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Technical Requirements for Large Computational Loads in Ontario's Power System

Fang Gao
Lead Power System Engineer, Connection Assessments, IESO

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Territory Acknowledgement

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

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

Engagement Principles

This engagement is conducted in accordance with the IESO's External Engagement Framework, which includes the following principles:

- **Purposeful** – Initiate meaningful conversations that move the sector forward
- **Inclusive** – Invite many voices and diverse perspectives to the table
- **Timely** – Seek input and insight when it can have the most impact
- **Accessible** – Ensure we meet people where they are on their energy journey
- **Traceable** – Allow everyone to follow the path that is being taken
- **Transparent** – Show how engagement helped shape the final outcome

Shared Commitment to Respectful Participation

To support a focused and constructive discussion:

- We will take questions one at a time; please use the raise-hand feature to enter the speaking queue
- We encourage concise and focused comments to allow time for multiple perspectives
- Participants are encouraged to raise relevant points during the discussion and provide more detailed feedback through the written submission process
- We ask that all participants maintain a respectful and professional tone throughout the session
- Facilitators will guide the discussion and manage participation to stay aligned with today's focus and agenda
- Where necessary, we may disable a participant's microphone to manage participation

Outline

- Large Computational Loads – Definition & Characteristics
- Establish New Reliability Requirements Roadmap
- New Reliability Requirements, Feedback, and Responses

Computational Loads - Definition

Computational load refers to loads attributable to information technology computing equipment, including servers, data storage systems, and networking hardware.

Such loads are commonly associated with **data centres, AI compute clusters, and cryptocurrency mining** operations, among other facilities.

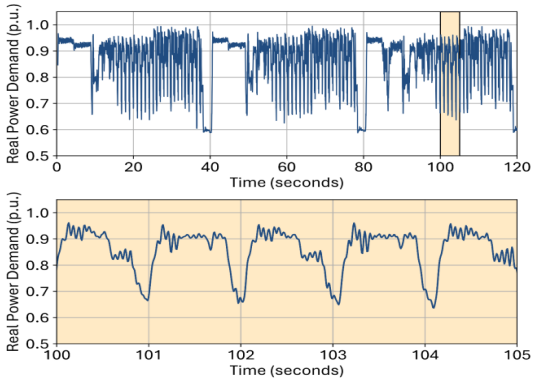
Large Computational Loads – Characteristics

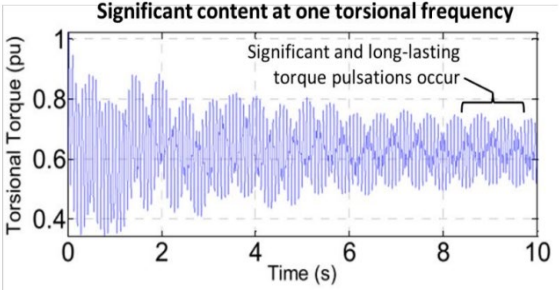
Hyperscale

Short and time sensitive in-service timeframe

Special load behavior

- Voltage sensitive
- Load fluctuation
- Periodic oscillation
- Fast ramping
- Unpredictable profile





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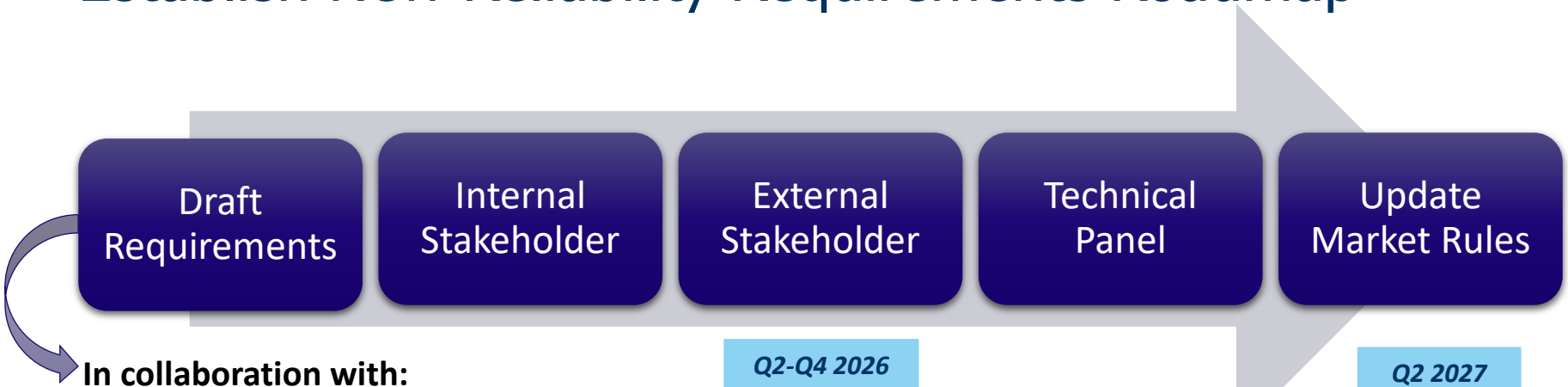
Establish New Reliability Requirements Roadmap



In collaboration with:

- Industrial Working Groups
- Utilities, OEMs, Developers, Applicants
- IESO Internal Teams

IESO Stakeholder Engagement Website:
Technical Requirements for Large Computational Loads Connecting to the Ontario Power System

Technical Requirements

Existing

- Data Collection
- Power Factor/Reactive Power Capability
- Automatic Under-Frequency Load Shedding (UFLS)
- Voltage Levels
- Short Circuit Levels
- Ride-through Capability
- Protection Systems
- Telemetry
- Metering

New

- Data Collection (Enhanced)
- Connection Arrangement
- Damping
- Periodic Oscillation
- Load Fluctuation
- Load Ramping
- Ride-through Capabilities (Enhanced)
- Phasor Measurement
- Dynamic Disturbance Recording
- Modelling and Performance Validation

New Requirements, Feedback, and IESO Responses

Data Collection (Enhanced) - Original

1) Project development plan
2) SLD
3) All primary equipment data
4) Type of LCLs
5) Load composition
6) Type of UPS system deployed and its capacity
7) Type of backup generation and its capacity
8) Normal and maximum load ramp rates (MW/min)
9) Post-fault active power recovery (PFAPC) time (seconds) for UPS loads
10) Protection description document
11) Typical hourly load profile (winter and summer)
12) Load fluctuation patterns with 1-minute granularity or 1-second granularity if applicable
13) Periodic power oscillations if applicable
14) Voltage and frequency operating ranges
15) Control schemes description including voltage/time and frequency/time settings for:

- switching the load to UPS supply,
- switching the load back from UPS supply,
- switching the load to backup generation.

16) Operating philosophy document including configurations under normal and outage conditions, startup/shutdown sequence, transfer logic and procedure for transferring between the system supply and backup power supplies
17) EMT model, UDM, Composite model

Data Collection (Enhanced) – Feedback and Response

Highly detailed technical inputs as prerequisites at the earliest SIA stage are not available. Requiring these inputs at the earliest SIA stage creates an unworkable sequencing constraint. A staged framework is needed for the IESO to obtain higher-quality technical information at the point where it is most stable and actionable.

- The IESO has developed a flexible connection process. When detailed project design is not yet available, the IESO will conduct steady-state studies only and issue a comfort letter along with a draft report indicating the available capacity for the project.
- The IESO will continue to evolve the interconnection process to better align with the development timelines of LCL projects.

Recommend collect hardware type which drives the fluctuation and ramp profile and varies most rapidly with technology generation.

- The IESO added the hardware class (such as GPU clusters, ASIC, CPU-dominant, liquid- vs. air-cooled) to the data list.

Data Collection (Enhanced) - Revised

1) Project development plan
2) SLD
3) All primary voltage equipment data
4) Type of LCLs
5) Hardware class (new)
6) Load composition
7) Type of UPS system deployed and its capacity
8) Type of backup generation and its capacity
9) Normal and maximum load ramp rates (MW/min)
10) Post-disturbance active power restoration time (seconds) from UPS to system for UPS loads
11) Protection description document
12) Typical hourly load profile (winter and summer)
13) Load fluctuation patterns with 1-minute granularity or 1-second granularity if applicable
14) Periodic power oscillations if applicable
15) Voltage and frequency operating ranges
16) Control schemes description including voltage/time and frequency/time settings for:

- switching the load to UPS supply,
- switching the load back from UPS supply,
- switching the load to backup generation.

17) Operating philosophy document including configurations under normal and outage conditions, startup/shutdown sequence, transfer logic and procedure for transferring between the system supply and backup power supplies
18) EMT model, PERC and Composite model (preferred) or UDM and Composite model

Connection Arrangement - Original

The connection arrangement of the project shall be agreed by the transmitter to meet the Transmission System Code.

No internal single point failure within the project results in a load loss above 600 MW or a lower value identified by system assessments.

Automatic load transfer between different system supplies within the project is not acceptable.

Connection Arrangement – Feedback and Response (1)

It is suggested to remove data centre load from load security requirements as the loss of this load would only impact on one customer and not a broader load interruption, which is the basis for the 600MW limit. The amount of interrupted load allowed following an internal fault shall be based on system impact.

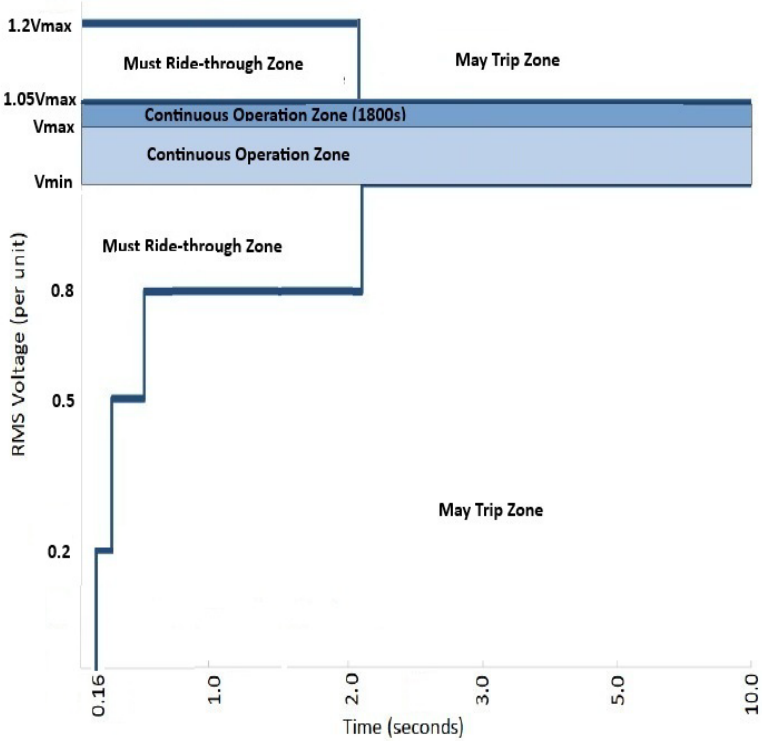
- This requirement is not intended for load security purposes. It is intended to mitigate broader reliability impacts that may result from an internal fault at a large computational load facility. A limit of 600 MW is adopted as this is the maximum allowable load loss associated with a system event in our system.
- The IESO has evaluated various values for the maximum load loss limit and concluded that a 600 MW threshold provides a practical and technically justified balance. This is aligned with best utility practice here in Ontario.
- Where a project cannot meet this threshold, a different value may be considered subject to IESO review and approval through the System Impact Assessment process.

Connection Arrangement – Feedback and Response (2)

Amend to clarify that the prohibition on automatic load transfer applies to inter-supply switching between independent facility-level power supplies during normal operation and does not apply to automatic engagement of internal energy storage during a voltage disturbance within the ride-through bounds of Section 6.7.1.

The IESO has revised the wording to clarify the prohibition on automatic load transfer applies to load transfer between different Point of Interconnections (POIs), not to the load transfer from the system supply to backup generation.

Voltage Ride-through (Enhanced) – Original



Notes:

(1) The load supplied by the UPSs shall only reduce active power consumption proportional to voltage sag for the POI voltage between 0.5 and 0.8 pu and may cease to withdraw power only when the POI voltage goes below 0.5 pu.

(2) PFAPR time: 1 second by default and configurable.

(3) No ramp rate limitations to recover its active power.

(4) Switching to UPS supply is not allowed for voltage rise at the POI.

(5) Not switch to the backup generation supply unless the disturbance trips the project by configuration.

(6) If switched to the backup generation supply, it shall not be reconnected automatically without the IESO's approval.

(7) The project shall have the capability to ride-through two consecutive voltage disturbances occurring within 30 s.

Voltage Ride-through (Enhanced) – Feedback and Response (1)

The UPS that could meet the following two requirements are not commercially available:

- Reduce active power proportionally to voltage during a 0.5–0.8 pu sag while remaining connected, and
- After voltage recovers, restore active power to the pre-disturbance level within 1 second.

Suggest to use a phased implementation approach like ERCOT.

- There are no inherent equipment limitations for implementation of these requirements.
- ERCOT is using a phased implementation approach, with mandatory compliance taking effect on January 1, 2028. Given that only a limited number of LCL projects are expected to be in service in Ontario before that date, the IESO has determined that an interim exemption period, like the one adopted by ERCOT, is not necessary.

Voltage Ride-through (Enhanced) – Feedback and Response (2)

Cooling or mechanical load is commonly 20–40% of total facility power and consists predominantly of induction motors. Induction motors below approximately 0.7 pu input voltage enter unstable regions of their torque-speed characteristic and risk stall, with consequential mechanical damage. This is a physical limit of the motor. It is recommended the IESO permit cooling or mechanical load trip when voltage conditions are below 0.35 pu like ERCOT.

- The IESO recognize that small motors serving cooling and mechanical loads may need to be tripped when the POI voltage falls below 0.35 pu.
- The IESO has updated the requirement to include that due consideration will be given to inherent limitations of small motors for non-UPS cooling and mechanical loads which are allowed to be tripped when POI voltage goes below 0.35 pu. However, tripping these small motors shall not restrict the operation or delay the restoration of other IT loads after the system disturbance.

Voltage Ride-through (Enhanced) – Feedback and Response (3)

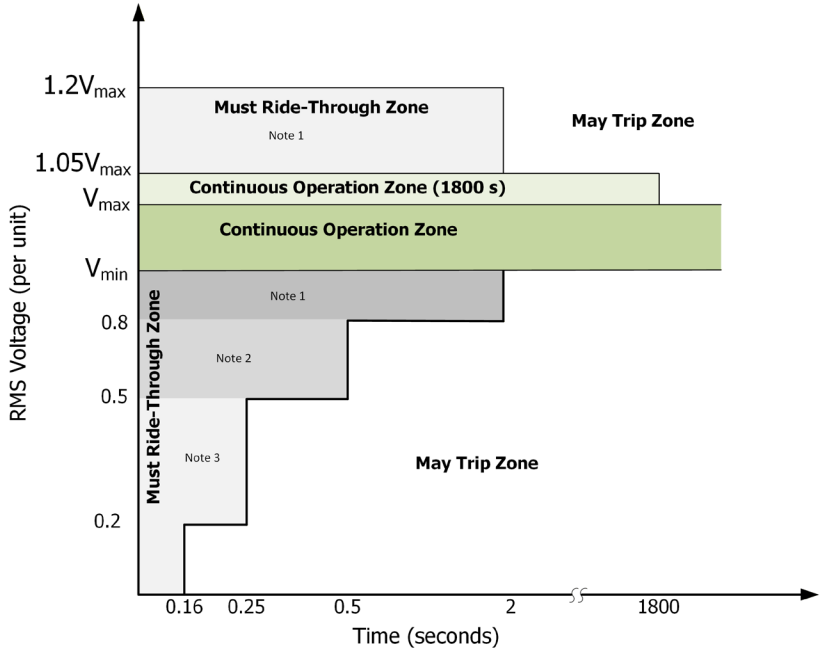
The 1-second recovery window is an aggressive approach, and therefore requests clarification as to whether restoration should be staged rather than introducing a large load to the system all at once. The necessity of a staged approach is dependent on the project size. If not, why not?

- The staged recovery is not necessary. Fast restoration of the load without ramp-rate limitations is required to balance the post-fault demand and generation in the system.
- The SIA may require different recovery timelines for individual projects.

The VRT may require ride-through of transient over-voltage up to 2 per unit as defined in Appendix 2 of TSC.

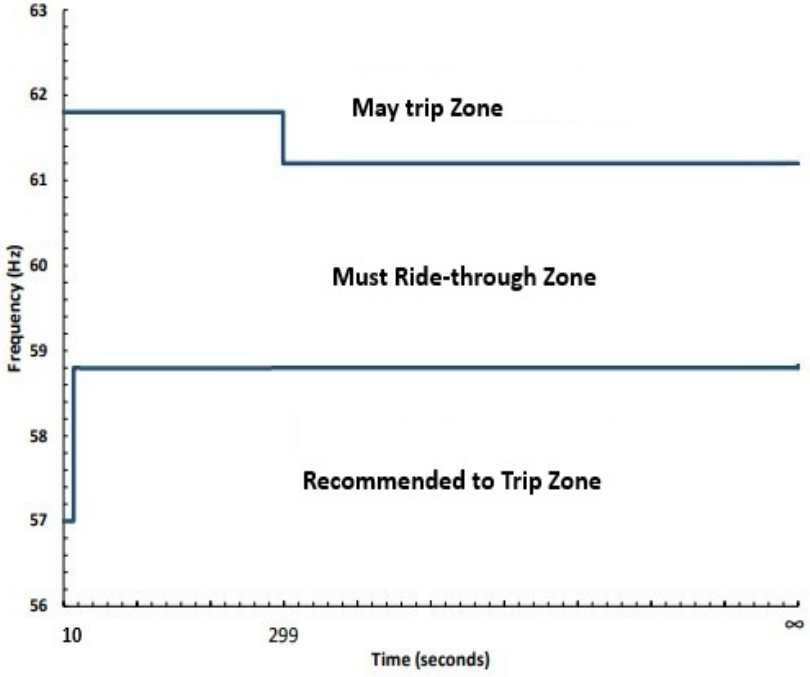
The 2 per unit value specified in Appendix 2 of the TSC refers to equipment capability to withstand capacitor switching surges, not from system reliability perspective.

Voltage Ride-through (Enhanced) – Revised Graph



Note 1: UPS loads shall not reduce active power consumption from the system. They should not start switching to UPS supply.
Note 2: UPS loads can reduce active power consumption from the system only to a level proportional to voltage sag at POI. Partial load may switch to UPS supply.
Note 3: UPS loads may cease to withdraw active power from the system and full load can switch to UPS supply.

Frequency Ride-through (Enhanced) - Original



Notes:

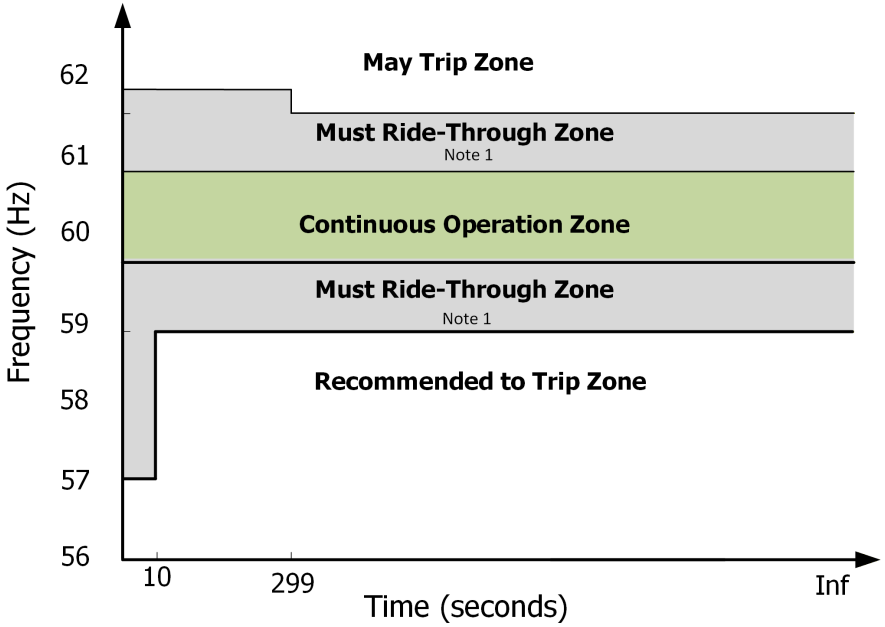
(1) The under-frequency settings are to coordinate the UFLS scheme for the Ontario power system. It is recommended the project be set to trip all loads when system frequency drops below 58.8 Hz for 10 seconds and trip instantaneously when frequency drops below 57 Hz.

(2) System under-frequency issue shall be addressed by automatic UFLS program. This under-frequency ride-through requirement is to avoid uncontrolled load tripping to a large amount of computational loads, allowing UFLS provide controlled load tripping to restore system frequency.

(3) During the frequency disturbance, the project shall maintain its active power consumption at the level prior to the disturbance. Switching to UPS supply is not allowed during the ride-through period.

No Feedback

Frequency Ride-through (Enhanced) – Revised Graph



Note 1: UPS loads shall not reduce active power consumption from the system. They should not start switching to UPS supply.

Other Ride-throughs - Original

- **Rate of Change of Frequency (RoCoF) Ride-Through:** To ride-through frequency excursions having an absolute RoCoF magnitude that is less than or equal to 5.0 Hz/s. RoCoF shall be calculated as the average RoCoF over a rolling 0.5 second averaging window.
- **Voltage Phase Angle Jump Ride-Through:** To ride-through positive-sequence phase angle jump initiated by no-fault switching events within a sub-cycle time frame of the POI voltage of less than or equal to 25 electrical degrees.
- **Volts per Hz (V/Hz) Ride-Through:** To ride-through grid disturbances with V/Hz, measured at the POI, of at least 1.1 per unit for 45 seconds, 1.18 per unit for 2 seconds, and 1.27 per unit for 1 second.

The project shall maintain pre-disturbance active power consumption during the above ride-through period. Switching to UPS supply is not allowed during the ride-through period.

Other Ride-throughs – Feedback and Response

The 1.27 pu V/Hz ride-through still stands out as higher than typical equipment capability.

- The IESO agrees and revised the requirement for the V/Hz ride-through capability to be the same as that for inverter-based resources in NERC PRC-029.

Several requirements assume settings and measurement windows are not configurable in standard relays and UPS controller's in-service today - notably the 0.5-s RoCoF averaging window (Section 6.7.3), the 3–6 cycle frequency window (Section 6.7.2), and the 25° phase-angle-jump capability (Section 6.7.4).

- There are no technical barriers to their implementation. The market and technology will evolve to provide commercially viable solutions for system needs.
- Requirements have been developed based on system needs rather than existing equipment practices.
- Similar requirements have already been applied to inverter-based resources.

On all Ride-throughs – Feedback and Response

Have a summary of voltage/ frequency / RoCoF / phase / V/Hz events, under what conditions switching to the UPS is allowed or is not allowed.

The IESO has added a summery to provide this clarification.

Clarification is needed for concurrent voltage/ frequency / RoCoF / phase / V/Hz events, under what conditions switching to the UPS is allowed.

- Switching to the UPS supply during voltage depression is permitted due to the equipment limitations of UPS loads.
- No such limitations apply under high voltage, frequency, RoCoF, phase jump, or V/Hz events.
- In concurrent events, switching to the UPS supply is allowed whenever voltage depression occurs.

Load Ramping and Fluctuation – Original

Load Ramping

The project has the capability to operate with linear ramp rates not exceeding 20 MW per minute during normal operation.

This maximum rate applies when reducing active power consumption and when restoring active power consumption. It is not intended for other system events such as load reduction programs, frequency excursions, voltage changes, or RAS runbacks.

Load Fluctuation

The load fluctuation frequency at the project does not exceed the limit specified in Ref 5, Appendix 2 of Transmission System Code, based on the voltage fluctuation magnitude caused by the project.

Voltage Fluctuation Magnitude (%)	Limit
0.5	3 per second
1.0	20 per minute
2.0	45 per hour
3.0	4 per day

Load Ramping and Fluctuation – Feedback and Response

Data centres typically transfer between grid & generators using automatic transfer switching (with breaker pairs or purpose-built Automatic Transfer Switches). While UPS/IT loads could be controlled to ramp during re-connection, mechanical loads would generally occur as switching events. The linear provision in Section 6.6 Load Ramping could be interpreted as not permitting this standard form of load transfer.

- The IESO acknowledges that non-UPS mechanical and cooling loads are typically connected through switching events during reconnection.
- The IESO has removed the linear ramping provision and established a maximum step load change of 5 MW over a 15-second period.

Clarifying the load ramping requirement applies at the project's Point of Interconnection (POI) rather than to internal load variations within the facility.

- The IESO has revised the wording to show load ramping constraint is applied at POI.

Periodic Oscillation and Damping – Original

Periodic Oscillation

The power consumption at the Point of Interconnection (POI) of the project has no periodic power oscillation within the sub-synchronous frequency band exceeding the lesser of +/- 2.5 MW or +/-0.25 % of the nominal power of the project unless the connection applicant provides the specific load profile which will be assessed by the IESO.

Damping

The project does not introduce any net negative damping to system oscillations within the sub-synchronous frequency range.

Periodic Oscillation and Damping – Feedback and Response

Section 6.4 - Periodic Oscillations. Recommend defining "periodic" with a minimum duration threshold and an assessment window (e.g., oscillations sustained beyond X seconds/minutes at the POI within the sub-synchronous band). As written, any transient oscillations during a workload step, which are inherent in many data centre use cases, would technically be noncompliant.

- The IESO has added an assessment window: The oscillation magnitude shall be measured using 1-second Fast Fourier Transform (FFT) window and being averaged over a 10-second rolling window for oscillation frequency equal to or more than 5 Hz and using a 10-second FFT window and averaged over a 60-second rolling window for oscillation frequency lower than 5 Hz.
- The applicant shall ensure monitoring equipment can continuously measure high resolution real-time data for analyzing periodic oscillations within the entire sub-synchronous frequency range.

Monitoring – Original

Phasor Measurement

The requirement is applicable for the transmission connected project whose MVA rating is equal or greater than 20 MVA.

Dynamic Disturbance Recording

The requirement is applicable for the transmission connected project whose MVA rating is equal or greater than 20 MVA.

No Feedback

Modelling and Performance Validation - Original

Modelling

The connection applicant must submit a PSS/E composite model, UDM, and an EMT model. The EMT model is used for fine-tuning the PSS/E model.

Performance Validation

The connection applicant must demonstrate the project's ride-through capabilities during commissioning by:

- Providing manufacturer test results, or
- Conducting field tests as per IESO specifications.
- Results must be verifiable using dynamic models submitted for the project.

No Feedback

Applicability – Feedback and Response

Will the new requirement be retroactively applied to the existing facilities?

What is the threshold of large computational loads that must comply with the new requirements?

The new requirements are applicable to all large computational loads (LCLs) whose final System Impact Assessment (SIA) report and Notification of Conditional Approval (NoCA) are issued after June 30th, 2026, including:

- LCLs rated higher than 10 MW that are directly connected to the Ontario transmission system and,
- LCLs rated higher than 10 MW connected to a distribution system.

Next Steps

- Develop Market Rule (MR) and Market Manual (MM) amendments to incorporate new technical requirements
- Conduct stakeholder engagement on the proposed MR and MM amendments (September 2026)
- Refine amendments based on stakeholder feedback
- Conduct stakeholder engagement on the revised amendments (November 2026)
- Obtain IESO Technical Panel Recommendation (Q1 2027)

Questions?

Thank You

ieso.ca

1.888.448.7777

customer.relations@ieso.ca

engagement@ieso.ca

@OntarioIESO

linkedin.com/company/IESO

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