EB-2007-0050
Chris Pappas - Interrogatories for Hydro One –19 - 21, Part 6
[OPA & IESO}
March 14, 2008

Preamble:

The Bruce Generating Facility is the largest Nuclear facility in North America. It is the second largest in the world, after the Kashiwazaki-Kariwa Nuclear Power Plant with 8,026 MW, gross. As such, it is a pre-eminent candidate for the installation of Thyristor Controlled Series Capacitors and/or Thyristor Protected Series Capacitors on, or prior to connection to, the transmission lines they feed. Very large thermal generation facilities, regardless of fuel [nuclear, oil, natural gas, coal] are subject to conditions not affecting smaller thermal generating facilities.

SSR, subsyncronous resonance is a deleterious and dangerous condition that can arise. While it is electrical in nature, it does not arise from electrical causes. It arises from physical origins, and requires a set of physical conditions to generate it. Firstly, it requires extremely large turbines and generators. Secondly, it requires long transmission lines without which the SSR would not arise. It is the great mass of these components and the physical vibrations, thereof, that give rise to the SSR. Also, their vibration of motion contributes. All objects have a natural vibratory frequency and the amplitude of those vibrations can be affected by the imposition of external vibratory energy.

The SSR situation is entirely analogous to the vibratory conditions that threaten bridges. When a marching army approaches a long bridge the soldiers break step and cross the bridge marching out of step. When strong winds strike suspension bridges they not only swing the bridge. If the bridge has not been designed with vibratory amplitude in mind, induced frequencies of vibration can cause the bridge to twist and tear itself apart. In fact, conventional Series Capacitors, without appropriate control devices, will actually exacerbate the situation in an SSR contingency. In fact, the SSR would “fool” these into thinking that the generation frequency was above or below the 60 Hz transmission frequency by the 8 Hz leeway, that they would automatically trip, instigating transmission loss. Also a higher percentage of conventional Series Compensation may even contribute to the induction of SSR. This is why only a small percentage of compensation by conventional Series Capacitors can be applied to such lines. Also, this unenhanced compensation must be immediately disconnected with the initiation of an SSR contingency. This is the very reason for the development of Thyristors,

Thyristor Controlled and Thyristor Protected transmission devices. Thyristors [electronic power controllers] imbue numerous protective attributes to various devices. In terms of SSR, they behave like a "filtering" device. Simply, they dissociate the series compensation and the transmission line from the generation components "quenching" the "parasitic" resonances/frequencies, eliminating them without the need for any disconnection. This allows the maximum percentage of compensation to be employed. Maximum compensation can be

applied with 30% TCSC [thyristor controlled series compensation] and the remainder as conventional series compensation behind this TCSC "firewall". This not only eliminates SSR contingencies but, therefore, eliminates the need to disconnect the conventional series capacitors, at all, regarding SSR. Thyristors are just one in a line of other power electronic devices that have been developed. The older capacitor technology with the power electronic technology are grouped together as FACTS, Flexible Alternating Current Transmission Systems. These provide control and protection to transmission and distribution systems. FACTS will control issues of power flow, voltage stability, resistance and impedance and, hence, heat losses. They provide efficiency and higher power factors to the lines and, thus, conservation on a large scale.

The proponents have cited that this technology is new to Ontario and, hence, their reservations. However, this is irrelevant because the capacitor technology has been applied since the 1920's and developed and evolved and began much wider installation in the late 1950's. From then its use spread globally. This is clear from the materials produced by the applicant in response to the requests of my first set of Interrogatories. The power electronics, starting with the thyristors, have been employed for over 30 years. The Kayenta substation servicing transmission lines energized by the Palo Verde Nuclear facility in Arizona, came into service in 1992. This Thyristor Controlled Series Capacitor installation has protected those lines all these years. The second installation of thyristor devices in association with a nuclear facility was in service in 1998. This was at the Strode substation servicing the Forsmark nuclear facility in Sweden. FACTS is considered as a conventional, proven and reliable transmission solution, world-wide. Series capacitors have been in use in the United states and other Canadian provinces for quite some time and the newer FACTS have been in use for decades. But it is new technology to Ontario. !EEE, which is one of the associations who set the standards regarding electricity, has championed these technologies all along. The World Bank and the UN support and encourage their use, especially in poor Third World Countries. These were barely, some if at all, electrified. The World Bank is working with the major manufacturers and top experts in the attempt to make this financially possible. These organizations wish to see the application of these technologies from the start so that these countries can avoid the tangled contraptions that were built hither and thither, over time, elsewhere. In most countries, even when it is absolutely necessary for new transmission builds, they are designed with FACTS, or at least the capacitor technology dependant on circumstances. But there is no interest in bare line builds, except here.

In the HONI and OPA RPF's, several of these do not even contain the terms thyristor, TCSC or power electronics. One document states that the scope does not include considering enhanced series capacitors, only conventional ones. This despite he fact that, again, it is well understood, world-wide, that conventional series capacitors are limited where SSR exists.\ They also will not consider any recommendations involving the generators and enhancements on their side. Well, as SSR derives from the generators equipment and as the generators equipment is at risk, as stated in their own documentation, it only seems

sensible for them to take preventative measures. I find these study parameters problematical.

Interrogatory No. 19
Ref. 1) APPENDIX A to Procedural Order No. 5 IN THE MATTER OF Leave to Construct Application by Hydro One Networks EB- 2007-0050 DATED February 25, 2008
2) Exhibit C Tab 4 Schedule 6 Attachment 1, Filed February 28, 2008.

Issue Number: 1.0 Project Need and Justification
Issue Number: 1.1
1.1 Issue: Has the need for the proposed project been established?
Issue Number: 1.3
1.3 Issue: Have all appropriate project risk factors pertaining to the need and justification (including but not limited to forecasting, technical and financial risks) been taken into consideration in planning this project?
Issue Number: 1.4
1.4 Issue: Is the project suitably chosen and sufficiently scalable so as to meet all reasonably foreseeable future needs of significantly increased or significantly reduced generation in the Bruce area?

Issue Number: 2.0 Project Alternatives
Issue Number: 2.1
2.1 Issue: Have all reasonable alternatives to the project been identified and considered?
Issue Number: 2.2
2.2 Issue: Has an appropriate evaluation methodology been applied to all the alternatives considered?
Issue Number 2.3
2.3 Issue For all of the considered alternatives, does the evaluation methodology utilized include a cost benefit comparison as well as a comparison of all quantitative and qualitative benefits?
Issue Number: 2.4
2.4 Issue:
a) Have appropriate evaluation criteria and criteria weightings been utilized in the evaluation process for the alternatives and the proposed project and what additional criteria/weightings could be considered?
b) Have appropriate comparisons been carried out on all reasonable alternatives with respect to reliability and quality of electricity service, including stability and transient stability levels, voltage performance and Loss of Load Expectation projections under normal and post-contingency conditions?
c) Do the alternatives meet the applicable standards for reliability and quality of electricity service?
Issue Number: 2.5
2.5 Issue: Is the proposal a better project than the reasonable alternatives?

Issue Number: 2.6

2.6 Issue: Are the project's rate impacts and costs reasonable for:

• the transmission line;
• the station modifications; and
• the Operating, Maintenance and Administration requirements.

Issue Number: 3.0 Near Term and Interim Measures

Issue Number: 3.1

3.1 Issue: Are the proposed near term and interim measures as outlined in the application appropriate?

Issue Number 3.2

3.2 Issue : Can the proposed near term and interim measures be utilized longer than the suggested two to three year time frame?

Issue Number: 3.3

3.3 Issue: If these proposed near term and interim measures could be utilized for a longer period than proposed, could they (or some combination of similar measures) be considered an alternative to the double circuit 500 kV transmission line for which Hydro One has applied?

Issue Number: 4.0 Reliability and Quality of Electricity Service

Issue Number: 4.1

4.1 Issue: For the preferred option, does the project meet all the requirements as identified in the System Impact Assessment and the Customer Impact Assessment?

Issue Number: 4.2

4.2 Issue: Does the project meet applicable standards for reliability and quality of electricity service?

Issue Number: 4.3

4.3 Issue: Have all appropriate project risk factors pertaining to system reliability and quality of electricity service been taken into consideration in planning this project?

Request

Provide the rationale for the following study parameter exclusion from pg 92 of Exhibit C Tab 4 Schedule 6 Attachment 1, Filed February 28, 2008.

1. Overview

1.1 Scope

"The scope of this document covers the technical aspects for three (3) fixed series capacitor (FSC) bank installations using overvoltage protection based on metal oxide varistors with or without a protective gap. The scope does not include the use of power electronic devices for the insertion, bypassing, protection or control of the capacitor bank."

Interrogatory No. 20

Ref. 1) APPENDIX A to Procedural Order No. 5 IN THE MATTER

OF Leave to Construct Application by Hydro One Networks EB-2007-0050 DATED February 25, 2008
2) Exhibit C Tab 4 Schedule 5 Attachment 1 Filed: February 28, 2008

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c) Do the alternatives meet the applicable standards for reliability and quality of electricity service?
Issue Number: 2.5
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2.6 Issue: Are the project's rate impacts and costs reasonable for:
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3.3 Issue: If these proposed near term and interim measures could be utilized for a longer period than proposed, could they (or some combination of similar measures) be considered an alternative to the double circuit 500 kV transmission line for which Hydro One has applied?

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Issue Number: 4.2
4.2 Issue: Does the project meet applicable standards for reliability and quality of electricity service?

Issue Number: 4.3
4.3 Issue: Have all appropriate project risk factors pertaining to system reliability and quality of electricity service been taken into consideration in planning this project?

Request

Provide the rationale for the exclusion of any mention of power electronics, such as thyristors, only citing conventional series compensation for study in the Request for Proposals.

Interrogatory No. 21
Ref. 1) APPENDIX A to Procedural Order No. 5 IN THE MATTER OF Leave to Construct Application by Hydro One Networks EB-2007-0050 DATED February 25, 2008
2) Exhibit C Tab 4 Schedule 5 Attachment 2 Filed: February 28, 2008

Issue Number: 1.0 Project Need and Justification
Issue Number: 1.1
1.1 Issue: Has the need for the proposed project been established?
Issue Number: 1.3
1.3 Issue: Have all appropriate project risk factors pertaining to the need and justification (including but not limited to forecasting, technical and financial risks) been taken into consideration in planning this project?

Issue Number: 1.4

1.4 Issue: Is the project suitably chosen and sufficiently scalable so as to meet all reasonably foreseeable future needs of significantly increased or significantly reduced generation in the Bruce area?

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2.2 Issue: Has an appropriate evaluation methodology been applied to all the alternatives considered?

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a) Have appropriate evaluation criteria and criteria weightings been utilized in the evaluation process for the alternatives and the proposed project and what additional criteria/weightings could be considered?

b) Have appropriate comparisons been carried out on all reasonable alternatives with respect to reliability and quality of electricity service, including stability and transient stability levels, voltage performance and Loss of Load Expectation projections under normal and post-contingency conditions?

c) Do the alternatives meet the applicable standards for reliability and quality of electricity service?

Issue Number: 2.5

2.5 Issue: Is the proposal a better project than the reasonable alternatives?

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- the transmission line;
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3.3 Issue: If these proposed near term and interim measures could be utilized for a longer period than proposed, could they (or some combination of

similar measures) be considered an alternative to the double circuit 500 kV transmission line for which Hydro One has applied?

Issue Number: 4.0 Reliability and Quality of Electricity Service
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Issue Number: 4.3
4.3 Issue: Have all appropriate project risk factors pertaining to system reliability and quality of electricity service been taken into consideration in planning this project?

Request

Provide the rationale for the following: “It is desirable to employ SSR mitigation measures which do not require additional facilities or modifications at generating stations. If additional facilities or modifications at generating stations are recommended, the Contractor will provide a discussion of the benefits and advantages over other mitigation measures which do not involve generating facilities. “