Kyoto energypark

Appendix L

Kyoto Wind Farm Prefeasibility Study
Econnect Pty Ltd
(6 Dec 2007)

pamada

Kyoto Wind Farm

Pre-Feasibility Study

Econnect Australia Project No: 2040

Prepared For	Mark Dixon Pamada Pty Ltd Level 16 14 - 24 college street Sydney NSW 2010

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1 Executive Summary

1. Introduction

Pamada Pty Ltd ('Pamada') is developing an energy project, named Kyoto on two nearby sites namely Middlebrook and Mountain station. The sites are located approximately 15km west of Scone in the Upper Hunter region of NSW. The initial intention for the sites is to install up 170MW of renewable energy generation. The anticipated break up of this capacity is 90MW of wind energy, 60MW of solar thermal and up to 20MW of other renewable technologies.

In 2005, Econnect Australia was commissioned by Pamada to undertake an assessment of the electrical power system in the general area of the wind farm in order to highlight general grid integration issues affecting the potential wind farm site and, if possible, identify, in relation to their development objectives, potential grid integration options considering geographic, economic and electro-technical constraints and thresholds. At the time of the study, the Kyoto project was planned to be a wind farm project with a installed capacity of up to 70MW. The following options were specifically investigated in the original:

- Option 1: Tee Connection to Scone 33kV feeder; and
- Option 2: Tee Connection to Dartbrook – Mitchell Line 66kV feeder.

Since the original study, The site proposed installed capacity has been revised upward and Energy Australia has officially announced the construction of new 33/66/11kV substation on the outskirts of Scone and an upgrade of the 33kV Scone and Aberdeen supply to 66kV.

As a result, Pamada has asked Econnect to review the original study to incorporate the latest project and network developments and to assess their potential impact on the Kyoto project grid integration options.

2. Conclusions

Following preliminary investigations, our conclusions are as follows:

Assuming that Energy Australia Strategy 3 is implemented, a connection to the Scone 66kV supply (Option 1) will provide up to 60MW of capacity until 2009. Following the upgrade of the Scone-Mitchell Line 66kV feeders expected to be completed 2012, connection to the Scone 66kV supply will provide up to 90MW of capacity providing that detailed power system studies confirm that steady state voltage can be managed successfully.

A tee connection to the Dartbrook 66kV feeder (Option 2) will not provide sufficient network capacity for the proposed 90MW. Capacity available under this option was estimated to be in the order of 60MW. Additional capacity may be added but will require the re-construction of the existing Dartbrook-Mitchell line 66kV circuit. However the latter will make this option a less economically attractive option when compared to Option 3.

A connection to Muswellbrook 132kV terminal (Option 3) will provide the required capacity to connect 90MW of wind generation at the proposed site. In fact, Option 3 can potentially provide capacity in the excess of 150MW and thus would provide Pamada with additional capacity headroom for future project expansion.

Option 1 will be the least costly connection option for a 90MW project but will also be the technically most challenging. Detailed power system studies will be required to demonstrate that export of 90MW at the new Scone 66/33/11kV substation (post network development) is technically manageable and compatible with Energy Australia Network Service Provider obligations. It should also be noted that network capacity available under Option 1 will depend on Energy Australia's preferred strategy for the network development of the Upper Hunter area and the timing of its roll out. This is a risk that should be considered when selecting the preferred connection option for this project. Furthermore, Option 1 will offer very limited scope for future project expansion. Electrical losses will also be significant under Option 1.

Option 3 is approximately $2-4M more expensive than Option 1 or 2 in a context of a 90MW project however, becomes rapidly economically attractive for project capacity above 90MW (i.e. Option 3C).

Overall single substation design will be a more cost effective design. However this may require overhead line to be built on both sides of the road between the two wind farm sites. Should planning issue arise, a 33kV underground cable can be used instead.

Table 1 provides a summary of budget prices for each of the connection options described.

Grid Integration Solution	Potential Capacity (MW)	Estimated Connection Cost ($M)	Estimated Connection Cost ($M/MW)	Issue/Opportunity
Option 1A	60	11	0.183	Will be technically challenging. Link to EA network development progress
	90	15.8	0.176	
Option 1B	60	13.8	0.230	
	90	18	0.200	
Option 2A	60	12.7	0.211	Limited capacity
	90	17.5	0.194	More expensive than option 3 without the capacity upside
Option 2B	60	16.7	0.278	
	90	18.5	0.206	
Option 3A	90	17	0.188	Capacity can be increased to 150MW without significant extra cost
Option 3B	90	21.5	0.239	
Option 3C	150	19	0.127	
Note 1: A means Single substation Design at Mountain station and B means two substation design one at Mountain station and one at Middlebrook station				

Table 1: Summary of Budget Prices

3. Recommendations

In order to take this project forward we recommend the following:

1. Decide on the ultimate size of the project

A. For a project ultimate size of project <90MW

- Perform further studies to quantify the wind farm impact on the local network, post network upgrade, for option 1.
- Refine network upgrade budget cost estimates for the 66kV option.
- Revaluate technical and economical merits of Option 1 and 3 based on study results.
- Prepare and submit a connection application to Energy Australia for the preferred connection option.

B. For a project ultimate size of project >90MW

- Prepare and submit a connection application to Energy Australia for the preferred connection Option 3.

Econnect

2 Scope of Works

The agreed scope of works (reference: Econnect Australia Proposal 0140.2295 dated 8 Nov 2005) was to provide the client with the following:-

The Scope of Work will include: -

1. Identification of the geographical location of the site and examination of the surrounding terrain for physical obstacles to possible methods of connection.
2. Review of the typical generation site data for the development.
3. Obtain and review current network data and information specific to the site from the appropriate Distribution and/or Transmission Network Service Provider (NSP).
4. Identification of potential connection options, considering technical constraints and economic implications of such constraints, illustrated with diagrams.
5. Technical assessment of the available connection capacity taking into account thermal circuit capacity, steady state voltage rise, voltage step, network fault level and connection costs for each of the proposed options.

More specifically, the work for each option will include: -

<u>Technical Assessment</u>

1. <u>A Sketch of the Proposed Connection Concept</u>. A Microsoft Power Point single line sketch of the proposed connection and an outline of the connection works involved, including the location of the substation.
2. <u>Thermal Limit Consideration</u>. Identification of the available capacity in MVA at the proposed connection point taking into account the existing equipment rating, replacement and/or upgrade of equipment, the generation unit(s) and load(s) connected to the system.
3. <u>Fault Level Consideration</u>. Estimate of the fault contribution of the proposed scheme, determination of the 'post-connection' fault level of the system and comparison against the existing circuit breaker ratings. This assessment does not involve detailed network modelling (which would be performed at a later stage as part of a High Level or Detailed Feasibility Study).
4. <u>Steady State Voltage Rise & Voltage Step</u>. Examination of the implications of generating the proposed capacity at the connection point upon the system voltage. This assessment will be based on network information to detect obvious voltage constraints in the system. This assessment does not involve detailed network modelling (which would be performed at a later stage as part of a High Level or Detailed Feasibility Study).
5. <u>General Planning Issue Consideration</u>. Identification of obvious planning issues with respect to the choice of overhead line or underground cable, line easement, potential substation extension work, presence or otherwise of adequate network communication and protection facilities to make a connection into the Distribution and / or Transmission network and provision of an indicative cost for each of the options.
6. <u>Conclusion and Budget Cost Figures.</u> Provision of a conclusion and budget estimate for each connection option to an accuracy of +/-30%, including:
7. <u>Overall Conclusion / Recommendations</u>. Review and selection of the optimum connection point with respect to both technical constraints and cost.

3 Introduction

Pamada Pty Ltd is developing a wind farm project, named Kyoto at two near by sites. The sites are located approximately 6km west of Scone in the Upper Hunter region of NSW, as shown in **Figure 1**.

The initial intention for the sites is to install up to 90MW of wind generation. At this stage of the development, Pamada has a requirement to understand in high-level terms, the significant issues, opportunities and costs associated with connecting the proposed 90MW wind farm to the grid in the area of concern.

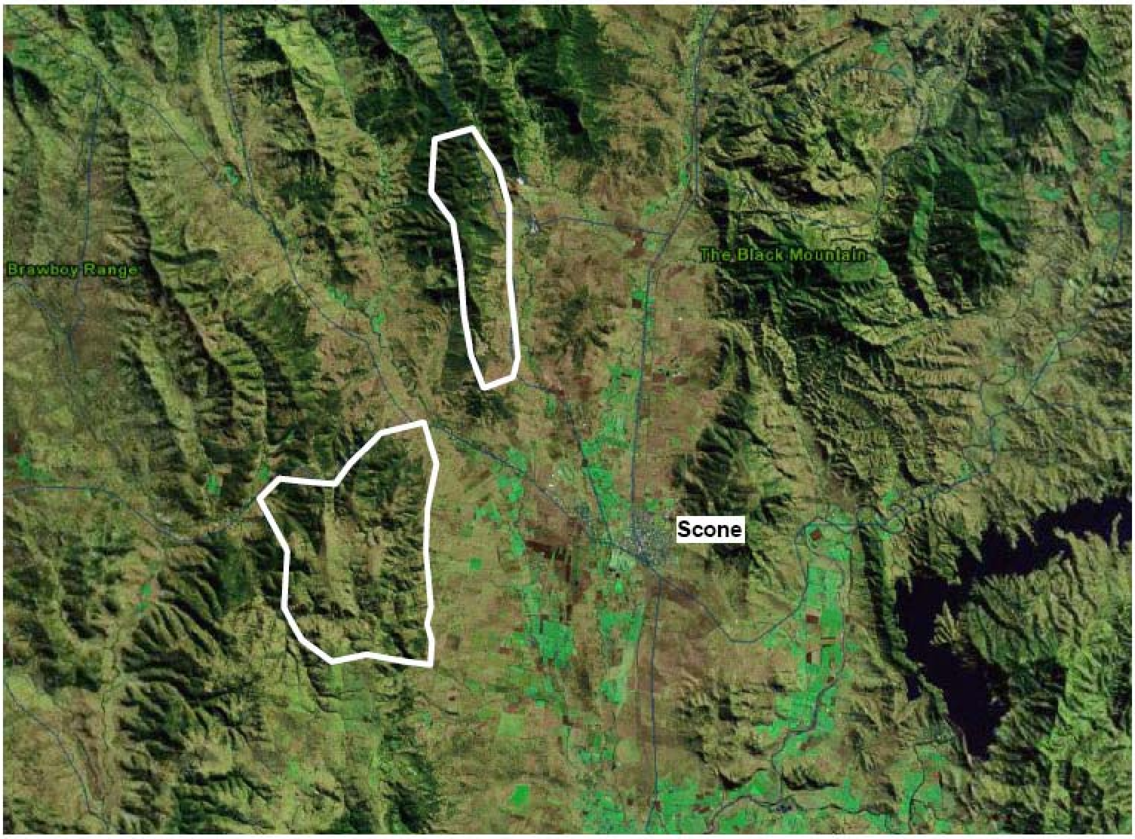

Figure 1: Kyoto Wind Farm Site (Map Courtesy of Pamada)

4 Existing Network Assets

4.1 Transmission Network

The local transmission network is owned, operated and maintained by Transgrid. There are two 330kV lines running from Muswellbrook and Liddell 330kV terminals and then to Tamworth 330kV terminal, namely Transgrid 84 and 88, 330kV circuits. The two 330kV circuits bypass Scone township on the eastern side at a distance of approximately 30-35km.

A 330kV connection would require the construction and commissioning of 330kV network infrastructure, which by its nature, is prohibitively expensive. Econnect's experience of network connection, in particular of wind energy projects, is that 330kV infrastructure is not economical for projects under 200MW. Accordingly, the 330kV connection option has not been considered further in this report.

In addition there is a 132kV line that runs from Muswellbrook terminal station to an industrial site owned by Macquarie Generation near Barnard River. The Muswellbrook-Barnard River 132kV circuit crosses the main road between Scone and Moonan approximately 30km northeast from Scone and is therefore very difficult to access from the proposed sites. This option has not been considered further in this report.

4.2 Distribution & Sub-Transmission Network

The local area is supplied from TransGrid Muswellbrook 330/132kV terminal station. Muswellbrook terminal substation supplies Muswellbrook, Mitchell Line, Singleton zone substations and a private industrial load located in the Barnard river region.

The local sub-transmission and distribution systems are owned, operated and maintained by Energy Australia. The distribution assets located in the vicinity of the proposed site are limited to the Scone 33/11kV zone substation which is located on the south east part of the town. Scone zone substation is supplied from a Muswellbrook zone substation via two single 33kV circuits. One of the 33kV circuits connects Scone to Muswellbrook zone substation via Aberdeen zone substation.

The second 33kV circuit runs on the other side of Pages River and connects Scone, Aberdeen, Muswellbrook Rouchel and Moonan zone substations. This 33kV circuit also connects a 5MW Hydro scheme located near Lake Glenbawn.

In normal operation the Scone, Aberdeen and Moonan 33kV loop is open at Scone 33kV terminal, thus Scone 33kV zone substation is radially supplied via a 33kV circuit fed from Muswellbrook 33kV terminal through Aberdeen zone substation. Should a fault occur on the 33kV circuit between Aberdeen and Scone, the supply at Scone may be re-established by closing the normally open point at Scone 33kV terminal. In addition there is a 66kV circuit that runs from Mitchell line – Dartbrook to supply two local mines sites. This is illustrated further in **Figure 2.**

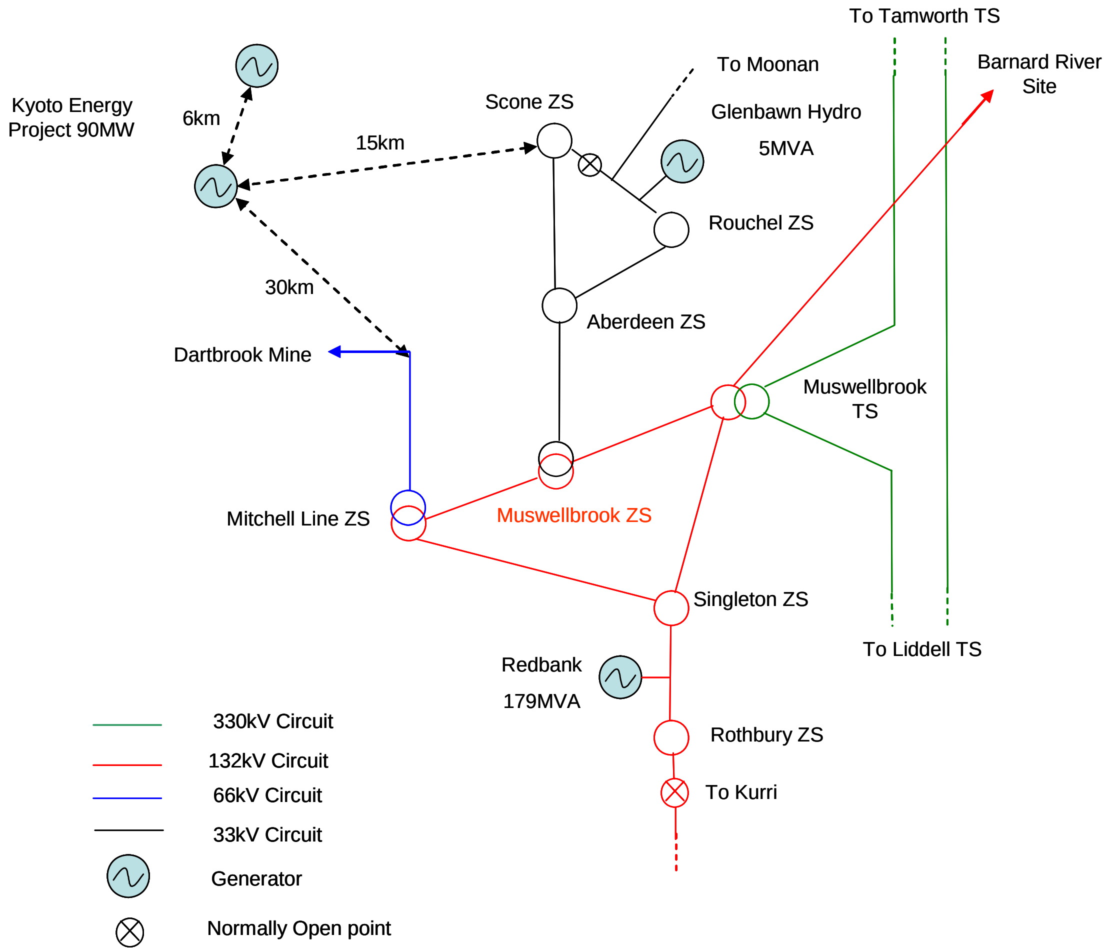

Figure 1 Existing Local Transmission and Distribution Networks

5 Network Future Development

As part of future network developments, Energy Australia has announced the decommissioning of the existing Scone 33/11kV zone substation and the construction of a new zone substation to provide additional capacity in the area [3].

Subsequent to this announcement a consultation paper has been issued by Energy Australia to outline the different network strategies under consideration for the Upper Hunter area. Three options are under consideration by Energy Australia:

- *Strategy 1 – a new Scone 33/11kV zone substation and a new 33kV feeder between Muswellbrook 132/33kV substation and the new Scone zone substation, consistent with a long term strategy to upgrade the existing 33kV network.*
- *Strategy 2 – a new Scone 66/11kV zone substation and extension of the existing 66kV 'Dartbrook' feeder to the new Scone zone substation, consistent with a long term strategy to convert to the network to a 66kV network.*
- *Strategy 3– a new hybrid 66/33kV and 66/11kV Scone STS and zone substation and extension of the existing 66kV 'Dartbrook' feeder to the new Scone zone substation, consistent with a long term strategy to convert to a hybrid 66kV and 33kV network to a 66kV network.*

Consultation is still ongoing however Energy Australia has indicated that its preferred strategy is Strategy 3. This report has been prepared assuming that Strategy 3 will be implemented by 2012.

Under Strategy 3, Scone and Aberdeen zone substations will be converted to 66/33/11kV hybrid substations and will provide 33kV supply to Moona and Rouchel zones, Genbawn Dam and Muswellbrook Mine. Muswellbrook zone will be converted to 66kV. This will allow the existing network supplied from Muswellbrook STS to be transferred to Mitchell Line STS, enabling Muswellbrook STS to be retired without requiring a new STS. Under this strategy Scone substation will be converted as a 66/33/11kV outdoor/indoor substation with two 33MVA transformers. The initial 66kV connection will be provided by extending the existing 'Dartbrook' feeder to Scone. Further 66kV connection will be provided by converting the existing 33kV network to 66kV operation.

The proposed network upgrade will be implemented in stages with 66kV supply to Scone available by 2009 and conversion of the Scone-Aberdeen 33kV to 66kV supply completed by 2012 [5].

A presentation of the network post network development is shown in Appendix A.

6 Connection Options Summary

Based on the previous discussion, the following connection options have been considered for the Kyoto Wind Farm development:

- Option 1: Direct Connection to proposed Scone 66kV Terminal
- Option 2: Tee Connection to Dartbrook – Mitchell Line 66kV feeder.
- Option 3: Direct Connection to Muswellbrook 132kV terminal STS

Please note that there are two others 132kV connection options available namely direct connection to Mitchell Line 132kV terminal and direct Connection to Muswellbrook 132kV Terminal Transgrid substation. Each of these substations connects to the same part of TransGrid transmission network and thus issue identified under Option 3 will be very similar. These options will require the construction of an additional 2-4km of new 132kV circuit and extension of existing substation to install new 132kV bay when compared to Option 3. As a result these connection options are expected to exhibit higher connection cost and have not been investigated in this report.

7 Option 1: Direct Connection to Scone 66kV Substation

7.1 Connection Arrangement

It is proposed to connect of up to 90MW wind generation to Scone 66kV substation terminal. This will require the construction of one or two step-up 33/66kV substation(s) at the proposed wind farm site and the construction of approximately 15-20km of new 66kV overhead line. Single or double circuit construction may be used depending on ultimate capacity required and preferred design. This arrangement will also require installation a one or two 66kV bays at the new Scone 66/33/11kV substation and therefore it is important that Pamada engage in open discussion with Energy Australia to ensure that sufficient head room will be available in the 66kV switchyard of the future Scone 66/33/11kV substation.

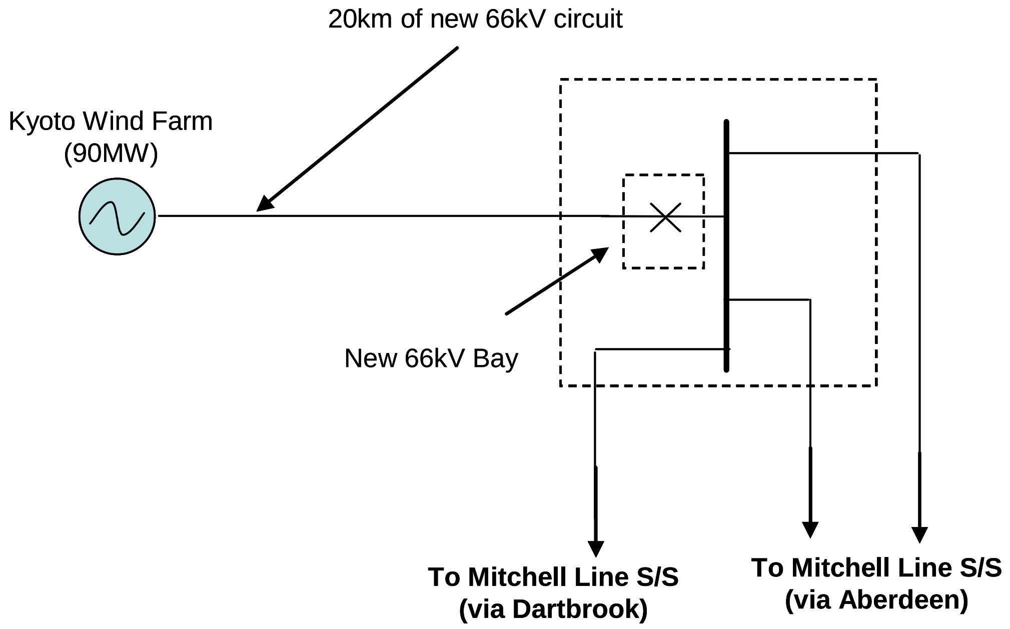

Figure 2 Option 1 – Proposed Connection Arrangement

8 Thermal Considerations

Existing Scone substation serves a summer peak load of approximately 17MVA which decreases to approximately 4MVA during low demand periods and therefore most of wind farm output will need to be transfer back to the Mitchell Line 132/66kV substation.

Under strategy 3 Stage 1 [4], Energy Australia is proposing to extend the Dartbrook 66kV to Scone. Assuming that similar conductor type and construction is used as for the Dartbrook – Mitchell Line 66kV circuit, the thermal rating of the line will be limited to approximately 578A or 66MVA during summer and 77MVA during winter.

As a result a 66kV connection to Scone 66kV terminal will be thermally limited to approximately 70MVA following the first phase of network development.

Energy Australia has indicated that upgrade of the Scone-Mitchell network from 33kV to 66kV will be completed by 2012. The existing Scone 33kV circuits a limited rating of 342A or 20MVA at 33kV and 40MVA at 66kV [5]. Assuming that existing conductors are used for the Scone upgraded 66kV network a thermal capacity of approximately 110-150MVA will be available, depending on how Energy Australia decides to operate the Scone 66kV network (i.e. two or three of the three 66kV circuits operated in parallel). However in the event of a fault on one of the two 66kV Scone circuits, capacity at Scone 66kV terminal will be limited to approx. 44-110MVA. Under such network conditions, wind farm output may need to be constrained.

Mitchell Line substation has a firm thermal capacity of 120MVA [4]. However Energy Australia advises that Mitchell line on load tap changers are not designed to handle reverse power flow of more than 20-25MVA and thus will need to be replaced to allow a greater amount of generation to be exported back into the 132kV network.

As a result it is concluded that providing that the voltage issues do not further constrain generation export at Scone new 66/33/11kV substation (please see Section 8.1), the existing network thermal capacity in the Scone area will be limited to:

- 70MVA following the implementation of the future network development under Strategy 3 (Stage 1) due to be completed by 2009.
- 110-120MVA following the completion of the Scone network upgrade from 33kV to 66kV.
- To allow export of generation at Mitchell line on-load tap changer will need to be upgraded.

8.1 Steady State Voltage Considerations

Network Service Providers (NSPs) have an obligation to ensure that steady state voltage on the transmission and distribution systems are within defined limits. In New South Wales statutory steady state voltage limits are +/-5% of the nominal voltage for all distribution voltages (i.e. 66kV and below).

Following network upgrade the closet point where the 66kV voltage is regulated will be in Mitchell Line STS 66kV terminal.

The Kyoto Wind Farm proposed site is located approximately approx. 15-20km away from the new proposed Scone substation. Scone-Aberdeen-Muswellbrook 66kV lines will be approximately 20-25km long and Muswellbrook STS is located approximately 5km away from Mitchell line STS. This a total distance of approximately 45km from the proposed site. This means that the network impedance seen at the proposed connection point will be substantial. As a result steady state voltage and voltage regulation issues are likely to arise.

Preliminary calculations showed that following the extension of the Dartbrook 66kV circuit export will be limited to approximately 60MW due to voltage regulation constraint. Installation of approximately 30MVAr or capacitor banks at Mitchell line 66kkV substation will also be required to assist with voltage regulation issues.

Following the completion of Strategy 3, Scone 66/33/11kV substation will be connected to Mitchell line via two or three 66kV circuits in parallel depending on Energy Australia's preferred mode of operation. Assuming that only two circuit are connected in parallel at a time, up to 90MW will be available at Scone 66/33/11kV. However, this will require operation of the wind turbines at leading power factor and the installation of approximately 40MVAr or capacitor banks at Mitchell 66kkV substation terminal to enable operation of the Scone-Mitchell line 66kV circuit within Energy Australia Statutory limits.

Further power system study will be required to confirm that voltage fluctuations on the 66kV network can be successfully managed.

Please note that operation at lower power factor will increase substantially line losses which will have an impact on the revenue of the wind farm and should be considered when comparing the different connection options for this project.

8.2 Fault Level Considerations

The proposed 90MW of wind generation will increase the present fault levels of the local distribution network. An increase of the existing fault levels due to the wind farm in the region of 450MVA or below 4kA is anticipated based on typical data.

The upper Hunter area is fed from the TransGrid Muswellbrook 330/132kV terminal station. Transgrid data indicates that fault level at Muswellbrook 132kV terminal is in the order of 3kA[5] [1] whereas fault level design fault level on the Muswellbrook STS 132kV terminal is stated to be 5.7GVA or 25kA.

Scone 132/66/11kV fault level design has not been confirmed by Energy Australia as the design of the substation is yet to be finalised. However based on typical design for 66kV zone substation, a fault design 25kA or above is expected. Assuming conservatively that the Scone 66kV fault level will be in the order of 8kA then an increase of 4kA at the Scone 66kV terminal will not be sufficient to exceed substation fault level design.

It can therefore be concluded that sufficient headroom will be available to accommodate the additional fault contribution of the proposed 90MW Kyoto Wind Farm. This will need to be verified with more detailed power system studies once final substation fault level design for the Scone substation will be available.

8.3 Planning Considerations

To connect 90MW of generation onto the Scone 66kV network will require a substantial amount of planning for the construction of the new 66kV and 33kV connection assets.

The line route for the new 66kV overhead lines to connect the wind farm to the existing Energy Australia network will need to be defined and line easements may need to be obtained, in consultation with the respective land owners. Other issues include the crossing of a river/stream and a railway, which will need to be addressed during the planning process.

[5] Data were extracted from Reference [1] and adjusted by approximately 15% to account for increase in system fault level from 2004 to 2007.

8.4 Other Issues

Energy Australia draft response to Pamada connection enquiry received 19/11/07 [6] has indicated that a 66kV connection to Scone 66kV supply was not considered feasible. Issues highlighted by Energy Australia included:

- o Thermal and reverse power flow
- o Voltage Regulation
- o Power quality issue
- o Fault level
- o Protection

Firstly, it is to be noted that Energy Australia's responses are based on Stage 1 of Strategy 3 of the planned network upgrade for the Scone 66kV supply been completed and therefore does not account for the upgraded Mitchell-Aberdeen-Scone circuit from 33kv to 66kV. As a result comment provided by Energy Australia should be considered as valid until 2009.

Secondly, Energy Australia assumptions regarding wind farm impact on the local network are mainly qualitative and were not based on wind farm specific data. This approach may have lead to overly conservative conclusions.

Overall, we agreed with Energy Australia the connection of a 90MW generator onto the local 66kV network at Scone will be technically challenging and will require network upgrade to address issues mentioned above which will impact on connection costs. However details power system study will be required to quantify the wind farm impact on the network. Study should be carried out in the context of the network post development.

Conclusions

Our preliminary investigations have shown that:

- The network thermal capacity in the Scone area will be limited to:
  - 70MVA following the implementation of the future network development under Strategy 3 (Stage 1) due to be completed by 2009.
  - 95-120MVA once Scone network upgrade from 33kV to 66kV has been completed in 2012.
- To allow export of generation at Mitchell line on-load tap changer will need to be upgraded.
- Voltage regulation will be one of the main technical challenges for this connection. Further studies will be required to establish the optimal network solution required to deal with this issue.
- Fault level was not identified as a potential issue.

The budget cost for this connection options are summarized in Table 2, 3, 4 and 5.

Two different designs are presented, Design A which assumes the construction of a single substation at Mountain station and Design B which assumes construction of two substations one at Mountain station and one at Middlebrook station with a switching station between the two sites.

Option 1A (60MW) - One substation design

Budget Cost Estimates ($M)	**Option 1A**
20km of 66kV dedicated line – single circuit	3
6km of new 33kV cable to connect the two sites	0.6
Establishment of a Connection Point at Scone 66kV (site extension, single new 66kV bay)	0.6
Establishment of 70MVA 66/33kV substation at Mountain station	5
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	1
30MVAr of capacitor banks	0.8
Total Estimated Connection Cost	**11**

Table 2

Option 1B (60MW) - Two substation design

Budget Cost Estimates ($M)	**Option 1B**
20km of 66kV dedicated line – single circuit	3
6km of new 66kV line to connect the two sites at junction point	0.9
Establishment of a new 66kV Switching Station (3 switches)	1.5
Establishment of a Connection Point at Scone 66kV (site extension, single new 66kV bay)	0.6
Establishment of 2x40MVA 66/33kV substation at Mountain and Middlebrook station	8
Energy Australia Network Upgrade (protection, control voltage regulation, etc)*	1
30MVAr of capacitor banks	0.8
Total Estimated Connection Cost	**15.8**

Table 3

Option 1A (90MW) - One substation design

Budget Cost Estimates ($M)	Option 1A
20km of 66kV dedicated line – single circuit	3
6km of new 33kV cable to connect the two sites	0.6
Establishment of a Connection Point at Scone 66kV (site extension, single new 66kV bay)	0.6
Establishment of 100MVA 66/33kV substation at Mountain station	7
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	1
40MVAr of capacitor banks	1
Total Estimated Connection Cost	**13.2**

Table 2

Option 1B (90MW) - Two substation design

Budget Cost Estimates ($M)	Option 1B
20km of 66kV dedicated line – single circuit	3
6km of new 66kV line to connect the two sites at junction point	0.9
Establishment of a new 66kV Switching Station 3 switches)	1.5
Establishment of a Connection Point at Scone 66kV (site extension, single new 66kV bay)	0.6
Establishment of 2x50MVA 66/33kV substation at Mountain and Middlebrook station	9
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	2
40MVAr of capacitor banks	1
Total Estimated Connection Cost	**18**

Table 3

9 Option 2: Tee Connection to Dartbrook- Mitchell 66kV Line

Option 2 is a tee connection to the existing the Dartbrook-Mitchell Line 66kV circuit. This will require the construction of approximately 30km of new 66kV circuit from the proposed site and establishment of new 66kV switching station close to the existing line. This is illustrated further in **Figure 4**.

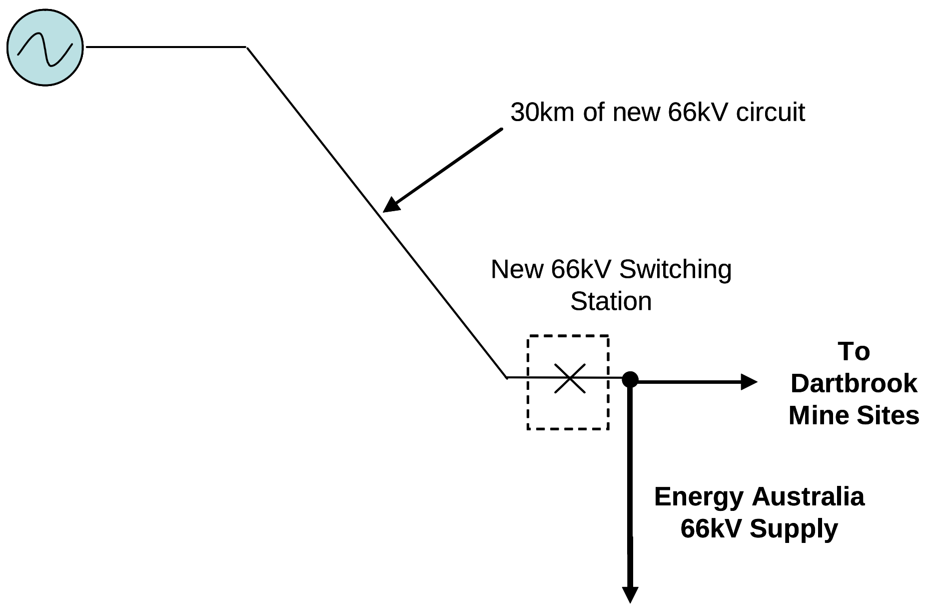

Figure 4: Option 2 Proposed Connection Arrangement

9.1 Thermal Considerations

The Dartbrook – Mitchell Line 66kV circuit is approximately 11km long and mostly constructed with Pluto (19/3.75 AAC) conductor at a design rating of 85C. The conductor is able to carry up to 578A or **66MVA**. Dartbrook mine is presently shut down and there is no indication with regards to when it will be in operation again. Therefore the existing Dartbrook – Mitchell Line 66kV circuit conductor will constrain the capacity to approximately **66MVA**.

Capacity at Dartbrook may be increased by replacing the existing conductor with a larger conductor.

As for Option 1 Mitchell line on-load tap changer will need to be upgraded to allow export in excess of 25MVA onto the 132kV network.

9.2 Voltage Considerations

The proposed Kyoto Wind Farm site is located approximately 45km away from Mitchell Line 66kV terminal where the 66kV voltage is regulated. This means that substantial impedance will be seen from the proposed connection point. This combined with a generation site capacity of 90MW, has the potential to cause steady state voltage and voltage fluctuation issues that will need to be managed.

Preliminary calculation indicates that steady state voltage constraints are likely to limit the network capacity to approximately 60MW.

Further study will be required to quantify the magnitude of this constraint and define a suitable network solution to manage steady state voltage fluctuations to an acceptable level.

9.3 Fault Level Considerations

As mentioned earlier in this report, the connection of 90MW of wind generation will increase the fault level to approximately 450MVA.

The present fault level design at Mitchell Line 66kV and 132kV substation terminals are 16kA and 25kA respectively. This is equivalent to a maximum circuit breaker interrupting capacity of 1830MVA at 66kV and 5715MVA at 132kV. Current fault levels at Mitchell Line substation terminals are in the order of 750MVA at 66kV and 2400MVA at 132kV5[6]. Therefore it is concluded that both Mitchell line 66kV and 132kV terminals have sufficient headroom to accommodate the proposed 90MW of additional generation.

9.4 Planning Considerations

The proposed connection arrangement will require the construction of new 33kV and/or 66kV single circuit and construction of step up substations. This will need to be coordinated with Energy Australia and all relevant authorities or parties, to secure the required line easement, planning consent, etc.

In sensitive areas, underground cable may be used, however the cost, as noted earlier, is two to three times more expensive when compared to an equivalent 66kV overhead line design.

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[6] Data were extracted from Reference [1] and adjusted by approximately 15% to account for increase in system fault level from 2004 to 2007.

9.5 Conclusions

Our preliminary investigations have shown that:

- A connection to the Dartbrook-Mitchell Line 66kV will not provide sufficient capacity to accommodate the proposed 90MW of wind generation. Replacement of the existing overhead line conductors will be required.
- Steady state voltage and voltage fluctuations were identified as potential issues. This will need to be verified with further study.
- Network fault levels were not identified as potential issues. This will need to be confirmed with detailed fault analysis.
- The proposed connection arrangement will require the obtaining planning consent for the construction of a 33/66kV substation(s) at the wind farm site and the construction of new 30km of 66kV overhead line.
- The budget cost for this connection options are summarized in Table 2 and Table 3.

Two different designs are presented, Design A which assumes the construction of a single substation at Mountain station and Design B which assumes construction of two substations one at Mountain station and one at Middlebrook station with a switching station between the two sites.

Option 2A (60MW) - One substation design

Budget Cost Estimates ($M)	**Option 2A**
30km of 66kV dedicated line – single circuit	4.5
6km of new 33kV cable to connect the two sites	0.6
Establishment of a new 66kV switching station near Dartbrook (site extension, single new 66kV bay)	0.6
Establishment of 70MVA 66/33kV substation at Mountain station	5
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	1
40MVAr of capacitor banks	1
Total Estimated Connection Cost	**12.7**

Table 5

Option 2B (60MW) - Two substation design

Budget Cost Estimates ($M)	**Option 2B**
30km of 66kV dedicated line – single circuit	4.5
6km of new 66kV line to connect the two sites at junction point	0.9
Establishment of a new 66kV Switching Station (site establishment, three new 66kV bays)	1.5
Establishment of a new 66kV switching station near Dartbrook (site extension, single new 66kV bay)	0.6
Establishment of 2x50MVA 66/33kV substation at Mountain and Middlebrook station	8
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	1
40MVAr of capacitor banks	1
Total Estimated Connection Cost*	**17.5**

Table 6

Option 2A (90MW) - One substation design

Budget Cost Estimates ($M)	**Option 2A**
30km of 66kV dedicated line – single circuit	4.5
6km of new 33kV cable to connect the two sites	0.6
Establishment of a new 66kV switching station near Dartbrook (site extension, single new 66kV bay)	0.6
Establishment of 100MVA 66/33kV substation at Mountain station	7
Replacement of Dartbrook line conductor (11km)	1
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	2
40MVAr of capacitor banks	1
Total Estimated Connection Cost	**16.7**

Table 2

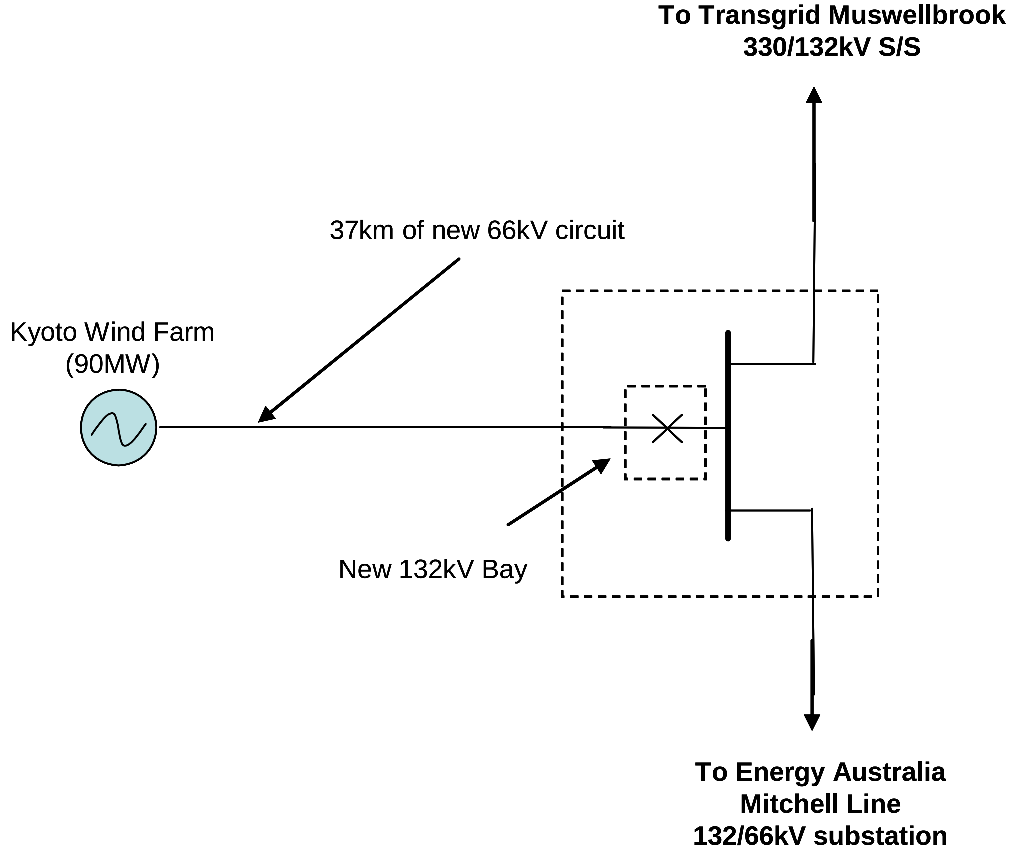
Option 2B (90MW) - Two substation design

Budget Cost Estimates ($M)	**Option 2B**
30km of 66kV dedicated line – single circuit	4.5
6km of new 66kV line to connect the two sites at junction point	0.9
Establishment of a new 66kV Switching Station (site establishment, three new 66kV bays)	1.5
Establishment of a new 66kV switching station near Dartbrook (site extension, single new 66kV bay)	0.6
Establishment of 2x50MVA 66/33kV substation at Mountain and Middlebrook station	8
Replacement of Dartbrook line conductor (11km)	1
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	1
40MVAr of capacitor banks	1
Total Estimated Connection Cost*	**18.5**

Table 3

10 Option 3: Direct Connection to Muswellbrook 132kV terminal STS

It is proposed to connect up to 90MW of wind generation to Muswellbrook 132kV terminal. Muswellbrook is an existing 132/33kV substation which is scheduled for decommissioning as part of Energy Australia network development plans for the Upper Hunter region. Connection to Muswellbrook will require construction of approximately 37km of new 132kV circuit, installation of new 132kV bay at Muswellbrook substation.



10.1 Thermal Considerations

Muswellbrook substation is connected to the 132kV network via two 132kV composite lines constructed with Lemon (54/3.00 AAC) and Olive (54/3.50) conductors at a design rating of 85C. . Each 132kV line is thermally limited to approximately 805A or 184MVA and therefore will provide ample capacity to connect the proposed 90MW of generation.

10.2 Voltage Considerations

Steady state voltage fluctuation is not anticipated to arise as a potential issue based on the proposed capacity, voltage level for the connection and distance involved. Further study will be required to confirm this result.

10.3 Fault Level Considerations

As mentioned earlier Mitchell Line, Musswellbrok (132/33kV) and Mussellbrook (330/132kV) substation fault levels are well below their design rating and additional fault contribution for the wind farm is not expected to increase existing fault level to such extend that substation design rating will be exceeded.

10.4 Planning Considerations

The proposed connection arrangement will require the construction of new 132kV single circuit and construction of step up substations). This will need to be coordinated with Energy Australia and all relevant authorities or parties, to secure the required line easement, planning consent, etc.

10.5 Conclusions

Our preliminary investigations have shown that:

- A connection to the Musswellbrook 132kV terminal will provide sufficient capacity to accommodate the proposed 90MW of wind generation.
- Connection to Musswellbrook 132kV terminal will also provide sufficient capacity for future project expansion in the excess of 150MW.
- Voltage fluctuations were not identified as a potential issue. This will need to be confirmed with further study.
- Network fault levels were not identified as a potential issue. This will need to be confirmed with a detailed study.
- The proposed connection arrangement will require the obtaining of planning consent for the construction of a 33/132kV substation(s) at the wind farm site. Line easement may be also be required.
- The budget costs for this connection option are summarized in Table 9 and Table 10.

Option 3A - One substation design

Budget Cost Estimates ($M)	**Option 3A**
37km of 132kV dedicated line – single circuit	7.4
6km of new 33kV line to connect the two sites	0.6
33kV R.M.U	0.1
Installation of a new 132kV bay at Musswellbrook	0.7
Establishment of 100MVA 132/33kV substation at Mountain station	8
Energy Australia Network Upgrade (protection & control, etc)	0.2
Total Estimated Connection Cost	**17**

Table 9

Two different designs are presented, Design A which assumes the construction of a single substation at Mountain station and Design B which assumes construction of two substations one at Mountain station and one at Middlebrook station with a switching station between the two sites.

Option 3B - Two substation design

Budget Cost Estimates ($M)	**Option 3B**
37km of 132kV dedicated line – single circuit	7.4
6km of new 132kV line to connect the two sites at junction point	1.2
Establishment of a new 132kV Switching Station (site establishment, three new 132kV bays)	2
Installation of a new 132kVbay at Musswellbrook	0.7
Establishment of 2x50MVA 132/33kV substation at Mountain and Middlebrook station	10
Energy Australia Network Upgrade (protection, control voltage regulation, etc)	0.2
Total Estimated Connection Cost	**21.5**

Table 10

Option 3C – One substation design

Budget Cost Estimates ($M)	Option 3A
37km of 132kV dedicated line – single circuit	7.4
6km of new 33kV line to connect the two sites	0.6
33kV R.M.U	0.1
Installation of a new 132kV bay at Musswellbrook	0.7
Establishment of 170MVA 132/33kV substation at Mountain station	10
Energy Australia Network Upgrade (protection & control, etc)	0.2
Total Estimated Connection Cost	**19**

Table 9

Econnect

11 Conclusions & Recommendations

Following preliminary investigations, our conclusions are as follows:

Assuming that Energy Australia Strategy 3 is implemented, a connection to the Scone 66kV supply (Option 1) will provide up to 60MW of capacity until 2009. Following the upgrade of the Scone-Mitchell Line 66kV feeders expected to be completed 2012, connection to the Scone 66kV supply will provide up to 90MW of capacity. Detailed power system study will be required to confirm that steady state voltage can be managed successfully.

A tee connection to the Dartbrook 66kV feeder (Option 2) will not provide sufficient network capacity for the proposed 90MW. Capacity available under this option was estimated to be in the order of 60MW. Additional capacity may be added but will require the re-construction of the existing Dartbrook-Mitchell line 66kV circuit. However the latter will make this option less economically attractive option when compared to Option 3.

A connection to Muswellbrook 132kV terminal (Option 3) will provide the required capacity to connect 90MW of wind generation at the proposed site. In fact, Option 3 can potentially provide capacity in the excess of 150MW and thus would provide Pamada with additional capacity headroom for future project expansion.

Option 1 will be the least costly connection options for a 90MW project but will also the technically most challenging. Detailed power system study will be required to demonstrate that export of 90MW at Scone new 66/33/11kV substation (post network development) is technically manageable and compatible with Energy Australia Network Service Provider obligations. It should also be noted that network capacity available under Option 1 will depend on Energy Australia preferred strategy for the network development of the Upper Hunter area and the timing of its roll out. This is risk that should be considered when selecting the preferred connection option for this project. Furthermore, Option 1 will offer very limited scope for future project expansion. Electrical losses will also be significant under Option 1.

Option 3 is approximately $4-5M more expensive than Option 1 or 2 in a context of a 90MW project however, becomes rapidly economically attractive for project capacity above 90MW.

Overall single substation design will be a more cost effective design. However this may require overhead line to be built on both side of the road between the two wind farm sites. Should planning issue arise a 33kV underground cable may be used instead.

In order to take this project forward we recommend the following:

2. Decide on the ultimate size of the project

C. For a ultimate size of project <90MW

- Perform further studies to quantify the wind farm impact on the local network post network upgrade.
- Refine network upgrade budget cost estimates for the 66kV option.
- Re- valuate technical and economical merits of Option 1 and 3 based on study result.
- And prepare and submit a connection application to Energy Australia for the preferred connection option.

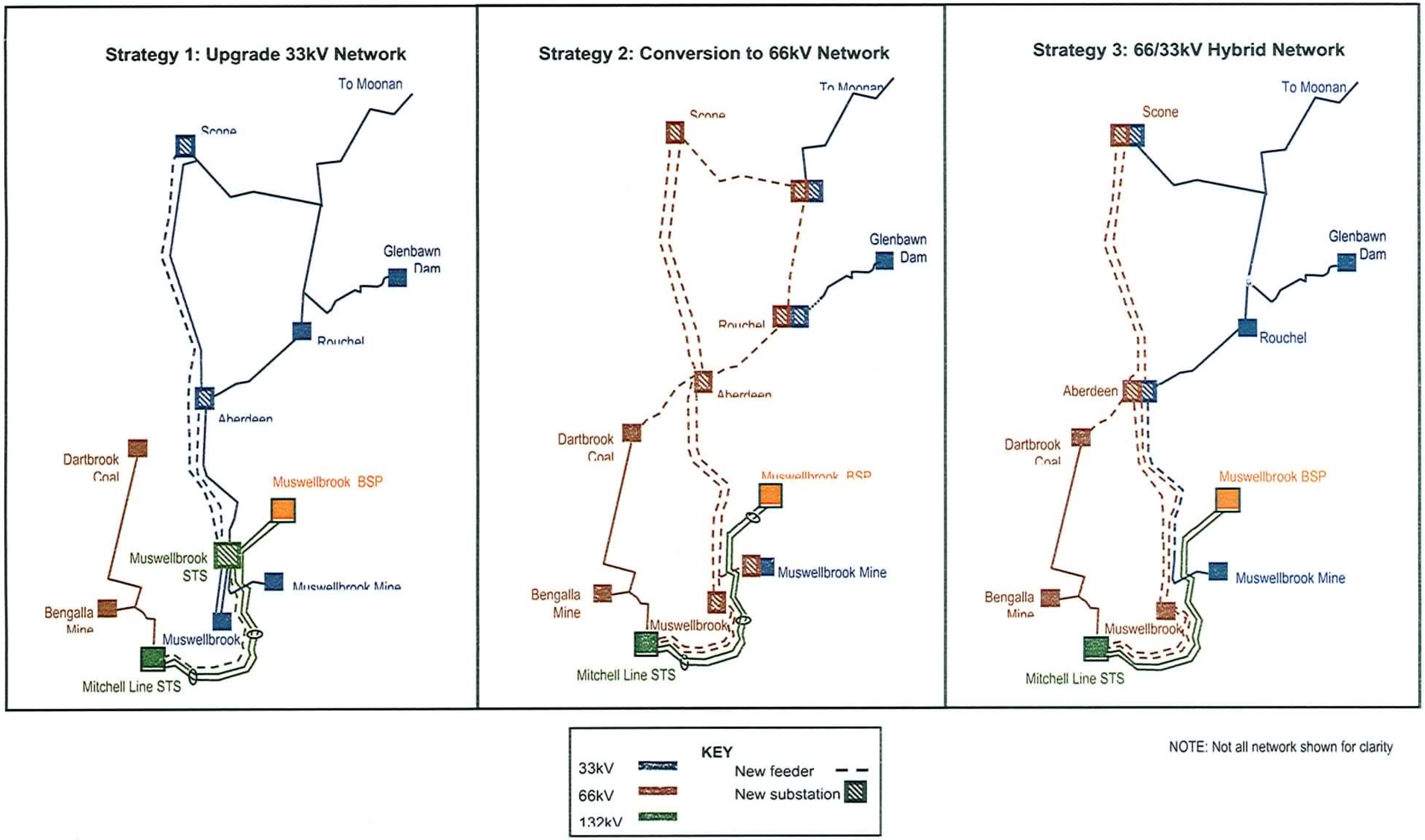
D. For a project ultimate size of project >90MW

- Prepare and submit a connection application to Energy Australia for the preferred connection Option 3.

12 References

1. Transgrid Data Book 2004
2. ESAA D(b) Standard: Line Conductor Rating
3. Energy Australia - Investing for Future Generations – Capital Works Plan 2005-2006 – Volume 1 Page 56-58.
4. Scone replacement substation –community newsletter – July 2007
5. Energy Australia Consultation Paper – Development of new Scone 66/33/11kV substation.
6. Energy Australia – Draft response to Pamada connection enquiry – email from Benjamin Ortner dated RE:2040 KYEP Revise pre-feasibility study - Energy Australia – data request'

13 Appendix A – Energy Australia – Network Development Strategies



NOTE: Not all network shown for clarity

14 Appendix B - Budget Cost Estimate Assumptions

Estimates include the electrical equipment required to transmit power from the wind farm site to the point of connection with the existing grid. This point of connection is at the wind farm substation.

All estimated costs for connection options provided to an accuracy of +/-30% in this report.

14.1 Inclusions

The following items have been included in the cost estimates as follows:

Network Augmentation

- HV connection's insulator and fittings
- Protection and SCADA modifications
- Transmission circuit as appropriate

Energy Australia Assets

- Civil Works
- Earthing
- Yard surface finishing
- Steel landing structures
- Steelwork
- Fence gate and electrical lighting
- bays
- Substation control building
- Communication equipment
- SCADA/RTU
- Protection & Controls
- Auxiliary Systems
- Cabling and terminations
- HV connections, insulators & fittings

Wind Farm Substation

- Civil works
- Earthing
- Yard surface finishing
- Fence gate and electrical lighting
- transformer(s)
- Substation control building
- Substation switchroom
- Steelwork

- Communication equipment
- SCADA/RTU
- Protection & controls
- Grid metering
- Auxiliary systems
- Cabling and terminations
- Operation and maintenance

14.2 Exclusions

The following items have been excluded in the cost estimates as follows:

- Transmission reinforcement costs (except where specified in the connection solutions
- Wind turbine generator array collection system
- Wind turbine generators
- Wind turbine transformers /switchgear
- Wind turbine foundations/erection
- Wind farm reticulation system
- FACTS devices and associated balance of plant
- Harmonics Filters
- Access tracks
- Line survey
- Environmental survey
- Planning consent
- Communication lines from public network to site
- Communication links (UHF radio, OPGW, leased lines or ADSS)
- Operation and maintenance cost