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PAGE
SUNSHINE COAST, QUEENSLAND

WOOLOOGA TO PALMWOODS 132KV SUNSHINE COAST POWER SYSTEM CAPACITY AND PERFORMANCE

STUDY REPORT

June 2010

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Study Report

Woolooga to Palmwoods 132kV Sunshine Coast Power System Capacity and Performance

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Prepared by: Mark Giacoppo 6 June 2010 6/6/2010

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1. Executive Summary

This report provides a desktop review of the Woolooga to Palmwoods 275kV PowerLink transmission system and 132kV Energex transmission system in light of the proposed project to construct a 275kV transmission line from Woolooga to Eerwah Vale along with a 275/132kV substation at Eerwah Vale.

This report concludes that:

1. the Eerwah Vale 275kV tee off line and substation is not required for the Energex 132kV system.
2. **the Energex 132kV system between Woolooga to Palmwoods could be augmented with a single Bus Section Circuit breaker at Gympie and the 132kV network could provide continuous plus N-1 contingency demand of the 132kV transmission system, to at least the year 2038.** The cost of a 132kV bus section circuit breaker is expected to be irrelevant in the scheme of the Energex system (less than $1.5M) and the minimal investment now could provide significantly clearer knowledge and understanding of future load demand and possible demand management solutions which could be pursued for the next 28 years at least.
3. **the Palmwoods 275kV substation supply security is significantly compromised and is likely to require augmentation in any case based on the proposed project or otherwise. The proposed project will require additional 132kV transmission lines between the proposed Eerwah Vale Substation and Palmwoods in order to support the proposed 132kV transmission flows to Palmwoods in N-1 configurations.**
4. **Beyond 2035 a new 132kV transmission line from Cooroy (or Eerwah Vale) to Palmwoods will be required in either the proposed project or otherwise. This transmission line has not been addressed in the EIS for the proposed project and it seems a significant misgiving given that it is required to support the stated project.**
5. The Cooroy to Sunrise Hills 132kV transmission system will need augmentation to maintain N-1 capacity around the year 2034. This aspect has not been addressed by the proposed project and it is required to support the transmission flows stated in the project. It appears a significant misgiving of the EIS to exclude this required system upgrade as part of the overall network augmentation assessment.
6. The proposed Woolooga to Eerwah Vale 275kV transmission line should be cancelled.
7. **With the proposed Gympie Bus Section circuit breaker augmentation as noted above and with operation of the 132kV network as noted in this report, then the 275kV transmission line duplication between Woolooga and Palmwoods would be required by the year 2027 if the 275kV transmission line rating is maintained at 800MW however this could be extended to at least the year 2037 if PowerLink even partially adopt transmission line rating strategies as used by Energex. The future 275kV transmission line required between Woolooga and Palmwoods secures the system capacity for the whole of the Sunshine coast. This project could be completed on existing easements adjacent to an existing 275kV transmission line and with an outcome that secures Palmwoods to 1600MW capacity as compared to the 1000MW capacity in the proposed project. The reader is referred to Section 5 and particularly Section 5.6 of this report for a more thorough account of the numerous benefits and considerations to completing the 275kV Woolooga the Palmwoods transmission system.**
8. **The PAGE option of a North Cooroy substation is technically feasible as noted in Appendix B of this report. The only differences between the PAGE proposal with a northern substation and the proposed project in [1] with a Southern Cooroy substation is:**

a. **that the PAGE proposal would require an additional 200MW line to Cooroy by the year 2028 as compared to 2033 in the proposed project of [1].**

b. **the PAGE proposal would require completion of the single circuit line as a double circuit line (similar to existing towers) by the year 2033.**

This report is based on information known at the time which is not complete. Reasonable extrapolations have been made and documented where necessary. Where such assumptions are not valid then the additional cost in transmission network augmentations required to making such an assumption valid in order to support the findings of the report, would need to be justified by PowerLink who has the necessary detailed information to make such assessments. If PowerLink were to supply such information, then a more detailed and thorough investigation could be conducted by this author upon commercial negotiation.

2. Introduction

PowerLink and Energex are electrical distributors for the transmission and sub-transmission systems supplying the Sunshine coast area of Queensland. PowerLink provide the 275kV transmission system while Energex provide the 132kV transmission system.

Load growth forecasts were completed and assessed by PowerLink and Energex which are reported in [1]. The outcome of the load growth forecasts were deemed in [1] to require a new 275kV injection feed into a newly proposed 275/132kV substation at Eerwah Vale (just south of Cooroy).

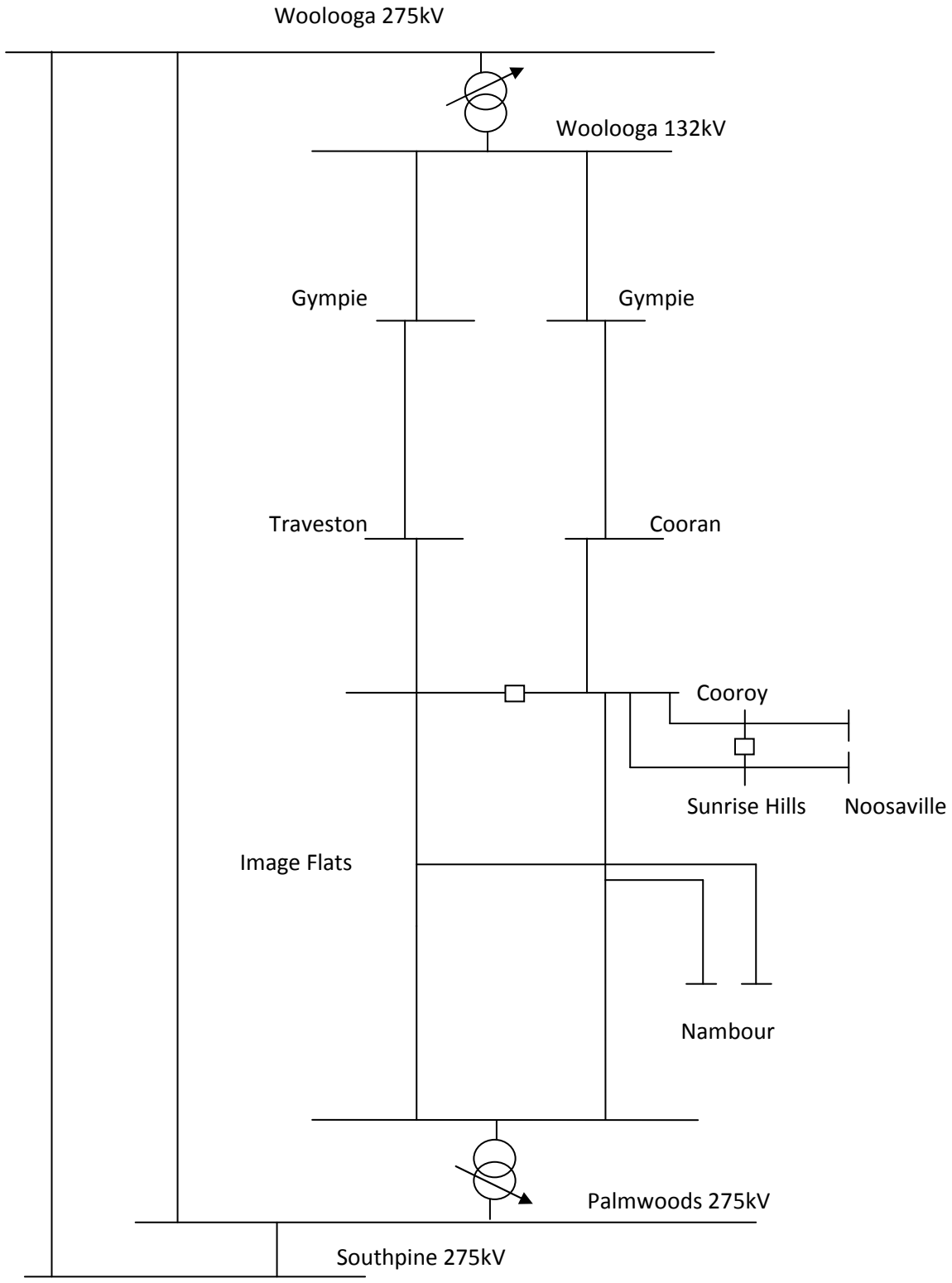
Powerlines Action Group Eumundi (PAGE inc) are a community group who are to be affected by the proposed project. PAGE have commissioned this report as a review of [1].

This report uses software called PowHarm, which has been verified over many years in high voltage power system consulting to both the private and government sectors.

3. Power System Structure

The 275kV and 132kV power system structure studied in this report is based on published data in Figure 10 of [2] and Figure 4.2 of [3]. The overall system is sketched here in Figure 1.

Figure 1 : Woolooga to Palmwoods 275kV and 132kV Transmission Network Ingle Line Diagram Sketch



With reference to [1] the 275kV transmission lines are rated at 800MW capacity while the 132kV transmission lines are able to be rated at 200MW capacity.

A site visit confirmed the structure of the 275kV transmission system to be single circuit towers with two conductors mechanically connected (bundled) per phase. PAGE has provided advice that the conductors used in the 275kV system are termed GOAT, which indicates they are ASCR/AC 30/3.71 7/3.71. This conductor is calculated to have a rating of 793 Amps with a typical conductor design temperature of 75 degrees Celsius, so for a two conductor bundle the rating of 1,585 Amps is derived. At 275kV this equates to a 755 MVA rating while at a typical 106% regulated voltage, the rating of the transmission line is calculated at 800MVA.

A site visit confirmed the structure of the 132kV transmission system to be twin circuit towers with single conductors per phase. Each of the two circuits on the 132kV towers represents a single feeder. PAGE has provided advice that the conductors used in the 132kV transmission system are a mixture of LEMON and PANTHER which indicates ASCR/GZ 30/3.00 7/3.00 or ASCR/AC 30/3.00 7/3.00. It is noted that the power conductors are similar with the exception of the king wire which provides mechanical support to the outer power conductors. Each wire is similarly rated, with calculated 613 Amps or 625 Amps respectively under nominal conditions based on typical 75 Degrees Celsius limit. This translates to a 150MVA capacity at 106% nominal voltage, which is lower than the Energex rating of 200MW. It is noted that the Energex rating is given as a 2 hour emergency rating for N-1 contingency assessment and hence the conductor temperature may be allowed to rise to 105 Degrees Celsius which then is calculated to provide the reported 200MW capacity. This emergency conductor rating temperature allowance is not uncommon, and for ASCR conductors the temperature considerations are typically based on knowledge of the particular materials the conductor was constructed with. ASCR conductors may have grease applied between the strand wires and above 120 degrees Celsius it may melt and drop from the conductor, therefore supply authorities may apply upto 120 Degrees Celsius emergency rating for such conductors. The sag of the conductor at high temperatures is of prime importance as ground clearances must be maintained, hence tensioning the conductors to maintain ground clearance at the elevated temperatures is also critical. Energex has advised in [1] that these practices are being pursued to achieve the stated 200MVA, 2 hour rating of the 132kV conductors

It is noted that the transmission line ratings are based on several factors with dominant factors being wind speed, ambient temperature and allowable conductor temperature. An example of the influence of such factors is noted whereby if we assume a $1.5ms^{-1}$ wind speed while maintaining a 35 Degrees Celsius ambient and 105Degrees Celsius conductor temperature, then the derived 2HEC rating becomes 224MW on the 132kV transmission system. Given the significant variation with wind and temperature assumptions, then generally a 200MW rating of the 132kV system is assumed as compared to maintaining assertions of 189MW to 200MW differences as given in [1].

Based on the above, the stated 800MW rating for 275kV assets is considered conservative for the transmission network, while the 200MVA rating of the 132kV transmission line is accepted as stated and applied to all 132kV feeders in Figure 1 given that all lines are relatively similar construction and able to be rated to 200MW if desired.

4. Sunshine Coast Load Demand

The analysis in [1] provides transmission line ratings in MW (Mega Watts) and load assessments in MW also. However this is slightly misleading given that transmission line ratings are based on Amps required to heat a conductor which is then converted to MVA by reference to the system operating voltage.

The units of MVA include active power (MW) and reactive power (MVAr) which accounts for the load power factor. Hence a transmission line demand will include both active and reactive power so the demand of real consideration is MVA and not MW. Accordingly the load of interest is MW and MVAr instead of just MW as reported in [1].

It will be assumed here, that the loads provided are infact predominantly MW and over and above this load a reactive power flow will be determined based on a minimum power factor controlled to 0.98 at major substations.

Reference [1] also provides advice that capacitor banks will be implemented at Cooroy and Sunrise Hills and it is understood these changes have already been implemented.

The capacitor banks will be recalculated for each staged load consideration (i.e. 2016 or 2032 or 2052 as necessary). Even if the calculated ratings are not as installed, they could be installed at marginal cost as compared to transmission line rebuilds or upgrades.

4.1 Woolooga to Palmwoods 132kV System Load Demand Assessment

Reference [1] does not clearly state the 132kV system projected load demand.

Reference [1] Table 2 provides an Energex demand assessment for the Woolooga to Palmwoods 132kV system at 269MW with the breakup of load at 132kV busses also provided.

Beyond this data in Table 2 of [1], the Woolooga to Palmwoods 132kV system demand is intermeshed with the demand which would otherwise be supplied from separate 132kV systems fed out of Palmwoods substation. It is important to note that the additional substations given in Table 3 of [1], are not part of the Woolooga to Palmwoods 132kV system and they will therefore be separated out here for individual assessment.

4.2 Palmwoods East and South 132kV demand

The load referred to here is all load fed from Palmwoods 275kV system, whish does not include the Woolooga to Palmwoods 132kV system discussed in Section 4.1 of this report.

The reported 2017 year total area demand in [1] is 778MW inclusive of Woolooga to Palmwoods 132kV system, and hence the East and South loads are extrapolated as 778 – 269 = 509MW.

4.3 System Load Projections

Extracting the base loads from Table 1 of [1] and providing a lumped load assessment of 509MW for the Palmwoods "East and South" 132kV system, then the following future load projections are summarised here in Table 4.1.

Table 4.1 : Woolooga to Palmwoods Long Term Projected Load Demand with Palmwoods "East and South" Load demand. All Loads are given in MW.

Year	2017	2022	2027	2032	2037	2042	2047	2052
Growth Rate p.a.	*Basis*	*2.80%*	*2.50%*	*2.20%*	*1.90%*	*1.80%*	*1.60%*	*1.50%*
COOROY	26.0	29.8	33.8	37.7	41.4	45.2	49.0	52.7
COORAN	6.0	6.9	7.8	8.7	9.5	10.4	11.3	12.2
GYMPIE 11	19.0	21.8	24.7	27.5	30.2	33.1	35.8	38.5
GYMPIE 33	68.0	78.1	88.3	98.5	108.2	118.3	128.1	138.0
NOOSA	49.0	56.3	63.6	71.0	78.0	85.2	92.3	99.4
TRAVESTON	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
SUNRISE	76.0	87.3	98.7	110.1	120.9	132.2	143.1	154.2
NAMBOUR 25%	23.0	26.4	29.9	33.3	36.6	40.0	43.3	46.7
	269.0	308.5	348.8	388.7	426.8	466.5	504.8	543.7
Palmwoods Other	509.0	584.4	661.2	737.2	809.9	885.5	958.6	1032.7
Total	778.0	892.9	1010.0	1125.8	1236.7	1351.9	1463.4	1576.4

It is seen that the summated total load compares well with the loads given in Section A3.4 of reference [1] and hence these loads will be used here as a basis for further study. It is in particular noted that the 2052 year peak load was given as 1,574MW in [1] where as it is estimated at 1576.4MW here.

5. Power Supply Capacity Assessment

PowerLink have noted in [1] that the power flow is generally southward. Hence the discussion here will address this mode of 275kV power flow.

If the 275kV power system could maintain a regulated voltage and insignificant phase shifted supply at Palmwoods with respect to Woolooga, then the 132kV Energex system could be reviewed in isolation of the 275kV system. An analysis is conducted here to determine the supply voltage phase shift characteristics under which the 132kV system could be analysed in isolation to the 275kV system. The resulting analysis of the 132kV system will then be considered conservative within the capacity of the 275kV system.

It is noted that a phase shifted 275kV supply voltage between Woolooga and Palmwoods would result in reactive power flows through the 132kV system. In any case if the 275kV system did become excessively phase shifted, then free flowing power from the 275kV system through the 132kV Energex system could be stopped by breaking the 132kV interconnection or adding impedance between the interconnection during the 275kV contingency condition. These options will be explored in the 132kV Energex system analysis.

5.1 275kV Supply Capacity

The 275kV system will be analysed in N-1 configuration with the Woolooga to Palmwoods 275kV transmission line out of service. This is expected to lead to a worst case N-1 contingency assessment for the Energex 132kV system operation which is subsequently analysed.

It is noted that there is generation at Tarong and Wivenhoe directly into the 275kV system which would act to stabilise the supply in the N-1 system condition to be assessed here. It is further noted that Tarong is approximately 100km in direct line from Southpine and Wivenhoe is only approximately 50km in direct line from Southpine. With the route of supply in the N-1 conditions possibly being Woolooga to Southpine and subsequently to Palmwoods in a southward power flowing network, then the route length of 275kV supply is in the order of at least 200km. It is unlikely that the noted southward supply would continue under N-1 conditions and it is expected that Wivenhoe and Tarong generation would pickup load to flow into Southpine and onto Palmwoods, hence the phase shift calculated in this assessment would certainly be worst case.

The Woolooga to Southpine 275kV transmission line is rated at 800MW capacity as is the Palmwoods 275kV transmission line. Reference [3] indicated inter regional power flows from Gladstone through Woolooga to Southpine are necessary and it is hence assumed an 800MW transfer from Woolooga is required. It will further be assumed that Palmwoods requires 800MW demand. In the N-1 condition, the phase shift of Palmwoods with respect to Woolooga will be assessed.

The resulting phase shift is calculated at approximately 46 Electrical Degrees which is relatively enormous in terms of feeding end supplies for an underlying interconnected power system. Such phase shift would be expected to result in unsustainable flow through the Energex 132kV system if it was left interconnected between Woolooga and Palmwoods during the 275kV N-1 condition.

In the 132kV system analysis, the resultant voltage drop along the 275kV transmission system will be compensated for in the 275/132kV regulating transformers at Woolooga and Palmwoods, hence the voltage magnitude is not of concern here if it can be regulated at the 132kV source bus.

The 275kV system therefore presents two Constraints:

1. In the N-1 configuration, the 275kV system is limited in its capacity to provide 800MW demand into Palmwoods.

2. The N-1 configuration will result in very high 46 degree electrical supply phase shift which must be dealt with in the 132kV underlying system.

The load demand forecasts presume the Palmwoods load, other than that to be considered in the Woolooga to Palmwoods Energex 132kV system, will exceed 800MW demand at approximately the year 2037. Hence by the year 2037 the Palmwoods supply will have to be augmented due to the first noted constraint. This constraint is apparently dealt with in the proposed project [1] by injecting supply into Eerwah Vale which could then allow Eerwah Vale to Palmwoods 132kV transmission flows to support Palmwoods substation. Infact in the year 2052, the proposed Eerwah Vale injection would be providing 236.3MW capacity into Palmwoods (Refer Appendix B, Figure B.1).

Under normal operating conditions with 800MW transfer from Woolooga and 800MW demand at Palmwoods, the 275kV Palmwoods supply was simulated with a 11.9 Degree Electrical phase shift with respect to Woolooga.

5.2 Energex 132kV System Operational Analysis

With the phase shift in 275kV supply accounted for at 12 Degrees (for the normal 275kV system configuration with maximum N-1 security load transfer of 800MW on the 275kV line rating from Woolooga), then the 132kV normal system operating arrangement will overload:

1. the Woolooga to Gympie 132kV transmission system at the year 2017 based on the 75 Degree Celsius conductor rating. Refer to Load Flow result in Appendix A1.

2. The Palmwoods to Image Flats 132kV lines from the year 2040 based on 2 hour emergency rating using 105 Degree Celsius conductor rating. Refer to Load Flow result in Appendix A2.

This overload can be controlled by adding impedance between Gympie and the Cooroy such that more of the southern substation load demand is source from the lightly loaded Palmwoods 132kV System. By installing a bus section at Gympie and opening the Traveston to Gympie transmission line The Energex 132kV system could be:

1. operated in the normal configuration within the 75 Degrees Celsius continuous rating to the year 2038. Refer to Load Flow result in Appendix A3.

2. operated in the N-1 configuration within the 105 Degrees Celsius 2 hour emergency rating to the year 2029 with no switching upon the outage occurring. Refer to Load Flow result in Appendix A4.

3. Operated in the N-1 configuration within the 105 Degrees Celsius 2 hour emergency rating to the year 2052 at least, by opening the Gympie to Cooran 132kV line and breaking the free flow between Woolooga and Palmwoods, as shown in Appendix A5 if a Woolooga to Gympie Line is taken out of service.

4. Operated in the N-1 configuration within the 105 Degrees Celsius 2 hour emergency rating to the year 2052 at least, by opening the Cooroy to Cooran 132kV line and breaking the free flow between Woolooga and Palmwoods, as shown in Appendix A6 if the Palmwoods to Image Flats Feeder 189-1 is taken out of service.

5. Operated in the N-1 configuration within the 105 Degrees Celsius 2 hour emergency rating to the year 2047 at least, with no further switching while breaking the free flow between Woolooga and Palmwoods, as shown in Appendix A7 if the Palmwoods to Image Flats Feeder 795-1 is taken out of service.

The above findings are supported by the fact that the 2 hour emergency rating of the 132kV lines can be made approximately 200MW. In the N-1 condition of the 132kV system, there will be 3 lines in service and hence the infeed capacity to the Energex system will be approximately 600MW. By review of Table 4.1 it is noted that in the year 2052 the Energex 132kV system load is estimated at 543.7MW. Hence the Energex system has ample capacity and the main concern is how to control that capacity using controlled switching as shown in Appendix A. Furthermore, the 2046 to 2052 system analysis is implemented with the free flow of power between Woolooga and Palmwoods broken, hence as long as the 275/132kV transformers regulate their respective 132kV voltage then the noted 132kV system operation is independent of the 275kV system operation.

It is noted that in the absence of any other information, the loads at each substation were assumed to be equally split between each bus section of the substation. Although this may not be the case in the present system it is expected that it could well be made as such based on underlying 33kV system configuration switching and it is to be expected that Energex would seek to implement this assumption in order to minimise general loading on their system elements and hence extend the life of such assets (including 132/33kV transformers).

It is therefore concluded that the 132kV Energex system could operate to the year 2038 based on 75 Degrees Celsius conductor ratings which allow continuous operation of the system and well into the future (at least 2047 and possibly to 2052) in the N-1 configuration to maintain the 2HEC rating of the 132kV transmission lines.

It is noted that a general 2HEC rating of 200MW was assumed based on all 132kV transmission lines being of a similar construction and given that Energex has indicated the 2HEC rating could be brought to this standard on the Gympie lines.

The bus section circuit breaker at Gympie is expected to cost less than $1.5M to implement.

It is noted that the Noosaville 132kV system voltage will drop significantly and possible out of a typical -5% operational allowance in the 2047 year analysis with 795-1 feeder out of service. However it is also noted that the Cooroy to Sunrise 132kV system will need augmentation beyond 2034 (refer to Table B.1 in Appendix B) when the projected demand of Sunrise and Noosaville exceeds the 132kV Cooroy to Sunrise Hills N-1 rating. It is further noted that the Palmwoods to Cooroy 132kV system will likely require an additional feeder beyond the year 2038 to support the Energex 132kV system continuous demand. The proposed augmentation in Section 5.4 of this report supports the system upgrade requirement (which would be ultimately required in any case) and corrects an voltage regulation issues. Hence the future load flows in Appendix A8 and A9 are more likely and the noted voltage regulation issues would not be likely to eventuate.

The above system analysis considers Normal, N-1 and N-2 operation of the 275kV and 132kV Energex systems combined with regard to the Woolooga to Palmwoods network demands. The greater Sunshine coast area assessment needs to be considered and this will be subsequently analysed.

5.3 Sunshine Coast 132kV System Demand Analysis

Assuming North to South power flow only, then:

1. The 275kV system has a firm capacity at 800MW based on one of the 275kV lines to Palmwoods being taken out of service.

2. The 132kV Energex system has a 200MW supply capacity based on N-1 conditions of one of the Woolooga to Gympie lines being out of service.

Hence the Overall area capacity is estimated at 1000MW. This overall sunshine coast area demand is forecast to be exceeded in the year 2027.

It has been shown that with a very modest respective invest at Gympie Substation of a single circuit breaker, the Woolooga to Palmwoods system could operate to at least 2038 based on 75 Degree Celsius continuous conductor rating and to at least 2047 based on N-1 configuration analysis to 2HEC rating. Assuming the Gympie Bus section circuit breaker is added then the first system constraint to be reached will be the Palmwoods area injection capacity at 2027.

Reference [1] deals with this Palmwoods constraint by proposing to build a new substation at Eerwah Vale and ultimately injecting 236.3 MW to Palmwoods along the 132kV transmission system. This solution review is shown in Appendix B Figure B.1 graphically. The ultimate injection to Palmwoods is then 795MW along the 275kV system and 236.3MW along the 132kV system to give a total of 1031MW. **We may note that the "Palmwoods Other" loads were estimated at 1033MW in Table 4.1 during the year 2052 and hence it is shown here that the Palmwoods system loads are relying on 800MW capacity of the 275kV system in N-1 configuration and 236.3 MW of the 132kV system in N-1 configuration. This analysis shows that the 132kV system will not be able to provide the N-1 capacity as it is limited to approximately 200MW based on 2 hour rating to 105 Degrees Celsius conductor temperature. The additional 132kV system amplification to achieve the required N-1 capacity is not dealt with in the EIS of the project however new easements and line constructions will be required to support the noted load.**

With the proposed Eerwah Vale substation going ahead, then the required 132kV line amplifications would eventually start from the proposed new substation and extend to Palmwoods (Refer to Appendix B where in the initial section to Image flats would be required by 2035 and the subsequent section from Image flats to Palmwoods would be required by 2045).

5.4 Approach to Support Woolooga to Palmwoods Long Range Forecast Demand

It was noted that the Woolooga to Palmwoods system can maintain the 75 Degrees Celsius rating to until at least 2038.

It has been noted that the proposed project in [1] does not deal with excessive load projected to flow in to Palmwoods on the 132kV system and that an additional 132kV transmission line would be required to support this load.

An assessment is made here of the impact on such a line and the ultimate Energex 132kV system configuration to the year 2052, if such a 132kV transmission line could be built from Cooroy to Palmwoods. A loadflow assessment is made assuming the required transmission line was built and assuming the Gympie to Cooran and Gympie to Traveston lines were switched off. The load flow is reported in Appendix A8.

It is noted that with the required 132kV line built, and with a bus section Circuit Breaker at Cooroy closed and with the Gympie load isolated from Palmwoods, then the Energex system remains within the 75 Degrees Celsius continuous current rating and it would maintain N-1 operating capacity beyond 2052.

It is further noted here that the splitting of the Energex 132kV network into 2 networks, breaks the possible free flow of power from Woolooga to Palmwoods and hence stops any unnecessary circulating reactive power flows through the 132kV system. This is significantly beneficial to the power system operation and it makes all considerations with regard to phase shift in voltages between Woolooga and Palmwoods redundant.

An N-1 investigation on either the Woolooga to Gympie network or the Palmwoods to Noosaville network is shown in Appendix A9. It is noted that all flows remain within the 2HEC rating of the proposed transmission network, voltage regulation is maintained well and the Cooroy bus section circuit breaker should be rated to at least 900 Amps.

5.5 Timing of 275kV Transmission Line Upgrade

If we assume the Eerwah Vale substation project does not go ahead, then we can investigate when the 275kV transmission line will need to be upgraded into Palmwoods. The two conditions to be assessed are the normal and contingency 132kV Energex system demand into Palmwoods via the 275kV injection. When this injection exceeds 800MW then the Palmwoods 275kV Augmentation would become necessary. This date of final requirement on the 275kV system will also dictate the project NPV costing.

With a proposed Gypmie Bus Section in service and the Gympie to Traveston 132kV line out of service (the normal proposed configuration), then Palmwoods injection reaches 800MW in the year 2028. Refer to Loadflow of Appendix A10.

With a proposed Gypmie Bus Section in service and the Gympie to Traveston 132kV line out of service (the normal proposed configuration), plus one of the Woolooga to Gympie lines out of Service in an N-1 outage, then Palmwoods injection reaches 800MW in the year 2027. Refer to Loadflow of Appendix A11.

It is therefore concluded that the Palmwoods 275kV transmission line upgrade would be required by the year 2027 if the Eerwah Vale substation is not progressed.

It is recalled here that the 275kV transmission line rating of 800MW was based on a 75Degrees Celsius rating as compared to the 132kV system which is being allowed to operate beyond 100 Degrees Celsius in the N-1 configuration. If we allow the 275KV transmission system to Palmwoods to operate to 90 Degrees Celsius in the N-1 condition then the line rating could be recalculated to 967MW based on 106% operating voltage.

It is then noted that if the 275kV transmission line to Palmwoods was allowed to operate to 90 Degrees Celsius in the N-1 configuration of the 275kV and 132kV systems, then the 275kV upgrade could be extended to the year 2037.

5.6 Conclusions

The 132kV Energex system from Woolooga to Palmwoods could overload the Woolooga to Gympie 132kV transmission lines continuous rating to 75 Degrees Celsius in the year 2017 if it was left as a free flowing network with no further upgrades. This can be overcome by opening the Gympie to Traveston 132kV transmission line and installing a 132kV bus section circuit breaker at Gympie substation with a relatively

modest cost estimated below $1.5M. With the proposed bus section circuit breaker and the 132kV line opened a Traveston, then the 132kV system would remain within its continuous 75 Degrees Celsius rating until the year 2038.

The Energex 132kV system could be made to (or has) a firm capacity at approximately 600MW based on 4 transmission lines infeeds each rated at 200MW and one of them being out of service. The Energex 132kV network demand is not projected to exceed 544MW even to the year 2052 based on long range forecasts in [1] and repeated here in this report. Hence the Energex system could be operated to maintain it's 2HEC rating far into the future load projections. The 132kV system continuous demand rating at 75Degrees Celsius is estimated at 150MW per line and hence 450MW in an N-1 configuration with three lines in service. This load is estimated around the year 2040.

Based on simple calculations and more detailed assessments made in this report, it is therefore concluded that a modest investment below $1.5M could maintain the Energex system within its continuous rating until at least 2038 and within its 2HEC ratings until at least 2047. The need to urgently amplify the 132kV system to support the Energex 132kV Woolooga to Palmwoods demand in not apparent.

The proposed project which installs a 275/132kV substation at Eerwah Vale proposes transmission flows to Palmwoods beyond the 2HEC capacity of the 275kV and 132kV system combined. To support the proposed project in an N-1 configuration of the 275kV and 132kV networks, then 132kV transmission line upgrades would be required from the new substation to Palmwoods. These upgrades have not been assessed in the project EIS.

With the required additional 132kV transmission line from Palmwoods to Cooroy in service, then the Energex system could be made to operate within its continuous and N-1 ratings beyond 2052 without the Eerwah Vale substation in service.

If the Eerwah Vale substation project is not progressed, then a 275kV line from Woolooga to Palmwoods would be required by the year 2027 due to the N-1 operation of the Energex 132kV system along with the Palmwoods other loads combining to exceed the 275kV 800MW N-1 configuration demand rating. However it is noted that the 275kV line might be deemed acceptable to operate to 90 Degrees Celsius in the N-1 emergency configuration and hence delay the 275kV upgrade to the year 2037.

Given :

1. **the above 132kV line amplifications which are required by the proposed project and not dealt with in the EIS but would ultimately be required in any case**
2. **that the Eerwah Vale 275/132kV substation is not needed as noted in this report**
3. **the need for load capacity into Palmwoods 275/132kV substation (ref [1] and Table 4.1 of this report)**
4. **the available 275kV easement from Woolooga to Palmwoods (ref [1] proposed project)**
5. **the already proposed half initiated construction of the 275kV line from Woolooga to Eerwah Vale by the proposed project (ref [1] proposed project)**
6. **the strategic requirement to complete the Woolooga to Palmwoods 275kV transmission system in order to maximise generation flows to the greater Brisbane area (ref [1] page 20)**
7. **The Energex 132kV system between Woolooga and Palmwoods has been shown to be operable in N-1 configuration of the 132kV system, N-1 configuration of the 275kV system and N-2 configuration when both systems are considered**

8. **The N-1 assessments of the 275kV system in this report will become redundant, and hence the enormous possible phase shift in the Woolooga and Palmwoods supply will be relieved to a more tolerable level as considered in the Normal configuration load flows and in the 132kV N-1 configuration load flows (having 12 Electrical Degree maximum phase shift)**
9. **It is further noted in reference [6] that capacitor banks in the Woolooga to Palmwoods underlying system have been considered and are planned for implementation already given an additional 20MVAr 33kV bank planned for Nambour 33kV system at a cost of $1.26M. It is therefore considered unlikely that the cost of capacitor banks to support the power factor correction of the Woolooga to Palmwoods 132kV system would need to be duplicated costed as part of this system assessment.**

then it would appear prudent to complete the 275kV transmission system to Palmwoods in order to secure Palmwoods with 1600MW capacity as compared to the present 800MW capacity and proposed project 1000MW capacity. The timing of this upgrade is required by the year 2027 if the 275kV transmission line emergency rating is maintained at 800MW (75 Degrees Celsius operation) and this could be extended to the year 2037 if the 275kV transmission line rating is increased to allow 90 Degree Celsius operation in the 2 Hour Emergency Condition rating. Such an allowance to operate the 275kV line to 90 Degrees Celsius would not seem unreasonable with strategies that are presently being used by Energex subsequently being adopted by PowerLink.

With completion of the 275kV line to Palmwoods then the capacity of Palmwoods substation would extend well beyond 2052.

It is incomprehensible from a system strategic assessment as to why the proposed 275kV injection with 800MW capacity would be fed into a 132kV bottle neck which is the 132kV system between Woolooga to Palmwoods given that the 132kV system limits the flows out of the 132kV system to the wider Sunshine coast area to 200MW in its present and proposed configuration, while the wider sunshine coast area is seen to be the area which demands the new additional supply capacity.

6. References

[1] Woolooga to Cooroy South Transmission Line and Cooroy South Substation Project, Final Environmental Impact Statement and Environmental Management Plan, Appendix G, Assessment of need; Parsons Brinkerhoff and PowerLink

[2] Proposed Establishment of a 132/11kV Zone Substation at Cooran (COR), Final Report, 28 May 2009; Energex.

[3] Annual Planning Report 2009; PowerLink

[4] ABB, Grid System, Internet advertisement for Woolooga SVC.

[5] Proposed Establishment of a 132/11kV Substation at Pacific Paradise (PPD) and double circuit 132kV Overhead feeders from Palmwoods to Pacific Paradise and West Maroochydore (Suncoast Power Project),29 September 2009; Energex

[6] Energex Project Approval Report, T16 Nambour – Install 1*20MVAr 33kV capacitor bank ; AEMO

Appendix A : Load Flow Results

In the following load flow assessment charts:

Grey Colouring of Transmission line depict the line is out of service

Green Colouring of Transmission line depict load within 75 Degree Celsius rating

Tan Colouring of Transmission line depict load above 75 Degree Celsius Rating but within 105 Degree Celsius 2 hour emergency rating

Red Colouring of Transmission line depict load above the 105 Degree Celsius 2 hour emergency rating

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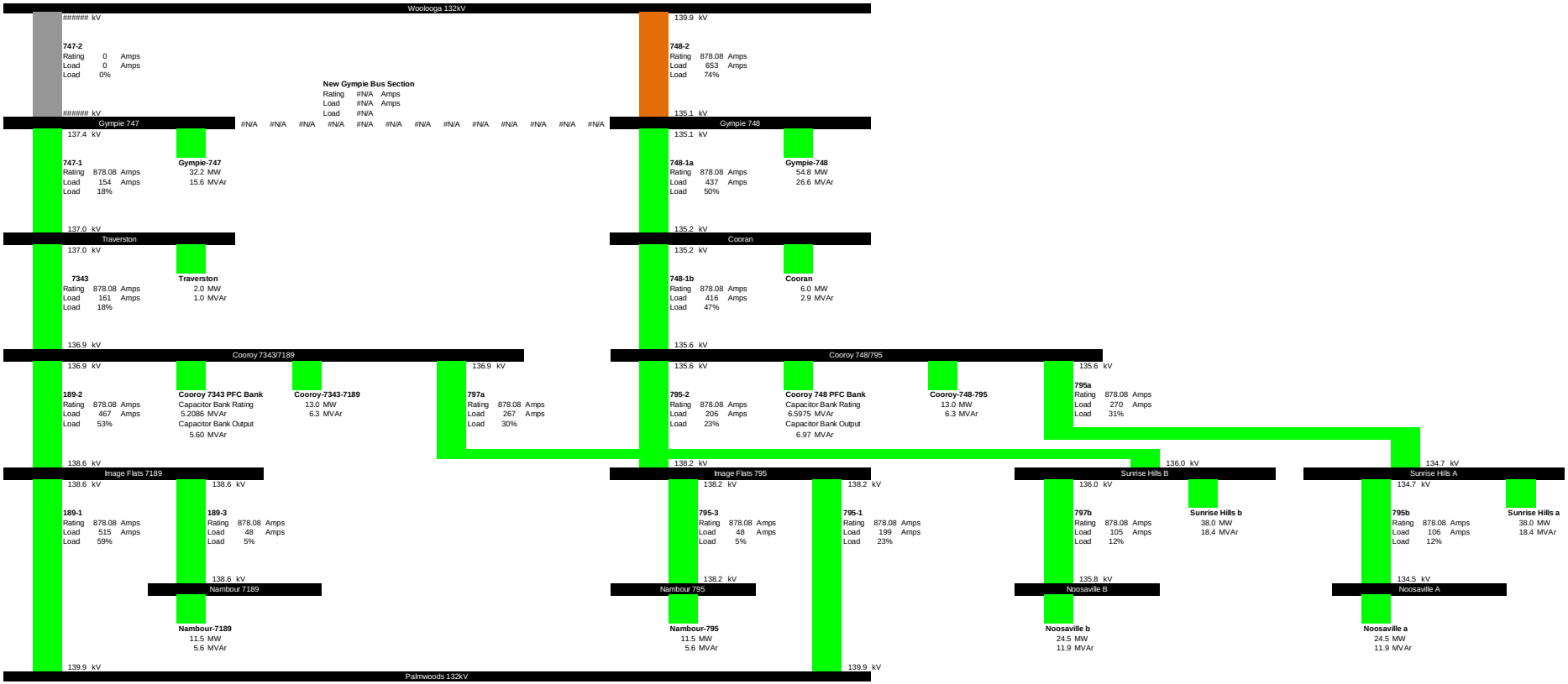
A1 : Existing System N-1 Load Flow to 2017



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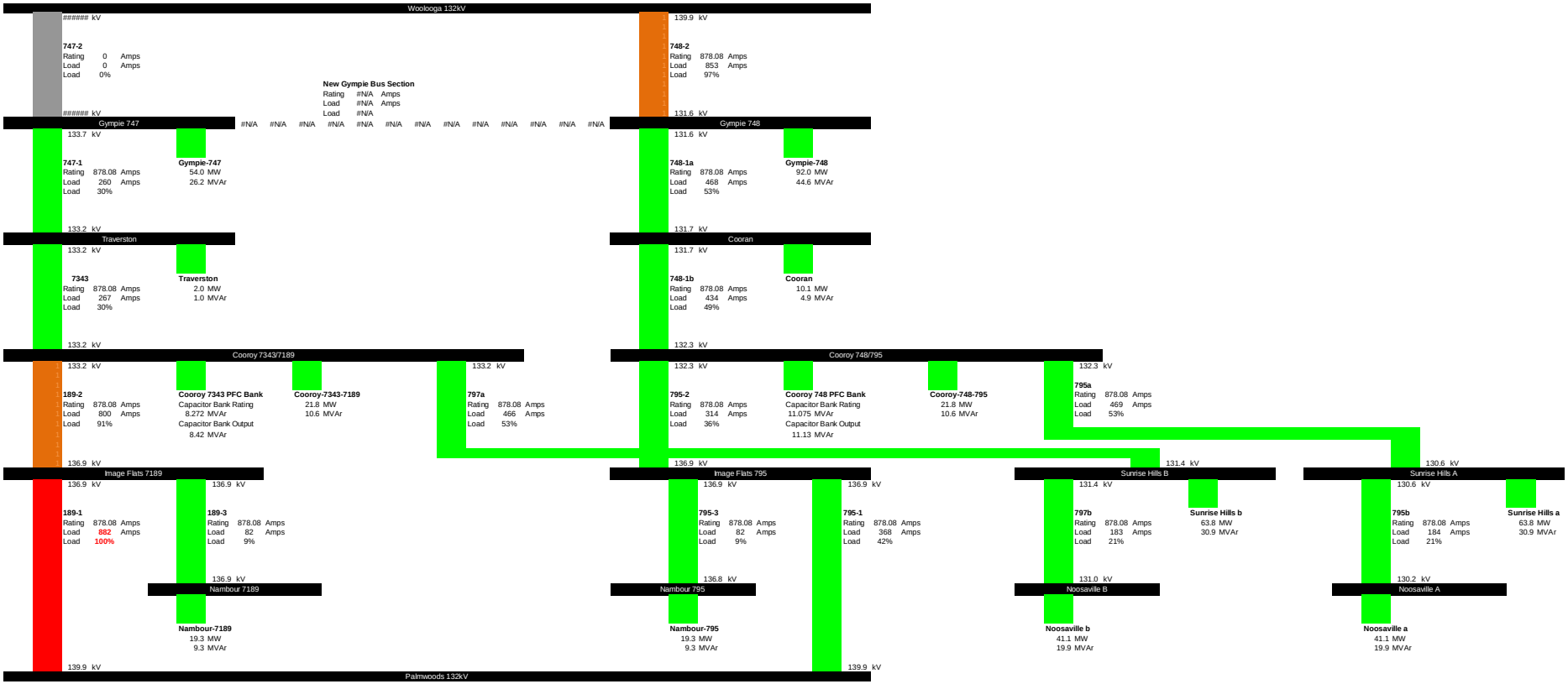
A2 : Existing System N-1 Load Flow to 2040



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A3 : Modified 132kV Energex System Load Flow to 2038 – Normal Configuration to 75 DegC Continuous Conductor Rating

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A4 : Modified 132kV Energex System Load Flow to 2029 : N-1 Configuration Control with 2HEC Rating of 132kV Lines

A5 : Modified 132kV Energex System Load Flow to 2052 : N-1 Configuration (Woolooga Line Outage) Control with 2HEC Rating of 132kV Lines

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A6 : Modified 132kV Energex System Load Flow to 2052 : N-1 Configuration (Palmwoods 189-1 Line Outage) Control with 2HEC Rating of 132kV Lines

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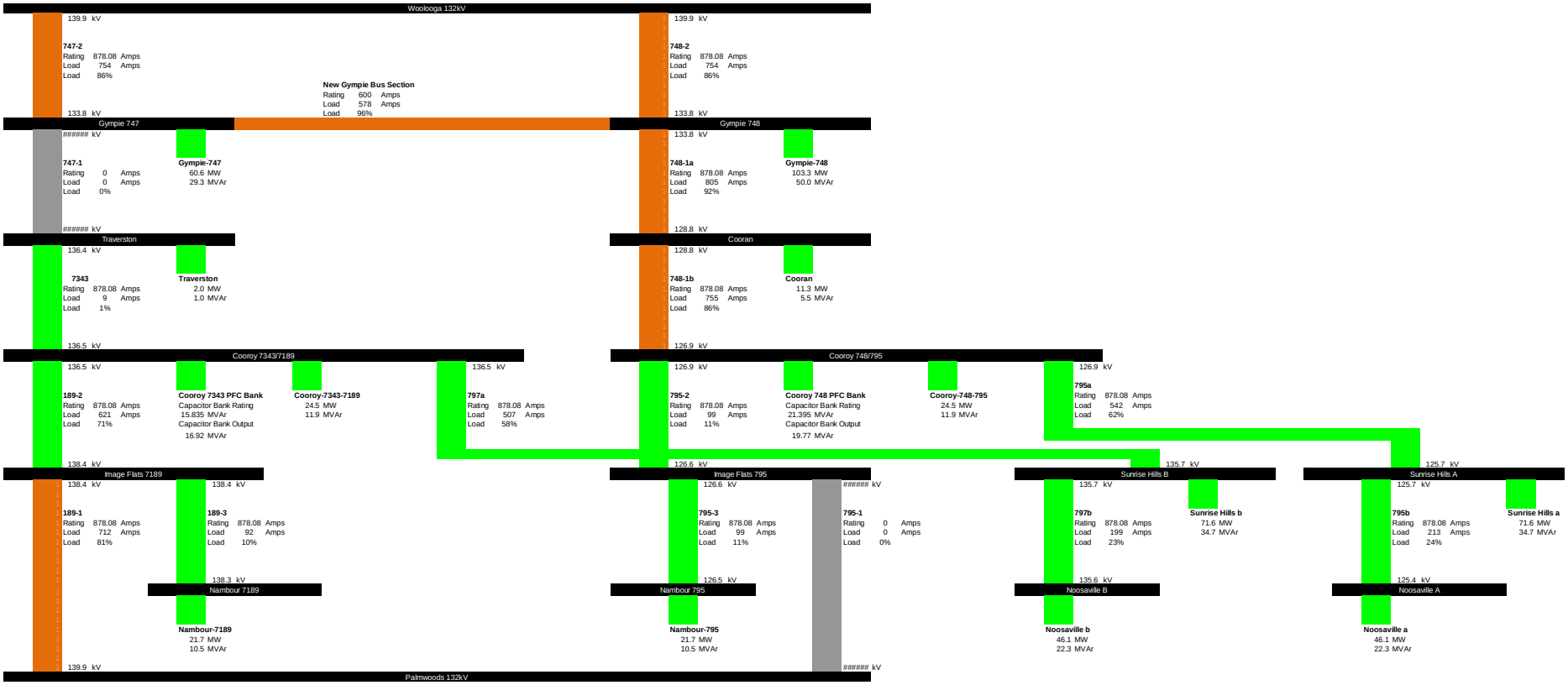
A7 : Modified 132kV Energex System Load Flow to 2047 : N-1 Configuration (Palmwoods 795-1 Line Outage) Control with 2HEC Rating of 132kV Lines



This study was subject to excessive voltage drop and increase power factor correction was allowed for. However the energex 132kV system would likely require Augmentation at this point in time.

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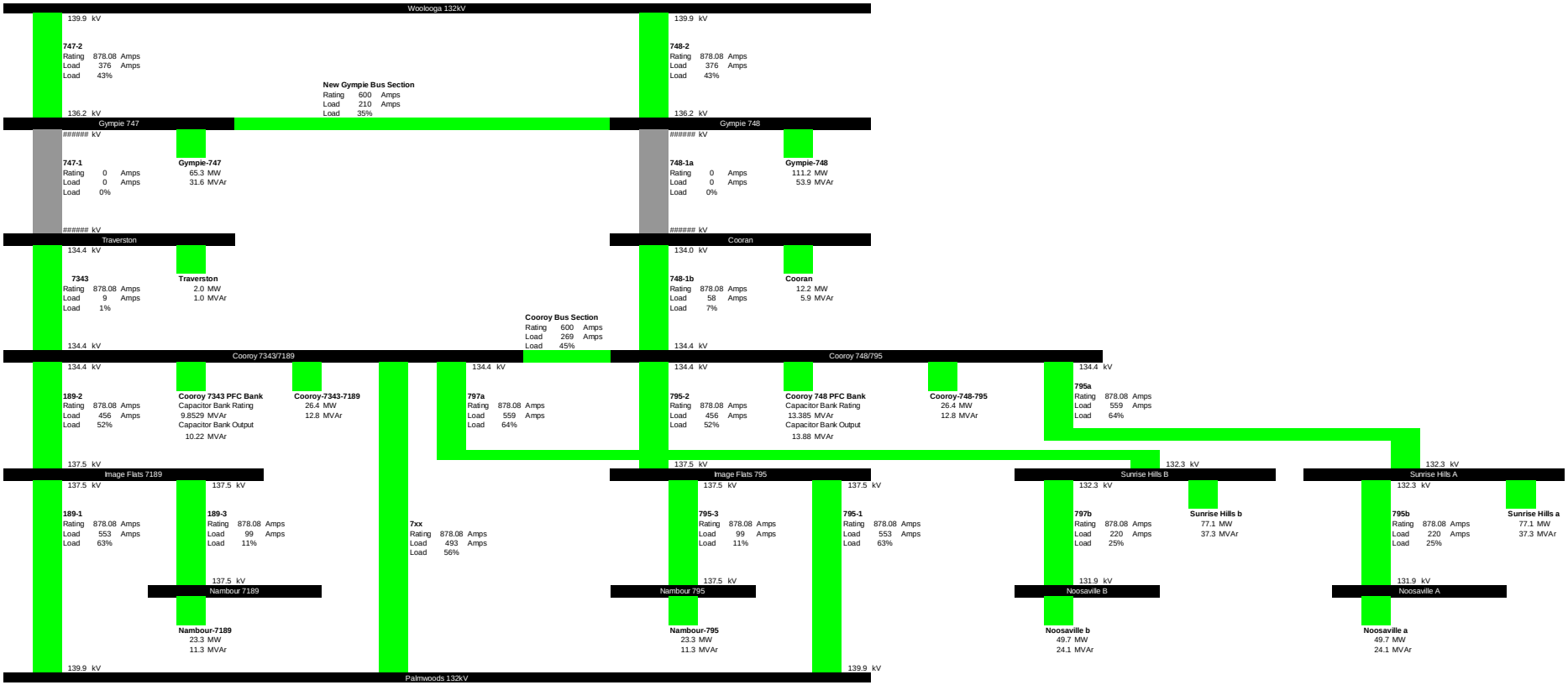
A8 : Possible 132kV Energex System future Augmentation to allow 2052 load demand within continuous rating of Transmission Lines



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A9 : Possible 132kV Energex System future Augmentation to allow 2052 load demand within continuous rating of Transmission Lines – Performance in N-1 configuration

Cooroy Bus Section CB required to be rated to 900 Amps if that is not the case now.

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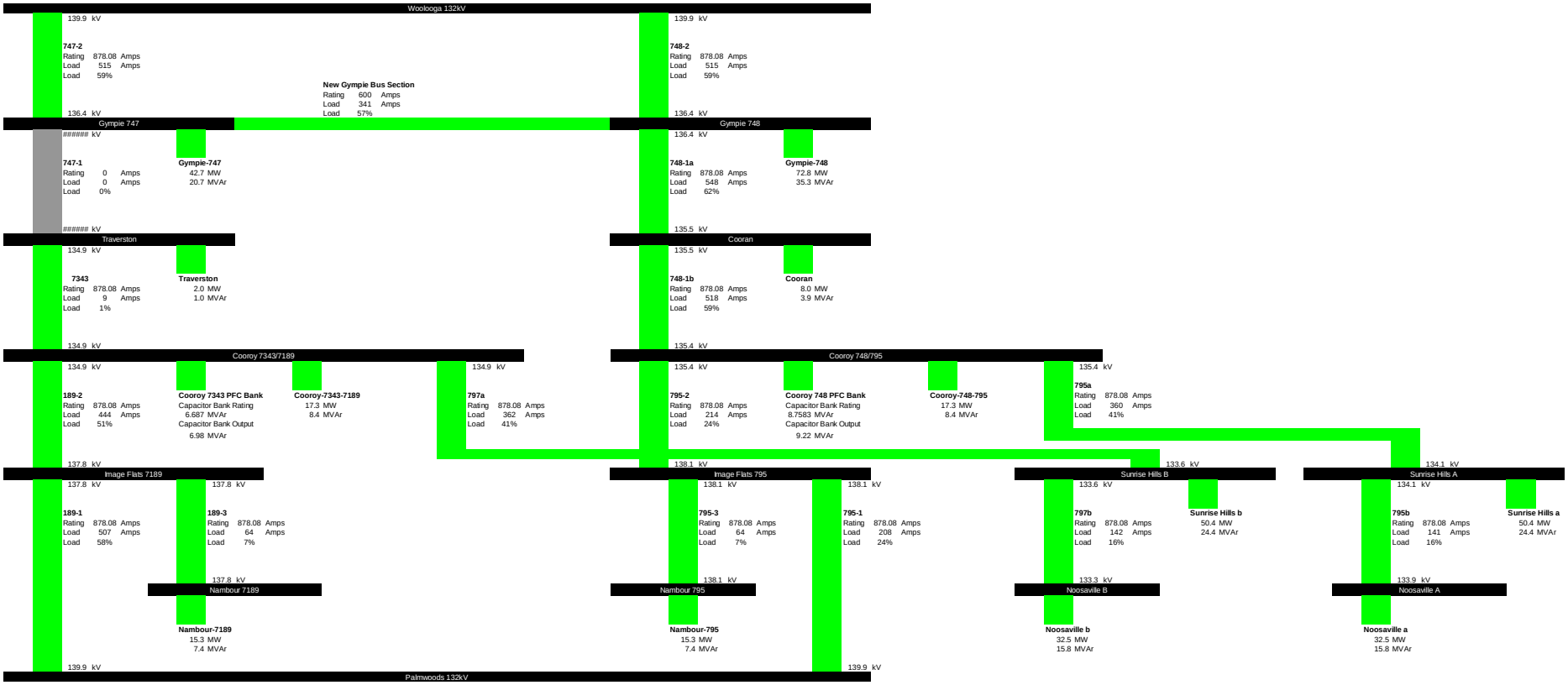
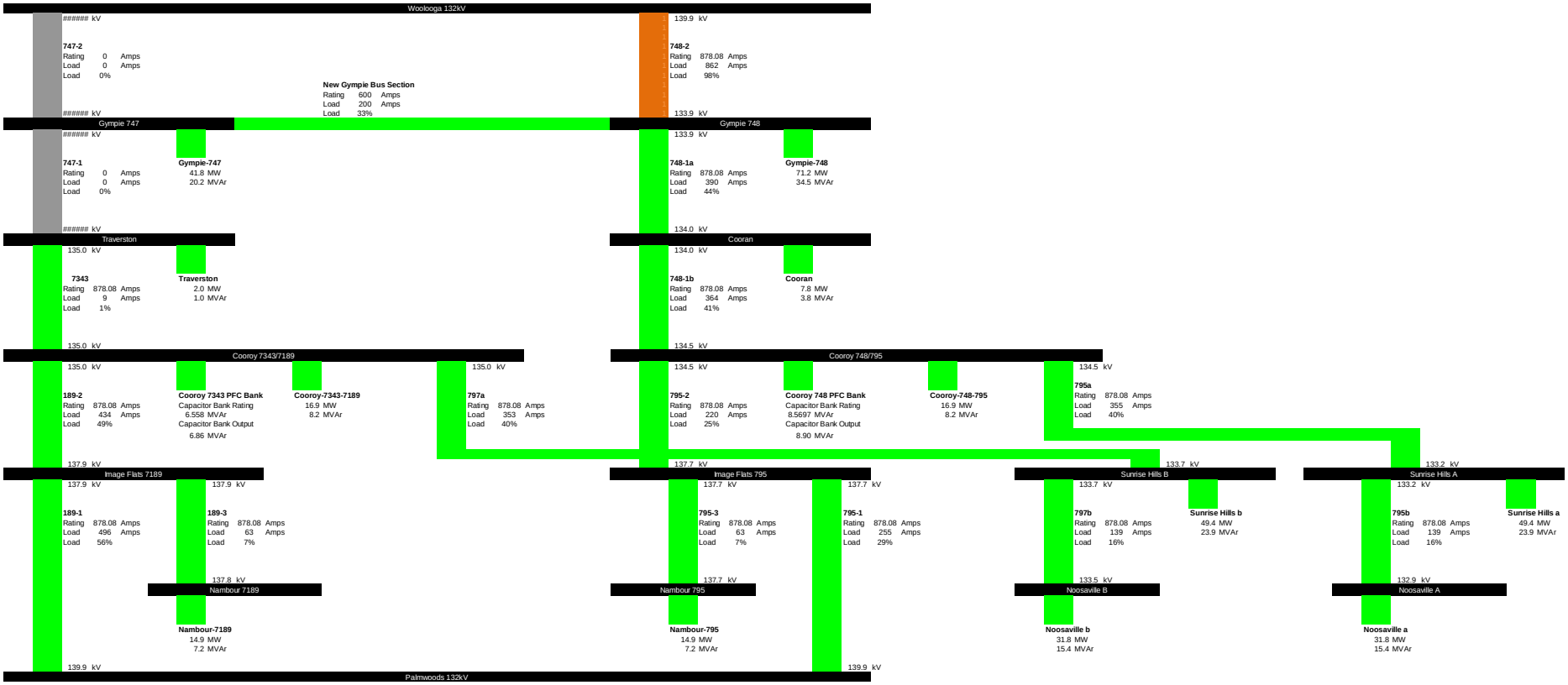
A10 : Possible 132kV Energex System future Augmentation timing to reach 800MW load injection from Palmwoods 275kV – Year 2028



A11 : Possible 132kV Energex System future Augmentation timing to reach 800MW load injection from Palmwoods 275kV – Year 2027 with 132kV in N-1 configuration at Woolooga to Gympie



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Appendix B : Analysis Of North and South Cooroy Feeding Options

Under the assumption that a 275/132kV substation must be built near Cooroy, then the aim of this analysis is to determine the differences of locating the proposed new substation to the north or south of Cooroy.

The analysis presented here is given based on:

1. an expanded version of Table 4.1 whereby each year is given as opposed to completing calculations on a 5 yearly basis after the year 2017 and

2. Reference [1] Page 32 Transmission System inflows for the years 2016/2017 and 2052/2053

The following noted are made with regard to the 275kV transmission flow data taken from [1] and used herein:

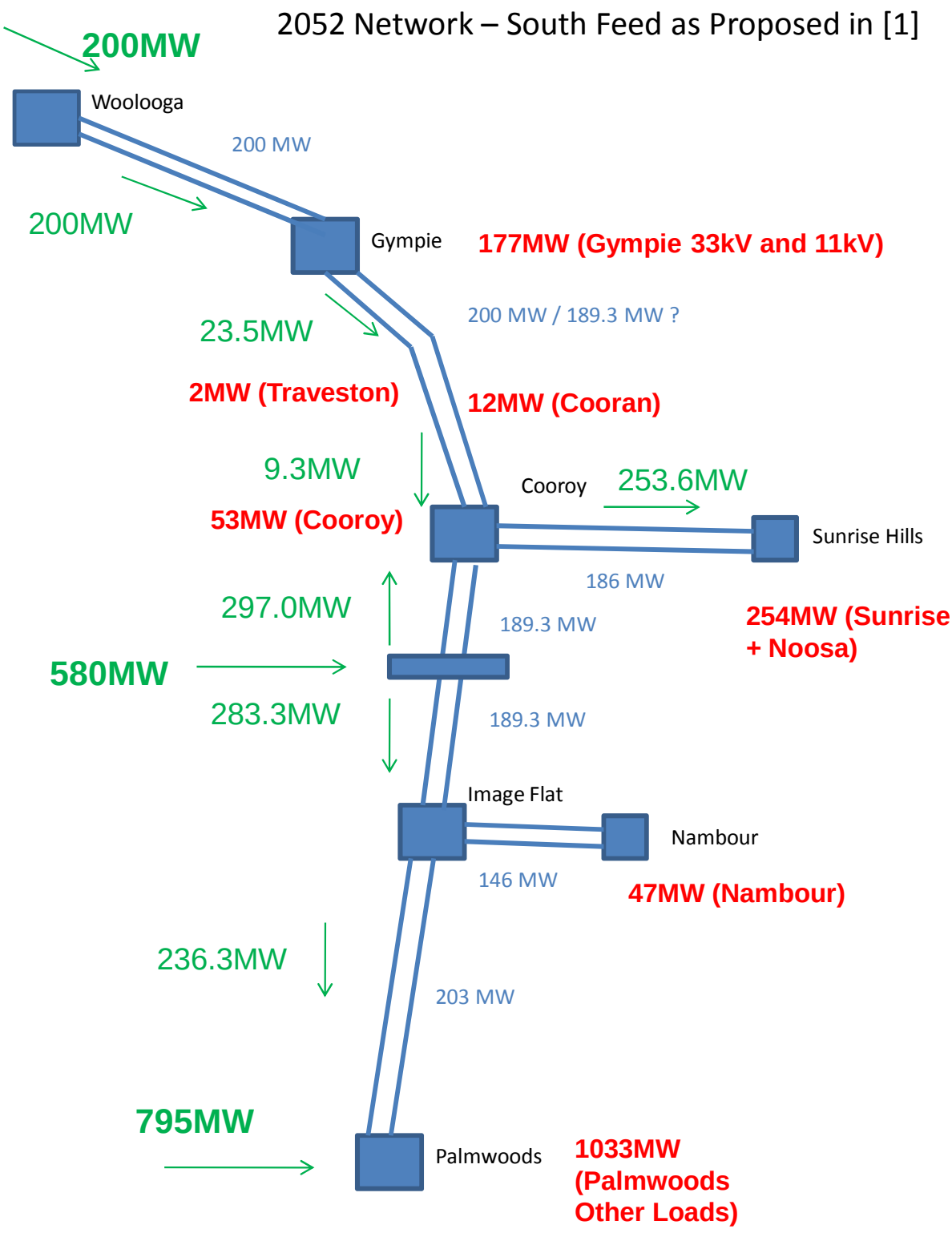
1. The transmission inflow data in Reference [1] appears uncharacteristic of a free flowing network when all loads are presumed to grow at an equal rate (as is assumed). For example it is noted that the Woolooga injected load grows by a margin of 133% when comparing the 2052 year injection to the 2017 year injection, while at the same time the New Substation infeed power grows by a margin of 276% and the Palmwoods injection grows by a margin of 189%. The loadflow model does not appear to be free flowing but instead the loadflow appears to be well controlled to maintain Woolooga infeed below 200MW as is the N-1 stated capacity of the 132kV transmission lines. **PowerLink should be requested to explain how the 275kV power flow control is being implemented or what are the parameters used in the load flow model which affect the 275kV system flows to Woolooga 132kV, Palmwoods and the New Cooroy Substation. Further PowerLink should be asked how such control could be used to benefit a proposed substation North of Cooroy.** Given this control is likely coming from the 275kV network operating system and given that the 275kV operating regime (including generation scheduling, SVC control, network loads, and network switching) are unknown in this report, then it was not possible to replicate the load flow results as presented. Significantly different flows were achieved with significantly higher flows from Woolooga to Gympie as would be expected in a free flowing network.

2. An assumption of linear demand growth applies at the 275kV injection points between the years 2017, 2031 and 2052 so as to allow interpolation of the infeed power between the years stated in [1].

3. It is assumed that a feeding point marginally north or south of Cooroy would result in the same 275kV injection however the 132kV system flows would only be changed. This assumption is expected to have an error margin which is well within the error margin of predicted load growth rates. A substation installed to the north or south of Cooroy by approximately 3km is not expected to give substantially different load flows from the 275kV system, particularly when the 275kV system can be controlled as noted above.

The ultimate 2052 load flow presented in [1] is expanded in Figure B.1 of this report for further discussion.

Figure B.1 : Reference [1] Proposed Power Flow Analysis 2052



By review of Figure B.1, it is noted (As pre reference [1] transmission flow diagrams) that:

1. the new substation is basically feeding Cooroy, Sunrise Hills, Noosaville, Nambour and Palmwoods

2. Woolooga supply is basically feeding Gympie, Traveston and Cooran

In order to defer required 132kV transmission line upgrades, the 132kV transmission system from the north to Image flats could be opened. Under these conditions the new substation would feed Cooroy, Sunrise Hills and Noosaville only while Palmwoods was left to supply all of the Palmwoods load plus Nambour.

Under the assumption of the transmission system being opened between Image Flats and the northern system, then the transmission flows between the new substation and Woolooga would be expected to be marginally changed from the reference [1] transmission flows. For the purpose of this desktop assessment due to lack of more detailed PowerLink operational data, then the flows will be assumed to remain unchanged between the New Substation and Woolooga.

Noting that the Nambour 25% load does not exceed the 132kV system N-1 rating, and that the Gympie load does not exceed the N-1 200MW rating, then the northern Cooroy substation option is then assessed against two criteria:

1. When does the Palmwoods load exceed the N-1 configuration 800MW rating of the 275kV system?

2. When does the new substation load exceed 132kV line N-1 rating of 200MW?

Table B.1 is presented to give the required assessment.

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Table B.1 : 132kV Network Upgrade Requirement to Maintain N-1 Conditions – Assuming Infeed Powers Can be Linearly Scaled

	Year	2017	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052
	Growth Rate p.a.	*Basis*	2.80%	2.50%	2.50%	2.50%	2.50%	2.50%	2.20%	2.20%	2.20%	2.20%	2.20%	1.90%	1.90%	1.90%	1.90%	1.90%	1.80%	1.80%	1.80%	1.80%	1.80%	1.60%	1.60%	1.60%	1.60%	1.60%	1.50%	1.50%	1.50%	1.50%	1.50%
	COOROY	26	29.8	30.6	31.4	32.1	32.9	33.8	34.5	35.3	36.1	36.8	37.7	38.4	39.1	39.8	40.6	41.4	42.1	42.9	43.6	44.4	45.2	46.0	46.7	47.4	48.2	49.0	49.7	50.4	51.2	52.0	52.7
	COORAN	6	6.9	7.1	7.2	7.4	7.6	7.8	8.0	8.1	8.3	8.5	8.7	8.9	9.0	9.2	9.4	9.5	9.7	9.9	10.1	10.3	10.4	10.6	10.8	10.9	11.1	11.3	11.5	11.6	11.8	12.0	12.2
	GYMPIE 11	19	21.8	22.4	22.9	23.5	24.1	24.7	25.2	25.8	26.3	26.9	27.5	28.0	28.6	29.1	29.7	30.2	30.8	31.3	31.9	32.5	33.1	33.6	34.1	34.7	35.2	35.8	36.3	36.9	37.4	38.0	38.5
	GYMPIE 33	68	78.1	80.0	82.0	84.1	86.2	88.3	90.3	92.3	94.3	96.4	98.5	100.4	102.3	104.2	106.2	108.2	110.1	112.1	114.1	116.2	118.3	120.2	122.1	124.1	126.0	128.1	130.0	131.9	133.9	135.9	138.0
	NOOSA	49	56.3	57.7	59.1	60.6	62.1	63.6	65.0	66.5	67.9	69.4	71.0	72.3	73.7	75.1	76.5	78.0	79.4	80.8	82.3	83.7	85.2	86.6	88.0	89.4	90.8	92.3	93.7	95.1	96.5	97.9	99.4
	TRAVESTON	2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	SUNRISE	76	87.3	89.4	91.7	94.0	96.3	98.7	100.9	103.1	105.4	107.7	110.1	112.2	114.3	116.5	118.7	120.9	123.1	125.3	127.6	129.9	132.2	134.3	136.5	138.7	140.9	143.1	145.3	147.5	149.7	151.9	154.2
	NAMBOUR 25%	23	26.4	27.1	27.7	28.4	29.1	29.9	30.5	31.2	31.9	32.6	33.3	33.9	34.6	35.2	35.9	36.6	37.3	37.9	38.6	39.3	40.0	40.7	41.3	42.0	42.6	43.3	44.0	44.6	45.3	46.0	46.7
		269	308.5	316.2	324.1	332.1	340.4	348.8	356.4	364.2	372.2	380.4	388.7	396.0	403.5	411.1	418.9	426.8	434.5	442.3	450.2	458.3	466.5	473.9	481.5	489.1	496.9	504.8	512.4	520.0	527.8	535.7	543.7
	Palmwoods Other	509	584.4	599.0	613.9	629.3	645.0	661.2	675.7	690.6	705.8	721.3	737.2	751.2	765.4	780.0	794.8	809.9	824.5	839.3	854.4	869.8	885.5	899.6	914.0	928.6	943.5	958.6	973.0	987.6	1002.4	1017.4	1032.7
	Total	778	893	915	938	961	985	1010	1032	1055	1078	1102	1126	1147	1169	1191	1214	1237	1259	1282	1305	1328	1352	1374	1395	1418	1440	1463	1485	1508	1530	1553	1576
	Woolooga	150	157.1	158.6	160.0	161.4	162.9	164.3	165.7	167.1	168.6	170	171.4	172.9	174.3	175.7	177.1	178.6	180.0	181.4	182.9	184.3	185.7	187.1	188.6	190.0	191.4	192.9	194.3	195.7	197.1	198.6	200
	New Cooroy Sth	210	260.0	270.0	280.0	290.0	300.0	310.0	320.0	330.0	340.0	350	361.0	371.9	382.9	393.8	404.8	415.7	426.7	437.6	448.6	459.5	470.5	481.4	492.4	503.3	514.3	525.2	536.2	547.1	558.1	569.0	580
	Palmwoods	420	477.1	488.6	500.0	511.4	522.9	534.3	545.7	557.1	568.6	580	590.2	600.5	610.7	621.0	631.2	641.4	651.7	661.9	672.1	682.4	692.6	702.9	713.1	723.3	733.6	743.8	754.0	764.3	774.5	784.8	795
	Total Injection	780										1100																					1575
N-1 Rating	**South Cooroy Injection**																																
200	Woolooga to Gympie	150.0	157	159	160	161	163	164	166	167	169	170.0	171	173	174	176	177	179	180	181	183	184	186	187	189	190	191	193	194	196	197	199	200.0
189	Gypmie to Trav and Cooran	63.0	57	56	55	54	53	51	50	49	48	46.7	45	44	43	42	41	40	39	38	37	36	34	33	32	31	30	29	28	27	26	25	23.5
189	Trav and Cooran to Cooroy	55.0	48	47	46	44	43	41	40	39	38	36.2	35	34	32	31	30	29	27	26	25	23	22	21	20	18	17	16	15	13	12	11	9.3
186	Cooroy to Sunrise and Noosa	125.0	144	147	151	155	158	162	166	170	173	177.1	181	184	188	192	195	199	202	206	210	214	217	221	224	228	232	235	239	243	246	250	253.6
189	New Sub to Cooroy	96.0	125	131	136	142	148	155	160	166	172	177.8	184	189	195	200	206	212	217	223	229	235	241	246	252	257	263	269	274	280	285	291	297.0
189	new Sub to Image Flats	114.0	135	139	144	148	152	155	160	164	168	172.2	177	183	188	194	199	204	209	215	220	225	230	235	241	246	251	257	262	267	273	278	283.0
146	Image Flats to Nambour	23.0	26	27	28	28	29	30	31	31	32	32.6	33	34	35	35	36	37	37	38	39	39	40	41	41	42	43	43	44	45	45	46	46.7
203	Imagae Flats to Palmwoods	91.0	109	112	116	119	123	125	129	133	136	139.6	144	149	154	158	163	167	172	177	181	186	190	195	199	204	209	213	218	223	227	232	236.3
	Woolooga to Gympie	75%	79%	79%	80%	81%	81%	82%	83%	84%	84%	85%	86%	86%	87%	88%	89%	89%	90%	91%	91%	92%	93%	94%	94%	95%	96%	96%	97%	98%	99%	99%	100%
	Gypmie to Trav and Cooran	33%	30%	30%	29%	29%	28%	27%	27%	26%	25%	25%	24%	24%	23%	22%	22%	21%	21%	20%	19%	19%	18%	18%	17%	17%	16%	15%	15%	14%	14%	13%	12%
	Trav and Cooran to Cooroy	29%	26%	25%	24%	24%	23%	22%	21%	21%	20%	19%	18%	18%	17%	17%	16%	15%	14%	14%	13%	12%	12%	11%	10%	10%	9%	8%	8%	7%	6%	6%	5%
	Cooroy to Sunrise and Noosa	67%	77%	79%	81%	83%	85%	87%	89%	91%	93%	95%	97%	99%	101%	103%	105%	107%	109%	111%	113%	115%	117%	119%	121%	123%	125%	127%	128%	130%	132%	134%	136%
	New Sub to Cooroy	51%	66%	69%	72%	75%	78%	82%	85%	88%	91%	94%	97%	100%	103%	106%	109%	112%	115%	118%	121%	124%	127%	130%	133%	136%	139%	142%	145%	148%	151%	154%	157%
	new Sub to Image Flats	60%	71%	74%	76%	78%	80%	82%	85%	87%	89%	91%	94%	97%	100%	102%	105%	108%	111%	114%	116%	119%	122%	125%	127%	130%	133%	136%	139%	142%	144%	147%	150%
	Image Flats to Nambour	16%	18%	19%	19%	19%	20%	20%	21%	21%	22%	22%	23%	23%	24%	24%	25%	25%	26%	26%	26%	27%	27%	28%	28%	29%	29%	30%	30%	31%	31%	31%	32%
	Imagae Flats to Palmwoods	45%	54%	55%	57%	59%	60%	62%	64%	65%	67%	69%	71%	73%	76%	78%	80%	82%	85%	87%	89%	91%	93%	96%	98%	101%	103%	105%	107%	110%	112%	114%	116%
N-1 Rating	**North Cooroy Injection with Cooroy to Image Flats Open**																																
800	**Palmwoods + Nambour**	532	611	626	642	658	674	691	706	722	738	754	770	785	800	815	831	846	862	877	893	909	925	940	955	971	986	1002	1017	1032	1048	1063	1079
200	Cooroy + Sunrise Hills+ Noosaville	151	173	178	182	187	191	196	200	205	209	214	219	223	227	231	236	240	245	249	253	258	263	267	271	275	280	284	289	293	297	302	306
		67%	76%	78%	80%	82%	84%	86%	88%	90%	92%	94%	96%	98%	100%	102%	104%	106%	108%	110%	112%	114%	116%	118%	119%	121%	123%	125%	127%	129%	131%	133%	135%
		76%	87%	89%	91%	93%	96%	98%	100%	102%	105%	107%	109%	111%	114%	116%	118%	120%	122%	124%	127%	129%	131%	133%	136%	138%	140%	142%	144%	146%	149%	151%	153%
N-1 Rating	**North Cooroy Injection with Cooroy to Image Flats Closed and New 132kV Line to Cooroy**																																
200	Woolooga to Gympie	150.0	157	159	160	161	163	164	166	167	169	170.0	171	173	174	176	177	179	180	181	183	184	186	187	189	190	191	193	194	196	197	199	200.0
189	Gypmie to Trav and Cooran	63.0	57	56	55	54	53	51	50	49	48	46.7	45	44	43	42	41	40	39	38	37	36	34	33	32	31	30	29	28	27	26	25	23.5
189	Cooran to New Sub	55.0	48	47	46	44	43	41	40	39	38	36.2	35	34	32	31	30	29	27	26	25	23	22	21	20	18	17	16	15	13	12	11	9.3
600	New Sub to Cooroy	265.0	308	317	326	334	343	351	360	369	378	386.2	396	406	415	425	435	444	454	464	473	483	492	502	512	522	531	541	551	560	570	580	589.3
186	Cooroy to Sunrise and Noosa	125.0	144	147	151	155	158	162	166	170	173	177.1	181	184	188	192	195	199	202	206	210	214	217	221	224	228	232	235	239	243	246	250	253.6
189	Cooroy to Image Flats	114.0	135	139	144	148	152	155	160	164	168	172.2	177	183	188	194	199	204	209	215	220	225	230	235	241	246	251	257	262	267	273	278	283.0
146	Image Flats to Nambour	23.0	26	27	28	28	29	30	31	31	32	32.6	33	34	35	35	36	37	37	38	39	39	40	41	41	42	43	43	44	45	45	46	46.7
203	Imagae Flats to Palmwoods	91.0	109	112	116	119	123	125	129	133	136	139.6	144	149	154	158	163	167	172	177	181	186	190	195	199	204	209	213	218	223	227	232	236.3
	Woolooga to Gympie	75%	79%	79%	80%	81%	81%	82%	83%	84%	84%	85%	86%	86%	87%	88%	89%	89%	90%	91%	91%	92%	93%	94%	94%	95%	96%	96%	97%	98%	99%	99%	100%
	Gypmie to Trav and Cooran	33%	30%	30%	29%	29%	28%	27%	27%	26%	25%	25%	24%	24%	23%	22%	22%	21%	21%	20%	19%	19%	18%	18%	17%	17%	16%	15%	15%	14%	14%	13%	12%
	Cooran to New Sub	29%	26%	25%	24%	24%	23%	22%	21%	21%	20%	19%	18%	18%	17%	17%	16%	15%	14%	14%	13%	12%	12%	11%	10%	10%	9%	8%	8%	7%	6%	6%	5%
	New Sub to Cooroy	44%	51%	53%	54%	56%	57%	59%	60%	61%	63%	64%	66%	68%	69%	71%	72%	74%	76%	77%	79%	80%	82%	84%	85%	87%	89%	90%	92%	93%	95%	97%	98%
	Cooroy to Sunrise and Noosa	67%	77%	79%	81%	83%	85%	87%	89%	91%	93%	95%	97%	99%	101%	103%	105%	107%	109%	111%	113%	115%	117%	119%	121%	123%	125%	127%	128%	130%	132%	134%	136%
	Cooroy to Image Flats	60%	71%	74%	76%	78%	80%	82%	85%	87%	89%	91%	94%	97%	100%	102%	105%	108%	111%	114%	116%	119%	122%	125%	127%	130%	133%	136%	139%	142%	144%	147%	150%
	Image Flats to Nambour	16%	18%	19%	19%	19%	20%	20%	21%	21%	22%	22%	23%	23%	24%	24%	25%	25%	26%	26%	26%	27%	27%	28%	28%	29%	29%	30%	30%	31%	31%	31%	32%
	Imagae Flats to Palmwoods	45%	54%	55%	57%	59%	60%	62%	64%	65%	67%	69%	71%	73%	76%	78%	80%	82%	85%	87%	89%	91%	93%	96%	98%	101%	103%	105%	107%	110%	112%	114%	116%

The updated load table is presented here as Table B.1, with the same data presented in a zoomed format in tables B.1a and B.1b respectively.

Table B.1a : 132kV Network Upgrade Requirement to Maintain N-1 Conditions – Assuming Infeed Powers Can be Linearly Scaled – Year 2017 to 2036

	Year	2017	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036
	Growth Rate p.a.	*Basis*	2.80%	2.50%	2.50%	2.50%	2.50%	2.50%	2.20%	2.20%	2.20%	2.20%	2.20%	1.90%	1.90%	1.90%	1.90%
	COOROY	26	29.8	30.6	31.4	32.1	32.9	33.8	34.5	35.3	36.1	36.8	37.7	38.4	39.1	39.8	40.6
	COORAN	6	6.9	7.1	7.2	7.4	7.6	7.8	8.0	8.1	8.3	8.5	8.7	8.9	9.0	9.2	9.4
	GYMPIE 11	19	21.8	22.4	22.9	23.5	24.1	24.7	25.2	25.8	26.3	26.9	27.5	28.0	28.6	29.1	29.7
	GYMPIE 33	68	78.1	80.0	82.0	84.1	86.2	88.3	90.3	92.3	94.3	96.4	98.5	100.4	102.3	104.2	106.2
	NOOSA	49	56.3	57.7	59.1	60.6	62.1	63.6	65.0	66.5	67.9	69.4	71.0	72.3	73.7	75.1	76.5
	TRAVESTON	2	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	SUNRISE	76	87.3	89.4	91.7	94.0	96.3	98.7	100.9	103.1	105.4	107.7	110.1	112.2	114.3	116.5	118.7
	NAMBOUR 25%	23	26.4	27.1	27.7	28.4	29.1	29.9	30.5	31.2	31.9	32.6	33.3	33.9	34.6	35.2	35.9
		269	308.5	316.2	324.1	332.1	340.4	348.8	356.4	364.2	372.2	380.4	388.7	396.0	403.5	411.1	418.9
	Palmwoods Other	509	584.4	599.0	613.9	629.3	645.0	661.2	675.7	690.6	705.8	721.3	737.2	751.2	765.4	780.0	794.8
	Total	778	893	915	938	961	985	1010	1032	1055	1078	1102	1126	1147	1169	1191	1214
	Woolooga	150	157.1	158.6	160.0	161.4	162.9	164.3	165.7	167.1	168.6	170	171.4	172.9	174.3	175.7	177.1
	New Cooroy Sth	210	260.0	270.0	280.0	290.0	300.0	310.0	320.0	330.0	340.0	350	361.0	371.9	382.9	393.8	404.8
	Palmwoods	420	477.1	488.6	500.0	511.4	522.9	534.3	545.7	557.1	568.6	580	590.2	600.5	610.7	621.0	631.2
	Total Injection	780										1100					
N-1 Rating	**South Cooroy Injection**																
200	Woolooga to Gympie	150.0	157	159	160	161	163	164	166	167	169	170.0	171	173	174	176	177
189	Gypmie to Trav and Cooran	63.0	57	56	55	54	53	51	50	49	48	46.7	45	44	43	42	41
189	Trav and Cooran to Cooroy	55.0	48	47	46	44	43	41	40	39	38	36.2	35	34	32	31	30
186	Cooroy to Sunrise and Noosa	125.0	144	147	151	155	158	162	166	170	173	177.1	181	184	188	192	195
189	New Sub to Cooroy	96.0	125	131	136	142	148	155	160	166	172	177.8	184	189	195	200	206
189	new Sub to Image Flats	114.0	135	139	144	148	152	155	160	164	168	172.2	177	183	188	194	199
146	Image Flats to Nambour	23.0	26	27	28	28	29	30	31	31	32	32.6	33	34	35	35	36
203	Imagae Flats to Palmwoods	91.0	109	112	116	119	123	125	129	133	136	139.6	144	149	154	158	163
	Woolooga to Gympie	75%	79%	79%	80%	81%	81%	82%	83%	84%	84%	85%	86%	86%	87%	88%	89%
	Gypmie to Trav and Cooran	33%	30%	30%	29%	29%	28%	27%	27%	26%	25%	25%	24%	24%	23%	22%	22%
	Trav and Cooran to Cooroy	29%	26%	25%	24%	24%	23%	22%	21%	21%	20%	19%	18%	18%	17%	17%	16%
	Cooroy to Sunrise and Noosa	67%	77%	79%	81%	83%	85%	87%	89%	91%	93%	95%	97%	99%	**101%**	**103%**	**105%**
	New Sub to Cooroy	51%	66%	69%	72%	75%	78%	82%	85%	88%	91%	94%	97%	**100%**	**103%**	**106%**	**109%**
	new Sub to Image Flats	60%	71%	74%	76%	78%	80%	82%	85%	87%	89%	91%	94%	97%	100%	**102%**	**105%**
	Image Flats to Nambour	16%	18%	19%	19%	19%	20%	20%	21%	21%	22%	22%	23%	23%	24%	24%	25%
	Imagae Flats to Palmwoods	45%	54%	55%	57%	59%	60%	62%	64%	65%	67%	69%	71%	73%	76%	78%	80%
N-1 Rating	**North Cooroy Injection with Cooroy to Image Flats Open**																
800	**Palmwoods + Nambour**	532	611	626	642	658	674	691	706	722	738	754	770	785	800	815	831
200	Cooroy + Sunrise Hills+ Noosaville	151	173	178	182	187	191	196	200	205	209	214	219	223	227	231	236
		67%	76%	78%	80%	82%	84%	86%	88%	90%	92%	94%	96%	98%	**100%**	**102%**	**104%**
		76%	87%	89%	91%	93%	96%	98%	**100%**	**102%**	**105%**	**107%**	**109%**	**111%**	**114%**	**116%**	**118%**
N-1 Rating	**North Cooroy Injection with Cooroy to Image Flats Closed and New 132kV Line to Cooroy**																
200	Woolooga to Gympie	150.0	157	159	160	161	163	164	166	167	169	170.0	171	173	174	176	177
189	Gypmie to Trav and Cooran	63.0	57	56	55	54	53	51	50	49	48	46.7	45	44	43	42	41
189	Cooran to New Sub	55.0	48	47	46	44	43	41	40	39	38	36.2	35	34	32	31	30
600	New Sub to Cooroy	265.0	308	317	326	334	343	351	360	369	378	386.2	396	406	415	425	435
186	Cooroy to Sunrise and Noosa	125.0	144	147	151	155	158	162	166	170	173	177.1	181	184	188	192	195
189	Cooroy to Image Flats	114.0	135	139	144	148	152	155	160	164	168	172.2	177	183	188	194	199
146	Image Flats to Nambour	23.0	26	27	28	28	29	30	31	31	32	32.6	33	34	35	35	36
203	Imagae Flats to Palmwoods	91.0	109	112	116	119	123	125	129	133	136	139.6	144	149	154	158	163
	Woolooga to Gympie	75%	79%	79%	80%	81%	81%	82%	83%	84%	84%	85%	86%	86%	87%	88%	89%
	Gypmie to Trav and Cooran	33%	30%	30%	29%	29%	28%	27%	27%	26%	25%	25%	24%	24%	23%	22%	22%
	Cooran to New Sub	29%	26%	25%	24%	24%	23%	22%	21%	21%	20%	19%	18%	18%	17%	17%	16%
	New Sub to Cooroy	44%	51%	53%	54%	56%	57%	59%	60%	61%	63%	64%	66%	68%	69%	71%	72%
	Cooroy to Sunrise and Noosa	67%	77%	79%	81%	83%	85%	87%	89%	91%	93%	95%	97%	99%	**101%**	**103%**	**105%**
	Cooroy to Image Flats	60%	71%	74%	76%	78%	80%	82%	85%	87%	89%	91%	94%	97%	100%	**102%**	**105%**
	Image Flats to Nambour	16%	18%	19%	19%	19%	20%	20%	21%	21%	22%	22%	23%	23%	24%	24%	25%
	Imagae Flats to Palmwoods	45%	54%	55%	57%	59%	60%	62%	64%	65%	67%	69%	71%	73%	76%	78%	80%

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Table B.1b : 132kV Network Upgrade Requirement to Maintain N-1 Conditions – Assuming Infeed Powers Can be Linearly Scaled – Year 2037 to 2052

	Year	2037	2038	2039	2040	2041	2042	2043	2044	2045	2046	2047	2048	2049	2050	2051	2052
	Growth Rate p.a.	1.90%	1.80%	1.80%	1.80%	1.80%	1.80%	1.60%	1.60%	1.60%	1.60%	1.60%	1.50%	1.50%	1.50%	1.50%	1.50%
	COOROY	41.4	42.1	42.9	43.6	44.4	45.2	46.0	46.7	47.4	48.2	49.0	49.7	50.4	51.2	52.0	52.7
	COORAN	9.5	9.7	9.9	10.1	10.3	10.4	10.6	10.8	10.9	11.1	11.3	11.5	11.6	11.8	12.0	12.2
	GYMPIE 11	30.2	30.8	31.3	31.9	32.5	33.1	33.6	34.1	34.7	35.2	35.8	36.3	36.9	37.4	38.0	38.5
	GYMPIE 33	108.2	110.1	112.1	114.1	116.2	118.3	120.2	122.1	124.1	126.0	128.1	130.0	131.9	133.9	135.9	138.0
	NOOSA	78.0	79.4	80.8	82.3	83.7	85.2	86.6	88.0	89.4	90.8	92.3	93.7	95.1	96.5	97.9	99.4
	TRAVESTON	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
	SUNRISE	120.9	123.1	125.3	127.6	129.9	132.2	134.3	136.5	138.7	140.9	143.1	145.3	147.5	149.7	151.9	154.2
	NAMBOUR 25%	36.6	37.3	37.9	38.6	39.3	40.0	40.7	41.3	42.0	42.6	43.3	44.0	44.6	45.3	46.0	46.7
		426.8	434.5	442.3	450.2	458.3	466.5	473.9	481.5	489.1	496.9	504.8	512.4	520.0	527.8	535.7	543.7
	Palmwoods Other	809.9	824.5	839.3	854.4	869.8	885.5	899.6	914.0	928.6	943.5	958.6	973.0	987.6	1002.4	1017.4	1032.7
	Total	1237	1259	1282	1305	1328	1352	1374	1395	1418	1440	1463	1485	1508	1530	1553	1576
	Woolooga	178.6	180.0	181.4	182.9	184.3	185.7	187.1	188.6	190.0	191.4	192.9	194.3	195.7	197.1	198.6	200
	New Cooroy Sth	415.7	426.7	437.6	448.6	459.5	470.5	481.4	492.4	503.3	514.3	525.2	536.2	547.1	558.1	569.0	580
	Palmwoods	641.4	651.7	661.9	672.1	682.4	692.6	702.9	713.1	723.3	733.6	743.8	754.0	764.3	774.5	784.8	795
	Total Injection																1575
N-1 Rating	**South Cooroy Injection**																
200	Woolooga to Gympie	179	180	181	183	184	186	187	189	190	191	193	194	196	197	199	200.0
189	Gypmie to Trav and Cooran	40	39	38	37	36	34	33	32	31	30	29	28	27	26	25	23.5
189	Trav and Cooran to Cooroy	29	27	26	25	23	22	21	20	18	17	16	15	13	12	11	9.3
186	Cooroy to Sunrise and Noosa	199	202	206	210	214	217	221	224	228	232	235	239	243	246	250	253.6
189	New Sub to Cooroy	212	217	223	229	235	241	246	252	257	263	269	274	280	285	291	297.0
189	new Sub to Image Flats	204	209	215	220	225	230	235	241	246	251	257	262	267	273	278	283.0
146	Image Flats to Nambour	37	37	38	39	39	40	41	41	42	43	43	44	45	45	46	46.7
203	Imagae Flats to Palmwoods	167	172	177	181	186	190	195	199	204	209	213	218	223	227	232	236.3
	Woolooga to Gympie	89%	90%	91%	91%	92%	93%	94%	94%	95%	96%	96%	97%	98%	99%	99%	100%
	Gypmie to Trav and Cooran	21%	21%	20%	19%	19%	18%	18%	17%	17%	16%	15%	15%	14%	14%	13%	12%
	Trav and Cooran to Cooroy	15%	14%	14%	13%	12%	12%	11%	10%	10%	9%	8%	8%	7%	6%	6%	5%
	Cooroy to Sunrise and Noosa	107%	109%	111%	113%	115%	117%	119%	121%	123%	125%	127%	128%	130%	132%	134%	136%
	New Sub to Cooroy	112%	115%	118%	121%	124%	127%	130%	133%	136%	139%	142%	145%	148%	151%	154%	157%
	new Sub to Image Flats	108%	111%	114%	116%	119%	122%	125%	127%	130%	133%	136%	139%	142%	144%	147%	150%
	Image Flats to Nambour	25%	26%	26%	26%	27%	27%	28%	28%	29%	29%	30%	30%	31%	31%	31%	32%
	Imagae Flats to Palmwoods	82%	85%	87%	89%	91%	93%	96%	98%	101%	103%	105%	107%	110%	112%	114%	116%
N-1 Rating	**North Cooroy Injection with Cooroy to Image Flats Open**																
800	**Palmwoods + Nambour**	846	862	877	893	909	925	940	955	971	986	1002	1017	1032	1048	1063	1079
200	Cooroy + Sunrise Hills+ Noosaville	240	245	249	253	258	263	267	271	275	280	284	289	293	297	302	306
		106%	108%	110%	112%	114%	116%	118%	119%	121%	123%	125%	127%	129%	131%	133%	135%
		120%	122%	124%	127%	129%	131%	133%	136%	138%	140%	142%	144%	146%	149%	151%	153%
N-1 Rating	**North Cooroy Injection with Cooroy to Image Flats Closed and New 132kV Line to Cooroy**																
200	Woolooga to Gympie	179	180	181	183	184	186	187	189	190	191	193	194	196	197	199	200.0
189	Gypmie to Trav and Cooran	40	39	38	37	36	34	33	32	31	30	29	28	27	26	25	23.5
189	Cooran to New Sub	29	27	26	25	23	22	21	20	18	17	16	15	13	12	11	9.3
600	New Sub to Cooroy	444	454	464	473	483	492	502	512	522	531	541	551	560	570	580	589.3
186	Cooroy to Sunrise and Noosa	199	202	206	210	214	217	221	224	228	232	235	239	243	246	250	253.6
189	Cooroy to Image Flats	204	209	215	220	225	230	235	241	246	251	257	262	267	273	278	283.0
146	Image Flats to Nambour	37	37	38	39	39	40	41	41	42	43	43	44	45	45	46	46.7
203	Imagae Flats to Palmwoods	167	172	177	181	186	190	195	199	204	209	213	218	223	227	232	236.3
	Woolooga to Gympie	89%	90%	91%	91%	92%	93%	94%	94%	95%	96%	96%	97%	98%	99%	99%	100%
	Gypmie to Trav and Cooran	21%	21%	20%	19%	19%	18%	18%	17%	17%	16%	15%	15%	14%	14%	13%	12%
	Cooran to New Sub	15%	14%	14%	13%	12%	12%	11%	10%	10%	9%	8%	8%	7%	6%	6%	5%
	New Sub to Cooroy	74%	76%	77%	79%	80%	82%	84%	85%	87%	89%	90%	92%	93%	95%	97%	98%
	Cooroy to Sunrise and Noosa	107%	109%	111%	113%	115%	117%	119%	121%	123%	125%	127%	128%	130%	132%	134%	136%
	Cooroy to Image Flats	108%	111%	114%	116%	119%	122%	125%	127%	130%	133%	136%	139%	142%	144%	147%	150%
	Image Flats to Nambour	25%	26%	26%	26%	27%	27%	28%	28%	29%	29%	30%	30%	31%	31%	31%	32%
	Imagae Flats to Palmwoods	82%	85%	87%	89%	91%	93%	96%	98%	101%	103%	105%	107%	110%	112%	114%	116%

By review of Table B.1, It is noted that:

1. a substation established to the North of Cooroy would require the 132kV transmission system to Cooroy to be amplified with a 400 MW circuit (duplicate the existing double circuit line) by the year 2028. It is noted that a 200MW circuit could be installed in 2028 with the second feeder on the tower installed around 2033 when the injection from the substation to the south would be expected to exceed 400MW.
2. To maintain the transmission flows as reported in reference [1] under N-1 contingency conditions of the 132kV network then the transmission line upgrade from the new substation to Cooroy would be required but it is not dealt with in the EIS. A substation established to the South of Cooroy would require the 132kV transmission system to Cooroy to be amplified with a 200 Amp circuit by the year 2033.
3. The Palmwoods system demand would exceed its 800MW N-1 capacity by the year 2034 at which point the Cooroy to Image Flats system would need to be re-closed in the north substation option.
4. By the year 2034 the 132kV system from Cooroy to Sunrise Hills will need amplification in either case to maintain N-1 contingency on the 132kV network. Such amplification is not accounted for in the EIS with regard to easements or routes of a possible parallel feeding 132kV transmission line and the proposed project in the EIS does not solve this issue.
5. To maintain the transmission flows as reported in reference [1] under N-1 contingency conditions of the 132kV network then by the year 2035, the 132kV lines From Cooroy to Image Flats will need amplification in either case of a North or South Substation of Cooroy. Such amplification is not accounted for in the EIS with regard to easements or routes of a possible parallel feeding 132kV transmission line.
6. To maintain the transmission flows as reported in reference [1] under N-1 contingency conditions of the 132kV network then by the year 2045, the 132kV lines From Image Flats to Palmwoods will need amplification in either case of a North or South Substation of Cooroy. Such amplification is not accounted for in the EIS with regard to easements or routes of a possible parallel feeding 132kV transmission line.
7. It is noted that in both cases the Woolooga to Gympie 132kV lines will be loaded to 100% of the N-1 capacity in the year 2052, However with the North Cooroy option the Gympie lines would be expected to carry slightly less load given the Cooroy substation would feed more of the Gympie load.

Hence it is concluded from this analysis that the only difference in a substation to the north of Cooroy as compared to a southern location, is the earlier requirement at 2028 to upgrade the 132kV line from the possible North location to Cooroy Substation. In both cases, to maintain the power flows as reported in [1] under N-1 conditions, then substantial 132kV transmission network upgrades will be required which are not accounted for in [1] or the EIS in general. Again it is noted that this conclusion assume that the three 275kV power infeeds to the Energex 132kV network can be controlled as appears to be the case when reviewing the demand growth rates of the 275kV infeeds as previously noted and given in reference [1].