

## Appendix 4.2 – Requirements for Generation Facilities Requirements-Connected to the IESO-Controlled Grid

The performance requirements set out below shall apply to *generation facilities* subject to a *connection assessment* finalized after ~~March 6, 2010~~ [new effective date]. Performance of alternative technologies will be compared at the ~~point of connection to the IESO-controlled grid high voltage terminal of the main output transformer<sup>1</sup>~~ with that of a conforming conventional synchronous *generation unit* with an equal apparent power rating to determine whether a requirement is satisfied.

Each generation facility that was authorized to connect to the *IESO-controlled grid* prior to ~~March 6, 2010~~ [new effective date] shall remain subject to the performance requirements in effect for each associated system (e.g. governor control mechanism, main exciter, main power inverter, etc.) at the time ~~of~~ its authorization to connect to the *IESO-controlled grid* was granted or agreed to by the *market participant* and the *IESO* (i.e. the “original performance requirements”). These performance requirements shall prevail until the main elements of the associated system (e.g. governor control mechanism, main exciter) are replaced or substantially modified. At that time, the associated system that was replaced or substantially modified system shall meet the applicable performance requirements detailed set out below. ~~All other systems, not affected by replacement or substantial modification, shall remain subject to the original performance requirements.~~

Category	<del>Generation facility directly connected to the IESO-controlled grid, generation facility greater than 50 MW, or generation unit greater than 10 MW shall have the capability to: Requirement</del>
1. Off-Nominal Frequency <u>Operation</u>	Operate continuously between 59.4 Hz and 60.6 Hz and for a limited period of time in the region <del>above</del> <u>bounded by the</u> straight lines on a log-linear scale defined by the points (0.0 s, 57.0 Hz), (3.3 s, 57.0 Hz), and (300 s, 59.0 Hz) <u>and the straight lines on a log-linear scale defined by the points (0.0 s, 61.8 Hz), (8 s, 61.8 Hz), and (600 s, 60.6 Hz).</u>
2. Speed/Frequency Regulation	Regulate speed with an average droop based on maximum active power adjustable between 3% and 7% and set at 4% unless otherwise specified by the <i>IESO</i> . Regulation deadband shall not be wider than $\pm 0.06\%$ . Speed shall be controlled in a stable fashion in both interconnected and island operation. A sustained <del>±0.2%</del> change of rated active power after 10 s in response to a <del>step constant rate of</del> change of speed of <del>0.5%±1%/s</del> during interconnected operation shall be achievable. Due consideration will be given to inherent limitations such as mill points and gate limits when evaluating active power changes. Control systems that inhibit <u>governor-primary frequency</u> response shall not be enabled without <del>the IESO's</del> approval.
3. Voltage Ride-Through	Ride through routine switching events and design criteria contingencies assuming standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times, unless disconnected by configuration. <u>Momentary current cessation is not permitted without IESO approval.</u>
Category	<del>Generation facility directly connected to the IESO-controlled grid shall have the capability to:</del>
4. Active Power	Supply continuously all levels of active power output <u>within a <del>for</del> +/-5% range of its rated deviations in</u> terminal voltage. Rated active power is the smaller output at either rated ambient conditions (e.g. temperature, head, wind speed, solar radiation) or 90% of rated apparent power. To satisfy steady-state reactive power requirements, active power reductions to rated active power are permitted.
5. Reactive Power	Inject or withdraw reactive power continuously (i.e. dynamically) at <u>the high voltage terminal of the main output transformer</u> <del>connection point</del> up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the <i>IESO</i> . <u>Reactive compensation shall be provided for the reactive power loss and/or charging introduced by the transmission elements located between the high voltage terminal of the main output transformer and the connection point in a manner approved by the IESO. A conventional synchronous unit with a power factor range of 0.90 lagging and 0.95 leading at rated active power connected via a main output transformer impedance not greater than 13% based on generator rated apparent power is acceptable.</u>

<sup>1</sup> A main output transformer steps up the voltage from the generation unit/facility to the transmission voltage level

6. Automatic Voltage Regulator (AVR)	Regulate <u>voltage</u> automatically <u>at the low voltage terminal of the main output transformer</u> . The <u>impedance of the main output transformer shall not exceed 13% based on the combined rated apparent power of all generation units connected on its low voltage side, without IESO approval. Reactive power-voltage droop or AVR reference compensation shall not be enabled without the IESO's permission.</u> <u>voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 12% from the highest voltage terminal based within ±0.5% of any set point within ±5% of rated voltage. If the AVR target voltage is a function of reactive output, the slope <math>\Delta V/\Delta Q_{max}</math> shall be adjustable to 0.5%.</u> The equivalent time constants shall not be longer than 20 ms for voltage sensing and 10 ms for the forward path to the exciter output. <u>AVR reference compensation shall be adjustable to within 10% of the unsaturated direct axis reactance on unit side from a bus common to multiple generation units.</u>
7. Excitation System for synchronous generation units greater than 20 MVA or synchronous generation facilities greater than 75 MVA	Provide (a) Positive and negative ceilings not less than 200% and 140% <u>,respectively,</u> of rated field voltage at rated terminal voltage <u>and under open circuit rated field current conditions</u> ; (b) <u>An excitation transformer impedance not greater than 10% on excitation system base</u> <u>A positive ceiling not less than 170% of rated field voltage at rated terminal voltage and 160% of rated field current</u> ; (c) A voltage response time to either ceiling not more than 50 ms for a 5% step change from rated voltage under open-circuit conditions; and (d) A linear response between ceilings. Rated field current is defined at rated voltage, rated active power, and <u>the required</u> maximum continuous reactive power <u>required under Category 5 of this Appendix</u> .
8. Power System Stabilizer (PSS) for synchronous generation units greater than 20 MVA or synchronous generation facilities greater than 75 MVA	Provide (a) A change of power and speed input configuration; (b) Positive and negative output limits not less than ±5% of rated AVR voltage; (c) Phase compensation adjustable to limit angle error to within 30° between 0.2 Hz and 2.0 Hz under conditions specified by the IESO, and (d) Gain adjustable up to an amount that either increases damping ratio above 0.1 or elicits poorly damped exciter modes of oscillation at maximum active output unless otherwise specified by the IESO. Due consideration will be given to inherent limitations.
9. Phase Unbalance	Provide an open circuit phase voltage unbalance not more than 1% <u>at a connection point</u> and to operate continuously with a phase unbalance as high as 2% <u>at the high voltage terminal of its main output transformer</u> .
10. Armature and Field Limiters	Provide short-time capabilities specified in IEEE/ANSI 50.13 and continuous capability determined by either field current, armature current, or core-end heating. More restrictive limiting functions, such as steady state stability limiters, shall not be enabled without <u>the IESO's</u> approval.
11. Technical Characteristics	Exhibit <u>at the high voltage terminal of its main output transformer, connection point</u> performance comparable to an equivalent synchronous <i>generation unit</i> with characteristic parameters within typical ranges. Inertia, unsaturated transient impedance, transient time constants, and saturation coefficients shall be within typical ranges (e.g. $H > 1.2$ Aero-derivative, $H > 1.2$ Hydroelectric <u>like</u> less than 20 MVA, $H > 2.0$ Hydroelectric <u>like</u> 20 MVA or larger, $H > 4.0$ Other synchronous <u>units</u> , $X'd < 0.5$ , $T'd > 2.0$ , and $S1.2 < 0.5$ ) except where permitted by the IESO.
12. Reactive Power Response to Voltage Changes of inverter-based units	<u>Reach steady state reactive power within 1.5 s following a 2% step change to the AVR voltage reference. AVR response to the voltage error signal must be consistent over the entire operating range.</u>

## Appendix 4.3 – Requirements of Connected Wholesale Customers and Distributors Connected to the IESO-Controlled Grid

The performance requirements set out below shall apply to connected wholesale customers and distributors that are connecting equipment or facilities to the IESO-controlled grid or to their distribution systems after [new effective date]. Equipment connected within a connected wholesale customer's or distributor's facilities or distribution systems that was authorized to connect prior to [new effective date] shall remain subject to the performance requirements in effect at the time its authorization to connect was granted (i.e. the "original performance requirements").

Ref#	Item	Requirement
1	Power Factor	Connected wholesale customers and distributors connected to the IESO-controlled grid shall operate at a power factor within the range of 0.9 lagging to 0.9 leading as measured at the defined meter point.
2	Under Frequency Load Shedding	Connected wholesale customers and distributors connected to the IESO-controlled grid may be required to participate in under frequency load shedding
3	Special Protection Systems	Connected wholesale customers and distributors connected to the IESO-controlled grid may be required to participate in special protection systems.
4	Voltage Reduction	Distributors connected to the IESO-controlled grid with directly connected load facilities of aggregated rating above 20 MVA and with the capability to regulate distribution voltages under load, shall install and maintain facilities and equipment to provide voltage reduction capability.
5	[Intentionally left blank]	
6	[Intentionally left blank]	
7	[Intentionally left blank]	
8	[Intentionally left blank]	
9	Testing and Compliance Monitoring	Connected wholesale customers and distributors connected to the IESO-controlled grid shall test and maintain their equipment in accordance with all applicable reliability standards.
10	Metering	Connected wholesale customers and distributors connected to the IESO-controlled grid shall comply with metering codes and standards set by the IESO.
<u>11</u>	<u>Generation Units</u>	<u>Any generation unit connected within a connected wholesale customer's or a distributor's facility or distribution system that is connected to the IESO-controlled grid shall meet, at a minimum, the performance requirements for Off-Nominal Frequency operation (category 1), Speed/Frequency Regulation (category 2), and Voltage Ride Through (category 3) specified in Appendix 4.2.</u> <u>If a connected wholesale customer injects active power into the IESO-controlled grid, all performance requirements specified in Appendix 4.2 are applicable to the generation units installed within their facility.</u>
<u>12</u>	<u>Voltage Ride-Through</u>	<u>Equipment connected within a connected wholesale customer's or a distributor's facility or distribution system that is connected to the IESO-controlled grid shall ride through routine switching events and design criteria contingencies on the transmission system assuming standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times unless either disconnected by configuration or a failure to do so has been assessed and confirmed by the IESO as having no material adverse effect on the operation of the IESO-controlled grid.</u>