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Establishing Grid-Forming Capability Requirements at IESO

Motivation, Development, and Verification

Mohamed ElNozahy, Ph.D., P.Eng
Engineering Manager, EMT Studies

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System Background: IESO-Controlled Grid (ICG)

- Part of the Eastern Interconnection.
- Comprised of 500 kV, 230 kV and 115 kV transmission networks.
- Ontario is interconnected with Manitoba, Minnesota, Michigan, New York and Quebec.
- Divided into 10 geographical zones.
- Consists of over: 4000 buses, 500 generators, 2500 circuits.
- The all-time peak for electricity demand set was 27,005 MW.

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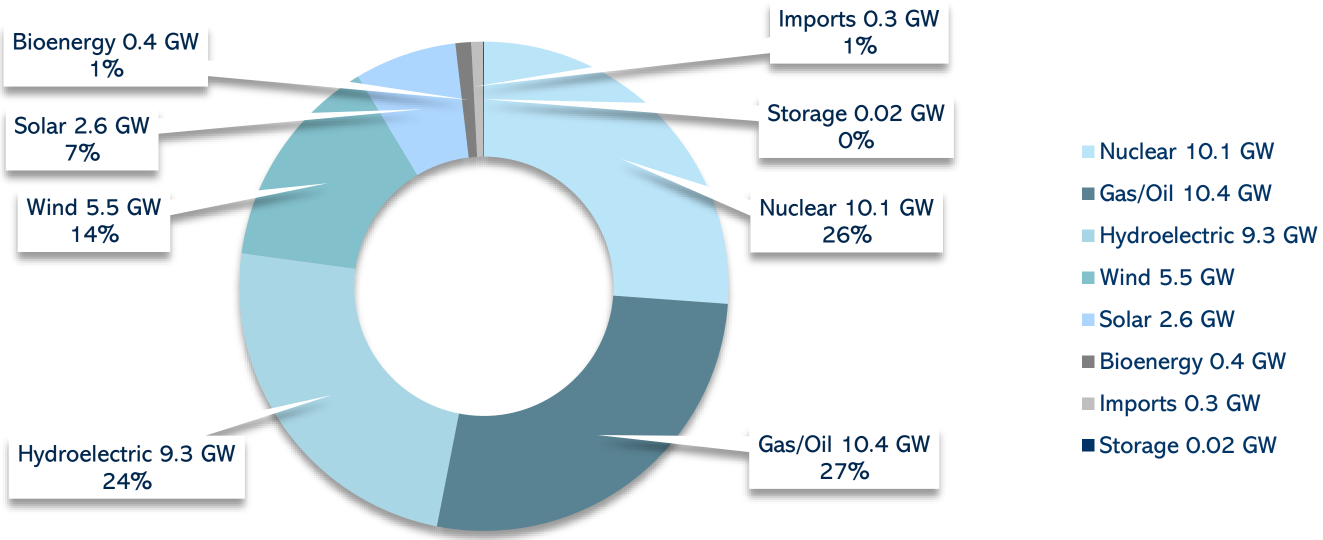
System Background: Installed Capacity by Fuel Type

Total installed capacity approximately 38.7 GW



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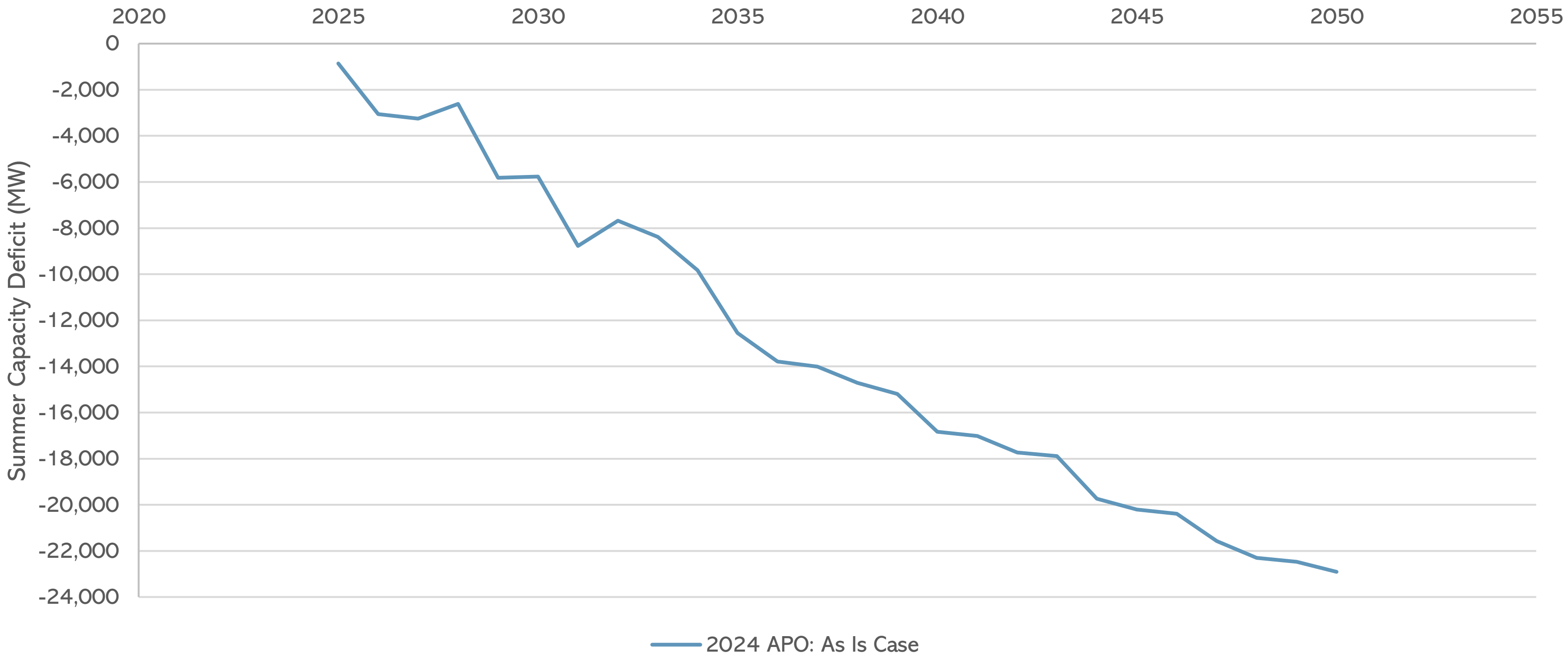
Significant Changes in Landscape



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IBR Capacity Soaring in Ontario: A New Era of Clean Energy

Ontario has plans to expand its renewable fleet through urgent procurement plans:

E-LT

1.2 GW of capacity by 2025-2026

LT1

2.2 GW of capacity between 2026 - 2028

LT2

2 GW in energy stream by 2030 and
1 GW of capacity by 2031

Ontario is expected to add 6.4 GW of IBR resources to the system by 2031.

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Bridging Today’s Strong Grid with Tomorrow’s Challenges

Proactive Approach

1 **IBR Penetration:** Levels remain relatively low compared to other regions.

2 **GFM Implementation:** Grid-wide implementation is not currently mandated due to the grid's strength but can be assessed on a case-by-case basis.

3 **Seizing the Opportunity:**

- Preparing for higher IBR penetration and addressing potential grid challenges early.
- Future-proofing Ontario’s grid by mandating GFM capability now for flexibility later.

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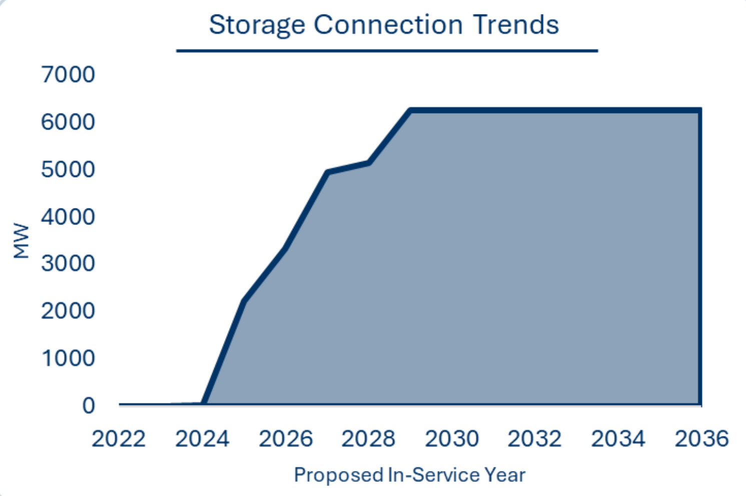
Bridging Today’s Strong Grid with Tomorrow’s Challenges

- Significant growth in the interconnection queue for battery storage projects.
- GFM for BESS is an almost cost-free solution.
  - Requires only software modifications.
  - No additional hardware investment needed.
  - Enhances grid stability and resilience.



IESO's GFM System Impact Assessment Approach

Key Requirement

All battery projects must include GFM capability, with the flexibility to enable it as needed.

Project-Specific Implementation

If system impact assessments indicate potential weak grid scenarios, GFM controls may be required for specific projects to ensure grid stability.

The Challenge

Lack of industry-wide agreed performance requirement.

BESS SIA: General Requirements

“The connection applicant shall ensure that the inverters are capable to operate in Grid Forming Control mode. As the power system evolves, the IESO may require the inverters to be operated in that mode. Grid Forming Control mode shall not be enabled without IESO approval. NERC functional specifications for Grid Forming Control mode specify that its primary objective is maintaining an internal voltage phasor that is constant or nearly constant in the sub-transient to transient time frame. The voltage phasor must be controlled to maintain synchronism with other devices in the grid and must also regulate active and reactive power appropriately to support the grid”

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IESO’s Current GFM Requirements

Review of Global Best Practices

Incorporating guidance from **NERC functional specifications, ERCOT, UK’s GC, etc.**

Stakeholder Engagement

- Ongoing dialogue with OEMs, market participants, and other grid operators.
- Gathering feedback on feasibility, implementation, and testing challenges.

Current Requirements

Currently, the IESO is adopting the fundamental agreed-upon requirements based on NERC’s GFM definition.

IESO's Current GFM Requirements

1 Maintains a constant or nearly constant internal voltage phasor in the sub-transient to transient timeframe.

- Immediately respond to changes in the external system and maintain IBR control stability during challenging network conditions

2 Synchronizes with other grid devices for smooth operation (interoperability).

3 Regulates active and reactive power to enhance grid stability and support.

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Verification and Testing of GFM Capabilities

- Based on NERC's GFM Functional Test System
- Utilizing IESO's Automated Model Quality Testing (MQT) framework to verify:

1. GFM BESS performance following Last Synchronous Generator trip when operating within its limits and in discharging state
2. GFM BESS performance when operating within its limits and transitioning from charging state to discharging state after the last Synchronous Generator trips
3. GFM BESS performance following last synchronous generator trip when operating at limits

- **Future Testing Enhancements:** Dynamic response requirements include performance during grid disturbances and weak system conditions, such as energy response tests, phase jump tests, etc.

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Future Considerations

1

Research and Development:

Ongoing assessment of emerging GFM technologies, their grid applications, and performance requirements in collaboration with research institutions (e.g., UoT).

2

Continued Industry Collaboration:

Aligning with global best practices and evolving grid codes.

3

Challenge:

Balancing proactive measures with the relatively low urgency due to strong grid conditions

4

Opportunities:

Proactively ensuring a seamless transition to higher renewable and IBR penetration.

Conclusions

IESO’s proactive approach ensures the Ontario grid is **prepared for future challenges**.

Mandating GFM capability for BESSs today **supports** long-term grid **reliability and resilience**.

Next Steps:

- **Finalize** and implement the **GFM requirements** document.
- **Enhance verification** and testing processes for seamless compliance.

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Questions

Mohamed.elnozahy@ieso.ca

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ieso.ca

1.888.448.7777

customer.relations@ieso.ca

engagement@ieso.ca

@IESO_Tweets

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