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## Market Rule Amendment Proposal

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### PART 1 – MARKET RULE INFORMATION

Identification No.:	MR-00445-R00		
Subject:	Updates to Performance Requirements: Market Rule Appendices 4.2 and 4.3		
Title:	Performance Requirements		
Nature of Proposal:	<input checked="" type="checkbox"/> Alteration	<input type="checkbox"/> Deletion	<input type="checkbox"/> Addition
Chapter:	4	Appendix:	4.2 and 4.3
Sections:	Chapter 4, Section 3.1		
Sub-sections proposed for amending:	Ch. 4 sub-section 3.1.3		

### PART 2 – PROPOSAL HISTORY

Version	Reason for Issuing	Version Date
1.0	Draft for Technical Panel review	June 16, 2020
1.1	Draft for Technical Panel review	June 17, 2020
2.0	Publish for Stakeholder Review and Comment	June 24, 2020
3.0	Published for Technical Panel review and vote	August 4, 2020
4.0	Recommended by Technical Panel	August 11, 2020
Approved Amendment Publication Date:		
Approved Amendment Effective Date:		

### PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

Provide a brief description of the following:

- The reason for the proposed amendment and the impact on the *IESO-administered markets* if the amendment is not made.
- Alternative solutions considered.
- The proposed amendment, how the amendment addresses the above reason and impact of the proposed amendment on the *IESO-administered markets*.

#### Summary

The *IESO* is proposing to amend the performance requirements for *generators, wholesale customers and distributors*, as well as expand the applicability of several existing requirements to all distributed energy resources, regardless of their size. The proposed amendment also specifies the required behavior for inverter-based *facilities* during and immediately following disturbances to avoid these *facilities* ceasing to inject current during system disturbances. In addition, the language of several other performance requirements is being clarified in order to help *market participants* better understand these requirements. These changes to performance requirements are aligned with industry-wide standards (NERC PRC-024 and CSA 22.3 no.9).

#### Background

In recent years, there has been a gradual shift in the supply mix, moving from traditional synchronous *generation facilities* to increasing amounts of inverter-based generation (e.g. wind and solar generators, and, more recently, storage facilities), many of them being distributed energy resources. The *IESO*'s 2019 Operability Study identified that the behavior of small distributed energy resources, combined with their increasing penetration levels, poses a risk to *transmission system reliability* as these units could cease producing power during and following significant system events, hence amplifying the effects of those events on the power grid.

The technical performance requirements for *generation, wholesale customer, and distribution facilities* are specified in Appendix 4.2 and Appendix 4.3 of the *market rules*. Appendix 4.2 lists the technical performance requirements for *generation facilities*, whereas Appendix 4.3 lists the technical performance requirements for *wholesale customers and distributors*.

To act on the recommendations from the 2019 Operability Study report, the *IESO* is proposing to amend the *generation facility* performance requirements to expand the applicability of several existing requirements to all distributed energy resources, regardless of their size. In addition, the *IESO* would like to use this opportunity to make improvements to the language of several other performance requirements that would help *market participants* more easily understand those requirements, and align these performance requirements with more recent industry-wide standards.

Through face-to-face meetings and webinars, the *IESO* has conducted broad stakeholder engagement of the proposed amendments to Appendices 4.2 and 4.3. These efforts have seen very high levels of engagement both in terms of total viewers and participation from attendees. Overall the stakeholder feedback received during and following these sessions has been positive, and the suggestions and requests have been considered and responded to by the *IESO*.

Information presented at these webinars can be found on the Updates to Performance Requirements [website](#), including presentations, written stakeholder feedback and *IESO* responses.

## PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

### Discussion

The lack of performance requirements for small distributed energy resources, combined with their increasing penetration levels, poses a risk to the *reliability* of the *IESO-controlled grid* as these units continue to displace larger generation, while not always having the ability to provide the necessary grid support during and following significant system events. Therefore, the *IESO* is proposing to extend the applicability of the ride-through and frequency response requirements to all units by removing the 10 MW minimum size threshold for distributed energy resources, to ensure that all *generation units* that are connected to the *electricity system* have, at a minimum, the capability to support its *reliability* by riding-through voltage and frequency excursions, and providing primary frequency response. This proposed change is aligned with the latest standard *CSA<sup>1</sup> 22.3 No. 9: Interconnection of Distributed Energy Resources and Electricity Supply Systems*.

In addition, the wording of several other performance requirements is proposed to be modified to help market participant more easily understand them.

The *IESO* is proposing the following changes to Chapter 4 and Appendices 4.2 and 4.3.

#### Chapter 4 - Grid Connection Requirements

##### Section 3.1.3

This sub-section is being modified to point to Appendix 4.3 instead of Appendix 4.2, as the requirements for *embedded generators* are being moved from Appendix 4.2 to Appendix 4.3, and to remove the applicability threshold for *embedded generators*.

#### Appendices 4.2 & 4.3

1. As the technical performance requirements for *wholesale customers' and distributors' facilities* are mainly in Appendix 4.3 of the *market rules*, with the exception of the technical performance requirements for distributed energy resources, which are in Appendix 4.2; *market participants* may overlook the requirements applicable to their distributed energy resource projects. To address this issue, the *IESO* is proposing to keep the technical performance requirements for transmission-connected *generation facilities* in Appendix 4.2, and consolidate the requirements for distributed energy resources in Appendix 4.3, together with the requirements applicable to *wholesale customers and distributors*. This proposed change will make it is easier for *market participants* to identify applicable performance requirements for their projects. As well, the applicability threshold for *embedded generators*, currently in Appendix 4.2, will be removed.
2. Although grid-connected inverter-based *generation facilities* are subject to the performance requirements in Appendix 4.2, the requirements in Appendix 4.2 are tailored more towards conventional technologies. Inverter-based units behave differently than conventional *generation units*. For example, inverter-based units could stay connected but cease current injections during and for a period of time after system disturbances, until which time they return to pre-disturbance levels at a

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<sup>1</sup> Canadian Standards Association

### PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

slow ramp rate. On the other hand, a conventional *generation unit* immediately responds to disturbances by providing voltage and frequency support for grid recovery. To address this issue, the *IESO* is proposing updates to Appendix 4.2 Category #1 “Off-Nominal Frequency Operation” and Category #3 “Voltage Ride-Through” to clarify required behavior for inverter-based *facilities* during and immediately following disturbances. This update is consistent with the latest NERC<sup>2</sup> PRC-024: *Generator Frequency and Voltage Protection* standard.

3. It is challenging for small transmission-connected synchronous *generation units* to meet Appendix 4.2 Category #7 “Excitation System” and Category #8 “Power System Stabilizer” requirements, and the *IESO* has approved a number of *exemptions* from these requirements over time. Typically, relaxing these requirements for small units has insignificant risk to *reliability*. As a result, the *IESO* is proposing to adopt the NERC threshold for Bulk Electric System generation, i.e., a *generation facility* larger than 75 MVA or a *generation unit* larger than 20 MVA, for the applicability of those two requirements.

4. The *IESO* is also proposing to take this opportunity to improve the clarity of some of the existing requirements in Appendix 4.2, e.g. Category #5 “Reactive Power” and Category #6 “Automatic Voltage Regulator”.

5. While there is a generic requirement for alternative technologies to perform in a manner comparable to conventional synchronous *generation unit* in Appendix 4.2, the reactive power response to voltage changes is prescribed through requirements for excitation systems, which is not relevant to other technologies. Therefore, the *IESO* is proposing to add a new requirement, Category 12 “Reactive Power Response to Voltage Changes of Inverter-Based Units”, that clearly specifies the parameters that need to be met by this technology.

6. Appendix 4.3 lacks a clear requirement for *wholesale customers* and *distributors* to prevent the equipment within their *facilities* from tripping for out-of-zone faults. The inadvertent tripping of large loads for out-of-zone faults poses a *reliability* risk to the *IESO-controlled grid* as it can result in excessive voltage levels, voltage collapse or equipment overloading. To address this issue, the *IESO* is proposing to add a new requirement in Appendix 4.3 to ensure that equipment within a *wholesale customer* or *distribution facility* does not inadvertently trip for out-of-zone faults.

The proposed amendments would apply only to new *facilities* and new equipment that connect after the approval of the amendments. The *IESO* is working with the *Ontario Energy Board* to find feasible ways to improve the performance of the distributed energy resources already connected to the system.

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<sup>2</sup> North American Electric Reliability Corporation

PART 4 – PROPOSED AMENDMENT

## Chapter 4 - Grid Connection Requirements

### 3. Performance Standards and Obligations of Market Participants

#### 3.1 General Requirement

- 3.1.3 Each *embedded generator* ~~whose *embedded generation facility* comprises either a *generation unit* rated at greater than 10 MW or *generation units* whose net output is greater than 50 MW~~ shall ensure that its equipment meets all applicable performance requirements in Appendix ~~4.2~~ 4.3.

## Appendix 4.2 – Requirements for Generation Facilities 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~~ shall be compared ~~at the point of connection to the IESO-controlled grid~~ 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 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 original performance requirements shall prevail until the main elements of an associated system (e.g. governor control mechanism, main exciter, power inverter) are replaced or substantially modified. At that time, the associated system that is was replaced or substantially modified system shall meet the applicable performance requirements set out detailed below. All other systems, not affected by replacement or substantial modification, shall remain subject to the original performance requirements.

Category	<i>Generation facilities</i> directly connected to the <i>IESO-controlled grid</i> , <i>generation facility greater than 50 MW</i> , or <i>generation unit greater than 10 MW</i> shall have the capability to:
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</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/ <u>frequency</u> 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/ <u>frequency</u> shall be controlled in a stable fashion in both interconnected and island operation. A sustained <del>94%</del> change of rated active power after 10 s in response to a <del>constant rate</del> <u>of step</u> change of speed of <del>0.45%/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 <del>governor-primary frequency</del> response shall not be enabled without <i>IESO</i> 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>For Inverter-based units, momentary current cessation or reduction of output current during system disturbances is not permitted without IESO approval.</u>
Category	<i>Generation facility</i> directly connected to the <i>IESO-controlled grid</i> shall have the capability to:
4. Active Power	<del>Supply e</del> Continuously <u>supply</u> all levels of active power output <del>for within a +/- 5% deviations in range of its</del> <u>rated</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	<p><del>Continuously (i.e., dynamically) inject or withdraw reactive power continuously (i.e., dynamically) at a connection point the high-voltage terminal of the main output transformer<sup>1</sup> up to 33% of its rated active power at all levels of active power output, and at the typical transmission system voltage, except where a lesser continually available capability is permitted by with the IESO's approval.</del> 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 generation unit rated apparent power is acceptable. <u>Reactive power losses or charging between the high-voltage terminal of the main output transformer and the connection point shall be addressed in a manner permitted by IESO approval.</u></p>
6. Automatic Voltage Regulator (AVR)	<p>Regulate <u>voltage</u> automatically <u>within ±0.5% of any set point within ±5% of rated voltage at the low-voltage terminal of the main output transformer if the transformer impedance is not more than 13% based on the rated apparent power of the generation facility, or</u> at a point <u>approved by the IESO, whose impedance (based on rated apparent power and rated voltage not more than 13% 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 ΔV/ΔQmax shall be adjustable to 0.5%.</u> <u>Reactive power-voltage droop or AVR reference load current compensation shall not be enabled without IESO approval.</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. <del>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.</del></p>
7. Excitation System for Synchronous Generation Units Greater than 20 MVA or Synchronous Generation Facilities Greater than 75 MVA	<p>Provide (a) Positive and negative ceilings not less than 200% and 140% of rated field voltage, <u>respectively, while supplying the field winding of the generation unit operating at nominal voltage under open circuit conditions—at rated terminal voltage and rated field current;</u> (b) <u>An excitation transformer impedance not greater than 10% on excitation system base. 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. <del>Rated field current is defined at rated voltage, rated active power, and required maximum continuous reactive power.</del></p>
8. Power System Stabilizer (PSS) for Synchronous Generation Units Greater than 20 MVA or Synchronous Generation Facilities Greater than 75 MVA	<p>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.</p>
9. Phase Unbalance	<p>Provide an open circuit phase voltage unbalance not more than 1% <del>at a connection point and to</del> operate continuously with a phase <u>voltage</u> unbalance as high as 2% <u>at the high-voltage terminal of its main output transformer.</u></p>
10. Armature and Field Limiters	<p>Provide short-time capabilities specified in IEEE/ANSI 50.13 and continuous capability determined by either <u>maximum field current, armature maximum stator current, or core-end heating, or minimum field current.</u> More restrictive limiting functions, such as steady state stability limiters, shall not be enabled without IESO approval.</p>
11. Technical Characteristics	<p>Exhibit, <u>at the high-voltage terminal of its main output transformer, connection point</u> performance comparable to an equivalent synchronous generation unit with characteristic parameters within typical ranges. Inertia, unsaturated transient impedance, transient time constants, and saturation coefficients shall be within typical ranges (e.g. H &gt; 1.2 Aero-derivative, H &gt; 1.2 Hydroelectric units less than 20 MVA, H &gt; 2.0 Hydroelectric units 20 MVA or larger, H &gt; 4.0 Other synchronous units, X'd &lt; 0.5, T'd0 &gt; 2.0, and S1.2 &lt; 0.5) except where permitted by IESO approval.</p>
12. Reactive Power Response to Voltage Changes of Inverter-Based Units	<p><u>For a constant voltage at the high-voltage terminal of the main output transformer, achieve a sustained reactive power change of 30% of generation facility rated apparent power at the low-voltage terminal of the main output transformer within 3s following a step change no larger than 4% to the AVR voltage reference. AVR response to the voltage error signal must be consistent over the entire operating range.</u></p>

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

## Appendix 4.3 – Requirements ~~for~~ 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"). These original performance requirements shall prevail until the main elements of an associated system are replaced or substantially modified. At that time, the associated system that is replaced or substantially modified shall meet the applicable performance requirements detailed below. All other systems not affected by replacement or substantial modification, shall remain subject to the original performance requirements.

<b>Category/Item</b>	<b>Requirement</b>
<u>1.</u> Power Factor	<i>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.</i>
<u>2.</u> Under Frequency Load Shedding	<i>Connected wholesale customers and distributors connected to the IESO-controlled grid may be required to participate in under frequency load shedding</i>
<u>3.</u> Special Protection Systems	<i>Connected wholesale customers and distributors connected to the IESO-controlled grid may be required to participate in special protection systems.</i>
<u>4.</u> Voltage Reduction	<i>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.</i>
<u>5.</u> [Intentionally left blank]	
<u>6.</u> [Intentionally left blank]	
<u>7.</u> [Intentionally left blank]	
<u>8.</u> [Intentionally left blank]	
<u>9.</u> Testing and Compliance Monitoring	<i>Connected wholesale customers and distributors connected to the IESO-controlled grid shall test and maintain their equipment in accordance with all applicable reliability standards.</i>
<u>10.</u> Metering	<i>Connected wholesale customers and distributors connected to the IESO-controlled grid shall comply with metering codes and standards set by the IESO.</i>
<u>11.</u> Voltage Ride-Through	<i>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.</i>
<del>11.</del> <u>12.</u> Generation Units	<i>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.</i>  <i>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.</i>



**PART 5 – IESO BOARD DECISION RATIONALE**

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