ANDREWS 115 KV SUB-STATION - UPGRADE
IESO EXPEDITED SYSTEM IMPACT ASSESSMENT – CAA ID 2005-EX248

PROJECT DESCRIPTION

Gartshore GS is located north of Sault Ste. Marie in the vicinity of Montreal River. The station collects the power output from three hydraulic plants; Gartshore GS consisting of one 12 kV generating unit with rated output of 22 MVA, Hogg GS consisting of one 12 kV generating unit with rated output of 16 MVA and Andrews GS consisting of three generating units with rated output of 11 MVA, 11 MVA and 32 MVA respectively. The combine output of the three hydraulic plants is injected into Mackay 115 kV bus via two 115 kV circuits designated as No.1 Gartshore and No.2 Gartshore.

Currently, each of the three Andrews units has its own step-up transformer. The owner of the station, Brascan Power Corporation intends to retire the existing step-up transformers of G1 and G2, and install a new single step-up transformer for both G1 and G2, associated air break disconnect switches and a breaker.

The IESO performed an expedited System Impact Assessment, and identified following requirements.

SUMMARY OF REQUIREMENTS

Prior to placing the new equipment in-service, the proponent is required to demonstrate to the IESO the compliance with applicable requirements of Appendix 4.2 of the Market Rules and those given below.

1. The registration of new equipment will need to be completed through the IESO's facility registration process before the new equipment can be placed in-service. The proponent is required to ensure that the performance of the equipment that is installed meets or exceeds the predicted performance observed in this System Impact Assessment.

2. The Market Rules require that for northern Ontario, the equipment with 115 kV nominal rating must have the capability to operate continuously at system voltages between 113 kV and 132 kV. The proponent must confirm whether the 115 kV winding of the new transformer and all new interrupting devices comply with this standard.

3. The Transmission Code requires that all 115 kV equipment to be rated to 50 kA for phase to ground and 3-phase fault level. The rated 3-phase short circuit level of the proposed breaker is only 40 kA. If any future system modification will result in an increase of the short circuit level in the area beyond 40 kA, the proponent will be required to replace the breaker with a higher rated unit.

4. The proponent is required to provide the data for the new disconnects switches.

5. The proponent is responsible for ensuring that adequate real-time telemetering of variables as described in Appendix 4.15 and 4.16 of the Market Rules are available to the IESO. This will include the status of the new 115 kV breaker and disconnect switches, and active and reactive power flows over the new step-up transformer. The real-time telemetry detailed requirements will be determined during the Facility Registration process.

6. After commissioning the new transformer, the generators G1 and G2 must continue to have the capability to supply at their terminals their entire range of reactive power for at least one constant voltage at the connection point.

NOTIFICATION OF APPROVAL

It is recommended that a *Notification of Approval for Connection* be issued for this project subjected to implementation of the requirements given above.

If the new equipment either does not meet the specified performance standard when installed, or are subsequently determined not to meet those performance standards, the IESO connection approval may be withdrawn until the specified performance standards, or their equivalent can be demonstrated.

ANDREWS 115 KV SUB-STATION - UPGRADE
EXPEDITED SYSTEM IMPACT ASSESSMENT REPORT – CAA ID 2005-EX248

1.0 INTRODUCTION

Andrews GS is located northwest region of Ontario in the vicinity of Montreal River and is equipped with two identical 12 kV, 11 MVA and one 12 kV, 32 MVA hydraulic generators. The generating facility is connected to Gartshore GS 115 kV bus which in turn connects to Mackay TS via two 115 kV circuits. The present connection arrangement of Andrews generating units to the Mackay TS is shown in Figure 1A.

Currently, each of the generators has its own step-up transformer. The owner of the station, Brascan Power Corporation has informed the IESO that they will replace the existing step-up transformers of G1 and G2 with a new single step-up transformer and the two oil circuit breakers CB1 and CB2 with a new SF6 breaker CB3 as shown in Figure 1B.

The 12 kV and 115 kV disconnect switches located on either side of the step-up transformers will also be replaced with new air break switches. In addition, a new transformer protection will be installed and the revenue meter will be relocated between the common 115 kV bus and the new circuit breaker CB3.

The energization of the new equipment is scheduled for April 7, 2006.

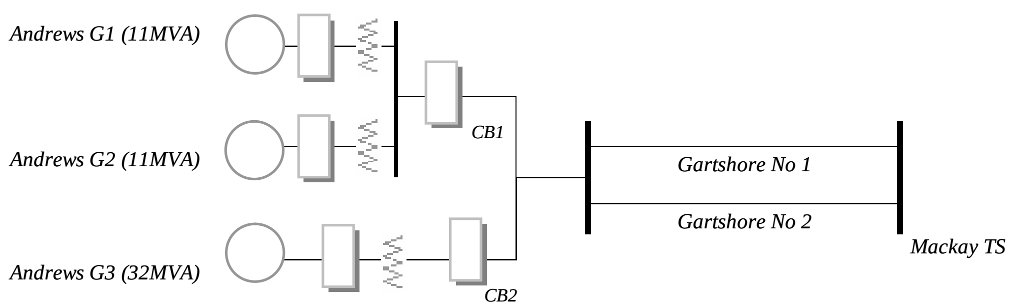


FIGURE 1A : CURRENT ARRANGEMENT IN ANDREWS GS

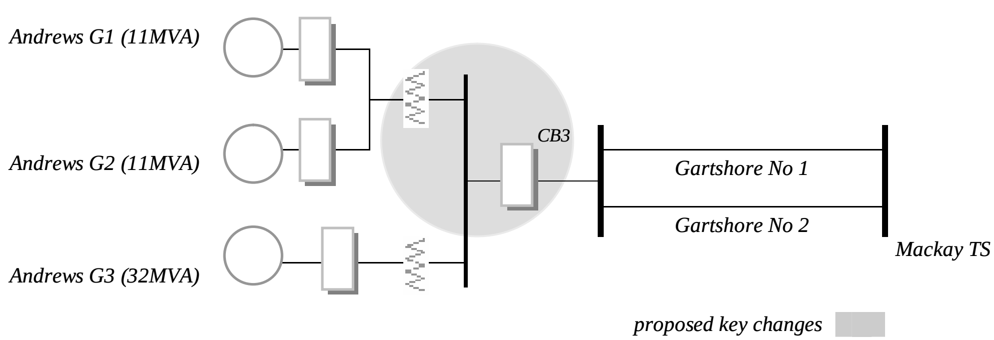


FIGURE 1B : PROPOSED ARRANGEMENT IN ANDREWS GS

2.0 MODELS

(a) Transformer

The proponent has indicated that the new step-up transformer will not have automatic ULTC, but will be equipped with an off-load tap changer.

The following data have been made available to the IESO at the time of this System Impact Assessment. If any of the data are inaccurate, the applicant should provide the correct data to the IESO prior to the completion of IESO's facility registration process.

Voltage Ratio	115/11 kV wye/delta connection
Rating	21/28/35 MVA ONAN/ONAF/ONAF summer continuous 24/31/38 MVA ONAN/ONAF/ONAF winter continuous
Impedance	0.0029 + j 0.085 pu on 21 MVA base
Off-Load Tap Changer Range	9 HT taps (center tap + four 2.5 % kV taps above + four 2.5 % kV taps below)

According to the data available to the IESO, the equivalent impedance of the two existing step-up transformers for G1 and G2 is 0.0405 + j0.4872 pu on 100 MVA base. On the same base, the impedance of the new single step-up transformer is 0.0138 + j0.4047 pu. Although the new step-up transformer appears to have a lower impedance than the existing equivalent, while this is better for the stability and for the voltage control, this change would slightly increase the line-ground fault level in the area. However, the increase is considered to be immaterial.

The impedance of the proposed transformer on machine MVA base is adequate to allow G1 and G2 to continue to supply at their terminals their entire range of reactive power for at least one constant voltage at the connection point.

The Market Rules also require that for northern Ontario, the equipment with 115 kV nominal rating must have the capability to continuously operate at 132 kV. The proponent must confirm whether the 115 kV winding and the accessories of the new transformer comply with such a standard.

(b) Circuit Breaker and Disconnects

The data for the new 115 kV circuit breaker is given below. The proponent is required to provide data associated with new disconnects.

Circuit Breaker		*Disconnect Switches*	
Rated voltage	145 kV	Nominal voltage	-
Interrupting time	50 ms (3 cycles)	Rated continuous current	-
Interrupting media	SF6	Rated shorted term current	-
Rated continuous current	2000 A		
Rated symm. short circuit capability	40,000 A		

The Transmission Code requires that all 115 kV equipment to be rated to 50 kA for single line to ground fault and 3-phase fault level, and the circuit breakers to have 5 cycles or less interrupting time.

While the interrupting time of the new breaker complies with the code, the rated symmetrical short circuit level of the proposed breaker is only 40 kA. If future system modification will result in an increase of the short circuit levels in the area beyond 40 kA, the proponent will be required to replace the breaker with a higher rated unit.

3.0 COMPUTER ANALYSIS

Andrews G1 and G2 are identical machines. Kestrel Engineering provided following *revised* GENSAL generator dynamic model data for those two machines.

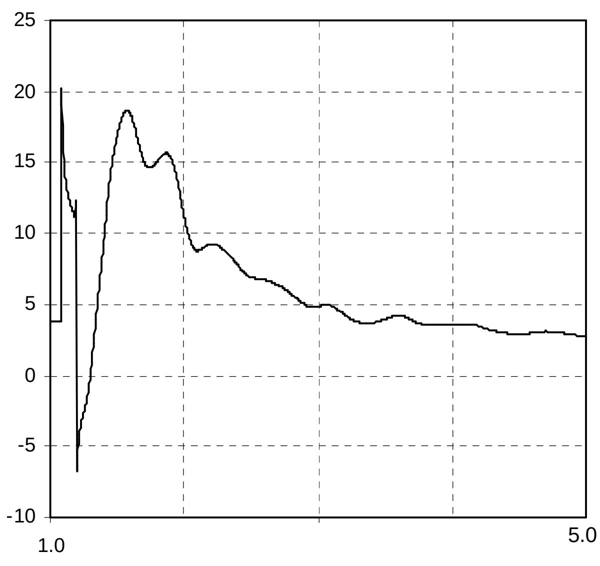
X_d = 1.286	X_q = 0.72	X'_d = 0.39	H = 2.36	X_l = 0.1	T'_{do} = 4.060
X''_d = 0.275	D = 0.0	S(1.0) = 0.126	S(1.2) = 0.571	T''_{qo} = 0.035	T''_{do} = 0.037

Each generator is equipped with identical excitation systems, stabilizers and governors. The respective PSS/E models are ESST1A, PSS2A, and WEHGOV. There is no change in these control model data.
Given that at post-contingency, the Gartshore GS may have only a single radial connection to Mackay TS, it is necessary to examine the transient stability of the Andrews generators with the new level of connection impedance. Thus, a *3-phase fault* was simulated in one of the Gartshore 115 kV circuits.

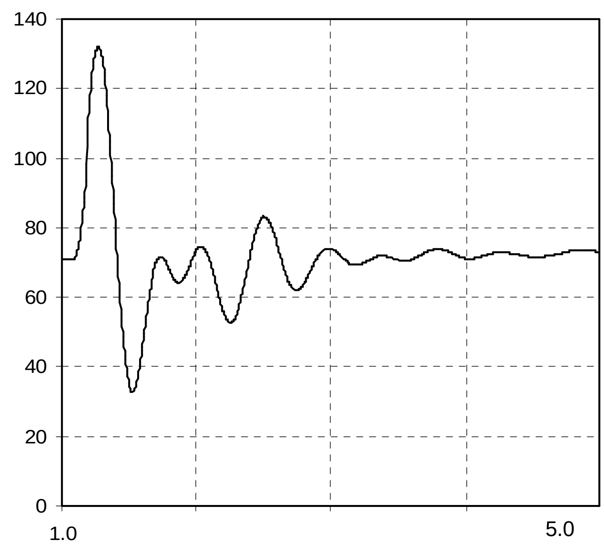
A *3-phase fault* is more severe than the standard line-to-ground normally used to test the performance of generators in northwest region of the IESO-controlled grid. However, the performance of generators under any less severe fault than simulated would be less impactive to the IESO-controlled grid.

The pre-contingency data used for computer simulations reflected 2005 summer peak conditions with all transmission elements in service and with Andrews unit outputs G1=9 MW, G2=9 MW and G3=25 MW. These outputs include 10% additional injections from registered maximum values in order to test the unit stability at a stressed level. The new 230 kV transmission reinforcement in GLP and the new Prince Park wind farm has been included in the data base.

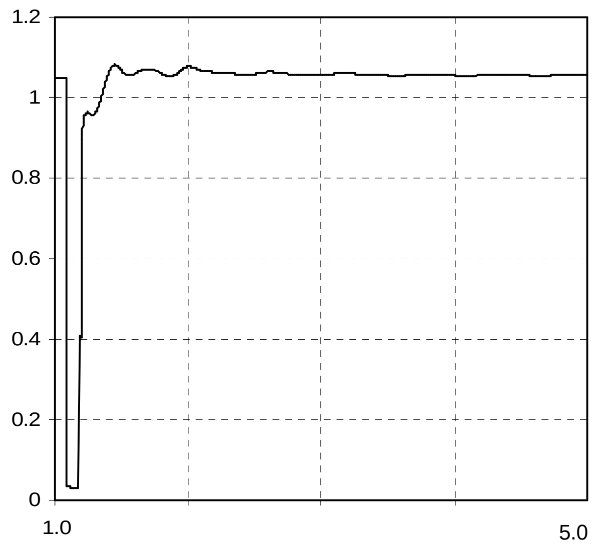
The projected variations in Andrews G1 (or G2) rotor angle, Andrews G1+G2 reactive power output, Andrews 115 kV voltage and the reactive loss occurring in the new transformer are shown below.



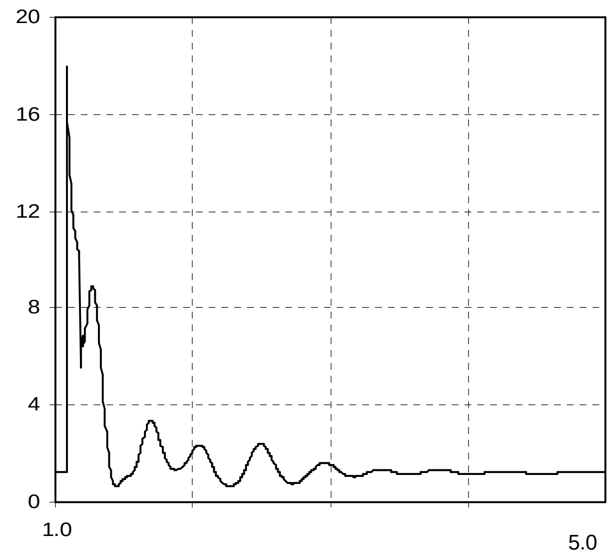
REACTIVE POWER OUTPUT OF ANDREWS G1+G2



ROTOR ANGLE OF ANDREWS G1 OR G2



ANDREWS 115 KV VOLTAGE



Q LOSS IN NEW TRANSFORMER

Observations:

The results of the transient stability studies show that the post-fault transients of the rotors appear to be sufficiently damped. Therefore, the impedance of the proposed transformer does not seem to have any detrimental effect on the stability of the generators.

Further, the initial transient surges/drops are expected to be shorter than shown above for line-to-ground faults that are normally used to test the performance of generators in northwest region of the IESO-controlled grid.

4.0 MONITORING REQUIREMENT

The status of the new breaker and all new disconnects and the active and reactive power flows over the new transformer should be monitored and made available to the IESO on a continuous basis via the on-line monitoring facilities that are required in accordance with Appendix 4 of the Market Rules.

The telemetry of the associated with the equipment that is retained must continue to be made available to the IESO control center.

5.0 CONCLUSIONS

Presently, the three step-up transformers in Andrews GS are accompanied by two 115 kV breakers. Thus, for a transformer fault, only a part of the generation would be lost. However, with the proposed arrangement, there would be only a single 115 kV breaker and this would increase the exposure for loss of entire generating station for a fault at a transformer or any local 115 kV busbar. Since, traditionally the fault incident rate for transformers and buses has been very low, the proposed installation of the new transformer is not expected to have any material impact on the reliability of the IESO-controlled grid.

The new step-up transformer impedance is slightly lower than the existing equivalent. This is better for the stability and for the voltage control, but would marginally increase the line-ground fault level. The change in fault levels is considered immaterial.

Based on this assessment, it is concluded that there is no further analysis is required for this installation. The proposed installation of the new transformer, the breaker and disconnect switches is not expected to have any adverse material impact on the reliability of the IESO-controlled grid.