IESO Engagement Session

Storage and Co-located Hybrid Integration Project Meeting #1

Enabling Resources Program (ERP)

July 24, 2025

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Disclaimer

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Territory Acknowledgement

The IESO acknowledges the land we are delivering today’s webinar from is the traditional territory of many nations including the Mississaugas of the Credit, the Anishnabeg, the Chippewa, the Haudenosaunee and the Wendat peoples and is now home to many diverse First Nations, Inuit and Métis peoples. We also acknowledge that Toronto is covered by Treaty 13 with the Mississaugas of the Credit First Nation.

As we have attendees from across Ontario, the IESO would also like to acknowledge all of the traditional territories across the province, which includes those of the Algonquin, Anishnawbe, Cree, Oji-Cree, Huron-Wendat, Haudenosaunee and Métis peoples.

Engagement Principals and Process

- The Enabling Resources Program ('ERP' or 'Program') will be conducted according to the **IESO Engagement Principles**
- Today’s session will be **recorded** and available for viewing online
- **Meeting materials** are posted on the ERP Storage & Co-located Hybrid Integration Project engagement webpage

Meeting Logistics and Participation

- For questions and comments, click on the "**raise hand**" icon (hand symbol) at the top of the application window. This will indicate to the host you would like to speak
- To **unmute** audio, click on the microphone icon at the top of the application window
- Audio should be **muted** when not speaking
- **Connection issues** contact engagement@ieso.ca or Microsoft Office Support directly

ERP Engagement Webpages

ERP engagement webpage: ERP webpage

- Main landing page for program-level updates, information and documents

ERP project webpages: Storage and Hybrid Integration Project

- ERP projects (e.g. Storage/Hybrids and DERs) have their own engagement webpage to communicate the meeting schedule, materials and related information

Purpose

- Provide the sector with an update of the Storage and Co-located Hybrid Integration (S/H) Project.
- As part of each meeting, the IESO's ERP team will encourage sector feedback on key areas of the participation model being designed within this project.

Agenda

Today's engagement session will cover the following topics:

- Overview & Scope: Storage & Co-located Hybrid (S/H) Project
- Recent Engagement Activity
- S/H Design Topics and Phased Delivery Approach
- Next Steps

S/H Project Overview and Scope

Enabling Resources Program Scope

The Enabling Resources Program is a set of projects that will further enable key emerging resources, specifically electricity storage (“storage”), hybrid generation-storage pairings (“hybrids”) and aggregations of Distributed Energy Resources ("DERs") into the IESO-administered markets, tools, and processes to provide required system services and contribute to the safe and reliable operation of the bulk power system in Ontario.

Program Overview: ERP Projects

Storage and Co-located Hybrid Integration Project (*Transmission and Distribution Resources*)

- **Storage** – ERP will implement an enhanced storage model, building upon the interim storage model that was implemented in 2018
- **Co-located Hybrids** – ERP will implement an enhanced co-located model which applies the enhanced storage model to the storage resource within a hybrid facility, building on the foundational co-located model implemented in 2023

Distributed Energy Resources (DER) Integration Project *(Distribution Resources)*

- **Distributed Energy Resources** – ERP will enable aggregated DERs and, potentially, smaller standalone DERs to participate in wholesale electricity markets. This work will include improving DER information sharing between LDCs and the IESO for enhanced visibility and, in the future, coordination

Recent Engagement Activity

Engagement Activity

- IESO's ERP team engaged with contracted storage organizations from IESO procurements (i.e., Energy Storage Facility Agreement contracts) recently to build awareness of the program's goals and objectives.
- The focus of these targeted discussions included updates on the optimization design module, the IESO's approach on prioritizing design features, and an open forum for discussion on priorities in the storage space.

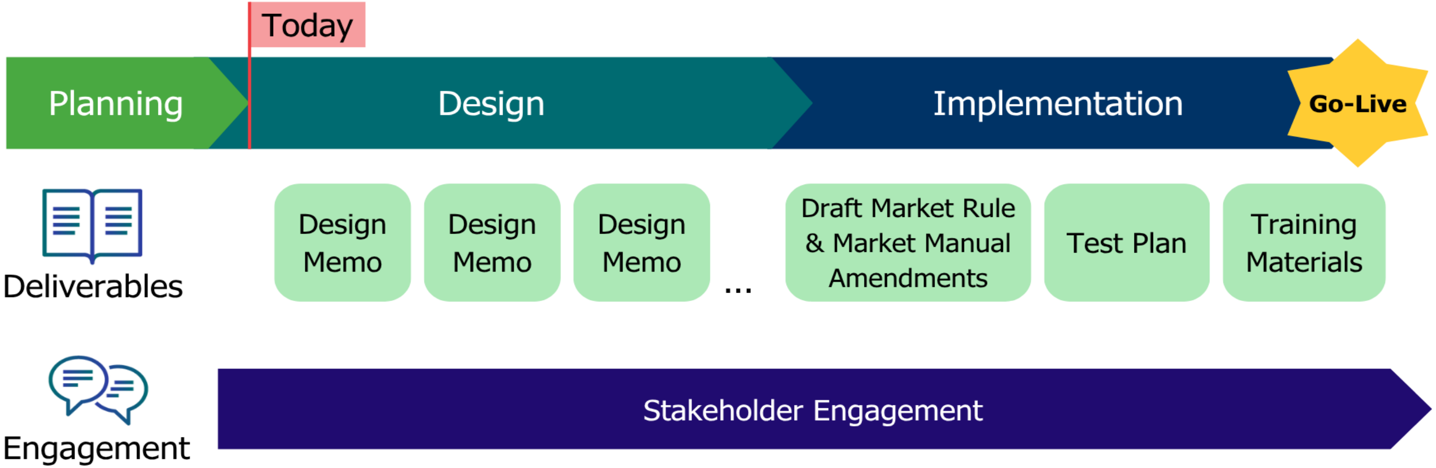
S/H Project – Scope & Timeline Updates

What has changed since we last met?

- Storage and Co-located Hybrid Project is adopting a phased delivery approach to expedite and prioritize the implementation of essential functionalities, including:
  - Bi-directional single resource model
  - State of Charge (SoC)
- Subsequent design phases will implement:
  - Regulation service
  - Any required enhancement resulting from Phase 1 implementation
- Given the construct of the Energy Storage Facility Agreement (ESFA) contracts these will not be subject to the new storage design and will continue participating as they currently do in the IESO-Administered Markets (IAMs) until their contracts expire.
- This enhanced market design will impact recent storage procurements, e.g., recently operational Oneida and those procured via Long-Term 1 (LT1) and Expedited Long-Term (ELT) procurements.

Phase 1 Storage Project – Timelines and Process

- The IESO is targeting a Phase 1 implementation date in 2027-28
- Design Memos will be shared with stakeholders to inform feedback throughout the engagement on design, and will also inform draft amendments to IESO market rules and manuals
- The next Design Memo on Optimization is targeted for October 2025



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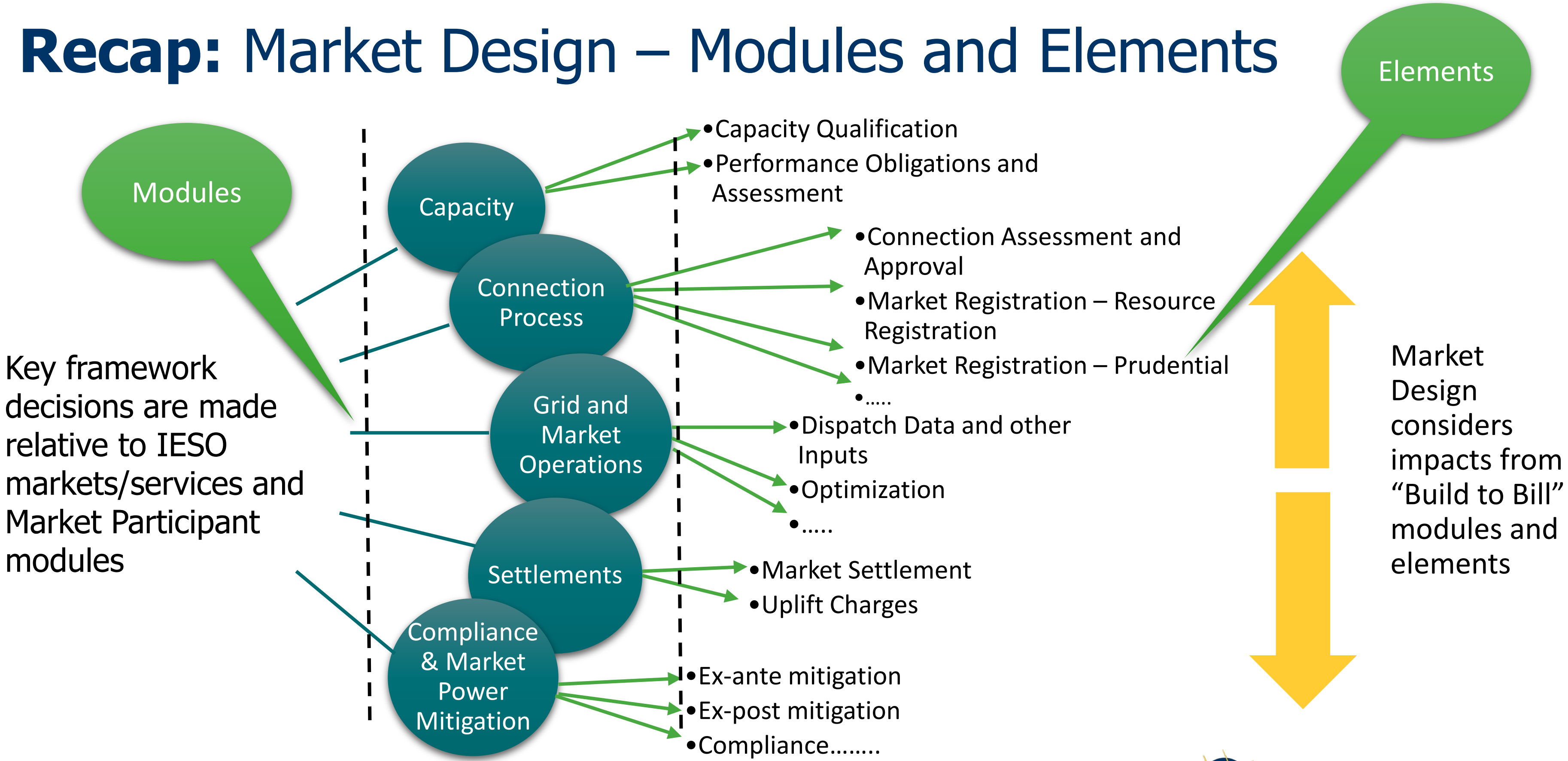
Recap: Market Design Approach

- Key framework decisions based on prior visioning work and need to be considered across various IESO/market systems and processes
- 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 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)
- Market design will be built on the foundation of MRP: locational marginal pricing, day-ahead market, enhanced real-time unit commitment, market power mitigation, etc.

Recap: Market Design – Modules and Elements



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Phase 1 – Design Batches and Modules

Design Batches	Design Module	Design Element
Batch 1 *Topic for our next engagement (October), with a design memo*	Grid and Market Operations	Optimization (Energy & Operating Reserves)
Batch 2 *The IESO will run all other design in parallel with an attempt to expedite the delivery. This involve design memos for clarity on these topics and will likely entail multiple engagements.*	Grid and Market Operations	Dispatch Data and Other Inputs
	Connection and Registration	Market Registration (resource registration, prudential security, revenue meter registration, telemetry)
	Compliance and Market Power Mitigation	Exante
	Settlements	Market Settlement
	Connection and Registration	Connection Assessment and Approval
	Capacity/Contracts	Capacity Qualifications
	Capacity/Contracts	Performance Obligations and Assessment
	Capacity/Contracts	Contract Impacts
	Compliance and Market Power Mitigation	Expost
	Compliance and Market Power Mitigation	Other compliance activities as required
Batch 3	Hybrid - All Modules	Market rules need to adjusted for the co-located hybrid model with the integration of the new storage model

Note: Batching may change, and specific design modules may not be exhaustive. Additional details of timing and modules/elements will have greater clarity after the Optimization design element (Batch 1).

Phase 1 – Design Batches and Modules

Design Batches	Design Module	Design Element
Batch 1 *Topic for our next engagement (October), with a design memo*	G... and Market Op...tions	Optimization (Energy & Operating Reserves)
Batch 2 *The IESO will run all other design in parallel with an attempt to expedite the delivery. This involve design memos for clarity on these topics and will likely entail multiple engagements.*	Grid ...	...patch Data ...
	C...	...ket Registra... ...on, prudential security, ...nue meter...
	Co...	...inte...
	S...	Market Settlem...
	Connect...	Connection Ass...
	Capacity/Contracts	Capacity Qualif...
	Capacity/Contracts	Performance Ob... ...ent
	Capacity/Contracts	Contract Im...
	Compliance and Market Power Mitigation	Expost...
	Compliance and Market Power Mitigation	Other complian...
Batch 3	Hybrid - All Modules	Market rules ... ...o-located hybrid model with the integration ... ...el

Design Batches considers immediate need and timelines to update systems, tools, processes

DSO

EMI, CROW

Online IESO

Various other internal IESO systems and tools

MP and IESO Processes

Market Rules/Manuals

Note: Batching may change, and specific design modules may not be exhaustive. Additional details of timing and modules/elements will have greater clarity after the Optimization design element (Batch 1).

S/H Design Overview & Considerations

Storage and Co-Located Hybrids – Scope [1/2]

Feature	Phase 1 Scope	Scope for Subsequent Phases
Technology	• Battery Storage	• Will consider applicability of other types of storage technologies and potential nuances that could require additional / different parameters
Resource Considerations	• Sole purpose of withdrawing electricity from the electricity system, storing that electricity, and re-injecting it into the electricity system • Single-site, dispatchable storage greater than 1 MW • Transmission or distribution connected (Not including aggregated DER participation)	• Self-scheduling less than 10 MW
Resource Modelling	• Will be modelled in IESO tools as a single bi-directional resource that can withdraw (bid) and inject (offer) across a continuous offer curve	• Improved design of energy offer curve (E.g. Bids/offers being tied to SoC ranges)
SoC	• Will be modelled, calculated and used as a constraint for all market timeframes i.e., Day-Ahead Market (DAM), Pre-Dispatch (PD) and Real-Time (RT), in IESO tools to support efficient/reliable use of storage	• Consider how to utilize the energy limited resource more effectively across the day to meet system needs
Market Opportunities for Resource	• Co-optimized participation in Energy and Operating Reserves (OR) • OR participation will be allowed from the generator side, load side and be allowed to branch/swing from withdrawal to injection	• N/A

Storage and Co-Located Hybrids – Scope [2/2]

Feature	Phase 1 Scope	Scope for Subsequent Phases
Uplifts	• ERP is starting to explore settlement for both transmission and distribution connected storage	• N/A
Regulation Service	• N/A	• Storage will be integrated into regulation service tools and systems, as well as determining ability and impacts to providing other grid services. Participation permitted in energy, OR and Regulation (like other resources providing these services). • **Note:** This is ONLY to support storage in IESO tool sets if eventually contracted. Necessary procurements/contracting is still required to facilitate participation in regulation service and will NOT be done as part of ERP. This also doesn't consider introducing further co-optimization between all grid services.

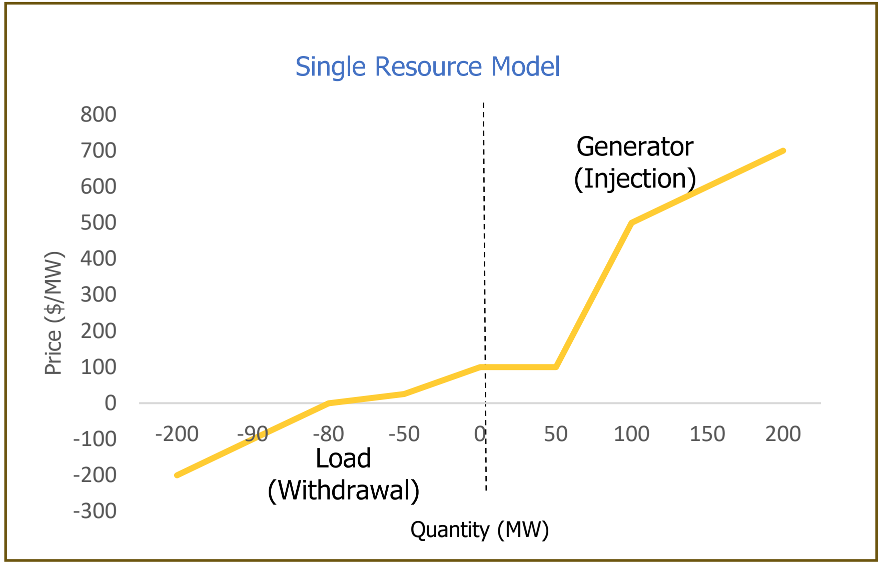
- Co-located resources under the hybrid model will be modelled as two distinct resources:
  - Dispatchable storage resource with a single continuous offer curve (i.e., based on the enhanced storage model)
  - Generator resource leveraging the appropriate existing resource model (e.g., a variable generator model for a solar or a wind facility) is expected to not be impacted

Design Topic Focus: Optimization Design Element

- Topics that will be discussed during today's session are:
  - What is the single-resource model?
  - Registered and Telemetered Parameters
  - Daily/Hourly MP submitted Parameters - Single Bid-Offer Curve for Energy; Operating Reserve Offers; Ramp Rates; Initial State of Charge; Cycling Daily Energy Limit; Bypass of Max/Min SoC
  - SoC Management - SoC Applicability; Constraints; and Examples
  - Derates
  - Uniform Transmission Rates

What is the single-resource model?

- Differs from the existing two-resource model which models the withdrawal portion of the resource as a load and injection portion as a generator separately
- The new single resource will have a continuous offer curve where the load portion operating as a "negative generator" (negative MWs) and the generator portion as a "positive generator" (positive MWs). This is like other jurisdictions and is needed within IESO systems to derive the single resource model
- Storage Design in Phase 1 is specific to battery resources
- Utilizing Quick-Start (QS) generator model characteristics: quick ramping capability and no commitment schedules



EXAMPLE ONLY; Capacity: 200 MW, Energy Limit: 800 MWh

Parameters – Registered [1/2]

All static/registered parameters that are common for all other dispatchable QS generators (e.g., primary fuel type, ramp rate) are applicable to storage resources. Static parameters unique to storage:

Parameter	Unit	Definition
Cycle/Round-trip efficiency	% or decimal	Ratio of the energy discharged to the energy charged expressed in percentage, degrades very gradually over time. Applied at time of withdrawal and used to discount the SoC based on total efficiency losses to reinject energy
Maximum Generator Resource Active Power Capability (maximum injection)	MW	Existing parameter for dispatchable generators, but in this case refers to the maximum active injection capability of the resource to validate the submission of offers for energy or Operative Reserves as dispatch data
Maximum Negative Generator Resource Active Power Capability (maximum withdrawal)	MW	The maximum withdrawal active power capability of the resource to validate the submission of offers for energy or Operative Reserves as dispatch data
Absolute MaxSoC	MWh	The maximum SoC availability of the battery that could be utilized by the IESO. Indicates the MWh max that the battery will ever be charged to.

Parameters – Registered [2/2]

Parameter	Unit	Definition
Lower Energy Limit (SoCmin)	MWh	The lowest energy amount to which the electricity storage system can be consistently discharged beyond expected degradation from normal use
Upper Energy Limit (SoCmax)	MWh	The maximum energy amount to which the electricity storage system can be consistently charged beyond expected degradation from normal use
Daily cycles*	at or above 1; includes decimals	The number of cycles that the resource is willing to complete in a day. A cycle is considered the difference between the upper and lower energy limits submitted by the participant during registration. Could also apply a method to denote no cycling limitations.

*Daily cycles supports MPs in limiting their operation as part of a new CycleDEL parameter. This is a tentative parameter as its currently being explored by the IESO and will be discussed in upcoming slides.

Parameters – Telemetered

- Telemetered SoC is required for calculations in PD and RT timeframes. This telemetered value is expected to inform the IESO of the injection capability of the resource in MWh. Therefore, it should account for any losses and other concerns that could impact this value. Current performance requirements will continue, sent every 4 seconds to the IESO.
  - ***Feedback Question:*** Do MP's have concerns or foresee challenges with this requirement?
- The following typical parameters that are used to monitor system conditions, resource response, and to support Dispatch Scheduling Optimization (DSO) calculations will still be applicable: active and reactive powers, voltage, equipment status.
- However, parameters such as economic min/max charge limits, base point, and dynamic max/min power limits are not required for phase 1. These were assumed to support regulation service, which is still being explored by the IESO and will be confirmed as part of upcoming phases of ERP.

Daily/Hourly MP Submitted Dispatch Parameters

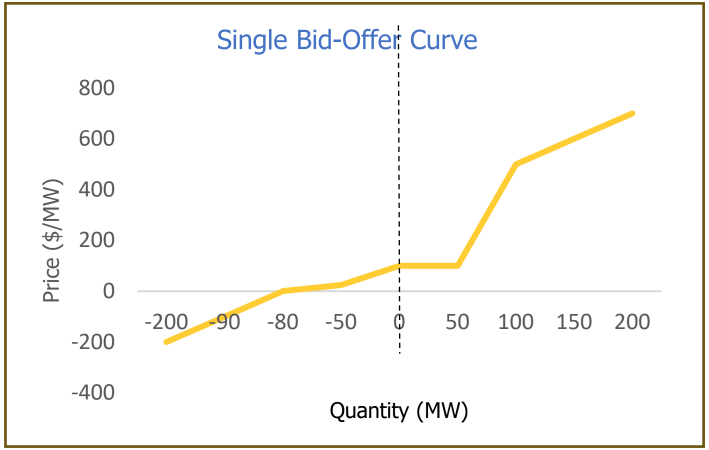
The following slides will detail information that will be submitted by participants through daily or hourly dispatch data. This information includes:

- Single continuous energy offers
- Operating reserve offers
- Energy and OR Ramp Rates
- Initial State of Charge
- Cycling Daily Energy Limit*
- Min/Max SoC Bypass*

*Both of these parameters are still under consideration by the IESO

Single Bid-Offer Curve for Energy

- Storage participants will be able to submit between 2 to 20 price-quantity (P-Q) pairs ($/MW) for energy.
- For storage, the quantities will monotonically increase and branch from withdrawal to injection crossing over 0 MW (as in example), if they offer to provide both injection and withdrawal in the same dispatch hour.
- Negative quantity indicates withdrawing/buying energy from the grid and positive denotes injecting/selling to the grid.
- If applicable, for hours when the storage only wants to withdraw, the offer will range from a negative MW to 0. For hours when the storage only wants to inject, the offer will range from 0 to a positive MW.



	Price ($/MW)	Quantity (MW)
Pair 1	-200	-200
Pair 2	-100	-90
Pair 3	0	-80
Pair 4	25	-50
Pair 5	100	0
Pair 6	100	50
Pair 7	500	100
Pair 8	600	150
Pair 9	700	200

Operating Reserve Offers [1/2]

- Storage participants will be able to submit up to five P-Q pairs for each class of operating reserve (10S, 10N, 30R) for each dispatch hour
- With a single-resource model in place, there are certain aspects of OR from storage that will remain unchanged (e.g., OR MW will always be either zero or a positive value)
- The IESO is exploring the feasibility of an OR offer that allows leveraging the maximum OR capability of a storage i.e., branching from withdrawal to injection (reducing charging and moving into discharge mode to provide OR)
- This implies that, for any given hour, the participant will be able to submit an offer for any of these: injection, withdrawal or branching

Operating Reserve Offers [2/2]

- The OR offer example supports OR provided from the load, generator, and branching between both.
- According to current market design, the maximum OR offer shouldn't exceed the maximum energy offer. E.g., in the example on the right under current rules, 200 MW would be the maximum OR limit.
- However, this limit is not supportive of the storage's branching capabilities and should be modified to the cumulative value of the maximum energy injection offer and the maximum energy withdrawal offer instead. E.g. in the example it would result in a 400 MW max OR limit.
- ***Feedback Question:*** Are there concerns about OR provided by storage being branched from withdrawal to injection?

Example Energy Offer		
P/Q Pair	**Price ($/MW)**	**Quantity (MW)**
Pair 1	-200	-200
Pair 2	-100	-90
Pair 3	0	-80
Pair 4	25	-50
Pair 5	100	0
Pair 6	100	50
Pair 7	500	100
Pair 8	600	150
Pair 9	700	200

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

Ramping of Storage

Ramping needs to be considered in the DSO to properly forecast operation in Real Time Multi-Interval Optimization (RT-MIO). Standardized expectations are required for resources to account for this. Additionally, there are RT operational concerns with extreme ramping of resources.

- 100 MW/min static energy ramp rate for operation and inclusion in the DSO for storage resources. This allows the IESO to still leverage the fast-ramping capability of storage upon dispatch but also limit operational concerns from extreme ramping on system balancing.
- Storage participants will also need to react to dispatches with a consistent approach to accurately reflect in DSO.
- This would likely require market rule interpretations, as well as consistent behavior from all storage market participants.

Feedback Question: Do you have feedback on the 100 MW/min static ramp rate and utilizing a standardized approach to dispatch?

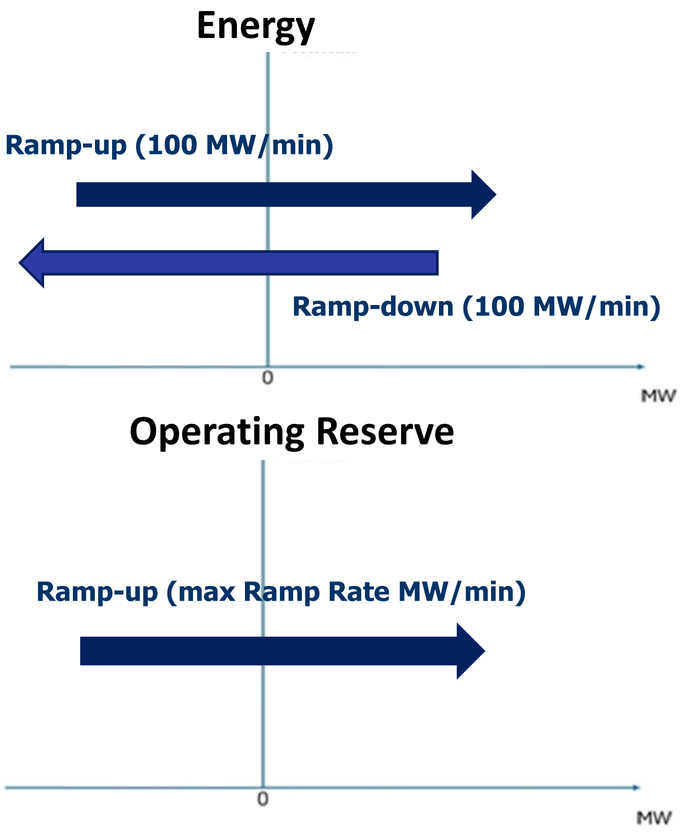
Ramp Rates

Energy Ramp Rate:

- A single set of 100 MW/Min ramp up and down rate for energy.
- Energy ramp up rates would refer to increasing generation or decreasing withdrawal (MW moving in the "positive" direction).
- Energy ramp down rates would refer to decreasing generation or increasing consumption (MW moving in the "negative" direction).

OR Ramp Rate:

- OR ramp rate will be a single max ramp rate in MW/Min (always in the positive direction)



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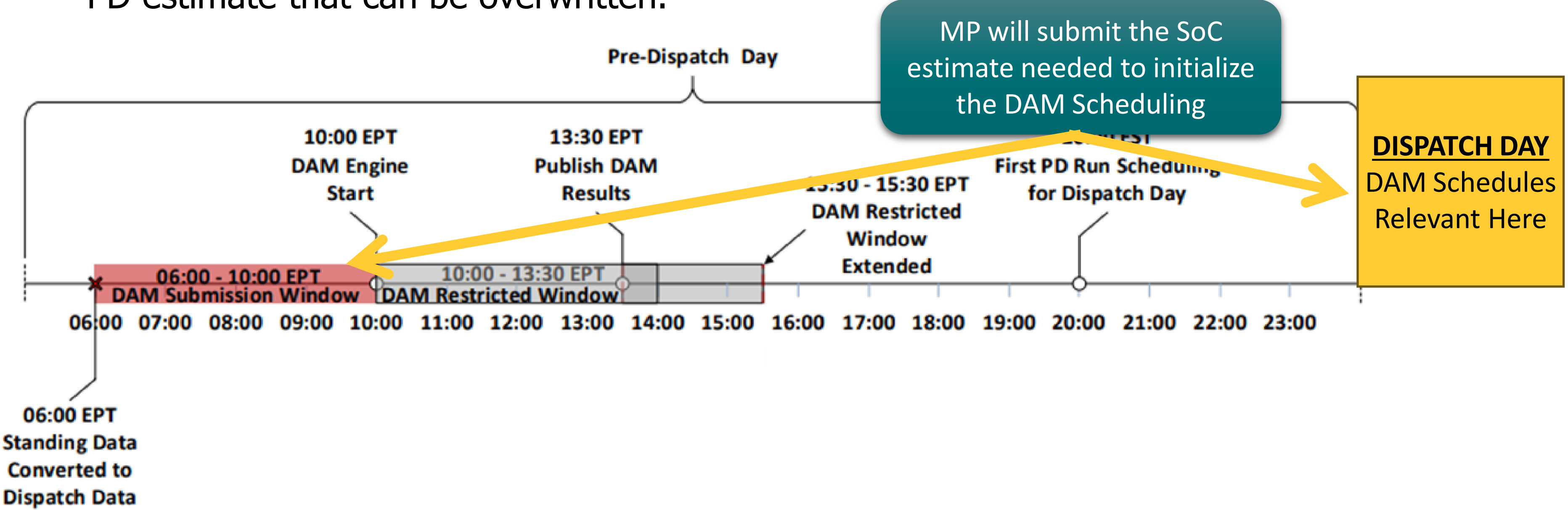
Initial State of Charge

- Market Participants will submit a single MWh SoC for the DAM; all other time frames do not require SoC submission outside of telemetered SoC information. IESO will provide PD estimate that can be overwritten.



Cycling Daily Energy Limit (CycleDEL)

- The IESO is exploring utilizing a new parameter adapted from MaxDEL. This parameter is used to track the maximum amount of energy, in MWh, that a storage can be scheduled to inject in a dispatch day.
- The MaxDEL parameter will not be able to be used by storage resources due to complications of integrating with a single resource model. A new parameter developed specific to storage resources will be required if feasible for phase 1.
- CycleDEL will be automatically provided based on the daily cycles* submitted by the MP during registration and multiplying it by the State of Charge Range “SoCR” of the battery (MaxSoC limit – MinSoC limit), also submitted during registration.
- It can be overwritten by MPs as part of their dispatch data to indicate willingness to operate at higher cycling limits; in other words, MPs can increase this value but not decrease. This value can also be increased throughout the day.
- Similar to MaxDEL, CycleDEL will be used in both the DAM and PD calculation engines. This is not constrained in RT DSO, but the Control Room (CR) has access to information to gauge how resources are approaching these values, and MPs can also update offers in PD to reflect capability to control cycling.
- ***Feedback Question:*** Is this CycleDEL sufficient to limit the cycling for storage for Phase 1? What is the expected default setting?

*Mentioned on slide 26

*****This is currently under consideration by the IESO and may not be in final phase 1 design***

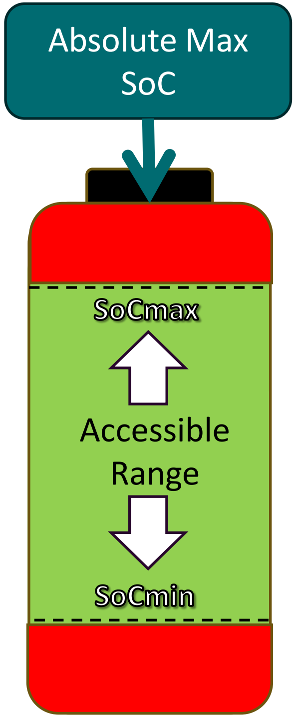
Bypass of Min/Max SoC Limits

The IESO may need to access the min/max SoC operating ranges of a storage under certain conditions. Methods being considered to achieve this include:

- The IESO CR could enforce operation beyond stated min/max SoC when certain necessary conditions met.
- Flag or submission of SoCMIN/MAX bypass* – allow MPs to indicate through a flag or hourly/daily increase to SoCMIN/MAX bypass for hours they are willing to bypass the SoCMIN/MAX value, offers submitted will be utilized and must be entered by MP prior to mandatory window
- “Uprates” – allow the resource to express a higher SoCMax and a lower SoCMin to be utilized primarily for maintenance purposes. Allows the resource to ensure that full battery health is maintained to “flush” all battery cells.

Feedback Question: Do you anticipate needing to exceed min/max SoC limits for specific market opportunities, or just maintenance and what are the typical min/max limits – is this a fixed/static value that can be derived for registration? Frequency and magnitude of exceeding these limits? Are there equipment concerns from this, what are the specific concerns (faster equipment aging/degradation, other)?

****This is currently under consideration by the IESO and may not be in final phase 1 design***



State of Charge

SoC Management Applicability [1/2]

SoC will be managed in all timeframes, i.e., DAM, PD, RT

- Primary Considerations for SoC management in the timeframes - Initial SoC; Min/Max SoC limits; Cycle efficiency; Ramping (mostly in RT); Schedules
- **DAM workflow:**
    - IESO will populate our PD estimate as a starting value, which can be updated up or down by the MP; technically MP submitted. MPs can estimate the SoC that indicate their MWh injection capability based on what they anticipate their SoC to be at the end of dispatch day leading into DAM (i.e. a hypothetical telemetered value). Each hour of DAM will keep a running total of the SoC based on the schedules produced by the DAM.
- **PD workflow:**
    - Initial SoC is collected through telemetry feeds. The PD engine then has an initialization phase that will estimate the SoC to the end of the RT dispatch hour. This sets the initial value to be used by PD-1 and then it will get recalculated for each PD hour based on the PD schedules
    - PD's schedules are advisory, financially non-binding schedules and storage will not receive any commitments from these schedules.

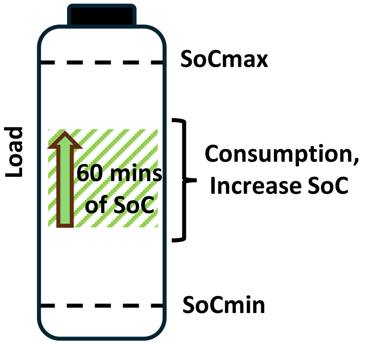
SoC Management Applicability[2/2]

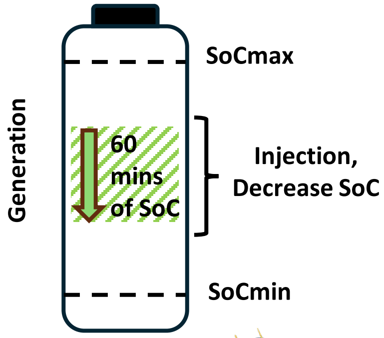
- **RT-MIO workflow:**
  - Initial SoC collected through telemetry feeds and utilized for multi-interval optimization by factoring in immediate dispatch schedule and ramp expectations
  - Multi-Interval Optimization (MIO) advisory schedules will forecast the SoC for all intervals
  - RT MIO scheduling can be significantly impacted by ramp rates; therefore, they will be included based on what that the IESO expects the resources to utilize (100 MW/Min for energy ramp up and down, Max ramp rate for OR activation)

SoC Constraints in All Timeframes [1/5]

- All services consider max/min SoC limits as constraints for all timeframes. The below tables denotes what will limit the scheduling of the resource as it relates to SoC availability when providing different services

Energy (only)		
	Load	**Generation**
DAM	Limited to what can be consumed over the hour. Must have 60 mins of SoC capability for what is scheduled for withdrawal	Limited to what can be injected over the hour. Must have 60 mins of SoC capability for what is scheduled for injection
PD	Same as DAM	Same as DAM





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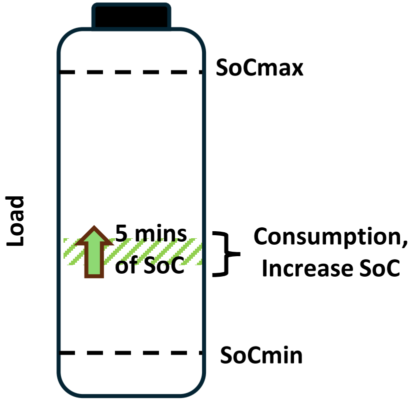
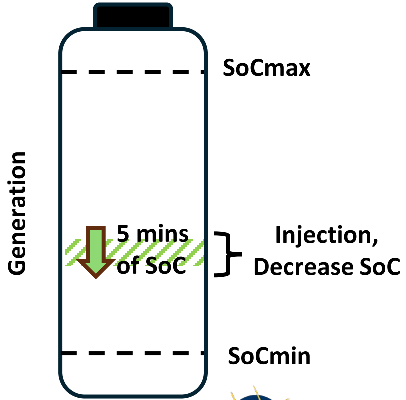
Energy

SoC Constraints in All Timeframes [2/5]

- All services consider max/min SoC limits as constraints for all timeframes. The below tables denotes what will limit the scheduling of the resource as it relates to SoC availability when providing different services

Energy (only)		
	Load	**Generation**
RT	Limited to what can be consumed over 5 min interval. Must have 5 mins of SoC capability for what is scheduled for withdrawal	Limited to what can be injected over a 5 min interval. Must have 5 mins of SoC capability for what is scheduled for injection





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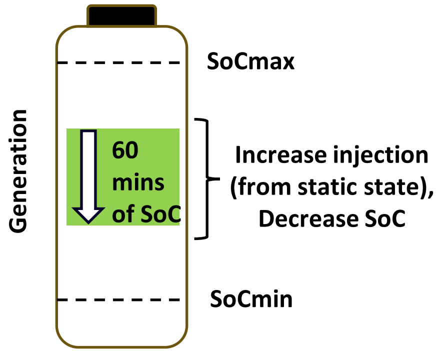
OR

SoC Constraints in All Timeframes [3/5]

	OR (only)
	Generation
DAM	Increase in injection from static state. Therefore, MW schedule will be limited by MWh availability (what could be sustained for 60 mins)
PD	Same as DAM
RT	Currently: 130 mins Proposed: MW limit that can be sustained for 60 mins based on SoC availability at the start of the interval



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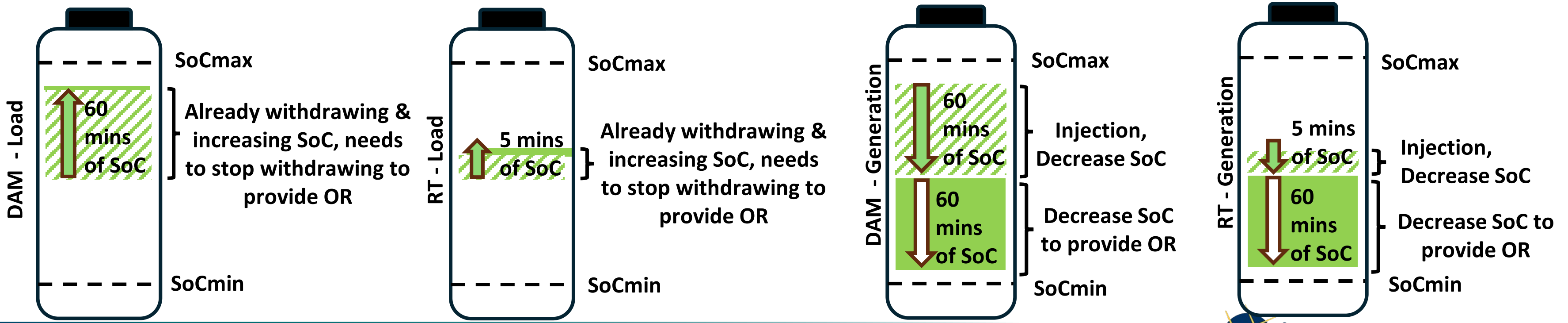
OR
Energy

SoC Constraints in All Timeframes [4/5]

Energy with OR		
	Load	**Generation**
DAM	OR Provided by reducing consumption, therefore will not exceed what can be consumed over a 60 min period; same limit as energy withdrawal	OR provided through increase in injection. Must at least have SoC availability for 120 Mins (OR simulates availability of OR being called at any point over the hour with sustainment of 60 mins + must also account for SoC required to provide energy)
PD	Same as DAM	Same as DAM
RT	*Currently:* 70 mins *Proposed:* must have 5 mins of withdrawal capability at the start of the interval	*Currently:* 130 mins *Proposed:* Must have SoC availability for at least 65 mins. energy that can be injected over 5 mins in the interval and MWh availability that supports 60 mins of sustained injection that could be required at the end of the interval



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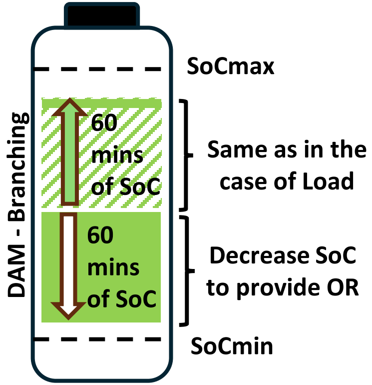
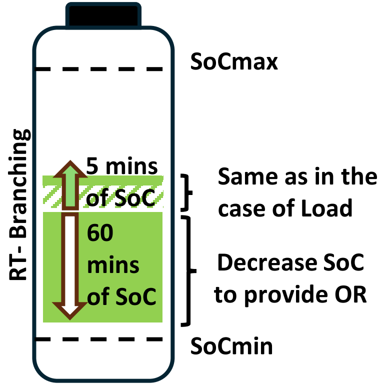
OR

Energy

SoC Constraints in All Timeframes [5/5]

Energy with OR	
	Branching (withdrawal to injection)
DAM	Reduction in withdrawal to zero, followed by injection. Combination of MW quantity that can sustain withdrawal for 60 mins PLUS MW quantity that can sustain injection for 60 minutes.
PD	Same as DAM
RT	*Currently: N/A* *Proposed:* energy that can be withdrawn over a 5 min period PLUS what can be injected at the start of interval and sustained for 60 mins.





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SoC Management – DAM Example

PMAX	200	Maximum Injection Rating
PMIN	-200	Maximum Withdrawal Rating
SOCMAX	750	Maximum SoC
SOCMIN	50	Minimum SoC
RTE	0.9	Round-trip efficiency

* SoC values represent beginning of the hour

** SoC in the initialization hour is **submitted**

DAM STUDY PERIOD

	HE01	HE02	HE03	HE04	HE05	HE06	HE07	HE08	HE09	HE10	HE11	
DAM ENERGY SCHEDULE	-100.0	-150.0	-200.0	-50.0	0.0	0.0	50.0	150.0	200.0	50.0	0.0	<- Energy dispatch for each hour.
**STATE OF CHARGE (SoC)	50.0	140.0	275.0	455.0	500.0	500.0	500.0	450.0	300.0	100.0	50.0	<- Estimated/forecast state of charge
*AVAILABLE SoC	0.0	90.0	225.0	405.0	450.0	450.0	450.0	400.0	250.0	50.0	0.0	<- Available state of charge
MAX OR FROM INJECTION	0.0	90.0	200.0	200.0	200.0	200.0	150.0	50.0	0.0	0.0	0.0	<- Reserve available from the injection range
MAX OR FROM WITHDRAWAL	100.0	150.0	200.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<- Reserve available from the withdrawal range
TOTAL MAX OR CAPABILITY	100.0	240.0	400.0	250.0	200.0	200.0	150.0	50.0	0.0	0.0	0.0	<- Total available Reserve that may be scheduled

Max OR limited by SoC

Max OR limited by SoC, SoC all utilized for ENG

Max OR limited by injection range, no SoC limitation

Max OR limited by injection range, no SoC limitation

Max OR limited by injection range, no SoC limitation

Max OR limited by injection range, no SoC limitation

Max OR limited by injection range, no SoC limitation

Max OR limited only by full range of battery, no SoC limitation

Max OR limited only by full range of battery, no SoC limitation

Max OR limited by withdrawal to zero + limited SoC on injection

Max OR limited by withdrawal to zero

MP submitted SoC

SoC Management – PD Example

PMAX	200	Maximum Injection Rating
PMIN	-200	Maximum Withdrawal Rating
SOCMAX	750	Maximum SoC
SOCMIN	50	Minimum SoC
RTE	0.9	Multiplier on withdrawals to calculate future SoC

* SoC values represent beginning of the hour

** SoC in the initialization hour is **telemetered**

Initiallization | PD STUDY PERIOD

	HE01	HE02	HE03	HE04	HE05	HE06	HE07	HE08	HE09	HE10	HE11	HE12	
PD ENERGY SCHEDULE	-50	-50.0	-100.0	-100.0	-50.0	0.0	0.0	50.0	100.0	150.0	65.0	0.0	<- Energy dispatch for each hour.
**STATE OF CHARGE (SoC)	100	145.0	190.0	280.0	370.0	415.0	415.0	415.0	365.0	265.0	115.0	50.0	<- Actual or forecast state of charge
*AVAILABLE SoC	0.0	95.0	140.0	230.0	320.0	365.0	365.0	365.0	315.0	215.0	65.0	0.0	<- Available state of charge
MAX OR FROM INJECTION		95.0	140.0	200.0	200.0	200.0	200.0	150.0	100.0	50.0	0.0	0.0	<- Reserve available from the injection range
MAX OR FROM WITHDRAWAL		50.0	100.0	100.0	50.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	<- Reserve available from the withdrawal range
TOTAL MAX OR CAPABILITY		145.0	240.0	300.0	250.0	200.0	200.0	150.0	100.0	50.0	0.0	0.0	<- Total available Reserve that may be scheduled

Max OR limited to zero due to SoC

Max OR limited to zero due to SoC when accounting for energy dispatch

Max OR limited to parital injection range based on energy dispatch, no SoC limitation

Max OR limited to parital injection range based on energy dispatch, no SoC limitation

Max OR limited to parital injection range based on energy dispatch, no SoC limitation

Max OR limited by full injection range, no SoC limitation

Max OR limited by full injection range, no SoC limitation

Max OR limited by withdrawal to zero + full injection range, no SoC limitation

Max OR limited by withdrawal to zero + full injection range, no SoC limitation

Max OR limited by withdrawal to zero + limited SoC to inject

Max OR limited by withdrawal to zero + limited SoC to inject

SoC Telemetered and initialized by PD engine

SoC Management – RT Example

PMAX	200	Maximum Injection Rating
PMIN	-200	Maximum Withdrawal Rating
SOCMAX	750	Maximum SoC
SOCMIN	50	Minimum SoC
RTE	0.9	Multiplier on withdrawals to calculate future SoC

* SoC values represent beginning of the hour
** SoC in the initialization hour is **telemetered**

Initiallization Interval

RT-MIO STUDY PERIOD

	INT5	INT6	INT7	INT8	INT9	INT10	INT11	INT12	INT1	INT2	INT3	INT4	
RT-MIO ENERGY SCHEDULE	-200	-200.0	-200.0	-200.0	-200.0	-200.0	-200.0	-200.0	0.0	0.0	50.0	150.0	<- Energy dispatch for each hour.
**STATE OF CHARGE (SoC)	150	165.0	180.0	195.0	210.0	225.0	240.0	255.0	270.0	270.0	270.0	265.8	<- Actual or forecast state of charge
*AVAILABLE SoC	100.0	115.0	130.0	145.0	160.0	175.0	190.0	205.0	220.0	220.0	220.0	215.8	<- Available state of charge
MAX OR FROM INJECTION		115.0	130.0	145.0	160.0	175.0	190.0	200.0	200.0	200.0	150.0	50.0	<- Reserve available from the injection range
MAX OR FROM WITHDRAWAL		200.0	200.0	200.0	200.0	200.0	200.0	200.0	0.0	0.0	0.0	0.0	<- Reserve available from the withdrawal range
TOTAL MAX OR CAPABILITY		315.0	330.0	345.0	360.0	375.0	390.0	400.0	200.0	200.0	150.0	50.0	<- Total available Reserve that may be scheduled

Max OR limited by range to inject, no SoC limit
Max OR limited by range to inject, no SoC limit
Max OR limited by range to inject, no SoC limit
Max OR limited by range to inject, no SoC limit
Max OR only limited by range of battery, no SoC limit
Max OR limited by withdrawal to zero + limited SoC to inject
Max OR limited by withdrawal to zero + limited SoC to inject
Max OR limited by withdrawal to zero + limited SoC to inject
Max OR limited by withdrawal to zero + limited SoC to inject
Max OR limited by withdrawal to zero + limited SoC to inject
Max OR limited by withdrawal to zero + limited SoC to inject

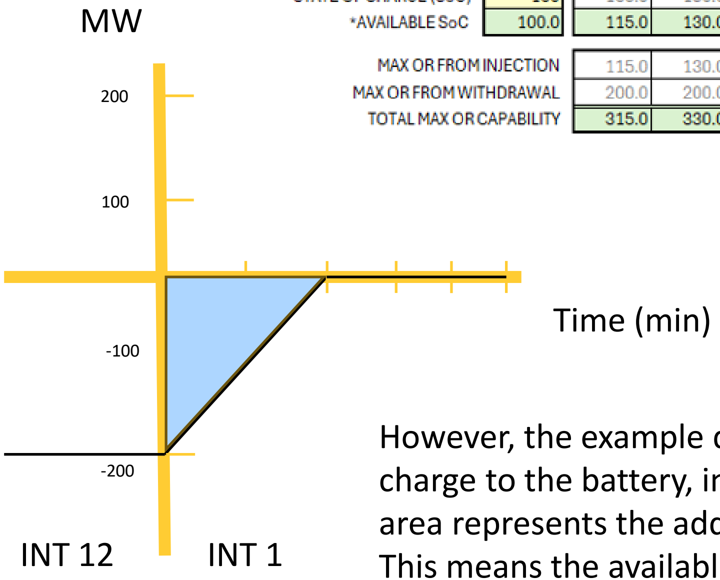
Ramping of the resource **will** affect the SoC calculation (100MW/min)

SoC Telemetered and initialized based on last dispatch

SoC calculation will account for 5-min dispatches as opposed to the previous hourly schedule

SoC Management – RT Scenario 1

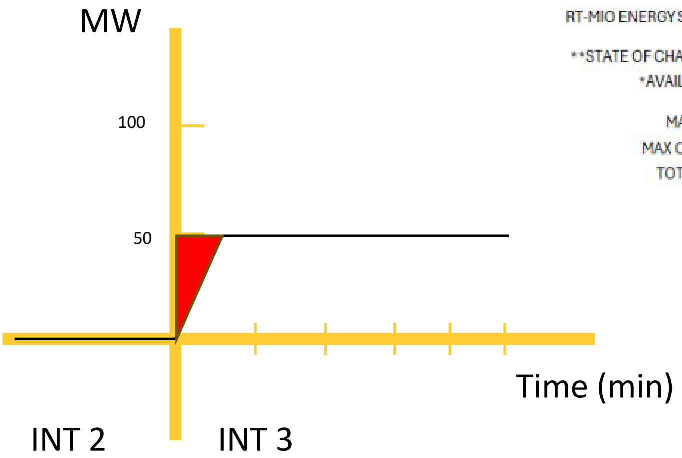
	Initiallization Interval	RT-MIO STUDY PERIOD							
	INT5	INT6	INT7	INT8	INT9	INT10	INT11	INT12	INT1
RT-MIO ENERGY SCHEDULE	-200	-200.0	-200.0	-200.0	-200.0	-200.0	-200.0	-200.0	0.0
**STATE OF CHARGE (SoC)	150	165.0	180.0	195.0	210.0	225.0	240.0	255.0	270.0
*AVAILABLE SoC	100.0	115.0	130.0	145.0	160.0	175.0	190.0	205.0	220.0
MAX OR FROM INJECTION		115.0	130.0	145.0	160.0	175.0	190.0	200.0	200.0
MAX OR FROM WITHDRAWAL		200.0	200.0	200.0	200.0	200.0	200.0	200.0	0.0
TOTAL MAX OR CAPABILITY		315.0	330.0	345.0	360.0	375.0	390.0	400.0	200.0



Scenario 1 outlines an example of a resource moving from a 200MW charging position to a “neutral” position. The chart above outlines that the SoC at the beginning of INT1 is 220MW.

However, the example does not include the implications of ramp rates adding additional charge to the battery, indicated by the shaded area under the graph on the left. This shaded area represents the additional charge being added to the battery during the ramp-down. This means the available SoC will be higher than the MW indicated in the chart.

SoC Management – RT Scenario 2



	Initialization Interval	RT-MIO STUDY PERIOD										
	INT5	INT6	INT7	INT8	INT9	INT10	INT11	INT12	INT1	INT2	INT3	INT4
RT-MIO ENERGY SCHEDULE	-200	-200.0	-200.0	-200.0	-200.0	-200.0	-200.0	-200.0	0.0	0.0	50.0	150.0
**STATE OF CHARGE (SoC)	150	165.0	180.0	195.0	210.0	225.0	240.0	255.0	270.0	270.0	270.0	265.8
*AVAILABLE SoC	100.0	115.0	130.0	145.0	160.0	175.0	190.0	205.0	220.0	220.0	220.0	215.8
MAX OR FROM INJECTION		115.0	130.0	145.0	160.0	175.0	190.0	200.0	200.0	200.0	150.0	50.0
MAX OR FROM WITHDRAWAL		200.0	200.0	200.0	200.0	200.0	200.0	200.0	0.0	0.0	0.0	0.0
TOTAL MAX OR CAPABILITY		315.0	330.0	345.0	360.0	375.0	390.0	400.0	200.0	200.0	150.0	50.0

Scenario 2 outlines an example of a resource moving from a “neutral” position to an injection position. The chart above indicates that the SoC at the end of INT3 and going into INT4 is 215MW.

However, the example does not include the implications of ramp rates; in this case, it takes 30 seconds for the battery to achieve the dispatch injection value. The shaded area on the graph indicates the “shortfall” of injection before the battery achieves the dispatch instruction. This implies that the battery would have additional charge available after INT3 vs the values shown in the chart above.

Derates

- A derate is the decrease in the available capacity of a generating resource, due to either a system/equipment modification or environmental/operational/reliability considerations.
- Currently MPs can submit derates for generation capability only. Derates may need to account for:
  - Both the injection and withdrawal capacity ranges of the resource
  - The state-of-charge/energy storage availability in MWh that will be applied for future scheduling of the resource; update of the absolute Max SoC, as well as the min/max variables that will shrink the SoC value.
  - Round-trip efficiency – could change based on various facility considerations (temperature, operating state, aging, etc.)
- ***Feedback Question:*** Do you have feedback on the derates that the IESO is considering; specifically, what requirements need to be set to ensure that these are used sporadically?
  - Will there be separate derate values for injection and withdrawal?
  - Will MPs need to derate their SoC limits? Does this only require update to max SoC limit which will result in overall SoC reduction?
  - How frequently does the MP need to update the round-trip efficiency?

“Uprates”

- A new hypothetical design that could be implemented is an “uprate” mechanism in the current derate tool used by MPs. This would be used to increase certain limits of the storage resource to account for maintenance needs of fully utilizing all battery cells.
- This would be used for the MP’s to increase the SoCMAX of the battery to charge up to full capability, or to allow the MP to reduce its SoCMIN to fully deplete the battery.
- This is generally expected that this is primarily for maintenance of the battery to avoid faster than anticipated degradation.
- Specific procedures and processes will need to be developed to support this type of design. This would include the conditions for performing this function, timing requirements, market participation requirements, etc.

***This is currently under consideration by the IESO and may not be in final phase 1 design*

OEB Decision on Uniform Transmission Rate

- The Ontario Energy Board's (OEB's) Uniform Transmission Rate (UTR) Decision and Order, dated March 27, 2025, states that, effective April 1, 2026, *transmission-connected energy storage facilities will be exempt from transmission charges when the facility is providing any of OR, frequency regulation, voltage regulation, responding to real-time market dispatch signals from the IESO, or supporting the IESO for transmission system reliability*.
- The IESO is working with the OEB to determine how this Decision will be implemented – this is **not** within the scope of ERP.
- The ERP team is exploring whether implementing an exemption to uplifts within the same timelines is appropriate
- The IESO notes the significance of this decision and that it may impact the operating philosophy of storage facilities participating in the wholesale market

Response to Stakeholder Feedback on Key Topics

Feedback Items	IESO Response
Cycling of storage limited by warranties for Original Equipment Manufacturer (OEM)	The IESO is proposing a new CycleDEL parameter to limit minimum cycling. It will be a function of daily cycles submitted by MPs and the total available MWh of the storage resource. The onus is on the MP to limit maximum cycling.
Station service treatment	Metering requirements and settlement treatment for station service and storage auxiliary loads is being investigated by other groups within the IESO. Current Market Rules do not state a specific treatment, and it is determined when facility is connecting. IESO to further consider this.
Overriding static/registration parameter values	Registration parameters such as round-trip efficiency gradually change over time and the participants will have an opportunity to update them, by updating their static parameters. The SoC max limit also may deviate from the registered values during derates or emergency conditions and the IESO is proposing a few methods to update this limit along with seeking feedback from stakeholders on the topic.
Bypassing SoC in DAM	SoC initialization and SoC constraints will be considered in all timeframes (DA, PD, RT). SoC in DAM may lower DA or RT risk by avoiding excessive scheduling of the resources.
Target implementation timeline	A draft timeline and implementation approach for enhanced storage/hybrid design has been included in this presentation

Next Steps

Feedback Questions [1/2]

General ERP Feedback Questions:

- Feedback on the engagement approach, sessions or the S/H Project?

Storage/Hybrid Project Feedback Questions:

- *Telemetered SoC:* Required for calculations in PD and RT timeframes. This value is expected to inform the IESO of the injection capability of the resource in MWh and therefore should account for any losses. Current performance requirements will continue, with data sent every 4 seconds to the IESO. Do MP's have concerns or foresee challenges with this requirement?
- *OR Offers:* Are there concerns about OR provided by storage being branched from withdrawal to injection?
- *Ramp Rates:* Do you have feedback on the 100 MW/min static ramp rate and utilizing a standardized approach to dispatch?
- *CycleDEL:* Is CycleDEL sufficient to limit the cycling for storage for Phase 1? What is the expected default setting?

Feedback Questions [2/2]

Storage/Hybrid Project Feedback Questions:

- ***Exceeding Min/Max SoC limits:*** Do you anticipate needing to exceed min/max SoC limits for specific market opportunities, or just maintenance and what are the typical min/max limits – is this a fixed/static value that can be derived for registration? Frequency and magnitude of exceeding these limits? Are there equipment concerns from this, what are the specific concerns (faster equipment aging/degradation, other)?
- ***Derates:*** Do you have feedback on the derates that the IESO is considering; specifically, requirements to ensure that these are primarily used sporadically?
  - Will there be separate derate values for injection and withdrawal?
  - Will MPs need to derate their SoC limits? Does this only require updates to min/max SoC limits, which will result in overall SoC reduction?
  - How frequently does the MP need to update the round-trip efficiency?

Submitting Feedback

- Feedback from participants is an important engagement principal of the IESO's refreshed external engagement framework to ensure your input and perspectives are considered
- The IESO is requesting written feedback via the **IESO's Feedback Form** available on the ERP S/H webpage (Project Webpage)
    - Feedback is being requested by **August 21, 2025**
- Please submit to IESO Engagement engagement@ieso.ca

Next Steps – Draft S/H Project Engagement Sessions

Timing	Engagement Activity
October 2025	Public Session – Storage and Hybrid Project (Meeting #2) ▪ Design Memo on Optimization Module and Elements
Q4-2025	Deadline for Feedback & IESO Response to Feedback
Q1-2026	Public Session – Storage and Hybrid Project (Meeting #3)
Q2-2026	Deadline for Feedback & IESO Response to Feedback
TBD: 2026	Ongoing Public Engagement Sessions and Targeted Outreach (1:1) with Impacted Resources

Questions?

Please submit feedback forms to IESO Engagement@ieso.ca

or contact us with any questions/concerns

Thank You

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