CONNECTION ASSESSMENT & APPROVAL PROCESS

System Impact Assessment Report

For Ontario to Quebec 1250 MW HVdc Interconnection Project

CAA ID Number 2000-001

Long Term Forecasts & Assessments Department

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Acknowledgement

The IMO wished to acknowledge the assistance of Hydro One in completing this assessment.

Disclaimers

IMO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IMO should issue a notice of approval or disapproval of the proposed connection under Chapter 4, section 6 of the Market Rules. 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 IMO in accordance with Chapter 4, section 6 of the Market Rules. The IMO assumes no responsibility to any third party for any use, which it makes of this report. Any liability which the IMO 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 IMO provides a draft of this report to the connection applicant, you must be aware that the IMO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IMO 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 system assessment study are based on the information available to Hydro One, at the time of the study.

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 OPGI) customers. The short circuit studies are for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection.

The ampacity rating of Hydro One facilities are established based on assumptions used in Hydro One for transmission system planning studies and in accordance with the Market Rules. 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.

System Impact Assessment Report

Ontario to Quebec 1250 MW HVdc Interconnection Project

Executive Summary

This System Impact Assessment (SIA) study has examined the impact of the proposed Ontario to Québec 1250MW –HVdc interconnection on the reliability of the IMO-controlled grid. The study also reviewed the impact of the proposed interconnection on the adequacy and performance of existing equipment, to determine if there is a need to replace or advance the date of replacement of such equipment.

This study was performed assuming all existing facilities in service. In particular, the consideration of various facility outage conditions or combinations of transfers over other HQ ties was outside of the study scope. During such conditions it is anticipated that the reliability of the IMO controlled grid can be maintained by reducing power transfers over the ties.

At the time of this study, there were no other electrically impactive connection proposals in the IMO Connection Assessment and Approval study queue. Hence, the proposed interconnection was not studied in conjunction with any other proposed project.

Proposed Facilities

The proposed interconnection facilities consist of a double-circuit 230kV line connecting the Ottawa Hawthorne Transformer Station (“TS”) and the Outaouais substation in Québec. Outaouais Substation will be connected to the existing Hydro-Québec 315 kV line between Chenier and Vignan.

New facilities will be added at the 230 kV Hawthorne TS to terminate the new circuits and other facilities will be replaced to accommodate the expected increase in power flow through the station. The new facilities consist of nine new breakers and two new shunt capacitors rated 200 MVARs each.

At the Outaouais substation, a back-to-back HVdc converter station with a 1250MW capacity will be installed by Hydro Québec and connected to its 315kV system.

Impact on Fault Levels

The results of fault level studies showed that the slight increase in fault levels resulting from the incorporation of the proposed interconnection are well within the fault interrupting capability of the existing breakers. Consequently, no additional breakers will need to be replaced to accommodate the proposed project.

<u>Impact on Thermal Transfer Capability</u>

IMO-controlled Grid

The results of linear load flow analysis studies indicated that the incorporation of the proposed 1250 MW interconnection between Ontario and Québec does not have an adverse impact on the thermal loading of the IMO-controlled grid facilities.

Ontario-New York Interconnection

The power flow thermal analysis concluded that, for some system scenarios, the power transfer on the Ontario-New York interface will be limited by the loss of the HVdc link at full output.
If under certain scenarios, the import or export to NY becomes limited due to the Ontario transaction with Québec, they can be controlled by adjusting the power transfer between Ontario and Québec. Load flow studies concluded that the incorporation of the HVdc interconnection will also change the angle of operation of the L33/34P phase shifters, but under most likely scenarios this will help maintain control of flow at St. Lawrence by avoiding maximum or minimum phase angle tap.

It is considered that mitigating measures are not required to correct this impact. However, if more flexibility is desired in the Ontario-Québec transfers then the addition of the loss of the HVdc link to the Saunders G/R scheme could be considered by Hydro One.

<u>Impact on Voltage Stability</u>

The additional Hawthorne TS facilities and upgrades which are proposed in order to accommodate the interconnection are expected to contribute to the increase of the Flow Into Ottawa transfer limit to about 3000 MW, by increasing the voltage stability limit.

The new voltage stability limit is sufficient to accommodate a power flow of about 1700 MW for supplying the Ottawa area, under heavy load conditions, and an export of 1250 MW to Québec.

<u>Impact on Voltage Decline</u>

The Ontario to Québec 1250 MW interconnection has no adverse impact on the immediate post fault voltage declines in the Ottawa area.

<u>Impact on Transient Stability</u>

The Ontario to Québec 1250 MW interconnection has no adverse impact on the IMO-controlled grid transient stability.

<u>Conclusions</u>

The conclusions are as follows:

- the integrated power system with the proposed facilities meets all applicable planning standards and design criteria included in the Market Rules;
- the proposed facilities have no adverse impact on the adequacy or performance of existing IMO-controlled grid equipment;

- the incorporation of the proposed facilities does not reduce the load meeting capability of the IMO-controlled grid;
- the incorporation of the proposed facilities results does not degrade the existing system transfer capability;
- there is no adverse impact on the reliability of the IMO-controlled grid.

This System Impact Assessment concluded that the incorporation of the proposed interconnection does not require new transmission facilities in addition to those proposed by this project.

1.0 Introduction

The Ontario Independent Electricity Market Operator has conducted a study to determine the impact of an interconnection transmission project proposed by Hydro One on the reliability of the IMO-controlled grid. Hydro One Networks proposes to construct, jointly with Hydro Québec of Québec, a 1250MW High Voltage Direct Current (HVdc) interconnection. The analysis included an assessment of the facilities required in Ontario to incorporate the proposed interconnection and its impacts on Ontario internal transfer limits, and some inter-area transfer limits.

The planned in service date of the interconnection is May 2003 with a best efforts target date of December 2002.

The purpose of the study was to evaluate the impact of the project on the reliability of the IMO-controlled grid. Specifically, this assessment focussed on determining if:

- the integrated power system with the proposed facilities meets all applicable planning standards and design criteria included in the Market Rules and the Ontario Transmission System Code;
- the proposed facilities impact on the adequacy or performance of existing equipment, indicating a need to replace or advance the date of replacement of such equipment;
- the incorporation of the proposed facilities adversely impacts the load meeting capability of the IMO-controlled grid or results in the degradation of the existing system reliability due to a reduction in system transfer capability.

A Preliminary Assessment for this project was not carried out by the IMO because when the IMO established its Connection Assessment and Approval procedures in May 2000, the project had already been evaluated by Hydro One. Earlier this year the IMO advised Hydro One that it would accept the Technical Study conducted by the TE-OHSC Technical Studies and Planning Working Group (OEB Interrogatory #8) in lieu of a Preliminary Assessment.

At the time of this study, there were no other electrically impactive connection proposals in the IMO Connection Assessment and Approval study queue. Hence, the proposed interconnection was not studied in conjunction with any other proposed project.

2.0 The Proposed Project

The proposed interconnection facilities will consist of 35 km of double circuit 230kV line connecting the existing Ottawa Hawthorne Transformer Station ("TS") in Ontario and the new Outaouais substation in Québec.

An illustration of the overall Hydro-Québec Interconnection is provided as Figure 1.

Figure 2 shows the geographical location of the transmission facilities in the Ottawa area. The proposed 230 kV double circuit line will be running east of Hawthorne TS on the same right of way with circuits D5A and H9A shown in the Figure.

A detailed description of the new proposed facilities is provided in the sections below.

2.1 Line Description

The 35 km double circuit 230kV interconnection circuits designated as HQ1/HQ2 will be built using lattice steel towers. The first 20 km between Hawthorne TS and the Inter-Provincial Boundary at Masson (IPB Masson) will be equipped with a twin 1192 kcmil ACSR conductors and the remaining 15 km with twin 1033 kcmil conductors.

With both circuits in service, the new line will be capable of carrying the full interconnection capacity of 1250MVA during summer and winter. The maximum summer current carrying capability, with one circuit out of service, will be 900 MVA.

In Ontario, the new 230 kV double circuit interconnection line will be built on the existing H9A/D5A right-of-way between Hawthorne and Gamble Jct. The two existing single circuit lines H9A and D5A will be replaced by two double-circuit lines between Hawthorne TS and IPB Masson. One double-circuit line will be used for the existing H9A/D5A circuit. The other double-circuit line will carry the two interconnection circuits (HQ1 and HQ2).

The ampacities of the HQ1/HQ2 circuits and the H9A/D5A circuits are given in Table 1.

Table 1. Ampacity of HQ TIE Circuits and the Rebuilt Sections of H9A and D5A

Circuits	Voltage	Conductor	Ambient Temp.	Rating Amps/MVA		
				Cont.	15 min	5 min.
New HQ Tie HQ1/HQ2	220kV	1192	30	2230/909	2970/1211	4510/1839
			10	2610/1064	3560/1452	5470/2230
			0	2770/1129	3830/1562	5910/2410
D5A	220kV	1443	30	1220/497	1600/652	2360/962
			10	1430/583	1960/799	2970/1211
			0	1510/616	2120/864	3240/1321
H9A	118kV	1443	30	1190/260	1560/341	2320/508
			10	1390/304	1920/420	2930/641
			0	1480/324	2090/457	3200/700

2.2 Station Facilities at Hawthorne TS

In Ontario, the new interconnection circuits HQ1/HQ2 will be terminated at the Hawthorne TS 230kV switchyard. The following facilities will be installed in the existing yard (see single line diagram shown in the Figure 3):

- Two new bays and five 230kV breakers to accommodate the two new interconnection circuits,
- Two 200 MVAR capacitor banks to provide reactive support, equipped with two breakers for full redundancy,
- Four existing 230kV breakers that are currently rated at 2000 Amperes will be replaced with new 3000 Amperes breakers to provide necessary current carrying capability,
- One 230kV breaker to re-terminate the existing 750MVA, 500-230kV transformer T1,
- Protection and control facilities to ensure proper system operation under both normal and abnormal conditions, and

– Telecommunication facilities between Hawthorne TS and Outaouais Substation for protection and control purposes.

2.3 Station Facilities at Outaouais

In Québec a new Substation will be constructed at Outaouais and connected to the existing Hydro-Québec 315 kV line between Chenier and Vignan. The interconnection circuits HQ1/HQ2 will terminate in the Outaouais Substation 230kV switchyard. This is a new station and will contain the following facilities:

– A new 315kV switchyard with six 315kV breakers,
– A new 230kV switchyard with six 230kV breakers (two are for future use),
– A back-to-back HVdc converter facility connecting the 230kV and 315kV switchyards. The HVdc converters will be consist of two bipoles each rated at 625MW,
– Protection and control facilities to ensure proper system operation under both normal and abnormal conditions, and
– Telecommunication facilities between Outaouais Substation and Hawthorne TS for protection and control purposes

In addition to the HVdc interconnection plan, Hydro Québec plans to build a 315 kV double-circuit line of 150 km between Grand-Brûlé 735-120/315 kV substation and Vignan 315/120 kV substation at Québec to improve the security of supply to the Outaouais Area. The in-service date of this new line is August 2002. This line however, was not considered in service in these studies.

3.0 Verification of Proposed Design

A detailed review of the design of the new interconnection showed that the proposed configuration of Hydro One facilities in Ontario meets all the requirements of the Market Rules. The rating of the equipment was selected based on sound planning criteria and the design of the Hawthorne TS and the 230 kV double circuit line to the Inter-Provincial Boundary at Masson meets all the requirements of the Market Rules.

The proposed reconfiguration of the Hawthorne 230 kV switchyard represents an improvement to the reliability of the station by eliminating the possibility of loosing two auto-transformers by a contingency on one element. In the present station configuration, the T1 transformer at Hawthorne is connected to the K bus resulting in the loss of T1 for any fault on the K bus. Similarly, a fault on the K bus with a stuck breaker condition (KLT2) will result in the loss of both T1 and T2. Under the new project it is proposed to connect T1 onto one of the new bays between two new breakers; thus the transformer connection becomes independent of any bus faults.

4.0 Fault Analysis Studies

Hydro One carried out the fault analysis studies.

The study results indicated that the HVdc interconnection has a minor effect on the system fault levels. These results are consistent with expectations, since the electrical configuration of the proposed HVdc project does not contribute to the fault current. However, there is a slight increase in the single line-to-ground and double line-to-ground fault levels due to the wye-grounded converter transformers at Outaouais.

Table 2 shows the Year 2003 fault currents at a number of Ottawa area stations in the absence of the interconnection and with the proposed HVdc facilities connected.

Table 2. Short Circuit Study Results

Station	Pre-fault kV	LLG Symmetrical(kA) Existing	LLG Symmetrical(kA) With Project	Lowest Breaker Rating (kA)
Hawthorne 500 kV	500.0	13.96	14.04	40
Hawthorne 230 kV	220.0	26.15	26.60	50
Hawthorne 118 kV	118.05	36.65	36.81	50
Merivale 220 kV	220.0	17.86	17.9	63
Merivale 118 kV	118.05	19.62	19.63	22.7
Riverdale 118 kV	118.05	18.54	18.55	22.7

It should be noted that, the fault currents seen by the station breakers are within the interrupting capability of these breakers.

5.0 Study Approach for Transient, Thermal and Voltage Studies

The approach used in the evaluation of this project was to investigate the most likely scenarios for power transactions between Ontario and Québec; maximum export at night and maximum import during the day. In lieu of examining other scenarios, Hydro One indicated that it would be willing to accept any operating restrictions imposed by the IMO which are necessary to mitigate adverse reliability impacts on the IMO-controlled grid for other system conditions not studied.

In performing this assessment, the IMO utilized the results of a study that was carried out by Hydro One and Hydro Québec to demonstrate to NPCC's Task Force on System Studies that the proposal does not have a significant adverse effect on the reliability of the eastern interconnection. The purpose of that study was to examine the impact on the interconnected system of the proposed 1250 MW HVdc, in view of obtaining NPCC approval for the proposed HVdc link.

5.1 Study Cases

The base cases used in this study were based upon the system representation developed by the IMO and Hydro One for the NPCC Transmission Reliability Assessment. The representation was modified to include a model of the HVdc model provided by Hydro Québec and more detailed modelling of the Eastern Ontario transmission system.

The study looked at the impact of the new interconnection under four system scenarios (decided upon based on the approach described in section 4.0) as described in Table 3 below.

Table 3. Study Cases

System Conditions	Case 1 Peak Load 1250 MW Export	Case 2 Light Load 1250 MW Export	Case 3 Peak Load 1250 MW Import	Case 4 Light Load 1250 MW Import
Ontario Load	22824 MW	20585 MW	22824 MW	20585 MW
Ottawa area Load	1743MW	624 MW	1743 MW	624 MW
Cherrywood East Load	2100 MW	1000 MW	2100 MW	1000 MW
Madawaska Generation[1]	610 MW	610 MW	610 MW	610 MW
Ottawa Generation[2]	982 MW	982 MW	982 MW	982 MW
Nanticoke Generation	4000 MW	1780 MW	3500 MW	1280 MW
Lambton Generation	1850 MW	1850 MW	400 MW	400 MW
Lennox Generation	1575	1575	1000	1000
Ontario Export to New York at St. Lawreance	159 MW	368 MW	-400 MW	-342 MW

It should be noted that the system scenarios in Table 3 were assessed prior to the beginning of the studies to identify the major concerns associated with each scenario. Based on this evaluation certain studies were carried out only for selected scenarios representing the worst possible cases. For example, Flow Into Ottawa (FIO) area represents a concern only for situations of heavy load and export to Québec, hence the impact of the proposed interconnection was verified for case 1 only.

It should be noted that in these base cases the proposed Grand-Brûlé – Vignan 315 kV line in Québec is not included. The incorporation of the Grand-Brûlé – Vignan 315 kV line will not require an additional study as it will have little effect on the performance of the IMO-controlled grid.

6.0 Thermal Loading Considerations

6.1 Transfer Capability over the Proposed Interconnection

The proposed interconnection consists of a double circuit 230 kV line with each circuit rated as shown in Table 1. The normal interconnection capability is 1250MW based on the rating of the two parallel HVdc converters. However, loss of either circuit would require the power flow on the HVdc converters to be runback to respect the single continuous circuit rating (e.g. a maximum of 909 MVA in summer - 30^{o}C ambient temperature - or 1064 MVA in winter - 10^{o}C ambient temperature). An HVdc power runback scheme and required telecommunications are part of the interconnection design, so the overloading of the HQ1 or HQ2 circuit for the loss of the companion circuit can be controlled.

[1] Includes: Arnprior GS, Barrett Chute GS, Stewartville GS and Mountain Chute GS.
[2] Includes: Chats Falls GS, Chaneux GS, Des Joachims GS and Holden GS.

6.2 Impact on the IMO-controlled Grid

Linear power flow analysis was used to determine the impact of the proposed 1250 MW interconnection on the thermal loading of the Eastern Ontario transmission lines. The analysis was performed for all cases summarized in Section 4.1 and with all transmission facilities in service.

The existing 230 kV and 500 kV Ottawa area transmission is shown in Figure 4. In addition to the transmission layout show in this Figure there is an underlying 115 kV system which connects Hawthorne 115 kV to Merivale 115 kV, and Merivale 115 kV to Cataraqui 115 kV. This study also looked at the impact that the incorporation of the proposed HVdc link might have on the 115 kV lines.

The results obtained from linear analysis studies indicated that power flows are unlikely to exceed the thermal overloading capability of the eastern Ontario transmission system.

6.3 Impact on Interconnections

In order to assess the effect of the proposed HVdc link on the capability of the Ontario – New York L33/34P interconnection at St. Lawrence, two types of studies were performed.

Firstly, a linear analysis investigation was used to evaluate the impact that the loss of the HVdc link on the power flowing on the L33/L34P interconnection. Based on the calculated distribution factors it was determined that the loss of the Ontario to Québec interconnection loaded at maximum capability will result in 151 MW flow on L33P and 181 MW flow on L34P.

These post contingency contributions to L33/34P flows were calculated based on the following formulae:

(1) $L33P_{post} = L33P_{pre} + 0.121*(HQ1+HQ2)$

(2) $L34P_{post} = L34P_{pre} + 0.145*(HQ1+HQ2)$

Consequently, for scenarios where maximum exports take place simultaneously on both Ontario-New York and Ontario-Québec interconnections, the Ontario-New York interconnection will become thermally overloaded for the loss of the Ontario-Québec interconnection. The same situation could occur for scenarios of simultaneous maximum imports on the above mentioned interconnections.

Table 4. Thermal Limitation of the Ontario- New York Interconnection

Limiting Contingency	L33P LTR (15 min) MVA	L34P LTR (15 min) MVA	Pre-contingency Limit(MVA)	
			L33P (1)	L34P (2)
Loss of the Ontario-Québec Interconnection	334	465	183 MVA	284

The results of the analysis indicate that the worst contingency for the calculation of the transfer limit of the Ontario-New York interconnection St. Lawrence is the loss of the HVdc link under conditions of maximum imports (exports) on both interconnections. Currently, the transfer limit on the Ontario New York interconnection is based the loss of the companion circuit which represents the worst possible contingency.

The thermal analysis concluded that, under the scenarios considered, the calculation of the power transfer limit of this interface will have to be based on the loss of the HVdc link.
If under certain scenarios, the import or export to NY becomes limited due to the Ontario transaction with Québec, then the transfer between Ontario and Québec may have to be restricted.

Secondly, load flow studies were performed to assess the contribution of 1250 MW import or export on the phase shifters angle on L33/34P.

It should be clarified that the capability of the phase shifters to control the power flow depends on the location of the flow injections and withdrawals from the power system. Also, any redispatch of generation that results in increased flow north(south) on L33P/L34P requires a compensating phase shifter tap movement down(up) to maintain flow on L33P and L34P.

The studies concluded that it would be necessary to move up to 7 taps on L33P and L34P to counteract the 1250 MW injection or withdrawal of power at IPB Masson.

The St. Lawrence phase shifters tend to approach the upper or lower tap limit during times of high imbalance between eastern Ontario generation and load or high Flow Into Ottawa. To the extent the HVdc link is operated to compensate for this imbalance (i.e export to HQ when eastern generation exceeds load and import from HQ when load exceeds generation), then the tap extremes will be approached less frequently. With anticipated operation (i.e. exports to Quebec off-peak and imports from Quebec on peak) the HVdc link will help maintain control of flow at St. Lawrence by avoiding maximum or minimum phase angle taps.

7.0 Flow into Ottawa – Voltage Stability Study

The Flow into Ottawa (FIO) area is defined as the sum of power flows on the following power lines (see Figure 4);

- the 230 kV line from Cherrywood TS to Merivale TS (M29C),
- the 230 kV line into Charts Falls from Merivale (C5S),
- the two 500 kV lines between Lennox and Hawthorne (X522A and X523A),
- the 230 kV line between Hawthorne and St. Lawrence (L24A), and
- the 230 kV line between St. Isidore TS and Beauharnois (B5D).

The present transfer limit on this interface is 1900 MW based on a voltage stability limitation at Hawthorne TS.

In order to assess the effect that the new proposed interconnection facilities has on the FIO a voltage stability study was performed for the present system and for a system with the proposed interconnection incorporated.

The study was carried out only for the most stressed system scenario represented by 1250 MW Ontario exports to Québec and peak load conditions. PV curves for the Hawthorne 500 kV bus and 230 kV bus are attached in Figures 5.1 and 5.2 for the present system and the system with the HVdc interconnection incorporated, respectively.

Figure 5.2 indicates that with the new interconnection, the transfer capability into the Ottawa area is adequate to support the peak Ottawa area load and the maximum export to Quebec. A comparison of the PV curves for the existing (Figure 5.1) and the proposed system configuration shows that the addition of the proposed facilities increases the FIO voltage stability limit to about 3000 MW.

The new voltage stability limit is sufficient to accommodate a power flow of about 1700 MW for supplying the Ottawa area and 1250 MW of exports to Québec.

8.0 Post-fault Voltage Considerations

A series of immediate post voltage decline studies were completed to assess the sudden change in the voltage at Hawthorne 230 kV under the following situations;

- when switching one of the proposed new shunt capacitors, rated 200 MVAR each, in service, or
- for the loss of both HVdc bipoles.

The results are summarized in Table 4 below for each of the study cases.

Table 4. Hawthorne 230 kV Voltage Change (immediate post)

Case	Capacitor Switching	Loss of the HVdc Bipoles
	% change	% change
Heavy Load Export (Case 1)	2.24%	5.55%
Light Load Export (Case 2)	2.17%	2.94%
Heavy Load Import (Case 3)	2.16%	-7.81%
Light Load Import (Case 4)	2.25%	-1.48%

The results indicate that the abrupt voltage change due to the capacitor switching is below the 4% margin that is allowed by the Market Rules.

The results also indicate that the largest abrupt voltage change due to the loss of the HVdc link is below 8%. The Market Rules requires the transmitter to ensure that the abrupt change in voltage due to line switching is not larger than 10%. This result is considered acceptable under the assumption that the effect of the loss of the bipoles is considered to be equivalent to line switching.

It was concluded that sudden voltage changes due to the capacitor switching or loss of the HVdc link are well within the margins set by the Market Rules.

Provision could be considered by Hydro One to include the new capacitors into the Ottawa Area Undervoltage and Hawthorne Reactor Switching Special Protection Schemes (SPSs) to allow for higher operating flexibility.

9.0 System Stability Considerations

Transient stability studies were carried out for all the study cases described in Section 4.1.
The most critical contingencies in the Ottawa area were selected for this investigation.
The following faults were studied by the IMO:

- Two phases-to- ground, normally cleared faults on L24A (Hawthorne to St. Lawrence) and D5A (Hawthorne to St. Isidore)
- Two phases-to-ground, fault on X522A (Hawthorne to Lennox) with loss of T1 due to delayed fault clearing because of a stuck breaker condition,
- Two phases-to-ground, normally cleared faults on X523A and M31A,
- Two phases-to-ground, normally cleared faults on HQ1 and HQ2.

These faults are more severe than those respected in day to day operation.

In addition, Hydro One completed a set of transient stability studies using the models developed for the purpose of obtaining NPCC Regional Council approval. The IMO has accepted the results of the NPCC studies but requested Hydro One to further investigate a number of simulations. The following representative set of contingencies was analyzed by Hydro One for the light load and import scenario:

1. 2 single phase-to-ground/Different phases, normally cleared fault on both X523A 500 kV circuit (Hawthorne x Lennox) and 230 kV circuit M30A (Hawthorne x Merivale)
2. 2 single phase-to-ground /Different phases, normally cleared fault on both X522A 500 kV circuit (Hawthorne x Lennox) and 230 kV circuit M29C (Cherrywood x Merivale)
3. Two phases-to-ground normally cleared fault near Outaouais TS on the double circuit line Outaouais x Hawthorne.
4. Two phases-to-ground, normally cleared fault near St. Isidore on 230 kV circuits D5A and B5D
5. Two phases-to-ground, normally cleared fault near Lennox on the 500 kV circuits X520 and X521B.
6. Two phases-to-ground, normally cleared fault near St. Lawrence on 230 kV tie lines L33P and L34P between Ontario and New York
7. Two phases-to-ground, normally cleared fault near St. Lawrence on 230 kV circuits B31L and L24A
8. Two phases-to-ground, normally cleared fault near St. Lawrence on 230 kV circuits L24A and L22H
9. Two phases-to-ground, normally cleared fault near St. Lawrence on 230 kV circuits L20H and L21H
10. Two phases-to-ground, normally cleared fault near Cherrywood on 230 kV circuits B23C and M29C

All transient stability study results showed that the system was stable. A detailed relay margin analysis was not performed as none of the power swings moved the locus of apparent system impedance near values that would approach Hydro One distance relaying.

Plots of the transient stability results are included in separate Appendices available upon request.

Results of the system stability tests indicate that the proposed interconnection does not have an adverse effect on system transient stability.

10. Conclusions

This System Impact Assessment has examined the impact that the incorporation of the 1250 MW interconnection project between Ontario and Québec, would have on the reliability of the IMO-controlled grid. At the time of this study, there were no other electrically impactive connection proposals in the IMO Connection Assessment and Approval study queue. Hence, the proposed interconnection was not studied in conjunction with any other proposed project.

The conclusions are as follows:

- the integrated power system with the proposed facilities meets all applicable planning standards and design criteria included in the Market Rules;
- the proposed facilities have no adverse impact on the adequacy or performance of existing IMO-controlled grid equipment;
- the incorporation of the proposed facilities does not reduce the load meeting capability of the IMO-controlled grid;
- the incorporation of the proposed facilities results does not degrade the existing system transfer capability;
- there is no adverse impact on the reliability of the IMO-controlled grid.

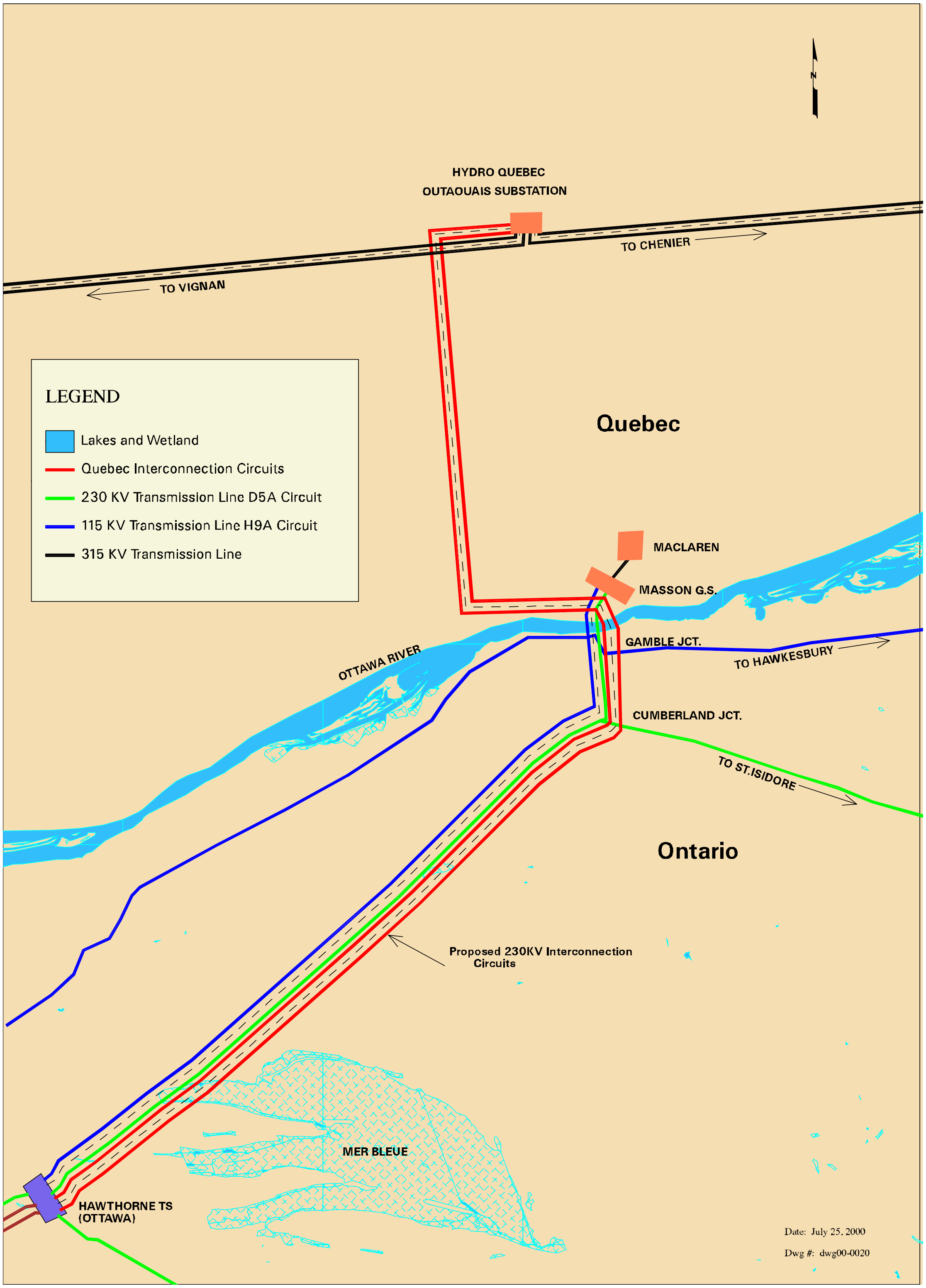

Figure 1: Hydro One –Hydro Québec Permanent 1250 MW Interconnection

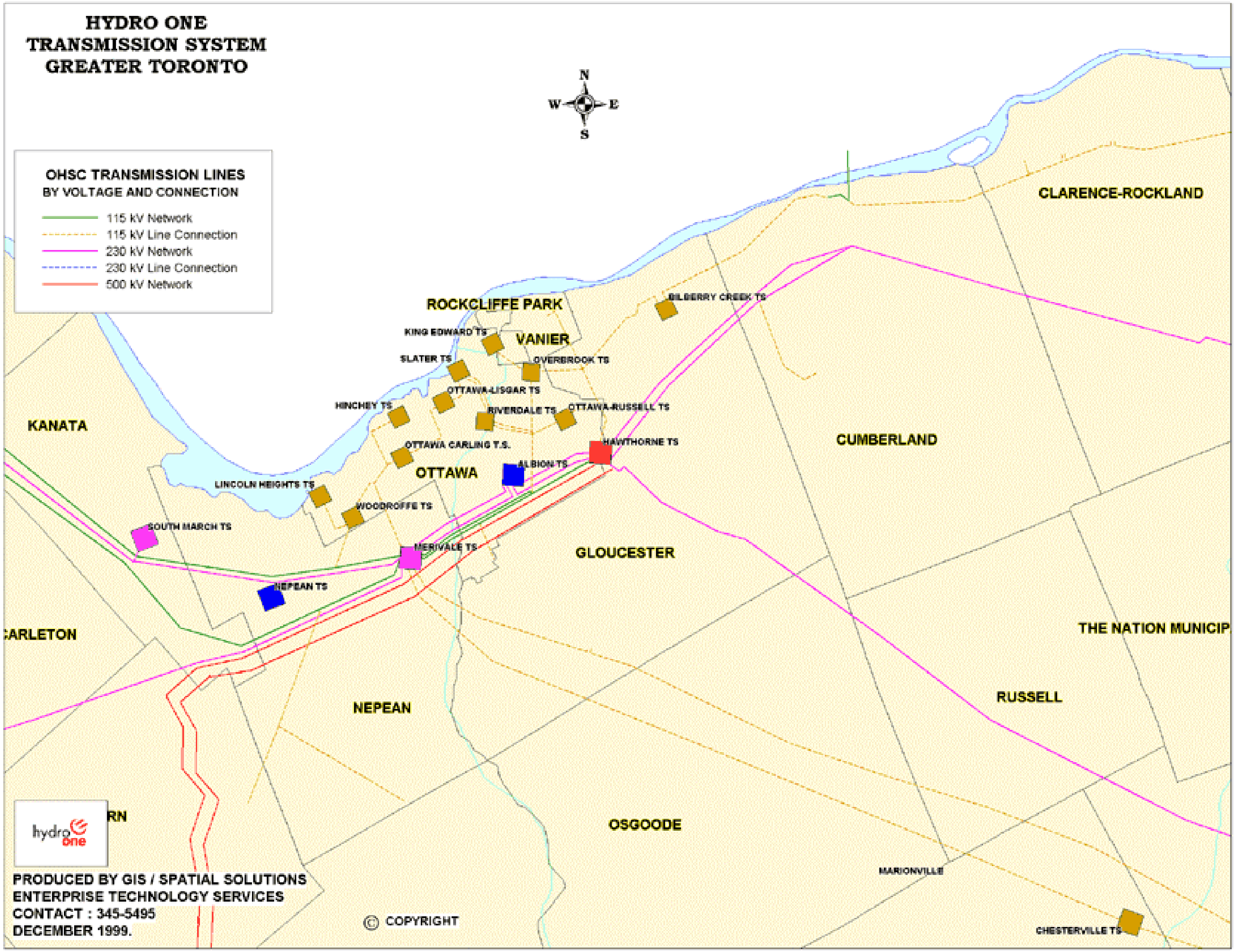

Figure 2. Ottawa Area Transmission Overview

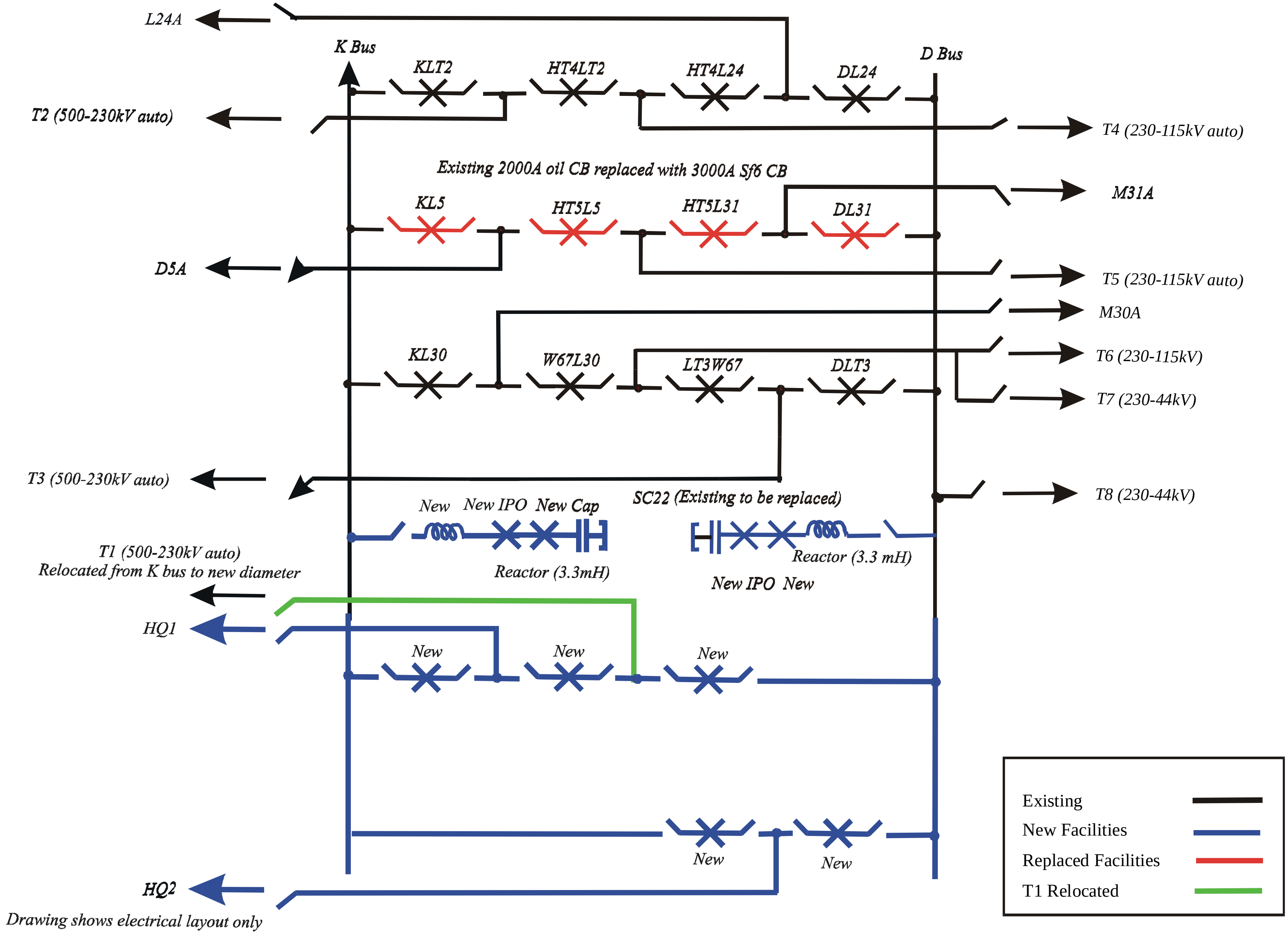

Figure. 3. Ottawa Hawthorne TS: 230 KV Switchyard Facilities

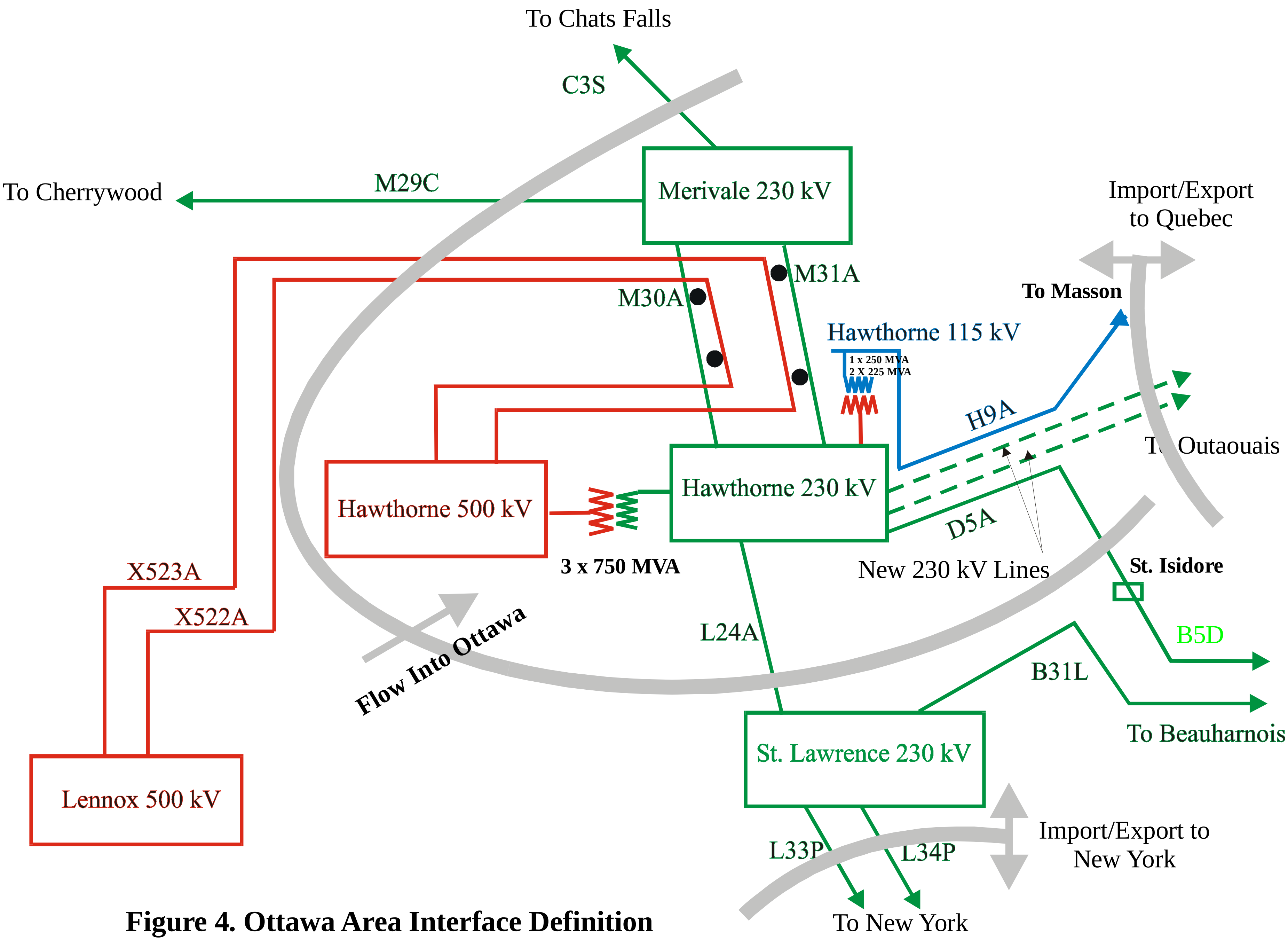

Figure 4. Ottawa Area Interface Definition

Figure 5.1 – PV Curves for the Present System

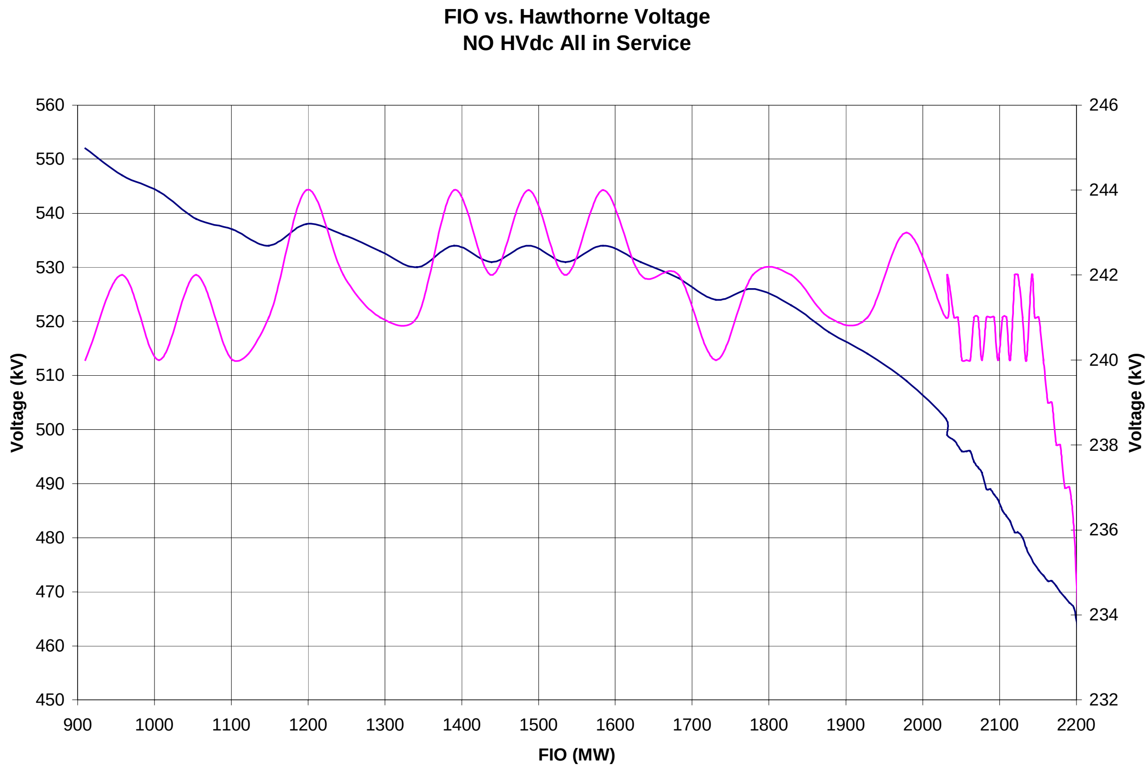

Figure 5.2 – PV Curves with Interconnection