Market Rule Amendment Proposal

PART 1 – MARKET RULE INFORMATION

Identification No.:	**MR-00288-R00**			
Subject:	**Generator Technical Requirements**			
Title:	**Reactive Power Capability Requirements for Induction Generation Units**			
Nature of Proposal:	☒ Alteration	☐ Deletion	☐ Addition	
Chapter:	4	Appendix:	4.2	
Sections:				
Sub-sections proposed for amending:	Reference 1			

PART 2 – PROPOSAL HISTORY

Version	**Reason for Issuing**	**Version Date**
1.0	Submit for Technical Panel Review	9 Feb 05
2.0	Submit for Technical Panel Review	16 March 05
3.0	Revised as per Technical Panel Comments;	24 Mar 05
4.0	Publish for Stakeholder Review and Comment	13 Apr 05
5.0	Submit for Technical Panel Review and Vote	10 May 05
6.0	Recommended by Technical Panel and Submitted for IESO Board Approval	17 May 05

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

It is proposed to amend the market rule requirements for induction generation unit reactive power capability. These amendments are required to address issues regarding the existing requirements that have been raised by proponents of induction generation projects.

The amendments would:

1. Establish that the requirement for reactive power capability would be at the generation facility level rather than the generation unit level;
2. Establish that the reactive power capability for an induction generation facility would be as measured at the facility connection point to the IESO-controlled grid;
3. Define a "ceiling" or "floor" default requirement for induction generation facilities, depending on injection voltage;
4. Permit a requirement different from the default as follows:
    - A higher requirement than the "floor" default requirement if a higher requirement is identified by the IESO during the connection assessment and approval process for a given induction generation facility as necessary to maintain reliable operation of the IESO-controlled grid;
    - A lower requirement than the "ceiling" requirement if the lower requirement is identified by the IESO as acceptable during the connection assessment and approval process for a given induction generation facility.
5. In the circumstance where the IESO has identified a lower requirement than the "ceiling", permit, at any time after the connection assessment is completed, the IESO to impose a higher requirement than that identified at the time of a connection assessment if the IESO determines that the higher requirement is needed to maintain reliable operation of the IESO-controlled grid; and
6. Clarify the voltage regulation requirements for induction generation units.

These amendments are intended to reduce barriers to market entry for induction generation projects while maintaining reliable operation of the IESO-controlled grid.

This amendment also proposes to update and clarify the technical terminology of the excitation system performance requirements and to replace all "IMO" references to the "IESO" to reflect the change of name of the organization's name under Bill 100.

Background

"Reactive power is the portion of electricity that establishes and sustains the electric and magnetic fields of alternating-current equipment. Reactive power must be supplied to most types of magnetic

PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

equipment, such as motors and transformers. It also must supply the reactive losses on transmission facilities. Reactive power is provided by generators, synchronous condensers, or electrostatic equipment such as capacitors. Reactive power directly influences electric system voltage. It is usually expressed in kilovars (kvar) or megavars (Mvar)".[1] Reactive power cannot be transmitted over long distances efficiently and so must be produced close to where it is consumed.

Under MR-00244, the IESO introduced changes to several aspects of the technical requirements for generation units. Among those changes was to specify requirements for provision of reactive power by induction generation units e.g. wind turbine generation. The IESO Board approved these changes in October 2004. The approved changes came into effect on December 8, 2004. The resulting requirements for provision of reactive power by induction generation units are as follows:

"4. An induction *generation unit* that is injecting electricity at a nominal voltage of greater than 50 kV shall have the capability to supply reactive power at its terminal within the range 90% lagging (overexcited) to 95% leading (underexcited) power factor based on rated active power at rated voltage. Rated active power shall be the lesser of registered maximum continuous real power or 90% of the unit nameplate MVA.

5. An induction *generation unit* that is injecting electricity at a nominal voltage equal to or less than 50 kV shall, as a minimum, have the capability of operating at unity power factor. Additional reactive power capabilities for such an induction generation unit, up to the capabilities specified for a synchronous generation unit of the same apparent power, may be required if identified during the Connection Assessment and Approval process for that induction generation unit."[2]

This existing requirement for induction generation units connected to the IESO-controlled grid (i.e. injecting electricity at a nominal voltage of greater than 50 kV) establishes a "ceiling" requirement. Under the existing rules, market participants would have to use the exemption process to request a lower requirement. The existing requirement for induction generation units connected to a distribution system (i.e. injecting electricity at a nominal voltage of $\leq$50 kV) establishes a "floor" requirement. The IESO is permitted to require a higher standard.

Following the publication of the approved amendment, a stakeholder identified a concern with provision #4 above in its application to wind turbine generation units, namely:

> "…fully appreciate the need to have the capability to supply reactive power, but I have a concern with one of the proposed changes related to the supply of reactive power by induction generators detailed in Appendix 4.2 – Ref 1, item 4.
>
> Namely, that "An induction generation unit … shall have the capability to supply reactive power AT ITS TERMINAL within ….."
>
> I am not aware of a single wind turbine generator (WTG) manufacturer that uses induction

[1] NPCC Glossary of Terms

[2] Appendix 4.2 Baseline 13.0 Market Rules.

PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

generators, which can presently meet this requirement.

If the intent is to have a facility that can deliver the required reactive power based on the accumulated capacity of the total wind farm then Ref 1 - item 4 should be re-phrased to require the supply of reactive power AT ITS CONNECTION POINT. This change of wording would allow for the installation of capacitor banks within the collection system, but not necessarily at the generation unit terminals."

Despite the claim noted above that wind turbine generators cannot meet the existing requirement, it should be noted that a doubly fed induction generation unit can supply reactive power within the range required at its terminals and there are a number of manufacturers that can provide this technology. Regardless, the existing requirement would:

- limit a market participant's choices with respect to wind generation turbine technology; and
- potentially increase costs with no commensurate benefit to reliable operation of the IESO-controlled grid. The important feature of reactive power is that be delivered to the connection point to the IESO-controlled grid.

Induction generation facilities typically have a number of individual generation units whose output is collected on a common bus connected to the low voltage side of the step-up transformer that forms the connection point to the IESO-controlled grid. A wind turbine farm is an example of an induction generation facility. Wind turbine farms are expected to become more prevalent in the supply of electricity in Ontario because of recent government initiatives (e.g. request for renewable generation proposals).

Discussion

Induction generation facilities, unlike synchronous generation facilities, are typically comprised of many small generation units behind a single connection point. Therefore, this amendment proposes to require reactive power capability of the induction generation facility rather than individual generation units.

Measurement of Reactive Power Capability for Induction Generation Facilities

It is proposed that the market rules require the reactive power capability of an induction generation facility be as measured at the facility's connection point rather than at the generation unit terminals. Such a requirement would allow for market participant flexibility in meeting the requirement in a cost-effective manner. The participant could install reactive power supply devices between the generation units and the connection point. This flexibility is needed given the nature of induction generation unit technologies and facility configurations.

Refer to proposed requirements 4 and 5 below in Part 4.

Induction Generation Units Injecting At A Nominal Voltage Greater Than 50 kV

It is proposed to specify the reactive power capability requirement for an induction generation facility injecting at a nominal voltage greater than 50 kV as a default "ceiling" requirement and allowing a lower requirement under appropriate conditions (refer to proposed requirement 4 below in Part 4).

The default requirement would be the same requirement as exists for a synchronous generation unit of the same apparent power. This proposed requirement would provide for equal treatment of induction and synchronous generation as well as result in all generation contributing to meet the reactive power

PART 3 – EXPLANATION FOR PROPOSED AMENDMENT

needs of the IESO-controlled grid. This amendment also proposes that a lower requirement would be permitted if the IESO determines that a lower requirement is acceptable during the connection assessment and approval process. This allowance, which does not exist for synchronous generation, is proposed to address known and expected situations where an induction generation facility will be located on part of the IESO-controlled grid where provision of the default reactive power capability is not necessary e.g. on a radial transmission line. Empowering the IESO to identify and allow a reduced requirement under the market rules would be more efficient than requiring the market participant to use the exemption process.

In the circumstances where a lower requirement was established at the time of the connection assessment, it is also proposed that at any time after the connection assessment, the IESO may impose a higher requirement than that identified during the connection assessment. This provision is intended to address the situation where the reactive power needs of the IESO-controlled grid at the location where the induction generation facility has located have changed sufficiently since the time of the connection assessment that the induction generation needs to do more to meet those needs. The limit on a higher requirement that the IESO could impose is the "ceiling" default requirement i.e. the same reactive power capability required of a synchronous generation unit of the same apparent power.

Induction Generation Units Injecting At A Nominal Voltage Less Than Or Equal To 50 kV

It is proposed to clarify the reactive power capability for these induction generation facilities from "the capability of operating at unity power factor" to "the capability to change its reactive power flow to zero". This change would remove the implication that power factor control operation of induction generation is permitted (refer to proposed requirement 5 below in Part 4). Voltage control operation is required and power factor control operation is not permitted, except with approval of the IESO (refer to existing market rule requirement 13 in Part 4 below).

Excitation System Performance Requirements Terminology

It is proposed to update the terminology used in specifying the excitation system performance requirements. Specifically it is proposed to replace "response ratio" with "excitation system nominal response" (refer to requirement 12 in Part 4 below). These terms have identical meanings, but "response ratio" is old terminology and is causing confusion among market participants and generation project proponents.

Automatic Voltage Regulation

This amendment proposes to clarify that induction generation facility must have the same voltage regulation capability and performance as a synchronous generation unit of the same apparent power.

PART 4 – PROPOSED AMENDMENT

Appendix 4.2 – Generation Facility Requirements (Embedded and Non-Embedded)

Each *generation facility* shall comply with the following requirements, provided that a *generation facility* that was in service or that existed and was *licensed* on the date of coming into force of this Chapter 4 shall preserve original excitation system design capabilities and shall not be required to comply with the requirements set forth in rows 12 to 15 of this Appendix until its exciter is replaced. Such *generation facility* shall, until that time, be required to operate in accordance with the design capabilities applicable in respect of each of the items referred to in rows 12 to 15 of this Appendix.

Ref	*Item*	*Requirement*
1	Reactive Power Capabilities	1. A synchronous *generation unit* shall have the capability to supply at its terminal reactive power within the range 90% lagging (overexcited) to 95% leading (underexcited) power factor based on rated active power at rated voltage. Rated active power shall be the lesser of registered maximum continuous real power and 90% of the unit nameplate MVA. 2. A non-embedded *generation unit* within a *generation facility* shall have the capability to supply its entire range of reactive power for at least one constant voltage at a *connection facility* terminal greater than 50 kV. A non-embedded *generation unit* within a *generation facility* for which a licence has first been issued on or before the date of coming into force of this Chapter 4, and lacking the capability to meet this requirement, shall maintain its existing capability and shall establish the capability to supply its entire range of reactive power for at least one constant voltage at a *connection facility* terminal greater than 50 kV upon upgrading of all of the limiting components of its *connection facilities*. 3. Where modifications to a *generation facility* made before the date of coming into force of this Chapter 4 make it no longer possible to meet these reactive requirements at a new higher active power, *generation units* within such *generation facility* shall, if so requested by the ~~*IMO*~~*IESO,* satisfy reactive power requirements based on rated active power before this modification. 4. An induction *generation facility* that is injecting electricity at a nominal voltage of greater than 50 kV, shall have, as measured at its *connection point*, the same capability to supply reactive power as required of a synchronous *generation unit* of the same apparent power. The *IESO* may permit a lower requirement for an induction *generation facility* if the *IESO* identifies during the *connection assessment* for the *facility* that the lower requirement will not adversely affect the *reliable* operation of the *IESO-controlled grid.* At any time after the *connection assessment* is complete, the *IESO* may impose a higher requirement than that identified at the time of the *connection assessment*, up to the capabilities required of a synchronous generation unit of the same apparent power, if the *IESO* determines that the higher requirement is necessary to maintain *reliable* operation of the *IESO-controlled grid*. ~~An induction *generation unit* that is injecting electricity at a nominal voltage of greater than 50 kV shall have the capability to supply reactive power at its terminal within the range 90% lagging (overexcited) to 95% leading (underexcited) power factor based on rated active power at rated voltage. Rated active power shall be the lesser of registered maximum continuous real power or 90% of the unit nameplate MVA.~~ 5. An induction *generation facility* that is injecting electricity at a nominal voltage equal to or less than 50 kV, shall have, as a minimum, the capability to reduce its reactive power flow to zero, as measured at the *facility's connection point*. The *IESO* may impose additional reactive power capability requirements, up to the capabilities

Ref	Item	Requirement
		required of a synchronous *generation unit* of the same apparent power, if the *IESO* identifies during the *connection assessment* for the *facility* that the additional capability is required to maintain *reliable* operation of the *IESO-controlled grid*.~~An induction *generation unit* that is injecting electricity at a nominal voltage equal to or less than 50 kV shall, as a minimum, have the capability of operating at unity power factor. Additional reactive power capabilities for such an induction *generation unit*, up to the capabilities specified for a synchronous *generation unit* of the same apparent power, may be required if identified during the Connection Assessment and Approval process for that induction *generation unit*.~~
2	Voltage Variations	Each *generation facility* shall be capable of operating continuously at full output within ± 5% of the *generation facility's* rated terminal voltage. All plant auxiliaries shall be capable of running continuously within this range. Each *generation facility* shall not be expected to operate continuously outside this voltage range to satisfy reactive power requirements.
3	Frequency Variations	Each *generation facility* shall be able to operate continuously at full power in the range 59.4 to 60.6 Hz. Each *generation facility* shall be capable of operating at full power for a limited period of time at frequencies as low as 58.8 Hz. Each *generation facility* shall not trip for underfrequency excursions that are above a straight line defined on a linear-log plot of time and frequency by the points (300s, 59.0Hz) and (3.3s, 57.0 Hz) unless the ~~*IMO*~~ *IESO* accepts other trip settings. Immediate tripping is allowed below 57.0 Hz.
4	Phase Unbalance	Phase voltage unbalance of *generation facilities* shall be limited to1% measured with the units operating unsynchronised. *Generation facilities* shall be able to continuously operate with a phase unbalance of 2%.
5	Connection Equipment	All equipment connecting the *generation unit's* terminal to the ~~*IMO*~~*IESO-controlled grid* shall be able to conduct for at least 4 hours the *generation unit's* rated apparent power, being the product of root-mean-square (rms) voltage and the rms current, minus auxiliary power requirements necessary to operate the unit at maximum output and minus a fair portion of the common service load required to run the entire *generation facility*.
6	[Intentionally left blank]	
7	Protective Systems and Relaying System Requirements	Protection systems shall be constructed and maintained in accordance with all applicable *reliability standards*.
8	[Intentionally left blank] Line	
9	~~*IMO*~~*IESO* Monitoring and Telemetry Requirements	*Generation facilities* that are required by this Chapter 4 to be monitored shall provide suitable space and facilities for the installation of telecommunications equipment to interface with the *generator's* data acquisition equipment. Data monitoring equipment shall be compatible with the ~~*IMO*~~*IESO* telecommunications interface and meet the requirements of this Chapter 4 and of Appendix 2.2 of Chapter 2, if such equipment is not already installed on the date of coming into force of this Chapter 4. Any such new installation shall be done at the *generator*'s cost.
10	Communication Facilities	Communication facilities are required for several or all of the following functions: protective relaying, SCADA, ~~*IMO*~~*IESO energy* management system, voice communication, *automatic generation control* (*AGC*), and *special protection systems* (*generation* rejection or runback). Details depend on the size and specific location of the generating plant under consideration
11	Testing/ Compliance Monitoring	*Generators* shall test and maintain their equipment in accordance with all applicable *reliability standards*.

Ref	Item	Requirement
	Generator Controls	
12	Excitation System Performance	1. Each synchronous *generation unit* rated at 10 MVA or higher shall be equipped with an excitation system with: • A voltage response time not longer than 50 ms for a voltage reference step change not to exceed 5%; • A positive ceiling voltage of at least 200% of the rated field voltage, and • A negative ceiling voltage of at least 140% of the rated field voltage. This performance requirement would not apply to a *generation unit* rated at 10 MVA or higher where the ~~*IMO*~~*IESO* determines through the *connection assessment* for that *generation unit*, that a lower requirement would not adversely impact the *reliable* operation of the ~~*IMO*~~*IESO-controlled grid*. In these circumstances, the synchronous *generation unit* shall be equipped with an excitation system with: • An excitation system nominal response ~~response ratio~~ of at least 0.50 and • A positive ceiling voltage at least 150% of rated field voltage 2. Each synchronous *generation unit* rated at less than 10 MVA shall be equipped with an excitation system with: • An excitation system nominal response ~~A response ratio~~ of at least 0.50 and • A positive ceiling voltage at least 150% of rated field voltage This performance requirement would not apply to a *generation unit* rated at less than 10 MVA where the ~~*IMO*~~*IESO* determines through the *connection assessment* for that *generation unit*, that a higher requirement is required to maintain *reliable* operation of the ~~*IMO*~~*IESO-controlled grid*. In these circumstances, the synchronous *generation unit* shall be equipped with an excitation system with: • A voltage response time not longer than 50 ms for a voltage reference step change not to exceed 5%; • A positive ceiling voltage of at least 200% of the rated field voltage, and • A negative ceiling voltage of at least 140% of the rated field voltage.
13	Automatic Voltage Regulator	Each synchronous *generating unit* shall be equipped with a continuously acting automatic voltage regulator (AVR) that can maintain terminal voltage under steady state conditions within ± 0.5% of any set point within ± 5% of rated voltage. ~~Each synchronous *generation unit* shall regulate voltage except where permitted by the *IMO*.~~ ~~-~~Each induction *generation* ~~*unit*~~ *facility* that is injecting electricity at a nominal voltage of greater than 50 kV shall be equipped with a voltage regulation system (VRS) that provides comparable performance to that of the AVR of a synchronous *generation unit* of the same apparent power. ~~shall regulate voltage except where permitted by the *IMO*.~~ Each AVR and VRS shall regulate voltage except where permitted by the *IESO*. Automatic set point adjustments shall be suspended when terminal voltage deviates from a fixed set point by an amount not to exceed ± 2% of the fixed set point. Where multiple *generation units* are connected to a common bus, each *generation unit's* AVR reference shall be compensated to a point as close a practicable to but not farther than this common bus. The reach of AVR compensation shall not exceed 10% of the *generation unit's* synchronous direct axis impedance from the common bus. ~~*IMO*~~*IESO* approval is required for all other schemes that compensate the AVR to a point other than the *generation unit's* terminals.
14	Power Factor Regulator	Each synchronous *generation unit* connected to the system at a voltage under 50 kV shall be provided with a power factor regulator or VAR regulator. A power factor regulator shall be capable of maintaining a power factor within ± 1% between 90% lagging and 95% leading. A VAR regulator shall be capable of maintaining reactive power within ± 2.5% of rated MVA. The power factor or VAR regulator shall have an adjustable effective response time between 10 to 60 seconds.
15	Power System Stabilizer	Each synchronous *generating unit* that is equipped with an excitation system that meets the performance requirements specified in sub-section 1 of section 12 above, shall also be equipped with a power system stabilizer. The power system stabilizer shall, to the extent practicable, be tuned to increase damping torque without reducing synchronizing torque.
16	Speed Governor	• Each synchronous *generation unit* with a nameplate rating of greater than 10 MVA shall be operated with a speed governor. The governor shall have a permanent speed droop that can be set in the range between 3% and 7% and the intentional deadband shall not be wider than ± 36 mHz . • The above droop and deadband requirements shall apply to an entire combined-cycle *generation*

Ref	Item	Requirement
		facility. • The governor shall be able to arrest the unit's speed, following full load rejection to prevent a trip due to overspeed, and shall demonstrate stable performance with adequate damping under all operating conditions. • Governors shall control speed in a stable fashion during both island and interconnected operation. • To the extent practical governors shall provide immediate, appropriate and sustained response to abnormal frequency excursions. • Control systems that inhibit governor response shall be automatically disabled by frequency deviations not larger than ± 100 mHz.

PART 5 – IESO BOARD COMMENTS

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