

Evolution of Generator Standards

The present state of IESO staff efforts to facilitate generation connections by revising IESO generator requirements is attached. The requirements for generators have been re-expressed in a format more suitable not only to prepare equipment specifications during purchasing but also to demonstrate performance compliance during commissioning. Experience has shown more specifics are needed in some places to maintain reliability and more clarity is needed in other areas to avoid misunderstanding. The changes proposed are intended to removing unnecessary barriers for generation proponents to connect to the IESO controlled grid by relaxing requirements where prudent, by simplification where possible and by removing uncertainty throughout. Some changes that appear relatively small are expected to bring significant improvements for generation proponents.

The inclusion of the “equivalent synchronous machine” concept will allow proponents both more latitude and certainty in the connection process. Proponents may be able to make technology changes without invalidating their conditional approval to connect. The change will make the assessment process more efficient by removing an often inefficient focus on device specific models while ensuring performance necessary to maintain reliability is retained.

A summary of the changes to the requirements is listed below. Red text in the accompanying table is used to make changes easier to recognize. The three requirements for those requiring a Connection Assessment for small embedded facilities are listed first. The following requirements are not applicable to embedded facilities unless the net output of the facility is greater than 50MVA or a unit is 10MVA or larger.

1. The present ambiguity for under-frequency performance between 300s and continuous operation has been removed.
2. The need for Low Voltage Ride Through (LVRT) and other such measures has been made explicit. The rules have been interpreted in this manner with the requirement to ride through faults on the ICG being specified in the specific connection assessments.
3. Droop has been replaced by speed regulation to better express the IESO’s performance requirement in an equivalent manner. The requirement for control systems that inhibit governor response is plainer.

The following requirements apply only to facilities directly connected to the ICG.

4. Active power/ voltage variation requirements have not been substantially changed.

5. Reactive power capability requirement has been made plainer by removing the references to leading and lagging power factor that were confusing. The old wording required more capability to withdraw than to provide reactive power to the transmission system. A balanced injection and withdrawal reactive requirement was felt to be more appropriate. The requirement to provide the entire required range of reactive power for a transmission voltage has been re-expressed in an equivalent form to match the reactive power range change. The provision regarding continuously available reactive capability is intended to give the IESO latitude to accept less complex and costly connection arrangements that present suitable reliability advantages.
6. Voltage regulation requirements have not been substantially changed.
7. Excitation System large-signal performance requirements for excitations systems have been made plainer. The requirement for a voltage response time for a 5% change to either the positive or negative ceiling requirement is a clarification. The performance measures for embedded connection needs some further vendor input. Some work remains to find the best manner to include small-signal requirements for ICG connections.
8. Stabilizer requirements have been made more specific to provide a measureable requirement as the previous requirement (i.e. provide as much damping as practicable) did not provide enough guidance. The form of the stabilizer ($\Delta P\omega$) has been specified to preclude less stable designs.
9. Phase unbalance requirements are unchanged
10. Generator Characteristic requirements have been added as experience has shown a trend to very low inertia machines. To ensure reliability is maintain over the longer term, minimum inertia values have been established.

It is not practicable to formulate concise performance requirements suitable for the entire range of generation technologies. Where appropriate, the performance of a conventional synchronous generating unit with the same apparent power rating will be used by the IESO to assess performance of other technologies.

All Facilities subject to a Connection Assessment (greater than 10 MW or connected to the ICG).	
1. Abnormal Frequency Capability	Each generation facility shall be able to operate continuously at full power when grid frequency is between 59.4Hz and 60.6Hz and for a limited period of time in the region above straight lines on a log-linear scale defined by the points (0.0s, 57.0Hz), (3.3s, 57.0Hz), (300s, 59.0Hz), and (740s, 59.4Hz) except where permitted by the IESO.
2. Protection Systems and Limiters	Protection systems shall be designed, constructed, operated and maintained in accordance with all applicable reliability standards. Protection systems and limiters shall not unduly limit equipment capability. Unless disconnected by configuration, generating units shall not trip for design criteria contingencies on the ICG except where permitted by the IESO.
3. Speed Governing Capability	All synchronous generating units rated larger than 10MVA shall be operated with a governor with an average steady state speed regulation that can be set in the range of 3% to 7% and an intentional deadband not wider than ± 36 mHz. Speed regulation and deadband requirements may be applied to a combined-cycle facility as a whole. The governor shall control speed in a stable fashion and provide immediate, appropriate, and sustained response to abnormal frequency excursions. Due consideration will be given to inherent limitations such as mill points. Control systems that inhibit governor response shall be automatically disabled when grid frequency is less than 59.9Hz or greater than 60.1Hz.
All Facilities directly connected to the ICG or Embedded Facilities with an output larger than 50MVA or unit 10MVA or larger.	
4. Active Power Capability	Each generation unit and all associated plant auxiliaries shall be able to operate continuously within $\pm 5\%$ of its rated terminal voltage at all levels of active power output.
5. Reactive Power Capability	Each generating facility shall be able to continuously inject or withdraw at its connection point to the transmission system reactive power up to 30% of its rated active power for any active output up to rated. Rated active power is the lesser of the registered maximum continuous active power and 90% of rated MVA. Each generation facility shall be able to continuously supply its entire range of reactive power over a 2% range of transmission system voltage identified by the IESO. The IESO may identify a lesser requirement for intermittent generating facilities that will continually produce reactive power where permitted by the IESO.
6. Voltage Regulation	Each generating facility shall be equipped with a continuously operating automatic voltage regulator (AVR) that will maintain voltage within $\pm 0.5\%$ of any set point within $\pm 5\%$ of rated voltage. Each voltage regulation system shall regulate voltage except where permitted by the IESO. Automatic setpoint adjustments shall be suspended when voltage deviates by more than $\pm 2\%$ of the setpoint. When multiple generating units are connected to a common bus, each unit's AVR reference shall be compensated to a point as close as practicable to but not farther from this common bus. Schemes that compensate more than 10% of the unit's unsaturated direct axis impedance from the common bus shall not be placed in service except where permitted by the IESO.
7. Excitation Systems	ICG connected: a positive ceiling of 200% of rated field voltage, and a negative ceiling of at least 140% of rated field voltage, and a voltage response time to either ceiling of not more than 50ms for a 5% step change. (placeholder for small signal stability requirements) Embedded connected: a nominal response ratio of at least 0.5 and a positive voltage ceiling of at least 150% of rated field voltage unless the IESO identifies a material adverse effect on reliable operation of the ICG.
8. Power System Stabilizer	Each generating unit with a higher requirement excitation system shall have a power and speed based ($\Delta P\omega$) power system stabilizer (PSS). The PSS shall be tuned to maximize stabilizer gain, to minimize phase compensation error for the dominant mode of oscillation, and to keep phase compensation error within 30 degrees within the range 0.2 to 2.0Hz to increase damping torque as much as possible while not reducing synchronizing torque. The positive and negative output limits shall be at least 10% and 5% respectively of terminal voltage unless otherwise permitted by the IESO.
9. Phase Unbalance	The open circuit phase voltage unbalance shall not exceed 1%. Generating facilities shall be able to continuously operate with a phase unbalance of at least 2%.
10. Generator Characteristics	For synchronous generator and turbine combinations, the inertia constant (rotating energy/rated power) shall be greater than 2.0s for hydraulic units, greater than 3.0s for 2-pole units and greater than 4.0s for 4-pole units except where permitted by the IESO.