NOVEMBER 10, 2026

Technical Panel Education: Ramp Rates for Battery Energy Storage System Facilities



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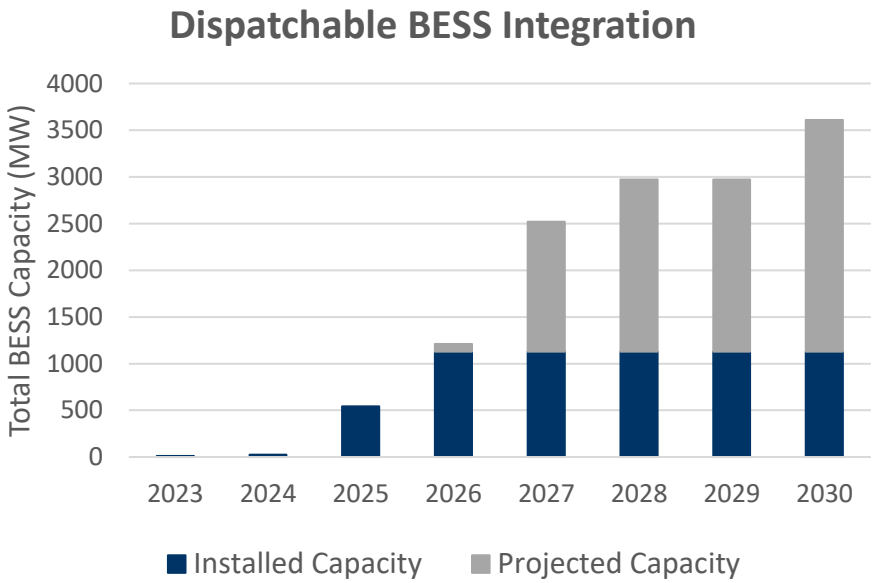
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- Context Setting: IESO Mandate & System Balancing
- Deeper Dive: How is System Balancing Maintained?
- Fast Ramping Capabilities & Impacts to System Balancing
- Stakeholder Feedback, Market Rule Impacts and Next Steps
- Appendix

Introduction

Introduction

- Ontario's electricity grid is undergoing significant change with ~3,600 MW of new Battery Energy Storage Systems (BESS) expected to become operational by 2030
- BESS, like all resources, play a critical role in supporting system reliability and overall adequacy.



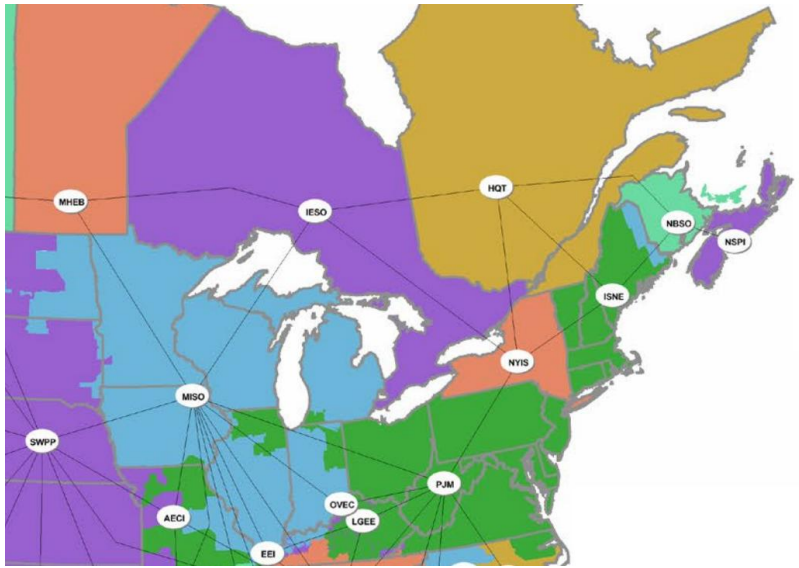
Introduction

- Near-instantaneous ramping characteristics are beneficial for quick response to system contingencies; however, they can pose challenges to system stability under normal operating conditions. Such behavior can negatively impact the Area Control Error (ACE), which the IESO must manage in accordance with North American Electric Reliability Corporation (NERC) standards.
- While near-instantaneous ramping is currently not the sole or primary cause of ACE challenges in Ontario, the impact of this characteristic on ACE is expected to significantly increase as more fast-ramping resources begin operating on the IESO-controlled grid (ICG).

Context Setting: IESO Mandate & System Balancing

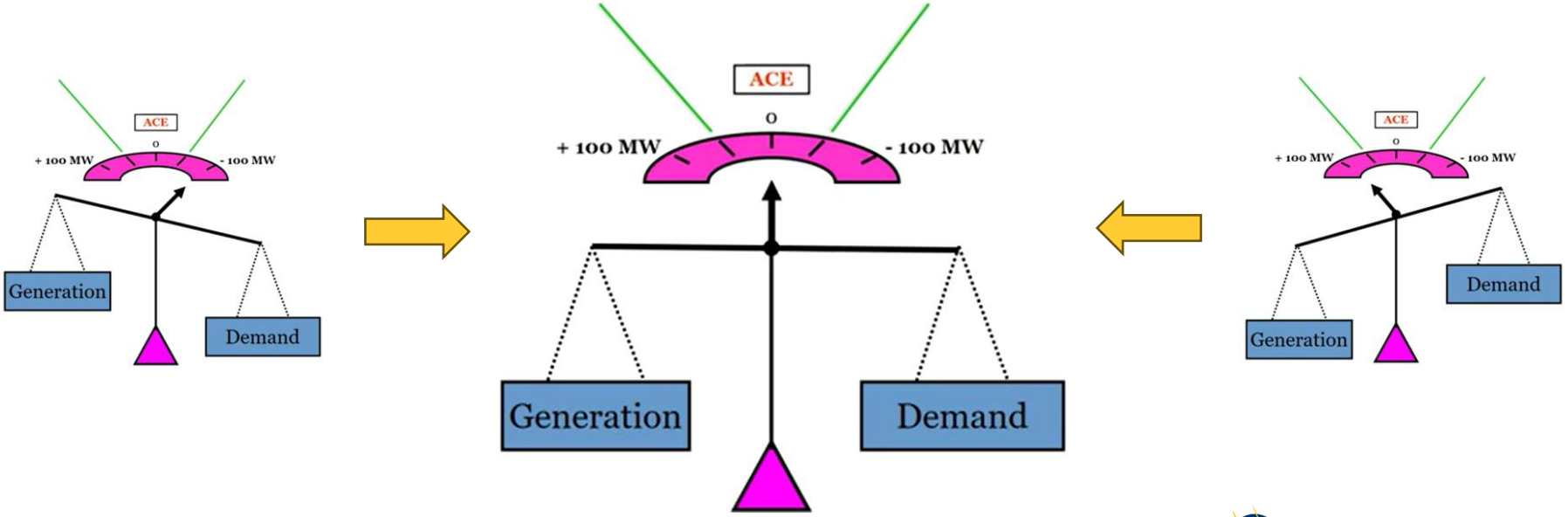
IESO and Neighbouring Balancing Authorities (BAs)

- As a Balancing Authority (BA), the IESO is obligated to manage reliability and maintain the real-time balancing of load and generation within our Balancing Authority Area (BAA)
- The IESO must operate within NERC's BAL Standards and regulate Area Control Error (ACE) to limit frequency deviation and grid disturbance.
    - ACE is a measure of the imbalance between generation and load within a BAA and its role in maintaining interconnection frequency at 60Hz



Relation between Generation, Demand and ACE

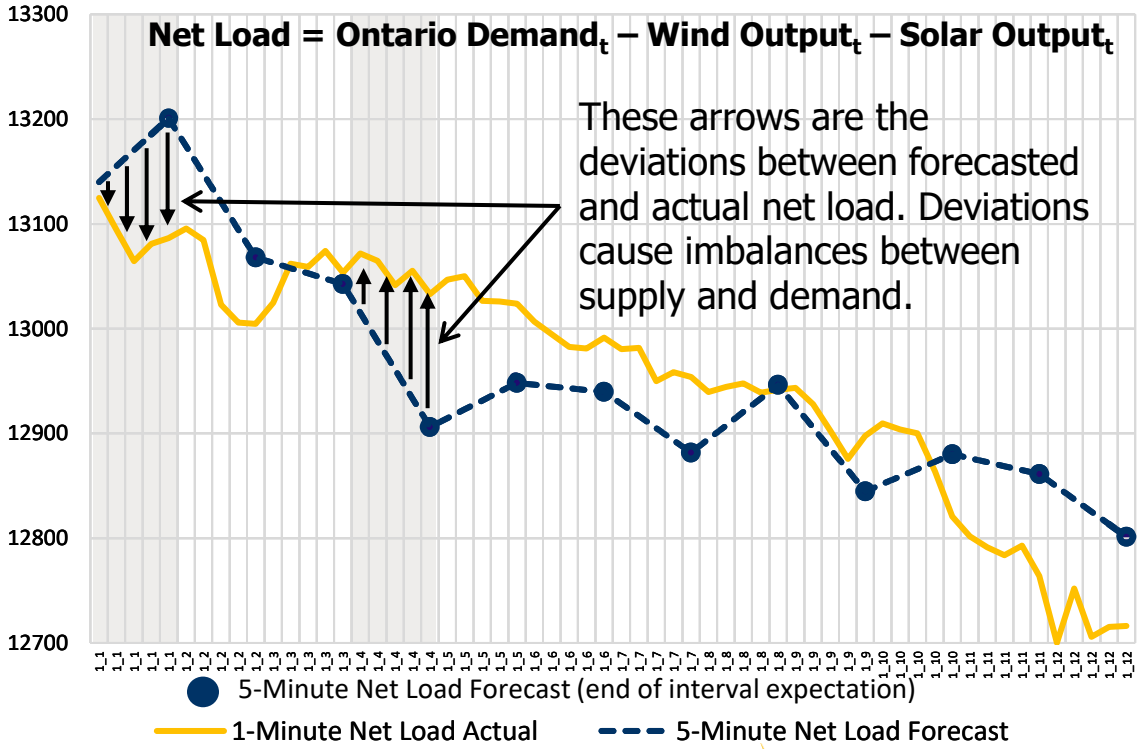
- System balance must be maintained at all times, second-to-second and minute-to-minute.



Deeper Dive: How is System Balancing Maintained?

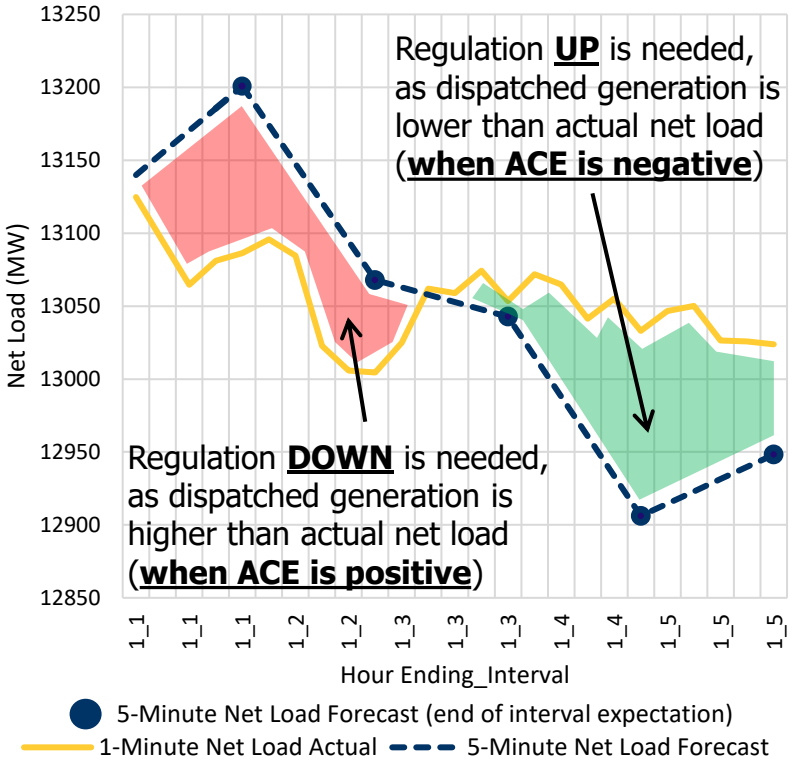
How does 5-minute Dispatch Work

- The IESO uses 5-Minute Ontario Demand Forecasts and 5-Minute Variable Generation (Wind and Solar) Forecasts to determine how much additional generation must be dispatched from the fleet
- Any mismatches between the forecasts and the actuals will cause imbalances



Regulation Service

- **What is it?** Regulation provides minute-to-minute balancing to ensure electricity supply matches demand and is currently provided by generation facilities with Automatic Generation Control (AGC) capability, which permits them to vary their output in response to signals sent by the IESO
- **Why is it required?** NERC BAL-001 assesses a Balancing Authority's ability to maintain Interconnection frequency within defined limits, and prescribes requirements that are meant to maintain balancing in the minute-to-minute timeframe as part of normal system operations



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Fast Ramping Capabilities & Impacts to System Balancing

Fast Ramping Capabilities & Impacts to System Balance

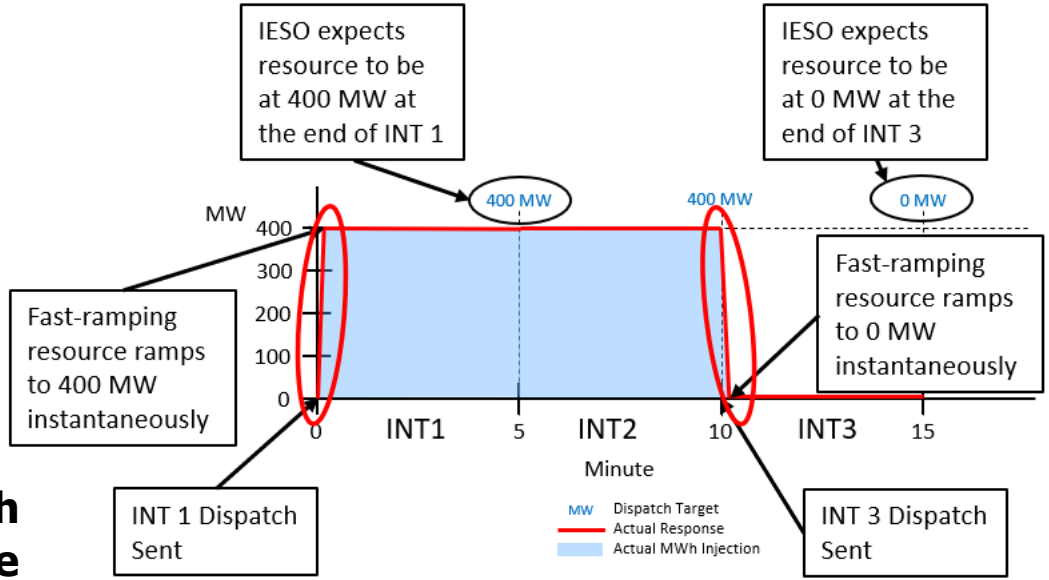
- Dispatch instructions issued by the DSO indicate the target energy output to be achieved **at the end** of the dispatch interval to meet the forecast demand.
- Resources with near-instantaneous ramp rates present unique challenges since they can ramp much faster than any other resource type and can do so at any point within a 5-minute interval, which can negatively impact system balancing.
- The following slides illustrate the challenges posed by these resources in the context of 5-minute energy dispatches and maintaining system balance.

Fast Ramping Capability: Example

A 400 MW fast-ramping resource at 0 MW receives the following three 5-minute dispatch instructions:

- INT1 Dispatch: 400 MW
- INT2 Dispatch: 400 MW
- INT3 Dispatch: 0 MW

Fast-ramping resources can reach their MW dispatch well before the end of the dispatch interval.



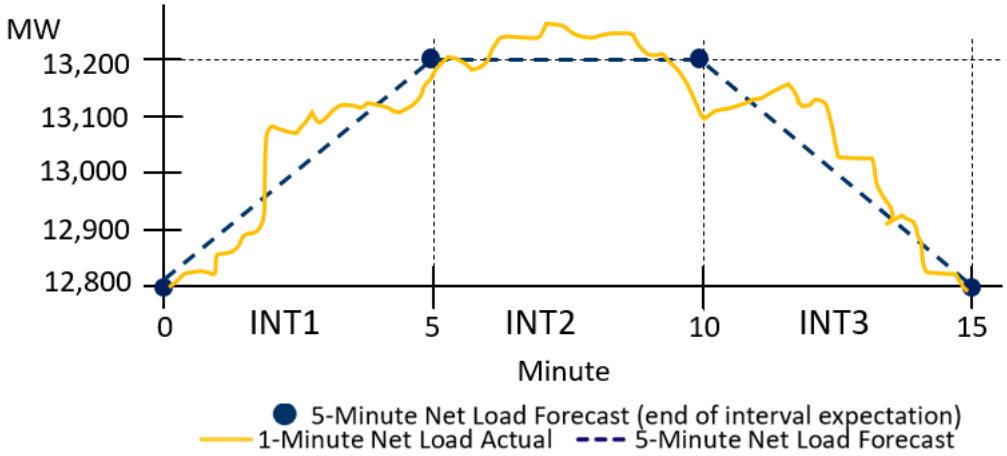
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Fast Ramping Impacts: Example

Very fast ramping can lead to over/under-generation which creates imbalances within the 5-minute dispatch interval.

Consider the following example:

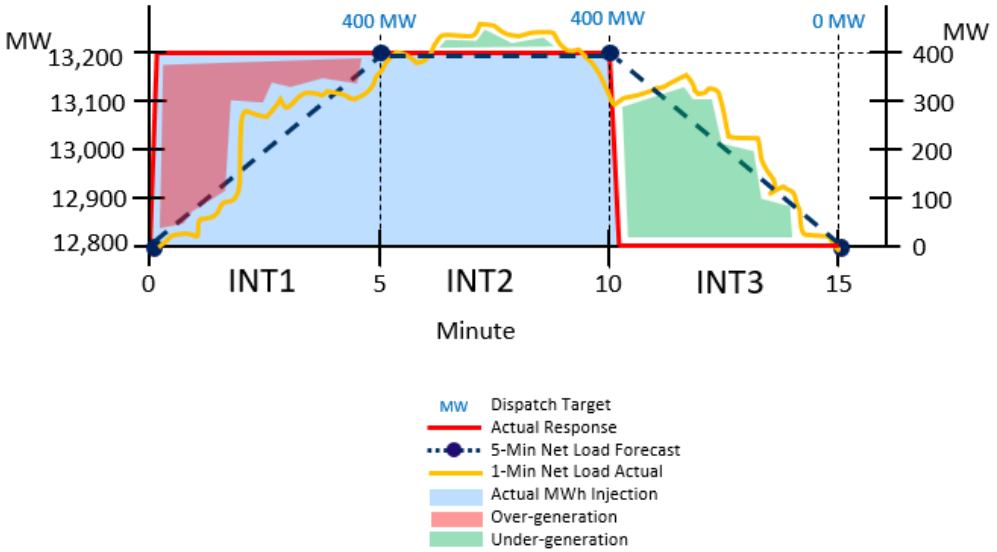
- The 5-Minute Net Load Forecast is projected to increase to 13,200 MW in INT1, remain at 13,200 MW in INT2, drop back down to 12,800 by the end of INT3
- 1-Minute Net Load Actual over this same 3-interval period is shown in yellow



Fast Ramping Impacts: Example (continued)

In response, the DSO dispatches a 400 MW fast-ramping resource from 0 MW to 400 MW in INT1, and back to 0 MW in INT3, expecting MW dispatches are reached at the end of the intervals (i.e., same dispatches as Slide 20)

Fast-ramping resources can create over- and under-generation conditions when they ramp instantaneously in response to IESO 5-minute dispatch instructions.

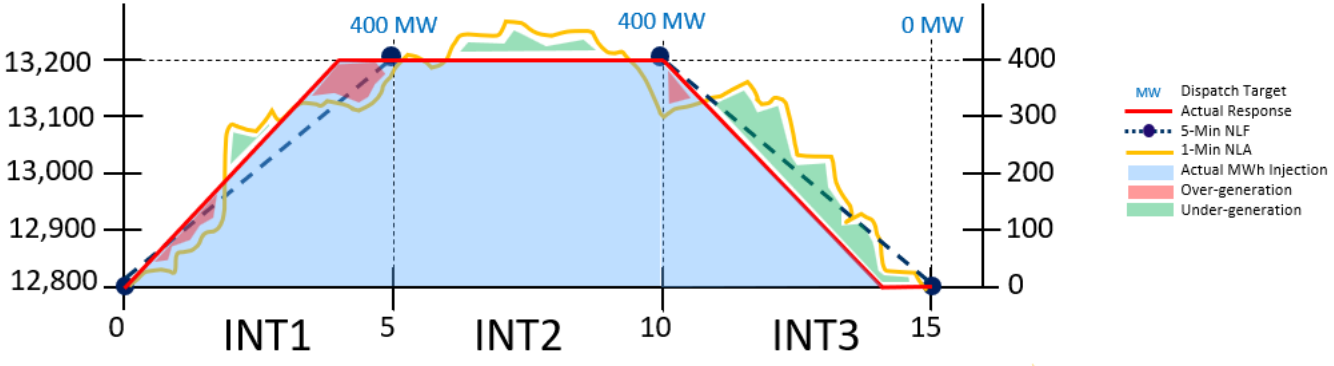


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Fast Ramping Impacts: Example (continued)

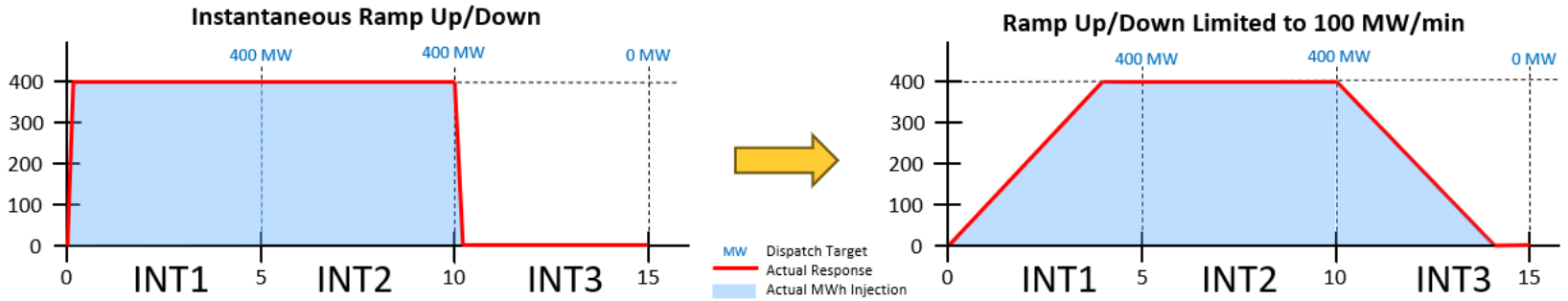
Consider the following example:

- Same 5-Minute Net Load Forecast, 1-Minute Net Load Actuals and dispatch assumptions as before, but this time the fast-ramping facility follows a ramp rate of 100 MW/min.
- Relative to the previous ramp example, the amount of over-generation and under-generation observed in INT1 & INT3 is mitigated by the 100 MW/min ramp rate limitation.



Fast Ramping Impacts: Mitigations

- With over 3,600 MW of fast-ramping BESS expected in the coming years and responding similarly to price signals, this represents a **significant** potential for system imbalance.
- As a result, a need for a ramp rate limitation was identified to dampen BESS' near-instantaneous response to 5-minute energy dispatches to mitigate impacts to ACE and reliance on AGC



Interim Ramp Rate Instruction

To mitigate adverse impacts and maintain balance, IESO has been issuing the following instruction to all registering BESS facilities:

- **All Electricity Storage Facilities shall be limited to a maximum ramp rate of 100 MW/minute (1.67 MW/second) when responding to 5-minute energy dispatch instructions.**
    - This maximum rate applies equally when injecting (discharging) or withdrawing (charging) active power.
    - This limit applies exclusively to 5-minute energy dispatch signals and does not apply to the facility's response to operating reserve activations, frequency excursions, voltage changes, or Remedial Action Scheme (RAS) runbacks.
    - This requirement shall not restrict the registered ramp rate at the resource level
    - The Ramp Rate instruction is applied through the registration process and is also identified in the System Impact Assessment (SIA) as a General Requirement that must be satisfied by the storage facility

Stakeholder Feedback, Market Rule Impacts and Next Steps

Stakeholder Feedback – July 22, 2026

- Stakeholder feedback received to date has been appreciative of the need; however, the following questions and concerns have been raised:
  - How the 100 MW/minute rate was identified
  - Concerns regarding the financial lost cost opportunity on storage participants
  - Concerns regarding implementation complexity
  - Potential for battery energy storage systems to provide regulation services
- IESO Response to Feedback following the July 22, 2026 webinar

Market Rule Impacts

The ramping constraints on storage facilities are expected to require the following market rule amendments:

1. **Chapter 7 System Operations and Physical Markets**: A ramping requirement will be structured at a facility level and applied to dispatch data submission and compliance with dispatch requirements.
2. **Chapter 4 Grid Connection Requirements - Appendices**: There will be a technical requirement for battery storage participants to have the ability to control the ramp rates of their equipment.

Next Steps

Timing	Engagement Activity
~~July 22, 2026~~	~~First public engagement session~~
November 10, 2026	Technical Panel (TP) Education
November 25, 2026	Second public engagement session
December 1, 2026	TP Vote to Post
January 12, 2027 (TBD)	TP Vote to Recommend
March 12, 2027	IESO Board Consideration
Q2, 2027	Target Implementation

Thank You

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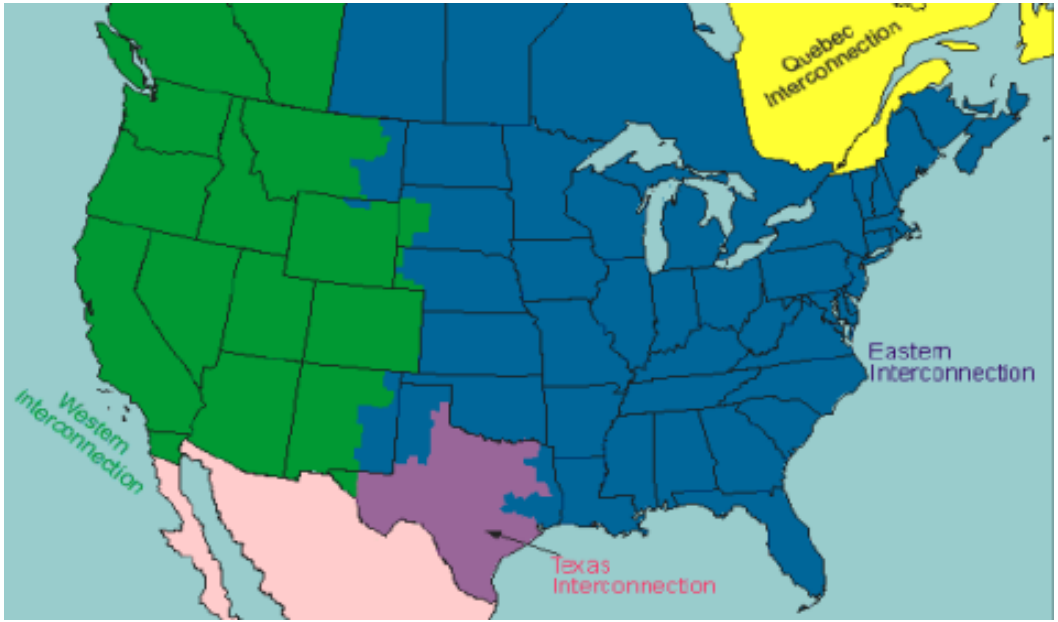
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Appendix

NERC Interconnections

- NERC footprint is divided into 4 major interconnections:
  - Western Interconnection
  - Texas Interconnection
  - Eastern Interconnection
  - Quebec Interconnection
- North America operates at a frequency of 60 Hz
- Frequency deviates when load ≠ generation



Balancing Products

In addition to regulation, balance between supply and demand may also be achieved via other balancing products, depending on the timing and nature of the event causing the imbalance.

Time

Mechanism	Inertial Response	Primary Frequency Response	Regulation	Operating Reserve	Ramping Capability
What is the response time?	Immediately following a system event	Within the first few seconds following a system event	Within less than 5-minutes of a mismatch between supply and demand	Within 10 minutes or 30 minutes of a system event	Five minutes to hours
How is balancing currently achieved?	Drawn from the stored kinetic energy of rotating equipment	Automatic adjustment of energy output by generators	Signal from IESO tools to a resource to adjust energy output	Activated by the IESO	Scheduled by the IESO's dispatch scheduling engine

Fast Ramping Impacts: Mitigations

- To manage these imbalances, the system must rely on regulation services for minute-to-minute balancing between supply and demand (currently at +/- 130 MW)
- When regulation is insufficient, the IESO needs to activate other balancing products such as the activation of operating reserve (10-minutes) to account for under-generation.
- This is not ideal, as these are out-of-market actions, and those products should be used for what they are intended (i.e., recovering from a contingency)
    - Although not a balancing product, one-time dispatches can also be issued to reduce generation when there is over-generation or to increase generation when there is under-generation. This too, is an out-of-market action.
- These out-of-market actions are not as effective in the minute-to-minute regulation balancing timeframe since they are typically in the "OR" and "Ramping Capability" timeframes as described on slide 17