

# CONNECTION ASSESSMENT & APPROVAL PROCESS

## ***PRELIMINARY ASSESSMENT REPORT***

*For the Proposed 54MW Macleans Mountain Wind Project  
by Northland Power Inc. & REPower Wind Corp.*

*CAA ID No. 2002-071*

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

***FINAL Version***

*Date: 3rd September 2003*

## ***Preliminary Assessment Report***

*For the Proposed 54MW Macleans Mountain Wind 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.

## **PRELIMINARY ASSESSMENT REPORT**

### ***For the Proposed 54MW Wind-turbine Generating Facility to be developed by the consortium of Northland Power Inc. & REPower Wind Corp. on Manitoulin Island***

#### ***1. Introduction***

A consortium consisting of Northland Power Inc. and REPower Wind Corp. is proposing to develop a 54MW wind-turbine generating facility on Manitoulin Island, approximately 5km from Manitoulin TS.

The proposed *54MW Macleans Mountain Wind Project* is to be incorporated either at 115kV, via a 5km tap on to circuit S2B, or at 44kV, via two dedicated connections on to the 44kV busbars at Manitoulin TS.

The scheduled in-service date for this Project is Q4-2004.

#### ***Related Project***

Superior Wind Energy Inc. is proposing to develop a 100MW wind-turbine generating facility on Manitoulin Island, approximately 5km from Manitoulin TS.

The proposed *100MW Manitoulin Island Wind Farm Project* is to be incorporated at 115kV via a 5km tap on to the section of circuit S2B between Espanola TS and Manitoulin TS.

Commissioning of this Project is scheduled to commence in Q4-2003, with full commercial operation commencing in Q1-2004.

#### ***Queue Position***

In the IMO Queue of Projects that are undergoing connection assessments, the *54MW Macleans Mountain Wind Project* has a higher position than the *100MW Manitoulin Island Wind Farm Project* by virtue of the earlier date that its Preliminary Assessment Agreement was executed.

*As stated in Part 2.10 of Market Manual 2: Connection Assessment & Approval*

*Queue position entitles a connection applicant to priority in the assessment of incremental system reinforcement requirements, with the objective being to permit connection to the transmission system at the minimum cost consistent with the connection applicant's queue position. Queue position will be used by the IMO to advise the OEB of the incremental impact on the reliability of the integrated power system of each request for connection assessment, and will assist in the allocation of costs of facilities pursuant to the Transmission System Code.*

Consequently, this assessment has considered the impact on the IMO-controlled grid of the *54MW Macleans Mountain Wind Project* in isolation of any other Projects.

#### ***2. Connection Arrangement***

The *Macleans Mountain Wind Project* is to consist of either 66 - 0.825MW wind-turbine generating units or 36 - 1.5MW units, to provide a total capacity of approximately 54MW.

Diagram 1 shows the arrangement that has been proposed for incorporating the wind farm at 115kV via a 5km single-circuit tap on to circuit S2B.

Diagram 2 shows the alternative arrangement that has been proposed with the wind farm incorporated at 44kV via two dedicated single-circuit feeders on to the existing 44kV busbars at Manitoulin TS.

The wind-turbine generators are to be configured into the following groupings, depending on the size of individual wind-turbine generators that are eventually selected, and the voltage at which the Project is to be incorporated into the IMO-controlled grid:

*Option 1: Connection via a single-circuit 115kV tap on to circuit S2B*

- 0.825MW units Five groups of thirteen or fourteen wind-turbine generators (for a total of 67)
- 1.5MW units Five groups of seven or eight wind-turbine units (for a total of 36)

*Option 2: Connection via two dedicated 44kV feeders on to the existing 44kV busbars at Manitoulin TS*

- 0.825MW units Six groups of eleven or twelve wind-turbine generators (for a total of 67)
- 1.5MW units Six groups of six wind-turbine units (for a total of 36)

Each group of wind-turbine generators is to be terminated via an individual circuit breaker on to a common 25kV or 34.5kV busbar. The voltage of the busbar will depend on the particular manufacturer that is eventually selected for supplying the wind-turbine generators.

Diagram 3 shows the proposed connection arrangement for the incorporation of the wind-turbine project on to circuit S2B via a 5km 115kV single-circuit transmission line, equipped with conductors with a minimum size of at least 336.4kcmil. This new 115kV line is to be connected to circuit S2B via a ganged 3-phase manually-operated isolating switch. This switch will also form the point of demarcation between the project's facilities and those of Hydro One Networks.

The new 115kV transmission line is to be terminated on to a 60MVA 115/25kV (or 34.5kV) step-up transformer via a 115kV circuit-switcher or circuit breaker. If a circuit breaker is installed, it will need to be combined with a motorised disconnect switch to provide a point of remote isolation.

Duplicate remote/transfer trip signals are to be provided to Martindale TS. Transformer faults are to be isolated via the circuit switcher (or circuit breaker), and in the event that this should malfunction, transfer trip signals would need to be initiated to isolate circuit S2B at Martindale TS.

Should Northland Power Inc./REPower Wind Corp. elect not to install duplicate remote/transfer trip facilities, then they would need to install a circuit breaker and a circuit-switcher, connected in series as shown in the separate window in Diagram 3. Operation of both devices would need to be initiated simultaneously.

The main 115/25kV (or 34.5kV) step-up transformer is to be connected HV-wye/LV-delta which would comply with the Transmission System Code. The transformer is also to be equipped with an under-load tap-changer.

For each individual wind-turbine generating unit, depending on the particular manufacturer selected, the local step-up transformer is to be connected HV-wye/LV-wye or HV-delta/LV-wye.

Diagram 4 shows the proposed alternative connection arrangement for the incorporation of the wind-turbine project on to the two 44kV busbars at Manitoulin TS via two dedicated 44kV feeders, equipped with conductors with a minimum size of at least 336.4kcmil.

Each dedicated 44kV feeder is to be terminated on to the 44kV busbar that is associated with either of the two step-down transformers, T3 or T4, via a 44kV breaker and a motorised disconnect switch. The disconnect switch will form the point of demarcation between the project's facilities and those of Hydro One Distribution.

Duplicate remote/transfer trip signals are to be provided to Manitoulin TS. Transformer faults would then be isolated via the respective 44kV circuit breaker at Manitoulin TS, and in the event that either of these should malfunction, transfer trip signals would be initiated to isolate circuit S2B at Martindale TS.

This Diagram also shows the normally-open point that is presently maintained between the two halves of the 44kV busbar at Manitoulin TS by operating with the bus-section disconnect switch open.

## *Incorporation of the Macleans Mountain Wind Project at 44kV into Manitoulin TS*

The arrangement proposed for incorporating the Macleans Mountain Wind Project into Manitoulin TS at 44kV would involve splitting the Project into two identical halves and connecting each half via a dedicated 44kV feeder on to one of the 44kV busbars at Manitoulin TS that are associated with each of the two step-down transformers.

Paralleling the two 44kV busbars at Manitoulin TS is presently not an option because of the configuration of the 44kV busbars and the presence of just two 44kV breakers.

Diagram 5 shows an alternative arrangement that would allow the Macleans Mountain Wind Project to be incorporated via a single 44kV incorporation circuit. This would require four additional 44kV breakers to be installed at Manitoulin TS.

In addition, the 44kV incorporation circuit would need to be equipped with conductors having a cross-sectional area of at least 477kcmil.

### **2.1 Transformer Impedance**

For the double-transformation arrangement that has been proposed, the effective, combined impedance of the transformers would total approximately 16% on the rating of the generators. This would exceed the maximum impedance value of 13% required to ensure compliance with the requirements of Reference 2 of Appendix 4.2 of the Market Rules.

This would mean that proportionately more of the reactive power output from the generating units would be absorbed within the transformers, leaving a lesser amount available to provide voltage support to the system.

The reactive power issue together with the manner in which it is proposed to compensate for the high impedance value of the connection to the IMO-controlled grid has been addressed in more detail in Section 8 of this Report

### **3. Thermal Ratings for the Existing Transmission Facilities**

The IMO and Hydro One have agreed to use the following criteria for determining the thermal ratings for transmission facilities to which wind-turbine generating projects are connected:

- For transmission facilities within a 50km radius of the wind-turbine project, the thermal ratings are to be determined using a wind-speed of 15km/hr instead of the normal 4km/hr value.

This is intended to recognise the requirement for substantial wind-speed before the wind-turbine project would be able to deliver its maximum output. However, the application of this relaxed criterion is to be limited to a 50km radius to acknowledge the variability of winds in different locations.

- For those transmission facilities whose loadings are directly affected by the output of a wind-turbine project, their continuous thermal ratings will be determined using a maximum conductor operating temperature of 127°C, or the individual sag temperature if it is lower, instead of the normal value of 93°C (or, if it should be lower, its sag temperature).

This relaxed criterion is intended to recognise the wide variation in the output of wind-turbine projects and the expectation that none of the projects would deliver full output for more than 50 hours per year while the ambient temperature is at 30°C. Since this criterion is to be applied only to those transmission facilities that are directly affected by the output of a wind-turbine project, the 50km radius limit will not apply.

Table 1 shows the thermal ratings for the 115kV circuit S2B that were used in this assessment. These ratings have also been shown on Diagram 6.

It is also worth noting that the following normally-open operating points have been included in this Diagram:

- the normally-open point at Creighton Junction, separating circuit S2B and circuit S5M.
- the normally-open point between Espanola Junction & Baldwin Junction.
- the normally-open point at Espanola TS between the taps to Manitoulin TS and to Eddy Forest Products.

The latter two normally-open points effectively separate circuit S2B into two halves so that it is not operated in parallel with the 230kV circuits S22A & X27A. One half of circuit S2B is therefore supplied radially from Martindale TS while the other half is supplied radially from Algoma TS.

#### **4. Critical 115kV Loads**

##### *Manitoulin TS*

A peak load of 17MW, at a power factor of 0.9, was assumed in this assessment. It has also been assumed that during off-peak periods, when the load at Manitoulin TS is reduced, that the ambient temperature would be lower. This would result in increased thermal ratings that are expected to more than compensate for the increased flows that would occur on the transmission facilities when the generating facilities are in-service and supplying less load.

##### *Domtar-Nairn TS, Whitefish DS & Falconbridge-Lockerby*

The intermediate loads that are supplied from the portion of circuit S2B between Espanola TS and Martindale TS, have a direct impact on the transfers that occur on each respective section. For the purpose of this assessment the values that were assumed at each location were as follows:

Domtar-Nairn	5.5MW
Whitefish DS	3.5MW and
Falconbridge-Lockerby	30.0MW

##### *Domtar (formerly E.B. Eddy Forest Products)*

The Domtar facility at Espanola presently has approximately 40MW of installed generating capacity.

Studies were therefore performed for selected cases with either zero net load at this facility (for the condition where all of the load is supplied from the local generation capacity) or with a peak load of 26MW (for the case with reduced output from the generating facilities).

#### **5. Incorporation of the Macleans Mountain Wind Project**

With only the Macleans Mountain Wind Project in-service, whether incorporated at 115kV or 44kV, the net flow on circuit S2B between Manitoulin TS and Espanola TS would only be approximately 40MVA. This would be well within the rating of this section of circuit S2B. Furthermore, a flow of only 40MVA would remain within the rating of the individual sections of circuit S2B between Espanola TS and Martindale TS, even before making allowance for the intermediate loads that are supplied from this portion of the circuit.

*Consequently, from a consideration of just the thermal ratings, the existing transmission facilities between Espanola Junction and Manitoulin TS, as shown in Diagram 7, would be capable of accommodating the net peak output of the Macleans Mountain Wind Project.*

#### **6. Incorporation of the Manitoulin Island Wind Farm Project**

If Superior Wind Energy Inc.'s Manitoulin Island Wind Farm Project, with a peak capacity of 100MW, were also to be developed, then after allowing for the local load at Manitoulin TS, the net transfer on the section of circuit S2B between Espanola Junction and Manitoulin TS would be:

~ 137MW (~152MVA at an assumed power factor of 0.9)

Since this section of circuit S2B would fall within the 50km radius from the wind-turbine Projects, the 15km/hr wind-speed criterion would apply when determining its continuous thermal rating. For the present maximum conductor operating temperature of 60°C, the continuous rating would only be 111MVA.

*The maximum continuous operating temperature of the conductors would therefore need to be increased to at least 80°C to provide a rating that would be adequate to accommodate the combined net output from both Projects.*

#### *Remaining Portion of Circuit S2B between Espanola Junction and Martindale TS*

To accommodate the combined net flow from **both** Projects over the remaining portion of circuit S2B, the following sections of circuit S2B would need to be updated so that they are suitable for operation at a maximum conductor temperature of *at least 80°C*:

- the 10.5km section between Espanola Junction & Domtar-Nairn Junction
  - the 11.9km section between Domtar-Nairn Junction & Turbine Junction
  - the 5.9km section between Drury Junction & Ethel Junction
- [for a combined length of 28.3km.]

## **7. Load Flow Analysis**

Studies were performed for the following system configurations:

- With the existing system configuration, with circuit S2B operated normally-open at Espanola TS  
This arrangement is shown in Diagram 7.
- With circuit S2B operated normally-closed at Espanola TS  
This arrangement, which is shown in Diagram 8, would require a new 115kV circuit breaker to be installed at Espanola TS.

The studies examined the effect of incorporating only the Macleans Mountain Wind Project.

In all the cases examined the reactive power output from the generating facility was assumed to total 9MVA<sub>r</sub>, regardless of whether the Project was considered to be incorporated at 115kV or 44kV.

This value had been determined to be equivalent to the approximate reactive power losses over the new connection facilities with the Project operating at full output and incorporated at 115kV. The reactive power flow at the point of connection of the incorporation circuit on to circuit S2B would therefore be zero.

The same reactive power output was used for the 44kV incorporation arrangement for the Project.

The results of the load flow analysis have been summarised in Tables 2 & 3.

*In these Tables, the convention used for identifying the flow direction is to indicate the direction of the MW flow. If the reactive power flow is in the opposite direction it is shown as a negative value.*

- e.g. 63.7/-7.0 (E) would mean that the corresponding flow is 63.7MW eastwards and 7.0MVA<sub>r</sub> westwards,  
and  
36.1/-8.7(N) would mean that the corresponding flow is 36.1MW northwards to Espanola TS and  
8.7MVA<sub>r</sub> southwards to Manitoulin TS.*

### **7.1 Results with circuit S2B operated normally-open at Espanola TS**

Table 2 shows the results with only the existing capacitor bank at Espanola TS in-service.

This shows that the flows on each section of circuit S2B would remain within their respective continuous ratings and the voltage profile is also acceptable.

The lower portion of the Table shows the results for the loss of the entire wind-turbine Project (which would occur in response to a contingency involving the single step-up transformer). With the generating facility producing only sufficient MVAr to supply the local losses, the maximum voltage decline would be 5.2% at Manitoulin TS. This would be within the IMO's criterion of 10% for a 'system' contingency.

However, in this study, with no additional reactive compensation installed on the system, the post-contingency voltage at Manitoulin TS is depressed below the 113kV minimum required by the Market Rules.

The study was repeated with a nominal 5MVar capacitor bank assumed to be connected to the 44kV busbar associated with transformer T3 at Manitoulin TS.

The results are summarised in Table 2A.

These results show a marked improvement in the voltage profile along circuit S2B, as well as a reduction to just 22MVar (from 39MVar) in the reactive power flow at Martindale TS.

### **7.2 Results with circuit S2B operated normally-closed at Espanola TS**

With circuit S2B operated normally-open at Espanola TS, the direction of the flow on the Algoma to Sudbury Interface will have no effect on the flows on circuit S2B. However, with circuit S2B operated normally-closed at Espanola TS, circuit S2B would then provide an additional connection between Algoma TS and Martindale TS, in parallel to the 230kV circuits X27A & S22A.

Table 3 shows the results with circuit S2B closed at Espanola TS and with a transfer eastwards across the Algoma to Sudbury Interface.

In this study a net load of 26MW has been assumed at the Domtar facility.

These results show that the flow into circuit S2B at Algoma TS would increase from 30MW (Table 2) to 56MW, as a direct consequence of closing circuit S2B. There would also be a corresponding change in the flow at Martindale TS (from 4MW *eastwards* to 19MW *westwards*). In addition, the reactive power flow into circuit S2B at Martindale TS would increase to 32MVar.

The lower portion of Table 3 shows the results for the loss of the entire 54MW wind-turbine Project.

These results are particularly interesting in that they show an increase in the voltage decline that would be experienced at Manitoulin TS from 5.2% (in Table 2) to 9.7%. Although this decline would be within the IMO's limit of 10%, it would be only marginally acceptable.

The cause of the increased voltage decline is the higher post-contingency flow into circuit S2B upon loss of the wind-turbine Project. With circuit S2B closed at Espanola TS and with the 54MW wind-turbine Project in-service, the flow into circuit S2B at Algoma TS would be approximately 56MW. This would increase to approximately 80MW, together with a corresponding increase in the reactive power flow of approximately 14MVar, when the wind-turbine Project is tripped. These increased post-contingency flows result in depressed voltages along circuit S2B, with the net effect that an increased incremental change would be experienced.

The results also show that with circuit S2B operated closed at Espanola TS, the 54MW Macleans Mountain Wind Project would have the effect of 'backing-off' the through-flow that would occur on circuit S2B.

However, any decline in the output from the Macleans Mountain Wind Project would similarly result in a reduced ability to back-off the through-flows on circuit S2B.

Furthermore, as shown in Table 3A, any reduction in the net load at the Domtar facility would also affect the flows on circuit S2B. With the Macleans Mountain Wind project producing a peak output of 54MW, and with a net load of 0MW at the Domtar facility, the flow into circuit S2B at Algoma TS would be reduced to 44MW from the 56MW that was recorded with an assumed net load of 26MW at Domtar.

Studies have also shown that excessive post-contingency transfers could occur through circuit S2B in response to contingencies involving either of the 230kV circuits S22A or X27A. The magnitude of these transfers would vary depending on the level and direction of the transfers across the Algoma to Sudbury Interface, as well as on the level of the local loads and the output from the generating facilities. To avoid possible post-contingency overloading of circuit S2B, facilities would therefore be required to initiate cross-tripping of the tie-breaker at Espanola TS, so that circuit reverts to its present radial-connection configuration, or selected amounts of generating capacity would need to be automatically rejected.

### 7.3 Voltage Declines for the Respective Incorporation Arrangements

The following Table summarises the results of a limited number of studies to examine the expected voltage declines that would occur in the event that all or half the Macleans Mountain Wind Project were to be lost in response to a line and/or step-up transformer contingency.

<i>Voltage Declines upon loss of generating capacity</i>				
	<i>'Net' Reactive Power Output</i>	<i>Status of 5MVar capacitor at Manitoulin TS</i>	<i>Generation Capacity Tripped</i>	<i>Voltage Decline</i>
<i>Macleans Mountain Project Incorporated at 115kV</i>				
Via a single 115kV circuit	18MVar	0MVar	54MW	~9.0%
	0MVar	5MVar	54MW	~3.7%
<i>Macleans Mountain Project Incorporated at 44kV</i>				
Via two 44kV feeders & with the 44kV busbar split	18MVar	0MVar	27MW	~5.9%
	0MVar	5MVar	27MW	~1.5%
Via a single 44kV feeder & with the 44kV busbar common	18MVar	0MVar	54MW	~10.3%
	0MVar	5MVar	54MW	~3.5%
	5MVar	0MVar	54MW	~6.0%

The studies were performed with a nominal peak load of 17MW at Manitoulin TS.

The studies show that with the Manitoulin Wind Project producing the reactive power output required under the Market Rules, the voltage decline experienced at Manitoulin TS following a trip of the entire Project would be close to, or greater than the 10% limit for a 'system' contingency. If the Project were to be incorporated via two dedicated feeders and only half the Project were to be lost, then the voltage decline would be reduced to approximately 6%. However, if the two 44kV feeders were to be installed on common structures, then the loss of the entire Project as a result of a double-circuit contingency would need to be recognised, and the voltage decline would be in the 10% range.

The results for the same contingency conditions but with a 5MVar capacitor bank in-service at Manitoulin TS result in substantially lower voltage declines by providing post-contingency voltage support to the Manitoulin busbars.

These voltage declines would also provide a suitable margin to allow the wind-turbine Project to produce additional reactive power output beyond the 9MVAR that has been assumed in the analysis, should this be necessary (with the Project operating at its peak output).

The final study in the Table provides a direct comparison with the preceding study to show the effectiveness of the 'external' capacitor bank. With a 5MVAR capacitor bank in-service at Manitoulin TS and with the wind-turbine Project producing a flow of 0MVAR at the connection point on to circuit S2B, the voltage decline would be approximately 3.5% for the loss of the entire Project. This would increase to approximately 6% if the capacitor bank was not in-service and instead the 5MVAR of reactive power were to be produced by the wind-turbine Project.

It should also be noted that the voltage declines would also be expected to vary depending on the magnitude of the load at Manitoulin TS and on its power factor.

*Since it is not expected to be possible for this Project to deliver all of the reactive power required under the Market Rules without exceeding the IMO's criterion, that limits voltage declines for 'system' contingencies to a maximum of 10%, the IMO therefore requires that a 5MVAR shunt capacitor bank be installed at Manitoulin TS as a condition for the connection of this Project to the IMO-controlled grid.*

#### **7.4 Conclusions from the Load Flow Analysis**

The results from the Load Flow Analysis can be summarised as follows:

*With circuit S2B operated normally-open at Espanola TS*

- The existing 115kV transmission facilities would be capable of accommodating the full output of the 54MW Macleans Mountain Wind Project, *in isolation*.

*With circuit S2B operated normally-closed at Espanola TS*

- While the existing 115kV transmission facilities would still be capable of accommodating the full output of the 54MW Macleans Mountain Wind Project, *in isolation*, the closure of circuit S2B would result in the following:
  - Through-flows that would effect both the reactive power losses on circuit S2B and the voltage profile.
  - An increase in the voltage decline experienced at Manitoulin TS for the loss of the wind-turbine Project.
  - A requirement to initiate either cross-tripping of the new 115kV breaker that would need to be installed at Espanola TS or post-contingency rejection of generating capacity at the wind-turbine Project.

It has therefore been concluded that there would be no merit in operating with circuit S2B normally-closed at Espanola TS.

*Incorporation of the wind-turbine Project at 44kV*

- If the wind-turbine Project is to be incorporated at 44kV then it can be connected into Manitoulin TS using either of the following arrangements:
  - via two dedicated 44kV feeders on to the respective 44kV busbars associated with the two step-down transformers. This arrangement would require two additional 44kV breakers to be installed at Manitoulin TS.

*OR*

- via a single dedicated 44kV feeder on to a common 44kV busbar at Manitoulin TS. This arrangement would require four additional 44kV breakers to be installed at Manitoulin TS.

## 8. Reactive Compensation

Reference 1 of Appendix 4.2 of the Market Rules states:

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

This means that the 54MW Macleans Mountain Wind Project should be capable of providing approximately 26MVA<sub>r</sub>.

However, analysis has shown that if the Macleans Mountain Wind Project were to be incorporated via a single-circuit connection on to the 115kV circuit S2B, the voltage change upon loss of the entire facility (due to a transformer fault) would exceed the IMO's 10% criterion if it were providing 26MVA<sub>r</sub> of reactive power as detailed above.

Similarly, if the Macleans Mountain Wind Project were to be incorporated via two, dedicated 44kV feeders on to the two 44kV busbars at Manitoulin TS, the voltage change upon loss of half the facility (due to a transformer fault) would exceed the IMO's 10% criterion if each half were providing 13MVA<sub>r</sub> of reactive power.

Reference 2 of Appendix 4.2 of the Market Rules states:

*Generation facilities shall be capable of operating continuously at full output within  $\pm 5\%$  of the generation facility's rated terminal voltage.*

In order to meet this requirement, the impedance of the step-up transformer would need to be limited to approximately 13% based on the generator MVA rating.

The portion of the reactive output from the generating facility that would normally be absorbed within the connection facilities [including the step-up transformer(s)] should therefore be based on a maximum impedance value of 13%.

### *Macleans Mountain Wind Project*

For the 54MW Macleans Mountain Wind Project, the 'allowable' reactive power losses (based on an impedance of 13%) would therefore be approximately 7.5MVA<sub>r</sub>.

Since the generating facility is required to be able to provide 26MVA<sub>r</sub> at the generator terminals, the amount of reactive power that should be available to the system would therefore be approximately 18MVA<sub>r</sub>.

### *Transmission Line Losses*

The approximate reactive power losses on the section of circuit S2B between Manitoulin TS and Espanola Junction would be as follows (at an assumed voltage of 121kV):

<b><i>Reactive Power Losses on circuit S2B resulting from the incorporation of the Macleans Mountain Wind Project</i></b>			
<i>Rating of the generating facility</i>	<i>Load at Manitoulin TS</i>	<i>Net Transfer on S2B</i>	<i>Approximate Reactive Losses</i>
60MVA	19MVA	41MVA	2.6MVA <sub>r</sub>

In addition, if the 54MW Macleans Mountain Wind Project were to be incorporated into Manitoulin TS at 44kV, then *additional* reactive power losses totalling approximately 1.25MVA<sub>r</sub> per transformer, for a total of 2.5MVA<sub>r</sub>, would occur.

### *Installation of Reactive Compensation*

Analysis has shown that any significant increase in the reactive power output from the individual generating facilities (beyond that required to supply the losses associated with the local connection) would be expected to result in voltage declines following the loss of the entire generating facility that could exceed the IMO's criterion of 10% for a 'system' contingency. Consequently, where a requirement for additional reactive compensation has been identified, it is therefore proposed that it should be installed on the system.

[This is addressed in Clause 3.2.3 of Chapter 4 of the Market Rules, which states:

*The generator may comply with its requirements to provide reactive power either by modifying any of its generating units that do not comply with any standard with respect to the provision of reactive power, or by obtaining reactive power from other appropriate generating units or market participants. The IMO shall determine whether these generating units or market participants are in sufficiently close electrical proximity to the non-compliant generating unit so as to provide the comparable or equivalent reactive power.]*

*It is therefore proposed that a single 5MVar shunt capacitor bank should be installed on the Hydro One system as a condition of connection for the Macleans Mountain Wind Project:*

<b><i>Supplementary Shunt Capacitor Requirement</i></b>	
<i>For the 54MW Macleans Mountain Project, in isolation</i>	
<b>At Manitoulin TS</b> <i>Install one 5MVar bank (rated at 44kV)</i>	On the 44kV busbar of transformer T3

The additional shunt capacitor bank has been shown in Diagram 9.

This capacitor bank would be in addition to the requirement that the Macleans Mountain Wind Project supply the following reactive power locally to compensate for the losses associated with its connection to the IMO-controlled grid:

Approximately 9MVar for the *54MW Macleans Mountain Project*

This reactive power requirement could be provided either from the generators (if they have the capability to supply MVars) or via separate shunt capacitor banks.

The following Table therefore summarises the reactive power requirements for the *54MW Macleans Mountain Project*

<b><i>Reactive Power Requirements for the 54MW Macleans Mountain Project, connected in isolated</i></b>			
'NET' MVar requirements to comply with the Market Rules	MVar capacity to be installed on the system (at Manitoulin TS)	Reactive Power capacity still 'owing'	Reactive Power output required from the Project to supply local losses
26MVar - 7.5MVar = 18MVar	5MVar	13MVar	9MVar

The first column details the 'net' reactive power that should be available to the system, when required, to comply with the Market Rules. This represents the required output corresponding to a power factor of 90% lagging, less the reactive power losses through a 'standard' connection with an impedance of 13% (based on the generator rating).

The second column refers to the amount of reactive compensation that is required be installed for the Project to be connected to the IMO-controlled grid. The third column shows the amount of reactive power compensation that would remain outstanding once the 5MVar capacitor bank has been installed at Manitoulin TS.

While there is no immediate requirement for the installation of additional reactive compensation beyond the 5MVAR capacitor bank that is to be installed at Manitoulin TS, the IMO reserves the right to require that either:

- additional compensation be installed in the future should system changes permit additional capacity to be accommodated or for the switching of higher-rated capacitor banks, or
- the reactive power output of the generating facility be increased beyond the 9MVAR required to supply the local reactive power losses when the facility is operating at full output.  
(or a combination of both).

This requirement for *additional* reactive power/compensation would be limited to a maximum of 13MVAR.

It is also recommended that the capacitor bank to be installed at Manitoulin TS should be designed so that additional capacitor cans could be installed at a future date to increase its rating. This would be particularly beneficial should a new 230/115kV auto-transformer be installed at Espanola TS in the future and the increased fault level would then permit switching of a larger capacitor bank without violating the 4% limit for abrupt voltage change.

#### *Under/Over-Voltage Switching*

Since the output from the wind farm will vary significantly depending on the prevailing wind conditions, as well as the operational status of either the individual or the groups of wind-turbine generators, the amount of reactive compensation that would need to be in-service is expected to need frequent revision.

It has therefore been assumed that the new capacitor bank will be controlled via a local under-voltage/over-voltage scheme, with suitable settings to avoid 'hunting' between it and any other existing or future capacitor banks.

This scheme would also be available to address potential over-voltage conditions in the event that, depending on the incorporation arrangement that is eventually selected, all or half of the entire wind farm should be lost due to a fault involving a main step-up transformer.

### **9. Transient Stability Analysis**

Transient stability studies were performed only for the existing system arrangement (i.e. with circuit S2B open at Espanola TS and with the wind-turbine Project therefore connected radially into Martindale TS). However, separate studies were performed for the following incorporation arrangements for the wind-turbine Project:

- With the 54MW Macleans Mountain Wind Project connected via a single-circuit 115kV transmission line to circuit S2B, and
- With the 54MW Macleans Mountain Wind Project connected via two 44kV feeders on to the 44kV busbars associated with the step-down transformers at Manitoulin TS

The results obtained from these studies are presented in Diagrams 11 to 16 inclusive, and have been summarised in the following Table.

The scales employed in the transient stability plots are as follows:

Voltages	0 to 2.0 pu
Power Flow on circuit S2B	0 to 200MW
Reactive Power Flow on circuit S2B	-100 to 100MVAR or -200 to 0MVA

<b>TRANSIENT STABILITY STUDIES: Operating Scenarios for which studies were performed</b>					
<i>With only the Macleans Mountain Wind-turbine Project in-service: Modelled as an Induction Generator</i>					
<b>Diagram</b>	<b>System Arrangement</b>	<b>Fault Condition</b>		<b>Result</b>	
11.	Incorporation via a single 115kV tap on to circuit S2B	3-Phase Fault	115kV circuit S5M at Martindale TS	OK	
12.			230kV circuit X27A at Algoma TS	OK	
13.	Incorporation via two 44kV feeders on to the 44kV busbars at Manitoulin TS		115kV circuit S5M at Martindale TS	OK	
14.			230kV circuit X27A at Algoma TS	OK	
15.			L-L-G Fault	230kV circuits A23P/A24P at Algoma TS	OK
16.			3-Phase Fault	44kV feeder at Manitoulin TS	OK

### **9.1 Model used for the Transient Stability Studies**

Diagram 10 provides details of the CIMTR3 Induction Generator Model that was used to represent the wind-turbine generators in the transient stability studies.

Since Northland Power Inc. and REPower Wind Corp. are still assessing the actual units that are to be installed, the values used in the analysis were a blend of the values from different manufacturers.

Once Northland Power Inc. and REPower Wind Corp. have selected a machine for their Project, the data will need to be submitted to the IMO for review and additional studies may need to be performed.

### **9.2 Discussion of the Results**

In all of the studies the wind-turbine generators were modelled as induction generators. Since every case exhibited a stable response, with good voltage recovery, it was not considered necessary to repeat any of the studies using a constant-current representation for the transient performance of the wind-turbine generators when the voltages are severely depressed.

#### *With the Macleans Mountain Wind Project incorporated at 115kV*

Diagrams 11 & 12 show the effect of a three-phase fault on 115kV circuit S5M and on 230kV circuit X27A, respectively. In both cases, the voltages at Manitoulin TS and at Espanola Junction recover to close to their pre-contingency values within about one second, as does the power output of the wind Project.

These responses show that the performance of the proposed 54MW Macleans Mountain Wind Project would be acceptable if it were to be connected to the existing 115kV facilities, in isolation.

#### *With the Macleans Mountain Wind Project incorporated at 44kV*

Diagrams 13 & 14 shows the corresponding responses to the same fault conditions represented in Diagrams 11 & 12 (for a three-phase fault on 115kV circuit S5M and on 230kV circuit X27A, respectively) for the arrangement with the Macleans Mountain Wind Project incorporated at 44kV

Although the response is marginally slower than that obtained for those cases with the Project incorporated at 115kV, the voltages at Manitoulin TS and at Espanola TS are shown to return to close to their pre-contingency values.

Diagram 15 shows the response to a line-to-line-to-ground fault involving the double-circuit line A23P/A24P. Once again, the voltages at Manitoulin TS and at Espanola Junction recover to close to their pre-contingency values within about one to two seconds, as does the power output of the wind Project.

Diagram 16 shows the response to a three-phase fault on one of the 44kV feeders at Manitoulin TS. This also shows a relatively quick return to their pre-contingency values of the power output of the Project and of the voltages at Manitoulin TS and at Espanola Junction.

### 9.3 Conclusions from the Transient Stability Studies

The transient stability studies have shown that with only the 54MW Macleans Mountain Wind Project in-service, the post-contingency transient performance would be acceptable regardless of whether the Project were to be incorporated at 115kV on to circuit S2B, or at 44kV on to the 44kV busbar(s) at Manitoulin TS.

### 10. Fault Level Analysis

Other than the terminal breakers at Algoma TS and Martindale TS, there are no 115kV breakers associated with circuit S2B. Consequently, apart from the LV breakers at Manitoulin TS and Espanola TS, there are no existing breakers whose fault interrupting capability is expected to be exceeded. It was therefore decided not to perform detailed fault level studies for this Project and instead perform some approximate calculations.

The results from these calculations, for which the sub-transient reactance was assumed to be 20% based on the generator rating, are as follows:

<i>Approximate Three-Phase Fault Levels</i>			
<i>System Configuration &amp; Generation Development Option</i>	<i>Espanola Junction 115kV</i>	<i>Manitoulin TS</i>	
		<i>115kV</i>	<i>44kV</i>
Existing system, with circuit S2B radial from Martindale TS	390MVA	245MVA	145MVA <i>split</i> 180MVA <i>common</i>
With only the 54MW Macleans Mountain Project in-service			
1. With the Project incorporated at 115kV	520MVA	400MVA	190MVA <i>split</i>
2. With the Project incorporated at 44kV -			
2.1 Via two 44kV feeders	500MVA	365MVA	245MVA <i>split</i>
2.2 Via a single 44kV feeder	495MVA	360MVA	320MVA <i>common</i>

The 44kV breakers at Espanola TS are rated at 500MVA, while those at Manitoulin TS are rated at 1000MVA and these breakers would be adequate for the projected fault levels with the Macleans Mountain Project in-service.

### 11. IMO Requirements for connection to the IMO-controlled grid

The IMO's requirements for the connection of the 54MW Macleans Mountain Wind Project can be summarised as follows:

### 11.1 General Requirements

Since the existing 115kV transmission facilities (specifically circuit S2B) would be capable of accommodating the full, net output of this Project, no uprating would be required for its incorporation.

However, the generating facility is required to supply all of the local reactive power losses, up to the point of connection on to circuit S2B. These losses, at full output, are estimated to total approximately 9MVAR. These losses can be supplied either from the generating units or from local capacitor banks.

In addition, to compensate for the losses on the section of circuit S2B between Manitoulin TS and Espanola TS, and thereby improve the voltage profile along circuit S2B while also reducing the reactive power flow into circuit S2B at Martindale TS, the IMO requires the following shunt capacitors to be installed:

At Manitoulin TS (44kV)

- A single 5MVAR capacitor bank (rated at 44kV) on the 44kV busbar of transformer T3

An under-voltage/over-voltage switching scheme is also to be installed for the new capacitor bank to control its operation so that acceptable voltages can be maintained at Manitoulin TS over the entire output range that is expected from the new facility.

Should a subsequent need be identified, the IMO also reserves the right to require that either:

- additional reactive compensation (to a maximum of approximately 13MVAR) be installed on the Hydro One system, or
- the reactive power output of the generating facility be increased beyond the 9MVAR required to supply the local reactive power losses when the facility is operating at full output.

This would then meet the Project's obligation under the Market Rules to be able to provide a *net* reactive output totalling 18MVAR.

Furthermore, if the wind-turbine generators that it is proposed to install employ solid state voltage source (ac-dc-ac) converters, then the proponent is required to provide evidence to the IMO that the facilities will have no adverse impact, including sub-synchronous resonance, on the IMO-controlled grid or on any existing generating units.

### 11.2 Specific Requirements depending on the Connection Arrangement that is Adopted

- *Incorporation at 115kV*

There are no specific requirements for the 115kV incorporation arrangement

- *Incorporation at 44kV, via two dedicated 44kV feeders*

Terminate each 44kV feeder at Manitoulin TS via a motorised line disconnect switch and a 44kV breaker.

- *Incorporation at 44kV, via a single dedicated 44kV feeder*

Install four 44kV breakers at Manitoulin TS and terminate the single 44kV feeder via a motorised line disconnect switch on to the new bus-section formed by two of these new breakers.

## **12. Approximate Cost Estimates**

An attempt has been made to provide approximate cost estimates for the work that would need to be done for the various options under consideration.

These costs are based on available unit costs and do not make any allowance for site conditions. Neither do they take account of outage or construction constraints; associated work that may be triggered by the work identified; or other unforeseen difficulties.

It should also be noted that, for those situations that involve modifications to existing facilities, the extent of any associated upgrades to station buswork is unlikely to be known until a detailed review of the existing station facilities has been undertaken.

### **12.1 Connection of the 115kV incorporation circuit on to circuit S2B**

Estimated Cost ≈ \$½ to \$1 million

### **12.2 Install a 5MVar 44kV shunt capacitor bank at Manitoulin TS**

Estimated Cost ≈ \$½ to \$¾ million

### **12.3 Install two 44kV breakers at Manitoulin TS**

Estimated Cost ≈ \$¾ to \$1½ million

### **12.4 Install four 44kV breakers at Manitoulin TS**

Estimated Cost ≈ \$1½ to \$3 million

## **13. Identification of 'Sole Beneficiary'**

Section 9.1.3 of the Transmission System Code states:

*The cost of modifications and upgrades on specific network facilities that are triggered by and are for the sole benefit of the generator shall be borne by the generator.*

The IMO considers the following system modifications to be for the 'sole benefit' of the 54MW Macleans Mountain Wind Project:

- i. The connection of the 115kV incorporation circuit on to circuit S2B
- ii. The installation of the 5MVar shunt capacitor bank at Manitoulin TS
- iii. The installation of the 44kV breakers at Manitoulin TS

## **14. 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.

Northland Power Inc. and REPower Wind Corp. have 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.

***15. System Impact Assessment***

All of the analysis required to determine the potential impact that this Project would be expected to have on the IMO-controlled grid has been completed in this assessment.

A separate System Impact Assessment will therefore not be required for this Project.

***16. Notification of Approval of the Connection Proposal***

Subject to the completion of the Customer Impact Assessment by Hydro One Networks Inc. and the satisfactory resolution of any issues that may raised, it is proposed to issue a Notification of Approval to Connect for this Project

# ***TABLES***

<b>TABLE 1</b>		<b>Thermal Ratings for 115kV Circuit S2B for an Ambient temperature of 30°C</b>							
<b>Section</b>		<b>Length</b>	<b>Conductor</b>	<b>Maximum conductor operating temperature</b>	<b>Rating at 30°C ambient &amp; 127°C, or the sag temperature if lower ('Continuous')</b>				
<i>Ratings for a wind speed of 4km/hr</i>					Amps	<i>MVA rating at 121kV</i>			
Martindale TS	Copper Cliff Junction	12.2km	795kcmil	60°C	470A	99MVA			
Copper Cliff Junction	Creighton Junction	9.4km	477kcmil	77°C	510A	107MVA			
Creighton Junction	Vermillion Junction	12.6km		74°C	490A	103MVA			
Vermillion Junction	Ethel Lake Junction	3.4km		126°C	780A	163MVA			
Ethel Lake Junction	Drury Junction	5.9km		62°C	380A	80MVA			
Drury Junction	Turbine Junction	7.4km		119°C	750A	157MVA			
Turbine Junction	Domtar-Nairn Junction	11.9km		68°C	440A	92MVA			
Domtar-Nairn Junction	Espanola Junction	10.5km							
Espanola Junction	Eddy Tap Junction	1.6km							
Eddy Tap Junction	Espanola Junction A	0.2km							
Espanola Junction A	Espanola TS	0.1km							
Espanola TS	Baldwin Junction	1.9km					133°C	790A#	166MVA
Espanola Junction	Baldwin Junction	0.8km					150°C	790A#	166MVA
Baldwin Junction	Massey Junction	25.8km					62°C	380A	80MVA
Massey Junction	Cameron Falls Junction	6.4km					60°C	360A	75MVA
Cameron Falls Junction	Spanish TS	14.2km							
Spanish TS	Cutler Junction	5.9km							
Cutler Junction	Serpent River Junction	7.1km							
Serpent River Junction	Reiss Lime Junction	11.0km							
Reiss Lime Junction	Blind River Junction	3.4km							
Blind River Junction	Algoma TS	0.6km							
<i>Rating for a wind speed of 15km/hr - for transmission facilities within a 50km radius of the wind-turbine Project</i>									
Espanola Junction	Manitoulin TS	48.4km	477kcmil	60°C	530A*	111MVA			

Note: # Rating at 127°C  
 \* Rating at a wind speed of 15km/hr

The 'Continuous' rating quoted is only applicable for wind-turbine Projects

**WITH 115kV CIRCUIT S2B OPEN AT ESPANOLA TS**

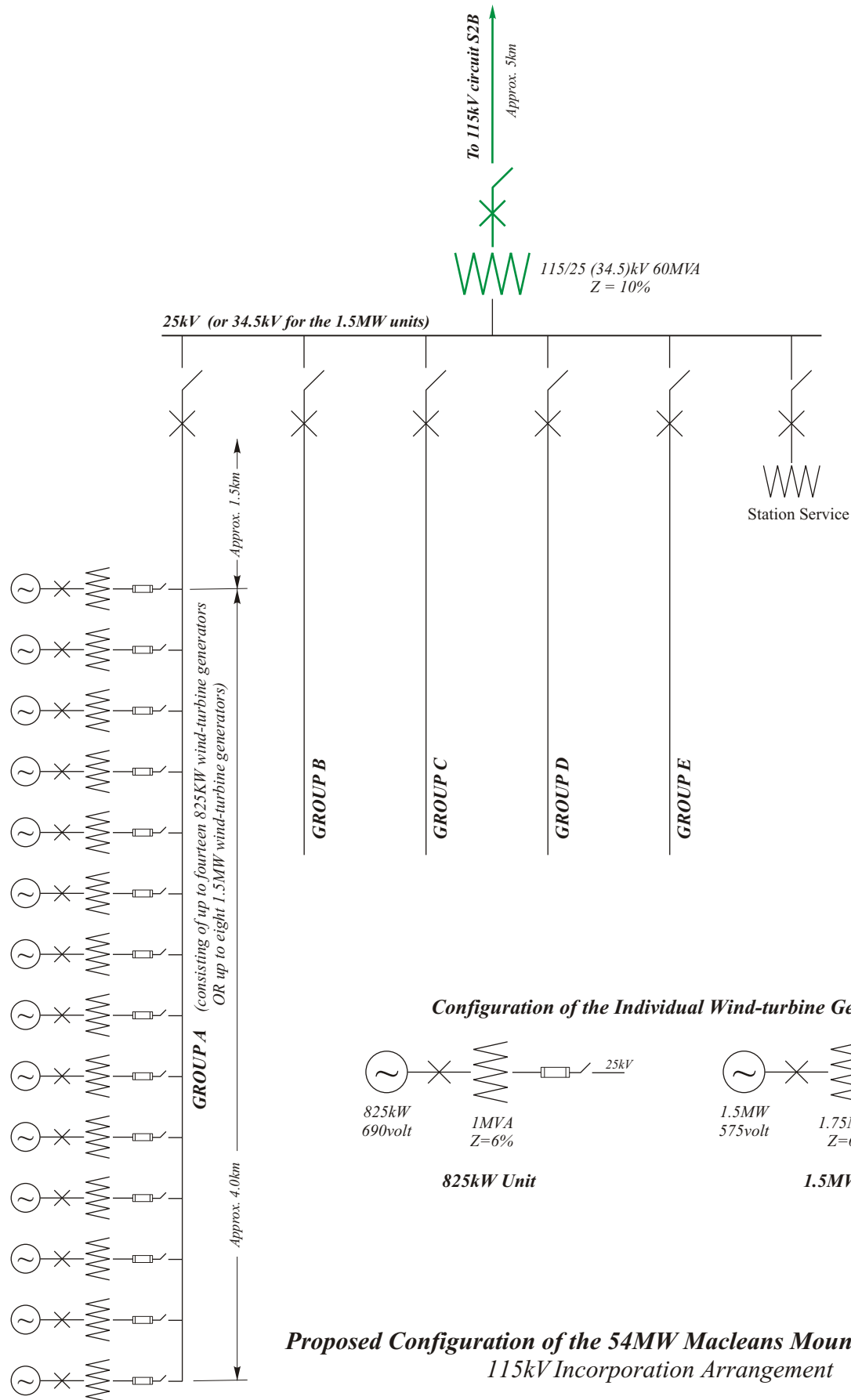
<b>TABLE 2</b>		<b>With only the 54MW Wind Project In-service: With Flow West</b>						<b>WITH NO COMPENSATION</b>	
<b>With circuit S2B OPEN at Espanola TS (Existing System): With a net demand of 26MW at Domtar</b>									
		<i>Algoma</i>	<i>Massey Junction</i>	<i>Baldwin Junction</i>	<i>Manitoulin TS</i>	<i>Espanola Junction</i>	<i>Domtar-Nairn Junction</i>	<i>Vermillion Junction</i>	<i>Martindale TS</i>
<i>Base Case:</i>	<i>Voltages:</i>	123.3kV	121.0kV	119.9kV	117.7kV	117.2kV	117.1kV	117.7kV	122.9kV
	<i>Flows: MW/MVAr</i>	30.0 / 4.7(E)	38.8 / 2.2(E)	35.7 / 1.0(E)	36.1 / -8.7(N)	36.1 / -8.7(E)	30.3 / -13.6(E)	26.5 / -15.0(E)	4.4 / 39.0(W)
54MW tripped	<i>Voltages:</i>	123.2kV	121.0kV	119.9kV	111.6kV	113.7kV	114.2kV	116.0kV	122.7kV
	<i>Flows: MW/MVAr</i>	30.0 / 4.7(E)	38.8 / 2.2(E)	35.7 / 1.0(E)	17.3 / 4.9(S)	17.3 / 4.8(W)	22.9 / 9.4(W)	26.6 / 10.6(W)	58.4 / 38.4(W)
	<i>Voltage Change</i>	-	-	-	-5.2%	-3.0%	-2.5%	-1.4%	-0.2%

<b>TABLE 2A</b>		<b>With only the 54MW Wind Project In-service: With Flow West</b>						<b>WITH COMPENSATION ADDED</b>	
<b>With circuit S2B OPEN at Espanola TS (Existing System): With a net demand of 26MW at Domtar</b>									
		<i>Algoma</i>	<i>Massey Junction</i>	<i>Baldwin Junction</i>	<i>Manitoulin TS</i>	<i>Espanola Junction</i>	<i>Domtar-Nairn Junction</i>	<i>Vermillion Junction</i>	<i>Martindale TS</i>
<i>Base Case:</i>	<i>Voltages:</i>	123.3kV	121.0kV	119.9kV	125.6kV	122.5kV	121.8kV	120.7kV	123.7kV
	<i>Flows: MW/MVAr</i>	30.0 / 4.7(E)	38.8 / 2.2(E)	35.7 / 1.0(E)	36.2 / 6.3(N)	36.1 / 6.3(E)	30.4 / 1.5(E)	26.6 / 0.4(E)	3.9 / 21.6(W)

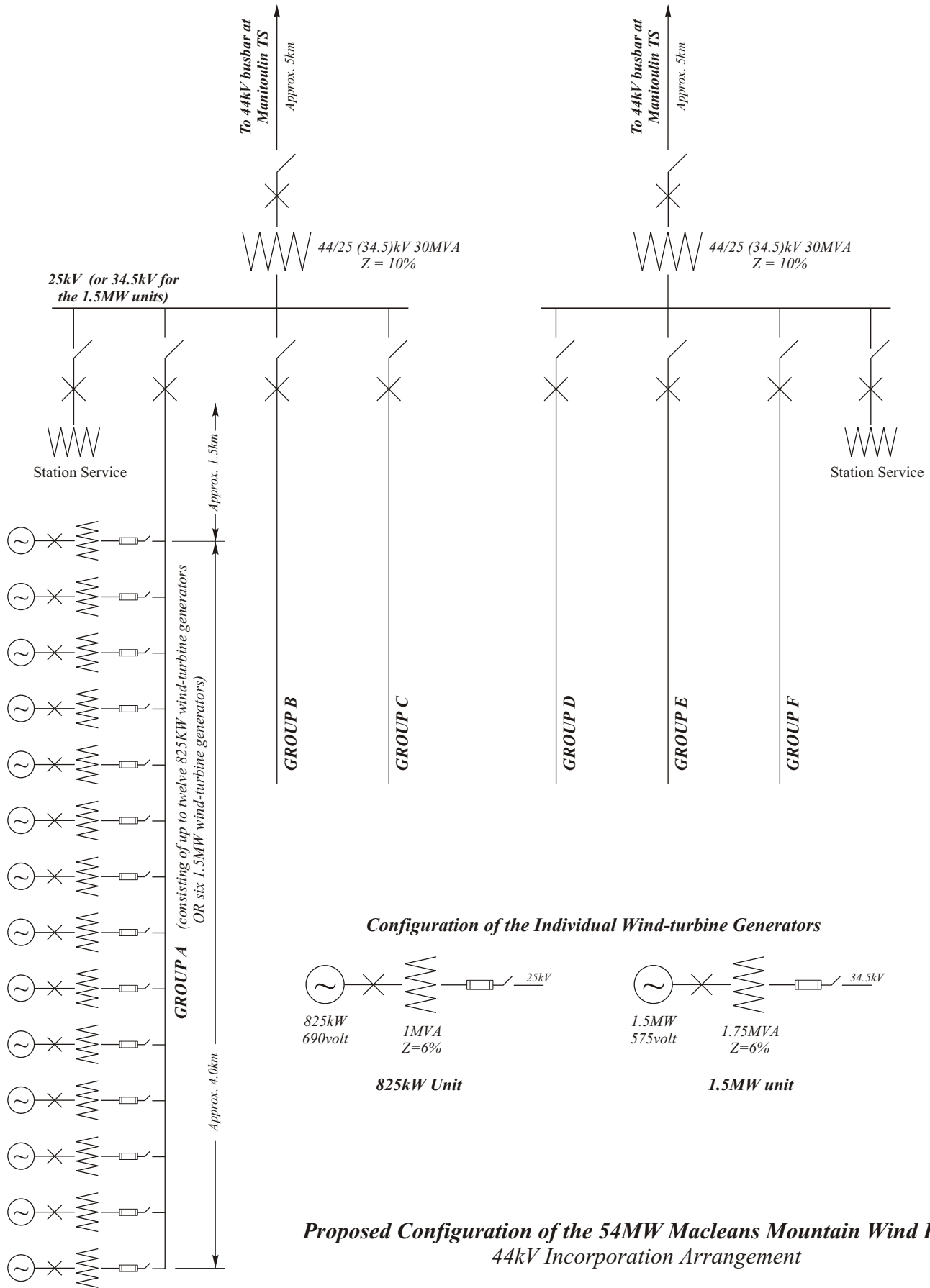
<b>TABLE 3</b>		<b>With only the 54MW Wind Project In-service: With Flow East of 600MW</b>						<b>WITH COMPENSATION ADDED</b>	
<b>With circuit S2B CLOSED at Espanola TS: With a net demand of 26MW at Domtar</b>									
		<i>Algoma</i>	<i>Massey Junction</i>	<i>Baldwin Junction</i>	<i>Manitoulin TS</i>	<i>Espanola Junction</i>	<i>Domtar-Nairn Junction</i>	<i>Vermillion Junction</i>	<i>Martindale TS</i>
<i>Base Case:</i>	<i>Voltages:</i>	123.5kV	121.3kV	120.5kV	124.5kV	120.5kV	119.8kV	118.8kV	122.3kV
	<i>Flows: MW/MVAr</i>	55.9 / -0.8(E)	63.7 / -7.0(E)	60.0 / -10.1(E)	36.1 / 11.1(N)	60.4 / 0.0(E)	54.4 / -5.5(E)	50.1 / -8.5(E)	19.3/-32.1(E)
54MW tripped	<i>Voltages:</i>	122.5kV	116.8kV	114.5kV	112.4kV	114.5kV	114.6kV	115.7kV	121.7kV
	<i>Flows: MW/MVAr</i>	79.5 / 13.5(E)	85.7 / 1.7(E)	81.1 / -4.6(E)	17.3 / 4.6(S)	28.1/-11.3(E)	22.5/-16.1(E)	18.7/-17.4(E)	12.3 / 42.3(W)
	<i>Voltage Change</i>	-0.8%	-3.7%	-5.0%	-9.7%	-5.0%	-4.3%	-2.6%	-0.5%

<b>TABLE 3A</b>		<b>With only the 54MW Wind Project In-service: With Flow East of 600MW</b>						<b>WITH COMPENSATION ADDED</b>	
<b>With circuit S2B CLOSED at Espanola TS:</b>		<b>With a net demand of 0MW at Domtar</b>							
		<i>Algoma</i>	<i>Massey Junction</i>	<i>Baldwin Junction</i>	<i>Manitoulin TS</i>	<i>Espanola Junction</i>	<i>Domtar-Nairn Junction</i>	<i>Vermillion Junction</i>	<i>Martindale TS</i>
<i>Base Case:</i>	<i>Voltages:</i>	123.7kV	122.0kV	121.3kV	124.9kV	121.3kV	120.5kV	119.2kV	122.7kV
	<i>Flows: MW/MVar</i>	44.3/-1.3 (E)	52.6/-5.5 (E)	49.2/-7.6 (E)	36.2 / 9.2 (N)	74.6/-0.6 (E)	69.5/-6.8 (E)	63.8/-11.1 (E)	32.6/-35.8 (E)

# ***DIAGRAMS***



**Proposed Configuration of the 54MW Macleans Mountain Wind Project  
115kV Incorporation Arrangement**



**Proposed Configuration of the 54MW Macleans Mountain Wind Project  
44kV Incorporation Arrangement**

To Espanola TS

115kV Circuit S2B

To Manitoulin Island TS

3-phase isolating device  
at point of connection

115kV transmission line: approximately 5km in length  
Equipped with 336.4kcmil conductors

Circuit Switcher or breaker  
(with duplicated transfer/remote trip signals)

115/25 (34.5)kV 60MVA

25kV (or 34.5kV for  
the 1.5MW units)

Wind-turbine generator Group 1

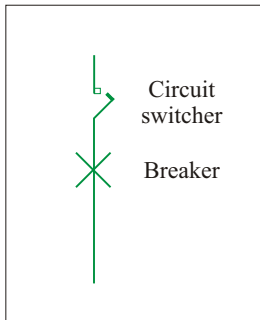
Wind-turbine generator Group 2

Wind-turbine generator Group 3

Wind-turbine generator Group 4

Wind-turbine generator Group 5

Station  
Service



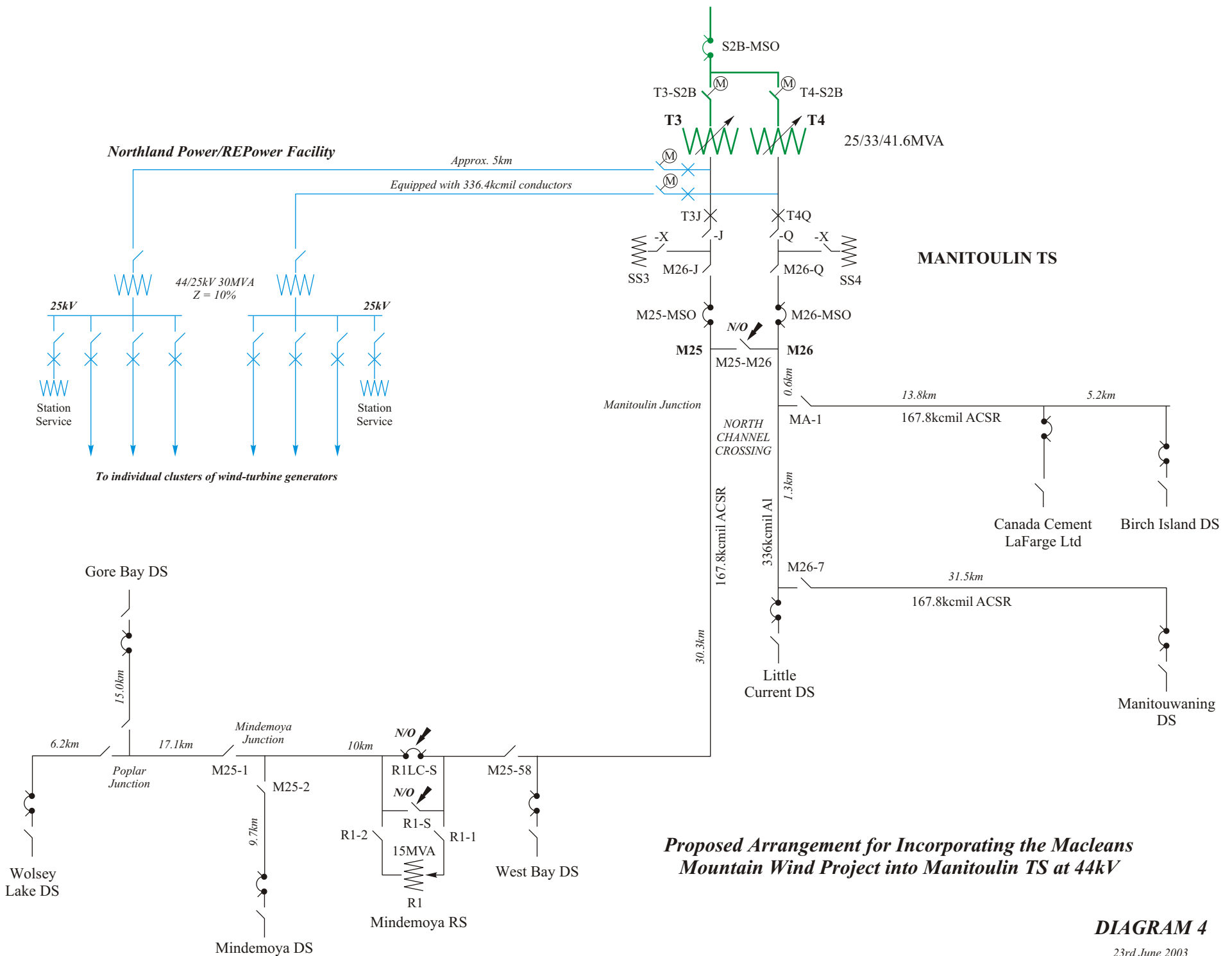
If duplicated transfer/remote trip signals are not provided, then one option would be to install a circuit switcher/circuit breaker arrangement.

This would address breaker failure and isolation concerns

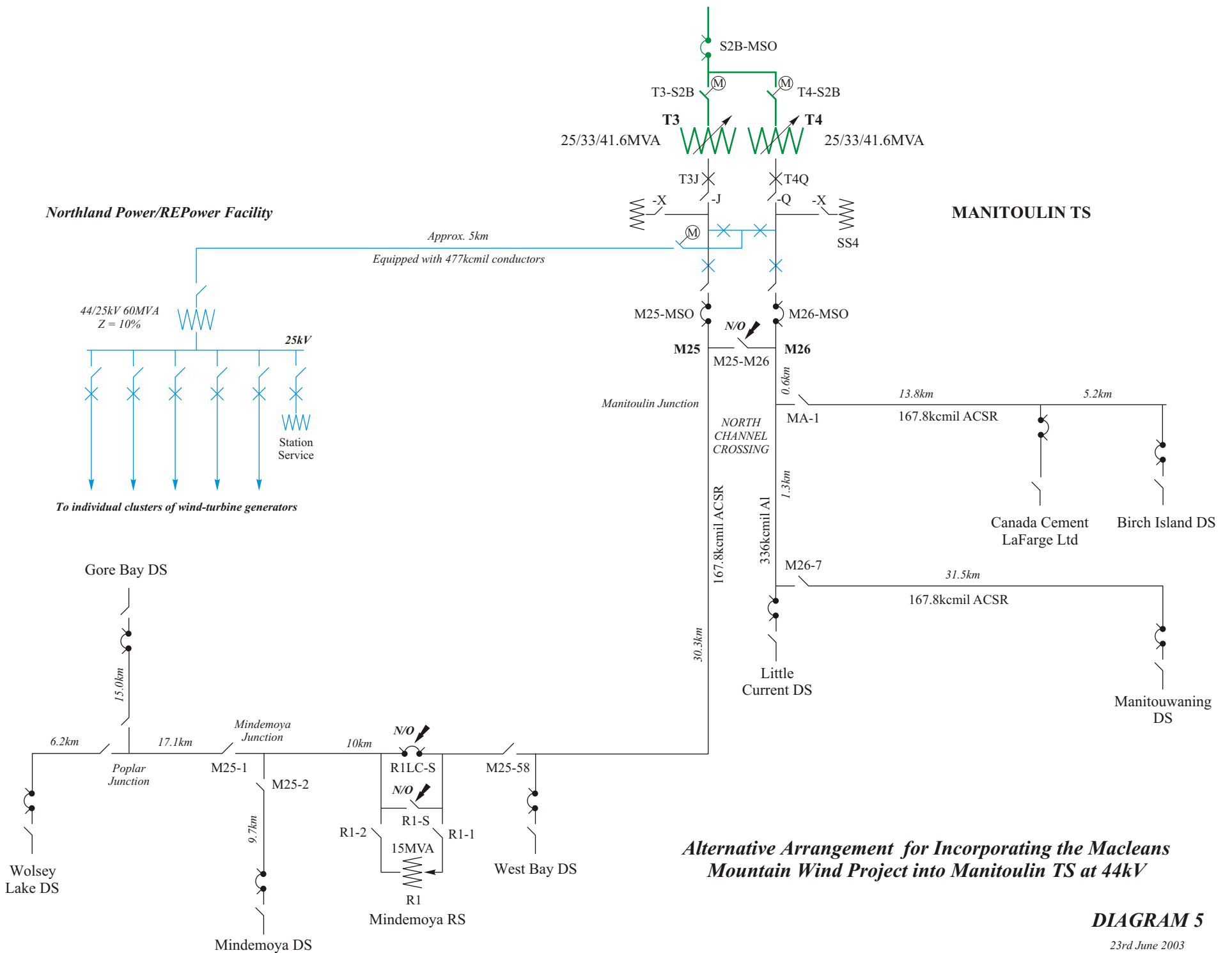
**Proposed Incorporation Arrangement  
for the 54MW Macleans Mountain Wind Project**

**DIAGRAM 3**

31st May 2003

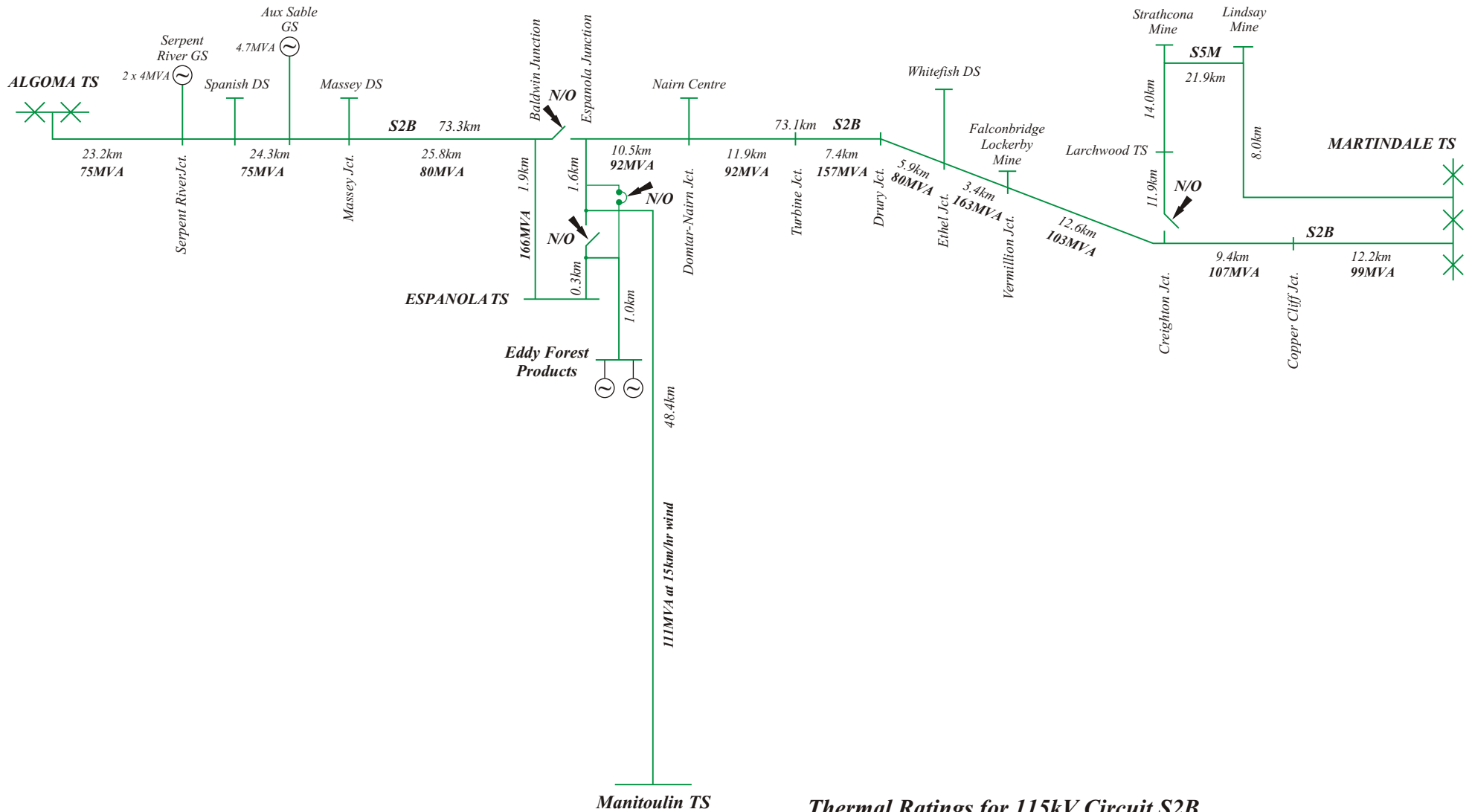


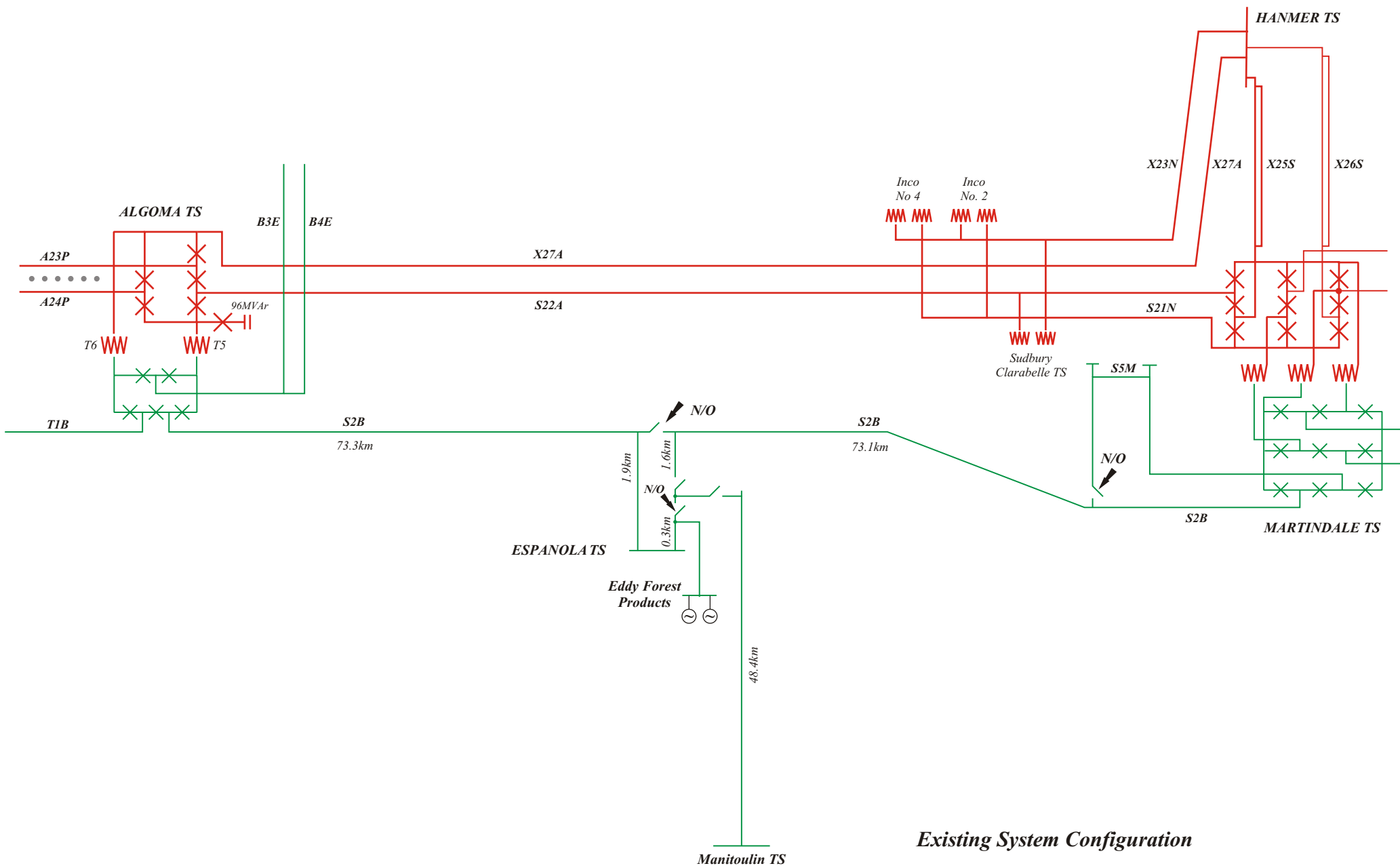
**Proposed Arrangement for Incorporating the Macleans Mountain Wind Project into Manitoulin TS at 44kV**



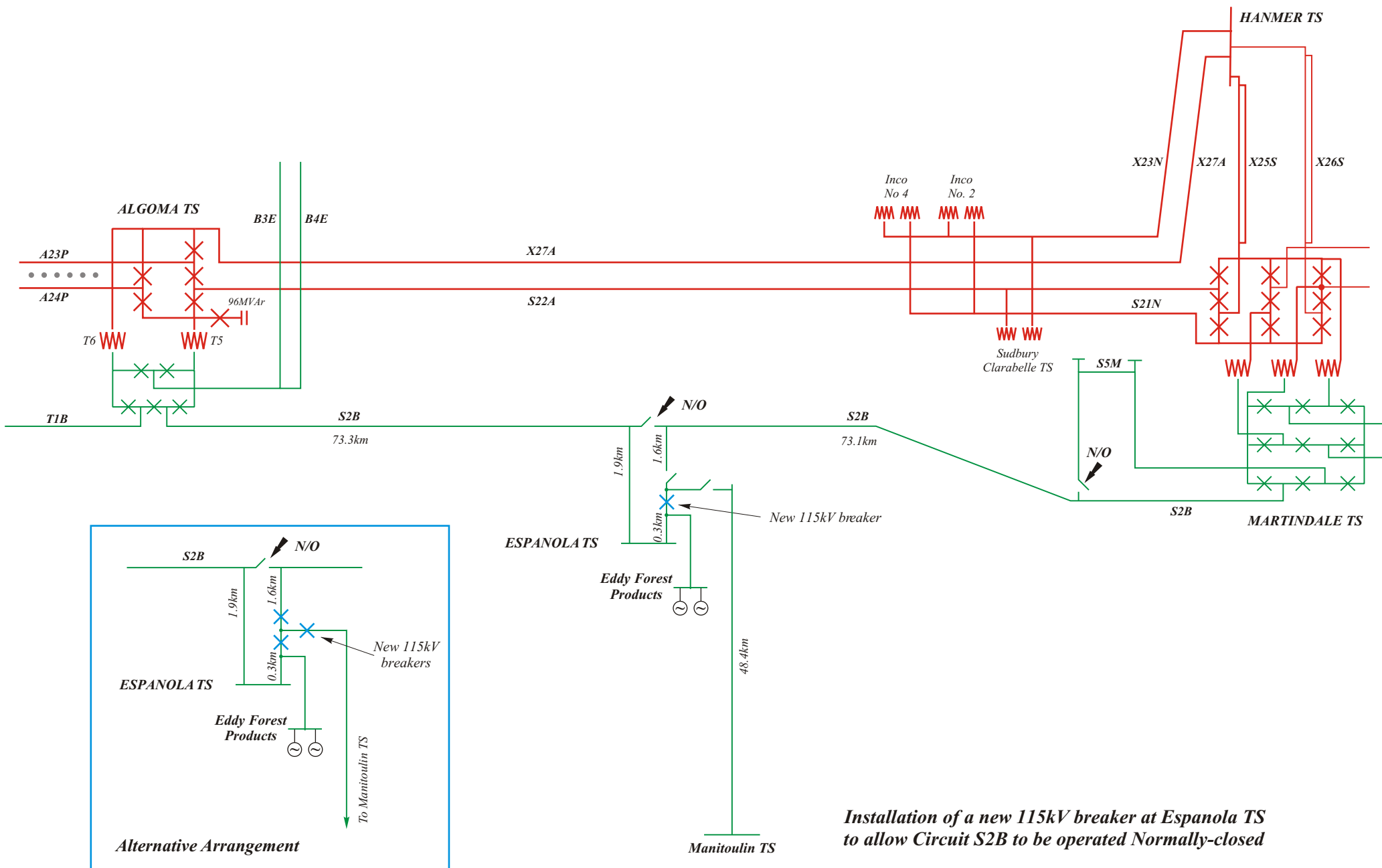
**DIAGRAM 5**

23rd June 2003



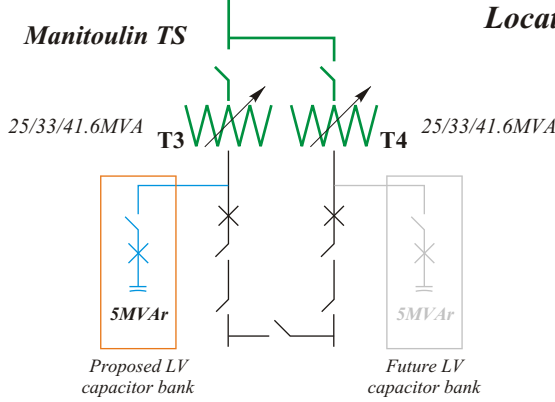
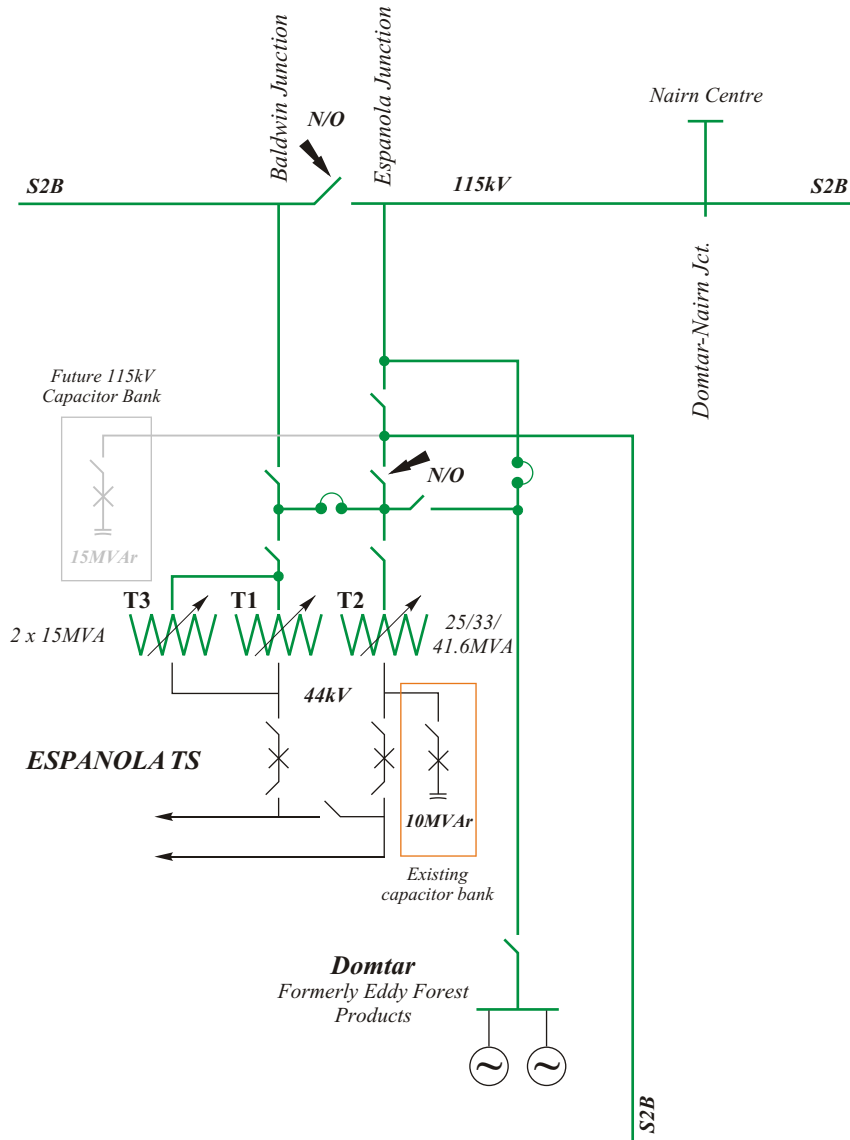


*Existing System Configuration*



**DIAGRAM 8**

23rd June 2003



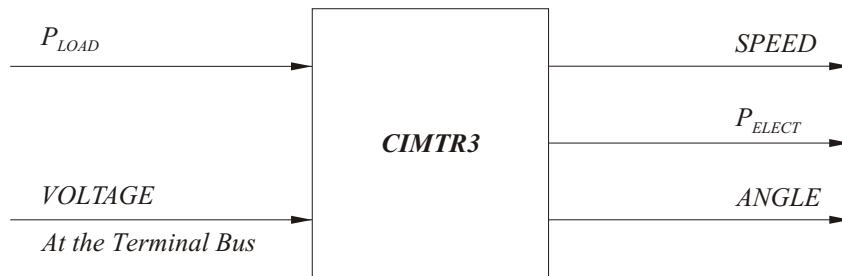
**Location & Rating of the Proposed Reactive Compensation**

**DIAGRAM 9**

25th June 2003

### CIMTR3

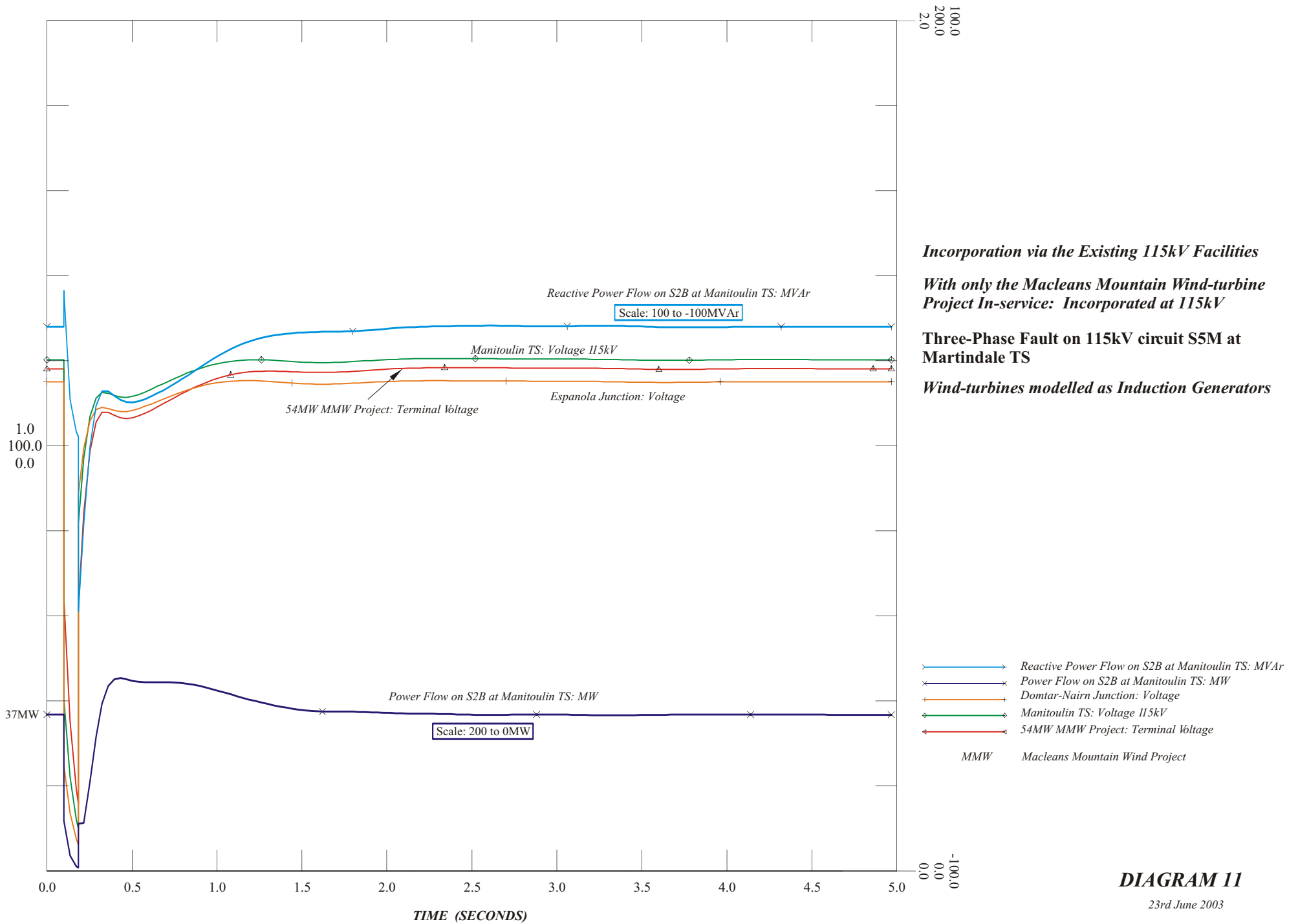
#### *Induction Generator Model Used in the Assessment*



The machines have been assumed to be single-cage and  $X'$  has therefore been set to  $Z_{SOURCE}$

PARAMETER	DESCRIPTION	VALUE
$T'$	Transient Open-Circuit Time Constant	0.840 sec
$T''$	Sub-transient Open-Circuit Time Constant	0.00 sec
$H$	Inertia Constant	4.40 kW-sec/kVA
$X$	Synchronous Reactance	11.0 pu
$X'$	Transient Reactance	0.35 pu
$X''$	Sub-transient Reactance	0.0 pu
$X_1$	Stator Leakage Reactance	0.27 pu
$E_1$	Saturation Factors	1.00
$S(E_1)$		0.1
$E_2$		1.2
$S(E_2)$		0.5
$O.$	Switch	0.0
$SYN-POW$	Mechanical power at synchronising speed Only used for starting	0.1

**DIAGRAM 10**



100.0  
200.0  
2.0

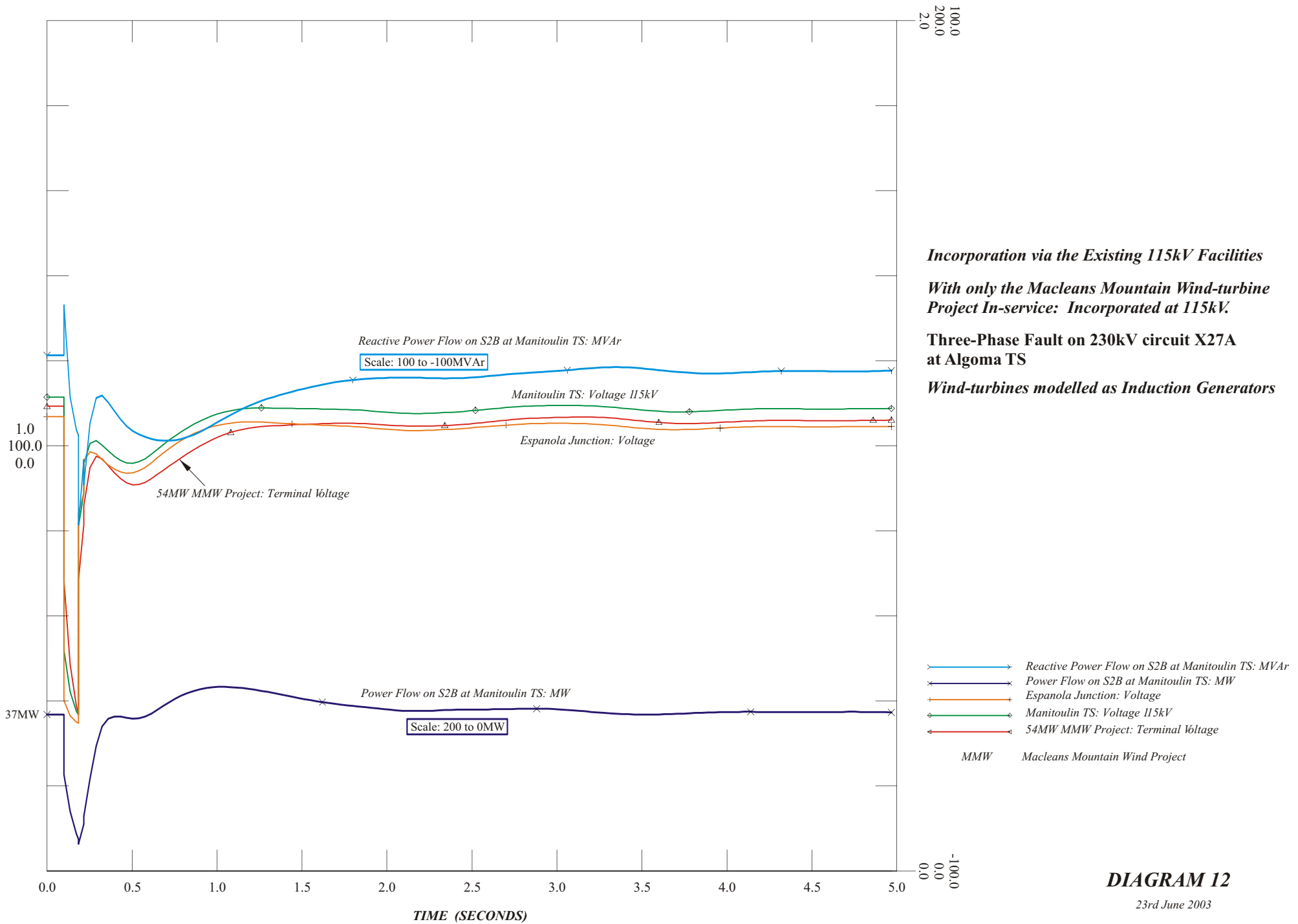
x Reactive Power Flow on S2B at Manitoulin TS: MVar  
 x Power Flow on S2B at Manitoulin TS: MW  
 + Domtar-Nairn Junction: Voltage  
 ◆ Manitoulin TS: Voltage 115kV  
 ◀ 54MW MMW Project: Terminal Voltage  
 MMW Macleans Mountain Wind Project

-100.0  
0.0  
0.0

**Incorporation via the Existing 115kV Facilities**  
**With only the Macleans Mountain Wind-turbine Project In-service: Incorporated at 115kV**  
**Three-Phase Fault on 115kV circuit S5M at Martindale TS**  
**Wind-turbines modelled as Induction Generators**

**DIAGRAM 11**

23rd June 2003



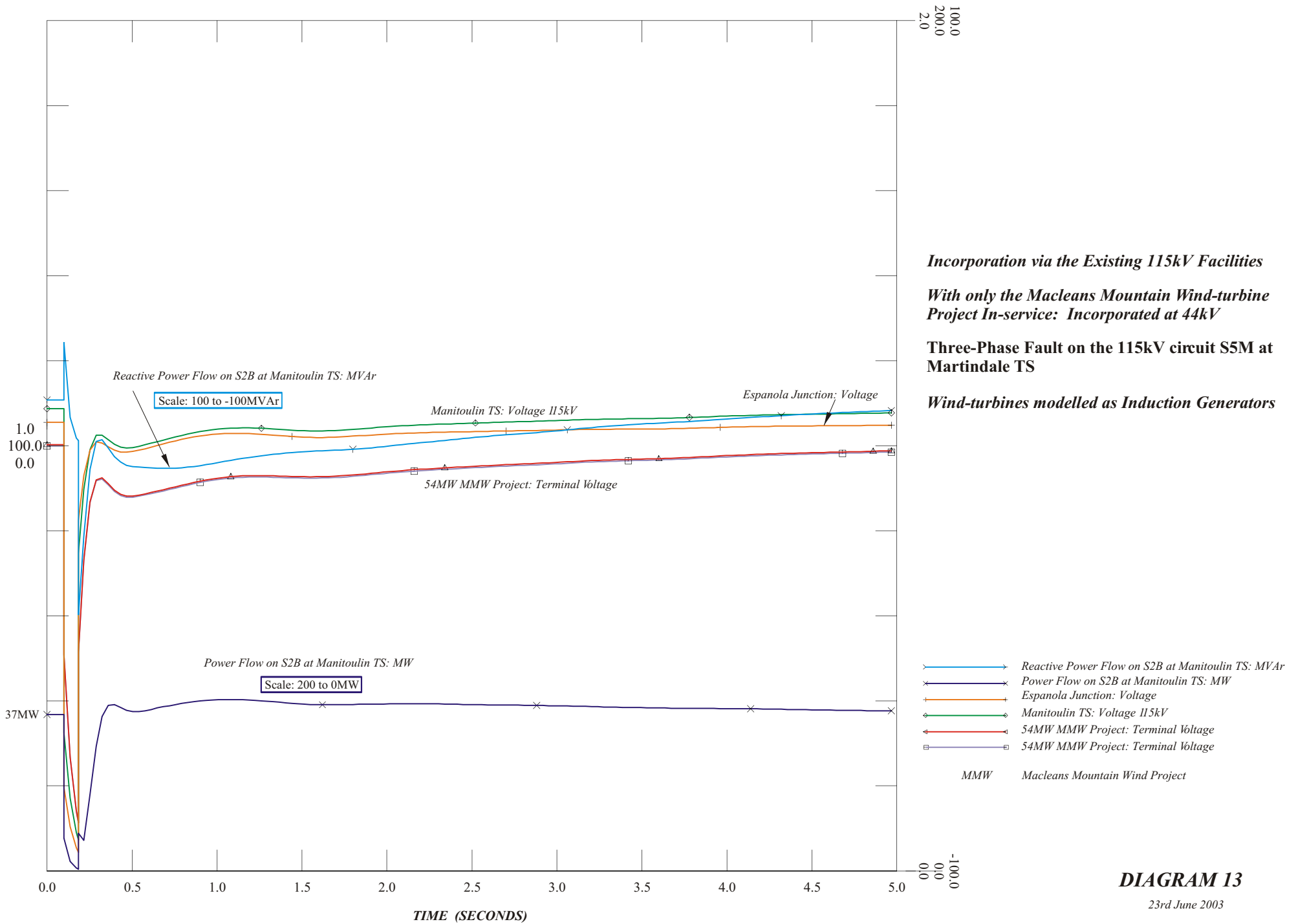
*Incorporation via the Existing 115kV Facilities*

*With only the Macleans Mountain Wind-turbine Project In-service: Incorporated at 115kV.*

**Three-Phase Fault on 230kV circuit X27A at Algoma TS**

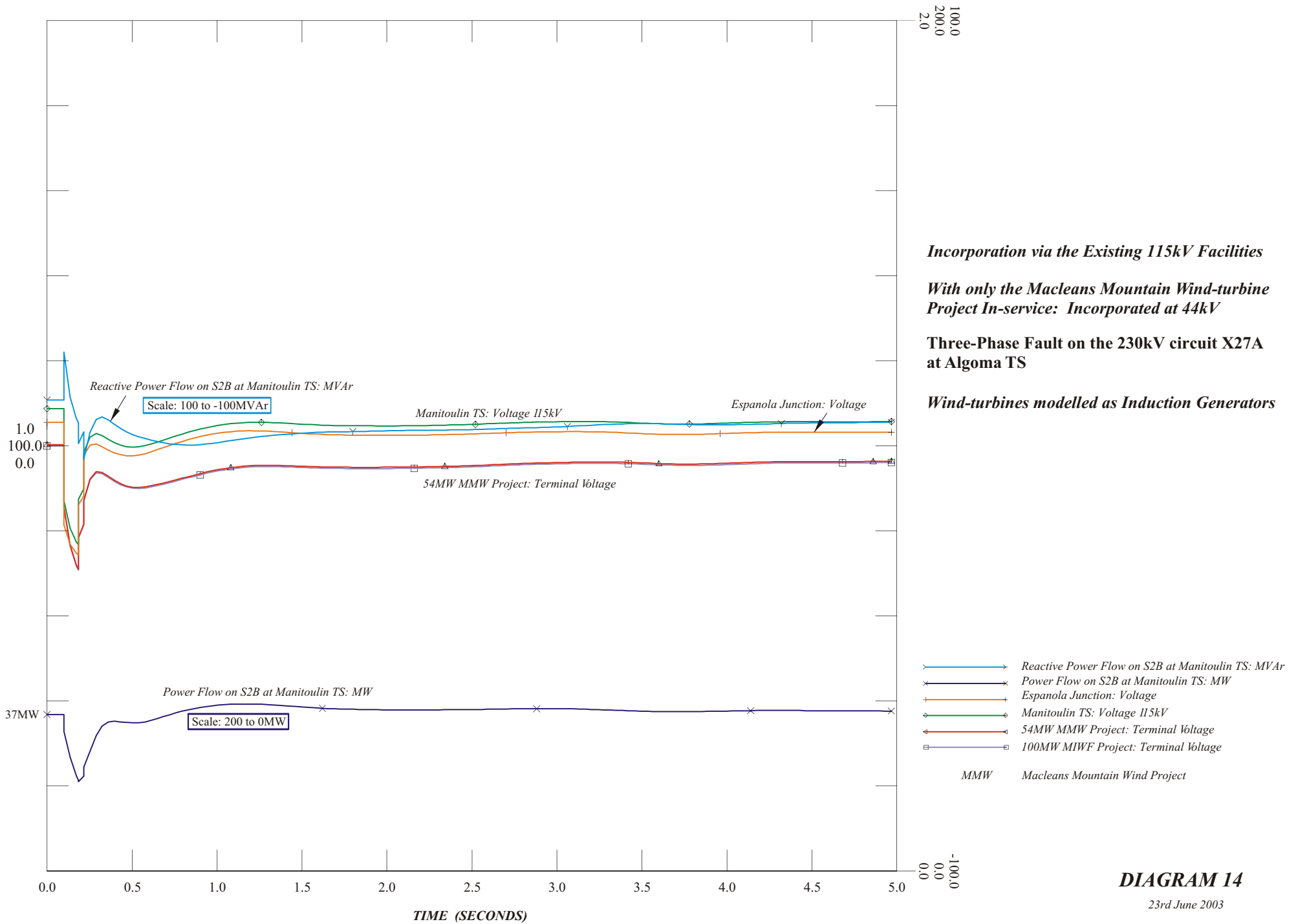
*Wind-turbines modelled as Induction Generators*

**DIAGRAM 12**  
 23rd June 2003



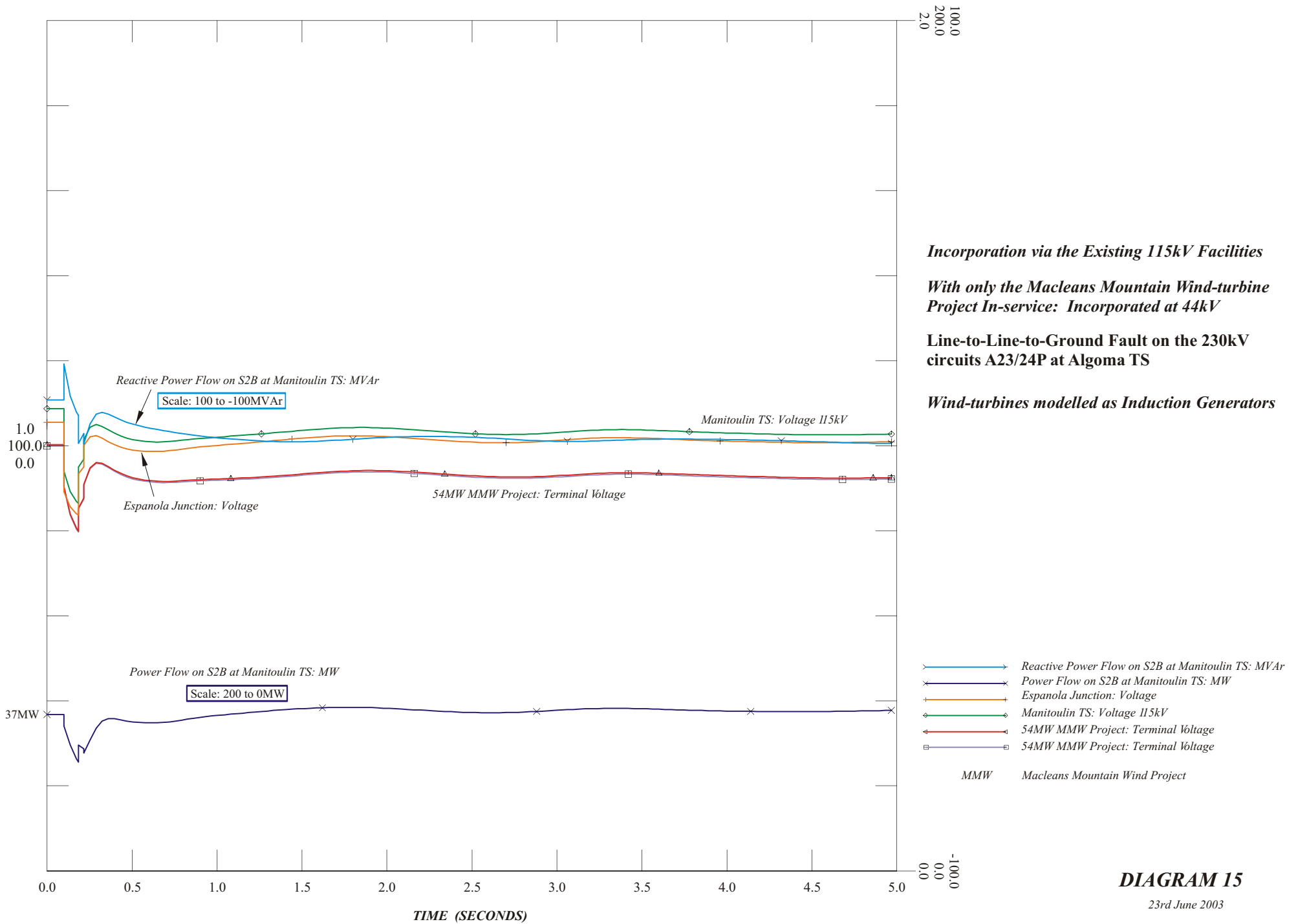
**DIAGRAM 13**

23rd June 2003



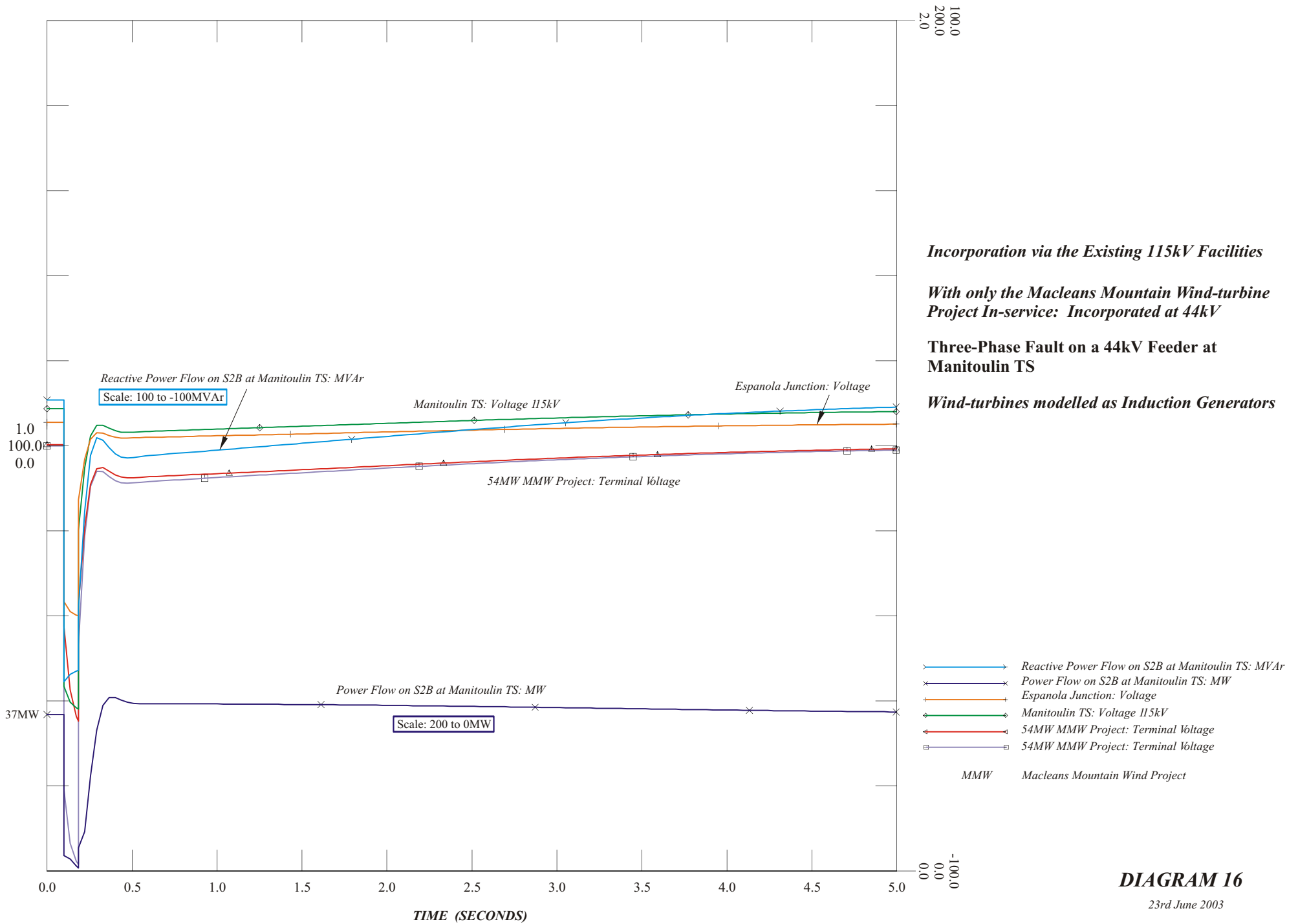
**DIAGRAM 14**

23rd June 2003



**DIAGRAM 15**

23rd June 2003



*Incorporation via the Existing 115kV Facilities*

*With only the Macleans Mountain Wind-turbine Project In-service: Incorporated at 44kV*

**Three-Phase Fault on a 44kV Feeder at Manitoulin TS**

**Wind-turbines modelled as Induction Generators**

**DIAGRAM 16**

23rd June 2003