REPORT

ieso

Power to Ontario.
On Demand.

System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Final Report

CAA ID: 2013-498
Project: NRC TS Replacement

Applicant: Hydro One Networks Inc.

Market Facilitation Department
Independent Electricity System Operator

Date: December 2, 2013

Document ID	CAA ID 2013-498
Document Name	System Impact Assessment Report
Issue	1.0
Reason for Issue	Final Report
Effective Date	December 2, 2013

System Impact Assessment Report

Acknowledgement

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

Disclaimers

IESO

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

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

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

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

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

Hydro One

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

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

This study does not assess the short circuit or thermal loading impact of the proposed connection on facilities owned by other load and generation (including OPG) customers.

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

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

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

Table of Contents

List of Figures

List of Tables

Executive Summary

Notification of Conditional Approval

Hydro One Networks Inc. (the "connection applicant") is planning to replace the existing 25/33.3/41.7 MVA transformers and other equipment which is currently at or near end of life at National Research Council (NRC) TS. The existing transformers are to be replaced with two 115-14-14 kV three-phase transformers sized 45/60/75 MVA. The load supplied at NRC TS will increase from the current 17.5 MW to 26 MW in 2024 based on the load forecast provided by Hydro One and Hydro Ottawa.

This assessment concludes that the proposed project with the load increase at NRC TS, subject to the requirements specified in this report, is expected to have no material adverse impact on the reliability of the IESO-controlled grid. Thus, it is recommended that a *Notification of Conditional Approval for Connection* be issued for the NRC TS Replacement project subject to the implementation of the requirements outlined in this report.

IESO's Requirements for Connection

Connection Applicant Requirements

Specific Requirements:

The following specific requirements are applicable for the incorporation of the new NRC TS. Specific requirements pertain to the level of reactive compensation needed, operation restrictions, Special Protection Systems, upgrading of equipment and any project specific items not covered in the general requirements:

1. The proposed NRC TS is required to participate in the Ottawa Area Under-Voltage Protection Scheme for automatic load rejection.
2. The transmitter must submit any proposed protection modifications to the IESO at least six (6) months before any actual modifications are to be implemented on the existing protection systems

General Requirements:

The connection applicant shall satisfy the applicable requirements and standards specified in the Market Rules, Market Manuals and the Transmission System Code (TSC). The following requirements summarize some of the general requirements that are applicable to the proposed project, and are presented in detail in section 2 of this report.

1. The connection applicant shall have the capability to maintain the power factor at the defined meter point of the proposed project within the range of 0.9 lagging and 0.9 leading.
2. The connection applicant shall ensure that the 115 kV equipment is capable of continuously operating between 113 kV and 127 kV, as specified in Appendix 4.1 of the Market Rules. Protective relaying must be set to ensure that transmission equipment remains in-service for voltages up to 5% above the maximum continuous value.
3. The connection applicant shall install and maintain facilities and equipment at the proposed facility to provide 3% and 5% voltage reduction within five minutes of receipt of the direction from the IESO.
4. The connection applicant shall ensure that the connection equipment is designed to be fully operational in all reasonably foreseeable ambient temperature conditions. The connection equipment must also be designed so that the adverse effects of its failure on the IESO-controlled grid are mitigated.

5. The connection applicant shall ensure that the new equipment at the project is designed to withstand the fault levels in the area. If any future system enhancement results in fault levels higher than the equipment's capability, the connection applicant is required to replace the equipment with higher rated equipment capable of withstanding the increased fault level, up to the maximum fault level specified in Appendix 2 of the Transmission System Code.

   Appendix 2 of the Transmission System Code states that the maximum rated interrupting time for the 115 kV breakers must be 5 cycles or less. Thus, the connection applicant shall ensure that the installed breakers meet the required interrupting time specified in the Transmission System Code. Fault interrupting devices must be able to interrupt fault currents at a maximum continuous voltage of 127 kV.

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

7. Currently, the connection applicant is not required to participate in the under frequency load shedding program (UFLS). If in the future, the aggregate peak load exceeds 25 MW, the connection applicant is required to ensure that the UFLS targets specified in Section 10.4.6 of Chapter 5 of the Market Rules and Section 4.5 of Market Manual 7.4 are met.

8. If revenue metering equipment is being installed as part of this project, the connection applicant should be aware that revenue metering installations must comply with Chapter 6 of the IESO Market Rules. For more details the connection applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group

9. The connection applicant shall ensure that the protection systems at the proposed project are designed to satisfy all the requirements of the Transmission System Code and any additional requirements identified by the transmitter.

   As currently assessed by the IESO, the facility is not part of the Northeast Power Coordinating Council (NPCC) defined Bulk Power System (BPS) and, therefore it is not designated as essential to the power system. However, the transmitter may deem it as essential.

10. The proposed facility must be compliant with applicable reliability standards set by the North American Electric Reliability Corporation (NERC) and in the future if the proposed facility is identified as part of NPCC-defined BPS, it must be compliant with applicable reliability criteria set by NPCC.

11. The connection applicant must complete the IESO Facility Registration/Market Entry process in a timely manner before IESO final approval for connection is granted.

    Models and data, including any controls that would be operational, must be provided to the IESO at least seven months before energization to the IESO-controlled grid. This includes both PSS/E and DSA software compatible mathematical models representing the new equipment for further IESO, NPCC and NERC analytical studies.

    The connection applicant must also provide evidence to the IESO confirming that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in this assessment. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. The evidence must be supplied to the IESO within 30 days after completion of commissioning tests. If the submitted models and data differ materially from the ones used in this assessment, then further analysis of the proposed project will need to be done by the IESO.

Assessment Conclusions

We have analyzed the impact of the project on the system reliability of the IESO-controlled grid, and based on our study results, we have identified that:

1. The proposed connection arrangement and equipment for the project are acceptable to the IESO.

2. The power factor at the existing NRC TS does not meet the Market Rules requirements and a small amount of reactive power compensation would be needed to meet the reactive power requirements at the defined meter point. The connection applicant should monitor the power factor at the station and ensure that the reactive power is compensated to meet the power factor requirement.
3. The increased load at NRC TS will not result in loading of the existing transmission lines beyond the rated capability of the lines.
4. The voltage performance with the proposed project is expected to be acceptable under both pre-contingency and post-contingency conditions.
5. To help mitigate under-voltage concerns under certain system conditions, the Ottawa area is equipped with the Ottawa Area Under-Voltage Protection Scheme. This scheme consists of high-speed re-closure, automatic load rejection, automatic capacitor switching and automatic reactor switching. The project will be required to participate in the Ottawa Area Under-Voltage Protection Scheme for automatic load rejection.
6. The proposed 115 kV disconnect switches have a rated symmetrical short circuit capability of 38 kA which is sufficient under the current system conditions but below the maximum short circuit level for 115 kV systems of 50 kA as indicated in the Transmission System Code. Should future system upgrades result in short circuit level increase the applicant will be responsible to upgrade the disconnect switches to withstand short circuit levels up to 50 kA.

– End of Section –

1. Project Description

The existing equipment at NRC TS is approaching its end-of-life. As well, based on the projected load growth by Hydro One Networks Inc. ("the connection applicant") and Hydro Ottawa, the existing equipment and transformer capacity available at NRC TS will be inadequate to reliably supply the load in the area. Load level at NRC TS facility is forecasted to grow to 26 MW by 2024.

The proposed NRC TS will be located at the existing location which is adjacent to Cyrville MTS and Bilberry Creek TS, in Ottawa. The station will be supplied from the Hydro One 115 kV transmission line A2, with and expected in-service date in December 2014.

Hydro One Networks Inc. is planning to build a new Dual Element Spot Network (DESN) comprising of two 110/14/14 kV, 45/60/75 MVA transformers at the existing NRC TS property. The transformers are both identical and configured with a Delta winding on the high side and Wye (grounded through reactor) winding on the low voltage side. Each transformer is oil filled, forced-air cooled and is equipped with an Under Load Tap Changer (ULTC) located on the low voltage winding with a range of about ±2.84 kV that is to be achieved in ±16 steps. Each transformer will be isolated by an 115kV motor operated disconnect switch. Each disconnect switch will be capable of interrupting the maximum magnetizing current of the specified 45/60/75 MVA transformer. The high voltage switching and connection equipment will be capable of maximum continuous voltage of 127 kV.

Two 14 kV main breakers will connect the transformer secondary windings to two 14 kV buses. One normally open (N/O) 2520 A bus tie breaker will provides a parallel connection between both the transformer connected buses. Each 14 kV bus will supply ten feeder breakers rated at 1200A.

The proposed NRC TS single line diagram is shown below in Figure 1.

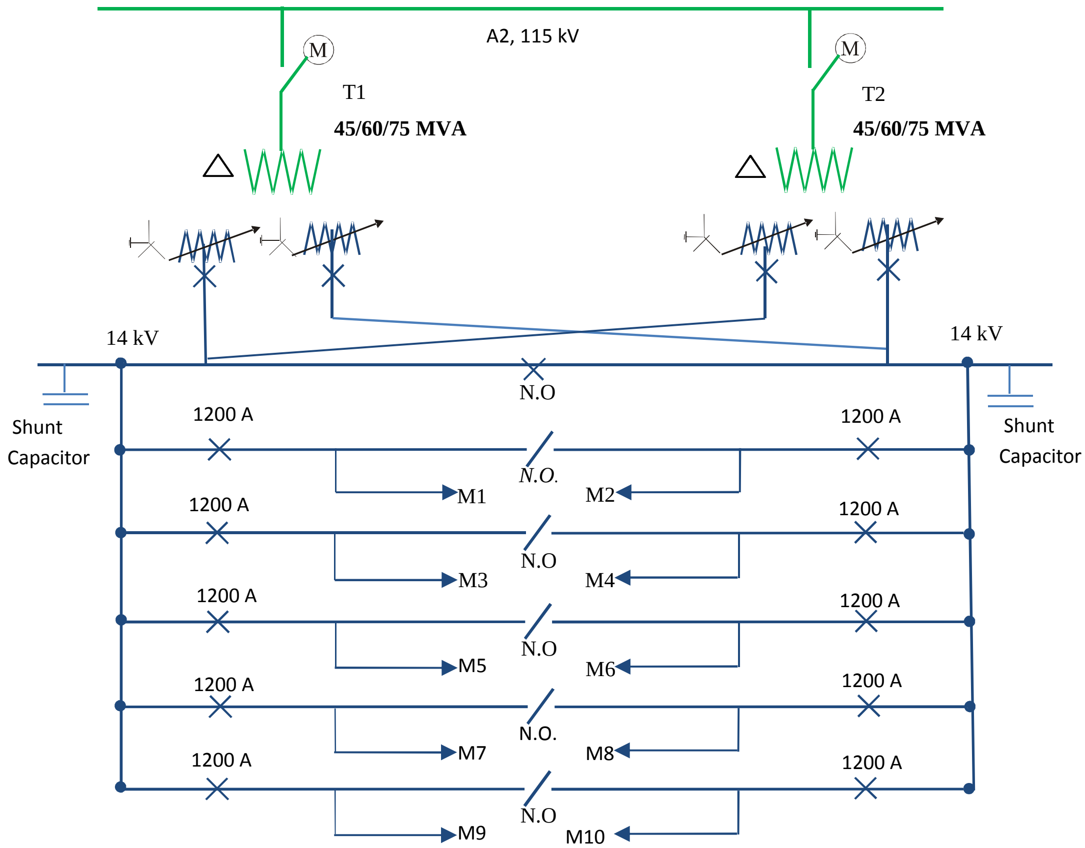

Figure 1: Single Line Diagram for NRC TS

2. General Requirements

The connection applicant shall satisfy all applicable requirements and standards specified in the Market Rules and the Transmission System Code. The following sections highlight some of the general requirements that are applicable to the proposed project.

2.1 Voltage Requirements

Appendix 4.1 of the Market Rules states that under normal operating conditions, the voltages in the 115 kV system in southern Ontario are maintained within the range of 113 kV to 127 kV. Thus, the IESO requires that the 115 kV equipment in southern Ontario must have a maximum continuous voltage rating of at least 127 kV.

Protective relaying must be set to ensure that transmission equipment remains in-service for voltages up to 5% above the maximum continuous value specified in Appendix 4.1 of the Market Rules, to allow the power system to recover from transient disturbances.

2.2 Voltage Reduction Facilities

Appendix 4.3 of the Market Rules requires that distributors connected to the IESO-controlled grid with directly connected load facilities of aggregated rating of 20 MVA or more and with the capability to regulate distribution voltage under load, shall install and maintain facilities and equipment to provide voltage reduction capability. Voltage reduction capability represents the capability of reducing demand by lowering the customer voltage by 3% and 5% within five minutes of receipt of the direction from the IESO. This is required to achieve load reduction during periods when supply resources are limited. The voltage reduction capability can be achieved by installing under-load tap changers (ULTC) at the proposed facility.

2.3 Power Factor

Appendix 4.3 of the Market Rules requires the connected wholesale customers and distributors connected to the IESO-controlled grid to have the capability to maintain a power factor within the range of 0.9 lagging and 0.9 leading as measured at the defined meter point of the facility.

2.4 Connection Equipment Design

The connection applicant shall ensure that the connection equipment is designed to be fully operational in all reasonably foreseeable ambient temperature conditions. The connection equipment must also be designed so that the adverse effects of its failure on the IESO-controlled grid are mitigated.

2.5 Fault Levels

The Transmission System Code requires the new equipment to be designed to sustain the fault levels in the area where the equipment is installed. Thus, the connection applicant shall ensure that the new equipment at the facility is designed to sustain the fault levels in the area. If any future system changes result in an increased fault level higher than the equipment’s capability, the connection applicant is required to replace the equipment with higher rated equipment capable of sustaining the increased fault level, up to maximum fault level specified in the Transmission System Code. Appendix 2 of the

Transmission System Code establishes the maximum fault levels for the transmission system. For the 115 kV system, the maximum 3 phase and single line to ground symmetrical fault levels are 50 kA.

Appendix 2 of the Transmission System Code states that the maximum rated interrupting time for the 115 kV breakers must be ≤ 5 cycles. Thus, the connection applicant shall ensure that the installed breakers meet the required interrupting time specified in the Transmission System Code. Fault interrupting devices must be able to interrupt fault currents at the maximum continuous voltage of 127 kV.

2.6 Under Frequency Load Shedding Requirement

Currently, the connection applicant has an aggregate peak load at all its stations that is less than 25 MW. Thus, the connection applicant is not required to participate in the under frequency load shedding (UFLS) according to Section 4.5 of the Market Manual Part 7.4. If in the future, the aggregate peak load exceeds 25 MW, the connection applicant is required to ensure that the UFLS targets specified in Section 10.4.6 of Chapter 5 of the Market Rules and Section 4.5 of Market Manual 7.4 are met.

2.7 Telemetry Data

In accordance with Section 7.5 of Chapter 4 of the Market Rules, the connection applicant shall provide to the IESO the applicable telemetry data listed in Appendix 4.17 of the Market Rules on a continual basis. The data shall be provided in accordance with the performance standards set forth in Appendix 4.22, subject to Section 7.6A of Chapter 4 of the Market Rules. The whole telemetry list will be finalized during the IESO Facility Registration/Market Entry Process.

The connection applicant must install monitoring equipment that meets the requirements set forth in Appendix 2.2 of Chapter 2 of the Market rules. As part of the IESO Facility Registration/Market Entry process, the connection applicant must also complete end to end testing of all necessary telemetry points with the IESO to ensure that standards are met and that sign conventions are understood. All found anomalies must be corrected before IESO final approval to connect any phase of the proposed project is granted.

2.8 Revenue Metering

If revenue metering equipment is being installed as part of this project, the connection applicant should be aware that revenue metering installations must comply with Chapter 6 of the IESO Market Rules. For more details the connection applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.

2.9 Protection Systems

The connection applicant shall ensure that the protection systems are designed to satisfy all the requirements of the TSC as specified in Schedules E, F and G of Appendix 1 of the TSC and any additional requirements identified by the transmitter. New protection systems must be coordinated with the existing protection systems.

Facilities that are essential to the power system must be protected by two redundant protection systems according to section 8.2.1a of the TSC. These redundant protections systems must satisfy all requirements of the TSC, and in particular, they must not use common components, common battery banks or common secondary CT or PT windings. As currently assessed by the IESO, this facility is not on the current BPS list, and therefore, is not considered essential to the power system. In the future, as the electrical system evolves, this facility may be placed on the BPS list.

The connection applicant is required to initiate an assessment of the protection systems proposed for the new facility with the transmitter.

Any modifications made to protection relays after this SIA is finalized must be submitted to the IESO as soon as possible or at least six (6) months before any modifications are to be implemented on the existing protection systems. If those modifications result in adverse impacts, the connection applicant and the transmitter must develop mitigation solutions.

The IESO will not assess aspects of protection systems which are solely the accountability of the transmitter (e.g. coordination of protection relays).

2.10 Reliability Standards

Prior to connecting to the IESO controlled grid, the proposed facility must be compliant with the applicable reliability standards established by the North American Electric Reliability Corporation (NERC) and reliability criteria established by the Northeast Power Coordinating Council (NPCC) that are in effect in Ontario. A mapping of applicable standards, based on the proponent's/connection applicant's market role/OEB license can be found here: http://www.ieso.ca/imoweb/ircp/orcp.asp

This mapping is updated periodically after new or revised standards become effective in Ontario.

The current versions of these NERC standards and NPCC criteria can be found at the following websites:
http://www.nerc.com/page.php?cid=2|20
http://www.npcc.org/documents/regStandards/Directories.aspx

The IESO monitors and assesses market participant compliance with a selection of applicable reliability standards each year as part of the Ontario Reliability Compliance Program. To find out more about this program, write to orcp@ieso.ca or visit the following webpage: http://www.ieso.ca/imoweb/ircp/orcp.asp

Also, to obtain a better understanding of the applicable reliability compliance obligations and engage in the standards development process, we recommend that the proponent/ connection applicant join the IESO's Reliability Standards Standing Committee (RSSC) or at least subscribe to their mailing list by contacting rssc@ieso.ca. The RSSC webpage is located at:
http://www.ieso.ca/imoweb/consult/consult_rssc.asp.

2.11 Facility Registration/Market Entry

The connection applicant must complete the IESO Facility Registration/Market Entry process in a timely manner before IESO final approval for connection is granted.

Models and data, including any controls that would be operational, must be provided to the IESO. This includes both PSS/E and DSA software compatible mathematical models representing the new equipment for further IESO, NPCC and NERC analytical studies. The connection applicant may need to contact the software manufacturers directly, in order to have the models included in their packages. This information should be submitted at least seven months before energization to the IESO-controlled grid, to allow the IESO to incorporate the proposed project into IESO work systems and to perform any additional reliability studies.

As part of the IESO Facility Registration/Market Entry process, the connection applicant must provide evidence to the IESO confirming that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in this assessment. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO.

Until this evidence is provided and found acceptable to the IESO, the Facility Registration/Market Entry process will not be considered complete and the connection applicant must accept any restrictions the IESO may impose upon this proposed project's participation in the IESO-administered markets or connection to the IESO-controlled grid. The evidence must be supplied to the IESO within 30 days after completion of commissioning tests. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

If the submitted models and data differ materially from the ones used in this assessment, then further analysis of the proposed project will need to be done by the IESO.

At the sole discretion of the IESO, performance tests may be required at generation and transmission facilities. The objectives of these tests are to demonstrate that equipment performance meets the IESO requirements, and to confirm models and data are suitable for IESO purposes. The transmitter may also have its own testing requirements. The IESO and the transmitter will coordinate their tests, share measurements and cooperate on analysis to the extent possible.

– End of Section –

3. Data Verification

Hydro One has provided the following specifications for the new equipment proposed for installation at NRC TS:

115 kV Transformer

Quantity	2
Thermal ratings	45/60/75 MVA (ONAF/OFAF/OFAF)
Rated voltage	115/14-14 kV
Under-load tap changer (ULTC)	±2.84 kV in 32 steps on LV winding
Transformer connections	HV: Delta, LV1, LV2: Wye (Grounded through Reactor)
Summary 10-day rating	108 MVA
Impedance	HX: 10% on 22.5 MVA Base
	HY: 10% on 22.5 MVA Base
	XY: 20% on 22.5 MVA Base

115 kV Disconnect Switch:

Quantity	2
Maximum continuous rated voltage	127 kV
Continuous current rating	1200 A
Rated symmetrical short circuit capability	38 kA

As indicated in the Transmission System Code, the maximum short circuit level for 115 kV systems is 50 kA. The short circuit capability of this disconnect switch is sufficient under the current system conditions but below 50 kA. Should future system upgrades result in short circuit level increase the applicant will be responsible to upgrade the disconnect switches to withstand short circuit levels up to 50 kA.

Transformer and Bus Tie Circuit Breakers:

Quantity	5
Maximum continuous rated voltage	14.6 kV
Interrupting time	2 Cycles (or less)
BIL voltage	110 kV
Rated continuous current	2520 A
Rated symmetrical short circuit interrupting capability	23 kA

Feeder Circuit Breakers:

Quantity	10
Maximum continuous rated voltage	14.6 kV
Interrupting time	2 Cycles (or less)
BIL voltage	110 kV
Rated continuous current	1200 A
Rated symmetrical short circuit interrupting capability	23 kA

– End of Section –

4. Fault Level Assessment

As the winding of the transformers is configured Delta/Wye–grounded and there is no major synchronous motor load to be installed at NRC TS, the project will not significantly change the fault levels in its surrounding area for both 3-phase and L-G faults. Thus, short circuits studies were not conducted for the SIA.

As there will be no fault interrupting equipment to be installed at the HV side of the project, fault level results are not needed in this report to assess new fault interrupting equipment.

– End of Section –

5. System Impact Studies

The system impact assessment studies focused on identifying the impact of the new load on the reliability of the IESO-controlled grid. It primarily includes a thermal loading assessment of transmission lines and a voltage assessment of local buses.

5.1 Existing System

NRC TS is a part of the load in the Ottawa Area. The Ottawa Area is bounded by 500 kV circuits X522A and X523A, 230 kV circuits C3S, M29C, B5D, L24A, A41T and A42T, 115 kV circuits W6MC, C7BM and H9A, and the normally open points on L2M and L1MB. The local generating facilities include Ontario Health Science Centre (OHSC) CGS, and 115 kV Madawaska Generation (Barrett Chute GS, Stewartville GS and Chats Falls G2 and G3 units). The Ottawa area load is normally a summer peaking area.

The power transfer through the Flow into Ottawa (FIO) interface is limited by pre and post-contingency voltage collapse. In addition, the Ottawa area voltage may decline to exceed acceptable limits under heavy load periods for the loss of 230/500 kV contingencies, primarily during equipment outages. To help mitigate under-voltage concerns, the Ottawa area is equipped with the Ottawa Area Under-Voltage Protection Scheme. This scheme consists of high-speed re-closure, automatic load rejection, automatic capacitor switching and automatic reactor switching.

The 115 kV transmission system in the vicinity of the project is shown in Figure 2. NRC TS is connected to the 115 kV line A2. In normal operation mode, A2 is connected radially from Hawthorne to Bilberry Creek TS and is disconnected from H9A by the normally open breaker 77A1-A2.

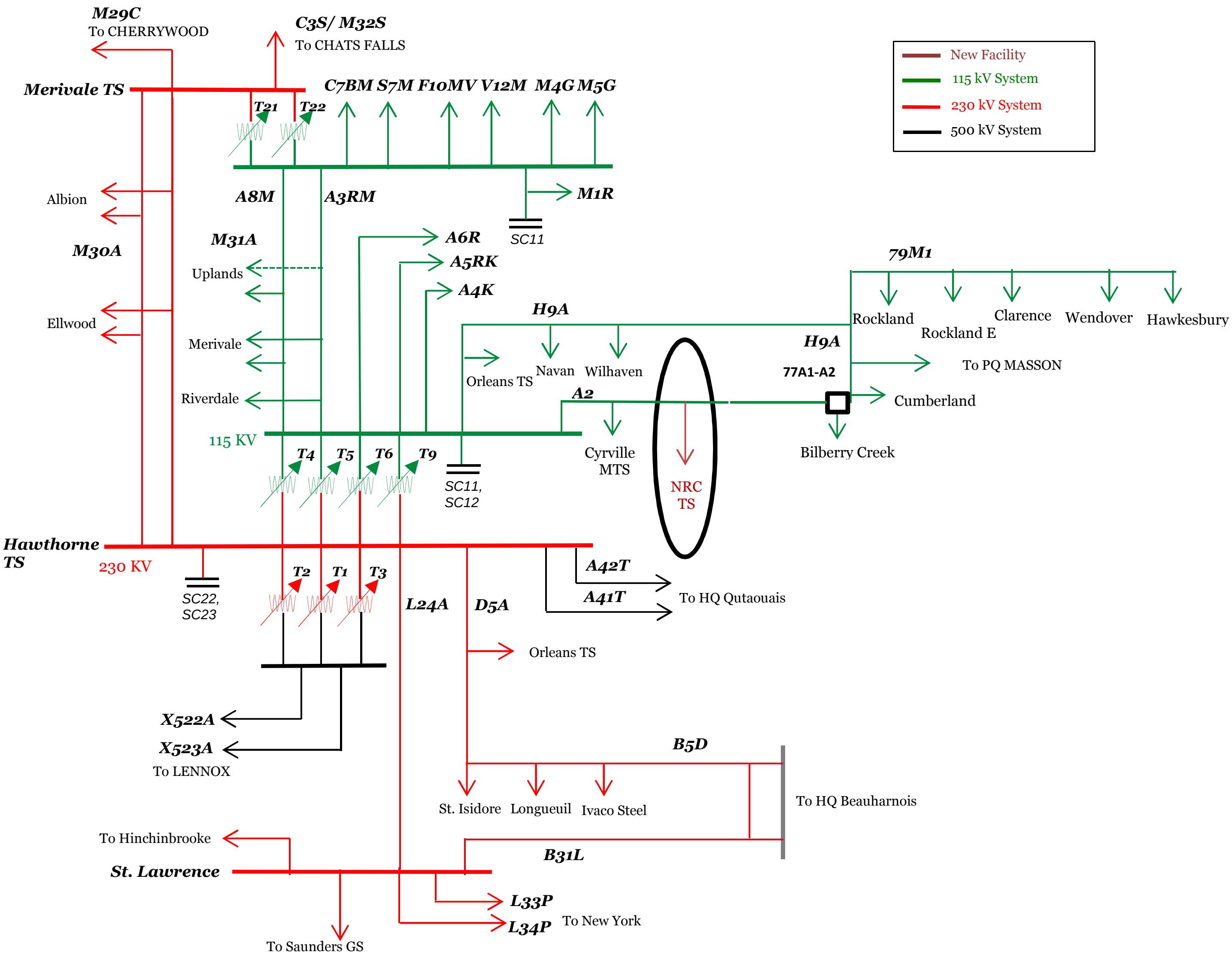

Figure 2: Transmission System in the vicinity of the project

5.2 Study Assumptions

In this assessment, the 2014 summer base case was used with the following assumptions:

(1) All existing and committed major transmission and generation facilities with 2024 in-service dates or earlier were assumed in-service.

(2) Ottawa demand was assumed 2,141 MW based on the extreme weather summer peak load forecast available to the IESO for the year 2024;

(3) Hydro One provided 2024 load forecast for stations connected to lines A2, 79MI and H9A except for NRC TS, as shown in Table 1 and Table 2. Hydro One also indicated that the power factor for all the loads is assumed 0.93 lagging unless stated otherwise.

(4) For NRC TS, Hydro Ottawa provided the load forecast and the load level in year 2024 is forecasted to be 26 MW, as shown in Table 2. However, the power factor was not provided for NRC TS.

(5) The Ontario-Quebec HVdc exported 860 MW to achieve a FIO transfer of 2,900 MW.

(6) Total generation of all units at Stewartville GS and Barrett Chute GS and units 2 & 3 at Chats Falls GS Units 2 was set to its historical minimum of 38 MW to stress the load supply behind Hawthorne transformers.

(7) Orleans TS was assumed to be in service (CAA ID 2012-491).

(8) The voltage at the Hawthorne 115 kV bus was 123.2 kV as observed from historical metering data.

(9) Loads are modeled as constant PQ unless stated otherwise.

Table 1: Load Forecast for 115 kV stations on circuit H9A and 79M1

Year	Orleans TS* (MW)	Navan DS (MW)	Wilhaven DS (MW)	Cumberland DS (MW)	Rockland DS (MW)	Rockland East DS (MW)	Hawkesbury DS (MW)	Clarence DS (MW)	Wendover DS (MW)	Total
2013	N/A	5.4	60.2	4.9	7.8	10.1	15.3	2.1	10.6	116.4
2014	58	5.4	2.7	5	7.8	10	14.8	2.1	10.5	116.3
2015	59.9	5.5	2.7	5	7.7	10	14.4	2.1	10.5	117.8
2016	61.8	5.5	2.8	5	7.7	10	14.1	2.1	10.5	119.5
2017	63.8	5.6	2.8	5	7.7	10	13.7	2.1	10.5	121.2
2018	65.7	5.7	2.8	5	7.7	10	13.4	2.1	10.5	122.9
2019	67.7	5.7	2.8	5	7.7	10	13.1	2.1	10.5	124.6
2020	69.7	5.8	2.9	5	7.8	10.1	13	2.1	10.6	127.0
2021	71.8	5.8	2.9	5	7.8	10.2	12.8	2.2	10.6	129.1
2022	73.9	5.9	2.9	5	7.9	10.2	12.7	2.2	10.7	131.4
2023	76	5.9	3	5	7.9	10.3	12.7	2.2	10.8	133.8
2024	78.1	6	3	5	8.0	10.4	12.6	2.2	10.9	136.2

*: Only half of the load is on H9A

Table 2: Load Forecast for 115 kV stations on circuit A2

Year	Cyrville MTS (MW)*	Bilberry Creek TS (MW)*	NRC TS (MW)	Total
2013	21.8	77	17.5	116.3
2014	22	78.2	18	118.2
2015	22.3	78.2	18	118.5
2016	22.5	78.2	19	119.7
2017	22.7	78.2	19	119.9
2018	22.9	78.2	24	125.1
2019	23.2	78.2	24	125.4
2020	23.4	78.2	24	125.6
2021	23.6	78.2	24.5	126.3
2022	23.9	78.2	24.5	126.6
2023	24.1	78.2	25	127.3
2024	24.3	78.2	26	128.5

*: Only half of the load is on A2.

5.3 Power Factor Analysis

The Market Rules (Appendix 4.3, reference 1) require that wholesale customers and distributors connected to the IESO-controlled grid shall operate at a power factor within the range of 90% lagging to 90% leading as measured at the defined meter point. For NRC TS, the defined meter point would be considered the HV sides of transformers T1 and T2.

The applicant did not provide the power factor at NRC TS in the load forecast sent to the IESO. Historical metering data was investigated for the past two years at NRC TS.

Figure 3 shows the power factor profile at the HV side of NRC TS based on hourly samples for the years 2012 and 2013.

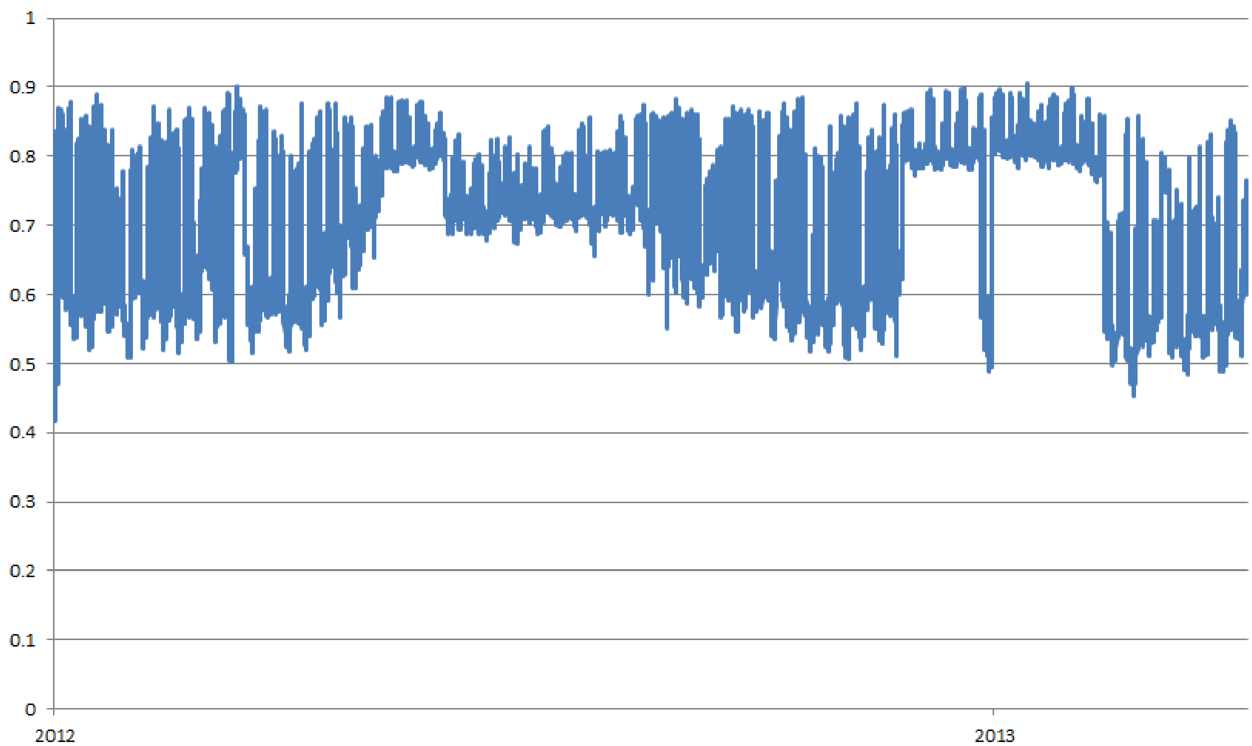

Figure 3: Historical Load Power Factor at NRC TS

It can be found from Figure 3 that the power factor was almost always below 0.9 and the lowest power factor value was approximately 0.5. Upon further analysis it was observed that the power factor got better with the higher load. The low power factor (less than 0.6) occurred only during off peak load conditions where the load is less than 3.5 MW. The historical load angles for instances when the load is greater than 80% of the peak load are shown in Figure 4. During peak load periods, the power factor was above 0.8 for the loads higher than 10 MW and above 0.83 for loads higher than 15 MW.

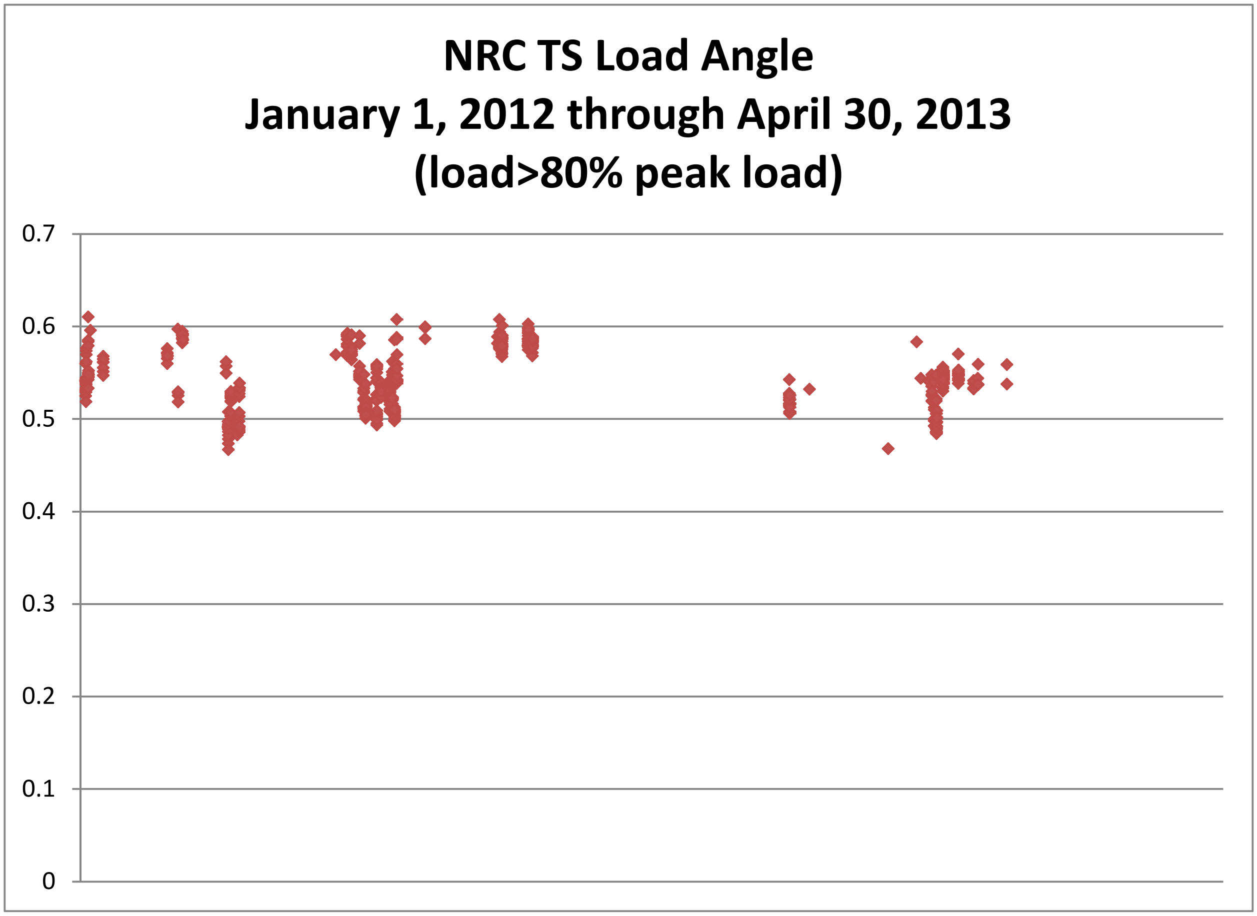

Figure 4: NRC TS load angles for load greater than 80% of the peak load

Power flow studies were performed to determine the amount of shunt capacitors needed to be installed at NRC TS assuming a power factor 0f 0.83 for a load of 18 MW. As result, an amount of 3 MVAr of static capacitive reactive power compensation would meet the reactive power requirements at the defined meter point. The applicant is required to monitor the load power factor at the station and ensure it meets the market rules requirements.

5.4 System Assessments

The Ontario Resource and Transmission Assessment Criteria (ORTAC) established load security criteria for use in the assessments of the adequacy and security of the IESO-controlled grid. The transmission system must exhibit the following acceptable performance:

1. With all transmission facilities in service, equipment loading must be within continuous ratings, voltages must be within normal ranges and transfers must be within applicable normal condition stability limits.
2. With any one element out of service, equipment loading must be within applicable long-term emergency (LTE) ratings, voltages must be within applicable emergency ranges, and transfers must be within applicable normal condition stability limits. Planned load curtailment or load rejection, excluding voluntary demand management, is permissible only to account for local generation outages. Not more than 150MW of load may be interrupted by configuration and by planned load curtailment or load rejection, excluding voluntary demand management.

3. With any two elements out of service, equipment loading must be within applicable short-term emergency (STE) ratings, voltages must be within applicable emergency ranges, and transfers must be within applicable emergency condition stability limits. Equipment loading must be reduced to the applicable LTE ratings in the time afforded by the STE ratings. Planned load curtailment or load rejection exceeding 150MW is permissible only to account for local generation outages. Not more than 600MW of load may be interrupted by configuration and by planned load curtailment or load rejection, excluding voluntary demand management.

5.4.1 Thermal Assessment and Load Security

Thermal ratings of the monitored circuits and transformers are listed in Table 3 and Table 4, respectively. These circuit ratings were provided by Hydro One and were calculated for the summer weather conditions with ambient temperature of 35°C and wind speed of 4 km/h. The continuous ratings for the conductors were calculated at the lower of the sag temperature or 93°C operating temperature. The LTE ratings for the conductors were calculated at the lower of the sag temperature or 127°C operating temperature. The STE ratings were calculated at the sag temperature with 100% continuous pre-load.

Table 3: Circuit Section Summer Thermal Ratings

Circuit	Section		Continuous	LTE Rating	STE Rating
	From	To	MVA	MVA	MVA
A2	Hawthorne TS	Cyrvle Rd JCT	165.6	218.8	245.4
A2	Cyrvle Rd JCT	Cyrvle JCT	165.6	218.8	284.2
A2	Cyrvle JCT	Bilberry Creek TS	120.6	157.4	184.0
H9A	Hawthorne TS	115 kV Orleans Tap	231.0	306.7	370.1
H9A	115 kV Orleans Tap	Borromee JCT	231.0	306.7	370.1
H9A	Borromee JCT	Wilhaven JCT	231.0	306.7	370.1
H9A	Wilhaven JCT	Cumberland JCT	231.0	306.7	370.1
H9A	Cumberland JCT	Gamble JCT	165.6	216.7	280.1
H9A	Gamble JCT	Cumberland DS JCT	100.2	100.2	100.2
H9A	Cumberland DS JCT	Bilberry Creek	100.2	100.2	100.2
A4K	HAWTHORNE_TS	CYRV_RD_JA4	165.6	218.8	284.2
A4K	CYRV_RD_JA4	CYRVILLE_JA4	165.6	218.8	284.2
A4K	CYRVILLE_JA4	MOULTON_J	186.1	245.4	323.1
A4K	OVERBROOK_TS	RIVERDL_JA5	186.1	245.4	323.1

Table 4: Transformer Ratings

Transformers	Continuous	LTE 10 DAY	STE 15 MIN
	MVA	MVA	MVA
Hawthorne T4	250	354	442
Hawthorne T5	225	264.2	362.7
Hawthorne T6	225	264.2	362.7
Hawthorne T9	250	387.9	487.8

With all elements in-service, half of the loads at Cyrville TS and Bilberry Creek will be connected to the 115 kV circuit A4K and H9A respectively, and the other half of the load will be connected to 115 kV circuit A2. In case any line is out of service, all the loads at these two stations can be supplied by the other remaining circuit.

With Orleans 230 kV transformer out of service, all of Orleans TS load will be supplied by the 115 kV network.

Table 5 summarizes the studied scenarios for thermal assessment which represent the potential worst-case conditions in terms of thermal loading around the project. It should be noted that some contingencies in the table are not related to the proposed project but were simulated to examine the impact of the forecasted load on the network to ensure that the performance of the local system meet ORTAC criteria.

Table 5: List of Studied Scenarios for Thermal Assessment

Note	Scenario	Outage Condition	Contingency
All in service	S0	None	None
N-1	S1	None	H9A
	S2	None	A4K
	S3	None	A2
	S4	None	Orleans 230 kV Transformer
	S5	None	Hawthorne T9
N-1-1	S6	H9A	A4K
	S7	Orleans 230 kV Transformer	A2
	S8	Orleans 230 kV Transformer	Hawthorne T9
	S9	Hawthorne T4	Hawthorne T9

Table 6 below shows the thermal analysis results for the monitored circuits and transformers after the incorporation of the project. The results include MVA flows, percentage flows compared to continuous rating for pre-contingency, compared to LTE for N-1 contingencies and compared to STE for N-1-1 contingencies.

It can be found that with all elements-in-service, the flows on all monitored line sections and transformers are within their continuous ratings with the project in-service pre-contingency. The post-contingency flows on all the monitored line sections are within their LTE/STE ratings.

It can be also found from Table 6 that with Hawthorne T9 out of service (S5), Hawthorne T6 is loaded to 100.4% of its LTE rating. However, this minor overload can be mitigated by dispatching Madawaska generation at higher output than the assumed minimum values.

In addition, with Hawthorne T4 out of service and following the loss of Hawthorne T9 (S9), the loading on the remaining transformers, i.e. Hawthorne T5 and T6, is below their STE but exceeds their LTE ratings. Some load curtailment would be needed post-contingency to reduce the loading of Hawthorne T5 and T6 below their LTE ratings within 15 minutes. Further studies show that about 240 MW of load curtailment behind Hawthorne TS would be needed to reduce the post-contingency loading of Hawthorne T5 and T6 below their LTE ratings. According to the OTRAC, for two elements out of service, load curtailment exceeding 150 MW is permissible, up to 600 MW, only to account for local generation outages. Since the local generation outage in this area is about 314 MW under this study scenario, the load security criteria is met. Moreover, if the Madawaska generation is in service at maximum output, the amount of load to be interrupted could be minimized or completely avoided.

Table 6: Thermal Loading Results

Crt	From Bus	To Bus	S0 (All I/S)		S1		S2		S3		S4		S5		S6		S7		S8		S9	
			MVA	%Cont	MVA	%LTE	MVA	%LTE	MVA	%LTE	MVA	%LTE	MVA	%LTE	MVA	%STE	MVA	%STE	MVA	%STE	MVA	%STE
A2	HAWTHORNE_TS	CYRV_RD_JA2	95	57.2	122	55.8	107	48.8	-	-	98.6	45.1	95.2	43.5	135	55.0	-	-	98.6	40.2	95.5	38.9
A2	Cyrville J	CYRVILLE_RD_J	81	48.8	108	49.5	80	36.7	-	-	84.7	38.7	81.4	37.2	108	38.0	-	-	84.8	29.8	81.7	28.7
A2	BILBERRY_A2	CYRVILLE_J	52	43.4	80	50.6	52	33	-	-	55.6	35.3	52.6	33.4	79.6	43.3	-	-	55.7	30.3	43.0	23.4
H9A	HAWTHORNE_TS	ORLEANS115	134	58.1	-	-	135	43.9	194.7	63.5	181.7	59.2	134	43.7	-	-	248.0	67.0	181.1	48.9	133.9	36.2
H9A	BORROMEE_J	ORLEANS115	89	38.4	-	-	89	29	145.6	47.5	85.9	28.0	88.5	28.9	-	-	145.7	39.4	85.4	23.1	88.3	23.9
H9A	BORROMEE_J	WILHAVEN_DS	82	35.6	-	-	83	26.9	138.9	45.3	79.4	25.9	82	26.7	-	-	139.4	37.7	78.9	21.3	81.9	22.1
H9A	CUMBERLN_JH	WILHAVEN_DS	79	34.1	-	-	79	25.8	134.5	43.9	75.9	24.7	78.5	25.6	-	-	134.6	36.4	75.4	20.4	78.3	21.2
H9A	CUMBERLN_JH	GAMB_H9AJ	79	47.5	-	-	79	36.5	134.3	62.0	75.9	35.0	78.4	36.2	-	-	134.6	48.1	75.4	26.9	64.9	23.2
H9A	GAMB_H9AJ15	CUMBR_DSJ	32	31.8	-	-	32	32.2	86.0	85.8	29.3	29.2	31.6	31.5	-	-	86.2	86.0	29.0	28.9	26.6	26.5
H9A	BILBERRY_H9A	CUMBR_DSJ14	27	26.8	-	-	27	27.2	80.5	80.3	24.6	24.6	26.6	26.5	-	-	79.6	79.4	24.4	24.4	26.5	26.4
A4K	HAWTHORNE_TS	CYRV_RD_JA4	144	87.1	146	66.5	-	-	154.8	70.7	144	65.8	142.2	65.0	-	-	154.4	54.3	142.1	50.0	139.6	49.1
A4K	CYRVILLE_JA4	CYRV_RD_JA4	132	79.4	133	60.6	-	-	128.8	58.9	131	59.9	130.0	59.4	-	-	128.2	45.1	129.6	45.6	127.1	44.7
A4K	CYRVILLE_JA4	MOULTON_J	132	70.7	133	54	-	-	128.6	52.4	131	53.4	129.7	52.9	-	-	128.2	39.7	129.4	40.0	126.9	39.3
A4K	OVERBROOK_TS	RIVERDL_JA5	88	47.2	47.2	18.7	-	-	47.2	18.7	46	18.7	47.3	18.7	-	-	47.2	14.6	47.3	14.6	48.6	15.0
Hawthorne T4			196	78.5	175.8	49.7	152.8	43.2	191.5	54.1	205.44	62.1	247.6	70.0	133.5	30.2	201.3	45.5	259.9	58.8	-	-
Hawthorne T5			196	87.1	175.6	66.5	152.7	57.8	191.3	72.4	205.3	80.5	247.4	93.6	142.9	39.4	201.2	55.5	259.7	71.6	334.5	92.2
Hawthorne T6			210	93.3	188.2	71.2	163.6	61.9	205.3	77.7	220.0	86.3	265.1	100.4	133.4	36.8	215.6	59.4	278.3	76.7	358.5	98.8
Hawthorne T9			199	79.8	178.7	46.1	155.3	40.0	194.6	50.2	208.8	55	-	-	135.7	27.8	204.7	42.0	-	-	-	-

Load tripped by configuration was counted for one and two elements out of service after the incorporation of the proposed project. Based on the load forecast for 2024 and the local system configuration, in case of single contingencies associated with A2, A4K or H9, the interrupted load would not exceed 150 MW, which satisfies the load security criteria.

With the simultaneous loss of both A2 and H9A, or A2 and A4K, the interrupted load does not exceed 600 MW, which satisfies the load security criteria.

5.4.2 System Voltage Assessment

For 115 kV systems, ORTAC states that, with all facilities in-service pre-contingency, the following criteria shall be satisfied:

- The pre-contingency voltage on 115 kV buses must not be less than 113 kV and greater than 127 kV;
- The post-contingency voltage on 115 kV buses must not be less than 108 kV and greater than 127 kV;
- The voltage change following a contingency must not exceed 10% pre-ULTC and 10% post-ULTC.

Simulations were performed to investigate the voltages at substations in the vicinity of the proposed project for pre and post contingency situations after the incorporation of the proposed project. The same list of studied scenarios as shown in Table 5 was used for voltage assessments.

The pre-contingency and post-contingency voltage results for all elements in service pre-contingency are shown in Table 7. Study results show that voltage levels are within the criteria under both pre- and post-contingency conditions, and post-contingency voltage changes are within acceptable ranges with the connection of the project.

Table 7: Voltage Assessment Results

Bus Name	Pre-Cont.	S1				S2				S3				S4				S5			
		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Orleans TS	120.8	-	-	-	-	121.4	0.5	120.4	-0.3	118.9	-1.6	119.5	-1.1	117.7	-2.6	117.9	-2.4	119.7	-0.9	119.7	-0.9
NRC TS	122.3	125.5	2.5	122.7	0.3	122.6	0.2	121.8	-0.4	-	-	-	-	120.9	-1.1	120.9	-1.1	121.5	-0.7	121.2	-0.9
Cyrville Rd DS	122.8	126.0	2.5	123.3	0.3	123.3	0.4	122.4	-0.3	-	-	-	-	121.4	-1.1	121.5	-1.1	121.8	-0.8	121.7	-0.9
Cumberland DS	119.7	-	-	-	-	120.3	0.5	119.3	-0.3	116.4	-2.9	117.2	-2.1	116.4	-2.8	116.9	-2.3	118.6	-0.9	118.6	-0.9
Bilberry	119.5	123.9	3.5	120.1	0.4	122.6	2.5	122.2	2.2	114.5	-4.3	115.7	-3.3	116.6	-2.4	116.8	-2.3	118.4	-0.9	118.4	-0.9
Wilhaven DS	120.1	-	-	-	-	120.7	0.5	119.7	-0.3	117.3	-2.4	118.1	-1.7	117.0	-2.6	117.2	-2.4	118.8	-1.1	118.9	-1.0
Hawkesbury TS	116.2	-	-	-	-	116.9	0.6	115.8	-0.3	112.9	-2.9	113.8	-2.1	113.0	-2.8	113.2	-2.6	115.0	-1.0	115.0	-1.0
Hawthorne TS	123.3	126.5	2.6	123.8	0.4	123.9	0.4	122.9	-0.3	123.1	-0.2	123.4	0.0	122.0	-1.1	122.0	-1.1	122.2	-0.9	122.2	-0.9
Overbrook TS	122.3	125.6	2.6	122.8	0.4	-	-	-	-	122.1	-0.1	122.4	0.1	121.0	-1.1	121.2	-0.9	121.3	-0.8	121.3	-0.8

Bus Name	S6				S7				S8				S9			
	Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC		Pre-ULTC		Post-ULTC	
	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
Orleans TS	-	-	-	-	115.3	-2.2	116.3	-1.4	116.6	-1.1	117.9	0.0	117.7	-1.7	119.0	-0.6
NRC TS	123.1	0.3	122.5	-0.1	-	-	-	-	119.7	-1.0	120.9	0.0	119.2	-1.7	120.5	-0.6
Cyrville Rd DS	123.7	0.3	123.1	-0.1	121.0	-0.4	121.0	-0.4	120.3	-1.0	121.5	0.0	119.8	-1.6	121.1	-0.5
Cumberland DS	-	-	-	-	112.4	-3.8	121.5	3.9	115.5	-1.2	116.9	0.0	116.5	-1.8	117.9	-0.6
Bilberry	122.6	2.0	122.0	1.5	110.3	-5.6	112.3	-3.9	115.4	-1.2	116.8	0.0	116.3	-1.8	117.7	-0.6
Wilhaven DS	-	-	-	-	113.4	-3.2	114.8	-2.0	115.9	-1.1	117.2	0.0	116.9	-1.7	118.3	-0.5
Hawkesbury TS	-	-	-	-	108.7	-4.0	110.3	-2.6	111.8	-1.2	113.2	0.0	112.9	-1.8	114.3	-0.6
Hawthorne TS	124.4	0.4	123.7	-0.1	121.6	-0.3	122.0	0.0	120.8	-1.0	122.0	0.0	120.3	-1.6	121.5	-0.6
Overbrook TS	-	-	-	-	120.6	-0.5	120.8	-0.3	119.8	-0.5	122.2	0.0	119.3	-1.6	120.6	-0.6

5.5 Ottawa Area SPS Participation

The Ottawa Area Undervoltage Scheme provides automatic correction measures to maintain satisfactory post-contingency voltage levels in the Ottawa Area for 230/500 kV contingencies, primarily during equipment outages. This scheme consists of high-speed re-closure, automatic load rejection, automatic capacitor switching and automatic reactor switching.

Currently, new or modified stations in the Ottawa area are expected to be a part of the Ottawa Area Undervoltage SPS. The NRC TS load will be a part of the Ottawa Area load. Thus, the proposed NRC TS shall be included in the Ottawa Area Undervoltage SPS for automatic load rejection.

– End of Report –