

# **CONNECTION ASSESSMENT & APPROVAL PROCESS**

## ***PRELIMINARY ASSESSMENT REPORT***

*For Phase I of the Proposed Development near Tilbury by AGSTAR Power Inc.*

*CAA ID No. 2000-023:*

*Phase I 102.8MVA - 115kV connection*

*Phase II 605.6MVA - 230kV connection*

***Long Term Forecasts & Assessments Department***

***FINAL Version***

*Date: 28<sup>th</sup> May 2001*

## ***Preliminary Assessment Report***

*For Phase I of the Proposed Development near Tilbury by AGSTAR Power Inc.*

### 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, on a preliminary basis, whether the connection applicant's proposed connection with the IMO-controlled grid would have an adverse impact on the reliability of the IMO-controlled grid and whether a System Impact Assessment of the proposed connection should be conducted under Chapter 4, Section 6 of the Market Rules. 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, Hydro One 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 which the IMO may have to the connection applicant in respect of this report is governed by Chapter 1, Section 13 of the Market Rules. In the event that the IMO provides a draft of this report to the connection applicant, you must be aware that the IMO may revise drafts of this report at any time in its sole discretion without notice to you. Although the IMO will use its best efforts to advise you of any such changes, it is the responsibility of the connection applicant to ensure that it is using the most recent version of this report. The IMO expects the connection applicant and affected transmitter to discuss the connection project with any persons located in the vicinity of the project and to advise the IMO of any concerns they might express about the impact of the project on system reliability.

#### ***Hydro One***

### Special Notes and Limitations of Study Results

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

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The short circuit and thermal loading levels have been computed based on the information provided by the connection proponent at the time of the study. These levels may be higher or lower if the connection information changes as a result of, but not limited to, subsequent design modifications or when more accurate test measurement data is available.

This study does not assess the short circuit or thermal loading impact of the proposed connection on facilities owned by other load and generation (including OPGI) customers.

In this preliminary feasibility study, short circuit adequacy is assessed only for Hydro One breakers and does not include other Hydro One facilities. The short circuit results are only for the purpose of assessing the capabilities of existing Hydro One breakers and identifying upgrades required to incorporate the proposed connection. These results should not be used in the design and engineering of new facilities for the proposed connection. The necessary data will be provided by Hydro One and discussed with the connection proponent upon request.

The ampacity rating 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 Phase I of the proposed AGSTAR Power Inc. Project near Tilbury***

#### ***EXECUTIVE SUMMARY***

The proposed AGSTAR Power Inc. Project near Tilbury is to be developed in two Phases:

*Phase I* is to consist of a single 102.8MVA steam-turbine generating unit, connected to the 115kV system. The scheduled in-service date for this initial unit is March 2002.

*Phase II* is to consist of two identical halves; with each half composed of a 204MVA gas-turbine unit and a 102.8MVA steam-turbine unit.

The scheduled in-service dates are October 2003 for the first pair of units, and November 2003 for the second pair.

A 230/115kV auto-transformer is also to be installed at the start of Phase II to interconnect the two Phases of the Project.

This Preliminary Assessment has examined the impact of connecting the single steam-turbine unit in Phase I of the AGSTAR Project on the transmission system in the south-western area of the IMO-controlled grid.

Although Phase II of the AGSTAR Project will be the subject of a separate Preliminary Assessment, a limited number of preliminary studies were conducted on the complete development (Phases I & II) to determine the general viability of the proposal.

These studies confirmed the benefit of connecting part of the development at 115kV and providing a 230/115kV interconnection between the two Phases, particularly during contingency conditions on the 230kV system, or whenever high transfers are being made eastwards.

#### ***Incorporation Arrangement***

The Assessment examined the impact of incorporating the single steam-turbine unit into the 115kV system via a single connection on to circuit K2Z. No adverse impact was identified.

Incorporation of Phase I of the AGSTAR development via a single 115kV connection to circuit K2Z would therefore be acceptable to the IMO.

However, during discussions with Hydro One, the IMO was informed of the possibility of changes being made to the configuration of Tilbury TS. Although no formal application for an Assessment has yet been made to the IMO, the possible impact of this change on the connection arrangement for the AGSTAR Project was reviewed.

Should these changes at Tilbury TS be made, then it could become necessary to establish a dual connection to the 115kV system. Furthermore, the preliminary studies on the complete AGSTAR development indicated that if a dual connection to the 115kV system were to be established as part of the Phase II work, this could avoid possible overloading of the 115kV system, under contingency conditions on the 230kV system. This will be pursued in the Preliminary Assessment for Phase II.

*The IMO has therefore recommended that the design of the connection arrangement for Phase I should incorporate provisions for the addition of a second 115kV connection to circuit K6Z.*

*Furthermore, the IMO has recommended that, if possible, the incorporation arrangement should include a 115kV circuit breaker for unit synchronisation since this could then form part of the 'ring' busbar. This breaker should also be capable of withstanding a 2 pu voltage across its open terminals.*

*The IMO recommends that the connection from the AGSTAR facility to circuit K2Z should be equipped with conductors having a cross-section greater than 477kcmil, so that the connection does not become the limiting component. In addition the impedance of the step-up transformer should be less than 14% on 100MVA<sub>base</sub> and 118kV<sub>base</sub> to ensure that the unit is capable of providing the required reactive power output throughout the defined operating range. [Market Rule - Reference 2 of Appendix 4.2]*

#### *Impact on Fault Levels*

Since the fault level analysis performed by Hydro One for their Feasibility Study of the AGRO Sun Project (the former name of the AGSTAR Project) showed no fault level concerns for the 600MVA development with a 230/115kV auto-transformer connection, it was decided that additional studies were not warranted for the Phase I development. A full series of fault level studies will be performed for the Preliminary Assessment and System Impact Assessment for the complete development.

#### *Impact on Transfer Capabilities*

Although the Phase I development would contribute to the general congestion within the Sarnia-Windsor area and on the Negative BLIP Interface, it will not reduce the transfer capabilities of any of the transmission Interfaces.

#### *Transient Stability*

Transient stability studies were performed for the Phase I development with both a single and a dual connection to the local 115kV system. In all cases stability was maintained with a positively damped response.

However, since the response of the exciter and power system stabiliser combination appears to be less than optimum, resulting in an unusual transient response, as well as high transient over-voltages at the terminals of the AGSTAR unit (10% for normally-cleared faults and 13% for the condition with delayed-clearance), the IMO will require the studies to be repeated once more definite data become available.

This work will need to be completed prior to the 'Facilities Registration' process.

#### *Budgetary Cost Estimate & Identification of 'Sole Beneficiary'*

An approximate budgetary cost estimate for the actual connection of the incorporation circuit from the AGSTAR facility on to circuit K2Z has been provided. However, this figure should be used with extreme caution in the absence of any review of the site conditions or of the circuit configuration at the proposed tapping point.

AGSTAR Power Inc. would be the 'sole beneficiary' of this work.

#### *Qualification for an Expedited CAA*

Since it has been concluded that incorporating Phase I of the AGSTAR Project into the local 115kV system will have no adverse impact on the IMO-controlled grid, no further analysis is required (other than the additional transient stability studies referred to above).

It has therefore been determined that this application can be addressed under the Expedited CAA Process, and that a System Impact Assessment can be foregone.

However, a System Impact Assessment will still be performed for the complete development (Phases I & II).

#### *Notification of Approval of the Connection Proposal*

***Subject to the requirement for the transient analysis to be repeated once more accurate data become available and for the IMO to be satisfied with the results, it is recommended that a Notification of Approval for the Connection be issued for Phase I of the AGSTAR Project.***

## ***Proposed Development near Tilbury by AGSTAR Power Inc.,***

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

AGSTAR Power Inc. is proposing to construct a 716MVA generating facility just west of Tilbury in south-western Ontario. The new generating facility is to be connected to both the local 115kV and 230kV systems, with a 230/115kV auto-transformer connecting the two parts of the new development.

The facility is to be developed in two Phases. Phase I is to consist of a single 102.8MVA steam-turbine unit connected to the 115kV circuit K2Z, between Kent TS and Lauzon TS. The scheduled in-service date for this initial unit is March 2002.

Phase II is to consist of two identical halves, each composed of a 204MVA gas-turbine unit and a 102.8MVA steam turbine unit. The four generating units in Phase II are to be connected to the 230kV circuits C21J & C22J, between Chatham TS and Keith TS. The scheduled in-service dates are October 2003 for the first pair of units, and November 2003 for the second pair. The 230/115kV auto-transformer connecting the two phases of the Project is to be installed at the start of Phase II.

Diagram 1 shows the approximate location of the proposed development and the routes of the existing 115kV & 230kV transmission lines in the area. 115kV circuit K2Z is approximately 0.5km north of the proposed site, while the 230kV right-of-way of circuits C21J, C22J, C23Z & C24Z is approximately 1.5km south of the site. The site is approximately 2km west of Tilbury.

Diagram 2 shows the proposed configuration of the new generating units and their associated switching facilities, while Diagram 3 shows the relationship between the new Project and the existing transmission facilities in the area.

### ***2. Comments on the Proposed Incorporation Arrangement for Phases I & II***

It is proposed to incorporate Phase II of the AGSTAR Project via the 230kV right-of-way that runs approximately 1.5km south of the site of the AGSTAR Project. Two double-circuit 230kV transmission lines occupy this right-of-way. Circuits C21J & C23Z are located on the northern-most line, while circuits C22J & C24Z are located on the southern line.

Over the section between Chatham TS and Sandwich Junction the circuits on the northern line are equipped with 1192.5kcmil conductors, while those on the southern line are equipped with 795kcmil conductors. At Sandwich Junction, the two lines diverge, with one double-circuit line going to Lauzon TS (circuits C23Z & C24Z) and the other double-circuit line continuing on to Keith TS (circuits C21J & C22J). Over these sections, circuits C23Z & C24Z are equipped with 1192.5kcmil conductors, while circuits C21J & C22J are equipped with 795kcmil conductors.

#### *Generation Projects that have been approved for connection to the IMO-controlled grid*

In December 2000, Notifications of Approval to Connect to the IMO-controlled grid were issued to the following Projects:

- The AES Project near Leamington. This Project, with a combined capacity of 625MVA, is scheduled to be in-service during Q4 of 2003.

This Project is to be incorporated into the 230kV circuits C23Z & C24Z, between Chatham TS and Lauzon TS.

- The ATCO project at Keith TS. This Project, with a combined capacity of 680MVA, is scheduled to be in-service during Q2 of 2003.

This Project is to be incorporated into both the 230kV & 115kV busbars at Keith TS. Any excess output over the local load in the Windsor area that is supplied from Keith TS will appear on the 230kV circuits C21J & C22J, between Chatham TS and Keith TS.

### *Selection of 230kV Circuits for the Incorporation of the AGSTAR Project*

The System Impact Assessment for the initial Sarnia-Windsor 'cluster' concluded that circuits C23Z & C24Z would be expected to be fully utilised by the AES Project. That would therefore leave only circuits C21J & C22J available for the incorporation of the AGSTAR Project.

Preliminary analysis showed that with the AGSTAR Project incorporated only at 230kV into circuits C21J & C22J there would be occasions, particularly during periods with heavy transfers eastwards, when these circuits could be overloaded. In general the problem was found to be more acute for circuit C22J because it is equipped with the smaller conductors.

Consideration was then given to reducing the transfers from the AGSTAR Project to the 230kV system by providing a direct connection for part of the development to the local 115kV system.

The arrangement shown in Diagram 2, with one unit connected directly to the 115kV system and with a 230/115kV auto-transformer connecting the 230kV and 115kV busbars at the AGSTAR facility proved to be the optimum arrangement. With this arrangement, the 230/115kV auto-transformer would provide a 'float' for any fluctuation in demand on the 115kV system, while also providing a back-up supply to the 115kV system in the event that the 115kV-connected unit should trip.

Since the section of circuit K2Z between Woodslee Junction and Kent Junction has a summer-time rating of approximately 120MVA, a nominal rating of 125MVA for the 230/115kV auto-transformer was proposed. This would be sufficient to allow for maximum transfers from the 230kV busbar to the 115kV system, during those periods when the 115kV-connected generator is out-of-service. In addition, during those periods when circuit K2Z is out-of-service, a 125MVA-rated auto-transformer would allow the output from the 115kV-connected unit to be transferred to the 230kV system (assuming the transfers on the 230kV system are at a level that would permit the full output of the AGSTAR Project to be accommodated).

### *115kV Incorporation Arrangement*

As shown in Diagram 3, it is normal practice to operate with the section of circuit K6Z, between Belle River Junction and Tilbury Junction, out-of-service.

This arrangement has been adopted because of the absence of a circuit breaker at Tilbury Junction between the terminals of circuits K2Z & K6Z. With both circuits in-service and with no circuit breaker at Tilbury Junction, any faults involving either 115kV circuit would result in a supply disruption to the major load at Kingsville TS. Operating with only one circuit in-service between Tilbury Junction and the tapping point of the connections to Kingsville TS means that contingencies involving one circuit do not result in the automatic isolation of the companion circuit and therefore reduces the exposure of Kingsville TS to possible supply disruptions.

Since circuit K2Z is equipped with 477kcmil conductors over the section between Belle River Junction & Tilbury Junction, while circuit K6Z is only equipped with 266.8kcmil conductors over the same section, circuit K2Z is the more robust of the two circuits. It is therefore the circuit that is normally in-service. Circuit K2Z has a summer-time rating of approximately 122MVA compared to 105MVA (at 124kV) for circuit K6Z.

AGSTAR Power Inc. has therefore proposed that the generating unit in Phase I of their Project be incorporated via a single 115kV connection to circuit K2Z, which is located on the northern boundary of their property. The proposed incorporation arrangement is shown in Diagram 2, and this arrangement, with either an HV or an LV breaker used for synchronising the generating unit, would be acceptable to the IMO.

Since circuit K2Z is equipped with 477kcmil conductors and the output from the AGSTAR Project will supply both the load at Tilbury (eastwards) and the load at Kingsville (westwards) it is recommended that the incorporation circuit be equipped with conductors having a cross-section greater than 477kcmil, so that the incorporation circuit does not become the limiting element.

While it would have been preferred to use both 115kV circuits, K2Z & K6Z, for the incorporation of the AGSTAR Project into the 115kV system, this would require the installation of an additional circuit breaker at the AGSTAR facility, together with the construction of an additional 115kV connection to circuit K6Z. Alternative 1 in Diagram 4 shows one arrangement that would allow the AGSTAR Project to be connected to both circuits.

However, should AGSTAR Power Inc. elect to employ an HV breaker for synchronising their 115kV generating unit, then the preferred arrangement that would provide greater operational flexibility, particular during outages for maintenance, is shown in Alternatives 2.1 & 2.2. These latter two arrangements would require the two ‘synchronising’ breakers to be capable of withstanding voltages of 2 pu across their open terminals during the synchronising period.

The arrangement shown in Alternative 2.1 would require a connection from the AGSTAR Project to circuit K6Z, and a normally-open point to be maintained at Tilbury Junction. The arrangement shown in Alternative 2.2 would require the normally-open point to be moved to the location at which the AGSTAR Project is connected to the 115kV system. Both incorporation circuits could therefore be terminated on to circuit K2Z, on either side of the new normally-open point. The shorter connection (on to circuit K2Z rather than to circuit K6Z) would have the added benefit of avoiding the need for a disconnect switch to be installed at the connection point to allow isolation of the incorporation circuit in the event of a permanent fault.

Although the incorporation of the AGSTAR Project into the 115kV system via two circuits would involve additional costs, there would be benefits to the Project of a dual connection. Normally-cleared faults involving the 115kV circuit K2Z would not result in the generating unit being automatically tripped, but instead allowing it to remain in-service connected to circuit K6Z. In addition, once both Phases of the Project have been completed, higher transfers to the 115kV system would be possible before corrective action would be necessary, under contingency conditions involving either of the 230kV circuits C21J or C22J.

There would also be benefits to the local 115kV system should the AGSTAR Project be incorporated via two circuits rather than only one. With the generator maintained in service post-contingency, it would be able to provide support to the voltages in the local area.

#### *Step-up transformer parameters*

In the absence of any data for the step-up transformer, the following parameters were assumed in the analysis that was performed.

- Turns Ratio: 125kV: 13.8kV [with a tap-changer range suitable for the voltage variation as stated in Appendix 4.1 of the Market Rules]
- Transformer Impedance: 14% [in order to comply with the requirements of Market Rule Reference 2 of Appendix 4.2, the impedance of the step-up transformer should be 14% or less on  $100\text{MVA}_{\text{base}}$  &  $118\text{kV}_{\text{base}}$ .]

### **3. Connection Assessment**

Since the Project is to be developed in two distinct Phases, it has been decided to undertake a separate Connection Assessment for Phase I, in isolation. This decision recognises that there will be no connection to the adjacent 230kV system, and hence no impact from it on the local 115kV system until the 230/115kV auto-transformer is installed in Phase II. In addition, since Phase I of this Project is to be connected at the extremity of the local 115kV system, it will not have any impact on other generating facilities in the area.

Phase II of the Project is to be the subject of a separate Connection Assessment, and this Assessment will examine the impact of the complete development, including the installation of the 230/115kV auto-transformer to interconnect the two Phases.

#### **4. Facilities at Tilbury West DS**

Diagram 5 shows the proposed connection of Phase I of the AGSTAR Project on to the 115kV circuit K2Z with the existing arrangement of the facilities at Tilbury West DS.

Hydro One has indicated that they are actively reviewing the supply arrangement at Tilbury West DS, with the intent of modifying the connection arrangement of the step-down transformers to provide a DESN (dual element spot network) supply. Although no formal application has yet been submitted to the IMO by Hydro One for this change, due consideration has been given to its possible impact on AGSTAR's proposal since it could influence the preferred arrangement for the incorporation of their 115kV generating unit.

Diagram 6 shows the arrangement that is currently under consideration for Tilbury West DS. This would involve reterminating one of the step-down transformers on to circuit K6Z, and introducing a normally-open point between the two transformers. The section of circuit K6Z between Belle River Junction and Tilbury Junction would also be returned to service.

With this arrangement, a contingency involving either 115kV circuit, K2Z or K6Z, would ensure that the supply to Tilbury West DS is maintained via the companion transformer. Under normal conditions with all elements in-service, it would be expected that there would be very little difference between the terminal voltages for circuits K2Z & K6Z at Tilbury West DS. However, with the AGSTAR Project connected to only one 115kV circuit, as shown in the Diagrams 5 & 6, the flow distribution on the 115kV system would be unbalanced and there is likely to be a significant difference in the terminal voltages at Tilbury West DS. This would result in circulating reactive power through the two step-down transformers, which together with the unbalanced loading on the two transformers due to the close proximity of the AGSTAR facility, could cause one of them to be overloaded.

Similarly, although to a lesser extent, the connection of the AGSTAR Project to just a single 115kV circuit is expected to create circulating reactive power through the step-down transformers at Kingsville TS as a result of the 115kV busbar at that location being operated normally-open.

#### *Impact of changes to the configuration of Tilbury West DS on the 115kV Connection Arrangement for the AGSTAR Project*

Should Hydro One decide to proceed with the proposed change in the configuration of the transformers at Tilbury West DS, then it may become necessary for the AGSTAR Project to be incorporated into the 115kV system via both 115kV circuits, K2Z & K6Z.

Furthermore, since the 115kV busbar at Tilbury Junction would need to be operated normally-open (to allow Tilbury West DS to be operated as a DESN), Alternative 2.2, as shown in Diagram 4, would no longer be a viable option. With the 115kV busbar at Tilbury Junction operated normally-open, it would no longer be possible to establish a connection to circuit K6Z via this 115kV busbar.

*The arrangement shown in Alternative 2.1, which would allow the 115kV busbar at Tilbury Junction to be operated normally-open while also addressing the concerns regarding unbalanced loading and circulating reactive power through the step-down transformers at both Tilbury West DS and Kingsville TS, would therefore represent the preferred arrangement.*

It is therefore recommended that the design of those facilities in Phase I of the AGSTAR Project should allow for its future development into the arrangement shown in Alternative 2.1.

#### **5. Initial Incorporation Arrangement**

Although there may eventually be a need to establish a connection from the 115kV busbar at the AGSTAR facility to 115kV circuits K2Z & K6Z, a single connection on to circuit K2Z would be acceptable to the IMO for the initial incorporation of Phase I.

However, as part of this initial arrangement it is recommended that a 115kV breaker be installed that would be used for both the synchronisation of the generating unit and for interrupting faults involving either the generator or the step-up transformer. This breaker would then form part of the 'ring' busbar that would be required for the termination of any future 115kV connection to circuit K6Z.

The proposed initial connection arrangement, which also shows those facilities that would be required for Phase II of the proposed development, is shown in Diagram 7.

## **6. Transfers on the 115kV System**

Phase I of the AGSTAR Project is expected to utilise approximately 20MW of the net output during off-peak periods for lighting. At all other times, most of the net output of approximately 80MW would be available for transfer to the system.

The combined peak load at Kingsville TS and Tilbury West DS/Tilbury TS is approximately 170MW. Part of the output from the 115kV generating unit would supply all of the load at Tilbury West DS/Tilbury TS, with the remainder supplying the load at Kingsville TS. During peak periods any deficit in the load-generation balance would be supplied via the auto-transformers at Lauzon TS and Keith TS. During light-load periods, any surplus in the output from the generating facility over the combined load at Kingsville TS and Tilbury West DS/Tilbury TS would supply the load in the Windsor area.

The net impact of the AGSTAR Project would therefore be to reduce the loading on the 230/115kV auto-transformers at Lauzon TS and Keith TS.

## **7. Transfers on the 500kV & 230kV Systems**

The System Impact Assessment Report for the four generation projects in the initial Sarnia-Windsor cluster addressed the potential for congestion on the 500kV and 230kV systems in the south-west, assuming all four projects proceed to completion.

Diagram 16 from that Report, which showed the approximate generation-load balance for the three principal centres in the Sarnia-Windsor study area, with all four of the new Projects in-service, has been reproduced as Diagram 8. The reproduced version has been amended to reflect the contribution to the net transfers that would result from the incorporation of Phase I of the AGSTAR Project, with a net output of approximately 80MW. The contribution from Phase II of the AGSTAR Project has not been included. It should also be noted that the loads shown represent the expected peak loading condition for the summer-2004, when all four of the new Sarnia-Windsor Projects are scheduled to be in-service.

This amended version of the Diagram shows that the AGSTAR Project would increase the net transfer across the London-Import Interface to approximately 2570MW, with no transfers into Ontario across the Ontario-Michigan Interface. Since the eastward transfer limit for the London-Import Interface is approximately 2815MW, the maximum transfer that could occur across the Ontario-Michigan Interface when all the generating facilities in the area are fully dispatched, would be limited to approximately 245MW. Conversely, with maximum transfers of 1500MW across the Ontario-Michigan Interface, approximately 1255MW of the generating capacity in the area would be constrained. Furthermore, during periods with reduced loads, the restrictions on the amount of generating capacity that could be dispatched and/or on the level of transfers into Ontario that could occur would be more severe.

For the situation when transfers are being made to Michigan across the Ontario-Michigan Interface, it would be possible to dispatch all of the generating capacity in the Sarnia and Windsor area and respect the transfer limit of approximately 2400MW, as long as there was a minimum transfer eastwards across the London-Import Interface of at least 170MW. Again, during periods with reduced loads, there would need to be a comparable increase in the transfer eastwards across the London-Import Interface, to allow all of the generating capacity to be dispatched.

For the Sarnia-Windsor study area the dispatch of generating capacity could also be restricted by a requirement to respect the Negative BLIP (Bruce-Longwood Input) Interface limit of 1500MW. As shown in Diagram 8, with all the generating facilities in the area fully dispatched and with no transfers into Ontario across the Ontario-Michigan Interface, the net transfer across the Negative BLIP Interface would be approximately 1370MW. This would restrict the maximum transfer into Ontario across the Ontario-Michigan Interface to approximately 130MW, or constrain approximately 1370MW of generating capacity in the area, whenever transfers of 1500MW are being made across the Ontario-Michigan Interface. As before the restrictions would be more severe during those periods when the loads are lighter, requiring a 1MW reduction in the eastward transfer across the Ontario-Michigan Interface, or on the amount of generating capacity that can be dispatch for every MW reduction in the load that has been assumed.

#### **8. Voltage Response under contingency conditions**

For the situation with the generating unit in Phase I of the AGSTAR Project connected only to circuit K2Z, any contingencies involving circuit K2Z would result in the loss of generating facility. Studies were performed to determine the impact on the voltage at Kingsville TS of the simultaneous loss of circuit K2Z and the AGSTAR generating facility.

For a peak load condition with 140MW of load at Kingsville TS and 23MW of load at Tilbury West DS/Tilbury TS, both at a power factor of 90%, the maximum voltage decline prior to tap-changer action was 7.4% at Kingsville TS, assuming voltage dependent loads.

This is within the IMO criterion of 10%.

A voltage decline of just 2% was recorded on the low-voltage busbar at Kingsville TS following tap-changer response.

Incorporation of the Phase I generating unit via a single 115kV circuit would therefore be acceptable to the IMO.

#### **9. Fault Level Analysis**

The fault level analysis performed by Hydro One for their Feasibility Study of the AGRO Sun Technologies Project (the former name of the AGSTAR Project), dated September 2000, showed no fault level concerns for a 600MVA development with a 230/115kV auto-transformer connection. Since Phase I of the Project involves only a 100MVA development with no connection to the 230kV system, it was decided that additional fault level analysis was not warranted.

A full series of fault level studies will be performed for the Phase II development, for both the Preliminary Assessment and the System Impact Assessment.

#### **10. Transient Stability Analysis**

Transient stability analysis was performed for the Phase I development for the arrangement with only a single 115kV connection (on to circuit K2Z), as well as with a dual 115kV connection (on to circuits K2Z & K6Z).

For faults on the 115kV system at Tilbury Junction, a dual 115kV connection was assumed, to examine the performance of the generating unit for close-up faults. For faults on the 230kV system at Lauzon TS, it was assumed that the generating unit was connected via only a single 115kV connection, since this would represent the most onerous arrangement.

Only three-phase faults were examined, both normally-cleared and with delayed-clearance.

A value of 0.195 was substituted for the stator leakage inductance,  $X_l$ , since the value provided of 2.056 is outside the normal range of 0.1 to 0.2 and prevented the studies from initialising. In addition, since the exciter data was presented in the IEEE ST4B model format, which is not a standard PTI representation, it was necessary to convert the data to a format suitable for that Program.

Transient stability studies were performed for the following conditions. In all cases stability was maintained with a positively damped response.

<b>Contingency Conditions Examined</b>						
<i>Three-phase fault, cleared in normal time</i>						
Designation of faulted circuit			Fault Location	Transfer on J5D Interconnection	Load Level	Response
1	K2Z	115kV single-circuit fault: Lauzon TS to Tilbury Junction	Tilbury Junction	0MW	Off-peak	Stable
2	K6Z			350MW Out	Off-peak	Stable
3				0MW	Peak	Stable
4	C23Z &	230kV double-circuit fault: Chatham TS to Lauzon TS	Lauzon TS	350MW Out	Off-peak	Stable
5	C24Z			0MW	Peak	Stable
6	C23Z			230kV single-circuit fault: Chatham TS to Lauzon TS	0MW	Peak
<i>Three-phase fault, with delayed clearance on back-up protection</i>						
Designation of faulted circuit			Fault Location	Transfer on J5D Interconnection	Load Level	Response
7	K6Z	115kV single-circuit fault: Lauzon TS to Tilbury Junction	Tilbury Junction	0MW	Off-peak	Stable

The results for studies 1, 2 & 4 are shown in Diagrams 9, 10 & 11, respectively.

It is worth noting that in Study 4 (Diagram 11), that simulated a double-circuit fault on the 230kV circuits C23Z & C24Z at Lauzon TS, that was cleared normally, the AES facility was deliberately retained in-service post-contingency via the section of circuit C24Z between Chatham TS and the tapping point of the AES Project. The AES Project was therefore allowed to remain in-service via a single, radial 230kV connection to Chatham TS. While this situation would not arise in practice (because the incorporation arrangement for the AES Project does not include any breakers at the tapping point), it was done to allow the relative responses of the AES & AGSTAR Projects to be compared.

Examination of Diagrams 9, 10 & 11 shows that while the AGSTAR generator remained stable for all the contingency conditions that were examined, the response is rather unusual. This may be the result of the actual data that were provided for the exciter and/or the power system stabiliser, or of the data conversion process.

However, from the response curves shown in Diagram 12 (for Study 2: corresponding to a three-phase fault on circuit K6Z at Tilbury), it would appear that the exciter initially produces an increase in the generator field voltage that is either insufficient in magnitude or is not maintained for a long enough interval. Although the exciter subsequently increases the generator field voltage and maintains it at the new value for a longer interval, it appears to over-compensate, resulting in transient over-voltages at the terminals of the AGSTAR generating unit of 10% for normally-cleared faults and 13% for the delayed-clearance conditions.

After approximately 1 second from the time that the fault was imposed initially, the generator field voltage was returned to a level close to its original pre-fault value, where it remained. The terminal voltage at the generator was eventually restored to 1 pu approximately 3 seconds after the maximum value occurred. The 115kV busbar at Tilbury West DS experienced an over-voltage of between 6% & 8%.

The net result of this response was a slow return of the generator angle to its revised steady-state operating value following the switching operations necessary to isolate the fault.

It is therefore a requirement of the IMO that further transient stability studies be performed once the equipment design is finalised and more definite data are available, to confirm the acceptability of the transient performance.

This work will need to be completed prior to the 'Facilities Registration' process.

## **11. Conclusions**

The Preliminary Assessment has examined the effect of incorporating the single 115kV generating unit in Phase I of the AGSTAR Project, into the IMO-controlled grid in the Tilbury area, and concluded that there would be no adverse impact.

The Assessment has also concluded that while the incorporation can be via a single 115kV connection initially, there would be advantages in making provision in the design for a second 115kV connection, either to coincide with the Phase II development, or to address issues that could arise should Hydro One decide to proceed with their proposal to modify the configuration of Tilbury West DS.

Furthermore, since there is expected to be no adverse impact from incorporating Phase I of this Project into the IMO-controlled grid, it has been concluded that no further analysis is warranted and that a System Impact Assessment can be foregone.

Based on the results of this Assessment it is therefore proposed to issue a *Notification of Approval of the Connection Proposal* for Phase I of this Project.

## **12. Budgetary Cost Estimate**

The budgetary cost for the work required to connect the incorporation circuit from the AGSTAR Project on to 115kV circuit K2Z has been estimated at \$250,000. [This does not include the cost of any changes to the protective relaying or telecommunications schemes, or for the cost of those facilities required for monitoring the status of the Project.]

This estimated cost should be used with caution, since no allowance has been made for site conditions or for the actual configuration of circuit K2Z at the proposed tapping point.

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

Since the connection to circuit K2Z is to be used exclusively for incorporating Phase I of the AGSTAR Project into the IMO-controlled grid, this Project is considered to be 'sole beneficiary' of this connection.

## **14. Next Steps**

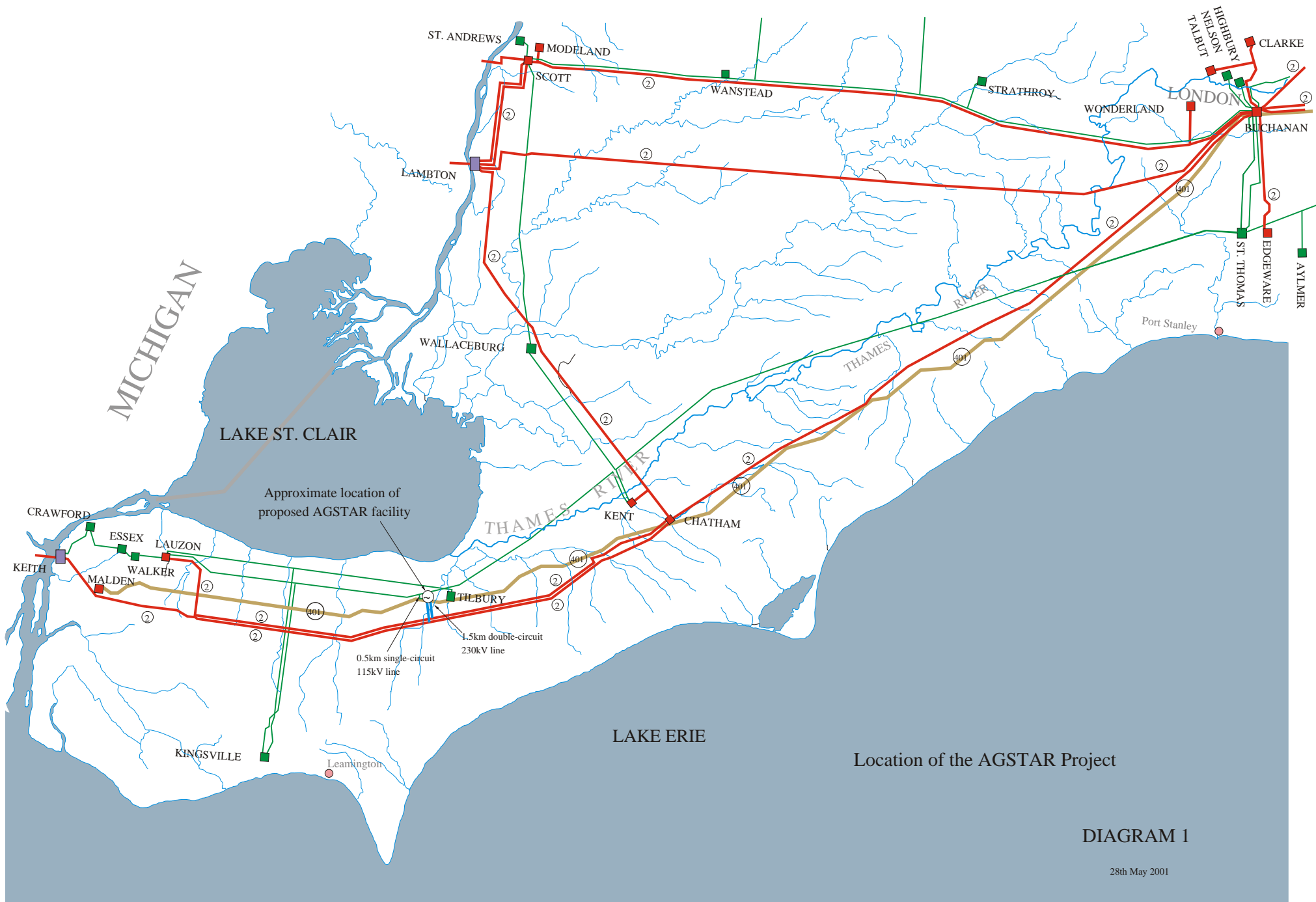
Provision should be made in the schedule for this Project for the following activities that need to be completed for Market Entry:

- Authorisation as a Market Participant
- Registration of Facilities
- Registration of the Metering Installation

These activities can require a lead-time of between six and eight months, particularly if telemetry is involved to monitor the status of the facilities.

Further information can be found on the IMO's web site -

[www.theimo.com/imoweb/marketEntry/me.asp](http://www.theimo.com/imoweb/marketEntry/me.asp)



Location of the AGSTAR Project

DIAGRAM 1

28th May 2001

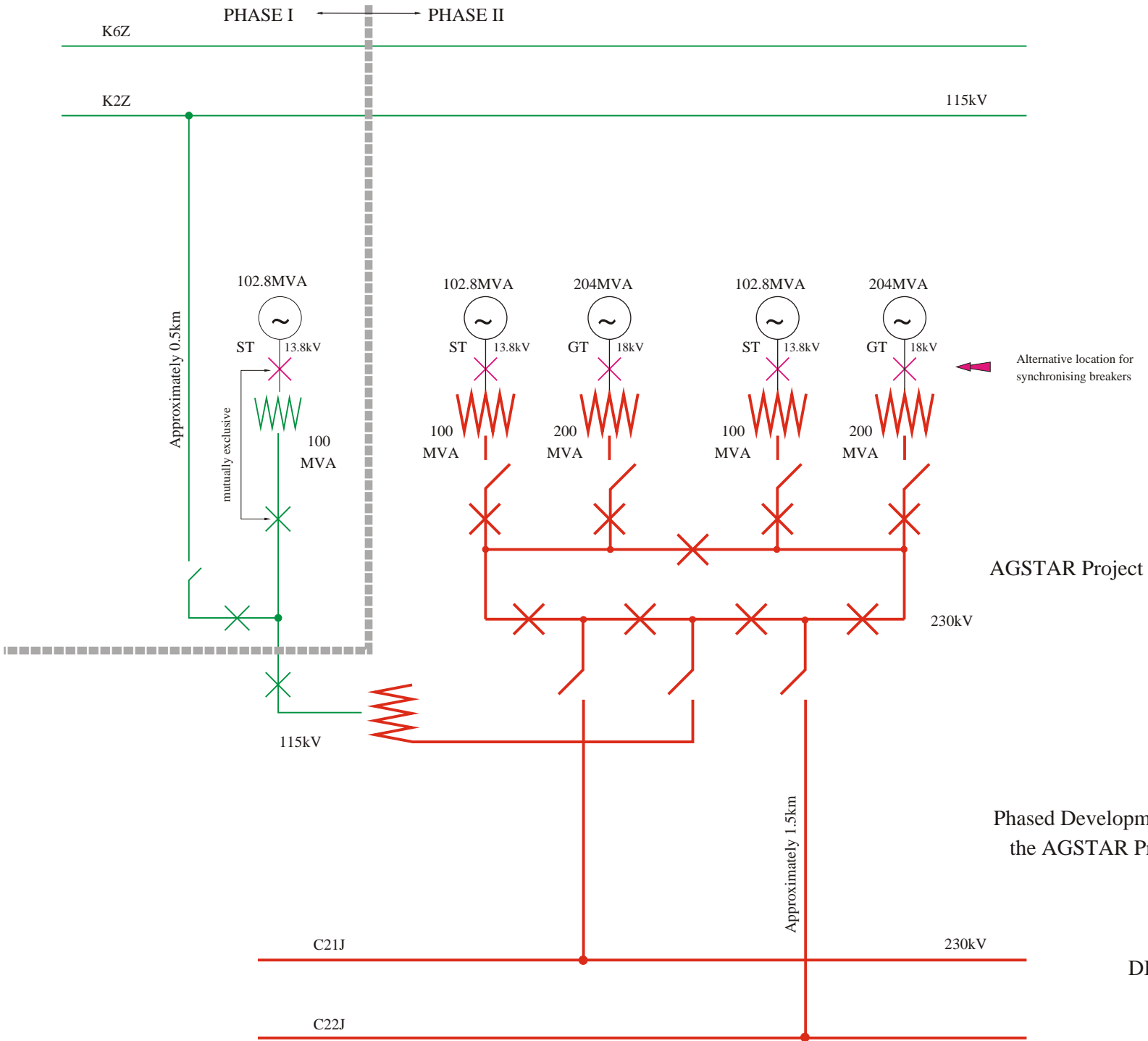
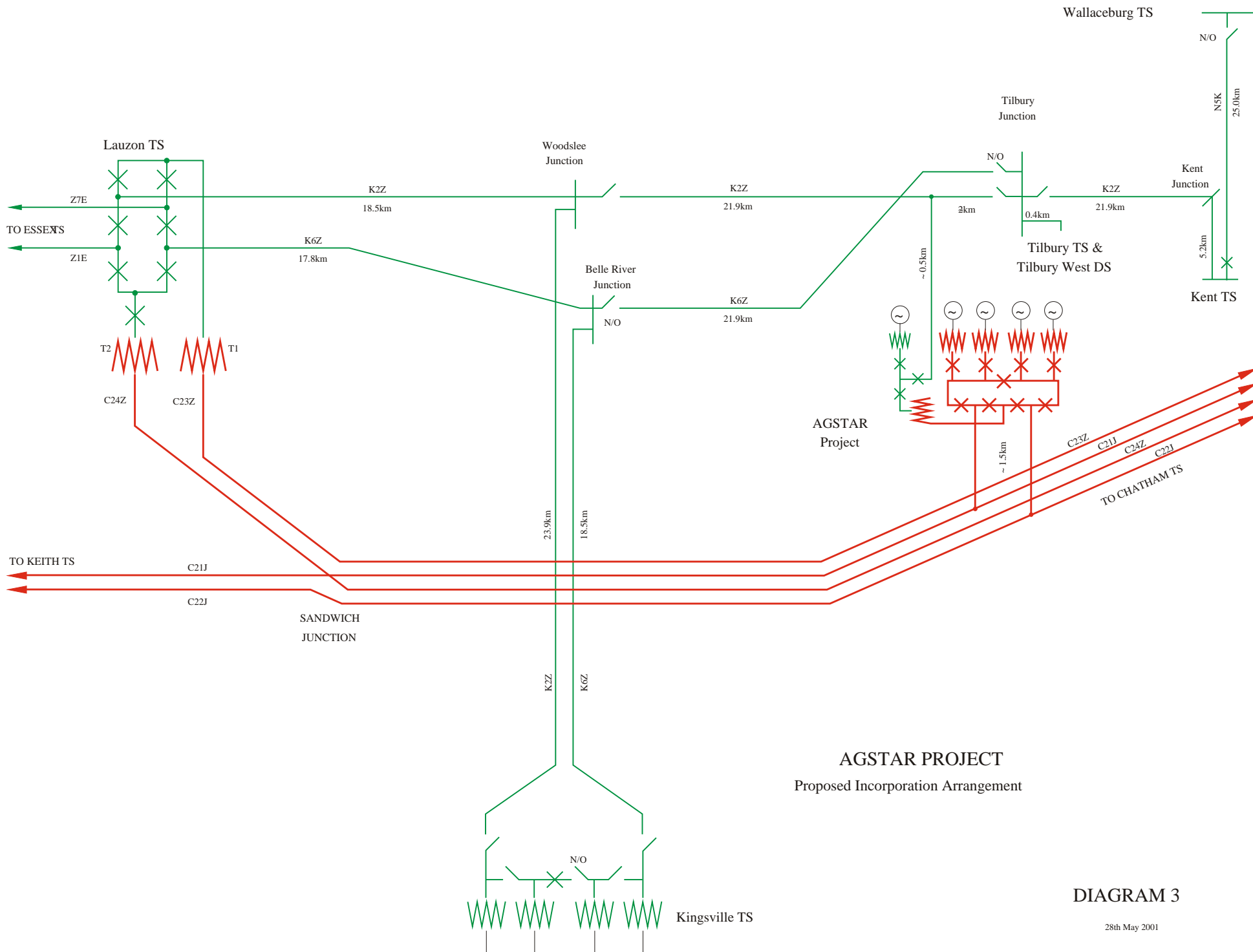


DIAGRAM 2

28th May 2001



AGSTAR PROJECT  
Proposed Incorporation Arrangement

DIAGRAM 3

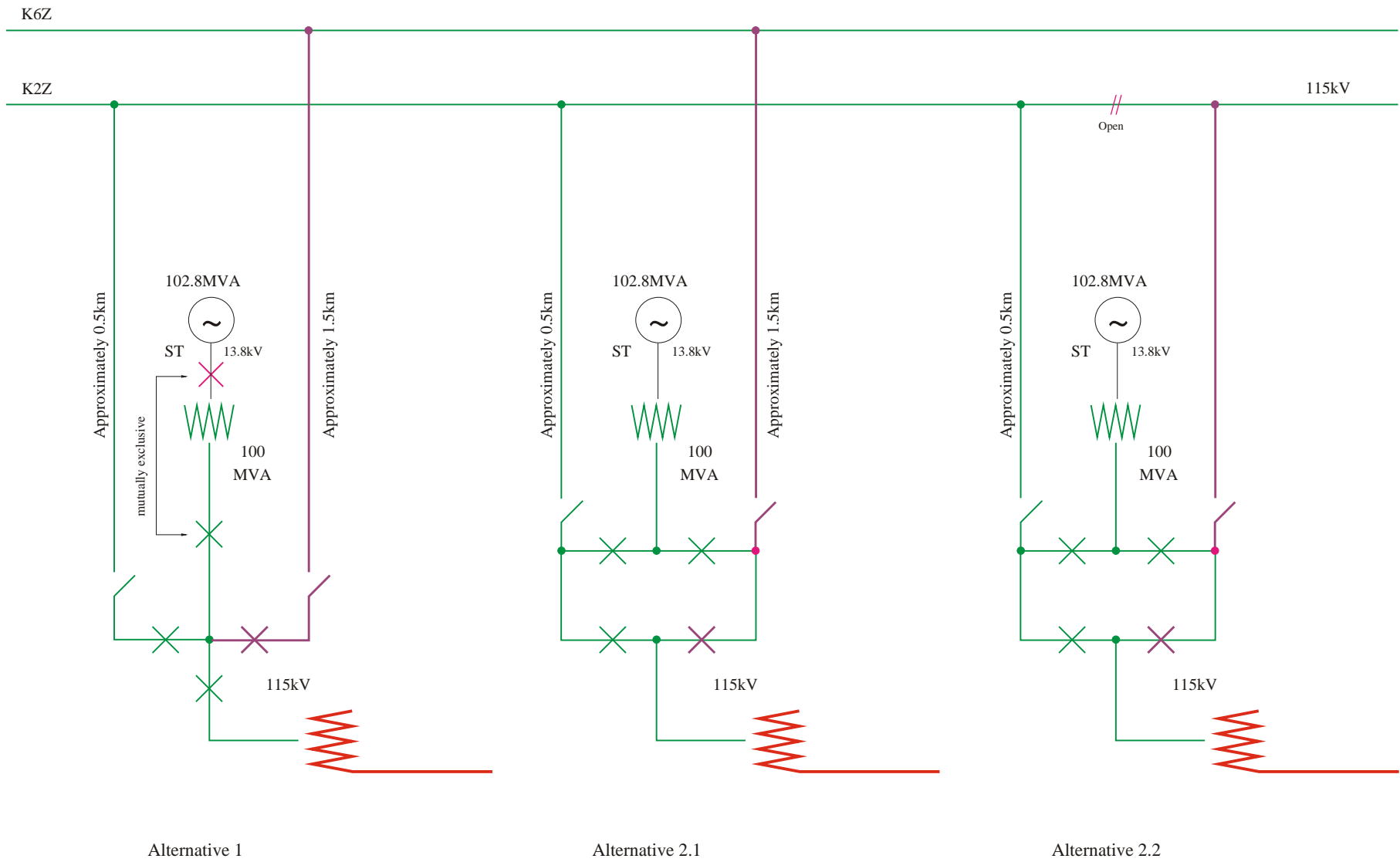
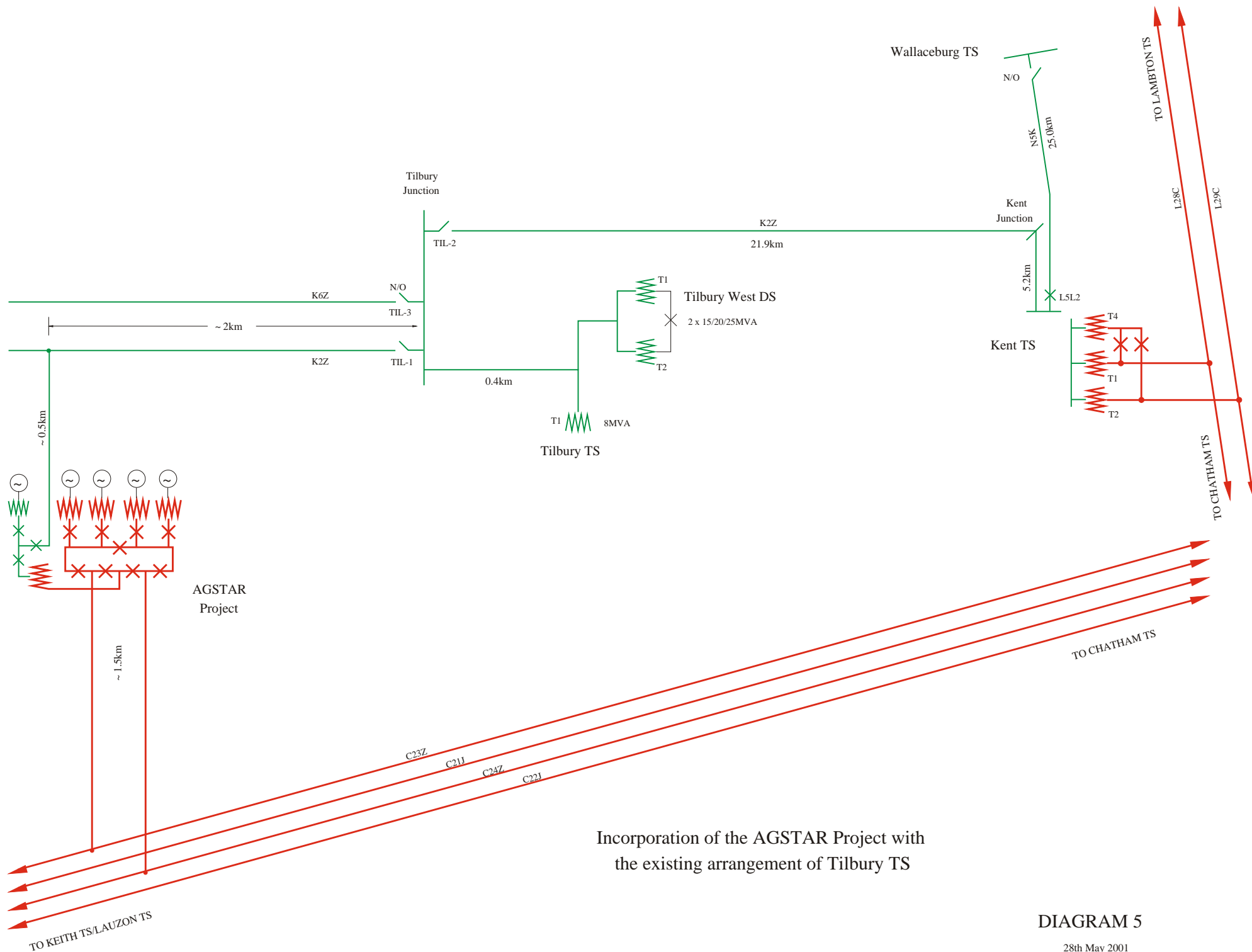


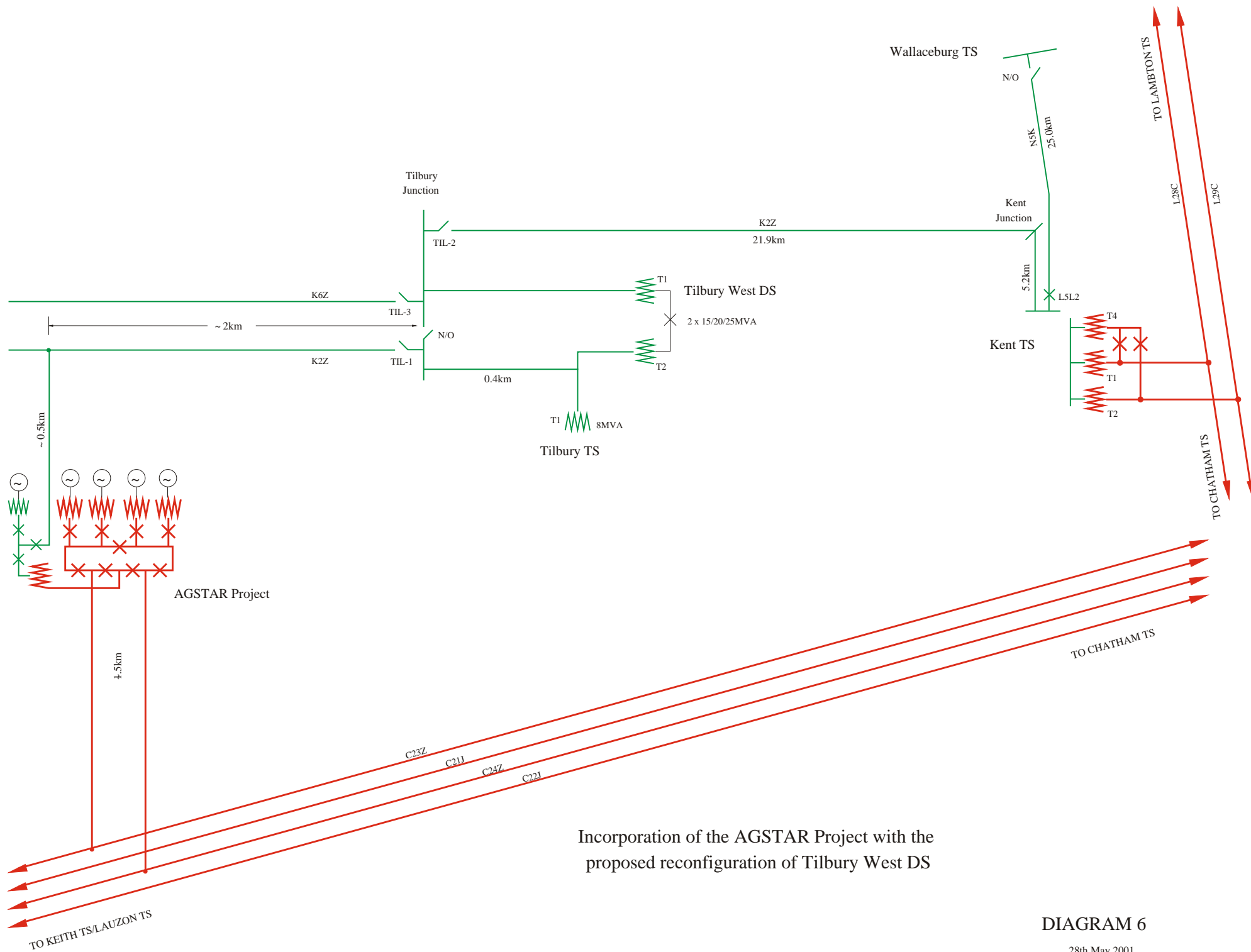
DIAGRAM 4

Options available for Incorporating Phase I of the AGSTAR Project

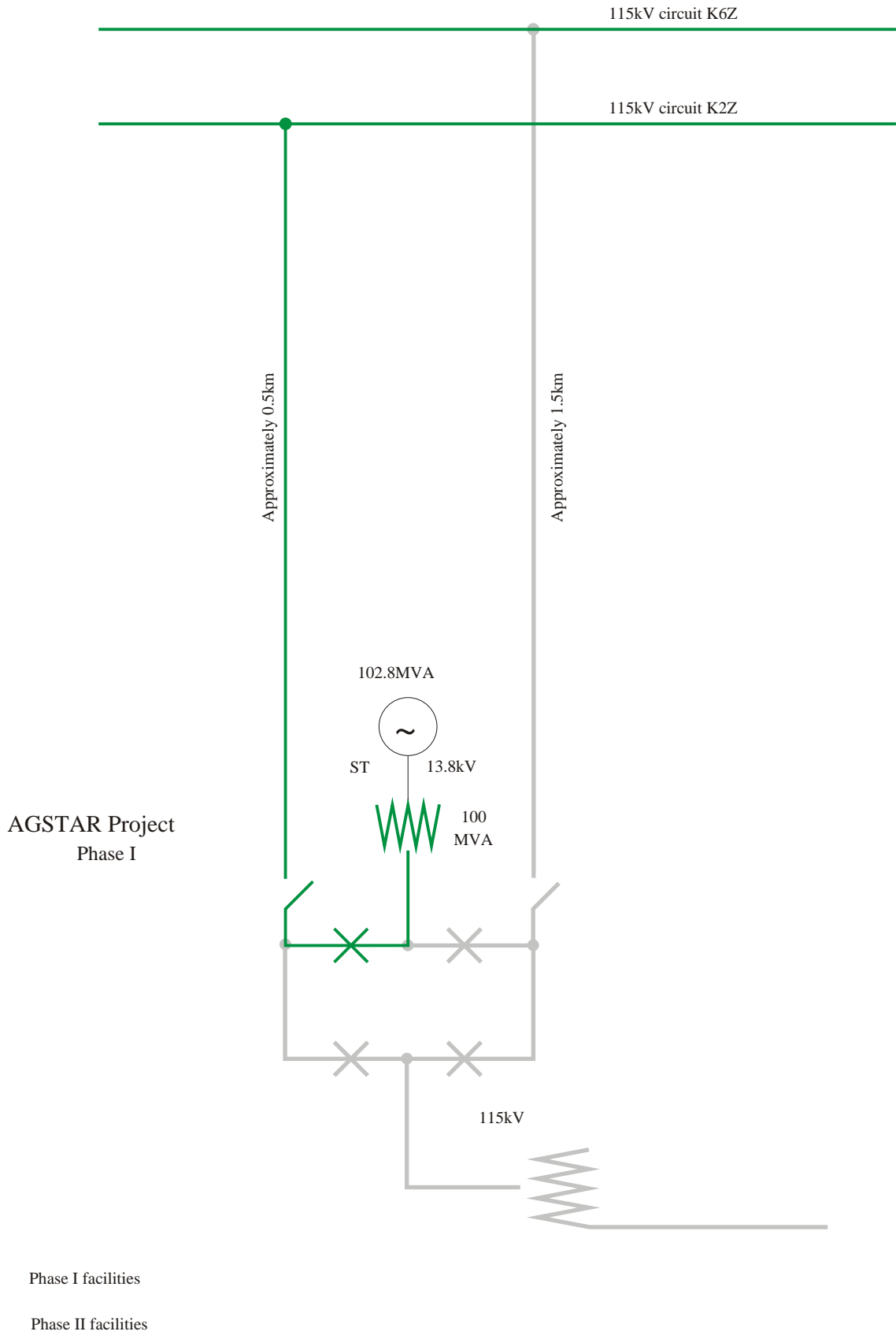
28th May 2001



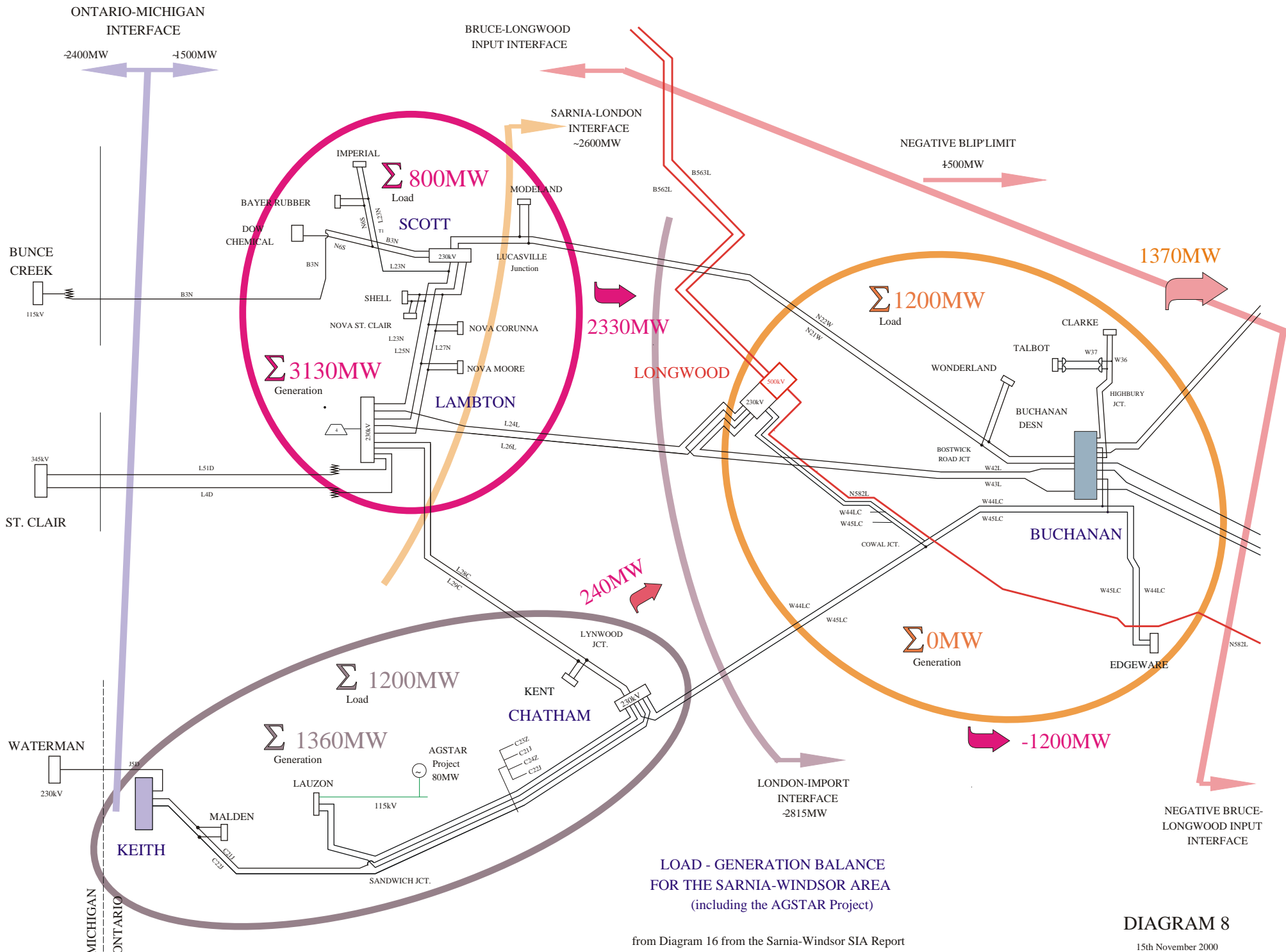
Incorporation of the AGSTAR Project with the existing arrangement of Tilbury TS



Incorporation of the AGSTAR Project with the proposed reconfiguration of Tilbury West DS



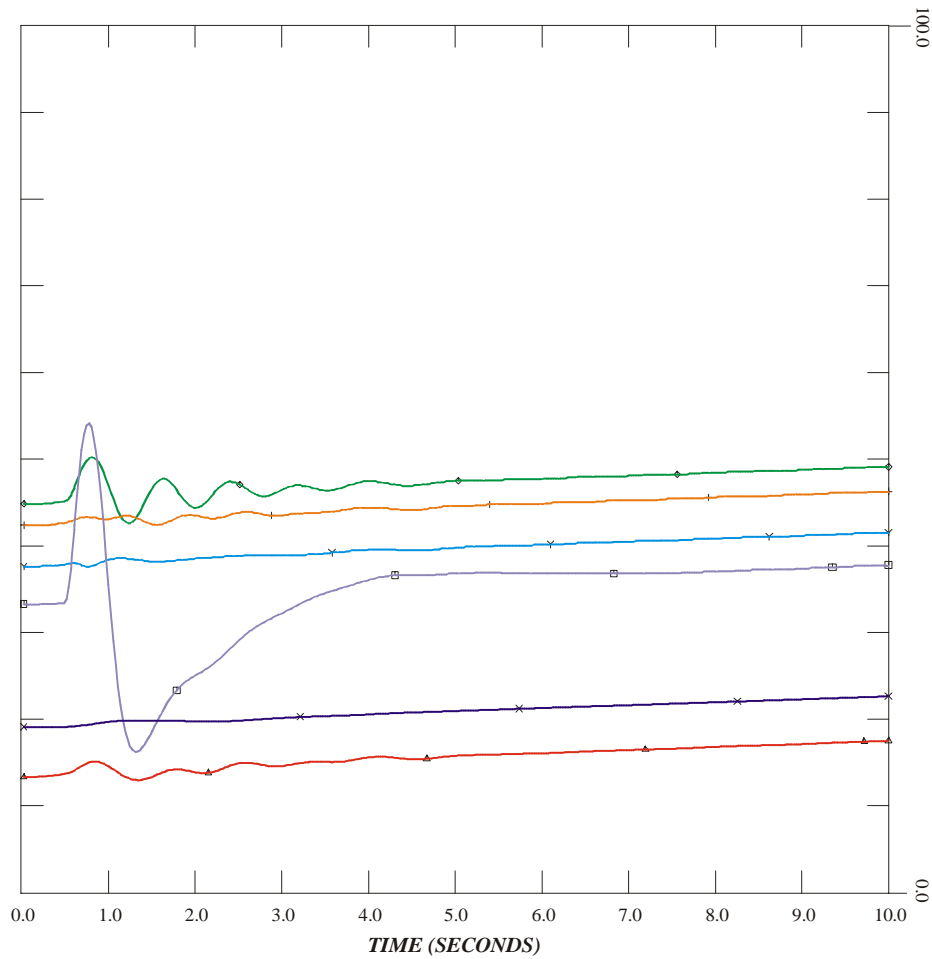
Incorporation Arrangement for  
Phase I of the AGSTAR Project



from Diagram 16 from the Sarnia-Windsor SIA Report

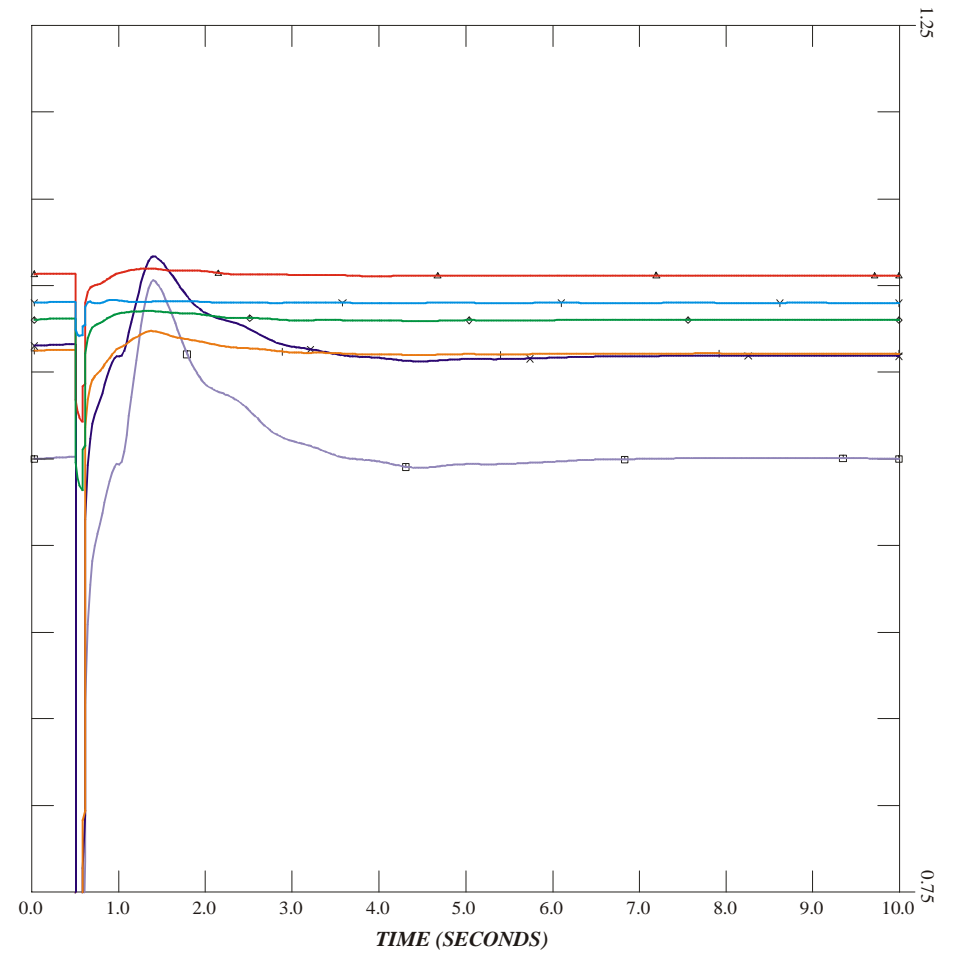
THREE-PHASE FAULT on 115kV circuit K2Z at Tilbury Junction - Cleared Normally:

July 2000 Summer Peak Loads: Windsor Area Demand 790MW  
Transfer on J5D Interconnection - 350MW Out



GENERATOR ANGLES - degrees

LAMBTON G2	→
NANTICOKE G2	×
ENRON G4	+
AES G2	◇
ATCO G2	◄
AGSTAR G1	□

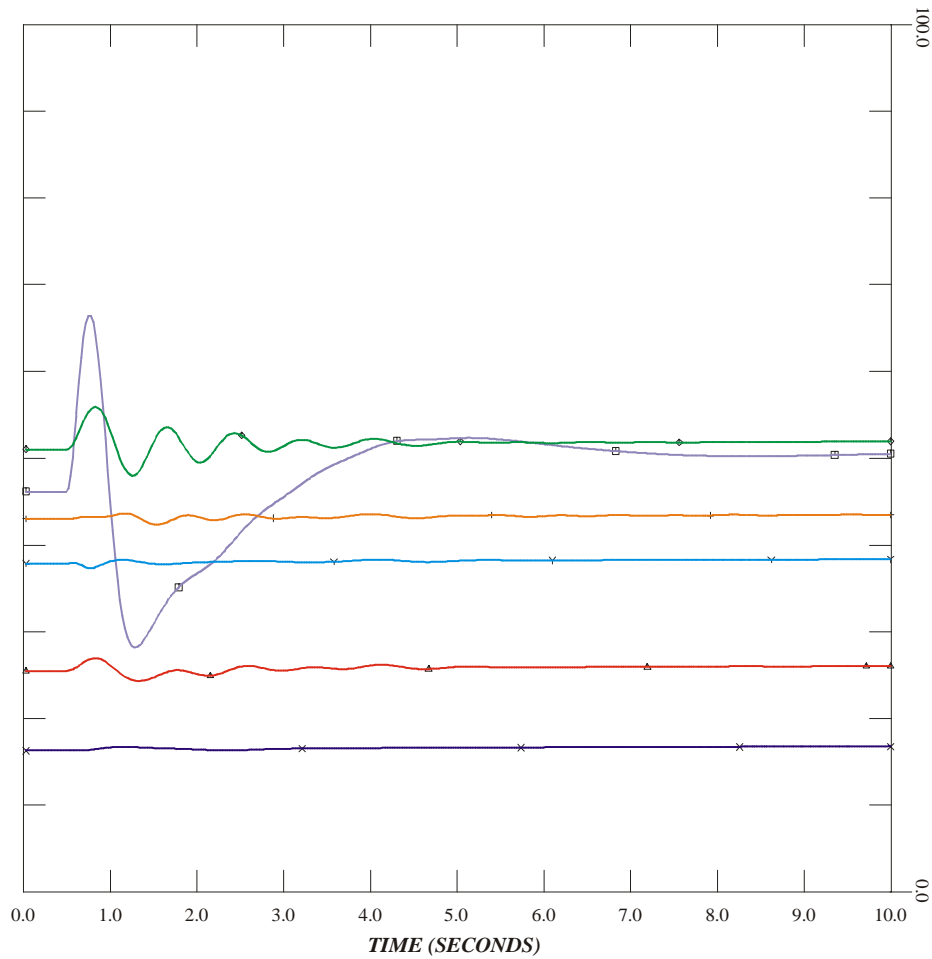


BUS VOLTAGES - p.u.

LAMBTON 220kV	→
TILBURY 115kV	×
LAUZON 230kV	+
KEITH 220kV	◇
CHATHAM 220kV	◄
AGSTAR-G1	□
Generator terminal voltage	

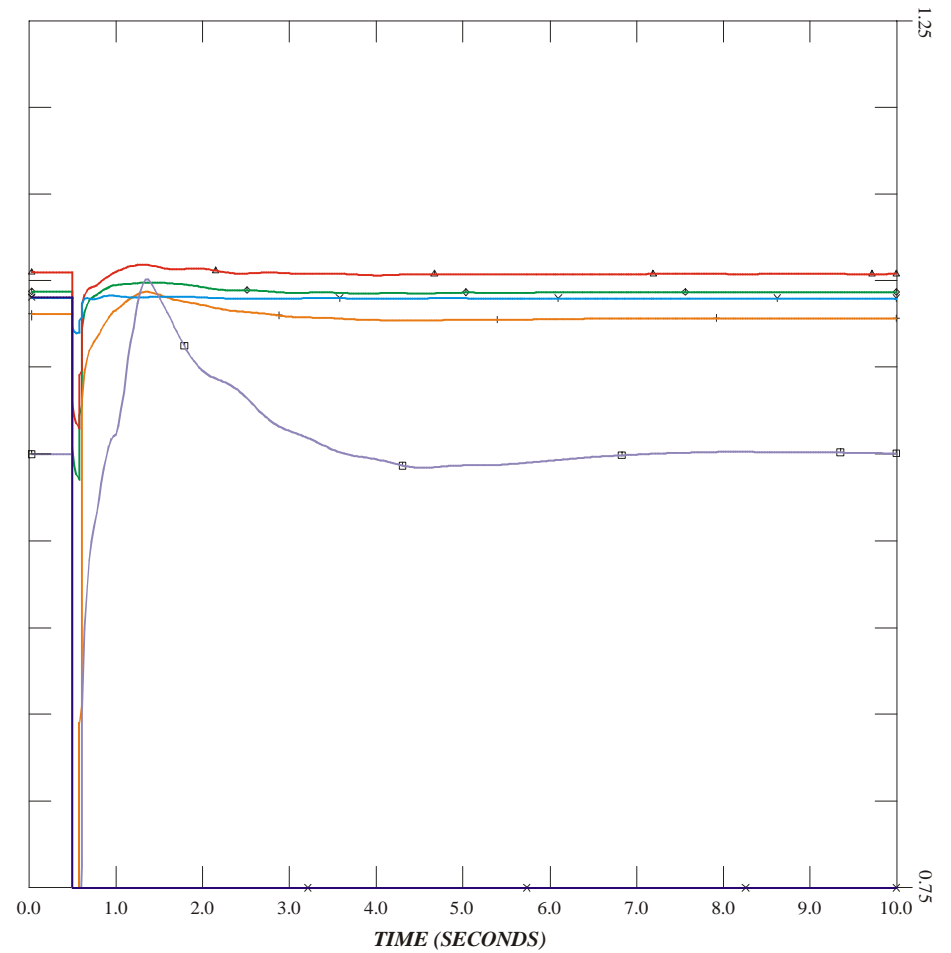
THREE-PHASE FAULT on 115kV circuit K6Z at Tilbury Junction - Cleared Normally:

July 2000 Summer Peak Loads: Windsor Area Demand 790MW  
Transfer on J5D Interconnection - 0MW



**GENERATOR ANGLES - degrees**

LAMBTON G2	>	<
NANTICOKE G2	x	x
ENRON G4	+	+
AES G2	◇	◇
ATCO G2	◄	►
AGSTAR G1	□	□

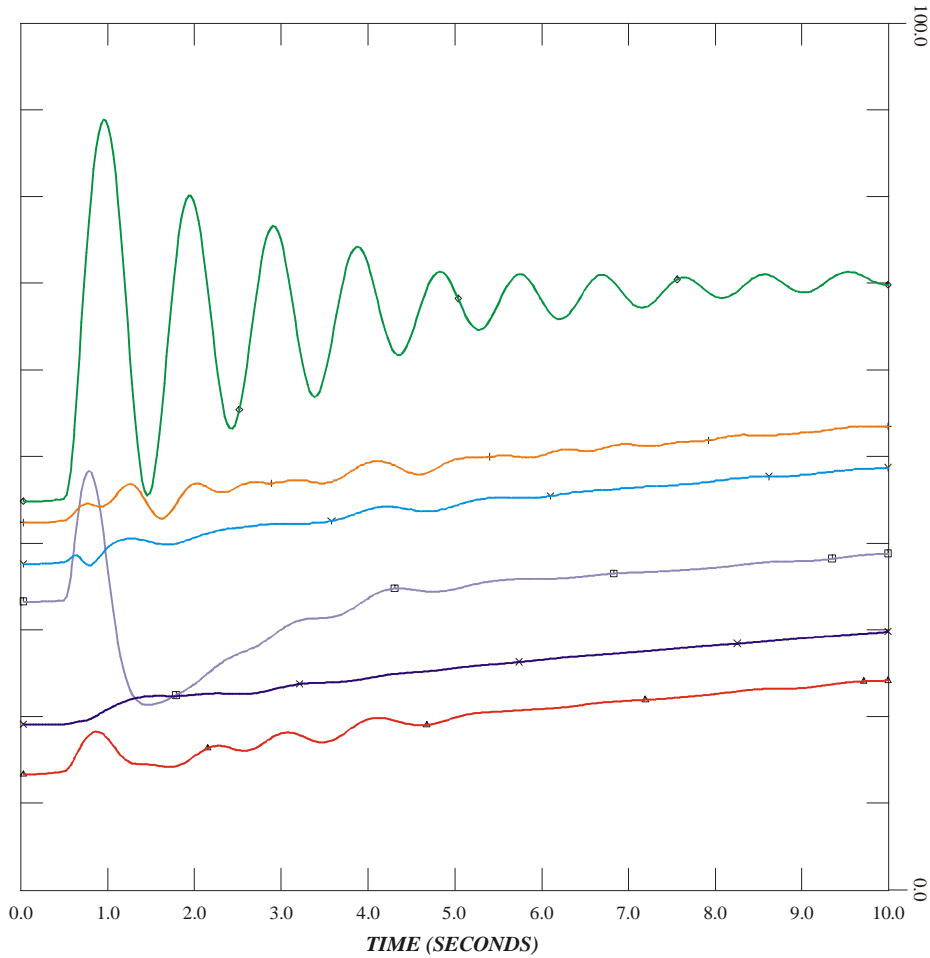


**BUS VOLTAGES - p.u.**

LAMBTON 220kV	>	<
TILBURY 115kV	x	x
LAUZON 230kV	+	+
KEITH 220kV	◇	◇
CHATHAM 220kV	◄	►
AGSTAR-G1	□	□
Generator Terminal Voltage		

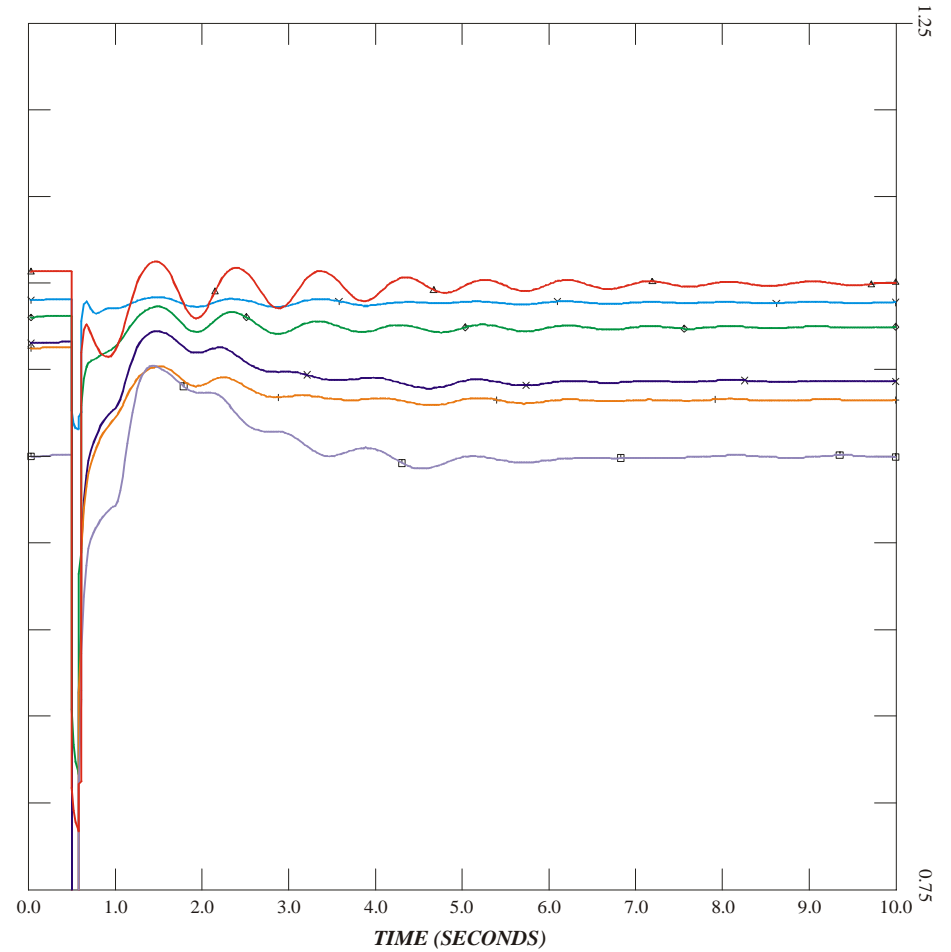
DOUBLE-CIRCUIT THREE-PHASE FAULT on 230kV circuits C23Z & C24Z at Lauzon TS - Cleared Normally:

July 2000 Summer Peak Loads: Windsor Area Demand 790MW  
Transfer on J5D Interconnection - 350MW Out



**GENERATOR ANGLES - degrees**

LAMBTON G2	→
NANTICOKE G2	×
ENRON G4	+
AES G2	◇
ATCO G2	◄
AGSTAR G1	□

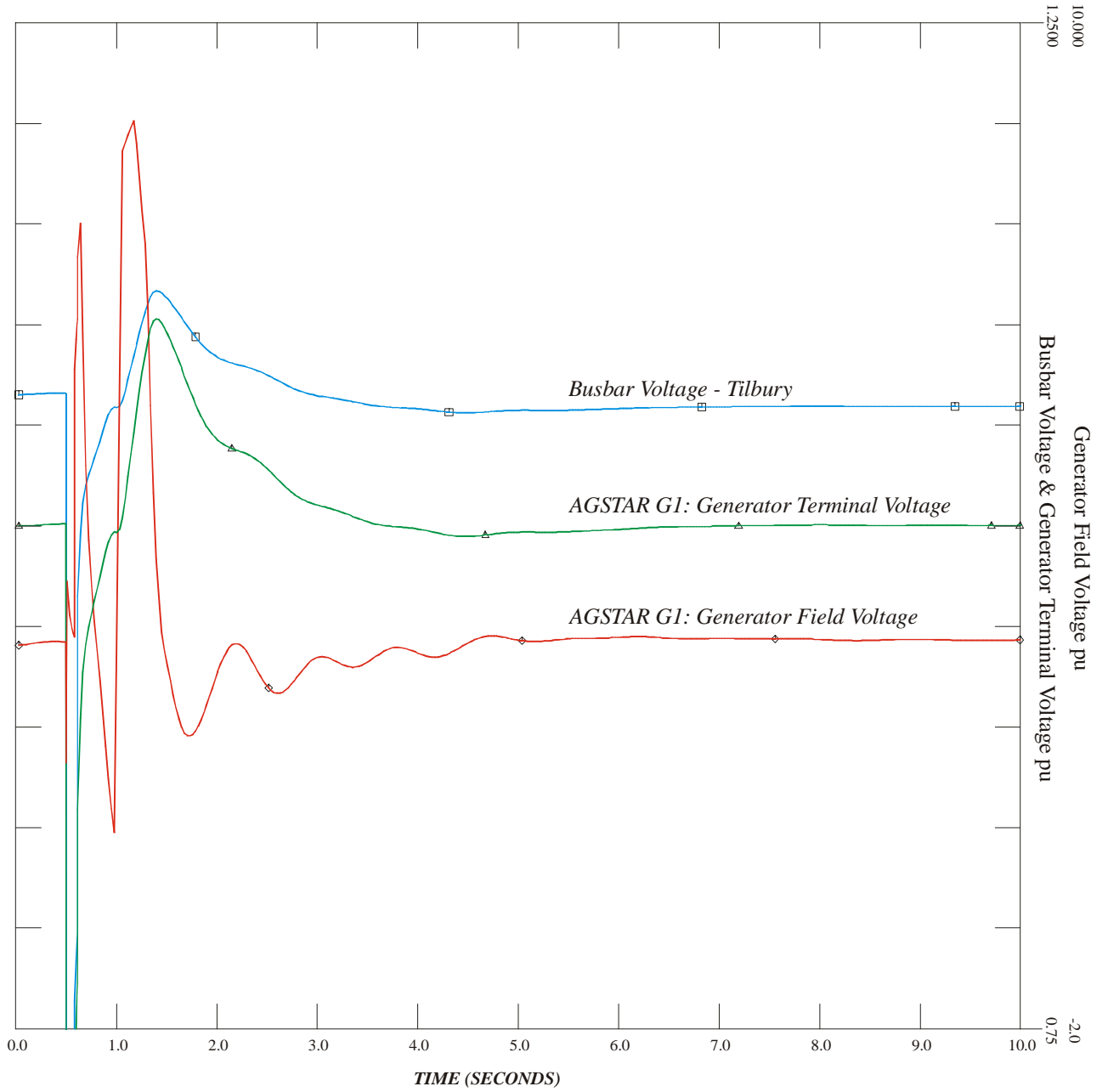


**BUS VOLTAGES - p.u.**

LAMBTON 220kV	→
TILBURY 115kV	×
LAUZON 230kV	+
KEITH 220kV	◇
CHATHAM 220kV	◄
AGSTAR-G1 Generator Terminal Voltage	□

THREE-PHASE FAULT on 115kV circuit K6Z at Tilbury Junction - Cleared Normally:

July 2000 Summer Peak Loads: Windsor Area Demand 790MW  
Transfer on J5D Interconnection - 350MW out



**DIAGRAM 12**

28th May 2001