JULY 23, 2020

Storage Design Project (SDP)

Energy Storage Advisory Group

ieso

Connecting Today. Powering Tomorrow.

Agenda

1. Project Recap and Next Steps
2. Stakeholder Feedback from May SDP Meeting
3. IESO State-of-Charge (SoC) Proposal: Addressing Stakeholder Feedback and Clarifying the Design Proposal

Project Recap and Next Steps

Background

- Throughout 2018, the IESO worked with stakeholders through the Energy Storage Advisory Group (ESAG) to identify obstacles for storage resources in Ontario
- At the end of 2018, the IESO published a report outlining identified obstacles, including those within the jurisdiction of the IESO, Ontario Energy Board and Ministry of Energy Northern Development and Mines
- Key priorities identified for the IESO included:
  - The need to clarify treatment of storage resources within Market Rules/Manuals
  - A desire to further enable storage resources to compete to provide multiple non-overlapping wholesale services
  - A desire to address wholesale uplift charges (within the IESO's mandate)
- The SDP was initiated in the fall of 2019 with a focus on addressing the above priorities

Scope

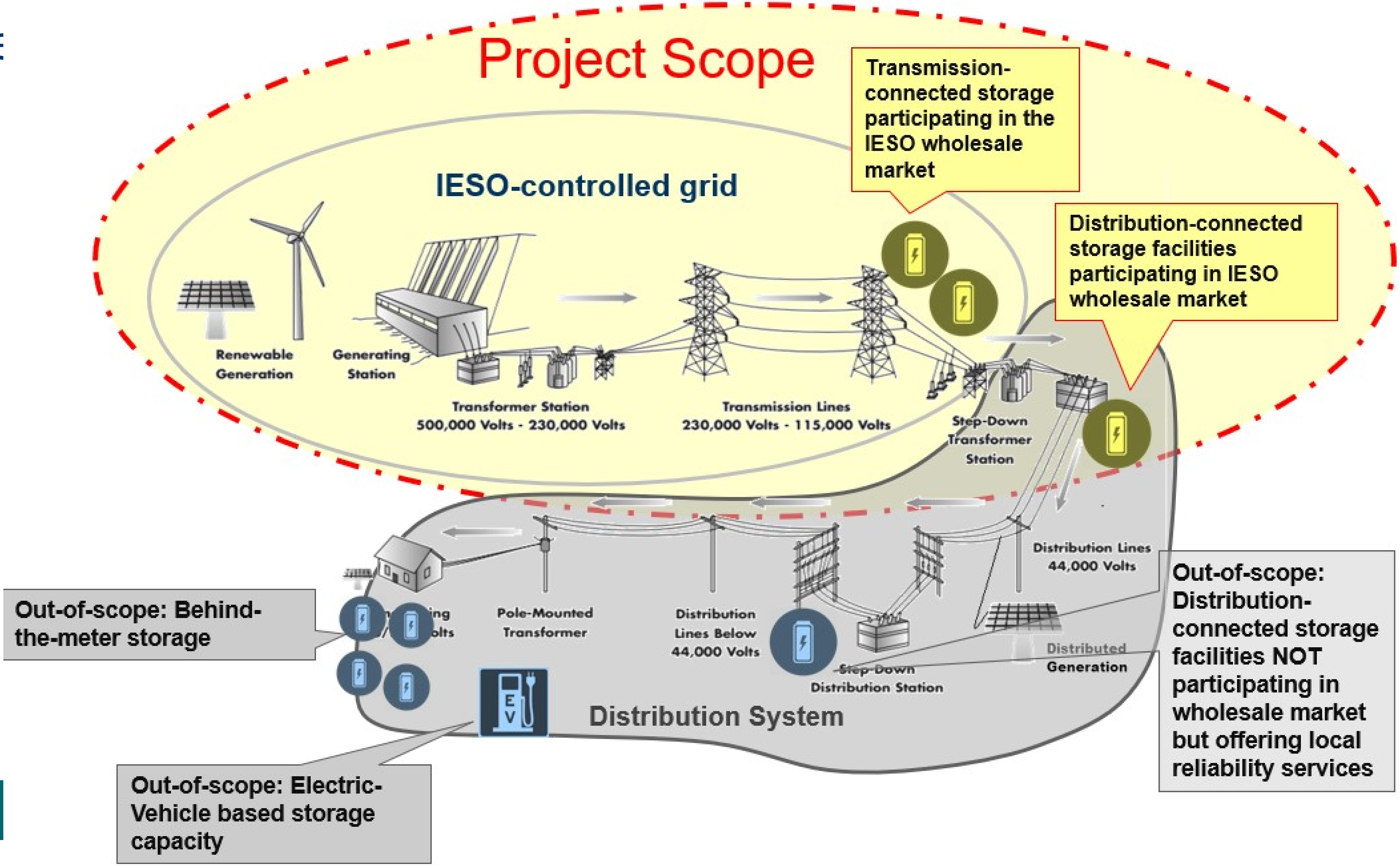
The Storage Design Project will:

1. Clarify how energy storage resources can participate in today's IESO-Administered Markets (the **interim period**), and

2. Provide a vision for how storage resources will participate in the IESO-Administered Markets on an enduring basis once investment in IESO tool upgrades to fully integrate storage resources are made (the **long-term period**)

The SDP is an important step towards ensuring energy storage can compete to reliably and efficiently provide needed system services

Facilitie



Project Scope
IESO-controlled grid
Transmission-connected storage participating in the IESO wholesale market
Distribution-connected storage facilities participating in IESO wholesale market
Renewable Generation
Generating Station
Transformer Station
500,000 Volts - 230,000 Volts
Transmission Lines
230,000 Volts - 115,000 Volts
Step-Down Transformer Station
Distribution Lines
44,000 Volts
Pole-Mounted Transformer
Distribution Lines Below 44,000 Volts
Step-Down Distribution Station
Distributed Generation
Distribution System
E V
Out-of-scope: Behind-the-meter storage
Out-of-scope: Electric-Vehicle based storage capacity
Out-of-scope: Distribution-connected storage facilities NOT participating in wholesale market but offering local reliability services

Key Project Deliverables

- Produce an interim storage design outlining major details of how storage resources will participate in today's markets
- Draft and engage with stakeholders on market rule and manual amendments to clarify treatment of storage resources in today's markets
- Answer key questions about how storage resources will participate over the long-term (i.e., produce an enduring vision for storage participation)
- Provide clarity on next steps for storage integration beyond the scope of this project

Making Design Decisions

- Adhere to Market Renewal Program (MRP) principles:
  - Efficiency, competition, implementability, certainty, and transparency
- And reflect design considerations discussed with ESAG:
  - Through this project we will seek design solutions that contribute to reliability, efficiency, and competition at the bulk level
  - We will build on the practical experiences of other jurisdictions that are integrating energy storage resources into wholesale markets

Making Design Decisions (cont'd)

- We will seek to maximize the chances of timely implementation by:
  - Leveraging the capabilities of existing or planned software tools
  - Reducing design complexity wherever possible
  - Avoiding design by exception – i.e. ensure that we have a single framework that can be applied to the widest possible range of storage technologies

Timeline

Oct 2019
Project scope and purpose

Feb 2020
Interim design

Mar 2020
Introduction and jurisdictional scan of long-term design questions

May 2020
Long-term design proposals: focus on SoC

June 2020
Draft interim rule and manual changes and uplift charges

July 2020
Additional SoC details

Aug/Sept 2020
Next steps for storage design efforts and vision document

Q1 2021
Go-live for interim design

Next Steps for Storage Integration – Focus Areas

1. Complete SDP (Storage Integration Phase 1)
2. Implement SDP Interim Design
3. Storage Integration Phase 2 (for MRP go-live)
4. Enduring Vision

Complete Storage Design Project (Phase 1)

- The storage design project is expected to conclude in Q3, 2020
- The IESO has completed design work for the interim period and drafted and shared market rules and manual changes to clarify storage participation in today's IAMs
- Prior to project completion, the IESO will:
  - Provide additional details on next steps for storage integration (current considerations are captured below)
  - Publish an enduring vision for storage participation, documenting long-term design work conducted through the SDP

Implement SDP Interim Design

- In June, the IESO shared draft Market Rule and Manual changes to clarify storage participation in today's markets
- The IESO will respond to and incorporate stakeholder feedback on the draft changes
- The IESO expects to begin the Technical Panel process for these changes in September with a go-live date in Q1, 2021
- Applicable forms and agreements, technical reference documents, training guides etc. will also be updated for go-live

Storage Integration Phase 2

- In June, the IESO clarified that the enduring storage design will not be implemented through the Market Renewal – Energy project
- As a result, the interim design and market rule/manual changes that have been developed through the SDP will need to be amended for Market Renewal – Energy project go-live to reflect the new energy market design
- The IESO will launch a new initiative to undertake this work, which will be closely coordinated with Market Renewal – Energy project design efforts
- Scope, timelines, and approach will be communicated through the new initiative

Enduring Vision

- In Q3, the IESO will publish a vision document that captures the long-term proposals developed through the SDP and highlights areas for future design work
- The document will position the IESO and stakeholders to move forward with more detailed design work and implementation at the appropriate time
- Timing for implementing the enduring vision has yet to be determined and further details will be explored through the storage integration Phase 2 initiative
- The IESO will consider and communicate opportunities to implement elements of the enduring design in advance of the full solution

Stakeholder Feedback from May ESAG Meeting

Feedback Received

- CanWEA/CanSIA
- Capital Power
- EDF Renewables Canada
- Electricity Distributors Association
- Energy Storage Canada
- EverGreen Energy
- Ontario Power Generation
- TC Energy

Complete feedback submissions and response document have been posted to the Energy Storage Advisory Group (ESAG) website

The following slides provide an overview of key themes received through the feedback and a summary of IESO responses; interested stakeholders are encouraged to review the complete response to stakeholder feedback document

SOC – Additional Details

- *Some stakeholders requested more information on the IESO's SoC proposal prior to providing an opinion*
    - *For example, stakeholders suggested that information such as a cost-benefit analysis, additional details on the SoC Lite proposal and how it differs from self-scheduling, and information on implementability of the proposal would be helpful*

- In today's presentation the IESO will provide additional details on the SoC Lite proposal, how the proposal compares to the self-scheduling option, and why the IESO supports the proposal

SOC – Additional Details (cont’d)

- The IESO does not intend to undertake a cost-benefit analysis on SoC management options
  - The IESO expects this effort would be time consuming and costly and unlikely to provide clear direction; further details on the IESO’s rationale for the SoC Lite proposal and how it aligns with the SDP design principles are discussed below
- The IESO has engaged with ABB, the vendor selected through MRP, to understand their capabilities and to put forward proposals that are expected to be implementable and cost-effective

SOC – Fairness

- *Some stakeholders expressed concern with the fairness of the IESO's proposal*
  - *One stakeholder suggested that IESO management of storage resources may provide an unfair advantage to storage resources*
  - *Another stakeholder suggested the proposal would result in more IESO control over storage resources than generators which would unfairly disadvantage storage*
- The IESO proposal will model storage resources' SoC to ensure their energy limited nature is reflected in schedules and dispatch instructions (e.g., supports reliability by ensuring the resource won't be dispatched if it has insufficient energy)

SOC – Fairness (cont'd)

- This approach aligns with how the IESO models the physical characteristics of other resources including hydroelectric resources, combined cycle resources and others
- Storage resources will submit competitive offers indicating when they wish to make their capacity available, how much is available and at what price
  - The IESO will produce schedules and dispatch instructions based on this information while respecting SoC
  - The IESO will not have a greater degree of control over storage than other resources; the concept of control is discussed in greater detail later in this presentation

Facility and Market Registration

Some stakeholders expressed a desire to exclude self-scheduling as an option for storage resources while another stakeholder identified this as a topic for future exploration if and when needed

- Through the SDP, the IESO has focused on removing unnecessary obstacles for storage facilities and enabling them to compete on an equal footing with other resources
- The IESO believes it is appropriate at this time to maintain the option for storage resources to register as self-scheduling on an equal basis with generators
- The IESO expects that storage resources will typically choose to participate as dispatchable facilities in order to be eligible to provide certain services (like operating reserve and regulation)
- The IESO remains open to exploring the concept of, and thresholds for, self-scheduling resources more broadly (i.e., to ensure equitable treatment for all impacted resources) in the future

Facility and Market Registration (cont'd)

Stakeholders generally expressed support for the other design proposals put forward (including offer curve, price setting, and regulation service) but some additional considerations were identified including:

- Whether a continuous offer curve could be implemented in the interim design, the need for design details on Market Power Mitigation, and the desire to introduce a competitive regulation market

Facility and Market Registration (cont'd..)

- For the interim period, the IESO has focused on minimizing tool changes and associated costs; we do not expect to introduce a continuous offer curve in advance of implementing the enduring design
- The IESO agrees that Market Power Mitigation for storage resources must be explored through future design work for both storage integration phase 2 and for the enduring design
- The IESO supports the potential for increased competition for regulation service (this was a topic of discussion at the January Market Development Advisory Group meeting), but further discussion is currently on hold as the IESO reassesses its supply and demand forecasts and due to a shift in focus resulting from Covid-19

IESO State-Of-Charge Proposal

Today’s Discussion

- A deeper look at the mechanics of SoC Lite to examine the aspects of “fairness” and “control” that were discussed in some stakeholder comments from the May 20th ESAG meeting, as well as the imperative of reliability
- Together, these arguments provide further insights into how the field of potential SoC management choices was narrowed to SoC Lite

SOC Lite Proposal in Review

Recall: The EPRI SoC Design Spectrum

	Strong ISO Intervention in storage operations	⟵	⟶	Little or no ISO intervention in storage operations
	EPRI "ISO-SoC-Management"	**EPRI "SoC-Management-Lite"**	**EPRI "Self-SoC Management"**	**EPRI "Self-Schedule" option**
Philosophy	The system operator has more information than any individual market participant and should therefore manage all aspects of optimizing and scheduling energy storage	Let energy storage facilities react to immediate price changes – and ensure any SoC constraints are accounted for within the DSO. Allow market participants to submit modified bid/offer data reflective of storage resource capabilities and/or other data to reflect SoC limitations.	Let energy storage facilities react to immediate price changes – and ensure any SoC constraints are indirectly accounted for within the DSO via bid/offer changes. Allow market participants to submit modified bid/offer data in order to signal SOC limits. *{analogous to current treatment of dispatchable storage in IESO Interim Design)*	Let energy storage facilities react to immediate price changes whenever and wherever possible – and don't worry if SoC constraints can be directly seen by the DSO. *{analogous to current treatment of self-scheduling storage in IESO Interim Design)*

Recall: The General Trade-off Across the SoC Management Design Spectrum

EPRI "ISO-SoC-Management"	EPRI "SoC-Management-Lite"	EPRI "Self-SoC Management"	EPRI "Self-Schedule" option

Benefits

- Optimized over the system-wide informational picture
- Feasible dispatch assured by IESO's dispatch engine

Drawbacks

- Limited by the system operator's view of the storage assets (excludes out-of-market uses)
- Potential sub-optimal use of individual storage facilities when accounting for out-of-market profits

Benefits

- Optimized over the complete informational picture seen by storage participant – including aspects not seen by the system operator

Drawbacks

- Potential sub-optimal outcome for system as a whole
- No guarantee of feasible dispatch

SoC Management Lite - In One Sentence and One Picture

The same market access as a generator, and accounting for the practical operating realities of a storage facility.

SoC Lite Benefits: Summarized at the May 20th ESAG Meeting

- ✓ **Efficiency**: Energy storage utilization is signaled into the market via offer curves, and accounts for the SoC limit of each facility
- ✓ **Competition**: Achieves the original SDP goal of providing access to wholesale market products on an equivalent footing to other types of dispatchable facilities
- ✓ **Implementability**: Supported by the market platform selected by the Market Renewal Program
- ✓ **Certainty**: Participant can largely control the extent to which the ISO constrains the facility's dispatch to its physical SoC limits
- ✓ **Transparency**: Energy storage information disclosure to and from the market on the same basis as other types of facilities

SOC Mechanics

- *Some stakeholders requested more information on the IESO's SoC proposal prior to providing an opinion*
- *For example, stakeholders suggested that information such as a cost-benefit analysis, additional details on the SoC Lite proposal and how it differs from self-scheduling, and information on implementability of the proposal would be helpful4 44*

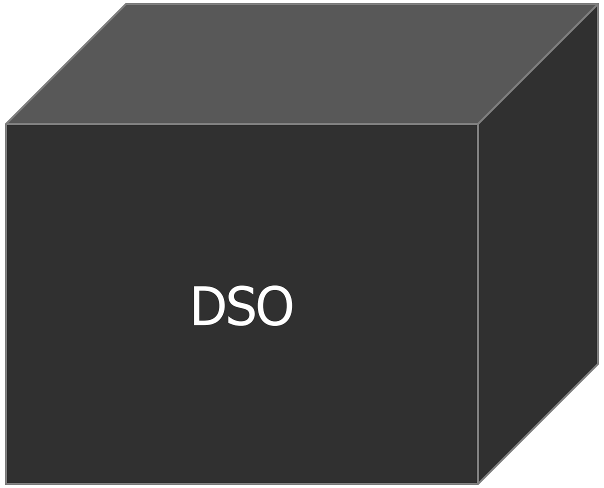
SoC Lite Mechanics

- To aid the understanding of the IESO's rationale behind the SoC Lite proposal, it is helpful to examine the mechanics of SoC management in both a day-ahead and real-time context
- This will aid the discussion of stakeholder comments in the subsequent portions of this slide deck

SoC Lite – SoC management now taken care of within the Dispatch Scheduling and Optimization (DSO) engine

Inputs

- Energy offers
- O.R. offers
- SoC values
- Storage registration data



Outputs

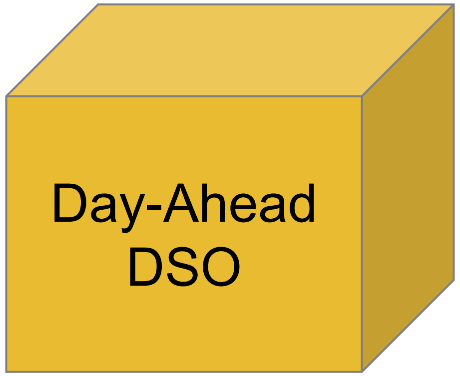
- LMPs
- Energy and O.R. Schedules and dispatch instructions that respect SOC levels

- SoC no longer has to be managed by the no-overlap rule (SoC 1) or changes to offers in the Mandatory Window (Interim Design Feature SoC 2)
- Operating Reserve schedules automatically respect SoC (replacing Interim Design Features O.R. 1 to 3)

Day Ahead Scheduling Using SoC

Inputs

- Energy offers
- O.R. offers
- Submitted SoC value to initialize DAM optimization
- Storage registration data



Outputs

- Day-Ahead prices
- Day-Ahead Energy Schedules that respect SOC constraints
- Day-Ahead O.R. Schedules that may* account for SoC constraints

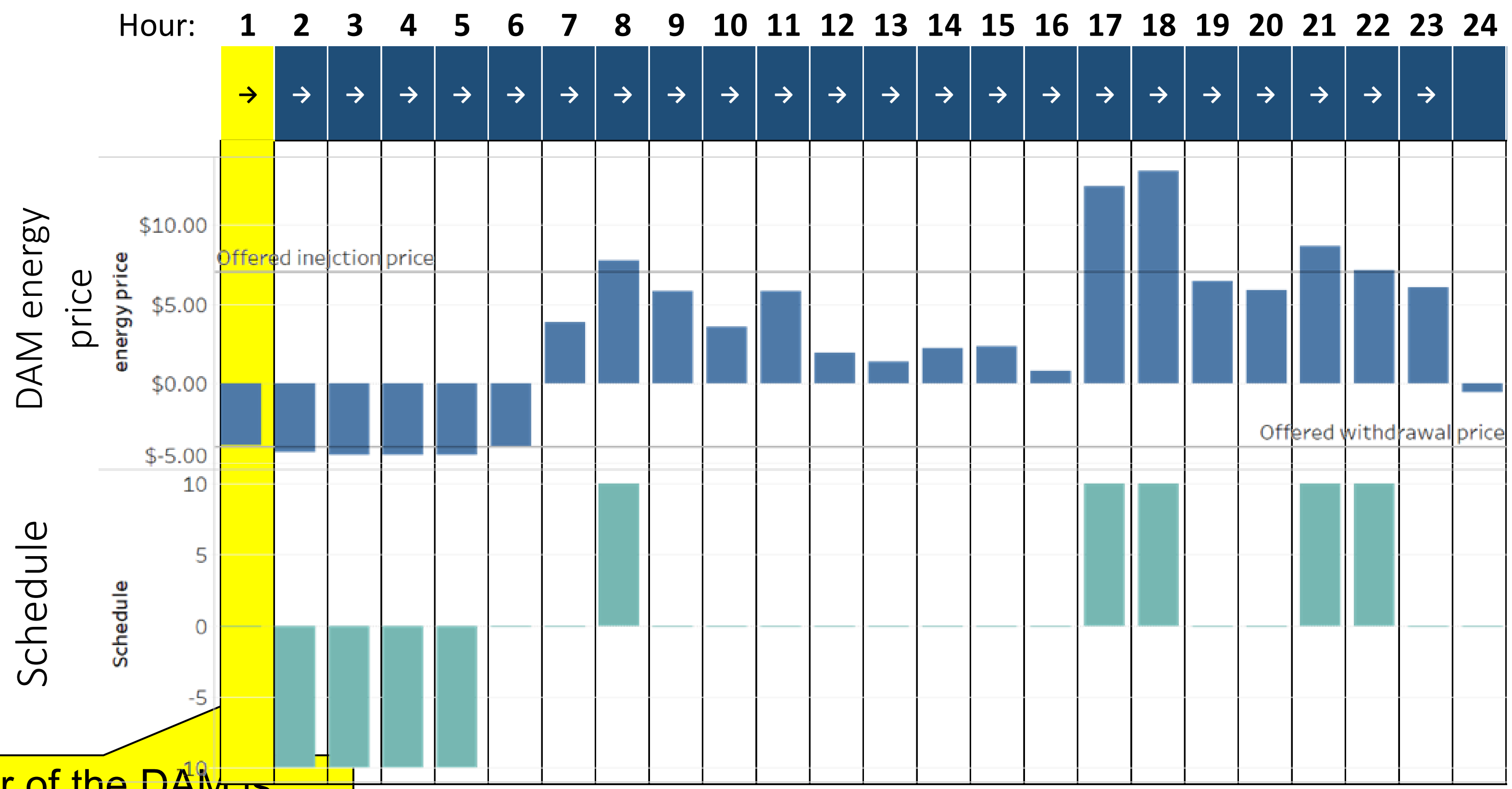
- As currently envisioned by MRP, the Day Ahead Market will run each pre-dispatch day from 6:00 a.m. to 10:00 a.m.
- This necessitates an assumed starting value for SoC for electricity storage facility energy schedules that don't begin until 12:00 a.m. the next day

**The necessity and computational impacts of SoC constraints for day-ahead O.R. schedules is a matter that will warrant further investigation once the DAM commences*

Day Ahead Energy Scheduling Using SoC

The DSO will use the facility's static parameters, and submitted SoC, to determine day-ahead schedules that respect SoC calculated relative to the initial, submitted value from hour 1 of the optimization

Example: DAM electricity storage offer curve with a withdrawal price of -$4 and an injection price of +$10



The first hour of the DAM is initialized with a submitted state-of-charge value

Real-Time Dispatch Using SoC

Inputs

- Energy offers and O.R. offers within registered maximum and minimum SoC values
- Facility capability
- Telemetered SoC
- Storage registration data

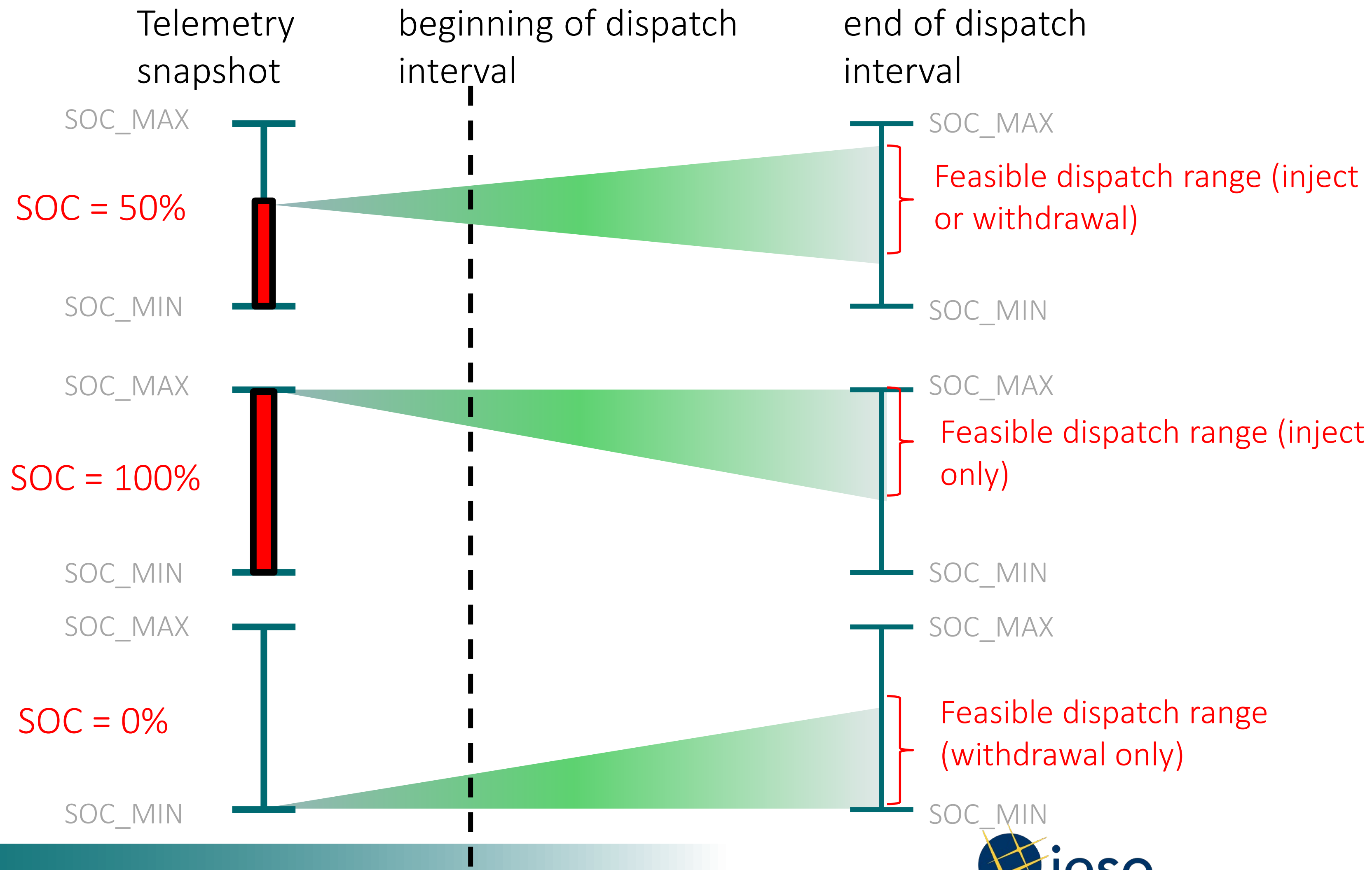
Outputs

- Real-time LMP prices
- Real-time Energy Schedules that respect SoC constraints
- Real-time O.R. Schedules that respect SoC constraints

- Real-time dispatch relies upon taking a snapshot of each storage facility's SoC value and assessing the potential states the facility will be in by the time the dispatch instruction is issued, several minutes after the snapshot is taken
- This constraint provides both the IESO and the market participant assurance that the facility can meet the dispatch schedules for energy and operating reserve

Real-Time Dispatch Using SoC (cont'd)

The DSO will use the facility's static parameters, current operational state, and telemetered SoC, to determine dispatch instructions which ensure SoC will be in an acceptable range by the end of the dispatch interval

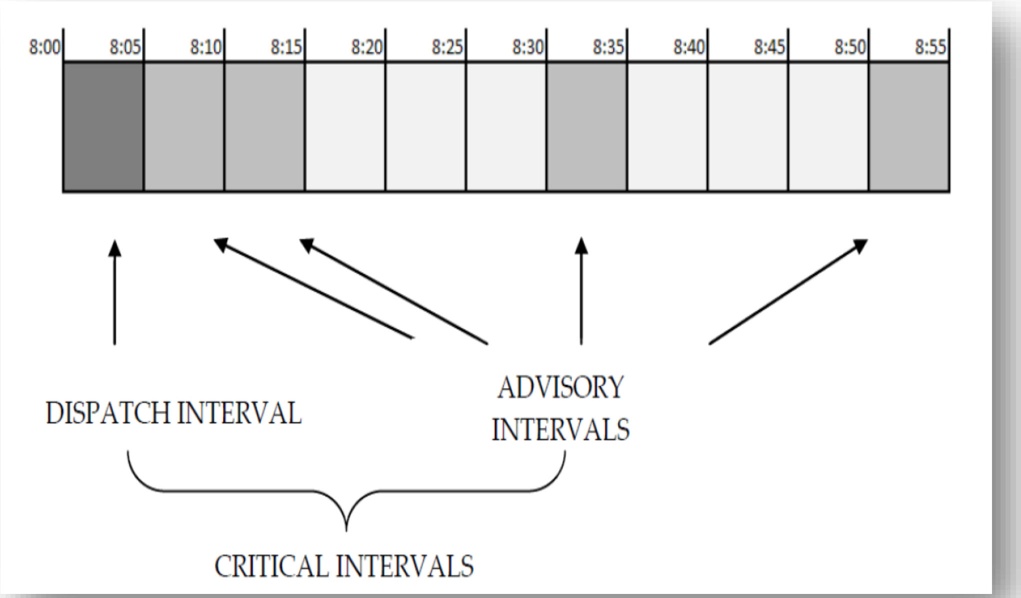


Background: Electricity Storage and Multi- Interval Optimization

Long-term Design Question: “Should SoC be included in Multi-Interval Optimization (MIO)?”

Background:

- In today’s market, the MIO process optimizes gains from trade over the coming hour, (i.e. beyond the immediate, 5-minute dispatch interval)
- It is, in fact, a two-step process of: i. combined optimization of a selected set of “advisory” intervals; and, ii. solving the constraints for each individual interval in the study period



Background: Electricity Storage and Multi- Interval Optimization (cont'd)

- In order to work properly, MIO must consider the same scope of inputs and constraints as would be used in single-interval ("myopic") dispatch
- In the example below, successively more expensive generators A,B, and C are more efficiently utilized when considering the next 12 intervals, as opposed to just the current, dispatch interval
- **The result:** an optimal outcome for the rolling, 1-hour study period, as opposed to each individual dispatch interval

Table Source: IESO Quick Take: Multi-Interval Optimization (MIO)

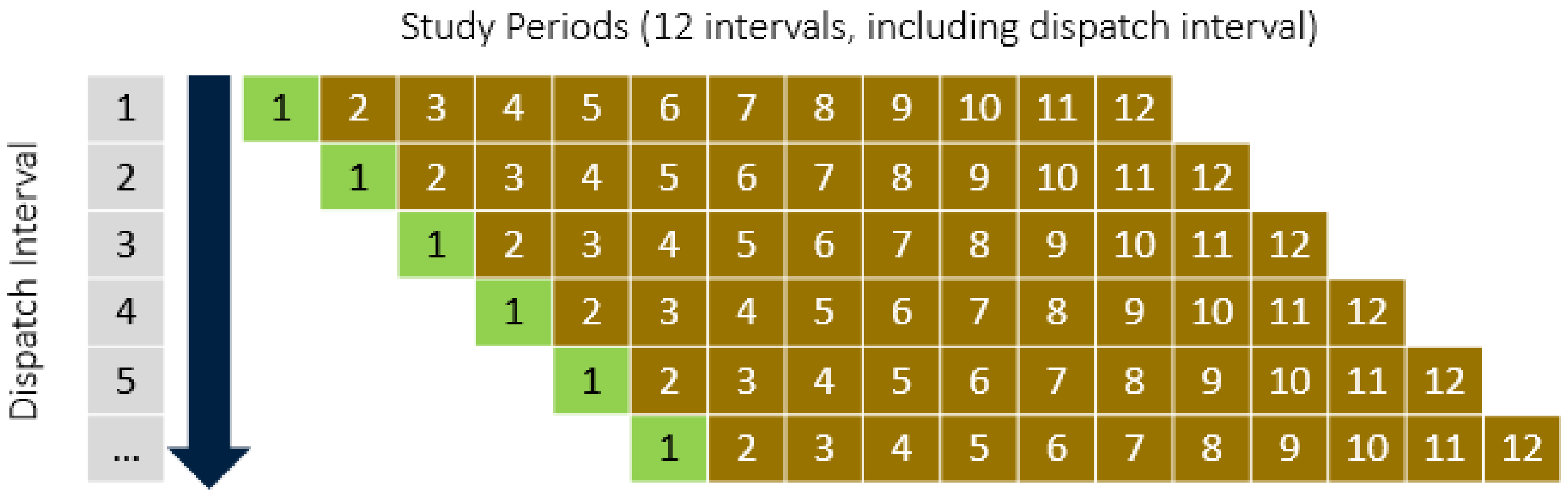
Interval	1	2	3	4	5
Generator A	50	100	100	100	100
Generator B	0	0	35	70	100
Generator C	0	0	15	15	0
Demand in MW	+50	+50	+50	+35	+15
Cost/Interval	$2,000	$4,000	$8,750	$10,500	$9,000
Total Cost	$34,250				

Table 2 - Single Interval Optimization

Interval	1	2	3	4	5
Generator A	50	85	100	100	100
Generator B	0	15	50	85	100
Generator C	0	0	0	0	0
Demand in MW	+50	+50	+50	+35	+15
Cost/Interval	$2,000	$4,150	$6,500	$8,250	$9,000
Total Cost	$29,900				

Table 3 - Multi-Interval Optimization

Background: MIO Workflow and SoC



Under SoC Lite the first interval of each 12 –interval MIO study period is initialized with telemetered SoC and the state estimation* for the first interval. This helps set the necessary parameters for the remaining intervals in the study period.

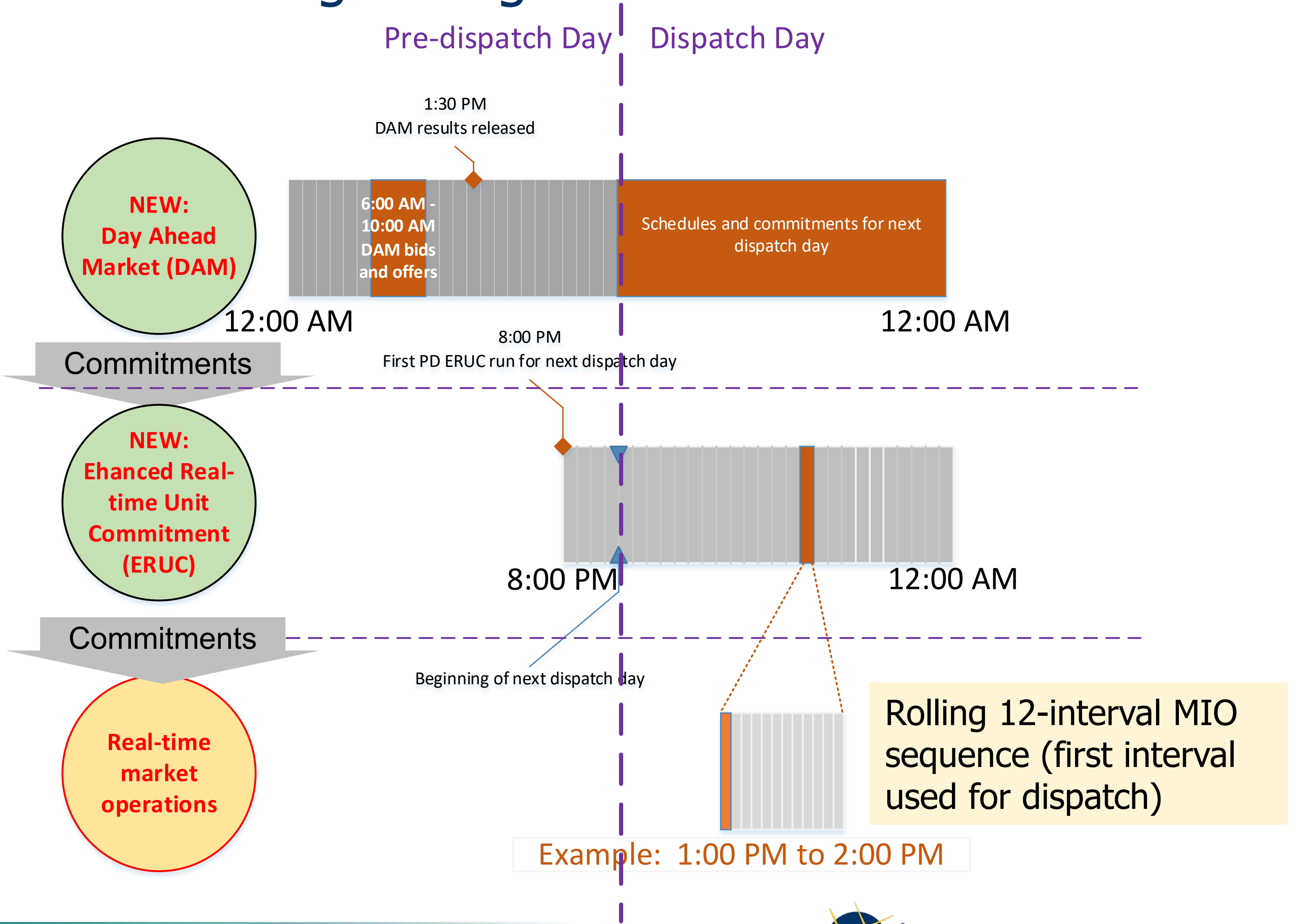
The estimated state that the electricity system and all facilities will be in by the time the dispatch instruction is calculated and issued to the market participant.

Example: Day-Ahead to Real-time Storage Integration

Every day:
Storage offers and starting SoC value submitted into DAM for next dispatch day

Every hour:
Storage offers and telemetered SoC snapshot provided to pre-dispatch process for remaining dispatch hours in the day

Every dispatch interval:
Storage offers and telemetered SoC snapshot provided to MIO sequence for real-time dispatch



“Control” Over Facilities

- *One stakeholder suggested that IESO management of storage resources may provide an unfair advantage*
- *Another stakeholder suggested the proposal would result in more IESO control over storage resources than generators which would unfairly disadvantage storage*

Background: "Control" Over Facilities

- In the most general terms, all registered market participants retain physical **control** over their facilities at all times
- They are however **obligated,** under the IESO Market Rules, to follow dispatch instructions, other than exceptional circumstances where safety, environment or legal considerations warrant
- Electricity storage facilities will adhere to this same principle both in the Interim Period and in the enduring design, **regardless of the SoC management method chosen**

IESO Market Rules, Chapter 7

7.5.1 "Each *registered market participant* shall ensure that each of its *registered facilities* complies with *dispatch instructions* issued to it under these *market rules*…."

Dispatch According to the Rules

- In both today's market and after Market Renewal – Energy project implementation, the dispatch of facilities is governed by a transparent set of rules and criteria as set out in Chapter 7 of the Market Rules and its Appendices which detail the workings of the DSO
- Under SoC Lite, the use of telemetered SoC data from electricity storage facilities would be written into these rules and reflected in modifications to the DSO engine

IESO Manual Intervention Defined by Rules

Constraints, network model and facility static data

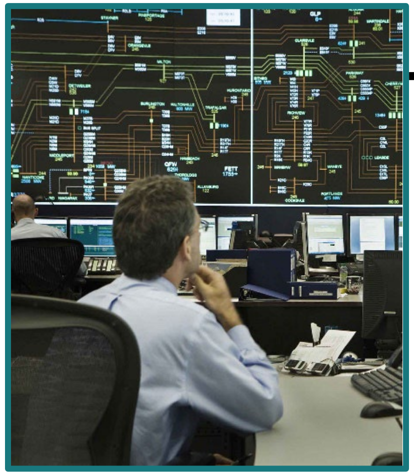
Dispatch data and telemetry

Dispatch instructions from the DSO

DSO

Registered facilities

IESO Control Room



Amended dispatch instructions

Intervention criteria:

1. Security and adequacy concerns
2. DSO failure
3. Material changes after dispatch instructions are formulated by DSO
4. Market suspension

There is a reciprocal obligation on the IESO to **only** intervene in the dispatch process under four very specific circumstances (IESO Market Rules, Ch. 7 section 7.2.1)

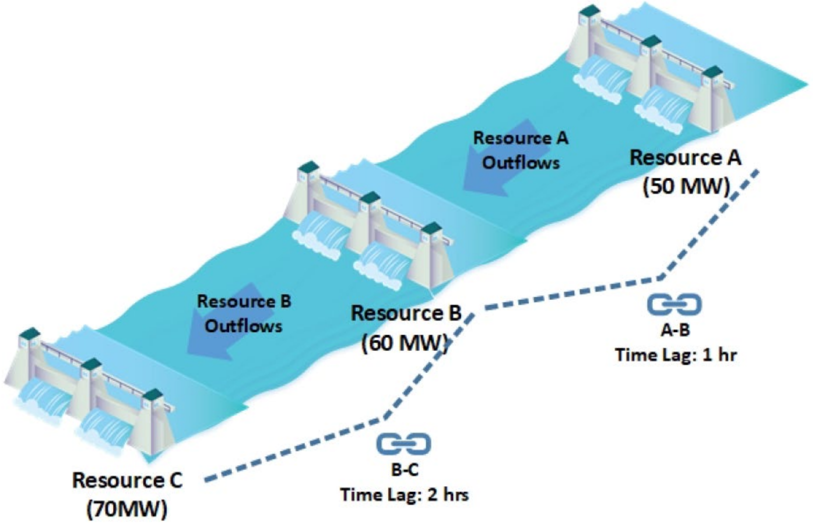
Constraints, Control and the Role of the System Operator

- To what extent should a system operator consider constraints occurring “behind the fence” within a market participant’s facility?
- This is a question that has been under extensive consideration both inside and outside of Ontario, and in the context of both energy storage facilities and other types of facilities.
- In three examples on the following slides, we see where these deliberations allowed for consideration of technology-specific physical facility attributes to ensure reliability without overriding the primacy of competitive bids/offers as the core function of an open electricity market.

Constraints, Control and the Role of the System Operator (cont'd)

Hydro modeling proposal

"During dispatch data submission, market participants will be able to select (link) which upstream and downstream resource pair must be jointly scheduled in respect of their cascade dependencies on a specific dispatch day. " *



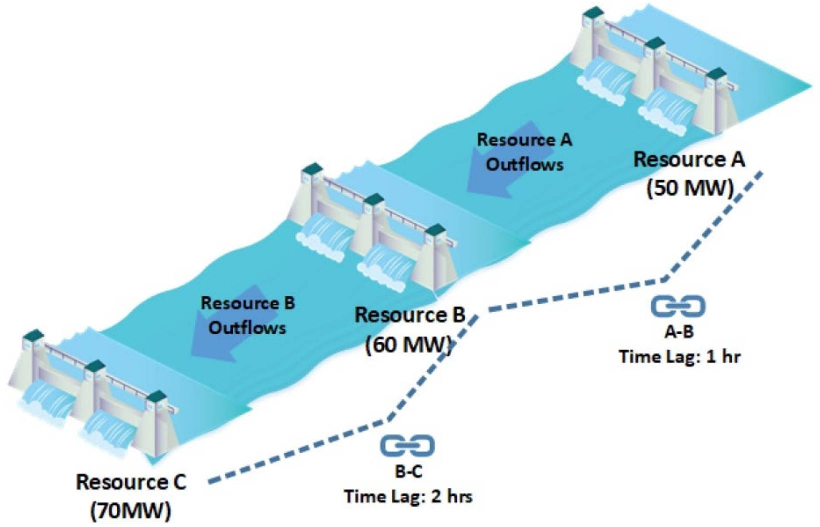
* *IESO Market Renewal Program, "Stakeholder Engagement Pre-Reading: Hydro Dispatch Data (Part 2) – February 6, 2020"*

Constraints, Control and the Role of the System Operator (cont'd..)

Supporting rationale

Solving a scheduling challenge already apparent in today's market:

"Market participants use today's DACP resubmission window to correct for infeasible cascade day-ahead schedules. In the future DAM, the proposed dispatch data will provide the calculation engine with the ability to produce feasible cascade schedules." *

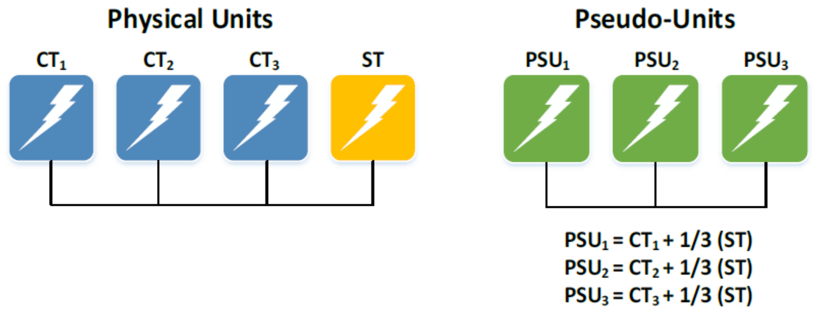


** IESO Market Renewal Program, "Stakeholder Engagement Pre-Reading: Hydro Dispatch Data (Part 2) – February 6, 2020"*

Important Example: Combined Cycle Plants in Ontario

Pseudo Units modeling proposal extended by MRP

"The IESO introduced PSU modelling in 2011 as part of enhancements to the Day-ahead Commitment Process (DACP). This modelling facilitates the commitment of combined cycle resources. The modelling schedules each PSU independently, where a CT and part of the ST is scheduled in parallel and proportioned according to a fixed ratio of energy output between the gas and steam resource." *

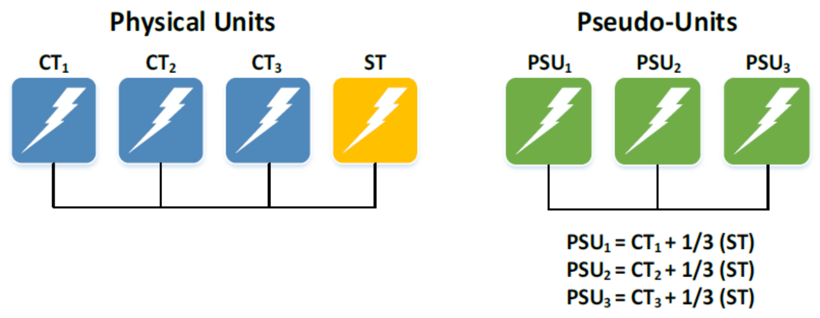


* IESO Market Renewal Program, *"Stakeholder Engagement Pre-Reading Pseudo-Units - February 27, 2020"*

Important Example: Combined Cycle Plants in Ontario (cont'd)

Supporting rationale

"Under day-ahead market (DAM) financially-binding schedules and binding pre-dispatch (PD) commitments for NQS resources, CCP resources may be exposed to greater financial risk if models are not accurately applied in all timeframes to achieve feasible physical resource schedules.."



Important Example: Energy Storage State of Charge Management in U.S. Markets

U.S. FERC Order 841

"Nothing in this Final Rule precludes an RTO/ISO from establishing telemetry or other communication requirements necessary to determine the capabilities of the electric storage resource in real time." *

* Federal Energy Regulatory Commission, Order 841 "*Electric Storage Participation in Markets Operated by Regional Transmission Organizations and Independent System Operators* Docket Nos. RM16-23-000, AD16-20-000"

Note: the IESO is not subject to FERC jurisdiction or precedents set by that organization.

Supporting Rationale

"We believe that this flexibility will ensure sufficient visibility of a resource using the participation model for electric storage resources to safeguard operational reliability and market integrity. We reiterate that self-managing electric storage resources, just like all market participants, are subject to any non-performance penalties in the RTO/ISO tariff, thus incentivizing them to ensure that they have sufficient energy available to meet their obligations."

The Common Thread Across the Previous Examples

- Each of the previous examples seeks to provide market participants with the ability to obtain their schedules and prices via competitive bids/offers:
  - In the first two examples, hydro-electric and combined cycle facilities must navigate the electricity market with competitive offers, though the relationship between resources is recognized.
  - In the third example FERC allowed for Self-SoC Management, though it still left the door open to system operators to consider SoC in dispatch – which in practicality allows for elements of SoC Lite to be employed. In all cases FERC also made it clear that there is no special exemption from the obligation to follow dispatch.
- In each of these precedents, we see a recognition that system operators may account for the practical physical realities of different facility types…so long as it doesn't upset the concept that schedules are awarded in merit order by bid/offer prices

Flexibility and SOC LITE – A Few Examples

- *Some stakeholders expressed general support for the SoC Lite proposal but noted additional considerations including:*
    - *A desire to ensure that modelling SoC does not limit storage resources' flexibility*
    - *A desire to keep the door open for self-management for storage resources that are uniquely complex in nature*

Examples: Day Ahead Market and Real-Time Market

- The differences between SoC Lite and a Self-SoC Management were a theme in some of the comments from the May 20th ESAG meeting
- A few examples of participation in the DAM and real-time markets illustrates that there are few mechanical differences in participation between SoC Lite and a Self-SoC Management option
- **The key difference, is where the risk of non-compliance with dispatch due to SoC falls…**

Examples: Day Ahead Market (Example 1)

Example 1: Target a specific hour in the Day Ahead Market to inject energy at $20

Dispatch Data submissions:

Example 1

	Hour	1	2	3	….	14	….	22	23	24
SOC Lite	**Injections**	MMCP	MMCP	MMCP	…	$20	…	MMCP	MMCP	MMCP
	Withdrawals	-MMCP	-MMCP	-MMCP	….	-MMCP	….	-MMCP	-MMCP	-MMCP
	Initial SOC	50%								

	Hour	1	2	3	….	14	….	22	23	24
Self-SOC Management	**Injections**	MMCP	MMCP	MMCP	…	$20	…	MMCP	MMCP	MMCP
	Withdrawals	-MMCP	-MMCP	-MMCP	….	-MMCP	….	-MMCP	-MMCP	-MMCP

Examples: Day Ahead Market (Example 2)

Example 2: Target a specific hour in the Day Ahead Market to withdraw energy at $0

Dispatch Data submissions:

Example 2

SOC Lite

Hour	1	2	3	....	14	....	22	23	24
Injections	MMCP	MMCP	MMCP	...	MMCP	...	MMCP	MMCP	MMCP
Withdrawals	-MMCP	-MMCP	-MMCP	....	0	....	-MMCP	-MMCP	-MMCP
Initial SOC	50%								

Self-SOC Management

Hour	1	2	3	....	14	....	22	23	24
Injections	MMCP	MMCP	MMCP	...	MMCP	...	MMCP	MMCP	MMCP
Withdrawals	-MMCP	-MMCP	-MMCP	....	0	....	-MMCP	-MMCP	-MMCP

Examples: Day Ahead Market (Example 3)

Example 3: Target a $40 withdrawal-to-injection price spread over the course of the entire day

Dispatch Data submissions:

Example 3

	Hour	1	2	3	….	14	….	22	23	24
SOC Lite	Injections	40	40	40	…	$40	…	40	40	40
	Withdrawals	0	0	0	….	0	….	0	0	0
	Initial SOC	50%								

	Hour	1	2	3	….	14	….	22	23	24
Self-SOC Management	Injections	40	40	40	…	$40	…	40	40	40
	Withdrawals	0	0	0	….	0	….	0	0	0

Examples: Day Ahead Market and Real-Time Market (cont'd)

- **Notice a pattern emerging?**
  - In all cases, the offer strategy between SoC Lite and Self- SoC management is the same
  - In all cases, the storage facility has no better or worse chance of being economic in each hour of the DAM run between the two SoC management methods
  - **The only difference:**
    - **Under SoC Lite**: the DAM schedule may be constrained by the calculated SoC value, initialized in hour 1 by a participant data submission
    - **Under Self-SoC Management:** the market participant faces a higher risk that they will end up with a Day Ahead schedule that is physically infeasible in real-time

Examples: Real-Time Market (Example 1)

Example 1: No risk of reaching a physical SoC limit (upper or lower) over the next three hours. Facility clears market to inject for entire dispatch hour.

	Example 1	Prior to Mandatory window Finalize Offer Curve for dispatch hour	Mandatory Window Dispatch minus 2	Dispatch minus 1	Dispatch Hour Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9	Interval 10	Interval 11	Interval 12
SOC Lite	Injections	$20	→	→	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20
	Withdrawals	$ - MMCP	→	→	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP
	Telemetered SOC accounted for in DSO	50%	→	→	48%	46%	44%	42%	40%	38%	36%	34%	32%	30%	28%	26%
	Schedule (MW)		0	0	10	10	10	10	10	10	10	10	10	10	10	10

	Example 1	Prior to Mandatory window Finalize Offer Curve for dispatch hour	Mandatory Window Dispatch minus 2 hours	Dispatch minus 1 hour	Dispatch Hour Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9	Interval 10	Interval 11	Interval 12
Self-SOC Management	Injections	$20	→	→	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20
	Withdrawals	$ - MMCP	→	→	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP
	Telemetered SOC (not accounted for in DSO)	50%	→	→	48%	46%	44%	42%	40%	38%	36%	34%	32%	30%	28%	26%
	Schedule (MW)		0	0	10	10	10	10	10	10	10	10	10	10	10	10

Examples: Real-Time Market (Example 2)

Example 2: Same example, but this time the market participant's energy store is exhausted during the dispatch hour.

	Example 2	Prior to Mandatory window Finalize Offer Curve for dispatch hour	Mandatory Window Dispatch minus 2 hours	Mandatory Window Dispatch minus 1 hour	Dispatch Hour Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9	Interval 10	Interval 11	Interval 12
SOC Lite	Injections	$20	→	→	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20
	Withdrawals	$ - MMCP	→	→	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP
	Telemetered SOC accounted for in DSO	10%	→	→	10%	8%	6%	4%	2%	0%	0%	0%	0%	0%	0%	0%
	Schedule (MW)		0	0	10	10	10	10	10	0	0	0	0	0	0	0

	Example 2	Prior to Mandatory window Finalize Offer Curve for dispatch hour	Mandatory Window Dispatch minus 2 hours	Mandatory Window Dispatch minus 1 hour	Dispatch Hour Interval 1	Interval 2	Interval 3	Interval 4	Interval 5	Interval 6	Interval 7	Interval 8	Interval 9	Interval 10	Interval 11	Interval 12
Self-SOC Management	Injections	$20	→	→	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20	$20
	Withdrawals	$ - MMCP	→	→	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP	$ - MMCP
	Telemetered SOC (not accounted for in DSO)	10%	→	→	10%	8%	6%	4%	2%	0%	0%	0%	0%	0%	0%	0%
	Schedule (MW)		0	0	10	10	10	10	10	10	10	10	10	10	10	10

Examples: Day Ahead Market and Real-Time Market (cont'd..)

- When reaching an SoC limit is not a possibility, both the offer strategy and market outcomes are largely the same between SoC Lite and Self-SoC Management
- When reaching an upper or lower SoC limit during the dispatch hour occurs in real-time:
  - **Under SoC Lite:** the remaining SoC will be allocated by Multi-Interval Optimization process to the highest-valued intervals and the facility won't be scheduled any intervals that are SoC-infeasible

Examples: Day Ahead Market and Real-Time Market (cont'd…)

- **Under Self-SoC Management:**
  - The DSO is oblivious to the facility's SoC capability, and will schedule the facility for any intervals where it clears the market
  - Under example 2, the facility will be non-compliant with dispatch instructions for half of the dispatch hour, running the risk of compliance penalties
  - In addition there is a loss of efficiency of solution in the MIO sequence

SOC OPTIONS: PROCESS OF ELIMINATION

Design Landmarks

Source	Key constraint/landmark
Existing and future Market Rules	A facility needs to be dispatchable in order to sell operating reserve in the IESO administered markets and have access to the 5-minute energy price
Stated aim of the SDP project	Ultimately, only dispatchable facilities will be able to provide regulation service
Existing and future Market Rules	A dispatchable facility needs to be able to comply with IESO dispatch instructions and is subject to compliance penalties if it fails to do so
Precedent set by Market Renewal – Energy project design	"the IESO will not implement an optimization solution, …based solely on a supplier's production costs." *

* IESO response to stakeholder feedback to MRP Hydro Modeling session, February 6, 2020 and posted with meeting summary of November 14 , 2019 meeting of the MRP Detail Design Engagement.

Process of Elimination

EPRI "ISO-SoC-Management"	EPRI "SoC-Management-Lite"	EPRI "Self-SoC Management"	EPRI "Self-Schedule" option

- Given the various constraints on the enduring design, the objectives of the SDP project and the role of the IESO as a neutral facilitator of an open electricity market: only SoC Lite and Self-SoC Management met the core design constraints, though ultimately SoC Lite prevailed for other reasons
- The next slides summarize the rationale for selecting SoC Lite above Self-SoC Management and the other EPRI SOC management options.

Process of Elimination (Part 1 of 4)

Eliminated: EPRI "ISO-SoC-Management"	EPRI "SoC-Management-Lite"	EPRI "Self-SoC Management"	EPRI "Self-Schedule" option

- Violates IESO precedent with respect to level of control over facilities
- Complex – likely involving extensive platform changes

Process of Elimination (Part 2 of 4)

Eliminated: EPRI "ISO-SoC-Management"	EPRI "SoC-Management-Lite"	EPRI "Self-SoC Management"	Eliminated: EPRI "Self-Schedule" option
• Violates IESO precedent with respect to level of control over facilities • Complex – likely involving extensive platform changes			• Provides no assurance that O.R. and energy schedules can be met • Increased reliability risk because SoC not explicitly used by DSO • Self-scheduling limit of 10 MW already in place

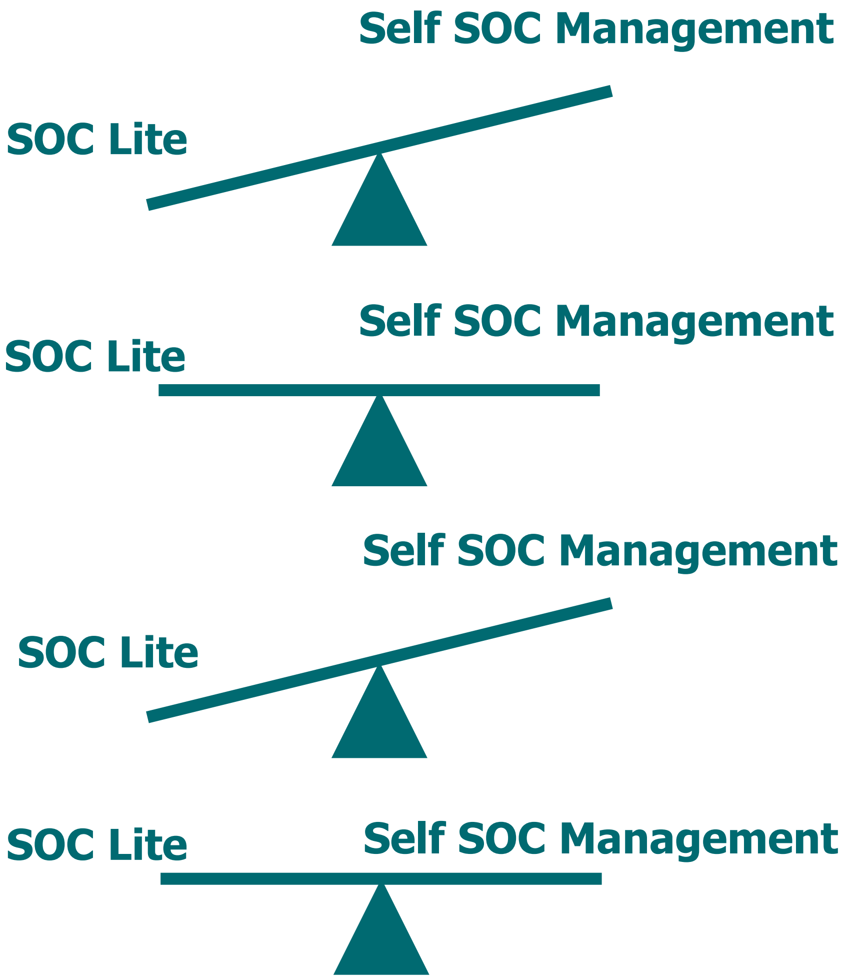
SoC Lite vs. Self-SoC Management

Protecting reliability by preventing infeasible dispatch

Flexibility to offer storage capabilities to the market

Transparency of information disclosure

Fairness of access to wholesale market products vs other facility types



SoC Lite and Self-SoC Management afford similar levels of market access and opportunity to signal value via competitive offers. However, Self-SoC Management leaves us with many of the same challenges as the current Interim Storage Design

Process of Elimination (Part 3 of 4)

Eliminated: EPRI "ISO-SoC-Management"	EPRI "SoC-Management-Lite"	Eliminated: EPRI "Self-SoC Management"	Eliminated: EPRI "Self-Schedule" option
• Violates IESO precedent with respect to level of control over facilities • Complex – likely involving extensive platform changes		• Provides no more assurance that O.R. and energy schedules can be met than today's interim design measures • Withholds information about a physical constraint from the dispatch algorithm	• Provides no assurance that O.R. and energy schedules can be met • Increased reliability risk because SoC not explicitly used by DSO • Self-scheduling limit of 10 MW already in place

Process of Elimination (Part 4 of 4)

Eliminated: EPRI "ISO-SoC-Management"	**Valid: EPRI "SoC-Management-Lite"**	**Eliminated: EPRI "Self-SoC Management"**	**Eliminated: EPRI "Self-Schedule" option**
• Violates IESO precedent with respect to level of control over facilities • Complex – likely involving extensive platform changes	• True state-of-charge of each storage facility disclosed to dispatch algorithm • Ensures feasible dispatch while maximizing opportunity to strategically offer facility in manner similar to Self-SoC Management • Better efficiency in the MIO sequence	• Provides no more assurance that O.R. and energy schedules can be met than today's interim design measures • Withholds information about a physical constraint from the dispatch algorithm	• Provides no assurance that O.R. and energy schedules can be met • Increased reliability risk because SoC not explicitly used by DSO • Self-scheduling limit of 10 MW already in place

In Summary

- SoC Lite is consistent with the notion of an open electricity market where control over facilities and how they are offered resides with the facility's registered market participant
- While Self-SoC Management also meets this bar, the reliability, and market efficiency drawbacks are inherent in a model that withholds SoC data from consideration by the dispatch algorithm that is seeking to optimize the entire electricity market
- Nothing in this design choice would relieve a storage facility from its obligation to follow dispatch instructions. However, SoC Lite transfers much of the responsibility for formulating SoC-feasible dispatch, in real-time, to the system operator, with little or no loss of 'flexibility' to the market participant

Stakeholder Feedback

- Today, the IESO has provided additional details on the SoC Lite proposal to address questions and comments provided by stakeholders after the May 20, SDP meeting
- In light of these additional details, the IESO is again seeking stakeholder feedback on whether the SoC Lite proposal offers a pragmatic solution for the participation of energy storage in the IESO-Administered Markets in the long-term
- Please use the feedback form that can be found under the July 23, 2020 entry on the ESAG webpage and send to engagement@ieso.ca by August 13, 2020