REPORT

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System Impact Assessment Report (Addendum)

CONNECTION ASSESSMENT & APPROVAL PROCESS

Addendum

CAA ID: **2010-394**
Project: **Kapuskasing/Ivanhoe**
Applicant: **Xeneca Limited Partnership**

Market Facilitation Department
Independent Electricity System Operator

Date: January 10th, 2014

Document ID	CAA 2010-394
Document Name	System Impact Assessment Report (Addendum)
Issue	Addendum
Reason for Issue	First Issue
Effective Date	January 10th, 2014

System Impact Assessment Report (Addendum)

Acknowledgement

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

Disclaimers

IESO

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

Conditional approval of the proposed connection is based on information provided to the IESO by the connection applicant and Hydro One 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 Hydro One at the request of the IESO. Furthermore, the conditional approval is subject to further consideration due to changes to this information, or to additional information that may become available after the conditional approval has been granted.

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

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

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

Hydro One

The results reported in this report are based on the information available to Hydro One, at the time of the study, suitable for a System Impact Assessment of this 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 facilities on load and generation customers.

In this report, short circuit adequacy is assessed only for Hydro One circuit breakers. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One circuit breakers and identifying upgrades required to incorporate the proposed facilities. These results should not be used in the design and engineering of any new or existing facilities. The necessary data will be provided by Hydro One and discussed with any connection applicant 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 project 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 facilities have been identified to the extent permitted by a System Impact Assessment under the current IESO Connection Assessment and Approval process. Additional project 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.

1. Notification of Conditional Approval

Xeneca Limited Partnership (the "connection applicant") is proposing to construct a new 27.44 MW hydroelectric generating project named Kapuskasing/Ivanhoe (the "project") in northeastern Ontario. The project will consist of several separate hydroelectric generation sites connected via one common connection to Hydro One's 115 kV circuit T61S, through a 115 kV- 69 kV network. The individual sites have been awarded Power Purchase Agreements under the Feed-In Tariff (FIT) program with the Ontario Power Authority. The project in-service date is November, 2015.

The original SIA examined the connection of six individual sites called Ivanhoe The Chutes GS (3.6 MW), Ivanhoe River Third Falls GS (5.1 MW), Near North Boundary GS (3.75 MW), Middle TWP GS (5.0 MW), Lapinigam Rapids GS (8.2 MW) and Outlet Kapuskasing Lake GS (1.79MW). Recently, the connection applicant has modified their design to remove the Outlet Kapuskasing GS site entirely from the project while increasing the output of the Lapinigam Rapids GS site to 9.99 MW. The connection applicant has also changed the generation technology of the Ivanhoe The Chutes GS, Ivanhoe River Third Falls GS, Near North Boundary GS and Middle TWP GS sites from traditional salient pole synchronous machines to permanent magnet generators connected through a full converter system. Since there is no change in the total active power output from the project, this assessment only examines the impact of these proposed changes with respect to the amount of reactive power compensation required at the facility to meet IESO Market Rules requirements and the transient performance of the newly proposed generators.

This assessment concludes that the proposed changes are expected to have no material adverse impact on the reliability of the integrated power system. Therefore, the IESO recommends that a *Notification of Conditional Approval for Connection* be issued for the Kapuskasing/Ivanhoe project subject to implementation of the requirements outlined in this report and the original SIA report.

2. IESO Requirements for Connection

Applicant Requirements

(1) The connection applicant is required to install an excitation system, power system stabilizer and governor equipment at Lapinigam Rapids GS which conform to IESO Market Rules and perform at least as well as the models used for this report. The synchronous generator located at the Lapinigam GS site must have an inertia constant of at least 1.3 with all other generator parameters values at least as good as what was assessed in this addendum. The connection applicant must provide valid dynamic simulation models for the equipment at all sites to confirm equipment performance.

(2) The project is required to have the capability to inject or withdraw reactive power continuously (i.e. dynamically) at the connection point up to 33% of its rated active power at all levels of active power output.

Based on the revised equipment parameters provided by the connection applicant, the project has a slight reactive power deficiency of +2 MX. Given the small size of the deficiency and that prevailing voltages in the local area are high the IESO deems the reactive power capability of the project adequate. No static reactive compensation devices are required to be installed.

The connection applicant has the obligation to ensure that the project has the capability to meet the Market Rules requirement at the connection point and be able to confirm this capability during the commission tests.

All other specific and general requirements as outlined in the original SIA remain the same.

Transmitter Requirements

All specific and general transmitter requirements are listed in the original SIA.

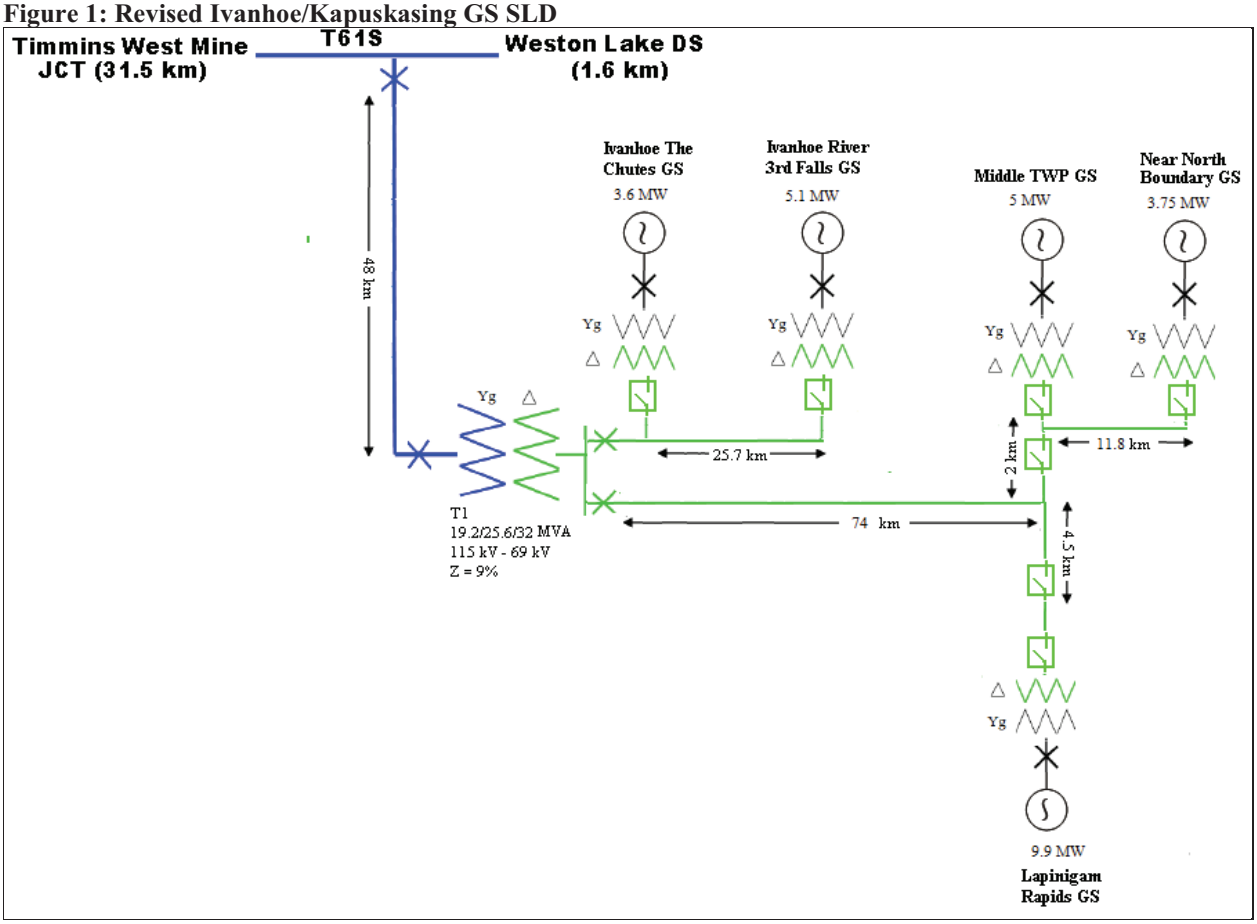
Due to the uncertainty of the in-service date of the Timmins Asset Replacement Project (CAA 2013-EX645), Transmitter Specific Requirement (3) from the original SIA report is still applicable with the updated required fault clearing times listed in this addendum report. This requirement can be implemented either through separate system upgrades or through the Timmins Asset Replacement Project, as long as protection upgrades are implemented prior to the connection of the Kapuskasing/Ivanhoe GS project. The conclusions and study results of this report have been based on the completion of those protection upgrades.

3. Assessment

Connection Arrangement

The following is the revised SLD showing the updated connection arrangement of the project:

Figure 1: Revised Ivanhoe/Kapuskasing GS SLD



Equipment Parameters

The following is the updated generator information for the project:

Table 1: Updated Generator Information

Site	Technology	Rated kV	Rated MVA	Rated MW	Output Limit MW	Transformer		
						MVA	R (%)	X (%)
Ivanhoe The Chutes GS	PMG w/ full converter	3	7	5.1	3.6	4	0.5	6
Ivanhoe River 3rd Falls GS	PMG w/ full converter	3	7	5.1	5.1	5.7	0.46	6.5
Near North Boundary GS	PMG w/ full converter	3	7	5.1	3.75	4.5	0.49	6.2
Middle TWP GS	PMG w/ full converter	3	7	5.1	5	6	0.45	6.7
Lapinigam Rapids GS	Salient Pole Synchronous	13.8	11.9	10.7	9.99	12	0.38	6

All converter sites will be equipped with Andritz ECObulb generators with the same GE MV7306 converter, which has a maximum output capacity of 5.1 MW. However, the generators will all be output limited to their contracted MW amounts.

No excitation system, power system stabilizer or governor models have been provided by the connection applicant for the Lapinigam Rapids GS site. For the purposes of transient studies, the connection applicant has agreed to use a typical PSS/E exciter and power system stabilizer model that would marginally meet IESO performance requirements. The connection applicant is required to install an excitation system and power system stabilizer which conform to IESO Market Rules and perform at least as well as the models used for these simulations. For conservatism, no governor models were assumed for this assessment. The connection applicant is required to install a governor which conforms to IESO Market Rules.

The following are the updated generator model and the assumed generator controls models for the Lapinigam Rapids GS site. The proposed generator must have an inertia constant of at least 1.3 to ensure the conclusions of the rest of this report still hold.

Table 2: Lapinigam Rapids GS GENSAL, EXST1, PSS2A PSS/E Models

Model	T'do	T''do	T''qo	H	D	Xd	Xq	X'd	X''d	Xl	S(1.0)	S(1.2)
GENSAL	2.96	0.042	0.045	**1.3**	0	1.382	0.859	0.467	0.304	0.207	0.071	0.212

Model	Tr	Vimax	Vimin	Tc	Tb	Ka	Ta	Vrmax	Vrmin	Kc	Kf	Tf
EXST1	0	999	-999	1.0	1.0	200	0.01	4.6	-3.2	0.08	0	0

Model	TW 1/2/3	T6	T4	T7	KS2	KS3	T8	T9	KS1	T1/T3	T2/T4	Vmax	Vmin
PSS2A	10	0	0	10	3.85	1	0.5	0.1	10	0.07	0.02	0.05	-0.05

All other project information including line impedances, circuit breakers, disconnect switches and the 115/69 kV transformer details remain identical to what was assessed in the original SIA.

Reactive Power Compensation

The Market Rules (MR) require that generators inject or withdraw reactive power continuously (i.e. dynamically) at a connection point up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the IESO. A generating unit with a power factor range of 0.90 lagging and 0.95 leading at rated active power connected via impedance between the generator and the connection point not greater than 13% based on rated apparent power provides the required range of dynamic reactive capability at the connection point.

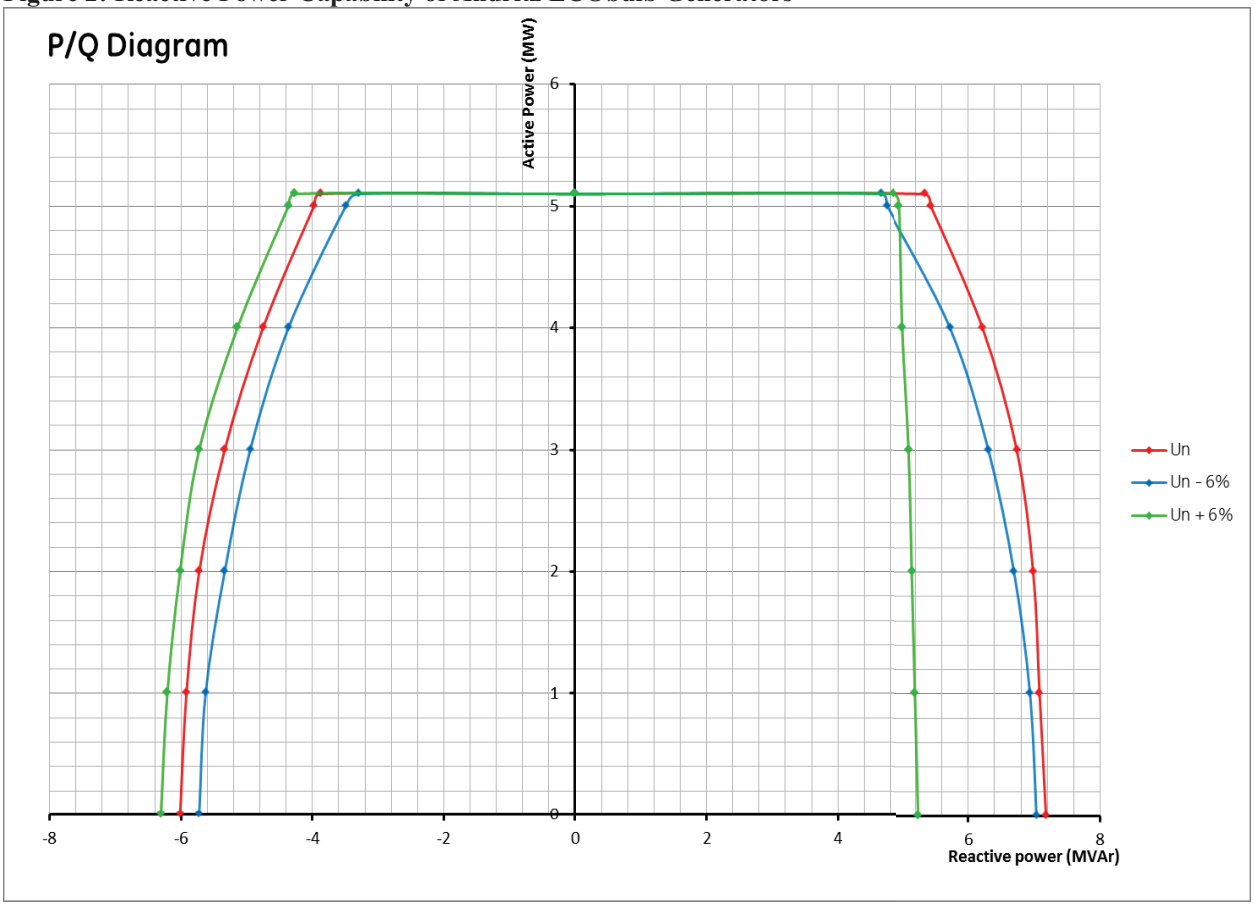
Dynamic reactive compensation (e.g. D-VAR or SVC) is required for a generating facility which cannot provide a reactive power range of 0.90 lagging power factor and 0.95 leading power factor at rated active power. For a facility with impedance between the generator and the connection point greater than 13% based on rated apparent power, provided the generators have the capability to provide a reactive power range of 0.90 lagging power factor and 0.95 leading power factor at rated active power, the IESO accepts that the facility compensates for excessive reactive losses in the collector system of the project with static shunts (e.g. capacitors and reactors).

This SIA Addendum proposes a solution for the project to meet the MR requirements on reactive power capability. However, the applicant can deploy any other solutions which result in its compliance with the MR. The applicant shall be able to confirm this capability during the commission tests.

Dynamic Reactive Power Capability

The reactive power capability curve for the Andritz ECObulb generators is shown in Figure 2. The converters are able to provide more than 0.9 lead - lag power factor for all levels of active power output, therefore their dynamic reactive power capability is sufficient. The salient pole synchronous machine used for the Lapinigam GS site can operate between 0.9 lead to lag for all levels of active power output, therefore its dynamic reactive power capability is also sufficient. No additional dynamic reactive power resources are required.

Figure 2: Reactive Power Capability of Andritz ECObulb Generators



Static Reactive Power Capability

In addition to the dynamic reactive power requirement identified above, the project has to compensate for the reactive power losses within the project to ensure that it has the capability to inject or withdraw reactive power up to 33% of its rated active power at the connection point. As mentioned above, the IESO accepts this compensation to be made with switchable shunt admittances.

Load flow studies were performed to calculate the static reactive compensation, based on the equivalent parameters provided by the connection applicant for the facility.

The IESO's reactive power calculation used the equivalent electrical model for the generators and collector feeders as provided by the connection applicant. It is very important that the project has proper internal design to ensure that the generators are not limited in their capability to produce active and reactive power due to terminal voltage limits or any other facility's internal limitations.

The reactive power capability in lagging power factor of the project was assessed under the following assumptions:

- typical low voltage of 121 kV at the connection point;
- maximum active power output from each hydroelectric machine;
- the main step-up transformer ULTC is available to adjust the 69 kV secondary voltage as close as possible to 1.00 pu voltage;
- Reactive power capability of converter sites assumed to be 0.9 PF of maximum active power capability;
- Reactive power capability of Lapinigam Rapids site taken from its generator capability curve;

The following table summarizes the study results:

Table 3: Project Lagging Power Factor Capability

Generator	Generator Terminal Voltage (pu)	Generator Output (MX)	Generator Transformer Windings
Ivanhoe The Chutes GS	1.06	+3.4	69/3 kV
Ivanhoe River 3rd Falls GS	1.06	+3.6	69/3 kV
Near North Boundary GS	1.06	+0.3	69/3 kV
Middle TWP GS	1.06	+0.5	69/3 kV
Lapinigam Rapids GS	1.07	+3.1	69/13.8 kV
Total Facility Output (including losses in the 69kV collector system)			+7.4 MX

The reactive power capability in leading power factor of the project was assessed under the following assumptions:

- typical high voltage of 127 kV at the connection point;
- minimum (zero) active power output from each hydroelectric machine;
- the main step-up transformer ULTC is available to adjust the 69 kV secondary voltage as close as possible to 1.00 pu voltage;
- Reactive power capability of converter sites assumed to be 0.9 PF of maximum active power capability;
- Reactive power capability of Lapinigam Rapids site taken from its generator capability curve;

The following table summarizes the study results:

Table 4: Project Leading Power Factor Capability

Generator	Generator Terminal Voltage (pu)	Generator Output (MX)	Generator Transformer Windings
Ivanhoe The Chutes GS	0.94	-3.3	69/3 kV
Ivanhoe River 3rd Falls GS	0.94	-3.7	69/3 kV
Near North Boundary GS	0.94	-0.9	69/3 kV
Middle TWP GS	0.94	-1.2	69/3 kV
Lapinigam Rapids GS	0.93	-4.3	69/13.8 kV
Total Facility Output (including losses in the 69kV collector system)			-10.0 MX

Based on the equivalent parameters for the project as provided by the connection applicant and the study results provided in Tables 3 and 4, the project has a slight reactive power deficiency of +2MX. Given the small size of the deficiency and that prevailing voltages in the local area are high, the IESO deems the reactive power capability of the project adequate. No static reactive compensation devices are required to be installed.

Voltage Control System

As per the Market Rules requirements, the project shall operate in voltage control mode by using all voltage control methods available within the project. The automatic voltage regulation philosophy for the project is summarized as follows:

(1) All generation sites control the voltage at a point whose impedance (based on rated apparent power and voltage of the projects) is not more than 13% from the connection point. Appropriate control slope is adopted for reactive power sharing among the generators as well as with adjacent generators. The reference voltage will be specified by the IESO during operation.

(2) The main transformer ULTC is adjusted, manually or automatically, to regulate the collector bus voltage such that it is within normal range and close to about 1.00 pu. The IESO may require automatic control for this ULTC if manual adjustment is too slow.

In the event that the solar farm voltage control becomes unavailable, the IESO requires that each generator operate in reactive power control and maintain its reactive power output to the value prior to the loss of signal from the solar farm voltage control. Depending on system conditions, further actions such as curtailing the output of the project may be required for reliability purposes

Transient Stability Performance

The transient stability analysis was repeated to determine if the power system will remain transiently stable after the incorporation of the updated project parameters. The study was completed under the same study assumptions outlined in the original SIA, but included the impacts of the Timmins TS Asset Replacement Project (CAA 2013-EX645) and revised NERC Transmission Planning Criteria. As part of the Timmins TS Asset Replacement project, existing teleprotections for P13T and P15T will be upgraded resulting in shorter remote end fault clearing times. Revised NERC Transmission Planning Criteria require all local area systems to withstand 3 phase faults with regular fault clearing. The studied contingencies are summarized in Table 5.

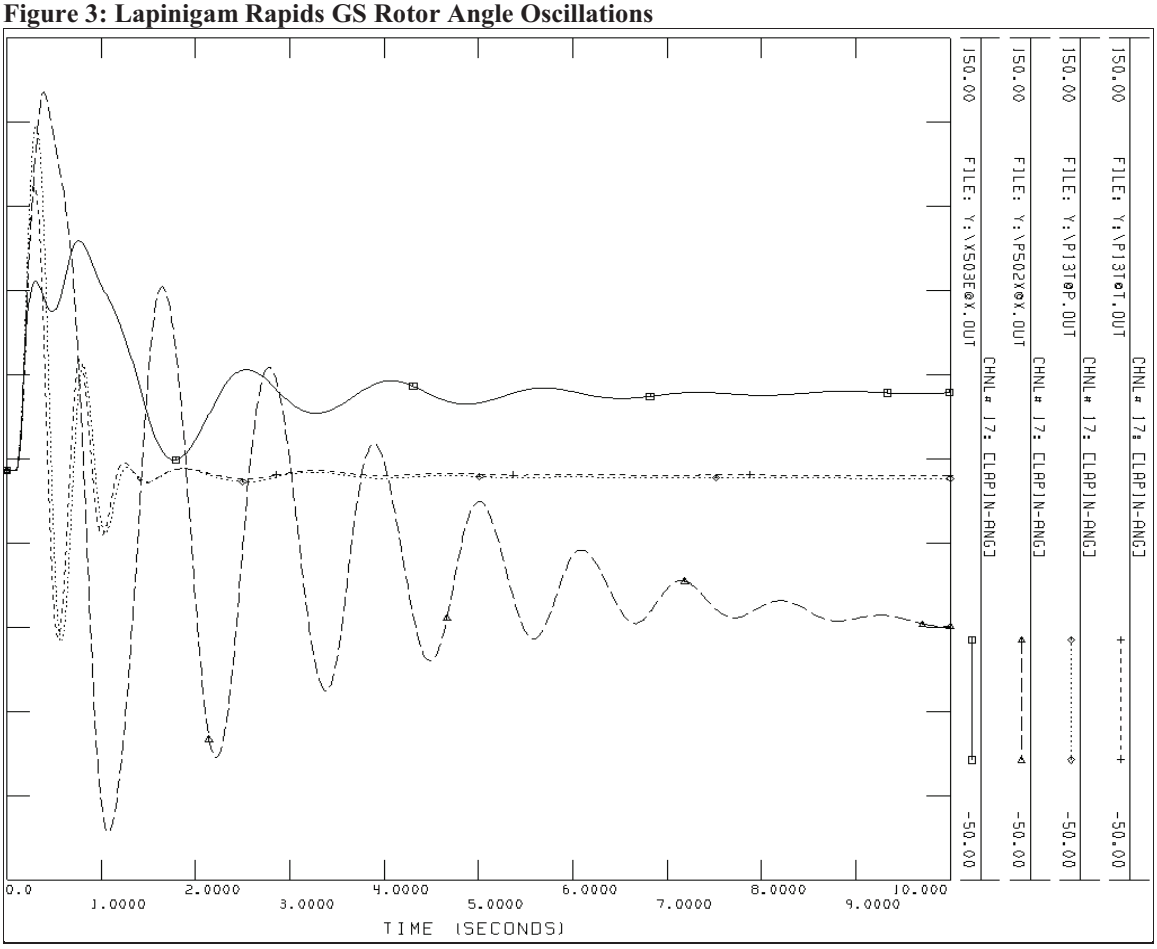
Table 5: Simulated Contingencies for Transient Stability Analysis

ID	Contingency	Location	Fault MVA	Fault Clearing Time (ms)	
				Local	Remote
C1	X503E	Hanmer	3 Phase	70	70
C2	P502X	Hanmer	3 Phase	66	91
C3	P13T	Porcupine	3 Phase	83	108(1)
C4	P13T	Timmins	3 Phase	83	108(1)

Notes:
(1) Assuming a communication time delay of 25 ms due to upgraded teleprotections as part of the Timmins TS Asset Replacement Project

The transient response of the Lapinigam Rapids GS synchronous generator for the outlined contingencies is shown in Figure 3. The plot shows that the Lapinigam Rapids generator rotor angle remains stable and well damped. All other generators (monitored but not shown here) also showed rotor angle stability with well damped oscillations. Transient instability of synchronous generators within the project for faults to the P13T circuit, which were observed during the original SIA are no longer an issue due to shorter fault clearing times. These shorter fault clearing times can be implemented either through the Timmins Asset Replacement project (as currently planned) or separately via other system upgrades as long as they are implemented prior to the connection of the Kapuskasing/Ivanhoe GS project.

Figure 3: Lapinigam Rapids GS Rotor Angle Oscillations



Fault Ride-Through

The IESO requires that the converters and associated equipment within the project be able to withstand transient voltages and remain connected to the IESO-controlled grid following a recognized contingency unless the generators are removed from service by configuration. This requirement is commonly referred to as fault ride-through capability. The ride through capability of the proposed Andritz ECObulb generators is summarized below.

Table 6: Andritz ECObulb Fault Ride-Through Capability

Voltage Range (% of base voltage)	Minimum Time for Generator to Remain Online (sec)
V<15	0.150
15<V<30	0.200
30<V<50	0.320
50<V<90	0.675
90<V<110	No trip
110<V<120	0.5
120<V<125	0.150
V>125	0

The ride through capability of the proposed Andritz ECObulb generators was assessed based on the terminal voltages of the closest and furthest converter sites under the simulated contingencies outlined in Table 5. Simulation results are shown in Figures 4 & 5.

Figure 4: Ivanhoe The Chutes GS Terminal Voltage vs. Fault Ride-Through Settings

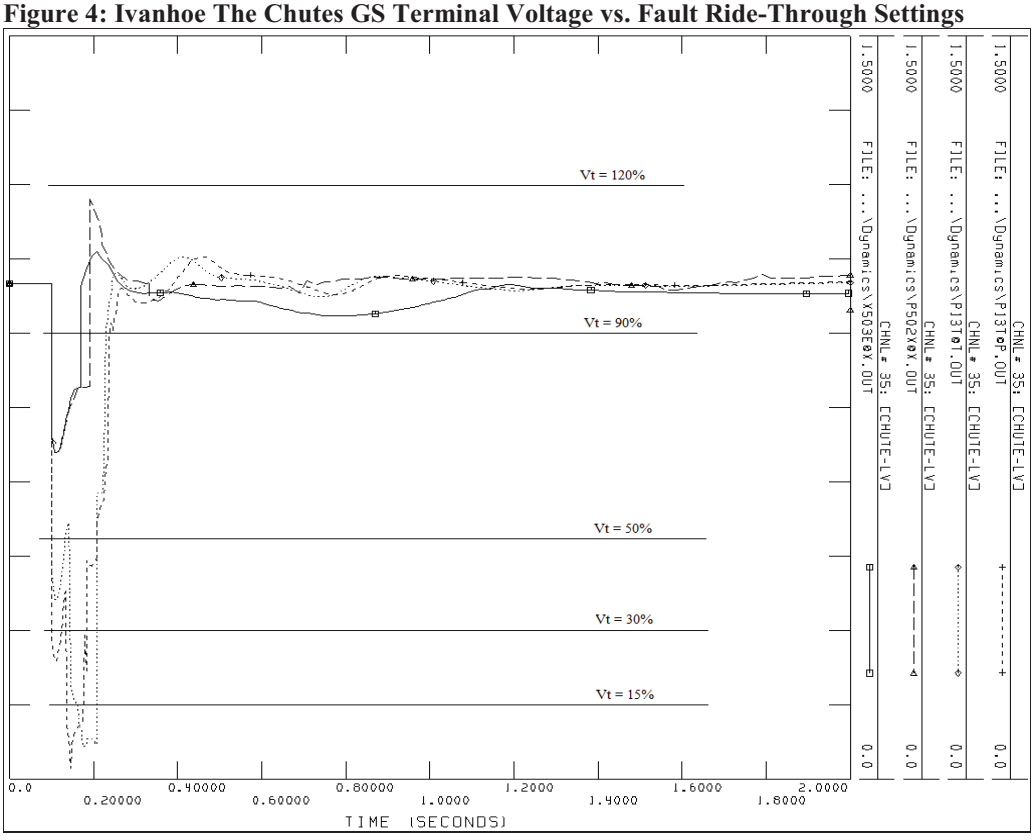
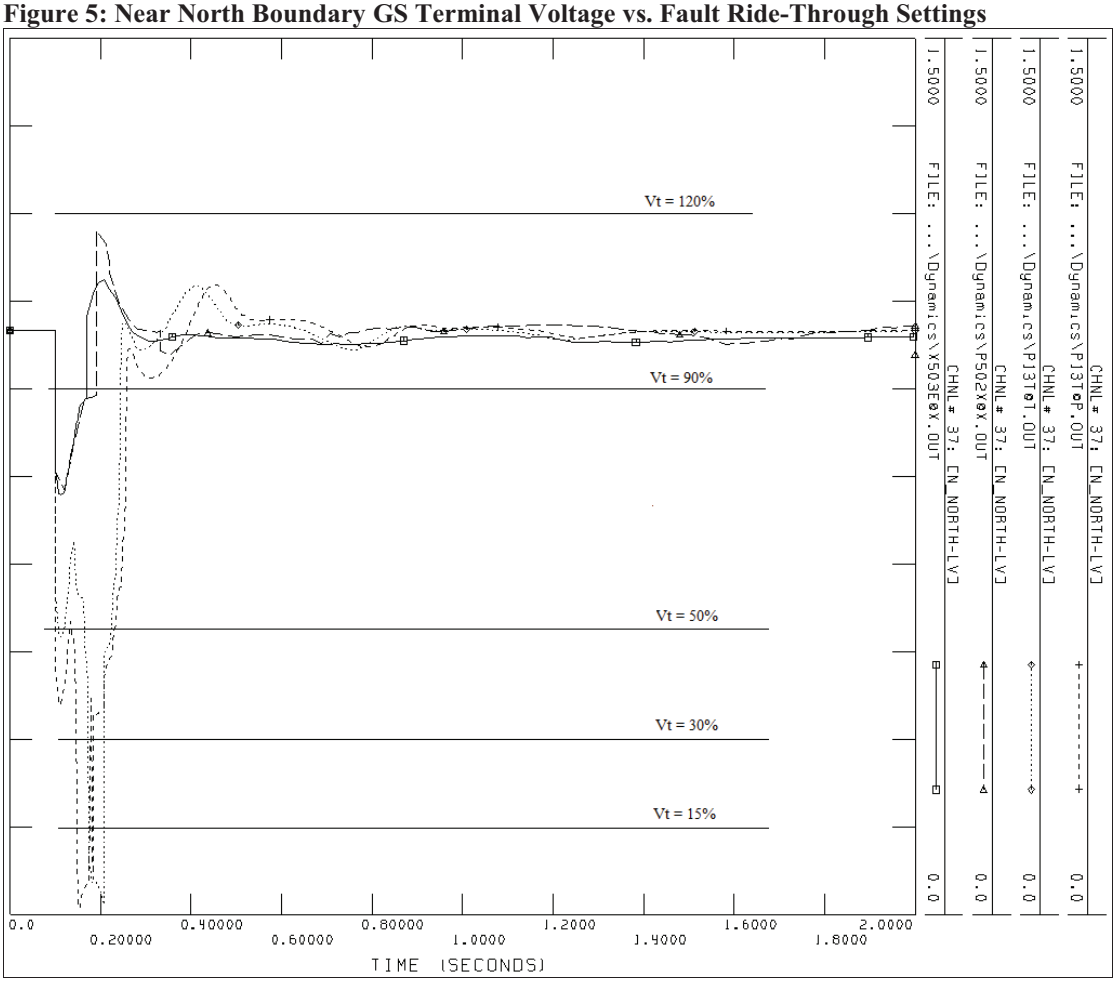


Figure 5: Near North Boundary GS Terminal Voltage vs. Fault Ride-Through Settings



The study results show that the ride through capability of the proposed generators is adequate and no issues are foreseen. However, when the project is incorporated into the IESO-controlled grid, should actual operation show that the generators trip for contingencies for which they are not removed by configuration, the IESO will require the voltage ride-through capability be enhanced by the applicant to prevent such tripping.

The voltage ride-through capability must also be demonstrated during commissioning by monitoring several variables under a set of IESO specified field tests and the results should be verifiable using the PSS/E model.

- End of Report -

Appendix A: PIA Report

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Hydro One Networks Inc.
483 Bay Street
Toronto, Ontario
M5G 2P5

PROTECTION IMPACT ASSESSMENT

KAPUSKASING GENERATING STATION PROJECTS

TOTAL 27.44 MW OF FIVE (5) GENERATIONS

PCT - 391

Date: October 23, 2013

Prepared by:

Hydro One Networks Inc.

Disclaimer

This Protection Impact Assessment has been prepared solely for the IESO for the purpose of assisting the IESO in preparing the System Impact Assessment for the proposed connection of the proposed generation facility to the IESO–controlled grid. This report has not been prepared for any other purpose and should not be used or relied upon by any person, including the connection applicant, for any other purpose.

This Protection Impact Assessment was prepared based on information provided to the IESO and Hydro One by the connection applicant in the application to request a connection assessment at the time the assessment was carried out. It is intended to highlight significant impacts, if any, to affected transmission protections early in the project development process. The results of this Protection Impact Assessment are also subject to change to accommodate the requirements of the IESO and other regulatory or legal requirements. In addition, further issues or concerns may be identified by Hydro One during the detailed design phase that may require changes to equipment characteristics and/or configuration to ensure compliance with the Transmission System Code legal requirements, and any applicable reliability standards, or to accommodate any changes to the IESO-controlled grid that may have occurred in the meantime.

Hydro One shall not be liable to any third party, including the connection applicant, which uses the results of the Protection Impact Assessment under any circumstances, whether any of the said liability, loss or damages arises in contract, tort or otherwise.

Revision History

Revision	Date	Change
R0	October 10, 2012	First draft
R1	October 23, 2013	Customer generator/transformer configuation change

EXECUTIVE SUMMARY

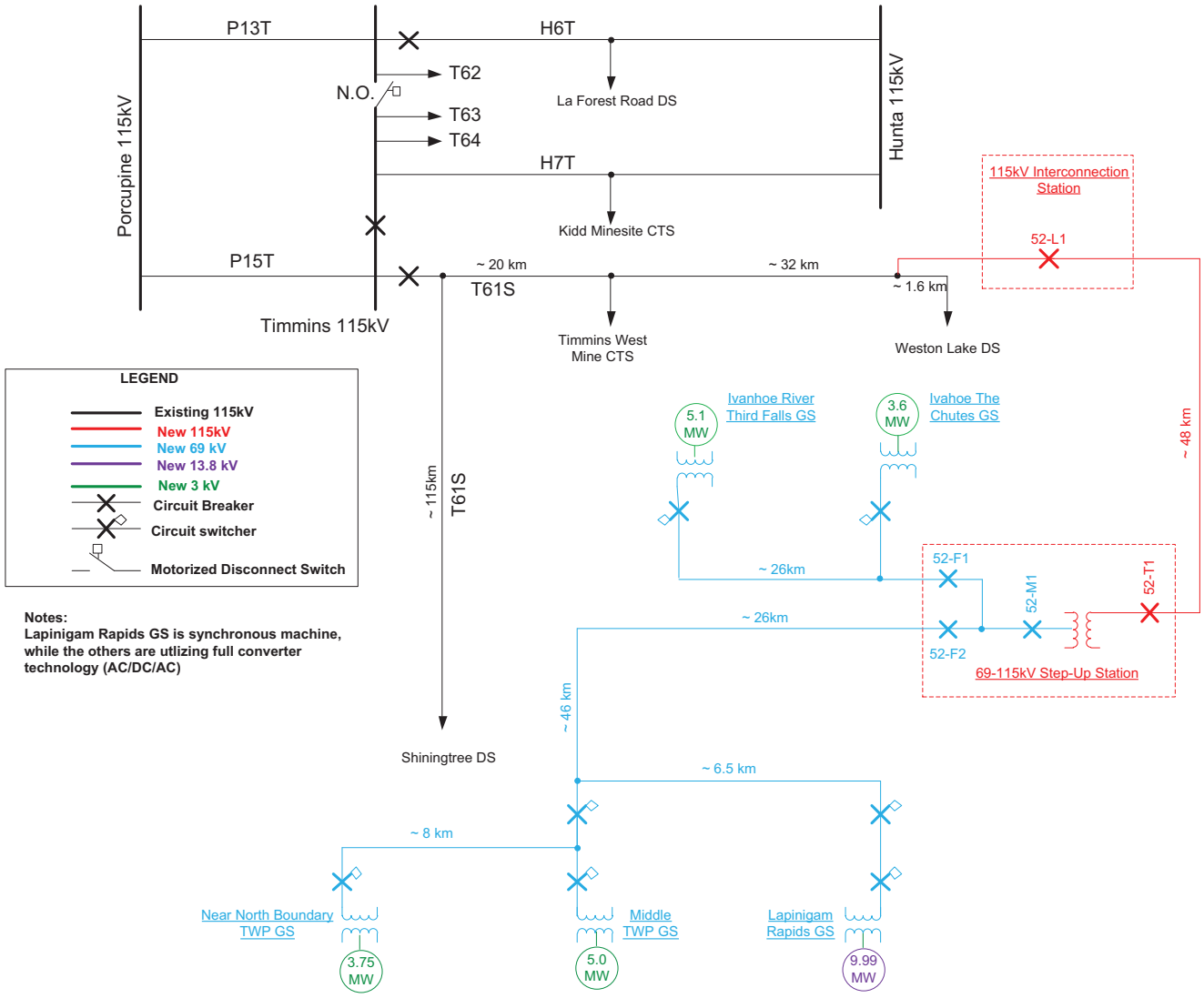

Figure 1: Kapuskasing Generating Station Projects connecting to HONI Transmission System

It is feasible for Xeneca Limited Partnership to connect new total 27.44MW generation facility with the proposals shown in Figure 1 as long as the below proposed changes are made:

PROTECTION HARDWARE

Hardware addition may need to be incorporated in Timmins TS in order to accept GEO, blocking and breaker failure signals from the new Kapuskasing Generation facility, to use line under voltage to supervise the auto-reclose, as well as to establish biderictional transfer trip with the proponent.

PROTECTION SETTING

Protection settings must be modified to accommodate new scheme.

TELECOMMUNICATIONS

Currently telecommuncation facilities are not available on T61S line.

New telecommunication links shall be established to transmit protection signals between Timmins TS and propronent's 115kV interconnection station in order to achieve effective fault clearance. The provision of the new telecommunication infrastructure required to facilitate this generation connection is the responsibility of the proponent, subject to final design consideration by Hydro One.

The proponent shall establish a dual channel link (Main and Alternate) from their facility to Hydro One Timmins TS. Geographic diversity is not required. The links will be used for breaker failure, blocking, transfer trip and GEO signals.

Performance of the telecommunication shall be compliant with the valid Transmission System Code. The system shall be constructed accordingly to applicable IESO and Hydro One standards.

PROPONENT'S RESPONSIBILITIES

The proponent shall provide a duplicate line protection compatible with Hydro One hardware and standards and shall be responsible to reliably disconnect their equipment for a fault on the line even in the case of a single contingency in their equipment. The proponent is responsible for transmitting breaker failure, blocking and GEO signals. Conversely, the proponent shall accept transfer trip signal from Hydro One Timmins TS.

In addition, the proponent is responsible for establishing all new telecommunication links needed to transmit protection signals to Hydro One Timmins TS as explained above.