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System Impact Assessment Report (Addendum)

CONNECTION ASSESSMENT & APPROVAL PROCESS

Addendum Report

CAA ID: **2010-388**
Project: **Summerhaven Wind Energy Centre**
Applicant: **Summerhaven Wind LP.**

Market Facilitation Department
Independent Electricity System Operator

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System Impact Assessment Report (Addendum)

Acknowledgement

The IESO wishes to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IESO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IESO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IESO should issue a notice of conditional approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules.

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One at the time the assessment was carried out. The IESO assumes no responsibility for the accuracy or completeness of such information, including the results of studies carried out by Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

If the connection applicant has engaged a consultant to perform connection assessment studies, the connection applicant acknowledges that the IESO will be relying on such studies in conducting its assessment and that the IESO assumes no responsibility for the accuracy or completeness of such studies including, without limitation, any changes to IESO base case models made by the consultant. The IESO reserves the right to repeat any or all connection studies performed by the consultant if necessary to meet IESO requirements.

Conditional approval of the proposed connection means that there are no significant reliability issues or concerns that would prevent connection of the proposed project to the IESO-controlled grid. However, the conditional approval does not ensure that a project will meet all connection requirements. In addition, further issues or concerns may be identified by the transmitter(s) during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with physical or equipment limitations, or with the Transmission System Code, before connection can be made.

This report has not been prepared for any other purpose and should not be used or relied upon by any person for another purpose. This report has been prepared solely for use by the connection applicant and the IESO in accordance with Chapter 4, section 6 of the Market Rules. The IESO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IESO may have to the connection applicant in respect of this report is governed by Chapter 1, section 13 of the Market Rules. In the event that the IESO provides a draft of this report to the connection applicant, the connection applicant must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to the connection applicant. Although the IESO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that the most recent version of this report is being used.

Hydro One

The results reported in this report are based on the information available to Hydro One, at the time of the study, suitable for a System Impact Assessment of this connection proposal.

The short circuit and thermal loading levels have been computed based on the information available at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed facilities on load and generation customers.

In this report, short circuit adequacy is assessed only for Hydro One circuit breakers. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One circuit breakers and identifying upgrades required to incorporate the proposed facilities. These results should not be used in the design and engineering of any new or existing facilities. The necessary data will be provided by Hydro One and discussed with any connection applicant upon request.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and project loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades which are required to incorporate the proposed facilities have been identified to the extent permitted by a System Impact Assessment under the current IESO Connection Assessment and Approval process. Additional project studies may be necessary to confirm constructability and the time required for construction. Further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

1. Notification of Conditional Approval

Summerhaven Wind LP. (the "connection applicant") is developing a new 125 MW wind farm, Summerhaven Wind Farm (the "project")located in Haldimand County, Nanticoke, Ontario. The project will be connected to Hydro One's 230 kV circuit N1M. The project has been awarded a Power Purchase Agreement under the FIT program with Ontario Power Authority. It is expected that commercial operation will start in June 2013.

The original SIA examined the connection of the project through a proposed overhead feeder collector system. Recently, the connection applicant has modified their collector system design to an under-ground cable feeder system. This assessment examines the impact of this proposed change with respect to the amount of reactive power compensation required at the facility to meet IESO Market Rules requirements.

This assessment concludes that the connection of the project with the proposed changes, operating up to 125 MW, subject to the requirements specified in this report and the original SIA report, is expected to have no material adverse impact on the reliability of the integrated power system. It is recommended that a *Notification of Conditional Approval for Connection* be issued for the Summerhaven wind project subject to implementation of the requirements outlined in this report and the original SIA report.

2. IESO Requirements for Connection

Applicant Requirements

Specific requirements:

(1) The project is required to have the capability to inject or withdraw reactive power continuously (i.e. dynamically) at the connection point up to 33% of its rated active power at all levels of active power output.

Based on the equivalent collector impedance parameters provided by the connection applicant, a static capacitive compensation device rated at 15 Mvar@34.5 kV installed at the 34.5 kV collector bus of the project would satisfy the reactive power requirement.

The connection applicant has the obligation to ensure that the wind farm has the capability to meet the Market Rules requirement at the connection point and be able to confirm this capability during the commission tests.

This requirement supersedes the applicant's specific requirement (1) in the Executive Summary of the original SIA report.

3. Assessments

Updated Equipment Parameters

Tap Line

Parameters of the 230 kV tap line provided by the connection applicant are listed below.

Voltage	240 kV

Rating	1785 A
Length	7.59 km
Impedance	0.51649+j3.534 ohms

Transformer

Parameters for the 34.5/230 kV step-up transformer are listed below.

Transformation	241.5/34.5 kV
Rating	84/112/140 MVA ONAN/ONAF/ONAF
Impedance	0.00231+j0.08362 pu based on 84 MVA
Configuration	3 phase, high side: wye-grounded, low side: delta
Tapping	off-load tap changers at HV(229.4, 235.5, 241.5, 247.6, 253.6 kV)

Feeder System

The following are the revised technical data of the collector system feeders at the project as provided by the connection applicant:

Table 1: Equivalent Impedance of Collectors

Circuit	Unit#	MW	Positive-Sequence Impedance (pu, S_B=100MVA)			Zero-Sequence Impedance (pu, S_B=100MVA)		
			R	X	B	R	X	B
F11	15	33.32	0.0643	0.0725	0.0402	0.0306	0.0102	0.0402
F12	11	24.43	0.0821	0.0943	0.0388	0.0391	0.0130	0.0388
F13	10	22.21	0.0388	0.0310	0.0154	0.0200	0.0063	0.0154
F14	11	24.43	0.0340	0.0234	0.0101	0.0188	0.0058	0.0101
F15	9	19.99	0.0816	0.0889	0.0168	0.0395	0.0130	0.0168

Reactive Power Compensation

The Market Rules (MR) require that generators inject or withdraw reactive power continuously (i.e. dynamically) at a connection point 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 IESO. A generating unit with a power factor range of 0.90 lagging/leading and 0.95 leading/lagging at rated active power connected via impedance between the generator and the connection point not greater than 13% based on rated apparent power provides the required range of dynamic reactive capability at the connection point.

Dynamic reactive compensation (e.g. D-VAR or SVC) is required for a generating facility which cannot provide a reactive power range of 0.90 lagging/leading power factor and 0.95 leading/lagging power factor at rated active power. For a wind farm with impedance between the generator and the connection point greater than 13% based on rated apparent power, provided the WTGs have the capability to provide a reactive power range of 0.90 lagging/leading power factor and 0.95 leading/lagging power factor at rated active power, the IESO accepts that the wind farm compensates for excessive reactive losses in the collector system of the project with static shunts (e.g. capacitors and reactors).

The SIA proposed a solution for the WF to meet the MR requirements on reactive power capability. However, the applicant can deploy any other solutions which result in its compliance with the MR. The applicant shall be able to confirm this capability during the commission tests.

Dynamic Reactive Power Capability

As concluded in the original SIA report, the proposed Siemens generators can deliver the IESO required dynamic reactive power to the generator terminal at rated power and at rated voltage. Thus, the IESO has determined that there is no need to install any additional dynamic reactive power compensation device.

Static Reactive Power Capability

The WF has to compensate for the reactive power losses within the project to ensure that it has the capability to inject or withdraw reactive power up to 33% of its rated active power at the connection point. As mentioned above, the IESO accepts this compensation to be made with switchable shunt admittances.

Load flow studies were performed to calculate the static reactive compensation, based on the equivalent parameters provided by the connection applicant for the WF.

The reactive power capability in lagging power factor of the project was assessed under the following assumptions:

- typical voltage of 240 kV at the connection point;
- maximum active power output from the equivalent WTG;
- maximum reactive power output (lagging power factor) from the equivalent WTG, unless limited by the maximum acceptable WTG terminal voltage;
- maximum acceptable WTG voltage is 1.06, as per WTG voltage and reactive power capability;

The reactive power capability in leading power factor of the project was assessed under the following assumptions:

- typical voltage of 240 kV at the connection point;
- minimum (zero) active power output from the equivalent WTG;
- maximum reactive power consumption (leading power factor) from the equivalent WTG, unless limited by the minimum acceptable WTG terminal voltage;
- minimum acceptable WTG voltage is 0.9, as per WTG voltage and reactive power capability;

The WTGs may automatically disconnect themselves from the system during high wind conditions. This leaves only the collector system connected to the grid providing charging reactive power to the system. Simulation results show that under this situation the project will inject about 14 MVAr reactive power into the system at the PCC, which may aggravate the high-voltage situation under some system conditions. The project shall be capable of reducing the reactive power injection at the PCC at the request of the IESO. This may be obtained by disconnecting the collectors. Shall the project fail to meet the IESO's direction, the IESO reserve the right to ask the applicant to disconnect the project from the system.

The IESO's reactive power calculation used the equivalent electrical model for the WTG and collector feeders as provided by the connection applicant. It is very important that the WF has a proper internal

design to ensure that the WTGs are not limited in their capability to produce active and reactive power due to terminal voltage limits or other facility's internal limitations. For example, it is expected that the transformation ratio of the WTG step up transformers will be set in such a way that it will offset the voltage profile along the collector, and all the WTG would be able to contribute to the reactive power production of the WF in a shared amount.

Based on the equivalent parameters for the WF provided by the connection applicant, an amount of 15 Mvar@34.5 kV of static capacitive compensation is required to be installed at the WF collector bus to meet the reactive power requirements at the connection point.

The capacitor banks shall be implemented as a part of the wind farm control system that automatically controls the switching of capacitors and regulates the overall WTGs' reactive output.

Static Reactive Power Switching

The IESO requires the voltage change on a single shunt switching to be no more than 4% at any point on the IESO-controlled grid. A switching study was carried out to investigate the effects on system voltages when switching in the new shunt capacitor. It was assumed that the largest capacitor step size is 10 Mvar. To reflect the reasonable restrictive system conditions, the voltage change study was studied under the light load conditions and assumed that circuit N2M is out of service.

Table 2: Capacitor Switching Results

Capacitor at LV bus	LV bus voltage (kV)	Voltage at connection point (kV)
Pre-switching	34.8	239.8
Post-switching	35.3	240.1
ΔV	1.44%	0.12%

The results show that switching a single capacitor of 15 Mvar produces less than 4% voltage change at the connection point.

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