REPORT

Power to Ontario.
On Demand.

System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Addendum Report

CAA ID: **2011-443**
Project: **Bornish Wind Energy Centre**
Applicant: **Bornish Wind LP**

Market Facilitation Department
Independent Electricity System Operator

Date: June 6, 2012

Document ID	IESO_REP_0767
Document Name	System Impact Assessment Report
Issue	Addendum Report
Reason for Issue	Revised connection configuration
Effective Date	June 6, 2012

System Impact Assessment Report

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

Bornish, Adelaide and Jericho Wind Energy Centres are three wind generating projects proposing to connect to 500 kV circuit B562L, via a 121 kV network and 525/121 kV step up transformer, both proponent owned. Initial System Impact Assessments (SIA) CAA ID 2011-441, CAA ID 201-443 and CAA ID 2011-446 were issued on December 21st, 2011, where the connection of the three projects to the IESO controlled grid was examined and given a Notice of Conditional Approval..

Suncor Energy Products Inc. is proposing to construct a 100 MW wind energy project named Cedar Point II Wind Power Project, which would connect to circuit B562L via the same 121 kV network as the three aforementioned projects. As agreed upon with the connection applicants for all four projects, new SIA studies were performed for the four projects as a cluster with requirements being developed for the combination of the Cedar Point II, Bornish, Adelaide and Jericho wind projects (the "projects").

Hydro One and the connection applicants are proposing an alternative solution to manage the high voltage concern identified in the original SIA at the 500 kV connection stations. Rather than installing a reactor, equipment at Parkhill CTS (generation side) and Evergreen SS (transmission side) will be upgraded to ensure that a maximum continuous voltage of at least 570 kV can be sustained.

This Addendum addresses changes to requirements previously developed for Bornish, Adelaide and Jericho Wind Energy Centres before the incorporation of the Cedar Point II Wind Power Project, as well as changes proposed by the transmitter and the proponents to mitigate potential over-voltages at the connection station Evergreen SS.

This assessment concludes that the proposed changes are expected to have no material adverse impact on the reliability of the integrated power system. Therefore, the IESO recommends that a *Notification of Conditional Approval for Connection* be issued for the Bornish Wind Energy Centre subject to implementation of the requirements outlined in this report and the original SIA report.

2. IESO Requirements for Connection

Transmitter Requirements

The following requirements are applicable to the transmitter for the incorporation of the projects:

(1) Equipment at Evergreen SS must be able sustain a continuous voltage up to 561 kV. Fault interrupting devices at Evergreen SS must be able to interrupt fault currents at voltages as high as 561 kV. Alternate solutions to manage the high voltage concern may be acceptable upon the approval of the IESO.

This requirement supersedes transmitter requirement (3) in the Executive Summary of the original SIA report.

(2) The circuit breakers at Evergreen will have a short circuit symmetrical rating of at least 50 kA at its maximum continuous operating voltage. This rating is sufficient in meeting the short circuit levels at Evergreen SS as presented in the original SIA. If any future system changes results in an increased fault level higher than the capability of the fault interrupting devices, these fault interrupting devices must be replaced with higher rated equipment capable of sustaining the increased fault level up to the maximum fault level specified in Appendix 2 of the Transmission System Code.

(3) The transmitter shall modify the existing Bruce Special Protection Scheme (BSPS) to incorporate the new project and the new switching station. The BSPS shall be expanded to recognize the disconnection of the circuits in the Bruce x Longwood corridor. A description of the modifications to the BSPS has to be provided to the IESO in a timely manner to allow for the required approvals of the BSPS to be obtained. A Facility Description Document (FDD) describing the functionality of the expanded BSPS has to be provided to the IESO during the market entry /facility registration process.

Applicant Requirements

Specific requirements:

(1) The projects are 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 of at least 120 Mvar@121 kV installed at the 121 kV Parkhill CTS bus would satisfy the reactive power requirement. The required capacitive compensation would need to be arranged into at least 4 approximately equal steps to allow for flexibility in adjustment of reactive power production.

The voltage profile along the projects' network greatly impacts their ability to provide full reactive support from the WTGs. The IESO recommends that projects' internal system voltages be controlled via automatic ULTC such that voltages remain within acceptable ranges, ultimately facilitating the WTGs ability to provide full reactive support.

The connection applicant has the obligation to ensure that the wind farm has the capability to meet the Market Rules' requirements 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.

(2) The connection applicant shall ensure that the equipments within the project have the capability to operate when the voltage at Evergreen SS is as high as 561 kV.

This requirement supersedes the applicant's specific requirement (2) in the Executive Summary of the original SIA report.

General Requirements:

(1) The connection applicant shall ensure that the 500 kV equipment is capable of continuously operating between 490 kV and 561 kV. Protective relaying must be set to ensure that transmission equipment remains in-service for voltages between 94% of the minimum continuous value and 105% of the maximum continuous value.

This requirement supersedes general requirement (4) in the Executive Summary of the original SIA report.

(2) The connection applicant shall ensure that all equipment within their facility is capable to sustain the fault levels in the area. If any future system changes results in an increased fault level higher than the equipment's capability, the connection applicant is required to replace the equipment with

higher rated equipment capable of sustaining the increased fault level, up to maximum fault level specified in Appendix 2 of the Transmission System Code.

Fault interrupting devices must be able to interrupt fault currents at voltages as high as 561 kV.

The requirement supersedes general requirement (7) in the Executive Summary of the original SIA report.

3. Assessment

The initial System Impact Assessments examined the connection of the Bornish, Adelaide and Jericho Wind Energy Centres to 500 kV circuit B562L, via a 121 kV network and 525/121 kV step up transformer, both proponent owned.

Suncor Energy Products Inc. is proposing to construct a 100 MW wind energy project named Cedar Point II Wind Power Project, which would connect to circuit B562L via the same 121 kV network as the three aforementioned projects. As agreed upon with the connection applicants for all four projects, the System Impact Assessment studies were performed as a cluster with requirements being developed for the combination of the Cedar Point II, Bornish, Adelaide and Jericho wind projects.

This Addendum addresses changes to requirements previously developed for Bornish, Adelaide and Jericho Wind Energy Centres before the incorporation of the Cedar Point II Wind Power Project, as well as changes proposed by the transmitter and the proponents to mitigate potential over-voltages at the connection station Evergreen SS.

3.1 Reactive Power Compensation

The Market Rules require generators to inject or withdraw reactive power continuously (i.e. dynamically) at a connection point equal to up to 33% of the generator's 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 and 0.95 leading 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 power factor and 0.95 leading power factor at rated active power. For a wind farm with an impedance between the generator and the connection point in excess of 13% based on rated apparent power, provided the WTGs have the capability to provide a reactive power range of 0.90 lagging power factor and 0.95 leading power factor at rated active power, the IESO accepts that the wind farm compensate 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 project to meet the Market Rules requirements on reactive power capability. However, the applicant can deploy any other solutions which result in its compliance with the Market Rules. The applicant shall be able to confirm this capability during the commission tests.

Dynamic Reactive Power Capability

The Siemens SWT 2.3 MW and GE 1.6 MW WTGs can deliver the IESO required dynamic reactive power at rated power and at rated terminal voltage. Thus, there is no need to install additional dynamic reactive power device.

Static Reactive Power Capability

In addition to the dynamic reactive power requirement identified above, the projects have to compensate for the reactive power losses within the projects' network 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 projects.

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

- typical voltage of 545 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 WTG voltage of 1.05 pu;
- main and intermediate level step-up transformer ULTCs are available to adjust the LV voltage as close as possible to 1 pu voltage, while ensuring the intermediate transmission and collector bus voltages within the Nextera system do not exceed 1.05 pu. No voltage limitations for the Cedar Point facility have been specified.

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

- typical voltage of 545 kV at the connection point;
- minimum (zero) active power output from the equivalent WTG;
- reactive power consumption (leading power factor) as required to meet the Market Rules requirement from the equivalent WTG.
- minimum acceptable WTG voltage is 0.9 pu, as per WTG voltage capability;
- main and intermediate level step-up transformer ULTCs are available to adjust the LV voltage as close as possible to 1 pu voltage, while ensuring the intermediate transmission and collector bus voltages within the Nextera system do not fall below 0.95 pu. No voltage limitations for the Cedar Point facility have been specified.

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 important that the project have 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 project 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 project in an equal amount.

Based on the equivalent parameters for the wind farm provided for the projects, a static capacitive reactive power compensation rated 120 Mvar at 121 kV is required to be installed at the Parkhill 121 kV bus to meet the reactive power injection requirement at the connection point. No reactor is required to meet the reactive power withdrawal requirement. A detailed summary of the results with reactive power compensation is provided in Table 1.

Table 1: Reactive Power Capability at the PCC

Operation	Intermediate Bus Voltage (kV)	Collector Bus Voltage (kV)	Max/Min Generator Terminal Voltage (pu)	PCC Reactive Power (Mvar)	PCC Voltage (kV)
Lagging PF	125.8	34.4	1.043	+134.0	545 kV
Leading PF	121	34.5	0.90	-203.3	545 kV

The required capacitive compensation will need to be arranged into at least 4 approximately equal steps to allow for flexibility in adjustment of reactive power production. It shall also be implemented as a part of wind farm control system that automatically controls the switching of capacitor banks to regulate the overall WTGs' reactive output to around zero.

Static Reactive Power Switching

The IESO requires the voltage change on a single capacitor switching to be no more than 4 % at the any point in the IESO Controlled Grid. A switching study was carried out to investigate the effect of the new shunt capacitor banks on the voltage changes. It was assumed that the largest capacitor step size is 30 Mvar. To reflect a reasonably restrictive system condition, the voltage change study was studied under light load conditions and assumed one Bruce to Longwood circuit out of service.

Table 2: Voltage Changes Due to Static Reactive Compensation Switching

Capacitor at 121 kV bus	Parkhill 121 kV voltage	Evergreen SS voltage
Pre-switching	120.2 kV	542.0 kV
Post-switching	122.2 kV	544.1 kV
ΔV	1.7%	0.4%

Table 2 shows that switching a single capacitor of 30 Mvar results in less than 4 % voltage change at the connection point, therefore meeting the Market Rules' requirement.

3.2 Over-voltage Management at Evergreen SS

Due to the long length of Bruce-by Evergreen 500 kV circuit, voltages at Evergreen SS may exceed maximum continuous levels of 550 kV specified by Appendix 4.1 of the Market Rules under certain operating scenarios.

The voltage analysis was carried out under the following assumptions:

- Voltage of 550 kV at Bruce A TS
- Evergreen-by-Longwood circuit out of service
- Cedar Point II, Jericho, Bornish and Adelaide WTGs off line with their proposed collector systems disconnected
- Parkhill CTS and Bornish TS remaining connected to Evergreen SS

Table 3: Voltage Analysis Results at Evergreen SS

Bus	Voltage with Evergreen-by-Longwood circuit out of service
Evergreen SS 500kV	561 kV

Table 3 shows the simulation results which indicate that the voltage at Evergreen SS could be as high as 561 kV.

In the previous System Impact Assessment, the SIA required that a 500 kV reactor be installed and switched automatically to ensure that voltages do not exceed 550 kV at Evergreen SS. Hydro One and the connection applicants are proposing an alternative solution to manage the high voltage concern at Evergreen SS. Rather than installing a reactor, equipment at Evergreen SS will be upgraded to ensure that a maximum continuous operating voltage of at least 570 kV can be sustained. This solution is acceptable to the IESO.

Thus, 500kV equipment at Evergreen SS and the project must be able to sustain a maximum continuous voltage of 561 kV as per the study results. The connection applicant shall also ensure that the equipment within the projects have the capability to operate when the voltage at Evergreen SS is as high as 561 kV. Fault interrupting device at Evergreen SS and the project must be able to interrupt fault currents at voltages as high as 561 kV.

Alternate solutions to manage high voltage concern may also be acceptable upon the approval of the IESO.

Equipment Data

The following are the technical specifications of the equipment at Evergreen SS provided by Hydro One:

- Circuit breakers at Evergreen SS will be of the 765 kV voltage class;
- Circuit breakers at Evergreen will have a short circuit symmetrical rating of at least 50 kA at its maximum continuous operating voltage. This rating is sufficient in meeting the short circuit levels at Evergreen SS as presented in the original SIA. Note the typical limited maximum 3 phase and single line to ground symmetrical fault levels allowed by the Transmission System Code on the 500 kV system is 63 kA ;
- Circuit breakers at Evergreen will have an interrupting time less than or equal to 2 cycles;
- All other equipment at Evergreen will have a maximum continuous operating voltage of at least 570 kV.

The connection applicants have also indicated that 500 kV equipment within projects' network will also have a maximum continuous operating voltage of at least 570 kV.

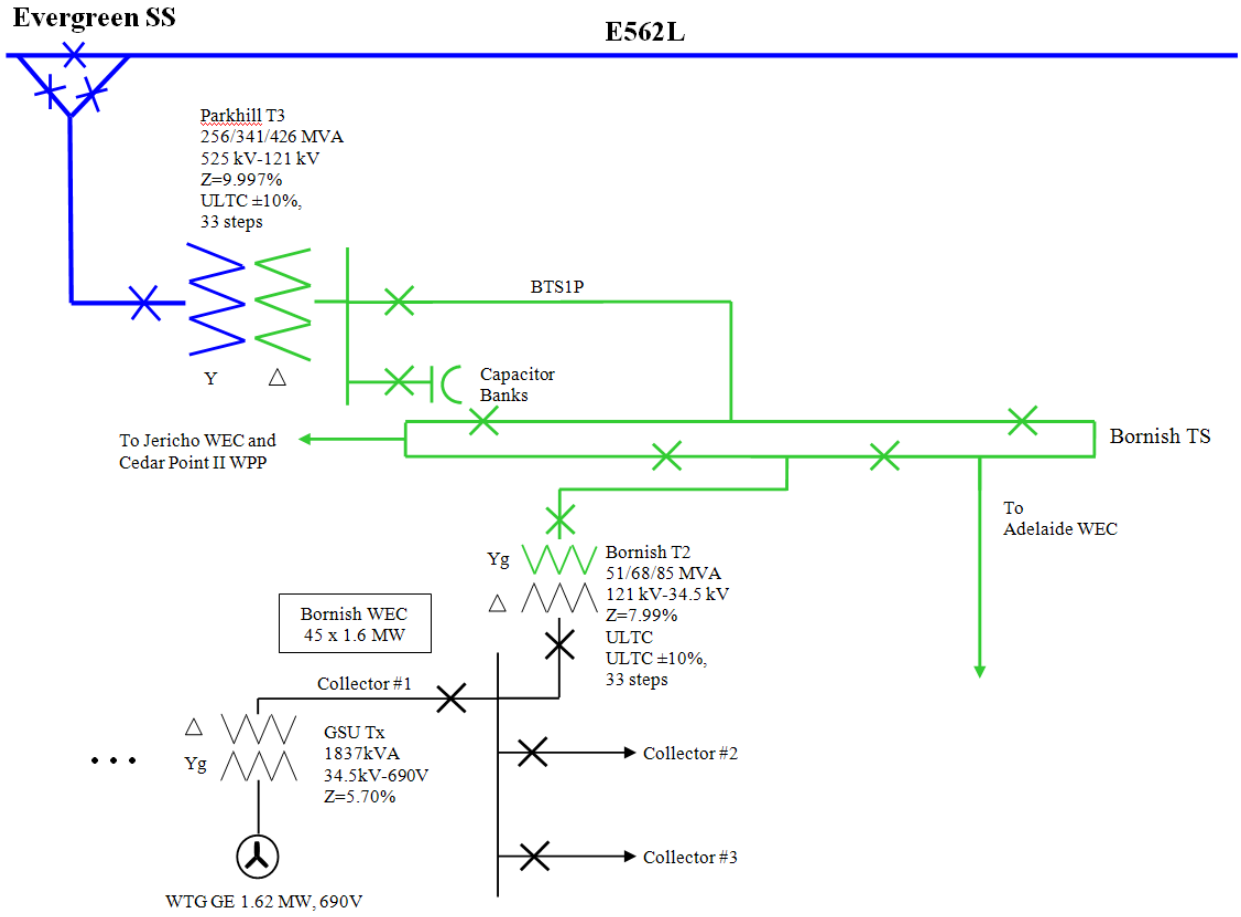
The simulation results indicate that the voltage at Evergreen SS could be as high as 561 kV, thus the IESO accepts the proposed solution to manage the high voltage concern at Evergreen SS. As the reactor is removed, the Evergreen SS arrangement will be modified from a four breaker switching station to a three breaker ring bus switching station, which is acceptable to the IESO.

Therefore, it is concluded that the proposed changes are expected to have no material adverse impact on the reliability of the integrated power system.

The connection applicant shall ensure that the equipment within the facility have the capability to operate under the condition when the connection point of the project is as high as 561 kV.

3.3 Revised Facility Single Line Diagram

Based on the incorporation of the Cedar Point II Wind Power Project into the 121 kV network behind Parkhill CTS and the configuration change at Evergreen SS, below is a revised single line diagram for the Bornish WEC.



- End of Document –