REPORT

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System Impact Assessment Report

CONNECTION ASSESSMENT & APPROVAL PROCESS

Issue 1.0

CAA ID No. 2006 - 214

Applicant: ***Ontario Power Generation Inc.***

Project: ***Pickering Auxiliary Power System***

Transmission Assessments & Performance Department

August 18, 2006

Document ID	IESO_REP_0325
Document Name	System Impact Assessment Report
Issue	Issue 1.0
Reason for Issue	First issue
Effective Date	August 18, 2006

System Impact Assessment Report

Pickering Auxiliary Power System Project

Acknowledgement

The IESO wished 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.

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 approval has been granted. 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, connection 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

Special Notes and Limitations of Study Results

The results reported in this System Impact Assessment are based on the information available to Hydro One, at the time of the study, suitable for a preliminary 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 OPGI) customers.

In this System Impact Assessment, 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 preliminary 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.

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Conclusions

This System Impact Assessment has been conducted to examine the effect of the Pickering Auxiliary Power Supply (APS) project on the reliability of the IESO-controlled grid. The project includes the connection of two 38 MW gas turbine generators to the 230 kV switchyard at Pickering GS. The new generators will only be operated as emergency backup generation and will not normally inject power into the grid. Periodically grid connection will be allowed to facilitate the testing of the new units. It is concluded that the proposed project will not have adverse impact on the IESO-controlled grid as an emergency power station.

It is also concluded that the current design of the APS project does not meet market rules if the operation mode of the APS is to be changed from emergency mode to normal grid connection. Based on this study, if OPG decides to offer the new units into the market then:

- new excitation systems, power system stabilizers which meet the Market Rule requirements must be installed,
- Market Rule requirements associated with on-line monitoring requirements, under frequency tripping and revenue metering must be met.

If OPG decides to change the operation mode of the new units to offer the generation into the market then a new System Impact Assessment Application needs to be submitted to the IESO.

Notification of Approval for Connection Proposal

Since the proposed work at Pickering GS will have no adverse impact on the IESO-controlled grid, it is therefore recommended that a Notification of Approval of the Connection Proposal be issued for the work in Phase 2 of the Pickering APS Project.

IESO's Requirements for Connection

The connection applicant is required to provide the IESO updated block diagrams and parameters of the generator, excitation system and governor as soon as the commissioning tests are completed and actual data are available.

ASSESSMENT SUMMARY (CAA ID No. 2006-214)

ONTARIO POWER GENERATION Inc.
Pickering TS: Connection of the Auxiliary Power Supply

1. Introduction

Following the blackout of 14th August 2003, OPG initiated the Remote Emergency Power Generator (REPG) Project for providing Class IV power to Pickering NGS to supply one of the High Pressure Emergency Core Injection (HPECI) Pumps in the event of the loss of the bulk electrical system. This involved the installation of a 22.5MW gas-turbine generating unit at the Hydro One Central Maintenance Shop connected to the adjacent 230kV circuit P7C between Pickering GS and Cherrywood TS. However, the REPG Project, which was completed in October 2004, was only intended to be an interim solution until a permanent emergency supply could be installed.

OPG has subsequently initiated the Auxiliary Power Supply Project which involves installing two 38 MW generating units adjacent to the Pickering 'B' station and connecting them into the Pickering Class IV power system bus and into the 230 kV Bus N bus.

The Project is to be completed in two phases: Phase 1, which required an outage of the Pickering G8 unit was completed in April 2006. Phase 2 the remainder of the work will then follow, with completion scheduled for the summer 2007. The 230 kV connection is scheduled to be completed and energized by January 31, 2007 and the power plant is scheduled to be completed and ready for testing by May 2007.

The 230 kV Phase 1 work involved the extension of the existing 230 kV Bus N bus and the installation of a new 230 kV motorized disconnect switch. This work was assessed by the IESO in November 2005 (CAA ID: 2005-EX225) and a conditional approval was granted to proceed.

Phase 2 work will involve the installation of the new generating facilities and their connection to the 230 kV bus via a new step-up transformer, a new 230 kV manual disconnect switch, a new 230 kV breaker and the 230 kV motorized disconnect switch installed in Phase 1.

This study examines the effect of the proposed Phase 2 project on the reliability of the IESO-Controlled grid as an emergency standby power source. In addition, since OPG requested the IESO investigate the requirements for generation opportunities in the future, concerns associated with the current design for the potential commercial operation are also identified in this report.

2. Description of the New Facilities

The new facilities are to consist of two 38 MW (0.8 P.F.) gas-turbine units connected to a 13.8 kV bus. A single 62.5 MVA 230/13.8 kV step-up transformer is to be installed to connect the LV bus to the 230kV Bus N bus at Pickering GS via a 610 m 230 kV cabled connection. The proposal also includes two 13.8 kV/4.16 kV transformers that will be connected and provide emergency power to the Pickering Class IV 4.16 kV bus. The proposed arrangement is shown in Figure 1.

During normal conditions, the two generating units will be idle and the 13.8 kV generating unit breakers will be open. The 230 kV connection will be used to provide station service supply to the new facility. Periodically, each generating unit will be started and paralleled with the IESO-controlled grid for testing. During these periods each unit would be operated at full load, delivering approximately 38 MW to the IESO-controlled grid.

Under emergency conditions, following a loss of supply from the IESO-controlled grid, the new facilities will be isolated from the 230kV Bus N bus to allow the two new APS generating units to be connected to the Pickering Class IV 4 kV bus via the new 13.8/4.16 kV step-down transformers.

3. Assessment – Units Providing Emergency Supply

This assessment covers the facilities proposed for installation in Phase 2 and addresses the performance of the new generating units. It should be noted that since the proposed generation units are backup power sources and are to be paralleled with the IESO-controlled grid for periodic testing only it is not required that the performance of the machines meet the Market Rules's requirements.

A review of the connection arrangement indicated that the installation is properly configured to provide power supply to Pickering GS auxiliaries when supply from the grid is unavailable.

The models and data provided by OPG for the new units are described in section 4. OPG is required to provide updated parameters and block diagram model of the excitation system as soon as the commissioning tests are completed and actual data is available.

4. Assessment – Units Normally Connected

As requested by OPG, studies were performed to identify concerns if in the future the new unit will be operated normally connected to the system. It should be noted that this assessment only covers the emergency operation scenario and OPG is required to submit a new System Impact Assessment application in the intended mode of operation will be changed in the future.

4.1 Generator

The rated capability of the generator is 63 MVA, but the maximum continuous active power output is limited by the associated combustion turbine engine power which is 38 MW at maximum ambient temperature of 35°C. At this operating temperature, the generator reactive capability curve shows the generator is capable of delivering + 28.5 MVar. This defines MCR of 38 MW @ 0.8pf lagging.

PTI's Round Rotor Generator Model (GENROU) was used to model the new generator. The data for the generator model are provided by proponent and given below.

$X_d = 2.19$	$X_q = 2.11$	$X'_d = 0.29$	$X''_d = 0.18$	$X_l = 0.14$	H = 29000 lb-ft^2
$T'_{do} = 6.17$	$T'_{qo} = 1.39$	$T''_{do} = 0.07$	$T''_{qo} = 0.5$	S(1.0) = 1.072	S(1.2) = 1.47

The finalized generator data should be provided to the IESO upon completion of the testing and commissioning the APS systems.

4.2 Excitation System

The parameters and the block diagram of the model of the excitation system were provided by the OPG. The data for the IEEE type AC8B excitation system model used in this study are given in Table 1 and the block diagram is given in Figure 2.

Table 1. Parameters for Excitation System

CONs #	Value	Description
J	0	TR (sec)
J+1	80	KP
J+2	20	KI
J+3	10	KD
J+4	0.01	TD (sec)
J+5	1	KA
J+6	0.004	TA
J+7	2.7	VRMAX or zero
J+8	0.0	VRMIN
J+9	1.2	TE > 0 (sec)
J+10	1	KE or zero
J+11	6.5	E1
J+12	0.3	SE(E1)
J+13	9.0	E2
J+14	3.0	SE(E2)

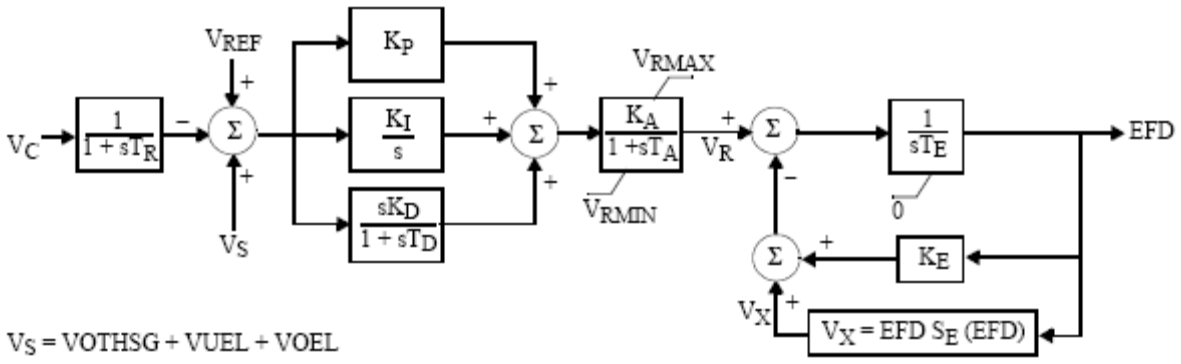


Figure 2. Excitation System Block Diagram

Dynamic simulations were performed to examine the response of the excitation system. The results of the exciter system voltage response test to a 5% step change in reference voltage are displayed in Figure 3 and the results of the exciter system response ratio test are shown in Figure 4.

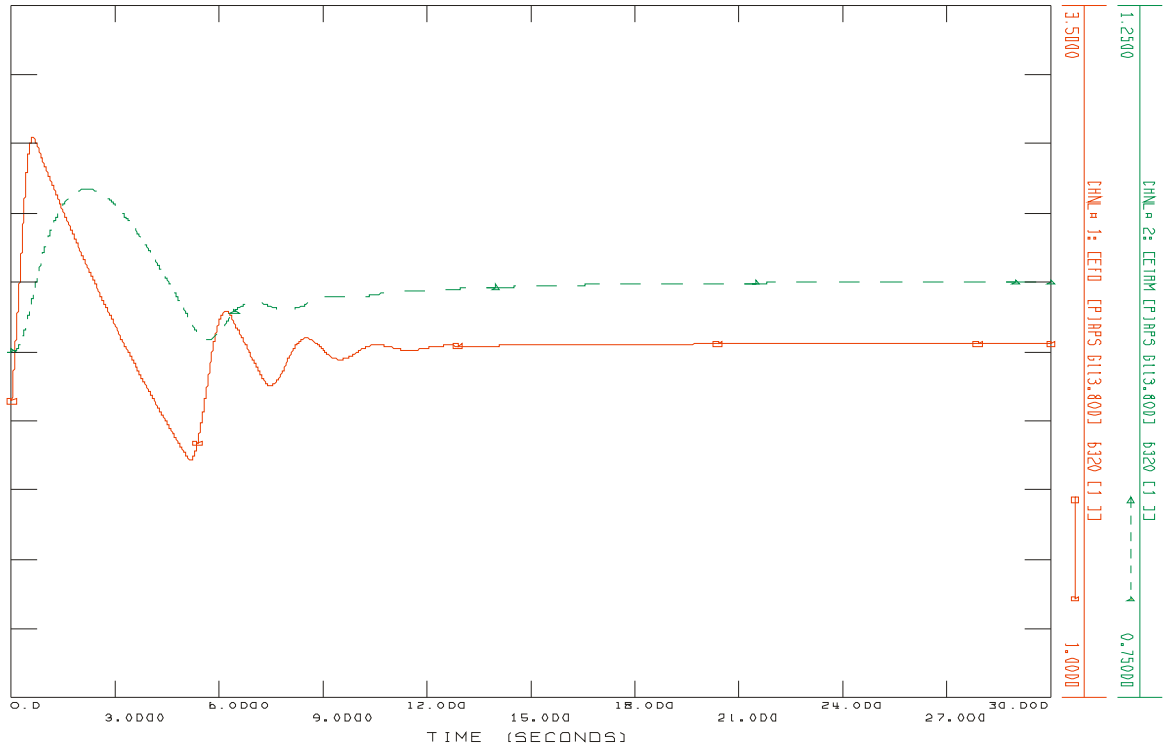


Figure 3. Open Circuit Test Results

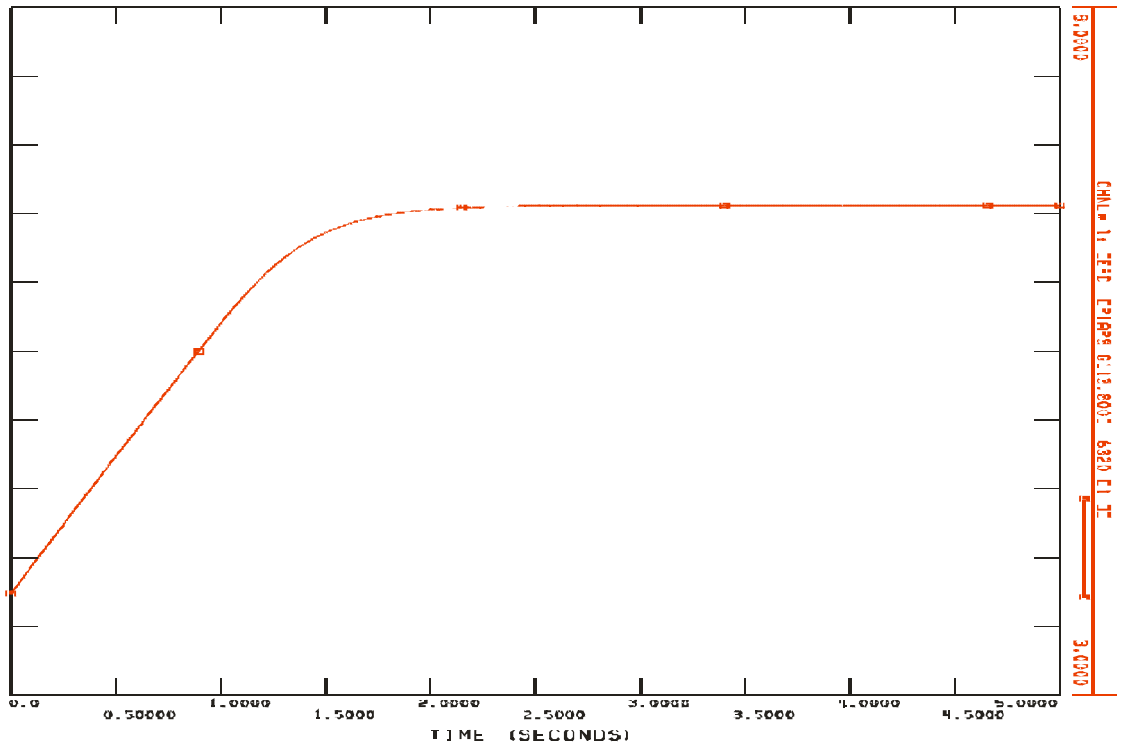


Figure 4. Response Ratio Test Results

Examination of the plots indicates that the exciter has a stable performance. It should be noted in the simulations the exciter field proportional constant, K_E, is set to 0 instead of 1 as shown in Table 1. The applicant noted that parameters (K_P, K_I, K_D, and T_D) will be adjusted at commissioning tests.

The Market Rules require in Reference 12 of Appendix 4.2, that synchronous generator units higher than 10 MVA be equipped with an excitation system with:

- A voltage response time not longer than 50 ms for a voltage reference step change not to exceed 5%;
- A positive ceiling voltage of at least 200% of the rated field voltage, and
- A negative ceiling voltage of at least 140% of the rated field voltage.

The study results show that the new generators are to be equipped with excitation systems that do not meet Market Rules requirements

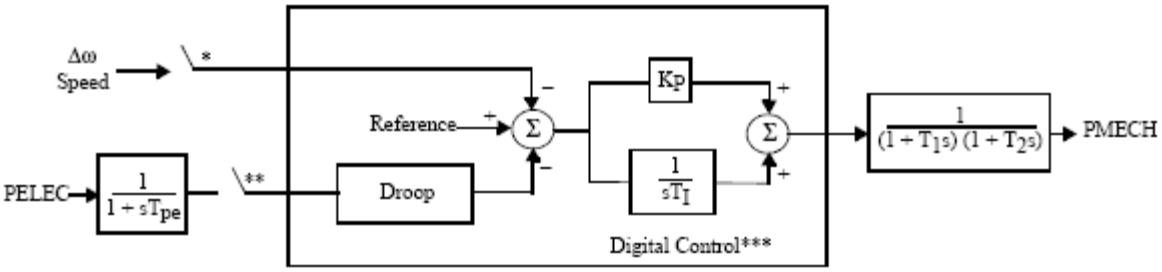
4.3 Governor

The parameters and the block diagram of the PSS/E model of the speed governor used for the simulations are provided by the connection applicant. This model is a standard PSS/E Westinghouse digital governor model for gas turbine. The model and corresponding parameters are shown in Table 2 and Figure 5.

Table 2. Parameters for Governor

CONs #	Value	Description
J	0.1	Δt sample for controls, ΔTC (sec)
J+1	0.04	Δt sample for P_E, ΔTP (sec)
J+2	5%	Droop

J+3	0.125	Kp
J+4	16	TI(>0.) (sec)
J+5	0.1	T1(sec)
J+6	0.25	T2 (sec)
J+7	1%	A_{LIM}
J+8	0.04	Tpe (sec)



*Sample hold with sample period defined by ΔTC.
**Sample hold with sample period defined by ΔTP.
***Maximum change is limited to A_{LIM} between sampling times.

Figure 5. Block Diagram for Excitation System

Dynamic simulations were performed to examine the transient response of the governor. In this study, the generator was initially loaded to 0.8 pu and a power factor of 1. At time t = 0 s the load supplied by the generator was increased to 0.9 pu. The results of the governor response test to this 0.1 step change in reference load are displayed in Figure 6. Figure 6 shows a plot of both the speed deviation in per unit and the generator's mechanical power in per unit on the machine's MVA base as a function of time. Examination of the plots indicates that the governor reached steady-state in approximately 100 s and the steady state values for speed deviation was approximately 0.005 pu which corresponds to a droop of 5%.

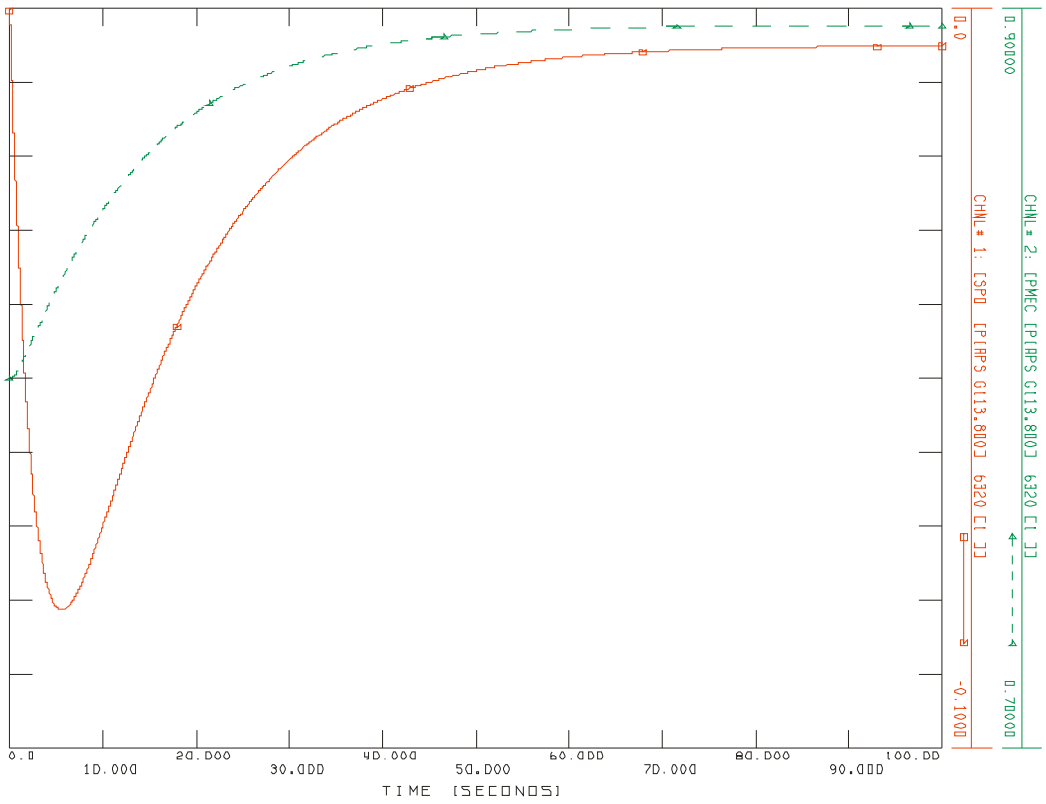


Figure 6. Simulation Results for Governor

It can be seen that the droop of the governor meets the requirements for governors listed in Reference 16 of Appendix 4.2 in Market Rules: the governor shall have a permanent speed droop that can be set in the range between 3% and 7%.

4.4 Step-up Transformer

Technical specifications of the step-up transformer provided by the connection applicant are listed as follows:

Transformation	234/13.1 kV
Continuous rating	37.5/50/62.5 MVA
Impedance	11.25% based on 37.5 MVA
Configuration	3 phase, High side: wye, Low voltage side: delta
Tapping	off-load tap changers at HV (224, 229, 234, 239, 244 kV)

The Market Rules requirement to be able to produce rated power output at a set value for the voltage on the HV system by varying the terminal voltage by ± 5%, effectively limits the impedance of the connection to the IESO-controlled grid maximum of about 13%, based on the MVA rating of the generating facility. As indicated by OPGI during the generation mode only one generation unit will be in service and the remaining one will stay in emergency mode. The equivalent impedance of the step-up transformer on the MVA rating of the generating facility (42.2 MVA, i.e., 38 MW at 0.9 pf) is 12.66% and thus meeting Market Rules requirements.

4.5 HV Breaker

Specifications for the new 230 kV circuit breaker are listed as follows:

Type	SF_6
Rated Voltage	250 kV (Maximum)
Rated Continuous Current	1200 A rms
Rated interrupting capability	63 kA (symmetrical)
Rated Interrupting time	3 cycles (maximum)

The Fault Levels specified in Appendix 2, Transmission System Connection Point Performance Standards, indicate 63 kA for a nominal voltage of 230 kV. The interrupting capability of the new switcher meets the requirements as specified in Transmission System Code.

4.6 HV Disconnect Switch

Specification for the new 230kV disconnect switch:

Maximum operating voltage	250 kV continuous
Basic Insulation Level	900 kV
Current Rating	1200 A continuous
Operating mechanism	Motorized

4.7 Power System Stabilizer

OPG did not provide any information on power system stabilizer (PSS). PSS is not required in this project since the APS generation units are only backup power sources.

According to the Market Rules, a synchronous generation unit (10 MVA or higher) should be equipped with a power system stabilizer. The installed PSS shall, to the extent practicable, be tuned to increase damping torque without reducing synchronizing torque. Therefore, it is required to install PSSs on the two generation units before they are put in commercial service.

4.8 Other Requirements

Before the APS units would be allowed to operate normally connected to the IESO-controlled grid other requirements need to be met such as on-line monitoring requirements, protection system requirements and under frequency tripping requirement, etc.

5. Fault Level Assessment

Fault level studies were completed by Hydro One to specifically examine the effect of the Pickering APS generation project on fault levels at existing facilities.

Table 3 summarizes the fault levels including 3-phase and line-to-ground (L-G) near the Pickering APS.

Table 3 Fault levels near Pickering APS

Bus	Symmetrical Fault (kA)*		Breaker Lowest Ratings (kA)**
	3-phase	(L-G)	
Existing system			
Pickering 230 kV	42.09	46.79	59
Cherrywood 500 kV	52.47	50.84	96
Cherrywood 230 kV	50.70	54.97	65
Dobbin 230 kV	7.40	8.20	13
Leas 118 kV	43.04	48.71	50
System with Pickering APS project			
Pickering 230 kV	42.33	46.84	59
Cherrywood 500 kV	52.64	50.94	96
Cherrywood 230 kV	50.82	55.06	65
Dobbin 230 kV	7.40	8.20	13
Leas 118 kV	43.11	48.78	50

* Based on a pre-fault voltage level of 550 kV for the 500 kV system, 250 kV for the 230 kV system and a pre-fault level of 127 kV for the 115 kV system.
** Worst case rating.

The results in Table 3 generally show that there is a slight increase in fault currents with the addition of the Pickering APS. However, the fault levels do not exceed the interrupting capabilities of the worst rated breakers.

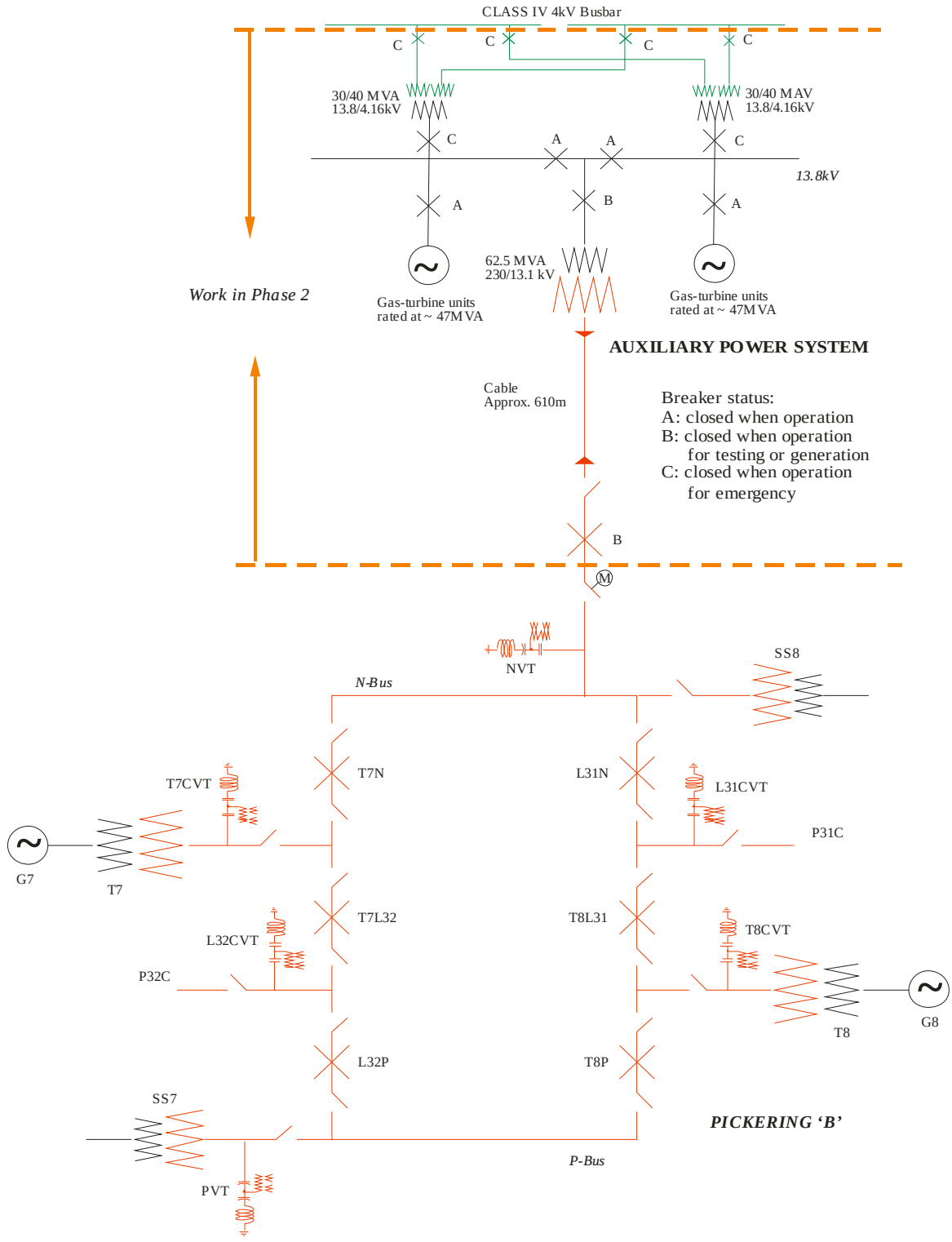


Figure 1. Proposed Connection of Pickering APS Project