Enabling Resources Program: Storage and Hybrid Integration Project

Market Power Mitigation

Memo 1.0

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Engagement Topic: MPM Design Element for Storage Resources

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Purpose

The purpose of this document is to provide detail on the IESO's market design work with respect to the 'Market Power Mitigation Design Element' for the storage resource participation model. It articulates how the IESO undertook the design and the decisions that are relevant to stakeholders for the enhanced storage participation model.

The IESO will utilize this document and materials from subsequent design phases to support the implementation of the design work for the Storage and Hybrid Integration Project. This will be captured in future changes to Market Rules, Market Manuals, software interfaces with the IESO, and internal IESO systems and processes. These external changes will be reviewed for input with stakeholders. Any material changes to this design as a result of implementation discovery will be discussed with stakeholders.

Batch #	Design Module	Design Element
1	Grid and Market Operations	Optimization (Energy & Operating Reserves)
2	Grid and Market Operations	Dispatch data and other inputs
	Grid and Market Operations	Operations Integration
	Connection and Registration	Market Registration
		Connection Assessment and Approval
	Settlements	Market Settlement
	Contracts	Contract Impacts
	Market Power Mitigation (MPM)	Ex-ante, ex-post, settlements mitigation
3	Hybrid	All modules

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List of Abbreviations

Abbreviation	Definition
BESS	Battery Energy Storage System
CROW	Control Room Operations Window
CRS	Commercial Reconciliation System
DA	Day-Ahead
DAM	Day-Ahead Market
DAPD	Day-Ahead Pre-Dispatch Engine
DSO	Dispatch Scheduling and Optimization
EMFC	Enhanced Mitigated for Conduct
EOP	Economic Operating Point
ESR	Energy Storage Resource
FRL	Financial Reference Level
HOL	High Operating Limit
LMP	Locational Marginal Price
LOL	Low Operating Limit
MaxSoC	Maximum State of Charge
MinSoC	Minimum State of Charge
MIO	Multi-Interval Optimization
MPM	Market Power Mitigation
MW	Megawatt
NFRL	Non-Financial Reference Level
OR	Operating Reserve
PD	Pre-Dispatch
PQ	Price-Quantity
RQ	Reference Quantity
RT	Real-Time
RTE	Round-Trip Efficiency
SoC	State of Charge
SMDP	Settlement Mitigation Data Preparation

Market Power Mitigation Background

This Phase 1 design document provides information to update the market power mitigation (MPM) framework and processes to incrementally incorporate changes relating to the new single model storage resource as part of the Enabling Resources Program (ERP).

This document serves as the basis upon which the MPM design will be implemented.

Outstanding items are listed in Appendix 1 and will be addressed in design activities subsequent to the completion of market power mitigation design.

Scope of MPM Phase 1 Design

This design outlines how MPM will implement key decisions to support the transition to the single resource model and ensure robust safeguards against the exercise of market power.

Ex-Ante Validations of Non-Financial Dispatch Data: MPM will validate non-financial dispatch data submissions against reference levels in the ex-ante timeframe to prevent exercise of market power through operational parameters.

Ex-Ante Mitigation of Single Model Storage Resources: The design incorporates single model storage resources into MPM's mitigation functionality in the DSO, enabling before-the-fact mitigation for these new resource types and addressing changes introduced by the updated bidirectional energy offer curve.

Settlement Mitigation of Make-Whole Payments: Settlement processes will utilize an enhanced mitigated conduct offer curve that reflects the updated energy offer and operating reserve offer structure, ensuring accurate make-whole payment calculations.

Ex-Post Mitigation for Physical Withholding: After-the-fact physical withholding assessment may be triggered when submitted quantities are less than the applicable reference quantities and if physical withholding is established, settlement charges will apply.

MPM will maintain current mitigation approaches for the dual model storage resource while incrementally updating design for single model storage resource. Stakeholder engagements will begin in Q1 2026 to gather feedback from market participants, which will inform the design of financial reference level components for the single model storage resource. The updated design will be presented in the next version of this document.

Design Principles

The guiding principles for MPM design of ERP phase 1 includes mitigation of exercise of market power through:

- economic withholding, which can occur when one or more market participants offer a portion of, or all, of their resource's available capacity at prices material higher than short-run marginal costs or opportunity costs;
- physical withholding, which can occur when one or more market participants refrain from offering energy or operating reserve otherwise available; and
- settlement payments, which can occur when submitted offers result in excessive payments when potential for exercise of market power is present.

To mitigate these risks, the MPM framework will promote competition, fair pricing and a reliable system operation.

MPM Enabling Resource Participation Design

Ex-Ante Validation of Non-Financial Dispatch Data Parameters

A resource may submit dispatch data parameters that may deviate from its registered non-financial dispatch data parameters. To mitigate potential market power concerns associated with newly introduced dispatch data parameters, the IESO will validate these submissions against the resource's registered parameters and predefined conduct thresholds.

If a submitted dispatch data parameter falls outside the acceptable range defined by the conduct threshold, the submission will be rejected. Once rejected, the resource may resubmit the dispatch data within the acceptable range to pass validation.

Refer to the 'Dispatch Data and Other Inputs' ERP Design Document for details on new dispatch data parameters applicable to:

- Minimum State of Charge
- Maximum State of Charge
- Round-Trip Efficiency

No new Non-Financial Reference Levels (NFRLs) will be registered for the above noted dispatch data submissions. Validation will be performed using predefined thresholds against specific registered parameters. The IESO will enshrine validation rules and applicable conduct thresholds within the Market Rules, allowing updates through amendment process as necessary.

These new MPM validations apply only to single model storage resources eligible to register and submit the new parameters. ***Table 1*** provides the conduct thresholds to be used in the validation of the non-financial dispatch data parameters:

Table 1: List of new parameters with NFRLs

Dispatch Data	**Threshold**
Minimum State of Charge	Submitted MinSOC is less than or equal to the registered MinSOC plus 30% of the registered MaxSOC
Maximum State of Charge	Submitted MaxSOC is greater than or equal to 70% of the registered MaxSOC parameter
Round-Trip Efficiency	Submitted round-trip efficiency is greater than or equal to 50% of the registered round-trip efficiency value

Ex-Ante Mitigation for Economic Withholding

The ex-ante mitigation approach for economic withholding remains conceptually unchanged from the design currently implemented through Market Rules. Market power conditions must be met for a resource's offer to be considered for ex-ante mitigation testing. When these conditions are satisfied, the resource will undergo a conduct test. If the conduct test fails, an impact test will be performed. Failure of the impact test results in replacing a portion or the entirety of the financial dispatch data parameter with the applicable reference level value. Existing market power conditions, conduct test thresholds and impact test thresholds will continue to apply to single model storage resources in the energy and the operating reserve markets.

This testing is performed independently in both the day-ahead engine and the pre-dispatch engine. The real-time engine does not perform ex-ante testing; instead, it carries forward any mitigation decisions from the pre-dispatch process for the applicable hours.

The IESO will continue to evaluate system conditions for potential local and global market power conditions. For single model storage resource, these conditions apply to the resource and are not specific to its operating mode (charging or discharging).

For the dual model storage resources, the IESO will maintain ex-ante testing functionality to mitigate the generation resource of a storage facility in both the energy and operating reserve markets. The load resource of the dual model storage resources will not be mitigated in the energy market and will only be tested in the operating reserve markets. This approach is based on the principle that the IESO does not mitigate energy bids from dispatchable loads, as they have no incentive to increase energy prices. These consumers of energy pay the LMP to consume energy. For operating reserve, dispatchable load resources are suppliers of operating reserve and can provide relief by ceasing to withdraw from the grid.

Ex-Ante Mitigation of Energy Offer

Ex-ante mitigation in the Day-Ahead Market and Pre-Dispatch calculation engines will be updated to incorporate the new single model storage resources. The withdrawal portion of the energy offer structure will not be subjected to ex-ante mitigation, unless an adjustment is needed to maintain monotonicity. This approach is consistent with existing framework, as

dispatchable load resources are not subjected to ex-ante mitigation for energy price impacts. The adjustment of withdrawal portion is described further below.

Single model storage resources will be assessed for conditions related to Narrow Constrained Area (NCA), Dynamic Constrained Area (DCA), Broad Constrained Area (BCA), and Global Market Power (GMP) testing in the energy market. These resources may be included in constrained area designations similar to generation resources in the dual model storage resources.

The injection portion of the energy offer curve of single model storage resource will be subject to ex-ante mitigation. When applicable conditions are met, this portion will be tested against the energy offer reference level, which is created exclusively for injection megawatt-hours. If the conduct test fails, the resource proceeds to the impact test.

Ex-Ante Energy Offer Mitigation Methodology

- If the market participant offers only withdrawal laminations, no mitigation is required.
- If the participant offers only injection laminations, mitigation is required.
- If both withdrawal and injection laminations are offered, mitigation applies to the injection portion, and adjustments may be required on the withdrawal side as applicable. Refer to the Optimization Design Element for Storage Resources document for additional information on this adjustment scenario.

An example of a normal mitigation scenario of energy offer is shown in *Table 2* and **Figure 1**.

Table 2: General example of a bidirectional energy offer and reference levels

SUBMITTED OFFER		REFERENCE LEVEL		MITIGATED OFFER	
MW	$	MW	$	MW	$
-200	-100			-200	-100
-100	-50			-100	-50
-70	100			-70	100
-30	150			-30	150
0	300	0	185	0	185
200	300	50	185	50	185
		200	200	200	200

This resource fails the impact test and the prices from the discharge laminations of 0 MW to 200 MW are copied from the reference level. The prices from the charging laminations from -30 MW to -200 MW are copied over from the submitted offer represented by the dotted yellow line.

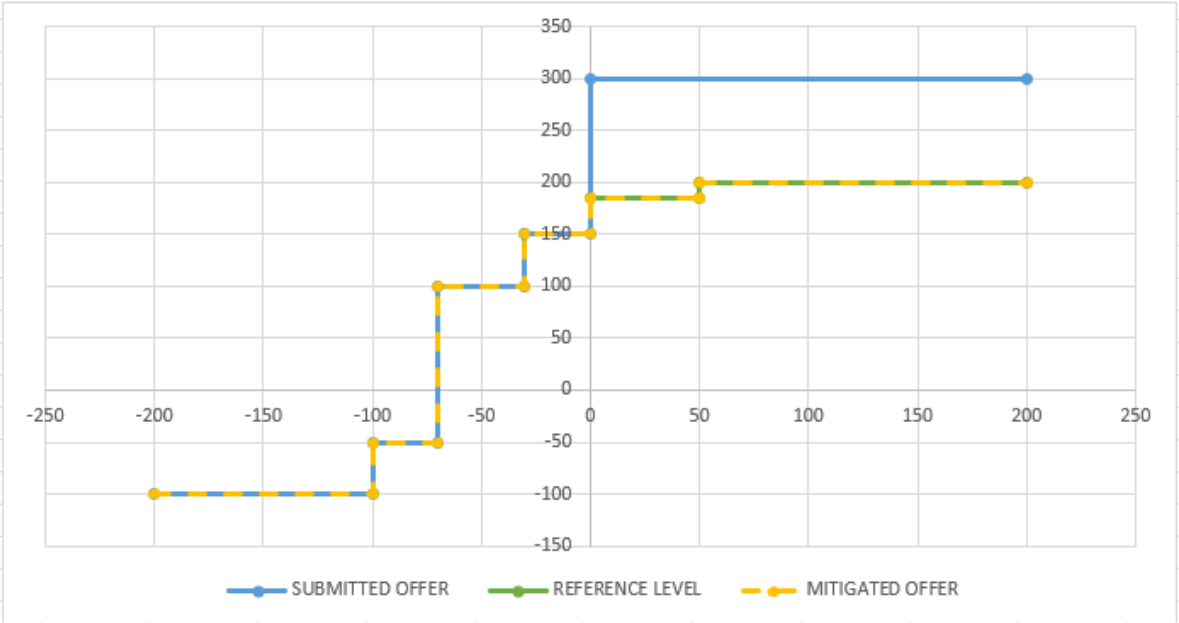

Figure 1: Mitigated offer for a general bidirectional energy offer example

During mitigation, the withdrawal laminations of the energy offer curve may require a price offset to maintain a monotonically non-decreasing price curve. The table below illustrates an uncommon scenario involving a hypothetical energy offer submission for both charging and discharging segments where an adjustment of the charging laminations is necessary. The reference level is set for the discharging portions, and an adjusted reference level is applied due to mitigation of those discharging segments. This situation is uncommon, as the energy offer reference level for an energy storage resource is typically higher than the values shown in this example.

An example of when price adjustment of the charging laminations is required to maintain monotonicity is shown in *Table 3* and **Figure 2**.

Table 3: Edge-case example of a bidirectional energy offer and reference levels

SUBMITTED OFFER		REFERENCE LEVEL		MITIGATED OFFER	
MW	$	MW	$	MW	$
-200	-100			-200	-100
-100	-50			-100	-50
-70	20			-70	9.98
-30	30			-30	9.99
0	50	0	10	0	10
50	50	50	10	50	10
100	100	100	20	100	20
150	150	150	50	150	50
200	200	250	100	200	100

The discharge laminations of 0 MW to 200 MW are copied from the reference level. The prices of the charging lamination from -30 MW to -200 MW is copied over to the mitigated offer.

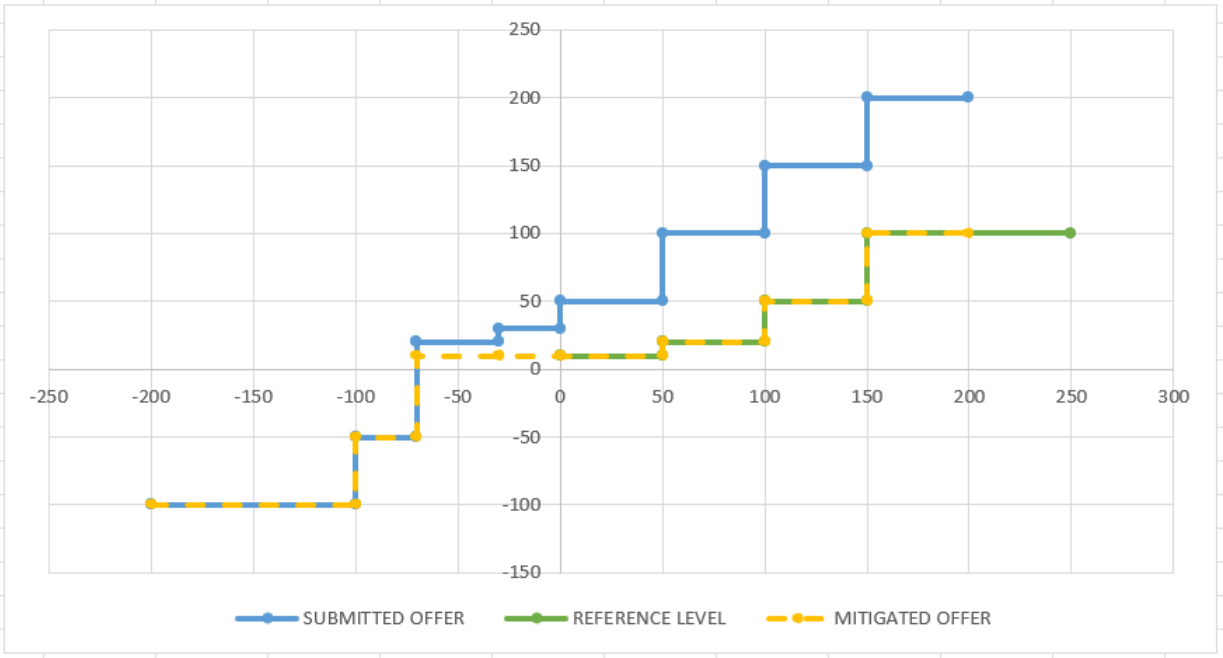

Figure 2: Mitigated offer for an edge-case example of bidirectional energy offer and reference levels

The graph above shows the submitted curve between -70 MW to 0 MW with a higher price than the lowest price of the first discharge lamination. Therefore, the price of charging lamination of -30 MW to 0 MW is reduced by 0.01 $/MWh lower than the price of the first discharge lamination. Price is further reduced by 0.01 $/MWh for the charging lamination of -70 MW to -30.1 MW. This ensures the mitigated offer respects monotonicity. When performing the conduct test for a single model storage resource, testing applies only to the positive megawatts-hours of the submitted energy offer curve.

Ex-Ante Energy Offer Mitigation Process for Single Model Storage Resource

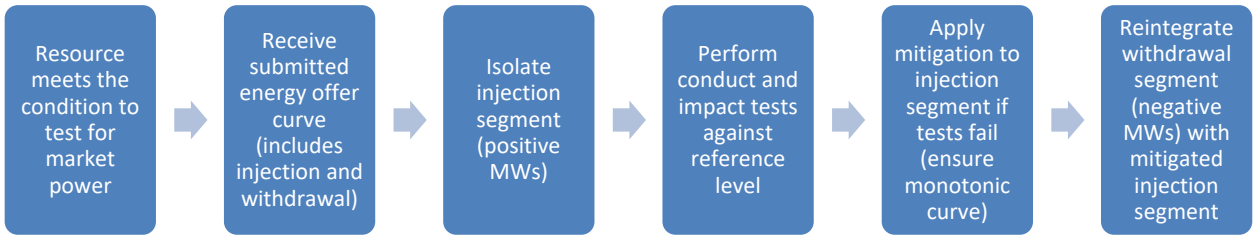

Figure 3: Ex-ante energy offers mitigation process for single model storage resource

Ex-Ante Mitigation of Operating Reserve Offer

The IESO will continue to test for both local market power and global market power across all three classes of operating reserve offers. Single model storage resource are subject to these assessments and may be included as candidates for testing. When testing a specific class of operating reserve, MPM evaluates all offers from any class capable of meeting the operating reserve requirement.

Single model storage resources will be tested for global market power condition for operating reserve. If a resource is included in a reserve area with minimum constraint, it will also be tested for local market power for operating reserve. The existing exemptions for resources located in reserve areas with a binding maximum constraint remain unchanged post-ERP. The conduct test will be performed using the methodology currently implemented. The only difference lies in the range of the operating reserve offer and the corresponding reference level, which now span from zero MW up to the sum of absolute maximum charge and maximum discharge capability of the resource. Details on the operating reserve reference level design for the single resource model are provided in later sections.

Application of Price Impact Test

For single model storage resources that fail the conduct test, the impact test will be performed. The current methodology of price impact test for energy and operating reserve will continue to be applied to single model storage resource.

For energy, resources that submitted offers outside the conduct thresholds will be subjected to the price impact test. If the price impact exceeds the applicable threshold, submitted offer will be replaced with mitigated offer as described above in "Ex-Ante Energy Offer Mitigation Methodology" section.

For operating reserve, resources that submitted offers outside the conduct thresholds will be subjected to the impact test. If the price impact exceeds the applicable threshold, the submitted offer will be replaced with corresponding reference level.

When price impact test fails, the mitigated energy and/or operating reserve offers will be used by the Day-Ahead (DA) and Pre-Dispatch (PD) scheduling engines to produce final schedules and prices.

Settlement Mitigation of Make-Whole Payments

The IESO will continue to apply settlement mitigation for make-whole payments related to local and global market power conditions, incorporating new single model storage resources into its assessments. Updates to make-whole payment are detailed in the ERP Settlement Design Document.

For settlement mitigation, the market power conditions, and the conduct and the impact test methodologies will remain unchanged from the current design. Settlement mitigation will continue to independently perform conduct test, consistent with the ex-ante mitigation design described earlier in this document. Settlement mitigation will test single resource for reliability conditions when present. Conduct test will use the most restrictive condition applicable to any dispatch hour.

If conduct test is failed, make-whole payment impact test will be performed consistent with current design.

Settlement Mitigation Applicability:

- If the market participant offers only withdrawal laminations, no settlement mitigation is required.
- If the participant offers only injection laminations, settlement mitigation is required.
- If both withdrawal and injection laminations are offered, settlement mitigation applies to the injection portion, and adjustments may be required on the withdrawal side as applicable.

Ex-Post Mitigation for Physical Withholding

The IESO may continue to test energy and operating reserve capabilities for physical withholding that a single model storage resource would otherwise offer into the market. Market power can be exercised when MWs or MWhs are withheld, resulting in increased LMPs. Physical withholding tests will remain an ex-post process, applied to both day-ahead and real-time offers.

For single model storage resources, the IESO will establish reference quantities in collaboration with market participants. The rules for registering market control entities remain unchanged. Market control entities will continue to play a role in the physical withholding process, and any dispatchable single model storage resource must register a market control entity for physical withholding. Testing will be performed at the individual resource level. The IESO is considering updates to the associated market control entity level conduct test to include hourly evaluations.

Physical withholding applies only to individual resources with a capacity greater than 10 MW. For market control entities, the aggregate capability of associated resources must also exceed 10 MW. For single model storage resources:

- Positive injection capability is represented by the maximum generating active power.
- Withdrawal capability is represented by the minimum generating active power.

To determine capacity criteria for this new model type, the IESO will use the maximum generator active power capability for energy, and maximum and minimum generator active power capability for operating reserve qualification in physical withholding testing. The IESO will not assess energy withdrawal range for physical withholding. Operating reserve supply capability during charging mode will be assessed for physical withholding.

Reference quantities for the single model storage resources differ from those for the dual model storage resources; these differences are detailed in the Reference Quantity section. The conditions for testing energy and operating reserve for physical withholding remain unchanged, as does the conduct and impact test approach. Energy conduct tests will be tested hourly for each hour of the dispatch day. The conduct tests for a class of operating reserve will also be tested for each hour of the dispatch day. The settlement charge calculations related to physical withholding will also remain consistent with pre-ERP design.

Financial Reference Levels

Before a resource is permitted to participate in the energy and operating reserve markets, the IESO must establish appropriate reference levels. These reference levels for financial dispatch data parameters are determined for both energy and operating reserve, based on the resource's registration eligibility.

For single model storage resources, reference levels must include:

- Energy offer reference level, and
- Operating reserve offer reference level for each class of operating reserve the resource is eligible to provide.

Energy Offer Reference Level

The IESO is exploring potential changes to the energy offer reference level for the single model storage resource in Phase 1 of ERP. Updates to the energy offer reference level, including revised cost components will be stakeholdered. The changes will be introduced in the next version of the document.

Existing Energy offer reference level for a generating resource of the dual model storage is seen in **Figure 4.**

$$
\begin{aligned}
&Energy\ Offer\ Reference\ Level\ \left(\frac{\$}{MWh}\right) \\
&\quad = MAX\Bigg(Charging\ Cost\left(\frac{\$}{MWh}\right) + Station\ Service\ Cost\left(\frac{\$}{MWh}\right) \\
&\quad + Total\ Global\ Adjustment\ Costs\left(\frac{\$}{MWh}\right) + Major\ Maintenance\left(\frac{\$}{MWh}\right) \\
&\quad + Scheduled\ Maintenance\ Electrical\ and\ Mechanical\ \left(\frac{\$}{MWh}\right) \\
&\quad + Unscheduled\ Maintenance\ Costs\left(\frac{\$}{MWh}\right), Opportunity\ Costs\left(\frac{\$}{MWh}\right)\Bigg)
\end{aligned}
$$

Figure 4: Existing formula for energy offer reference level

As outlined in earlier sections, only injection megawatts (MWs) are subject to economic withholding in ex-ante; therefore, the energy offer reference level is created exclusively for the injection portion of the curve. This reference level represents the short-run marginal cost of incremental production through energy injection.

For the single model storage resource, the MW range for the energy offer reference level will span from 0 MW to the maximum generating active power capability of the resource. To maintain a total of 20 price-quantity (PQ) pairs across both injection and withdrawal operating ranges, the energy offer reference level will have a maximum of 18 price laminations, reserving space for withdrawal laminations if mitigation occurs.

A resource may maintain multiple financial reference level datasets to reflect different cost configurations, such as seasonal profiles (summer vs. winter) or alternative operating modes. To determine which reference level applies for a given hour, the IESO performs a total hourly cost calculation, which sums the energy costs across profiles. For single model storage resources, this calculation will use the injection reference levels only. The selected reference level is reported and passed to the DSO for mitigation purposes.

Operating Reserve Offer Reference Level (10S, 10N, 30R)

For the single model storage resource, a market participant may submit its full range of operating reserve capability covering both withdrawal and injection operations. However, the offer does not explicitly indicate which laminations correspond to charging or discharging. Each operating reserve offer consists of up to five laminations, where each lamination represents a MW range paired with a price.

The operating reserve reference level is not designed to dynamically adjust based on the resource's operating mode (charging or discharging). Therefore, the operating reserve reference level will be represented using the discharging mode across the full range, as this reflects the higher cost of providing operating reserve compared to charging. This approach ensures that the reference level is conservative and avoids underestimating costs when the resource is dispatched for reserve while discharging.

The reason for this design choice is that market participants cannot associate their short-run marginal cost of providing operating reserve with specific MW quantities across different operating modes. In other words, the cost structure for reserve provision is not granular enough to differentiate between charging and discharging segments, making a single-mode reference level necessary for simplicity and consistency.

The operating reserve reference level is calculated using the following formula:

**Operating Reserve Reference Level ($/MW) =** Auxiliary Energy Consumption ($/MW)

Auxiliary energy consumption refers to the energy used by auxiliary systems necessary for the electricity storage resource to respond to dispatch instructions. The calculation for auxiliary energy consumption is:

Auxiliary Energy Consumption ($/MW) =
(Auxiliary Power Consumed During Operation (MWh) ÷ MW Offered on Operating Reserve) ×
Average Electricity Purchase Price from Previous Year ($/MWh) ×
IESO Annual Escalation Factor

This formula ensures that the cost of providing operating reserve reflects the incremental energy consumed by auxiliary systems during reserve provision. It accounts for historical electricity prices and applies an escalation factor to keep the reference level aligned with current market conditions.

The design of this reference level formula will be the same as that used for the generating resource in the dual model storage resources. The key difference introduced by ERP relates to the MW range applied to the operating reserve reference level. For the single resource model, the MW range covers both charging and discharging capabilities, starting from the minimum generating active power capability and extending to the maximum generating active power capability. This approach will ensure that the reference level applies consistently across the full operating range of the resource, regardless of its mode.

Reference Quantities

Reference quantities for a single model storage resource will be established for both the energy market and each class of operating reserve and will apply to the day-ahead and real-time markets. These quantities will be published before the day-ahead submission window opens at 06:00 EPT, and prior to the first pre-dispatch run for the next day at 20:00 EST, ensuring participants have visibility before submitting offers. Two distinct approaches are required because of structural differences between the existing dual model storage resources and the single resource model. For the dual model storage resources, the current design remains unchanged: the IESO creates separate reference quantities for the generating resource and the load resource.

Market participants can provide outage and derate information to reflect the high and low operating limits of the resource. Outages can be submitted for:

- Positive MW range (representing discharging capability), and
- Negative MW range (representing charging capability).

Reference quantities will be adjusted to account for these outages and derates, ensuring that energy and operating reserve capabilities reflect the resource's actual availability. As participants are able submit independent derate values for positive and negative ranges, the resource may have different capabilities for charging and discharging, which must be factored into reference quantity calculations.

Reference quantities do not factor in state of charge information as the IESO will manage the resource's state of charge and schedule energy and operating reserve according to feasibility.

Energy Offer Reference Quantities

The energy offer reference quantity for a single model storage resource represents the resource's maximum potential injection capability only, adjusted for any outages or derates for each hour of the dispatch day. There will be no energy offer reference quantity established for the withdrawal capability.

The maximum potential injection output is defined as the registered Maximum Generating Active Power Capability, less any submitted outages or derates. This ensures that reference quantities reflect the resource's actual available injection capacity rather than its theoretical maximum.

Special Rule for Overnight Hours:

For dispatch hours between 23:00 and 07:00 EST, the energy offer reference quantity will be set to zero. Market participants have indicated their preference to charge within this period. An energy reference quantity of zero means, under the physical withholding framework, that the resource will not fail the conduct test regardless of whatever injection offers it submits for the day-ahead or real-time timeframe during this specific time period (i.e., HE 24 to HE 7).

Operating Reserve Reference Quantities

For any class of operating reserve, the operating reserve offer reference quantity represents the resource's outage-adjusted capability for each dispatch hour to provide operating reserve from both charging and discharging operations. This will ensure that the calculation reflects the actual availability of the resource rather than its theoretical maximum capability.

Under the dual model storage resource, the operating reserve reference quantity was set to zero for the individual dispatchable generation or dispatchable load resources as the reserve capability was not aggregated across modes. This separation in modeling and scheduling created complexity in how resources submitted operating reserve offers, so the reference quantity design allowed for some flexibility. With the updated single resource modeling, this limitation will no longer apply. Reserve capability can now be aggregated across both modes under a single resource, eliminating the need for constant zero MW operating reserve offer reference quantities and simplifying reserve offer structures.

For the single model storage resource, the formula for calculating the operating reserve offer reference quantity is:

OR Offer Reference Quantity =
(Maximum Generating Active Power Capability – Injection Outages) + ABS(Minimum Generating Active Power Capability) – ABS (Withdrawal Outages)

This formula accounts for both injection and withdrawal capabilities, adjusted for outages, and uses the absolute value of the withdrawal range to ensure positive MW representation.

Special Rule for Overnight Hours:

For dispatch hours between 23:00 and 07:00 EST, the operating reserve offer reference quantity applies only to the charging capability. This design will provide market participants with greater flexibility to recharge during overnight periods while still meeting reserve requirements.

Next Steps

Several critical MPM design elements remain under development and require further refinement to ensure robust and transparent implementation.

One key area is Financial Reference Levels Design, which determines the baseline cost structure for resources. This includes Opportunity Cost, representing the foregone revenue when a resource provides energy instead of pursuing alternative market opportunities. Another cost component is Charging Cost, which captures the expense associated with energy consumption for storage resources.

These components are essential for accurately reflecting resource economics and preventing undue mitigation.