PUBLIC **IESO_REP_0490**

SIA Report

Near-Term Measures for the Return-to-Service of two units at Bruce 'A' NGS:
Install Seven 230kV Capacitor Banks in South-Western Ontario

1.0

CAA ID No. 2007-295

Transmission Assessments & Performance Department

FINAL DRAFT Version

Date: 12th February 2008
Revised: 12th February 2009

HYDRO ONE NETWORKS Inc.: Middleport TS, Nanticoke TS & Buchanan TS

Install Seven 230kV Shunt Capacitor Banks

1. Summary

In their letter to Hydro One dated 3rd December 2007, the Ontario Power Authority instructed Hydro One to proceed with the installation of seven 230kV shunt capacitor banks in south-western Ontario in preparation for the return to service of the remaining two generating units at Bruce 'A' NGS in May 2009. The new shunt capacitor banks are to be installed at the following locations:

- Middleport TS — Four shunt capacitor banks: — each rated at 250MVAr at 250kV
- Nanticoke TS — Two shunt capacitor banks: — each rated at 250MVAr at 250kV
- Buchanan TS — One shunt capacitor bank: — rated at 200MVAr at 250kV

Unit G2 at the Bruce 'A' NGS is scheduled to return to service in Q2-2009, with unit G1 scheduled to follow in Q4-2009. However, prior to the return to service of unit G1, one of the existing units is scheduled to be removed from service for long-term maintenance. During the interim period until the new 500kV line between the Bruce Complex and Milton TS becomes available there are therefore only expected to be a maximum of seven units in-service at the Bruce Complex, together with all of the committed wind-turbine projects.

The seven capacitor banks are therefore intended to supply the reactive power requirements in the area so that an acceptable pre-contingency voltage profile can be maintained with all transmission elements in-service when seven Bruce units, together with all 675MW of the committed wind-turbine facilities, are in-service. It has also been assumed that there will be no restrictions on the transfers across the Negative-BLIP Interface and that transfers of up to 1500MW could be accommodated across this Interface.

This requirement for an additional 1700MVAr of reactive capacity also assumes that none of the existing generating units at Nanticoke GS will be available to provide pre-contingency reactive support.

This Assessment has concluded that the installation of the seven capacitor banks would increase the pre-contingency voltage stability limit for transfers across the FABC (Flow Away from the Bruce Complex) to approximately 6675MW. This value corresponds to the situation with all of the committed wind-turbine projects in-service and with a transfer of 1500MW across the Negative-BLIP Interface.

Since the required transfer limit with seven units operating at the Bruce Complex would be 6208MW, the increased limit achieved by installing the seven new capacitor banks would therefore be more than adequate to accommodate the output from the seven generating units.

This Assessment has also shown that the voltage changes that would be experienced when individually switching the new capacitor banks would be approximately 2%, which would be well within the maximum of 4% allowed under the Market Rules.

Since it has been determined that there would be no adverse effect on the IESO-controlled grid from the installation of the seven shunt capacitor banks at Middleport TS, Nanticoke TS & Buchanan TS, it is therefore recommended that a Notification of Conditional Approval of the Connection Proposal be issued for these facilities.

Scheduled In-service Dates

The seven shunt capacitor banks are scheduled to come into service in stages during the period May to October of 2009.

2. *Proposed New Facilities*

Following the explosive failure of the 400MVAr SC22 shunt capacitor bank at Richview TS on 30th January 2007, Hydro One has identified additional measures to limit the possibility that any of these new capacitor banks should experience a similar failure. These measures include:

- the installation of capacitive voltage transformers to limit the rate of rise in the recovery voltage (RRRV) that was recorded across the breakers of the Richview capacitor bank when they attempted to interrupt the fault current.
- the installation of breakers with a fault interrupting capability of 80kA.
- the installation of insulators on the individual capacitor cans that have a greater creepage profile to reduce the possibility of flashovers under moderate levels of contamination, and
- the inclusion of breaker-failure protection to initiate automatic operation of the breakers in the next protection zone in the event that the breakers associated with the shunt capacitor bank should fail to operate.

The following Figure shows the proposed arrangement that is to be used for each of the new capacitor bank installations:

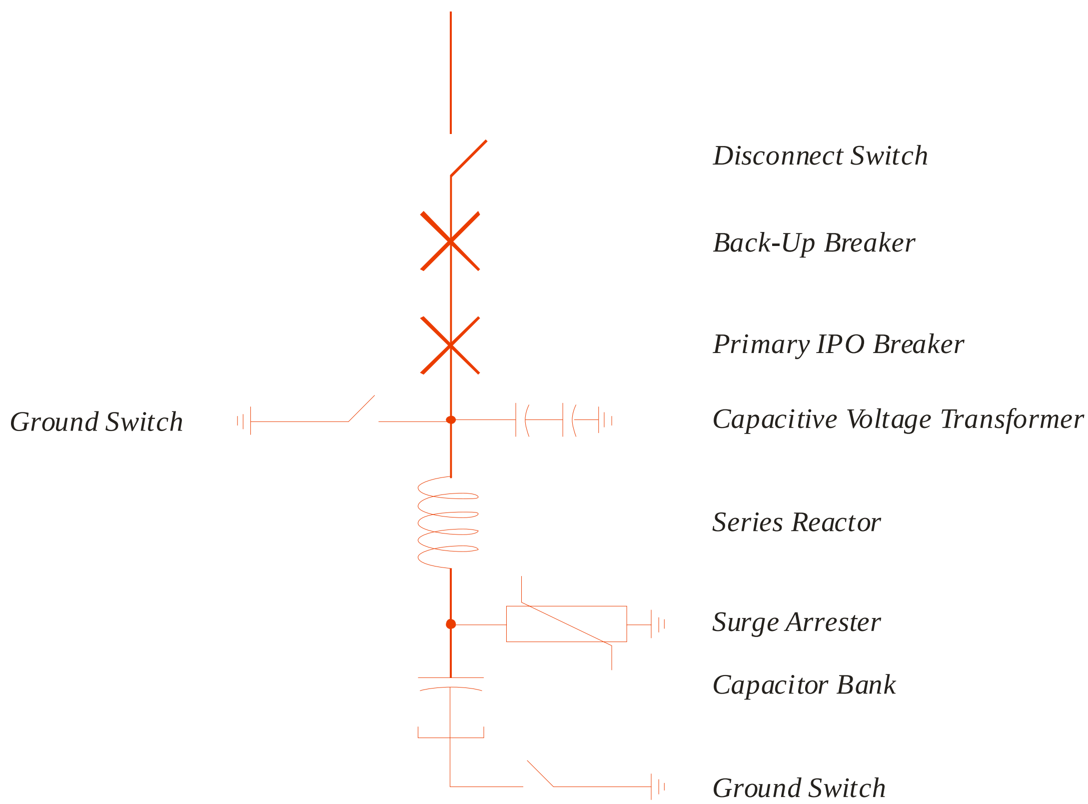


Figure 1: Typical Arrangement for the new Shunt Capacitor Bank Installations

Location of the new Capacitor Banks at Middleport TS, Nanticoke TS & Buchanan TS

The locations within the 230kV switchyards at Middleport TS, Nanticoke TS & Buchanan TS where the new shunt capacitor banks are to be connected are shown in Diagrams 1, 2 & 3, respectively,

Middleport TS

At Middleport TS, which has existing bus-section breakers, each new capacitor bank is to be connected to one of the four main busbar sections. However, to limit the size of the series reactors that are to be installed on each capacitor bank to 3.3mH, it has been agreed that the 230kV busbar will be operated split whenever more than two capacitors banks are required to be in-service. Without this restriction, the rating of the series reactors would increase to 6.6mH.

Nanticoke TS

Nanticoke TS also has existing bus-section breakers, resulting in there being four main busbar sections. To each of these busbar sections is connected one of the existing Nanticoke generating units. In addition, busbar sections K2 & P1 each has a Station Service transformer connected to it.

The new capacitor banks are to be connected to the two remaining busbar sections that do not have a Station Service transformer connected to it: the K1-bus & P2-bus.

On the assumption that the 230kV busbar at Nanticoke TS will continue to be operated closed, and since only two capacitor banks are to be installed at that station, a rating of 3.3mH for the series reactors to be installed on each bank would therefore be sufficient to limit the out-rush currents to an acceptable level.

Buchanan TS

Since Buchanan TS has no bus-section breakers, there are therefore only two main busbars at this station. A shunt capacitor bank is already connected to each of these busbars, so in order to provide a connection point for the new capacitor bank, a new 230kV breaker is to be installed in one of the existing 230kV diameters.

With a total of three shunt capacitor banks installed at Buchanan TS, the series reactors will need to be rated at 5.0mH to limit the out-rush currents to an acceptable level.

Since the series reactors on the two existing capacitor banks are only rated at 1.0mH, these are to be replaced with 5.0mH units.

Operational Requirement

Energisation of the new capacitor banks must be possible without implementing any special operating procedures.

Scheduled In-Service Date

The new shunt capacitor banks are scheduled to be placed in-service, in stages, beginning in May 2009 and finishing in October 2009.

3. Equipment Specifications

Details of the new facilities that are to be installed at each transformer station have been summarised below:

3.i Shunt Capacitor Banks

Shunt Capacitor Banks		
Rated Capacitance	6 banks	250MVAr (Max.) to 240MVAr (Min.) at 250kV ± 1kV
	1 bank	200MVAr (Max.) to 190MVAr (Min.) at 250kV ± 1kV
Rated Maximum Voltage	$255kV_{rms}$	
Maximum system voltage unbalance	2%	
Symmetrical Short Circuit Level	$63kA_{rms}$ (min)	
Configuration	Double-wye ungrounded	
Fusing	Fuseless	
Insulation Level	$900kV_{peak}$ BIL (min)	
Discharge Devices	None, other than the standard 5-minute discharge resistor provided with each capacitor bank	
Contamination Withstand	The largest available creep bushings (assumed to be ~ 43mm/kV) are to be installed on the individual capacitor units comprising the bank	

3.ii Series Reactors

Each capacitor bank is to be equipped with three, single-phase transient current limiting reactors to maintain the magnitude and frequency of the out-rush current to an acceptable level.

The existing 1.0mH reactors installed on the SC21 & SC22 capacitor banks at Buchanan TS are to be replaced with 5.0mH units to accommodate the installation of the third shunt capacitor bank at that location.

Current Limiting Series Reactors			
Number required: A total of 27	Middleport TS	12 units	Three for each capacitor bank (one per phase)
	Nanticoke TS	6 units	
	Buchanan TS	9 units	
Type	Air-cored		
Rated System Voltage (line-to-line)	$240kV_{rms}$		
Rated Maximum Voltage	$255kV_{rms}$		
Emergency Operating Voltage	$300kV_{rms}$ for 5 minutes		
Inductance at Rated Frequency of 60 Hz	Middleport TS	3.3mH per phase	
	Nanticoke TS	3.3mH per phase	
	Buchanan TS	5.0mH per phase	
Continuous Current (rms)	$800A_{rms}$		
Symmetrical Fault Current	$63kA_{rms}$ for 0.5 seconds		
Asymmetrical Fault Current	$108kA_{peak}$		
Insulation Level:	$900kV_{peak}$ BIL		

3.iii 230kV Circuit Breakers

The new capacitor bank is to be equipped with both a Primary & a Secondary (back-up) circuit breaker, connected in series.

Both the Primary & Secondary circuit breaker is to be equipped with 362kV interrupters to allow switching of the capacitor banks at voltages up to 255kV in order to allow a maximum continuous voltage of 250kV on the 230kV system to be respected.

Independent Pole Operated (IPO) breakers are to be installed for both the Primary & Secondary breaker at Nanticoke TS & Middleport TS, although only the Primary breakers are to be equipped with Synchronising Control Units. At Buchanan TS, a ganged-pole breaker is to be installed as the Secondary breaker.

230kV Primary Breakers

230kV Circuit Breakers: Primary units		
Number required: A total of 7	Middleport TS	4 breakers
	Nanticoke TS	2 breakers
	Buchanan TS	1 breaker
Breaker Type	SF_6 - Independent pole operated (IPO) equipped with control units for synchronized closing. Outdoor dead tank with CTs for protection & metering.	
Rated Maximum Voltage	$255kV_{rms}$ (min) *[362kV Interrupters are to be installed.]*	
Rated Interrupting Current	Middleport & Nanticoke TSs	$80kA_{rms}$ symmetrical
	Buchanan TS	$63kA_{rms}$ symmetrical
Rated Continuous Current	$2000A_{rms}$	
Inter-pole Closing Time Spread Limit	2.0ms (max)	
Closing and Latching Capability	$170kV_{peak}$	
Shunt Capacitor In-rush Current Capability	$20kA_{peak}$ (magnitude) 4250Hz (frequency)	
Tested Transient Recovery Voltage (TRV) across pole	$620kV_{peak}$ (3 per unit)	
Insulation Level	$900kV_{peak}$ BIL (min)	
Insulation Level across open CB	$1050kV_{peak}$ BIL (min)	
Rated Interrupting Time	3 cycles (max)	
Interrupter	Restrike-free (up to $620kV_{peak}$ TRV) and Pre-strike free when switching a 250MVAr ungrounded-wye capacitor bank, rated at 250kV.	

Secondary (Back-up) Breaker

230kV Circuit Breakers:	***Secondary units***		
Number required:	A total of 7	Middleport TS	4 breakers
		Nanticoke TS	2 breakers
		Buchanan TS	1 breaker
Breaker Type	At Nanticoke & Middleport TSs:	SF_6: Independent pole operated (IPO) without SCUs	
	At Buchanan TS:	SF_6: Ganged-pole	
	General (all three locations):	Outdoor dead tank with CTs for protection & metering.	
Rated Maximum Voltage		255kV $_{rms}$ (min) *[362kV Interrupters are to be installed.]*	
Rated Interrupting Current		Middleport & Nanticoke TSs	$80kA_{rms}$ symmetrical
		Buchanan TS	$63kA_{rms}$ symmetrical
Rated Continuous Current		2000A $_{rms}$	
Closing and Latching Capability		170kV $_{peak}$	
Tested Transient Recovery Voltage (TRV) across pole		620kV $_{peak}$ (3 per unit)	
Insulation Level		900kV $_{peak}$ BIL (min)	
Insulation Level across open CB		1050kV $_{peak}$ BIL (min)	
Rated Interrupting Time		3 cycles (max)	
Interrupter		Restrike-free (up to 620kV $_{peak}$ TRV) and Pre-strike free when switching a 250MVAr ungrounded-wye capacitor bank, rated at 250kV.	

Station Breaker

230kV Circuit Breaker:	***For Installation in the existing diameter at Buchanan TS***	
Number required	Buchanan TS	1 breaker
Breaker Type	SF_6: General Purpose	
Rated Maximum Voltage	250kV $_{rms}$ (min)	
Rated Interrupting Current	$63kA_{rms}$ symmetrical	
Rated Continuous Current	3000A $_{rms}$	
Closing and Latching Capability	170kV $_{peak}$	
Tested Transient Recovery Voltage (TRV) across pole	As per ANSI Standard C37.11 - 1979 (Re-affirmed 1988)	
Insulation Level	900kV $_{peak}$ BIL (min)	
Insulation Level across open CB	1050kV $_{peak}$ BIL (min)	
Rated Interrupting Time	3 cycles (max)	
Other	Suitable for energising up to 100km of 230kV line	

3.iv 230kV Disconnect Switches

230kV Disconnect Switches		
Number required: A total of 7	Middleport TS	4 disconnect switches
	Nanticoke TS	2 disconnect switches
	Buchanan TS	1 disconnect switches
Type	Motor operated, 3-phase unit	
Continuous Current (min)	1200A $_{rms}$	
Operating Voltage	230kV $_{rms}$ (nominal), 255kV (max. continuous), 300kV $_{rms}$ (emergency for 5 minutes)	
Insulation Level (phase-to-ground & phase-to-phase) (min)	900kV $_{peak}$ BIL	
Short-circuit Withstand Capability (min)	63kA $_{rms}$ symmetrical	

3.v Ground Switches

A total of seven sets of 3-phase ground switches are to be installed: one set on each capacitor bank installation, located between the capacitor bank and the breaker closest to it. These switches are to have a symmetrical fault rating of at least 63 kA

A further seven, single-phase ground switches are also to be installed on each capacitor bank installation, connected to the neutral point of each new capacitor bank for use during maintenance.

3.vi Surge Arresters

In the event that one of the poles of the IPO breaker should not open, or as a result of delayed opening of a pole, a transient recovery voltage of up to 4.37 E_{max} phase-to-ground could occur. Surge arresters are therefore to be installed to limit the transient recovery voltage to below 3 E_{max} phase-to-ground (612kV_{peak}).

The surge arrestors are to be located between the series reactors and the capacitor banks.

230kV Surge Arresters			
Number required: A total of 21	Middleport TS	12 units	Three for each capacitor bank (one per phase)
	Nanticoke TS	6 units	
	Buchanan TS	3 units	
Type	Metal Oxide Gapless – Station Class		
Maximum Continuous Operating Voltage (MCOV)	150kV $_{rms}$ (minimum)		
Front-of-Wave Impulse Protective Level	Maximum Equivalent Front-of-Wave not more than 720kV $_{crest}$		
Maximum discharge voltage for 8x20µs 10kA impulse current	Not more than 460kV $_{crest}$		
Maximum Switching Surge Protection Level	Not more than 380kV $_{crest}$ at 1kA		
Temporary Over-voltage Capability	Capable of withstanding a power frequency over-voltage of not less than 200kV Phase-Ground (rms) for a duration of not less than 1 second after the rated energy absorption.		
Maximum energy dissipation per arrester	Not less than 1500kJ/phase (i.e. single impulse energy capability).		
Pressure relief capability	As recommended by ANSI/IEEE C62.11-1993 Standard: not less than 65kA $_{rms}$		

3.vii Surge Capacitors

Surge capacitors, consisting of a three-phase set of capacitive voltage transformers, are to be installed on each capacitor bank between the primary (IPO) breaker and the series reactor. Their purpose is to ensure that the rate of rise of the recovery voltage (RRRV) for a 3-phase fault on the capacitor bank remains with the fault interrupting capability of the breakers.

The 50nF surge capacitors that are presently installed on the SC21 & SC22 capacitor banks at Buchanan TS are to be replaced with units rated at 70nF.

230kV Surge Capacitors (CVTs)				
Number required: A total of 27	Middleport TS	12 units	Three for each capacitor bank (one per phase)	
	Nanticoke TS	6 units		
	Buchanan TS	9 units		
Rated Maximum Voltage	$250kV_{rms}$ (min)			
Rated Capacitance	Middleport TS	50nF	Four	3-phase sets
	Nanticoke TS	50nF	Two	3-phase sets
	Buchanan TS	70nF	Three	3-phase sets
Insulation Level (phase-to-ground) (min)	$1050kV_{peak}$ BIL			

3.viii Protection, Control, Communications & Monitoring

In addition to the standard relay protection, control, communications & monitoring facilities, breaker failure protection is to be installed to clear the next protection zone should the capacitor breakers fail to clear a fault involving the capacitor bank installation.

Since all three stations where the new capacitor banks are to be installed have been designated as NPCC-impactive stations, all of the new protection facilities have been designed to comply with NPCC Criteria Document A5.

4.0 Assessment

The results from a load flow study for the expected peak load condition during the summer-2009 have been summarised in Diagram 4. In this study, a total of seven generating units at the Bruce Complex, together with the 675MW of committed wind-turbine projects have been assumed to be in-service. A peak transfer of approximately 1500MW across the Negative-BLIP Interface has also been assumed.

The corresponding primary demand for the summer-2009 that was used in this study was 28400MW.

All available shunt capacitor banks, including the seven units that are the subject of this Report, were also assumed to be in-service in this study.

Even with these capacitor banks, together with all transmission elements in-service, the voltages at Guelph-Cedar TS, Grand Bend TS & Brant TS were found to be below the minimum acceptable value of 113kV, as stipulated in the Market Rules. Additional shunt capacitors, with the nominal ratings shown below, were therefore added to these 115kV busbars to raise their voltages above the 113kV minimum:

- Guelph-Cedar TS 40MVAr
- Grand Bend TS 20MVAr &
- Brant TS 30MVAr.

While the resulting voltage profile that is shown in Diagram 1 would be acceptable, it is worth noting that the voltage at Milton TS (523.9kV) would be close to the minimum value of 522kV (for a primary demand above 24500MW) that is stipulated in the current version of the operating instructions for southern Ontario.

Power-Voltage Analysis

Diagrams 5 & 6 show the results from the PV-Analysis that was performed on the reference case shown in Diagram 4. For this analysis, the output from the Bruce Complex was gradually increased to stress the transmission system between the Bruce Complex and the GTA. To compensate for the increased output from the Bruce Complex, corresponding decreases were made in the output from Darlington GS.

Diagram 6, in which the reactive outputs remaining available from the principle generating facilities in the area have been summarised, shows the reactive outputs from the Bruce & Pickering generating units reaching their maximum limits for FABC transfers of approximately 7300MW & 7400MW, respectively. Once the generating units at the Bruce Complex and at Pickering GS were unable to provide further support, termination of the study occurred at an FABC Transfer of 7417MW.

With the knee points of the PV-curves occurring at an FABC Transfer of 7417MW, the pre-contingency voltage stability limit, which requires a margin of 10% to be maintained from the knee-point of the PV-curves, would therefore correspond to a maximum FABC Transfer of 6675MW, as shown in Diagram 5.

Diagram 5 also shows that in order to provide the required 10% margin on the maximum FABC Transfer of 5587MW that is expected to occur once seven Bruce units are in-service, as was shown in Diagram 4, the voltage stability limit would need to be at least 6208MW. The actual transfer limit of 6675MW would therefore be well in excess of this minimum required value of 6208MW.

However, since an eighth unit at the Bruce Complex would add approximately 750MW to the FABC Transfer, the required voltage stability limit would therefore need to increase to approximately 7040MW to accommodate all eight Bruce units. Since the voltage stability limit with the seven new capacitor banks in-service has been shown to be only 6675MW, it would therefore not be sufficient to meet the pre-contingency voltage stability criterion for the condition with all eight units at the Bruce Complex in operation.

Should it be necessary to operate all eight units at the Bruce Complex with no new transmission facilities in place, then additional dynamic reactive support would need to be installed since it is not expected that any additional shunt capacitor banks could be placed in-service pre-contingency without exceeding the voltage rating of the existing equipment on the system.

Load Flow Analysis

Diagram 7 shows the results from the load flow study performed on the limiting case from the PV-analysis. This corresponds to an FABC Transfer of 7417MW, which would be approximately 32% above the reference FABC Transfer shown in Diagram 4, of 5586MW.

This shows the reduced voltages at the Bruce Complex and within the GTA, particularly at Burlington TS and Milton TS, in response to absence of any further voltage support from the generating units at the Bruce Complex and at Pickering NGS.

Voltage Change on Switching the Individual Capacitor Banks

The results from the studies that examined the effect of individually switching one of the new capacitor banks out-of-service at each location are summarised below.

In these studies the loads were modelled as ‘voltage dependent’ (i.e. $P \alpha V^{1.5}$ & $Q \alpha V^{2}$), in accordance with the Ontario Resource & Transmission Assessment Criteria for switching reactive devices.

The results correspond to the situation immediately following the switching of each capacitor bank, before the transformer tap-changers have had an opportunity to respond.

Location of Capacitor Bank being Switched			Nanticoke		Middleport M585M		Middleport V586M		Detweiler		Buchanan	
Size of Capacitor Bank (Q)			250MVAr		250MVAr		250MVAr		250MVAr		200MVAr	
Fault Level at 230kV busbar			12431MVA		15411MVA		17129MVA		8910MVA		12392MVA	
ΔQ/Fault Level			2.01%		1.62%		1.46%		2.81%		1.61%	
			Nanticoke		*Middleport M585M*		*Middleport V586M*		*Detweiler*		*Buchanan*	
Monitored Busbars		*Pre-switching*	*Post capacitor bank switching*									
Nanticoke	230kV	245.06kV	240.48kV	1.87%	243.21kV	0.75%	243.26kV	0.73%	244.05kV	0.41%	244.17kV	0.36%
Middleport M585M	230kV	243.98kV	242.13kV	0.76%	240.65kV	1.36%	242.59kV	0.57%	242.76kV	0.50%	242.97kV	0.41%
Middleport V586M	230kV	243.85kV	242.01kV	0.75%	242.43kV	0.58%	240.63kV	1.32%	242.63kV	0.50%	242.95kV	0.37%
Detweiler	230kV	242.04kV	240.97kV	0.44%	240.75kV	0.53%	240.79kV	0.52%	236.40kV	2.33%	240.50kV	0.64%
Buchanan	230kV	239.91kV	239.19kV	0.30%	239.05kV	0.36%	239.21kV	0.29%	238.59kV	0.55%	236.16kV	1.56%
Orangeville	230kV	245.70kV	245.08kV	0.25%	245.03kV	0.27%	245.05kV	0.26%	243.43kV	0.92%	244.98kV	0.29%
Longwood	230kV	244.18kV	243.60kV	0.24%	243.69kV	0.20%	243.77kV	0.17%	243.59kV	0.24%	242.58kV	0.66%
Nanticoke	500kV	547.04kV	542.17kV	0.89%	544.08kV	0.54%	544.13kV	0.53%	545.24kV	0.33%	545.24kV	0.33%
Middleport M585M	500kV	543.55kV	539.74kV	0.70%	540.40kV	0.58%	541.03kV	0.46%	541.83kV	0.32%	541.95kV	0.29%
Middleport V586M	500kV	544.54kV	540.60kV	0.72%	541.95kV	0.48%	541.35kV	0.59%	542.79kV	0.32%	542.95kV	0.29%
Milton	500kV	530.56kV	528.61kV	0.37%	528.86kV	0.32%	528.95kV	0.30%	529.41kV	0.22%	529.59kV	0.18%
Longwood	500kV	546.59kV	544.99kV	0.29%	545.39kV	0.22%	545.52kV	0.20%	545.35kV	0.23%	543.88kV	0.50%
Detweiler	118kV	125.16kV	124.57kV	0.47%	124.47kV	0.55%	124.44kV	0.57%	122.41kV	2.20%	124.38kV	0.62%

Included in the table is the voltage decline that would be expected to occur based on the size of the capacitor bank being switched and the fault level at that particular busbar. In all cases, this approach is shown to yield a slightly higher voltage change, primarily because the rating assumed for the capacitor bank being switched corresponds to the maximum continuous system voltage of 250kV.

In all instances the voltage declines recorded were less than the 4% limit specified in Reference 1 of Appendix 4.4 of the Market Rules for the maximum abrupt voltage change that is permitted for capacitor switching operations.

5.0 Conclusions

The study results have shown that the installation of the seven shunt capacitor banks at Middleport TS, Nanticoke TS & Buchanan TS would increase the pre-contingency voltage stability limit for Transfers across the FABC Interface to approximately 6675MW for the condition with all the committed wind-turbine projects in-service and with a transfer of 1500MW across the Negative BLIP Interface.

This increased limit would be sufficient to accommodate a total of seven generating units at the Bruce Complex, when all transmission facilities are in-service. Additional dynamic reactive support would need to be installed to accommodate all eight units at the Bruce Complex, again with all transmission elements in-service, should the proposed Bruce-to-Milton 500kV double-circuit line be delayed.

Additional reactive facilities, which are not covered by this Assessment, will also be required to address the system requirements following system contingencies.

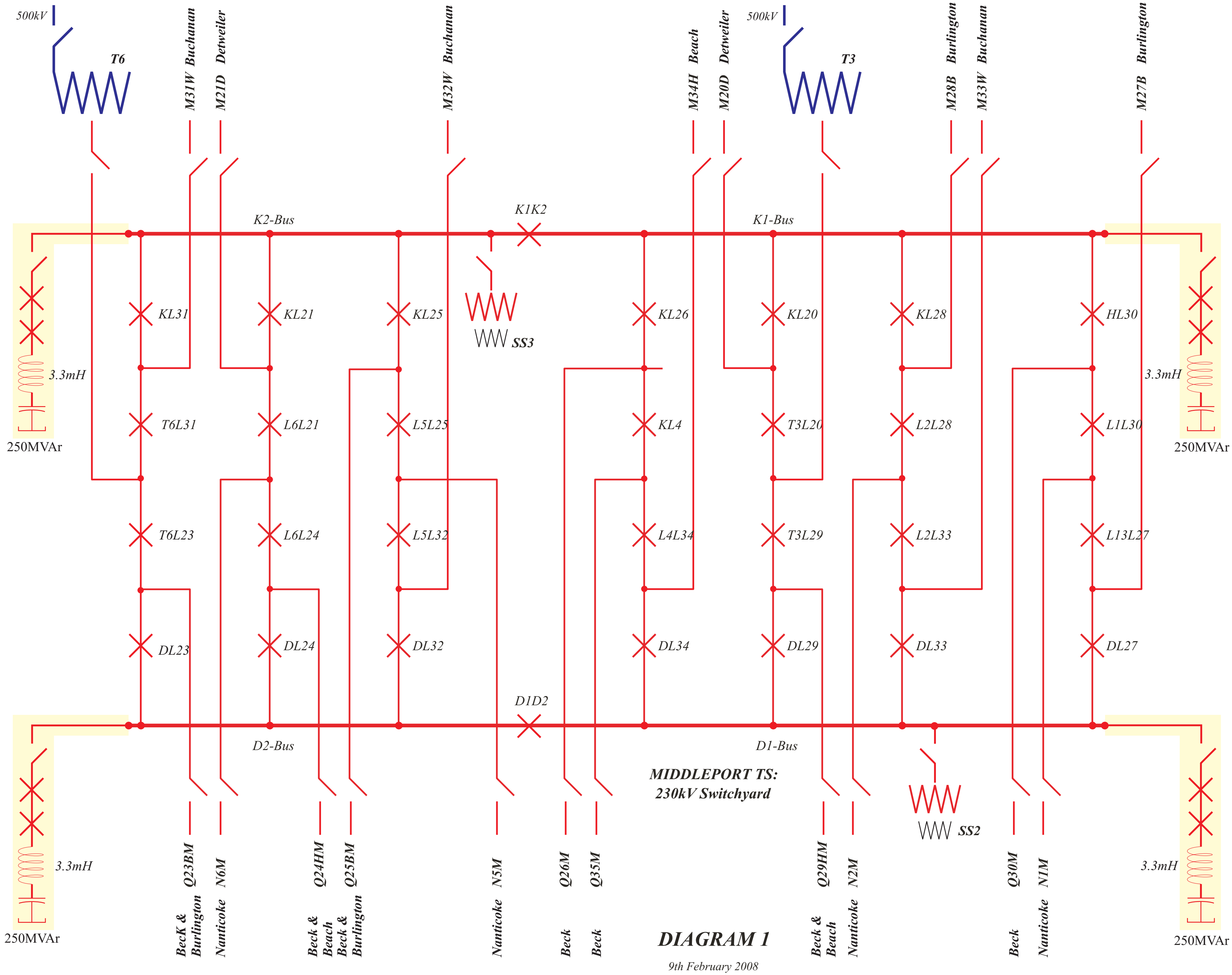
The study results have also shown that the individual switching of any of the new capacitor banks would result in a maximum voltage change of approximately 2%, which would be well within the maximum of 4% allowed under the Market Rules.

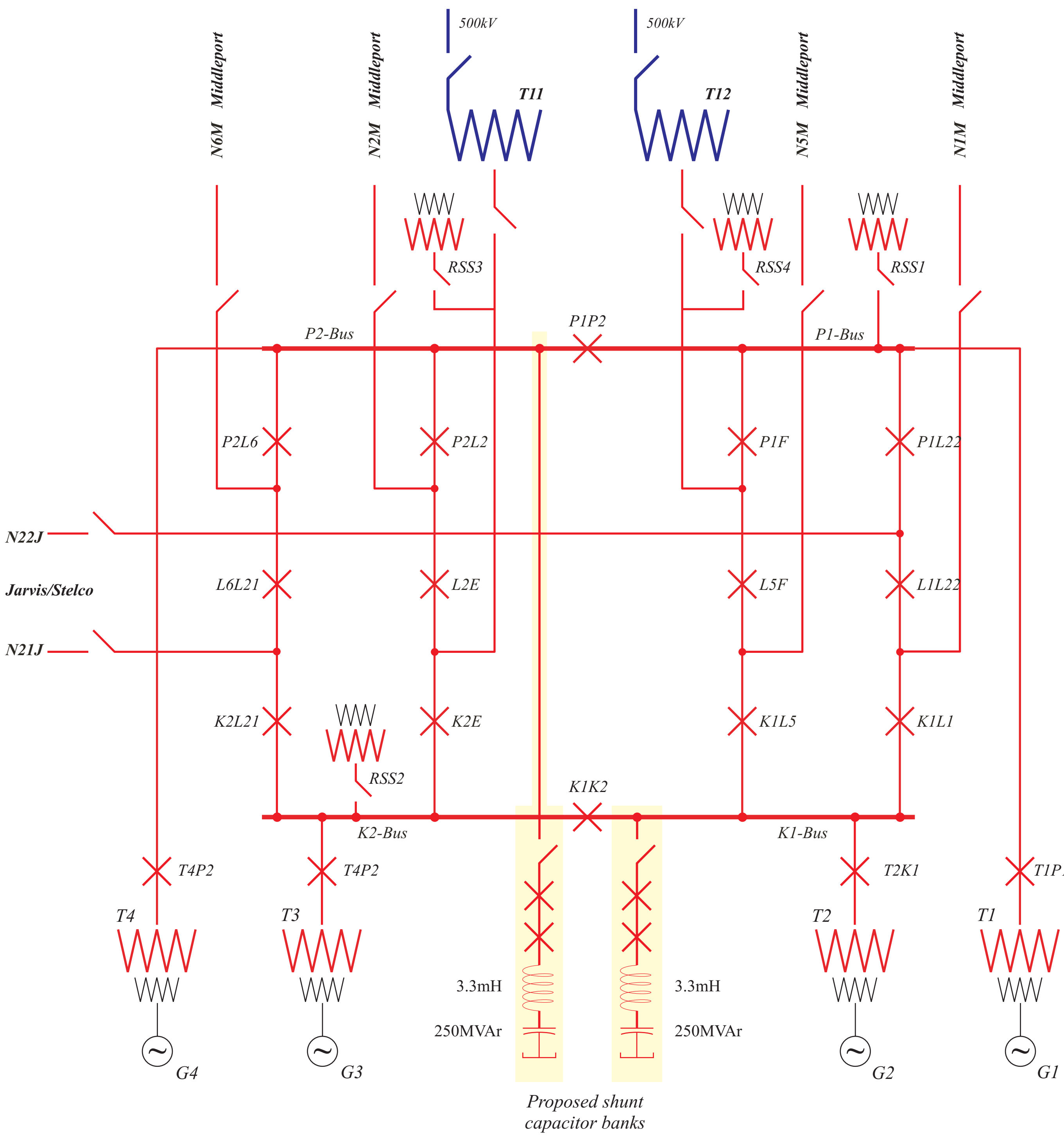
6.0 Customer Impact Assessment

Hydro One has notified the IESO that a formal Customer Impact Assessment will not be required for the new capacitor banks to be installed under this Project.

7.0 Notification of Approval

Since it has been determined that there would be no adverse effect on the IESO-controlled grid from the installation of the seven shunt capacitor banks at Middleport TS, Nanticoke TS & Buchanan TS, it is therefore recommended that a Notification of Conditional Approval of the Connection Proposal be issued for these facilities.

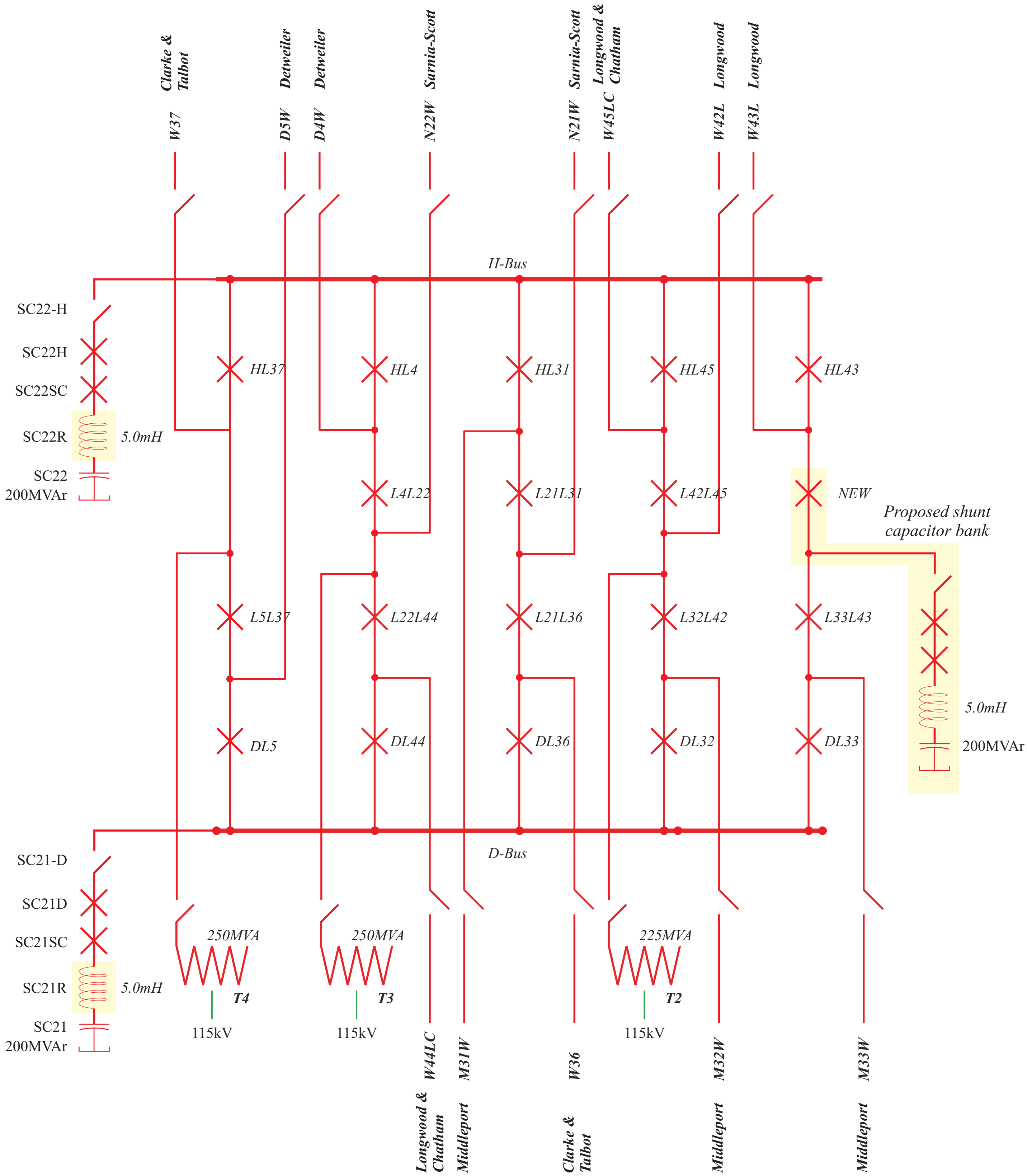

500kV
T6
M31W Buchanan
M21D Detweiler
M32W Buchanan
M34H Beach
M20D Detweiler
500kV
T3
M28B Burlington
M33W Buchanan
M27B Burlington
K2-Bus
K1K2
K1-Bus
KL31
KL21
KL25
SS3
KL26
KL20
KL28
HL30
3.3mH
3.3mH
T6L31
L6L21
L5L25
KL4
T3L20
L2L28
L1L30
250MVAr
250MVAr
T6L23
L6L24
L5L32
L4L34
T3L29
L2L33
L13L27
DL23
DL24
DL32
DL34
DL29
DL33
DL27
D1D2
D2-Bus
D1-Bus
MIDDLEPORT TS:
230kV Switchyard
SS2
3.3mH
3.3mH
250MVAr
250MVAr
Q23BM BecK & Burlington
N6M Nanticoke
Q24HM Beck & Beach
Q25BM Beck & Burlington
N5M Nanticoke
Q26M Beck
Q35M Beck
Q29HM Beck & Beach
N2M Nanticoke
Q30M Beck
N1M Nanticoke
DIAGRAM 1
9th February 2008



NANTICOKE TS: 230kV Switchyard

DIAGRAM 2

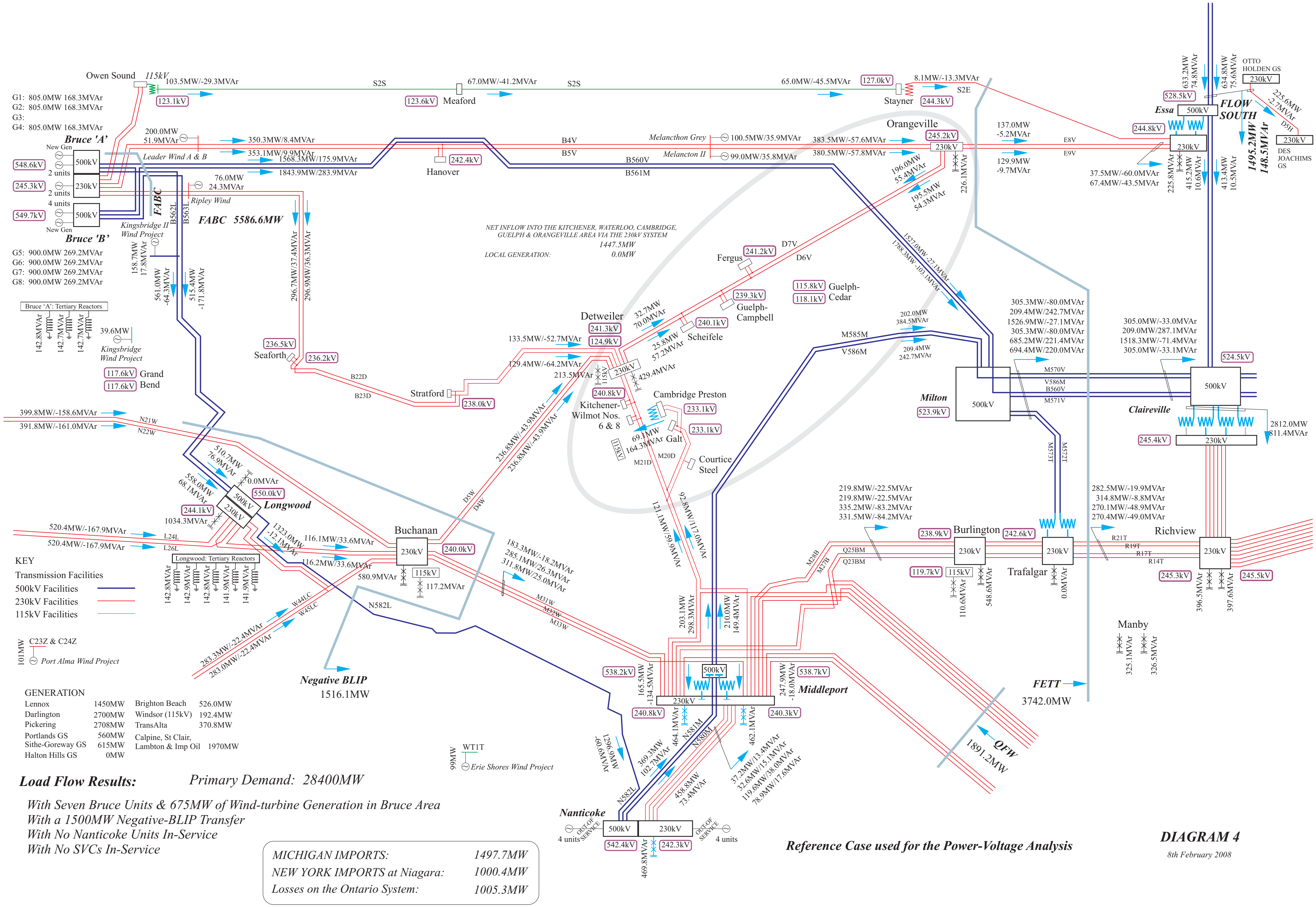
9th February 2008



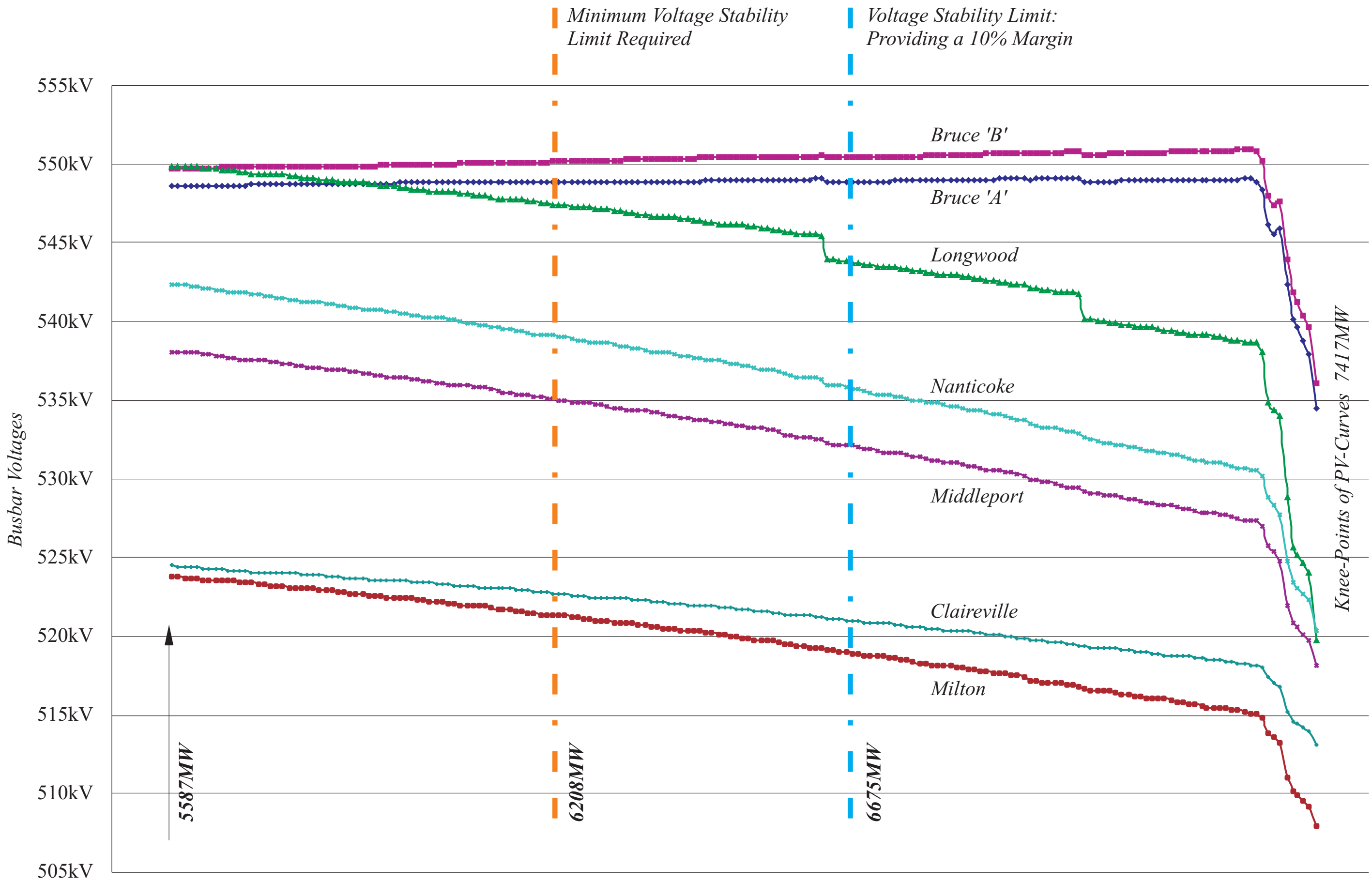
BUCHANAN TS: 230kV Switchyard

DIAGRAM 3

9th February 2008



Owen Sound
115kV
103.5MW/-29.3MVAr
123.1kV
S2S
67.0MW/-41.2MVAr
Meaford
123.6kV
65.0MW/-45.5MVAr
127.0kV
8.1MW/-13.3MVAr
S2E
Stayner
244.3kV
G1: 805.0MW 168.3MVAr
G2: 805.0MW 168.3MVAr
G3:
G4: 805.0MW 168.3MVAr
Bruce 'A'
New Gen
548.6kV
500kV
2 units
230kV
245.3kV
2 units
4 units
549.7kV
Bruce 'B'
G5: 900.0MW 269.2MVAr
G6: 900.0MW 269.2MVAr
G7: 900.0MW 269.2MVAr
G8: 900.0MW 269.2MVAr
200.0MW
51.9MVAr
Leader Wind A & B
350.3MW/8.4MVAr
353.1MW/9.9MVAr
1568.3MW/175.9MVAr
1843.9MW/283.9MVAr
76.0MW
24.3MVAr
Ripley Wind
B4V
B5V
B560V
B561M
Hanover
242.4kV
Melancthon Grey
100.5MW/35.9MVAr
Melancton II
99.0MW/35.8MVAr
383.5MW/-57.6MVAr
380.5MW/-57.8MVAr
Orangeville
245.2kV
230kV
137.0MW
-5.2MVAr
129.9MW
-9.7MVAr
E8V
E9V
FABC
FABC 5586.6MW
Kingsbridge II Wind Project
158.7MW
17.8MVAr
561.0MW
-64.3MVAr
515.4MW
-171.8MVAr
296.7MW/37.4MVAr
296.9MW/36.3MVAr
NET INFLOW INTO THE KITCHENER, WATERLOO, CAMBRIDGE, GUELPH & ORANGEVILLE AREA VIA THE 230kV SYSTEM
1447.5MW
LOCAL GENERATION: 0.0MW
Bruce 'A': Tertiary Reactors
142.8MVAr
142.7MVAr
142.7MVAr
39.6MW
Kingsbridge Wind Project
117.6kV Grand
117.6kV Bend
236.5kV
Seaforth
236.2kV
B22D
B23D
Stratford
238.0kV
Detweiler
241.3kV
124.9kV
133.5MW/-52.7MVAr
129.4MW/-64.2MVAr
213.5MVAr
230kV
429.4MVAr
32.7MW
70.0MVAr
25.8MW
57.2MVAr
Fergus
241.2kV
D7V
D6V
239.3kV
Guelph-Campbell
240.1kV
Scheifele
115.8kV Guelph-
118.1kV Cedar
196.0MW
55.4MVAr
195.5MW
54.3MVAr
226.1MVAr
OTTO HOLDEN GS
230kV
633.2MW
74.8MVAr
634.8MW
75.6MVAr
528.5kV
Essa
500kV
FLOW SOUTH
1495.2MW
148.5MVAr
225.6MW
-2.7MVAr
D5H
DES JOACHIMS GS
244.8kV
230kV
37.5MW/-60.0MVAr
67.4MW/-43.5MVAr
225.8MVAr
415.2MW
10.6MVAr
413.4MW
10.5MVAr
1527.0MW/-27.1MVAr
1788.3MW/-103.1MVAr
399.8MW/-158.6MVAr
391.8MW/-161.0MVAr
N21W
N22W
240.8kV
Kitchener-Wilmot Nos. 6 & 8
Cambridge Preston
233.1kV
233.1kV
Galt
69.1MW
164.3MVAr
Courtice Steel
M20D
M21D
M585M
M586M
202.0MW
384.5MVAr
209.4MW
242.7MVAr
305.3MW/-80.0MVAr
209.4MW/242.7MVAr
1526.9MW/-27.1MVAr
305.3MW/-80.0MVAr
685.2MW/221.4MVAr
694.4MW/220.0MVAr
305.0MW/-33.0MVAr
209.0MW/287.1MVAr
1518.3MW/-71.4MVAr
305.0MW/-33.1MVAr
524.5kV
Milton
523.9kV
500kV
M570V
V586M
B560V
M571V
500kV
Claireville
2812.0MW
811.4MVAr
245.4kV
230kV
M573T
M572T
510.7MW
76.9MVAr
558.0MW
68.1MVAr
0.0MVAr
550.0kV
500kV
230kV
Longwood
244.1kV
1034.3MVAr
1323.0MW
-12.1MVAr
D5W
D4W
236.8MW/-43.9MVAr
236.8MW/-43.9MVAr
Buchanan
230kV
240.0kV
116.1MW/33.6MVAr
116.2MW/33.6MVAr
580.9MVAr
115kV
117.2MVAr
520.4MW/-167.9MVAr
520.4MW/-167.9MVAr
L24L
L26L
Longwood: Tertiary Reactors
142.8MVAr
142.9MVAr
142.8MVAr
141.9MVAr
141.9MVAr
141.9MVAr
183.3MW/-18.2MVAr
285.1MW/26.3MVAr
311.8MW/25.0MVAr
M31W
M32W
M33W
121.1MW/59.9MVAr
92.8MW/117.0MVAr
219.8MW/-22.5MVAr
219.8MW/-22.5MVAr
335.2MW/-83.2MVAr
331.5MW/-84.2MVAr
282.5MW/-19.9MVAr
314.8MW/-8.8MVAr
270.1MW/-48.9MVAr
270.4MW/-49.0MVAr
238.9kV
Burlington
230kV
242.6kV
230kV
Trafalgar
Richview
230kV
Q25BM
Q23BM
M28B
M27B
R21T
R19T
R17T
R14T
119.7kV
115kV
110.6MVAr
548.6MVAr
0.0MVAr
245.3kV
245.5kV
396.5MVAr
397.6MVAr
Manby
325.1MVAr
326.5MVAr
KEY
Transmission Facilities
500kV Facilities
230kV Facilities
115kV Facilities
C23Z & C24Z
101MW
Port Alma Wind Project
W44LC
W45LC
283.3MW/-22.4MVAr
283.0MW/-22.4MVAr
N582L
Negative BLIP
1516.1MW
203.1MW
298.3MVAr
210.0MW
149.4MVAr
538.2kV
165.5MW
-134.5MVAr
500kV
230kV
538.7kV
247.9MW
-18.0MVAr
Middleport
240.8kV
240.3kV
464.1MVAr
462.1MVAr
N581M
N580M
FETT
3742.0MW
QFW
1891.2MW
GENERATION
Lennox 1450MW
Darlington 2700MW
Pickering 2708MW
Portlands GS 560MW
Sithe-Goreway GS 615MW
Halton Hills GS 0MW
Brighton Beach 526.0MW
Windsor (115kV) 192.4MW
TransAlta 370.8MW
Calpine, St Clair, Lambton & Imp Oil 1970MW
99MW
WT1T
Erie Shores Wind Project
1296.9MW
-60.6MVAr
369.3MW
102.7MVAr
458.8MW
73.4MVAr
37.2MW/13.4MVAr
32.6MW/15.1MVAr
119.6MW/38.0MVAr
78.9MW/17.6MVAr
N582L
Nanticoke
4 units
OUT OF SERVICE
500kV
230kV
OUT OF SERVICE
4 units
542.4kV
242.3kV
469.8MVAr
Load Flow Results:
Primary Demand: 28400MW
With Seven Bruce Units & 675MW of Wind-turbine Generation in Bruce Area
With a 1500MW Negative-BLIP Transfer
With No Nanticoke Units In-Service
With No SVCs In-Service
MICHIGAN IMPORTS: 1497.7MW
NEW YORK IMPORTS at Niagara: 1000.4MW
Losses on the Ontario System: 1005.3MW
Reference Case used for the Power-Voltage Analysis
DIAGRAM 4
8th February 2008



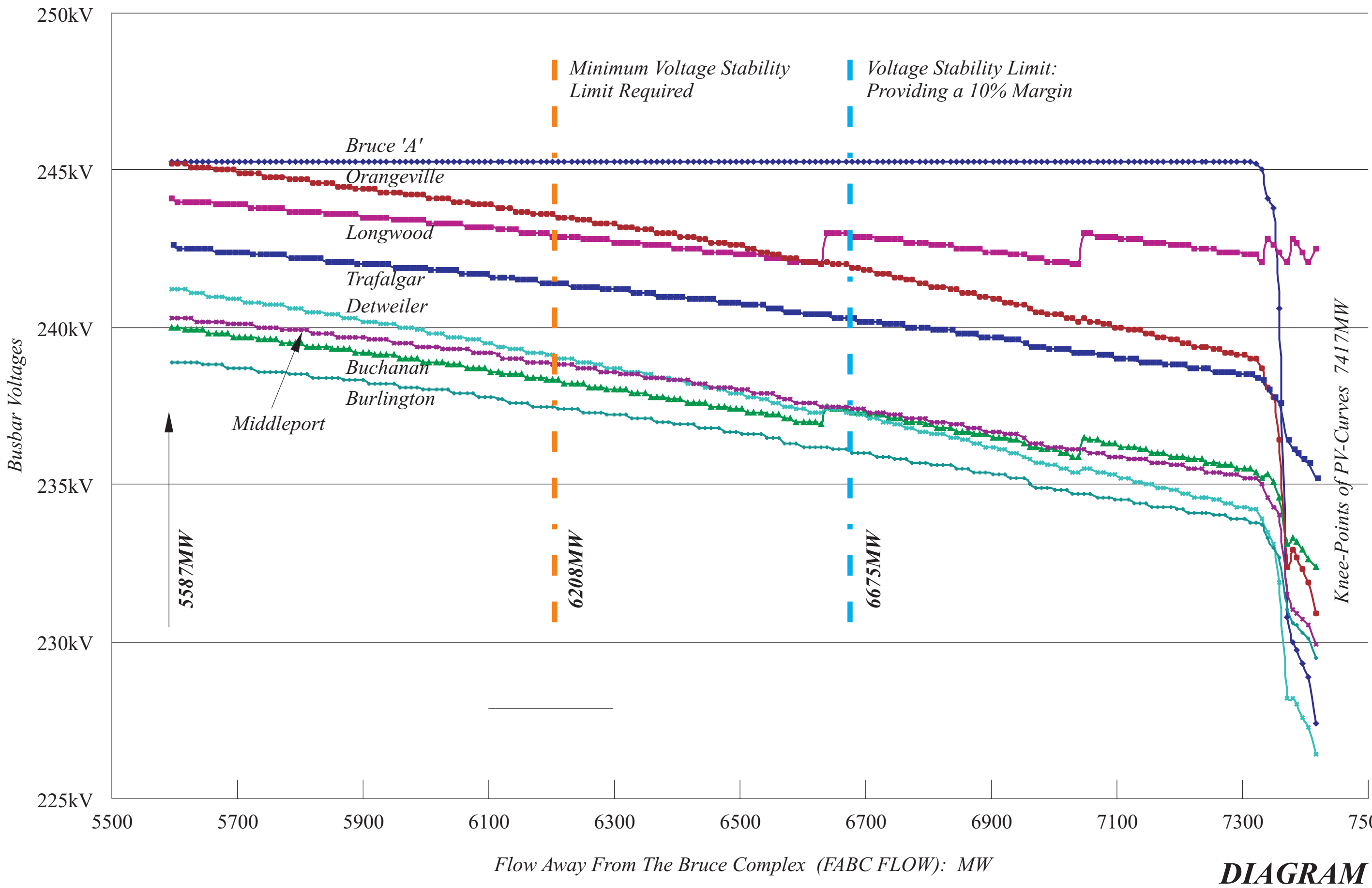
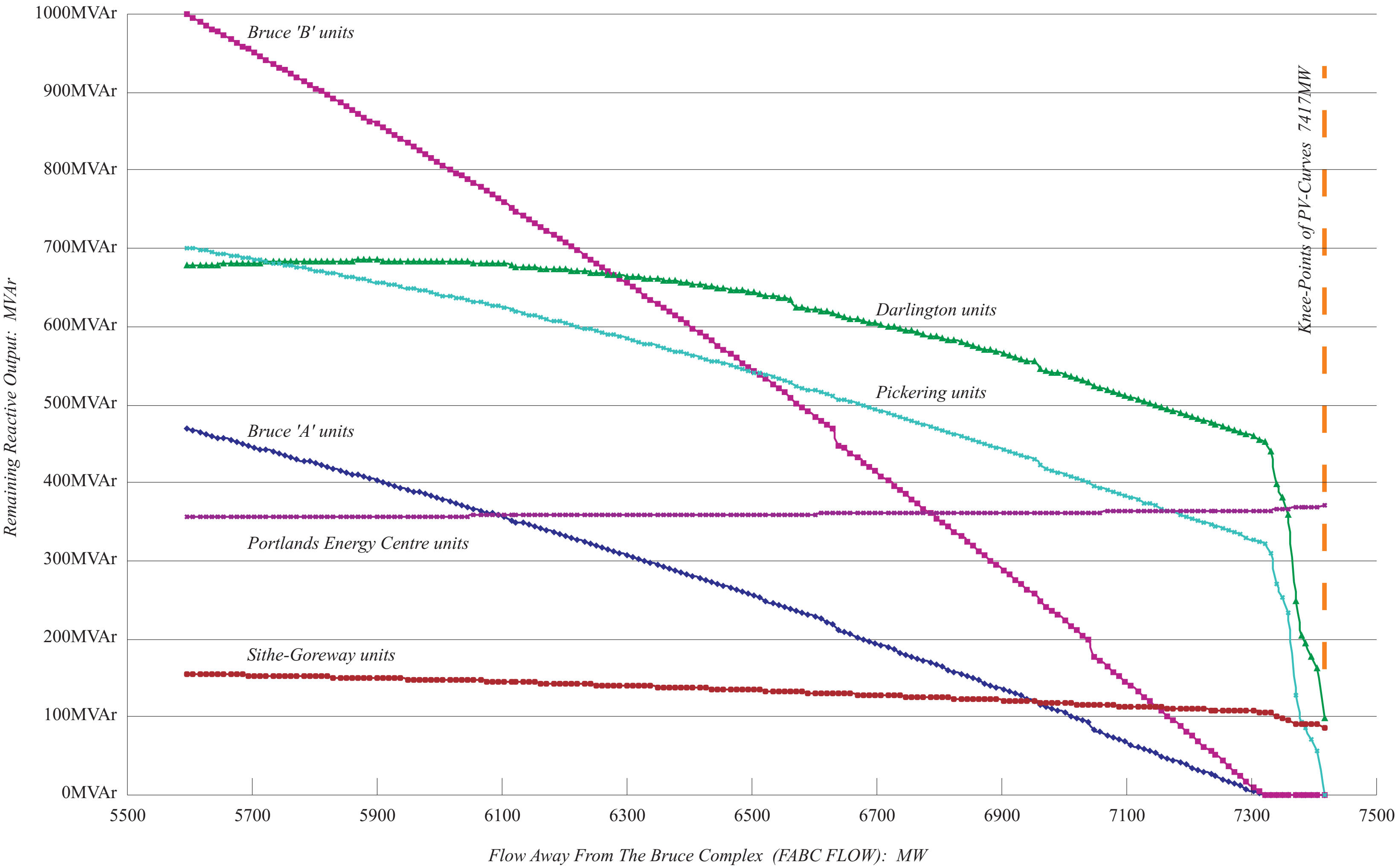


DIAGRAM 5

Voltage Response at selected 500kV & 230kV busbars to increases in the FABC Transfer

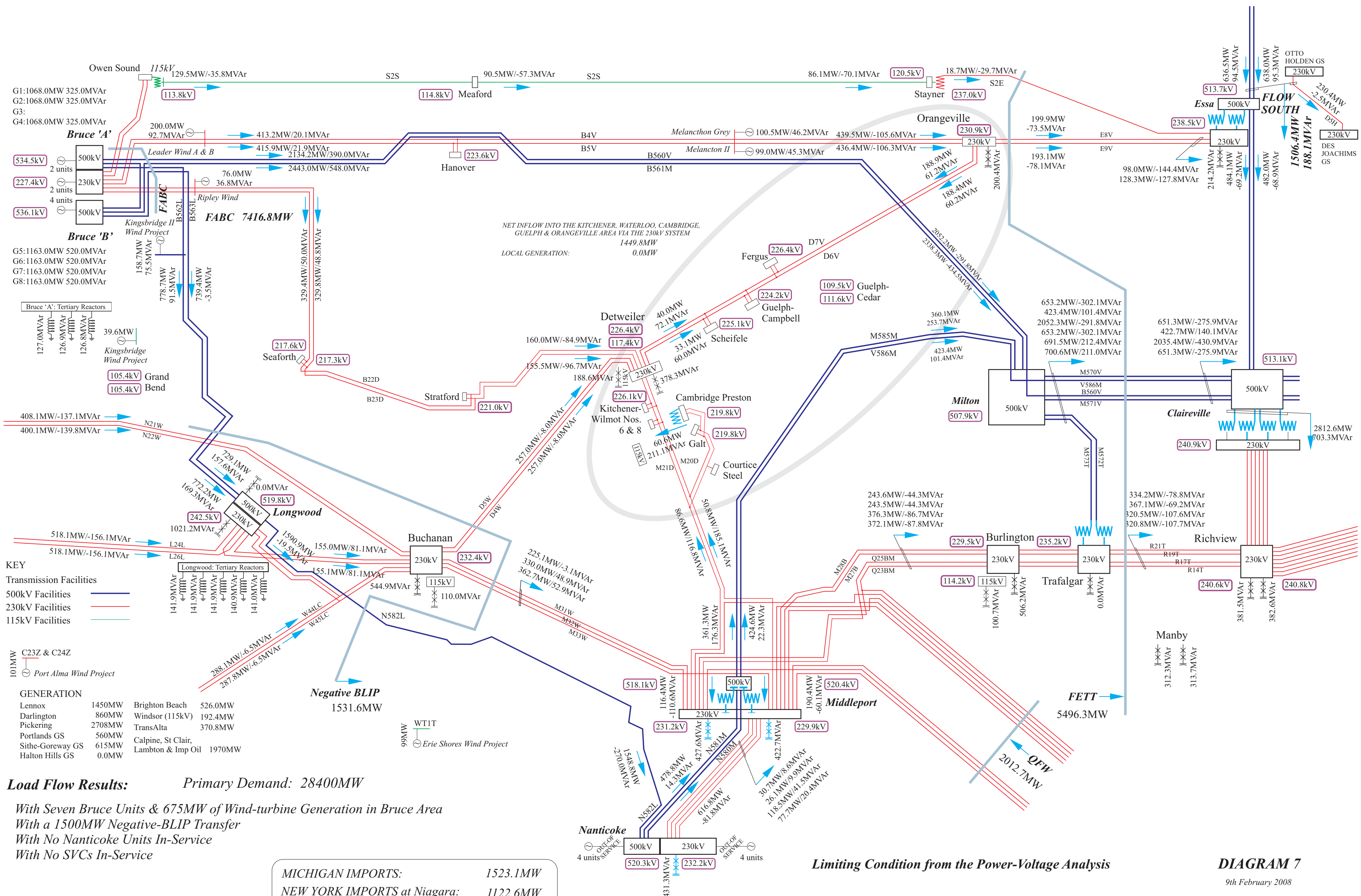
6th February 2008



Reactive output remaining available at the principle generating facilities in response to increases in the FABC Transfer

DIAGRAM 6

6th February 2008



GENERATION

Lennox	1450MW	Brighton Beach	526.0MW
Darlington	860MW	Windsor (115kV)	192.4MW
Pickering	2708MW	TransAlta	370.8MW
Portlands GS	560MW	Calpine, St Clair, Lambton & Imp Oil	1970MW
Sithe-Goreway GS	615MW		
Halton Hills GS	0.0MW		

Load Flow Results: *Primary Demand: 28400MW*

With Seven Bruce Units & 675MW of Wind-turbine Generation in Bruce Area
With a 1500MW Negative-BLIP Transfer
With No Nanticoke Units In-Service
With No SVCs In-Service

MICHIGAN IMPORTS:	*1523.1MW*
NEW YORK IMPORTS at Niagara:	*1122.6MW*
Losses on the Ontario System:	*1236.5MW*

Limiting Condition from the Power-Voltage Analysis

DIAGRAM 7

9th February 2008