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BY COURIER AND ELECTRONIC MAIL

August 20, 2007

Ms. Kirsten Walli
Secretary
Ontario Energy Board
P.O. Box 2319
2300 Yonge Street, 27th Floor
Toronto, ON M4P 1E4

Dear Ms. Walli:

Re: Canadian Renewable Energy Corporation Application for Leave to Construct Transmission Facilities (EB-2007-0034)

Please find enclosed three (3) copies of the Independent Electricity System Operator's comments regarding Procedural Order No. 3 in respect of the above-noted proceeding.

Yours truly,

Carl Burrell
Senior Regulatory Analyst
Regulatory Affairs
Independent Electricity System Operator

Encl.

cc. All Intervenors
Mr. Rob Miller, Canadian Renewable Energy Corporation
Ms. Sharon Wong, Blake Cassels & Graydon LLP
Mr. John Rattray, IESO

EB-2007-0034

ONTARIO ENERGY BOARD

IN THE MATTER OF the *Ontario Energy Board Act, 1998*, S.O. 1998, c.15, Schedule B;

AND IN THE MATTER OF an Application by Canadian Renewable Energy Corporation, for an Order or Orders granting Leave to construct Transmission Facilities near Kingston.

COMMENTS
of
THE INDEPENDENT ELECTRICITY SYSTEM OPERATOR IN RESPECT OF PROCEDURAL ORDER NO. 3

1. The Independent Electricity System Operator (the "IESO") wishes to comment on the matters set out in the Ontario Energy Board's (the "Board") Procedural Order No. 3 regarding Canadian Renewable Energy Corporation's ("CREC's") Wolfe Island Wind Project ("Project").

2. In Procedural Order No. 3 the Board requested written comments concerning the proposed Issues List, including possible additions or deletions to the Issues List, as well as comments concerning the Draft Conditions of Approval.

3. In relation to the reliability effects of the proposed project on the IESO-controlled grid, the IESO is supportive of the proposed Issues List and recommends a minor revision to the Draft Conditions of Approval.

4. The IESO carried out a System Impact Assessment ("SIA") for the proposed Project to assess the reliability effect of the proposed connection to the IESO-controlled grid. This SIA was amended on August 12, 2007 to clarify a comment regarding the

connection of the Project. The amended SIA report is attached to this submission as Appendix 1.

5. The original connection arrangement for connecting the proposed Project to the IESO-controlled grid would have utilized a Customer Switching Station (CSS) in the mainland to locate new 230 kV switchgear. It is now proposed that this switchgear will now be placed in the Gardiner Transformer Station (TS), and the CSS will be eliminated. The IESO's analysis revealed that this revised configuration had no adverse impact on the SIA results. The study also concluded that the post-contingency voltage declines and power flows in equipment are within IESO criteria, as well as their required ratings.

6. The IESO noted that it is possible that station equipment could be overloaded due to configuration of the transmission system during outages that result in the wind farm being connected through the low-voltage side of Gardiner TS. This mode of operation would not be acceptable and should be avoided; the amended SIA confirms that this mode of operation may be avoided if the wind farm is connected through an available alternative tap.

7. The SIA also notes that the proposed Siemens MK II generators which are proposed for the Project do not fully meet the requirements of the Market Rules with respect to dynamic reactive capability. However, the Market Rules allow the IESO to accept a lower reactive power capability for an induction generation facility if the IESO identifies during the connection assessment that such lower capability will not adversely affect the reliable operation of the IESO-controlled grid. In relation to this Project, through the SIA the IESO has imposed certain connection and operating constraints on CREC to ensure that the dynamic reactive capability of the wind farm will be within acceptable limits, including limiting the output of each wind generator under certain conditions.

8. Furthermore, the IESO may impose a higher requirement than that identified at the time of the connection assessment, up to the capabilities required of a synchronous generation unit of the same apparent power, if the IESO subsequently determines that the higher capability is necessary to maintain reliable operation of the IESO-controlled grid. This exemption provision is set out in Appendix 4.2, Reference 1.5, of the Market Rules.

9. The IESO is supportive of the Draft Conditions of Approval requiring CREC to comply with the requirements and recommendations of the SIA and such further and other conditions which may be imposed by the IESO. Given the release of an amended SIA, the IESO proposes that condition 1.4 be amended to read:

> 1.4 CREC shall satisfy the Independent Electricity System Operator ("IESO") requirements and recommendations as reflected in the System Impact Assessment document dated August 12, 2007, and such further and other conditions which may be imposed by the IESO.

Submitted this Monday, August 20, 2007

REPORT

APPENDIX 1

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Power to Ontario.
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System Impact Assessment Report

Wolfe Island
Wind Generation Station (WGS)

CONNECTION ASSESSMENT & APPROVAL PROCESS

CAA ID 20045-111

Applicant: Canadian Hydro Developers

Transmission Assessments & Performance Department

2007 Aug 12~~June 20~~

Document ID	IESO_REP_0344
Document Name	System Impact Assessment Report
Issue	Issue 2~~1~~.0
Reason for Issue	Final.
Effective Date	2007 Aug 12~~June 20~~

System Impact Assessment Report

Wolfe Island 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.

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

SIA Findings

The Canadian Renewable Energy Corporation together with Canadian Hydro Developers is developing a new 198 MW wind power generation farm in Wolfe Island. The project was awarded a contract under the government RFP II, and is expected to start commercial operation at the end of 2008.

Summary

This Assessment examined the impact of injecting 198 MW of wind power generation to the 230 kV circuit X2H or X4H at Gardiner Transformer Station on the reliability of the IESO-controlled grid.

Following conclusions were made.

Conclusions

(1) The proposed wind farm does not have a negative adverse impact to the reliability of the IESO-controlled grid provided the requirements for connection are fulfilled.

(2) The post-contingency voltage declines are within IESO criteria.

(3) The configuration of the transmission system during outages that result in the connection of the wind farm through the low voltage side of Gardiner TS could overload the station equipment. This mode of operation is not acceptable and could be avoided by connecting the wind farm via the available alternative tap.~~The connection of the wind farm to the IESO-controlled grid via LV side of the Gardiner TS is not acceptable.~~

(4) The original connection arrangement used a Customer Switching Station (CSS) in the mainland to locate new 230 kV switchgear. This switchgear will now be placed in Gardiner TS and the CSS will be eliminated. This change has no impact on SIA results.

(5) Siemens MK II generators which are used in this wind farm do not fully meet IESO Market Rules on dynamic reactive capability requirement. The connection impedance between the wind turbine generators and the IESO-controlled grid exceeds the required limit.

(6) The power flows in equipment are within required ratings.

IESO's Requirements for Connection

The following requirements for the incorporation of Wolfe Island WGS to X2H or X4H have been identified.

(1) The generators must operate at nominal voltage of 673 V instead of 690 V. That means all generators should be able to operate in the range of 639 – 706 V and still be able to produce the full MW output. All auxiliary systems including low voltage ride through capability, protections, controls etc must operate reliably in this entire range.

(2) The tap ratio of each generator step-up transformer must be changed from 34,500/690 = 50 to 34,500/673 = 51.26 or the tap must be placed at 51.26/50 = 1.025 position compared to the nominal setting.

(3) The first under-voltage trip setting of the generator must be at 605 V.

(4) The output of each generator must be limited to 2.23 MW when directed by the IESO. The proponent has agreed to comply with this requirement. The Wind Farm Management System must have the capability to implement this limit in a timely manner in all 86 generators.

(5) The total static reactive compensation requirement is 100 MVAr. Since there are two collector buses, 50 MVAr (5 steps of 10 MVAr) must be connected to each collector bus. These must be auto-switched by the Wind Farm Management System via suitable over/under voltage settings.

(6) The generators and the capacitor bank must control the local 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 combine voltage control by generators and capacitors to avoid 'hunting'. Periodically, the IESO will revise the voltage set point as necessary.

(7) The generators should not trip for contingencies except for which the generators will be disconnected by configuration. If generators trip for contingencies for which they are not disconnected by configuration, the low voltage ride through capability must be upgraded.

(8) The 34.5/230 kV transformers must have manual tap changer facilities.

(9) At any time, the wind farm must be connected only to one circuit X2H or X4H. An interlock must be provided between disconnect switches to X2H and X4H such that only one is closed at any time.

(10) During commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within three months of the conclusion of commissioning. The field test results should be verifiable using the PSS/E models used for this SIA.

(11) The Ontario Transmission System Code must be followed and protection systems must be coordinated with those of Hydro One. The back-up batteries and communication channels must be duplicated.

(12) The connection of the wind farm to the IESO-controlled grid through LV side of the Gardiner TS is not permitted.

(13) The autoreclosure of new 230 kV breakers at the connection point must be blocked. Upon its opening for a contingency, the resynchronization must be done only after the IESO approval is granted. The IESO will require reduction of power generation prior to resynchronization followed by gradual increase of power to avoid a power surge.

(14) The generator under-frequency settings should be set such that the generators do not trip for frequency variations that are above the curve in Figure 1.

(15) If the Wind Farm Management System is unavailable, the generator factory settings must be set up such that each generator must start controlling its own terminal voltage while capacitors continue to control 34.5 kV voltage. Generators controlling power factor without the prior approval of the IESO is not permitted.

(16) A disturbance monitoring device must be installed. The device must meet the technical specifications including the quantities to be recorded, the sampling rate and the trigger settings provided by Hydro One. In the event of a disturbance, the applicant is required to provide the collected data to the IESO upon request from the IESO.

(17) Documentation describing the functionalities of the Siemens Wind Farm Management System (WFMS) must be provided to the IESO.

(18) The applicant is responsible for providing real-time telemetering of following variables to the IESO.

- net active and reactive power measured either at 34.5 kV or 230 kV side of the transformers T1,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
- voltage controlling set point

(19) The registration of the new facilities will need to be completed through the IESO's facility registration process before any part of the facility can be placed in-service. If the data or models 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 before the facilities are allowed to connect.

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 Wolfe Island wind generating station subject to the IESO receiving written acknowledgement that the requirements listed in this report will be implemented.

1. Project Description

Wolfe Island is the largest of the 1000 islands in eastern Ontario, and is located at the entrance of the St Lawrence River between Kingston, Ontario and Water Town, New York. This 125 square km island has roughly 1300 full-time residents which virtually double in summer.

As a part of selected RFP Renewable II projects, Canadian Renewable Energy Corporation together with Canadian Hydro Developers plan to develop a 198 MW wind power generation facility in Wolfe Island. The power generated at this facility will be converted to 230 kV at a new transformer station to be built on the island, transmitted across St Lawrence River using a large submarine cable and underground cable in the mainland then injected into the IESO-controlled grid at Gardiner TS. At any time, the power from the wind farm will be injected only into either X2H or X4H. The construction is to commence in the spring of 2007 with commercial operation expected to start in end of 2008.

The generating facility will consist of eighty six 2.55 MVA, 2.3 MW, 690 V, Siemens 2.3MK II, 60 Hz variable speed wind turbine generators that employ squirrel cage induction generators. Each of them has two AC/DC converters connected back-to-back interfacing the stator and the generator step-up transformer. Each converter has the capability to operate in all four quadrants, so they enable the two-way transfer of active and reactive power. While these converters perform conversion of power from fluctuating frequency at stator to constant frequency at step-up transformer, the dc link provides added advantage of restricting the propagation of disturbances between the generator and the grid. The harmonics generated by the dc link are attenuated by a filter and a series reactor connected to the generator terminals. During voltage drops in the grid, the low voltage ride through capability gets activated by the grid side AC/DC converter producing more reactive current at the expense of active current to increase the terminal voltage.

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 six 34.5 kV circuits C1, C2, C3, C4, C5 and C6. Each circuit will have following number of generators connected and maximum power flow.

Circuit ID	C1	C2	C3	C4	C5	C6	Total
Number of generators	14	15	14	16	14	13	86
Maximum MW flow	32.2	34.5	32.2	36.8	32.2	29.9	197.8

Each 0.690/34.5 kV transformer has 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 % voltage variation. The circuits C1, C2 and C3 will be connected to one collector bus which will be connected to 110 MVA, 34.5/230 kV transformer T1 with reactance 0.0930 pu on 100 MVA base. Similarly, the circuits C4, C5 and C6 will be connected to another collector bus which will be connected to second 110 MVA, 34.5/230 kV transformer T2 with same reactance as T1. The collectors, the transformers T1, T2 and switch gear will be located in two new substations to be built by the within the Wolfe Island. The 230 kV side of T1 and T2 will be connected to Gardiner 230 kV busbar via an underground cable within the Wolfe Island and then a submarine cable across the St Lawrence River and then another underground cable in the mainland. The connection to X2H and X4H will comprise one breaker and two disconnects where one disconnect will be normally open and other normally closed. The 34.5/230 kV transformers will have manual tap change facilities. It will have 8 equal steps above nominal and 8 equal steps below nominal on HV winding giving a total of –10 % to +10 % voltage variation.

- End of Section -

2. General Requirements

Models & Data

1. The Connection Applicant must complete the IESO Facility Registration process before IESO final approval for connection is granted. Final models and data including any details of control systems that would be operational must be provided to the IESO prior to the first energisation of any equipment.

2. During commissioning, the Connection Applicant must provide evidence to the IESO that the equipment installed meets the Market Rules requirements and matches or exceeds the performance predicted. 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 accordance with widely recognized standards and to the satisfaction of the IESO. Until this evidence is provided, the Connection Applicant must accept any restrictions the IESO may impose upon their participation in IESO-administered market or connection to the IESO-controlled grid.

Generators

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

The generators must have the capability to operate ± 5 % of the nominal terminal voltage.

The generators must have the dynamic reactive power capabilities to 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.

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, 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. The 230 kV equipment connected to terminal stations must be capable of continuously operating in the range between 220 kV and 250 kV as per Appendix 4.1 of Market Rules.

Some recognized contingencies such as load shedding, open line end can cause a temporary voltage increase above the maximum continuous limit of 250 kV. For these conditions, connection equipment may be exposed to voltages slightly above its maximum continuous rating for the short period of time that it takes the IESO to direct operations to restore a normal voltage and to prepare for the next contingency. This re-preparation period will be as short as possible, but it will not take longer than 30 minutes.

The 230 kV equipment must be able to interrupt rated fault current for voltages up to the maximum continuous rating. They must remain in service, and not automatically trip for voltages up to 5% above the maximum continuous rating for up to 30 minutes to allow the system to be re-dispatched to return voltages within their normal range.

2. The Transmission System Code states that 230 kV connection equipment should have a rated 3-phase symmetrical short circuit capability of 63 kA and a rated single line to ground short circuit capability of 80 kA (usually limited to 63 kA). It also requires that 230 kV breakers have a rated interrupting time of three cycles (50 ms) or less.

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

The Appendix 4.15 and Appendix 4.19 of Market Rules list the requirements with respect to the telemetry that must be provided to the IESO and to the standards that must be achieved on a continual basis by all generators.

In accordance with the requirements for a *major generation facility*, Connection Applicant must ensure that all the equipment needed to provide the telemetry data and meet the performance standards will be installed.

The IESO will finalize items to be telemetered during the IESO Market Entry Process.

Protection Systems

1. Faults within the facility must not trip 230 kV circuits X2H/X4H except for the failure of the new Wolfe Island 230 kV connection breaker. After the facility begins operation, if the tripping of X2H or X4H occurs due to events at the wind generation facility, the facility may be required to be disconnected until the problem is solved.

2. Protection systems must be designed to meet all the requirements of the Transmission System Code and any additional requirements identified by Hydro One.

3. The facility must be capable of operating at full active power for a limited period of time for frequencies as low as 58.8 Hz. The wind turbine 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.

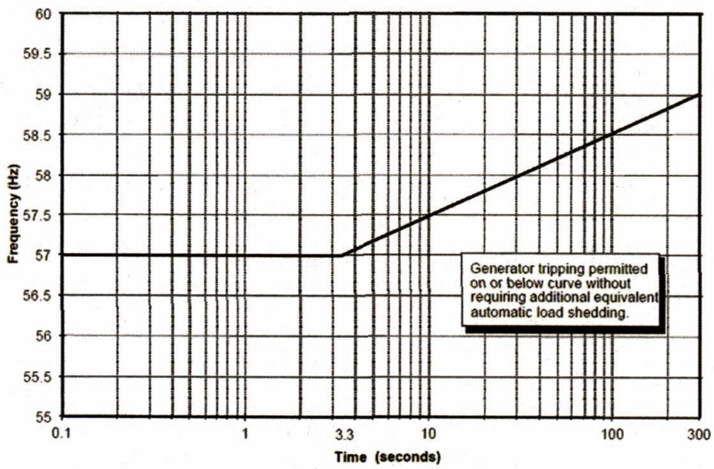


Figure 1: Standards for Setting Under-frequency Trip Protection for Generators

Miscellaneous

1. The generators must be capable of operating continuously in the range between 59.4 Hz and 60.6 Hz as specified in Appendix 4.1 of Market Rules.

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

3. All plant auxiliaries must be capable of operating continuously within the voltage range of 220 kV to 250 kV.

4. 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.

– End of Section –

3. Review of Connection Proposal

3.1 Proposed Connection Arrangement

The proposed connection arrangement is shown in Figure 2.

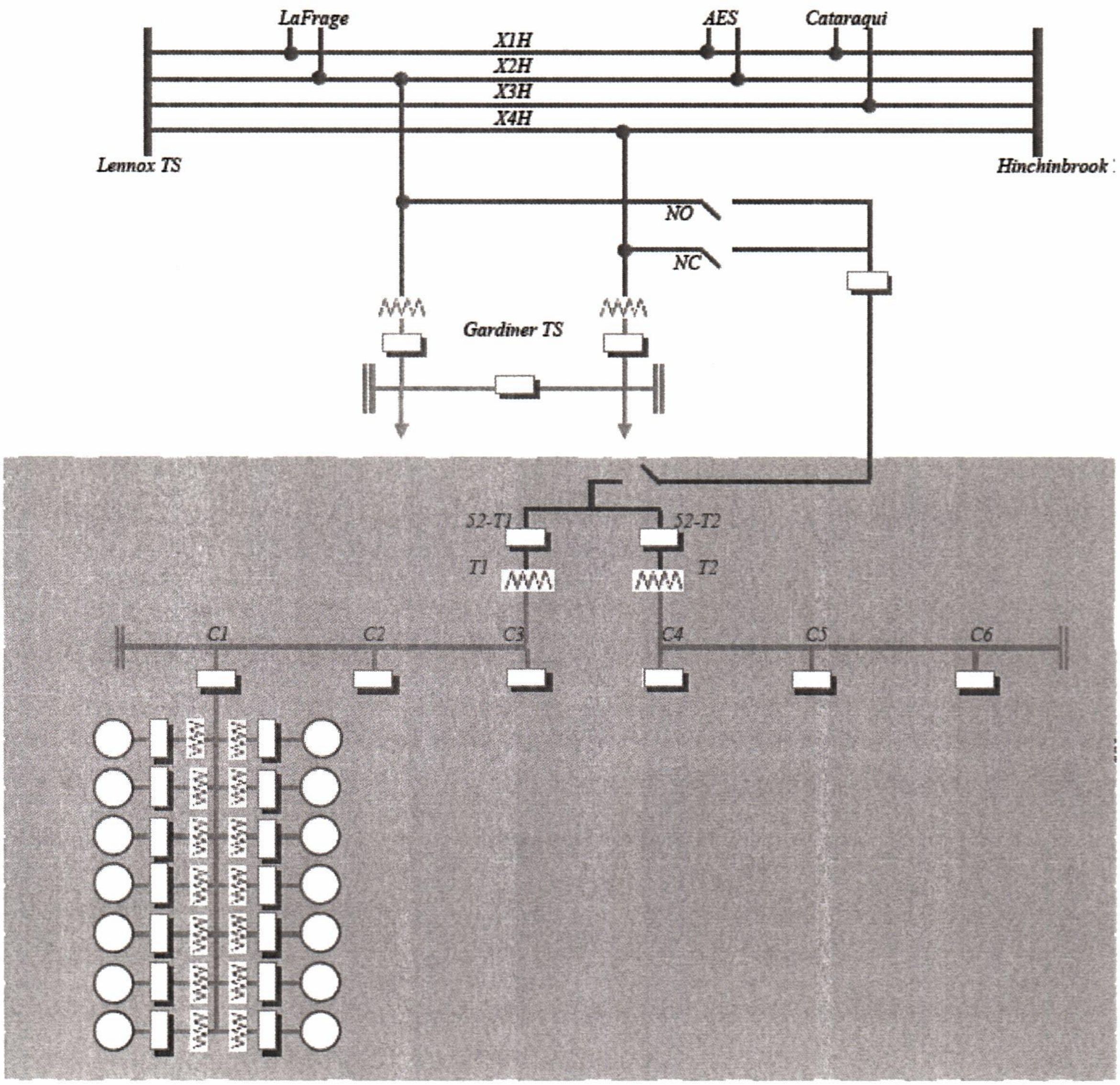


FIGURE 2 – PROPOSED CONNECTION ARRANGEMENT

The number of turbines N per circuit and MW injection is summarized below.

Circuit	*C1*	*C2*	*C3*	*C4*	*C5*	*C6*	*Total*
N	14	15	14	16	14	13	86
MW	32.2	34.5	32.2	36.8	32.2	29.9	197.8
		98.9			98.9		

3.2 Existing System

Figure 3A, 3B, 3C, 3D and 3E show the power flow in X2H and X4H at Lennox and Hinchinbrook, the net MW flow into X4H, the power flow in Gardiner transformers T1 and T2, and the Lennox 230 kV voltage in 1 Hr samples during the period of Jan 1 - Dec 31, 2005. The positive flow is leaving the bus.

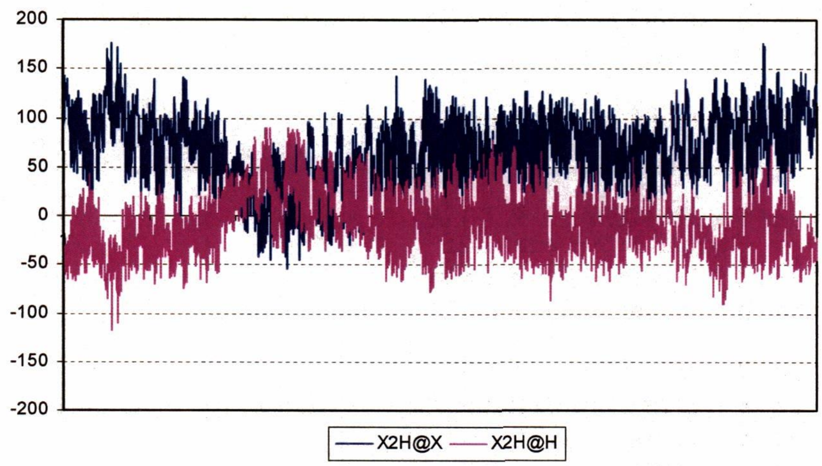


FIGURE 3A – MW FLOW IN X2H

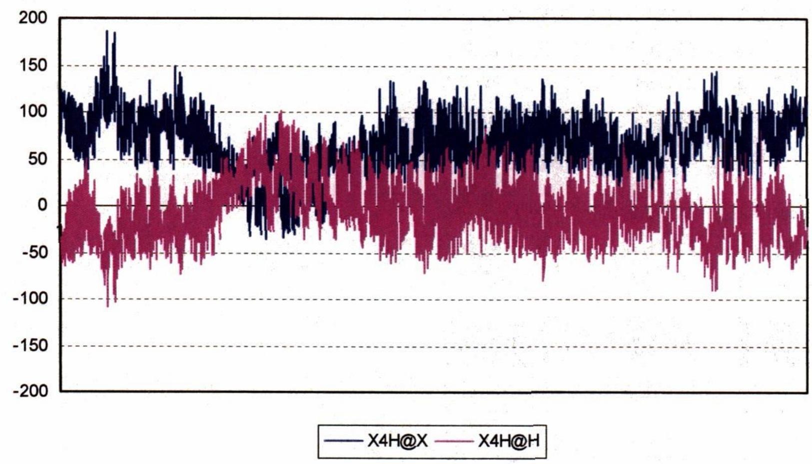


FIGURE 3B – MW FLOW IN X4H

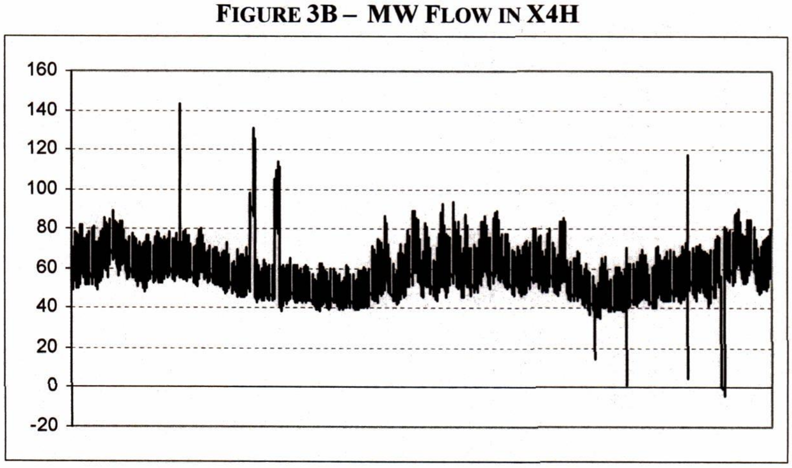


FIGURE 3C – X4H@X + X4H@H

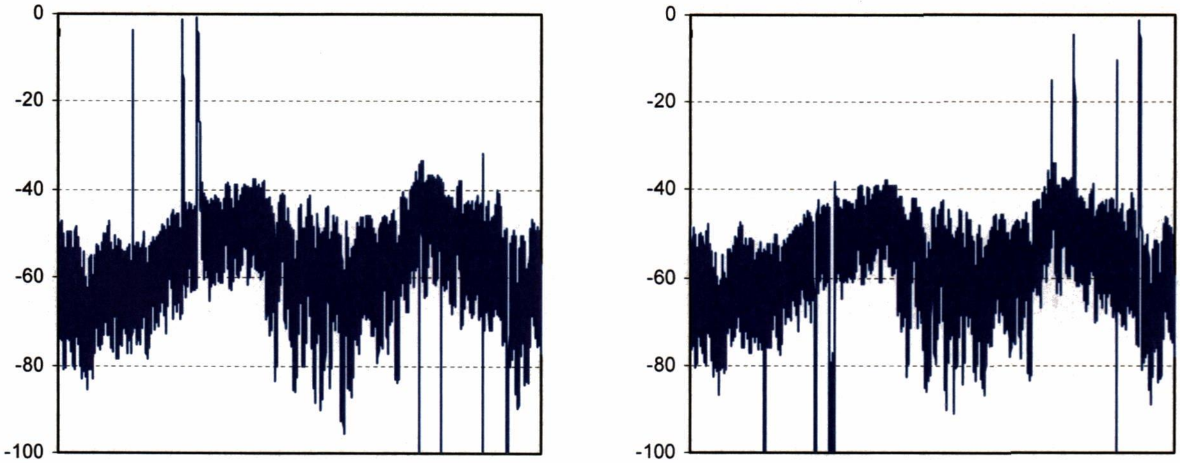


FIGURE 3D – MW FLOW IN GARDINER T1 AND T2

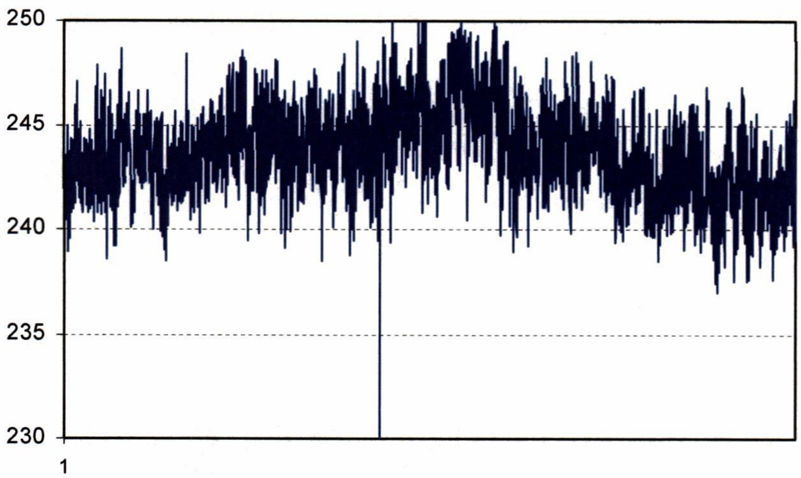


FIGURE 3E – LENNOX 230 KV VOLTAGE

- Figure 3E shows the Lennox 230 kV voltage. The IESO does not have real-time telemetry from Gardiner TS. Considering the electrical proximity of Gardiner to Lennox and the local loads in the vicinity, it can be assumed that the Gardiner voltage could be in the range of 240 – 245 kV. Thus, the reactive resources of the Wolfe Island wind project must have the capability to maintain such high voltages at the connection point. If not, the wind farm could absorb reactive power from the IESO-controlled grid and appear like a new reactive load.

- Figure 3D shows that the average flows in Gardiner T1 and T2 are about 60 MW each. That would mean the 2005 average Gardiner load was about 120 MW. Figure 3C show that the net MW flow into X4H circuit (X4H@X + X4H@H) is also approximately 60 MW which agrees with the MW flow obtained for Gardiner T1.

- From MW flows of Gardiner T1 and T2 given in Figure 3D, it can be concluded that occasionally the Gardiner load reached 170 MW. That means the 197 MW wind project might be able to fully support Gardiner load if sufficient wind prevails.

– End of Section –

4. Data Verification

4.1 Wind Turbine Generators

The data of the generator are given in Appendix A.

4.2 Transformers

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

Transformation	240/34.5 kV
Maximum Rating	110 MVA
Impedance	0.0930 pu based on 100 MVA
Configuration	3 phase, high side: wye, low side: delta
Tapping	on-load tap changers at HV (± 10 % in 17 steps)

Each of 0.690/34.5 kV generator step-up transformers has reactance of 0.06 pu on 2.6 MVA base and has manual off-load tap changers on HV windings. They have 2 equal steps above nominal and 2 equal steps below nominal giving a total of –5 % to +5 % tap variation.

4.3 Circuit Breakers and Switches

Specifications for the breakers and the switches provided by the connection applicant are listed below. If any of the data are inaccurate or recently revised, including absent data must be provided to the IESO. The data must comply with IESO Market Rules and Transmission System Code.

Breakers	**LV**	**HV**
Rated line-to-line voltage	34.5 kV	-
Interrupting time	-	3 cycles
Interrupting media	-	SF6
Rated continuous current	-	1200 A
Rated short circuit breaking current	-	63 kA
Switches		
Rated line-to-line voltage	34.5 kV	-
Rated continuous current	-	1200 A

4.4 Connection Circuits

The impedance of the collector system and the 230 kV connections to Gardiner TS is given in Section 6.4.2.

– End of Section –

5. Fault Level Assessment

Following is an summary of the projected fault currents at key buses that are associated with 230 kV X2H/X4H circuits extracted from Customer Impact Assessment report produced by Hydro One when the in-feed from full output Wolfe Island project is connected to the circuit X4H. These projected currents are computed as if the buses of nominal voltages of 230, 115, 44 kV are at maximum permissible levels of 250, 127, 46 kV in the power system, so that a margin already exists when comparing with ratings.

Busbar	Sym 3-ph	Asym 3-ph	Sym LG	Asym LG
Lennox 230 kV	31.05	40.50	38.31	51.36
Gardiner X2H 230 kV	9.18	9.89	8.08	8.86
Gardiner X4H 230 kV	9.45	10.18	10.98	11.63
Lafarge X2H 230 kV	17.11	18.77	15.42	15.84
Hinchinbrook 230 kV	18.41	19.84	12.30	12.38
Wolfe Island 230 kV	8.40	8.53	10.13	10.38

The Ontario Transmission Code requires that the 230 kV circuit breakers have a minimum 63 kA 3-phase short circuit current interrupting capability and a minimum 80 kA single line to ground short circuit current interrupting capability.

It is concluded that the new fault levels resulting from the incorporation of the Wolfe Island wind farm does not exceed the fault interrupting capability of the breakers in the IESO-controlled grid.

– End of Section –

6. System Impact Studies

This connection assessment was done to identify the effect of the proposed facility on thermal loading of circuits, the system voltages for pre/post contingencies and the transient performance of the system.

6.1 Assumptions and Background

Following sections summarizes the assumptions and the background information used for the analysis.

6.1.1 Pre-contingency conditions

- The study was performed for a system with all transmission elements in service.
- The loads used were 2008 summer coincident peaks under extreme weather conditions. The total Ontario demand is 27,500 MW and the zonal load distribution is :

NW	NE	Essa	Ottawa	East	Toronto	Niagara	SW	Bruce	West
923	1169	1673	1916	1738	10149	1045	5391	57	3439

- The key generations and loads in the vicinity are followings.

Beauh. Import	St Law Import	Lennox GS	Saunders GS	AES GS	Wolfe Island	Gardiner Load
200	300	2200	925	140	198	170 with pf = 0.9

- The proposed Ontario-Quebec HVDC link has been modeled in the load flow used for the thermal analysis with a 1250 MW imports from Hydro Quebec to stress the eastern Ontario further.
- 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.
- The Gardiner TS load is assumed 170 MW. This is the forecast peak for 2008 and also the Figure 2D shows that this level of load was occasionally reached in 2005.
- The large power stations in the province had following number of units in service.

Darlington GS	Bruce GS	Nanticoke GS	Lennox GS	Pickering GS	Lambton GS
4	6	8	4	6	0

- Wind farm generates 198 MW. After losses, 173 MW is injected into Gardiner TS in which 77 MW or 45 % of the power flows into X4H and 96 MW or 55 % of the power flows into Gardiner load. The Gardiner load is 170 MW in which 96 MW or 56 % of the load comes through T1 connected to X4H and 75 MW or 44 % of the load comes through T2 connected to X2H. It can be concluded that the connection of the wind farm to one circuit only does not result into a material unbalance on the loading of the Gardiner transformers.

6.1.2 Siemens MK II reactive power limits

The Siemens MK II wind turbine generator has a dc link between the stator and the grid. Therefore, the reactive capability of the MK II generator not only depends on the AC voltage at terminals, but also depends on the active power capability of the DC link, i.e. the DC voltage and the DC current. As a result, the *reactive power capability* curves of MK II are different to those of synchronous machines, and the Q_{max} and Q_{min} can no longer be assumed constants within ± 5% of rated voltage. Therefore, the variation of Q_{max} and Q_{min} in MK II with terminal voltage needs to be correctly modelled in the load flow simulation; if not, a conservative Q_{max} and Q_{min} corresponding to rated power within ± 5% of rated voltage need to be used instead of using Q_{max} and Q_{min} corresponding to rated power and rated voltage.

The Figure 4 shows the pu reactive power capability of MK II corresponding to rated power. It must be noted that the pu values which are plotted as provided by Siemens are not based on machine MVA, but based on P_{max} of 2.3 MW.

The IESO requires that any generator including MK II must be able to continuously operate within ± 5 % of rated voltage. For that entire range, the MK II must have the capability to generate $2.55 \times \sin [\cos^{-1} (0.9)]/2.3 = 0.47$ pu reactive power and to absorb $2.55 \times \sin [\cos^{-1} (0.95)]/2.3 = 0.34$ pu reactive power on P_{max} base. The Figure 4 also shows this required level of lag and lead reactive power.

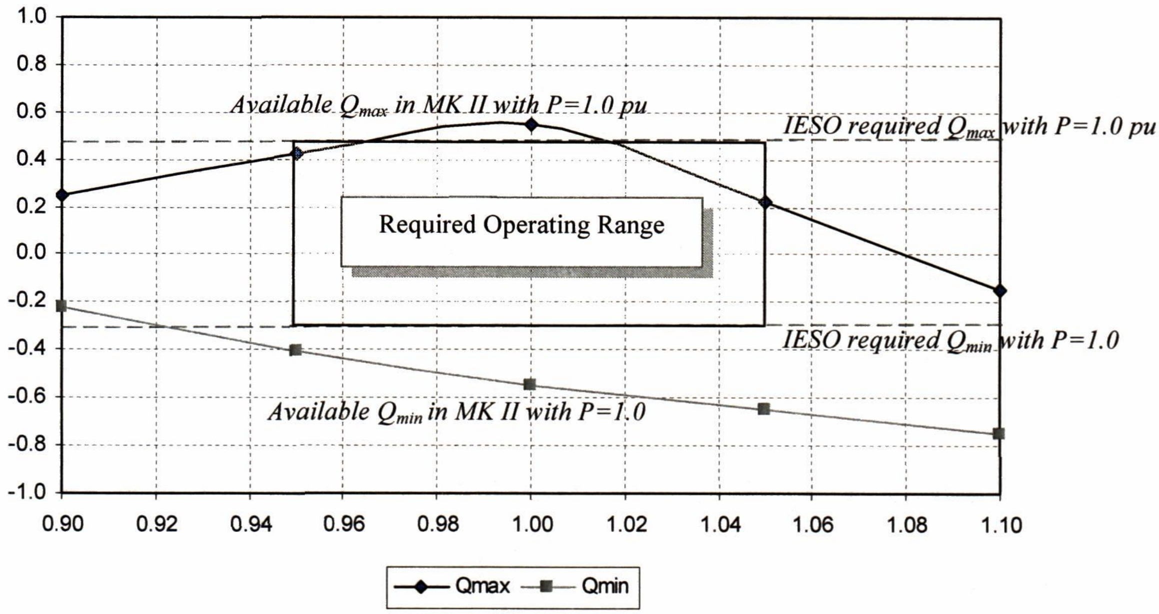


FIGURE 4 – VARIATION OF Q_{MAX} AND Q_{MIN} WITH TERMINAL VOLTAGE

It can be seen that if the rated voltage is 1.0 pu, at the extremes of the ± 5% voltage range, the generator can deliver only $Q_{max} = 0.42$ pu (at 0.95 pu voltage) and $Q_{max} = 0.22$ pu (at 1.05 pu voltage). That would mean each MK II generator can be short of delivering $0.47 - 0.22 = 0.25$ pu or $0.25 \times 2.3 = 0.575$ MVAr of required dynamic reactive power. As far as the entire wind farm is concerned, it can be short of delivering $0.575 \times 86 = 49$ MVAr of required dynamic reactive power. Conversely, the MK II can absorb $Q_{min} = 0.41$ pu (at 0.95 pu voltage) and $Q_{min} = 0.65$ pu (at 1.05 pu voltage). That would mean each MK II has the capability to absorb excess reactive power than the amount required by the IESO.

6.2 Post-contingency voltage decline

The ΔV_1 was found for contingencies when the new facility is connected to the circuit X4H which is the normal operating mode. The ΔV_2 was found when the new facility is connected to the circuit X2H. The ΔV_1 and ΔV_2 given below are the worst of pre-ULTC and post-ULTC values. For pre-ULTC, ΔV_1 and ΔV_2 are calculated after loads are converted into voltage dependant functions and for post-ULTC, ΔV_1 and ΔV_2 are calculated after converting the loads back to constant MVA loads assuming that the loads have returned to the pre-contingency levels. The Gardiner capacitor bank was put O/S pre-contingency in order to produce a weak voltage profile in the local area. For the loss of wind farm, the power factor of all wind turbine generators was made 0.9 lag.

Monitored Bus	$\lvert\Delta V_1\rvert$ %				$\lvert\Delta V_2\rvert$ %
	Loss of X522A	Loss of X1H + X2H	Loss of Lennox T52	Loss of Wind Farm	Loss of X3H + X4H
Lennox 500 kV	0.5	0.1	0.3	0.1	0.1
Lennox 230 kV	0.3	0.4	2.1	0.2	0.3
Hawthorne 500 kV	6.8	0.0	0.2	0.1	0.0
Hawthorne 230 kV	4.8	0.0	0.2	0.1	0.0
Hawthorne 115 kV	4.6	0.0	0.2	0.1	0.0
Hinchinbrook 230 kV	0.3	1.8	1.5	0.3	1.7
Merivale 230 kV	4.4	0.0	0.1	0.1	0.0
Cataraqui 230 kV	0.3	1.5	1.8	0.3	1.5
Cataraqui 115 kV	0.3	2.6	1.6	0.2	2.6
Gardiner 230 kV	0.3	1.7	1.7	1.3	1.7
Gardiner 44 kV	0.2	9.4 (pre)	1.8	0.8	9.7 (pre)
Frontenac 44 kV	0.3	2.7 (pre)	1.6	0.3	2.7 (pre)

The voltage declines are within the required 10 % limit.

6.3 Thermal analysis

A purchase of 1250 MW from Hydro Quebec via proposed HVDC link has been modeled.

Ratings

	X1H@X	X2H@X	X3H@X	X4H@X	X1H@H	X2H@H	X3H@H	X4H@H	Gard T1
Continuous	1579 A	1579 A	1401 A	1579 A	1433 A	1393 A	1118 A	1528 A	125 MVA
STE	1717 A	1717 A	1524 A	1717 A	1556 A	1515 A	1213 A	1661 A	Xxx MVA

Pre-contingency analysis

Projected Current Flow/Continuous Rating							
X1H@X	X2H@X	X3H@X	X4H@X	X1H@H	X2H@H	X3H@H	X4H@H
0.20	0.19	0.27	0.11	0.08	0.15	0.09	0.20

Post-contingency analysis

	Projected Current Flow/STE Rating							
Loss of	X1H@X	X2H@X	X3H@X	X4H@X	X1H@H	X2H@H	X3H@H	X4H@H
X1H+X2H	-	-	0.43	0.25	-	-	0.09	0.23
X3H+X4H	0.36	0.38	-	-	0.11	0.19	-	-

The results do not indicate any thermal over-loading of circuits due to the incorporation of the wind farm.

6.4 Reactive Power Sources

6.4.1 Dynamic Reactive Power Source

The Figure 5 shows the dynamic reactive power range of MK II or the variation of Q_{max} and Q_{min} from 0.9 pu to 1.1 pu terminal voltage if the power output is at rated level (1.0 pu or 2.3 MW) and 97 % of the rated level (0.97 pu or 2.23 MW) with the IESO required level of Q_{max} and Q_{min} for any generator.

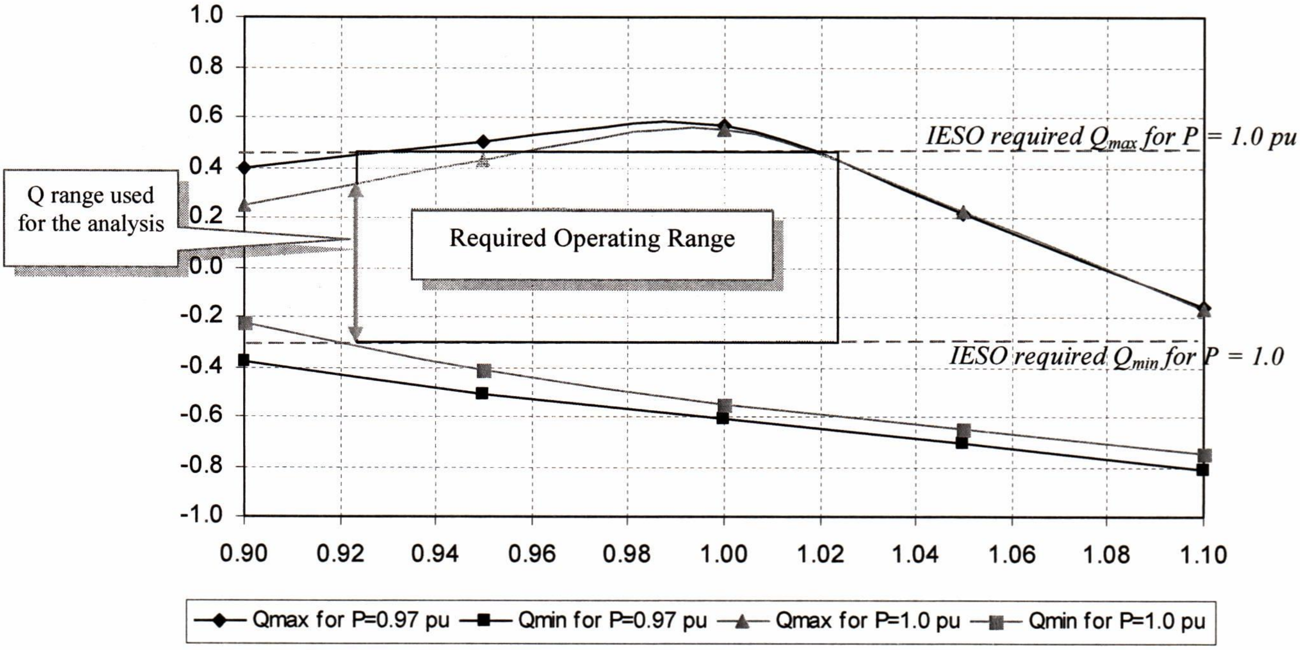


FIGURE 5 – VARIATION OF Q_{MAX} AND Q_{MIN} WITH WTG TERMINAL VOLTAGE

It was evident from the Figure 4 of the Section 6.1.2, that if the MK II is operated at 1.0 pu as nominal voltage, the generator is not able to supply the IESO required level of reactive power near the extremes of the ± 5% voltage range. This will impose a requirement to have an extra dynamic reactive power source to compensate for above deficiency. As an alternative solution, it can be seen from Figure 5 that if the nominal operating voltage is reduced to 0.975 pu and the generator produces only up to 0.97 pu active power, the generator could largely meet the IESO requirement on reactive power capability without having any extra dynamic reactive power source.

This would mean,

(a) the generator must be nominally operated at 673 V
(b) the maximum power output should be 2.23 MW
(b) the generator must be able to continuously produce 2.23 MW within 639-706 V range

The IESO has been notified that given the location of the wind farm, pitch angle, air density etc for the Wolfe Island installation, the MK II will exceed producing 2.23 MW only when the wind speed exceeds 13.5 m/s. The proponent reviewed the wind farm model that was prepared using the data collected during the year 2004 from Wolfe Island wind farm site meteorological measurement towers and indicated that the hourly mean wind speed exceeded 13.5 m/s only for an annualized 577 hours or 6.5 % of the time of the year. Therefore, the prediction is that the wind turbines in Wolfe Island will generate in excess of 2.23 MW only for a relative short period of the year. Therefore, the IESO has determined that during this short period of time, it could allow generators at Wolfe Island to make more than 2.23 MW when the wind speed exceeds of 13.5 m/s, but if the system conditions require, the proponent must limit the output of each turbine to 2.23 MW upon the request of the IESO control room. The proponent has agreed to comply with this requirement.

Having a lower requirement of this nature on reactive power for induction generation facilities is in accordance with Market Rules since the IESO has identified that the lower requirement does not adversely affect the reliability of the IESO-controlled grid. It must be noted that this is a mere 6 MW penalty on the entire wind farm output, but what is required is not a reduction of collective output of wind farm to 191 MW, but a reduction of each generator output to 2.23 MW. As this reduction must be performed in 86 separate generators, the WFMS must have the capability to perform this reduction in a rapid manner in order to maintain the security of the IESO-controlled grid.

In load flow and dynamic studies, the proposed Wolfe Island WGS was modeled with six radial circuits with a single equivalent MK II generator connected to end of each circuit. For the general analysis, it has been assumed that each generator is producing maximum output = 2.3 MW. The Q_{max} and Q_{min} used for the analysis correspond to 2.3 MW and the terminal voltage 0.925 pu since Q_{max} = 0.35 pu and Q_{min} = 0.32 pu that corresponds to 0.925 pu voltage are the minimums within 0.925 pu to 1.025 pu voltage range. The equivalent P_{max}, P_{min}, Q_{max} and Q_{min} are calculated by aggregating P_{max}, P_{min}, Q_{max} and Q_{min} for the number of generators connected to each circuit.

	Per WTG	C1	C2	C3	C4	C5	C6	Total
WTG	1	14	15	14	16	14	13	86
Q_{max} (MVAr)	0.80	11.2	12	11.2	12.8	11.2	10.4	68.8
Q_{min} (MVAr)	0.73	10.22	10.95	10.22	11.68	10.22	9.49	62.78
P_{max} (MW)	2.30	32.2	34.5	32.2	36.8	32.2	29.9	197.8
P_{min} (MW)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

6.4.2 Static Reactive Power Source

If any generator is operated within 1.05 – 0.95 pu voltage in a system where the reactance between generator terminals and the HT connection point is in excess of 0.1313 pu on generator MVA base, the reactive power produced by the generator will not be sufficient to maintain the HT voltage to a single value. This will result in the need to install a static reactive compensation.

If the rated terminal voltage is reduced to 0.975 pu, the maximum limit on reactance to avoid installing compensation will be reduced and consequently, the compensation for excess reactance must be increased. With 0.975 terminal voltage, the taps of each generator step-up transformer must be changed to 1.025 pu to obtain 1.0 pu voltage at the collector bus. This 0.025 pu tap change will increase the impedance of each of eighty six step-up transformers by a factor of $(0.025)^2$. Thus, the compensation must be further increased to account for this increase in the actual impedance.

Equivalent impedance

The followings are the impedances on 100 MVA base to represent the six feeders in the collector network and equivalent generator step-up transformers (tap changed to 1.025 pu).

	C1	C2	C3	C4	C5	C6
R_{Feeder}	0.3080	0.2736	0.4072	0.4251	0.2352	0.3306
X_{Feeder}	0.2001	0.1937	0.3742	0.3851	0.2040	0.3094
B_{Feeder}	0.0000778	0.0000886	0.0002122	0.000226	0.000114	0.000179
$R_{Generator\ Transformer}$	0.02367	0.02209	0.02367	0.02071	0.02367	0.02549
$X_{Generator\ Transformer}$	0.17318	0.16163	0.17318	0.15153	0.17318	0.18650

The 230 kV transmission consists of an underground cable in mainland, a submarine cable across the St Lawrence River and underground cables with in Wolfe Island. The parameters for this combination and 34.5/230 kV transformers T1 and T2 on 100 MVA base are followings.

	T1	T2	230 kV connection
R	0.0000	0.0000	0.001745
X	0.0930	0.0930	0.003888
B	-	-	0.000000

Followings are various reactances (on 100 MVA base) computed from data provided by the proponent.

Reactance of collector circuits C1, C2, C3 and their GSU transformers	= 0.1367	pu
Reactance of Wolfe Island T1	= 0.0930	pu
(a) Reactance of generator terminals of C1, C2, C3 and Wolfe Island T1	= 0.2297	pu
Reactance of collector circuits C4, C5, C6 and their GSU transformers	= 0.1535	pu
Reactance of Wolfe Island T2	= 0.0930	pu
(b) Reactance of generator terminals of C4, C5, C6 and Wolfe Island T2	= 0.2465	pu
(c) Reactance of the 230 kV cables	= 0.0038	pu
(a) // (b) + (c) Reactance of the entire wind farm up to Gardiner 230 kV bus	= 0.1228	pu

Capacitor requirement

The reactance of the entire wind farm on facility MVA base (219 MVA) is 0.2694 pu. The calculation of the static compensation is based on each generator is producing 2.23 MW, so that the generator can produce maximum reactive power (at 0.9 lag power factor).

	Acceptable conditions	*Actual conditions*
WTG terminal voltage	0.975 pu	0.975 pu
Total reactive power generation from wind farm	95 MVAr	95 MVAr
Total connection impedance on 219 MVA base	0.1306 pu	0.2694 pu
230 kV Gardiner voltage can be controlled up to	1.0 pu	0.96 pu
Reactive power injected into existing 230 kV system	69 MVAr	41 MVar

The difference in actual and acceptable reactive power flow into 230 kV bus is 26 MVAr. Due to this difference, the wind farm can maintain the Gardiner 230 kV voltage only up to 0.96 pu, i.e. 220 kV. If the voltage to be maintained to 1.0 pu, i.e. 230 kV, the above extra loss of 26 MVAr must be supplied to the 230 kV bus in the form of a reactive compensation.

However, often the Gardiner voltage is more than 230 kV and can be as high as 245 kV at times. If that level of voltage is to be maintained by the wind farm, more than 26 MVAr compensation must be added to the 230 kV bus. The additional compensation is calculated using QV analysis. Figure 6 shows the QV curve for the Gardiner 230 kV bus. This graph demonstrates the variation of the voltage with additional reactive power injected into 230 kV bus.

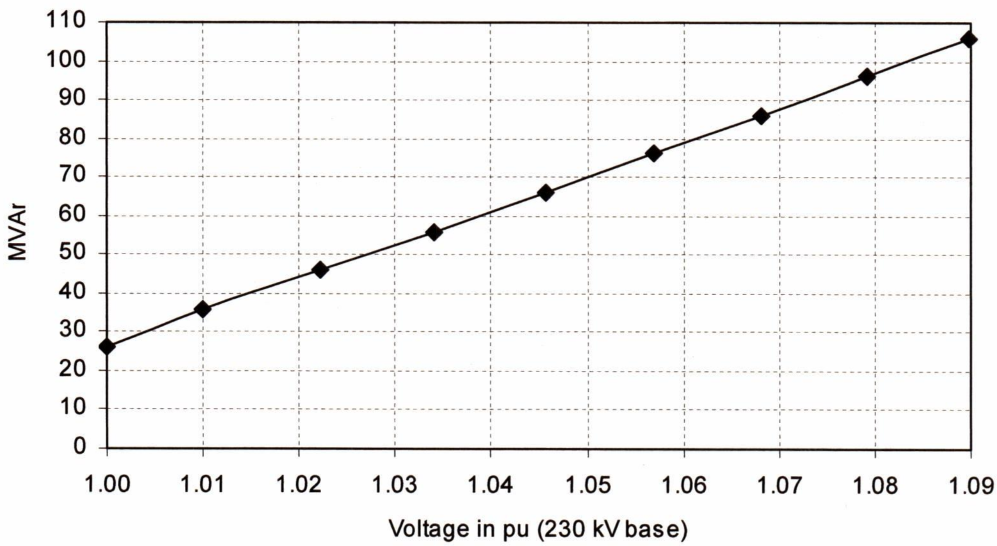


FIGURE 6 – QV CURVE FOR GARDINER 230 KV BUS

If the voltage reaches 245 kV or 1.07 pu, approximately 85 MVAr of compensation would be required at 230 kV bus so that the wind farm could maintain that voltage. If not, the wind farm would draw reactive power from the grid. Instead to the 230 kV bus, the compensation can be provided to the collector buses if an added compensation is provided to supply losses occurring in the 230 kV cables and two 34.5/230 kV transformers. These losses appear to be about 10 - 15 MVAr depends on the operating condition. Thus, the IESO requires 50 MVAr to be provided at each collector bus and be supplied in 5 steps of 10 MVAr.

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 and direct the capacitor switching and generator reactive power production as both equipment controls the voltage at the same busbar.

Post-capacitor switching voltage

Following table shows different voltages if entire 100 MVAr is switched on. The generators are controlling the collector bus voltage to 1.0 pu. For this particular simulation, the 34.5/230 kV transformer tap has been set to 1.1 pu while generator step-up transformer taps are set to 1.025 pu.

Generator ID	G1	G2	G3	G4	G5	G6
Terminal voltage	691 V	688 V	693 V	700 V	677 V	682 V
Collector bus voltage	34.5 kV			34.5 kV		
230 kV bus	Gardiner = 242 kV, Wolfe Island = 242 kV					

The results show that even if the entire 100 MVAr capacitor bank is switched on, the turbine terminal voltages will be in the range of 677 - 700 V. This is within the required range of 673 – 706 V where the IESO lag power factor requirement is met. Further, since the first over-voltage trip setting is normally set to 740 V (10 % above nominal voltage of 673 V) the capacitor switching will not trip the generators. In case, the 230 kV voltage is higher than 242 kV, the voltage control set point of the generators can be raised above 1.0 pu.

It must be noted that the entire 100 MVAr of reactive compensation is required to cater losses only when all eighty six turbines are generating maximum capacity of 2.3 MW each. Based on historic wind speed statistics, all generators in Wolfe Island wind farm may not be running full capacity very frequently, thus the full 100 MVAr may not be switched on too frequently.

Voltage change due to capacitor switching

The IESO allows a voltage change ΔV on a single capacitor switching to be no more than 4 %. Following summarizes the percentage change in voltage due to simultaneous switching of the first 10 MVAr capacitors at both collector buses. All generators are made to operate at a fixed power factor to prevent their dynamic reactive power capability change bus voltages, so that the ΔV is only due to switching of the capacitors. The generators absorb maximum reactive power so that the ΔV due to capacitor switching is larger than under normal conditions. The transformer ULTCs have been locked.

ΔV % @ 34.5 kV collector buses	1.8, 1.8
ΔV % @ Wolfe Island 230 kV bus	0.7
ΔV % @ Gardiner 230 kV bus	0.6

The results show that 10 MVAr step size would not exceed IESO requirement on ΔV.

6.5 Transient Analysis

Eight contingencies were tested. They include a permanent three-phase fault on a circuit cleared with normal fault clearing time (TSC1, TSC3, TSC5, TSC6), 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 times (TSC2, TSC4), a permanent phase to ground fault on a circuit cleared by delayed fault clearing time (TSC7) and a multiple outage (TSC8). Usually, the double contingencies are not respected in eastern Ontario, however they were included to provide any additional insight. It is assumed that 500, 230 and 44 kV breakers open in 2, 3 and 8 cycles respectively.

Contingencies

- TSC1 Normally cleared 3ph fault at X522A@X
- TSC2 Normally cleared LG fault at X1H@X + LG fault at X2H@X
- TSC3 Normally cleared 3ph fault at X2H@X
- TSC4 Normally cleared LG fault at X522A@X + LG fault at X523A@X
- TSC5 Normally cleared 3ph fault at Gardiner 44 kV load bus
- TSC6 Normally cleared 3ph fault at HT side of Wolfe Island Transformer T1
- TSC7 LG fault at X2H@X + H52L2 BF at Lennox and loss of T52 transformer
- TSC8 Three X4H terminal breakers open + fourth breaker open by a fault in adjacent circuit

The simulation results are shown in Appendix C.
None of the contingencies except TSC8 which associates a multiple-outage caused any unacceptable transient performance to the IESO-controlled grid. For the post-TSC8, the wind farm is connected to the 230 kV system only via two Gardiner 230/44 kV transformers in series. This high impedance caused a significant voltage drop at generator terminals for an extended period causing oscillations. Given that the terminal voltage is low and sustained, the low voltage ride through capability does not assist. The generator oscillations caused the Gardiner 230 kV voltage also to experience oscillations. Therefore, any probable outages that may result in the wind farm connecting to the 230 kV system only via 44 kV busbar must be avoided by connecting the wind farm to the companion circuit X2H pre-contingency.

Islanding

When X4H is tripped, the MK II generators in the wind farm will island with available capacitors. Subsequently, the capacitors may switch out by over-voltages and generators may trip by over-frequency. The IESO attempted to simulate the transient performance of this over-generated island to investigate the resulting island voltages and turbine speeds. It does not appear that the MK II model is suitably developed to simulate wide variations of frequency and voltage occurring in islanding situations.

6.6 Low-voltage ride through capability

As any other generator, 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 generator terminals is to be temporarily mitigated by the 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. However, in PSS/E model for MK II, the LVRT feature accompanies a change of under-voltage setting as shown below.

With No LVRT		*With LVRT*	
Voltage range	*Event*	*Voltage range*	*Event*
1.00 – 0.90 pu	No trip	1.00 – 0.90 pu	No trip
0.90 – 0.85 pu	Relay 1 trips in 3.1 sec	0.90 – 0.70 pu	Relay 1 trips in 3.1 sec
0.85 – 0.00 pu	Relay 3 trips in 0.075 sec	0.70 – 0.15 pu	Relay 2 trips in 2.5 sec
		0.15 – 0.00 pu	Relay 3 trips in 0.15 sec

The LVRT capability must be demonstrated during commissioning by conducting a set of IESO specified field tests and the result should be verifiable using the PSS/E model with LVRT enabled.

The results of transient analysis performed with LVRT concluded that above settings are adequate.

6.7 Wind Farm Management System

The Wind Farm Management System 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 Section –

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	

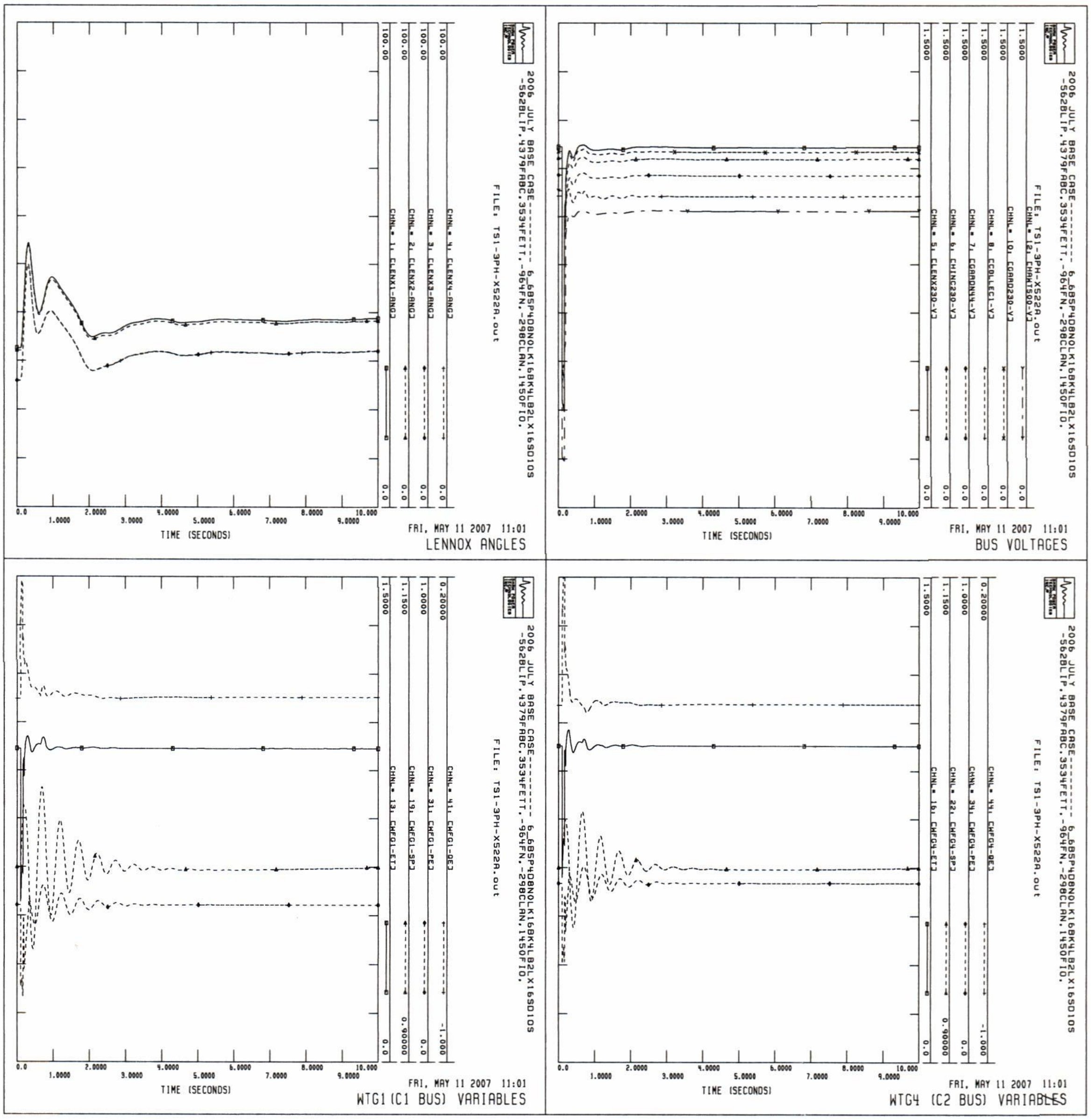
DYRE Data (auto-generated from datasheet information. Copy/paste into DYRE file.)

```
/ 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 /
```

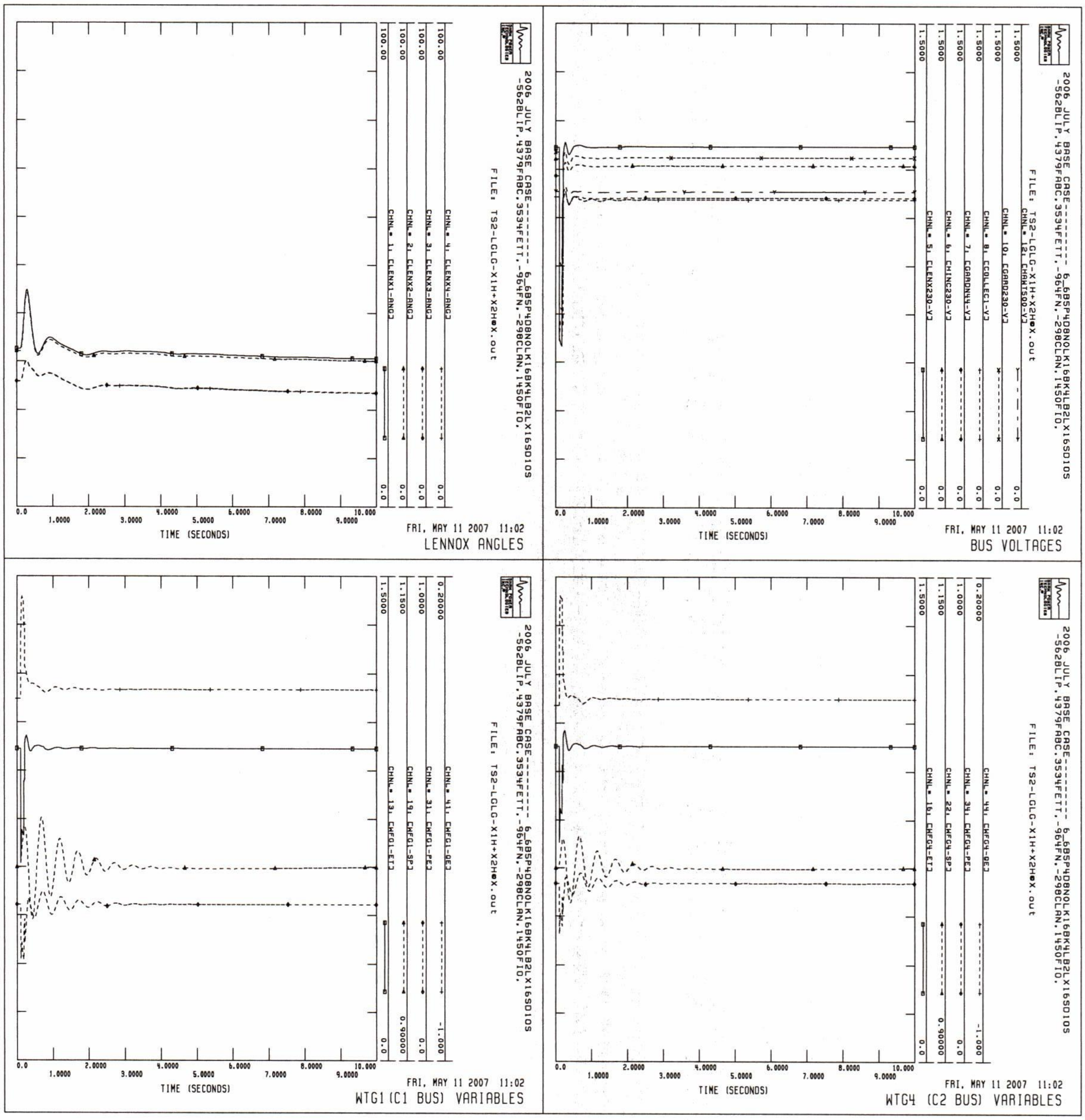
– End of Section –

APPENDIX B

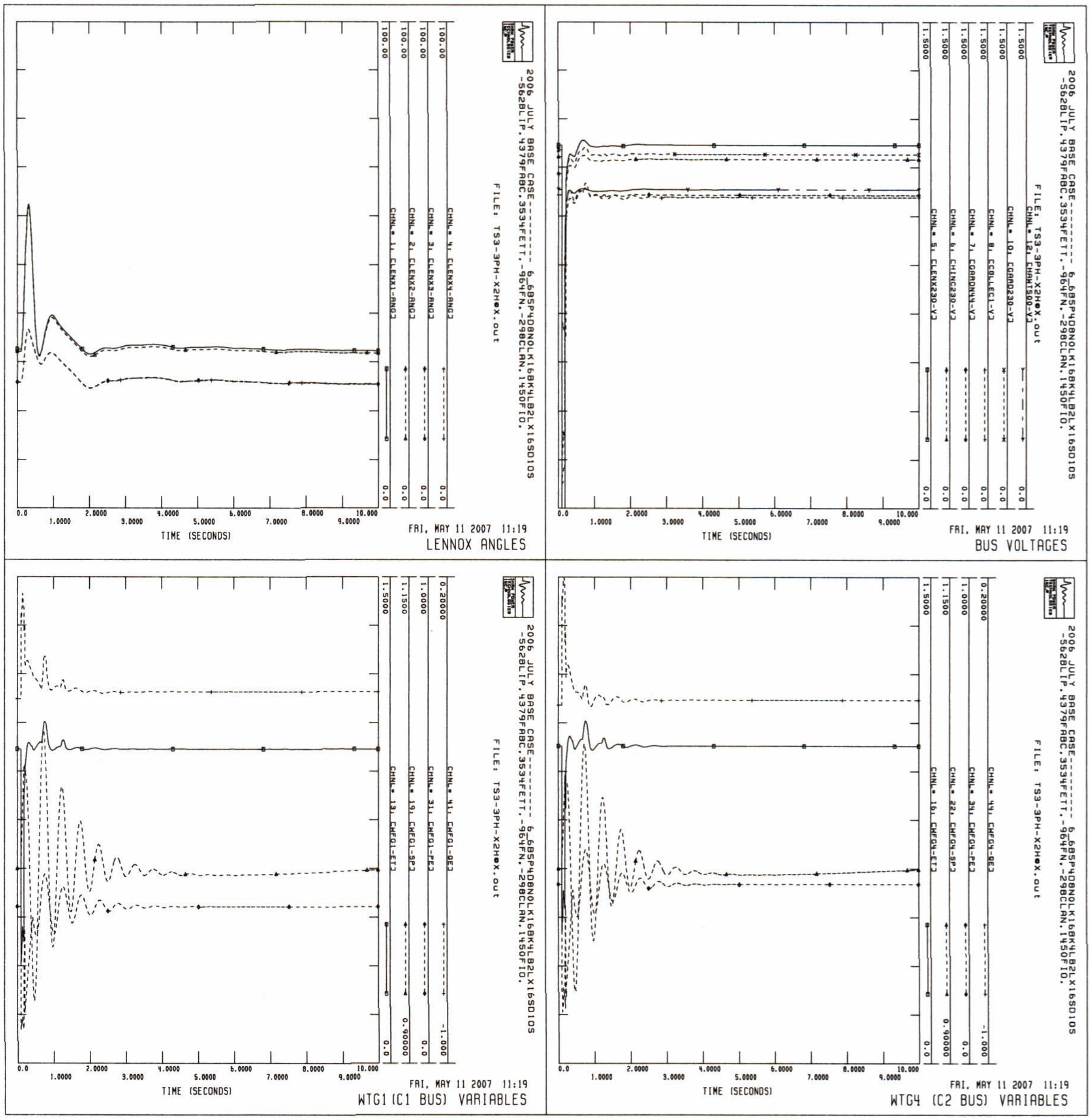
TSC1-Normally cleared 3ph fault at X522A@X



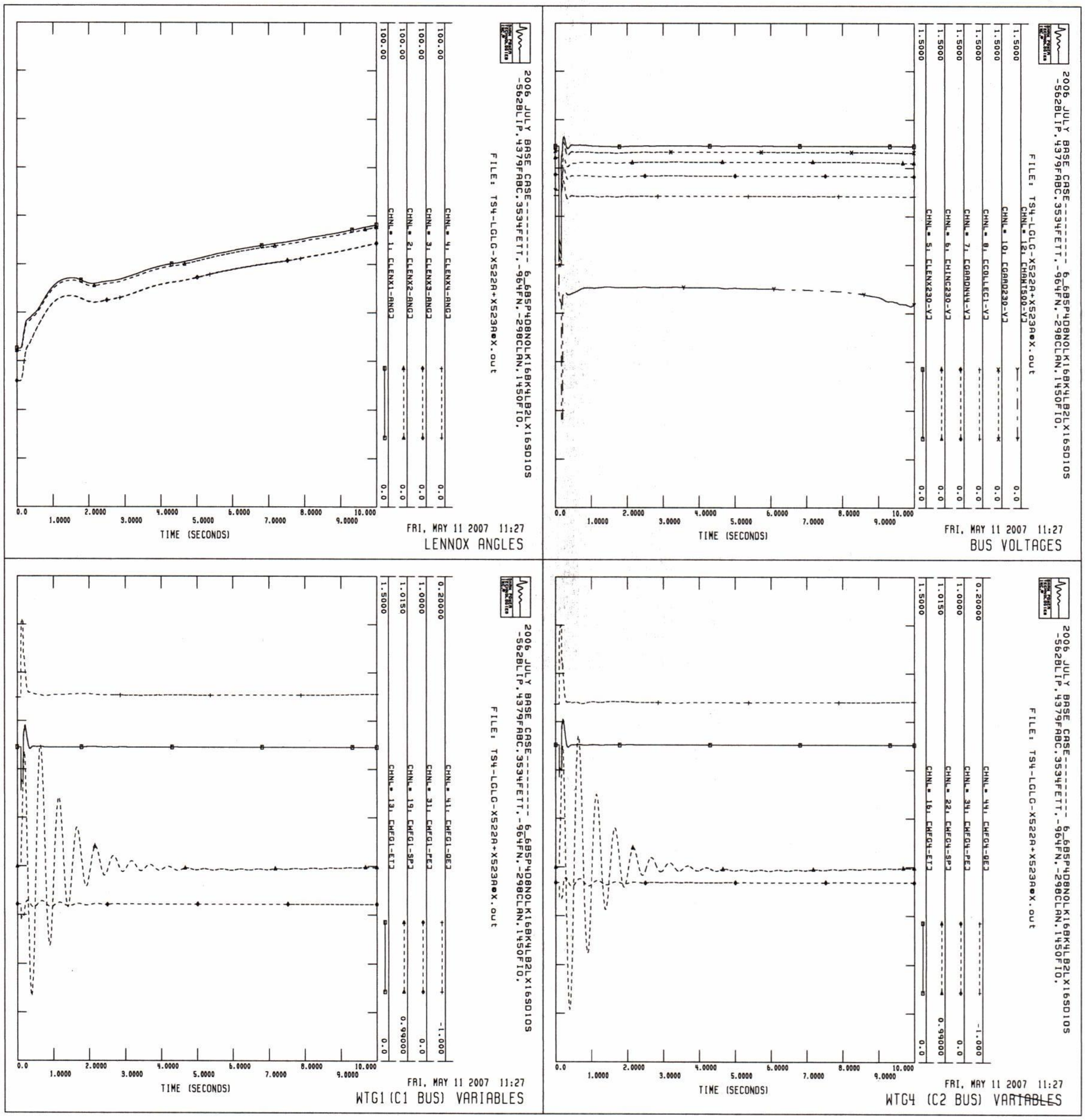
TSC2-Normally cleared LGLG faults at (X1H+X2H)@X



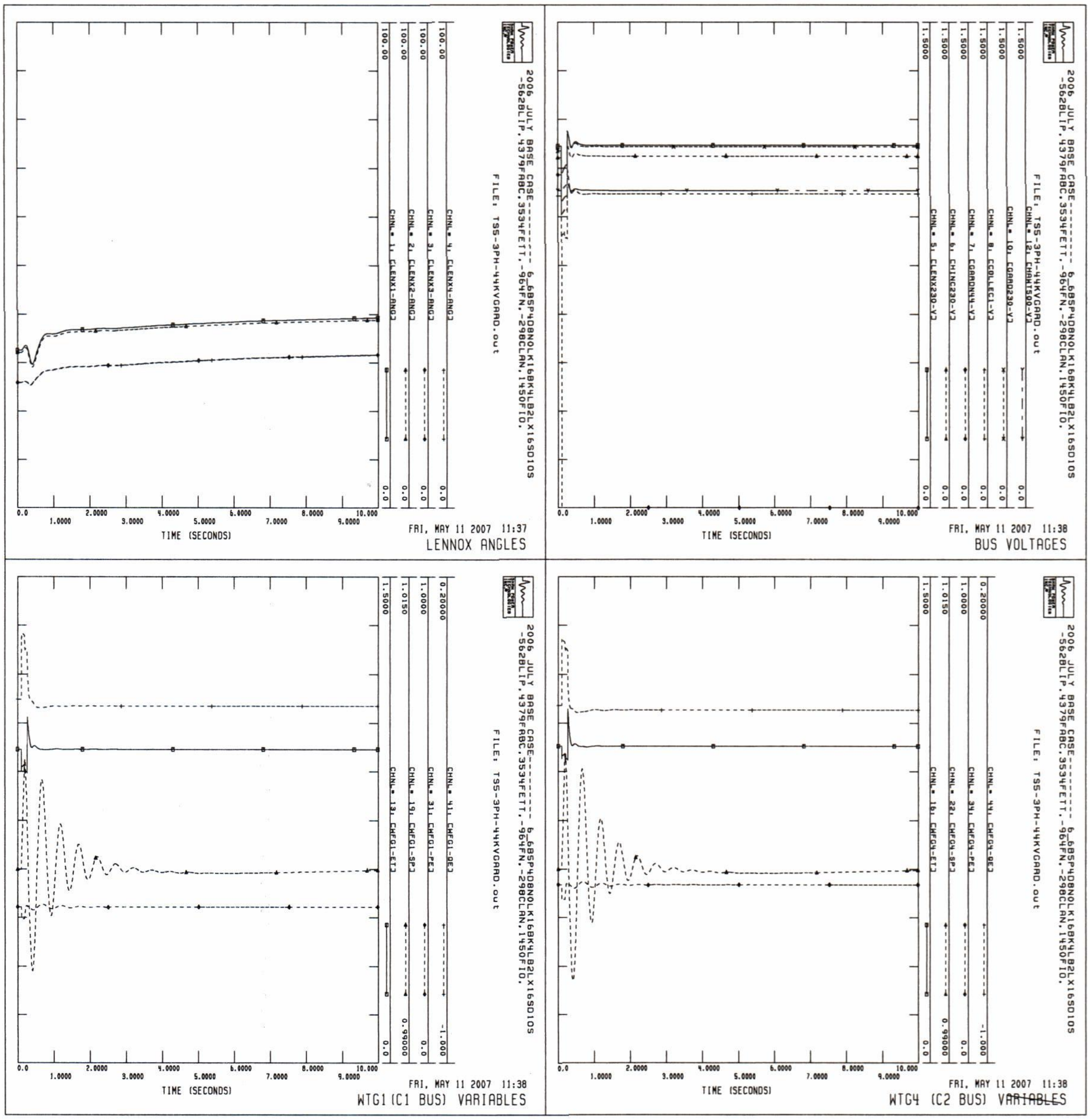
TSC3-Normally cleared 3ph fault at X2H@X



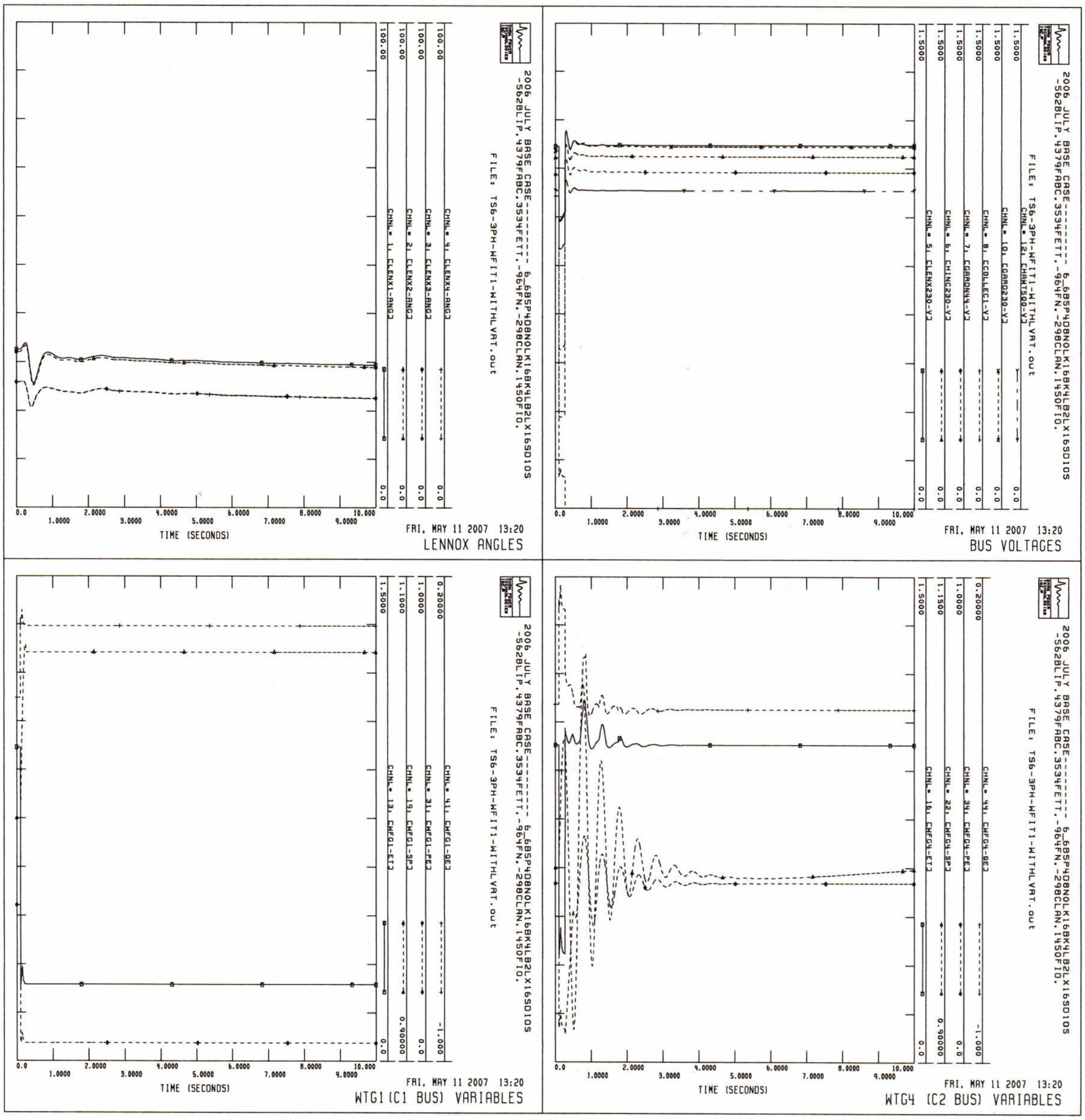
TSC4-Normally cleared LGLG faults at (X522A+X523A)@X



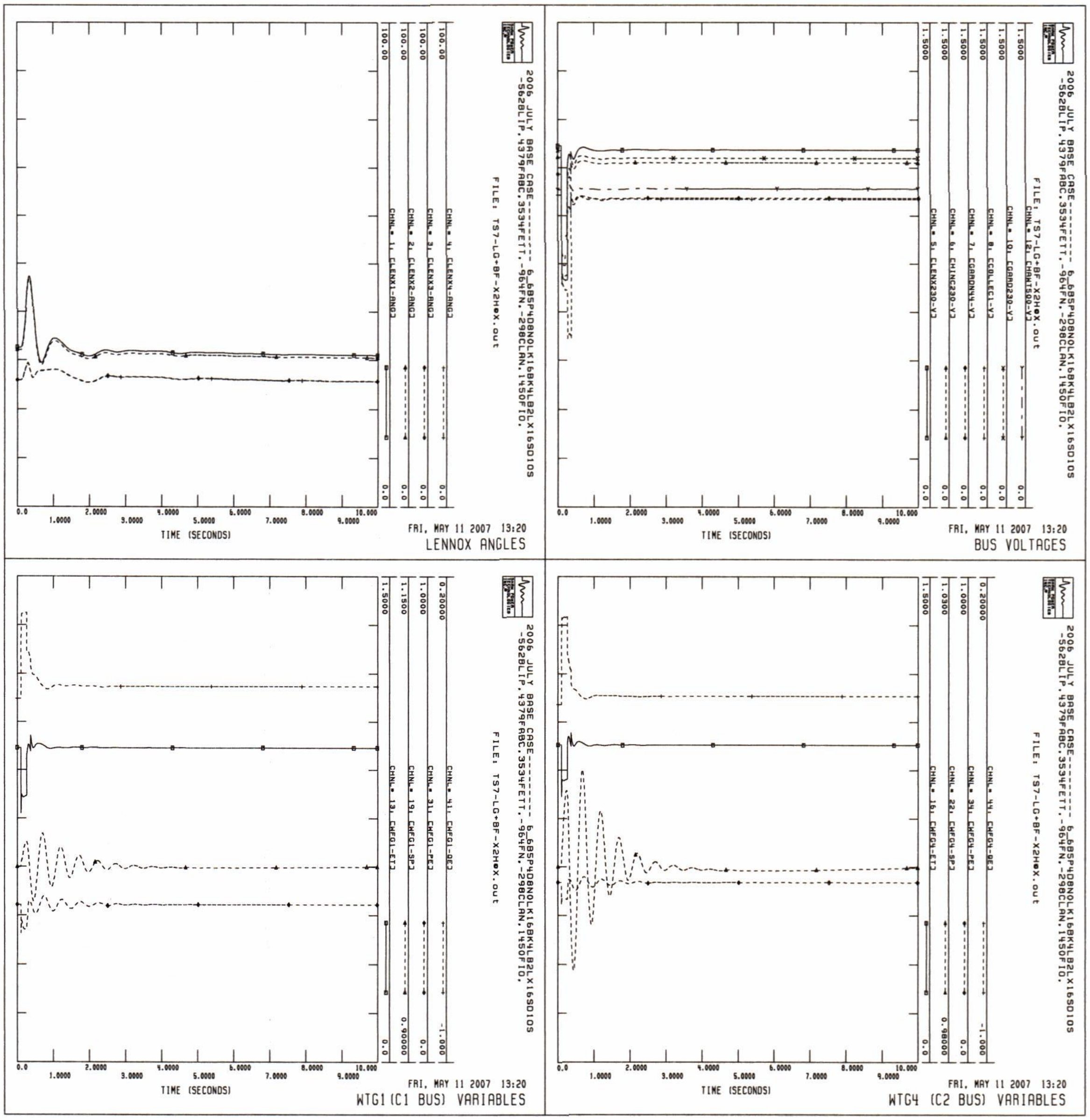
TSC5-Normally cleared 3ph fault at a 44 kV circuit



TSC6-Normally cleared 3ph fault at a Gardiner Transformer



TSC7-LG fault at X1H@X + BF at Lennox



TSC8 -Three X4H terminal breakers open + fourth breaker open by a fault in adjacent circuit