FEBRUARY 18, 2020

Storage Design Project (SDP): Overview of Interim Design Features

Energy Storage Advisory Group

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Overview and Purpose

The primary purpose of this presentation is to lead a discussion of the interim design proposals - *captured in the draft Energy Storage Design Project design document* - which aim to clarify how storage resources can participate in today's IESO-Administered Markets

Agenda

1. Project Recap
2. Stakeholder Feedback from October ESAG Presentation
3. The "Interim Period"
4. Design Document Overview
5. Interim Period - Design Features in Summary
6. Interim Period - Design Features in Detail

Recap: Design Issues, Principles and Scope

Storage Design Project (SDP) Scope

- The SDP 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 on an enduring basis in markets resulting from the Market Renewal Program (the **long-term period** - once investment in IESO tool upgrades to fully integrate storage resources are made)
- The SDP is an important step towards ensuring energy storage can fully compete to reliably and efficiently provide needed system services

Project Scope and Deliverables

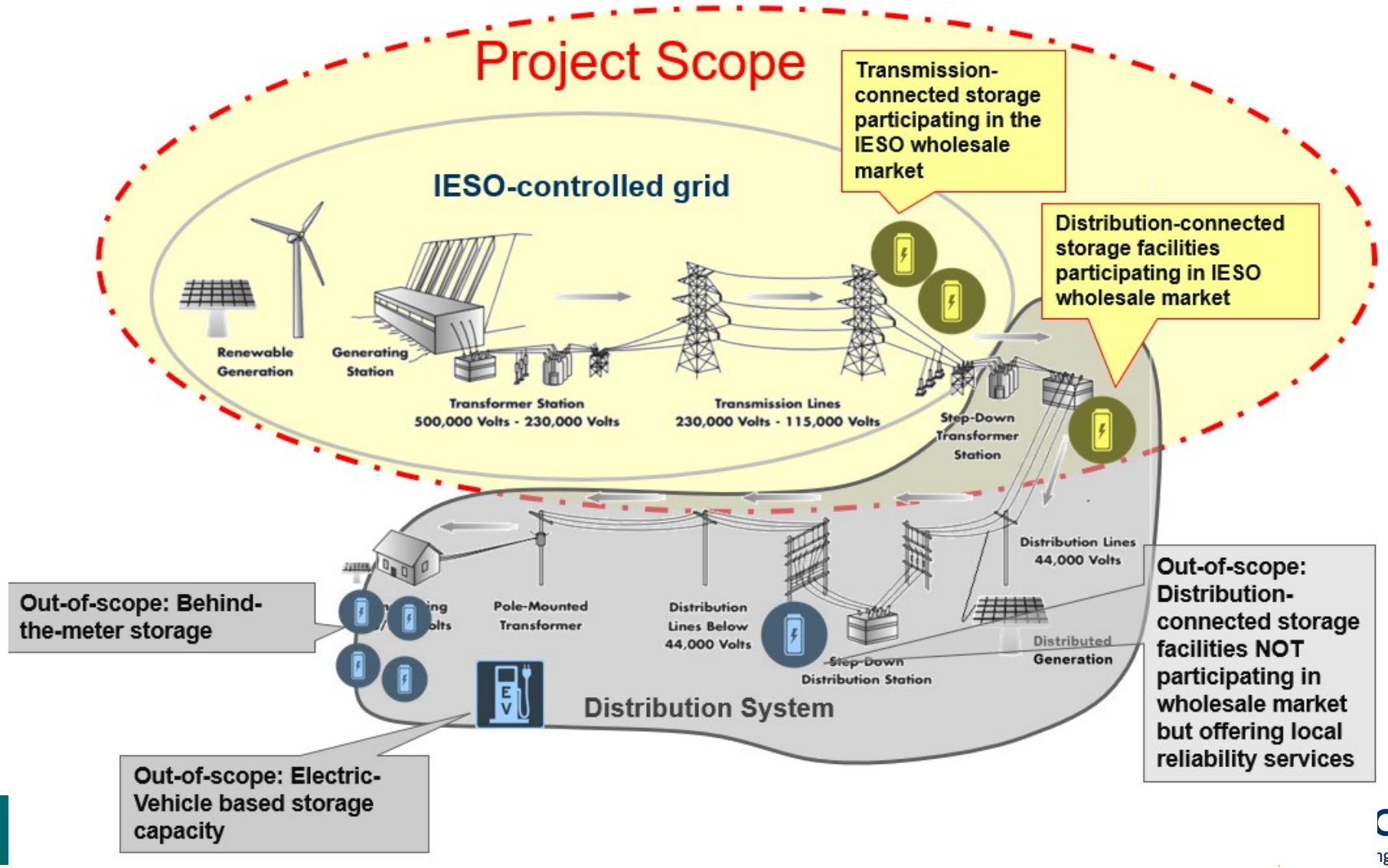
The project includes four key deliverables:

1. **Design Document**
   - Answer key questions about how IESO will treat storage in IESO Administered Markets (IAMs)
   - Reflect different timeframes (e.g. greater detail for interim / pre-Market Renewal Program (MRP) measures and higher-level design discussion for long-term / post-MRP changes)
2. **Market Rules and Manuals**
   - Draft, and invite stakeholder feedback on, market rule/manual language required to implement interim measures
   - Produce inventory and description of future market rules/manual changes required to implement long-term design questions addressed in the project

Project Scope and Deliverables (cont'd)

3. **Inventory of IESO Tool/Process Changes**
   - Develop list of tools/processes that will require updating to enable design questions addressed in the project
4. **Schedule for Market Updates**
   - Develop schedule to roll out changes that reflects dependencies on/timing of other initiatives

Energy Storage Design Project – Scope of facilities involved



Making Design Decisions

Adhere to Market Renewal Program 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
- We will seek to maximize the chances of timely implementation by:
  - Accounting for the capabilities of the software tools that will be selected outside the scope of this project
  - 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

Timelines

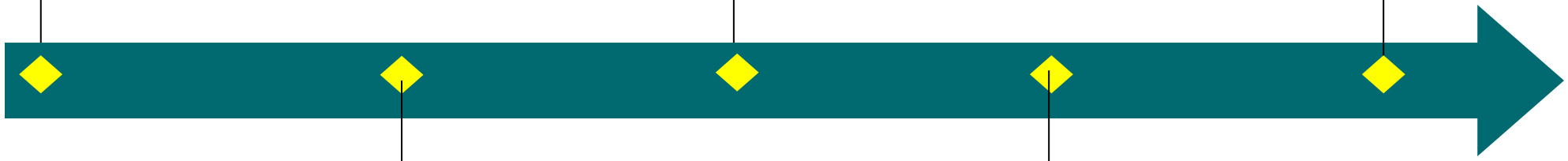
Oct. 28
Meeting 1
- Introduce project
- Seek feedback on design questions

Feb. 18
Meeting 2
- Introduce interim design proposals
- Seek feedback on interim design decisions

March 26
Webinar
- Introduce long- term design questions
- Update on storage integration efforts in the US (EPRI)

Q2 (Date TBC)
Meeting 3
- Introduce long-term design proposals
- Introduce rule/manual changes for interim design
- Introduce schedule for market updates

Q3 (Date TBC)
Meeting 4
- Finalize design proposals
- Respond to feedback on rule/manual language
- Finalize schedule for market updates



Stakeholder Feedback

Feedback Submissions Received

- The IESO requested stakeholder feedback on the draft engagement plan and the appropriateness of the design questions and received the following eight submissions:
  - CanSIA Nexus
  - Electricity Distributors Association (EDA)
  - Energy Storage Canada
  - Hydro One
  - Peak Power
  - Power Workers Union
  - Saturn Power
  - TC Energy
- The IESO's detailed response to feedback document has been posted to the Energy Storage Advisory Group engagement page

Summary of Feedback Themes

Timing – Desire for enduring storage design to be implemented alongside MRP

- A high-level schedule for when design decisions within the SDP will be implemented is a key deliverable for the project

Scope - Desire to expand scope or understand where conversations on Behind-the-Meter Storage and Hybrid participation will occur

- Exploration of these topics is under consideration for the Expanding Participation in Operating Reserve and Energy research initiative in 2020, undertaken at the Market Development Advisory Group

Summary of Feedback Themes (cont'd)

Distribution System Coordination – Desire to understand relationship between SDP and transmission/distribution (TD) coordination

- SDP is focused on clarifying the rules and requirements that apply to storage resources that participate directly in the IAMs
- IESO agrees TD coordination is an increasingly important topic and is exploring it outside the SDP through multiple avenues (e.g. Grid-LDC Interoperability Standing Committee, IESO York Region Non-Wires Alternative Demonstration Project, IESO white papers)

Summary of Feedback Themes (cont'd again)

IESO Coordination – Request that IESO ensure appropriate coordination across related initiatives

- *IESO notes important relationships between the SDP and the Capacity Auction and Market Development Advisory Group, IESO is working to ensure there is appropriate alignment across initiatives*

Different Timeframes - Desire to separate design proposals into different timeframes and release design document in parts

- *IESO agrees with this approach; the initial iteration of draft design document is focused on interim-proposals, long-term proposals will be addressed at future ESAG meetings*

Jurisdictional Review – Desire to learn from storage integration in other jurisdictions as an input into storage design in Ontario

- *IESO agrees this is an important consideration and plans to build on learnings from other jurisdictions (plan for educational webinar in March on this topic)*

Storage Charges – Desire to explore application of Global Adjustment and delivery charges for storage resources

- *The SDP will explore the application of uplift charges to energy storage resources but will not include charges that are outside of the IESO's accountability*

The “Interim Period”

Stages of Development

Today's Focus

The "Interim Period" See Chapter 2

Stage 1: Interim framework to clarify storage participation in today's IESO-administered markets

- **Related project:** Capacity Auction

Long-Term design changes:

See Chapter 3

Stage 2: Changes to allow energy storage resources to provide regulation service, energy and operating reserve

- **Related project:** SCADA EMS Upgrade (nominally targeting Q1 2022), plus additional requisite system changes to effect the use of the energy storage for regulation service

Stage 3: Enduring participation model for energy storage resources enabling more efficient scheduling of energy and operating reserve

- **Related projects:** future Dispatch Scheduling and Optimization (DSO) tool changes and Replacement Settlement Systems

The "Interim Period":

- During the Interim Period it is anticipated that:
  - Dispatchable energy storage facilities will be admitted into the Capacity Auction
  - Energy storage facilities may participate in the real-time energy market as dispatchable facilities
  - Energy storage facilities may participate in the real-time energy market as self-scheduling facilities if they are between 1 MW and 10 MW in size
  - Energy storage facilities may participate in the real-time operating reserve market as dispatchable facilities
  - Energy storage facilities may participate in the regulation service market as self-scheduling facilities

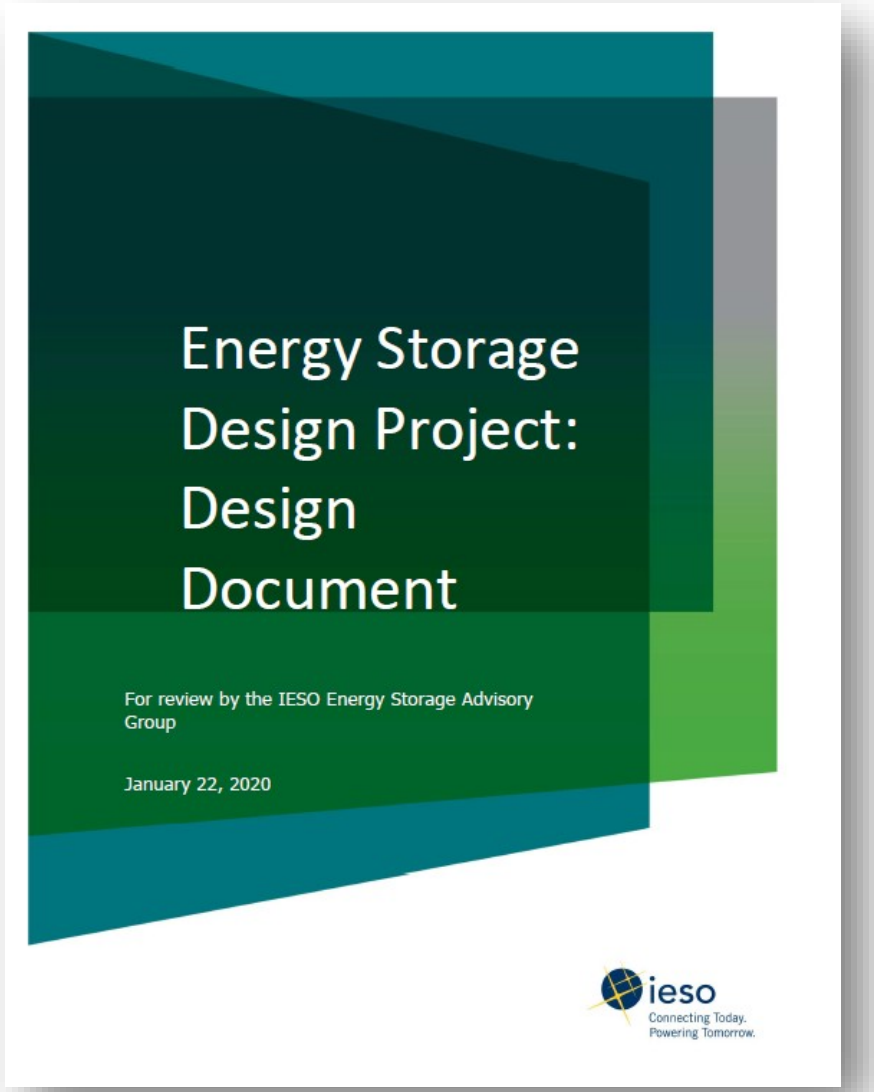
Design Issues for the Interim Period

Design Element	Design Questions
Ability of Energy Storage Resource (ESR) to set market clearing price in the energy and operating reserve markets	Should ESRs > 10 MW be allowed to self-schedule?
Market and Facility Registration	How should an energy storage facility be registered into the IESO-administered markets?
Prudential Security	What prudential security requirements will apply to ESRs?
Day-Ahead Market (DAM) and Day-Ahead Commitment Process (DACP): bidding and scheduling of ESRs	How should ESRs participate in the DACP pre-Market Renewal Program?
State of Charge (SoC) management in Real-Time energy market	Who should optimize SoC of ESRs in the real-time energy market: the ESR, the system operator; or give ESRs the choice?
Real-time energy and operating reserve markets: bidding and scheduling of ESRs	What guidelines or restrictions should be placed on ESRs providing operating reserve?

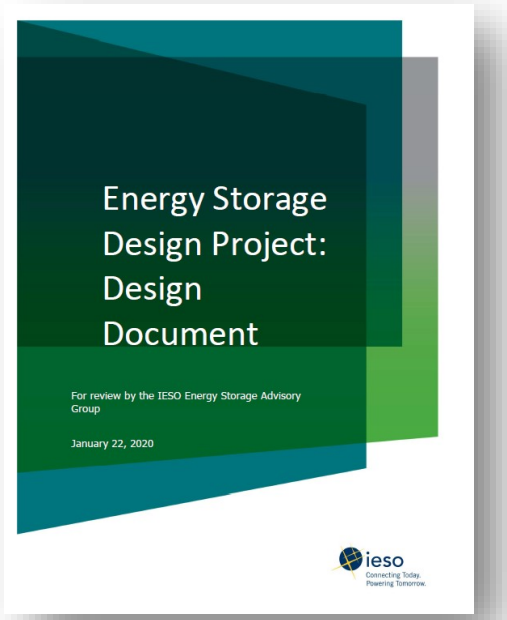
Design Document Overview

Design Document Overview

- Draft **Chapter 1** – Introduction and context to the project
- Draft **Chapter 2** – Interim Design Features – today's discussion
- {Future} **Chapter 3** – Long-Term Design Features
- **Appendix 'A'** – Glossary of storage-related terms
- **Appendix 'B'** – cross reference to market manuals (to be completed)



Future Steps for Interim Design Features



ESAG feedback

13 Interim Design Features

Market Rule Amendment Proposals

IESO business process impacts*

Market Manual Changes

IESO Baseline Management Process

* Includes any requisite software tool changes that may be required during the Interim Period.

Structure of Chapter 2

- A functional description of each interim design feature:
  - Design issue and its importance
  - Functional description of proposed design feature
  - Rationale
  - Summary of inputs, processing and outputs

Out-of-Scope

- Chapter 2 is **not** meant to specify the details of:
  - Market Rule amendments
  - Market Manual amendments
  - Specific features of any underlying software changes that may be required
- These will be addressed through Market Rules amendment process and the IESO's Baseline Management Process

Interim Period – Design Features in Summary

Common Rationale for Interim Design Features

- At a high level, most of the proposed Interim Design Features share a common rationale:
  - **Increase competition and market efficiency through transparent access for energy storage facilities**
    - Provide transparent access to arrangements that are in use already – having been developed over the past seven years of IESO interaction with non-PGS energy storage.
    - **Related Market Renewal Design Principles**: Efficiency, competition, and transparency

Common Rationale for Interim Design Features (cont'd)

- **Building on the practical experiences of other jurisdictions**
  - In many cases, the Interim Design Features put forward in Chapter 2 are stepping stones towards the long-term implementation of an energy storage resource model.
  - **Related Market Renewal Design Principles**: Certainty
- **Maximize chances of timely implementation**
  - Reduce reliance on tools changes given current IESO resource constraints and priorities with the Market Renewal Program.
  - **Related Market Renewal Design Principles**: Implementability and Certainty

Recall: Combinations of Accessible Wholesale Product Participation for Storage Today

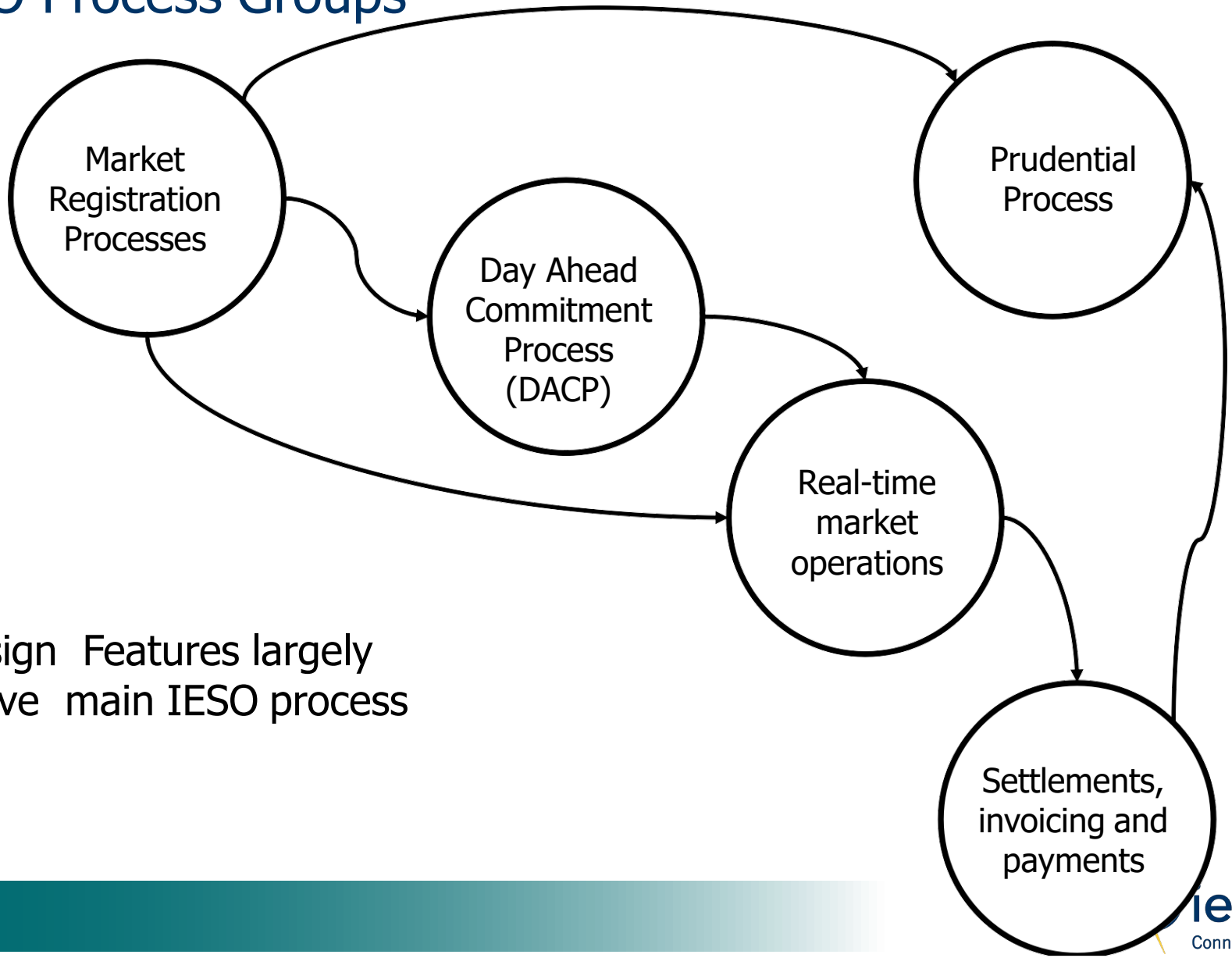
This matrix depicts the combinations of wholesale market products that an ESR can participate in today. In many cases, registration to participate in a given wholesale market service product is mutually exclusive to providing another service (e.g. regulation service precludes participation in the energy and operating reserve markets). In other cases, although participation may be allowable, it may be less than optimal for both the facility operator and the market as a whole.

	Real-time Energy	**Operating Reserve**	**Regulation Service**	**Reactive Support and Voltage Control**	**Demand Response (to be replaced with Capacity Auction)**
Real-time Energy	Yes – but with efficiency losses	Yes – but with restrictions and efficiency loss	No	Yes – but with efficiency losses	No
Operating Reserve	Yes – but with restrictions and efficiency loss	Yes – but with restrictions and efficiency loss	No	Yes – but with restrictions and efficiency loss	No
Regulation Service	No	No	Yes – but with efficiency losses	Yes – but with efficiency losses	No
Reactive Support and Voltage Control	Yes – but with efficiency losses	Yes – but with restrictions and efficiency loss	Yes – but with efficiency losses	Yes	No
Demand Response	No	No	No	No	Yes - rules for storage to be clarified in Capacity Auction Design

Target Market Access for Storage During the Interim Period

	Real-time Energy	Operating Reserve	Regulation Service	Reactive Support and Voltage Control	Capacity Auction
Real-time Energy	Yes – but with efficiency losses	Yes – but with restrictions and efficiency loss	Subject to additional tools modifications (see design document)	Yes, in later stages – but with efficiency losses	Yes – but with efficiency losses
Operating Reserve	Yes – but with restrictions and efficiency loss	Yes – but with restrictions and efficiency loss	Subject to additional tools modifications (see design document)	Yes, in later stages – but with restrictions and efficiency loss	Yes – but with restrictions and efficiency loss
Regulation Service	Subject to additional tools modifications (see design document)	Subject to additional tools modifications (see design document)	Yes	Yes, in later stages – but with efficiency losses	Yes, subject to Capacity Obligations
Reactive Support and Voltage Control	Yes – but with efficiency losses	Yes – but with restrictions and efficiency loss	Yes – but with efficiency losses	Yes	Yes
Capacity Auction	Yes – but with efficiency losses	Yes – but with restrictions and efficiency loss	Yes, subject to Capacity Auction obligations	Yes	Yes

Affected IESO Process Groups



The Interim Design Features largely centre around five main IESO process groups

13 Design Features for the Interim Period

Design Feature cross reference	Affected IESO processes
Design Feature SoC 1 – restriction against overlapping or equal bid/offer prices	DACP Real-time market operations
Design Feature SoC 2 – addressing potential changes to SoC-limited bids and offers	Real-time market operations
Design Feature DACP 1 – DACP data submission requirements for each class of interim energy storage participation	DACP
Design Feature DACP 2 – No overlap rule for bids and offers into the DACP for energy storage facilities	DACP
Design Feature O.R. 1 – no simultaneous offers of operating reserve from the two resources comprising a dispatchable energy storage facility	Real-time market operations
Design Feature O.R. 2 – operating reserve requirements specific to a dispatchable load resource comprising a dispatchable energy storage facility	Real-time market operations

Design Feature cross reference	Affected IESO processes
Design Feature O.R. 3 – operating reserve requirements specific to a dispatchable generator resource comprising a dispatchable energy storage facility	Real-time market operations
Design Feature P.S. 1 – Prudential Support Obligation for market participants with energy storage facilities.	Prudential Security
Design Feature Self-Scheduling 1 – maintain current capacity limit of 10 MW for- Self-scheduling energy storage resources in the real-time energy market	Facility Registration
Design Feature Self-Scheduling 2 – raise current capacity limit of 10 MW for- Self-scheduling energy storage resources providing regulation service only	Facility Registration
Design Feature F.R. 1 – Registration of self-scheduling energy storage facilities providing regulation service only	Facility Registration
Design Feature F.R. 2 – Registration of self-scheduling energy storage facilities in the real-time energy market	Facility Registration
Design Feature F.R. 3 – Registration of dispatchable energy storage facilities	Facility Registration

2 of 13 Design Features are expected to endure beyond the Interim Period

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Design Feature SoC 1 – restriction against overlapping or equal bid/offer prices	DACP Real-time market operations
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Design Feature cross reference	Affected IESO processes
Design Feature O.R. 3 – operating reserve requirements specific to a dispatchable generator resource comprising a dispatchable energy storage facility	Real-time market operations
Design Feature P.S. 1 – Prudential Support Obligation for market participants with energy storage facilities.	**Prudential Security**
Design Feature Self-Scheduling 1 – maintain current capacity limit of 10 MW for- Self-scheduling energy storage resources in the real- time energy market	**Facility Registration**
Design Feature Self-Scheduling 2 – raise current capacity limit of 10 MW for- Self-scheduling energy storage resources providing regulation service only	Facility Registration
Design Feature F.R. 1 – Registration of self-scheduling energy storage facilities providing regulation service only	Facility Registration
Design Feature F.R. 2 – Registration of self-scheduling energy storage facilities in the real- time energy market	Facility Registration
Design Feature F.R. 3 – Registration of dispatchable energy storage facilities	Facility Registration

The method of implementation of one of the Design Features is currently under review by the IESO

Design Feature cross reference	Affected IESO processes
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Design Feature SoC 2 – addressing potential changes to SoC-limited bids and offers	**Real-time market operations**
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Design Feature F.R. 3 – Registration of dispatchable energy storage facilities	Facility Registration

Interim Period – Design Features in Detail

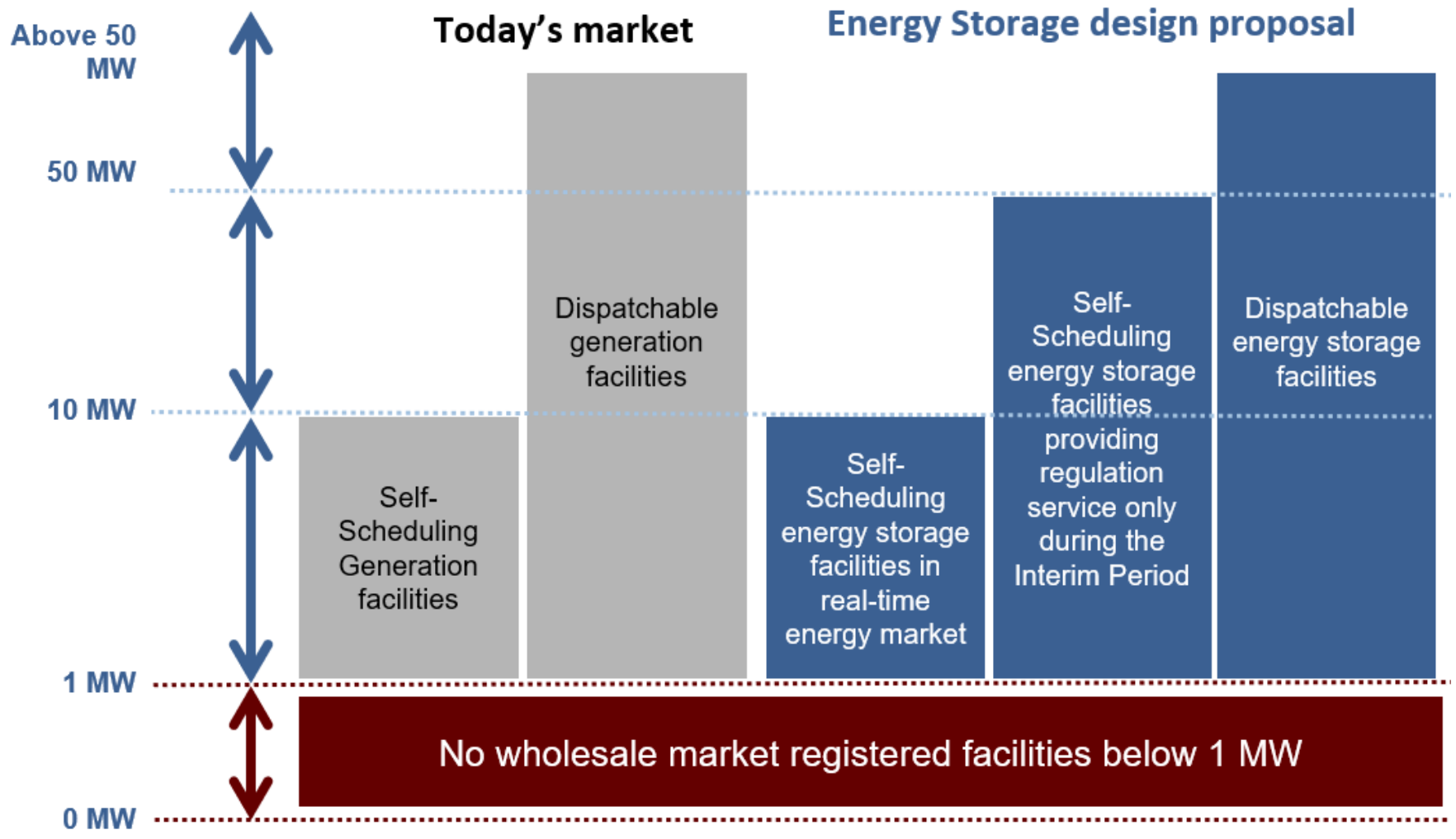
Design Features: Size Thresholds for Self-Scheduling Storage Facilities

Design Features – Self-Scheduling 1-2

Design Element	Design Question
Ability of energy storage facility to set market clearing price in the energy and operating reserve markets	Should energy storage facilities > 10 MW be allowed to self-schedule?

1. **Self-Scheduling 1:** Self-scheduling threshold for energy storage facilities participating in the energy market
2. **Self-Scheduling 2:** Self-scheduling threshold for energy storage facilities providing regulation service

Proposed size thresholds for energy storage facilities



Design Features specific to Self-Scheduling Storage facilities

Design Element	Design Question
Ability of energy storage facility to set market clearing price in the energy and operating reserve markets	Should energy storage facilities > 10 MW be allowed to self-schedule?

Design Feature	Proposed Design	Rationale
Self- Scheduling 1	**Self-scheduling energy storage resources** in the real-time energy market: no change to today's 10 MW threshold	No evidence that storage brings any unique considerations to the materiality threshold. Storage is an inherently controllable facility and should be encouraged to become dispatchable.
Self- Scheduling 2	**Self-scheduling energy storage resources** providing regulation service: may be allowable up to 50 MW facility size subject to IESO approval	Self Scheduling requirement is an artificial consequence of the current tools framework. In the meantime, energy storage can be a viable source of regulation

Design Features: Facility Registration

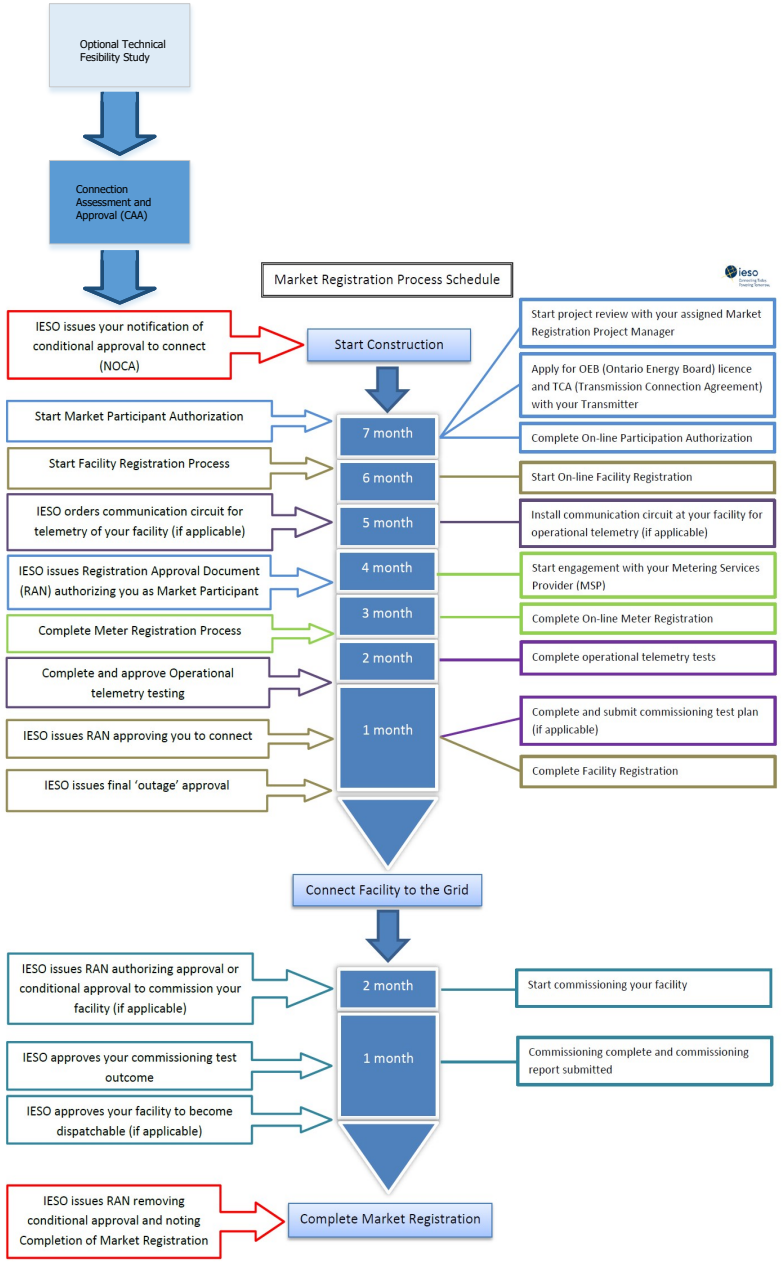
Design Features – F.R. 1-3

Design Element	Design Question
Market and Facility Registration	How should an energy storage facility be registered into the IESO-administered markets?

1. **F.R. 1:** Facility Registration requirements for self- scheduling energy storage facilities providing regulation service only
2. **F.R. 2:** Facility Registration requirements for self-scheduling energy storage facilities in the real-time energy market only
3. **F.R. 3:** Facility Registration requirements for dispatchable energy storage facilities

Process Context

- Facility Registration is a sub-process within the broader market registration process, which also includes:
  - Market Participant Registration
  - Connection Assessment and Approval Process
  - Telemetry set-up and testing
  - Meter Registration Process
  - Commissioning Process



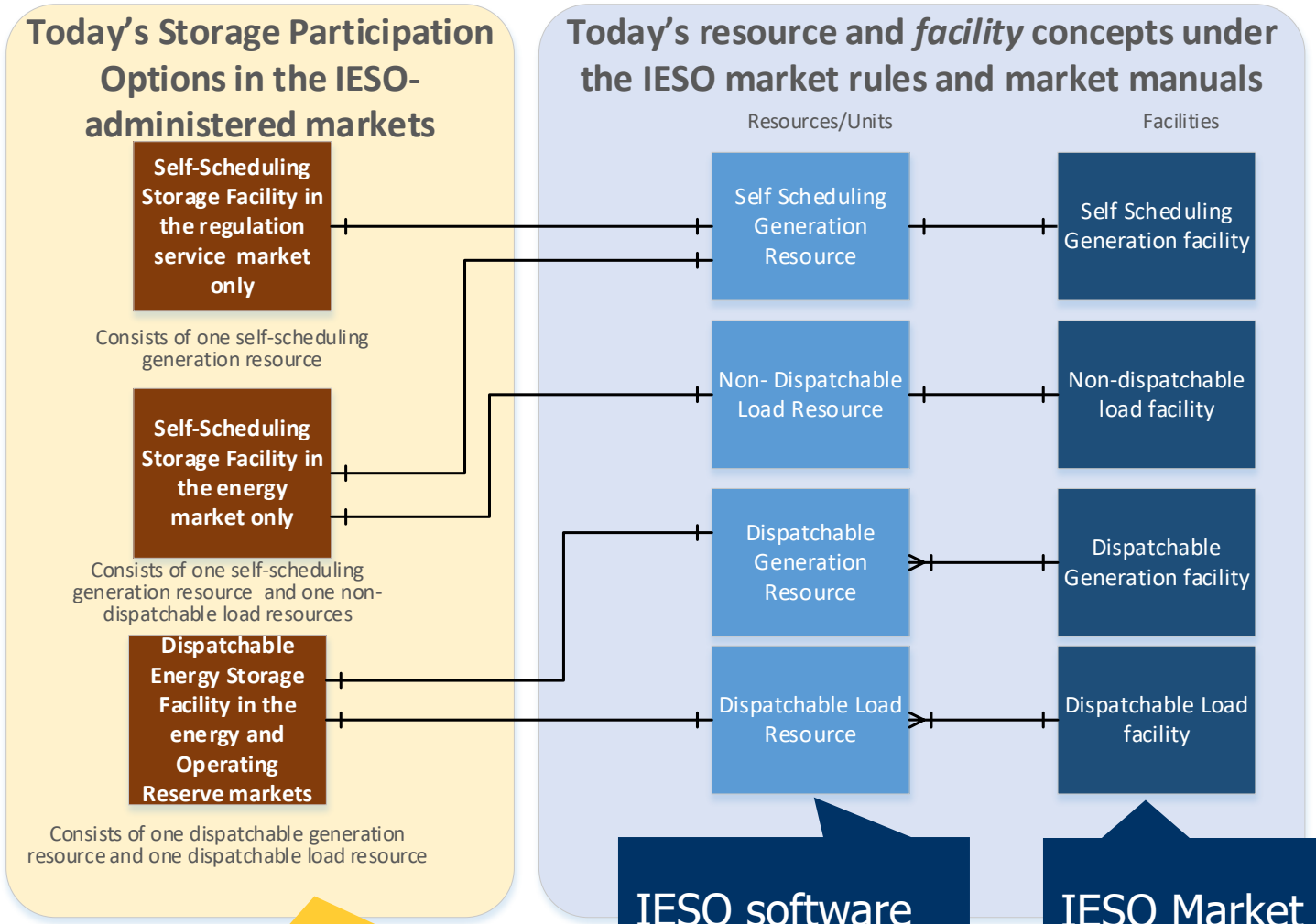
Crucial Terminology: "Facilities" and "Resources"

In today's wholesale market, the market rule concept of a "*facility*" is logically sub-divided into one or more "resources" within the IESO's market systems.

"A **resource** is a representation in the *IESO* registration system of a part of or the entire physical ***facility***. Each resource record is associated with a unique connection point (also referred to as Defined Point of Sale (DPOS), … to the *IESO-controlled grid*.
As a result, a single physical ***facility*** may need to be modeled as two or more **resource** records in the *IESO* registration system."

- **IESO Market Manual 1.2**

Today's Facility Registration Arrangements for Storage Facilities

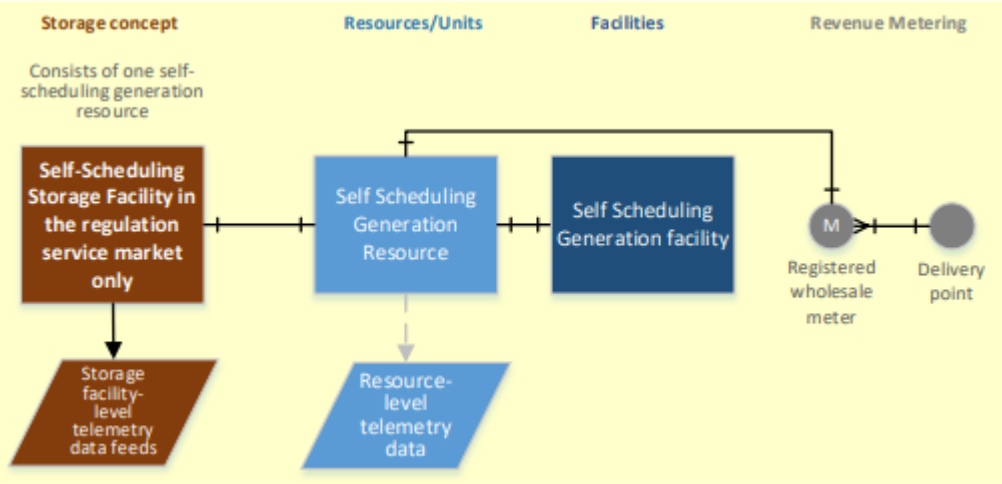


Design document concepts of "energy storage facilities"

IESO software concept of "resources"

IESO Market Rule concept of "facilities"

F.R. 1: Facility Registration requirements for self-scheduling energy storage facilities providing regulation service only



A **self scheduling energy storage facility** providing regulation service only, will be registered as:

- A single, self-scheduling generator **resource**

With…

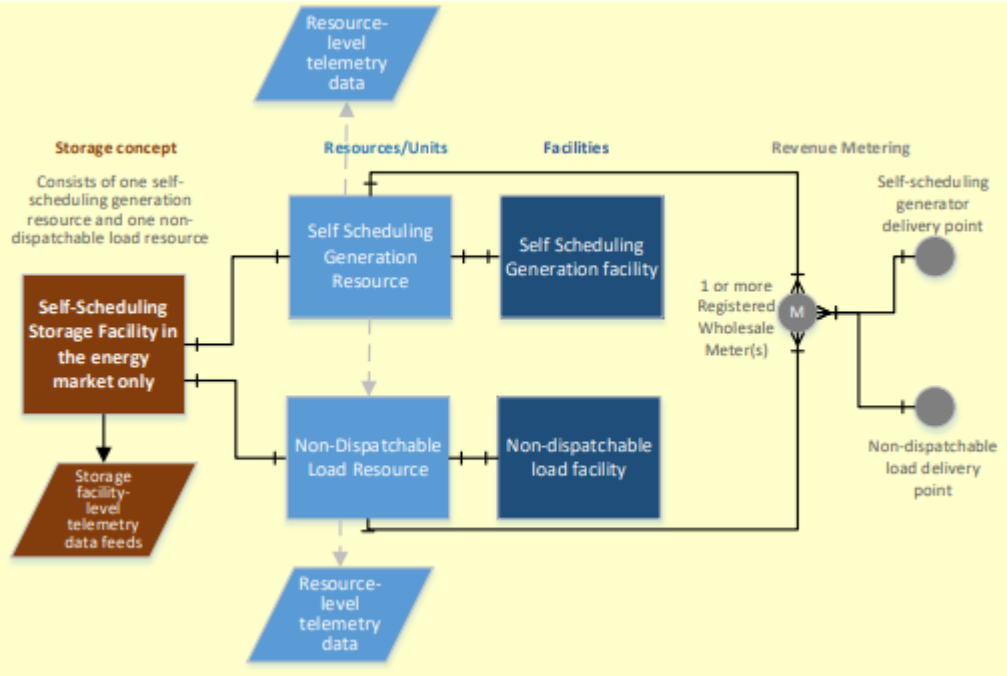
- One or more registered wholesale meters mapped to a single delivery point

Rationale

- In use for the past 5 years with four storage facilities in the IESO-Administered Market
- This is the only feasible arrangement that works with the IESO's current tools construct

Design Features for Market and Facility Registration: F.R. 2 (self-scheduling)

Design Element	Design Question
Market and Facility Registration	How should an energy storage facility be registered into the IESO-administered markets?



A **self scheduling energy storage facility** in the real-time energy market, will be registered as:

- a single, self-scheduling generator resource

AND:

- a single non-dispatchable load **resource**

with…

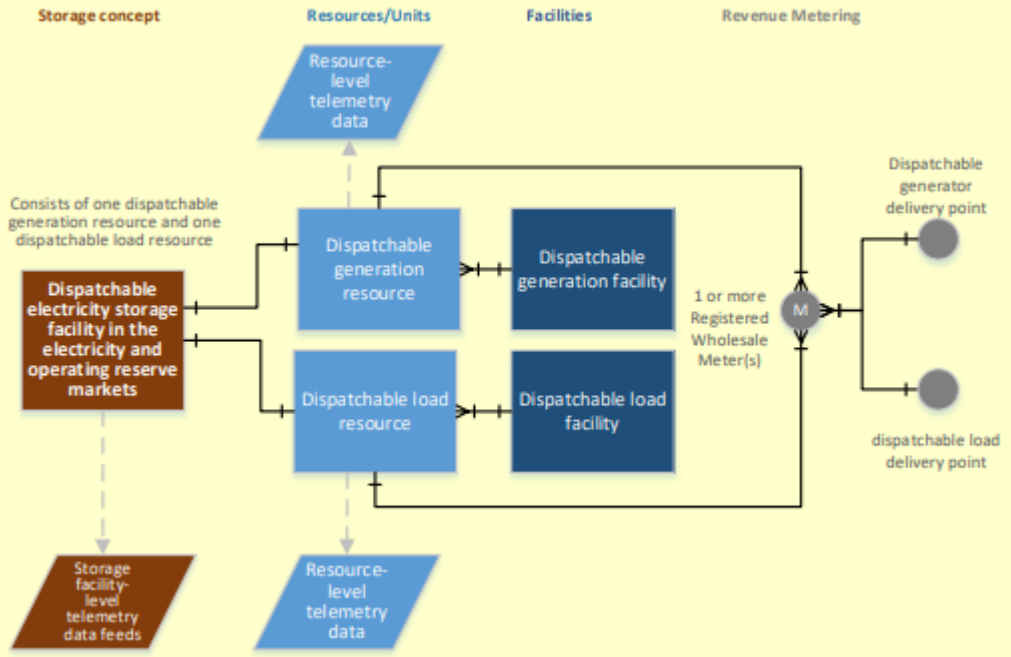
- One or more registered wholesale meters mapped to delivery points for the load and generator resources

Rationale

- In use with the Phase 2 storage fleet today
- Allows participants with small storage facilities <10 MW to self-manage state-of-charge during the Interim Period

Design Features for Market and Facility Registration: F.R. 3 (dispatchable)

Design Element	Design Question
Market and Facility Registration	How should an energy storage facility be registered into the IESO-administered markets?



A **dispatchable energy storage facility** in the real-time energy market, will be registered as:

- a single, dispatchable generator resource

AND:

- a single dispatchable load **resource**

with…

- One or more registered wholesale meters mapped to delivery points for the load and generator resources

Rationale

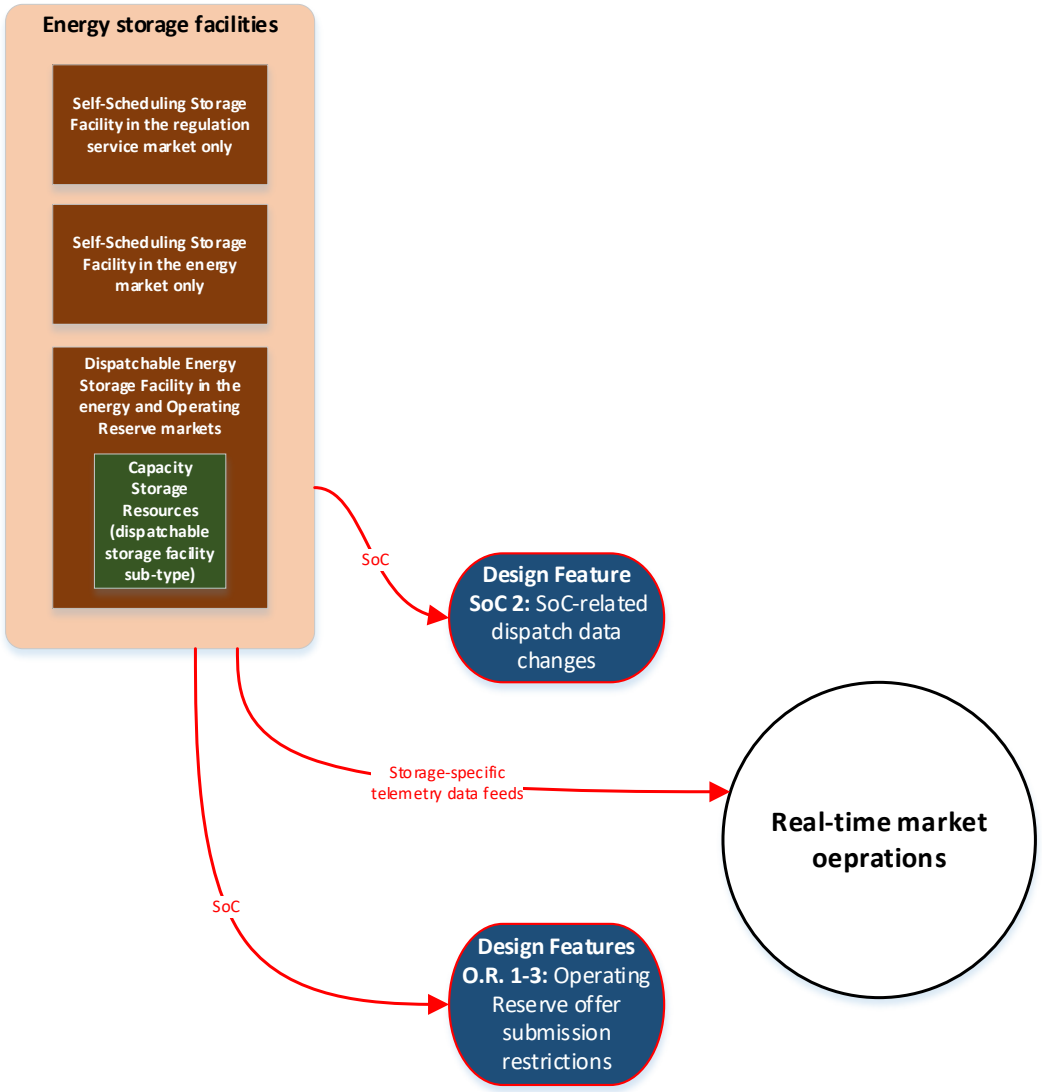
- Currently in use with the Phase 1 energy storage fleet
- Maximize transparency to the market and reduce gaming opportunities
- Congruent with the future SoC management mode where the storage facility's charge and discharge capabilities will be dispatchable

Telemetry for storage sub-types

- All sub-types of storage facilities will need to provide a State-of-Charge (SoC) telemetry feed to the IESO and for use by the participant
- In addition, storage facilities will also be registered to provide telemetry data points* for possible use by the future State of Charge construct

The specific data points are:

- Economic Maximum Power Mode ($ECO\_P_{max,g}$)
- Economic Minimum Power Mode ($ECO\_P_{min,g}$)
- Economic Minimum State of Charge ($ECO\_SOC_{min,g}$)
- Economic Maximum State of Charge ($ECO\_SOC_{max,g}$) see design document for details.



Interim Design Features: Prudential Security

Prudential Security – the basics

- **Purpose: "…to protect the *IESO* and *market participants* from payment defaults."** (IESO Market Rules, Ch. 2 section 5.1.1)
- A condition of participation in the IESO administered markets (IESO Market Rules, Ch. 2 section 5.2.1)
- Requires the initial assessment of a prudential support obligation to be met by each applicable market participant
- Within certain limits, market participants may self-assess their own trading limits to balance the size of prudential support vs. potential frequency of margin calls
- Further reductions to prudential support allowable under a variety of criteria set out in the market rules

Design Feature P.S.1 – balancing the two ends of the risk spectrum

Risk averse viewpoint:
Assess energy storage prudential requirements on the assumption that they will maximize their energy withdrawals, lose money in the market and default on payment at the end of the billing period

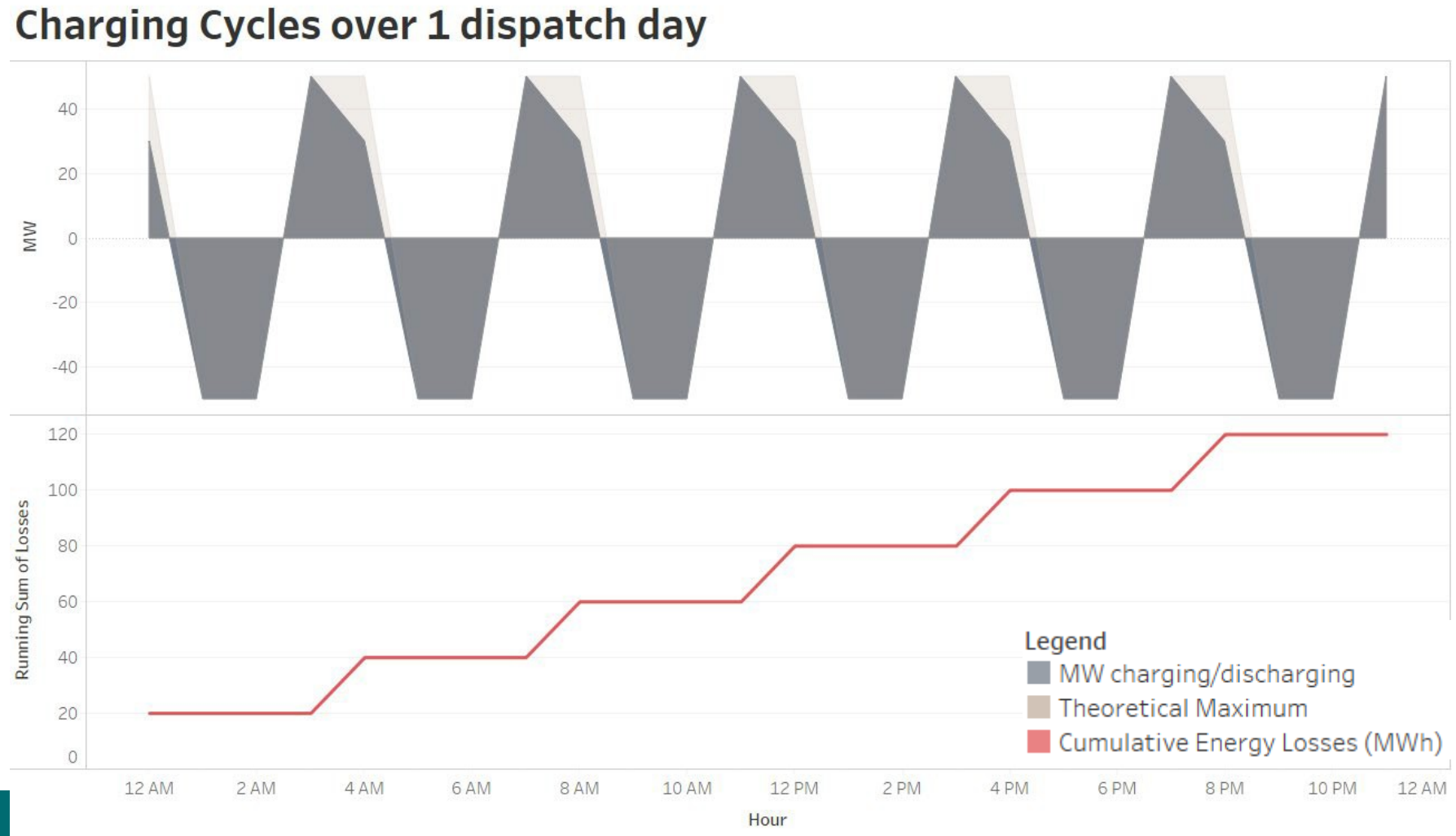
Risk tolerant viewpoint:
Assume all energy storage facilities will successfully navigate the electricity market and will be market creditors at the end of each and every billing period

Design Feature P.S.1: Assess risk on the basis of the energy that will never return to the market due to Cycle Efficiency Losses, using the same, existing rates and parameters that are applied to prudential calculations for energy withdrawals from the market

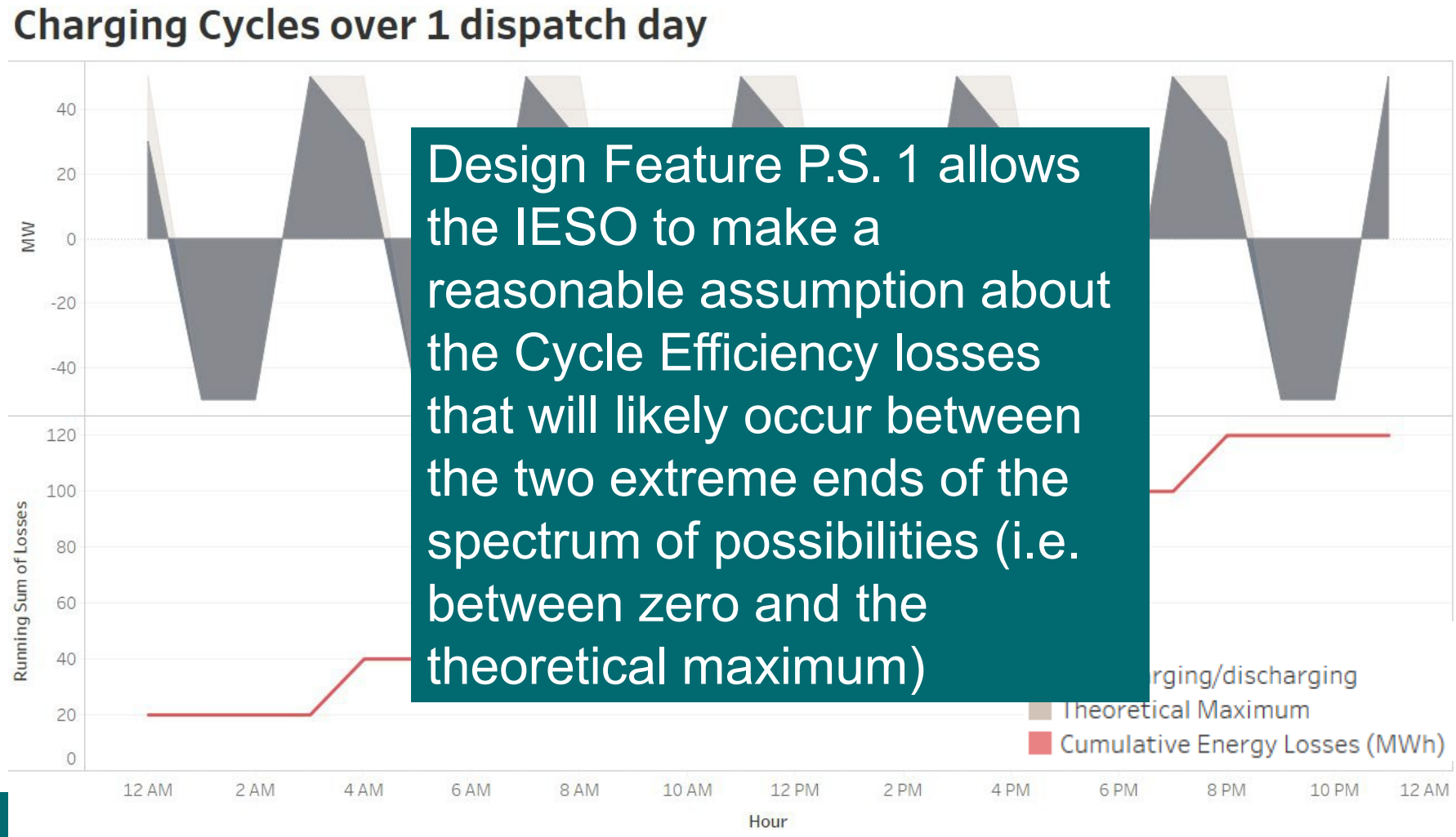
Design Feature P.S. 1

- Design Feature P.S.1 only affects the basis of calculating the "energy exposure" components of the minimum trading limit and default protection amounts, which comprise a market participant's prudential support obligation
- P.S. 1 focuses on the assumed amount of energy which will not return to the market due to Cycle Efficiency Losses over the course of a billing period
- **All other aspects of the current prudential security framework will apply to energy storage facilities**

Theoretical maximum losses for a 50 MW/100 MWh storage facility with a registered Cycle Efficiency of 80% = 120 MWh per day



Theoretical maximum losses for a 50 MW/100 MWh storage facility with a registered Cycle Efficiency of 80% = 120 MWh per day (cont'd)



Design Feature P.S. 1 allows the IESO to make a reasonable assumption about the Cycle Efficiency losses that will likely occur between the two extreme ends of the spectrum of possibilities (i.e. between zero and the theoretical maximum)

Design Feature P.S. 1 (cont'd)

Basis of calculation:

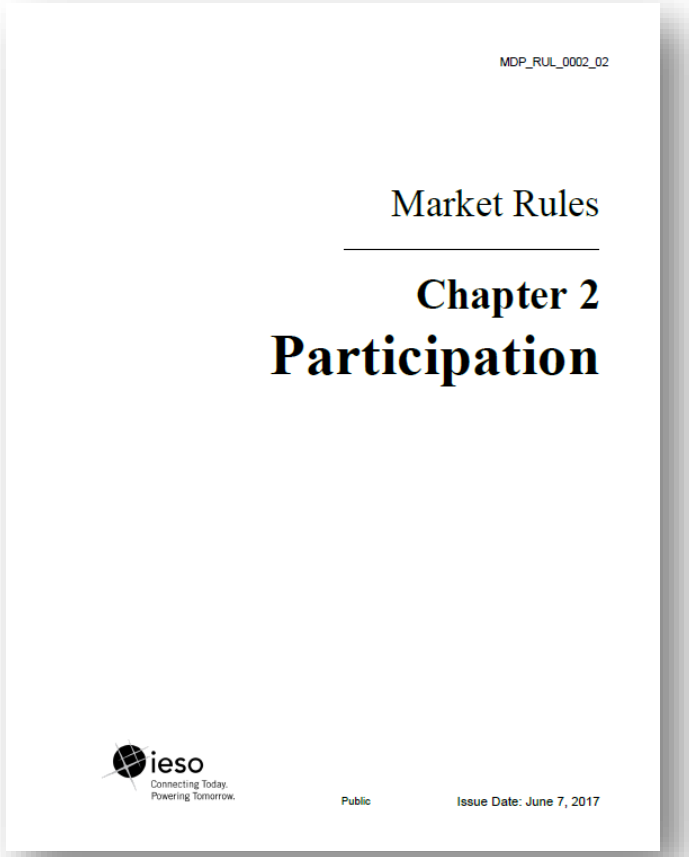
Losses for prudential estimation = Estimated number of charging cycles during the assessment period × (1 – Cycle Efficiency) × $SOCMAX_g$

Where:

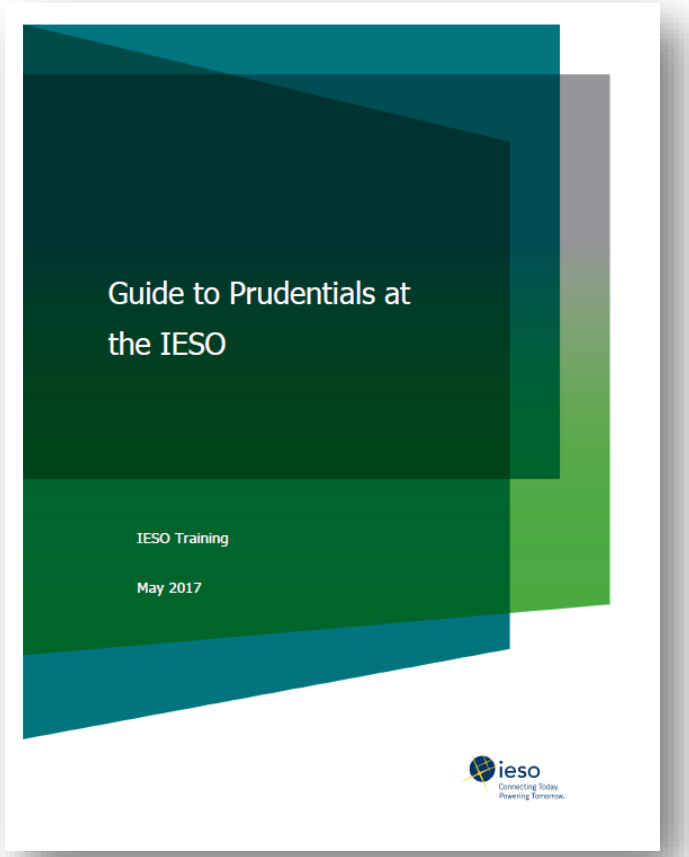
- $SOCMAX_g$ = Registered size of the energy storage facility storage buffer
- Estimated no. of cycles which will be ≤ the theoretical maximum number of cycles
- Cycle Efficiency = Registered Cycle Efficiency of the storage facility

Prudentials: Recommended further reading

IESO Market Rules, Ch. 2,section 5



Guide to Prudentials at the IESO

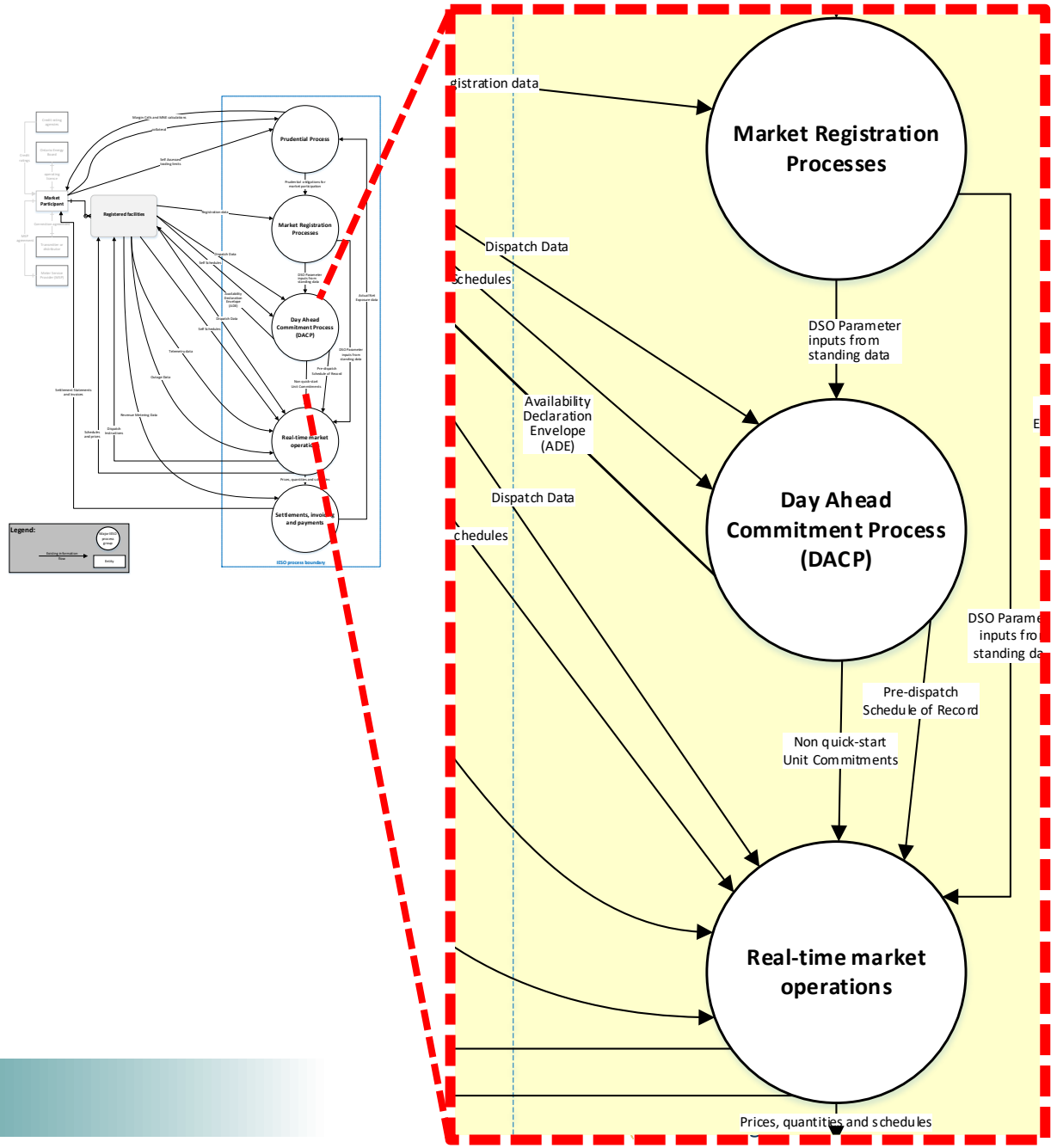


Interim Design Features: Day-Ahead Commitment Process (DACP)

But first… what exactly is the DACP?

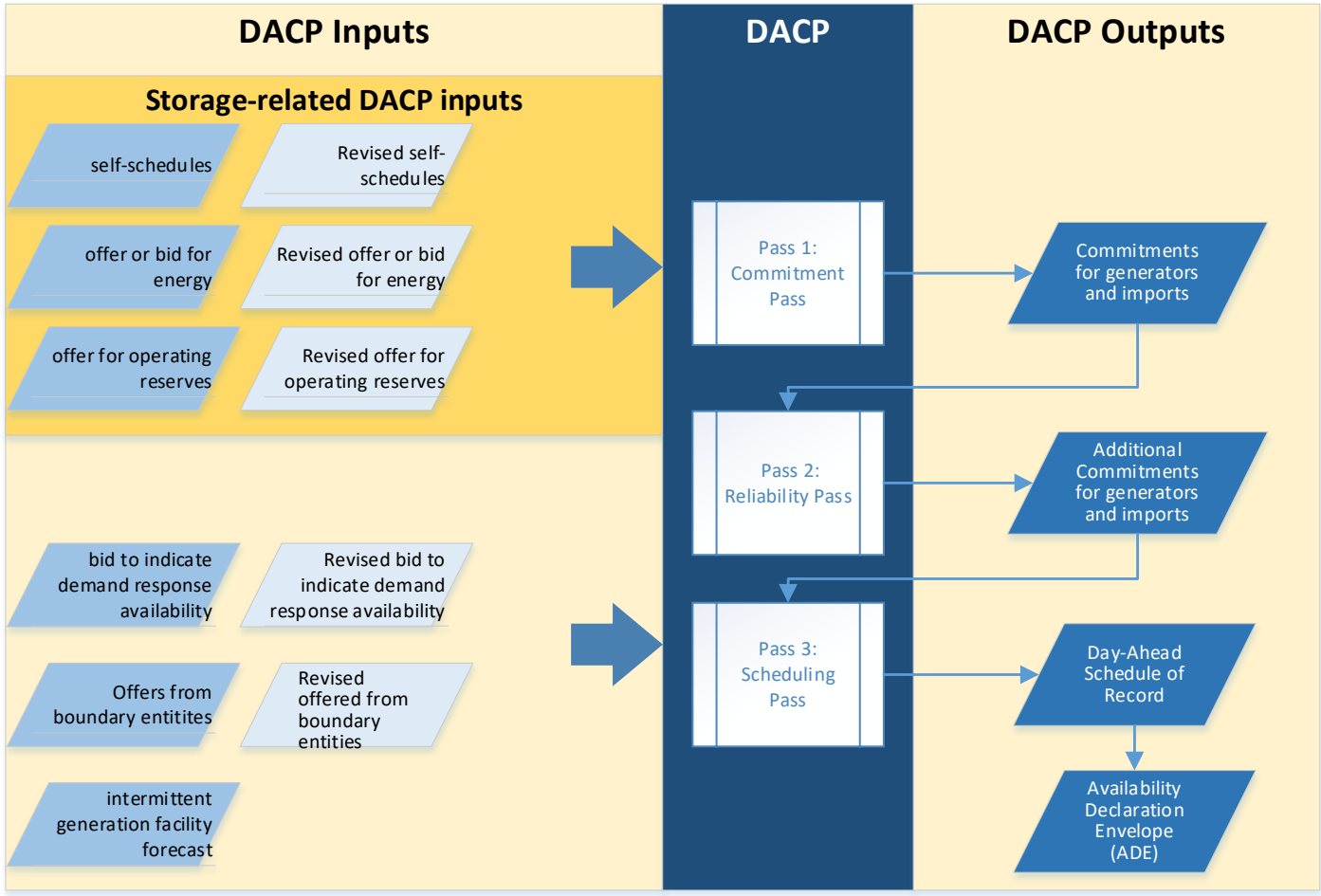
"The DACP uses a dedicated calculation engine to optimize energy and operating reserve for the 24 hours of the next day. The day-ahead calculation engine (DACE) operates over three passes to determine the least- cost security-constrained solution for a dispatch day based on the day-ahead bids and offers submitted by all resources."

IESO Market Manual 1.2

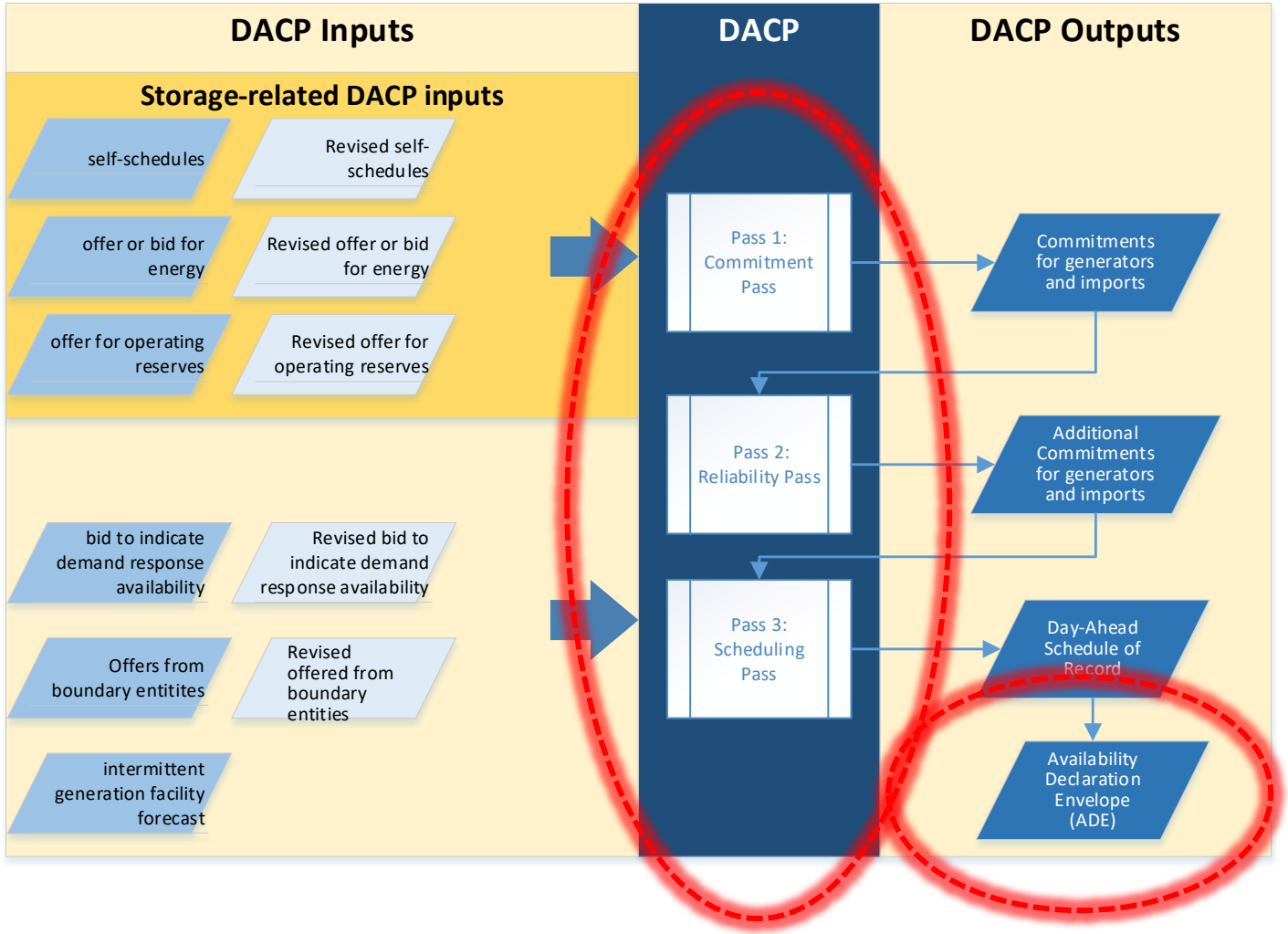


DACP Context

The Day Ahead Commitment Process produces the first pre-dispatch projection for the next dispatch day. It helps ensure that there are adequate resources to meet anticipated demand at the time this first projection is formulated. To do so, all internal resources are required to signal their intent for the next day.



DACP Relevance to Energy Storage



Importance to market participants:
A basic requirement in order to be allowed to participate in the real-time energy market the next day

Importance to overall system reliability: Commitments made to internal and external resources to ensure overall adequacy for the next dispatch day

DACP Design Features – DACP 1-2

Design Element	Design Question
Day-Ahead Market (DAM) and Day-Ahead Commitment Process (DACP): bidding and scheduling of ESRs	How should ESRs participate in the DACP pre-Market Renewal Program?

1. **DACP 1:** All storage facilities must participate, with the exception of those providing regulation service

   Rationale: consistent and fair application of information discovery process used in today's market for all dispatchable and self- scheduling resources

2. **DACP 2**: All dispatchable storage facilities bidding/offering into the DACP must observe the 'no overlap' rule whereby no bid price can exceed any offer price from that facility for a given dispatch hour (more on this in the next section)

   Rationale: to avoid infeasible schedules being issued to energy storage facilities from the Day Ahead Calculation Engine (more on this in Design Feature SoC 1)

Implications of DACP participation

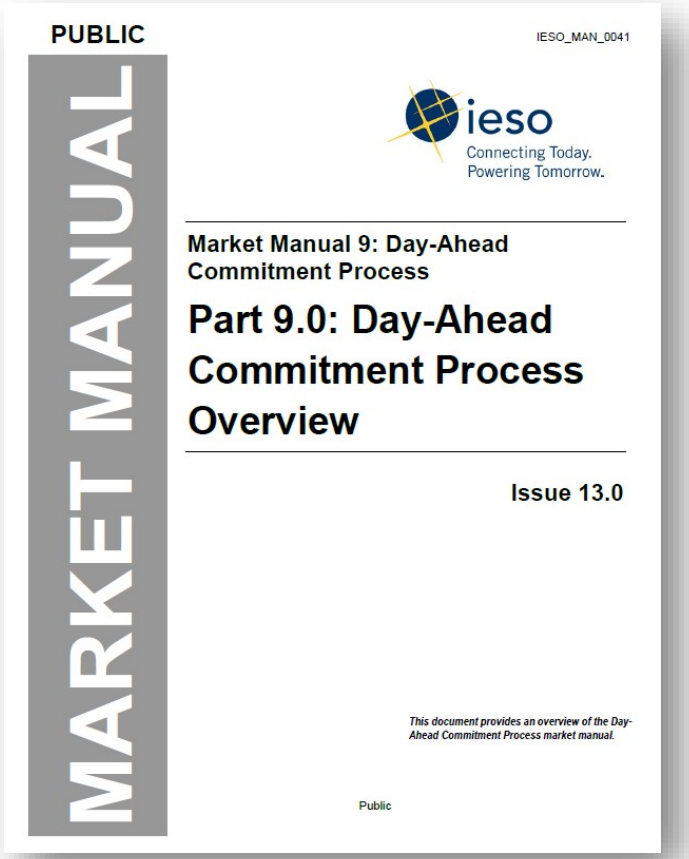
Comparable facility types

Comparable facility types

	Dispatchable generation facility – Non-Quick Start	Dispatchable generation facility – Quick Start	Dispatchable Energy Storage Facility	Self-Scheduling generation facility in real-time market	Self-Scheduling Energy Storage facility in real-time market
Required to submit dispatch data into DACP?	YES	YES	YES	YES	YES
Financially- binding Unit Commitment schedule?	YES	NO	NO	NO	NO
Recovery of committed costs indicated in DACP offers?	YES	NO	NO	NO	NO
Withdrawal Charge for not adhering to DACP schedule	YES	NO	NO	NO	NO
Availability Declaration Envelope (ADE) to participate in real-time market?	YES	YES	YES	YES	YES

DACP: Recommended for further reading

IESO Market Manuals 9.0 to 9.5



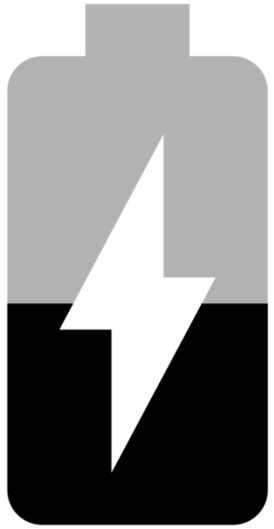
Guide to the Day-Ahead Commitment Process

State-Of-Charge Management in the Real-Time Market

Design Element	Design Questions
State of Charge (SoC) management in Real-Time energy market	Who should optimize SoC of energy storage facilities in the real-time energy market: the energy storage facility, the system operator; or give ESRs the choice?

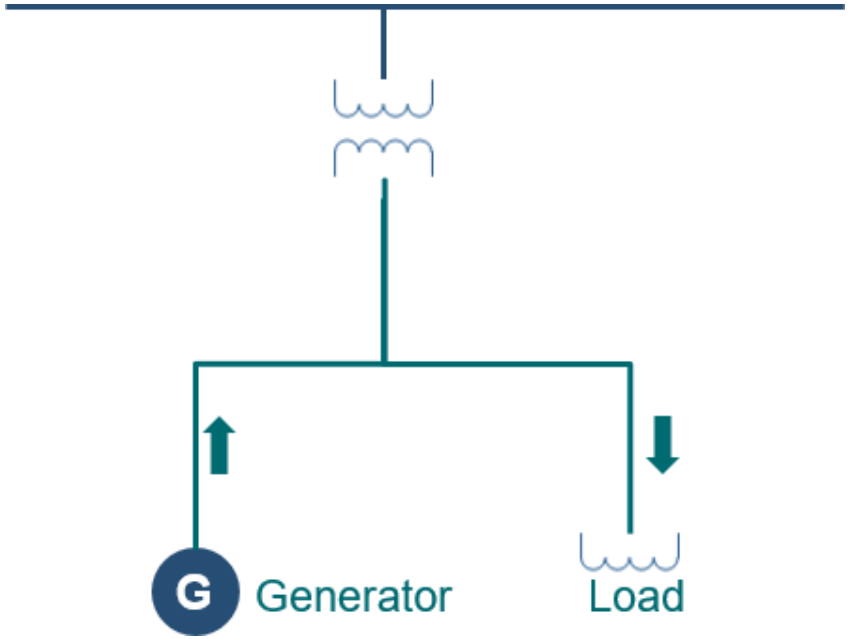
A specific barrier within the IESO's dispatch system lies at the heart of solving several of these issues

Reality



A **SINGLE** storage facility that can withdraw, store and inject energy

What the IESO system model sees



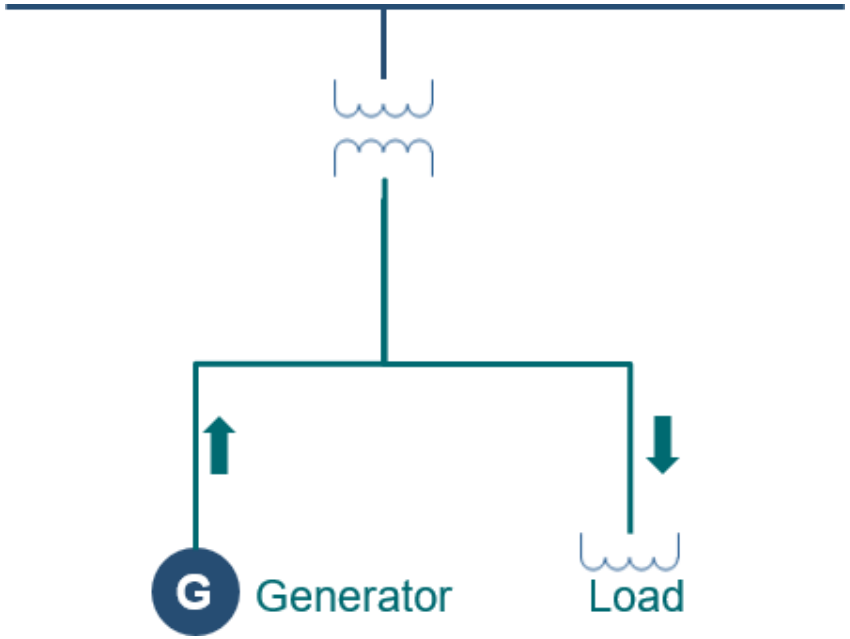
TWO separate facilities with no storage capacity and no discernable relationship with each other

A specific barrier within the IESO's dispatch system lies at the heart of solving several of these issues (cont'd)

The Result

- Storage facilities cannot provide regulation service and be dispatchable at the same time – creating a barrier to broader market participation
    - *Increased competition could benefit ratepayers through lower resource costs*
- Potential for conflicting dispatch between the two facility components modeled
    - *Facility may not respond as anticipated by IESO*
- Dispatch Scheduling and Optimization model has no awareness of storage capacity or ability to optimize it
- Regulation storage facilities not seen in pricing calculations
    - *Leading to injections/withdrawals that are not factored into market price*

What the IESO system model sees



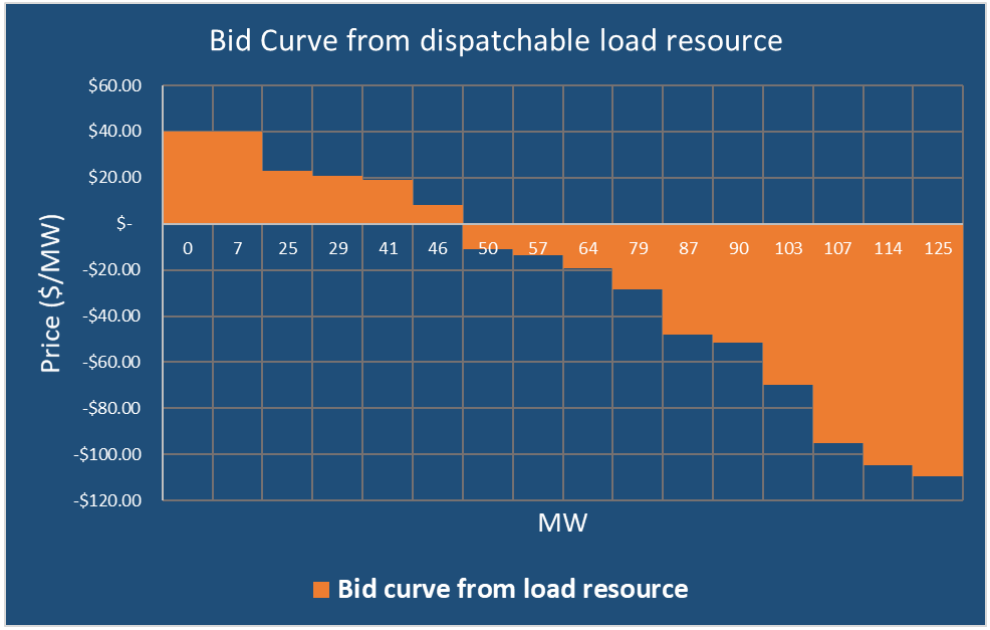
TWO separate facilities with no storage capacity and no discernable relationship with each other

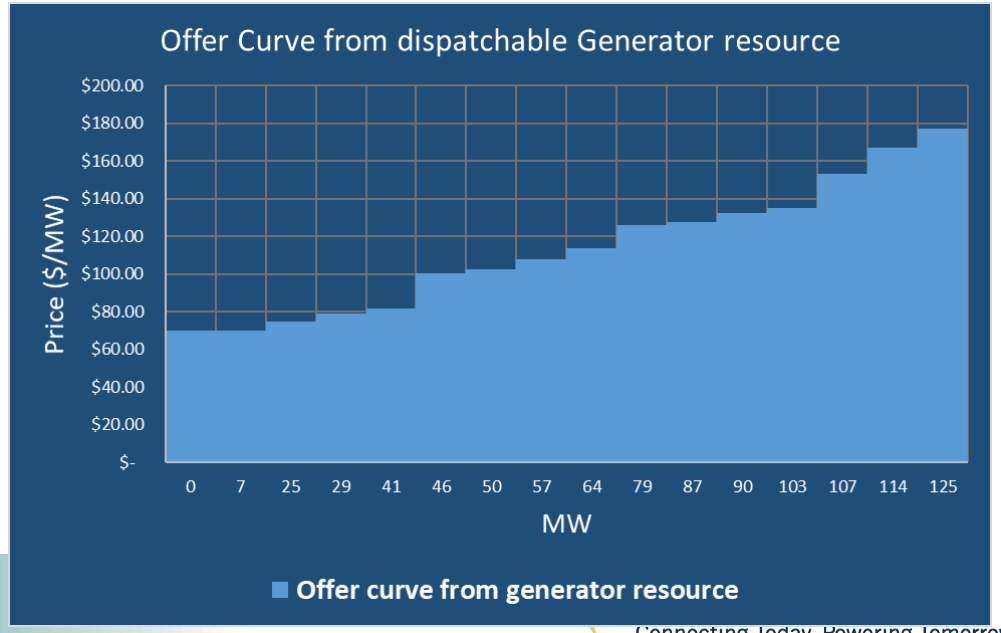
SoC Management Design Features – SoC 1-2

1. **SoC 1:** The "no-overlap" rule for dispatchable energy storage facilities: Ensure that bid prices (to charge) cannot exceed offer prices (to discharge) for any given facility in any given hour. This is a preventative measure to help avoid the infeasible dispatch problem during the Interim Period.
2. **SoC 2:** Allowing energy storage facilities to signal state of charge limitations to the IESO prior to each dispatch hour. This measure is also intended to reduce the instances where a storage facility may have to refuse a dispatch instruction.

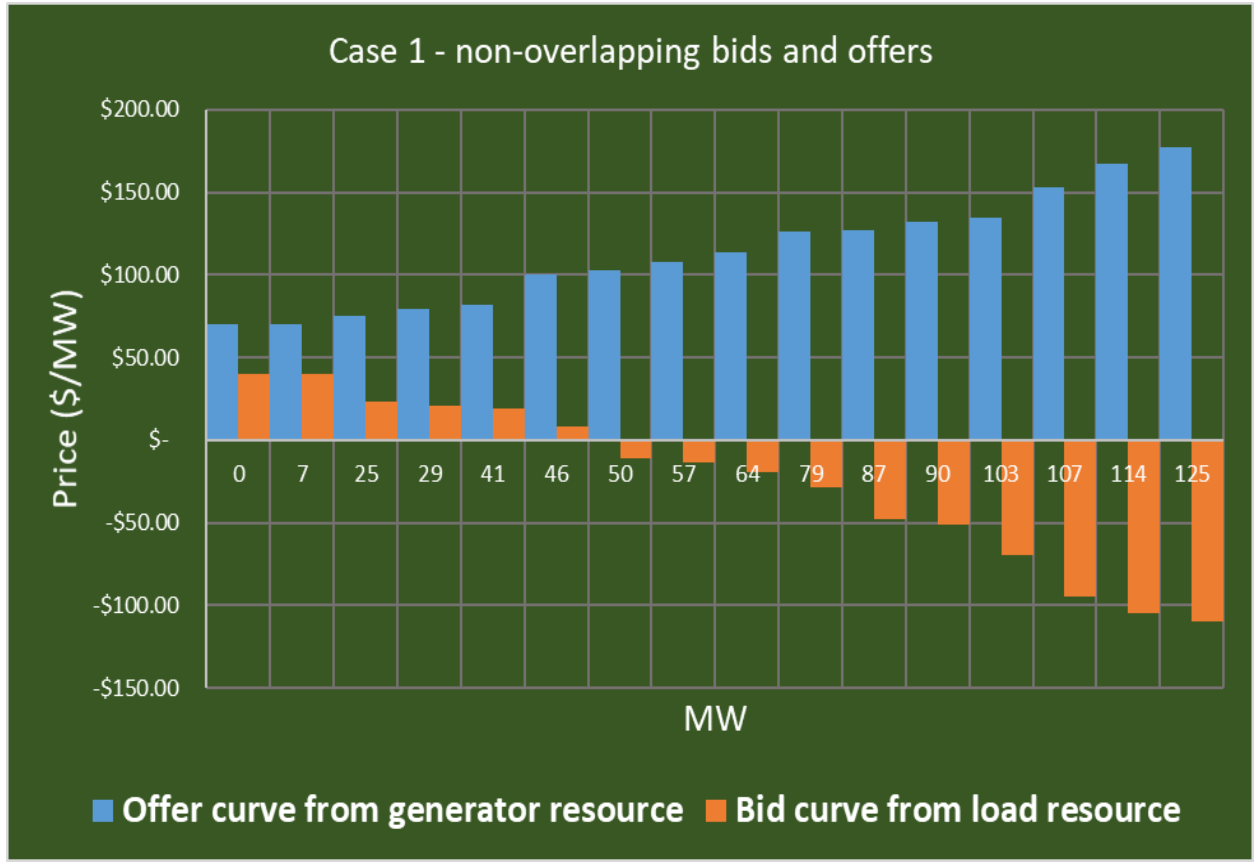
Design Feature SoC 1 – What does "overlap" mean?

"**Overlap**" constitutes any situation where a bid price for any segment of the bid curve for the dispatchable load resource is greater than or equal to the price of any segment of the offer curve for the corresponding dispatchable generation resource.

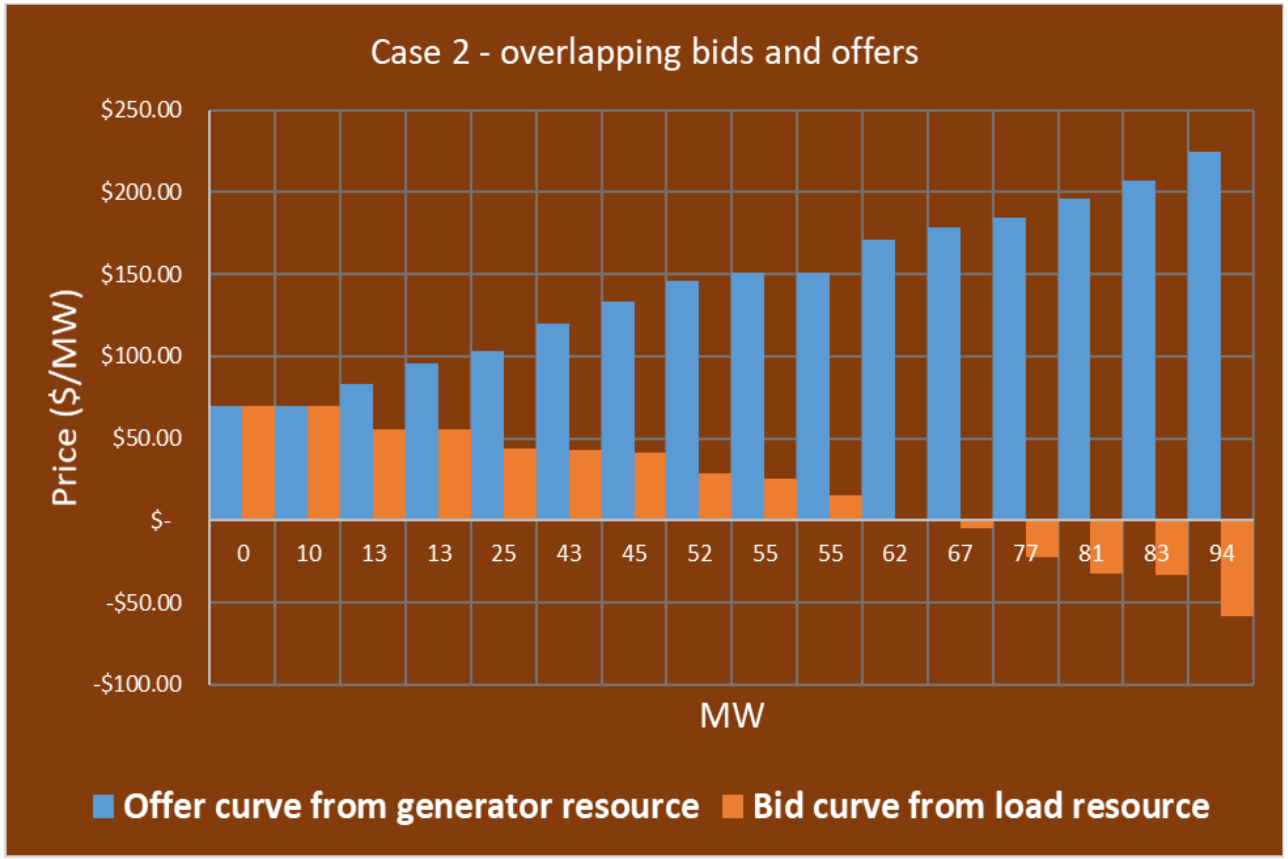




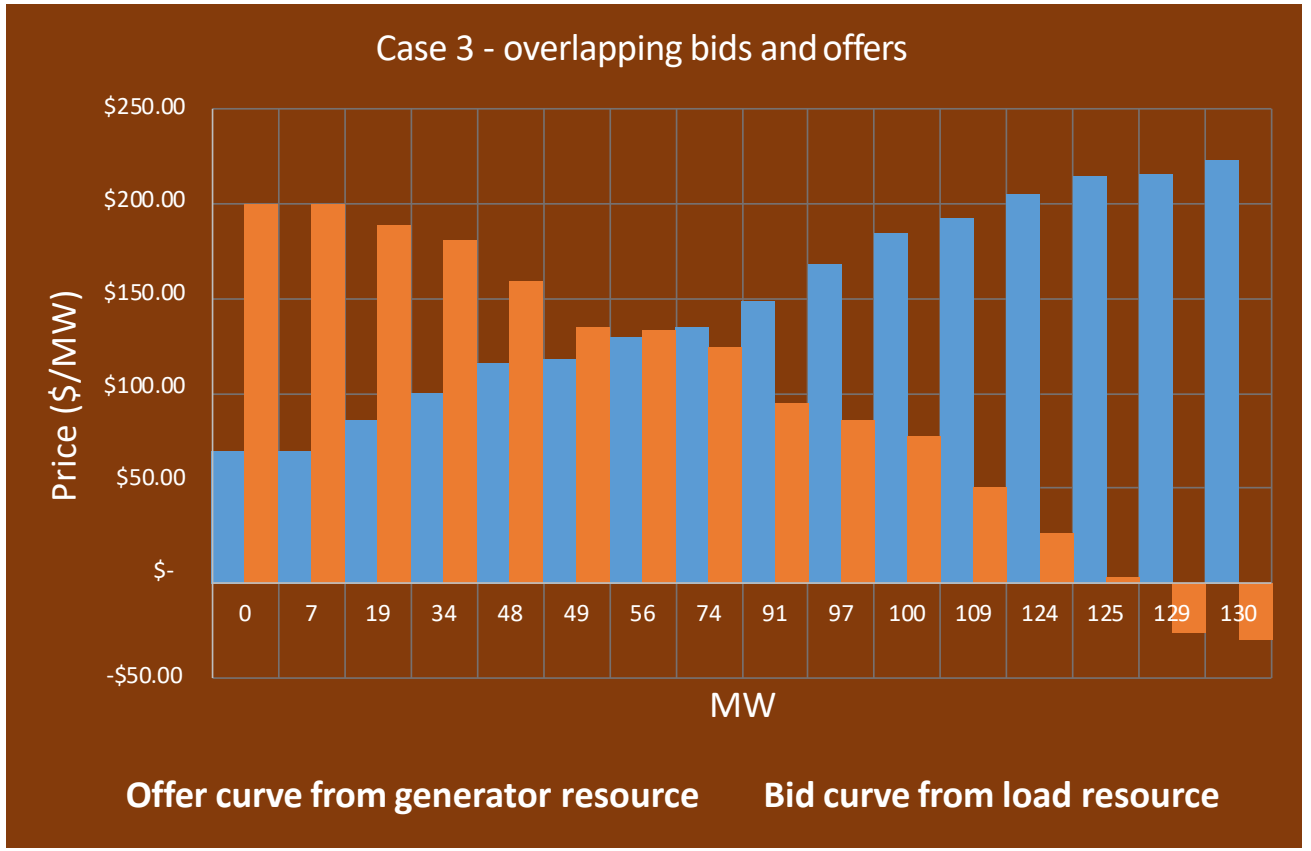
Example 1 – Acceptable bid/offer combination where the bid curve and offer curve for a storage facility do not overlap



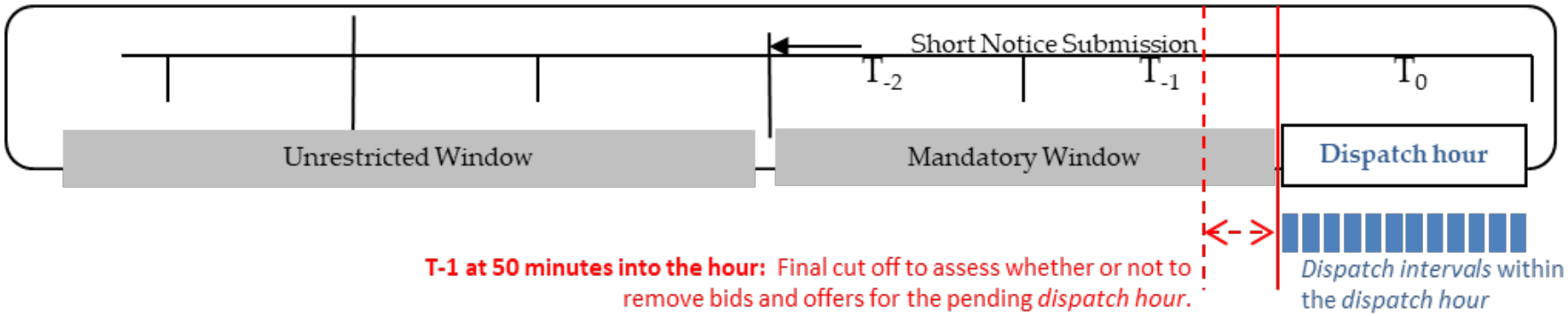
Example 2 – Unacceptable bid/offer combination where a portion of the bid curve price is equal to a portion of the curve price



Example 3 – Unacceptable bid/offer combination where a portion of the bid curve price is greater than a portion of the curve price

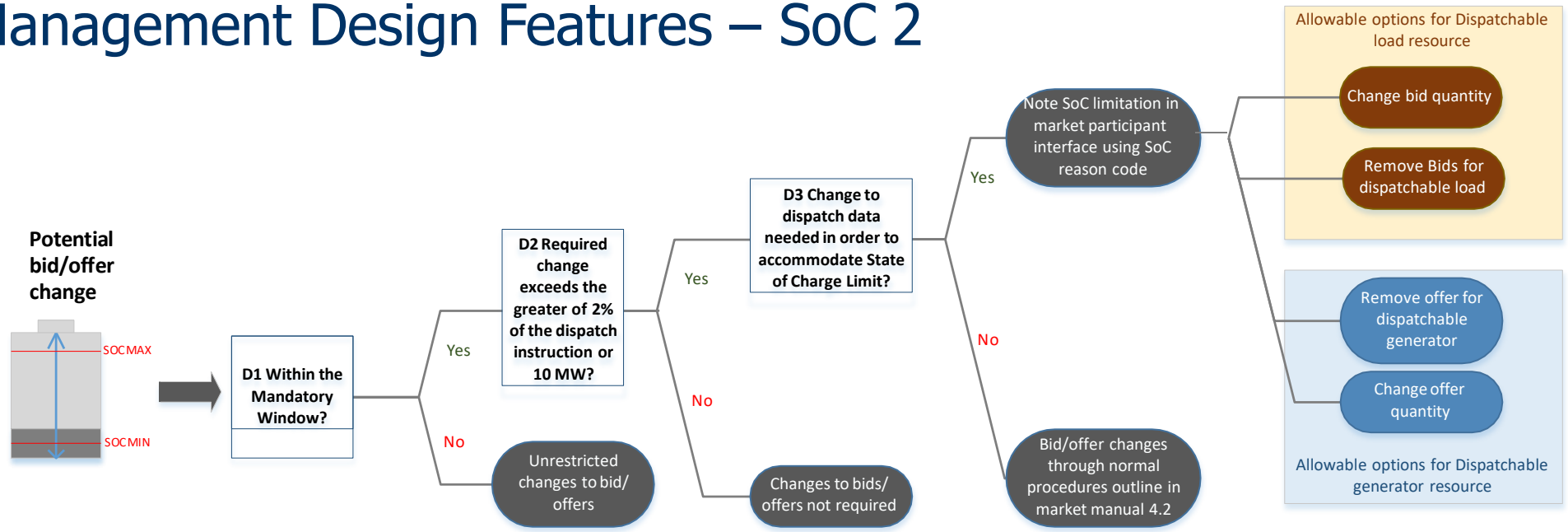


Design Feature SoC 2 – addressing potential changes to SoC-limited bids and offers



- **Timeframe:** This design feature focuses on potential changes to *dispatch data* during each "Mandatory Window", which occurs over two hours prior to each dispatch hour
- Each Mandatory Window ends at 10 minutes prior to each dispatch hour

SoC Management Design Features – SoC 2

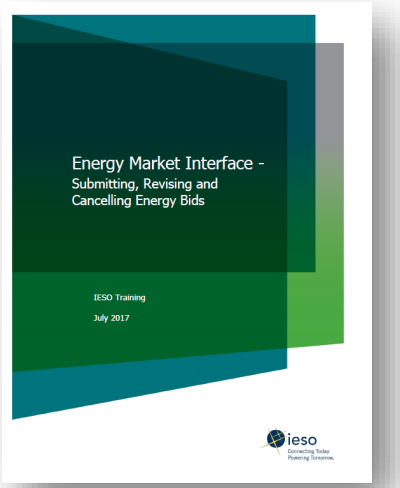


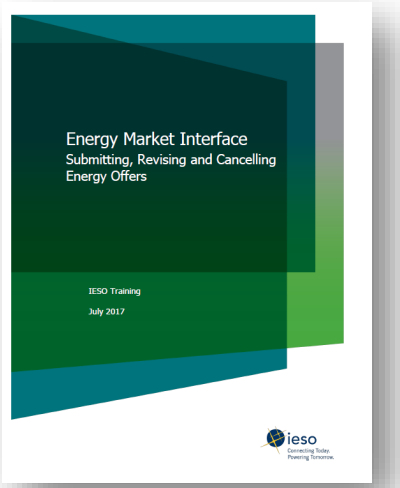
- Design Feature SoC 2 describes the decision logic that a storage facility needs to follow during the Mandatory Window in order to manage its state-of-charge
- **Note:** The specific method of informing the IESO of SoC limitations is still under review by the IESO and may change in the final edition of the SDP design document

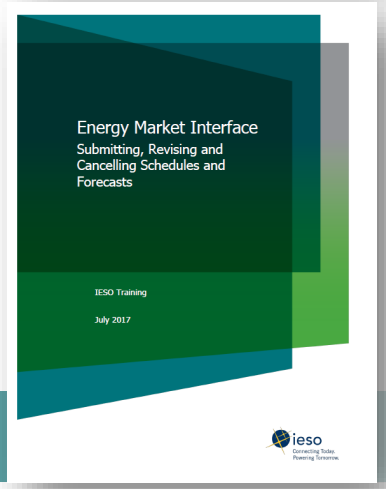
Real-time bid/offer submission: Recommended further reading

Market Manual 4.2

Interface training guides for dispatch data and schedule submissions.







Operating Reserve Participation

Design Element	Design Question
Real-time energy and operating reserve markets: bidding and scheduling of ESRs	What guidelines or restrictions should be placed on ESRs providing operating reserve?

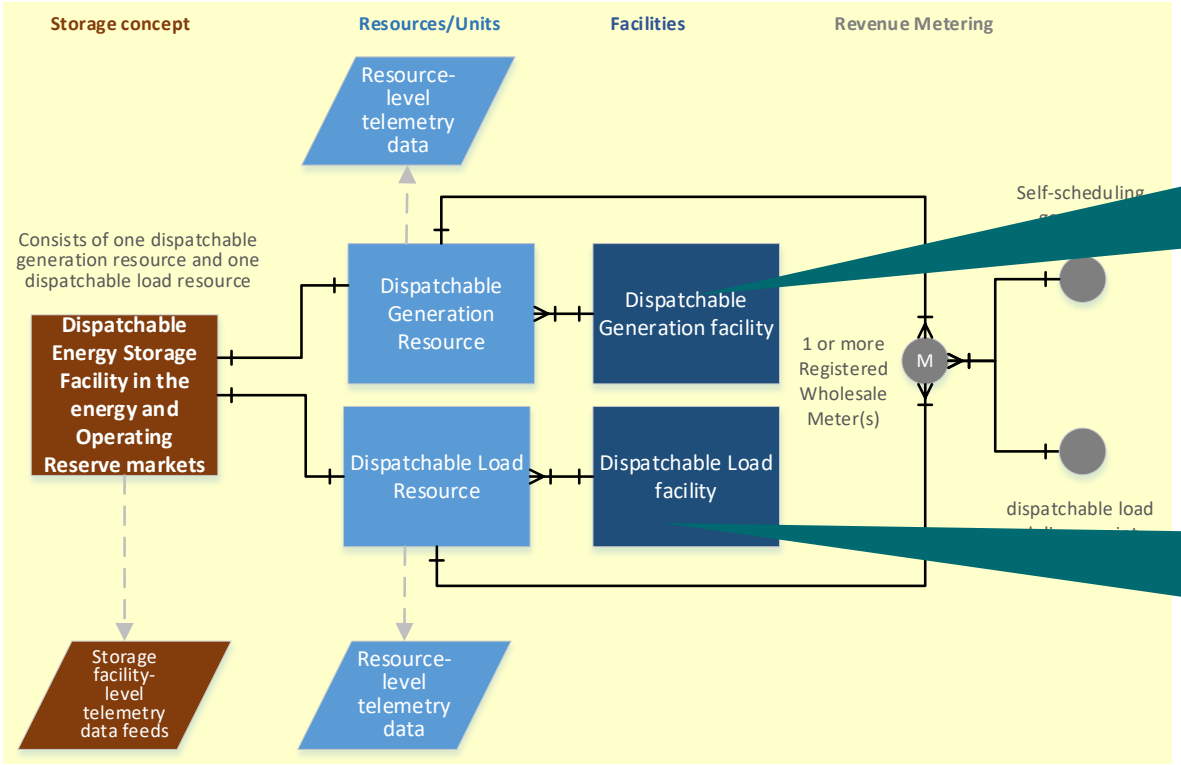
Prerequisites to Offer Operating Reserve

- Must be a dispatchable energy storage facility
- Must have specific authorization from the IESO to provide operating reserve from the facility registration process
- Facility must have a minimum duration of service to satisfy the requirements of O.R. 2 and O.R. 3

Operating Reserve Design Features O.R. 1-3

1. **O.R. 1:** No simultaneous operating reserve offers from the generation and load resources comprising a dispatchable energy storage facility
2. **O.R. 2:** Minimum duration of service requirement to offer operating reserve from the dispatchable load resource comprising an energy storage facility
3. **O.R. 3:** Minimum duration of service requirement to offer operating reserve from the dispatchable generation resource comprising an energy storage facility

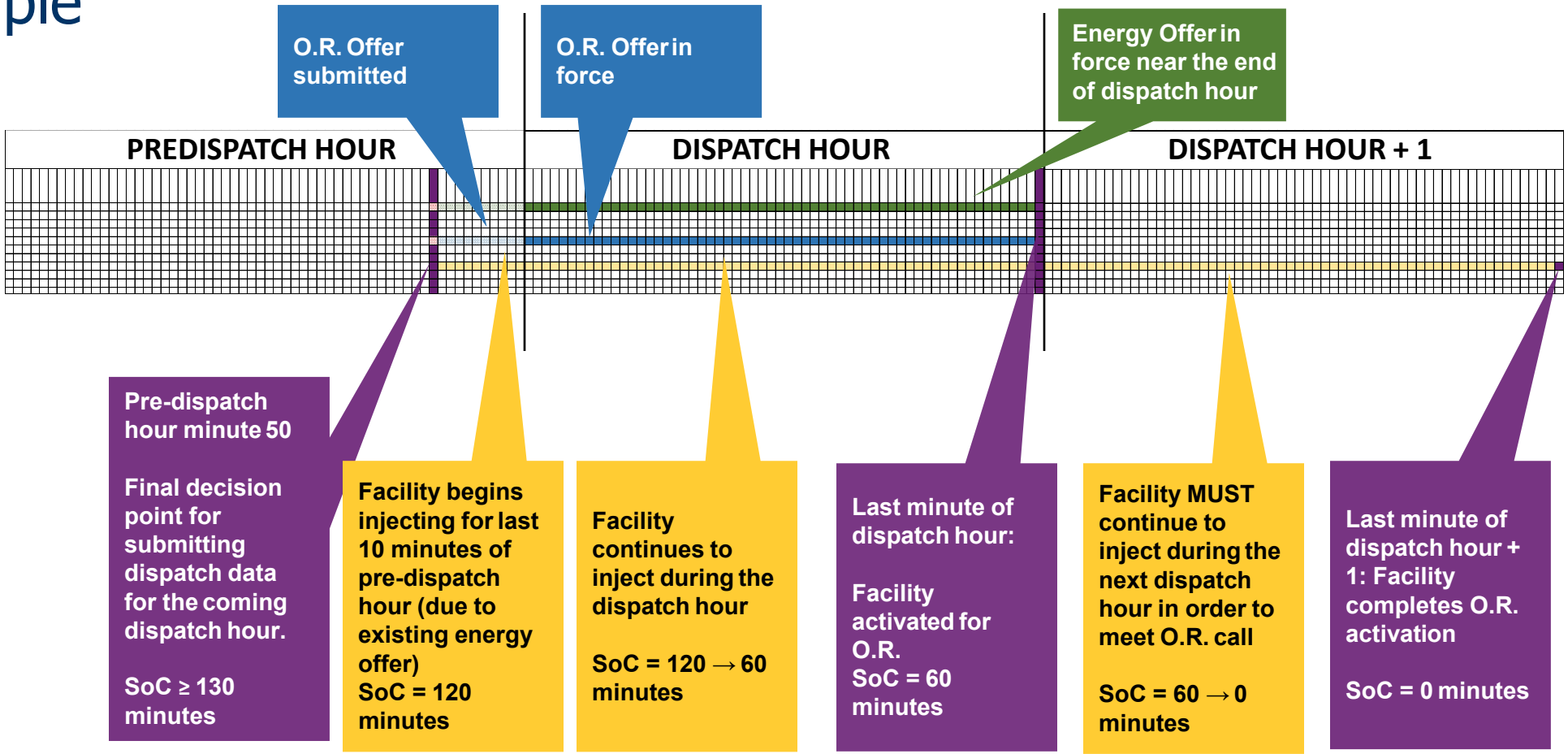
Operating Reserve minimum duration of service requirements



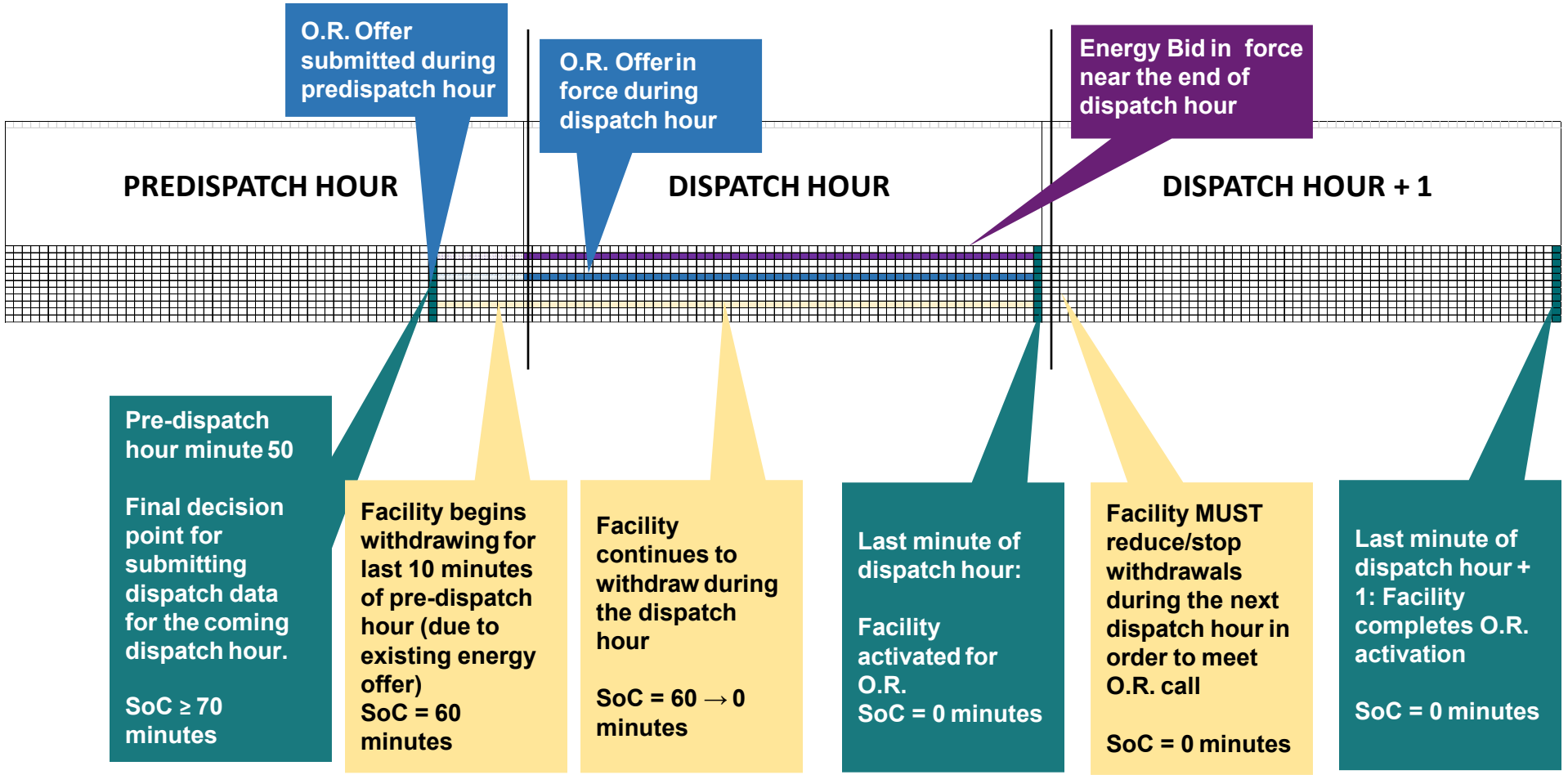
Generation Resource, minimum duration of service: 130 minutes in order to be able to provide operating reserve for the coming dispatch hour

Load Resource, minimum duration of service: 70 minutes in order to be able to provide operating reserve for the coming dispatch hour

Requirement: Meeting the 'worst case scenario'. Example: **Generation** resource comprising a storage facility – 130-minute Duration of Service example



Requirement: Meeting the 'worst case scenario'. Example: **Load** resource comprising a storage facility. 70-minute Duration of Service



Operating Reserve Design Features O.R. 1-3 (cont'd)

Design Element	Design Question
Real-time energy and operating reserve markets: bidding and scheduling of ESRs	What guidelines or restrictions should be placed on ESRs providing operating reserve?

Operating Reserve Design Features O.R. 1-3 (cont'd again)

Design Feature	Proposed Design	Rationale
O.R. 1	**No simultaneous O.R. offers from the load and generator resource comprising a storage facility**	• Infeasible to expect a facility to reduce consumption and increase injections at the same time. • The integrity of the O.R. product must always be safeguarded
O.R. 2 and O.R. 3	**Minimum SoC requirements for the generator or load resource comprising a storage facility to offer O.R. for the pending dispatch hour and sustain an O.R. activation for at least 1 hour thereafter**	• The IESO cannot knowingly allow any participant to offer operating reserve unless they can sustain O.R. for at least 1 hour from any moment during a dispatch hour in which the activation might occur.

Operating Reserve: Recommended further reading

Market Manual 4.2

Guide to Operating Reserve

Next Steps: Request for Feedback

- The IESO is requesting stakeholder feedback on whether Interim Design Features captured within the design document offer pragmatic solutions for integrating energy storage into the IESO Administered Markets in the near term

- Please use the feedback form that can be found under the February 18, 2020 entry on the ESAG webpage and send to enagegement@ieso.ca by March 3, 2020

- The IESO will work to consider feedback and incorporate comments as appropriate and post responses on the ESAG webpage