



Power to Ontario.
On Demand.

System Impact Assessment Report

Kruger Chatham
Wind Generation Station (WGS)

CONNECTION ASSESSMENT & APPROVAL PROCESS

Final Report

CAA ID 2008-343

Applicant: Kruger Energy Chatham LP

Market Facilitation Department

December 4, 2009

REPORT

System Impact Assessment Report

Document ID	IESO_REP_0578
Document Name	System Impact Assessment Report
Issue	Issue 1.0
Reason for Issue	First issue
Effective Date	December 4, 2009

System Impact Assessment Report

Kruger-Chatham Wind Generation Project

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 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 study 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.

System Impact Assessment Report

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 OPG) customers.

In this study, 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.

Table of Contents

Table of Contents	v
SIA Findings	1
Summary	1
Conclusions and Recommendations	1
IESO’s Requirements for Connection	2
Notification of Conditional Approval	3
1. Project Description	4
2. General Requirements	5
3.1 Proposed Connection Arrangement	9
3.2 Existing System	9
4. Data Verification	12
4.1 Generator	12
4.2 Transformer	12
4.3 Circuit Breakers and Switches	12
5. Fault Level Assessment	13
6. System Impact Studies	17
6.1 Assumptions and Background	17
6.2 Protection Impact Assessment	17
6.3 Thermal Analysis	18
6.4 Voltage Analysis	20
6.5 Reactive Power Compensation	22
6.5.1 Dynamic Reactive Power Compensation	22
6.5.2 Static Reactive Power Compensation	22
6.6 Transient Analysis	23
6.7 Low-voltage ride through capability	24
6.8 Wind Farm Management System	25
Appendix A	26
Appendix B	30

KRUGER WIND GENERATION PROJECT IESO SYSTEM IMPACT ASSESSMENT

SIA Findings

Kruger Energy Ltd is developing a new 101 MW wind power generation farm in Chatham. The project was awarded a contract under the government RES III, and is expected to start commercial operation at the end of 2011.

Summary

This assessment examined the impact of injecting 101 MW of wind power generation to the provincial grid via 230 kV circuit C24Z south of Chatham on the reliability of the IESO-controlled grid.

The following conclusions and recommendations were made.

Conclusions and Recommendations

Conclusions:

The analysis concluded that:

- (1) The proposed wind farm does not have a material adverse impact on the reliability of the IESO-controlled grid.
- (2) The post-contingency voltage declines are within IESO criteria.
- (3) None of the recognized contingencies cause any material adverse impact to the transient performance of the IESO-controlled grid.
- (4) Special protection schemes existing in Windsor area can continue to be used as specified in the IESO operational instructions.
- (5) The new wind farm is not required to be part of any special protection scheme.
- (6) The connection impedance between the wind turbine generators and the IESO-controlled grid exceeds the limit derived from Market Rules requirements, resulting in reactive power deficiency. To compensate for this deficiency reactive compensation devices have to be installed as indicated in Section 6.5 of this SIA.

Recommendations:

- (1) The proponent provides a copy of the functionalities of the Wind Farm Management System (WFMS) to the IESO.

- (2) The transmitter changes the relay settings of C24Z/C23Z terminal stations to account for the effect on apparent impedance due to power injection from the wind farm.

IESO's Requirements for Connection

The following requirements for the incorporation of Kruger WGS to C24Z have been identified:

- (1) A static compensation of 18 MVAR must be connected to the collector bus. This must constitute 3 steps of 6 MVAR each. The capacitors will need to be auto-switched via suitable over/under voltage settings.
- (2) The generators and the capacitor bank must control the 34.5 kV collector bus voltage to a value to be determined by the IESO operating staff. The Wind Farm Management System must coordinate and direct the combined voltage control by generators and capacitors to avoid 'hunting'. Periodically, the IESO will revise the voltage set point as necessary.
- (3) The generators should not trip for contingencies except for which the generators will be removed by configuration. If generators trip for contingencies for which they are not removed by configuration, the LVRT capability must be upgraded.
- (4) The 34.5/240 kV transformer must have under load tap changing facilities to be operated in manual mode.
- (5) During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. The field test results should be verifiable using the PSS/E models used for this SIA.
- (6) All protection systems must be supplied from separate batteries and separate communication paths.
- (7) The autoreclosure of the new 230 kV tap breaker at the connection point must be blocked. Upon its opening for a contingency, it must be closed only after the IESO approval is granted. The IESO will require reduction of power generation prior to the closure of the breaker followed by gradual increase of power to avoid a power surge.
- (8) The generators should not trip for frequency variations that are above the curve in Figure 1.
- (9) The applicant is responsible for providing real-time telemetering of the following variables to the IESO:
 - Active and reactive power measured either at 34.5 kV or 230 kV side of the transformer T2
 - status of new 34.5 kV and 230 kV breakers and disconnect switches
 - 230 kV and 34.5 kV voltages at the transformer station
 - in service status of the Wind Farm Management System (WFMS)
 - voltage controlling set point

Additional telemetry requirements may be identified if necessary by the IESO during Market Entry process.

- (10) If the Wind Farm Management System (WFMS) is unavailable, each generator must control its own terminal voltage while capacitors continue to control the 34.5 kV voltage.

- (11) A disturbance monitoring device must be installed. The applicant is required to provide disturbance data to the IESO upon request.
- (12) The registration of the new facilities will need to be completed through the IESO's Market Entry process before any part of the facility can be placed in-service. If the data or assumptions supplied for the registration of the facilities materially differ from those that were used for the assessment, then some of the analysis might need to be repeated.

Notification of Conditional Approval

From the information provided, our review concludes that the proposed changes will not result in a material adverse impact on the reliability of the IESO-controlled grid. It is recommended that a Notification of Conditional Approval be issued for Kruger Chatham WGS subject that the requirements listed in this report will be implemented.

1. Project Description

Kruger Energy Inc. has proposed to develop a new 101 MW wind power generation facility in the municipality of Chatham-Kent in southwestern Ontario. This project participated in one of Ontario government's generation procurement programs initiated by the OPA for renewable generation, and a contract was awarded. It is expected that commercial operation will start at the end of 2011.

The proposed Kruger Chatham Wind Farm is connected to the existing 230 kV tap line for Port Alma Wind Farm at 8 km from the switching station.

The development will consist of a total forty four Siemens SMK203 wind turbine generators with a rated power output of 2.3 MW each. Two back-to-back AC/DC links and a 2.6 MVA, 0.06 pu reactance (on 2.6 MVA base), 0.69/34.5 kV transformer connects each generator to one of the four 34.5 kV collector circuits C5, C6, C7 or C8. Each collector circuit will have following number of generators.

Siemens SMK203 (2.55 MVA, 2.3 MW each)					
Circuit ID	C5	C6	C7	C8	Total
Number of generators	11	11	14	8	44
Maximum MW	25.3	25.3	32.2	18.4	101.2

The collector circuits will be connected to a single 34.5 kV collector bus which will be connected to a 66/88/110 MVA, 34.5/230 kV transformer T2 (of impedance 0.055 pu on 66 MVA base). The transformer will be connected to the existing KEPA owned 12 km long 230 kV circuit 4 km from Port Alma WF.

Under normal conditions, the Kruger Chatham and Port Alma wind farms will be connected to C24Z only. During outages of C24Z the Kruger Chatham and Port Alma wind farms will be connected to C23Z.

-End of Section –

2. General Requirements

Generators

1. Each generator must satisfy the Generator Facility requirements in Appendix 4.2 of Market Rules.

The Market Rules (appendix 4.2, reference 1) require that the generation facility connecting to the IESO-controlled grid must have the minimum capability to supply reactive power continuously in the range of 90% lagging to 95% leading power factor based on active power output at its generator terminals for at least one constant 230 kV system voltage. The connection applicant shall submit the generator's reactive capability curve to the IESO as evidence that the generator is capable of meeting the reactive power requirements.

If necessary, shunt capacitors must be installed to offset the reactive power losses within the facility in excess of the maximum allowable losses. If generators do not have dynamic reactive power capabilities as described above, dynamic reactive compensation devices must be installed to make up the deficient reactive power.

2. The generators must be able to ride through recognized contingencies on the IESO-controlled grid that does not disconnect the facility by configuration.

3. The connection and disconnection of the generators must minimize any adverse effects on the IESO-controlled grid.

Connection Equipment (Breakers, Disconnects, Transformers, Buses)

1. Appendix 4.1, reference 2 of the Market Rules states that under normal conditions voltages are maintained within the range of 220 kV to 250 kV. Thus, the IESO requires that the 230 kV equipment in Ontario must have a maximum continuous voltage rating of at least 250 kV. Fault interrupting devices must be able to interrupt fault current at the maximum continuous voltage of 250 kV.

If revenue metering equipment is being installed as part of this project, please be aware that revenue metering installations must comply with Chapter 6 of the IESO Market Rules for the Ontario electricity market. For more details the applicant is encouraged to seek advice from their Metering Service Provider (MSP) or from the IESO metering group.

2. The Transmission System Code (TSC), Appendix 2 establishes maximum fault levels for the transmission system. For the 230 kV system, the maximum 3 phase symmetrical fault level is 63 kA and the single line to ground (SLG) symmetrical fault level is 80 kA (usually limited to 63 kA).

The TSC requires that new equipment be designed to sustain the fault levels in the area where the equipment is installed. If any future system enhancement results in an increased fault level higher than the equipment's capability, the connection applicant is required to replace the equipment at their own expense with higher rated equipment capable of sustaining the increased fault level, up to

the TSC's maximum fault level of 63 kA for the 230 kV system.

3. The connection equipment must be designed so that the adverse effects of failure on the IESO-controlled grid are mitigated.

4. The connection equipment must be designed so that it will be fully operational in all reasonably foreseeable ambient temperature conditions. This includes ensuring that SF6 breakers are equipped with heaters to prevent freezing.

IESO Monitoring and Telemetry Data

In accordance with the telemetry requirements for a generation facility (see Appendices 4.15 and 4.19 of the Market Rules) the connection applicant must install equipment at this project with specific performance standards to provide telemetry data to the IESO. The data is to consist of certain equipment status and operating quantities which will be identified during the IESO Market Entry Process.

As part of the IESO Facility Registration/Market Entry process, the connection applicant must also complete end to end testing of all necessary telemetry points with the IESO to ensure that standards are met and that sign conventions are understood. All found anomalies must be corrected before IESO final approval to connect any phase of the project is granted.

Protection Systems

1. Protection systems must be designed to satisfy all the requirements of the Transmission System Code as specified in Schedules E, F and G of Appendix 1 and any additional requirements identified by the transmitter. New protection systems must be coordinated with existing protection systems.

2. Facilities designated as essential to power system reliability must be protected by two redundant protection systems according to section 8.2.1a of the TSC. These redundant protection systems must satisfy all requirements of the TSC but in particular they may not use common components, common battery banks or common secondary CT or PT windings.

This facility is designated as essential to power system reliability and therefore the above protection requirements apply.

3. Protective relaying must be set to ensure that transmission equipment remains in-service for voltages between 94% of the minimum continuous and 105% of the maximum continuous values in the Market Rules, Appendix 4.1.

4. The Applicant is required to have adequate provision in the design of protections and controls at the facility to allow for future installation of Special Protection Scheme (SPS) equipment.

5. Any modifications made to protection relays by the transmitter after this SIA is finalized must be submitted to the IESO as soon as possible or at least six (6) months before any modifications are to

be implemented on the existing protection systems. If those modifications result in adverse impacts, the connection applicant and the transmitter must develop mitigation solutions.

Send documentation for protection modifications triggered by new or modified primary equipment (i.e. new or replacement relays) to connection.assessments@ieso.ca.

For protection modifications that are not associated with new or modified equipment (i.e. protection setting modifications) please send documentation to protection.settings@ieso.ca.

6. Protection systems within the generation facility must only trip the appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of the 230 kV circuits C24Z occurs due to events within the facility, the facility may be required to be disconnected from the IESO-controlled grid until the problem is resolved.

Frequency Requirements

The facility must be capable of operating continuously for grid frequencies in the range between 59.4 Hz and 60.6 Hz as specified in Appendix 4.2, Reference 3 of the Market Rules.

The facility must be capable of operating at full active power for a limited period of time for grid frequencies as low as 58.8 Hz. Generators must not trip for under-frequency system conditions that are below 60 Hz but above 57.0 Hz and above the curve shown in Figure 1.

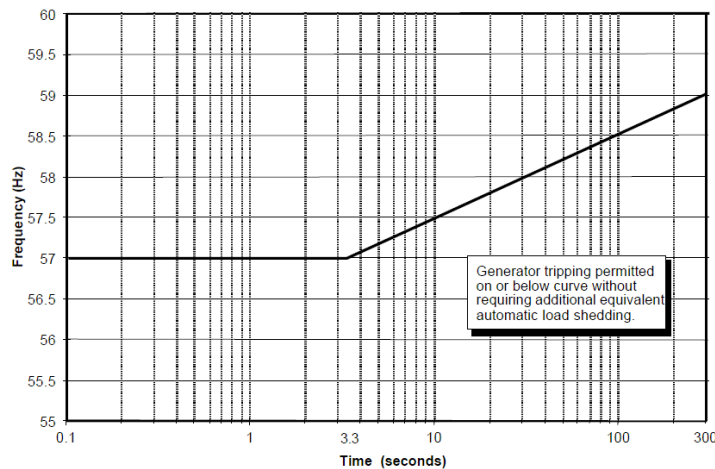


Figure 1: Setting for Grid Under-frequency Trip Protection

Miscellaneous

1. The generators must operate in the voltage control mode. Operation of the facility in power factor control or reactive power control is not acceptable.

2. Connection Applicant is required to install at the facility a disturbance recording device with clock synchronization that meets the technical specifications provided by Hydro One. The device will be used to monitor and record the response of the facility to disturbances on the 230 kV system in

order to verify the dynamic response of generators. The quantities to be recorded, the sampling rate and the trigger settings will be provided by Hydro One.

Facility Registration/Market Entry Requirements

The connection applicant must complete the IESO Facility Registration/Market Entry process in a timely manner before IESO final approval for connection is granted. Models and data, including any controls that would be operational, must be provided to the IESO. This information should be submitted at least seven months before energization to the IESO-controlled grid, to allow the IESO to incorporate this project into IESO work systems and to perform any additional reliability studies.

As part of the IESO Facility Registration/Market Entry process, the connection applicant must provide evidence to the IESO confirming that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted in this assessment. This evidence shall be either type tests done in a controlled environment or commissioning tests done on-site. In either case, the testing must be done not only in accordance with widely recognized standards, but also to the satisfaction of the IESO. Until this evidence is provided and found acceptable to the IESO, the Facility Registration/Market Entry process will not be considered complete and the connection applicant must accept any restrictions the IESO may impose upon this project's participation in the IESO administered market or connection to the IESO-controlled grid.

The evidence must be supplied to the IESO within 30 days after completion of commissioning tests. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

If the submitted models and data differ materially from the ones used in this assessment, then further analysis of the project will need to be done by the IESO.

Reliability Standards

Prior to connecting to the IESO controlled grid, the proposed facility must be compliant with the applicable reliability standards set by the North American Electric Reliability Corporation (NERC) and the North East Power Coordinating Council (NPCC). A list of applicable standards, based on the proponent's/connection applicant's market role/OEB licence can be found here:

<http://www.ieso.ca/imoweb/ircp/reliabilityStandards.asp>

In support of the NERC standard EOP-005, the proponent/ connection applicant may meet the restoration participant criteria. Please refer to section 3 of Market Manual 7.8 (Ontario Power System Restoration Plan) to determine its applicability to the proposed facility.

The IESO monitors and assesses market participant compliance with these standards as part of the IESO Reliability Compliance Program. To find out more about this program, visit the webpage referenced above or write to ircp@ieso.ca.

Also, to obtain a better understanding of the applicable reliability obligations and find out how to engage in the standards development process, we recommend that the proponent/ connection applicant join the IESO's Reliability Standards Standing Committee (RSSC) or at least subscribe to their mailing list at rssc@ieso.ca. The RSSC webpage is located at: http://www.ieso.ca/imoweb/consult/consult_rssc.asp.

- End of Section -

3. Review of Connection Proposal

3.1 Proposed Connection Arrangement

The proposed connection arrangement is shown in Figure 2.

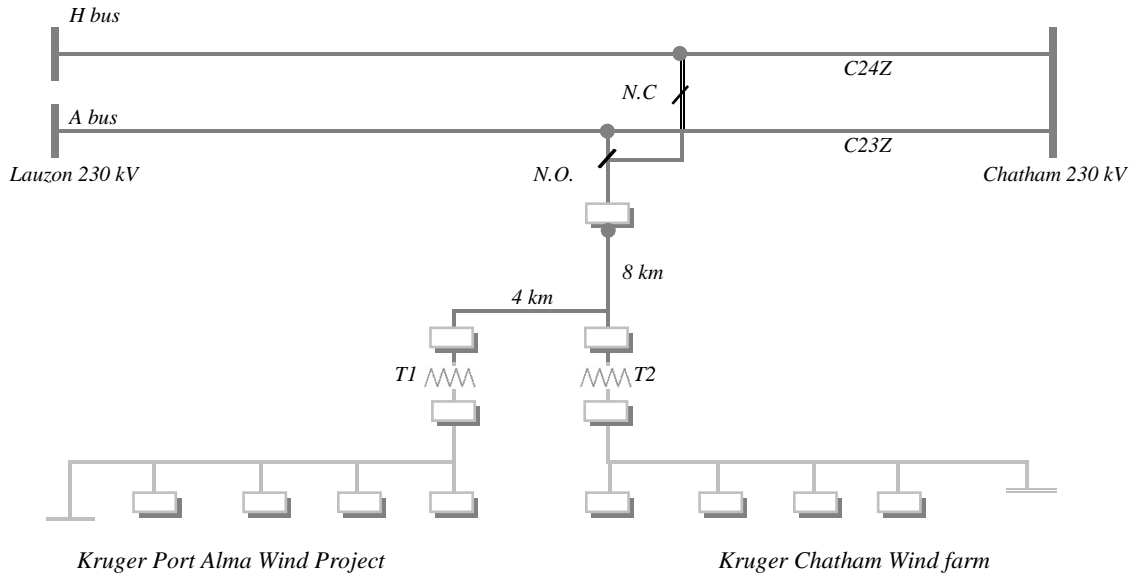


Figure 2: Proposed Connection Arrangement

3.2 Existing System

The geographical area in which the new facility will be located is supplied by C24Z and C23Z at Chatham, Keith autotransformers T11 and T12 and three generating stations, i.e. West Windsor GS, Windsor Transalta GS and Brighton Beach GS.

The Windsor 115 kV system which is a sub-system of above area is considered ‘closed’ when there is a continuous 115 kV transmission path between Lauzon TS and Keith TS. The Windsor 115 kV System is considered ‘open’ when the 115 kV transmission path between Lauzon TS and Keith TS is broken. Since the SIA is performed with all transmission elements in service, this assessment is limited to analysing the closed Windsor 115 kV system configuration.

Figure 3A, 3B, 3C and 3D show the MW flow in C24Z and voltage at Chatham, and Lauzon in 1 Hr average samples during the period of Jan 1- Dec 31, 2008 obtained from IESO real-time data.

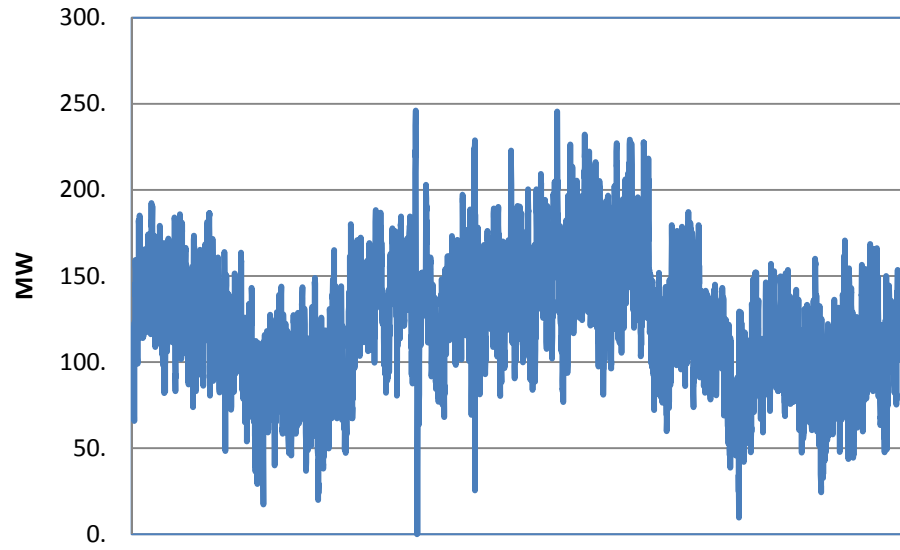


Figure 3A: MW Flow on C24Z at Chatham

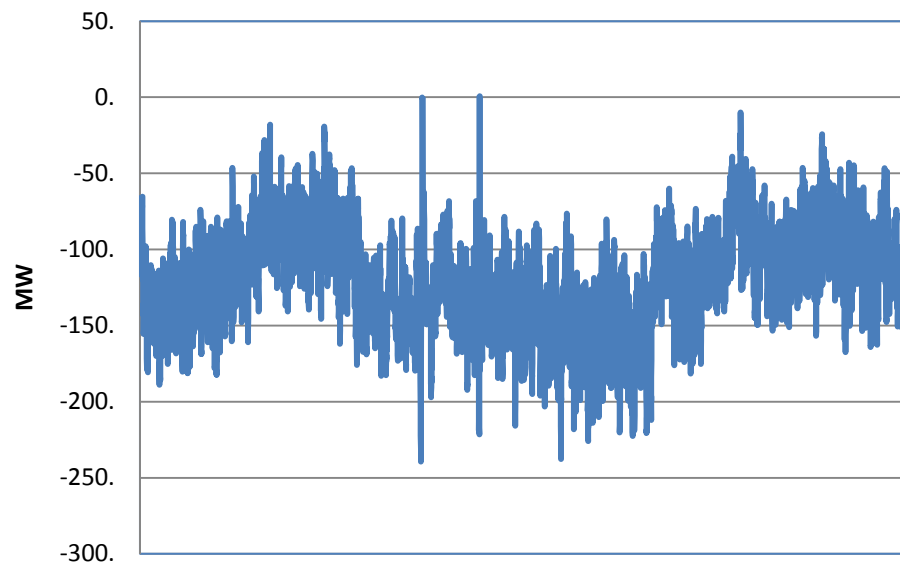


Figure 3B: MW Flow on C24Z at Lauzon

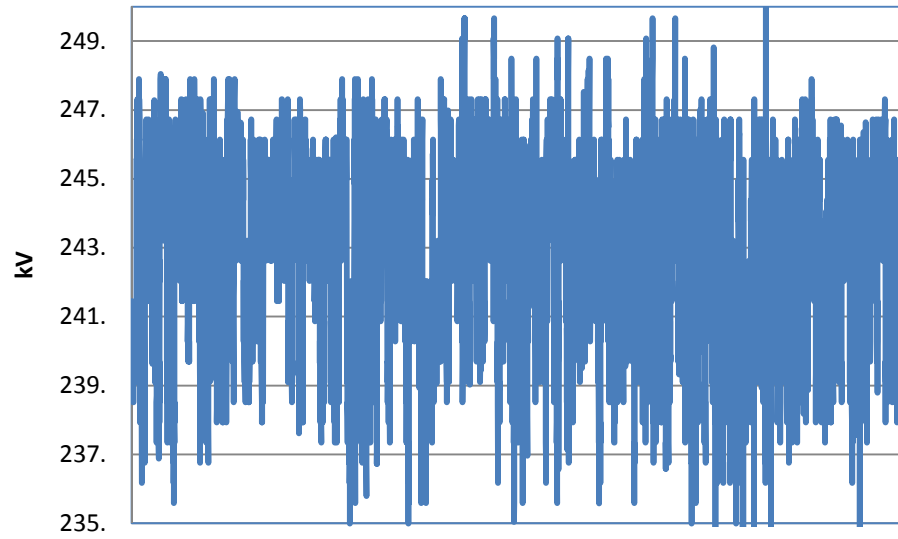


Figure 3C: Chatham 230 kV Voltage

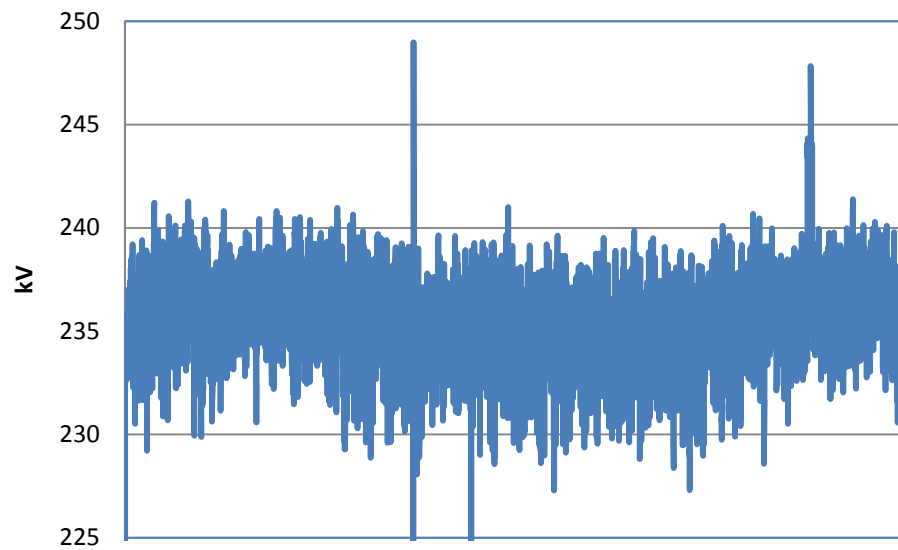


Figure 3D: Lauzon 230 kV Voltage

The followings can be observed.

Chatham average voltage	243 kV or 1.06 pu on 230 kV base		
Lauzon average voltage	234 kV or 1.02 pu on 230 kV base		
C24Z@Z MW flow load (max)	240 MW	C24Z@Z MW flow load (min)	50 MW

4. Data Verification

4.1 Generator

A generator connecting to the IESO-controlled grid must have the capability to perform the following unless specified otherwise.

- Supply reactive power continuously at all active power outputs in the range of 0.9 lag to 0.95 lead power factor based on rated active power at its generator terminals for at least one constant 230 kV system voltage, and
- Supply full active power continuously while operating at a generator terminal voltage ranging from 0.95 pu to 1.05 pu of the generator’s rated terminal voltage

The details of the generator data used in this assessment are given in Appendix A.

4.2 Transformer

Specifications for the 34.5/230 kV step-up transformer is listed below.

Transformation	240/34.5 kV
Rating	66/88/110 MVA ONAN/ONAF/ONAF
Impedance	0.055 pu based on 66 MVA
Configuration	3 phase, high side: wye, low side: delta
Tapping	on-load tap changers at HV ($\pm 10\%$ in 17 steps)

4.3 Circuit Breakers and Switches

Specifications of the isolation devices provided by the connection applicant are listed below. The incomplete data must be provided to the IESO.

Breakers and switches	LV	HV
Rated line-to-line voltage	34.5 kV	250 kV
Interrupting time	-	50 ms
Rated continuous current	-	2000 A
Rated short circuit breaking current	-	63 kA

– End of Section –

5. Fault Level Assessment

Fault level studies were completed by Hydro One to examine the effects of the Kruger Chatham Wind Farm on fault levels at existing facilities in the area. Studies were performed to analyze the fault levels with and without Kruger Chatham and other proposed wind farms in the surrounding area. The short circuit study was carried out with the following facilities and system assumptions:

The 6 RES III awarded projects:

- Kruger Energy Chatham Wind Project
- Greenwich Windfarm
- Talbot Windfarm
- Raleigh Wind Energy Centre
- Byran Wind Project
- Gosfield Wind Project

Base case conditions:

Northwestern & Northeastern system

Existing facilities

- Atikokan GS
- Thunder Bay G2 & G3
- Prince I & II WGS
- Terrace Bay Pulp CTS STG1 & STG2
- Umbata GS (M2W)
- GLP transmission system reinforcement

New facilities

- Wawatay G4
- Lac Seul GS
- Algoma Steel GS
- Lakehead TS SVC
- Mississagi TS SVC
- Series capacitors at Nobel SS in each of the 500kV circuits X503E & X504E to provide 50% compensation for the line reactance
- Porcupine TS & Kirkland Lake TS SVC
- Mattagami expansion (Upper and Lower Mattagami)

The rest of the system

Existing generation facilities

8 Bruce units
4 Darlington units
6 Pickering units
8 Nanticoke units
4 Lambton units
4 Lennox units
All hydraulic generation

GTAA (44 kV buses at Bramalea TS and Woodbridge TS)
TransAlta Douglas (44 kV buses at Bramalea TS)
TransAlta Sarnia (N6S/N7S)
West Windsor Power (J2N)
Brighton Beach (J20B/J1B)
Imperial Oil (N6S/N7S)
Greenfield Energy Centre (Lambton SS)
St. Clair Energy Centre (L25N & L27N)

All constructed wind farms including:

Erie Shores WGS (W8T)
Kingsbridge WGS (Goderich TS)
Amaranth WGS – Amaranth I (B4V) & Amaranth II (B5V)
Ripley WGS (B22D/B23D)
Prince I & II WGS (K24)
Underwood (B4V/B5V)
Kruger Port Alma (C24Z/C23Z)

New generation facilities

Committed wind generation:

- Wolfe Island (X4H & X2H)
- Kingsbridge II (159 MW)

Other New generation:

- Sithe Goreway GS (V41H(V72RS)/V42H(V73RS))
- Thorold GS (Q10P)
- East Windsor Cogen (E8F & E9F) + existing Ford generation
- Beck I G7 conversion to 60 Hz
- Greenfield South GS (R24C)
- Halton Hills GS (T38B/T39B)
- Portlands GS (Hearn SS)
- Bruce standby generators

Transmission system configuration

Existing system with the following upgrades:

Bruce x Orangeville 230 kV circuits up-rated

Hurontario SS in service with R19T+V41H(V72RS) open from R21T+V42H(V73RS) (230 kV circuits V41H(V72RS) and V42H (V73RS) extended and connected from Cardiff TS to Hurontario SS)

Allanburg x Middleport 230 kV circuits (Q35M and Q26M) installed

Claireville TS 230 kV re-configured as per SIA CAA ID 2006-220 and operated *open*

V75R terminated at Richview for a total of six 230 kV circuits between Claireville TS and RichviewTS

Two 245 Mvar (@ 230 kV) shunt capacitor banks installed at Orangeville TS and Detweiler TS, one per station

Four 250 Mvar (@ 250 kV) shunt capacitor banks installed at Middleport TS

Two 250 Mvar (@ 250 kV) shunt capacitor banks installed at Nanticoke TS

One 250 Mvar (@ 250 kV) shunt capacitor banks installed at Buchanan TS

LV shunt capacitor banks installed at Meadowvale and Halton TS

Essa-Stayner 115 kV circuit replaced by 2 x 230 kV circuits; Stayner TS converted to 230 kV; 230/115 kV auto installed to supply Meaford TS

New 230/115 kV autotransformer at Cambridge-Preston TS

1250 MW HVDC line ON-HQ in service

Tilbury West DS second connection point for DESN arrangement using K2Z and K6Z

Windsor area transmission reinforcement :

- 230 kV transmission line from Sandwich JCT (C21J/C22J) to Lauzon TS
- New 230/27.6 DESN, Leamington TS, that will connect C21J and C22J and supply part of the existing Kingsville TS load
- Replace Keith 230/115 kV T11 and T12 transformers
- 115 kV circuits J3E and J4E upgrades

System Assumptions

Lambton TS 230 kV operated *open*

Richview TS 230 kV operated *open*

Claireville TS 230 kV operated *open*

Leaside TS 230 kV operated *open*

Leaside TS 115 kV operated *open*

Middleport TS 230 kV bus operated *open*

Hearn SS 115 kV bus operated *open* – as required in the Portlands SIA

Cooksville TS 230 kV bus operated *closed*

Cherrywood TS north & south 230kV buses operated *open*

All capacitors in service

All tie-lines in service and phase shifters on neutral taps

Maximum voltages on the buses

The following table summarizes the symmetric fault levels near Windsor area and corresponding breaker ratings.

Bus	All Wind Farms O/S		All Wind Farms I/S		Breaker Ratings Symmetrical (kA) ⁽¹⁾
	Total Fault Current Symmetrical (kA)		Total Fault Current Symmetrical (kA)		
	3-phase fault	L-G	3-phase fault	L-G	
Chatham 230 kV	21.9	14.7	24.5	15.4	32.8
Lambton 230 kV	47.7	50.9	48.0	51.1	65 / 70 ⁽²⁾
Lambton A 230 kV	43.8	46.9	44.1	47.1	65 / 70 ⁽²⁾
Keith 230 kV	20.0	22.3	20.3	22.6	43.3
Keith 115 kV	26.9	31.7	27.1	32.1	39.3
Lauzon 115 kV	24.4	27.1	25.2	27.2	40
Scott 230 kV	44.8	41.6	45.0	41.7	50
Scott 115 kV	20.5	24.4	20.5	24.4	50
Buchanan 230 kV	32.6	27.6	33.0	27.4	50
Buchanan 115 kV	26.4	30.8	26.5	30.9	50
Longwood 500 kV	24.4	24.1	24.6	24.2	63
Longwood 230 kV	41.7	48.9	42.2	49.3	63

(1) Worst case rating

(2) The 65 kA rating applies to breakers PL4 & KL4; the 70kA rating to remaining 230 kV breakers at Lambton SS.

The results show that the fault levels in the surrounding area of the Windsor area are below the symmetrical breaker ratings. Fault levels increase slightly when all the wind farms are in service with the highest increase at Chatham of 2.6 kA.

Further studies were performed assuming that Port Alma WGS and Kruger Chatham are connected to C23Z during outages of C24Z. The results show there is very slight difference in the fault levels.

Therefore, it can be concluded that the increases in fault level, due to the proposed Kruger Chatham WGS, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

– End of Section –

6. System Impact Studies

This connection assessment was carried out to identify the effect of the proposed facility on thermal loading of transmission interfaces in the vicinity, the system voltages for pre/post contingencies, the ability of the facility to control voltage and the transient performance of the system.

6.1 Assumptions and Background

The following sections summarizes the study assumptions and the background information required for the analysis

- The study was performed for a system with all transmission elements in service.
- For this connection assessment the summer 2010 base case was used as a starting point and then one system representation was developed with stressed transmission lines in Southwest area as follows,

Ontario PD (Load + Losses)	West Zone Generation	West Zone Load	BLIP	J5D	FABC
29200 MW	5650 MW	3300 MW	-1524 MW	150 MW to Ont	4350 MW
Wind plants	Kruger Port Alma	Kruger Chatham	Raleigh	Gosfield@K2Z	Talbot@W45LC
	101 MW	101 MW	79 MW	50 MW	99 MW
West of Chatham Generation			West of Chatham Load		
1200 MW			1100 MW		

- Part of transmission upgrades proposed to Windsor area is incorporated. That includes:
 - Install a new 230/27.6 kV DESN, Leamington TS that will connect circuits C21J and C22J and supply part of the existing Kingsville TS load.
 - Replace Keith transformers T11 and T12

The following projects are not included due to uncertain in-service date as indicated by Hydro One:

- Establish a 230 kV connection between Lauzon TS and Sandwich Junction on C21J/C22J
- Upgrade 115 kV circuits J3E and J4E.
- For voltage decline studies, the MW loads were converted into constant current and admittance loads equally. The MVar loads were converted only into constant admittance loads.

6.2 Protection Impact Assessment

A Protection Impact Assessment (PIA) was performed by Hydro One to examine the impact of the new generators on existing transmission system protections. The existing protections for C24Z/C23Z at Chatham SS and Lauzon TS were described in the PIA report and the proposed protection settings were analyzed based on preliminary fault calculations.

The addition of the Kruger Energy Chatham wind farm will increase the current contribution from the existing Port Alma PCC to line faults. The resultant increase in apparent impedance will require setting revisions for the zone 2 relays at Chatham SS and Lauzon TS. Additional KEPA windfarm protections

will interface with the existing blocking and transfer trip signals from Raleigh wind farm to Chatham SS and Lauzon TS. No additional impact is expected on the existing protections.

However, the addition of the Raleigh Wind Energy Center wind farm close to the Chatham terminal will require the existing zone 1 settings at Chatham SS on circuit C23Z to be set to the 20 km rule so that the reach will extend beyond the Raleigh tap into the Raleigh transformer. Fault current contribution from the Raleigh windfarm and the existing Port Alma PCC, when connected, will result in an increased apparent impedance. Zone 2 relays at Chatham SS and Lauzon TS will require setting revisions. Faults beyond the zone 1 coverage will be cleared by the zone 2 with 50 ms time delay. In the following stability study dynamic simulations will be performed to examine the impact of the 50 ms delay in the clearing time for circuit C23Z on the Kruger wind farm operation.

It was concluded in the PIA report that detailed fault calculations should be run to derive the new apparent impedance due to the proposed connection and the existing line protection settings and the reclosing schemes at terminal stations should be revised.

6.3 Thermal Analysis

The summer day-time ratings of circuits (based on most restricting section) near Kruger Chatham WGS under 35°C and 5 km/h conditions are as follows.

Circuit	Wind km/hr	Sag Temp	Ambient Temp.	Conductor Size (kcmil), Strands	Continuous Rating	15-min LTR
K2Z	4	133 °C	35 °C	477, 26/7	800 A	940 A
K6Z	4	150 °C	35 °C	336, 26/7	690 A	770 A
J3E	4	127 °C	35 °C	795.0, 26/7	810 A	1070 A
J4E	4	127 °C	35 °C	795.0, 26/7	810 A	1000 A
C23Z	4	132 °C	35 °C	1192.5, 54/19	1060 A	1670 A
C24Z	4	116 °C	35 °C	795.0, 26/7	840 A	1130 A
C21J, C22J	4	116 °C	35 °C	795.0, 26/7	840 A	1130 A
Z1E, Z7E	4	127 °C	35 °C	997.2, 21/7	910 A	1380 A
W44LC, W45LC (WC)	4	150 °C	35 °C	1307.4, 28/19	1110 A	2000 A
W44LC, W45LC (LC)	4	127 °C	35 °C	1843.2, 72/7	1350 A	2170 A

- The lower of the sag temp or 93 °C is used to calculate the continuous rating (for pre-contingency)
- The sag temp is used to calculate the 15-min LTR (for immediate post-contingency)

Pre-contingency analysis

The following are the pre-contingency flows for various circuits in the local area prior to and after the connection of Kruger Chatham. The largest flow on each circuit is expressed in Amperes and percentage of continuous rating as well. Two scenarios were studied considering the connection of Kruger Chatham and Port Alma wind farms.

Option 1: Kruger Chatham and Port Alma wind farms are connected to C24Z and Raleigh WGS is connected to C23Z.

Option 2: Kruger Chatham and Port Alma wind farms as well as Raleigh WGS are connected to C23Z during outages of C24Z.

Circuit	Before the Connection of Kruger Chatham				After the Connection of Kruger Chatham			
	Option 1		Option 2		Option 1		Option 2	
	Amps	%	Amps	%	Amps	%	Amps	%
K2Z	220	27.5	222	27.8	219	27.4	222	27.8
K6Z	218	31.6	218	31.6	218	31.6	219	31.7
J3E	950	117.3	1031	127.3	916	113.1	991	122.3
J4E	956	118.0	1035	127.8	924	114.1	993	122.6
C23Z	284	26.8	425	40.1	213	20.1	466	44.0
C24Z	234	27.9	0	0.0	335	39.9	0	0.0
C21J	404	48.1	379	45.1	397	47.3	375	44.6
C22J	396	43.5	371	40.8	388	42.6	367	40.3
Z1E	859	77.4	931	83.9	839	75.6	893	80.5
Z7E	866	78.0	924	83.2	831	74.9	885	79.7
W44LC	971	71.9	974	72.1	995	73.7	997	73.9
W45LC	1000	74.1	1002	74.2	1022	75.7	1025	75.9

The flows from the table above indicate that prior to the Kruger Chatham connection, J3E/J4E are overloaded pre-contingency. With the connection of Kruger Chatham, J3E/J4E remain overloaded. The results of this pre-contingency analysis indicate that for peak load conditions, the thermal capability of the 115 kV lines from Keith to Essex is not adequate. This is an existing system problem, and it is not a result of the proposed wind generating station. The subsequent analysis presented in this report was carried out with J3E/J4E overloaded pre-contingency.

Post-contingency analysis

The followings are the post-contingency loadings of the monitored circuits including loading in amperes, 15-min LTR and percentage of loading over LTR.

Circuit	Pre-contingency : Option 1			
	C23Z = Raleigh		C24Z = Port Alma + Chatham	
	Contingency			
	K6Z	J3E+J4E	C21J+C22J+T12	C21J+C23Z
K2Z	423/940=0.45	231/940=0.25	223/940=0.24	235/940=0.25
K6Z	0	230/670=0.34	221/670=0.33	231/670=0.34
J3E	927/1070=0.87	0	1140/1070 = 1.07	1063/1070 = 0.99
J4E	931/1000=0.93	0	1138/1000 = 1.14	1052/1000 = 1.05
C23Z	226/1670=0.14	615/1670 = 0.37	140/1670 = 0.08	0
C24Z	311/1130=0.28	716/1130 = 0.63	304/1130 = 0.27	391/1130 = 0.35

C21J	397/1130=0.35	690/1130 = 0.61	0	0
C22J	389/1130=0.34	679/1130 = 0.60	0	669/1130 = 0.59
Z1E	826/1380=0.60	569/1380 = 0.41	1039/1380 = 0.75	994/1380 =0.72
Z7E	819/1380=0.59	561/1380 = 0.41	1032/1380 = 0.75	936/1380 = 0.68
W44LC	990/2000=0.50	975/2000 = 0.59	1011/2000 = 0.51	997/2000 = 0.50
W45LC	1018/2000=0.51	1005/2000 = 0.50	1041/2000 = 0.52	996/2000 = 0.50

Circuit	Pre-contingency : Option 2		
	C23Z = Raleigh + Port Alma + Chatham		C24Z = O/S
	Contingency		
	K6Z	J3E+J4E	C21J+C22J+T12
K2Z	439/940=0.47	224/940=0.24	226/940=0.24
K6Z	0	236/670=0.35	219/670=0.33
J3E	1001/1070=0.94	0	1154/1070 = 1.08
J4E	1014/1000=1.01	0	1155/1000 = 1.16
C23Z	443/1670=0.27	1405/1670 = 0.84	524/1670 = 0.31
C24Z	0	0	0
C21J	374/1130=0.33	694/1130 = 0.61	0
C22J	367/1130=0.32	682/1130 = 0.60	0
Z1E	893/1380=0.65	562/1380 = 0.41	1059/1380 = 0.77
Z7E	885/1380=0.64	572/1380 = 0.41	1051/1380 = 0.76
W44LC	993/2000=0.50	984/2000 = 0.49	1028/2000 = 0.51
W45LC	1021/2000=0.51	1013/2000 = 0.51	1055/2000 = 0.53

Ignoring the overloads of lines J4E and J3E, the results for 2010 extreme weather indicate that the post flows are within LTR given that sufficient control actions are initiated. It must be emphasized that these percentages are based on a rating obtained with 95 % pre-load value where in most cases the actual pre-load values are below this threshold.

6.4 Voltage Analysis

The voltage decline studies were performed with the Kruger Chatham facility connected to the circuit C24Z. Both declines of pre-ULTC and post-ULTC values are given in the following tables.

Pre-ULTC Voltage Declines											
Contingency	Chatham 230 kV	Lauzon 230 kV	Lauzon 115 kV	Keith 230 kV	Keith 115 kV	K6Z@K 115 kV	Kingsville 27 kV	Kruger 230 kV	Kruger 35 kV	Raleigh 230 kV	Talbot 230 kV
K2Z	0.00	0.00	0.00	0.00	0.00	-0.81	0.00	-0.04	0.00	0.00	0.00
J2N	-0.13	-0.43	-0.41	-0.34	-0.66	-0.49	-0.68	-0.26	-0.28	-0.17	-0.04
J5D	0.13	0.09	0.16	0.25	0.16	0.16	0.00	0.04	0.00	0.08	0.13
J3E+J4E	-1.47	-3.86	-3.28	-0.21	0.16	-3.40	-3.41	-2.27	-2.22	-1.98	-1.04
Z7E+Z1E	0.42	2.87	4.50	-0.04	-0.33	4.53	4.44	0.64	-0.28	0.76	0.25
Brighton Beach	0.21	0.09	0.16	0.21	0.16	0.16	0.00	0.13	0.28	0.21	0.38
C24Z	-0.21	-2.17	-1.47	-0.25	-0.58	-1.54	-1.71	-0.81	-0.83	-	-0.13
C23Z	0.67	-0.91	-0.74	0.00	-0.25	-0.73	-0.68	-	-	0.42	0.63
C24Z+C23 Z	1.01	-6.47	-4.83	-0.63	-1.89	-4.94	-5.12	-	-	-	0.92
C21J+C22J +T12	0.38	0.48	0.25	-0.21	0.41	0.24	0.00	0.34	0.56	0.38	0.25

Post-ULTC Voltage Declines											
Contingency	Chatham 230 kV	Lauzon 230 kV	Lauzon 115 kV	Keith 230 kV	Keith 115 kV	K6Z@K 115 kV	Kingsville 27 kV	Kruger 230 kV	Kruger 35 kV	Raleigh 230 kV	Talbot 230 kV
K2Z	0.00	0.00	-0.08	0.00	0.00	-0.97	0.34	-0.04	0.00	0.00	0.00
J2N	0.13	0.09	0.25	0.04	0.25	0.24	0.00	0.09	0.28	0.13	0.21
J5D	0.13	0.09	0.16	0.25	0.16	0.16	0.00	0.04	0.00	0.13	0.17
J3E+J4E	-1.39	-3.43	-2.87	-0.21	0.16	-2.59	-1.02	-2.14	-2.22	-1.85	-1.00
Z7E+Z1E	0.00	1.56	2.87	-0.13	-0.41	-0.08	-1.02	-0.17	-1.67	0.21	-0.08
Brighton Beach	0.25	0.09	0.16	0.21	0.16	0.16	0.00	0.09	0.28	0.21	0.38
C24Z	-0.21	-2.04	-1.39	-0.25	-0.58	-1.30	0.00	-0.81	-0.83	-	-0.08
C23Z	0.71	-0.91	-0.74	0.00	-0.25	-0.73	-0.68	-	-	0.42	0.67
C24Z+C23 Z	1.05	-5.21	-3.85	-0.46	-1.48	-3.72	-0.68	-	-	-	0.92
C21J+C22J +T12	0.42	0.48	18.26	-0.21	0.41	0.24	0.00	0.34	0.56	0.42	0.25

Only single contingencies are needed to be respected in Windsor 115 kV local area. However, double contingencies are simulated to check any voltage concerns in Windsor area. It can be concluded that all the voltage declines are less than 10.0 % which meets the voltage decline criteria.

6.5 Reactive Power Compensation

6.5.1 Dynamic Reactive Power Compensation

The following summarizes the IESO required level of dynamic reactive power and the available capability.

	Terminal Voltage	Active Power	Reactive Power Capability/Turbine
IESO Required	1.0 pu	1.0 pu	$Q_{\text{gen}} = 2.55 \times \sin [\cos^{-1} (0.9)] = 1.11 \text{ Mvar}$
			$Q_{\text{abs}} = 2.55 \times \sin [\cos^{-1} (0.95)] = 0.8 \text{ Mvar}$
SMK203 Capability	1.0 pu	1.0 pu	$Q_{\text{gen}} = 2.3 \times 0.55 = 1.26 \text{ Mvar}$
			$Q_{\text{abs}} = 2.3 \times 0.55 = 1.26 \text{ Mvar}$

The SMK203 generators can deliver IESO required dynamic reactive power to the generator terminal at rated power and at rated voltage. Thus, the IESO has determined that there is no need to install any additional dynamic reactive power compensation device.

6.5.2 Static Reactive Power Compensation

Kruger Chatham Wind Farm must have the same capability to supply reactive power continuously as required of a synchronous generator with the same apparent power, as measured at the point of connection to the IESO-controlled grid. With this assumption, Kruger Chatham Wind Farm and Port Alma Wind Farm must have a minimum capability of supplying approximately **+71.5 MVar** (capacitive) to **-67.5 MVar** (inductive) at the connection point for at least one constant 230 kV system voltage at all active power outputs.

Load flow studies were performed to justify a need for static reactive compensation. Besides the conditions described in Chapter 4, additional simulation conditions for these load flow studies include that:

- The 230-kV voltages at Chatham, Lauzon are about 243 and 234 kV, respectively;
- The terminal voltages of the WTGs vary between 0.95 pu and 1.05 pu;

The inductive capability of the generation facility was assessed with the WTGs operating at full active power output. The voltage at the connection point is about 118 kV. The WTG units are operated to control the terminal voltages to their lowest values. The generation facility can absorb a maximum reactive power of **70 MVar** at the connection points, indicating that Kruger Chatham Wind Farm meet the inductive reactive power requirement.

The capacitive capability of the generation facility was assessed with the WTGs operating at full active power output. The generation facility for both Kruger Chatham and Port Alma including all the existing shunt capacitors can supply a maximum reactive power of **57.8 MVar** at the connection points when the WTG units are operated to control the terminal voltages to their highest values (1.05 pu). This indicates that static reactive compensation is required to be installed at collector bus to meet the capacitive reactive power requirement.

A capacitor bank, with equipment capacity of **18 MVAR@34.5 kV**, is installed at the 34.5 kV bus of the interconnection substation to increase the reactive power injection at the connection point. With this capacitor bank, the wind farm can supply a maximum reactive power of **+71.9 MVAR** at the connection point, which meets the capacitive reactive requirement.

In order to avoid hunting, the capacitor switching must be done automatically by a local over/under voltage scheme with suitable settings by the Wind Farm Management System. Instead of controlling the 230 kV voltage, it is also acceptable to the IESO if the capacitor bank controls the collector bus voltage to a level that is determined by the IESO operating staff. In that case, the Wind Farm Management System must coordinate the capacitor switching and generators as both equipment controls the voltage at same busbar. The voltage set point could be asked to be changed by the IESO control room as system conditions change.

Voltage change due to capacitor switching

Switching study was carried out to investigate the effect of the new LV shunt capacitor banks on the voltage changes.

Following summarizes the change in voltage due to switching of a single capacitor of 18 MVAR at the collector bus. All generators are made to operate at a fixed power factor to prevent their dynamic reactive power capability changes bus voltages, so that the ΔV is only due to capacitor switching. The ΔV has been tested when generators offer no voltage support and at the worst condition, i.e. the generators absorb maximum reactive power so that the ΔV due to cap switching is at its maximum. The transformers ULTCs have been locked.

LV			HV		
PRE	POST	%	PRE	POST	%
35.2	35.8	1.7	232.1	233.2	0.47

The IESO allows ΔV on a single capacitor switching to be no more than 4 %. Study results show that switching of a single capacitor of 18 MVAR produces less than 4 % voltage increase. However, it is necessary to supply the 18 MVAR in 3 steps to increase the operational flexibility.

6.6 Transient Analysis

Transient stability analyses were performed considering fault in Windsor area with the proposed Kruger Chatham WGS in-service. Ten contingencies were tested. They include a permanent three-phase fault on a circuit cleared with normal fault clearing time (SC1-SC7), simultaneous permanent phase to ground faults on different phases of each of two adjacent circuits on a multiple circuit tower cleared with normal fault clearing time (SC8- SC10). It should be noted that based on Protection Impact Assessment reports for the wind projects in Southwest from Hydro One, part of C23Z will be covered only by zone 2 protections. To allow for a blocking signal the clearing timing of the zone 2 faults will be increased by 50 ms.

Contingencies	
SC1	Normally cleared LLLG fault on K6Z @ Lauzon
SC2	Normally cleared LLLG fault on C22J@Chatham
SC3	LLLG cleared by zone 2 protection on C23Z @Chatham

SC4	Normally cleared LLLG fault on J4E @ Keith
SC5	Normally cleared LLLG fault on Z7E @ Lauzon
SC6	Normally cleared LLLG fault on W45LC @ Chatham
SC7	Normally cleared LLLG fault on L28C @ Chatham
SC8	Normally cleared LG fault on C21J + LG fault on C22J @ Chatham
SC9	Normally cleared LG fault on W44LC + LG fault on W45LC @ Chatham
SC10	Normally cleared LG fault on L28C + LG fault on L29C @ Chatham

The Appendix B show the transient curves. None of the contingencies caused any significant adverse impact on IESO-controlled grid. It can be concluded from the results that, with Kruger Chatham WGS on-line, none of the simulated contingencies caused transient instability or undamped oscillations.

6.7 Low-voltage ride through capability

As any other generators, the MK II is expected to trip only for contingencies which removes the generator by configuration or abnormal conditions such as severe and sustained under-voltage, over-voltage, under-frequency, over-frequency etc. The severity of under-voltage seen by the generator terminals is to be temporarily mitigated by the low voltage ride through (LVRT) capability. The LVRT feature is implemented by injection of additional reactive current by the grid side AC/DC converter to maintain generator terminal voltage in the event of a disturbance in the power system that caused terminal voltage to drop.

The implementation of LVRT should not require any instant modification to under-voltage protection settings. In PSS/E model for MK II, the LVRT feature accompanies a change of under-voltage setting as shown below.

<i>Voltage range</i>	<i>Event</i>
1.00 – 0.90 pu	No trip
0.90 – 0.75 pu	Relay 1 trips in 10 sec
0.75 – 0.15 pu	Relay 2 trips in 0.650 sec
0.15 – 0.0 pu	Relay 3 trips in 0.25 sec

In order to examine the need for the LVRT capability, the three phase fault on C23Z at Chatham with Zone 2 protection 50 ms delayed clearing time was simulated. This particular contingency is electrically much closer to the new generation facility than other contingencies with longest clearing time. Thus, it could potentially have a greater impact on the terminal voltage of the facility. The variation of the terminal voltage of the new generation facility is plotted in Figure 4 below. It can be seen that the duration during which the generator terminal voltage drops below 0.5 pu is about 0.16 sec. Therefore, fault ride through capabilities of the wind turbines are adequate.

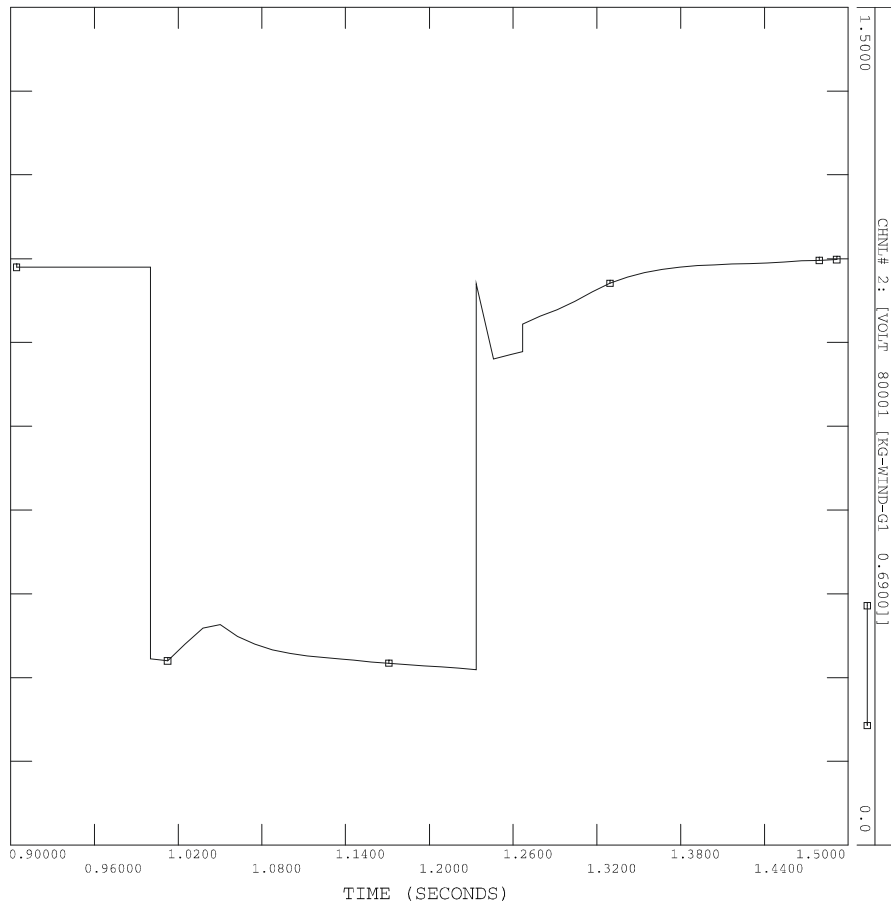


Figure 4: Terminal Voltage of Wind Generator During 3-phase fault at Chatham TS

The LVRT capability must be demonstrated during commissioning by monitoring several variables under a set of IESO specified field tests and the result should be verifiable using the PSS/E model.

6.8 Wind Farm Management System

The Wind Farm Management System (WFMS) must coordinate the voltage control process. The proponent must submit a description of the functionalities of the WFMS, including the coordination between the automatic capacitor switching and generator reactive power production to control the voltage at a desired point. This document also must contain the settings of the automatic capacitor switching scheme. If the WFMS is unavailable, the IESO requires each generator controls its own terminal voltage.

– End of Report –

Appendix A

Generator Data

2.30	Machine Active Power Rating (MW)	MBASE
0.69	Stator Voltage Rating (kV)	
60	Rated network frequency (Hz)	FBASE
90200	Connection busbar number	
1	Generator Identifier	
0.0000	Generator Resistance in Loadflow (Rs, pu)	RSORCE
0.6415	Generator Reactance in Loadflow (Xd", pu)	XSORCE
2.6	Unit Transformer Rating (MVA)	Note 1
0.0084	Unit Transformer Resistance (pu)	Note 1
0.0600	Unit Transformer Reactance (pu)	Note 1
Value	Description	Ref:
1	Model Version Number	
1	Reactive control mode (0=fixed, 1=voltage, 2 & 3 not in use)	
1	Fault Ride Through mode (0=disabled, 1=enabled)	
1	Enable Under-voltage relay 1	
1	Enable Under-voltage relay 2	
1	Enable Under-voltage relay 3	
1	Enable Over-voltage relay 1	
1	Enable Over-voltage relay 2	
1	Enable Under-frequency relay 1	
1	Enable Under-frequency relay 2	
1	Enable Over-frequency relay 1	
Value	Description	Ref:
54.62		
1.0927	Generator Inertia Constant (MW.s/MVA)	
14.3349	Rotor Inertia Constant (MW.s/MVA)	
0.1458	Shaft Damping	
138.49	Shaft Stiffness	
1.2471	Description N/A	
1.1432	Description N/A	
1.1109	Description N/A	
1.0003	Description N/A	
1.40	Description N/A	
1.10	Description N/A	
0.10	Description N/A	
22	Description N/A	
100000	Description N/A	
3.00	Description N/A	
100000	Description N/A	
2.00	Description N/A	
0.10	Voltage dip threshold for FRT activation (pu)	Normal
0.40	Voltage dip threshold for FRT activation (pu)	Post-Fault
0.090	Description N/A	
0.090	Description N/A	
0.160	Description N/A	
1.00	Description N/A	

3.2	Description N/A	
63.7	Description N/A	
0.90	Description N/A	
50.00	Description N/A	
10.00	Description N/A	
0.472	Description N/A	
66.0	Description N/A	
1.0878	Description N/A	
0.0022	Description N/A	
0.1348	Description N/A	
0.040	Description N/A	
2.10	Description N/A	
0.70	Description N/A	
1.20	Description N/A	
0.70	Description N/A	
1.89	Description N/A	
2.00	Description N/A	
0.82	Description N/A	
0.50	Description N/A	
0.40	Description N/A	
4.00	Description N/A	
1.225	Air density	
15.00	User defined wind speed for rated power operation (m/s)	
1.00	Description N/A	
0.1768	Description N/A	
0.6464	Description N/A	
1.0069	Description N/A	
13.05	Description N/A	
-94.25	Description N/A	
-52.36	Description N/A	
0.15	Description N/A	
7.0	Description N/A	
-8.0	Description N/A	
45.0	Maximum pitch angle	
-1.0	Minimum pitch angle	
2.0	Description N/A	
0.060	Description N/A	
0.9655	Description N/A	
-4.7283	Description N/A	
-0.6755	Description N/A	
0.2174	Description N/A	
-0.2174	Description N/A	
1.00	Description N/A	
0.90	Under Voltage Relay 1 - Voltage Setting (pu)	
3.000	Under Voltage Relay 1 - Time Setting (s)	
0.100	Under Voltage Relay 1 - Relay activation time (s)	
0.70	Under Voltage Relay 2 - Voltage Setting (pu)	
2.400	Under Voltage Relay 2 - Time Setting (s)	
0.100	Under Voltage Relay 2 - Relay activation time (s)	
0.15	Under Voltage Relay 3 - Voltage Setting (pu)	FRT Mode

0.100	Under Voltage Relay 3 - Time Setting (s)	FRT Mode
0.050	Under Voltage Relay 3 - Relay activation time (s)	FRT Mode
0.85	Under Voltage Relay 3 - Voltage Setting (pu)	
0.075	Under Voltage Relay 3 - Time Setting (s)	
0.000	Under Voltage Relay 3 - Relay activation time (s)	
1.10	Over Voltage Relay 1 - Voltage Setting (pu)	
1.000	Over Voltage Relay 1 - Time Setting (s)	
0.000	Over Voltage Relay 1 - Relay activation time (s)	
1.20	Over Voltage Relay 2 - Voltage Setting (pu)	
0.200	Over Voltage Relay 2 - Time Setting (s)	
0.000	Over Voltage Relay 2 - Relay activation time (s)	
0.95	Under Frequency Relay 1 - Frequency Setting (pu)	
10.000	Under Frequency Relay 1 - Time Setting (s)	
0.000	Under Frequency Relay 1 - Relay activation time (s)	
0.94	Under Frequency Relay 2 - Frequency Setting (pu)	
0.100	Under Frequency Relay 2 - Time Setting (s)	
0.000	Under Frequency Relay 2 - Relay activation time (s)	
1.04	Over Frequency Relay 1 - Frequency Setting (pu)	
0.100	Over Frequency Relay 1 - Time Setting (s)	
0.000	Over Frequency Relay 1 - Relay activation time (s)	
0.10	Description N/A	
11.47	Description N/A	
22.91	Description N/A	
2.522	Description N/A	

DYRE Data (auto-generated from datasheet information. Copy/paste into DYRE file.)

/ SMK203 V1.0, 2.3 MW Turbine Data

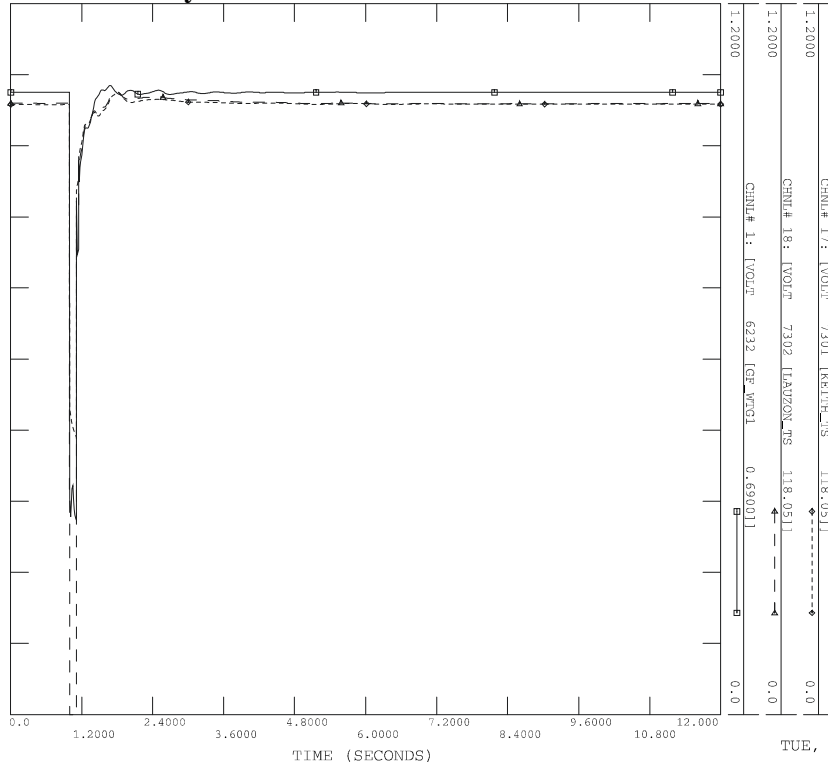
90200 'USRMDL' 1 'SMK203' 1 1 11 97 19 78

1 1 1 1 1 1 1 1 1 1 54.62 1.0927 14.3349 0.1458 138.49 1.2471 1.1432 1.1109 1.0003 1.40 1.10 0.10 22 100000 3.00 100000
2.00 0.10 0.40 0.090 0.090 0.160 1.00 3.2 63.7 0.90 50.00 10.00 0.472 66.0 1.0878 0.0022 0.1348 0.040 2.10 0.70 1.20
0.70 1.89 2.00 0.82 0.50 0.40 4.00 1.225 15.00 1.00 0.1768 0.6464 1.0069 13.05 -94.25 -52.36 0.15 7.0 -8.0 45.0 -1.0 2.0 0.060
0.9655 -4.7283 -0.6755 0.2174 -0.2174 1.00 0.90 3.000 0.100 0.70 2.400 0.100 0.15 0.100 0.050 0.85 0.075 0.000 1.10 1.000 0.000
1.20 0.200 0.000 0.95 10.000 0.000 0.94 0.100 0.000 1.04 0.100 0.000 0.10 11.47 22.91 2.522 /

– End of Section –

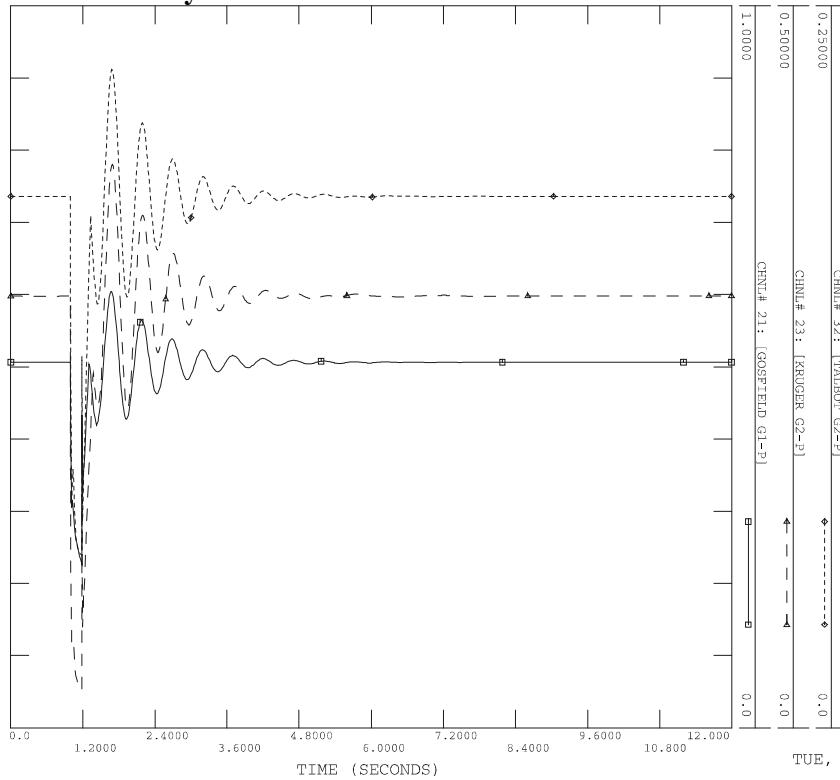
Appendix B

SC1: Normally cleared LLLG fault on K6Z @ Lauzon



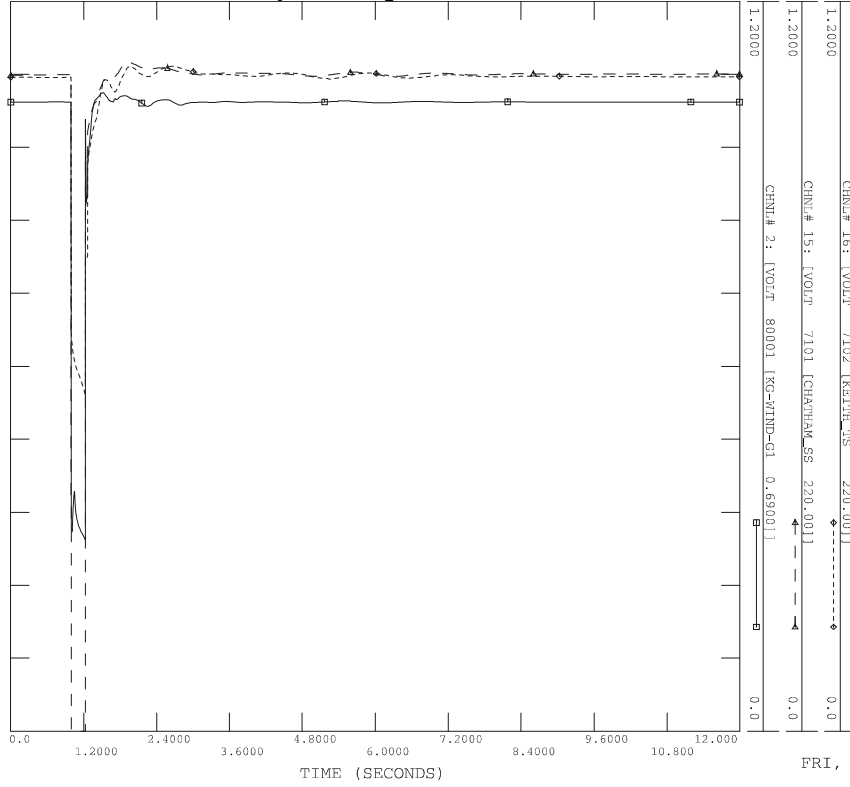
2010 SUMMER LOAD FLOW-----5_SBSP4DRNUK16BK4LB4LX14SDIOS
 675BLIP,3398FABC,3129FETI,-296FN,79ICLAN,544FIO,
 FILE: D:\PPI\Gosfield\Dynamic\Results\111q_K6Z@lauzon.out

SC2: Normally cleared LLLG fault on C22J@Chatham

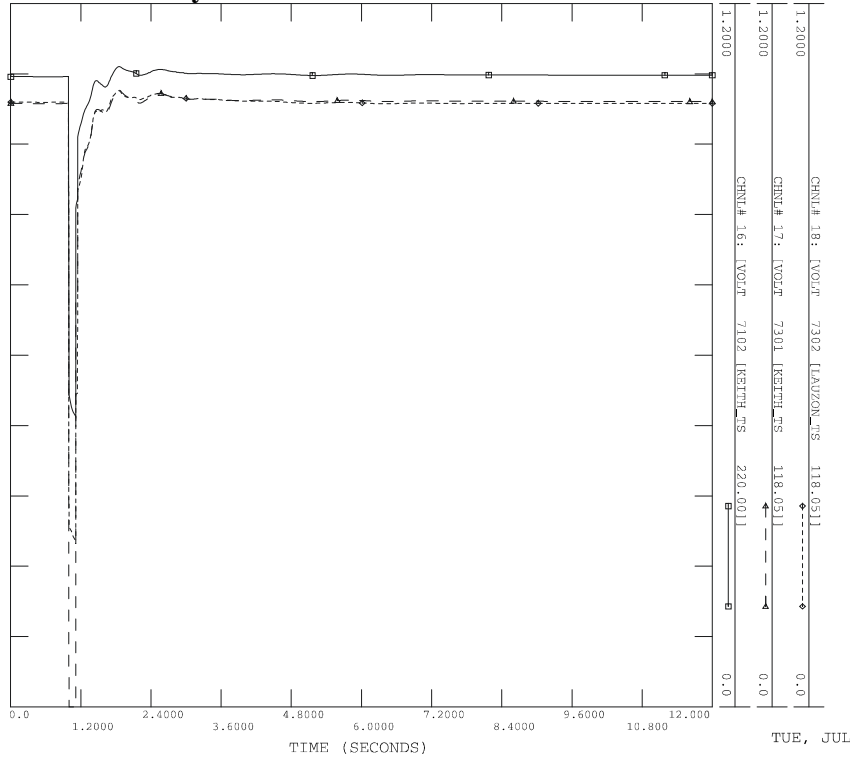


2010 SUMMER LOAD FLOW-----5_SBSP4DRNUK16BK4LB4LX14SDIOS
 675BLIP,3398FABC,3129FETI,-296FN,79ICLAN,544FIO,
 FILE: D:\PPI\Gosfield\Dynamic\Results\111q_C22@chatham.out

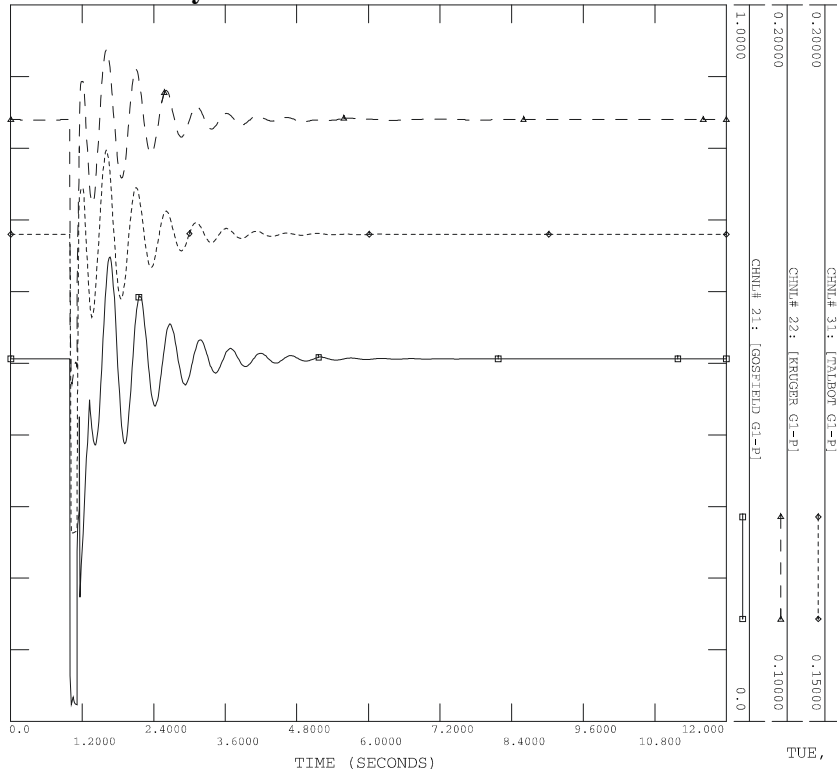
SC3: LLLG cleared by zone 2 protection on C23Z @ Chatham



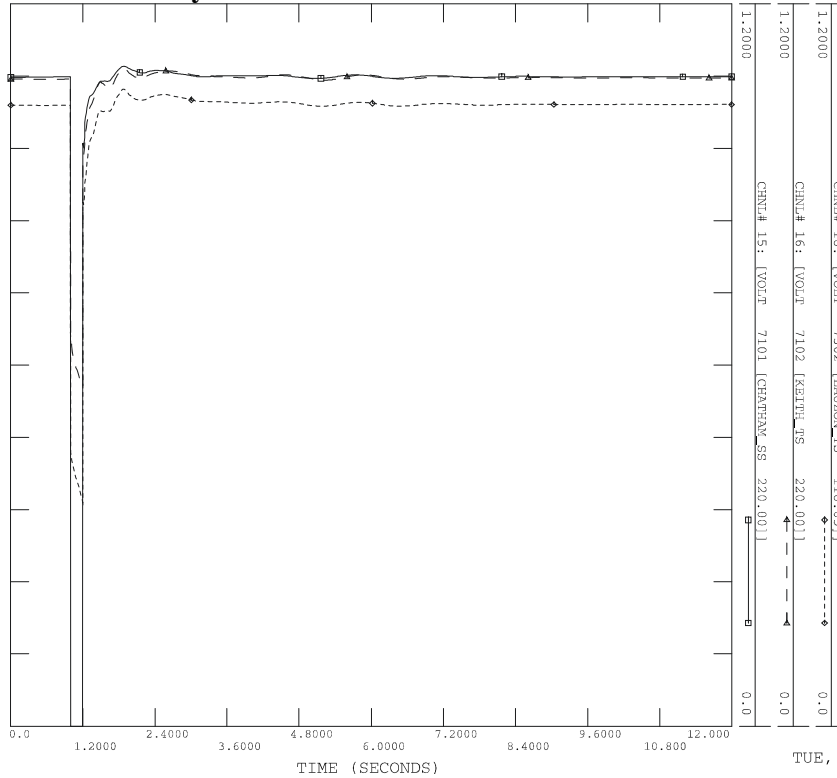
SC4: Normally cleared LLLG fault on J4E @ Keith



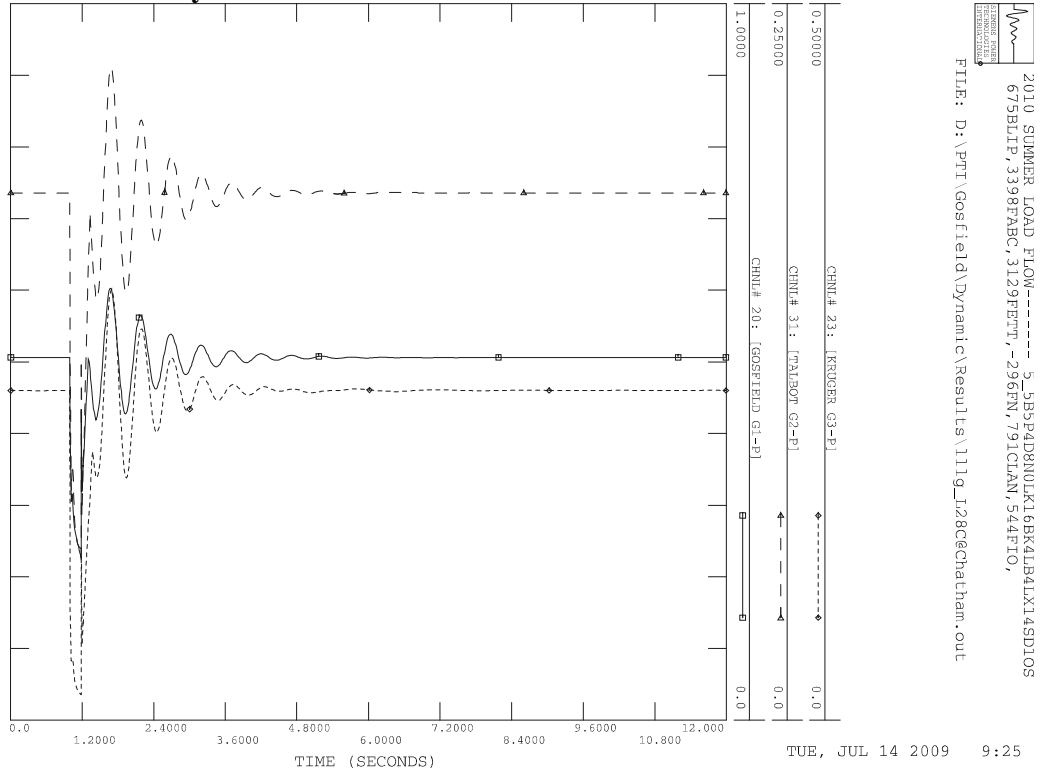
SC5: Normally cleared LLLG fault on Z7E @ Lauzon



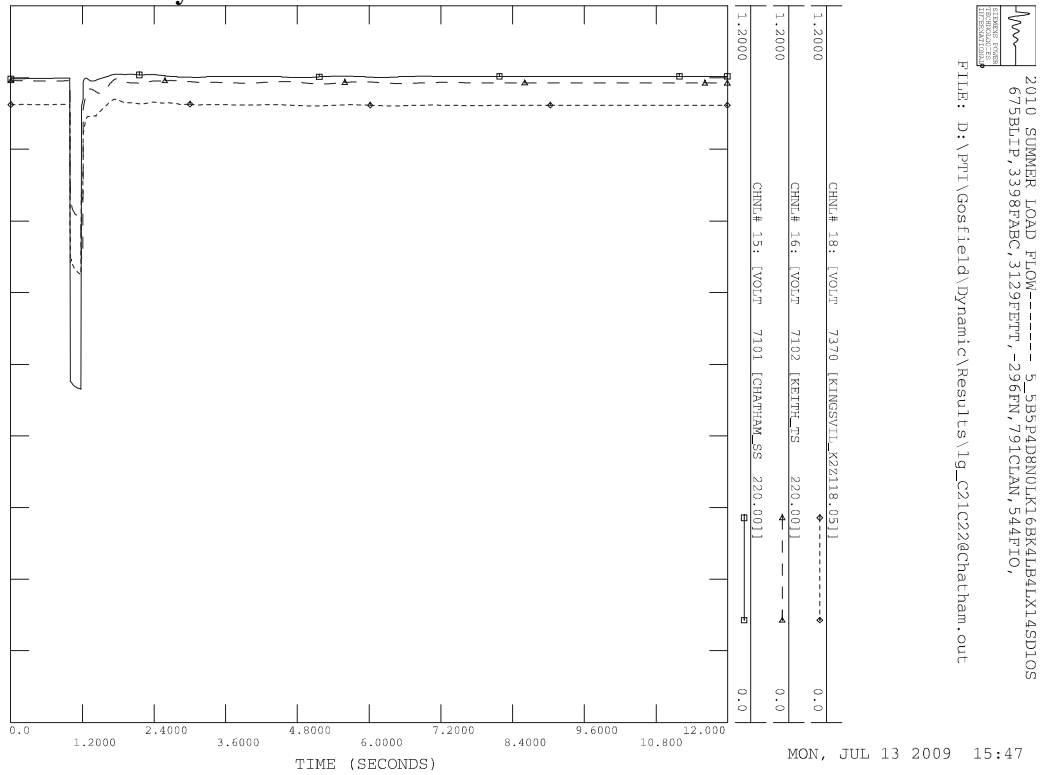
SC6: Normally cleared LLLG fault on W45LC @ Chatham



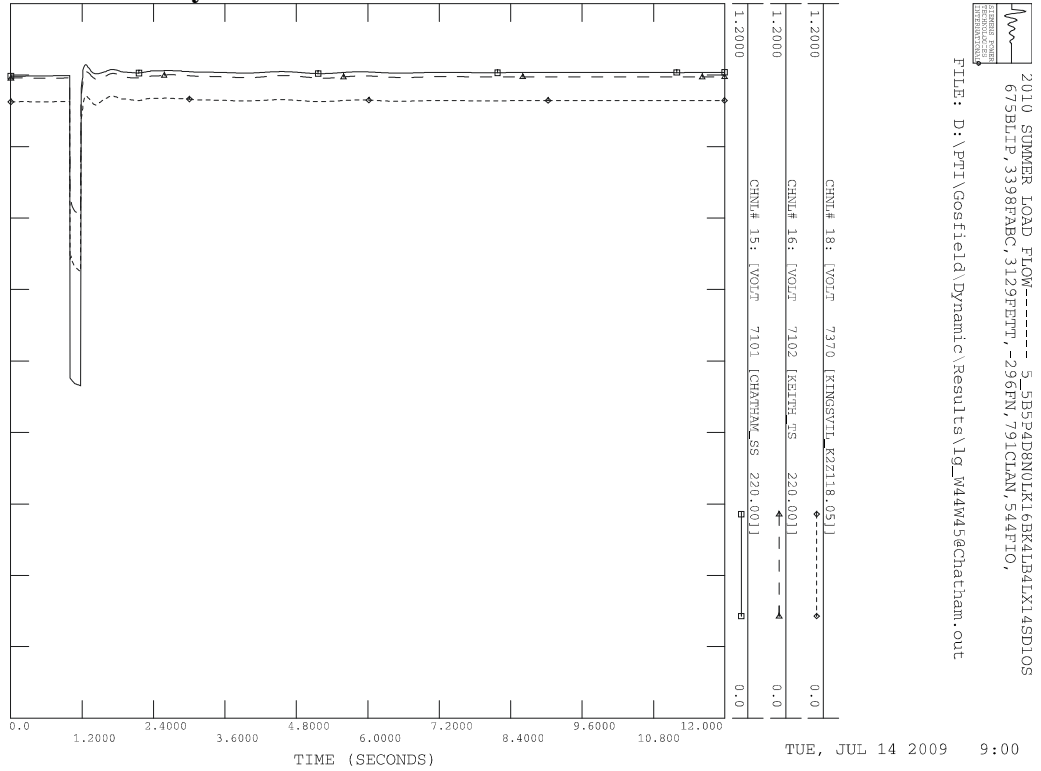
SC7: Normally cleared LLLG fault on L28C @ Chatham



C8: Normally cleared LG fault on C21J + LG fault on C22J @ Chatham



SC9: Normally cleared LG fault on W44LC + LG fault on W45LC @ Chatham



SC10: Normally cleared LG fault on L28C + LG fault on L29C @ Chatham

