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CONNECTION ASSESSMENT & APPROVAL PROCESS

PRELIMINARY ASSESSMENT REPORT

For the Proposed 200MW Essex Wind Park Project

by Superior Wind Energy Inc.

CAA ID No. 2002-078

Consistent Information Set Department, and
Long Term Forecasts & Assessments Department

FINAL Version

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Preliminary Assessment Report

For the Proposed 200MW Essex Wind Park Project

Acknowledgement

The IMO wishes to acknowledge the assistance of Hydro One in completing some of the studies for this assessment.

Disclaimers

IMO

This report has been prepared solely for the purpose of assessing whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the integrated power system and whether the IMO 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 IMO by the connection applicant and the transmitter(s) at the time the assessment was carried out. The IMO 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 IMO. 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 IMO-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 IMO in accordance with Chapter 4, Section 6 of the Market Rules. The IMO assumes no responsibility to any third party for any use, which it makes of this report. Any liability that the IMO may have to the connection applicant in respect of this report is governed by Chapter 1, Section 13 of the Market Rules. The IMO reserves the right to revise this report at any time, at its sole discretion, without notice to the connection applicant. Although the IMO will use its best efforts to advise the connection applicant of such changes, it is the responsibility of the connection applicant to ensure that the most recent version of this report is being used.

Hydro One

Special Notes and Limitations of Study Results

The results reported in this preliminary assessment are based on the information available to Hydro One, at the time of the study, suitable for a preliminary assessment of a new generation or load connection proposal.

The ampacity ratings of Hydro One facilities are established based on assumptions used in Hydro One for power system planning studies. The actual ampacity ratings during operations may be determined in real-time and are based on actual system conditions, including ambient temperature, wind speed and facility loading, and may be higher or lower than those stated in this study.

The additional facilities or upgrades, which are required to incorporate the proposed connection, have been identified to the extent permitted by a preliminary assessment. Additional facility studies may be necessary to confirm constructability and the time required for construction. System impact or further studies at more advanced stages of the project development may identify additional facilities that need to be provided or that require upgrading.

Executive Summary

This preliminary assessment has been conducted to examine the proposed 200 MW wind generation facility in Essex County, near the Town of Kingsville, and its impact on the reliability of the IMO-controlled grid. It has been concluded that, subject to implementation of the IMO's requirements, the proposal would not have any adverse impact on the IMO-controlled grid and that a separate System Impact Assessment would not be necessary.

Project Description

Superior Wind Energy Inc. is the proponent of the 200 MW wind park project in Essex County. The proposed facility is to be incorporated at 115 kV via a new line tap (5 to 10 km) connected to the existing Woodslee Junction to Kingsville TS line tap of the Hydro One Networks Inc. transmission circuit K2Z between Lauzon TS and Kent TS.

The proponent is presently evaluating vendors and various models of wind turbine generators, and has requested the IMO to conduct the connection assessment using typical wind turbine generator data in the 1.5 MW - 2 MW range. Superior Wind Energy Inc. fully understands that before connection to the IMO-controlled grid can be made, the wind turbine generators and the associated connection facilities shall meet all applicable Market Rules requirements and their performance and characteristics shall be equivalent to or better than those assumed by the IMO using typical data.

Commissioning of the project is scheduled to commence in Q2-2004, with full commercial operation starting in Q3-2004.

Conclusions

Based on the results of this assessment, it is concluded that:

1. The proposed 200 MW Essex Wind Park with a single tap incorporation arrangement would result in overloading of the transformers at Kingsville TS, a Hydro One Networks Inc. facility in the Municipality of Leamington.

2. With a single tap incorporation arrangement, post contingency voltage declines at Kingsville TS could exceed the acceptable limit.

3. If the proposed 200 MW Essex Wind Park is connected to both K2Z and K6Z via two line taps, it will not have any adverse impact on the transfer capabilities and reliability of the IMO-controlled grid.

4. The increases in fault level, due to the proposed 200 MW generation, will not exceed the interrupting capabilities of the existing breakers.

IMO Requirements for Connection

1. A two-tap incorporating arrangement connecting the 200 MW wind generation facility to circuits K2Z and K6Z is required. Alternatively, with a single tap connection to K2Z, Superior Wind Energy Inc. has to reduce the maximum capacity of the wind generation facility to 60 MW to respect the thermal ratings of the Kingsville TS transformers.

2. The connectivity based load rejection scheme at Lauzon TS shall be modified to include rejection of the Essex Wind Park and to include all outage conditions that will result in the loss of 230kV to 115kV connection at Lauzon TS.

3. Upon its decision to select a specific model of wind turbine generator for the Essex Wind Park, Superior Wind Energy Inc. is required to:
   - ❖ Provide evidence and documentation to demonstrate that the proposed wind turbine generators are in compliance with the Market Rules requirements as stated in Chapter 4 Appendix 4.2, including ride through capabilities during system disturbances.
   - ❖ Provide the modeling suitable for use in load flow and transient stability studies in PTI - PSS/E format and evidence to support the modeling of the proposed wind turbine generators. It is preferred that the evidence be based on recorded dynamic responses of similar wind turbine generators, including terminal voltages, active and reactive power injections into the grid, obtained during commissioning tests or from existing installations which had experienced system disturbances.
   - ❖ Provide adequate reactive power to compensate for the reactive power consumption on the 34.5-115 kV step-up transformer and the dedicated transmission lines. This can be achieved with combinations of low impedance 34.5-115 kV step-up transformer and provision of reactive power, whichever combination is more economic and subject to approval of the IMO.
   - ❖ If the selected wind turbine generators are equipped with ac-dc-ac voltage source converters or equivalent equipment, engage the service of an expert consultant with experience in modeling the dynamic behavior of that model of wind turbine generators and power systems to assess the potential adverse interactions (e.g. sub-synchronous resonance) with the IMO-controlled grid and its existing generators. The results are subject to IMO's review and acceptance. If any adverse interaction is identified, the applicant is responsible for providing appropriate mitigation measures subject to IMO's approval.
   - ❖ If the selected wind turbine generators are not equipped with ac-dc-ac voltage source converters or equivalent equipment, provide an expert statement from the wind turbine generator manufacturer indicating the dynamic behavior of the units is no different than that of a conventional induction generator.

4. Superior Wind Energy Inc. must complete the IMO facility registration process including meter registration before placing the proposed 200 MW Essex Wind Park generation in service.

5. Hydro One Networks Inc. has indicated that a Customer Impact Assessment (CIA) will be required to determine the impact of new generation connection on other transmission customers and a detailed CIA study will be carried out by Hydro One Networks Inc.

Budgetary Cost Estimates

Apart from the connection of the new 115kV lines onto circuits K2Z and K6Z, and the modification of the special protection scheme at Lauzon TS, there is only minor work associated with review and verification of protection schemes and final equipment data, and witness verification during commissioning. No budgetary cost estimate is provided for this work.

Identification of "Sole Beneficiary"

No facility that is triggered by, and deemed to be for the sole benefit of this project has been identified.

Notification of Approval

This Preliminary Assessment has investigated the impact of the proposed 200 MW Essex Wind Park on the reliability of the IMO-controlled grid and has identified the requirements for connection to ensure that the project has no adverse impact on the reliability of the IMO-controlled grid.

It is therefore recommended that a Notification of Approval be granted, subject to the completion of a Customer Impact Assessment and the implementation of the requirements for connection stipulated in this report.

1. Proposal Description

Superior Wind Energy Inc. is the proponent of a wind park project in the Essex County, near the Town of Kingsville. The proposed generation facility, Essex Wind Park, will have a maximum capacity of about 200 MW and depending on the make of wind turbine generators finally chosen, will consist of about 110 to 133 wind turbine generators. The proposed facility is to be incorporated at 115 kV via a new 5 to 10 km long single circuit transmission line connecting to the Woodslee Junction to Kingsville TS tap from the Hydro One Networks Inc. transmission circuit K2Z between Lauzon TS and Kent TS. The connection point to the IMO-controlled grid is about 10 km from Kingsville TS. Figure 1 shows the existing transmission facilities in the area and the proposed facility.

Commissioning of the project is scheduled to commence in Q2-2004, with full commercial operation starting in Q3-2004.

2. Data Verification

Superior Wind Energy Inc. is considering wind turbine generators in the range of 1.5 MW to 2 MW per unit for the Essex Wind Park.

The proponent is evaluating vendors and various models of wind turbine generator, and has requested the IMO to conduct the Preliminary Assessment using typical wind turbine generator data in the 1.5 MW - 2 MW range. Superior Wind Energy Inc. understands that before connection to the IMO-controlled grid can be made, the wind turbine generators and the associated connection facilities shall meet all applicable Market Rules requirements and their performance and characteristics shall be equivalent to or better than those typical data assumed by the IMO.

2.1 Connection Arrangement

The proposed 200 MW wind park project, based on the use of 1.5 MW units, will comprise 21 groups of 6 x 1.5 MW wind turbines and 1 group of 7 x 1.5 MW wind turbines. Each of the 22 wind turbine groups will be connected via a 34.5 kV breaker to a common 34.5 kV bus. The 34.5 kV bus will be connected via a 34.5-115 kV step-up transformer bank, a 115 kV breaker, 5 to 10 km of 115 kV line tap and a high voltage isolating device onto the Woodslee Junction to Kingsville TS tap of the 115kV circuit K2Z between Lauzon TS and Kent TS. Figure 2 shows the proposed connection arrangement at the Essex Wind Park.

The unit size and grouping will be adjusted accordingly to accommodate other unit sizes.

The Transmission System Code (the Code) under the jurisdiction of the Ontario Energy Board establishes the minimum standards for all equipment connected to the transmission system. The Code and the connection agreement that will be executed between the proponent and the transmitter, Hydro One Networks Inc. set out the requirements, standards, terms and conditions of the proponent's obligation to connect to and remain connected to the transmission system.

The design of the station facilities and the connection arrangement are governed by the Code. This Preliminary Assessment does not evaluate this aspect of the proposal. Superior Wind Energy Inc. is advised to seek approval from Hydro One Networks Inc. regarding the design of the station facilities at the Essex Wind Park.

2.2 Generating Facility Requirements

Market Rules Chapter 4 Appendix 4.2 contains the generating facility requirements for connection to the IMO-controlled grid.

Superior Wind Energy Inc. has not decided on the choice of wind turbine generator and has requested the IMO to evaluate its application based on typical wind turbine generator data.

Superior Wind Energy Inc. shall, upon its final selection of wind turbine generators for the Essex Wind Park project, provide evidence that the generating facility at Essex Wind Park is in compliance with the Marlet Rules requirements. The wind turbine generators and the associated equipment must be capable of remaining in service for system disturbances or contingencies that do not involve the transmission circuit or circuits onto which Essex Wind Park is incorporated.

3. Impact on the IMO-Controlled Grid

This Preliminary Assessment has investigated the impact of the proposed new 200 MW EssexWind Park on the IMO-controlled grid and is based on information included in the connection assessment application. Results presented in this report are only valid for the data provided by the connection applicant. If subsequent equipment testing indicates that the specifications for new facilities are significantly different from the values provided, then additional studies might be required to re-assess the impact on the IMO-controlled grid.

3.1 Impact on Transfer Capabilities of Major Transmission Interfaces

Essex Wind Park will be located near Windsor, one of the interconnection points with a utility in the State of Michigan across the Ontario-Michigan Interconnection interface. The proposed wind generation facility could potentially impact on the Ontario-Michigan Interconnection interface and other major transmission interfaces within the IMO-controlled area. Figure 3 shows the major transmission interfaces in the Sarnia-London-Windsor area that could potentially be affected by Essex Wind Park.

Four generation developments totaling 2300 MVA in Sarnia and three developments totaling 1400 MVA in Essex County have been approved for connection by the IMO. System Impact Assessments of this cluster of generation developments have concluded that these developments would not materially change the transfer capabilities of the Ontario-Michigan Interconnection interface and major IMO-controlled grid interfaces in the Sarnia-London-Windsor area. Furthermore, the System Impact Assessments demonstrated developments in the Windsor area would have no adverse impact on these major transmission interfaces.

At present, two of the four approved developments (692 MVA) in Sarnia are in-service, while one of the three developments (680 MVA) in Essex County is under construction and will be in-service in 2004. The remaining approved generation developments are dormant.

The addition of Essex Wind Park in 2004 is therefore not expected to materially change the transfer capabilities of major IMO-controlled grid interfaces.

The System Impact Assessments of generation developments in the Sarnia and Windsor areas have also stressed the fact that with the concentration of new generation developments in these two area, generation constraints because of major interfaces transfer limits could occur.

Given the nature of wind generation, the output of Essex Wind Park would be very unpredictable and can vary significantly over time. Essex Wind Park falls under the category of self-scheduling generation and would not incur any congestion management cost. Nevertheless the addition of the 200 MW wind generation facility in Essex County would aggravate the Sarnia and Windsor areas generation constrain problem that has been identified in previous System Impact Assessments.

3.2 Impact on Special Protection Schemes in Windsor Area

Special protection schemes, including overload protection and load rejection, are available in the Windsor area to protect the transmission system against overloading of elements and excessive voltage declines under pre and post contingency conditions.

Of the three components of the Windsor area special protection scheme, the proposed Essex Wind Park will have a direct impact on the load rejection (L/R) scheme at Lauzon TS.

The L/R scheme at Lauzon TS, a connectivity based scheme, under certain contingency conditions that result in the loss of the 230kV to 115kV connection at Lauzon TS, will trip both K2Z and K6Z resulting in the rejections of loads supplied from stations connected to these two circuits.

With the addition of Essex Wind Park onto the radial circuits K2Z and K6Z, the operation of the L/R scheme will result in an operating island comprising Essex Wind Park and stations connected to circuits K2Z and K6Z. Furthermore, the present L/R scheme at Lauzon TS does not cover all possible outage conditions that result in the loss of the 230kV to 115kV connection at Lauzon TS. In order to avoid the unacceptable islanding operation, a generation rejection of Essex Wind Park must be included in the L/R scheme at Lauzon TS and the scheme will have to be extended to include all outage conditions that result in the loss of 230kV to 115kV connection.

3.3 Impact on Local 115 kV System

Essex Wind Park is to be incorporated onto the IMO-controlled grid via the radial circuit K2Z from Lauzon TS. Presently, K2Z supplies Kingsville TS, Tilbury TS, and Tilbury West DS. A Hydro One Networks Inc. new distribution station, Belle River East DS, will be connected to K6Z at Belle River Junction in 2004.

The combined forecast 2004 summer peak load at Kingsville TS, Tilbury TS, Tilbury West DS, and the new Belle River East DS (in-service 2004) is approximately 175 MW. During peak load periods, most of the output from Essex Wind Park would be supplying the load at Kingsville TS with the remaining output supplying Belle River East DS, Tilbury TS, and Tilbury West DS. During off-peak periods, any surplus generation from Essex Wind Park in excess of the combined load of the four stations in the area would supply loads in the Windsor area.

Essex Wind Park would be expected to reduce the loading on the 230/115 kV autotransformers at Lauzon TS and on local 115 kV transmission circuits, and to provide voltage improvements in the local 115 kV System.

Load flow studies have been carried out to assess the impact of Essex Wind Park on the local 115 kV system in the area of:

- Thermal loading of the local 115 kV transmission circuits under normal and contingency conditions
- Voltage performance of the local 115 kV system under normal and contingency conditions including the loss of the 200 MW Essex Wind Park

3.3.1 Assumptions

The forecast 2004 summer peak load conditions form the basis of the assessment. All generation resources in the Windsor area, including the approved generation facilities that are under development and will be in-service in 2004, are operating at their respective maximum output level. All transmission facilities in the Windsor area are in service pre-contingency.

Available capacitor banks in the area are in-service to maintain acceptable voltage levels.

The phase shifter on the J5D interconnection with Michigan at Windsor was set to regulate a transfer of either 300 MW to Michigan or 300 MW into Ontario to simulate export or import conditions.

The results from the following studies have been summarized in Tables 2 and 3.

Import Conditions

LF-I1 represents the system before the incorporation of the Essex Wind Park. It serves as the baseline to assess the impact of this proposal on the IMO-controlled grid.

LF-I2 represents the system after the incorporation of the Essex Wind Park.

Export Conditions

LF-E1 represents the system before the incorporation of the Essex Wind Park. It serves as the baseline to assess the impact of this proposal on the IMO-controlled grid.

LF-E2 represents the system after the incorporation of the Essex Wind Park.

3.3.2 Impact on Thermal Loading of Local 115 kV Transmission Circuits

The IMO normally uses transmission line thermal ratings based on ambient conditions of 30°C and 4 km/h wind to assess the impact of new development on thermal loading of transmission lines. However, wind turbine generators cannot achieve maximum output at wind speed lower than 15 m/s (54 km/h). Hydro One Networks Inc. and the IMO have therefore agreed to use thermal ratings based on 15 km/h wind speed to assess the impact on the transmission lines that are within a 50 km radius of the proposed wind park. Table 1 lists the thermal ratings of the local 115 kV transmission circuits that are within a 50km radius of the proposed Essex Wind Park.

Circuit	From	To	Conductor (kcmil)	Max. Op. Temp (°C)	Summer Ratings	
					Continuous[1]	15-min. LTR[2]
K2Z	Lauzon TS	Woodslee Jct	477 ACSR	127	1010	1040
	Woodslee Jct	Tilbury Jct	477 ACSR	90	800	820
	Woodslee Jct	Essex Wind Park Jct	477 ACSR	127	1010	1040
	Essex Wind Park Jct	Kingsville TS	477 ACSR	127	1010	1040
K6Z	Lauzon TS	Belle River Jct	795 ACSR	127	1390	1490
	Belle River Jct	Junction Point	336.4 ACSR	127	810	820
	Junction Point	Essex Wind Park Jct	795 ACSR	127	1390	1490
	Essex Wind Park Jct	Kingsville TS	795 ACSR	127	1390	1490

Notes:
1. Based on maximum operating temperature, 30° C ambient temperature, and 15 km/h wind
2. Based on maximum operating temperature, 30° C ambient temperature, 15 km/h wind, and pre-contingency current at 75% of continuous

Table 1: Summer Thermal Ratings of Local 115 kV Transmission Circuits

The connection applicant is proposing to incorporate the Essex Wind Park via a new 5 to 10 km long single circuit transmission line connecting to the Woodslee Junction to Kingsville TS tap from the Hydro One Networks Inc. transmission circuit K2Z between Lauzon TS and Kent TS. The connection point to the IMO-controlled grid is about 10 km from Kingsville TS.

With its proximity to the Kingsville TS, the Essex Wind Park would likely supply most of the loads at Kingsville TS, a Hydro One Networks Inc. facility. As shown in Figure 1, Kingsville TS is presently supplied via the two 115kV transmission circuits K2Z and K6Z from Lauzon TS. The transformer station has four 25/33.3/41.7 MVA transformers, with transformers T1 and T3 connected to the line tap from K2Z and transformers T2 and T4 connected to the tap from K6Z. With the present proposal of a single connection to K2Z, the new Essex Wind Park would cause serious unbalanced loading on the four transformers at Kingsville TS.

A load flow study, which models the proposed connection of the Essex Wind Park, shows that about 75% of the Kingsville TS total demand would be supplied via the tap that also connects to the new wind park. The 2002 summer peak load at Kingsville TS was about 134 MW. With the present summer peak demand at Kingsville TS, a single tap incorporation arrangement would exceed the continuous ratings of the transformers T1 and T3 at Kingsville TS during peak load periods.

Furthermore studies also showed that with a single tap incorporation arrangement, post contingency voltage declines at Kingsville TS would exceed the acceptable limit.

In order to incorporate the proposed 200 MW Essex Wind Park, two line taps connecting to circuit K2Z and K6Z would be required. Figure 4 shows two alternatives for two line taps incorporation arrangement. Both alternatives, subject to meeting Transmission System Code requirements and approval of Hydro One Networks Inc. would be acceptable to the IMO.

However, it should be noted that depending on the demand at Kingsville TS, contingencies involving either line tap, could result in power flows on the transformers at Kingsville TS exceeding their continuous ratings but within their short time ratings. But if either line tap had a protracted outage, the maximum output of the wind park would have to be reduced to respect the 10-day limited time ratings of the transformers at Kingsville TS. If the outage extended beyond ten days, output must be reduced further to respect the continuous ratings.

A dual connection to the IMO-controlled grid via K2Z and K6Z would provide additional benefit. A single-tap incorporation arrangement via K2Z would result in the removal of the Essex Wind Park for any outage involving K2Z, while the dual connection proposal would allow the wind park to remain in-service for normally cleared faults involving either K2Z or K6Z.

Alternatively, with a single line tap connection to K2Z the maximum output of Essex Wind Park must be limited to about 60 MW under normal conditions and its output might be reduced further when either transformer T1 or T3 at Kingsville is out of service.

Based on the above discussion, the following assessment is based on the assumption that a dual connection to both K2Z and K6Z (Alternative 2) would be implemented for the incorporation of Essex Wind Park.

Results of load flow studies show that the addition of Essex Wind Park would reduce the loading on all 115 kV transmission circuits in the Windsor area. It is expected that with Essex Wind Park in service, the post contingency loading on the 115 kV transmission facilities would be lower than the cases without Essex Wind Park.

Therefore, only contingency cases involving circuit K6Z were studied to illustrate the direct impact of Essex Wind Park on the connecting circuits. Results of these studies show the addition of Essex Wind Park does reduce the loading on both K2Z and K6Z and are summarized in Table 2. The local 115 kV transmission system is capable of incorporating the proposed 200 MW wind generation facility.

Circuit Loadings[1] and Ratings (Ampere) Based on 2-Tap Incorporation Arrangement								
		Circuit K2Z				Circuit K6Z		
Base	Contingency	Lauzon to Woodslee Jct	Woodslee Jct to Essex Wind Park	Essex Wind Park to Kingsville	Woodslee Jct to Tilbury	Lauzon to Belle River Jct	Belle River Jct to Essex Wind Park	Essex Wind Park to Kingsville
		Continuous[2]: 1010 LTR[3]: 1040	Continuous[2]: 1010 LTR[3]: 1040	Continuous[2]: 1010 LTR[3]: 1040	Continuous[2]: 800 LTR[3]: 820	Continuous[2]: 1390 LTR[3]: 1490	Continuous[2]: 810 LTR[3]: 820	Continuous[2]: 810 LTR[3]: 820
LF-I1	None	440	304	304	145	465	395	395
	K6Z	856	703	703	155	N/A	N/A	N/A
LF-I2	None	60	158	310	138	89	134	351
	K6Z	229	300	693	138	N/A	N/A	N/A
LF-E1	None	430	298	298	142	455	386	386
	K6Z	836	692	692	147	N/A	N/A	N/A
LF-E2	None	62	158	309	138	91	135	350
	K6Z	236	306	684	138	N/A	N/A	N/A

Notes:

1. Based on 2-tap incorporation arrangement
2. Continuous rating, based on maximum operating temperature, 30°C ambient temperature and 15km/h wind
3. 15-min. limited time rating, based on maximum operating temperature, 30°C ambient temperature, 15km/h wind and pre-contingency loading equal to 75% of continuous rating

Table 2: Pre and Post Contingency Loading of K2Z and K6Z (Based on 2-Tap Incorporation Arrangement)

3.3.3 Impact on Local 115 kV System Voltage

Post contingency voltage decline in the Windsor area is an on-going concern. Two load rejection (L/R) schemes are presently available at Lauzon TS and Kingsville TS to address excessive post contingency voltage declines at stations supplied from K2Z and K6Z.

The load rejection scheme at Lauzon TS is a connectivity based scheme. This L/R scheme, under certain contingency conditions, will trip both K2Z and K6Z resulting in the rejections of loads supplied from stations connected to these two circuits.

The load rejection scheme at Kingsville TS is a voltage dependent scheme. If the Kingsville TS voltages at both K2Z and K6Z terminals are at 104 kV or less for certain duration, pre-selected feeders at Kingsville TS will be tripped.

Load flow studies have been carried out to evaluate the post contingency voltage declines at Lauzon TS, Kingsville TS, Belle River East DS, Tilbury TS, and Tilbury West DS. As contingency cases that are covered by the L/R scheme at Lauzon TS are existing issues irrespective of Essex Wind Park, they were not studied.

The following contingency conditions were studied:

- Loss of the 115 kV circuit K6Z
- Loss of the 230 kV double circuit transmission line C21J and C23Z (Chatham – Lauzon and Chatham – Keith)
- Loss of the 200 MW Essex Wind Park

Results of the load flow studies are summarized in Table 3. Results of the load flow studies show that the addition of Essex Wind Park would improve the voltage profile of the local 115 kV system. With Essex Wind Park in service, post contingency voltage declines measured at Lauzon TS, Kingsville TS, Tilbury TS, and Tilbury West DS would be less than the maximum decline allowed, 10% before and after under load tap changer action.

However, as the output of the Essex Wind Park is very unpredictable and can vary significantly over time, it will be necessary to provide co-ordination and control of reactive compensation or voltage control devices between Essex Wind Park and Kingsville TS to minimize excessive voltage fluctuation in the area.

Base	Contingency	*115 kV Bus Voltage/Voltage Decline Based on 2-Tap Incorporation Arrangement*															
		Lauzon TS				*Belle River East DS*				*Kingsville TS*				*Tilbury/Tilbury West*			
		Pre Tap[1]		Post Tap[2]		Pre Tap[1]		Post Tap[2]		Pre Tap[1]		Post Tap[2]		Pre Tap[1]		Post Tap[2]	
		kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%	kV	%
LF-I1	None	N/A	N/A	119.4	N/A	N/A	N/A	117.9	N/A	N/A	N/A	K2Z Bus: 114.2 K6Z Bus: 113.2	N/A	N/A	N/A	114.2	N/A
	K6Z	119.1	0.25	118.4	0.84	O.S.	N/A	O.S.	N/A	K2Z Bus: 104.9	8.14	K2Z Bus: 102.1	10.60	109.6	4.03	107.5	5.87
	C21/23Z	115.7	3.10	113.9	4.61	114.2	3.14	112.2	4.83	K2Z Bus: 110.6 K6Z Bus: 109.6	3.15 3.18	K2Z Bus: 108.0 K6Z Bus: 107.0	5.43 5.48	110.5	3.24	108	5.43
LF-I2	None	N/A	N/A	121.7	N/A	N/A	N/A	121.2	N/A	N/A	N/A	K2Z Bus: 120.9 K6Z Bus: 120.0	N/A	N/A	N/A	119.2	N/A
	K6Z	121.4	0.25	121.3	0.33	O.S.	N/A	O.S.	N/A	K2Z Bus: 117.2	3.06	K2Z Bus: 116.1	3.97	117.8	1.17	117.4	1.51
	C21/23Z	119.1	2.14	118.5	2.63	118.9	1.90	118.3	2.39	K2Z Bus: 119.2 K6Z Bus: 118.2	1.41 1.50	K2Z Bus: 118.7 K6Z Bus: 117.7	1.82 1.92	117.1	1.76	116.6	2.18
	Wind Park	119.9	1.48	119.7	1.64	118.5	2.23	118.2	2.48	K2Z Bus: 115.3 K6Z Bus: 114.3	4.63 4.75	K2Z Bus: 114.6 K6Z Bus: 113.5	5.21 5.42	115.2	3.36	114.5	3.94
LF-E1	None	N/A	N/A	121.4	N/A	N/A	N/A	120	N/A	N/A	N/A	K2Z Bus: 116.6 K6Z Bus: 115.5	N/A	N/A	N/A	116.4	N/A
	K6Z	121.0	0.33	120.6	0.66	O.S.	N/A	O.S.	N/A	K2Z Bus: 107.7	7.55	K2Z Bus: 105.4	9.61	112.0	3.78	110.4	5.15
	C21/23Z	117.5	3.21	116.2	4.28	116.2	3.17	114.8	4.33	K2Z Bus: 112.8 K6Z Bus: 111.8	3.18 3.20	K2Z Bus: 111.2 K6Z Bus: 110.2	4.63 4.59	112.7	3.18	111.0	4.64
LF-E2	None	N/A	N/A	122.1	N/A	N/A	N/A	121.5	N/A	N/A	N/A	K2Z Bus: 121.2 K6Z Bus: 120.2	N/A	N/A	N/A	119.5	N/A
	K6Z	121.8	0.25	121.7	0.33	O.S.	N/A	O.S.	N/A	K2Z Bus: 117.4	3.14	K2Z Bus: 116.5	3.88	118.1	1.17	117.7	1.51
	C21/23Z	119.6	2.05	119.0	2.54	119.5	1.73	118.8	2.22	K2Z Bus: 119.6 K6Z Bus: 118.6	1.32 1.33	K2Z Bus: 119.1 K6Z Bus: 118.1	1.73 1.75	117.6	1.59	117.0	2.09
	Wind Park	120.2	1.56	119.5	2.13	119.0	2.14	118.0	2.88	K2Z Bus: 115.7 K6Z Bus: 114.7	4.54 4.58	K2Z Bus: 114.4 K6Z Bus: 113.4	5.61 5.66	115.5	3.35	114.4	4.27

Notes:
1. Pre-tap: Before under load tap changer action
2. Post-tap: After under load tap changer action

Table 3: Voltage Changes at Local 115kV Buses (Based on 2-Tap Incorporation Arrangement)

3.3.4 Voltage Changes due to Start up

The in-rush current during starting is assumed to be less than 8 kA. This is acceptable since the voltage change in the local 115 kV due to start-up of one unit is less than 4%.

After its selection on a specific model of wind turbine generator for Essex Wind Park, Superior Wind Energy Inc. shall provide the in-rush current and the start-up/shutdown characteristics of the wind turbine generators to the IMO to ensure there will be no adverse impact on the ICG.

Voltage Flicker

Wind turbine generators are expected to go through start-ups and shutdowns during day-to-day operations and would result in voltage fluctuations (voltage flicker) affecting the supply voltages in the local area. It is noted that the voltage flicker standard is a part of the Transmission System and Connection Point Performance Standards (Appendix 2) in the Transmission System Code which is not under IMO's jurisdiction.

It is provided below as a reference to the proponent to ensure that the start up control of the wind turbine units is in compliance with the Transmission System Code.

Magnitude (%)	Limit
0.5	3 per second
1.0	20 per minute
2.0	45 per hour
3.0	4 per day
A higher flicker may be acceptable for infrequent starts	

3.4 Reactive Power Compensation

Wind turbine generators operate at a terminal voltage of about 600 V. The units go through a two-stage voltage transformation to deliver power to the IMO-controlled grid. Power output of the wind turbine generator goes through a 600 V to 34.5 kV unit transformer and then collectively through a 34.5 kV to 115 kV transformation to the IMO-controlled grid.

The two-stage transformation is equivalent to that of a conventional generator unit transformer, which must be properly sized so that the generator can provide adequate voltage control and reactive support to the IMO-controlled grid within specific transmission system operating voltage range. This is usually achieved by limiting the impedance of the unit transformer to less than 12.5% on generator machine MVA base while meeting the power factor requirements of the synchronous or induction generators.

To meet the Market Rules requirements, the proponent may choose to use an economic combination of low impedance 34.5-115 kV transformer and provision of reactive power, subject to IMO's approval.

The Market Rules, Chapter 4 Appendix 4.2 Item 1 also stipulates that:

> *"Induction generation facilities shall be supported by reactive power correction equipment designed to raise the equivalent power factor of the unit to 90% lagging at rated output.'*

Additional reactive compensation is also required on the line taps that are owned and used exclusively by Essex Wind Park.

An estimate of the reactive power consumption on the 34.5-115 kV transformer and 10 km of 115 kV line as a result of the 200 MW generation facility is provided below.

- Reactive Power Consumption on 10 km of 115 kV line ≅ 11 Mvar
- Reactive Power Consumption on 34.5-115 kV transformer ≅ 35 Mvar

Assumptions:

- 477 kcmil conductor for 115 kV line
- 8.5% impedance on 100 MVA base for 34.5-115 kV 250 MVA transformer

3.5 Transient Stability and Ride Through Capability under System Disturbances

Transient stability simulations have been carried out using the following contingencies to assess the impact of the proposed 200 MW generation on the IMO controlled grid and the ride through capabilities of the proposed wind turbine generators for contingencies external to the transmission line to which these units are connected.

- Contingency 1: 3 phase fault at Essex Wind Park Junction, loss of 115 kV circuit K6Z
- Contingency 2: 3 phase fault at Lauzon, loss of 230kV circuit C23Z
- Contingency 3: LLG fault at Sandwich Junction, loss of 230kV circuits C21J and C23Z

The studies were based on the assumption of a dual connection to both K2Z and K6Z. The initial system conditions prior to the simulated disturbances are based on LF-I2 and LF-E2. The results of the transient stability simulations are summarized in Table 4 below:

Base Case Conditions	Stability Case	Contingency	Results Plot	System Responses
LF-I2 Import	TS1	1	Figure 5	Stable, positive damping
	TS2	2	Figure 6	Stable, positive damping
	TS3	3	Figure 7	Stable, positive damping
LF-E2 Export	TS4	1	Figure 8	Stable, positive damping
	TS5	2	Figure 9	Stable, positive damping
	TS6	3	Figure 10	Stable, positive damping

Table 4: Transient Stability Studies Results

Transient stability studies based on system conditions with the Bruce Longwood Input (BLIP) westward power flow at about 3850 MW (3500 MW limit + 10% margin) have also been carried out. For the heavy BLIP flow case, the following contingencies were evaluated:

- Contingency 4: LLG at Bruce, loss of 500 kV Bruce to Longwood circuits B562L and B563L
- Contingency 5: LLG at Bruce, loss of 500 kV Bruce to Claireville circuit B560V and Bruce to Milton circuit B561M

Results of the studies are summarized in Table 5.

Base Case Conditions	Stability Case	Contingency	Results Plot	System Responses
Heavy BLIP flow and export	TS7	4	Figure 11	Stable, positive damping
	TS8	5	Figure 12	Stable, positive damping

Table 5: Transient Stability Studies Results

From the overall system stability perspective, the incorporation of the proposed 200 MW generation facility would not have an adverse impact on the IMO-controlled grid since the simulation results display stable and positively damped system responses.

As discussed earlier, the above studies were based on typical data of 1.5 MW wind turbine generator. Superior Wind Energy Inc. shall provide evidence that the performance of the wind turbine generators chosen for Essex Wind Park will be at least equivalent to those assumed by the IMO, and that the wind turbine generators and the associated equipment will be capable of remaining in service for system disturbances or contingencies that do not involve the transmission line(s) to which they are connected. This is for compliance with the Market Rules, Chapter 4 Appendix 4.2 Item 7, which states:

> *"Protection systems shall be constructed and maintained in accordance with all applicable reliability standards."*

3.6 Possible Adverse Interactions with the IMO controlled grid

Certain models of wind turbine generator are equipped with solid state voltage source converter (ac-dc-ac converter) with a dynamic behavior significantly different than that of the conventional synchronous or induction generators. The proponent is required to engage the service of an expert consultant to investigate the potential of such wind turbine generators having adverse interactions with the IMO-controlled grid and the existing generating units, including sub-synchronous resonance. If an adverse interaction is identified, the applicant will be responsible for providing appropriate mitigation measures subject to IMO's approval.

If the specific model of wind turbine generator is not equipped with ac-dc-ac voltage source converter or equivalent equipment, the proponent is to provide an expert statement from the wind turbine generator manufacturer stating that the dynamic behavior of the units is no different than that of a conventional induction generator. No special system study is required.

3.7 Fault Level Analysis

Hydro One Networks Inc. has conducted fault level analysis to determine the impact of the proposed wind park project on the existing transmission facilities. The base condition for the study assumes that all approved generation projects that are being developed are in service.

The study results are summarized in Table 6 and show that the increases in fault levels due to the proposed Essex Wind Park would not exceed the interrupting capabilities of the existing circuit breakers.

Case	***Maximum Fault Levels (kA) Based on 2-Tap Arrangement***					
	Kingsville TS 27.6kV Bus			Lauzon TS 115kV Bus		
	3-Phase	SLG	Breaker Rating	3-Phase	SLG	Breaker Rating
Before Essex Wind Park	12.7	10.3	22	20.2	22.8	39.3
After Essex Wind Park	15.0	11.3	22	22.7	24.9	39.3

Table 6: Maximum Fault Levels with Two-Tap Arrangement

4. Effects of Future Transmission Development in the Area

Hydro One Networks Inc. has received approval under CAA 2002 – 066 for the installation of a single 125MVA 230/115kV autotransformer at Kent TS to interconnect the existing 230kV and 115kV systems. A new normally open point will also be established in the Woodslee Junction to Kent TS circuit K2Z at Tilbury Junction, so that Tilbury West DS and Tilbury TS will be transferred to Kent TS. This project is scheduled for service in late 2004 or early 2005.

Once the Kent TS project is complete, it can provide an alternate route for Essex Wind Park when circuits K2Z and K6Z are open at Lauzon TS. Connecting Essex Wind Park to Kent TS will increase the fault levels at Kent TS. But the fault levels at Kent TS would be well within the 40kA rating of the station. However, the Woodslee Junction to Tilbury Junction section of K2Z is limited to about 800A continuous (based on 15km/h wind and 30°C ambient temperature). Depending on the ambient conditions, the output of Essex Wind Park might have to be curtailed to respect the thermal ratings of K2Z when the wind park is connected to Kent TS.

5. Conclusions

Based on the results of this assessment, it is concluded that:

1. The proposed 200 MW Essex Wind Park with a single tap incorporation arrangement would result in overloading of the transformers at Kingsville TS, a Hydro One Networks Inc. facility in the Municipality of Leamington.

2. With a single tap incorporation arrangement, post contingency voltage declines at Kingsville TS could exceed the acceptable limit.

3. If the proposed 200 MW Essex Wind Park is connected to both K2Z and K6Z via two line taps, it will not have any adverse impact on the transfer capabilities and reliability of the IMO-controlled grid.

4. The increases in fault level, due to the proposed 200 MW generation, will not exceed the interrupting capabilities of the existing breakers.

6. IMO Requirements

The IMO requirements that have been identified during this Connection Assessment for the proposed incorporation of the 200 MW Essex Wind Park facility are as follows:

1. A two-tap incorporating arrangement connecting the 200 MW wind generation facility to circuits K2Z and K6Z is required. Alternatively, with a single tap connection to K2Z, Superior Wind Energy Inc. has to reduce the maximum capacity of the wind generation facility to 60 MW to respect the thermal ratings of the Kingsville TS transformers.

2. The connectivity based load rejection scheme at Lauzon TS shall be modified to include rejection of the Essex Wind Park and to include all outage conditions that will result in the loss of 230kV to 115kV connection at Lauzon TS.

3. Upon its decision to select a specific model of wind turbine generator for the Essex Wind Park, Superior Wind Energy Inc. is required to:

   - Provide evidence and documentation to demonstrate that the proposed wind turbine generators are in compliance with the Market Rules requirements as stated in Chapter 4 Appendix 4.2, including ride through capabilities during system disturbances.
   - Provide the modeling suitable for use in load flow and transient stability studies in PTI - PSS/E format and evidence to support the modeling of the proposed wind turbine generators. It is preferred that the evidence be based on recorded dynamic responses of similar wind turbine generators, including terminal voltages, active and reactive power injections into the grid, obtained during commissioning tests or from existing installations which had experienced system disturbances.
   - Provide adequate reactive power to compensate for the reactive power consumption on the 34.5-115 kV step-up transformer and the dedicated transmission lines. This can be achieved with combinations of low impedance 34.5-115 kV step-up transformer and provision of reactive power, whichever combination is more economic and subject to approval of the IMO.
   - If the selected wind turbine generators are equipped with ac-dc-ac voltage source converters or equivalent equipment, engage the service of an expert consultant with experience in modeling the dynamic behavior of that model of wind turbine generators and power systems to assess the potential adverse interactions (e.g. sub-synchronous resonance) with the IMO-controlled grid and its existing generators. The results are subject to IMO's review and acceptance. If any adverse interaction is identified, the applicant is responsible for providing appropriate mitigation measures subject to IMO's approval.
   - If the selected wind turbine generators are not equipped with ac-dc-ac voltage source converters or equivalent equipment, provide an expert statement from the wind turbine generator manufacturer indicating the dynamic behavior of the units is no different than that of a conventional induction generator.

4. Superior Wind Energy Inc. must complete the IMO facility registration process including meter registration before placing the proposed 200 MW Essex Wind Park generation in service.

5. Hydro One Networks Inc. has indicated that a Customer Impact Assessment (CIA) will be required to determine the impact of new generation connection on Transmission Customers and a detailed CIA study will be carried out by Hydro One.

7. Budgetary Cost Estimates

Apart from the connection of the new 115kV lines onto circuits K2Z and K6Z, and the modification of the special protection scheme at Lauzon TS, there is only minor work associated with review and verification of protection schemes and final equipment data, and witness verification during commissioning. No budgetary cost estimate is provided for this work.

8. Identification of "Sole Beneficiary"

No facility that is triggered by and deemed to be for the sole benefit of this project has been identified.

9. Customer Impact Assessment

Hydro One Networks Inc. has informed the IMO that a Customer Impact Assessment will be required to determine whether the proposed facilities could have an adverse impact on the existing supply facilities in the area.

Superior Wind Energy Inc. has elected to postpone this phase of the process. This Report has therefore been finalised but should any issues be raised when the Customer Impact Assessment is subsequently undertaken, then they will be addressed through an Addendum to the PA Report.

10. Notification of Approval

This Preliminary Assessment has investigated the impact of the proposed 200 MW Essex Wind Park on the reliability of the IMO Controlled Grid. It has also identified IMO's requirements for connection to ensure that the project has no adverse impact on the reliability of the IMO Controlled Grid.

It is therefore recommended that a Notification of Approval be granted, subject to the completion of the Customer Impact Assessment and the implementation of the requirements stipulated in this report.

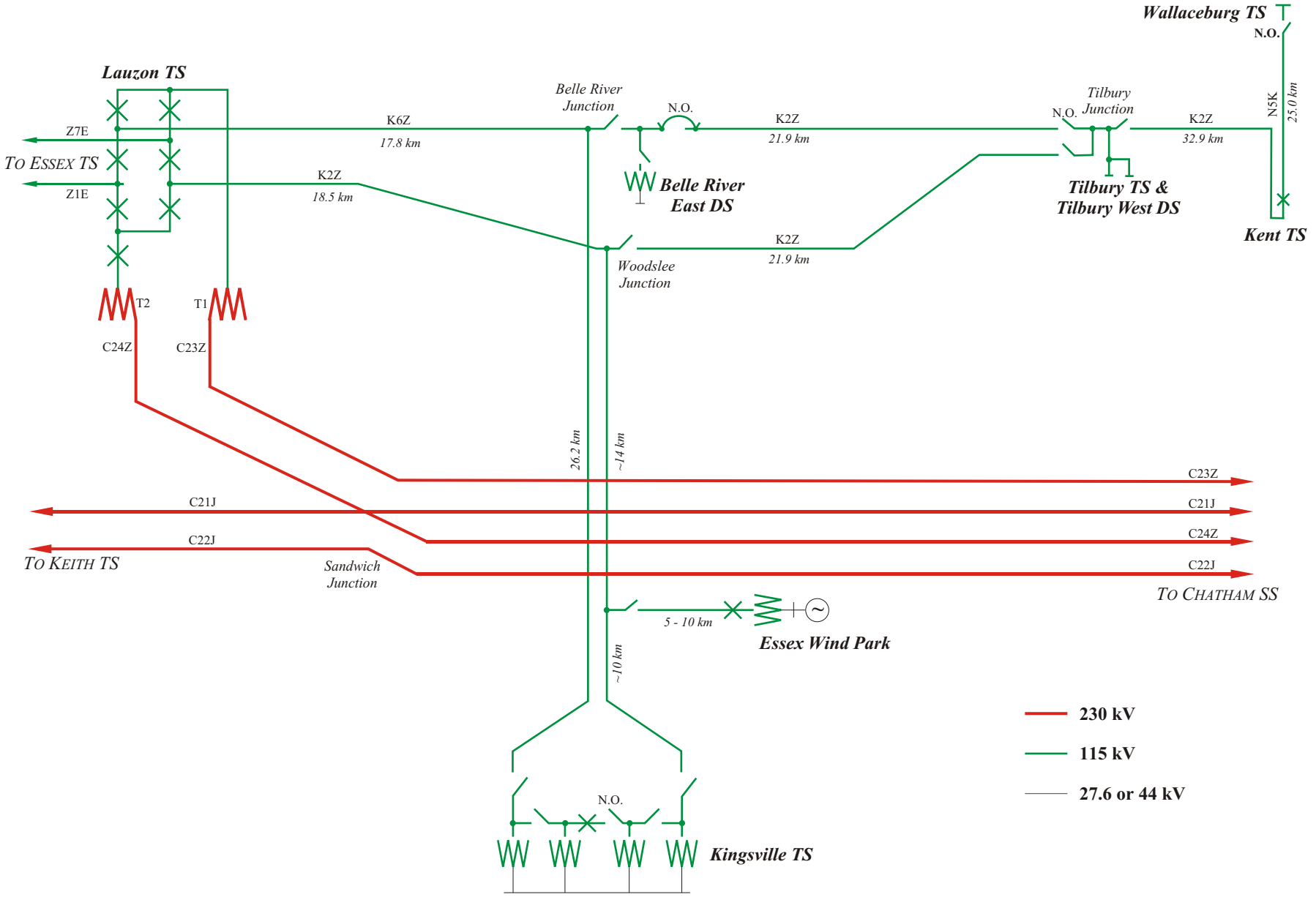


Figure 1: Transmission Facilities with the Proposed Essex Wind Park in-service

May 2003

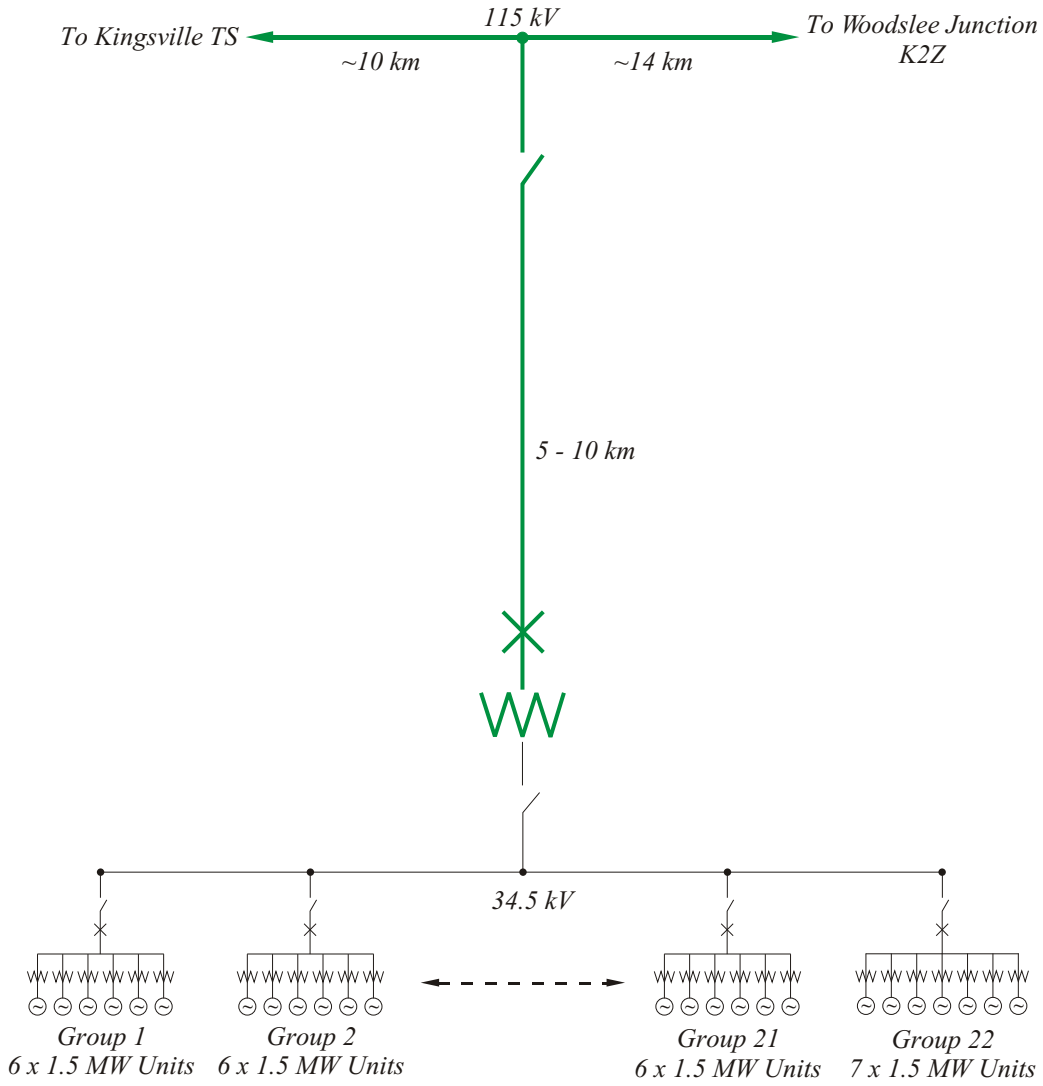


Figure 2: Essex Wind Park - Proposed Connection Arrangement (Based on 1.5 MW Units)

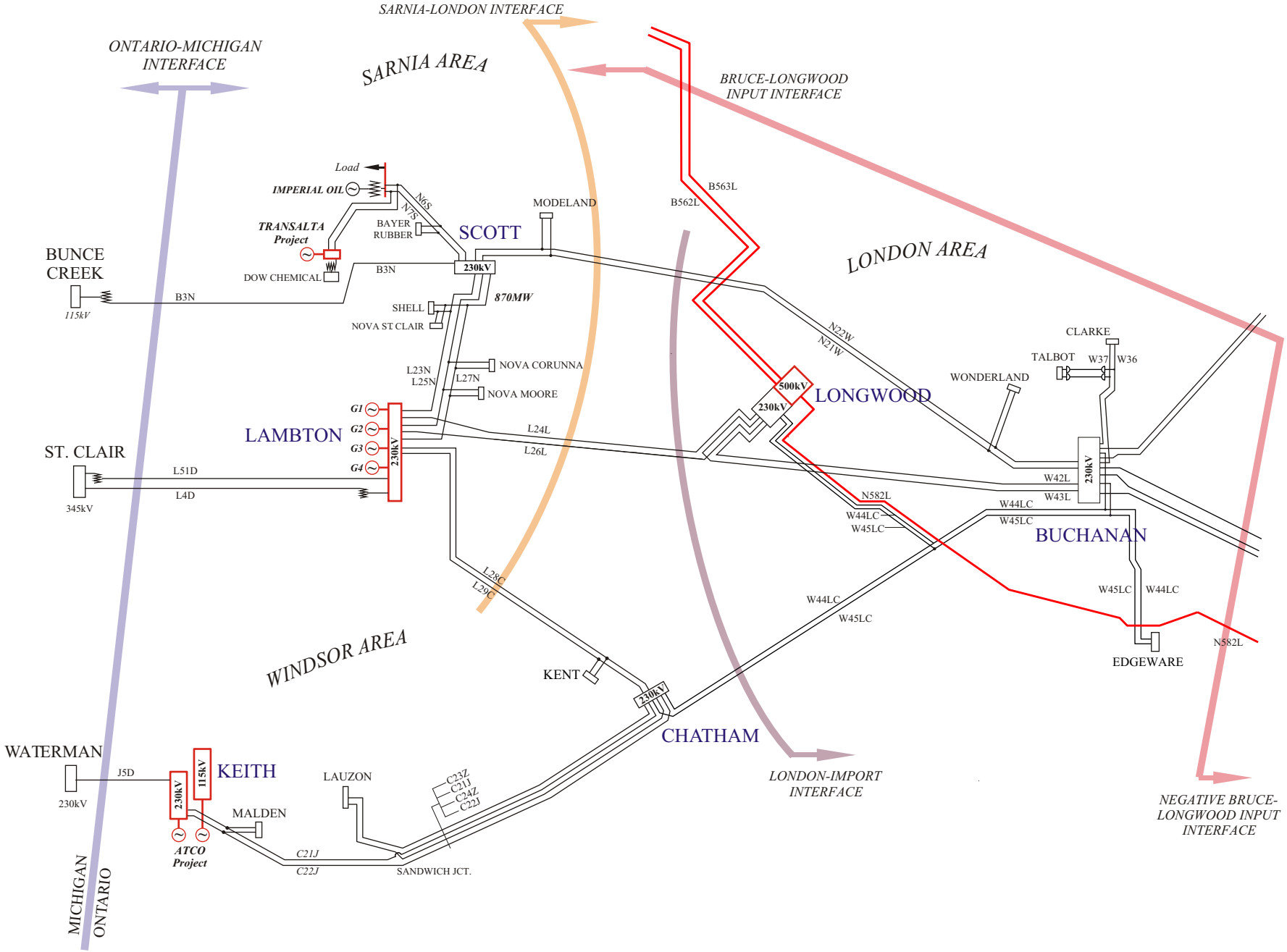
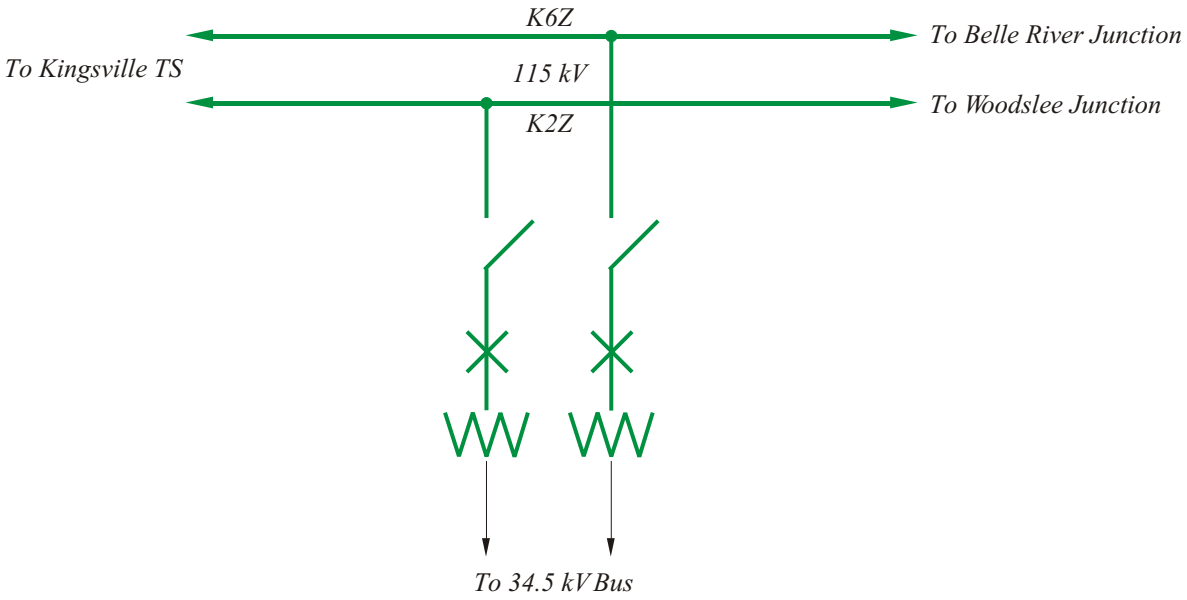
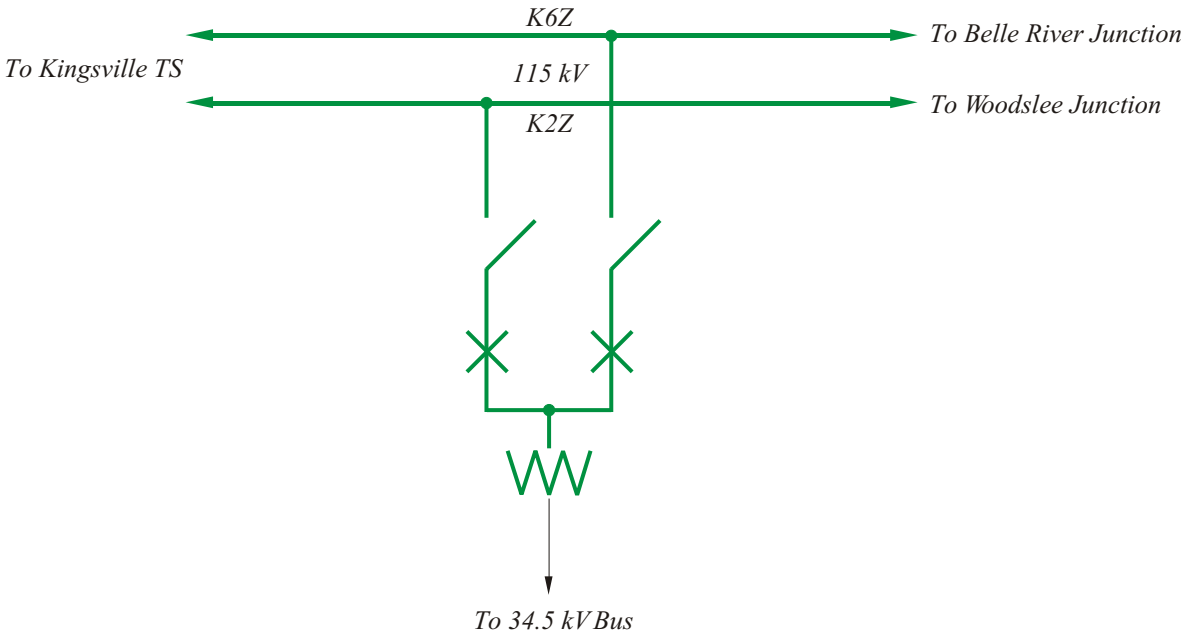


Figure 3: Major Transmission Interfaces in Sarnia-London-Windsor Area

May 2003



Alternative 1



Alternative 2

Figure 4: Essex Wind Park - Alternative Connection Arrangements

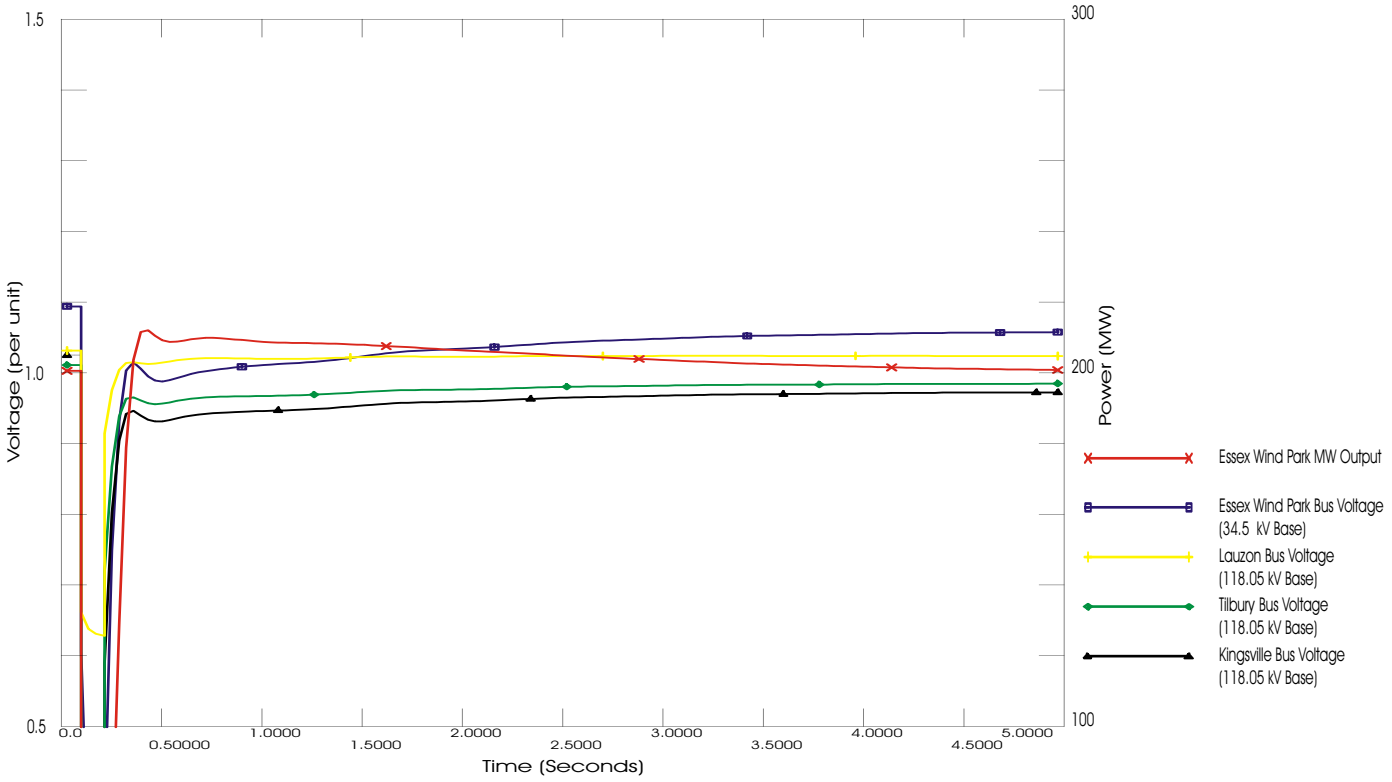


Figure 5:Transient Case TS1 - Import Conditions, 3-phase Fault at Lauzon Loss of K6Z

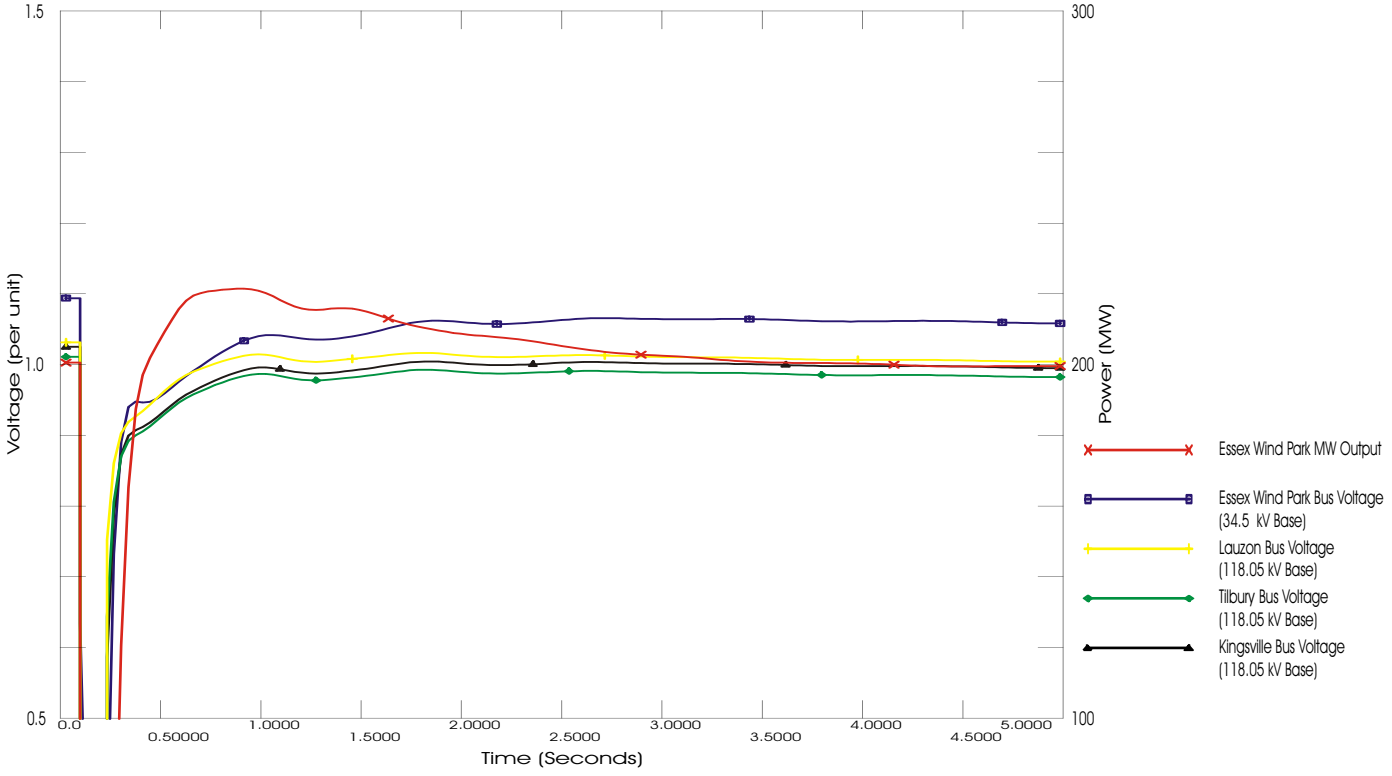


Figure 6:Transient Case TS2 - Import Conditions, 3-phase Fault at Lauzon Loss of C23Z

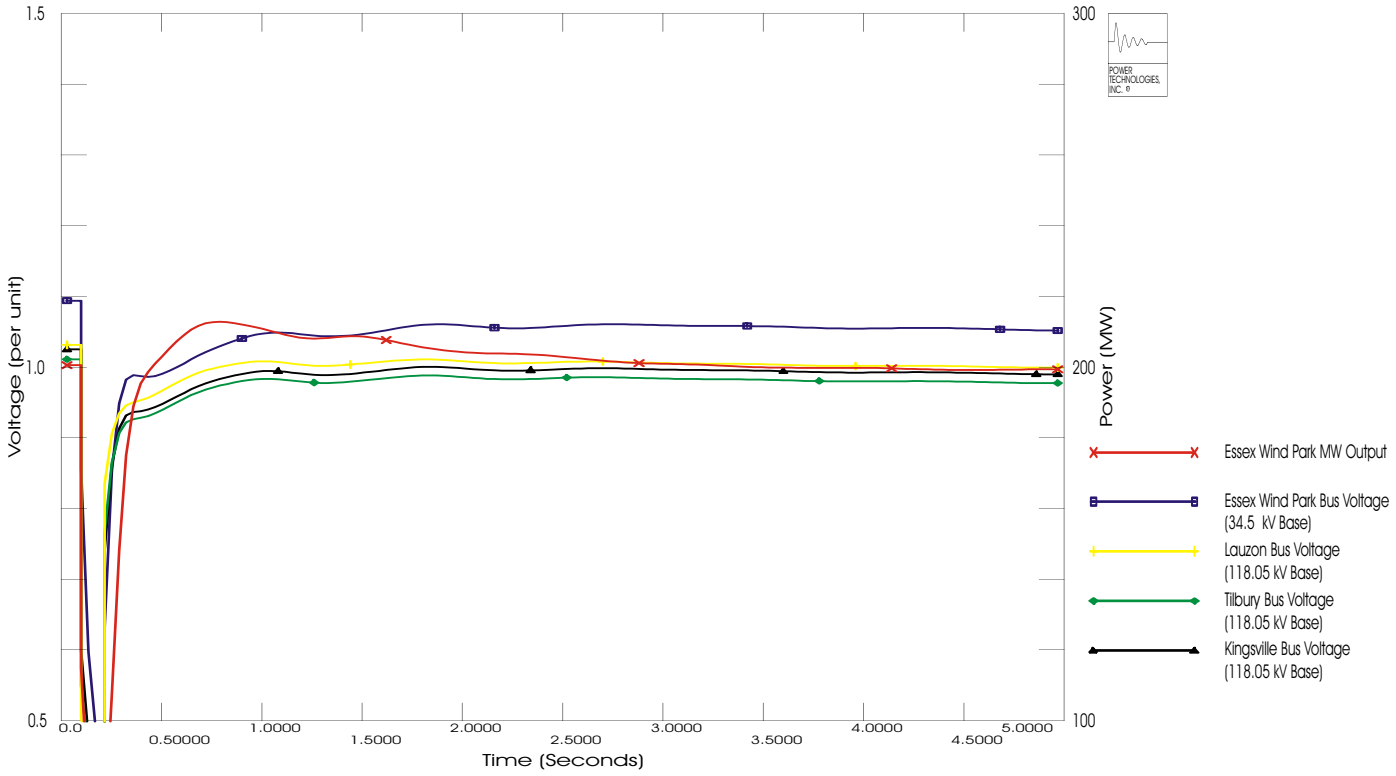


Figure 7:Transient Case TS3 - Import Conditions, LLG Fault at Sandwich Jct Loss of C21J & C23Z

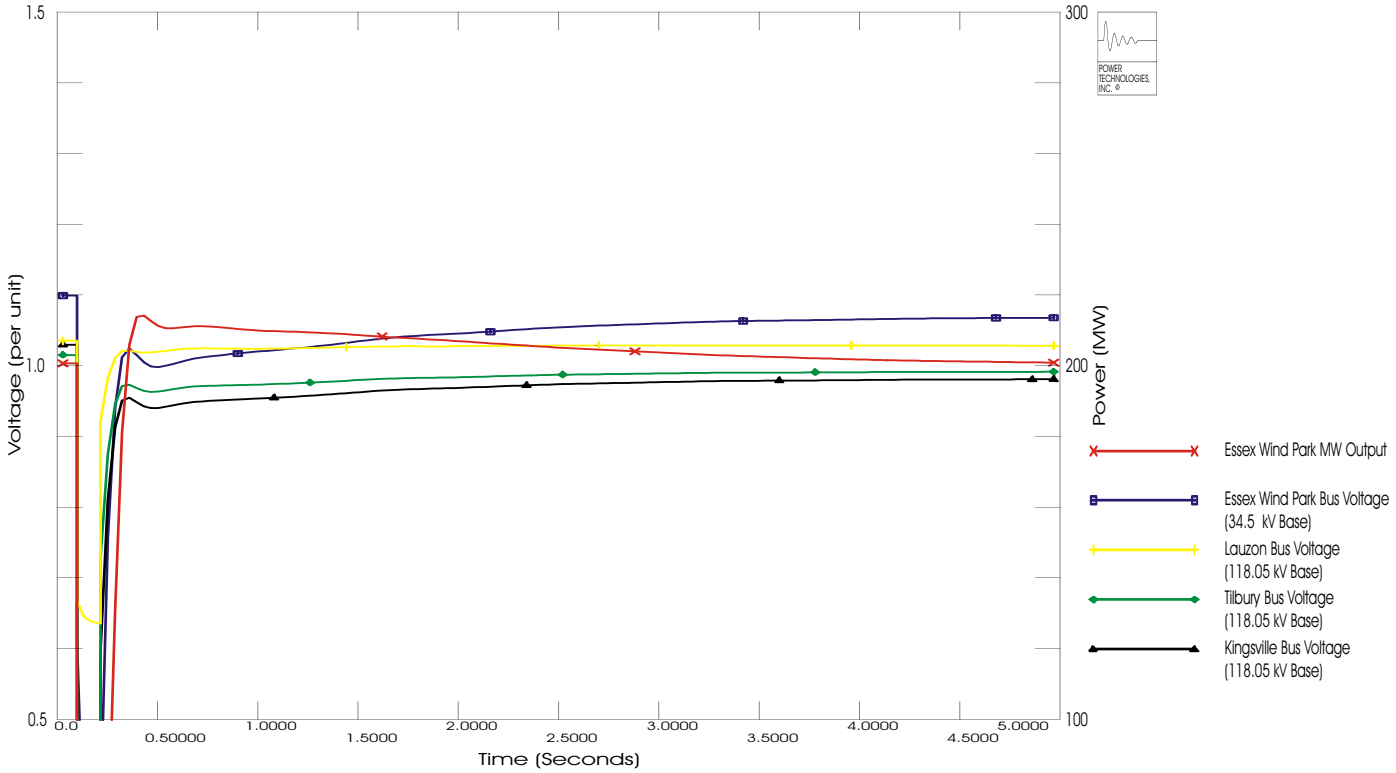


Figure 8:Transient Case TS4 - Export Conditions, 3-phase Fault at Lauzon Loss of K6Z

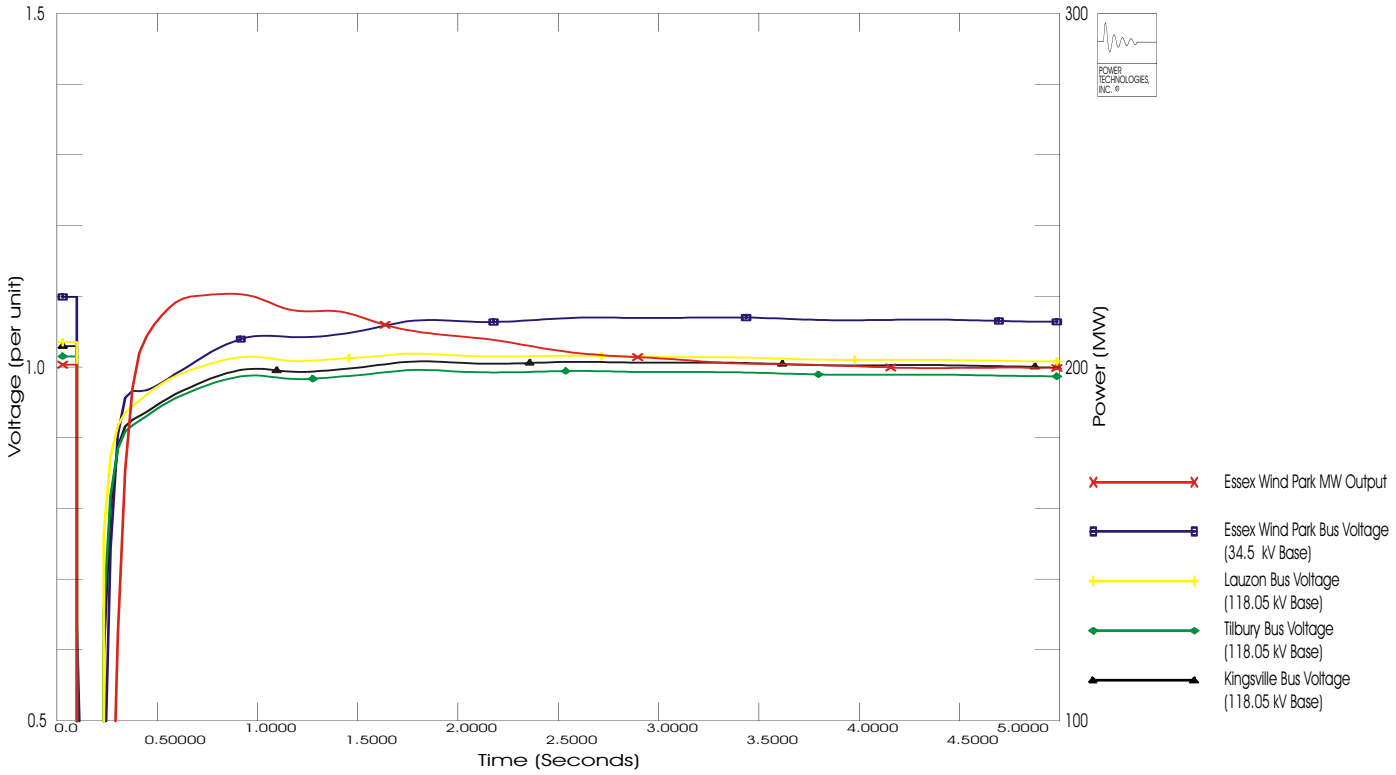


Figure 9:Transient Case TS5 - Export Conditions, 3-phase Fault at Lauzon Loss of C23Z

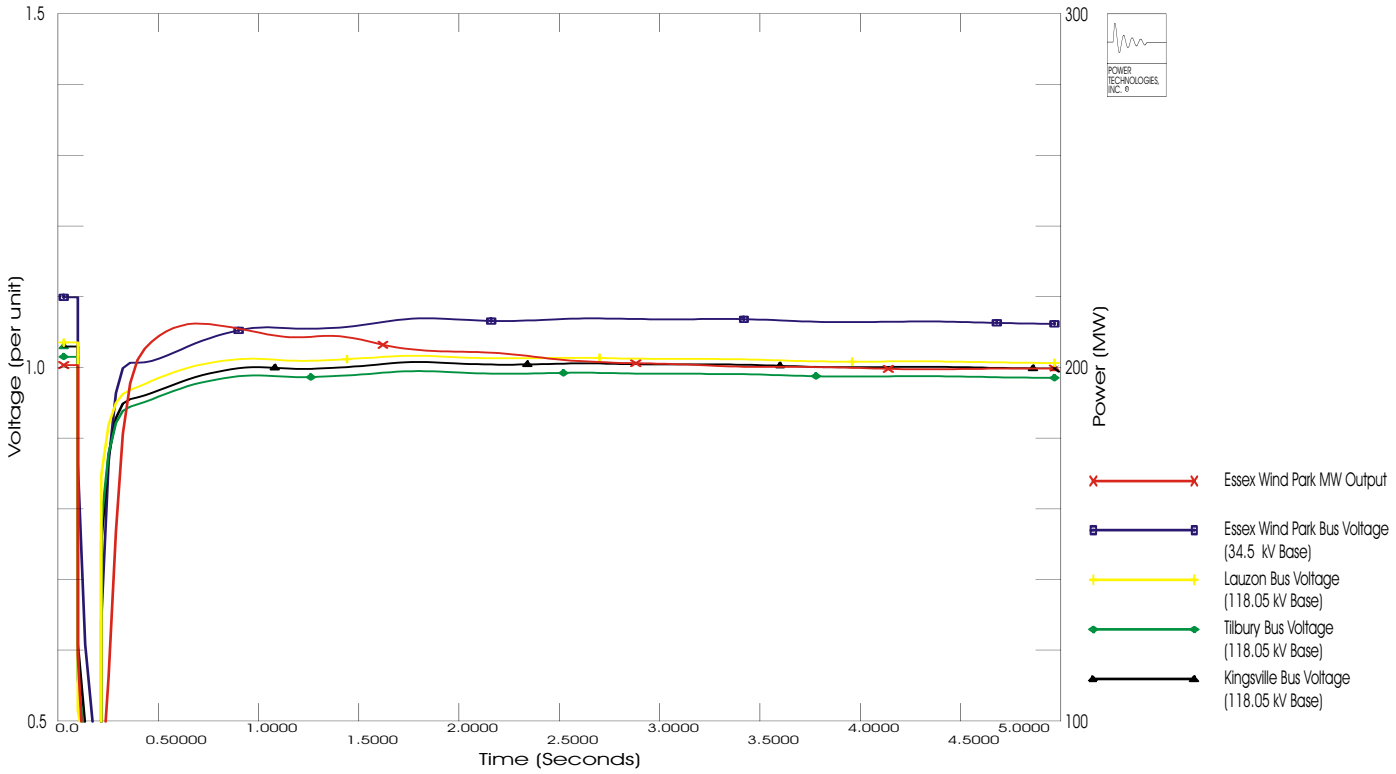


Figure 10:Transient Case TS6 - Export Conditions, LLG Fault at Sandwich Jct Loss of C21J & C23Z

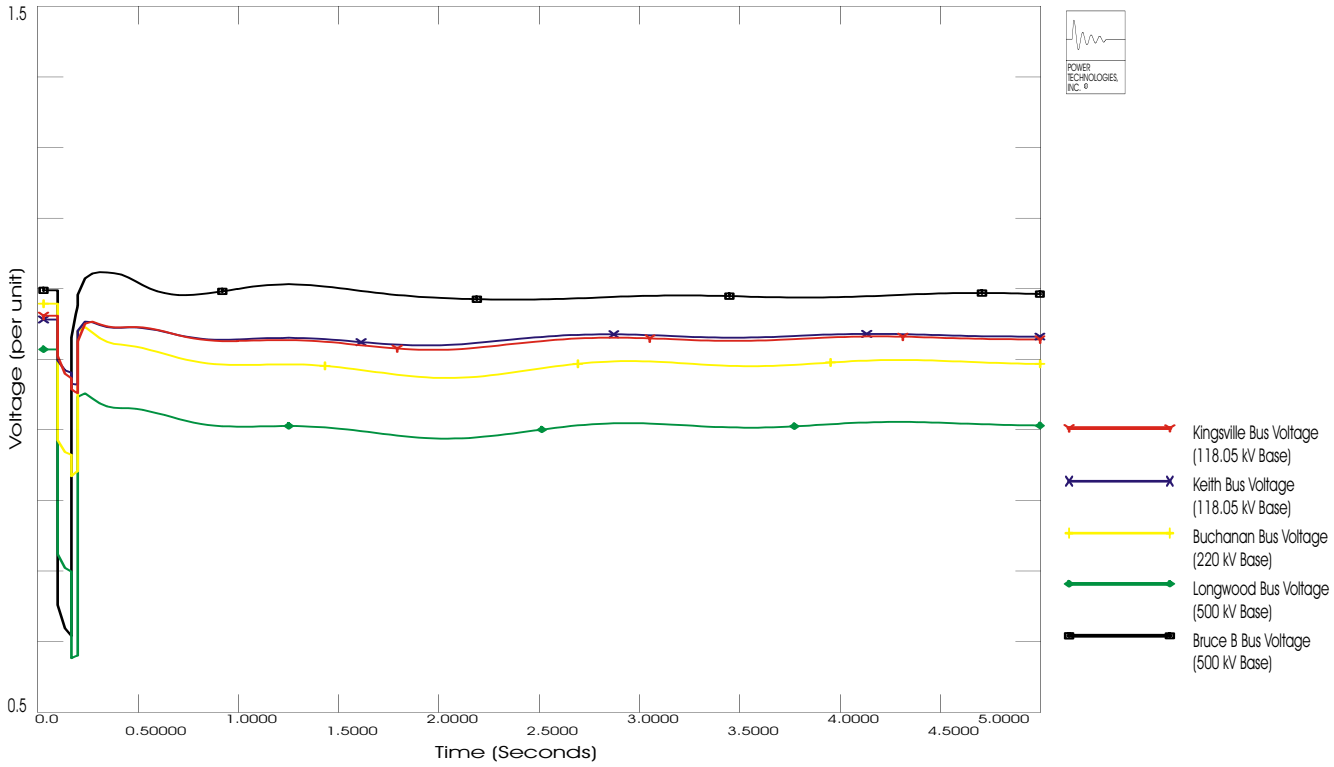


Figure 11: Transient Case TS7 - Heavy BLIP, LLG Fault at Bruce Loss of B562L & B563L

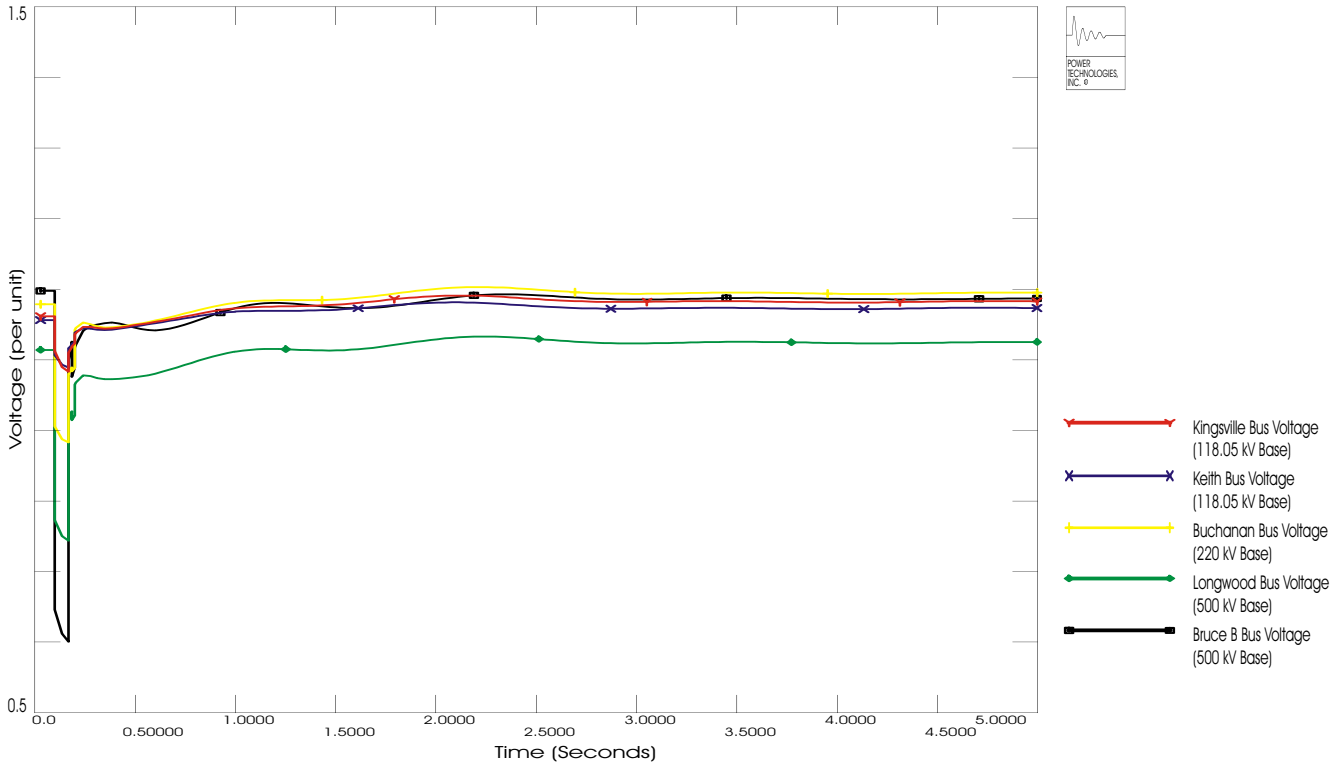


Figure 12: Transient Case TS8 - Heavy BLIP, LLG Fault at Bruce Loss of B560V & B561M