IN THE MATTER OF the *Ontario Energy Board Act*,1998, S.O. 1998, C.15 (Sched. B);

IN THE MATTER OF an Application by Hydro One Networks Inc. pursuant to section 92 of the Act, for an Order or Orders granting leave to construct a transmission reinforcement project between the Bruce Power Facility and Milton Switching Station, all in the Province of Ontario.

AFFIDAVIT

of

WHITFIELD A. RUSSELL

on behalf of

THE SAUGEEN OJIBWAY NATIONS

Statement of Qualifications

1. My name is Whitfield A. Russell. I am a public utility consultant and principal in Whitfield Russell Associates. I hold a Bachelor of Science degree in Electrical Engineering from the University of Maine, a Master of Science degree in Electrical Engineering from the University of Maryland, and a Juris Doctor degree from Georgetown University Law Center. I have been accepted as an expert on bulk power systems in more than 150 proceedings before State and Federal courts, administrative agencies and other tribunals in approximately 30 States and in two other Canadian provinces (Manitoba and Alberta). My complete resumé and a description of cases on which I have worked are attached as Exhibit No. 1.

2. I am testifying on behalf of the Saugeen Ojibway Nations. The purpose of my testimony is to review the analyses performed by the Ontario Power Authority

("OPA"), Hydro One Network, Inc. ("Hydro One"), and the Independent Electric System Operator of Ontario ("IESO") in support of the application to construct a proposed Bruce-to-Milton double circuit 500 kV transmission line project ("Bruce-Milton Lines", composed of two 500 kV circuits on a single set of towers).

3. My analysis has been informed by the scope and standard of review set out in the Board Issues List in this matter as revised, the Ontario Energy Board Act, and other relevant policy.

Summary of Findings

4. My principal findings are:

A. Based on the evidence filed in this matter regarding existing and committed generation from the Bruce area, and the existing transmission infrastructure, Hydro One's proposal to construct a new double circuit 500 kV transmission line project from Bruce to Milton cannot be justified as a better project than the reasonable alternatives.

B. Hydro One has misstated the need for transmission capability by including in its analysis significant sources of generation that have not been committed or approved. Hydro One includes in its analysis 1000 MW of potential wind generation that is identified in the Integrated Power System Plan ("IPSP") that has not yet been approved, committed or developed and that would require the construction of further transmission infrastructure to realize. Hydro One also assumes the refurbishment of 4 Bruce B nuclear reactors producing approximately 3400 MW of generation beginning in 2018 – a decision that will not be made or approved until some time in the future.

C. Hydro One's faulty assessment of need has resulted in (1) its preference for a proposal that would result in excessive transmission capability given the existing and committed generation capacity in the Bruce area, and (2) its dismissal of available and reasonable alternatives to its preferred project, including alternatives Hydro One identifies in its application as potential near term and interim measures.

D. The construction of excessive transmission capacity will also cause the impedance of the transmission system to be reduced, thereby inducing more power to flow from generation in the United States through Ontario's grid and back to loads in the United States. This well known "circulating loop flow" problem uses up Ontario's transmission capacity, adds to transmission losses, and requires costly reactive compensation and off-setting measures.

E. A corrected assessment of need suggests that the near term and interim measures identified by Hydro One are sufficient to provide any transmission upgrades that are required to serve the existing and committed generation from the Bruce area.

F. The installation of series capacitors on the existing transmission infrastructure in Southwestern Ontario is a better alternative than Hydro One's proposed construction of the new Bruce-Milton Lines. Series capacitors are a benefit to consumers in that they will cost considerably less ($97 million) than the proposed $635 million Bruce-Milton Lines and will avoid the premature construction of transmission capability that is surplus to Ontario's demonstrated needs. In addition, series capacitors will optimize the use of existing infrastructure and public service facilities in that series capacitors can be added to facilities in existing rights-of-way south of the Bruce-Milton path. Use of series capacitors will protect the interests of consumers with respect to reliability in that such an upgrade

would be less susceptible to construction delays than would two entirely new circuits on expanded rights-of way, would meet industry reliability criteria and would avoid undue concentration of delivery facilities on the Bruce-Milton right-of-way that has historically been susceptible to tornadoes. The series capacitor alternative would not prejudice a later decision to add the Bruce-Milton Lines if their need is established in the future.

G. Series capacitors coupled with generation rejection will be a reasonable alternative for delivering the output of as many as eight units at the Bruce Nuclear Generating Station ("Bruce NGS") plus the output of approximately 1075 MW of wind generation, approximately 375 MW more than currently exists or is committed. That is, the existing 500 kV transmission system configuration augmented by series capacitors and generation rejection will be sufficient to deliver all existing and committed generation capacity in the vicinity of the Bruce Complex without the proposed Bruce-Milton Lines. Accordingly, a decision to construct the proposed Bruce-Milton Lines should not be made until there is an approved decision for, and commitment to, new nuclear generation or substantial new wind generation in the Bruce area.

H. The generation rejection ("GR") of nuclear units at the Bruce complex is well established practice. Multiple (simultaneous or overlapping) forced outages of critical transmission lines emanating from the Bruce Complex have historically been dealt with by implementing a Special Protection System ("SPS") that would allow for the rejection of as many as four Bruce nuclear generating units (meaning that four units could be instantaneously shut down for a short time) and shedding up to 1,500 MW of load in the Greater Toronto Area. Because such multiple transmission line forced outages are extremely rare, this historical practice has provided a high degree of reliability with no actual historical costs incurred but for

the costs of implementing the SPS. Under the recently published Regional Reliability Reference Directory #7, Special Protection Systems, December 7, 2007, Directive No. 7 of the Northeast Power Coordinating Council, ("NPCC"), any SPS that was previously in use may continue to be used even if it does not meet the new criteria. See Exhibit No. 2 at p. 2. Accordingly, Ontario may continue to use its existing SPS under NPCC criteria.

I. Series capacitors in combination with generation rejection is a far more cost-effective and economically efficient alternative to the project proposed by Hydro One. Further, this alternative is scalable to accommodate both significantly increased or decreased generation from the Bruce area in the future. In contrast, Hydro One's proposal cannot be scaled down in response to reduced generation from the Bruce area, and would result in excess transmission capacity in the near term, and substantial excess capacity in the event that there is a significant reduction in generation from the area in the future.

J. Hydro One claims a need for transmission capability to deliver 100% of the maximum expected installed capability of future wind generation (both committed and uncommitted) and Bruce nuclear units after the loss of both 500 kV lines on the most critical double circuit towers emanating from the vicinity of the Bruce NGS (referred to as firm transmission service). Hydro One makes this claim despite the facts that (a) OPA relies on only 20% of the installed capability of wind generation in meeting peak demands and (b) on average, wind energy production represents only 29% of the installed capability of the wind generation. In other words, Hydro One asserts that the transmission system should be built to deliver the full nameplate output of the Bruce NGS units coincident with the overstated wind generation capacity. For Hydro One to build and operate firm transmission capacity for delivery of the full installed capability of

intermittent energy sources (that is significantly above the projected on-peak output on which Ontario relies) is not consistent with sound system planning principles, and is neither cost-effective nor economically efficient.

K. Hydro One's analysis of the comparative economics of various transmission expansion alternatives cannot be relied upon for several reasons, including the following; Hydro One has refused to release the underlying models and data, denying the Board the benefit of any independent audit of Hydro One's analysis. The analysis models a forecast amount of future wind generation (1000 MW) that the Ontario Government has not yet committed to purchase. It also assumes upgrades to the Bruce B units that may not occur until 2018 or later. Further, the feasibility of an alternative that employs series capacitors and generation rejection was determined on the basis of an understated transfer capacity (7075 MW as opposed to the more appropriate transfer capacity of 7475 MW). These assumptions unreasonably increase the forecast cost of undeliverable energy, particularly with respect to the alternative involving series capacitors and generation rejection. Lastly, the analysis fails to account for the significant costs associated with remedying the "circulating loop flow" problem that will be caused, or exacerbated, by the construction of new Bruce Milton lines.

Project Need and Justification – Hydro's Case

5. OPA attributes the need for new transmission facilities to the Minister of Energy's directives dated June 13, 2006, in which directives the OPA was required to strengthen the transmission system in order to:

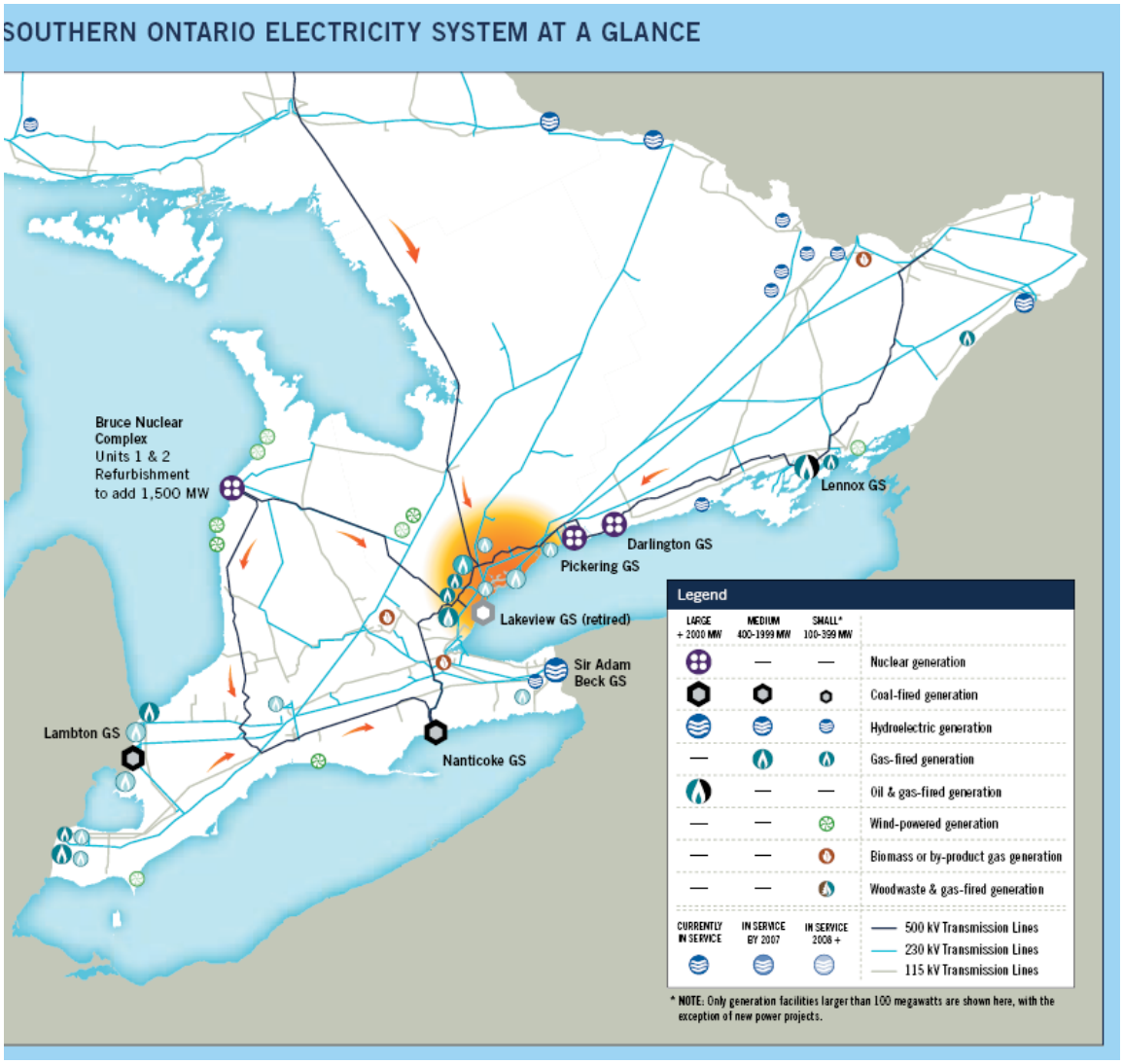
- Enable the achievement of the supply mix goals of the directive, including reduced usage of coal-fired generation and increased usage of nuclear generation;
- Facilitate the development and use of renewable energy resources such as wind power;
- Promote system efficiency and congestion reduction and facilitate the integration of new supply, in a manner consistent with the need to maintain system reliability cost-effectively.

See Hydro One's Application, Exhibit B, Tab 6, Schedule 5, Appendix 1, page 2.

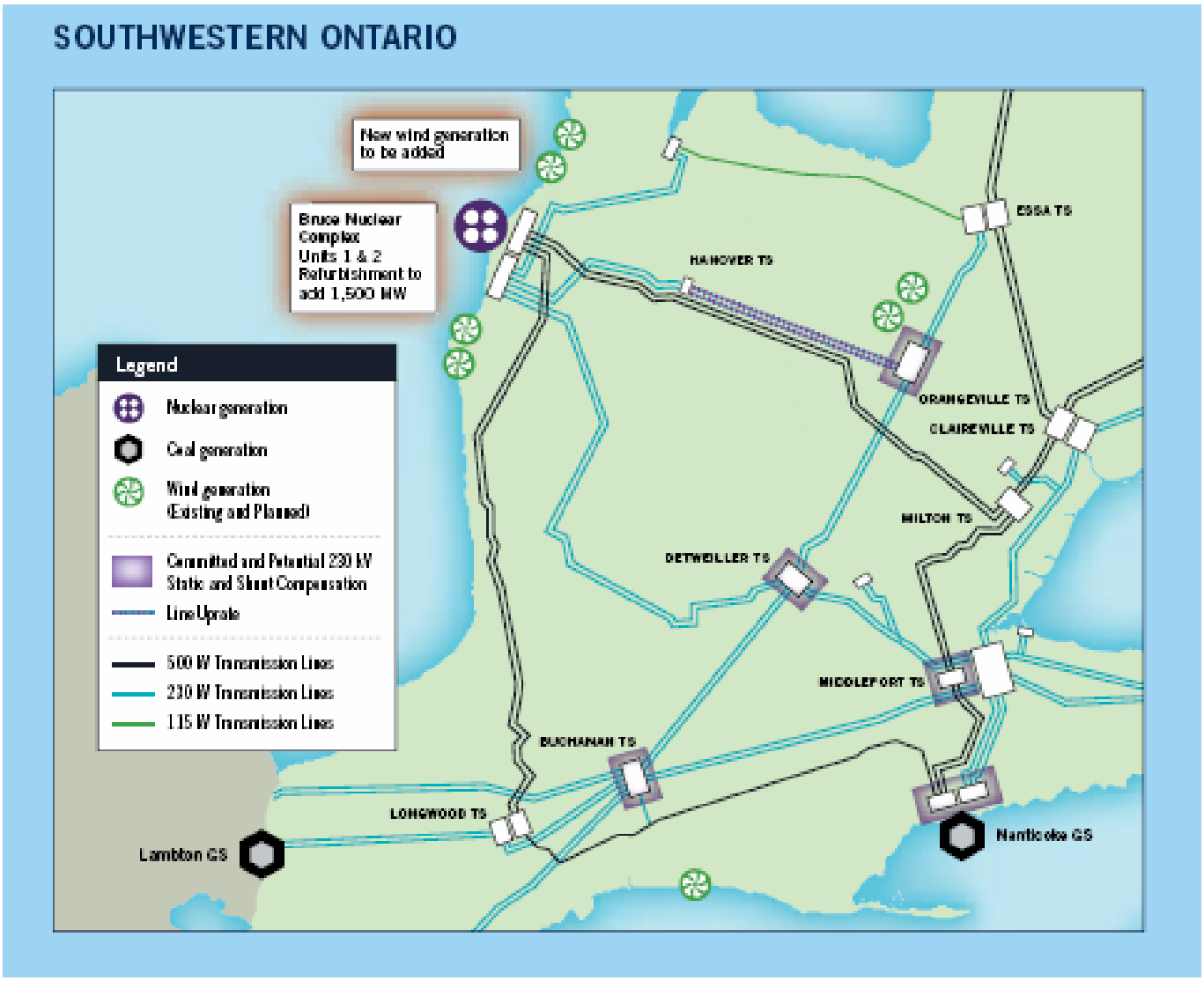
6. More specific to the Bruce area, Hydro One's stated need for the Bruce-Milton Lines is based on OPA's determination that the lines are allegedly required in order to meet the increased need for transfer capability from the Bruce Complex to the Toronto area associated with (a) development of committed and forecast wind generation, (b) the return to service of two nuclear units at the Bruce NGS and (c) vaguely defined upgrades of other Bruce Units. As part of the arrangement to return to service two nuclear units, the Ontario Government has committed to pay for the energy output that Bruce arguably could produce in the future but would be unable to produce because of insufficient transmission capability ("deemed energy"). See Exhibit No. 3. OPA says that unless enough transmission capability is available, the government is likely to be paying for Bruce energy without receiving all of the actual energy that could be generated. OPA further determined that, despite being included in the OPA's preliminary IPSP, the Bruce-Milton Lines project cannot await completion of the IPSP if they are to be placed in service by December, 2011. See Hydro One's Application, Exhibit A, Tab 1, pp 1-2.

7. The transmission system in Southwestern Ontario is composed of 115 kV, 230 kV and 500 kV transmission lines. The primary load center is in Toronto. Power tends to flow toward the Greater Toronto Area ("GTA") from the Bruce Peninsula and from Hydro One's interconnections with utilities in New York and Quebec to

the east and in Michigan to the west of Southwestern Ontario. The first map below shows the Southern Ontario transmission system, while the second map shows the existing lines as well as existing and proposed generation in the area more immediate to the Bruce Complex and the GTA.



Source: Application, Exhibit B, Tab 6, Schedule 4, "The Ontario Reliability Outlook", March 2007, page 6.



Source: Application, Exhibit B, Tab 6, Schedule 4, "The Ontario Reliability Outlook", March 2007, page 8.

8. The OPA asserts that new 500 kV double circuit lines are needed from Bruce to the GTA. See Hydro One's Application, Exhibit A, Tab 2, p. 1 of 5. Hydro One intends to increase transmission capacity away from the Bruce area from an existing transfer level (that Hydro One states is approximately 5000 MW) to a level of about 8100 MW in order to accommodate the maximum possible output of all eight Bruce units (refurbished and upgraded) as well as 700 MW of committed wind generation and about 1000 MW of nameplate capacity of

anticipated but uncommitted wind generation projects. Hydro One asserts that nearly all of this power must be transmitted to the GTA in order to serve loads in that area and replace the output of to-be-retired coal generation. See Exhibit No. 4, excerpts from the October 15, 2007 Technical Conference at pp. 15-16, and Application, Exhibit B, Tab 1, Schedule 1, pp. 3-4.

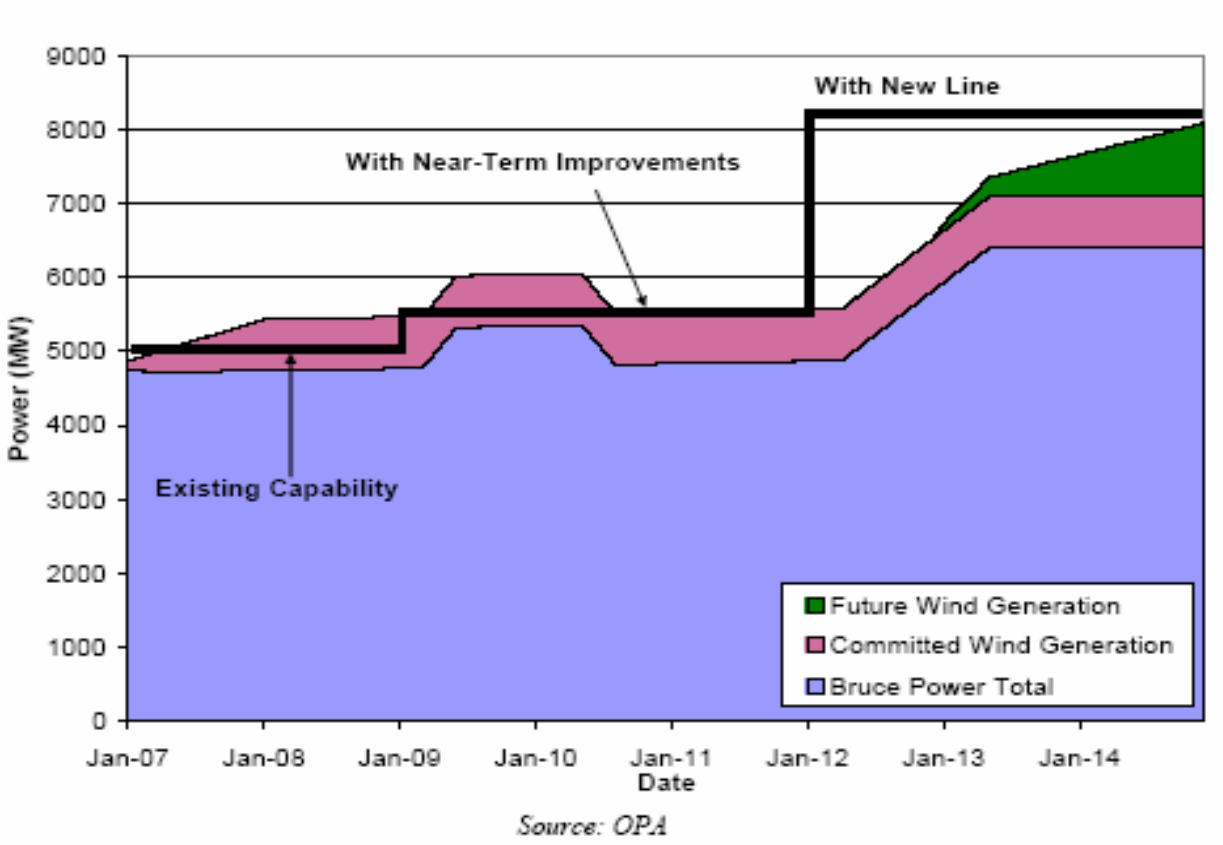
Project Need and Justification – Analysis of Hydro One's Assessment of Need

9. It is critical to note that in its assessment of the need for its proposed project, Hydro One, relying on OPA analysis and reports, has included two significant sources of generation that have not been approved or committed. First, Hydro One has included 1000 MW of potential wind generation from the Bruce region that has been identified in the IPSP. Second, Hydro One has included in its analysis 4 refurbished Bruce B units with an estimated combined output of approximately 3400 MW. The inclusion of these two unapproved and uncommitted sources of generation has fundamental implications both as a justification for the proposed project from a system design perspective, as well as for the economic evaluation of the project and other reasonable alternatives.

10. A proper need analysis ought to be based on existing and committed generation from the Bruce area. Removing the two major sources of unapproved and uncommitted generation that have been included in Hydro One's analysis results in a picture of the transmission facilities that are required to service the Bruce area dramatically different from that conveyed by Hydro One. This difference is evident when comparing Hydro One's graphic representation of the need for the new line, shown in Figure 1, to my analysis, shown as Figure 2. As can be seen in Figure 2, the amount of generation that needs to be accommodated in the Bruce area never exceeds 7000 MW, using actual existing ratings and removing uncommitted generation.

Figure 1

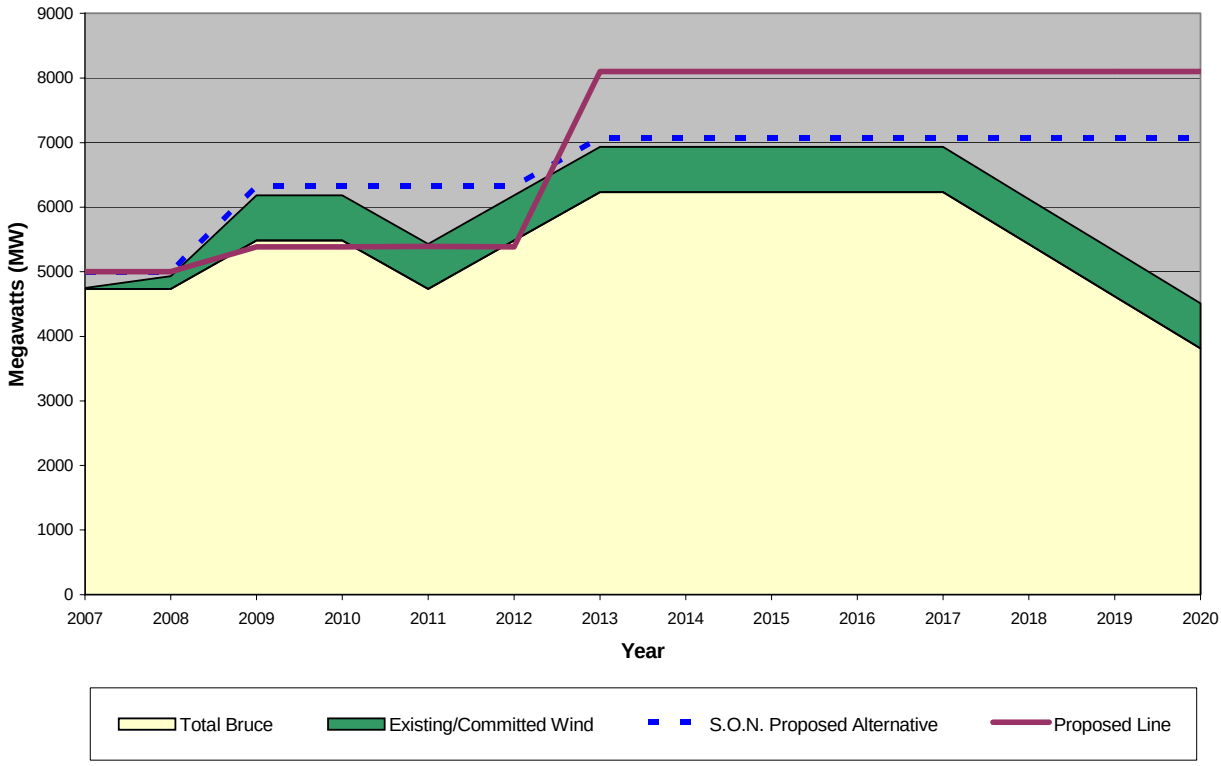
Hydro One Transmission Capacity with Near-Term Upgrades and New Line



Source: Application, Exhibit B, Tab 3, Schedule 1, Figure 1.

Figure 2

S.O.N. Analysis of Committed Capacity



11. My analysis of the need for transmission upgrades is based on the actual existing and committed generation planned for the Bruce area as described in filed evidence in this matter. My analysis indicates that, while some transmission enhancement is required in order to serve all of the approved generation capacity in the Bruce area, the proposed Bruce-Milton Lines are neither the most economic nor the best suited upgrades for the amount of capacity actually committed at this time.

12. Given the several alternative scenarios for expanding generation from the Bruce region that may possibly develop in the future, any transmission project chosen now should be sufficiently scalable to accommodate various future scenarios. As

discussed elsewhere herein, my proposed alternative is less costly than Hydro One's preferred plan, and is scalable. E.g., the series capacitors and generation rejection incorporated in my proposal do not preclude further upgrades and can be expected to add to the transfer capability of almost any subsequent transmission system upgrade. For example, if one or more 500 kV Bruce-Milton circuits are later determined to be needed because increased generation capacity is approved, series capacitors can be expected to enhance the N-1 transfer capability of that upgraded system.

13. According to the revised filing, there is approximately 4734 MW of capacity at the Bruce NGS. Also, there is approximately 15 MW of existing wind generation in the vicinity of the Bruce area. This combined capacity of the existing nuclear and wind generation capability totals 4750 MW, 250 MW less than the 5000 MW of average generation capacity and minimum transmission transfer capability that OPA and Hydro One cite as currently existing. See Hydro One's Application, Exhibit B, Tab 1, Schedule 1, p. 3 and Exhibit B, Tab 6, Schedule 5, Appendix 1, p. 3. During the Technical Conference, an OPA representative stated that the existing generation in the vicinity of the Bruce Complex has an installed capability of 4749 MW. Exhibit No. 4 at p. 15.

14. OPA intends to add another 1500 MW of generation by refurbishing Units 1 and 2 at Bruce A. While doing this work, OPA will also be removing the other two Bruce A units. All eight units are scheduled to be operating as of 2013. With the addition of the two Bruce A units, Bruce NGS capacity will total 6234 MW. Responses to Interrogatories indicate that upgrades of 40 MW are to be performed on each Bruce B unit, increasing the total Bruce NGS capacity to 6400 MW.[1] Hydro One has not provided any information on the dates by which each of these upgrades will begin or be completed. Nevertheless, Hydro One uses the full 6400 MW of capacity in its planning and economic studies of the alternatives to the Bruce-Milton Lines. OPA has already committed to purchase 675-700 MW of

[1] See Exhibit No. 5, Response to Fallis Interrogatory #26, List 1.

wind generation capacity to be sited in the vicinity of the Bruce Complex. The sum of this existing and committed generation is approximately 6900 MW, if the Bruce B upgrades are not included (as no date for the upgrades was provided). The chart below lists the maximum amount of transfer capacity that will be required year-by-year in order to deliver all of the committed generation planned near the Bruce. The chart uses Hydro One's rating of 5000 MW for the existing system, but, as described below, there are a number of issues that must be addressed surrounding the amount of transfer capacity necessary to transmit power from the wind generation.

Forecast of Capacity in the Bruce Area

	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Generation (MW)														
Existing/Committed Wind	15	200	700	700	700	700	700	700	700	700	700	700	700	700
Bruce Existing	4734	4734	4734	4734	4734	4734	4734	4734	4734	4734	4734	4734	4734	4734
New Bruce			1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500	1500
Bruce out for Maintenance			-750	-750	-1500	-750	0	0	0	0	0	0	0	0
Bruce B License Ends												-808	-1616	-2424
Total Bruce	4734	4734	5484	5484	4734	5484	6234	6234	6234	6234	6234	5426	4618	3810
Total Generating Capacity	4749	4934	6184	6184	5434	6184	6934	6934	6934	6934	6934	6126	5318	4510
Existing Transfer Capacity	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000	5000
Need for Transfer Capacity	NA	NA	1184	1184	434	1184	1934	1934	1934	1934	1934	1126	318	NA

Also see Exhibit No. 6 for supporting Interrogatory Responses.

15. Hydro One's filing anticipates, and reflects plans to add, transmission capability for the development of another 1000 MW of potential wind generation capacity. See Hydro One's Application at Exhibit B, Tab 1, Schedule 1, p. 4 and Exhibit B, Tab 6, Schedule 5, Appendix 1, p. 4. I have not included this additional 1000 MW of future wind generation capacity in my chart above as (a) this potential wind generation capacity is identified in the IPSP, but is as yet unapproved, (b) according to the OPA, much of this 1000 MW of potential wind generation would require the construction of new gathering and enabler transmission lines before it could be realized, (c) no commitment has yet been made to develop or contract for this generation and related transmission facility requirements, and (d) in any event, firm transmission capability in the amount contemplated by Hydro One

would not be required to serve potential future wind generation amounting to 1000 MW, as explained below.

16. The chart above also shows the expected retirement of the Bruce B units. Data were not available on the expected end-of-life of the Bruce B units. However, the responses to Pollution Probe Interrogatories #3 and #4, List 1 (Exhibit No. 7) indicate that these units will be taken out of service beginning in 2018 for refurbishment. I assumed that one unit would retire each year, as the units entered service on a similar schedule back in the mid-1980s.

17. In contrast to the contentions of OPA and Hydro One that an additional 3100 MW (for a total of 8100 MW) of transfer capability is required, this chart shows that the needed amount of future transfer capacity is smaller. As noted above, Hydro One states that existing transmission capacity equals approximately 5000 MW. Using these assumptions, my calculations indicate that there will be a shortfall of approximately 1200 MW in 2009-2011, and approximately 1950 MW by 2013. This shortfall of approximately 2000 MW will last only until 2018, at which time the Bruce B units will begin to retire unless further commitments are made.

Near-Term and Interim Measures Sufficient to Meet Actual Need

18. Certain plans for constructing transmission upgrades already are in place for the Bruce Area. The filing describes what are called "near-term upgrades." Near-term upgrades are those upgrades planned and in-service in 2009, which include:

    a. Upgrades to the Hanover-Orangeville 230 kV line
    b. Addition of Dynamic and Static Reactive devices.

    These two near-term upgrades are projected to result in a 385-400 MW increase in transmission capacity (See Application Exhibit B, Tab 6, Schedule 5, Appendix 5, p. 46 and Exhibit No. 8, Response to Interrogatory Pollution Probe #16, List 2, Table 1).

19. Hydro One has also proposed "Interim Measures," one of which (restricting generation additions) is to be in place only until the proposed Bruce-Milton Lines are constructed. Hydro One claims that the majority of these measures should not be in place for a lengthy period of time, or be installed in place of the proposed line. Hydro One's Interim Measures include:

a. Restricting further generation development in the Bruce area, primarily refusing to contract for potential new wind capacity in the Orange Zone area, which OPA has implemented (Exhibit No. 4, pp. 33-34 and Application Exhibit B, Tab 6, Schedule 5, Appendix 5, p. 50).

b. Expanding the Bruce Generation Rejection scheme ("GR"), a type of special protection system ("SPS") that has been in effect since the mid-1980s (Ibid).

c. Installation of series capacitors/series compensation (Ibid). According to Hydro One, the earliest installation date possible for series compensation is 2011, and the cost of this interim measure is estimated to be $97 million, only about one-sixth the cost of the proposed Bruce-Milton 500 kV line. Hydro One is not inclined to pursue this interim measure.

20. Table 1 of the Response to Pollution Probe Interrogatory #16, List 2 at Exhibit No. 8 shows that the use of the Near Term Measures and the Bruce SPS arrangement can provide up to 6326 MW of transfer capability. When the Near Term Measures are combined with series compensation in combination with the Bruce SPS arrangement, there are two transmission capabilities referenced: 6326 MW and 7076 MW. Hydro One is differentiating between an SPS that is armed during normal conditions, as has been its practice historically and currently, and the use of an SPS that is armed only under contingency conditions—once an outage of a facility has already occurred. As I will describe later, Hydro One wishes to move from (a) its current practice that permits continuous arming of SPS and generation rejection under N-2 contingency conditions (and that is projected to achieve at least 7076 MW of transfer capacity with series capacitors and GR) to (b) a more restrictive practice of arming GR (the GR SPS is armed

only after a single or double outage and activated by occurrence of the next contingency). As is clear from my chart above, 7076 MW of transfer capacity is sufficient to serve all of the committed nuclear generation at the Bruce NGS as well as the committed wind generation under contract at this time.

21. Hydro One asserts that the proposed Bruce-Milton Lines will increase transmission capacity to approximately 8100-8200 MW (Exhibit No. 4, p. 45 and Application Exhibit B, Tab 6, Schedule 5, Appendix 4 and Exhibit No. 8). This amount of increased transmission capacity appears to be designed to allow Hydro One to interconnect all of the committed wind generation, as well as allow Hydro One to interconnect up to 1000 MW of unapproved and uncommitted potential wind generation from the Bruce region. In addition, the excess transmission capacity would permit additional generation to be obtained from the Bruce NGS in form of a refurbishment of Bruce B reactors at the end of their operational lives, as well as increased generation from additional reactors beyond the eight that are presently installed.

22. The increased transfer capacity that would be available with the construction of the proposed Bruce-Milton Lines could have a deleterious effect on Ontario's transmission infrastructure and consumers. As the actual transmission system could accommodate 8100 MW after the proposed project is built, while existing generation capacity would only reach approximately 6900 MW until subsequent generation capacity additions are approved and go into operation, the impedance of the transmission system will be reduced. This lowered impedance will induce more power to flow from generation in the United States through Ontario's grid to loads in the United States. This phenomenon is the well-known "circulating loop flow" problem that soaks up Ontario's transmission capacity, adds to the transmission losses on Ontario's grid and adds to the need for reactive compensation and expensive measures to offset such loop flows. Even though any upgrade to transmission facilities in the vicinity of the Bruce Complex will reduce the impedance of Ontario's grid to loop flows, Hydro One's proposed

upgrades will tend to exacerbate the loop flow problem more than would an alternative that is scalable to match the actual generation from the area. One such alternative involves the installation of series capacitors and continued implementation and use of a generation rejection scheme.

Project Alternatives

23. Hydro One and OPA have determined that their preferred solution is the new double circuit 500 kV lines from Bruce-to-Milton, situated on an expansion (widening) of existing rights-of-way. In its evidence, Hydro One indicates that its proposal is better than reasonable alternatives, in large part, because it avoids the need to install series capacitors in the short run and lessens the need for rejecting wind or nuclear generation to deal with multiple line outages.

24. However, from the evidence, it does not appear that Hydro One's proposal is a better project than other available and reasonable alternatives. Further, Hydro One's preferred plan adds transfer capability well before it is demonstrated to be needed, requires substantial amounts of additional land to be set aside for rights-of-way, is projected to cost approximately six times as much as would series capacitors and leaves Hydro One susceptible to increased loop flows and the loss of increased amounts of transfer capacity should tornadoes take out a complete right-of-way (as has happened once on the Bruce-Milton right-of-way). Because it involves construction of new infrastructure on additional rights-of-way, implementation of Hydro One's preferred alternative is inconsistent with Section 1.62 of the 2005 Provincial Policy Statement, as found at Application, Exhibit B, Tab 6, Schedule 5, Appendix 13, page 10.

25. My analysis suggests that the series compensation alternative combined with the continuation of the existing SPS arrangement (or an SPS arrangement that would reject even fewer generating units) would reliably satisfy, or even exceed, the level of transmission capacity needed to deliver all of the existing and committed

generation capacity in the Bruce area, and has a number of significant advantages over the project proposed by Hydro One. According to data provided at Application, Exhibit B, Tab 6, Schedule 5, Appendix 5 page 52, the addition of series capacitors coupled with one Bruce unit under GR will bring transfer capacity up to 7300-7400 MW. In response to Saugeen Ojibway Nations Interrogatory #2 (Exhibit No. 9) and Pollution Probe Interrogatory #16 (Exhibit No. 8), Hydro One indicates that this transfer capacity (Near Term Measures + Series Capacitors + BSPS for use under normal conditions) has been dropped to 7076 MW without any explanation for the discrepancy between this amount and those shown previously in other IESO and Hydro One sources. In any event, it is clear that even 7076 MW of transfer capacity is sufficient to deliver the output of all 8 Bruce units plus the output of committed wind generation. Furthermore, an even higher transfer capability is indicated in Exhibit No. 10, Hydro One's response to Saugeen Ojibway Nations Interrogatory #10, List 1. I understand from that response that series capacitors plus generation rejection will enable Hydro One to deliver the output of eight Bruce nuclear units plus 1075 MW of wind generation, which exceeds the amount of existing and committed wind generation in the region by about 375 MW.

Project Alternatives – Series Compensation

26. Hydro One and the IESO have both studied the introduction of series capacitors on transmission facilities in the Bruce area. Hydro One requested a study of the Southwestern Ontario Transmission System, and a report was issued by ABB Consulting on November 30, 2005. This Draft Report (provided in response to Pappas Interrogatory #1, List 1, excerpts provided in Exhibit No. 11) concluded that

> . . . both the power flow and dynamic simulation results confirm that the proposed series compensation of the 500 kV lines is feasible and will meet the power transfer requirements. The simulation results show that further optimization (both technical and economic) of both the series and shunt compensation levels is desirable. See page S-4.

After this Draft Report was issued, Hydro One requested that the IESO perform a System Impact Assessment to determine whether series capacitors could increase the capability of the existing transmission facilities in order to deliver power from the Bruce area, including additional output from Bruce Units 1 and 2 and 725 MW of committed wind. The IESO study was also meant to determine whether series capacitors could avoid the need for rejecting any generation in response to a "first contingency," the loss of both existing Bruce-to-Milton circuits (which is actually an N-2 event).

27. The IESO Study determined that 30% series compensation could provide enough transfer capability to deliver the output of seven Bruce units as well as 925 MW of wind generation (See Exhibit No. 12 at 9-10). This analysis of series compensation did not include generation rejection. The transfer capability was limited to this amount because of the IESO's goal to avoid GR in response to a "first contingency" (N-2 event), even though the system historically has been operated by using GR in response to a "first contingency" (N-2 event). Table 1 in Exhibit No. 8 reflects the IESO's recognition that arming the generation rejection scheme under normal conditions (rather than waiting for a contingency condition) would increase transfer capacity to 7076 MW. This is enough transfer capacity to deliver the output of all eight Bruce units and the committed wind generation. However, the IESO study still preferred the construction of new transmission lines.

28. Another report favorable to the use of series capacitors was published in October 5, 2007. It is the "*Final Report Due Diligence Study and Development of High Level Planning Specifications for the Installation of 500 kV Series Capacitor Banks in the Southwestern Ontario Transmission Network*," for the Ontario Power Authority, OPA Purchase Order 50000488, OPA Project Manager: Jim Lee, by Duane Torgerson, Dennis Woodford, Garth Irwin and Randy Wachal ("Due Diligence Report"). See excerpts provided at Exhibit No. 13. The full document was provided in response to Pappas Interrogatory #6, List 2. The Due Diligence

Report reviews (at 11 *et seq.*) hundreds of installations throughout the world of series capacitors manufactured by four major manufacturers. The Due Diligence Report finds that "Applying series compensation with series capacitors (SCAP) is an accepted method of increasing transfer capacity of a high voltage transmission line that is impedance limited." The report states (at 8) that "Series capacitor application to high voltage transmission lines, and at 500 kV is a mature technology in North America and around the world" that has been in use since 1948, including in Canada. The report notes that the effectiveness of series capacitors has been substantially improved over the years. This finding is made in the introduction (at 7) and again in the conclusions (at 52). Furthermore, the reliability of series capacitors is high. The Due Diligence Report states (at 31):

> [I]t is not unusual for series compensation systems, including their ancillary equipment, to be specified with guaranteed availability performance requirements of 99.6% to 99.7%. The number and duration of scheduled maintenance outages of fixed series capacitors (FSC) banks each year typically do not exceed 1 outage for a maximum duration of 12 hours with no more than 2 forced outages per year.

29. The Due Diligence Report indicates that problems associated with series capacitors can be overcome. It states (Summary at 2):

> Careful design of the Bruce special protection system (BSPS) can counteract reduced system reliability when adding series capacitors for these increased power flows but is a complex adjustment to do successfully. In addition, careful design applied to each series capacitor bank can minimize the impact of failure modes within the bank and its consequential negative influence on system reliability.

The report contains a warning about sub-synchronous resonance ("SSR"), yet states (at 9):

> Fortunately the mechanism of SSR, its analysis and design for prevention is now well known and a number of mitigating measures exist to address this issue . . . . Generally it is true that the lower the proportion of series compensation on a transmission line, the less likely the electrical series resonance will decrease damping of complementary shaft torsional

resonant modes and cause shaft damage.

30. These documents clearly indicate that series capacitors will work in lieu of the Bruce-Milton Lines, but that some additional fine-tuning is necessary. However, it appears that Hydro One wishes to treat the series capacitor alternative as one solely related to interim measures. Hydro One has expressed strong reservations[2] about using series capacitors as a long-term solution, and does not reconcile its reservations with the fact that series capacitors are very common in other parts of the world, especially within Canada and the United States where transmission systems operate under roughly the same regulatory and reliability criteria as does the transmission system in Ontario.

31. Furthermore, Hydro One has stated that series capacitors cannot be installed until 2011 at the earliest. This position seems unnecessarily restrictive. In fact, the facilities required to be installed require little if any new right-of-way or transmission towers. Although OPA earlier promoted implementation of series capacitors and generation rejection,[3] Hydro One has since shifted its preference away from series capacitors and toward the construction of its proposed Bruce-Milton lines.

32. Series capacitors alone will increase transmission capacity from 5385 MW to 6325 MW, and the transfer capacity would be even higher with the continuation of the existing GR plan to drop one Bruce unit upon loss of both circuits of the existing Bruce-Milton Lines. With GR included, transmission capability increases to no less than 7076 MW as noted in Table 1 of Exhibit No. 8, and this amount may be even more, as discussed later.

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[2] See Application, Exhibit B, Tab 6, Schedule 5, Appendix 2, p. 4 and Exhibit B, Tab 6, Schedule 5, Appendix 3.

[3] "10-Year Outlook: An Assessment of the Adequacy of Generation and Transmission Facilities to Meet Future Electricity Needs in Ontario from January 2006 to December 2015," Independent Electricity System Operator, August 15, 2005, provided in response to Pappas Interrogatory #1, List 1. See Exhibit No. 14 at page 47.

Project Alternatives - Generation Rejection as a Component of a Reliable Alternative

33. Hydro One indicates that the existing generation capability at Bruce is approximately 5000 MW from six units. As noted previously, Hydro One has since provided a lower figure for the existing generation at Bruce, indicating that the net continuous rating of the existing Bruce NGS is 4734 MW. However, there was a period during 1987 through 1995 when all eight units at Bruce were operating. The combined capacity of these units is approximately 6200-6400 MW. During the Technical Conference held on October 15, 2007, Hydro One and OPA were questioned about this inconsistency. OPA's representative indicated that, in the past, the existing transmission facilities emanating from Bruce had enough capacity to transmit power from the eight previously-installed Bruce units. According to the OPA representative, the transmission system can no longer handle eight Bruce units because the transmission system connected to Bruce NGS has become loaded with increased power flows from non-Bruce generation in the west and because a heavy water plant near Bruce (a plant load that formerly absorbed 300 MW of Bruce's output locally) is no longer operating. Hydro One asserts that the prevailing direction of power flows has changed from its former east to west direction to the west to east direction and will presumably continue flowing in that direction (Exhibit No. 4, pp. 22-23). As a result, Hydro One takes the position that the transmission capacity out of Bruce is now limited to approximately 5000 MW.

34. However, based on responses to interrogatories, it appears that the transmission system in existence during the period that all eight Bruce units were operating (1987-1995) was able to deliver the output of all eight Bruce units only by means of a Special Protection System ("SPS") arrangement. See Exhibit No. 15 (Ross-IESO Interrogatory #10, List 1, with quotation below at P 36). That SPS involved use of generation rejection following substantial outages of transmission facilities. The prior practice permitted substantial amounts of Bruce generation to be

rejected under rarely occurring and tightly defined conditions from the mid-1980s through 1995.

35. Hydro One is now unwilling to continue use of the Bruce SPS that has been relied on historically. This evolution in attitude is now a major factor relied upon to justify the need for new transmission facilities, and is explained in some detail in Exhibit No. 14, "10-Year Outlook: An Assessment of the Adequacy of Generation and Transmission Facilities to Meet Future Electricity Needs in Ontario from January 2006 to December 2015," Independent Electricity System Operator, August 15, 2005, provided in response to Pappas Interrogatory #1, List 1. The 10-Year Outlook states at pp. 45 *et seq*. [emphasis added]:

> **5.1.7 System Requirements Associated with the Incorporation of Bruce Units**
>
> The Bruce system consists of eight nuclear units, totaling approximately 6,500 MW of capacity, connected to the power system through four 500 kV lines (two circuits from Bruce to Milton TS, one of which continues on to Claireville and two circuits from Bruce to Longwood TS), and six 230 kV circuits (two circuits from Bruce to Orangeville, two circuits from Bruce to Detweiler and two circuits to Owen Sound, one of which connects to the 115 kV network through to Essa). The Bruce complex is the largest concentration of generating units in North America.
>
> The generation was installed over the mid 70's to mid 80's. Four units were removed from service in 1998, at the same time as four Pickering units. Of these four Bruce units, two units have since been returned to service in 2003. Two units (1 and 2) remain out of service.
>
> The transmission additions constructed to incorporate the station into the Ontario network were not as desired by Ontario Hydro. The preferred implementation included a double circuit 500 kV line from Bruce to Essa in the Barrie area. Public opposition to these circuits ultimately prevented this construction. The Bruce to Longwood 500kV circuits were installed as a somewhat less capable alternative. As a result of this change, the full output of the Bruce complex could not be accommodated by the transmission system. In order to increase the capability of the transmission system to the level required, an automated "Special Protection Scheme" (SPS) was installed. In taking this step, the reliability of both the Bruce generation and many customers in Ontario was reduced to achieve increased economic benefits of the Bruce complex. In essence, the SPS

allows for detection of certain power system events and immediately disconnects generators at Bruce and a large amount of customer load throughout southern Ontario to prevent a system disturbance such as that experienced in August 2003.

Without the SPS, Bruce output is limited to approximately 5,000 MW (capacity equivalent to approximately six Bruce units). With the SPS, Bruce output with eight units in operation (6,500 MW) could be accommodated provided up to four units (3,200 MW) were 'rejected' or disconnected instantaneously together with 1,500 MW of customer load (approximately half the load in downtown Toronto). These extensive and complex automatic actions, representing by far the largest use of an SPS by an interconnected system operator, were considered a temporary measure until additional transmission could be constructed. Ontario's neighbouring system operators insisted on stringent conditions with respect to the design and use of the SPS in order to protect their own systems from a cascading disturbance. The majority of the SPS has not been used in over a decade following the shutdown of four Bruce units in 1998.

In the consideration of additional Bruce generation, it is important to understand the relationships of the various factors which impact on the ability of the system to accommodate increased Bruce generation, as well as how the evolution of the electricity system has affected this capability. This information is summarized in the following table.

[Table deleted. That table makes the points that (1) more west-east power flows are superimposed on the Bruce transmission system because Ontario formerly exported power to Michigan and now imports power from Michigan and has added substantial thermal generation near Sarnia and Windsor, (2) that the Nanticoke coal units are becoming less reliable, and (3) that loads in the GTA have grown, power factor has declined, and generation in the GTA has declined.]

In each case, the evolution of the system has been to reduce the capability of the system to accommodate additional Bruce generation. Of course this is not exclusively true; for example, Darlington was constructed to help meet GTA load, expansion of the 500 kV network in south western Ontario has been undertaken and a large number of shunt capacitors have been added in the GTA. However, in general, the net effect has been negative from the perspective of accommodating additional Bruce generation.

In addition, the past reliance on the large 'Special Protection Scheme' to accommodate Bruce output is no longer a desirable practice. The three and four unit rejection associated with this scheme as well as associated customer load rejection have not been required to be used in a decade. The

experience of the August 2003 blackout has altered industry and system operators view of the risks associated with use of these schemes. The side-effects of their operation may no longer be acceptable. The IESO does not recommend reliance on an SPS of this magnitude that involves the rejection of more than 2 generating units combined with extensive load rejection. There is a high degree of uncertainty with respect to our neighbours' agreement with such a scheme's future use. **The IESO believes it is prudent to enhance the transmission system so that generation rejection is limited to 2 Bruce units, and the load rejection portion of the special protection scheme is not required to be used in conjunction with generation rejection to maintain Bruce stability.** The load rejection portion of the scheme should be maintained only to overcome difficulties in the operating time frame that would otherwise require pre-contingency load shedding. From the late 1990's this was not a major concern as there were no firm plans to rehabilitate units at Bruce. When this became desirable, **the studies performed by the IESO, Hydro One and Bruce Power have identified the need for transmission expansion to accommodate additional generation at Bruce. This may take the form of series compensation of existing transmission lines or the addition of new transmission lines.**

In summary, the existing system is much less capable of accommodating additional supply at Bruce than it was in the past. A number of factors associated with the dynamic and changing nature of the system have contributed to this including:

- High load growth in the GTA, particularly in summer as air conditioner use has surged;
- Changing nature of the load in the GTA;
- The shutdown of Pickering A;
- The shutdown of Lakeview;
- The growth of imports from Michigan on-peak;
- The addition of generation in southwest Ontario;
- The overall reduction in dependability of some OPG facilities; and
- **Changing industry expectations with respect to use of large 'Special Protection Schemes'**.

Even with transmission enhancements, it is recognized that the incorporation of additional Bruce units together with the need to cease burning coal at Nanticoke will require significant changes in the supply and delivery infrastructure.

Fortunately, the same types of system developments required to eliminate the need for Nanticoke generation described earlier [in] this section are the same enhancements needed to accommodate additional generation at the Bruce site. These developments include the following:

- Installation of generation in proximity to the large GTA demand. Location of generation close to the load facilitates the installation of additional generation at Bruce in two ways; first, less energy needs to be transported long distances to the GTA reducing competition for transmission capability between Nanticoke and Bruce, and second, reactive power needs of the system are met by the local generation in the GTA;
- Installation of series compensation in the 500 kV lines serving Bruce and Nanticoke. This form of compensation reduces the need for reactive power to support the large power flows to support the GTA, and reduces the need for post-contingency voltage support; and
- Installation of shunt capacitors in southwestern Ontario. This form of compensation provides voltage support to the steady state power system, freeing up dynamic voltage control capability of generating units.
- As was the case for the shutdown of Nanticoke, it is unlikely that these measures will eliminate the need for dynamic voltage support from the Nanticoke site. The most effective means to provide this capability while meeting the government's policy to cease burning coal at Nanticoke is to convert several units to synchronous condenser operation.

While the IESO's 10-Year Outlook recommends the use of series capacitors and the rejection of two Bruce units, Hydro One now contends on the basis of analyses by the IESO that it should not employ generation rejection at all in order to deal with a first contingency. Hydro One would continue to use an SPS involving GR after a "first contingency" event (e.g., arm the SPS during maintenance of, or after a first contingency involving, loss of one or two 500 kV lines so that, in the event of a second contingency, generation can be dropped).

36. When asked to reconcile its request to build the Bruce-Milton Lines with the findings of the 10-Year Outlook (See Exhibit No. 15, Ross-IESO Interrogatory #10, List 1), Hydro One responded as follows:

> The 10-Year Outlook was released shortly after the IESO began consideration of using series compensation on the Bruce to Milton line. The 10-Year Outlook also notes that the IESO has yet to perform its full assessment of the impact of the 500 kV series capacitors at the paragraph immediately following the reference above.

> Detailed analyses were subsequently carried out for both series compensation and the Bruce to Milton line by the IESO and were presented in SIA documents. Please see the response to Pappas Interrogatory 1 for the series compensation SIA and Exhibit B, Tab 6, Schedule 2 for the Bruce to Milton line SIA.
>
> Consistent with the conclusion of the series compensation SIA, the installation of series capacitors is sufficient neither to accommodate all of the committed Bruce Area generation, nor to enable the development of additional potential wind resources in the area. The above references are accordingly consistent with each other.

37. It must be noted that this response is unsatisfactory as it is based on the same faulty system requirement assumptions identified in paragraph 9 above. Hydro One assumes that the Bruce B nuclear units will be refurbished, and that additional as-yet-uncommitted wind generation will be approved in the Bruce area. Hydro One also assumes that wind generation is required to be transmitted on a firm basis. Without these assumptions, Hydro One's dismissal of series capacitors coupled with generation rejection as a reasonable alternative is not justified.

38. Further, Hydro One has provided two differing amounts of transmission capability possible when the Bruce SPS is in place. Hydro One stated, in response to a data request concerning the transfer capability under the following scenario:

> (d) The existing transmission system with the existing generation rejection scheme, nearterm upgrades and series capacitors.
>
> • *Transfer capability*: Approximately 6325MW - with no G/R initiated.
>
> • *Transfer capability*: Approximately 7075MW - with the rejection of one Bruce unit initiated post-contingency
>
> Without generation rejection, the installation of series capacitors would allow the output from seven units at the Bruce Complex together with that from the 675MW of committed wind-turbine projects to be accommodated.

> With a single unit at the Bruce complex rejected post-contingency, the series capacitors would allow the combined output from all eight units at the Bruce Complex together with the committed wind-turbine projects to be accommodated.

See Exhibit No. 9. The rejection of two units, or the rejection of one unit plus blocks of wind generation, were not discussed. As I note, even more transfer capacity is achievable when series capacitors are employed in addition to a GR scheme.

39. Continuation of the existing, or more limited, practice of generation rejection from the Bruce area is acceptable for a number of reasons. First, historically, generation rejection has not resulted in significant undeliverable energy, as far as the data provided by Hydro One indicates. This is based upon Hydro One's answers concerning the loss of the existing 500 kV Bruce-Milton lines, as Hydro One would not provide data on the operation of the SPS schemes historically. Second, generation rejection in the Bruce context meets applicable regulatory and reliability criteria as indicated by a review of industry reliability criteria and Hydro One's responses to interrogatories.

40. Typically, an SPS of the kind implemented at Bruce is not called on often. Indeed, this SPS is necessary because of the very slight possibility that Southwest Ontario will suffer the outage of both existing circuits on the double circuit line from Bruce to Milton at the same time. Outages of even single 500 kV circuits are rare. The contingency outage of both existing circuits on a double circuit line at the same time is even rarer. The response to Board Staff Interrogatory #1.4 (Exhibit No. 16) notes that the GR scheme has been armed frequently, but Hydro One has no data on how often rejection has occurred.

41. In fact, the sustained outage rate (one minute or more) of double circuit 500 kV overhead transmission circuits on Hydro One's transmission system was 0.00100821 outages/year/km for the period covering 1990-2006. The momentary outage rate (lasting less than one minute) for the same facilities for the same time

period was 0.00175624 outages/year/km, See Exhibit No. 17, response to Pollution Probe Interrogatory #34 List 4. The outage rates for all 500 kV transmission lines in the Province are similarly low. Indeed, Hydro One's data on outages/year/km equate to one outage per 200-250 miles per year, even better than the general rule of thumb to the effect that transmission lines tend to experience only one outage per year per 100 miles of line and even fewer outages per mile on both circuits of double circuit lines.

42. Other data provided by Hydro One indicate that the number of momentary outages for the specific facilities comprising the high voltage transmission system near the Bruce area is fewer than 0.58 per circuit per year, and the number of sustained outages range from zero to .6218 per circuit per year. The average duration of outages per year is less than 5.7 hours per year on all but circuits B560V and B561M (the existing Bruce-Milton and Bruce-Claireville circuits) on which the average circuit unavailabilities are 74.7873 hours per year and 35.1128 hours per year, respectively. See Exhibit No. 18, Hydro One's response to Pollution Probe Interrogatory #18, List 2.

43. These are not data on hours of blackouts or brownouts but are data indicating the probability or rates at which a single circuit will experience an unscheduled contingency outage. Such contingencies are events which all transmission systems are designed to withstand. That is, a fundamental transmission planning criterion is that the system must withstand the loss of each single system facility (line, generator or transformer) without overloading the remaining system elements (lines and transformers), without unduly depressing or elevating voltage levels and without causing instability. That is, after each and every loss (or contingency) of a single system element, all remaining equipment must stay within specified ratings and voltage limits, and the system must remain stable. Industry operating reliability criteria (and some planning criteria) allow firm load to be shed after the second contingency outage of both circuits on a double-circuit

line, an event which – as the Hydro One data indicate - is even more improbable than a single contingency.

44. Exhibit No. 16 indicates that only two momentary outages and one sustained outage of both circuits on the existing Bruce-Milton line have occurred since January 1990. However, the narrative accompanying the data indicates that all data may be related to a single event on September 15, 1998. In response to Energy Probe #10 (c), List 2 (Exhibit No. 19), Hydro One failed to provide data but indicated that "the contingency conditions that have been reviewed in the SIA Report [outage of both lines on a double circuit 500 kV tower] **occur very rarely** . . . ." [Emphasis added] The very low probability associated with the design contingency event supports the engineering judgment which led Ontario Hydro to operate a 4-Bruce-Unit generation rejection SPS for the years 1985 through 1998.

45. Hydro One's response to Pollution Probe Interrogatory #46, List 4 (Exhibit No. 20) supports the idea that generation rejection has not been of significance in the past:

> Although the arming of Bruce units for generation rejection has been the rule rather than the exception in the recent past, the occurrences of contingencies that trigger generation rejection are relatively uncommon. Most of the time, the most limiting contingency for the Bruce Complex is the loss of the Bruce-Milton-Claireville line. This contingency last occurred May 31, 1985 as a result of damaging tornados that swept across Central Ontario. The Bruce Special Protection System tripped Bruce units G1, G3 and G5 (net 2175 MW) and 737 MW of pre-selected customer load. Primary demand at this time was 14234 MW.

This response acknowledges that transmission outages of the 500 kV transmission lines are very rare, which undermines Hydro One's and OPA's fundamental assertion that the alternatives (i.e., enhancements to the existing line) are less desirable than a new additional line. In its application, Hydro One implies that a new transmission line would increase reliability by reducing the incidence of transmission failure from the Bruce area. In so doing, it downplays the benefits of

alternatives to the proposed new lines by appeal to the amount of undeliverable energy that will allegedly be trapped when transmission capacity is lacking. However, as the facts indicate, transmission outages of 500 kV facilities are extremely rare, and the sustained loss of the most critical contingency (the double circuit loss of Bruce-Milton and Bruce-Milton-Claireville) has only occurred once, back in 1985. A momentary loss of both circuits occurred in 1998.

46. Furthermore, the IESO has alluded to the notion of rejecting wind generation in place of, or in combination with, rejection of a Bruce unit. Indeed, wind generation lends itself to fast backdowns and/or rejection on those occasions when transmission outages suddenly limit Hydro One's transmission capability. Clearly, wind generation can be backed down or rejected in more finely tuned megawatt blocks (1.5 MW per wind machine or whole wind projects (of 40-100 MW)) than can nuclear generation (700+ MW per nuclear generating unit), and such backdowns and rejections of wind generation pose fewer risks and costs than do those associated with nuclear generation. In my opinion, the IESO's plan to add rejection of wind generation as part of an SPS arrangement in the Bruce area is sound and could be usefully implemented.

47. Not only has generation rejection been of low historical significance from a system reliability perspective, but also the practice can continue in full compliance with applicable regulatory criteria. That is, current regulatory criteria permit the continued operation of the existing generation rejection scheme at Bruce NGS. Ontario Resource and Transmission Assessment Criteria, Issue 5.0, IMO_REQ_0041[4] (excerpts in Exhibit No. 21) states [emphasis added]:

> **3.4 Permissible Control Actions**
>
> Following the occurrence of a contingency, the following control actions may be used to respect the loading, voltage decline, and stability limits referenced in this document:

[4] Full document available at:
http://www.ieso.ca/imoweb/pubs/marketAdmin/IMO_REQ_0041_TransmissionAssessmentCriteria.pdf

- Generation Redispatch
- **Automatic tripping of generation (generation rejection)**

. . . .

3.4.1 Special Protection System

. . . .

Automatic Tripping of Generation (Generation Rejection)

Automatic tripping of generation via Generation Rejection Schemes (G/R) is an acceptable post-contingency response in limited circumstances as specified below in section 7.3, Control Action Criteria. Arming of G/R may be acceptable for selected contingencies provided the G/R corrects a *security* violation and results in an acceptable operating mode.

The referenced Section 7.3 of the Assessment Criteria states:

7.3 Control Action Criteria

The deployment of control actions and *special protection systems* must not result in material adverse effects on the bulk system.

. . . .

The reliance upon a *special protection system* must be reserved only for exceptional circumstances, such as to provide protection for infrequent contingencies, temporary conditions such as project delays, unusual combinations of system *demand* and *outages*, or to preserve system integrity in the event of severe outages or extreme contingencies.

Transmission expansion plans for areas that may have a material adverse effect on the interconnected bulk power system must not rely on *NPCC* Type I *special protection systems* with all planned transmission facilities in service.

The present situation with respect to transmission facilities emanating from the Bruce Complex qualifies for reliance upon SPS on several of the accounts enumerated in Section 7.3. The loss of both circuits on a double circuit 500 kV line is an infrequent contingency. Moreover, the Province-wide shutdown of

coal-fired generation over a relatively short period of time represents an exceptional circumstance. However, under my proposed alternative, the GR necessary in combination with series capacitors would be limited to the rejection of no more than two Bruce units.

48. Previously existing SPSs (such as those allowing as many as four Bruce units to be rejected) may continue to be relied upon under NPCC rules. Although the GR used historically by Ontario relied upon rejecting up to four Bruce Units and shedding 1500 MW of load, my proposed alternative requires no load shedding and rejection of only one Bruce Unit plus 400 MW of wind generation. When asked about its past and current submissions to NPCC with respect to SPS and generation rejection, Hydro One represented in its interrogatory response that its prior submissions to NPCC were not available because they occurred more than 20 years ago (See Exhibit No. 22). An additional excerpt from the submissions was provided after further requests. From this limited information, it is clear that information regarding Hydro One's proposed changes to its SPS is highly relevant in this matter and the Board's inquiry. Furthermore, it appears that Hydro One is planning to continue the use of an SPS arrangement at Bruce even in the event it is allowed to build its proposed Bruce-Milton Lines.

49. Hydro One's right to grandfather existing SPS is provided for in NPCC Regional Reliability Reference Directory #7, Special Protection Systems, December 7, 2007 (see Exhibit No. 2), which provides:

> 1.6.2.2 Existing Facilities
>
> . . . .
>
> a. Planned Renewal or Upgrade to Existing Facilities. It is recognized that there may be SPSs, which existed prior to each TO's, GO's and DP's adoption of *Special Protection System Criteria* that do not meet these criteria. If any **Special Protection Systems** or sub-systems of these facilities are replaced as part of a planned renewal or upgrade to the facility and do not meet all of these criteria, then an assessment

shall be conducted for those criteria that are not met. The result of this assessment shall be reported on TFSP Form #1-5.

50. Much of the relevant information on prior and proposed SPSs should have been included in those submissions to NPCC. Section 2.0 of these criteria, produced below, indicate that Hydro One and/or OPA have been in the past, and are in the future, required to submit substantial information to NPCC that is highly relevant to the engineering matters at issue in this proceeding. Nonetheless, Hydro One declined to provide that information.

51. NPCC Regional Reliability Reference Directory #7 provides:

NPCC Reliability Reference Directory #7, Appendix B
Procedure for Review of Special Protection Systems

Introduction

This Appendix provides the procedure to follow to obtain concurrence from NPCC if an entity concludes that a new **Special Protection System** or a modification of an existing **Special Protection System** will be required which affects the **bulk power system**. The procedure is also shown on the attached flow chart.

2.0 NPCC Review and Concurrence

2.1 Allowing for sufficient lead time to ensure an orderly review, the entity will notify the chairman of the Task Force on Coordination of Planning (TFCP) of its proposal to install a new **Special Protection System** or modify an existing **Special Protection System**. The entity will send copies of the complete notification to TFCO and TFSP. This notification will include statements that describe possible failure modes and whether misoperation, unintended operation or failure of the **Special Protection System** would have local, inter-company, inter-**Area** or inter-Regional consequences, when the **Special Protection System** is planned for service, how long it is expected to remain in service, the specific **contingency**(s) for which it is designed to operate and whether the **Special Protection System** will be designed according to the NPCC *Bulk Power System Protection Criteria* (Document A-5) and the *Special Protection System Criteria* and Standards requirements listed in this docment (sic).

See Exhibit No. 2. These criteria make clear that generation rejection remains a Permissible Control Action under the limited circumstances specified in Section 7.3. As noted, the present situation with respect to transmission facilities emanating from the Bruce Complex qualifies as an exceptional circumstance for reliance upon SPS on several of the accounts enumerated in Section 7.3. The loss of both circuits on a double circuit 500 kV line is an infrequent contingency. Moreover, the Province-wide shutdown of coal-fired generation over a relatively short period of time represents an exceptional circumstance.

52. Under applicable reliability criteria, the Ontario bulk power system is permitted to engage in generation rejection in amounts greater than those now deemed acceptable by Hydro One under applicable reliability criteria. This self-imposed limit on generation rejection appears to be justified by Hydro One on the basis of an undocumented IESO-NPCC commitment governing interconnections with New York and Michigan. Hydro One's responses to interrogatories indicate that that commitment limits imports to 1500 MW immediately following a contingency outage event. See Exhibit Nos. 20 and 23 (Hydro One's responses to Pollution Probe Interrogatories #46 and #39) and Exhibit 24 (Hydro One's response to Saugeen Ojibway Nations Interrogatory #9). Hydro One has not provided copies of the governing agreements, made clear what the parameters of that contractual limit are or why that limit cannot be lifted by operating additional amounts of fast-responding spinning reserve (e.g., from spinning-but-unloaded hydro generation that typically can ramp to full load in a matter of seconds or automatic industrial load shedding).

53. In Exhibit No. 10, Hydro One cites the April 11, 2006, series capacitor study (Exhibit No. 12) and reaffirms its finding that the existing system with series capacitors and the near term measures would be "capable of accommodating" the output of seven nuclear units plus 675 MW of wind in the Bruce area without generation rejection. The choice of language ("capable of accommodating") does not state that the limit is the output of seven nuclear units plus 675 MW of wind,

or what the actual limit is. In other words, the existing system with series capacitors and near term measures would accommodate 6325 MW (3 Bruce A units at 750 MW each plus four Bruce B units at 850 MW each plus 675 MW of wind).

54. The response to Saugeen Ojibway Nations Interrogatory #10, Exhibit No. 10, goes on to state that the maximum amount of generation rejection "permissible" is the output of one nuclear unit "and up to 400 MW of wind" when including the post-contingency loss increase. This is consistent with Hydro One's contention that it has agreed to limit imports after a contingency to 1500 MW (a 750 MW nuclear unit, plus 400 MW wind, plus 350 MW in incremental losses = 1500 MW).

55. Combining the data in both parts of the response makes it clear that, with series capacitors and generation rejection, Hydro One will have the ability to transmit at least 7475 MW, equal to the output of eight nuclear units plus wind generation in excess of the 700 MW existing and committed wind generation (i.e., delivery of 1075 MW of wind can be achieved - seven Bruce units plus 675 MW of wind (6325 MW) plus the eighth, rejectable, Bruce unit at 750 MW plus 400 MW of rejectable wind). These data indicate, after rejecting one Bruce unit and 400 MW wind, the output of the Bruce NGS and wind generation in the vicinity of Bruce would drop down to that of seven nuclear units plus 675 MW of wind (that can be handled by the existing transmission system supplemented with series capacitors plus interim measures).

56. It is clear, based upon the information provided in the various studies by the IESO and others that the installation of series capacitors and a continuation of the current practice of generation rejection (albeit rejecting only 1 Bruce unit and some wind generation rather than the previous SPS that could reject up to 4 Bruce units along with dropping load) is a reliable and far more cost effective and economically efficient alternative to the project proposed by Hydro One. Further,

this alternative is scalable to meet the future possibility of increased or decreased generation in the Bruce area. In contrast, Hydro One's proposal is to build a substantial amount of excess transmission capacity well before generation facilities that would load up that transmission capacity are approved or constructed, and that transmission capacity could not be scaled down in response to any decrease in the need for generation from the Bruce area.

Project Need and Justification – Firm Transmission Capacity Not Needed for Wind

57. The Hydro One application and the OPA work leading up to the filing is based upon a plan to build enough redundancy into its system to provide firm transmission capacity to deliver 100% of the committed and planned wind generation. Such a plan will produce surplus transmission capability and would not protect the interests of consumers or promote economic efficiency or cost effectiveness.

58. Firm transmission is the amount that can be delivered after the loss of the most critical load serving facility (generation, transmission line or transformer). In this case, Hydro One defines the most critical contingency as the loss of not just one line, but two lines – both of the existing double circuit 500 kV lines from Bruce to Milton. However, it is rare for multiple 500 kV lines to experience simultaneous outages. Moreover, it is rare for all wind generators to be generating at their peak capacity at the same time. One must also consider that wind generation may be at its peak output during periods of low system demand (i.e., daily and seasonal off-peak periods) and therefore logically should have little economic impact in terms of driving transmission upgrades. It is both contrary to principles of sound transmission planning and economically imprudent to expend $635 million on transmission facilities capable of delivering 1700 MW of wind generation on a firm basis when significantly more than the existing and committed 700 MW of wind generation can be delivered on a nearly firm basis at a cost of $97 million.

59. Hydro One does not need firm transmission capability in order to deliver existing and committed wind generation from the Bruce region. Nor would firm transmission capability be required if additional wind generation from the region were to be approved in the future. Wind generation is intermittent, and not all wind turbines will be in operation even if wind velocities are sufficient to produce power. In recognition of wind generation's intermittent nature, Hydro One's policy is to rely only upon 20% or 1/5th of its installed wind capacity as a firm generating resource in planning to meet future peak demands. See Exhibit No. 25, the response to Saugeen Ojibway Nations Interrogatory #18 List 1. Even if the full 1700 MW of potential wind generation in the Bruce region identified in the IPSP were approved, developed and contracted for, its firm component would be only 340 MW. In fact, series capacitors and generation rejection can provide transmission capability for an additional 375 MW of wind generation in excess of the currently installed and committed generation, assuming that 400 MW of wind generation (and one Bruce Unit) would be rejected in the event Hydro One experiences its most critical contingency. In addition, capacity equal to the output of only 7 of the 8 Bruce Units are expected to operate on average, based upon outages, leaving line capacity available for transmitting 1825 MW, 125 MW more than the entire 1700 MW of committed and potential wind generation (equal to 1075 MW that can be rejected plus the average amount of transmission capacity devoted to Bruce that, on average, remains unused - 750 MW).

60. On a day-to-day basis, Hydro One and the IESO could determine what amount of wind generation could be accommodated. On most occasions, the amount that could be accommodated should significantly exceed 700 MW of wind generation in addition to the output of eight Bruce nuclear units, all of which could be transmitted using series capacitors and GR. And, as noted previously, because 500 kV transmission outages are rare, all of the committed and most, if not all, of the potential wind generation should be transmittable by use of non-firm transmission capacity. Because wind generation can decline quickly, the IESO

can be expected to carry operating reserves at least equal to the amount of wind generation which is at risk of being lost when winds die down.

61. Relying upon transmission capability that is rarely unavailable for delivery of intermittent wind energy would cause relatively little wind energy production to be lost, especially when one considers that the eight nuclear units are unlikely to all be on, and at full output, at the same time for very many hours per year. Their average availability is 85%. See Exhibit No. 26, Hydro One's response to Energy Probe Interrogatory #3, List 1. Hydro One takes the position that providing transmission service to wind generation that is rarely unavailable "would be employing generation rejection for normal operation, which is not consistent with the applicable planning standards (please see the response to OEB Interrogatory 3.2)." See Hydro One's response to Saugeen Ojibway Nations Interrogatory #15, List 1, Exhibit No. 27. However, rejecting generation from an intermittent source such as wind generation on the rare occasions that all nuclear units and all wind units are operating at full capacity would be consistent with prudent planning, would have a relatively negligible effect upon bulk power reliability, and would be most economically efficient and cost effective.

62. Furthermore, when the wind is strong, it cools transmission line conductors, enabling utilities to increase the ratings of transmission lines in the vicinity of the wind generators. Technical means exist to continuously monitor sag in line conductors and the velocity of the wind (as well as ambient temperature and sunlight levels) and to adjust the ratings of transmission lines in real time. This practice is known as dynamic rating. One of the world's seminal minds and equipment developers on this topic is Mr. Tapani Seppa who has found that use of dynamic ratings would allow utilities to assign up to 30% higher ratings on many circuits for up to 98% of the time. See Exhibit No. 28.

63. In its analysis of the feasibility of series capacitors, the IESO has accepted a limited version of that design practice with respect to its 230 kV lines B4V and

B5V within 50 km of the Amaranth wind generation by adopting a static rating based on a wind velocity of 15 km/Hr as compared to its usual ratings based on a wind velocity of 4 km/Hr. However,

> Hydro One has not conducted any studies of the correlation between the wind velocities in the vicinity of committed and potential wind [generation] in the Bruce area with the wind velocities along any transmission corridor.

See the response to Saugeen Ojibway Nations Interrogatory #14(a) and (b) in Exhibit No. 29. In response to subpart 14(c), Hydro One states:

> For the actual day-to-day operation of the transmission system, the IESO receives "dynamic" ratings from Hydro One at 5 minute intervals that recognize both the local ambient temperatures and the prevailing wind speeds, while also allowing for the solar conditions and the actual pre-contingency loadings on the circuits. With this latest information, the IESO is then able to maximize the use of the available transfer capability.

Overall, because of Hydro One's failure to provide requested supporting documentation, it is not possible to determine whether Hydro One has adequately considered dynamic ratings as a part of a reasonable alternative to its proposed project. It has not been possible to determine the extent of Hydro One's current monitoring or whether more could be done to reflect wind velocities in assigning ratings to transmission lines for planning and design purposes as well as for purposes of operations. Further, other data suggest that more can, in fact, be done (e.g., IESO's occasional use of static ratings based on a single higher wind velocity as opposed to statistical data taken from dynamic ratings).

64. It is important to recognize that the use of dynamic ratings affects thermal ratings but does not affect the impedance of transmission lines. It is the impedance and associated angular stability limit of a network which often dictate the network's transfer capability. E.g., the angular stability limit can be increased by lowering a network's impedance through use of series capacitors, new conductors, or new

parallel lines. Accordingly, where transfer capabilities can be limited by angular stability or voltage stability as well as by thermal capability (as is the case in the vicinity of Bruce), increasing a line's thermal rating by use of dynamic rating techniques will not necessarily be helpful. Nevertheless, the IESO did determine that increased thermal ratings on several 500 kV and 230 kV transmission lines attributable to higher assumed wind velocities of 15 km/hour did increase transfer capabilities achievable through use of series capacitors on the Bruce-Longwood-Nanticoke-Middleport 500 kV segments of the path between Bruce and the GTA. See Exhibit No. 12 at 6. With thermal limits taken care of, there are many ways to raise stability limits.

65. For Hydro One to build firm transmission capability in excess of 1700 MW in order to serve 700 MW of wind is contrary to sound system design principles. Further, it is neither cost effective nor economically prudent to do so, as the transmission cost of units of wind generation will be excessively high. Instead, economic prudence and cost effective design dictate that Hydro One should construct transmission capability for no more than the existing and committed wind generation of 700 MW. Further, if new wind generation from the area is approved and contracted for in the future, Hydro One should consider whether to enhance the transmission infrastructure or whether the pre-existing infrastructure has enough capacity to deliver all but a small portion of the available wind production. I expect an objective engineering analysis seeking to protect the interests of consumers, and to determine whether proposed actions promote efficiency and reliability, would result in a decision not to build transmission capacity sufficient to deliver the full installed capability of all committed and projected wind generation because that full amount would be used only very rarely.

Project Alternatives – Cost Benefit Comparison

66. Hydro One has supplied several responses to interrogatories that purport to evaluate the relative costs of the proposed Bruce-Milton Lines and two alternatives. In particular, there were a series of responses to interrogatories propounded by Pollution Probe, Energy Probe, and the Ontario Energy Board (Board Staff). In these replies, Hydro One indicated that it believed that an appropriate measure of determining a reasonable quantification of the comparative economics could be based upon a comparison of the Capital Costs, Costs of Undelivered Energy and Costs of Losses that would be anticipated to result under the alternative assumptions. However, in the information provided in prefiled evidence and in response to interrogatories, Hydro One has (1) failed to provide critical data, (2) has provided insufficient data in a number of key areas, (3) has applied a questionable methodology, (4) has improperly included various unapproved generation sources in its analysis, and (5) has failed to consider various factors that will have a significant impact on the economic analysis. As a result, the overall reliability of Hydro One's economic comparison of the project and its reasonable alternatives ought not to be accepted.

67. First, and most importantly, Hydro One has declined to provide the detailed workpapers and computer models that were used to quantify the costs of undelivered energy and losses. See Exhibit No. 30, the response to Pollution Probe Interrogatory #47, List 5, subpart a. Hydro One admits "initially, the proposed Bruce to Milton line has the highest cost due to its larger upfront capital costs." It is only when "the costs of the increased undelivered energy and losses " from alternatives are included that Hydro One reaches its conclusion that the Bruce-Milton Line is "less expensive in the long-run." See Exhibit No. 31, response to Energy Probe Interrogatory #29, List 4. Hydro One's withholding of key workpapers frustrates attempts to validate Hydro One's analysis and prevents critical evidence from coming before the Board in the matter.

68. Second, Hydro One has elected to provide generic verbal descriptions of the modeling procedures and data inputs that were utilized in its analysis, some representative graphical depictions of intermediate modeling results and tabular summaries of the modeling output. See, for example, Exhibit No. 32, response to Pollution Probe Interrogatory # 9, as well as Exhibit Nos. 30 and 31. Even these limited insights into the process have been provided in a piecemeal fashion in response to numerous interrogatories. Based on the evidence that is on record in this matter, Hydro One's responses provide a superficial treatment of what appears to be a very complex modeling effort. Under industry custom and practice, Hydro One would maintain documentation for its modeling efforts that are employed by those staff responsible for conducting the analysis. It therefore could and should have been provided.

69. In addition, Hydro One does not provide the data employed in its determinations of "capability reduction" on lines leading out of the Bruce area. See Exhibit No. 30, response to Pollution Probe Interrogatory #47, List 5. I am therefore unable to determine the appropriateness of the capacity deratings employed in the model or the suitability of such derating assumptions. Hydro One makes references to "equipment outages" but makes no mention of whether these outages were planned or forced or whether the planned outages in the model reflect planning schedules uniquely associated with the new Bruce-Milton Lines.

70. Third, in addition to my concern with the lack of proper support for the conclusions reached by Hydro One, I have other concerns with the studies. First, the determination of undelivered energy savings attributable to the construction of the Bruce-Milton Lines should not have been based on the assumption that uncommitted "future wind" will materialize. Whether such wind will be developed is uncertain, but, if the construction of the Bruce-Milton Lines is approved, the capital cost of the line is absolutely certain. Some wind projects that had previously been approved were ultimately not developed. Therefore, the analysis performed by Hydro One should exclude contributions of uncommitted

wind generators to the purported economic benefits of the Bruce-Milton Lines or, at a minimum, should discount the assumed benefits in order to reflect their uncertainty.

71. Fourth, as I have described earlier, Hydro One bases its economic analysis on the assumption that the Bruce B units will be refurbished, beginning in 2018. The analysis assumes that one unit will be out of service during the years following 2018 until all four units are back to their full output in January of 2024. See Exhibit No. 30, Attachment A. This assumption, like that of the uncommitted 1000 MW of wind capacity, should not be included in the economic analysis.

72. Despite Hydro One's cryptic description of its methodology, adjusting benefits for uncertainty can be expected to have a significant impact. Although the wind energy from uncommitted wind generation is less than 5% of the total energy presumed to be available for transmission from Bruce to Ontario loads, it does amount to roughly an average of 280 MW per hour on an annual basis. In 2012 the cost of undelivered energy ($3 million) is projected by Hydro One to be relatively small --this is for a period during which no new wind generation was assumed to have been added. See Exhibit No. 32, response to Pollution Probe Interrogatory #9, List 1. In 2013 the cost of undelivered energy increases to $69 million, which suggests that Hydro One is assuming that the uncommitted but potential installations of future wind generation will begin to start generating in 2013 or that all 8 Bruce Units are available by then. The costs of undelivered energy for 2013 and 2014 continue to rise, perhaps as a result of assuming that more future potential wind generation will be interconnected. After this point, the costs begin to decline, which is attributable to the use of present value discounting. Beginning in 2018, about the time at which Hydro One assumes that the Bruce B units will begin their refurbishment, the value of undeliverable energy is very low, a level that continues until such time as the Bruce B refurbishment is projected to be complete. Thereafter, the value of undeliverable energy again is projected to become significant. See Exhibit No. 32, response to

Pollution Probe Interrogatory #9, List 1. From this pattern, it appears that excluding the uncommitted future wind generation and the unapproved refurbishment of Bruce B would result in significant reductions in Hydro One's estimate of undelivered energy costs.

73. Fifth, Hydro One may or may not have considered the following factors, which could have an impact on an accurate economic analysis of various alternatives.

A. Hydro One included the effect of changes in losses. However, there is no discussion of how the loss calculation is affected by the undeliverable energy calculation. From the limited description provided, I am unable to tell whether Hydro One is valuing losses on energy that it models as being undeliverable. Such double counting would inflate the estimate of the purported cost of the alternative transmission options.

B. Another factor involves the description of the assumed availability of the Bruce generation units, which is too cursory to allow me to determine its appropriateness. Hydro One has included a sensitivity assessment of this latter issue by including an assumption of a 10% lower availability of the Bruce units. See Exhibit No 32, response to Pollution Probe Interrogatory #9, subpart (e).

C. Hydro One's analysis assumes that the amount of energy that could be delivered by use of series capacitors plus GR is 7076 MW. Based on my analysis, it is more appropriate to base the comparison on a capacity of 7475 MW, which would make this alternative more attractive from a cost benefit perspective.

D. Hydro One has failed to take account of the increased costs associated with remedying the "circulating loop flow" problem that will be caused or exacerbated by its proposal. Remedial action, likely involving the

installation of costly phase shifting devices, will have a significant effect on the cost benefit comparison of the various alternatives.

E. Finally, Hydro One makes no mention of the use of dynamic ratings on the transmission lines. Although Hydro One has acknowledged that the use of dynamic ratings may be appropriate, the undeliverable energy analysis does not seem to have employed this technique to allow the use of the transmission system to deliver the energy. Ignoring the benefits of dynamic ratings would overstate the amount of energy that is considered to be undeliverable.

These concerns lead me to believe that Hydro One's projection of undeliverable energy is probably excessive and that the Board should not rely upon Hydro One's studies.

74. In summary, there are a number of very serious concerns about the appropriateness and reliability of Hydro One's economic analysis comparing its proposed project to the reasonable alternatives. Hydro One has failed to provide intervenors or the Board, through its prefiled evidence, with sufficient data to validate its analysis or assess its credibility. As a result, the Board should not accept the conclusions of Hydro One's economic analysis as presented.

75. This concludes my affidavit.

IN THE MATTER OF the *Ontario Energy Board Act*, 1998, S.O. 1998, C.15 (Sched. B);

AND IN THE MATTER OF an Application by Hydro One Networks Inc. pursuant to section 92 of the Act, for an Order or Orders granting leave to construct a transmission reinforcement project between the Bruce Power Facility and Milton Switching Station, all in the Province of Ontario.

AFFIDAVIT

of

WHITFIELD A. RUSSELL

on behalf of

THE SAUGEEN OJIBWAY NATIONS

I, Whitfield A. Russell, certify that the attached Affidavit and Exhibits on behalf of the Saugeen Ojibway Nations, which bears my name, were prepared by me or under my direct supervision and are true and accurate to the best of my knowledge and belief formed after a reasonable inquiry.

Whitfield A. Russell

Subscribed and sworn to before me this 18th day of April, 2008, by Whitfield A. Russell.

City of Alexandria
Commonwealth of Virginia

Notary Public: Tara K. Parker-Johnson

Notary registration Number: 333663

My Commission Expires: November 30, 2011

TARA K. PARKER-JOHNSON
Notary Public
Commonwealth of Virginia
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My Commission Expires Nov 30, 2011