REPORT

Power to Ontario.
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System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Final Report

CAA ID: **2011- 429**
Project: **Ballyduff Wind Farm**

Applicant: **Hydro One Networks Inc.**
Proponent: **wpd Canada Corporation**

Market Facilitation Department
Independent Electricity System Operator

Date: August 30, 2011

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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 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 the transmitter(s) 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 the transmitter(s) at the request of the IESO. Furthermore, the connection 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 facility to the IESO-controlled grid. However, 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, you must be aware that the IESO may revise drafts of this report at any time in its sole discretion without notice to you. 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 it is using the most recent version of this report.

Hydro One

The results reported in this study are based on the information available to Hydro One, at the time of the study, suitable for a System Impact Assessment of a new generation or load 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 connection on facilities owned by other load and generation (including OPG) customers.

In this study, short circuit adequacy is assessed only for Hydro One breakers and does not include other Hydro One facilities. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection. These results should not be used in the design and engineering of new facilities for the proposed connection. The necessary data will be provided by Hydro One and discussed with the connection proponent 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 facility 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 connection have been identified to the extent permitted by a System Impact Assessment under the current IESO Connection Assessment and Approval process. Additional facility 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.

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SIA Findings

Summary

wdp Canada Corporation is developing a new 10.25 MW wind generating station, Ballyduff Wind Farm, near Pontypool, Ontario. The project was awarded a contract under the government Feed-In Tariff (FIT) program, and is expected to start commercial operation in January 2013.

This assessment examined the impact of injecting 10.25 MW of wind power generation to the provincial grid via the 44 kV feeder M12 embedded within Wilson TS T3/T4 on the reliability of the IESO-controlled grid.

Conclusions

The following conclusions were achieved based on this assessment:

(1) The system fault levels after the incorporation of Ballyduff Wind Farm will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid at stations surrounding this facility.

(2) The voltage performance and thermal loading with Ballyduff Wind Farm in service are expected to be acceptable under both pre-contingency and post-contingency operating conditions.

(3) The incorporation of Ballyduff Wind Farm will not require additional capacitors to be installed behind Wilson TS.

(4) Hydro One has determined that the incorporation of the proposed project will not have any adverse impact on existing protections on the 230 kV M29C and B23C transmission lines.

(5) The Market Rules governing the connection of renewable generation facilities in Ontario are currently being reviewed through the SE-91 stakeholder initiative and, therefore, new connection requirements (in addition to those outlined in the SIA), may be imposed in the future. More details can be found through the following link:

http://www.ieso.ca/imoweb/consult/consult_se91.asp

IESO Requirements for Connection

Transmitter Requirements

No requirements are applicable for the Hydro One for the incorporation of the project.

Connection Applicant Requirements

The connection applicant shall ensure that the proposed connection complies with all the applicable requirements from the Transmission System Code (TSC), IESO Market Rules, standards and criteria, and specific requirements identified in this SIA. The most relevant requirements are summarized below and presented in more detail in Section 2 of this report.

1. The connection applicant must ensure that the requirements from the Distribution System Code are being followed. Specifically, the connection applicant shall ensure that the connection of the generation facility will not cause any material increase in the reactive power requirements at the transmission transformer station, under any distribution feeder load conditions.
2. The generation facility should be able to operate continuously between 59.4Hz and 60.6Hz and for a limited period of time in the region above straight lines on a log-linear scale defined by the points (0.0s, 57.0Hz), (3.3s, 57.0Hz), and (300s, 59.0Hz). If the new EG units trip prematurely on under-frequency, the connection applicant must revise the amount of load connected to under-frequency relays to account for the early tripping of the EG units.
3. The connection applicant shall revise the automatic load shedding scheme behind the substation to account for the generation facility tripping by configuration, if the feeder where the generation facility connects to is connected to the Under Frequency Load Shedding (UFLS) scheme. In this case, the connection applicant in conjunction with the relevant transmitter have to either increase the demand connected to UFLS relays to compensate for the loss by configuration of generation from the generation facility, or to substitute the feeder with a different feeder with at least the same amount of load for the participation in the UFLS program.
4. The connection applicant shall ensure that the generation facility will respond to frequency increase by reducing the active power with an average droop based on maximum active power adjustable between 3% and 7% and set at 4%. Regulation dead band shall not be wider than ± 0.06%.

   The connection applicant shall ensure that the generation facility will respond to system frequency decline by temporarily boosting its active power output for some time (i.e. 10 s) by recovering energy from the rotating blades. This usually refers to “inertia emulation control” function within the WF control system.

   The connection applicant will need to indicate to the IESO whether the function of inertia emulation control is commercially available for the proposed type of WTG at the time when the wind farm comes into service. If this function is available, the connection applicant is required to have the proponent implement it before the new facility can be placed in-service. If this function is commercially unavailable, the IESO reserves the right to ask the connection applicant to have the proponent install this function in the future, once it is commercially available for the proposed type of WTG.

5. If the generation facility has automatic reconnection capability, the connection applicant shall ensure that the generation facility has the capability to disable the automatic reconnection to allow for orderly power system restoration by preventing unwanted generation during a system restoration process. The connection applicant shall ensure that the automatic reconnection is disabled when the system frequency is above 60 Hz. The frequency supervisory relay shall allow for settings to be changed, and changes shall be made only at the IESO request.

6. The connection applicant shall ensure that the telemetry requirements are satisfied as per the applicable Market Rules requirements. The determination of telemetry quantities and telemetry testing will be conducted during the IESO Facility Registration/Market Entry process.

7. The connection applicant must ensure that the generation units will ride through transmission contingencies in the IESO-controlled grid that do not disconnect the facility by configuration. This will require adequate low and high voltage ride through capability.

8. The actual performance of the equipment must meet or exceed the predicted performance observed in simulations done by the IESO for this SIA. The connection applicant may be required to take corrective actions up to generation facility disconnection if the performance of the facility would result in adverse impact on the IESO-controlled grid, e.g. sustained oscillations or excessive voltage decline.

9. The registration of the new facility will need to be completed through the IESO's Market Entry process before any part of the new facility can be placed in-service. During the IESO Market Entry process, the connection applicant will be required to demonstrate to the IESO that all requirements identified in this SIA report have been satisfied.

Notification of Conditional Approval

The proposed connection of Ballyduff Wind Farm, operating up to 10.25 MW, subject to the requirements specified in this report, is expected to have no material adverse impact on the reliability of the IESO-controlled grid.

It is recommended that a *Notification of Conditional Approval for Connection* be issued for the Ballyduff Wind Farm subject to the implementation of the requirements outlined in this report.

– End of Section –

1. Project Description

wpd Canada Corporation (the proponent) is proposing to develop a wind generating station, Ballyduff Wind Farm, near Pontypool, Ontario, under a power purchase contract (FIT program) with the OPA.

The proposed generating facility will be a 10.25 MW wind farm that is embedded into Hydro One's distribution system. The facility will be connected to the 44 kV feeder M12 out of Wilson TS T3/T4 at a tap location near Ballyduff DS. The connection point is approximately 40 km from Wilson TS and the facility is approximately 1.8 km from the connection point. The main electrical components of this project are:

- Five (5) Repower MM92 wind turbine generators, rated 2.05 MW each, with 575V - 44 kV pad mounted transformers;
- One 44 kV motorized load break switch, one 44 kV circuit breaker, surge arrestors, protection CT's and VT's, and one prefabricated protection and control building, at the Ballyduff Wind Farm;
- Overhead lines and underground cables that collect power from the WTG step up transformers and connect them to a 44 kV bus at the Ballyduff Wind Farm Switching Station (BSS);
- A 1.8 km long overhead tap line between the BSS and the connection point.
- One set of outdoor current and voltage transformers, surge arrestors and 44 kV recloser, at the point of connection.

The proposed in service date for the generation facility is January 31, 2013.

– End of Section –

2. General Requirements

The IESO's System Impact Assessment (SIA) determines the impact of the connection proposal on the reliability of the IESO-controlled grid and identifies project modifications and transmission system enhancements that would be required in order to mitigate any adverse reliability impacts.

The IESO has the following general requirements for the proposed EG facility:

1. The connection applicant must ensure that the requirements from the Distribution System Code are being followed. Specifically, the connection applicant shall ensure that the connection of the generation facility will not cause any material increase in the reactive power requirements at the transmission transformer station, under any distribution feeder load conditions.

2. The generation facility should be able to operate continuously between 59.4Hz and 60.6Hz and for a limited period of time in the region above straight lines on a log-linear scale defined by the points (0.0s, 57.0Hz), (3.3s, 57.0Hz), and (300s, 59.0Hz). If the new EG units trip prematurely on under-frequency, the connection applicant must revise the amount of load connected to under-frequency relays to account for the early tripping of the EG units.

3. The connection applicant shall revise the automatic load shedding scheme behind the substation to account for the generation facility tripping by configuration, if the feeder where the generation facility connects to is connected to the Under Frequency Load Shedding (UFLS) relays. In this case, the connection applicant in conjunction with the relevant transmitter have to either increase the demand connected to UFLS relays to compensate for the loss by configuration of generation from the generation facility, or to substitute the feeder with a different feeder with at least the same amount of load for the participation in the UFLS program.

4. The connection applicant shall ensure that the generation facility will respond to frequency increase by reducing the active power with an average droop based on maximum active power adjustable between 3% and 7% and set at 4%. Regulation dead band shall not be wider than ± 0.06%.

   The connection applicant shall ensure that the generation facility will respond to system frequency decline by temporarily boosting its active power output for some time (i.e. 10 s) by recovering energy from the rotating blades. This usually refers to "inertia emulation control" function within the WF control system. It is not required for wind facilities to provide a sustained response to system frequency decline.

5. If the generation facility has automatic reconnection capability, the connection applicant shall ensure that the generation facility has the capability to disable the automatic reconnection to allow for orderly power system restoration by preventing unwanted generation during a system restoration process. The connection applicant shall ensure that the automatic reconnection is disabled when the system frequency is above 60 Hz. The frequency supervisory relay shall allow for settings to be changed, and changes shall be made only at the IESO request.

6. According to Section 7.3 of Chapter 4 of the Market Rules, the connection applicant shall provide to the IESO the applicable telemetry data listed in Appendix 4.15 of the Market Rules on a continual basis. The data shall be provided in accordance with the performance standards set forth in Appendix 4.19 of the Market Rules.

   The connection applicant shall ensure that the telemetry requirements are satisfied as per the applicable Market Rules requirements. The determination of telemetry quantities and telemetry testing will be conducted during the IESO Facility Registration/Market Entry process.

7. The connection applicant must ensure that the generation units will ride through transmission contingencies in the IESO-controlled grid that do not disconnect the facility by configuration. This will require adequate low and high voltage ride through capability. The voltage settings shown in Table 1 will meet the IESO's requirements.

Table 1: Over/Under Voltage Settings for EG units

Voltage Range (% of Nominal Voltage)	Disconnection Time (s)
V <50	0.16
50 ≤ V< 88	2.0
110 < V < 120	1.0
V ≥ 120	0.16

8. The actual performance of the equipment must meet or exceed the predicted performance observed in simulations done by the IESO for this SIA. The connection applicant may be required to take corrective actions up to generation facility disconnection if the performance of the facility would result in adverse impact on the IESO-controlled grid, e.g. sustained oscillations or excessive voltage decline.
9. The registration of the new facility will need to be completed through the IESO's Market Entry process before any part of the new facility can be placed in-service. During the IESO Market Entry process, the connection applicant will be required to demonstrate to the IESO that all requirements identified in this SIA report have been satisfied.

Note that the Market Rules governing the connection of renewable generation facilities in Ontario are currently being reviewed through the SE-91 stakeholder initiative and, therefore, new connection requirements in addition to the list above may be imposed in the future. Details on the SE-91 stakeholder initiative can be found at the link http://www.ieso.ca/imoweb/consult/consult_se91.asp.

-End of Section-

3. Technical Assessments

Since the capacity of the proposed facility is below 50 MW and no single unit is greater than 10 MW, the IESO concludes that only a limited range of technical studies need to be performed for this SIA.

3.1 Study Assumptions

The study was carried out based on the Wilson TS 44 kV bus loadings given in Table 2 below. Hydro One Distribution has provided the CIA study results for all embedded generation (EG) projects behind Wilson TS, as shown in Table 2. This table shows the net substation loads with the EG projects as they are scheduled to connect. All EG units are operated in power factor control, as required by Hydro One.

Table 2: Hydro One CIA Study Results

Criteria	Light Load				Peak Load				EG Type	# Unit	MW Of Unit	Total MW
	Transformer Flow		EG Project		Transformer Flow		EG Project					
	MW	MX	Power Factor	V_{Term} (pu)	MW	MX	Power Factor	V_{Term} (pu)				
No Generation	42.75	14.06			151.91	49.50						
+10250	23.20	16.77	unity	1.058	132.35	52.21	unity	1.058	Synch. Steam Turbine	1	20	20
+12470	13.18	18.04	-0.9915	1.046	121.62	50.75	-0.9915	0.982	Doubly-fed Wind Turbine	5	2	10
+12610	-6.34	22.23	-0.993	1.053	101.70	53.46	-0.993	1.025	Doubly-fed Wind Turbine	10	2	20
+FIT1606	-6.48	22.23	1	1.036	101.55	53.40	1	1.024	Roof Top Solar			0.135
+FIT1579	-6.58	22.23	1	1.05	101.45	53.40	1	1.05	Roof Top Solar			0.1
+12,810 Ballyduff Wind Farm	-16.45	25.53	-0.984	1.045	90.95	54.31	-0.984	0.988	Doubly-fed Wind Turbine	5	2.05	10.25

Note: For peak load conditions, one existing capacitor bank (of SC3 and SC4) at Bus JQ of Wilson TS was assumed to be in-service and for light load conditions both capacitor banks were assumed to be out of service.

3.2 Power Factor Analysis

The connection applicant shall ensure that the proposed EG project shall not deteriorate the power factor of Wilson TS to a level that the power factor of Wilson TS T3/T4 DESN cannot meet the Market Rules' requirement. If the load power factor at Wilson TS T3/T4 DESN cannot meet the Market Rules' requirement after the proposed project is in-service, additional corrective measures will be required behind the LV bus of Wilson TS T3/T4 DESN.

The Market Rules (Appendix 4.3, Reference 1) require that wholesale customers and distributors connected to the IESO-controlled grid shall operate at a power factor within the range of 90% lagging

to 90% leading as measured at the defined meter point. For Wilson TS T3/T4 DESN, the defined meter point would be considered the HV sides of transformers T3 and T4.

Power flow simulations show that with the connection of Ballyduff Wind Farm, and under the peak load condition, the active load of Wilson TS T3/T4 DESN is **152.6 MW** and the reactive flow at the HV sides of transformer T3 and T4 is about **69.3 MVAr**. Therefore, the load power factor at Wilson TS is **0.911 lagging**, meeting the Market Rules' requirement. No additional correction measures are required behind Wilson TS.

Note that when calculating the power factor of a TS after the incorporation of EG projects, the IESO will use the active flow through the transformers plus total active output of all EG units as the active load for the power factor equation, and the reactive flow through the transformers as the reactive load for the power factor equation.

3.3 Thermal Loading Assessment

A preliminary load flow was carried and results are in Appendix A. At a capacity of 10.25 MW, connected behind Wilson TS, flows due the Ballyduff Wind Farm are expected to have no material impact on a part of the system that does not experience a lot of congestion.

3.4 Voltage Decline Assessment

The voltage decline assessment was carried out under peak load conditions at Wilson TS to determine the impact on system voltages following the loss of Ballyduff Wind Farm. The results given in Appendix B indicate that there is no voltage decline at the monitored buses as a result of losing the proposed embedded generation project.

3.5 Short Circuit Assessment

Fault level studies were completed by Hydro One to examine the effect of Ballyduff Wind Farm on fault levels at existing facilities in the vicinity of Wilson TS. The following base conditions were assumed for the short circuit analysis:

Generation Facilities In-Service

Niagara, South West, West Zones

- All hydraulic generation
- 6 Nanticoke
- 2 Lambton
- Brighton Beach (J20B/J1B)
- Greenfield Energy Centre (Lambton SS)
- St. Clair Energy Centre (L25N & L27N)
- East Windsor Cogen (E8F & E9F) + existing Ford generation
- TransAlta Sarnia (N6S/N7S)
- Imperial Oil (N6S/N7S)
- Thorold GS (Q10P)
- Kruger Port Alma (C24Z)

Central, East Zones

- All hydraulic generation
- 6 Pickering units
- 4 Darlington units
- 4 Lennox units
- GTAA (44 kV buses at Bramalea TS and Woodbridge TS)
- Sithe Goreway GS (V41H/V42H)
- Portlands GS (Hearn SS)
- Halton Hills GS
- Kingston Cogen
- TransAlta Douglas (44 kV buses at Bramalea TS)
- Wolf Island WGS

Northwest, Northeast Zones

- All hydraulic generation
- 1 Atikokan
- 2 Thunder Bay
- NP Iroquois Falls
- AP Iroquois Falls
- Kirkland Lake
- 1 West Coast (G2)
- Lake Superior Power
- Terrace Bay Pulp STG1 (embedded in Neenah paper)
- Prince I & II WGS

Bruce Zone

- 8 Bruce units
- 4 Bruce B Standby Generators
- Erie Shores WGS (WT1T)
- Kingsbridge WGS (embedded in Goderich TS)
- Amaranth WGS – Amaranth I (B4V) & Amaranth II (B5V)
- Ripley WGS (B22D/B23D)
- Underwood (B4V/B5V)
- Wolf Island (injecting into X4H)

New Generation Facilities:

Committed wind generation

- Greenwich Wind Farm (M23L and M24L)
- Gosfield Wind Project (K2Z)
- Kruger Energy Chatham Wind Project (C24Z)
- Raleigh Wind Energy Centre (C23Z)

- Talbot Wind Farm (W45LC)

Other new generation additions or modifications:

- Bruce G1 and G2: 835 MW each
- Beck 1 G9: 68.5 MVA
- Greenfield South GS
- York Energy Centre
- Island Falls
- Becker Cogeneration
- New Post Creek GS
- Mattagami Lake Dam
- Wawatay G4
- All currently contracted embedded and transmission connected FIT generation included in the after FIT study results

Transmission System Configuration

Existing system with the following upgrades:

- Bruce x Orangeville 230 kV circuits up-rated
- Burlington TS: Rebuild 115 kV switchyards
- Leaside TS to Birch JCT: Build new 115 kV circuit. Birch to Bayfield: Replace 115 kV cables.
- Uprate circuits D9HS, D10S and Q11S
- Cherrywood TS to Claireville TS: Unbundle the two 500 kV super-circuits (C551VP & C550VP)
- Allanburg x Middleport 230 kV circuits (Q35M and Q26M) installed
- One 250 MVAr (@ 250 kV) shunt capacitor bank installed at Buchanan TS
- 1250 MW HVDC line ON-HQ in service
- Tilbury West DS second connection point for DESN arrangement using K2Z and K6Z
- Second 500kV Bruce-Milton double-circuit line in service.
- Windsor area transmission reinforcement (okay):
    - 230 kV transmission line from Sandwich JCT (C21J/C22J) to Lauzon TS
    - New 230/27.6 DESN, Leamington TS, that will connect C21J and C22J and supply part of the existing Kingsville TS load
    - Replace Keith 230/115 kV T11 and T12 transformers
    - 115 kV circuits J3E and J4E upgrades
- Woodstock Area transmission reinforcement:
    - Karn TS in service and connected to M31W & M32W at Ingersol TS
    - W7W/W12W terminated at LFarge CTS
    - Woodstock TS connected to Karn TS
- Nanticoke and Detweiler SVCs
- Series capacitors at Nobel SS in each of the 500 kV circuits X503 & X504E to provide 50% compensation for the line reactance
- Lakehead TS SVC
- Porcupine TS & Kirkland Lake TS SVC
- Porcupine TS: Install 2x125 MVAr shunt capacitors
- Essa TS : Install 250 MVAr shunt capacitor
- Hanmer TS: Install 149 MVAr shunt capacitor

- Pinard TS: Install 2x30 MVAr LV shunt capcitors
- Upper Mattagami expansion
- Fort Frances TS: Install 22 MVAr moveable shunt capacitor
- Dryden TS: Install shunt capacitors

System Assumptions

- Lambton TS 230 kV operated ***open***
- Claireville TS 230 kV operated ***open***
- Leaside TS 230 kV operated ***open***
- Leaside TS 115 kV operated ***open***
- Middleport TS 230 kV bus operated ***open***
- Hearn SS 115 kV bus operated ***open –*** as required in the Portlands SIA
- Napanee TS 230 kV operated ***open***
- Cherrywood TS North & South 230kV buses operated ***open***
- All capacitors in service
- All tie-lines in service and phase shifters on neutral taps
- Maximum voltages on the buses

Monitored Buses

Bowmanville 500 kV
Lennox 230 kV, 500 kV
Dobbin 230 kV, 115 kV
Belleville 230 kV
Havelock 230 kV
Hinchinbrooke 230 kV
St. Lawrence 230 kV, 115 kV
Hawthorne 500 kV, 230 kV, 115 kV
Riverdale 115 kV
Merivale 230 kV, 115 kV
Chatfalls 230 kV
Chenaux 230 kV, 115 kV
Sidney 115 kV
Frontenac 115 kV
Kingston Cogen 230 kV
Cataraqui 115 kV
Barrett Chute 115 kV
Stewartville 115 kV

The following tables summarize the symmetric and asymmetric fault levels at stations near Wilson TS after addition of FIT projects, and the corresponding breaker ratings.

Table 3: Short Circuit Results and Transformer Station Breaker Ratings

	Total Fault Current Symmetrical (kA)		Breaker Ratings Symmetrical (kA) [1]	Total Fault Current Asymmetrical (kA)		Breaker Ratings Asymmetrical (kA) [1]
	3-phase fault	L-G		3-phase fault	L-G	
Belleville 230 kV	4.669	4.634	40	5.143	5.414	42.1
Cherrywood 230 kV[2]	44.565	47.927	60	59.039	66.435	70.6
Merivale 230 kV	17.442	18.728	63	21.300	23.767	72.4

(1) Most Restrictive Breaker Rating at the Maximum Operating Voltage Level

(2) Results for Cherrywood 230 kV bus DK3 with breaker parting time of 33 ms for asymmetrical currents

Tables 3 shows that after the addition of embedded generation, both the symmetrical and asymmetrical fault currents at stations near Wilson TS do not exceed the interrupting capability of the most restrictive breaker ratings.

3.6 Frequency Control Performance

The generation facility shall respond to frequency increase by reducing the active power with an average droop based on maximum active power adjustable between 3% and 7% and set at 4%. Regulation dead band shall not be wider than ± 0.06%. The generation facility shall respond to system frequency decline by temporarily boosting its active power output for some time (i.e. 10 s) by recovering energy from the rotating blades. This usually refers to "inertia emulation control" function within the WF control system. It is not required for wind facilities to provide a sustained response to system frequency decline.

The connection applicant did not provide the functional description of frequency control for the wind farm during this SIA. The connection applicant will be required to provide such information during the IESO Market Entry process before any part of the new facility can be placed in-service.

Specially, the connection applicant will need to indicate to the IESO whether the function of inertia emulation control is commercially available for the proposed type of WTG at the time when the wind farm comes into service. If this function is available, the connection applicant is required to have the proponent implement it before the new facility can be placed in-service. If this function is commercially unavailable, the IESO reserves the right to ask the connection applicant to have the proponent install this function in the future, once it is commercially available for the proposed type of WTG.

3.7 Protection Impact Assessment

Hydro One has indicated that the incorporation of Ballyduff Wind Farm will have no adverse impact on the existing protections of the transmission lines, thus a detailed Protection Impact Assessment was not required for the purposes of this System Impact Assessment.

-End of Document-

Appendix A: Thermal Loading Assessment

Table A1: Thermal Loading Analysis for Circuits in the Vicinity of Wilson TS

Circuit	Section		After Addition of Ballyduff Wind Farm		
	From	To	Rating (MVA)	Flow (MVA)	Ldg (%)
B23C	Belleville TS	Pancake JCT	320.1	27.9	8.7
	Pancake JCT	Wilson TS	320.1	28.0	8.7
	Wilson JCT	Whitby JCT	514.4	91.5	17.8
	Wilson JCT	Wilson TS	320.1	63.5	19.8
	Whitby JCT	B23C H26C Tie Jct	514.4	166.1	32.3
	Whitby JCT	Whitby TS	320.1	74.3	23.2
	B23C H26C Tie Jct	Cherrywood TS	514.4	166.1	32.2
M29C	Almonte TS	Wilson JCT	228.6	30.7	13.4
	Wilson JCT	Whitby JCT	514.4	94.9	18.4
	Wilson JCT	Wilson TS	320.1	64.1	20.0
	Whitby JCT	Cherrywood TS	514.4	171.4	33.3

Appendix B: System Voltage Assessment Results

Table B1: Pre and Post-Contingency Analysis for Proposed Ballyduff Wind Farm

Monitored Bus		All elements in service	Loss of Ballyduff Wind Farm			
			Pre-ULTC		Post-ULTC	
Bus Name	Base voltage (kV)	Voltage (kV)	Voltage (kV)	V_{change} (%)	Voltage (kV)	V_{change} (%)
Wilson TS B23C	220	238.5	238.5	0.0	238.5	0.0
Wilson TS M29C	220	237.3	237.3	0.0	237.3	0.0
Whitby TS (B23C)	220	240.9	240.9	0.0	240.9	0.0
Whitby TS (M29C)	220	240.5	240.5	0.0	240.5	0.0
Cherrywood TS	220	243.1	243.1	0.0	243.1	0.0
Belleville TS	220	240.8	240.8	0.0	240.8	0.0
Hinchinbrooke TS	220	245.6	245.6	0.0	245.6	0.0
Almonte TS (T3)	220	242.0	242.0	0.0	242.0	0.0
Almonte TS (T4)	220	242.0	242.0	0.0	242.0	0.0
Merivale TS	220	242.5	242.5	0.0	242.5	0.0
Wilson TS (Bus JQ)	44	46.5	46.5	0.0	46.5	0.0
Wilson TS (Bus BY)	44	46.5	46.5	0.0	46.5	0.0