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August 2, 2011

Kirsten Walli
Board Secretary
Ontario Energy Board
2300 Yonge Street, Suite 2700
Toronto ON M4P 1E4

Dear Madame:

Re: EB-2011-0063 – Grand Renewable Wind, LP (the "Applicant")
Final customer impact assessment ("CIA") and system impact assessment ("SIA")

Please find enclosed a copy of each of the final SIA and final CIA, as issued by the Independent Electricity System Operator and Hydro One Networks Inc., respectively, for the Grand Renewable Energy Park.

Please contact the undersigned if you require further clarification.

Yours truly,

McCarthy Tétrault LLP

Per:

Kristyn Annis

C: J. T. Lee
Encl.

REPORT

Power to Ontario.
On Demand.

System Impact Assessment Report

GRAND RENEWABLE ENERGY PARK PROJECT

CONNECTION ASSESSMENT & APPROVAL PROCESS

Final Report

CAA ID 2010-399

Applicant: Samsung Renewable Energy Inc.

Market Facilitation Department

May 5, 2011

Document ID	IESO_REP_0717
Document Name	System Impact Assessment Report
Issue	1.0
Reason for Issue	First Issue
Effective Date	May 5, 2011

System Impact Assessment Report

Grand Renewable Energy Park 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 System Impact 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 System Impact 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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GRAND RENEWABLE ENERGY PARK PROJECT

IESO SYSTEM IMPACT ASSESSMENT

SIA Findings

Samsung Renewable Energy Inc. is developing a new 254 MW (154 MW wind and 100 MW solar) power generation system, Grand Renewable Energy Park (GREP), in Haldimand County, Nanticoke, Ontario. The project is one of the renewable energy developments resulted from the agreement between Ontario government and the Korean consortium. The new generation facility is expected to start commercial operation in December 2012.

Summary

This assessment examined the impact of injecting 254 MW of wind and solar power generation to the provincial grid, via the 230kV circuit N5M, on the reliability of the IESO-controlled grid.

The following conclusions and recommendations were made:

Conclusions and Recommendations

Conclusions:

The analysis concluded that:

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

(2) The proposed project does not cause new violations of existing circuit breaker interrupting capabilities on the IESO-controlled grid.

(3) The main step up transformers (166 MVA and 108 MVA) may limit the full output for the wind and solar farms.

(4) The 230 kV over-head line, underground cable and 230 kV breakers don’t have required maximum continuous voltage rating of at least 250 kV. The proponent confirmed that final equipment selections will be made to ensure compliance to the maximum 250 kV voltage level for the main breaker and 230 kV underground cable.

(5) The reactive capability of the solar inverters and wind turbine generators along with the impedance between the wind turbine generators and the IESO-controlled grid results in a reactive power deficiency at the connection point.

(6) No overloads were identified. but the pre-contingency flows on the 230 kV circuits Q23BM/Q25BM approach the continuous ratings, and post-contingency flows on the 230 kV circuits Q23BM/Q25BM, R14T/R17T and R19TH/R21TH approach Long Term Emergency ratings.

(7) For all contingency cases tested with the proposed GREP in service, the voltage decline criteria are met.

(8) With the proposed project in service, none of the recognized contingencies cause any material adverse impact to the transient performance of the IESO-controlled grid.

(9) Based on the information provided by the applicant, the fault ride through capabilities of the wind turbines and solar inverters are adequate.

Recommendations:

(1) It is recommended that the main step up transformers have higher ratings than proposed in GREP project. If system requires full reactive output the active power of the wind farm/solar farm may need to be reduced as a result of transformer restriction. The proponent acknowledges the concerns and accepts to operate the transformers at higher ratings or reduce the output of the facility if required.

(2) Since the Wind Farm Management System (WFMS) must coordinate the voltage control process, it is recommended that all WTGs control the PCC voltage to a reference value, reactive power compensation devices are automatically controlled/switched to regulate the overall WTGs' reactive power generation to around zero output, while the WF main transformer ULTC is adjusted to regulate the collector bus voltage such that it is within normal range. Once the WFMS description document is provided to the IESO, we will assess if the voltage control philosophy is acceptable.

IESO's Requirements for Connection

Transmitter Requirements

The following requirements are applicable for Hydro One for the incorporation of GREP project:

(1) The transmitter changes the relay settings of N5M terminal stations to account for the effect of the wind farm.

Modifications to protection relays after this SIA is finalized must be submitted to IESO as soon as possible or at least six (6) months before any modifications are to be implemented. If those modifications result in adverse impacts, the connection applicant and the transmitter must develop mitigation solutions.

Applicant Requirements

Specific Requirements: The following specific requirements are applicable to the applicant for the incorporation of GREP project. Specific requirements pertain to the level of reactive compensation needed, operation restrictions, Special Protection System, upgrading of equipment and any project specific items not covered in the general requirements:

(1) The wind/solar farm is required to have the capability to inject or withdraw reactive power continuously (i.e. dynamically) at a connection point up to 33% of its rated active power at all levels of active power output.
Based on the equivalent parameters for the generation system provided by the connection applicant, the IESO's simulations resulted in the following:

- dynamic compensation of -33 /+48 Mvar (i.e. SVC) installed at the solar collector bus to compensate for the dynamic reactive power capability of the facility will satisfy the dynamic reactive power requirement.
- a static compensation device of 50 Mvar in steps no larger than 10 Mvar, installed at the wind collector bus to compensate for the losses within the facility will satisfy the static reactive power requirement. The capacitors will need to be auto-switched via the Wind Farm Management System.

The connection applicant is required to provide the model for the dynamic reactive power compensation device to the IESO.

The connection applicant has the obligation to ensure that GREP GS has the capability to meet the MR requirement at the connection point and be able to confirm this capability during the commission tests.

(2) The applicant is required to provide a copy of the functionalities of the Wind Farm Management System (WFMS) to the IESO.

(3) Based on the Protection Impact Assessment performed by Hydro One, to overcome relaying difficulties, both the wind generation and solar generation step-up transformers are required to have the primary windings (high voltage) ungrounded. The proponent agreed that the transformers configuration will be Y/y-grounded/delta for the 230/34.5/13.8 kV transmformers.

General Requirements: The proposed connection must comply with all the applicable requirements from the Transmission System Code (TSC), IESO Market Rules and standards and criteria. The most relevant requirements are summarized below and presented in more detail in Section 2 of this report.

(1) The new generator must satisfy the Generator Facility Requirements in Appendix 4.2 of the Market Rules.

(2) All 230kV equipment must have a maximum continuous voltage rating and the ability to interrupt fault current at a voltage of at least 250 kV.

(3) Any revenue metering equipment that is installed must comply with Chapter 6 of the Market Rules.

(4) Equipment must sustain increase fault levels due to future system enhancements. Should future system enhancements result in fault levels exceeding equipment capability, the applicant is required to replace equipment at its own expense with higher rated equipment, up to 63 kA as per the Transmission System Code for the 230 kV system.

(5) The 230 kV breakers must meet the required interrupting time of less than or equal to 3 cycles as per the Transmission System Code.

(6) The connection equipment must be designed such that adverse effects due to failure are mitigated on the IESO-controlled grid.

(7) The connection equipment must be designed for full operability in all reasonably foreseeable ambient temperature conditions.

(8) The facility must satisfy telemetry requirements as per Appendices 4.15 and 4.19 of the Market Rules. The determination of telemetry quantities and telemetry testing will be conducted during the IESO Facility Registration/Market entry process.

(9) Protection systems must satisfy requirements of the Transmission system code and specific requirements from the transmitter. New protection systems must be coordinated with existing protection systems.

(10) Protective relaying must be configured to ensure transmission equipment remains in service for voltages between 94% of minimum continuous and 105% of maximum continuous values as per Market Rules, Appendix 4.1.

(11) Although the SIA has found that a Special Protection Scheme (SPS) is not required for GREP project, provisions must be made in the design of the protections and controls at the facility to allow for the installation of Special Protection Scheme equipment. Should a future SPS be installed to improve the transfer capability in the area or to accommodate transmission reinforcement projects, GREP will be required to participate in the SPS system and to install the necessary protection and control facilities to affect the required actions.

(12) Protection systems within the generation facility must only trip appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of the 230 kV circuit N5M 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.

(13) The autoreclosure of the new 230kV breakers at GREP main transformers 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 breaker, followed by gradual increase of power to avoid a power surge.

(14) The generator must operate in voltage control mode. The generation facility shall regulate automatically voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 13% from the highest voltage terminal based within ±0.5% of any set point within ±5% of rated voltage. If the AVR target voltage is a function of reactive output, the slope $\Delta V / \Delta Q_{max}$ shall be adjustable to 0.5%.

(15) A disturbance monitoring device must be installed. The applicant is required to provide disturbance data to the IESO upon request.

(16) Mathematical models and data, including any controls that would be operational, must be provided to the IESO through the IESO Facility Registration/Market Entry process at least seven months before energization from the IESO-controlled grid. That includes both PSS/E and DSA software compatible mathematical models representing the new equipment for further IESO, NPCC and NERC analytical studies. The *connection applicant* may need to contact the software manufacturers directly, in order to have the models included in their packages. 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. During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. Field test results should be verifiable using the PSS/E models used for this SIA.

(17) The registration of the new facilities will need to be completed through the IESO's Market Entry process before IESO final approval for connection is granted and any part of the facility can be placed in-service. During the IESO's Market Entry process, the connection applicant will be required to demonstrate to the IESO that all requirements identified in this SIA report have been satisfied.

(18) 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. 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. Failure to provide evidence may result in disconnection from the IESO-controlled grid.

(19) During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. Field test results should be verifiable using the PSS/E models used for this SIA

(20) The proposed facility must be compliant with applicable reliability standards set by the North American Electric Reliability Corporation (NERC) and the North East Power Coordinating Council (NPCC) prior to energization to the IESO controlled grid.

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 GREP subject to the implementation of the requirements listed in this report.

1. Project Description

Samsung Renewable Energy Inc. has proposed to develop a 254 MW wind and solar generation system located in Haldimand County, Nanticoke, Ontario, known as Grand Renewable Energy Park (GREP).

The project is one of the renewable energy developments resulted from the agreement between Ontario government and the Korean consortium. The new generation facility is expected to start commercial operation in December 2012.

GREP will be connected to Hydro One's 230 kV circuit N5M via a new tap connection through a breaker. The tap position will be about 19.5 km away from Nanticoke TS. GREP substation will be located about 20 km from the new tap position.

The GREP is comprised of a combination of a 100 MW solar farm and a 154 MW wind farm. Each of the generators (69 individual 2.3MW Siemens WTGs and the 200 SMA 500HE-US solar inverters) will have step up transformers to 34.5 kV and be connected to one of two collector substations, one for the wind and one for solar. The wind collect substation will have six collector feeders while the solar will have five.

The wind and solar 34.5 kV electrical distribution systems will be kept separate but located on a common site. The wind collector bus will be connected to a 100/133/166 MVA, 230/34.5 kV transformer while the solar collector bus will be connected to a 65/86/108 MVA, 230/34.5 kV transformer. Both transformers will be connected to the 230 kV circuit N5M through the 20 km tap line (19.3 km overhead circuit and 0.7 km underground cable).

The wind turbines will be Siemens SWT 2.3 VS wind turbine generators with a rated power output of 2.22 MW each. Two back-to-back AC/DC links and a 2.6 MVA, 0.06 pu reactance (on 2.6 MVA base), 0.69/34.5 kV transformer connects each generator to one of the six 34.5 kV collector circuits C1, C2, C3, C4, C5 or C6.

The solar inverters will be SMA 500HE-US rated 500 kW. The set-up transformer will be an outdoor oil filled pad-mounted transformer 1000 kVA rated 34.5kV wye to two 500 kVA rated 208 V delta connected secondaries (Dual secondary windings). The proposed impedance is 5% on each HV-LV winding.

Each collector circuit will have the following number of generators:

Collector Station	Wind						Solar				
Circuit ID	C1	C2	C3	C4	C5	C6	C1	C2	C3	C4	C5
Number of generators	11	11	13	11	12	11	40	40	40	40	40
Maximum MW	24.4	24.4	28.9	24.4	26.6	24.4	20	20	20	20	20

– End of Section –

2. General Requirements

Generators

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

The Market Rules (appendix 4.2) require that the generation facility directly connecting to the IESO-controlled grid must have the capability to operate continuously between 59.4Hz and 60.6Hz and for a limited period of time in the region above straight lines on a log-linear scale defined by the points (0.0s, 57.0Hz), (3.3s, 57.0Hz), and (300s, 59.0Hz).

The generators shall respond to frequency increase by reducing the active power with an average droop based on maximum active power adjustable between 3% and 7% and set at 4% . Regulation deadband shall not be wider than ± 0.06%. A sustained 10% change of rated active power after 10 s in response to a constant rate of change of frequency of 0.1%/s during interconnected operation shall be achievable.

The generators shall respond to frequency decline by temporary boosting their active power output by recovering energy from the rotating blades. It is not required for wind facilities to “spill” wind to provide a sustained response to frequency decline.

The generators must be able to ride through routine switching events and design criteria contingencies assuming standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times unless disconnected by configuration.

The generation facility directly connecting to the IESO-controlled grid must have the minimum capability to supply continuously all levels of active power output for 5% deviations in terminal voltage. Rated active power is the smaller output at either rated ambient conditions (e.g. temperature, head, wind speed, solar radiation) or 90% of rated apparent power. To satisfy steady-state reactive power requirements, active power reductions to rated active power are permitted. the generation facility must have the capability to inject or withdraw reactive power continuously (i.e. dynamically) at a *connection point* up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the *IESO*.

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.

Connection Equipment (Breakers, Disconnects, Transformers, Buses)

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

   Fault interrupting devices must be able to interrupt fault current at the maximum continuous voltage of 250 kV.

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

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

   The TSC requires that new equipment be designed to sustain the fault levels in the area where the equipment is installed. If any future system enhancement results in an increased fault level higher than the equipment's capability, the connection applicant is required to replace the equipment at their own expense with higher rated equipment capable of sustaining the increased fault level, up to the TSC's maximum fault level of 63 kA for the 230 kV system.

3. The Transmission System Code (TSC), Appendix 2 states that the maximum rated interrupting time for 230 kV breakers must be ≤ 3 cycles. The connection applicant shall ensure that the new breakers meet the required interrupting time as specified in the TSC.

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

5. The connection equipment must be designed so that it will be fully operational in all reasonably foreseeable ambient temperature conditions.

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 (version B) and any additional requirements identified in the Protection Impact Assessments (PIA) by the transmitter. New protection systems must be coordinated with existing protection systems.

2. 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.

3. The Applicant is required to have adequate provision in the design of protections and controls at the facility to allow for installation of Special Protection Scheme (SPS). Should a future SPS be installed to improve the transfer capability in the area or to accommodate transmission reinforcement projects, the applicant will be required to participate in the SPS system and to install the necessary protection and control facilities to affect the required actions.

4. 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.

5. Protection systems within the generation facility must only trip the appropriate equipment required to isolate the fault. After the facility begins commercial operation, if an improper trip of the 230 kV circuit N5M 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.

6. The autoreclosure of the new 230 kV breakers 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.

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. The connection applicant is required to install at the facility a disturbance recording device with clock synchronization that meets the technical specifications provided by Hydro One. The device will be used to monitor and record the response of the facility to disturbances on the 230 kV system in order to verify the dynamic response of generators. The quantities to be recorded, the sampling rate and the trigger settings will be provided by Hydro One.

Facility Registration/Market Entry Requirements

1. The registration of the new facilities will need to be completed through the IESO's Market Entry process before IESO final approval for connection is granted and any part of the facility can be placed in-service. During the IESO's Market Entry process, the connection applicant will be required to demonstrate to the IESO that all requirements identified in this SIA report have been satisfied.

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.

During the commissioning period, a set of IESO specified tests must be performed. The commissioning report must be submitted to the IESO within 30 days of the conclusion of commissioning. Field test results should be verifiable using the PSS/E models used for this SIA. 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 need to 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 1.

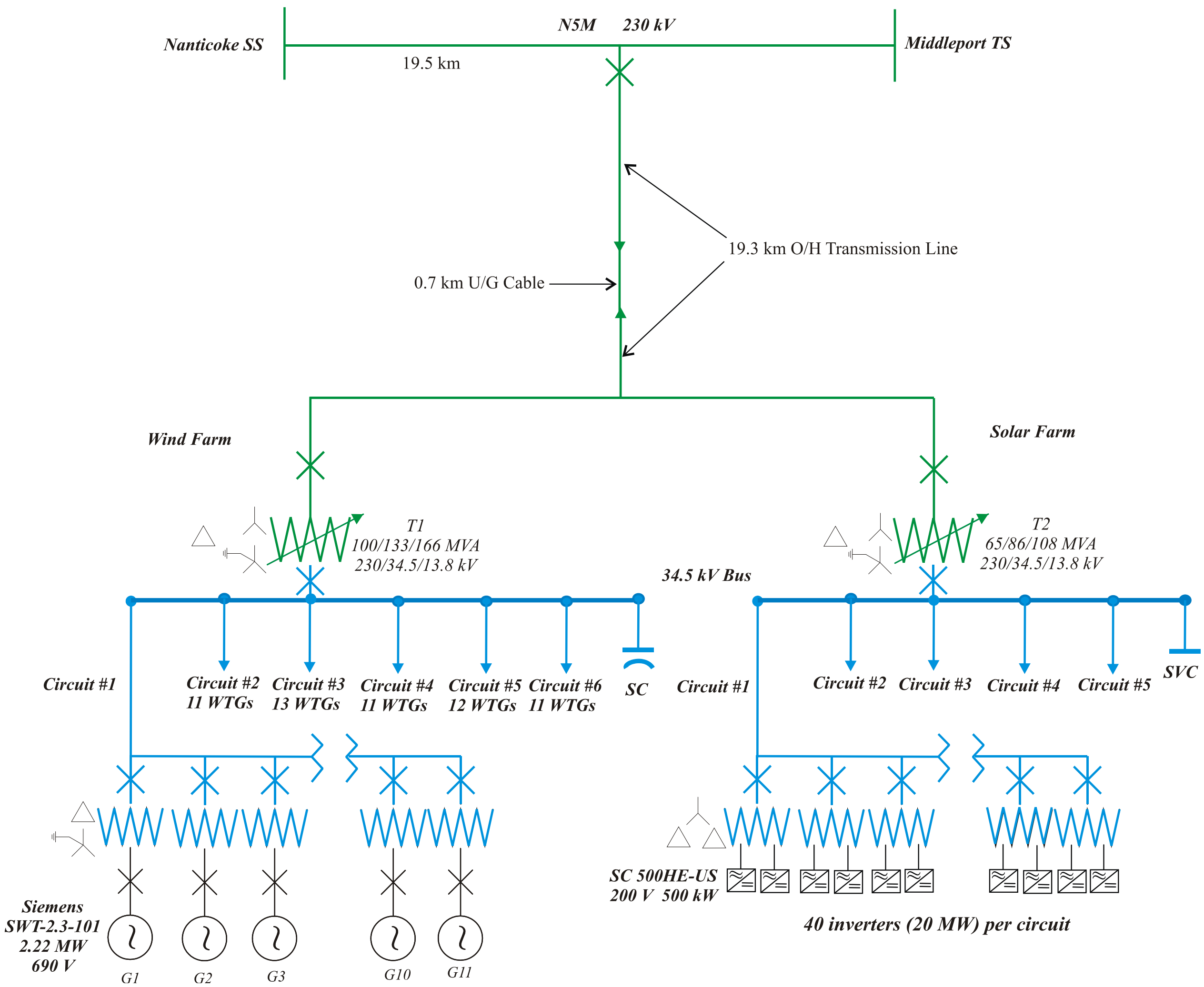


Figure 1: Proposed Connection Arrangement

The initial proposed main step-up transformer configuration was Y-grounded/Y-grounded/Delta as shown in Figure 1. Based on the study results from the Protection Impact Assessment it is required to leave the HV winding ungrounded. This will be discussed in Chapter 4.

3.2 Existing System

GREP is proposed to connect to the existing Hydro One 230 kV circuit N5M between Nanticoke SS and Middleport TS. The graphs below display the MW flow out N1M, N2M and N5M at Nanticoke SS and 230 kV voltages at Nanticoke SS and Middleport TS. These are hourly average samples from Jan 1 to Dec 31, 2010 obtained from IESO real-time data. For MW flow graphs, positive values mean flow out of the station.

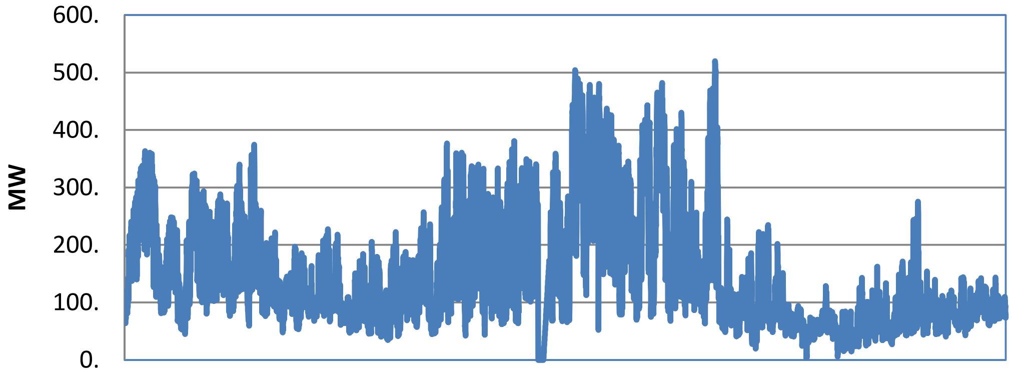


Figure 2: MW flow on N1M at Nanticoke SS

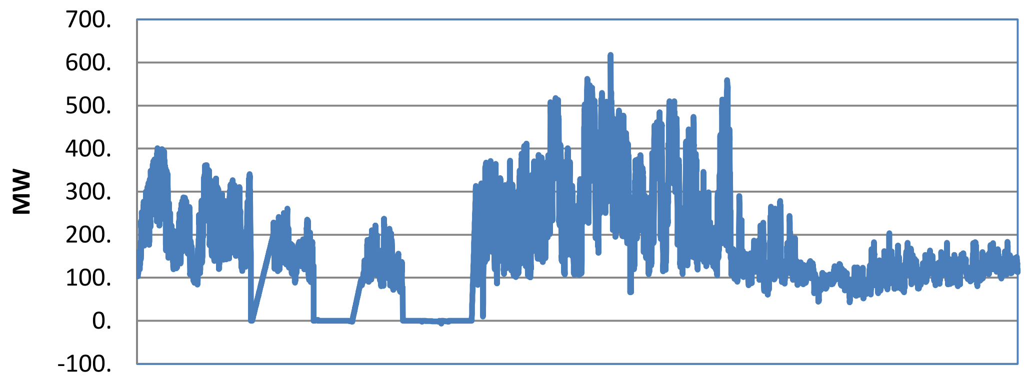


Figure 3: MW flow on N2M at Nanticoke SS

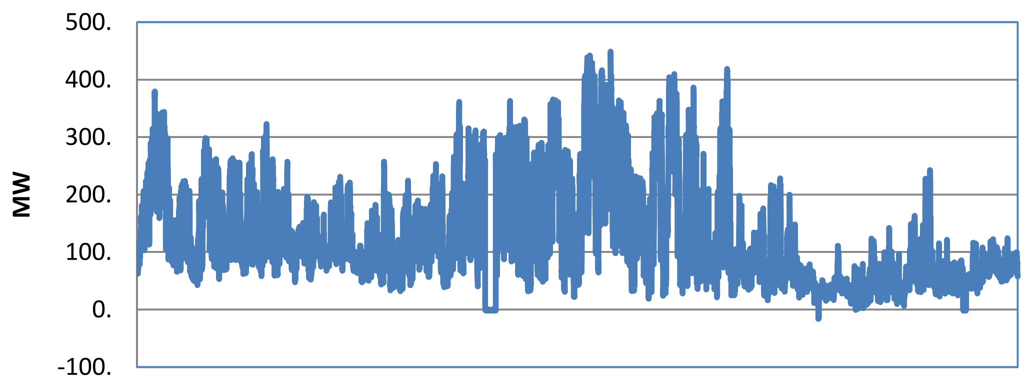


Figure 4: MW flow on N5M at Nanticoke SS

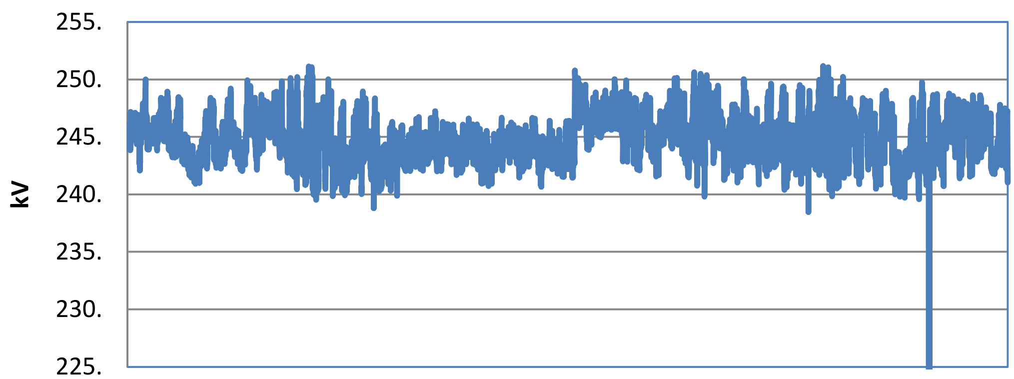


Figure 5: 230 kV Voltage at Nanticoke SS

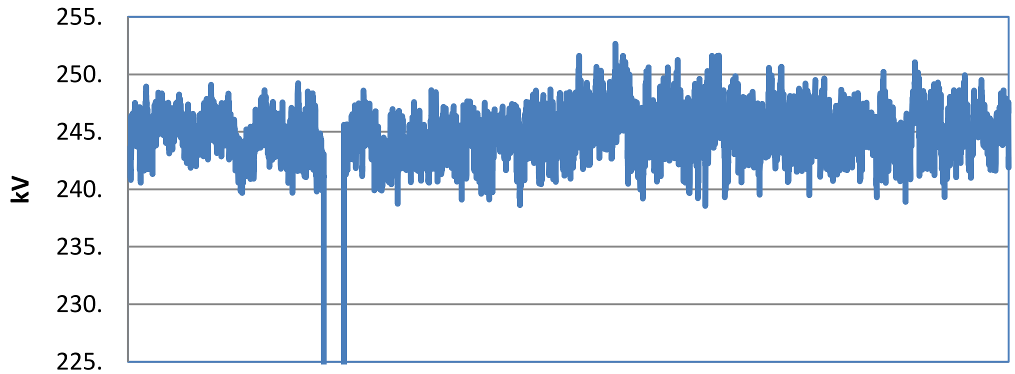


Figure 6: 230 kV Voltage at Middleport TS

The following can be observed.

Nanticoke SS	Average voltage (kV)	244.8
	N1M MW (max flow)	520.2
	M2M MW (max flow)	618.0
	N5M MW (max flow)	448.6
Middleport TS	Average voltage (kV)	244.9

4. Data Verification

4.1 Tap Line

Specifications of the 230 kV tap line provided by the connection applicant are listed below.

	Overhead Line	Underground Cable
Voltage (kV)	240	245
Rating (A)	905	850
Length (km)	19.3	0.7
Impedance (Ω/km)	0.0738+j0.4843	j0.0361
Charging	0.2960 MΩ-km	0.1554 pF/km

It should be noted that the max voltage rating for the underground cable is 245 kV which does not meet Market Rules requirements, i.e., all 230 kV equipment must have a maximum continuous voltage rating of at least 250 kV.

4.2 Generator

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

- Supply continuously all levels of active power output for 5% deviations in terminal voltage. Rated active power is the smaller output at either rated ambient conditions (e.g. temperature, head, wind speed, solar radiation) or 90% of rated apparent power. To satisfy steady-state reactive power requirements, active power reductions to rated active power are permitted.

- Inject or withdraw reactive power continuously (i.e. dynamically) at a connection point up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the *IESO*.

The details of the generator data used in this assessment are given below:

Siemens SWT-2.3- 60 Hz variable speed wind turbine

Voltage	0.69 kV
Rating	2.221 MW
Power Factor	0.9 leading – 0.9 lagging

SMA 500HE-US solar inverter

Voltage	0.2 kV
Rating	500 kW
Power Factor	1

4.3 Transformer

Specifications for the 34.5/230 kV step-up transformers are listed below.

	Wind	Solar
Transformation (kV)	240/34.5/13.8	240/34.5/13.8
Rating (MVA)	100/133/166	65/86/108
Impedance	0.18+j8.998% (100 MVA base)	0.182+j7.748% (65 MVA base)
Configuration	Y/Y-grounded/Δ	Y/Y-grounded/Δ
Tapping	±16×1.25% ULTC	±16×1.25% ULTC

The capacities of wind farm and solar farm are 154 MW and 100 MW, respectively. The main step up transformers (166 MVA and 108 MVA) may limit the full output. It is recommended that the main step up transformers have higher ratings than proposed. The proponent acknowledges the concerns and accepts to operate the transformers at higher ratings or reduce the output of the facility if required.

It should be noted that based on the Protection Impact Assessment performed by Hydro One, to overcome relaying difficulties it is required to leave the HV windings on both the wind generation and solar generation step-up transformers ungrounded. The proponent agreed that the transformers configuration will be Y/Y-grounded.

4.4 Circuit Breakers and Switches

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

Breakers and switches	LV	HV
Rated line-to-line voltage (kV)	34.5	245
Interrupting time (ms)	N/A	33
Rated continuous current (A)	2000/1200	1200
Rated short circuit breaking current (kA)	31	63

It should be noted that the max voltage rating for the HV breakers is 245 kV which does not meet Market Rules requirements, i.e., all 230 kV equipment must have a maximum continuous voltage rating of at least 250 kV.

4.5 Collector System

The 34.5 kV collector system equivalent circuit impedance including the pad mount transformers provided by the connection applicant are listed as follows:

Feeder #	Wind			Solar		
	Equivalent Impedance(pu)		Charging (Mvar)	Equivalent Impedance(pu)		Charging (Mvar)
	R	X		R	X	
1	0.051	0.139	N/A	0.018	0.014	N/A
2	0.032	0.077	N/A	0.024	0.020	N/A
3	0.062	0.220	N/A	0.031	0.025	N/A

4	0.100	0.431	N/A	0.037	0.031	N/A
5	0.036	0.104	N/A	0.037	0.031	N/A
6	0.127	0.601	N/A			

Per unit data are based on 100 MVA & 34.5 kV.

– End of Section –

5. Fault Level Assessment

Fault level studies were completed by Hydro One to examine the effects of the GREP on fault levels at existing facilities in the area. Studies were performed to analyze the fault levels with and without GREP and other proposed projects in the surrounding area. Studies were carried out with the following facilities and system assumptions:

Niagara, South West, West Zones:

- All hydraulic generation
- 6 Nanticoke
- 2 Lambton
- Brighton Beach (J20B/J1B)
- Greenfield Energy Centre (Lambton SS)
- St. Clair Energy Centre (L25N & L27N)
- East Windsor Cogen (E8F & E9F) + existing Ford generation
- TransAlta Sarnia (N6S/N7S)
- Imperial Oil (N6S/N7S)
- Thorold GS (Q10P)

Central, East Zones:

- All hydraulic generation
- 6 Pickering units
- 4 Darlington units
- 4 Lennox units
- GTAA (44 kV buses at Bramalea TS and Woodbridge TS)
- Sithe Goreway GS (V41H/V42H)
- Portlands GS (Hearn SS)
- Kingston Cogen
- TransAlta Douglas (44 kV buses at Bramalea TS)

Northwest, Northeast Zones:

- All hydraulic generation
- 1 Atikokan
- 2 Thunder Bay
- NP Iroquois Falls
- AP Iroquois Falls
- Kirkland Lake
- 1 West Coast (G2)
- Lake Superior Power
- Terrace Bay Pulp STG1 (embedded in Neenah paper)

Bruce Zone:

- 8 Bruce units (Bruce G1 and Bruce G2 maximum capacity @ 835 MW)
- 4 Bruce B Standby Generators

All constructed wind farms including:

- Erie Shores WGS (WT1T)
- Kingsbridge WGS (embedded in Goderich TS)
- Amaranth WGS – Amaranth I (B4V) & Amaranth II (B5V)
- Ripley WGS (B22D/B23D)
- Prince I & II WGS (K24G)
- Underwood (B4V/B5V)
- Kruger Port Alma (C24Z)
- Wolf Island (injecting into X4H)

New Generation Facilities:
Committed wind generation:

- Greenwich Wind Farm (M23L and M24L)
- Gosfield Wind Project (K2Z)
- Kruger Energy Chatham Wind Project (C24Z)
- Raleigh Wind Energy Centre (C23Z)
- Talbot Wind Farm (W45LC)
- Greenfield South GS (R24C)

Other committed generation projects:

- Halton Hills GS (T38B/T39B)
- Oakville Generating Station (B15C/B16C)
- York Energy Centre (B82V/B83V)
- Island Falls (H9K)
- Becker Cogeneration (M2W)
- Wawatay G4 (M2W)
- Beck 1 G9: increase capacity to 68.5 MVA (Beck #1 115 kV bus)
- Lower Mattagami Expansion
- All renewable generation projects awarded FIT contracts

Transmission System Configuration

Existing system with the following upgrades:

- Bruce x Orangeville 230 kV circuits up-rated
- Burlington TS: Rebuild 115 kV switchyards
- Leaside TS to Birch JCT: Build new 115 kV circuit. Birch to Bayfield: Replace 115 kV cables.
- Uprate circuits D9HS, D10S and Q11S
- Hurontario SS in service with R19T+V41H open from R21T+V42H (230 kV circuits V41H and V42H extended and connected from Cardiff TS to Hurontario SS). Huronontario SS to Jim Yarrow 2x3km 230 kV circuits in-service

- Cherrywood TS to Claireville TS: Unbundle the two 500 kV super-circuits (C551VP & C550VP)
- Allanburg x Middleport 230 kV circuits (Q35M and Q26M) installed
- Claireville TS: Reterminate circuit 230 kV V1RP to Parkway V71P Reterminate circuit 230 kV V72R to Cardiff(V41H)
- One 250 Mvar (@ 250 kV) shunt capacitor bank installed at Buchanan TS
- LV shunt capacitor banks installed at Meadowvale
- Modeling of Michigan system with short circuit equivalent provided by International Transmission Company (ITC).
- 1250 MW HVDC line ON-HQ in service
- Tilbury West DS second connection point for DESN arrangement using K2Z and K6Z
- Second 500kV Bruce-Milton double-circuit line in service. Double-circuit line from the Bruce Complex to Milton TS with one circuit originating from Bruce A and the other from Bruce B
- 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
- Woodstock Area transmission reinforcement:
    - Karn TS in service and connected to M31W & M32W at Ingersol T
    - W7W/W12W terminated at LFarge CTS
    - Woodstock TS connected to Karn TS
- Nanticoke and Detweiler SVCs
- Series capacitors at Nobel SS in each of the 500 kV circuits X503 & X504E to provide 50% compensation for the line reactance
- Lakehead TS SVC
- Porcupine TS & Kirkland Lake TS SVC
- Porcupine TS: Install 2x125 Mvar shunt capacitors
- Essa TS : Install 250 Mvar shunt capacitor
- Hanmer TS: Install 149 Mvar shunt capacitor
- Pinard TS: Install 2x30 Mvar LV shunt capcitors
- Upper Mattagami expansion
- Fort Frances TS: Install 22 Mvar moveable shunt capacitor
- Dryden TS: Install shunt capacitors
- Lower Mattagami Expansion – H22D line extension from Harmon to Kipling.

System Assumptions

- Lambton 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
- Napanee TS 230 kV operated open
- Cherrywood TS north & south 230kV buses operated open
- Cooksville TS 230 kV bus operated open
- Richview TS 230 kV bus operated open
- Burlington 115 kV bus operated open

- Allanberg 115 kV bus 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 fault levels near Nanticoke area before and after GREP and other projects and corresponding breaker ratings.

Bus	Before GREP and other new projects i/s				After GREP and other new projects i/s				Lowest Breaker Ratings (kA) (at max operational voltage)	
	3-phase Fault (kA)		L-G Fault (kA)		3-phase Fault (kA)		L-G Fault (kA)			
	Sym.	Asym.	Sym.	Asym.	Sym.	Asym.	Sym.	Asym.	Sym.	Asym.
Beach 230	37.7	44.4	35.9	45.7	37.8	44.6	36.0	45.8	41.1	46.2
Beach 115	26.7	32.7	32.3	41.5	26.7	32.7	32.3	41.5	39.3	45.5
Burlington 230	51.5	61.8	43.6	55.7	51.8	62.1	43.7	55.8	63	75.6
Burlington 115	25.4	32.1	26.8	35.1	25.4	32.1	28.5	37.8	39.3	45.5
Middleport 230	46.7	58.7	43.8	57.4	47.1	59.3	44.2	57.9	60	70.4
Buchanan 230	31.7	37.1	27.0	34.3	31.8	37.2	27.1	34.4	39.4	46.2
Buchanan 115	25.0	29.8	27.8	34.9	25.1	29.8	29.1	36.7	39.3	45.5
Nanticoke 230	40.9	58.2	40.1	59.5	42.3	60.1	42.4	62.8	54.3	65.6
Detweiler 230	22.4	26.1	19.5	24.8	22.7	26.5	19.7	25.0	40	42.1
Detweiler 115	23.7	27.3	26.6	34.3	24.1	27.8	27.0	33.1	39.3	45.5
Beck 230	56.6	77.7	62.0	85.9	56.7	77.8	62.1	86.0	69.5	91
Beck 115	24.1	29.3	28.7	36.5	24.1	29.3	28.7	36.5	36	39
Allanburg 115	25.6	30.0	27.9	33.6	25.6	30.1	27.9	33.6	39.3	45.5

The results show that there are slightly increases in fault levels in the surrounding area of the GREP project, due to the proposed project. It can be concluded that the proposed project will not cause any new violations of existing circuit breaker interrupting capabilities 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 voltages, and the transient performance of the system.

6.1 Assumptions and Background

A base case with a peak demand of 25,912 MW was the starting point for this study, along with the following assumptions and modifications:

System Conditions

Ontario demand was scaled to summer 2013 values as shown in the following table:

Demand: 25,912 MW									
NW	NE	Essa	Ottawa	East	Toronto	Niagara	SW	Bruce*	West
604	1221	1541	1840	1491	10099	949	5052	133	3061

All transmission system elements were in service.

The following table summarizes some of the major in-service generation for each scenario.

Generation Station	Units In-service
Atikokan	1
Nanticoke	5
Thunder Bay	1
Lambton	0
Bruce	7
Pickering	4
Lennox	0
Darlington	4
Halton Hills	3
Thorold	2
York Energy Centre	2
Portlands	0
Sithe Goreway	0
West Coast	1

According to the schedule for Nanticoke GS shut off there will be only four units by the end of 2013. This study assumed five units and this assumption does not have any negative impact on the study results.

Dispatch Philosophy

Where possible, the following philosophy was used to dispatch units:

- Hydraulic units were put in-service at 90% of their maximum continuous rating

- Nuclear units were put in-service at 100% of their maximum continuous rating
- NUGS units were put in-service at 100% of their maximum continuous rating
- Gas units were put in-service at 100% of their maximum continuous rating
- Wind was placed at 100% of its maximum continuous rating.

Interface Flows

The base case was adjusted to stress the transmission lines from Nanticoke to Toronto. The following table lists the interface flows for the study scenario.

FABC	BLIP	FETT	QFW
4200	-1500	4500	1300

The interfaces are defined as follows:

Interface	Definition
FABC	Flow Away From the Bruce Complex
BLIP	Buchanan Longwood Input
FETT	Flow East to Toronto
QFW	Queenston Flow West

6.2 Protection Impact Assessment

A Protection Impact Assessment (PIA) was completed by Hydro One to examine the impact of the new generators on the existing transmission system protections. The existing protections for N5M at Nanticoke TS and Middleport TS were described in the PIA report and the proposed connection arrangements and protections were analyzed.

For the line to ground fault at Middleport 230 kV bus the Nanticoke terminal exhibits zero sequence current reversal and very high L-G apparent impedance in reverse direction. The step-up transformers being grounded on the HV side at the GREP facility are the main contributor to the current reversal at the Nanticoke bus. To overcome the relaying difficulties it is required to leave the HV windings on both the wind generation and solar generation step-up transformers ungrounded.

The proponent agreed to choose the Y/Y-grounded/Delta as the configuration of the step-up transformer.

The IESO concluded that the proposed protection adjustments have no material adverse impact on the IESO-controlled grid. The PIA report is attached in Appendix D.

6.3 Special Protection System (SPS)

Although the SIA has found that a Special Protection Scheme (SPS) is not required for GREP project, provisions must be made in the design of the protections and controls at the facility to allow for the installation of Special Protection Scheme equipment. Should a future SPS be installed to improve the transfer capability in the area or to accommodate transmission reinforcement projects, GREP project, will be required to participate in the SPS system and to install the necessary protection and control facilities to affect the required actions.

6.4 Reactive Power Compensation

Market Rules (MR) require that generators inject or withdraw reactive power continuously (i.e. dynamically) at a connection point up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the IESO.

A generating unit with a power factor range of 0.90 lagging and 0.95 leading at rated active power connected via a main output transformer with an impedance not greater than 13% based on generator rated apparent power provides the required range of dynamic power at the connection point.

Typically, the impedance between the WTG and the connection point is larger than 13%. However, provided the WTG has the capability to provide a reactive power range of 0.90 lagging power factor and 0.95 leading power factor at rated active power, the IESO accepts the WF to compensate for the full reactive power requirement range at the connection point with switchable shunt admittances (e.g. capacitors and reactors). If the WTG technology has no capability to supply the full dynamic reactive power range at its terminal, the shortfall has to be compensated with dynamic reactive power devices (e.g. SVC).

This section of the SIA indicates how the WF can meet the MR requirements regarding reactive power capability, but the connection applicant is free to deploy any other solutions which result in compliance with the MR.

It is the connection applicant’s responsibility to ensure that the WF has the capability to meet the MR requirement at the connection point and be able to confirm this capability during the commission tests.

6.4.1 Dynamic Reactive Power Compensation

The following summarizes the IESO required level of dynamic reactive power and the available capability of SWT-2.3 from Siemens document “Reactive Power Capability” (Document PG-R3-30-0000-0113-05).

	Active Power	Reactive Power Capability/Turbine
IESO Required	1.0 pu	$Q_{gen} = 2.22 \times \tan[\cos^{-1}(0.9)] = 1.08$ Mvar
		$Q_{abs} = 2.22 \times \tan[\cos^{-1}(0.95)] = 0.72$ Mvar
SWT-2.3 Capability	1.0 pu	$Q_{gen} = 2.3 \times \tan[\cos^{-1}(0.9)] = 1.11$ Mvar
		$Q_{abs} = 2.3 \times \tan[\cos^{-1}(0.9)] = 1.11$ Mvar

The SWT-2.3 generators can deliver the 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.

The following table summarizes the IESO’s adequate level of reactive power from each generator and the available capability of SMA 500HE-US wind turbine generators, at rated terminal voltage and rated power.

	Rated Voltage	Rated Active Power	Reactive Power Capability
IESO Requirements	200 V	500 kW	Q_{max} = 500 × tan[cos^{-1}(0.9)] = 242kvar
			Q_{min} = -500 × tan[cos^{-1}(0.95)] = -164 kvar
SMA 500HE-US	200 V	500 kW	Q_{max} = 0 kvar
			Q_{min} = 0 kvar

The SMA 500HE-US has no dynamic reactive capability at full real power output and therefore cannot deliver the required dynamic reactive power. For 200 inverters the requirement is 200 × 0.242 = 48 Mvar & -200 × 0.164 = -33Mvar.

A dynamic reactive power device with a capability of **-33/+48 Mvar** installed at the solar collector bus to compensate for the dynamic reactive power capability of the facility will meet the dynamic reactive power requirement.

The connection applicant is required to provide the model for the dynamic reactive power compensation device to the IESO.

6.4.2 Static Reactive Power Compensation

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

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

The reactive power capability in lagging p.f. of the generation facility was assessed under the following assumptions:

- typical voltage of 242 kV at the connection point;
- maximum active power output from the equivalent WTG;
- maximum reactive power output (lagging power factor) from the equivalent WTG, unless limited by the maximum acceptable WTG terminal voltage;
- maximum acceptable WTG voltage is 1.05, as per WTG voltage capability;

The reactive power capability in leading p.f. of the generation facility was assessed under the following assumptions:

- typical voltage of 242 kV at the connection point;
- minimum (zero) active power output from the equivalent WTG;
- maximum reactive power consumption (leading power factor) from the equivalent WTG, unless limited by the minimum acceptable WTG terminal voltage;
- minimum acceptable WTG voltage is 0.9, as per WTG voltage capability;

The IESO's reactive power calculation used the equivalent electrical model for the WTG and collector feeders as provided by the connection applicant. It is very important that the WF has a proper internal design to ensure that the WTG are not limited in their capability to produce active and reactive power due to terminal voltage limits or other facility's internal limitations. For example, it is expected that the transformation ratio of the WTG step up transformers will be set in such a way that it will offset the voltage profile along the collector, and all the WTG would be able to contribute to the reactive power production of the WF in a shared amount.

Based on the equivalent parameters for the WF provided by the connection applicant, an amount of 50 Mvar of static reactive power compensation installed at the WF collector bus will meet the static reactive power requirements at the connection point.

The connection applicant has the obligation to ensure that the WF design and the reactive power compensation system takes into account the real electrical parameters and real limitations within the WF facility.

Similar studies were performed for the solar farm and it was found there is no need for the static reactive power compensation at the solar farm after the required dynamic reactive compensation device is installed.

6.4.3 Static Reactive Power Switching

A switching study was carried out to investigate the effect of the new LV shunt devices on the voltage changes. It was assumed that the largest capacitor step size is 50 Mvar. To reflect the reasonable restrictive system conditions, the voltage change study assumed that one transmission element (N2M) is out of service.

Capacitor at LV kV bus	LV bus voltage	ICG connection point
Pre-switching	34.5 kV	246.7 kV
Post-switching	35.8 kV	248.0 kV
ΔV	3.8%	0.5%

The IESO requires the voltage change on a single capacitor switching to be no more than 4 % at the any point in the ICG. The results show that switching a single capacitor of 50 Mvar produces less than 4 % voltage change at the connection point. However, it is necessary to supply the static reactive compensation in small enough steps to have operational flexibility over the entire range of active power output from the wind turbines. The amount of static reactive power compensation should be shared between at least five switchable shunt capacitors.

The IESO has no restrictions on voltage changes within the WF facility; however, if the equipment within the proposed facility is sensitive to voltage changes, small enough shunt capacitor size steps have to be designed to cater to the facility needs.

6.5 Wind Farm Management System

If the generation facility connects to the IESO-controlled grid, the IESO requires that the facility assists in maintaining adequate voltages in the high voltage system. It is expected that the wind farm controls the voltage at a point as close as possible to the connection point to values specified by the IESO. This requires that wind farms possess the ability to supply sufficient dynamic reactive power to the high voltage system during voltage declines.

The generation facility shall regulate automatically voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 13% from the highest voltage terminal based within ±0.5% of any set point within ±5% of rated voltage. If the AVR target voltage is a function of reactive output, the slope $\Delta V / \Delta Q_{max}$ shall be adjustable to 0.5%.

The Wind Farm Management System (WFMS) must coordinate the voltage control process. The IESO recommend the following two voltage control philosophies:

Option #1

(1) All WTGs control the PCC voltage to a reference value. A control slope is applied for reactive power sharing among the WTGs as well as with adjacent generators.
(2) Capacitor banks are automatically switched in/out to regulate the overall WTGs' reactive generation to around zero output.
(3) WF main transformer ULTC is adjusted to regulate the collector bus voltage (LT bus voltage) such that it is within normal range;

Option #2

(1) The capacitor banks are automatically switched in/out according to the WF active power output. A sample capacitor switching scheme is shown in the following table.

P - overall WF active power output	Capacitor banks to be switched on
$0 < P < P_1$	(No capacitor)
$P_1 < P < P_2$	C_1
$P_2 < P < P_3$	C_1+C_2
……	……
$P_N < P < P_{MAX}$	$C_1+C_2+\ldots+C_N$

(2) All WTGs control the PCC voltage to a reference value. A control slope is applied for reactive power sharing among the WTGs as well as with adjacent generators.
(3) WF main transformer ULTC is adjusted to regulate the collector bus voltage (LT bus voltage) such that it is within normal range;

The proponent has chosen Option #1 and 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.

6.6 Thermal Analysis

The assessment examined the effect the proposed facility would have on the thermal loadings of the Southwest-Center area 500/230 kV transmission elements.

The *Ontario Resource and Transmission Assessment Criteria* requires that all line and equipment loadings be within their continuous ratings with all elements in service, and within their long-term emergency ratings with any element out of service. Lines and equipment may be loaded up to their short-term emergency ratings immediately following the contingencies to effect re-dispatch, perform switching, or implement control actions to reduce the loading to the long-term emergency ratings.

Hydro One provided the Continuous, Long Term Emergency and Short Term Emergency planning thermal ratings for various circuits under summer weather conditions. The algorithm for deriving these ratings is as follows:

- *Ambient conditions*: 35ºC temperature , 4 km/hr wind speed, daytime
- *Continuous*: Rating obtained at the lesser of conductor temperature of 93 ºC or sag temperature
- *Long Term Emergency*: Rating obtained at the lesser conductor temperature of 127ºC or sag temperature
- *Short Term Emergency*: Rating obtained at the sag temperature with a pre-contingency loading of 100% of the continuous rating.

The following table summarizes the ratings for various circuits monitored for the thermal analysis. For circuits with several sections having different ratings, the ratings for the most limiting section are chosen.

Element	Monitored Element		Rating (A)		
	From	To	Continuous	Long Term Emergency	Short Term Emergency
N580M	NANTICOKE_TS500	MIDDLEPT 500	2820	3660	3930
N581M	NANTICOKE_TS500	MIDDLEPT 500	2820	3660	3930
M585M	MIDDLEPT8185500	MILTON_SS 500	2820	3620	3880
V586M	MIDDLEPT8185500	CLAIREVILLE 500	2820	3620	3880
M572T	MILTON_SS 500	TRAFALG_M 500	2820	3620	3880
M573T	MILTON_SS 500	TRAFALG_M 500	2820	3620	3880
M570V	MILTON_SS 500	CLAIREVILLE 500	2820	3660	4010
M571V	MILTON_SS 500	CLAIREVILLE 500	2820	3660	4010
N1M	NANTICOKE_TS220	MIDDLEPT_DK1 220	1350	1350	1350
N2M	NANTICOKE_TS220	MIDDLEPT_DK1 220	1350	1350	1350
N5M	NANTICOKE_TS220	MIDDLEPT_DK2 220	1350	1350	1350
N6M	NANTICOKE_TS220	MIDDLEPT_DK2 220	1350	1350	1350
Q23BM	MIDDLEPT_DK2220	BURLINGTON 220	1060	1300	1470
Q25BM	MIDDLEPT_DK2220	BURLINGTON 220	1060	1400	1900
M27B	MIDDLEPT_DK1220	BURLINGTON 220	1060	1400	1900
M28B	MIDDLEPT_DK1220	BURLINGTON 220	1060	1300	1470
T36B	BURLINGTON 220	TRAFALGAR_TS 220	1110	1350	1570
T37B	BURLINGTON 220	TRAFALGAR_TS 220	1110	1350	1570
T38B	BURLINGTON 220	TRAFALGAR_TS 220	1110	1350	1570
T39B	BURLINGTON 220	TRAFALGAR_TS 220	1110	1350	1570

R14T	TRAFALGAR_TS220	RICHVIEW_AH1 220	1110	1420	1660
R17T	TRAFALGAR_TS220	RICHVIEW_AH1 220	1110	1420	1660
R19TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	1110	1420	1660
R21TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	1110	1420	1660

The following table summarizes the pre-contingency amps and loading as a percentage of the continuous ratings, with the GREP project in service.

Element	Monitored Element		Pre-Contingency Load Flow	
	From	To	Amps	% of Cont. Rating
N580M	NANTICOKE_TS500	MIDDLEPT 500	1028	36.5
N581M	NANTICOKE_TS500	MIDDLEPT 500	1004	35.6
M585M	MIDDLEPT8185500	MILTON_SS 500	835	29.6
V586M	MIDDLEPT8185500	CLAIREVILLE 500	773	27.4
M572T	MILTON_SS 500	TRAFALG_M 500	611	21.7
M573T	MILTON_SS 500	TRAFALG_M 500	596	21.1
M570V	MILTON_SS 500	CLAIREVILLE 500	584	20.7
M571V	MILTON_SS 500	CLAIREVILLE 500	584	20.7
N1M	NANTICOKE_TS220	MIDDLEPT_DK1 220	705	52.2
N2M	NANTICOKE_TS220	MIDDLEPT_DK1 220	709	52.5
N5M	NANTICOKE_TS220	*MIDDLEPT_DK2 220*	739	54.7
N6M	NANTICOKE_TS220	MIDDLEPT_DK2 220	582	43.1
Q23BM	MIDDLEPT_DK2220	BURLINGTON 220	1038	97.9
Q25BM	MIDDLEPT_DK2220	BURLINGTON 220	1045	98.6
M27B	MIDDLEPT_DK1220	BURLINGTON 220	684	64.5
M28B	MIDDLEPT_DK1220	BURLINGTON 220	684	64.5
T36B	BURLINGTON 220	TRAFALGAR_TS 220	466	42.0
T37B	BURLINGTON 220	TRAFALGAR_TS 220	467	42.1
T38B	BURLINGTON 220	TRAFALGAR_TS 220	412	37.1
T39B	BURLINGTON 220	TRAFALGAR_TS 220	412	37.1
R14T	TRAFALGAR_TS220	RICHVIEW_AH1 220	910	82.0
R17T	TRAFALGAR_TS220	RICHVIEW_AH1 220	914	82.3
R19TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	861	77.6
R21TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	859	77.4

As shown, all pre-contingency flows were found to be within the continuous ratings. However, it should be noted that the flows on Q23BM/Q25BM from Neale Jct to Burlington Jct were approaching continuous ratings.

The following list of contingencies was studied as part of the thermal analysis:

ID	Loss of Circuit	ID	Loss of Circuit	ID	Loss of Circuit
C1	N580M	C2	M585M	C3	V586M

C4	M572T	C5	M570V	C6	N1M (Nanticoke-Summerhaven)
C7	N1M (Summerhaven-Middleport)	C8	N2M (Nanticoke-PDNW)	C9	N2M (PDNW-Middleport)
C10	N5M	C11	N6M	C12	Q23BM
C13	M27B	C14	T36B	C15	R14T
C16	R19TH	C17	N1M+N2M	C18	N5M+N6M
C19	Q23BM+Q25BM	C20	M27B+M28B	C21	T36B+T37B
C22	T38B+T39B	C23	R14T+R17T	C24	R19T+R21T

The following tables summarize the post-contingency loading as a percentage of the Long Term Emergency rating for contingencies C1 - C24.

Element	Monitored Element		% of Long Term Emergency Rating							
	From	To	C1	C2	C3	C4	C5	C6	C7	C8
N580M	NANTICOKE_TS500	MIDDLEPT 500	0	37	13	28	29	29	30	27
N581M	NANTICOKE_TS500	MIDDLEPT 500	42	13	37	27	27	29	29	28
M585M	MIDDLEPT8185500	MILTON_SS 500	34	0	32	21	21	24	24	23
V586M	MIDDLEPT8185500	CLAIREVILLE 500	7	30	0	21	23	21	22	21
M572T	MILTON_SS 500	TRAFALG_M 500	17	14	16	0	18	17	17	17
M573T	MILTON_SS 500	TRAFALG_M 500	17	14	16	21	18	16	17	17
M570V	MILTON_SS 500	CLAIREVILLE 500	22	9	22	20	0	16	16	16
M571V	MILTON_SS 500	CLAIREVILLE 500	22	9	22	20	27	16	16	16
N1M	NANTICOKE_TS220	MIDDLEPT_DK1 220	69	58	54	54	53	22	22	52
N2M	NANTICOKE_TS220	MIDDLEPT_DK1 220	69	59	54	54	53	45	65	0
N5M	NANTICOKE_TS220	MIDDLEPT_DK2 220	62	57	60	56	55	59	63	55
N6M	NANTICOKE_TS220	MIDDLEPT_DK2 220	51	45	48	44	43	47	50	43
Q23BM	MIDDLEPT_DK2220	BURLINGTON 220	88	92	85	84	80	82	82	80
Q25BM	MIDDLEPT_DK2220	BURLINGTON 220	82	86	79	79	75	76	77	75
M27B	MIDDLEPT_DK1220	BURLINGTON 220	45	54	57	52	49	46	45	49
M28B	MIDDLEPT_DK1220	BURLINGTON 220	48	59	62	56	53	50	48	52
T36B	BURLINGTON 220	TRAFALGAR_TS 220	36	46	44	40	36	34	33	35
T37B	BURLINGTON 220	TRAFALGAR_TS 220	36	47	44	40	35	34	33	35
T38B	BURLINGTON 220	TRAFALGAR_TS 220	32	42	40	36	31	30	29	31
T39B	BURLINGTON 220	TRAFALGAR_TS 220	32	42	40	36	31	30	29	31
R14T	TRAFALGAR_TS220	RICHVIEW_AH1 220	67	68	71	54	67	64	63	64
R17T	TRAFALGAR_TS220	RICHVIEW_AH1 220	67	68	71	54	68	64	64	64
R19TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	63	65	68	48	65	67	60	61
R21TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	63	64	68	48	64	60	60	60

Element	Monitored Element		% of Long Term Emergency Rating							
	From	To	C9	C10	C11	C12	C13	C14	C15	C16
N580M	NANTICOKE_TS500	MIDDLEPT 500	30	27	28	28	27	28	28	28
N581M	NANTICOKE_TS500	MIDDLEPT 500	29	28	30	28	29	29	28	28
M585M	MIDDLEPT8185500	MILTON_SS 500	24	21	23	24	24	23	23	23
V586M	MIDDLEPT8185500	CLAIREVILLE 500	22	21	22	22	22	22	22	22
M572T	MILTON_SS 500	TRAFALG_M 500	17	17	17	18	17	18	16	16
M573T	MILTON_SS 500	TRAFALG_M 500	17	16	17	18	17	17	16	16
M570V	MILTON_SS 500	CLAIREVILLE 500	16	14	16	16	16	16	17	17
M571V	MILTON_SS 500	CLAIREVILLE 500	16	15	16	16	16	16	17	17
N1M	NANTICOKE_TS220	MIDDLEPT_DK1 220	65	55	58	54	49	51	52	52
N2M	NANTICOKE_TS220	MIDDLEPT_DK1 220	19	54	61	54	49	52	52	52
N5M	NANTICOKE_TS220	MIDDLEPT_DK2 220	62	0	65	59	56	54	55	55
N6M	NANTICOKE_TS220	MIDDLEPT_DK2 220	52	50	0	40	45	43	43	43
Q23BM	MIDDLEPT_DK2220	BURLINGTON 220	82	73	76	0	85	78	79	79
Q25BM	MIDDLEPT_DK2220	BURLINGTON 220	77	68	71	92	79	73	74	73
M27B	MIDDLEPT_DK1220	BURLINGTON 220	45	48	50	56	0	48	48	48
M28B	MIDDLEPT_DK1220	BURLINGTON 220	49	52	54	60	67	52	52	51
T36B	BURLINGTON 220	TRAFALGAR_TS 220	33	30	33	30	32	0	33	33
T37B	BURLINGTON 220	TRAFALGAR_TS 220	33	30	33	30	32	46	33	33
T38B	BURLINGTON 220	TRAFALGAR_TS 220	29	26	29	26	28	37	29	29
T39B	BURLINGTON 220	TRAFALGAR_TS 220	29	26	29	26	28	37	29	29
R14T	TRAFALGAR_TS220	RICHVIEW_AH1 220	63	61	63	62	63	63	0	73
R17T	TRAFALGAR_TS220	RICHVIEW_AH1 220	64	61	64	62	63	63	99	74
R19TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	60	57	60	58	59	59	69	0
R21TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	60	57	60	58	59	59	69	86

Element	Monitored Element		% of Long Term Emergency Rating							
	From	To	C17	C18	C19	C20	C21	C22	C23	C24
N580M	NANTICOKE_TS500	MIDDLEPT 500	33	28	29	26	27	28	27	28
N581M	NANTICOKE_TS500	MIDDLEPT 500	31	31	28	30	28	29	28	28
M585M	MIDDLEPT8185500	MILTON_SS 500	25	22	27	25	23	25	23	24
V586M	MIDDLEPT8185500	CLAIREVILLE 500	22	21	24	24	21	23	21	23
M572T	MILTON_SS 500	TRAFALG_M 500	18	17	18	18	17	17	17	13
M573T	MILTON_SS 500	TRAFALG_M 500	17	17	18	18	17	17	17	13
M570V	MILTON_SS 500	CLAIREVILLE 500	16	14	17	16	16	17	16	20
M571V	MILTON_SS 500	CLAIREVILLE 500	16	14	17	16	16	17	16	20
N1M	NANTICOKE_TS220	MIDDLEPT_DK1 220	22	64	55	44	52	50	52	51
N2M	NANTICOKE_TS220	MIDDLEPT_DK1 220	19	65	55	41	53	51	53	51
N5M	NANTICOKE_TS220	MIDDLEPT_DK2 220	75	0	47	59	55	53	55	54
N6M	NANTICOKE_TS220	MIDDLEPT_DK2 220	72	0	35	48	44	42	43	42
Q23BM	MIDDLEPT_DK2220	BURLINGTON 220	87	67	0	92	80	75	80	75
Q25BM	MIDDLEPT_DK2220	BURLINGTON 220	81	63	0	86	75	70	75	45
M27B	MIDDLEPT_DK1220	BURLINGTON 220	39	51	65	0	49	45	49	45
M28B	MIDDLEPT_DK1220	BURLINGTON 220	41	55	70	0	53	48	53	29
T36B	BURLINGTON 220	TRAFALGAR_TS 220	30	28	27	28	0	53	35	29
T37B	BURLINGTON 220	TRAFALGAR_TS 220	30	28	27	28	0	53	35	25
T38B	BURLINGTON 220	TRAFALGAR_TS 220	26	24	23	24	31	0	31	25
T39B	BURLINGTON 220	TRAFALGAR_TS 220	26	24	23	24	31	0	31	25
R14T	TRAFALGAR_TS220	RICHVIEW_AH1 220	62	60	61	61	64	66	0	93
R17T	TRAFALGAR_TS220	RICHVIEW_AH1 220	62	60	61	61	64	66	0	93
R19TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	58	56	57	57	61	62	92	0
R21TH	TRAFALGAR_TS220	RICHVIEW_AH2 220	58	56	57	57	60	62	91	0

As shown, all post-contingency flows were found to be within the Long Term Emergency ratings. However, it should be noted that circuits Q23BM/Q25BM, R14T/R17T and R19TH/R21TH would be approaching LTE ratings when their companion circuit is out of service.

Appendix B shows the diagrams for thermal study simulations.

It should be noted that the concerns on the pre-contingency and post-contingency flow existed before GREP's connection to the IESO-Controlled grid. GREP will make the situation slightly worse but the flows are still below ratings.

6.7 Voltage Analysis

The assessment of the voltage performance in the Nanticoke area was done in accordance with the IESO's *Ontario Resource and Transmission Assessment Criteria.* The criteria states that with all facilities in service pre-contingency, 230 kV, 115 kV, 44-13.8kV system voltage declines following a contingency shall be limited to 10% before and after transformer tap changer action, and absolute maximums and minimums of 250-207kV, 127-108kV and 112%-88% of nominal, respectively. The 44-13.8kV system voltages are further limited to 5% voltage decline after tap changer action.

The voltage decline studies were performed with the GREP facility connected to the circuit N5M. A constant MVA load model was used in both immediate post-contingency state and in post-ULTC state. Generally GREP will help system voltage performance. The worst case due to the addition of GREP is loss of GREP with full output and one unit at Nanticoke GS is out of service. The study results for this case are summarized in the following table.

Monitored Busses	**Pre-Cont Voltage (kV)**	**Loss of GREP**			
		Pre-ULTC		**Post-ULTC**	
		kV	**%**	**kV**	**%**
Nanticoke 230	246.5	245.4	-0.4	245.3	-0.5
Summerhaven 230	246.9	245.9	-0.4	245.8	-0.4
Port Dover 230	246.7	245.7	-0.4	245.6	-0.4
GREP 230	248.0	-	-	-	-
Middleport 230	246.6	245.7	-0.4	245.6	-0.4
Burlington 230	245.0	244.2	-0.3	244.0	-0.4

The study results indicate that both declines of pre-ULTC and post-ULTC values are within the IESO’s criteria of 10%.

In conclusion, addition of the GREP project does not result in material adverse impact on the voltage performance of the IESO-controlled grid.

6.8 Transient Analysis

Transient stability analysis was performed considering faults in Nanticoke and Middleport area with the proposed GREP project in-service. All contingencies studied were three-phase faults cleared with normal fault clearing times. Double circuit contingencies were simulated as three phase faults occurring on two both circuits simultaneously. It should be noted that the simulations for double circuit contingencies are more onerous than required in Ontario Resource and Transmission Assessment Criteria so the study results are more conservative and acceptable. The contingencies that were studied for dynamic analysis are listed in the table below.

ID	**Contingency**	**Location**	**Fault Clearing Time (ms)**	
			Near	**Remote**
SC1	N1M	Nanticoke	83	116
SC2	N2M	Middleport	83	116
SC3	N5M	Nanticoke	83	116
SC4	N6M	Nanticoke	83	116
SC5	M27B	Middleport	83	116
SC6	N1M+N2M	Nanticoke	83	116

SC7	N5M+N6M	Nanticoke	83	116
SC8	M27B+M28B	Middleport	83	116
SC9	Q23BM+Q25BM	Middleport	83	116

The transient simulation plots are shown in Appendix C. The transient simulation results suggest that none of the simulated contingencies caused transient instability or undamped oscillations. All results show gradual attenuation of the oscillations.

In conclusion, addition of the GREP project does not result in material adverse impact on the transient performance of the IESO-controlled grid.

6.9 Low-voltage ride through capability

The new generating facility is required to ride through routine switching events and design criteria contingencies assuming standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times, unless disconnected by configuration.

As any other generators, the Siemens WTG and SMA Sunny Central PV inverters are expected to trip only for contingencies which remove 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 causes the 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 settings as shown below (From Siemens document “UserInputData-SMK223_InputData_SWT-2.3-101_VS_60 Hz_V1.3.xls”).

Voltage range	*Event*
1.00 – 0.85 pu	No trip
0.85 – 0.4 pu	Relay 1 trips in 3.05 sec
0.4 – 0.15 pu	Relay 2 trips in 1.65 sec
0.15 – 0.0 pu	Relay 3 trips in 0.90 sec

In PSS/E model for SMA, the LVRT feature accompanies a change of under-voltage settings as shown below (From SMA document “Modeling of SMA’s Sunny Central Photovoltaic Inverters for Power Flow and Stability Studies with PSS/E Version 30.3”).

Voltage range	*Event*
1.00 – 0.85 pu	No trip
0.85 – 0.45 pu	Relay 1 trips in 2 sec

0.45 – 0.0 pu	Relay 2 trips in 0.165 sec

In order to examine the need for low voltage ride through (LVRT) capability, the three phase faults on N1M and N6M at Nanticoke SS (SC1 and SC4) with normal clearing time were simulated. These particular contingencies are electrically much closer to the new generation facility than other contingencies at Middleport TS. Thus, they could potentially have a greater impact on the terminal voltage of WTG and PV inverters.

The variation of the terminal voltage of the new generation facility is plotted in Figure 7 below. It can be seen that the duration during which the generator terminal voltage drops below 0.3 pu is about 0.116 sec. Therefore, the fault ride through capabilities of the wind turbines and PV inverters are adequate.

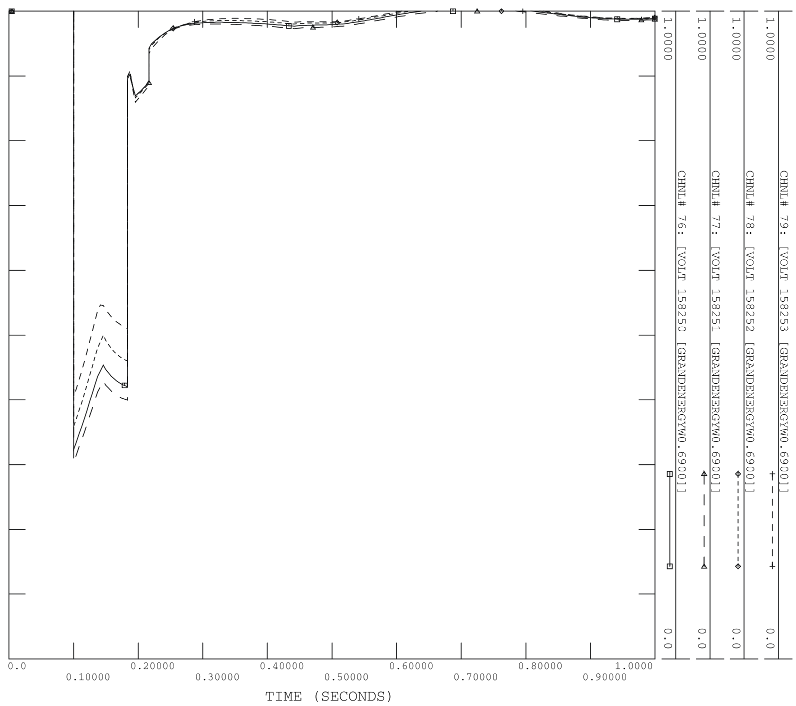


Figure 7: Terminal Voltage of Wind Generator during LLLG Faults at Nanticoke SS

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

– End of Report –

Appendix A Market Rules: Appendix 4.2

Appendix 4.2 – Generation Facility Requirements

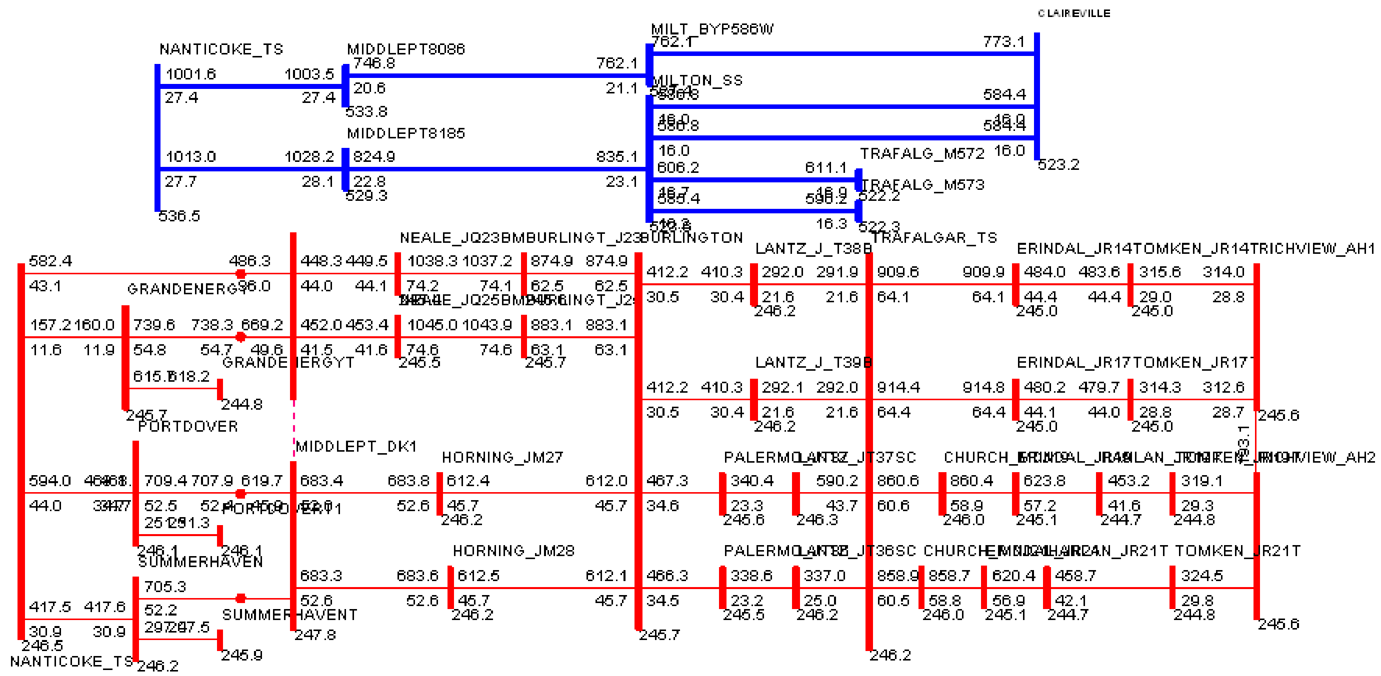
The performance requirements set out below shall apply to *generation facilities* subject to a *connection assessment* finalized after March 6, 2010. Performance of alternative technologies will be compared at the point of connection to the *IESO-controlled grid* with that of a conforming conventional synchronous *generation unit* with an equal apparent power rating to determine whether a requirement is satisfied.

Each *generation facility* that was authorized to connect to the *IESO-controlled grid* prior to March 6, 2010 shall remain subject to the performance requirements in effect for each system at the time of its authorization to connect to the *IESO-controlled grid* was granted or as agreed to by the *market participant* and the *IESO* (i.e. the "original performance requirements"). These requirements shall prevail until the main elements of an associated system (e.g. governor control mechanism, main exciter) are replaced or substantially modified. At that time, the replaced or substantially modified system shall meet the applicable performance requirements set out below. All other systems, not affected by replacement or substantial modification, shall remain subject to the original performance requirements.

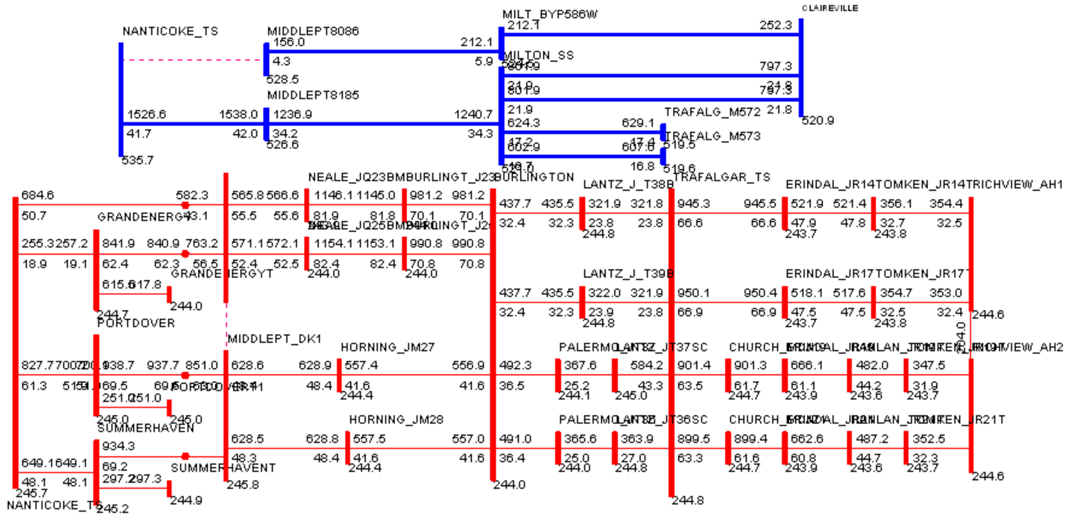
Category	***Generation facility* directly connected to the *IESO-controlled grid, generation facility* greater than 50 MW, or *generation unit* greater than 10 MW shall have the capability to:**
1. Off-Nominal Frequency	Operate continuously between 59.4 Hz and 60.6 Hz and for a limited period of time in the region above straight lines on a log-linear scale defined by the points (0.0 s, 57.0 Hz), (3.3 s, 57.0 Hz), and (300 s, 59.0 Hz).
2. Speed/Frequency Regulation	Regulate speed with an average droop based on maximum active power adjustable between 3% and 7% and set at 4% unless otherwise specified by the *IESO*. Regulation deadband shall not be wider than ± 0.06%. Speed shall be controlled in a stable fashion in both interconnected and island operation. A sustained 10% change of rated active power after 10 s in response to a constant rate of change of speed of 0.1%/s during interconnected operation shall be achievable. Due consideration will be given to inherent limitations such as mill points and gate limits when evaluating active power changes. Control systems that inhibit governor response shall not be enabled without *IESO* approval.
3. Low Voltage Ride Through	Ride through routine switching events and design criteria contingencies assuming standard fault detection, auxiliary relaying, communication, and rated breaker interrupting times unless disconnected by configuration.
Category	***Generation facility* directly connected to the *IESO-controlled grid* shall have the capability to:**
4. Active Power	Supply continuously all levels of active power output for 5% deviations in terminal voltage. Rated active power is the smaller output at either rated ambient conditions (e.g. temperature, head, wind speed, solar radiation) or 90% of rated apparent power. To satisfy steady-state reactive power requirements, active power reductions to rated active power are permitted.
5. Reactive Power	Inject or withdraw reactive power continuously (i.e. dynamically) at a *connection point* up to 33% of its rated active power at all levels of active power output except where a lesser continually available capability is permitted by the *IESO*. A conventional synchronous unit with a power factor range of 0.90 lagging and 0.95 leading at rated active power connected via a main output transformer impedance not greater than 13% based on generator rated apparent power is acceptable.
6. Automatic Voltage Regulator (AVR)	Regulate automatically voltage within ±0.5% of any set point within ±5% of rated voltage at a point whose impedance (based on rated apparent power and rated voltage) is not more than 13% from the highest voltage terminal. If the AVR target voltage is a function of reactive output, the slope $\Delta V / \Delta Q_{max}$ shall be adjustable to 0.5%. The equivalent time constants shall not be longer than 20 ms for voltage sensing and 10 ms for the forward path to the exciter output. AVR reference compensation shall be adjustable to within 10% of the unsaturated direct axis reactance on the unit side from a bus common to multiple

	units.
7. Excitation System	Provide (a) Positive and negative ceilings not less than 200% and 140% of rated field voltage at rated terminal voltage and rated field current; (b) A positive ceiling not less than 170% of rated field voltage at rated terminal voltage and 160% of rated field current; (c) A voltage response time to either ceiling not more than 50 ms for a 5% step change from rated voltage under open-circuit conditions; and (d) A linear response between ceilings. Rated field current is defined at rated voltage, rated active power and required maximum continuous reactive power.
8. Power System Stabilizer (PSS)	Provide (a) A change of power and speed input configuration; (b) Positive and negative output limits not less than ±5% of rated AVR voltage; (c) Phase compensation adjustable to limit angle error to within 30° between 0.2 and 2.0 Hz under conditions specified by the IESO, and (d) Gain adjustable up to an amount that either increases damping ratio above 0.1 or elicits exciter modes of oscillation at maximum active output unless otherwise specified by the *IESO*. Due consideration will be given to inherent limitations.
9. Phase Unbalance	Provide an open circuit phase voltage unbalance not more than 1% at a *connection point* and operate continuously with a phase unbalance as high as 2%.
10. Armature and Field Limiters	Provide short-time capabilities specified in IEEE/ANSI 50.13 and continuous capability determined by either field current, armature current, or core-end heating. More restrictive limiting functions, such as steady state stability limiters, shall not be enabled without *IESO* approval.
11. Performance Characteristics	Exhibit *connection point* performance comparable to an equivalent synchronous *generation unit* with characteristic parameters within typical ranges. Inertia, unsaturated transient impedance, transient time constants and saturation coefficients shall be within typical ranges (e.g. H > 1.2 Aero-derivative, H > 1.2 Hydraulic less than 20 MVA, H > 2.0 Hydraulic 20 MVA or larger, H > 4.0 Other synchronized units, X'd < 0.5, T'do > 2.0, and S1.2 < 0.5) except where permitted by the *IESO*.

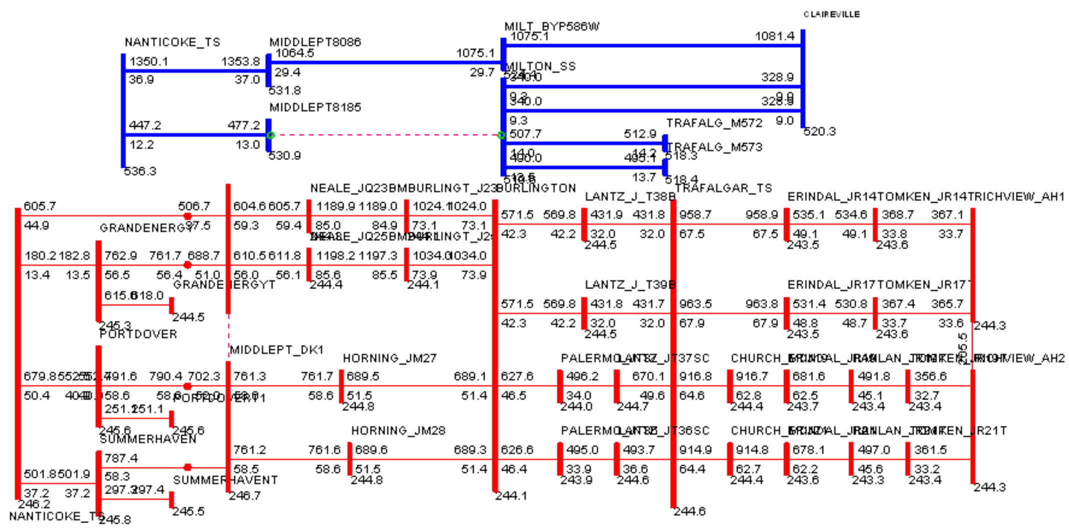
Appendix B Diagrams for Load Flow Results



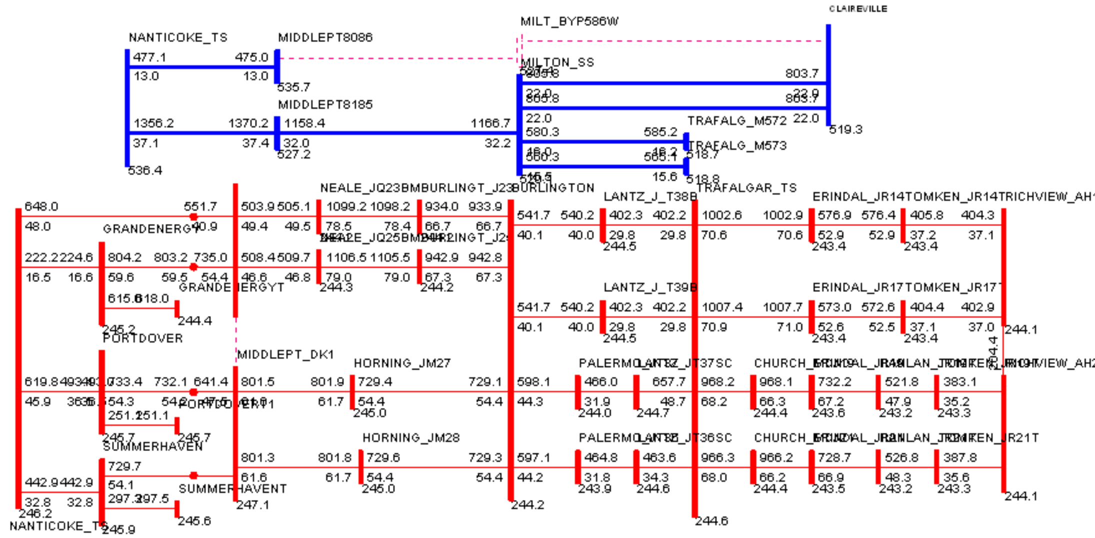
Load Flow Diagram 1: Pre-contingency



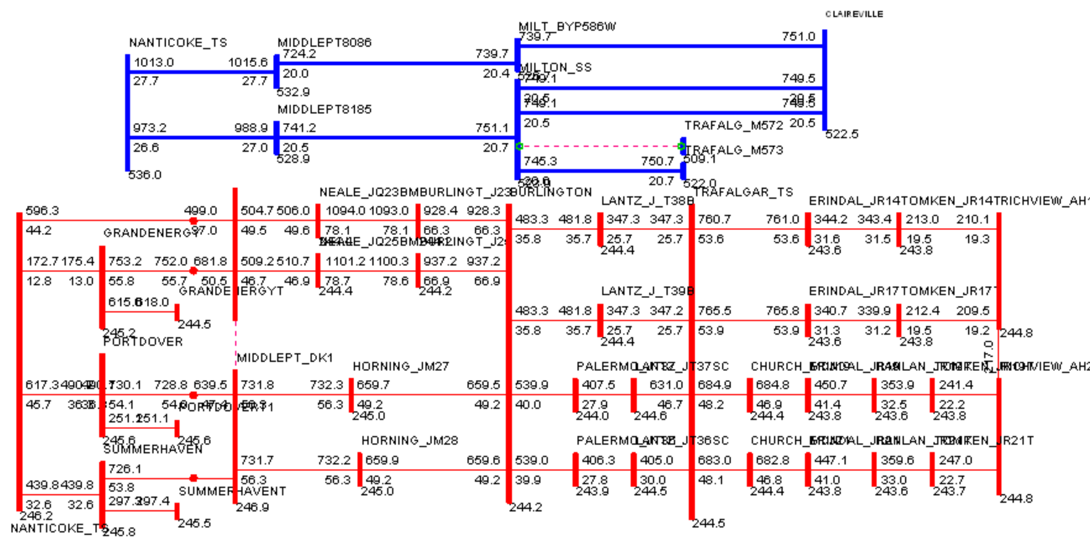
Load Flow Diagram 2: Loss of N58M



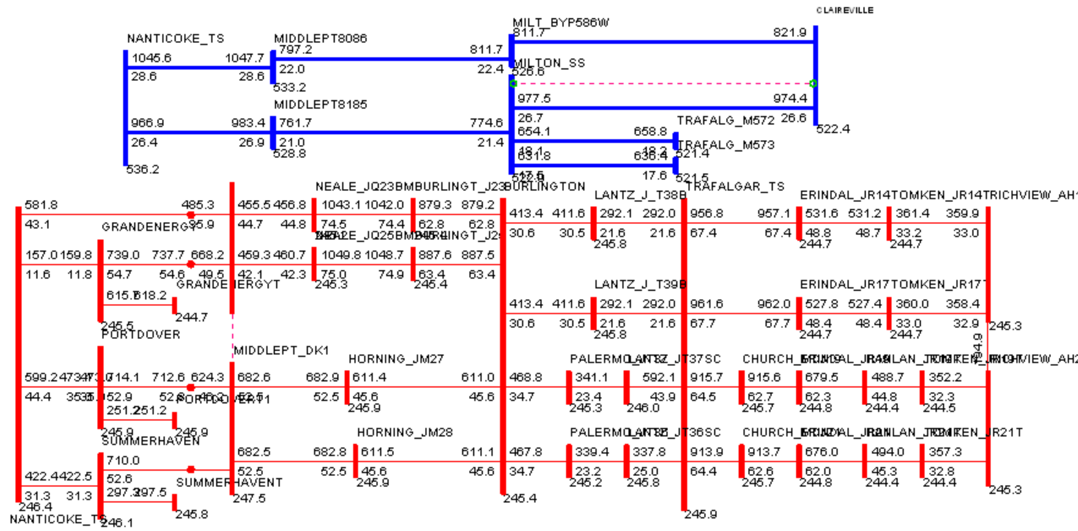
Load Flow Diagram 3: Loss of M585M



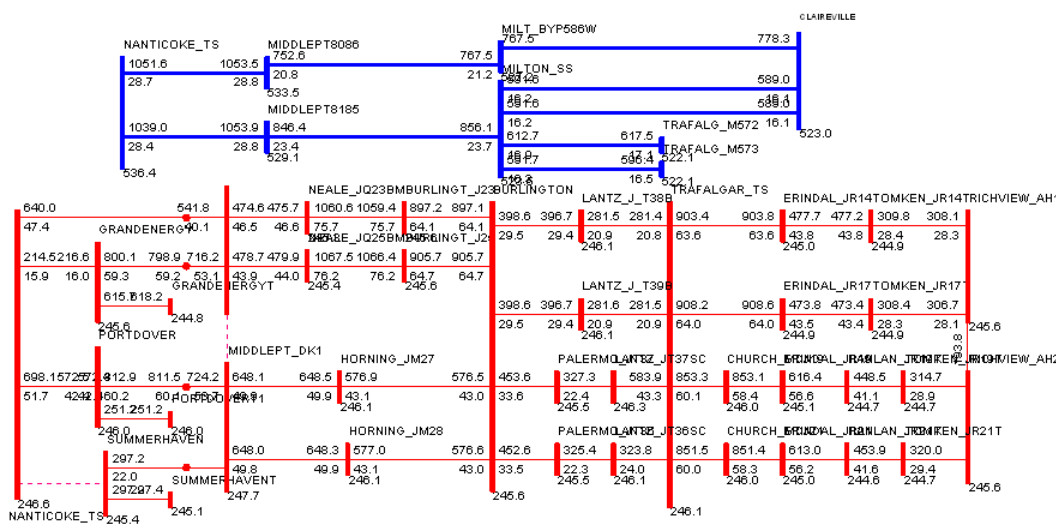
Load Flow Diagram 4: Loss of V586M



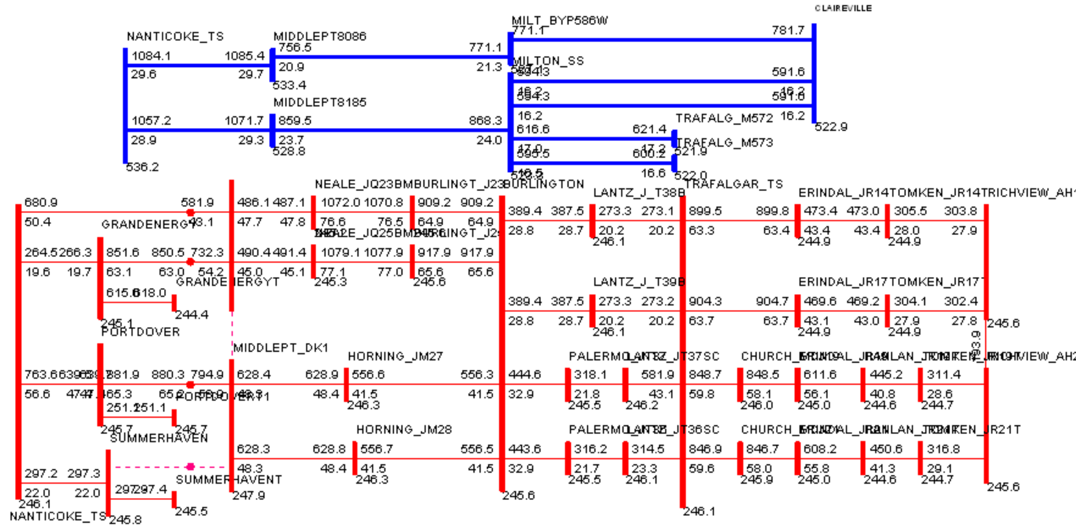
Load Flow Diagram 5: Loss of M572T



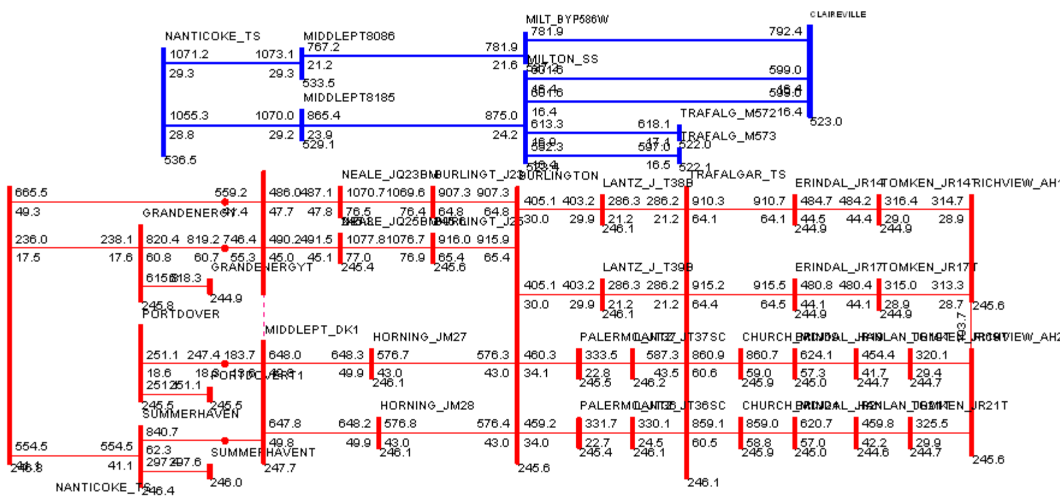
Load Flow Diagram 6: Loss of M570V



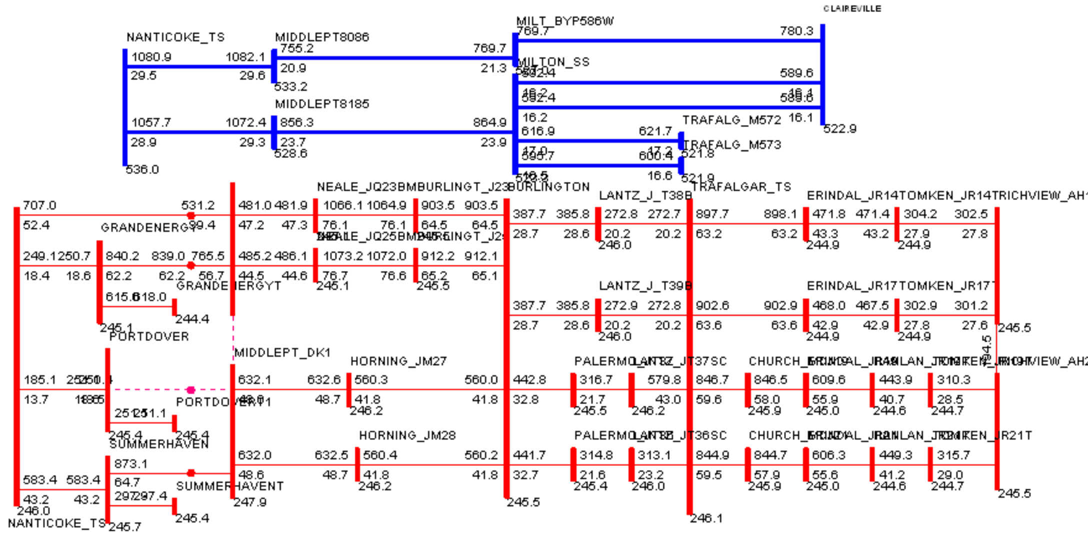
Load Flow Diagram 7: Loss of N1M (N.-Summerhaven)



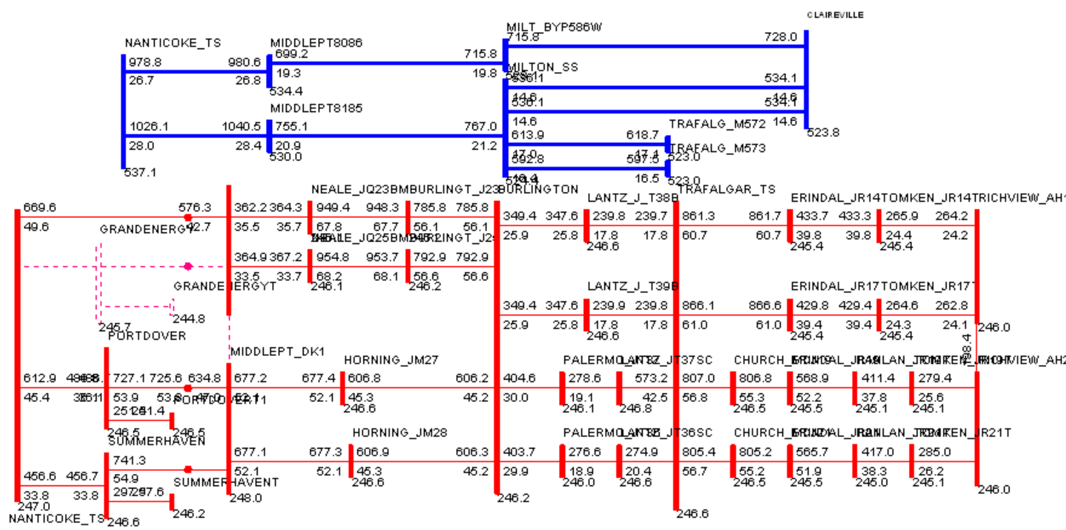
Load Flow Diagram 8: Loss of N1M (Summerhaven-M.)



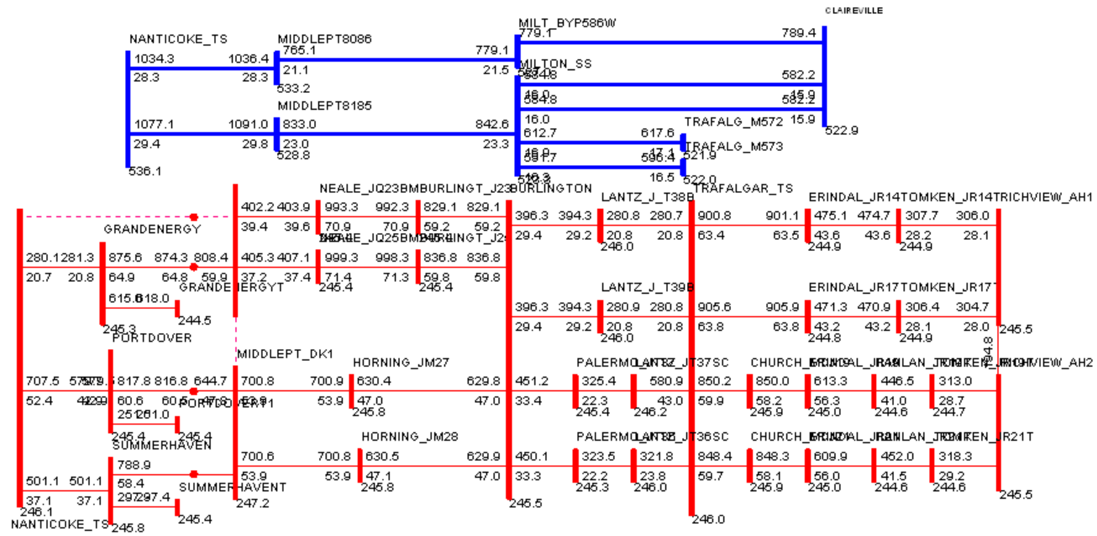
Load Flow Diagram 9: Loss of N2M (N.-PDNW)



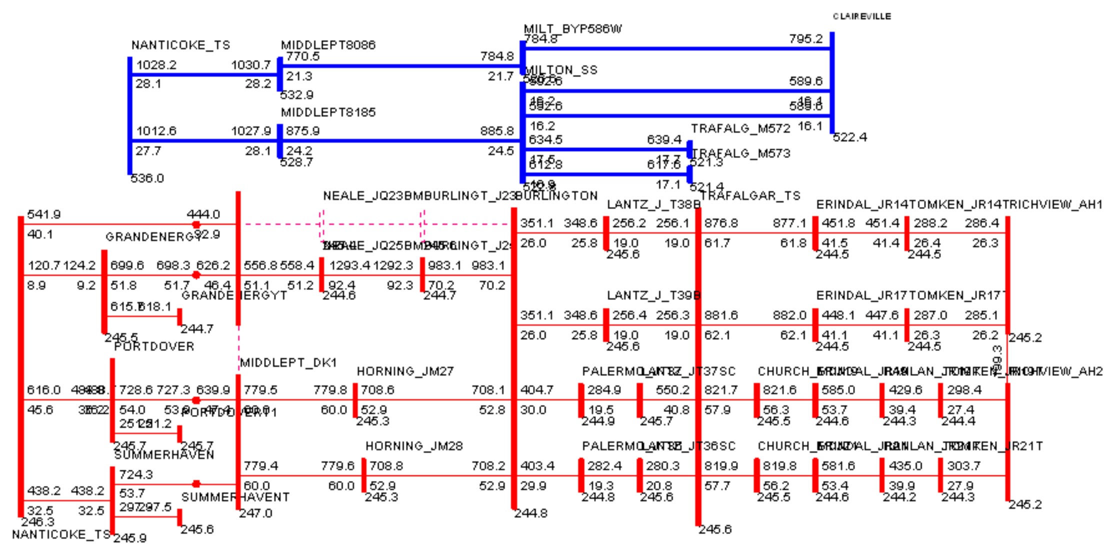
Load Flow Diagram 10: Loss of N2M (PDNW-M.)



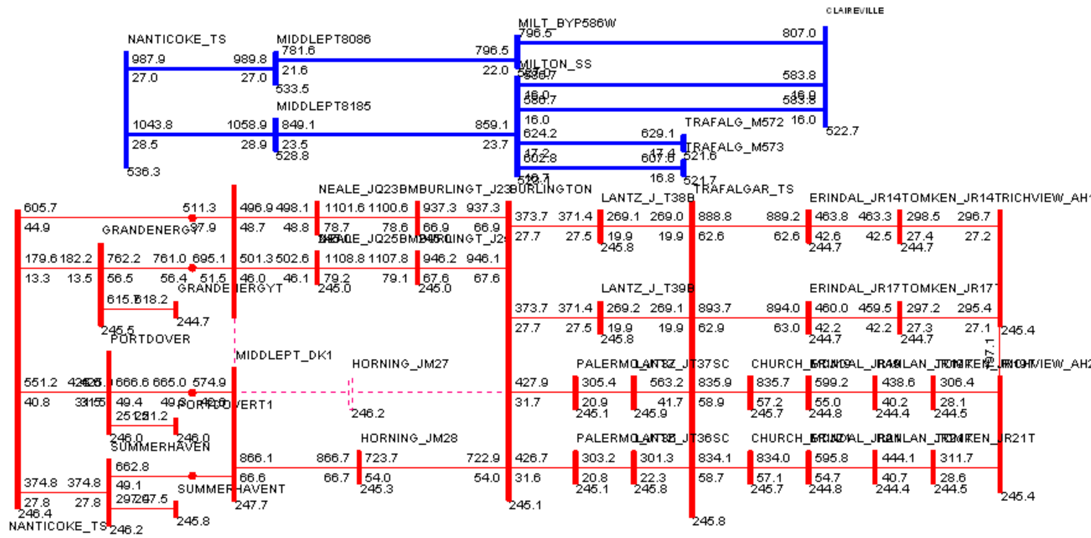
Load Flow Diagram 11: Loss of N5M



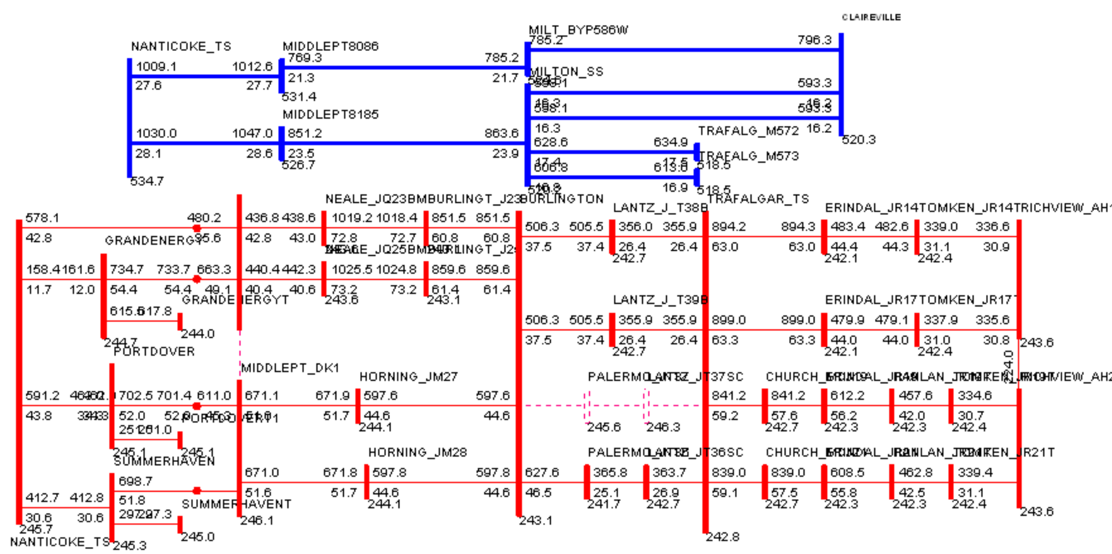
Load Flow Diagram 12: Loss of N6M



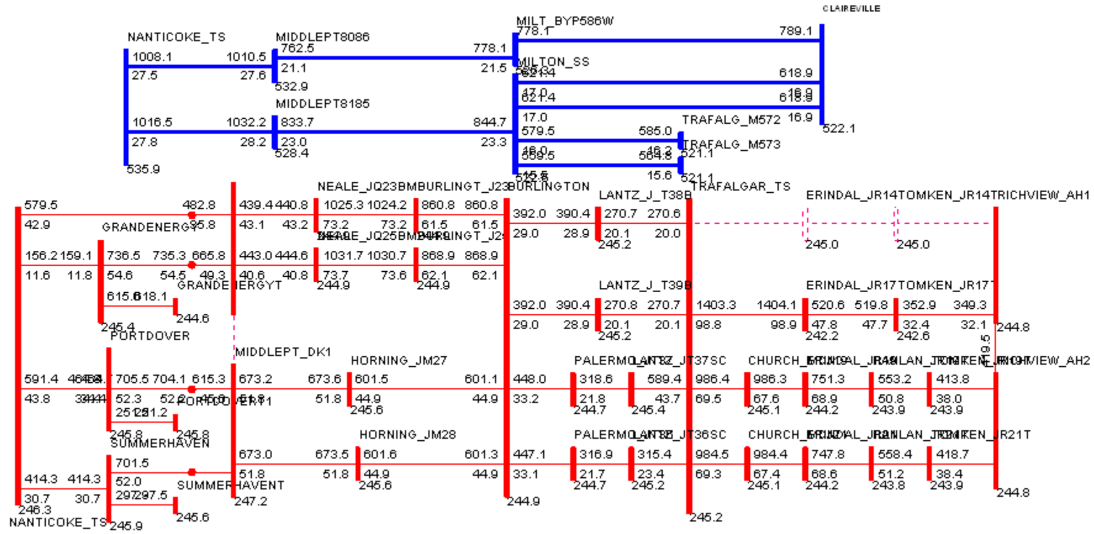
Load Flow Diagram 13: Loss of Q23BM



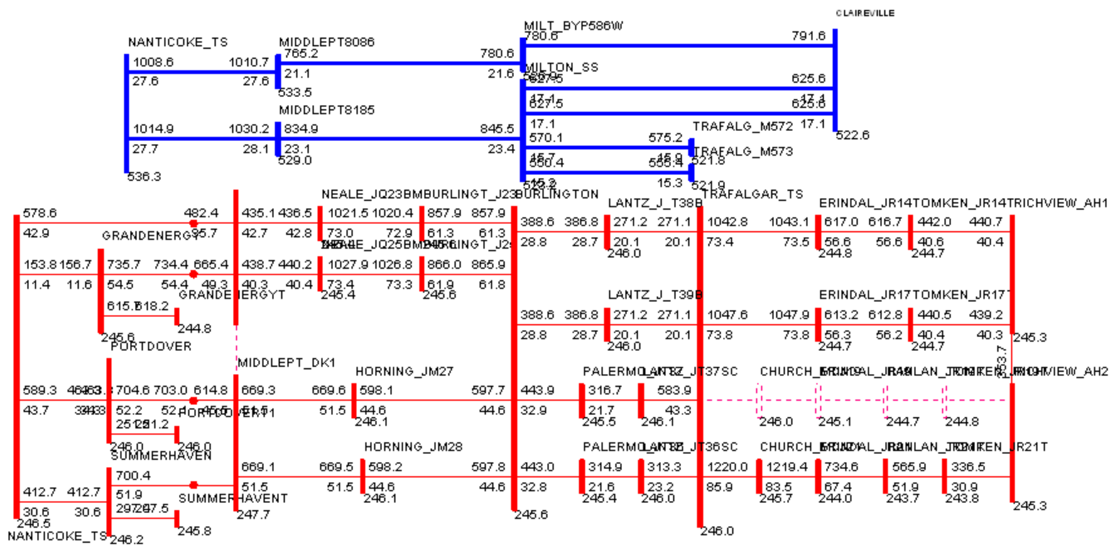
Load Flow Diagram 14: Loss of M27B



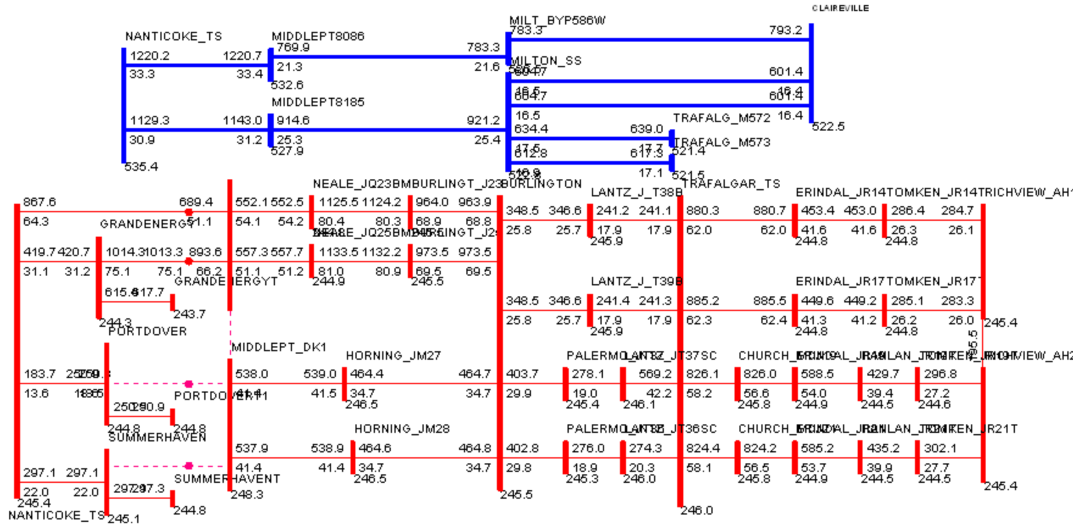
Load Flow Diagram 15: Loss of T37B



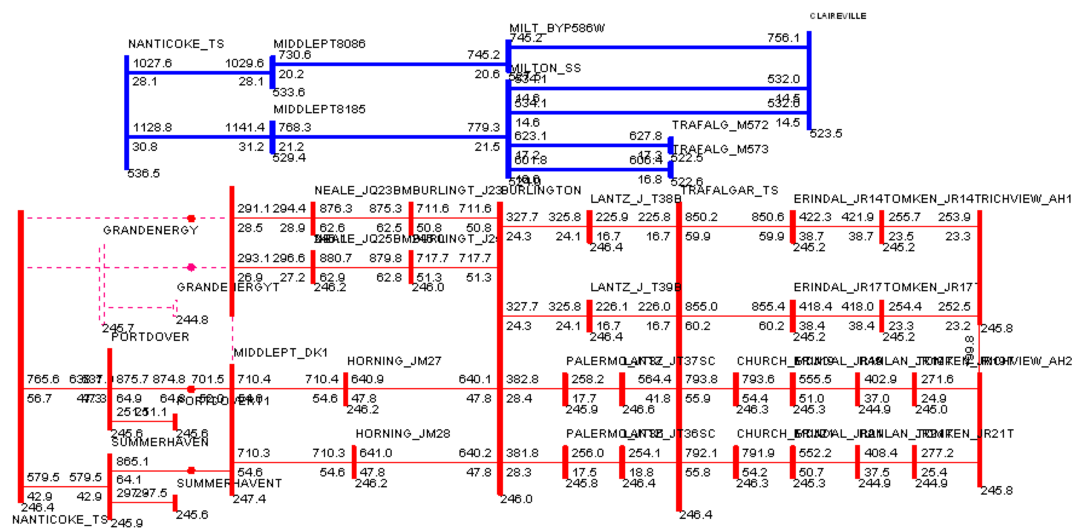
Load Flow Diagram 16: Loss of R14T



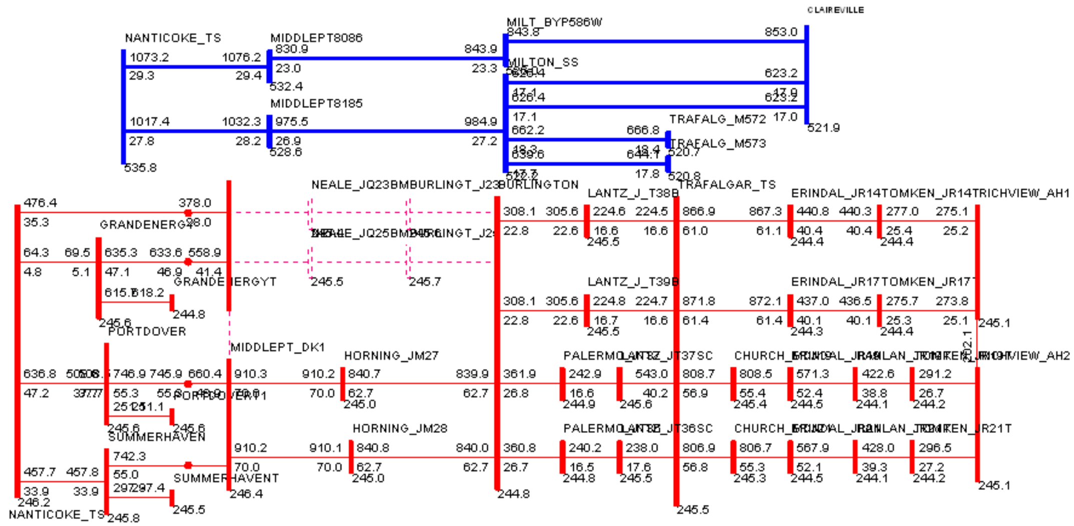
Load Flow Diagram 17: Loss of R19TH



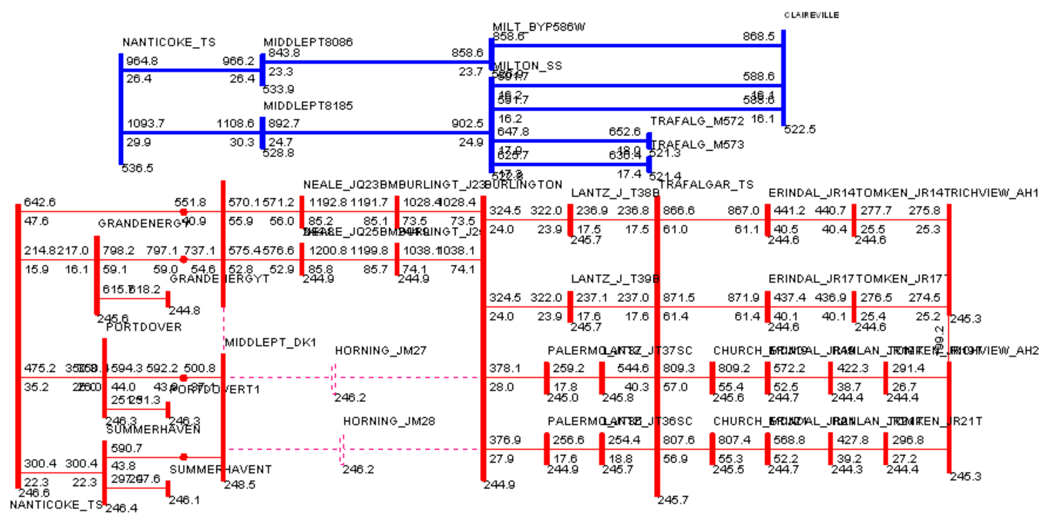
Load Flow Diagram 18: Loss of N1M/N2M



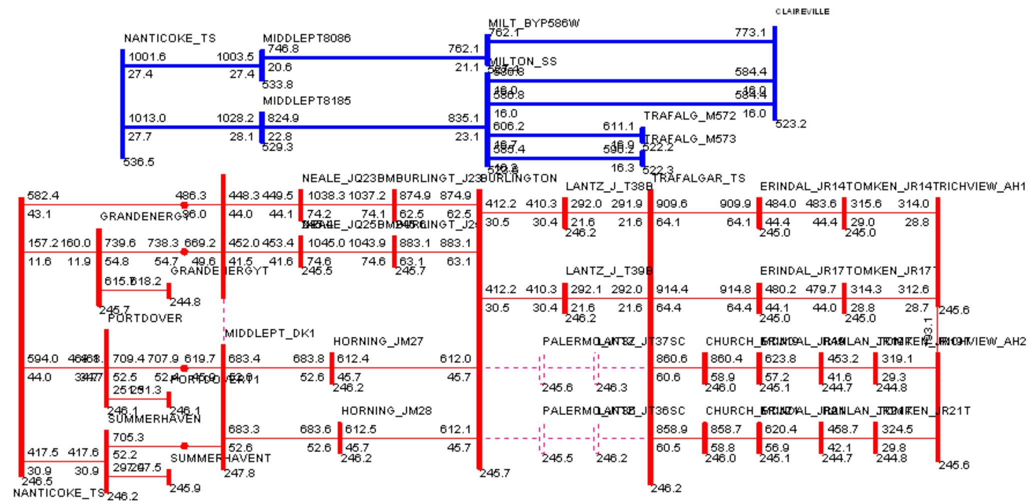
Load Flow Diagram 19: Loss of N5M/N6M



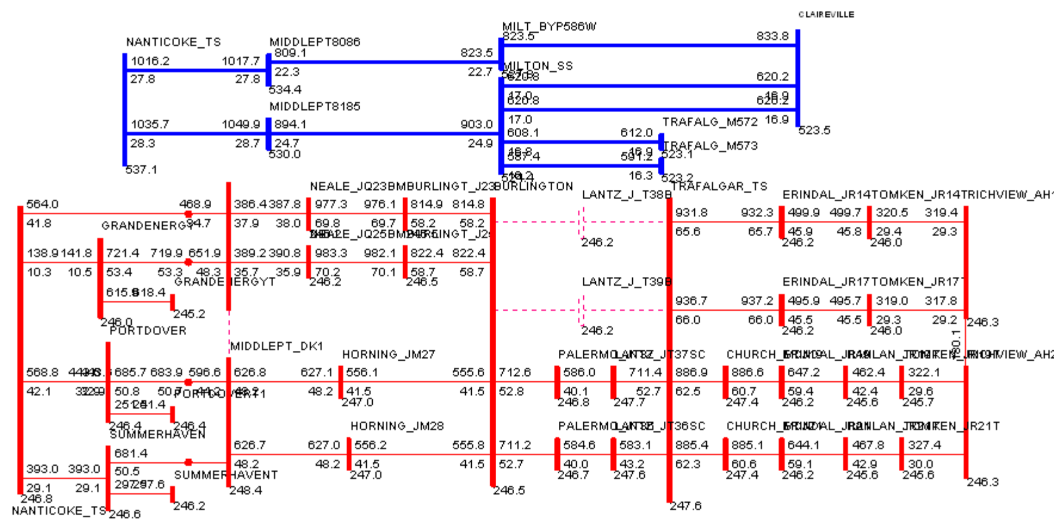
Load Flow Diagram 20: Loss of Q23BM/Q25BM



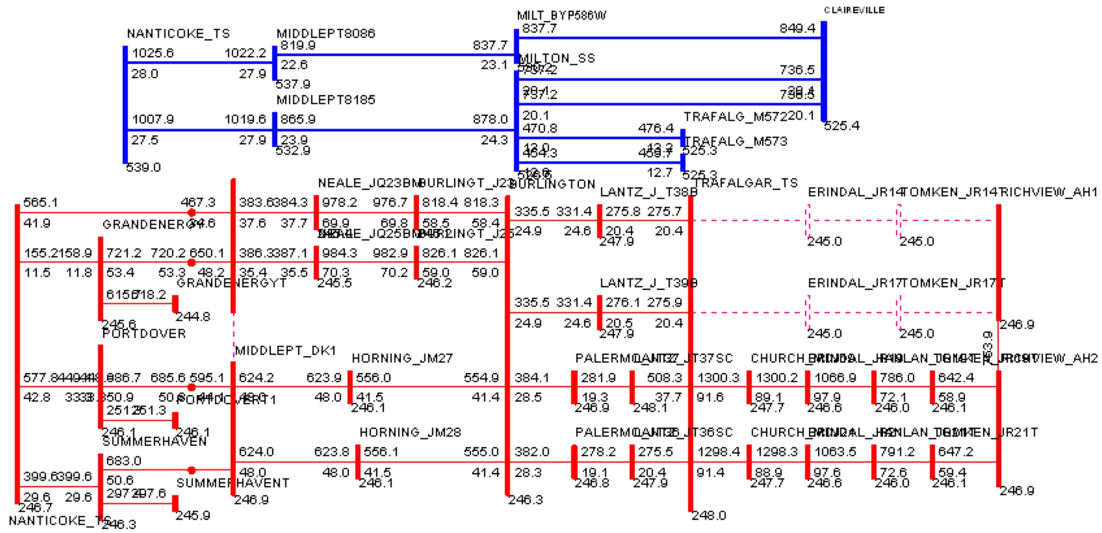
Load Flow Diagram 21: Loss of M27B/M28B



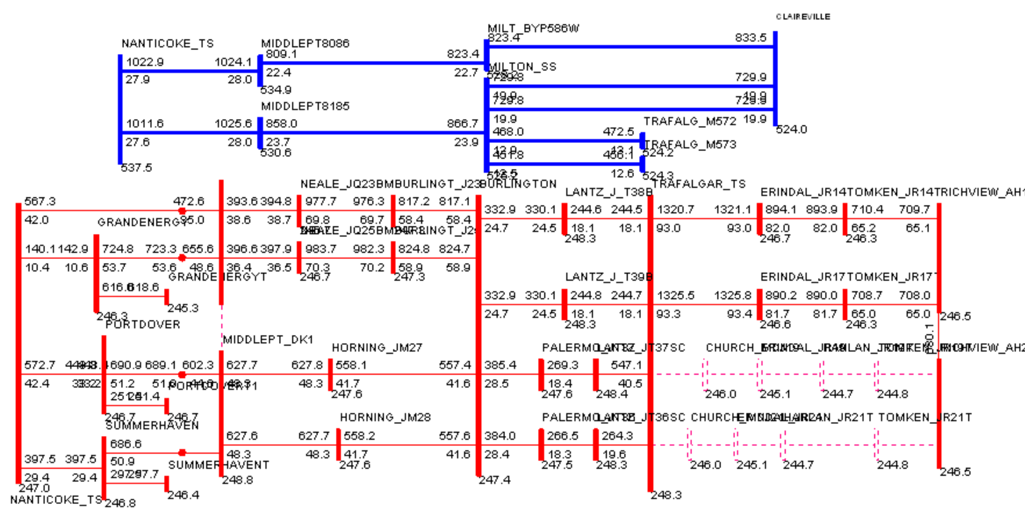
Load Flow Diagram 22
: Loss of T36B/T37B



Load Flow Diagram 23: Loss of T38B/T39B



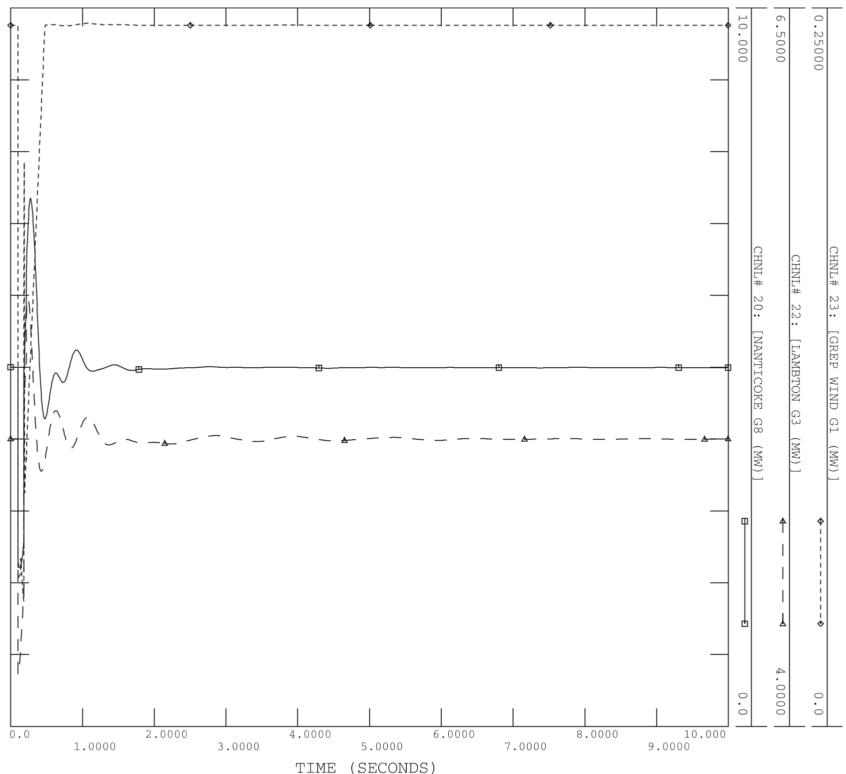
Load Flow Diagram 24: Loss of R14T/R17T

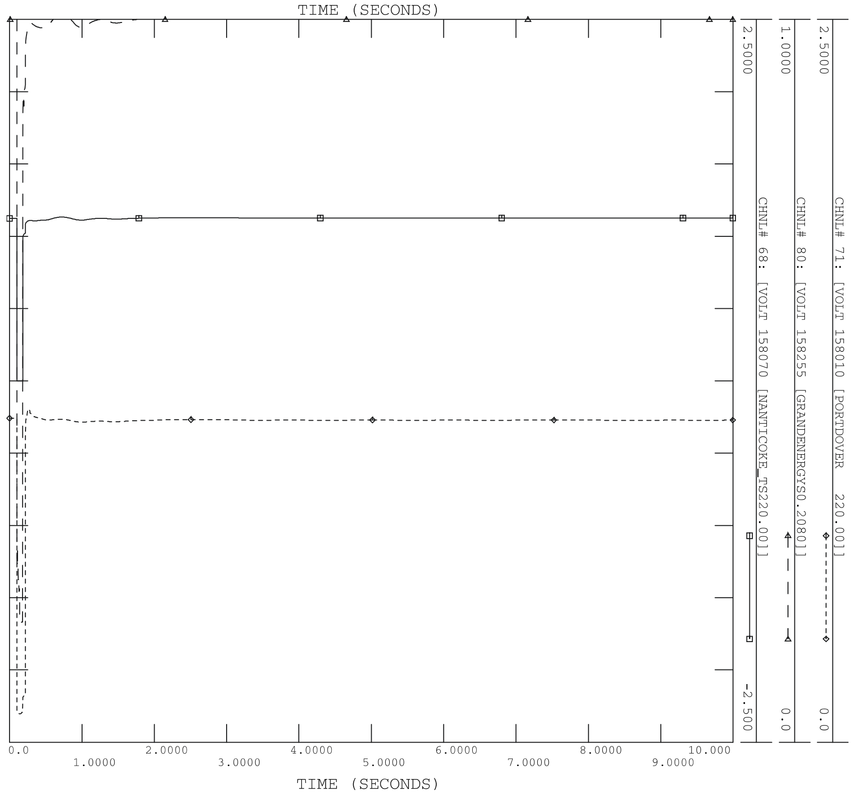


Load Flow Diagram 25: Loss of R19T/R21T

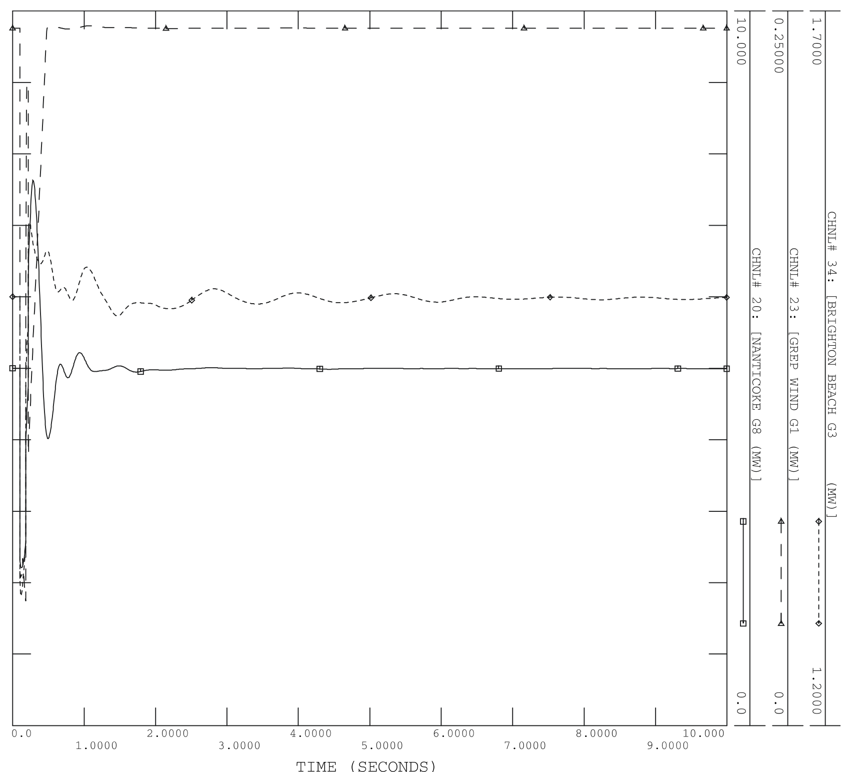
Appendix C Diagrams for Transient Simulation Results

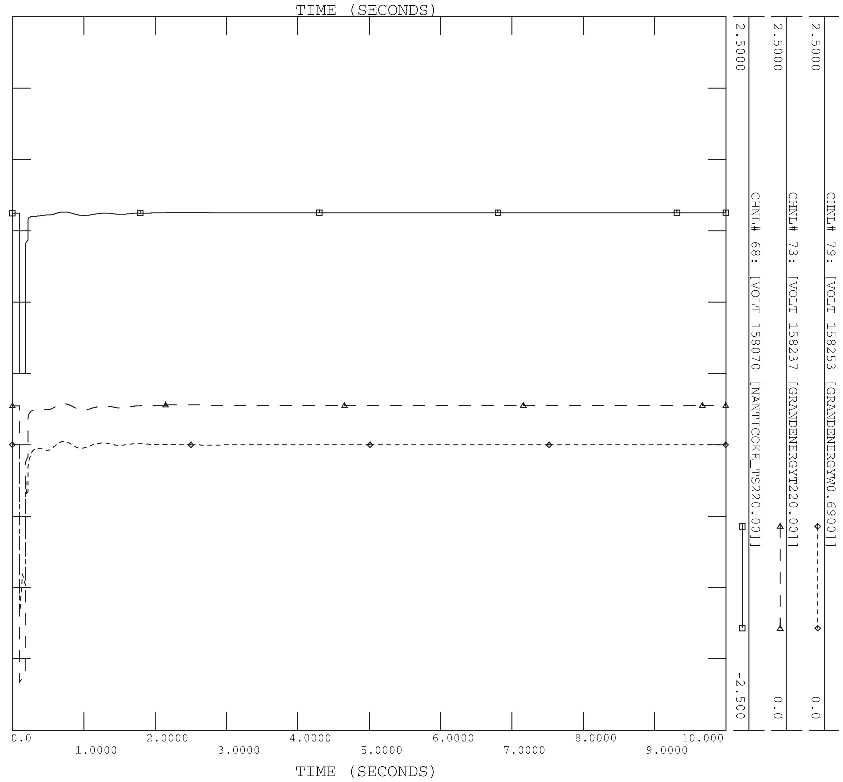
SC1: LLLG Fault on N1M at Nanticoke



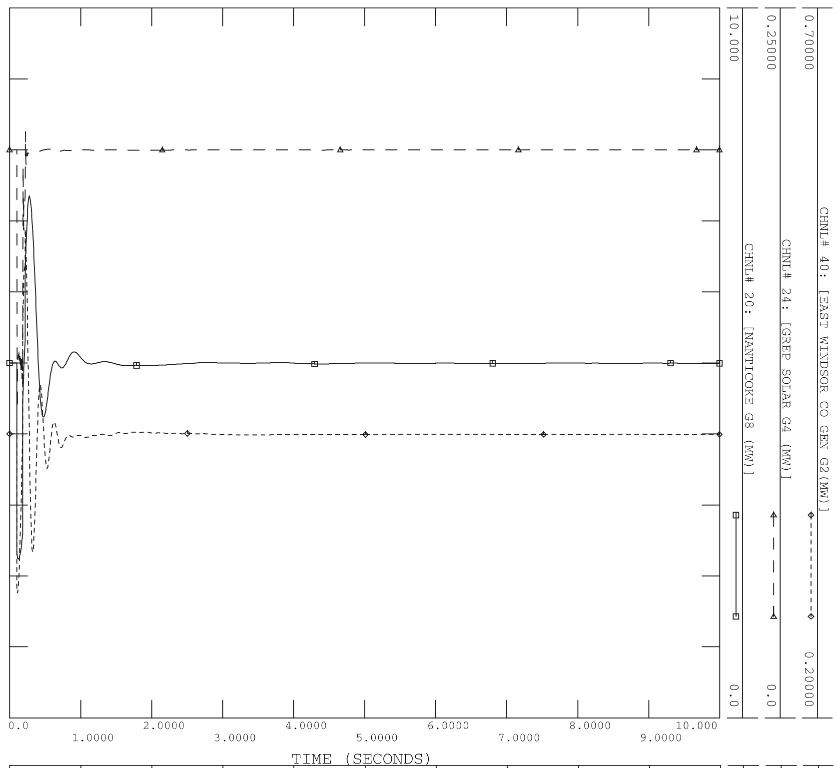


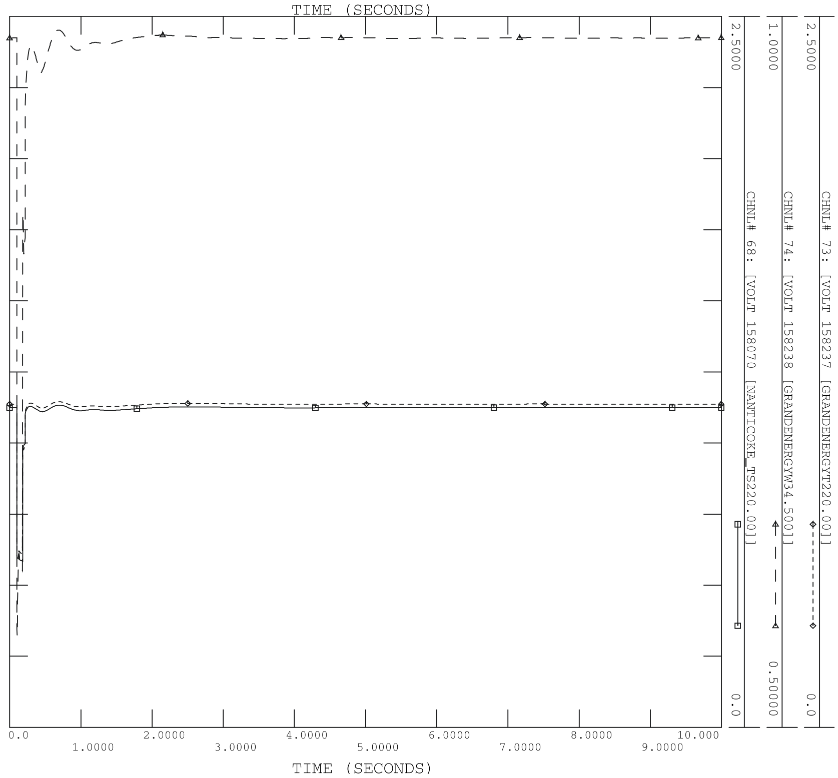
SC2: LLLG Fault on N2M at Middleport



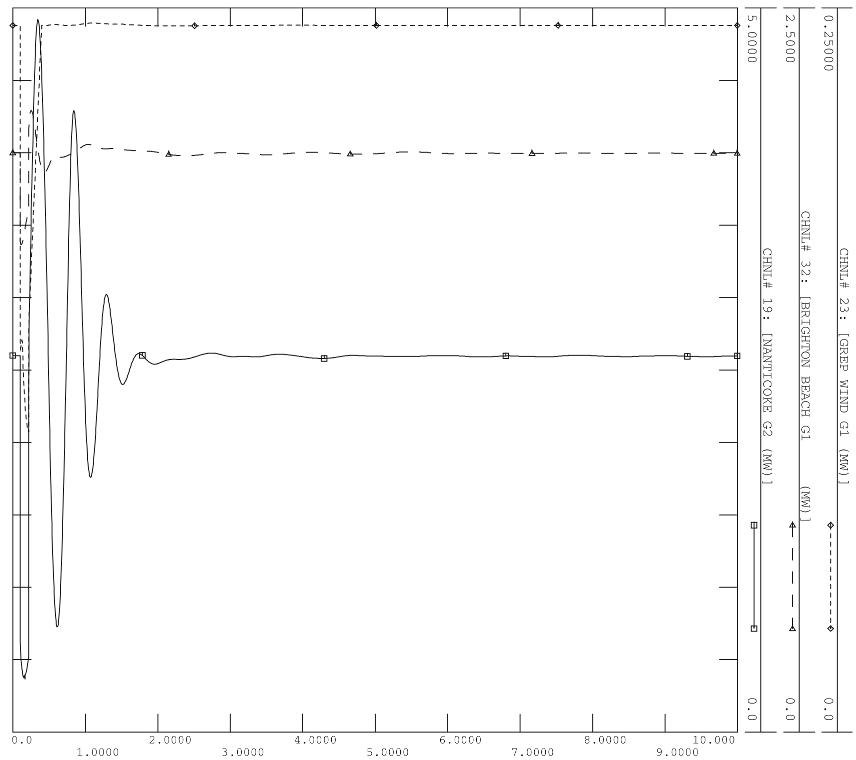


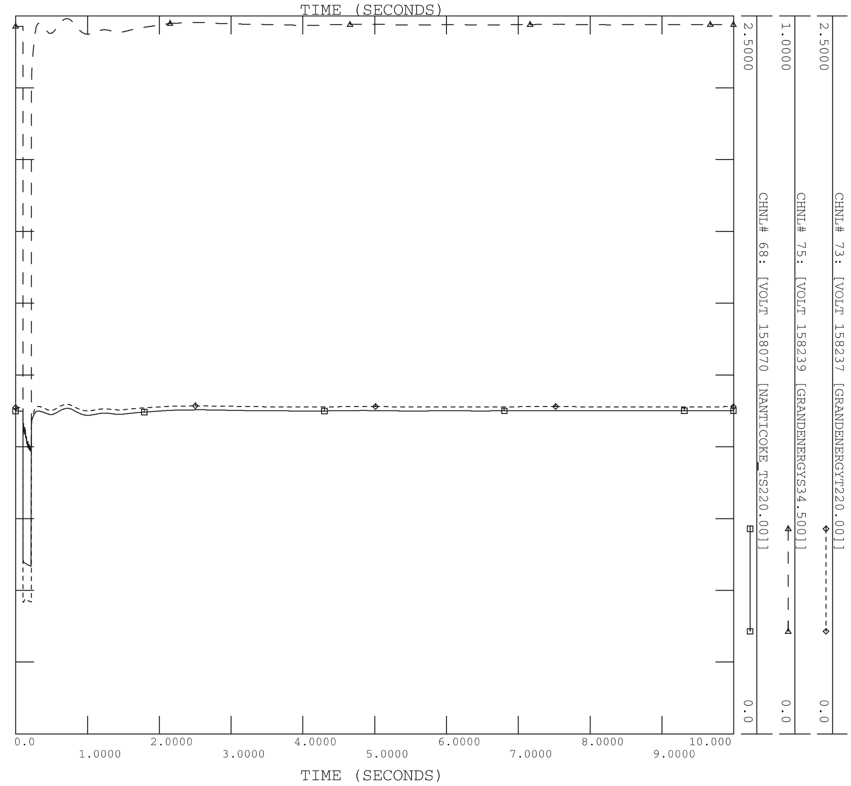
SC3: LLLG Fault on N5M at Nanticoke



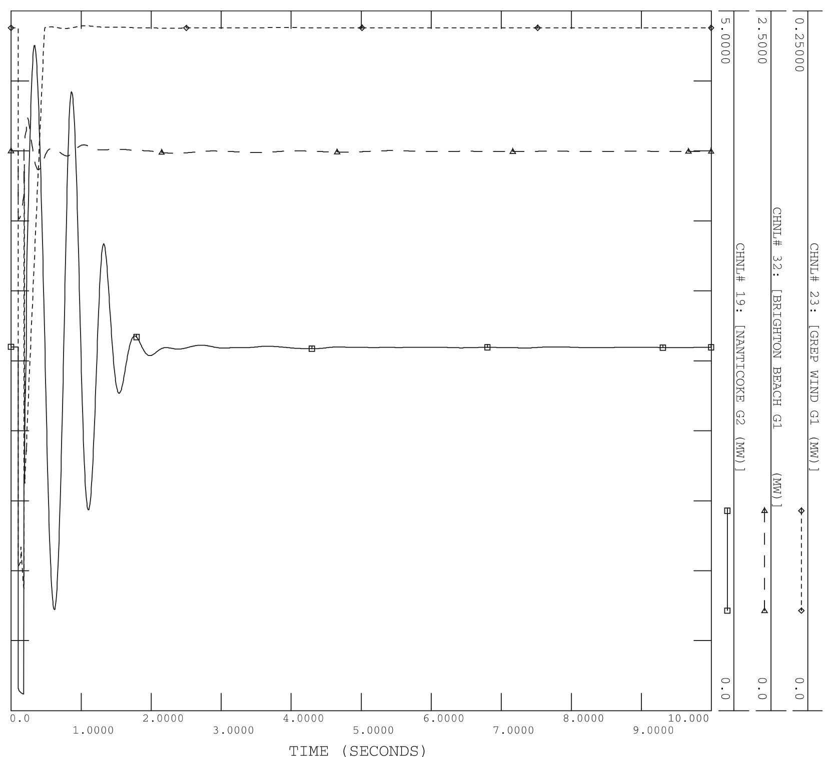


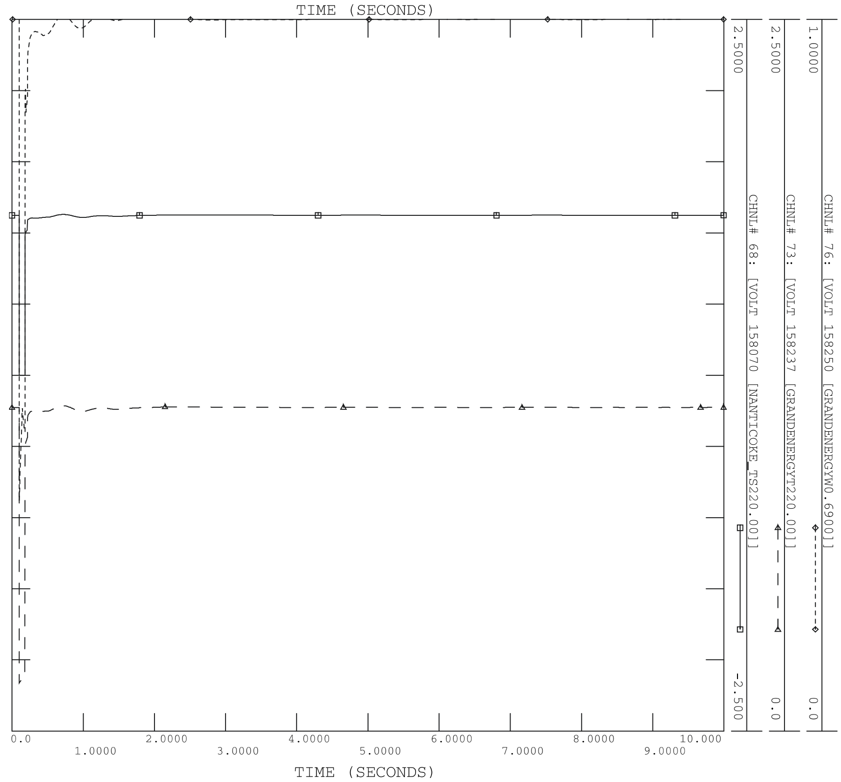
SC4: LLLG Fault on N6M at Nanticoke



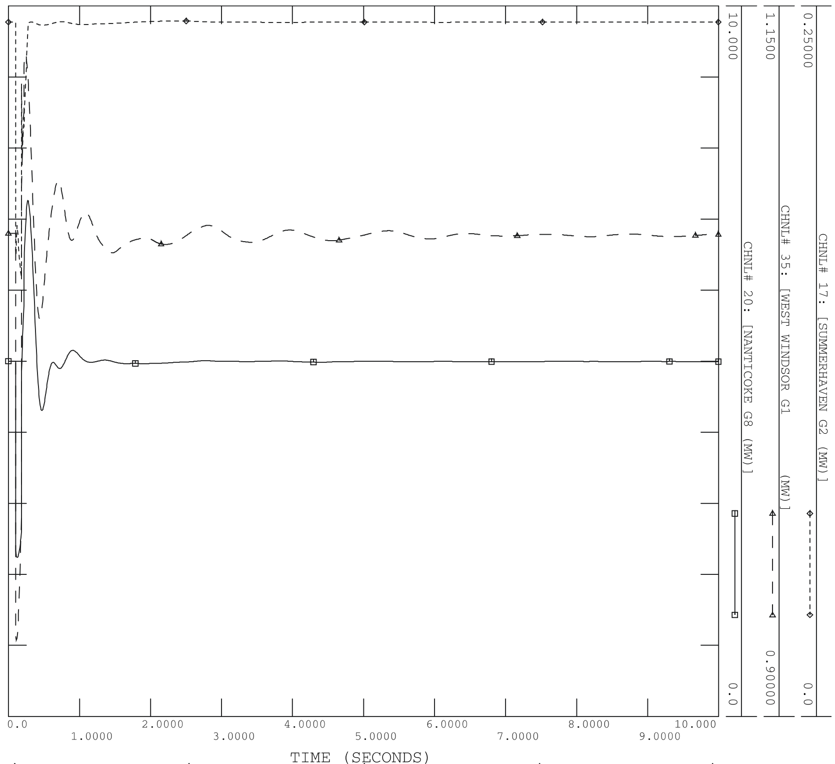


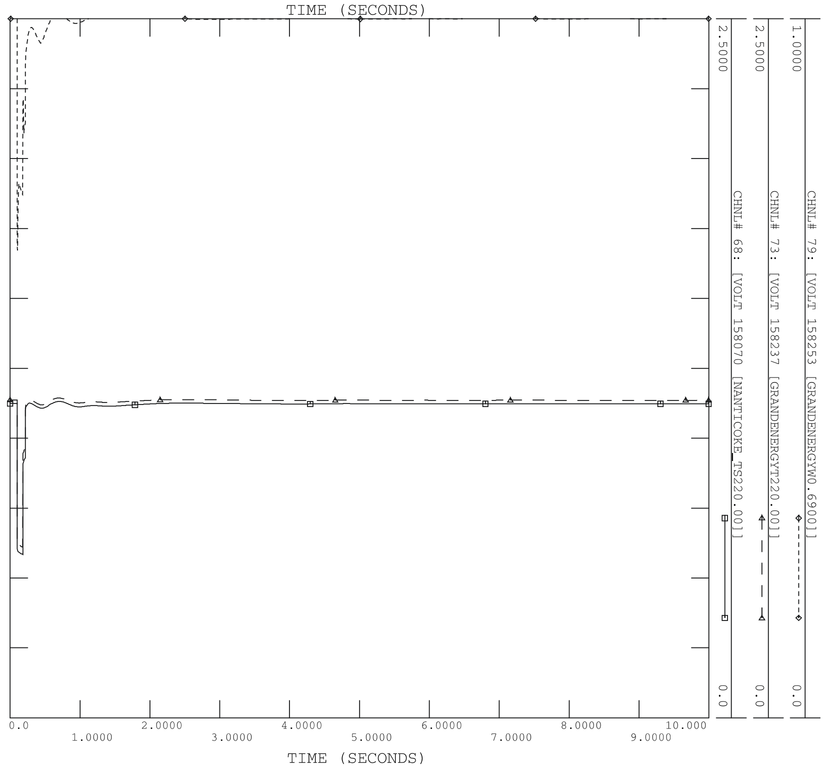
SC5: LLLG Fault on M27B at Middleport



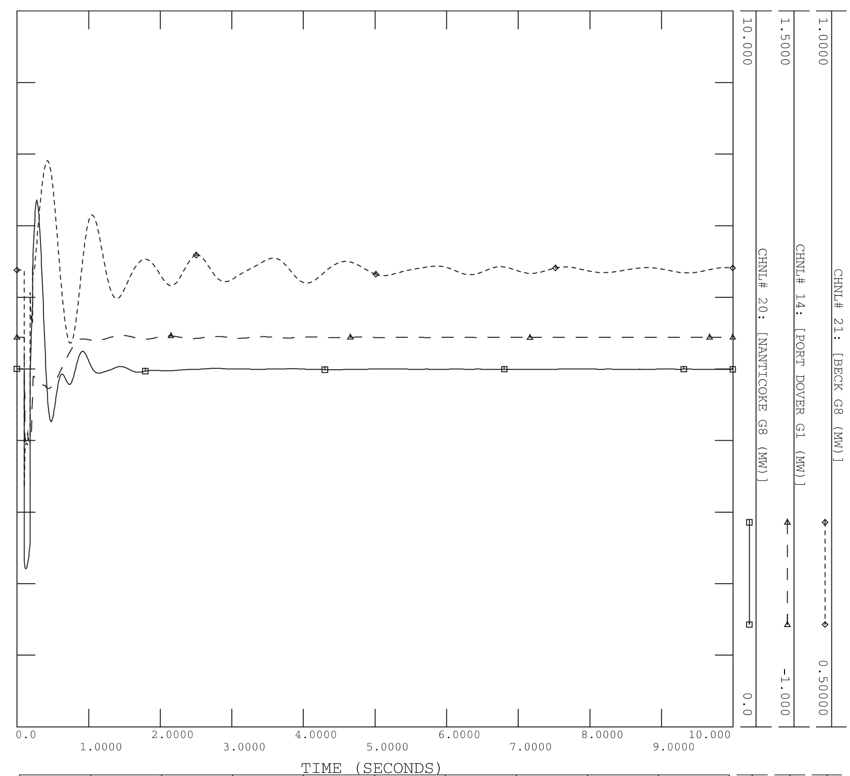


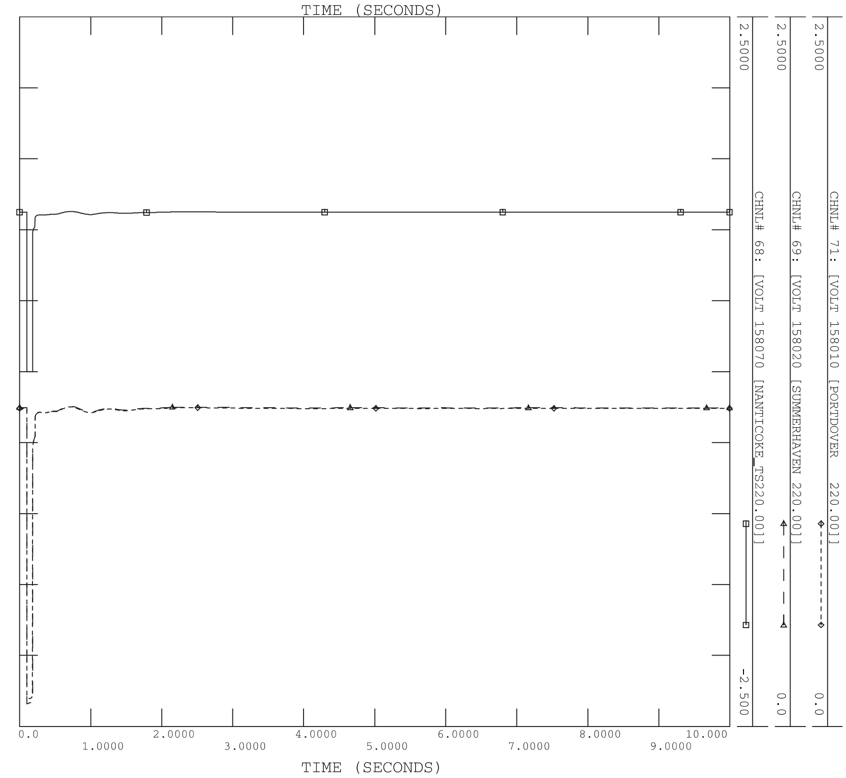
SC6: LLLG Fault on N1M/N2M at Nanticoke



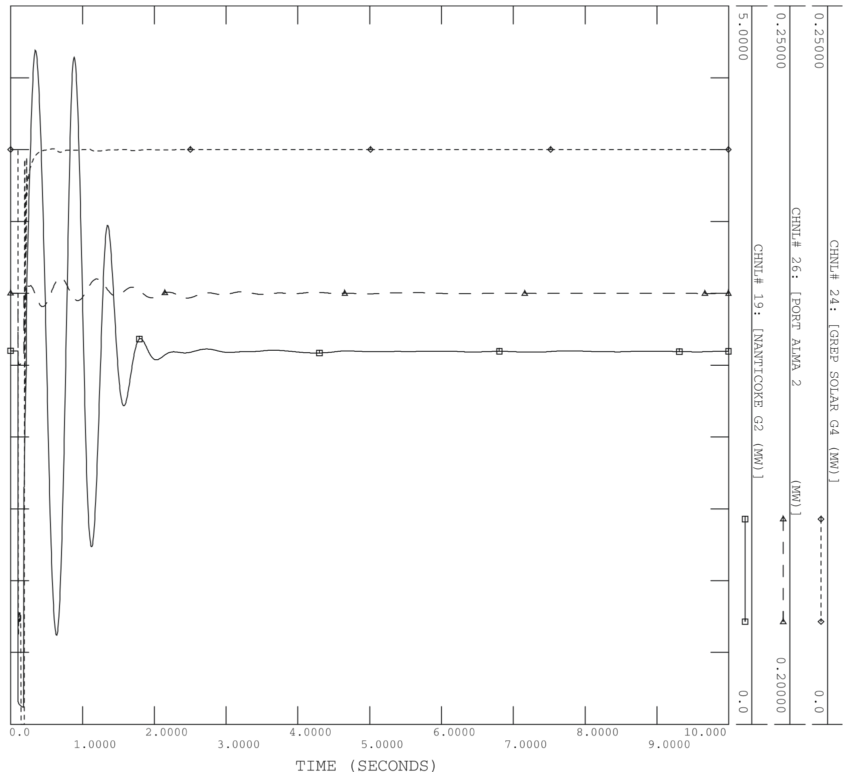


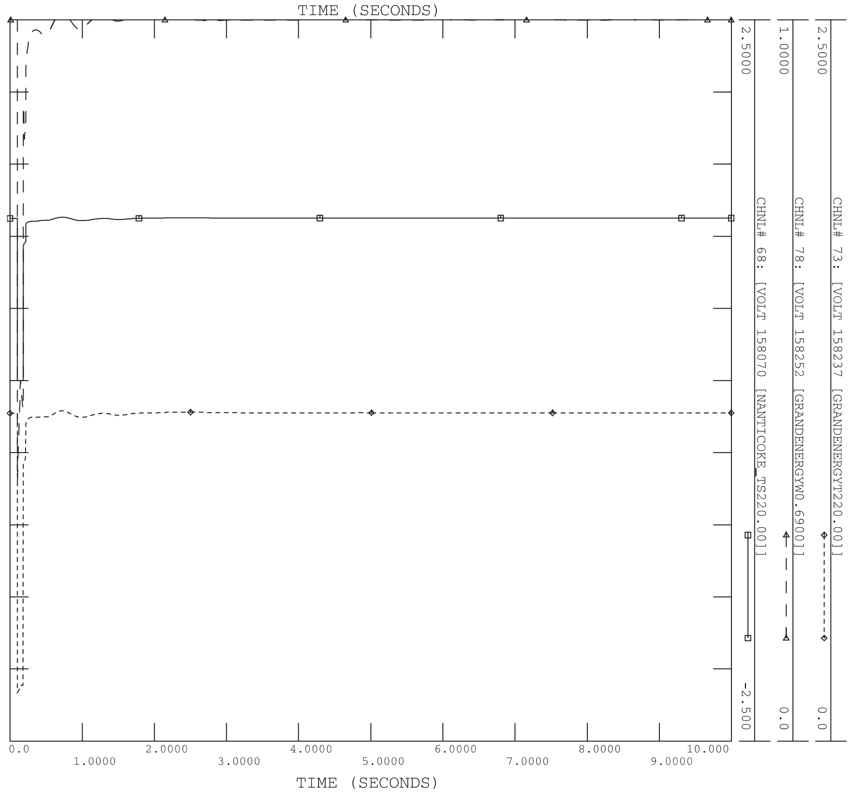
SC7: LLLG Fault on N5M/N6M at Nanticoke



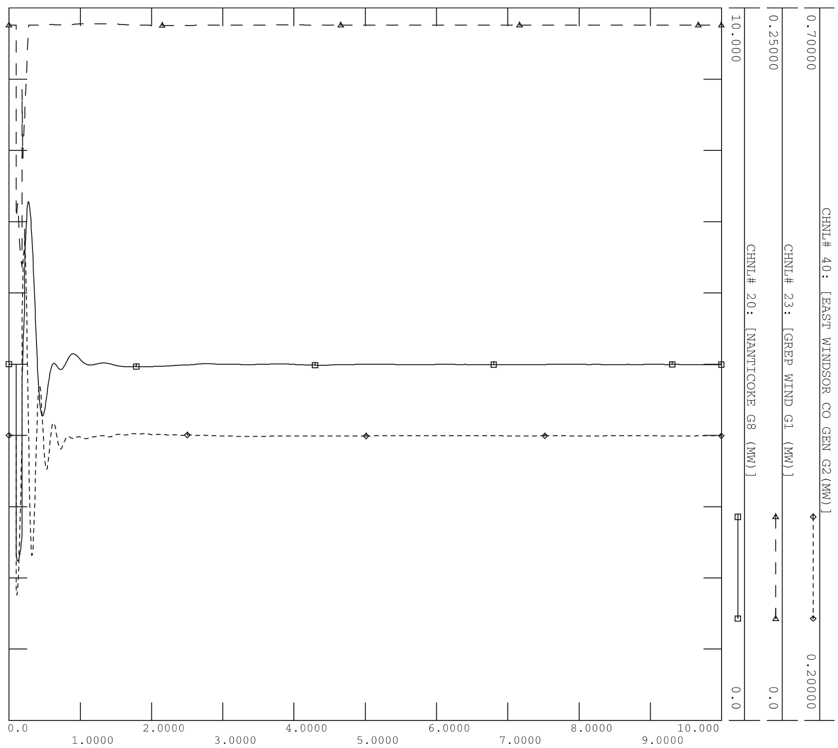


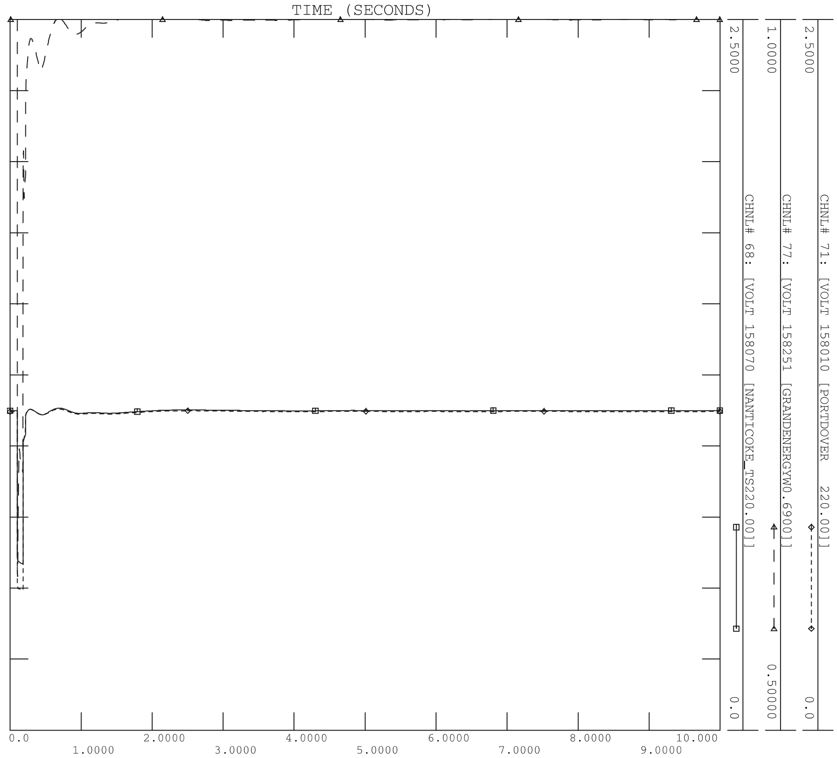
SC8: LLLG Fault on M27B/M28B at Middleport





SC9: LLLG Fault on Q23BM/Q25BM at Middleport





Appendix D Protection Impact Assessment

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

Protection Impact Assessment

Samsung Grand Renewable Energy Park

154 MW Wind + 100 MW Solar Project

Date: Mar 23, 2011
P&C Planning Group Project # PCT-116-PIA

Prepared by:

Hydro One Networks Inc.

Disclaimer

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

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

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

EXECUTIVE SUMMARY

It is feasible for Samsung Grand Renewable Energy Park to connect the proposed 154 MW and 100 MW generation to circuit N5M at the location as shown in Figure 1 as long as the proposed changes are made:

Proposals:

Connection
The winding configurations for both the wind generation and solar generation transformers must be changed to one of the following:

Leave the HV windings on both the wind generation and solar generation step-up transformers ungrounded; or
Connect both the wind generation and solar generation step-up transformers Delta on the HV side and Wye grounded on the LV side; or
Connect both the wind generation and solar generation step-up transformers Wye grounded on the HV side and Zig-Zag on the LV side.

Protection Scheme
The Protective relay scheme for circuit N5M will be required to be changed to a line differential scheme and changes to the reclosing scheme at Middleport TS will be also required.

Telecom Scheme
The new protection telecommunication scheme will be required.

Protection Settings
Protection Setting changes will be required.

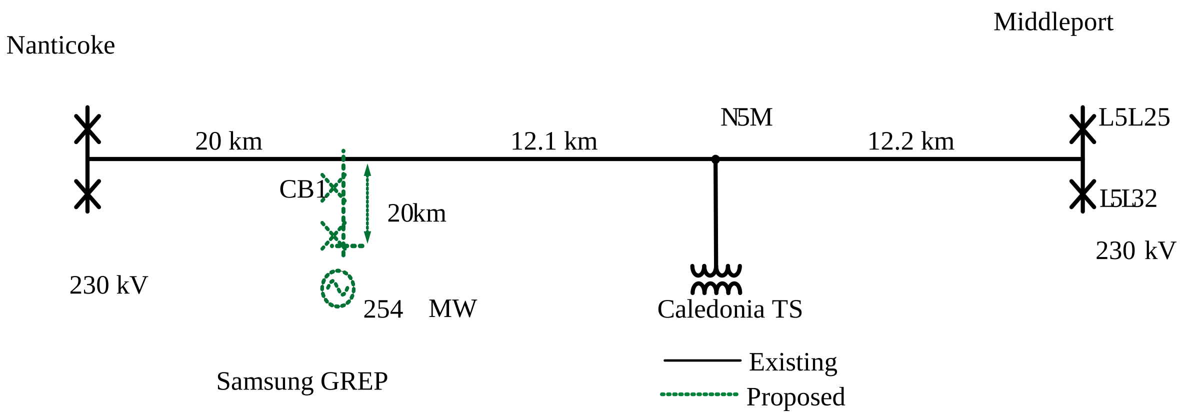


Figure 1: Samsung Grand Renewable Energy Park Connection to HONI Transmission System.

Protection and Relay Settings Changes

Current Reversal at Nanticoke TS

The fault study was conducted to determine the suitability of the connection of GREP facility to circuit N5M to ensure line protection viability.

To arrive at the maximum apparent impedance as seen at the Nanticoke bus, the equivalent bus impedance was maximized. The generation was removed at Nanticoke bus in the study to reflect future plans to mothball Nanticoke GS. Also, a contingency of an outage of one autotransformer at Nanticoke TS was incorporated. The step-up transformers and the generators were modeled as per data submitted by GREP.

The three phase fault at Middleport 230 kV bus resulted in the apparent impedance on circuit N5M at Nanticoke TS equal to two times the line impedance. The required relay setting of zone 2 to cover the line apparent impedance should be acceptable.

For the line to ground fault at Middleport 230 kV bus the Nanticoke terminal exhibits zero sequence current reversal and very high L-G apparent impedance in the reverse direction. For this condition only the line protection at Middleport TS will provide fault coverage. The proposed configuration of the step-up transformers (Yg-D-Yg) at the GREP facility is the main contributor to the current reversal at the Nanticoke bus. The generation reduction at GREP facility will not reduce the L-G apparent impedance at Nanticoke bus. This is due to the increase of the positive sequence current at Nanticoke bus and the vectorial relation between the positive and zero sequence currents.

To overcome the above relaying difficulties the following options are recommended for the configuration of the step-up transformers at GREP facility:

1) Leave the HV windings on both the wind generation and solar generation step-up transformers ungrounded.

2) Connect both the wind generation and solar generation step-up transformers Delta on the HV side and Wye grounded on the LV side.

3) Connect both the wind generation and solar generation step-up transformers Wye grounded on the HV side and Zig-Zag on the LV side.

In options 1 and 2 the ground source on the HV side of each step-up transformer is removed. As a result there is no current reversal at Nanticoke bus and the L-G apparent impedance is significantly reduced.

In option 3 the zero sequence path of the step-up transformer for the HV L-G faults is very large (1-2 pu). Therefore, the impact on current distribution at Nanticoke bus is minimal and there is no current reversal.

Modifications to the protections at Nanticoke TS

To avoid the zone 1 line protection at each terminal station to operate for faults on the GREP tap provision of the three-terminal line current differential protection for N5M circuit along with dual routing fiber optic cabling for communication to all line terminals including GREP would be necessary.

The existing DESN station Caledonia TS will be included in the line differential zone Nanticoke – Middleport– GREP Wind Farm SS. The pickup settings of the differential relay should be set to accommodate this load. To prevent operation of the differential protection for faults on the LV side at Caledonia station, the line differential protection should be supervised by the distance element. If this is not possible, blocking channels from Caledonia TS will have to be incorporated. In this case, the operation of line differential protection will be time delayed to allow for receipt of the blocking signal.

Modifications to the protections at Middleport TS and Caledonia TS

Line protection modifications similar to Nanticoke TS.

Reclosing of the breakers at Middleport TS should not be permitted until it has been established that the GREP station HV line breaker or both collector substation HV breakers have successfully opened. This can be implemented in one of two ways. A GEO signal can be sent from the GREP station to Middleport TS to interlock the reclosing circuit. This signal can be also broadcasted to Nanticoke and Caledonia stations. Alternatively, synchrocheck reclosing can be applied for the Middleport breakers, excluding the lead breaker that recloses on undervoltage and time. Synchrocheck autoreclosing should be also applied at Caledonia TS.

Telecommunications

Dual separate and independent fiber connections from the GREP wind farm to Nanticoke TS and Middleport TS will be required for the new line differential protection.

483 Bay Street
Toronto, Ontario
M5G 2P5

CUSTOMER IMPACT ASSESSMENT

GRAND RENEWABLE ENERGY PARK
254 MW WIND AND SOLAR GENERATION FACILITY
GENERATION CONNECTION
- FINAL -

Revision: Rev 0
Date: 6 May 2011

Issued by: Transmission System Development Division
Hydro One Networks Inc.

Prepared by:

Warren King
Transmission System Development
Hydro One Networks Inc.

Reviewed by:

John Sabiston
Manager, Transmission Planning
Transmission System Development
Hydro One Networks Inc.

Disclaimer

This Customer Impact Assessment was prepared based on information available about the connection of the proposed Grand Renewable Energy Park. It is intended to highlight significant impacts, if any, to affected transmission customers early in the project development process and thus allow an opportunity for these parties to bring forward any concerns that they may have. Subsequent changes to the required modifications or the implementation plan may affect the impacts of the proposed connection identified in Customer Impact Assessment. The results of this Customer Impact Assessment are also subject to change to accommodate the requirements of the IESO and other regulatory or municipal authority requirements.

Hydro One shall not be liable to any third party which uses the results of the Customer Impact Assessment under any circumstances whatsoever for any indirect or consequential damages, loss of profit or revenues, business interruption losses, loss of contract or loss of goodwill, special damages, punitive or exemplary damages, whether any of the said liability, loss or damages arises in contract, tort or otherwise. Any liability that Hydro One may have to Samsung Renewable Energy Inc. in respect of the Customer Impact Assessment is governed by the Agreement between Samsung Renewable Energy Inc. and Hydro One dated January 5, 2011.

CUSTOMER IMPACT ASSESSMENT

SAMSUNG RENEWABLE ENERGY INC. – GRAND RENEWABLE ENERGY PARK

254 MW WIND AND SOLAR GENERATION FACILITY

1 INTRODUCTION

Samsung Renewable Energy Inc. is to develop the 254MW Grand Renewable Energy Park ("GREP") in Haldimand County, Ontario. The facility consists of 154MW of wind generation and 100MW of solar generation.

The wind generation will include of 69 Siemens SWT-2.3VS, 60Hz, 2.3MW wind turbine generators (WTG); each WTG will be limited to 2.221MW. The solar generation will include 200, 500kW SC 500HE-US solar inverters. The generating station will connect to a new, customer owned 230kV transmission line approximately 20km long, which will then connect to Hydro One's transmission system on 230kV circuit N5M approximately 19.5km north of Nanticoke TS along Hydro One's right-of-way, near Regional Road 20 as shown in Figure 1.

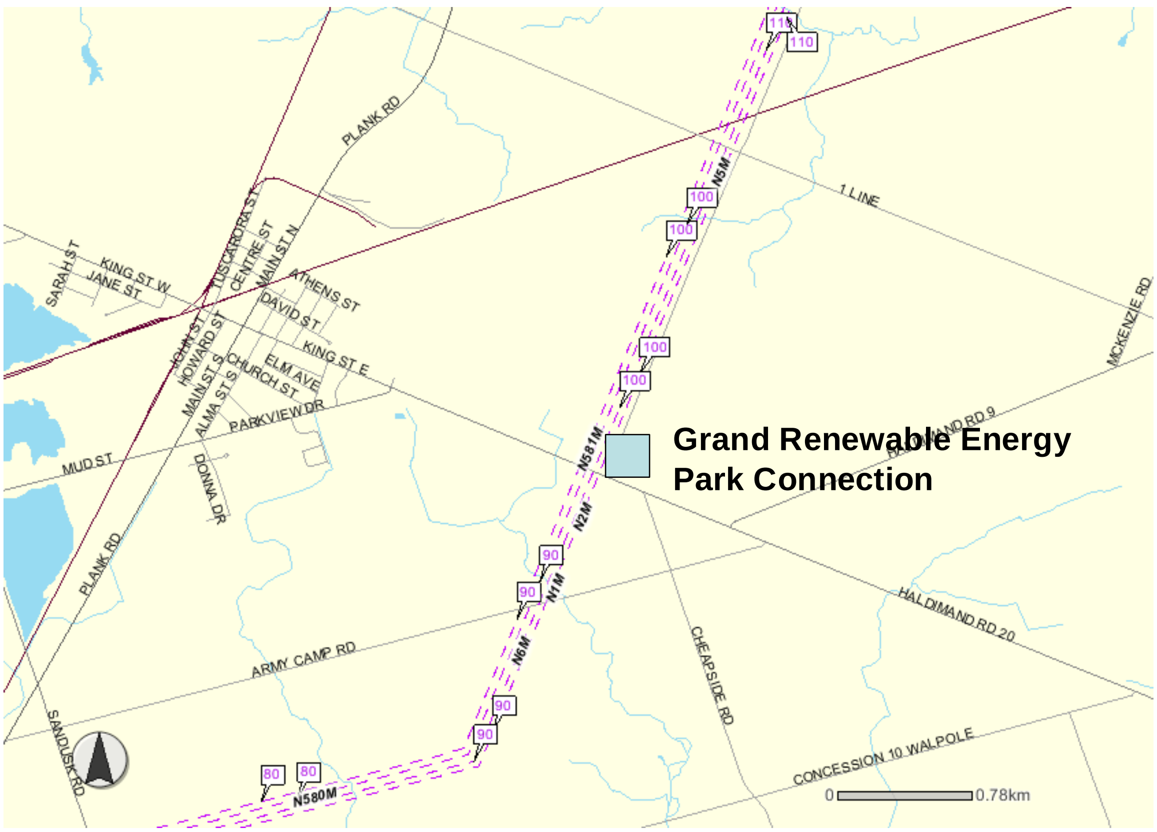


Figure 1: GREP connection to Hydro One's network

As part of the Connection Assessment and Approval (CAA) process, the IESO will carry out a System Impact Assessment (SIA) of the proposed wind generation connection.

A Draft version of this report was issued to potentially impacted customers on April 6, 2011 and all comments received were incorporated into this report.

Hydro One Networks Inc. (Hydro One) Customer Impact Assessment (CIA) assesses the impact of the proposed generation connection on existing customers in the affected area.

This study does not evaluate the overall impact of the Grand Renewable Energy Park on the bulk system. The impact of the new generator on the bulk system is the subject of the System Impact Assessment issued by the Independent Electricity System Operator (IESO).

The study does not evaluate the impact of the Grand Renewable Energy Park on the network Protection and Control facilities. Protection and Control aspects will be reviewed during the preparation of the Connection cost Estimate and will be reflected in the Connection and Cost Recovery Agreement.

1.1 Generating Station Connection

The GREP project proposes to connect to Hydro One circuit N5M. Circuit N5M connects Nanticoke TS and Middleport TS and supplies customer load at Caledonia TS, a 230/27.6kV transformer station. The study area is shown in Figure 2.

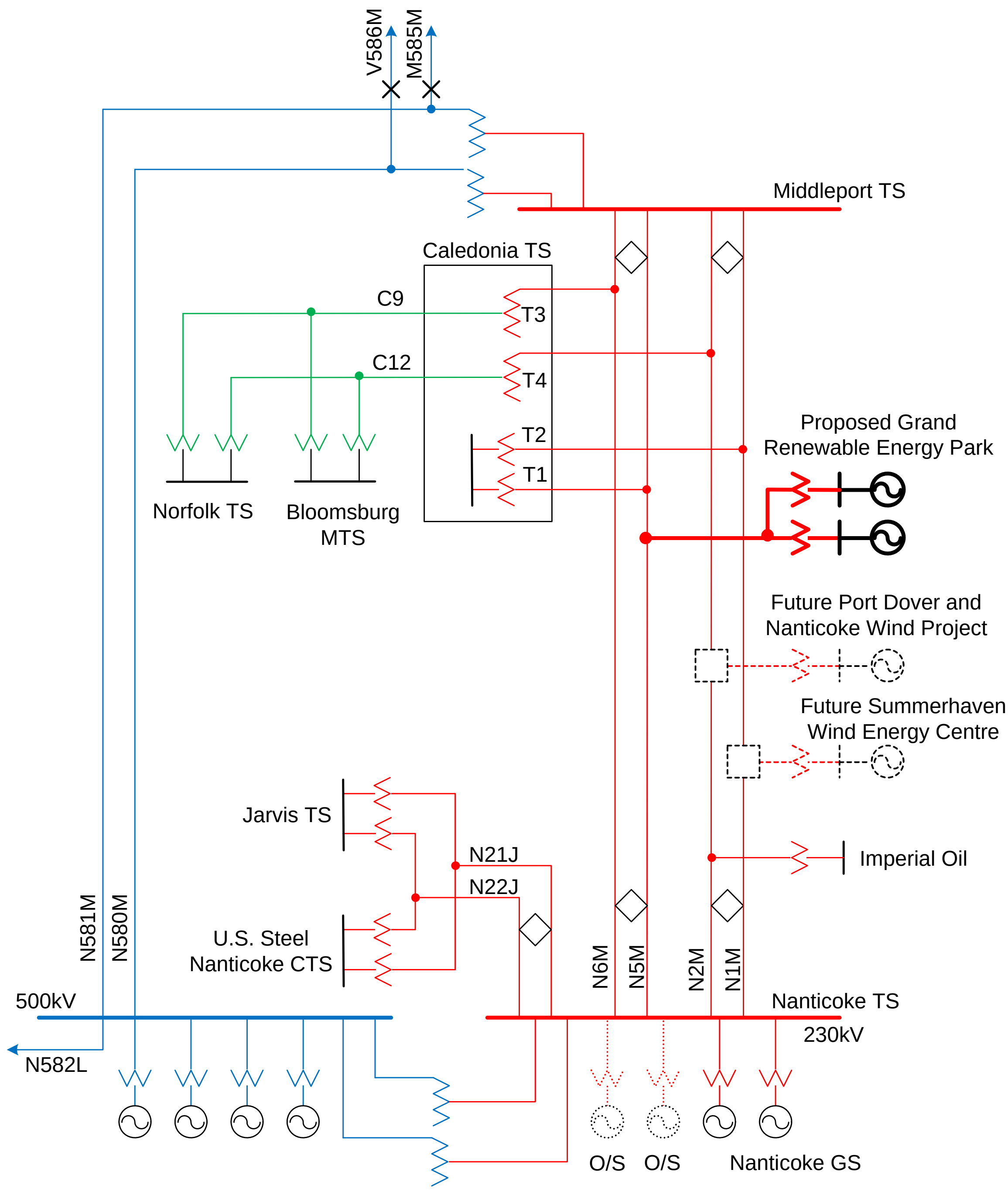


Figure 2: GREP CIA study area

The wind and solar generation facilities connect to the 230kV/34.5kV substation via two separate 34.5kV collector systems. Each collector system connects to 230kV via separate 230/34.5kV transformers as shown in Figure 3. The 69 WTGs connect to the customer's 230/34.5kV substation via six, 34.5kV feeders as shown in Table 1. The 200 solar inverters connect to the customer's 230/34.5kV substation via five, 34.5kV feeders as shown in Table 2.

Table 1: WTG Feeder Circuits

	1	2	3	4	5	6
Number of WTGs	11	11	13	11	12	11
Max. Generation per circuit (MW)	24.4	24.4	28.9	24.4	26.7	24.4

Table 2: Solar Feeder Circuits

Circuit	**1**	**2**	**3**	**4**	**5**
Number of Solar Inverters	40	40	40	40	40
Max. Generation per circuit (MW)	20	20	20	20	20

The IESO requires the installation of a dynamic reactive power device with a capability of -33/+48Mvar at the solar collector buses as well as a static reactive power device of +50Mvar at the wind collector buses. The static reactive compensation is to be shared between at least five switchable shunt capacitors[1].

Each Siemens SWT-2.3 WTG is rated at 2.556MVA, +/- 0.9 power factor but limited to 2.221MW output. Each SC 500HE-US solar inverter operates at unity power factor when operating at full (500kW) output.

The 20km customer transmission line will connect the GREP 230/34.5kV collector substation to Hydro One's N5M circuit. The customer's connection line will be approximately 19.3km of overhead line, and 0.7km of underground cable, with breakers as shown in Figure 3

[1] IESO Grand Renewable Energy Park Project System Impact Assessment, CAA ID 2010-399

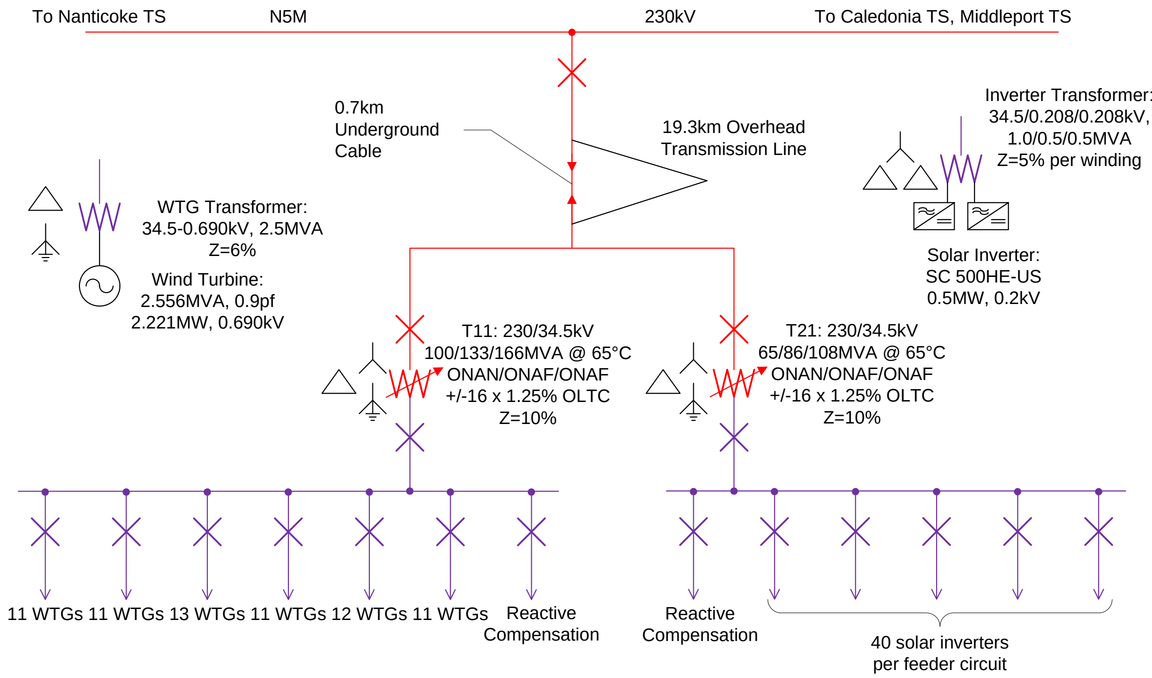


Figure 3: GREP connection to N5M

1.2 Study Scope

The CIA Study is a requirement of the Ontario Energy Board (OEB) to assess the potential impacts of the proposed GREP Project on the existing transmission connected customer(s). The following areas are reviewed:

- Supply capacity/reliability
- Voltage and thermal performance
- Short circuit analysis
- Preliminary outage impact assessment

1.3 Customer Connections

The focus of this study was on customers supplied by stations directly connected to circuit N5M and other 230kV circuits originating from Nanticoke TS, as well as the Caledonia 115kV system (circuits C9 and C12). Affected customers are shown in Table 3.

Table 3: Transmission Customers connected in the study area

Station	Customer
Imperial Oil Nanticoke CGS	Imperial Oil Limited - Nanticoke
U.S. Steel Canada - Nanticoke CTS	U.S. Steel Canada Inc.
Jarvis TS	Haldimand County Hydro Inc. Hydro One Networks Inc.
Nanticoke GS	Ontario Power Generation Inc. [Nanticoke GS]
Caledonia TS	Haldimand County Hydro Inc. Hydro One Networks Inc.
Bloomsburg MTS	Norfolk Power Distribution Inc.
Norfolk TS	Norfolk Power Distribution Inc. Hydro One Networks Inc.

2 METHODOLOGY AND CRITERIA

2.1 Planning Criteria

The IESO's Ontario Resource and Transmission Assessment Criteria (ORTAC) forms the basis for the planning criteria used in this CIA.

2.1.1 Voltage Change Limits

With all planned facilities in service pre-contingency, system voltage changes in the period immediately following a contingency shall not result in a voltage decline greater than 10% for pre-transformer tap-changer action (including station loads less than 50kV) and 10% post-transformer tap-changer action (5% for station loads less than 50kV). In addition, the steady state voltage at station loads less than 50kV are to remain within 6% of the nominal voltage.

2.1.2 Short Circuit Limitations

Appendix 2 of the transmission system code (TSC) specifies the maximum symmetrical three phase and single line to ground short circuit levels. These limits are summarized in Table 4.

Table 4: Transmission System Code Short Circuit Limits

Nominal Voltage (kV)	Max. 3 Phase Fault (kA)	Max. SLG Fault (kA)
230	63	80(1)
115	50	50
27.6 (4-wire)	17(2)	12(2)
13.8	21(2)	10(2)

Notes:

(1) Usually limited to 63kA

(2) Effective September 1, 2010, Hydro One requires a 5% margin on the acceptable TSC limits at voltage levels of <50kV to account for other sources of fault current on the distribution system such as unmodeled synchronous motors and data inaccuracies.

2.2 Study Assumptions

Summer 2010 peak loading conditions were assumed in this study.

Hydro One is aware of the following additional two transmission connected renewable generation projects that intend to connect in the study area:

- Summerhaven Wind Energy Centre (connection to circuit N1M) – 124MW
- Port Dover and Nanticoke Wind Project (connection to circuit N2M) – 105MW

The results of this CIA include the impact of these other two generation projects.

Nanticoke GS has historically operated with up to 8 units in-service. Two of these units were closed on September 30, 2010. The following future bulk system conditions were assumed in this study:

- Nanticoke GS: 2 units in-service at 240kV, 4 units in-service at 500kV
- Nanticoke TS: 350Mvar SVC at the 500kV bus
- New Bruce to Milton 500kV double circuit transmission line in-service

3 STUDY RESULTS

The proposed GREP Project is not expected to adversely impact the transmission connected customers in the area. The findings of this CIA are summarized below.

3.1 Supply Capacity/Reliability

The proposed point of connection on circuit N5M has enough capacity to incorporate the plant's full capacity.

The proposed point of connection will not adversely affect supply reliability to customers connected to this line.

3.2 Voltage and Thermal Performance

The thermal and voltage study considered the impact of the GREP interconnection on the local transmission system. The study included the following contingencies:

- Loss of GREP
- N1M north and south of Summerhaven Connection
- N2M north and south of the Port Dover and Nanticoke Wind Project Connection
- Double circuit loss of N1M and N2M for circuit sections on a common tower
- N5M, N6M, N5M and N6M
- N21J, N22J, N21J and N22J
- N580M, N581M
- N582L
- Loss of Nanticoke TS 500/230kV autotransformer

The analysis reviewed the effect of contingencies both before and after tap changer action. Both Norfolk TS and Bloomsburg MTS are supplied by the Caledonia 115kV circuits C9 and C12. The loads at these two stations were assumed to be voltage dependent in the before tap changer analysis; constant power loads were assumed in all other cases.

In all of the contingencies studied, the post-contingency voltage changes in the affected area met the criteria outlined in Section 2.1.1. Detailed results are shown in Appendix A. None of the above contingencies resulted in thermal overloads on the affected circuits.

3.3 Short Circuit Analysis

The short circuit analysis reviews the short circuit levels at customer buses with GREP in-service. The incremental short circuit contribution from GREP on customer buses is summarized in Appendix B. All customers are required to check to ensure that the equipment and grounding system at their stations meet the expected increase in fault level.

3.3.1 Impact at Stations Previously Mitigated for Fault Level

Where, Customer Impact Assessment studies conducted for projects that have either previously connected or plan to connect prior to the connection date planned for this project have identified stations at less than 50 kV where the fault level is within 5% of the values in Appendix 2 of the Transmission System Code (TSC); Hydro one requires connecting proponents who elevate fault levels within the 5% margin to contribute to the cost of installing mitigating measures to reduce the fault level below 95% of the TSC limit. Hydro One applies a 5% margin to maximum short circuit levels in the TSC to manage uncertainties in the calculation of expected short circuit levels. The TSC requires that any customer that benefits from such an installation that connects within five calendar years of the in-service date of the mitigation measure also contribute towards the cost of the measure, and that any such payments be refunded to the original contributing customer(s). This Section of this CIA report is to report on the impact that this project has at those previously mitigated stations to see if this project is required to financially contribute to the cost for any of those measures.

Table 5: GREP impact on 3 phase fault levels at stations previously mitigated for fault levels

Station	3ph Sym. Fault level without GREP* (kA)	3ph Sym. Fault level with GREP (kA)	Difference
Windsor Walker TS #1	17.57	17.57	0.00
Martindale Z	14.91	14.91	0.00
Caledonia TS	**16.51**	**16.53**	**0.02**
Kingsville TS	16.90	16.90	0.00

* Includes future generation projects expected to be in-service prior to GREP

Table 6: GREP impact on single line to ground (SLG) fault levels at stations previously mitigated for fault levels

Station	SLG Sym. Fault level without GREP* (kA)	SLG Sym. Fault level with GREP (kA)	Difference
Windsor Walker TS #1	3.50	3.50	0.00
Martindale Z	19.78	19.78	0.00
Caledonia TS	9.91	9.91	0.00
Kingsville TS	11.91	11.91	0.00

* Includes future generation projects expected to be in-service prior to GREP

The results of the fault level studies in the tables above show that the GREP Project has a measureable (>= 0.01kA) impact at the fault level at Caledonia TS and hence has to make a contribution towards the cost of the mitigation measures installed for this problem.

3.4 Preliminary Outage Impact Assessment

The work required to connect GREP to circuit N5M will involve outages to this circuit and these outages will be coordinated with existing transmission customers. With appropriate construction and outage planning, it is expected that the connection of GREP can be performed with minimal supply impact to the existing transmission customers.

4 CONCLUSIONS AND RECOMMENDATIONS

This CIA study has reviewed the impact of the GREP Project on the existing transmission customers in the vicinity of the proposed connection. The results show that this project does not adversely affect existing customers in the area. The short circuit results show that the GREP Project is required to make a contribution towards the cost of short circuit mitigation measures required at Caledonia TS because it elevates fault levels within the 5% margin.

All customers are required to check to ensure that the equipment and grounding system at their stations meet the expected increase in fault level.

APPENDIX A

Voltage Study Results

Voltage change was modeled both before and after under load tap changer action was reviewed. The Summerhaven, Port Dover and Nanticoke Wind and Grand Renewable Energy Park Projects were assumed in-service. The following contingencies were studied:

- Loss of GREP
- N1M North and South of Summerhaven connection
- N2M North and South of Port Dover and Nanticoke Wind connection
- N1M North and N2M North
- N1M North and N2M South
- N1M South and N2M South
- N5M, N6M, N5M and N6M
- N21J, N22J, N21J and N22J
- N580M, N581M
- N582L
- Loss of Nanticoke TS 500/230kV autotransformer

Buses where the voltage change was greater than 2% are shown in the following tables.

Contingency N1M North of Summerhaven Connection

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Caledonia TS (27.6kV)	232.5	225.1	-3.2%	230.8	-0.8%

Contingency N2M North of Port Dover Nanticoke Wind Connection

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Caledonia C9 (115kV)	123.8	120.7	-2.5%	119.5	-3.5%
Bloomsburg MTS (27.6kV)	27.8	25.2	-9.5%	28.2	1.1%
Norfolk TS (27.6kV)	28.7	26.4	-8.0%	28.8	0.5%

Contingency N1M North of Summerhaven, N2M North of Port Dover Nanticoke Wind

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Caledonia C9 (115kV)	123.8	120.2	-2.9%	119.5	-3.4%
Bloomsburg MTS (27.6kV)	27.8	25.1	-9.9%	28.1	1.1%
Caledonia TS (27.6kV)	29.2	28.1	-3.7%	29.3	0.5%
Norfolk TS (27.6kV)	28.7	26.2	-8.4%	28.8	0.4%

Contingency N1M North of Summerhaven, N2M South of Port Dover Nanticoke Wind

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Caledonia TS (27.6kV)	29.2	28.2	-3.4%	29.3	0.3%

Contingency N6M

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Caledonia C12 (115kV)	123.9	120.6	-2.7%	119.3	-3.7%
Bloomsburg MTS (27.6kV)	27.8	25.1	-9.7%	28.0	0.5%
Norfolk TS (27.6kV)	28.7	26.1	-9.1%	28.7	0.1%

Contingency N5M

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Caledonia TS (27.6kV)	29.2	28.2	-3.4%	29.3	0.3%

Contingency N5M, N6M

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Caledonia C12 (115kV)	124.0	120.2	-3.0%	119.3	-3.7%
Bloomsburg MTS (27.6kV)	28.2	25.4	-9.9%	28.4	0.8%
Caledonia TS (27.6k)	29.2	28.1	-3.8%	29.2	0.2%
Norfolk TS (27.6kV)	28.6	26.0	-9.3%	28.7	0.1%

Contingency N21J

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Jarvis TS (27.6kV)	29.0	28.2	-2.6%	29.3	1.0%
US Steel A1A2 (13.8kV)	14.5	14.1	-2.5%	14.5	-0.4%
US Steel B1B2 (13.8kV)	14.5	14.1	-2.5%	14.5	-0.4%

Contingency N22J

Bus	Initial Voltage (kV)	Before ULTC (kV)	Change	After ULTC (kV)	Change
Jarvis TS (27.6kV)	29.0	28.3	-2.4%	29.0	-0.1%
US Steel A1A2 (13.8kV)	14.5	14.2	-2.5%	14.5	-0.4%
US Steel B1B2 (13.8kV)	14.5	14.2	-2.5%	14.5	-0.4%

APPENDIX B

Short Circuit Analysis

			Before GREP (4) (kA)				After GREP (kA)				Incremental (kA)				Limiting Breaker Rating (kA)	
			3 Phase		L-G		3 Phase		L-G		3-Phase		L-G			
Bus #	Bus Name	Max kV	Sym	Asym	Sym	Asym	Sym	Asym	Sym	Asym	Sym	Asym	Sym	Asym	Sym	Asym
5954	Bloomsburg JQ	29.0	6.765	7.511	5.656	6.887	6.766	7.512	5.656	6.888	0.001	0.001	0.000	0.001	(2)	(2)
5415	Bloomsburg T2	127.1	3.238	3.453	1.966	2.033	3.239	3.454	1.967	2.033	0.001	0.001	0.001	0.000	-	-
5411	Bloomsburg T1	127.0	3.239	3.454	1.962	2.028	3.240	3.455	1.962	2.028	0.001	0.001	0.000	0.000	-	-
5968	Caledonia BY	29.0	16.514	21.641	9.908	13.927	16.532	21.673	9.912	13.935	0.018	0.032	0.004	0.008	22.00	23.10
6271	Imperial Oil Nanticoke	29.0	13.128	17.705	1.280	1.460	13.131	17.708	1.280	1.460	0.003	0.003	0.000	0.000	(2)	(2)
5145	Imperial Oil Nanticoke	250.0	29.561	37.712	26.079	31.783	29.790	37.974	26.198	31.905	0.229	0.262	0.119	0.122	-	-
6083	Jarvis BY(1)	29.0	14.346	18.294	9.170	12.686	14.349	18.299	9.171	12.688	0.003	0.005	0.001	0.002	22.00	23.10
5105	Nanticoke	250.0	41.883	59.462	41.869	62.010	42.386	60.171	42.203	62.506	0.503	0.709	0.334	0.496	(2)	(2)
5003	Nanticoke	550.0	30.904	42.977	33.138	47.973	31.037	43.179	33.240	48.137	0.133	0.202	0.102	0.164	(2)	(2)
6164	Norfolk BY	29.0	8.566	8.566	7.826	8.529	8.568	8.568	7.827	8.530	0.002	0.002	0.001	0.001	9.60	9.95
6230	US Steel A	14.2	19.695	26.173	0.752	0.752	19.702	26.183	0.752	0.752	0.007	0.010	0.000	0.000	(2)	(2)
6231	US Steel B	14.2	19.695	26.173	0.752	0.752	19.702	26.183	0.752	0.752	0.007	0.010	0.000	0.000	(2)	(2)
5279	US Steel D1	250.0	22.491	28.904	18.735	22.401	22.635	29.071	18.802	22.468	0.144	0.167	0.067	0.067	-	-
5280	US Steel D2	250.0	22.491	28.904	18.765	22.429	22.635	29.071	18.832	22.497	0.144	0.167	0.067	0.068	-	-

Notes:

(1) Includes current limiting reactors being installed at Jarvis TS

(2) Customer to check and verify breaker rating

(3) Contact parting times used are as follows: 230kV and higher buses: 25ms, Norfolk BY 27.6kV: 50ms, all other buses: 33ms

(4) Includes future generation projects expected to be in-service prior to GREP