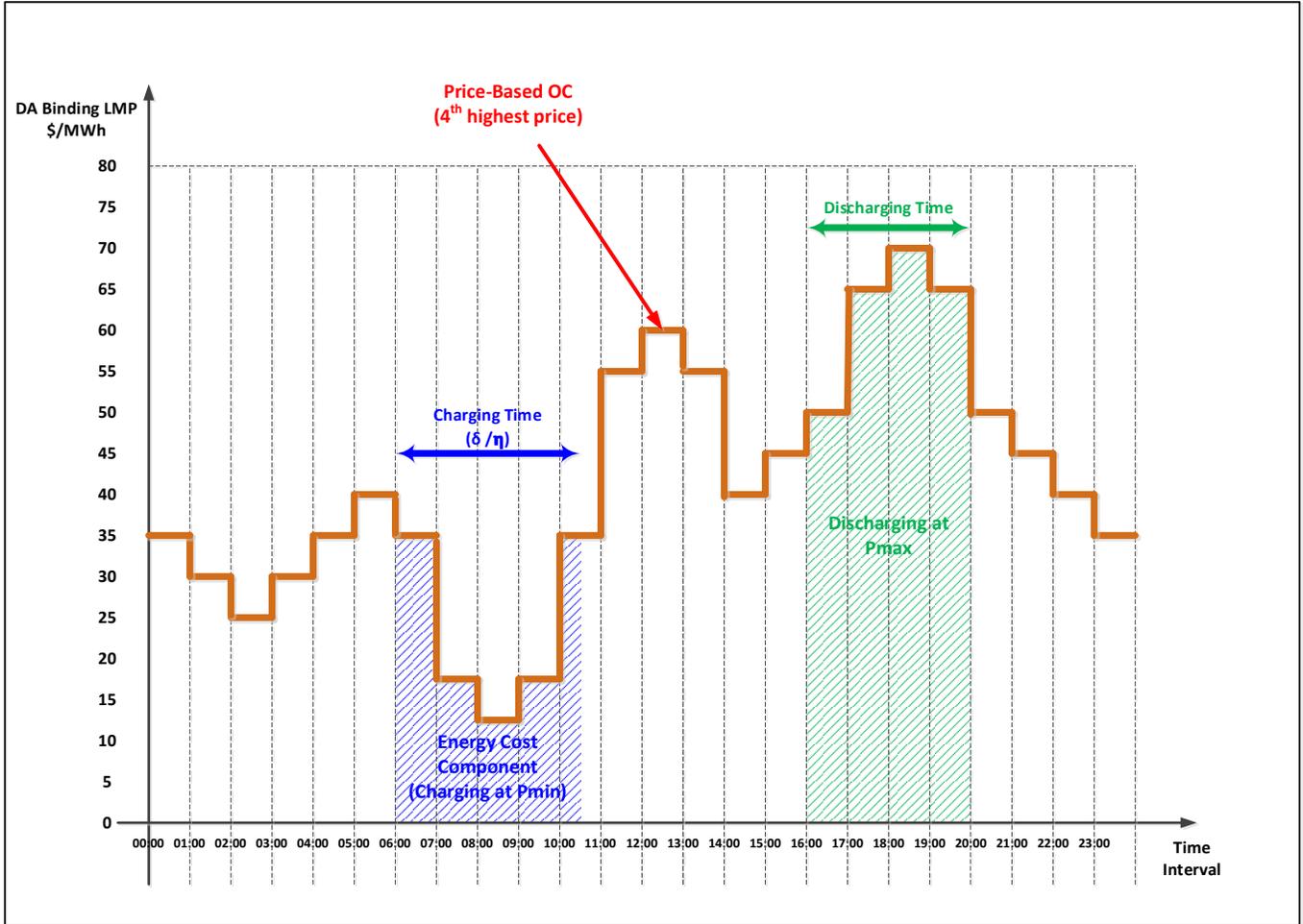


- $En_{\delta/\eta} = [(20*1) + (15*1) + (10*1) + (15*1) + (20*0.44)]/4.44 = 15.5 \text{ \$/MWh}$
- $PBOC_{\delta} = 60 \text{ \$/MWh}$

MW Segment Range	RTM Storage DEB: $\text{Max}\{[\text{Max}(En_{\delta/\eta}, 0) + \rho], PBOC_{\delta}\} * DS$
Pmin to 0 (-10 to 0)	$\text{Max}\{[15.5 + 0], 60\} * 1.1 = 66 \text{ \$/MWh}$
0 to Pmax (0 to 10)	$\text{Max}\{[15.5 + 30], 60\} * 1.1 = 66 \text{ \$/MWh}$



7.2.6 Example-4 – RTM Storage DEB Calculations



- $En_{\delta/\eta} = [(35*1) + (15*1) + (10*1) + (15*1) + (35*0.44)]/4.44 = 20.375 \text{ \$/MWh}$
- $PBOC_{\delta} = 60 \text{ \$/MWh}$

MW Segment Range	RTM Storage DEB: $\text{Max} \{ [\text{Max} (En_{\delta/\eta}, 0) + \rho], PBOC_{\delta} \} * DS$
Pmin to 0 (-10 to 0)	$\text{Max} \{ [20.375 + 0], 60 \} * 1.1 = 66 \text{ \$/MWh}$
0 to Pmax (0 to 10)	$\text{Max} \{ [20.375 + 30], 60 \} * 1.1 = 66 \text{ \$/MWh}$

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7.3 Appendix-C –Alignment of EOH SOC Constraints between RTUC/FMM & RTED

7.3.1 Background

The more limited look-out horizon in RTED may impact a resources ability to achieve its target end-of-hour state-of-charge. Below we detail how we are proposing to align visibility between FMM and RTED to help ensure that the end-of-hour state-of-charge While the Short-term Unit Commitment (STUC) market runs have no influence on energy storage resources, the EOH SOC bids could still influence the decision to commit (or not) additional medium-start units. Since real-time bids can be submitted and changed from the close of the day ahead market to T-75 minutes prior to the start of the hour, to prevent any potential gaming opportunities, the CAISO will only release the EOH SOC bids from SIBR to STUC once the real-time market closes for that interval. Next, we provide details and examples of how the EOH SOC would be treated in the FMM and RTED.

For example, a 40 MWh resource with a -10 MW Pmin and 10 MW Pmax may submit a minimum end-of-hour state-of-charge parameter of 30 MWh (75%) applicable for hour ending 10.¹ Bids for hour-ending 10 (the period 09:00-10:00) are due at 07:45, or 75 minutes prior to 09:00. At 07:50 one of the market runs for the real-time unit commitment (RTUC) process begins, which generates binding market instructions for the FMM interval, from 08:30-08:45, and advisory instructions for the five successive intervals from 08:45-10:00. Because this is the first RTUC market run to observe the end-of-hour state-of-charge bid submitted, effective for hour-ending 10, the value will be considered in this market run. If the resource has a 10 MWh (25%) initial state-of-charge in this run, the resource will be scheduled to fully charge in all binding and advisory intervals, assuming that all intervals of charging are required based on its resource characteristics to meet the state of charge of at least 75% by hour-ending 10.

The RTED market is different. This market runs 7.5 minutes prior to the start of a specific 5-minute interval and looks out up to 65 minutes, which represents one binding and up to 12 advisory 5-minute intervals. At 08:07:30, one of the market runs for the RTED process begins, which generates binding market instructions for the interval from 08:15-08:20, and advisory instructions for the 12 successive intervals from 08:20-09:20. This is the first RTED market run to receive and optimize bids applicable to hour ending (HE) 10, however the run will not take the end-of-hour state-of-charge parameter into consideration because the last interval of that run does not end at the last interval of HE 10. The first RTED run that will take the end-of-hour state-of-charge parameter into consideration is the run for the binding interval 09:05-09:10, with 10 advisory intervals from 09:10-10:00. Because the RTED runs for binding intervals 08:30-09:05 do not consider the end-of-of hour state-of-charge parameter, there may be a sub-optimal situation where those RTED runs could undo what was planned by the RTUC/FMM, by not dispatching to charge the resource until it is too late to meet the end-of-hour SOC targets.

¹ In these examples, the resource also submits a maximum end-of-hour SOC of 35 MWh (87.5%), which does not come into play. Batteries are fast ramping resources; this example assumes an infinite ramp. For simplicity, it is assumed that the charging efficiency of the battery is 1.0

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7.3.2 Proposal

The CAISO proposes to align visibility of the end-of hour state-of-charge bid parameters to the same binding intervals for both RTED and RTUC/FMM. Specifically, the CAISO will apply an implied end-of-hour constraint at the end-of-time horizon for RTED runs for binding intervals starting 08:30 to 09:00. This end-of-horizon constraint will be set to the end-of-hour constraint, adjusted for the resource’s charging activity for intervals beyond the RTED time horizon as determined by the latest RTUC advisory instructions for that period.

For the purposes of the following two examples, we will modify the previous example slightly. Suppose the 40 MWh resource has a 25 MWh (62.5%) initial SOC for the RTUC 08:30 run, and must get to at least 30 MWh (75%) by the end of hour 10, thus an additional five MWh of charging is required.² In this same example, the initial state-of-charge for the RTED 08:30 run is also 25 MWh. Suppose the resource is not economic to charge in the any of the binding or advisory intervals of the RTPD and RTED runs.

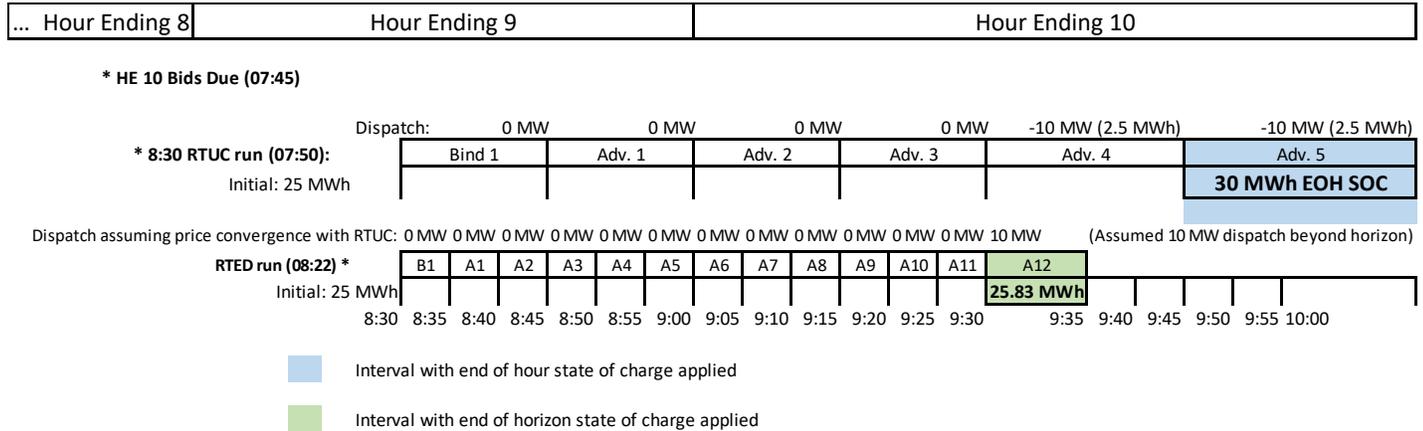
² This requires two 15-minute intervals of full charging (-10 MW * ½ hour = five MWh.)

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7.3.3 RTED End of Horizon Example-1

For the RTUC, the most economic prices to meet this target are for the last two intervals of the horizon, 09:30-09:45 and 09:45-10:00, so the resource will be scheduled at -10 MW for the 09:30 and 09:45 advisory intervals. When creating an end of horizon constraint for the RTED 08:30 run for which the horizon ends at 09:35, it is assumed that the RTED results will be following RTUC, thus there will be 4.17 MWh of charging for the intervals 09:35-10:00 that are beyond the optimization time horizon.³ The end-of-horizon constraint for RTED thus becomes 30 MWh – 4.17 MWh, or 25.83 MWh. Assuming prices between RTUC and RTED are converging, the incremental 0.83 MWh of charging will be dispatched in the interval 09:30-09:35.⁴

Figure 1: RTED End of Horizon Example-11



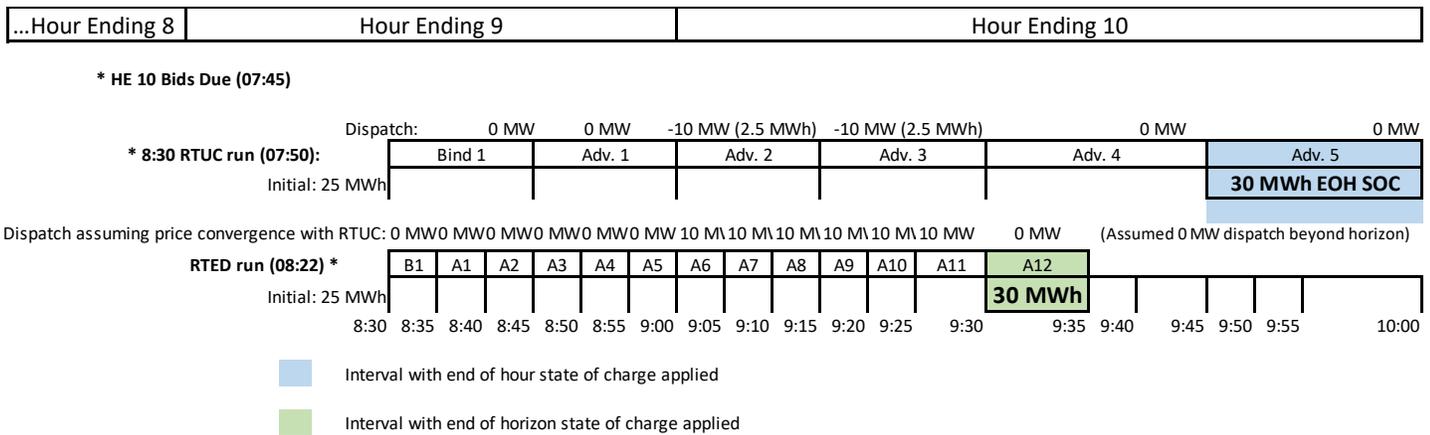
³ 10 MW * 25 minutes * (1 hour / 60 minutes) = 4.17 MWh.
⁴ -10 MW * 5 minutes * (1 hour / 60 minutes) = 0.83 MWh.

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7.3.4 RTED End of Horizon Example-2

For the RTUC, the most economic prices to meet the target are for the two intervals of the horizon, 09:00-09:15 and 09:15-09:30, so the resource will be scheduled at -10 MW for the 09:00 and 09:15 advisory intervals. When creating an end-of-horizon constraint for the RTED 08:30 run for which the horizon ends at 09:35, it is assumed that the RTED results will follow RTUC, thus there will be no charging for the intervals 09:35- 10:00 that are beyond the optimization time horizon. The end of horizon constraint for RTED thus becomes 30 MWh. Assuming prices between RTUC and RTED are converging, the five MWh of charging will be picked up in the intervals 09:00-09:30⁵.

Figure 2: RTED End of Horizon Example-2



⁵ Although the inputs to both real-time markets are the same, the two markets can lead to different results, and prices may not always converge