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Enabling Resources Program: Storage and Hybrid Integration Project

Dispatch Data and Other Inputs

Memo 1.0

Engagement Topic: Dispatch Data and Other Inputs Design Element

Date: January 22, 2026

Purpose

The purpose of this document is to provide detail on the IESO's market design work with respect to the 'Dispatch Data and Other Inputs 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.

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List of Abbreviations

Abbreviation	Definition
ADE	Availability Declaration Envelope
CM	Contract Manager
CROW	Control Room Operations Window
CycleDEL	Cycling Daily Energy Limit
DAM	Day-Ahead Market
DSO	Dispatch Scheduling and Optimization
ELT	Expedited Long Term
IAM	IESO Administered Market
ESR	Energy Storage Resource
EUC	End Use Computing
FRL	Financial Reference Level
HOL	High Operating Limit
ISL	Internal Service Load
LOL	Low Operating Limit
LT-1	Long Term 1
MaxSoC	Maximum State of Charge
MinSoC	Minimum State of Charge
MP	Market Participant
MPM	Market Power Mitigation
NFRL	Non-Financial Reference Level
PD	Pre-Dispatch
PQ	Price-Quantity
RL	Reference Level
RQ	Reference Quantity
RT	Real-Time
RTE	Round-Trip Efficiency
SoC	State of Charge
SMSR	Single Model Storage Resource

Background

ERP's Storage and Hybrid Integration Project is focused on developing an enhanced participation model for storage resources and co-located hybrid facilities. During the design phase, the IESO first proceeded with the core 'Optimization' element within the 'Grid and Market Operations' module, which has been a main precursor to design decisions to support other design modules and elements. The 'Dispatch Data and Other Inputs' design element under the 'Grid and Market Operations' module clarifies how a single model storage resource participates in energy and Operating Reserve (OR) markets. This includes what the IESO needs to dispatch resources and consider them in the optimization engine across all timeframes.

Phased Approach

The Storage and Hybrid Implementation Project has adopted a phased delivery approach to expedite and prioritize the implementation of essential functionalities, including:

- Single model storage resource (battery) with bidirectional offers
- State of Charge (SoC) Management

As seen in **Figure 1**, subsequent design phases will implement:

- Regulation service
- Uplift exemptions
- Any required enhancement resulting from Phase 1 implementation

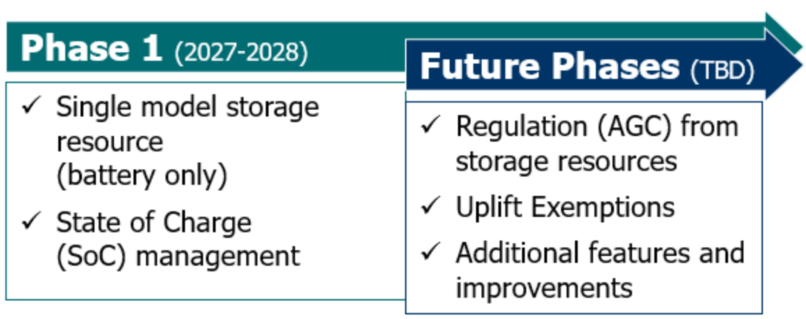

Figure 1: Project Scope

Scope of Batch 2, Phase 1

For Phase 1 of the enhanced market design, the IESO will focus on Battery Energy Storage Systems (BESS). In subsequent phases, the IESO will consider the applicability of other types of storage technologies and potential nuances that could require additional/different parameters.

The scope of design modules and elements for Phase 1 design is depicted in **Figure 2**, with the focus on 'Dispatch Data and Other Inputs' in this document. During Batch 2 Design, the IESO progressed with all the relevant design elements in parallel to expedite delivery.

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

Figure 2: Design Elements and Design Modules for Phase 1 design

The IESO's focus is on single-site, dispatchable storage resources greater 1 MW. This enhanced market design will support recent storage procurements via Long-Term 1 (LT1) and Expedited Long-Term (ELT) procurements. Some of these BESS facilities are/will have achieved their Commercial Operation Date before the enhanced participation model is live; the transition of these facilities to the enhanced model will be discussed with stakeholders later. Most existing resources that participate in the IESO Administered Markets (IAMs) as the foundational dual model storage having Energy Storage Facility Agreement (ESFA) contracts will participate as single model storage resources, after their existing contracts expire.

Design Methods and Outcomes

Principles

The ERP market design principles guide decision criterion and help to verify the design meets the needs of the IESO and market participants. These principles were utilized for the Market Renewal Program (MRP) and were considered as part of the long-term vision for storage:

- Efficiency - Lower out-of-market payments and focus on delivering efficient outcomes to reduce system costs
- Competition - Provide open, fair, non-discriminatory competitive opportunities for participants to help meet evolving system needs
- Implementation - Work together with our stakeholders to evolve the market in a feasible and practical manner
- Certainty - Establish stable, enduring market-based mechanisms that send clear, efficient price signals
- Transparency - Accurate, timely and relevant information is available and accessible to market participants to enable their effective participation in the market
- Operability – Based on the decisions for this model, can the IESO plan/ forecast the operational needs of the grid, and continue to have the ability to manage the grid, without detriment

Method

The design and integration of storage will be organized in a 'build-to-bill' format called 'modules' (representing larger functions) and 'elements' (more specific functions within a module). The build-to-bill modules and elements are specific to the market participant and IESO processes to bring new resources onto the grid and facilitate their participation in markets and services. Design modules and elements will be engaged on based on project dependencies and priorities (i.e. not in a chronological format regarding a typical build-to-bill decision-making process).

Dispatch Data and Other Inputs Design Element

Data inputs here refer to information submitted by single model storage resource market participants and inputs from other tools and processes within the IESO required for scheduling and dispatching these resources. Market Participants (MPs) submit different types of data in different time frames. This chapter focuses on all time frames except pre-market, i.e. it focuses on primarily dispatch data and other MP or IESO inputs during Day-Ahead Market (DAM), Pre-Dispatch (PD) and Real Time (RT).

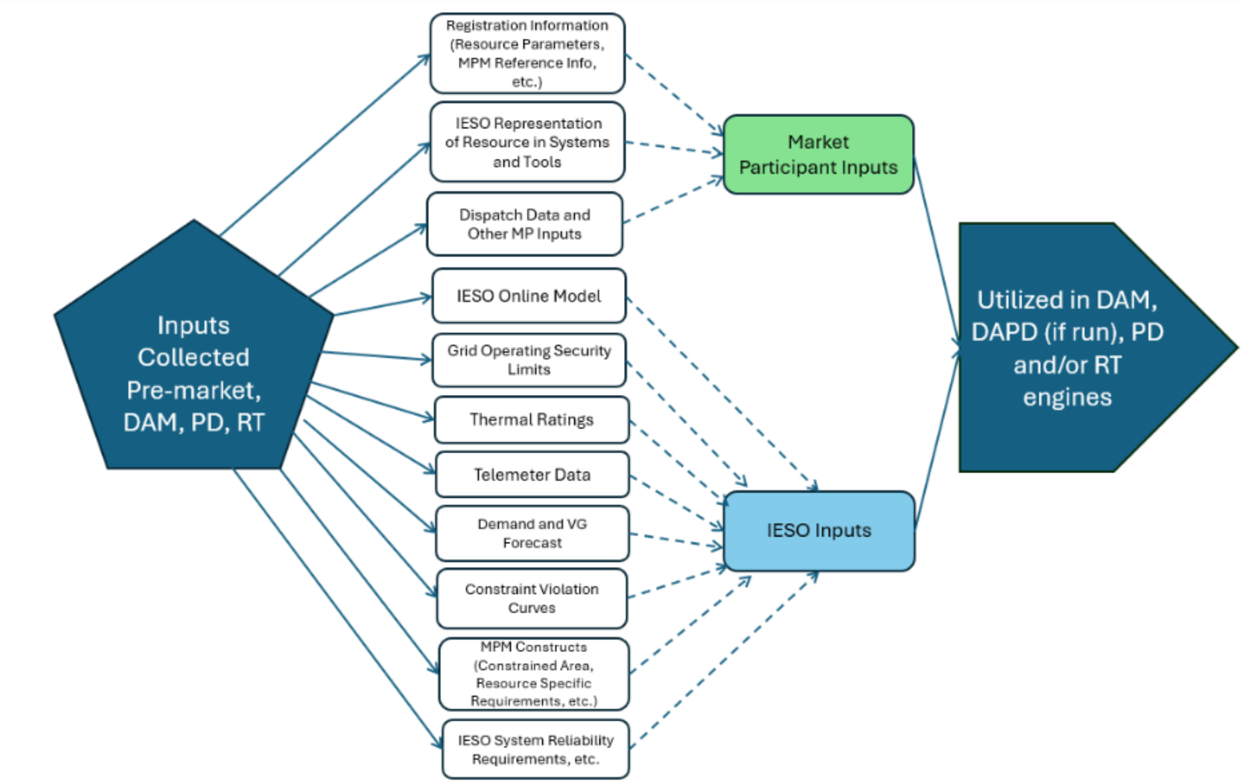

Figure 3: Inputs utilized by the IESO optimization engines

This design element focuses on the inputs required by the Dispatch Scheduling Optimization (DSO) tool in order to optimize schedules and real time dispatch of the single model storage resource to provide energy and Operating Reserve (OR) services to the transmission grid. This consists of MP and IESO inputs and will include information relevant to the dispatchable single model storage resource, as well as some requirements related to commissioning of this resource. (Please note - Details of some of the MP and IESO inputs may be found in other design elements and modules as they relate to the tools/systems/processes required in their respective design).

Similar to what is depicted in **Figure 3**, MP inputs include the following:

- Daily dispatch parameters - data that is applicable for the entire dispatch day but can be updated through the course of the day if required.
- Hourly dispatch parameters - data that can vary from one dispatch hour such as energy or Operating Reserve bidirectional offers
- Other MP inputs – information submitted in power outages or derates.
- Information such as registered information and telemetered data required for monitoring purposes and various systems and tools are included in the Connection and Registration design.

IESO inputs include the following:

- Demand forecasts.
- Market Power Mitigation (MPM) inputs,
- Penalty Pricing inputs,
- Fundamental sets and location identifiers
- Resource minimum and maximum constraints entered by the IESO.

Design Decisions

Below details the decisions for the scope described above. Please note that some of these items have been updated since batch 1 optimization design. The IESO has been able to further contemplate that design and have made updates that are needed to support a Phase 1 delivery and addresses various technical challenges with implementation. This design will continue to evolve with other design batches and elements as needed. This document will be updated accordingly.

Data inputs and optimization constructs encompass a lot of the key data points collected to support the optimization process in the DSO. Hence, initial decisions on the following parameters were made during Optimization design for the resource. However, this design was revisited during Batch 2, Phase 1 design phase to firm up decisions related to the list of required data parameters unique to the single model storage resource.

Requirements for Commissioning of dispatchable Single Model Storage Resources

When commissioning the resource, the resource will still operate under a single storage resource model meaning that the online model requirements will apply, although they will participate as a 'self-scheduler' during this time-period. There will be certain exclusions and requirements to support this period of the resources operation and to adapt the self-scheduling model for the single model storage resource, these include:

- The Single Model Storage Resource (SMSR) will participate generally like a self-scheduling generator under existing requirements but utilizing negative generator characteristics. When injecting they will provide their self-schedule with a positive MW quantity, when withdrawing they will provide their self-schedule with negative MW quantity. Further details of this will be shared as the IESO further clarifies the technical requirements, and additional procedures needed to support such model.
- SoC will not be modelled when entering self-schedules, the resource will manage these and must submit self-schedules that respects its own state of charge limitations. Daily dispatch data parameters will not be required, as per the fully commissioned model that is described in the subsequent section.

Registration Parameters

Registration parameters from MPs are required for the various calculation engines in the DSO. Please refer to the 'Connection and Registration' design document for details on those parameters. MPs have an opportunity to submit daily dispatch parameters in the DAM. Some of the registration parameters will be utilized to set validation rules for these dispatch parameters and some may be used to trigger alarms if the dispatch parameter deviate largely from their corresponding registration parameter.

Dispatch Parameters

Daily Dispatch Parameters

Similar to other existing resources, dispatch data must be accompanied by the registered market participant name, resource type and resource name. The data submission timeline for both hourly and daily dispatch data for the single model storage resource is consistent with the timeline for other existing resources. If they are updated prior to a new engine run being initialized, the updated parameters will be utilized by the engine.

Table 1 lists the daily dispatch parameters unique to dispatchable single model storage resource. It also describes, at a high level, the submission and validation logic imposed on Market Participants. The information in **Table 1** is utilized in all timeframes unless stated otherwise in the 'Submission and Validation Notes' column. Further details on how these dispatch data parameters are utilized in the day-ahead, pre-dispatch and real time optimization engines can be found in the Optimization design memo posted on Oct 16, 2025. Although their role in the optimization engines has not changed, updates have been made to their submission and validation requirements.

Table 1: List of new daily dispatch parameters

Attribute	Unit of Measure	Description	Submission and Validation Notes
ISoC *Initial State of Charge*	MWh	Represents the total forecasted state of charge, which corresponds to the amount of MWh available to inject into the grid. Value should already exclude all losses associated with withdrawal and injection.	• Mandatory submission used by DAM only. • It should not include any ISL reductions and should be between the submitted MaxSoC and MinSoC values (i.e. ≤ MaxSoC and ≥ MinSoC) • Can have up to 1 decimal digit
RTE *Cycle / Round-trip Efficiency*	Decimal value	A multiplier applied to withdrawals used to update the calculated state of charge; Represents the	• Mandatory submission • Should be greater than 0 and less than or equal to 1 • Can have up to 2 decimal digits

		combined injection and withdrawal efficiencies. Value should be independent of any losses associated with internal service load.	• MPM validation
ISL *Internal Service Load*	MW	The average estimated hourly MW draw on the resource's SoC to supply its auxiliary load or other service loads. This discounts the calculated SoC at the beginning of each hour.	• Optional submission, currently this applies to DAM and PD. The IESO is considering applying to RT. • Value should be between zero and the ISL submitted during registration, inclusive of those values. • Can have up to 1 decimal digit • Will be defaulted to zero if not submitted
CycleDEL *Cycling Daily Energy Limit*	MWh	The maximum amount of daily injections that may be scheduled for energy across all hours and for feasibility on OR scheduled from the injection side. To assist the MP to avoid over-cycling their battery if deemed necessary to avoid degradation.	• Optional submission used by DAM and PD. The IESO is considering removing the application of CycleDEL in PD. • Can have up to 1 decimal digit • In the absence of a submission the default value will be 999999.9

Validation Rules

In addition to the validation rules stated in 'Submission and Validation Notes' above, with the introduction of new daily dispatch parameters unique to the single model storage resource, MPM is introducing validation rules for Round Trip Efficiency. MPM validations occur along with other dispatch data validation in the same IESO tool.

Round Trip Efficiency: Consistent with conduct thresholds for most existing NFRLs for other resource types, this submitted value should not be less than 50% of the registered Cycle Efficiency value.

Hourly Dispatch Data Parameters

State of Charge Limits

Potential update - MPs will be able to submit hourly Max and Min SoC limits that will be used to schedule and dispatch the resource between the appropriate SoC range, as in **Table *2***. This permits the MP to schedule different limits that could differ from hour to hour. The IESO determining feasibility of these parameters being hourly, if unable to implement these will be daily parameters.

Table 2: Details of hourly MinSoC and MaxSoC parameters

Attribute	Unit of Measure	Description
MaxSoC *Maximum State of Charge or Upper Energy Limit*	MWh	The maximum energy amount to which the resource can be consistently charged without damage beyond expected degradation from normal use.
MinSoC *Minimum State of Charge or Lower Energy Limit*	MWh	The lowest energy amount to which the resource can be consistently discharged without damage beyond expected degradation from normal use.

When MPs submit these parameters, they should use caution that submissions do not contradict their SoC telemetry or estimated SoC values based on scheduling. The DSO will attempt to respect these limits and could enforce a schedule to ensure that these are maintained. In cases that the DSO will enforce a schedule the MP will not be reimbursed with make whole payments. ERP is exploring logic into the calculation engines to counter these conditions.

An example of specific logic includes requiring that the DSO accept new SoC Limits as the new SoC set point if above or below expected SoC limits derived from economic scheduling in the preceding hour. i.e. Hour 1 MP has limits between 100 MWh and 25 MWh, currently at 100 MWh. Hour 2 – MP adjusts SoC Max to 50 MWh and leaves Min at 25 MWh. If economically scheduled in hour 1 to move anywhere between 100 MWh and 51 MWh, it would take 50 MWh as the estimated SoC set point for hour 2. If scheduled economically scheduled in hour 1 below 50 MWh, for instance down to 30 MWh, it would take 30 MWh as the new SoC set point as it is between the range of 50 and 25 MWh for hour 2.

Validation rules

In addition to the validation rules stated in 'Submission and Validation Notes' above, with the introduction of new daily dispatch parameters unique to the single model storage resource, MPM is introducing validation rules for Round Trip Efficiency. MPM validation also occurs in the same tool.

- Max SoC:
    - Mandatory submission
    - Must be greater than the submitted Min SoC.
    - Must be less than or equal to the registered absolute Max Soc
    - Should have 1 decimal digit
    - MPM validation (described below)
- Min SoC:
    - Mandatory submission
    - Must be less than the submitted Max SoC.
    - Must be greater than or equal to the registered absolute Min Soc
    - Should have 1 decimal digit
    - MPM validation (described below)
- Rules applicable to both Max/Min
    - MPs must ensure that there is overlap between SoC ranges between hours. E.g. MP submits an HE 1 Max of 100 MWh and Min of 25 MWh, HE 2 the MP must have a submission that overlaps with one of these values. An example of a submission that would not be permitted is if the MP adjusts their Max to 200 MWh and a min of 125 MWh. There is no overlap in this circumstance.
    - MPM NFRL requirement: As these parameters are being validated against NFRLs, the MPM validation rules will be such that they do not permit the submitted MaxSoC to be lower than the registered MaxSoC by 30% of the registered MaxSoC, under normal conditions. Similarly, MPM will restrict the submitted MinSoC from being higher than the registered MinSoC by 30% of the registered MaxSoC. The upper limit for MaxSoC submission is registered Absolute MaxSoC. The lower limit for MinSoC submission is registered Absolute MinSoC. **Figure 4** shows the permitted limits for MaxSoC and MinSoC under normal operational conditions.

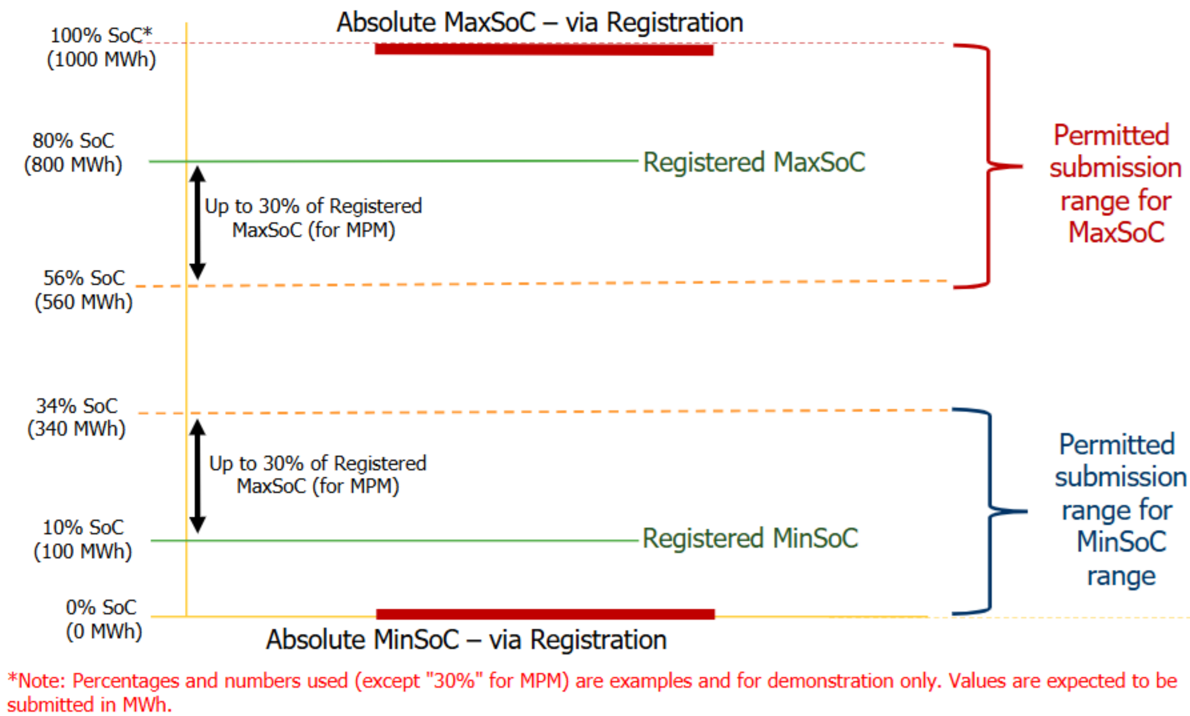

Figure 4: Validation logic for MinSoC and MaxSoC

MPM validation will exempt market participants from the '30% of registered Max SoC' validation rule in case of outage or derate reasons i.e. participants must submit a valid reason code if they wish to be exempted from the MPM validation due to outages or derates. **Figure 5** shows the extended permitted ranges for MaxSoC and MinSoC when exempted from MPM NFRL validation rules. In this example, the MaxSOC dispatch data parameter is submitted as 700 MWh and the minSOC is submitted as 200 MWh. Due to the submission of a valid reason code, the market participant's submitted values are accepted without any MPM validation.

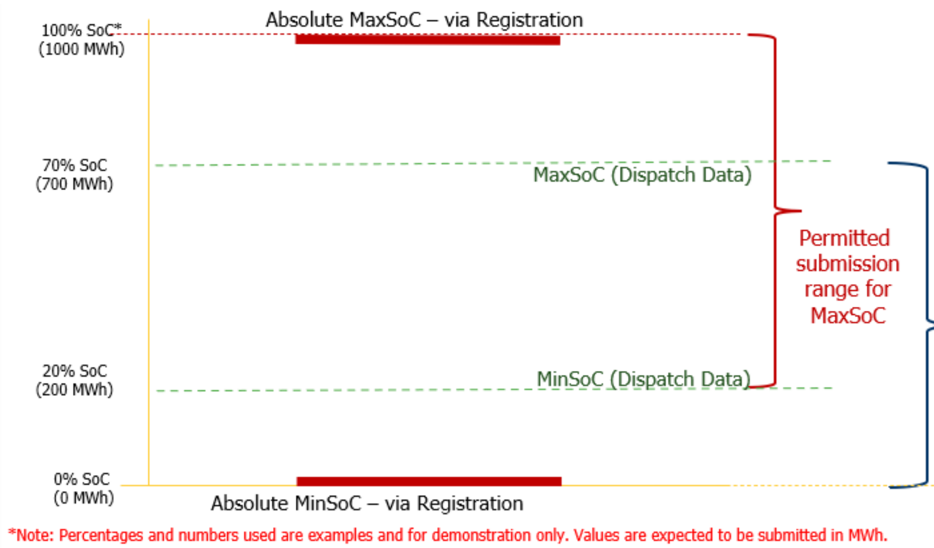

Figure 5: MPM validation logic for MinSoC and MaxSoC

Bidirectional Energy Offer

Currently, resources are allowed to submit between 2 to 20 price-quantity (PQ) pairs ($/MW) for energy, which will continue to be the case for single model storage resources. The unique feature of an energy offer curve for single model storage resource will be that it will be a single continuous offer curve, representing both offers for charging (withdrawal) and for discharging (injection). This offer curve will be referred to as a 'bidirectional offer' curve.

For an offer with both withdrawal and injection portions:

- The first lamination for the storage participant's will indicate the largest MW quantity withdrawal, utilize a negative MW value, as well as have their lowest (or highest in the negative direction) price in $/MW as the part of the same lamination.
- Each subsequent lamination will have a monotonically increasing MW quantity, and a monotonically non-decreasing $/MW price.
- After expressing all withdrawals, the participant must enter a zero MW quantity to denote the cut over point to injections, which will share the same $/MW value as the participants next injection lamination (the lowest price the market participant is willing to accept for an injection).
- Each injection will be denoted by a positive MW quantity and will also have monotonically increasing MW quantities and monotonically non-decreasing prices in $/MW.
- Withdrawal prices in $/MW denotes the maximum price that the MP is willing to withdraw. Injection prices in $/MW denotes the minimum price that the MP is willing to inject.
- For a bidirectional energy offer, this is what is implied by the signs (+ or -) for the PQ pairs:
    - Negative quantity & negative price =MP willing to withdraw if paid by the market to do so
    - Negative quantity & positive price = MP willing to pay to withdraw
    - Positive quantity & negative price = MP willing to inject, even if they must pay to do so as they want to be scheduled no matter what
    - Positive quantity & positive price = MP willing to inject if paid that price

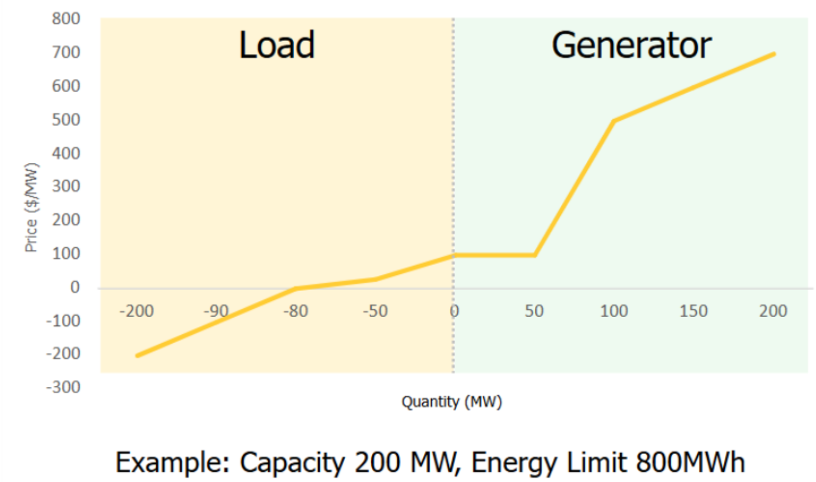

Figure 6: Bidirectional Energy Offer curve example

Table 3: Bidirectional Energy Offer Laminations Example

Example Bidirectional Offer with 9 laminations				
P/Q Pair	**Price ($/MW)**	**Quantity (MW)**	Price to Schedule ($/MW)	MW that could be scheduled
Pair 1	-200	-200	-200 or less (more negative)	Withdrawal 90.1 to 200
Pair 2	-100	-90	-199.99 to -100	Withdrawal 80.1 to 90
Pair 3	0	-80	-99.99 to 0	Withdrawal 50.1 to 80
Pair 4	25	-50	0.01 to 25	Withdrawal 0.1 to 50
Pair 5	100	0	25.01 to 99.99	Idle
Pair 6	100	50	100 to 499.99	Inject 0.1 to 50
Pair 7	500	100	500 to 599.99	Inject 50.1 to 100
Pair 8	600	150	600 to 699.99	Inject 100.1 to 150
Pair 9	700	200	700	Inject 150.1 to 200

- In **Table *3***, the MP submits 9 laminations. The MP is showing a maximum withdrawal capability of 200 MW (denoted by the -200 MW quantity) and a maximum injection capability of 200 MW (denoted by the +200 MW quantity). The MP will be able to provide up to these values in PD and RT as per the ADE requirement. The zero quantity in the laminations is indicative that this market participant will not be scheduled economically between market prices of $25.01 to $99.99. Their withdrawals will start at a $25/MW market price, and their injections will start at the $100/MW market price.
- Currently, a dispatchable load may identify all or a portion of the energy to be consumed at such resource as non-dispatchable load in accordance with the applicable market manual. However, a market participant registered as an electricity storage resource is not entitled to change its load (withdrawing) status to 'non-dispatchable' in a similar manner. This rule will continue to apply to the single model storage resource. Similar to dispatchable generation and dispatchable loads, the Maximum Market Clearing Price (MMCP) for bidirectional offers in either direction will be $2,000/MWh.

For an offer with only withdrawal portion of the bidirectional offer:

- If just withdrawing, the curve goes from the largest withdrawal to zero. See example in **Table *4***.
- Positive prices in this example denote that the participant will be paying that amount.

Table 4: Withdrawal only example

PQ Pair	**Price ($/MW)**	**Quantity (MW)**	Price to Schedule ($/MW)	MW that could be scheduled
1	5	-200	Less than or equal to 5	Withdraw 75.1 to 200
2	30	-75	5.01 to 30	Withdraw 60.1 to 75
3	65	-60	30.01 t0 65	Withdraw 25.1 to 60
4	100	-25	65.01 to 100	Withdraw 0.1 to 25
5	110	0	N/A	Idle

For an offer with only injection portion of the bidirectional offer:

- If just injecting, it starts at zero and goes to highest injection capability they want to express in the market. See example in **Table *5***.
- Positive prices in this example denote that the participant will be paid that amount.

Table 5: Injection only example

PQ Pair	Price ($/MW)	Quantity (MW)	Price to Schedule ($/MW)	MW that could be scheduled
1	35	0	0.01 to 35	Idle
2	35	50	35 to 99.99	Inject 0.1 to 50
3	100	100	100 to 129.99	Inject 50.1 to 100
4	130	150	130 to 299.99	Inject 100.1 to 150
5	300	200	300	Inject 150.1 to 200

Accounting for Station Service and Auxiliary Load: The IESO will subtract the value of ISL from the SoC in DAM and PD for each hour, prior to completing the scheduling of the resource. This is to account for the necessary service loads on the resource and therefore will limit the IESO from overcommitting the resource
beyond the stated SoCMin and SoCMax limits. In RT, the submitted ISL value for each hour will be divided by 12 to reflect a value for each 5-minute dispatch interval.

Availability Declaration Envelope (ADE): Storage resources will continue to be subject to ADE requirement. The ADE is the hourly injection or withdrawal capacity offered day-ahead for dispatchable resources. SMSRs must submit their maximum injection, and maximum withdrawal offers to fully utilize that range in PD and RT through their continuous offer.

Generation Without Offer: In instances that MP do not submit an offer for market transactions for an hour, the IESO will assign the resource a value of zero MW based on the assumption that the resource is offline and will not be charging or injecting.

Validation Rules:

- Energy offers must be submitted for each dispatch hour that the MP is looking to participate in the market.
- Each PQ pair is submitted as a set of 2 values:
  - Price: expressed in dollars and whole cents (0.00) per MWh and must be greater than or equal to the minimum market clearing price (negative MMCP) and less than or equal to the maximum market clearing price (MMCP)
  - Quantity: expressed in MW or MWh per hour to one decimal place.
- Minimum of 2 PQ pair sets must be submitted.
- Maximum of 20 PQ pair sets can be submitted.
- There must be only one lamination submitted with quantity 0.

- Quantity must be monotonically increasing for each subsequent PQ pair set.
- For PQ pair laminations submitted for an hour, the absolute value of Quantity of the highest positive or negative quantity value of all laminations must be greater than or equal to 1.0 MWh. For 'injection only' laminations, this would refer to only the maximum positive quantity. For 'withdrawal only' laminations, this would refer to only the absolute maximum negative quantity.
- Quantity in the last PQ pair set must be less than or equal to the 'Maximum Generator Resource Active Power Capability' parameter from Registration.
- Quantity in the first PQ pair set must be greater than or equal to the 'Minimum Generator Resource Active Power Capability' from Registration.
- Price must be non-decreasing for each subsequent PQ pair set.
- For Injection portion of the offer (when ESR intends to Generate):
- The Price must be the same in the first and second PQ pair sets.
- Price must be non-decreasing for each subsequent PQ pair set except the first and second PQ pair sets.

Energy Ramp Rate

- Energy ramp-up rate will refer to increasing generation or decreasing withdrawal (MW moving in the positive direction). Energy ramp-down rate will refer to decreasing generation or increasing consumption (MW moving in the negative direction).
- Similar to existing resources, as part of MPM, ramp up and ramp down rates will be validated against registered energy ramp up and down rate Non-Financial Reference Levels (NFRLs) respectively.
- The IESO will look to set a 100 MW/Min max requirement on a storage facility's ramp rate to be utilized by storage resources for injection and withdrawal when scheduled for energy, as depicted in **Figure 7**. The IESO is exploring methods to derive a facility ramp rate down to the resource level for submission and scheduling.
    - The 100 MW/min ramp rate applies at the facility level. This means that if a facility has multiple resources, their combined ramp rate should total 100 MW/min.
    - This 100 MW/min requirement will support more stable grid performance and supports SoC calculations throughout the different engines.

- The MP is not required to adhere to the 100MW/Min max ramping requirement when activated for OR, frequency excursions, voltage changes, or equipment protection operations including Remedial Action Scheme (RAS) runbacks.
- As dispatch data validations occur at a resource level and as each facility has a unique number of resources, which may be of different sizes and different availability status, it may be impractical to include this 100 MW/min requirement as part of dispatch data validation.

- At the resource level, MPs can submit up to 2 ramp rates that are less than or equal to registered Maximum Ramp rate.

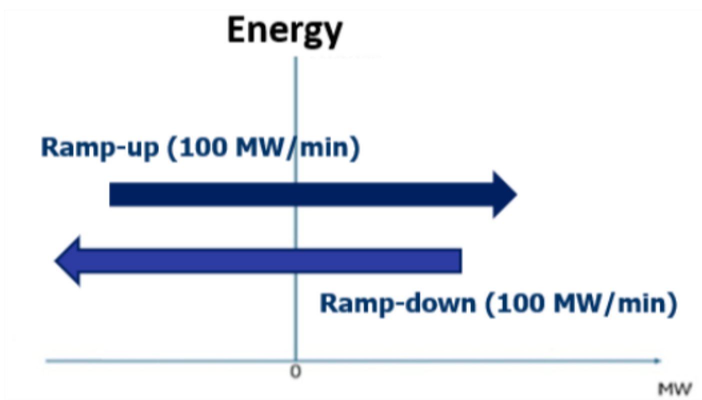

Figure 7: Energy Ramp Rates Design (Facility Level)

Validation Rules:

- Energy ramp rate (hourly) is submitted for each dispatch hour, and energy ramp rate (daily) is submitted for each dispatch day. Other validation rules are common among both parameters. Both are mandatory submissions.
- Participants will be allowed to submit maximum up to 2 values for ramp rates and must submit at least 1 ramp rate.
- Each ramp rate is submitted as a set of 3 values:
  - MW quantity or Breakpoint:
    - Expressed in MW up to one decimal place (0.0) and must be greater than 0.0MW i.e. must be positive.
    - MW quantity must be monotonically increasing for each subsequent ramp rate set.
    - MW quantity in the last ramp rate set submitted must be greater than or equal to the greatest value from the set comprising of absolute values of maximum quantity of the consumption and/ or
      generation quantity laminations submitted for the corresponding dispatch hour.

- Ramp rate up and Ramp rate down:
  - Expressed in MW/min to one decimal place (0.0) and must be greater than 0.0MW/min i.e. must be positive.
  - The same ramp up rate submission will be utilized for increasing injection and reducing consumption. The same ramp down rate submission will be utilized for decreasing injection and increasing consumption. MP will submit 2 ramp rate breakpoints. The IESO will then utilize these two ramps and apply them to the ramp rate breakpoints on the negative side of the resource to produce all ramp break points for the resource. This is illustrated in **Table *6***.
  - The ramp rate value should be less than or equal to registered Maximum Energy Storage Ramp rate.
  - Each submitted energy ramp rate value must be greater than or equal to the following value: (Seasonal MPM energy ramp up rate reference level) X (MPM energy ramp rate percentage conduct threshold).

Table 6: Energy Ramp Rate example and interpretation in IESO tools

+/- 200 MW BESS Resource

	MP Submits				
	1	**2**	**3**	**4**	**5**
Break Point	25	200	N/A	N/A	N/A
Ramp Up Rate	100	50	N/A	N/A	N/A
Ramp Down Rate	45	60	N/A	N/A	N/A

Interpretation in IESO Tools			
1	**2**	**3**	**4**
-200	-25	25	200
50	100		50
60	45		60

Operating Reserve Offer

- OR offers will be consistent with other resource types where:
  - Participants are allowed to submit between two to five P-Q pairs / laminations for each class of operating reserve (10S, 10N, 30R) for each dispatch hour with their OR MW quantity and $/MW price.
  - OR offer is always either 0 or positive for MW quantities.
- Storage resources can offer the full operating range of the storage resource as a net positive value. Specifically, this means that they can submit a combination of the absolute values of the withdrawal MW range and injection MW range as a single lamination into OR. This will support the resource in providing an OR activation by reducing charging and then immediately discharging; referred to as "branching".

Table 7: OR offer example

Example OR offer with 5 laminations		
P/Q Pair	**Price ($/MW)**	**Quantity (MW)**
Pair 1	0.1	0
Pair 2	0.1	50
Pair 3	5	80
Pair 4	10	200
Pair 5	10.01	400

- The example in **Table *7*** has 5 laminations where the first OR offer is 50 MW, and the last offer is 400 MW. If correlated to the MP's energy offer in the previous energy offer example, the MP submitted a -200 MW, and +200 MW quantity offers into the market. This 400 MW OR offer accounts for the resources capability to be consuming for 200 MW and immediately provide injection capability of 200 MW if activated. To simulate this action the MP would stop their consumption and immediately inject the 200 MW for a 400 MW swing of response.
- The optimization engine will determine the correlation between energy offers and OR to support co-optimization efforts due to OR offers expressing withdrawal, injection, and branching opportunities.

OR Ramp Rate

- Design for storage will be consistent with other resources where only one value is permitted, as seen in **Figure 8**.
- It will be validated against registered OR ramp rate NFRL.

- Unlike energy ramp up/down rates, the OR ramp rate will not be limited by the 100 MW/Min requirement but must respect the resource's registered maximum ramp rate value, as depicted.

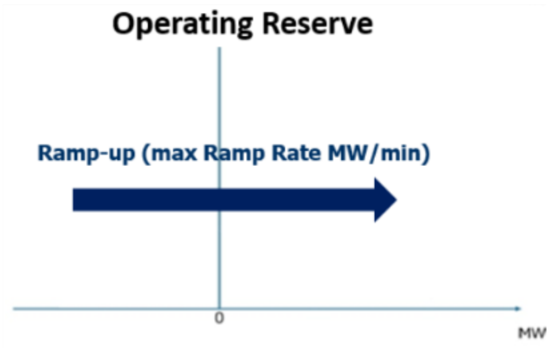

Figure 8: Operating Reserve Ramp Rate Design

Reserve Loading Point

- This denotes the minimum generation level in MW at which a resource associated with a dispatchable generation facility can provide the maximum operating reserve of the class of operating reserve being offered.
- A reserve loading point must be zero for all OR classes for a single model storage resource. This will accommodate the resource providing OR from a static state, the complete operational range of the resource (withdrawal to injection), while injecting, or only withdrawing.

Other MP Inputs

Data Monitoring Requirements

All facilities must comply with the applicable data monitoring requirements, which are listed in the IESO Market Rules (Chapter 0.4 Appendices, Section 4.24), and are used to ensure reliability of the grid by monitoring system conditions and resource response as well as to support DSO calculations. Any updates to these requirements during Batch 2 design may be found in the 'Connection and Registration' design document. Although these are utilized as data inputs, it is necessary that the MP are aware of these during the connection and registration phase to integrate the necessary monitoring into the facility and resource.

Outage Information

MPs must provide outage or derate information via the Control Room Operations Window (CROW) interface of the outage management system to properly reflect the operational capability of resources. The derates are then read by the DSO where it is used in the determination of Lower Operating Limits (LOLs) and Higher Operating Limits (HOLs). Outages will need to account for the capacity of the single model storage resource for both the injection and withdrawal ranges. The IESO will allow the resource to submit information that would independently reduce either the injection or withdrawal capacity of the resource. This means that MPs could independently update the HOL and the LOL. The HOL & LOL in case of storage could be either negative or positive. Derates for maximum active power (reflecting the max injection capability) are permitted to be entered down to zero MW, and derates for minimum active power (reflecting the max withdrawal capability) can be entered up to zero MW.

For example, if a storage facility rated at +/- 200 MW submits a derate to the maximum active power capability down to + 150 MW, this will impact the HOL. At the same time, if it submits a derate to the minimum active power capability up to -150 MW, this will impact the LOL. In the case of derates, the HOL could decrease to 0 and the LOL could increase to 0. A 0 value for both HOL and LOL could also indicate a complete outage of the resource. **Figure 9** showcases a few scenarios for derates and how they would impact the HOL and LOL respectively.

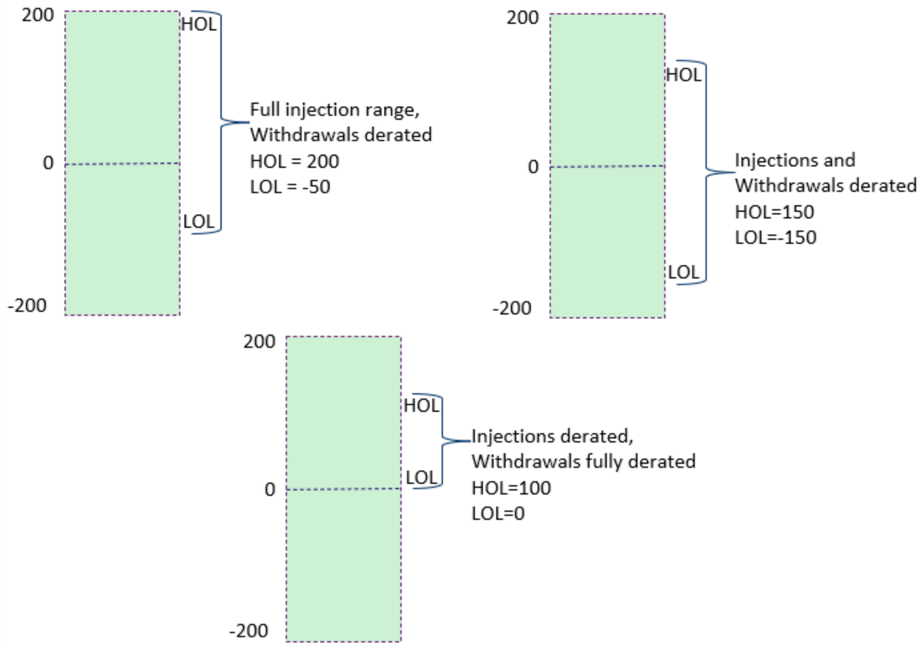

Figure 9: Examples of HOL and LOL for a single model storage resource

IESO Inputs

Demand Forecasts

Demand forecasts calculated by the IESO are inclusive of all loads, irrespective of whether they are dispatchable or non-dispatchable, and transmission losses. Before the demand forecasts can be used by the optimization functions of the DAM, PD and RT calculation engines, they are automatically adjusted by removing the forecast consumption of dispatchable load facilities. Additionally, transmission losses are removed before the non-dispatchable demand forecast is used by the security assessment function of the DSO. DAM and PD calculation engines use hourly average demand forecasts and hourly peak non-dispatchable load forecasts. RT calculation engine utilizes 5-minute non-dispatchable load forecasts. As part of ERP storage design, the IESO must ensure that demand forecasts and associated calculations accurately apply data related to a single model storage resource when the resource is expected to withdraw.

To facilitate the new single model storage resource, new Ontario demand calculations that excludes single model storage charging will be created by the IESO. These new demand calculations are required by the IESO's demand forecasting software and by the Control Room Operator (CRO). Updated new demand calculations will serve as inputs for the demand forecasting software, within which, demand forecast models will produce the appropriate demand forecasts for RT, PD and DAM to be used as inputs for DSO. Additionally, any historical demand data used by End-Use Computing tools (EUCs) will need to be re-calculated using the new single model method to remove the historical charging of any single model storage resources that were once connected as dual model storage resource. The new storage resource will also impact similar day load forecasting.

Market Power Mitigation

The IESO establishes reference levels and reference quantities with market participants for its dispatchable resources. Financial Reference Levels (FRLs) and Non-Financial Reference Levels (NFRLs) are determined based on the resource's registration eligibility to participate in the IESO markets. These are used to support the ex-ante, settlement and ex-post MPM processes in the energy and operating reserve markets. Non-financial reference level validation based on MPM validation rules for dispatch data parameters is described in the 'Daily Dispatch Parameters' section of this document. New MPM validations are implemented for the Round Trip

Efficiency, MaxSOC and MinSOC dispatch data parameters to ensure these values accurately reflect the resource's operational capabilities and prevent potential market power abuse.

Violation Pricing

The IESO uses constraint violation pricing when it is unable to resolve all system constraints that are needed to ensure a reliable schedule and dispatch of the grid. Certain constraints can be bypassed based on certain prices to ensure reliability and can be reflected in market prices. In lieu of this, the DSO will not solve, alternative means to manage of the grid must be taken and administrative pricing would take effect which could result in more costly outcomes. Below describes the constraint violation penalty curves that this resource model will utilize in the scheduling pass (penalty pricing in the pricing pass to be determined):

- Typical violation pricing that are used in the network constrained unit commitment will apply to support the scheduling of the storage resource when they are necessary.
- For the scheduling pass the violation prices are noted below to bypass constraints:
    - CycleDEL: $3,000/MW
    - MaxSoC, MinSoC: $50,000/MW.
    - When MaxSoC, MinSoC are set to Absolute MaxSoC and Absolute MinSoC: $95,000/MW.
- Additional variations of the above are being considered in the design to ensure economic decisions are made and avoid various forced charging and injecting scenarios the DSO might undertake to respect MP constraints. Potential variations include setting more granular CVPs on SoC Max for withdrawal and SoC Min when injecting only.

Pricing locations

The IESO will need to model an ESR at a single delivery point and bus. This is to ensure pricing is consistent during injection and withdrawal. The IESO can utilize a generator bus to support this design where both the injection and withdrawal will be denoted from the same location. Within a facility there could be multiple resources, each dispatchable single model storage resource would be a "single resource" with injection and withdrawal capability, depending on the configuration of the facility.

Resource Constraints Manually entered by the IESO

Constraints applied by the IESO in IESO systems tools must allow negative and positive ranges of the resource to be constrained by the DSO. Contract Manager (CM) tool is used to enter constraints on the resource to restrict the HOL and LOL of the resource.

- Minimum, Maximum and Fixed constraints may be applied to storage resources in the injection and withdrawal ranges. In the withdrawal range a maximum (Max) constraint will impact the HOL, and a minimum (Min) constraint will impact the LOL.
- For example, for a +/- 200 MW resource with a Max constraint of -50 MW and a Min constraint of -150 MW, the generator may operate between -50 MW and -150 MW.
- Overlapping constraint rules in the DSO remain unchanged with the following exceptions:
  - In the withdrawal range, a Max constraint lower than an overlapping Min constraint will be ignored, and, for the period of overlap, both the HOL and the LOL will equal the Min constraint. See scenario 4 in **Figure 10**.
  - A Min constraint in the injection range that is higher than an overlapping Max constraint in the withdrawal range will cause the HOL and LOL to be set to zero. See scenario 6. The User Interface rules will be updated to either warn or prevent the user from entering this type of conflict.

Figure 10: Scenarios for submission of resource constraints in CM

- If any new codes are introduced, then they must be added to the reason code prioritization table.

Next Steps

The IESO thanks external stakeholders for their valuable inputs to this design element and seeks written feedback from them on the same. This design will be applied to hybrid resources with energy storage components; details on this will be included in Phase 1, Batch 3 design. A few critical design topics remain under development and require further refinement to ensure robust and transparent implementation. Implementation of facility level energy ramp rate limitation is the most prominent of them. These topics and their impacts on both the IESO and the Market Participants are detailed in Appendix 1.

Appendix 1 – Outstanding Design Items

#	Design Item	Description	Impacts	Outcome
1	Hourly dispatch data submission for SoC limits	The IESO is determining feasibility of the MaxSoC and MinSoC parameters being hourly to provide MPs additional flexibility. If unable to implement them hourly, they will be daily dispatch parameters.	IESO: • Updates to dispatch data submission forms and validations • Additional DSO logic to address changes in SoC ranges that could trigger potential engine scheduling. Market Participant: • Will provide greater flexibility in their submissions to account for SoC ranges that could change throughout the day due to outages, or other factors	TBD
2	Energy Ramp Rate Limit	The IESO is exploring methods to derive a facility ramp rate, down to the resource level, for submission and scheduling. This is to ensure that the participants do not exceed a 100 MW/min energy ramp rate at the facility level.	IESO: • Depending on solution this could require changes to validations for submission and DSO logic Market Participant: • Require clarity on how to submit ramp to produce schedules and support a facility	TBD

			level ramp requirement	
3	Inclusion of Internal Service Load requirement in Internal Service Load impacts across different timeframes	The IESO is considering reviewing the application of applying ISL in DAM when reducing to SoC Min as well as application into the RT-MIO to account for future interval ISL reductions, (although due to the expected small values that may be derived, this may not be pursued).	IESO: • Additional DSO logic to avoid over scheduling as a result of ISL parameter • Introduction of ISL tracking in various RT-MIO supporting systems and tools to track and calculate value • Could provide more accurate scheduling but additional logic above could create degradation of engine solve times. Market Participant: • More accurate scheduling and greater certainty in achieving dispatch	TBD
4	Exclusion of CycleDEL require ment from PD	• The IESO is considering removing the application of CycleDEL in PD to give MPs better visibility into RT schedules.	IESO: • Removal of CycleDEL logic from the PD engine DSO logic • Potential need to adjust daily submission forms after DAM. Market Participant: • More accurate reflection of how the RT engine will	TBD

			schedule the resource to avoid	
5	Constraint Violation Pricing in pricing pass	Penalty pricing in the pricing pass will be determined by the Markets team and incorporated in subsequent Phases.	IESO: • Minor update in the DSO required to adjust CVP pricing values. Market Participant: • Inclusion in pricing pass could give greater incentive to bypass limits if required to meet schedule/dispatch.	TBD