IESO_REP_0577

REPORT

Power to Ontario.
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System Impact Assessment Report

Gosfield Wind Generation Station (WGS)

CONNECTION ASSESSMENT & APPROVAL PROCESS

Final Report

CAA ID 2002-078

Applicant: Brookfield Wind Power Corporation

Market Facilitation Department

December 9, 2009

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System Impact Assessment Report

Gosfield Wind Generation Project

Acknowledgement

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

<u>Disclaimers</u>

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.

<u>HYDRO ONE</u>

<u>Special Notes and Limitations of Study Results</u>

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.

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.

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SIA Findings

Brookfield Power Wind Corporation has been awarded a Power Purchase Agreement with Ontario Power Authority to develop a new 50.6 MW wind project ("Gosfield") located in the Town of Kingsville, Essex County. The project will commence construction in summer 2009 and is expected to start commercial operation in July/August 2010.

Summary

This Assessment examined the impact of injecting 50.6 MW of wind power generation to the provincial grid via 115 kV circuit K2Z north of Kingsville TS on the reliability of the IESO-controlled grid.

Following conclusions and recommendations were made.

Conclusions and Recommendations

Conclusions:

The analysis concluded that:

(1) The proposed project will not have a material adverse impact on the reliability of the IESO-controlled grid.

(2) The increase in fault levels, due to the proposed Gosfield WGS, will not exceed the interrupting capabilities of the existing breakers on the IESO-controlled grid.

(3) Overloads of the 115 kV circuits J3E/J4E were identified prior to the connection of Gosfield WGS. The project reduces the J3E/J4E overloads, although it does not completely alleviate them.

(4) For all contingency cases tested with the proposed Gosfield WGS, all voltage declines are within the 10% pre and post-ULTC action limit. Thus, the voltage performance would meet the voltage decline criteria.

(5) The dynamic simulation results show that, with Gosfield generators on-line, all of the simulated contingencies exhibit a stable and acceptably damped response.

(6) Based on the information provided by the applicant, the fault ride through capability of the wind turbines is adequate.

Recommendations:

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

(2) The transmitter upgrades 115 kV circuits J3E/J4E to mitigate overloading.

IESO's Requirements for Connection

The following requirements for the incorporation of Gosfield WGS to K2Z have been identified:

(1) A static compensation of 15 MVAr constituting 2 steps must be connected to the collector bus. The capacitors will need to be auto-switched via suitable over/under voltage controls.

(2) The generators and the capacitor banks 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 34.5/115 kV transformer must have under load tap changer facilities to be operated in manual mode.

(5) During 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 115 kV 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 115 kV side of the transformer
- status of new 34.5 kV and 115 kV breakers and disconnect switches
- 115 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 effect on the reliability of the IESO-controlled grid. It is recommended that a Notification of Conditional Approval be issued for Gosfield WGS subject that the requirements listed in this report will be implemented.

1. Project Description

Brookfield Power Corporation is proposing to develop a wind farm having a total capacity of 50.6 MW located in the Town of Kingsville, Essex County. The proposed Gosfield wind farm will be connected approximately 5 km away from Kingsville TS to circuit K2Z. The project will commence construction in summer 2009, connect to the grid in March/April 2010 for back-feed power and achieve commercial operation in July/August 2010.

The development will consist of 22 Siemens SWT 2.3 MW wind turbines totaling 50.6 MW. Each turbine is composed of a 2.3MW, 690V asynchronous generator connected through a Four Quadrant Full Bridge Converter (AC/DC - DC/AC). By virtue of the DC link, the generator's electrical characteristics are completely isolated from the grid and the short circuit contribution of the turbine is a function of the converter. The Pitch Regulated Variable Speed technology provides high power quality and controllable output.

Each tower will have a generator, two AC/DC converters, a step-up transformer and a breaker, and will be connected to a collector system that consists of two 34.5 kV circuits C1 and C2. Each 0.690/34.5 kV transformer has a reactance of 0.06 pu on 2.6 MVA base and has manual off-load tap changers on HV windings. They will have 2 equal steps above nominal and 2 equal steps below nominal giving a total of –5 % to +5 % tap variation. Each circuit will have following number of generators:

Circuit ID	C1	C2	Total
Number of generators	11	11	22
Maximum MW	25.3	25.3	50.6

Both circuits will be connected to one collector bus which will be connected to a single 33/44/55 MVA, 34.5/120 kV transformer with a reactance of 0.08 pu on 33 MVA base, then connected to K2Z via a new breaker located at Gosfield TS.

– 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 115 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 in the south are maintained within the range of 113 kV to 127 kV. Thus, the IESO requires that the 115 kV equipment in southern Ontario must have a maximum continuous voltage rating of at least 127 kV.

Fault interrupting devices must be able to interrupt fault current at the maximum continuous voltage of 127 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 115 kV system, the maximum 3 phase symmetrical fault level is 50 kA and the single line to ground (SLG) symmetrical fault level is 50 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 50 kA for the 115 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 protections 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 115 kV circuits K2Z 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 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.

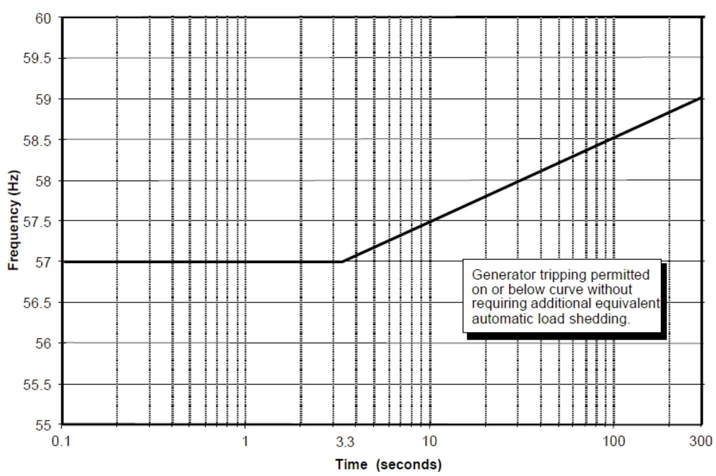


Figure 1: Setting for Grid Under-frequency Trip Protection

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 115 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.

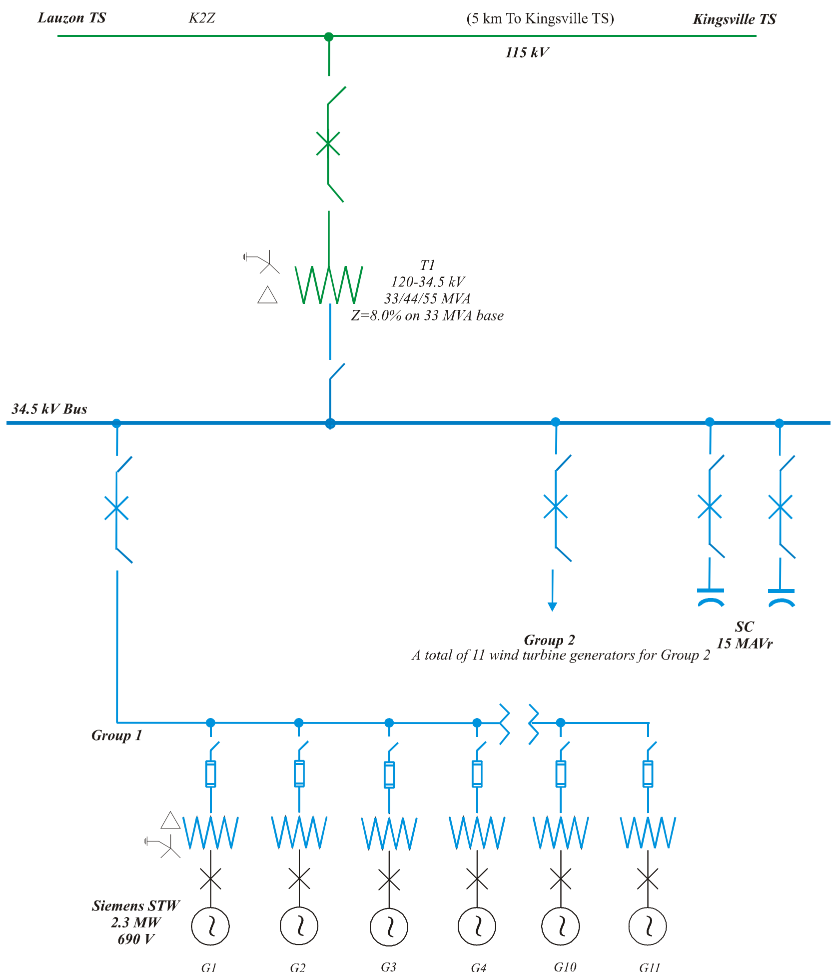


Figure 2: Proposed Connection Arrangement

3.2 Existing System

The Windsor area is bounded by circuits C23Z and C24Z from Chatham to Lauzon, circuits C21J and C22J from Chatham to Keith and by circuit J5D from Keith to Michigan. The Windsor 115 kV area load is supplied from Lauzon 230/115 kV autotransformers T1 and T2, Keith 230/115 kV autotransformers T11 and T12, West Windsor GS G1 and G2, the Windsor TransAlta CGS G1 and G2 and Brighton Beach CGS G1A.

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.

The proposed Gosfield WGS is to be connected to the 115 kV circuit K2Z. The double circuit 115 kV line K2Z/K6Z from Lazon TS provides radial supply to Belle River TS, Tilbury DS and Kingsville TS loads.

Figures 3Aand 3B show the 115 kV voltages at Lauzon TS and Kingsville TS based on available data in 2008 from Jan 1 - Dec 31 and Figures 3C and 3D show the MW flow on K2Z and K6Z at Lauzon, respectively.

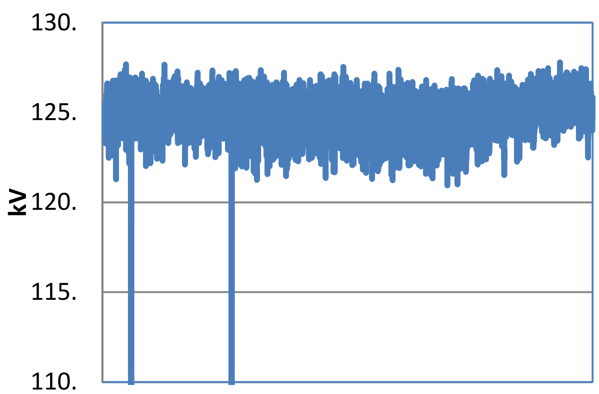


Figure 3A: Lauzon 115 kV Voltage

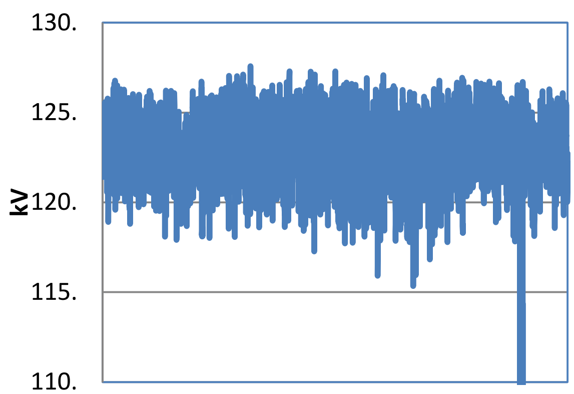


Figure 3B: Kingsville 115 kV Voltage

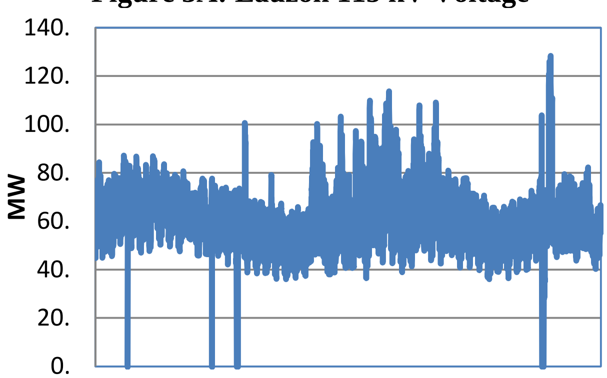


Figure 3C: MW Flow on K2Z

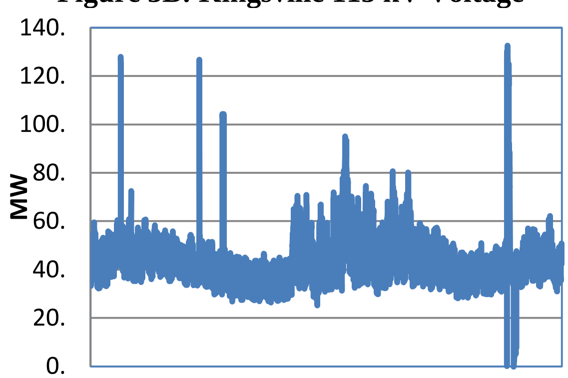


Figure 3D: MW Flow on K6Z

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 115 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 34.5/115 kV step-up transformer is listed below.

Transformation	120/34.5 kV
Rating	33/44/55 MVA ONAN/ONAF/ONAF
Impedance	0.08 pu based on 33 MVA
Configuration	3 phase, high side: wye, low side: delta
Tapping	on-load tap changers at HV (± 8×1.25%)

4.3 Circuit Breakers and Switches

Specifications of the isolation devices provided by the connection applicant are listed below.

Breakers	**HV**	**LV**
Rated line-to-line voltage	145 kV	38 kV
Interrupting time	3 cycles	5 cycles
Rated continuous current	1200 A	800 A
Rated short circuit breaking current	50 kA	50 kA
Switches		
Rated line-to-line voltage	145 kV	35 kV
Rated continuous current	1200 A	600/1200 A

– End of Section –

5. Fault Level Assessment

Fault level studies were completed by Hydro One to examine the effects of the Gosfield Wind Farm on fault levels at existing facilities in the area. Studies were performed to analyze the fault levels with and without Gosfield 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:
<u>Northwestern & Northeastern system</u>

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)

<u>The rest of the system</u>

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 (C24)
Underwood (B4V/B5V)
Kruger Port Alma (C23Z/C24Z)

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
Buchanan230 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 an outage 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 Gosfield 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

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,

<table>
<tr><th>Ontario PD
(Load + Losses)</th><th>West Zone
Generation</th><th>West Zone
Load</th><th>BLIP</th><th>J5D</th><th>FABC</th></tr>
<tr><td>29200 MW</td><td>5650 MW</td><td>3300 MW</td><td>-1524 MW</td><td>150 MW to Ont</td><td>4350 MW</td></tr>
<tr><td rowspan="2">Wind plants</td><td>Kruger Port Alma</td><td>Kruger Chatham</td><td>Raleigh</td><td>Gosfield@K2Z</td><td>Talbot@W45LC</td></tr>
<tr><td>101 MW</td><td>101 MW</td><td>79 MW</td><td>50 MW</td><td>99 MW</td></tr>
<tr><td colspan="3">West of Chatham Generation</td><td colspan="3">West of Chatham Load</td></tr>
<tr><td colspan="3">1200 MW</td><td colspan="3">1100 MW</td></tr>
</table>

- 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.

6.2 Protection Impact Assessment

A Protection Impact Assessment (PIA) was completed by Hydro One to examine the impact of the new generators on existing transmission system protections. The existing protections at Lauzon TS, Kent TS and Kingsville TS/Beller River TS were described in the PIA report and the proposed protection settings were analyzed based on preliminary fault calculations. Finally, protection solutions were proposed and recommendations were presented.

It was found that there is no adverse impact on the line apparent impedance as seen from Lauzon TS with the proposed connection of Gosfield Wind Farm. Detailed fault calculations should be run to derive new apparent impedance due to the proposed connection and the existing line protection settings and the reclosing schemes at associated stations should be revised.

The IESO concluded that the proposed protection adjustments have no material adverse impact on the ICG.

6.3 Thermal Analysis

The summer day-time ratings of circuits (based on most restricting section) near Gosfield WGS under 35ºC 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 ^{o}C	35 ^{o}C	477, 26/7	800 A	940 A
K6Z	4	150 ^{o}C	35 ^{o}C	336, 26/7	690 A	770 A
J3E	4	127 ^{o}C	35 ^{o}C	795.0, 26/7	810 A	1070 A
J4E	4	127 ^{o}C	35 ^{o}C	795.0, 26/7	810 A	1000 A
C23Z	4	132 ^{o}C	35 ^{o}C	1192.5, 54/19	1060 A	1670 A
C24Z	4	116 ^{o}C	35 ^{o}C	795.0, 26/7	840 A	1130 A
C21J,C22J	4	116 ^{o}C	35 ^{o}C	795.0, 26/7	840 A	1130 A
Z1E, Z7E	4	127 ^{o}C	35 ^{o}C	997.2, 21/7	910 A	1380 A
W44LC, W45LC (WC)	4	150 ^{o}C	35 ^{o}C	1307.4, 28/19	1110 A	2000 A
W44LC, W45LC (LC)	4	127 ^{o}C	35 ^{o}C	1843.2, 72/7	1350 A	2170 A

- The lower of the sag temp or 93 ^{o}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 Gosfield. 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 Gosfield**				**After the Connection of Gosfield**			
	Option 1		**Option 2**		**Option 1**		**Option 2**	
	Amps	**%**	**Amps**	**%**	**Amps**	**%**	**Amps**	**%**
K2Z	405	50.6	410	51.3	219	27.4	222	27.8
K6Z	266	38.6	269	39.0	218	31.6	219	31.7
J3E	982	121.2	1068	131.9	916	113.1	991	122.3

J4E	976	120.5	1065	131.5	924	114.1	993	122.6
C23Z	244	23.0	514	48.5	213	20.1	466	44.0
C24Z	365	43.5	0	0.0	335	39.9	0	0.0
C21J	386	46.0	361	43.0	397	47.3	375	44.6
C22J	378	41.5	353	38.8	388	42.6	367	40.3
Z1E	895	80.6	965	86.9	839	75.6	893	80.5
Z7E	887	79.9	958	86.3	831	74.9	885	79.7
W44LC	984	72.9	986	73.0	995	73.7	997	73.9
W45LC	1012	75.0	1014	75.1	1022	75.7	1025	75.9

The flows from the table above indicate that prior to the Gosfield connection, J3E/J4E are overloaded pre-contingency. With the connection of Gosfield, 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 following are the post-contingency loadings of the monitored circuits including loading in ampers, 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 J3E and J4E, 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 Gosfield facility connected to the circuit K2Z. Both declines of pre-ULTC and post-ULTC values are given in the following tables.

Pre-ULTC Voltage Declines									
Contingency	**Chatham 230 kV**	**Lauzon 115 kV**	**Keith 230 kV**	**Keith 115 kV**	**Essex 115 kV**	**K6Z@K 115 kV**	**Kingsville 27 kV**	**Gosfield 115 kV**	**Gosfield 35 kV**
K2Z	0.00	0.00	0.00	0.00	0.00	-0.81	0.00	-	-
J2N	-0.13	-0.41	-0.34	-0.66	-0.50	-0.49	-0.68	-0.41	0.00
J5D	0.13	0.16	0.25	0.16	0.17	0.16	0.00	0.16	0.28
J3E+J4E	-1.47	-3.28	-0.21	0.16	-3.31	-3.40	-3.41	-2.94	-1.39
Z7E+Z1E	0.42	4.50	-0.04	-0.33	-0.58	4.53	4.44	3.68	1.11
Brighton Beach	0.21	0.16	0.21	0.16	0.17	0.16	0.00	0.16	0.28
C23Z	-0.21	-1.47	-0.25	-0.58	-1.16	-1.54	-1.71	-1.31	-0.55

C24Z	0.67	-0.74	0.00	-0.25	-0.58	-0.73	-0.68	-0.65	-0.28
C23Z+C24Z	1.01	-4.83	-0.63	-1.89	-3.73	-4.94	-5.12	-4.25	-1.94
C21J+C22J+T12	0.38	0.25	-0.21	0.41	0.25	0.24	0.00	0.25	0.28

Post-ULTC Voltage Declines									
Contingency	**Chatham 230 kV**	**Lauzon 115 kV**	**Keith 230 kV**	**Keith 115 kV**	**Essex 115 kV**	**K6Z@K 115 kV**	**Kingsville 27 kV**	**Gosfield 115 kV**	**Gosfield 35 kV**
K2Z	0.00	-0.08	0.00	0.00	-0.08	-0.97	0.34	-	-
J2N	0.13	0.25	0.04	0.25	0.25	0.24	0.00	0.25	0.28
J5D	0.13	0.16	0.25	0.16	0.17	0.16	0.00	0.16	0.28
J3E+J4E	-1.39	-2.87	-0.21	0.16	-2.90	-2.59	-1.02	-2.53	-1.11
Z7E+Z1E	0.00	2.87	-0.13	-0.41	-0.58	-0.08	-1.02	3.51	1.11
Brighton Beach	0.25	0.16	0.21	0.16	0.17	0.16	0.00	0.16	0.28
C23Z	-0.21	-1.39	-0.25	-0.58	-1.08	-1.30	0.00	-1.14	-0.28
C24Z	0.71	-0.74	0.00	-0.25	-0.58	-0.73	-0.68	-0.65	-0.28
C23Z+C24Z	1.05	-3.85	-0.46	-1.48	-2.98	-3.72	-0.68	-3.19	-1.39
C21J+C22J+T12	0.42	18.26	-0.21	0.41	0.25	0.24	0.00	0.25	0.28

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	$Q_{gen} = 2.55 \times \sin[\cos^{-1}(0.9)] = 1.11$ Mvar
			$Q_{abs} = 2.55 \times \sin[\cos^{-1}(0.95)] = 0.8$ Mvar
SMK203 Capability	1.0 pu	1.0 pu	$Q_{gen} = 2.3 \times 0.55 = 1.26$ Mvar
			$Q_{abs} = 2.3 \times 0.55 = 1.26$ 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

Gosfield 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, Gosfield Wind Farm must have a minimum capability of supplying approximately **+17.9 MVAr** (capacitive) to **-16.9 MVAr** (inductive) at the connection point for at least one constant 115 kV system voltage at all active power outputs.

Load flow studies were performed to justify a need for static reactive compensation. Besides the information described in Sections 4.1 and 4.2, additional simulation conditions for these load flow studies include that:

- The 115-kV voltage at Lauzon is about 120 kV.
- The terminal voltages of the WTGs vary between 0.9 pu and 1.1 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 **20.6 MVAr** at the connection points, indicating that Gosfield 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 can supply a maximum reactive power of **2.3 MVAr** at the connection points when the WTG units are operated to control the terminal voltages to their highest values. 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 1**5 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 **+17.9 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 115 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 15 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	%
33.4	34.3	2.7	118	119.2	1.0

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 15 MVAr produces less than 4 % voltage increase. However, it is necessary to supply the 15 MVAr in 2 steps to increase the operational flexibility.

6.6 Transient Analysis

Transient stability analyses were performed considering fault in Windsor area with the proposed Gosfield 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).

Contingencies	
SC1	Normally cleared LLLG fault on K6Z @ Lauzon
SC2	Normally cleared LLLG fault on C22J@Chatham
SC3	Normally cleared LLLG fault on C24Z @ Lauzon
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 Gosfield 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.

Voltage range	Event
1.00 – 0.90 pu	No trip
0.90 – 0.85 pu	Relay 1 trips in 3.1 sec
0.85 – 0.50 pu	Relay 2 trips in 1.835 sec
0.50 – 0.15 pu	Relay 3 trips in 0.24 sec

In order to examine the need for LVRT capability, the three phase fault on K6Z at Lauzon with normal clearing time was simulated. This particular contingency is electrically much closer to the new generation facility than other contingencies. 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 0.11 sec. Therefore, fault ride through capability of the wind turbines is adequate.

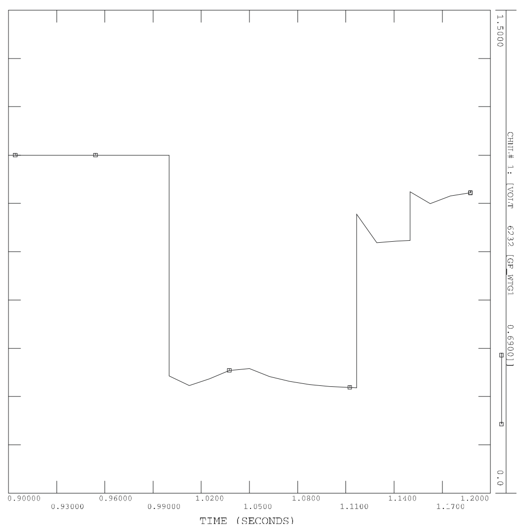


Figure 4: Terminal Voltage of Wind Generator During 3-phase fault at Lauzon TS

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 must also contain the settings of the automatic capacitor switching scheme. If the WFMS is unavailable, the IESO requires that 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	

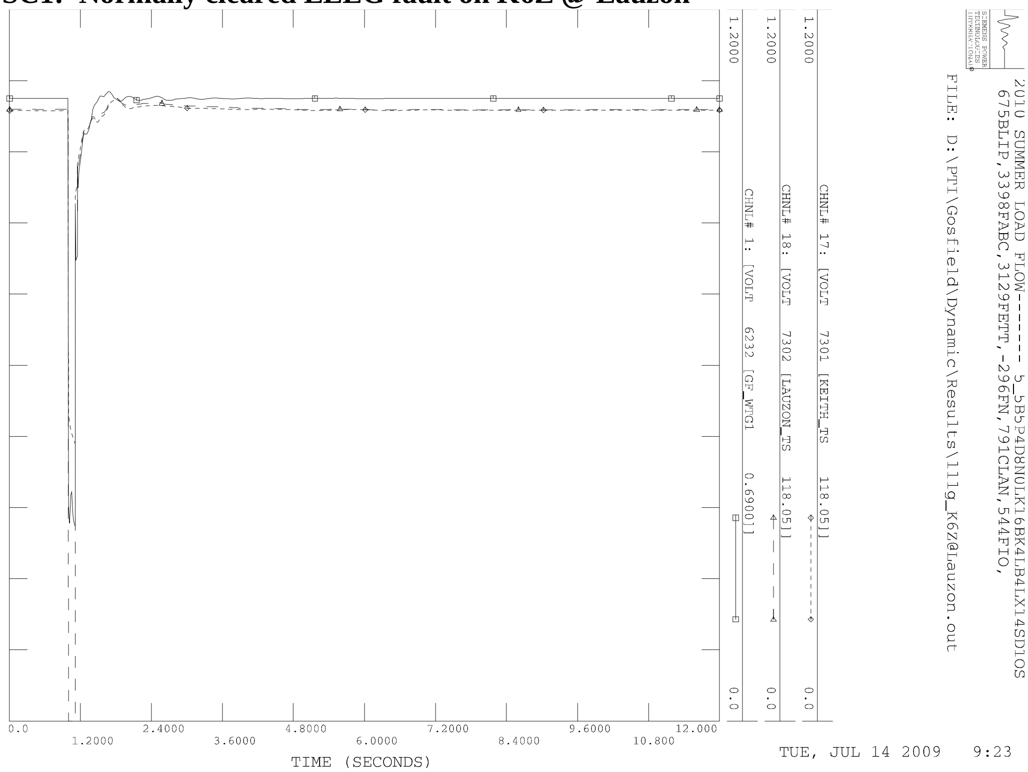
DYRE Data (auto-generated from datasheet information. Copy/paste into DYRE file.)

```
 / 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 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 /
```

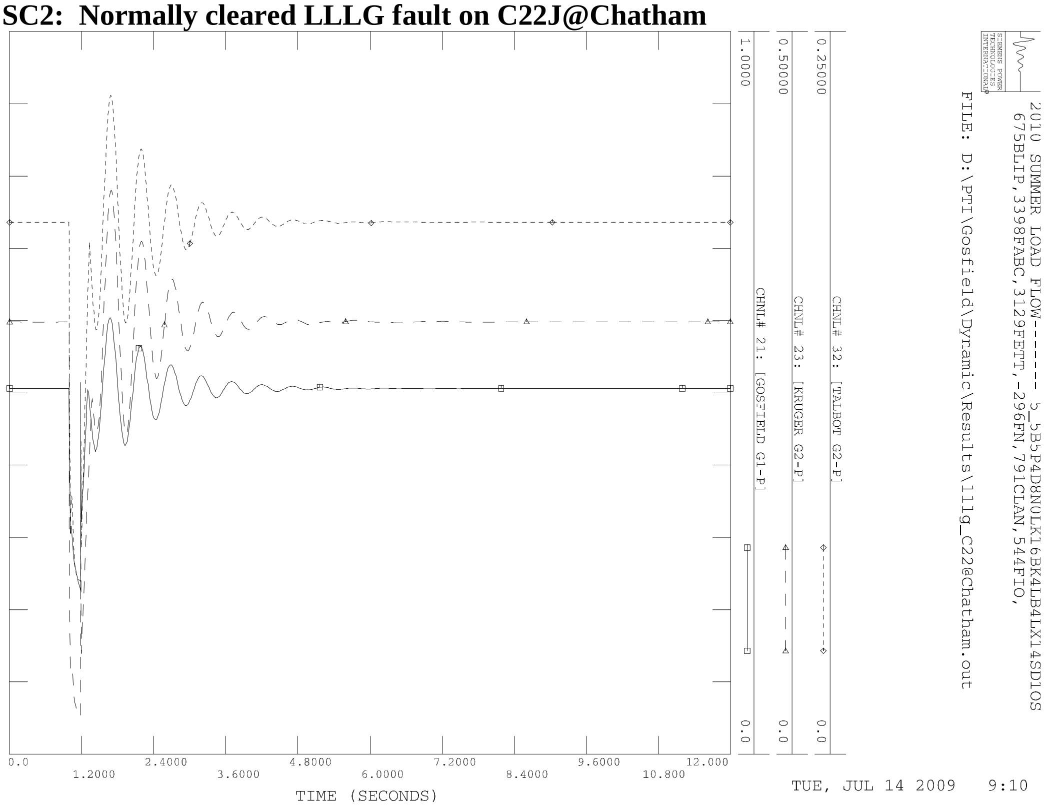
– End of Section –

Appendix B

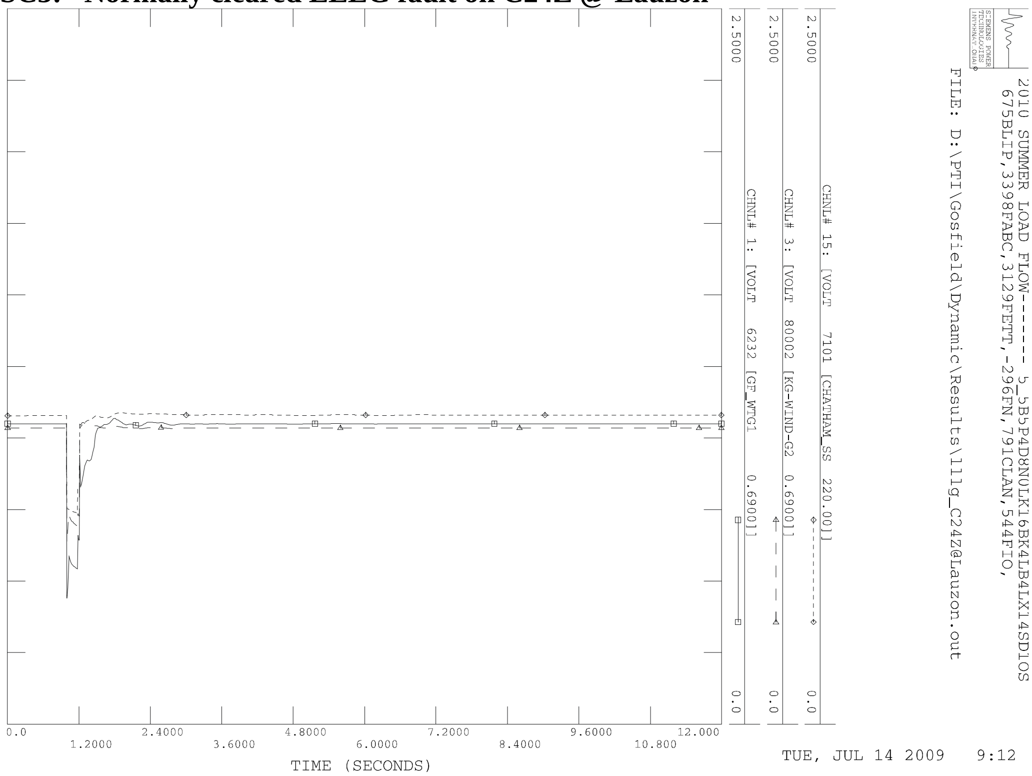
SC1: Normally cleared LLLG fault on K6Z @ Lauzon



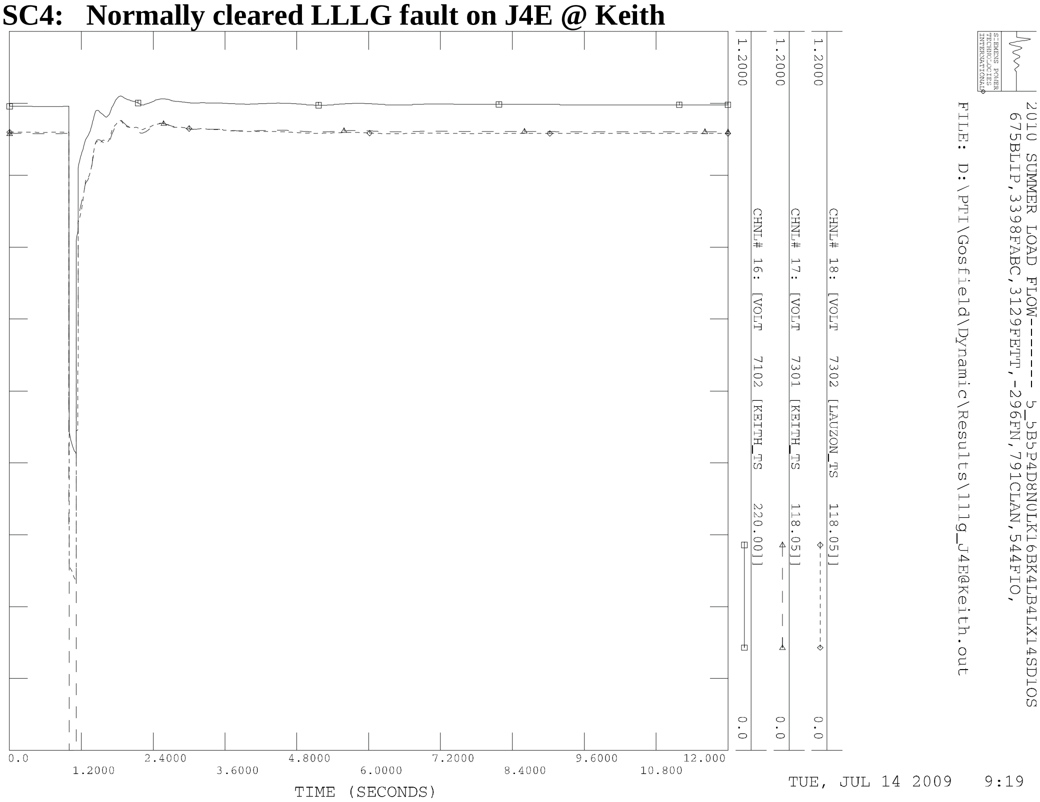
SC2: Normally cleared LLLG fault on C22J@Chatham



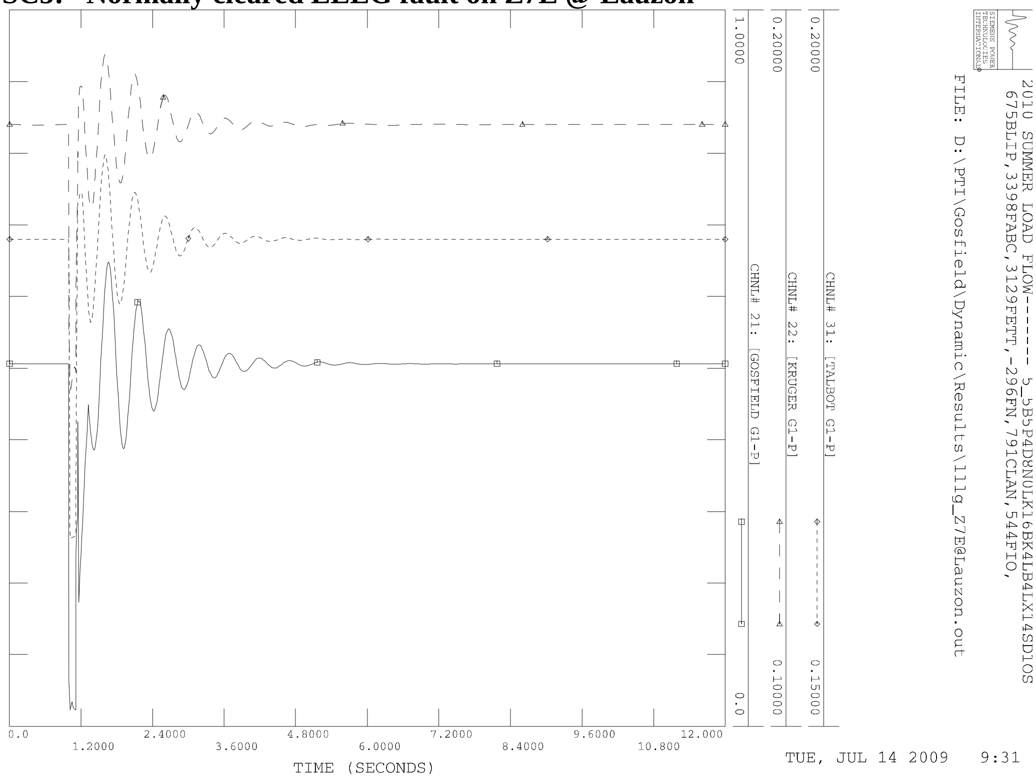
SC3: Normally cleared LLLG fault on C24Z @ Lauzon



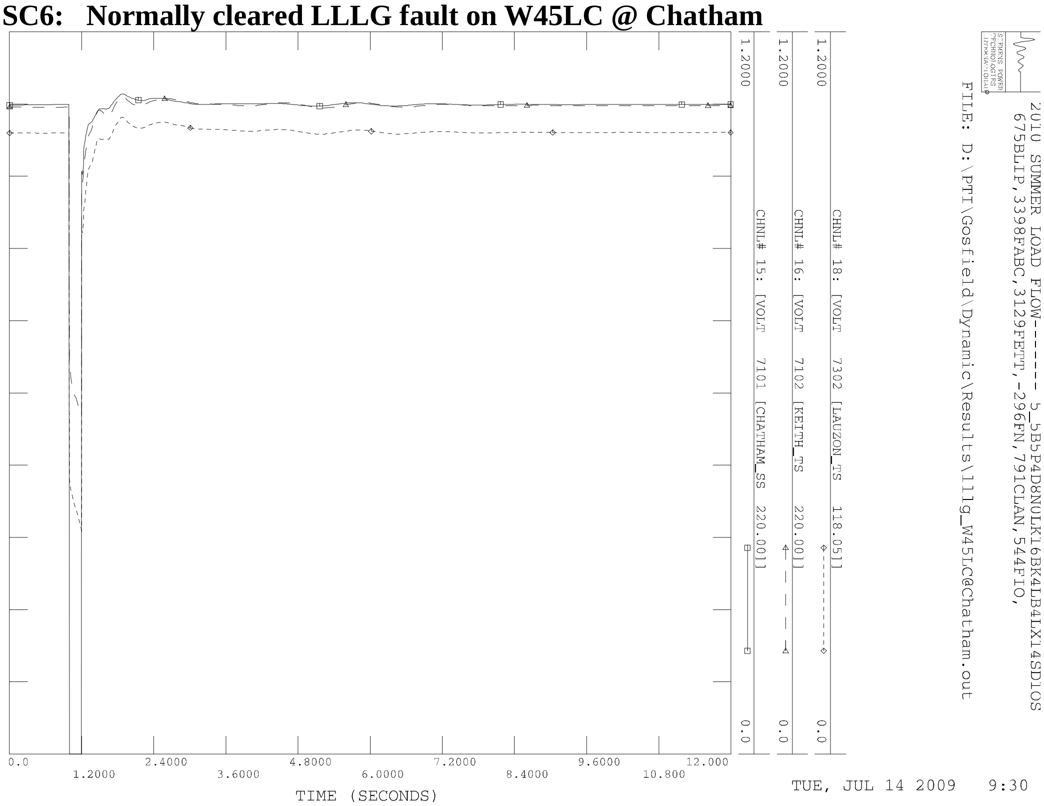
SC4: Normally cleared LLLG fault on J4E @ Keith



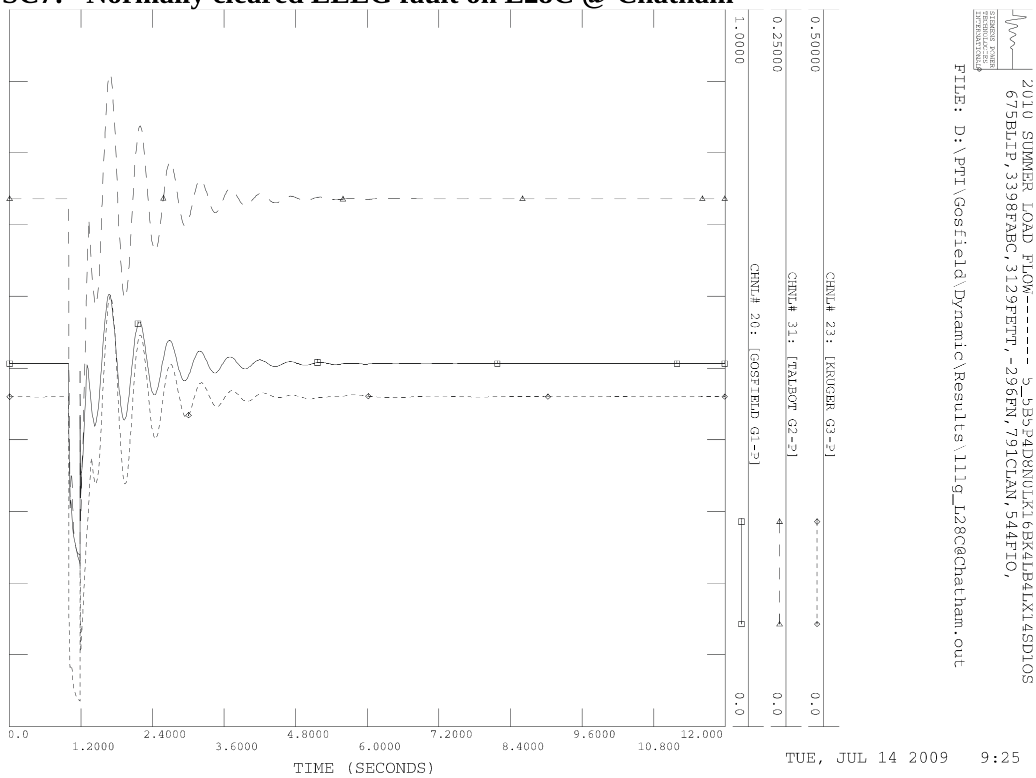
SC5: Normally cleared LLLG fault on Z7E @ Lauzon



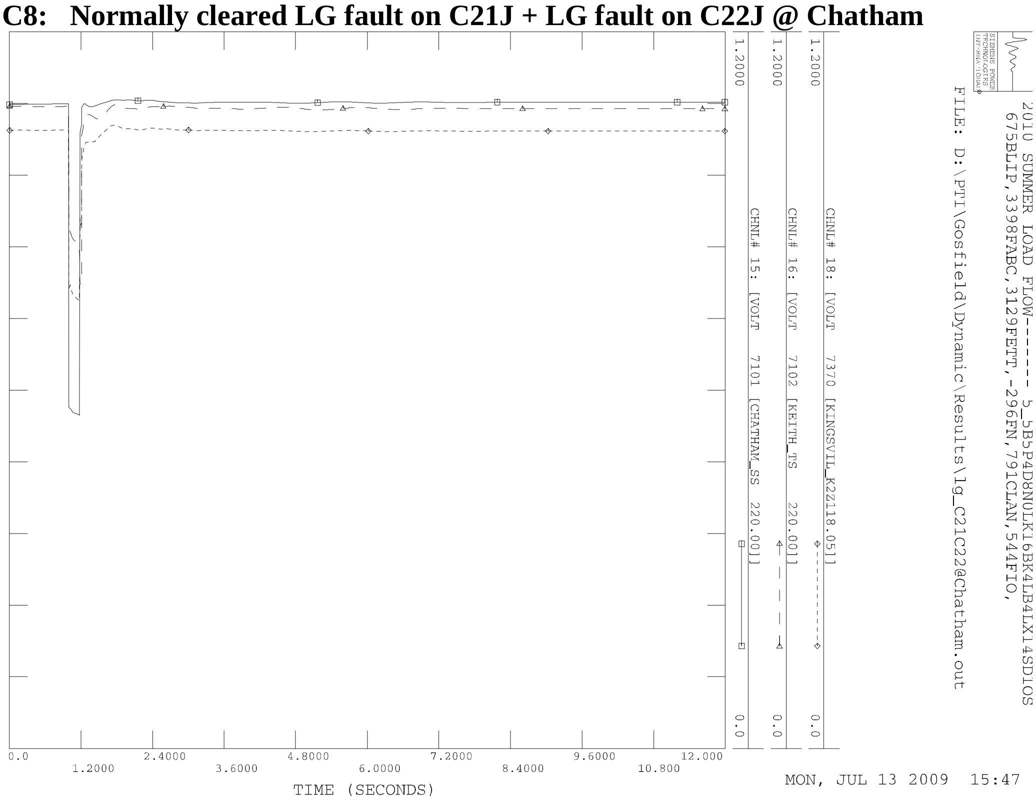
SC6: Normally cleared LLLG fault on W45LC @ Chatham



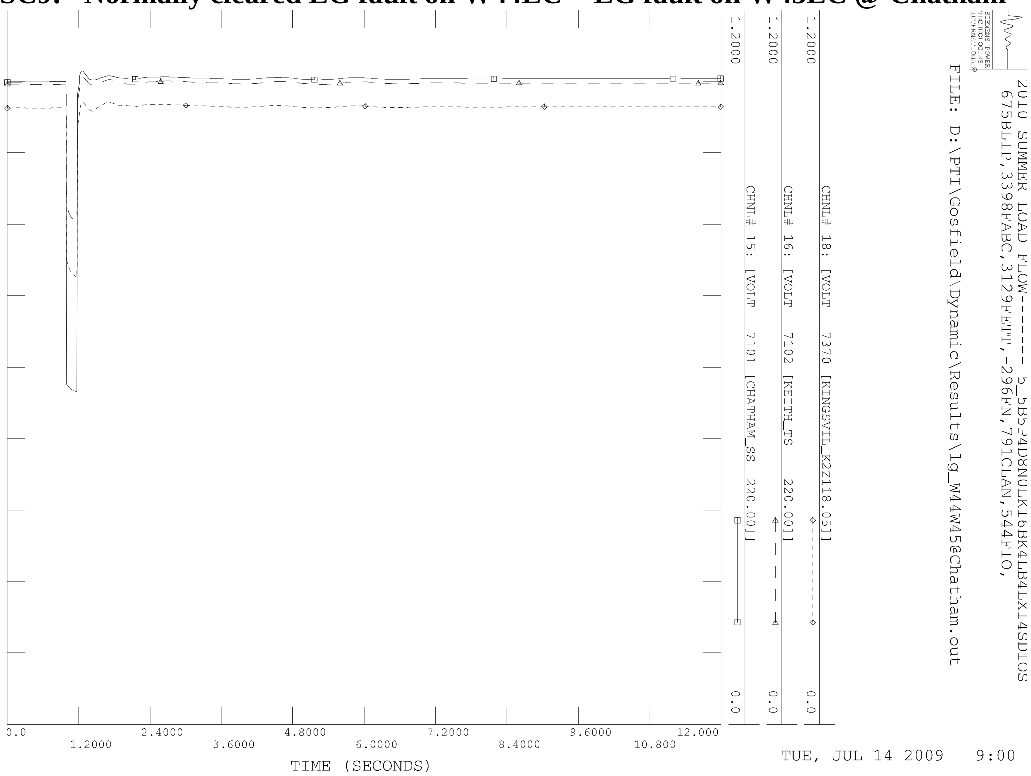
SC7: Normally cleared LLLG fault on L28C @ Chatham



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