Enabling Resources Program: Storage and Hybrid Integration Project

Dispatch Data and Other Inputs

Memo 2.0

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Engagement Topic: Dispatch Data and Other Inputs 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 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
BESS	Battery Energy Storage Systems
CM	Contract Manager
CROW	Control Room Operations Window
CVP	Constraint Violation Prices
CycleDEL	Cycling Daily Energy Limit
DAM	Day-Ahead Market
DFS	Demand Forecast System
DFT	Demand Forecast Tool
DMSR	Dual Model Storage Resource
DSO	Dispatch Scheduling and Optimization
ELT	Expedited Long Term
EMS	Energy Management System
IAM	IESO Administered Market
ESR	Energy Storage Resource
EUC	End Use Computing
FRL	Financial Reference Level
HOL	High Operating Limit
ISoC	Initial State of Charge
ISL	Internal Service Load
LOL	Low Operating Limit
LT-1	Long Term 1
MaxSoC	Maximum State of Charge
MIM	Market Information Management
MinSoC	Minimum State of Charge
MP	Market Participant
MPM	Market Power Mitigation
NFRL	Non-Financial Reference Level
OR	Operating Reserve
PD	Pre-Dispatch
PQ	Price-Quantity
RAS	Remedial Action Scheme
RL	Reference Level
RQ	Reference Quantity
RT	Real-Time
RT-MIO	Real-Time Multi Interval Optimization
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 started with the core Optimization element within the Grid and Market Operations module, which has been the main precursor to design decisions that 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 (SMSR) 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 Integration Project adopted a phased delivery approach to expedite and prioritize the implementation of essential functionality, including:

- Single Model Storage Resource (SMSR);
- State of Charge (SoC) Management.

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

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

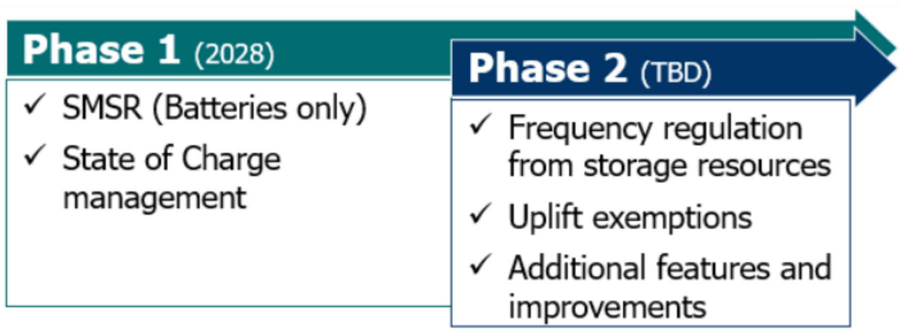

Figure 1: Project Scope

Scope of Dispatch Data & Other Inputs Phase 1 Design

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 below, with this document focusing on Dispatch Data and Other Inputs. During Batch 2 design, the IESO worked on all the relevant design elements in parallel to expedite delivery.

Batch #	Design Module	Design Element
1	Grid and Market Operations	Optimization (Energy & Operating Reserves)
	Grid and Market Operations	Dispatch data and other inputs
2	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 Modules and Elements for Phase 1

The IESO's focus is on single-site, dispatchable storage resources greater than 1 MW. This enhanced market design will support recent storage procurements via Long-Term 1 (LT1) and Expedited Long-Term (ELT) procurements. Some of the BESS facilities 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 at a later date. Most existing resources that participate in the IESO Administered Markets (IAMs) as the foundational dual model storage resources (DMSRs) with Energy Storage Facility Agreement (ESFA) contracts will participate as SMSRs, after their existing contracts expire.

Design Principles and Methods

Principles

The ERP market design principles guide design decision criteria to verify that the design meets the needs of the IESO and market participants (MPs). These principles were derived from the foundational Market Renewal Program (MRP) and were considered as part of the long-term vision for storage.

- **Efficiency** - Deliver efficient market outcomes to benefit consumers;
- **Competition** - Provide open, fair, non-discriminatory competitive opportunities to enable MPs to meet evolving system needs;
- **Implementation** - Collaborate with our stakeholders to evolve the market in a feasible and practical manner;
- **Certainty** - Maintain enduring market-based mechanisms that send clear, efficient price signals;
- **Transparency** - Accurate, timely and relevant information is available and accessible to MPs to enable their effective participation in the market;
- **Operability -** The new participation models will improve the IESO's ability to plan/forecast the operational needs of the grid and provide accurate signals to BESS resources.

Method

The design and integration of storage will be organized in a build-to-bill format called modules (representing larger functions) and elements (specific functions within a module). The build-to-bill modules and elements are specific to the market participant (MP) 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 based on project dependencies and priorities (i.e., not in a chronological format like a typical build-to-bill decision-making process).

Dispatch Data and Other Inputs Design Element

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

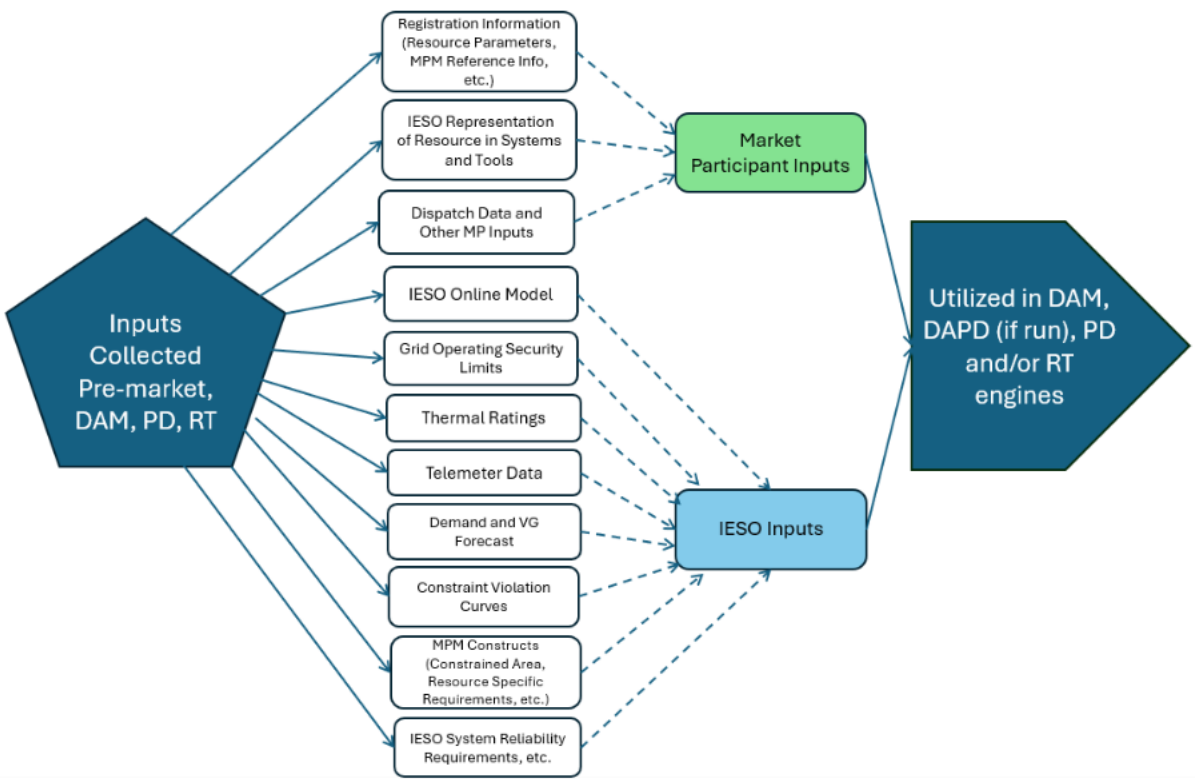

Figure 3: Inputs utilized by the IESO Optimization Engines

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 SMSR to provide energy and OR services to the transmission grid. This consists of MP and IESO inputs and will include information relevant to the dispatchable SMSR, as well as some requirements related to commissioning of this resource. Note that details of some of the MP and IESO inputs are available 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 above, 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 bi-directional offers.
- Other MP inputs – information submitted in power outages or derates.
- Information - 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 are details of the decisions supporting the scope described in the Scope of Dispatch Data & Other Inputs Phase 1 Design section. Please note that some of these items have been updated since the Batch 1 Optimization design. The IESO has made necessary updates to support a Phase 1 delivery and address various technical challenges with implementation. This design will continue to evolve with other design batches and elements as needed and this document will be updated accordingly.

Data inputs and optimization constructs in engines encompass many of the key data points collected to support the Optimization process in the DSO. Hence, initial decisions on the parameters in the Registration Parameters and Dispatch Parameters sections were made during the Optimization design for the resource. However, this design was revisited during the Batch 2, Phase 1 design phase to firm up decisions related to the list of required data parameters unique to the SMSR.

Requirements for Commissioning of dispatchable Single Model Storage Resources

When commissioning the resource, the resource will operate under an SMSR 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 resource's operation and to adapt the self-scheduling model for the SMSR, which include:

- The SMSR will participate 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 clarifies the technical requirements, and the additional procedures needed to support such a model.
- SoC will not be modeled when entering self-schedules, the resource will manage these and must submit self-schedules that respect its own SoC limitations. Daily dispatch data parameters will not be required, as per the fully commissioned model that is described in the Registration Parameters and Dispatch Parameters sections.

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 deviates largely from their corresponding registration parameter.

Dispatch Parameters

Daily Dispatch Data Parameters

Similar to other existing resources, dispatch data must be accompanied by the registered MP name, resource type and resource name. The data submission timeline for both hourly and daily dispatch data for the SMSR 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 below lists the daily dispatch parameters unique to SMSRs. It also describes, at a high level, the submission and validation logic imposed on MPs. The information in Table 1 is utilized in all timeframes unless stated otherwise in the Submission and Validation Notes column. Additional details on how these dispatch data parameters are utilized in the day-ahead (DA), PD and RT optimization engines are available in the Optimization design memo posted on the ERP Storage and Co-located Hybrid Integration Project engagement webpage 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. • Can have up to one decimal digit
Cycle Efficiency Cycle Efficiency	Decimal value	This value is applied to the withdrawal MWh to account for efficiency losses on both sides of the resource to provide accurate information on the MWh available. It should not account for other draw on the battery, such as auxiliary load etc.	• Mandatory submission used in all timeframes • Should be greater than zero and less than or equal to one • Can have up to two decimal digits • MPM validation • Value between 0.00 - 1.00
CycleDEL Cycling Daily Energy Limit	MWh	The maximum amount of daily energy 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	• Optional submission used by DAM • Can have up to one decimal digit • In the absence of a submission, the default value will be 99999.9

Attribute	Unit of Measure	Description	Submission and Validation Notes
		if deemed necessary to avoid degradation.	

Validation Rules

In addition to the validation rules stated in the Submission and Validation Notes column of Table 1 above, with the introduction of new daily dispatch parameters unique to the SMSR, MPM is introducing validation rules for Cycle Efficiency. MPM validation also occurs in Market Information Management (MIM).

Cycle Efficiency: Consistent with conduct thresholds for most existing Non-Financial Reference Levels (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

MPs will be able to submit hourly Max and MinSoC limits that will be used to schedule and dispatch the resource between the appropriate SoC range, as in Table 2 below. This permits the MP to schedule different limits that could differ from hour to hour.

Table 2: 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 be careful 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 the parameters in Table 2 above are maintained. In cases where 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.

Validation Rules

With the introduction of new hourly dispatch parameters unique to the SMSR, MPM is introducing validation rules. MPM validation also occurs in the same tool.

- MaxSoC:
  - Mandatory submission;
  - Must be greater than the submitted MinSoC;
  - Must be less than or equal to the registered absolute MaxSoC;
  - Should have one decimal digit;
  - MPM validation (refer to Figure 4 below).
- MinSoC:
  - Mandatory submission;
  - Must be less than the submitted MaxSoC;
  - Must be greater than or equal to the registered absolute MinSoC;
  - Should have one decimal digit;
  - MPM validation (refer to Figure 4 below).
- Rules applicable to both Max/Min:
  - MPs must ensure that there is overlap between SoC ranges between hours. For example, 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 the registered values, the MPM validation rules will not permit the submitted MaxSoC to be lower than the registered MaxSoC by 30% of the registered value, under normal conditions. Similarly, MPM will restrict the submitted MinSoC from being higher than the registered MinSoC by 30% of the registered value. The upper limit for MaxSoC submission is registered Absolute MaxSoC. The lower limit for MinSoC submission is registered Absolute MinSoC. Figure 4 below shows the permitted limits for MaxSoC and MinSoC under normal operational conditions.

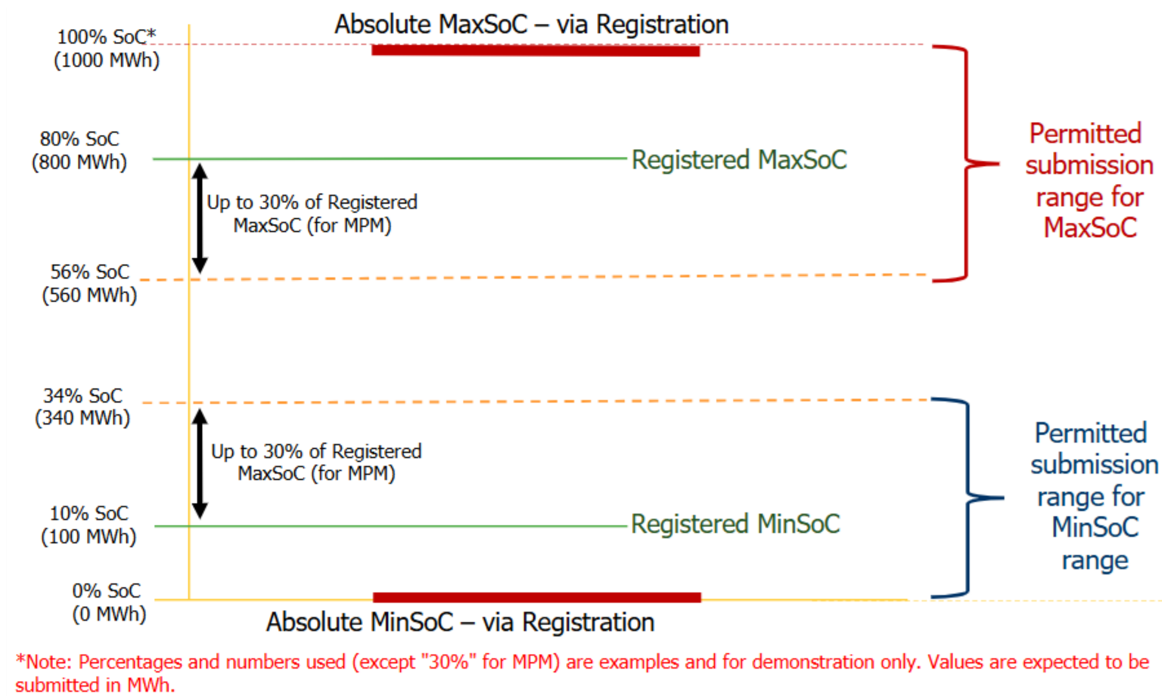

Figure 4: Validation Logic for MinSoC and MaxSoC

The IESO will exempt the MPM validation rule pertaining to the MinSoC and MaxSoC dispatch data submission rule in case of outage or derate reasons i.e., MPs must submit a valid reason code if they want to be exempted from the MPM validation due to outages or derates. Figure 5 below shows the extended permitted ranges for MaxSoC and MinSoC when exempted from the 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 MP's submitted values are accepted without any MPM validation.

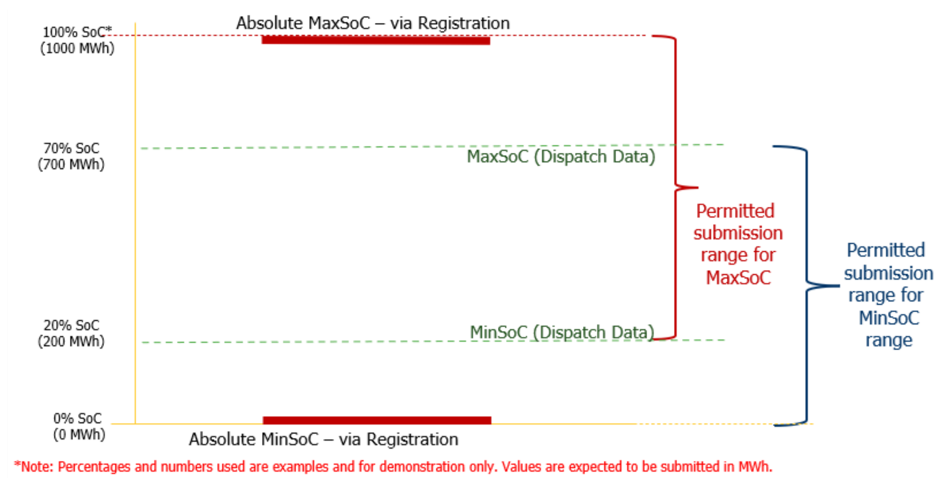

Figure 5: MPM Validation Logic for MinSoC and MaxSoC

Bi-directional Energy Offer

Currently, resources are allowed to submit between two to 20 price-quantity (PQ) pairs ($/MW) for energy, which will continue for SMSRs. The unique feature of an energy offer curve for an SMSR is 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 bi-directional offer curve.

For an offer with both withdrawal and injection portions:

- The first lamination for the MP 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 MP must enter a zero MW quantity to denote the cutover point to injections, which will share the same $/MW value as the MP's next injection lamination (the lowest price the MP 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 denote the maximum price that the MP is willing to withdraw at. Injection prices in $/MW denote the minimum price that the MP is willing to inject at.
- For a bi-directional energy offer, this is what is implied by the signs (+ or -) for the PQ pairs:
    - Negative quantity and negative price = MP willing to withdraw if paid by the market to do so;
    - Negative quantity and positive price = MP willing to pay to withdraw;
    - Positive quantity and negative price = MP willing to inject at, even if they must pay to do so, since they want to be scheduled for an injection;
    - Positive quantity and positive price = MP willing to inject at if paid that price.

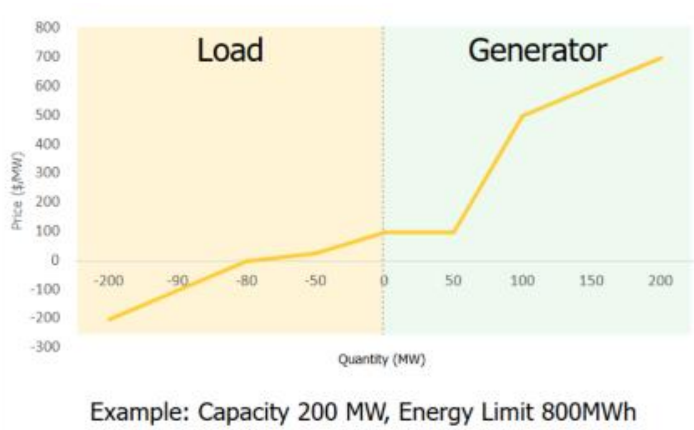

Figure 6: Bi-directional Energy Offer Curve Example

Table 3: Example Bi-directional Offer with nine laminations

Example Bi-directional Offer with nine 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 above, the MP submits nine 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 availability declaration envelope (ADE) requirement. The zero quantity in the laminations indicates that this MP will not be scheduled economically between market prices of $25.01 to $99.99. Their withdrawals will start at the $25/MW market price, and their injections will start at the $100/MW market price.
- Currently, dispatchable loads have the option to designate all or a portion of their load as non-dispatchable by either pricing Megawatts (MW) at the Maximum Market Clearing Pricing (MMCP) or not entering a bid for those hours they wish to be non-dispatchable, in accordance with the applicable market rules and manuals. However, an MP registered as an electricity storage resource is not entitled to change its load (withdrawing) status to non-dispatchable in a similar manner. As a result, SMSRs will be ineligible to change load status as per the existing rule. Similar to dispatchable generation and dispatchable loads, the MMCP for bi-directional offers in either direction will be $2,000/MWh.

For an offer with only withdrawal portion of the bi-directional offer:

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

Table 4: Withdrawal only Example of Bi-directional Offer

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 to 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 bi-directional offer:

- If just injecting, it starts at zero and goes to highest injection capability that the MPs want to express in the market;
- Positive prices in this example denote that the MP will be paid that amount.

Table 5: Injection only Example of Bi-directional Offer

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 Internal Service Load (ISL) from the SoC in DAM 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 MinSoC and MaxSoC limits. In RT, the submitted ISL value for each hour will be divided by 12 to reflect a value for each five-minute dispatch interval. ISL will default to zero in Phase 1.

Availability Declaration Envelope (ADE): Storage resources will continue to be subject to the 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 the MP does 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 bi-directional offers must be submitted for each dispatch hour that the MP wants to participate in the market. The following validation will take place.

- Each PQ pair is submitted as a set of two 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 two 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 only refer to the maximum positive quantity. For withdrawal only laminations, this only refers to 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;
- In the withdrawal range, price must be non-decreasing for each subsequent PQ pair set;
- For Injection portion of the offer (when Energy Storage Resource (ESR) intends to Generate):
  - The price must be the same in the first and second PQ pair sets;
  - The price must be non-decreasing for each subsequent PQ pair set except the first and second PQ pair sets.

Energy Ramp Rate

The IESO is exploring methods to derive a facility ramp rate down to the resource level for submission and scheduling. The currently proposed design is as follows:

- 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 NFRLs respectively.
  - The IESO has already implemented a maximum ramp rate restriction for injection and withdrawal when a resource is scheduled for energy. The IESO will continue to utilize a 100 MW/min ramp rate at the facility level. The ramp restriction the IESO will be imposing applies to both injection and withdrawal when facilities are scheduled for energy. This means that if a facility has multiple resources, their combined ramp rate should total no more than 100 MW/min.

    - This requirement will support more stable grid performance and supports SoC calculations throughout the different engines.
    - The MP is not required to adhere to the 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 statuses, it may be impractical to include this requirement as part of dispatch data validation.
- At the resource level, MPs can submit up to two ramp rates that are less than or equal to registered Maximum Ramp rate.

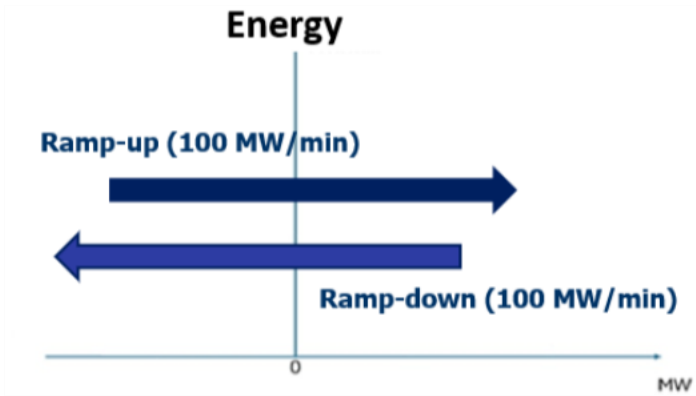

Figure 7: Energy Ramp Rates Design (Facility Level)

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.
- MPs will be allowed to submit a maximum of two positive breakpoints with ramp-up and ramp down rates and must submit at least one ramp rate.
- Each ramp rate is submitted as a set of three values:
    - MW quantity or Breakpoint:
        - Expressed in MW up to one decimal place (0.0) and must be greater than 0.0 MW 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 two 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 breakpoints for the resource. This is illustrated in Table 6 below.
- The ramp rate value should be less than or equal to the 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					Interpretation in IESO Tools			
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**
Break Point	25	200	N/A	N/A	N/A	-200	-25	25	200
Ramp Up Rate	100	50	N/A	N/A	N/A	50	100		50
Ramp Down Rate	45	60	N/A	N/A	N/A	60	45		60

Operating Reserve Offer

MPs who intend to participate in OR must submit OR offers. 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 must be zero and then 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: Example OR Offer with five Laminations

Example OR offer with five 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 above has five 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 offer into the market. This 400 MW OR offer accounts for the resource's capability to move from consuming for 200 MW to immediately providing 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 below.
- It will be validated against registered OR ramp rate NFRL.
- Unlike energy ramp up/down rates, the OR ramp rate will not be limited but must respect the resource's registered maximum ramp rate value, as depicted.

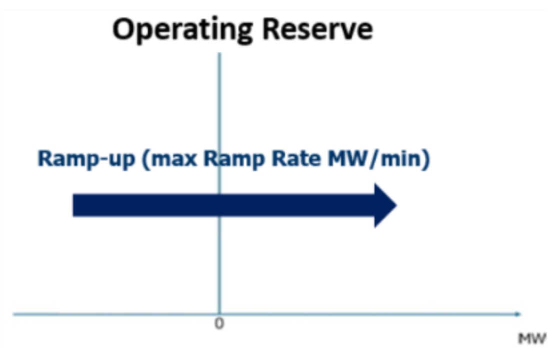

Figure 8: Operating Reserve Ramp Rate Design

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 OR of the class of OR being offered.

A reserve loading point must be zero for all OR classes for an SMSR. 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 4 Appendices, Section 4.24), and are used to ensure reliability of the grid by monitoring system conditions and resource responses as well as to support DSO calculations. Any updates to these requirements during Batch 2 design are available in the Connection and Registration Design document. Although these data monitoring requirements are utilized as data inputs, it is necessary that the MPs 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 they are used in the determination of generator Lower Operating Limits (LOLs) and Higher Operating Limits (HOLs).

Outages must account for the capacity of the SMSR 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. In the case of storage, HOL must be zero or positive and LOL must be zero or negative. 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 zero and the LOL could increase to zero. A zero value for both HOL and LOL could also indicate a complete outage of the resource. Figure 9 below shows a few scenarios for derates and how they would impact the HOL and LOL respectively.

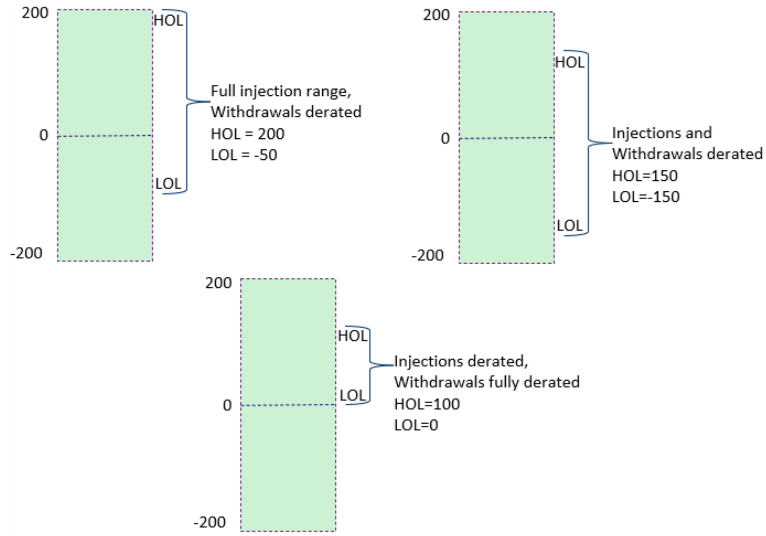

Figure 9: Examples of HOL and LOL for an SMSR

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. Ontario hourly demand forecasts are used as inputs to the PD and DAM sequences. RT demand forecasts use similar modeling techniques, but forecasts are generated for five-minute intervals. IESO Energy Management System (EMS) demand calculations include both non-dispatchable and dispatchable loads plus transmission losses. These historical loads inform IESO demand forecasts used by the DSO to set market schedules. As part of ERP storage design, the IESO must ensure that demand forecasts and associated calculations accurately apply data related to an SMSR when the resource is expected to withdraw.

To facilitate the new SMSR, new Ontario demand calculations that exclude SMSR charging within the EMS will be created by the IESO. These new EMS demand calculations are required by the IESO's Demand Forecast System (DFS), the demand forecasting tool (Metrix) and by the Control Room Operator (CRO). Updated new EMS demand calculations will serve as inputs for Metrix. Within Metrix, demand forecast models will produce the appropriate demand forecasts for RT, PD and DAM for DFS, to be used as inputs for DSO. Additionally, any historical demand data used by EMS-related End-Use Computing tools (EUCs) must be re-calculated using the new SMSR method to remove the historical charging of any SMSRs that were once connected as DMSRs. These EUCs include the Demand Forecast Tool (DFT) used by the control room. The new storage resource will also impact similar day load forecasting.

Market Power Mitigation

The IESO establishes reference levels and reference quantities with MPs for its dispatchable resources. Financial Reference Levels (FRLs) and NFRLs are determined based on the resource's registration eligibility to participate in the IESO markets. NFRLs are used to support the ex-ante, settlement and ex-post MPM processes in the energy and operating reserve markets. NFRL validation based on MPM validation rules for dispatch data parameters occurs in MIM as described in the **Error! Reference source not found.**and Hourly Dispatch Data Parameters sections of this document. New MPM validations are implemented for the Cycle 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 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. Constraint Violation Prices (CVPs) are used to avoid the DSO not providing a solution, which would require alternative means to manage the grid, and could result in more costly outcomes. The constraint violation penalty curves that this resource model will utilize in the scheduling pass are described below (Penalty pricing in the pricing pass will be determined by the Markets team and incorporated in subsequent Phases):

- Typical violation pricing that are used in the network constrained unit commitment will apply to support the scheduling of the storage resource when necessary.
- For the scheduling pass, the violation prices are noted below to bypass constraints.
    - We will utilize the following parameters for testing and adjust as required based on the outcomes of scenarios:
        - Absolute Min/Max CVPs $95,000/MWh - included in Scheduling passes and pricing passes;
        - Min/MaxSoC CVPs - $50,000/MWh - included in scheduling passes and pricing passes;
        - CycleDEL CVP - $36,000/MWh - included in scheduling passes and multi-interval pricing pass (not in the single interval pricing).
- 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 MaxSoC for withdrawal and MinSoC when injecting only.

Pricing Locations

The IESO must 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 SMSR 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. The 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 below.
    - 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 in Figure 10 below. The User Interface rules will be updated to either warn or prevent the user from entering this type of conflict.

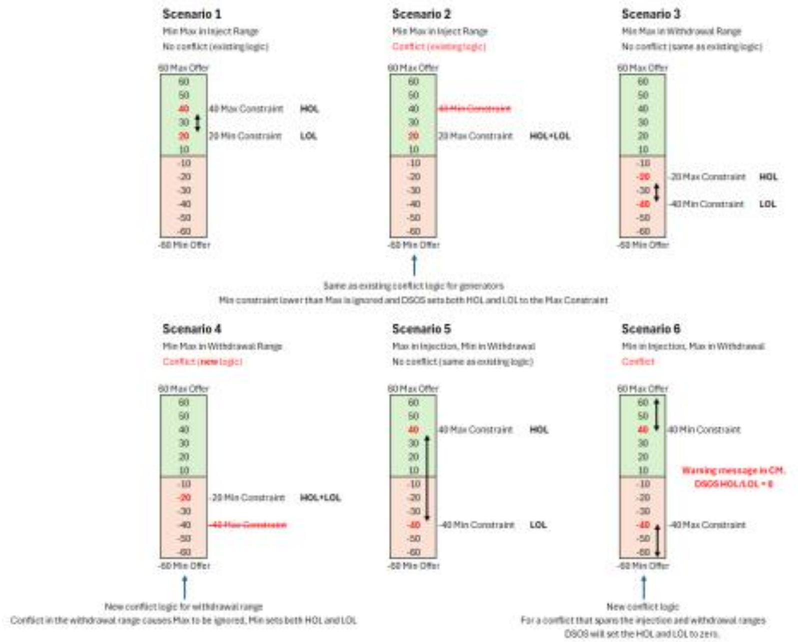

Figure 10: Scenarios for submission of Resource Constraints in CM

- If any new codes are introduced, 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 the 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 MPs are detailed in Appendix 1 – Outstanding Design Items.

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 rigger potential engine scheduling. MP: • Will provide greater flexibility in their submissions to account for SoC ranges that could change throughout the day due to outages, or other factors.	Approved; SoC limits have been switched to hourly parameters.
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 MP: • Require clarity on how to submit ramp rates to produce schedules and support a facility level ramp requirement	TBD
3	Inclusion of Internal Service Load requirement in Internal Service	The IESO is considering reviewing the application of applying ISL in DAM	IESO: • Additional DSO logic to avoid over scheduling as a	The IESO will not be utilizing the ISL

#	Design Item	Description	Impacts	Outcome
	Load impacts across different timeframes	when reducing to MinSoC as well as application into the Real-Time Multi Interval Optimization (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).	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 MP: • More accurate scheduling and greater certainty in achieving dispatch	parameter for Phase 1; the parameter will default to zero
4	Exclusion of CycleDEL requirement 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 MP: • More accurate reflection of how the RT engine will schedule the resource	CycleDEL logic has been removed from PD
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 MP:	CVPs have been updated and will be tested to determine if further

#	Design Item	Description	Impacts	Outcome
			• Inclusion in pricing pass could give greater incentive to bypass limits if required to meet schedule/dispatch.	changes are required.