



## **CONSULTATION PAPER**

# **DEVELOPMENT OF ENGADINE ZONE SUBSTATION**

**20<sup>th</sup> April 2009**

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## EXECUTIVE SUMMARY

This paper has been prepared to provide a basis for EnergyAustralia to consult with registered participants and interested parties on the possible options for the development of the electricity supply network in the Engadine load area (part of Sutherland area) to address projected limitations of that part of EnergyAustralia's distribution system.

**Section 1** of the paper provides a description of the Sutherland load area.

**Section 2** presents EnergyAustralia's service standards for the area and describes, in detail, the nature of the load growth in the area, the issues affecting the supply network in the area and the need for augmentation of supply to the area.

**Section 3** outlines the possible options to address the issues affecting the supply network including options for supply system development. Two feasible augmentation options are described:

Option 1 – Convert Engadine zone substation to 132/11kV operation

Option 2 – Refurbish existing Engadine zone substation at 33/11kV

**Section 4** presents the results of a preliminary application of the regulatory test and ranks the options.

**Section 5** concludes that the most cost effective strategy within the regulatory test is Option 1 – Convert existing 33/11kV Engadine zone substation to 132/11kV operation.

EnergyAustralia's recommended action is to convert the existing 33/11kV Engadine zone substation to 132/11kV at an estimated capital cost of \$44.1M which includes zone conversion, feeder connection, decommissioning of the existing zone, reconfiguration of the associated 33kV and 132kV feeder networks. This recommendation is made based on the least cost test to provide increased future capacity and address condition issues of existing equipment at Engadine zone substation.

# 1. INTRODUCTION

## 1.1. Purpose and Scope

This paper has been prepared to provide a basis for EnergyAustralia to participate with and consult registered participants and interested parties so as to identify possible options to address projected limitations of the electricity supply network in the Engadine load area (part of Sutherland area). It includes:

- A discussion of supply system limitations identified by EnergyAustralia that have led to the necessity of identifying possible options for augmentation of the distribution network in the area;
- A discussion of the service standard that has been adopted for planning purposes;
- A description of possible options which have currently been identified for development of the electricity supply in the area; and
- A detailed preliminary cost effectiveness analysis of each of these options, carried out in accordance with the requirements of the regulatory test.

## 1.2. Background

The Sutherland network area extends from the Kurnell peninsula in the north-east, along the southern side of Botany Bay and the Georges River, south as far as Waterfall and west towards the coast. The network in Sutherland serves a mixture of residential, commercial and industrial loads and is supplied from TransGrid's Sydney South BSP via two double circuit 132kV tower lines. The Sutherland network area includes two subtransmission substations at Kurnell and Port Hacking which supply seven 33/11kV zone substations together with three 132/11kV zones.

Engadine 33/11kV zone substation is located in the south-west portion of the Sutherland supply area and is currently supplied by Port Hacking STS. Engadine zone supplies parts of the following suburbs: Engadine, Heathcote, Loftus, Lucas Heights, Menai, North Engadine, Waterfall, Woronora Heights and Yarrawarrah.

Engadine is not forecast to exceed its licence capacity within the forecast period. However, a substantial proportion of the substation equipment is in a deteriorated state and in need of replacement within the next five years.

Furthermore, Port Hacking STS is forecast to exceed firm capacity in winter 2009. An 11kV load transfer from Jannali zone, supplied by Port Hacking STS, to Kirrawee zone, supplied by Kurnell STS, is planned to temporarily relieve the load at Port Hacking STS in 2009. Additionally, the conversion of Gwawley Bay 33/11kV zone to 132/11kV operation will also alleviate the load constraint at Port Hacking STS. However, the load at Port Hacking STS is expected to exceed firm capacity again in 2012.

Figures Figure 1 and Figure 2 below indicate the geographic overview and schematic overview of the area respectively.

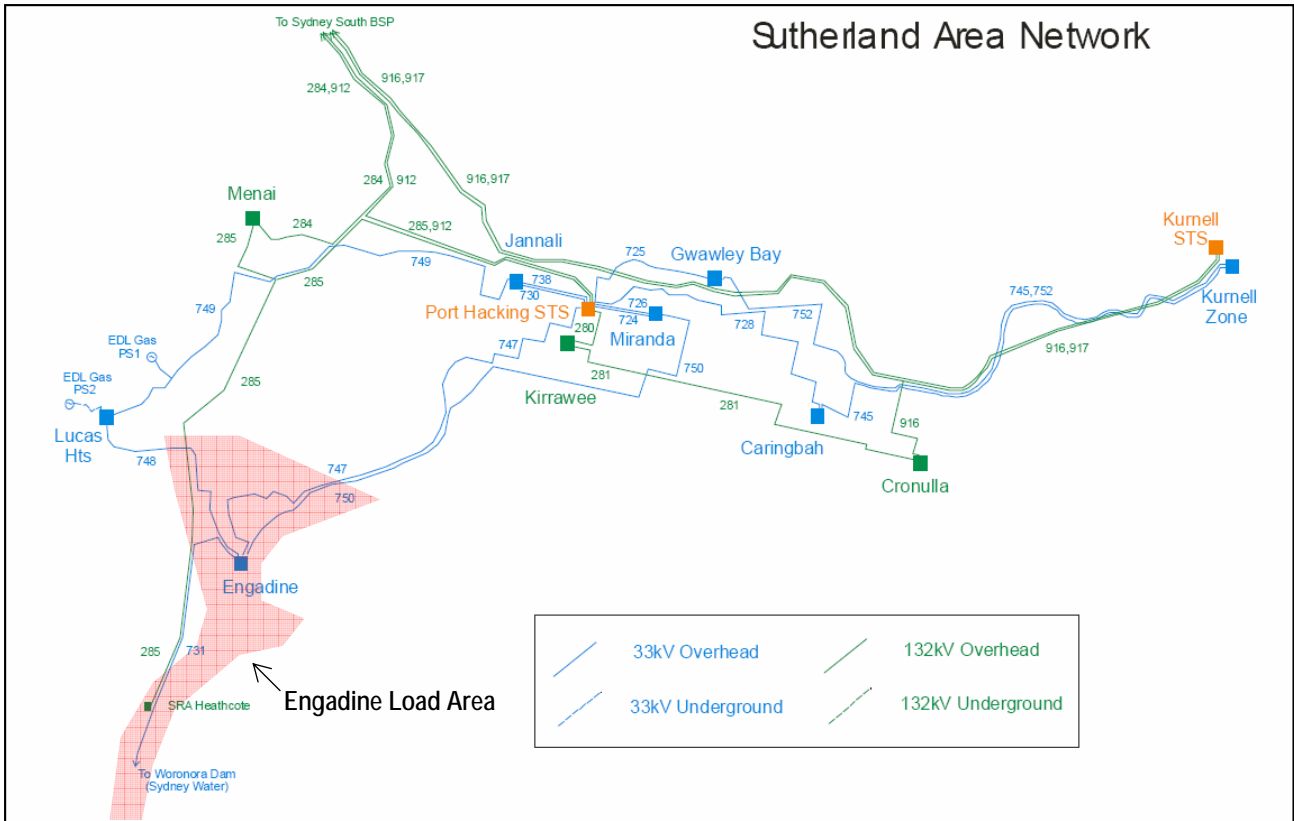


Figure 1: Geographical overview of the existing Sutherland network showing the Engadine load area

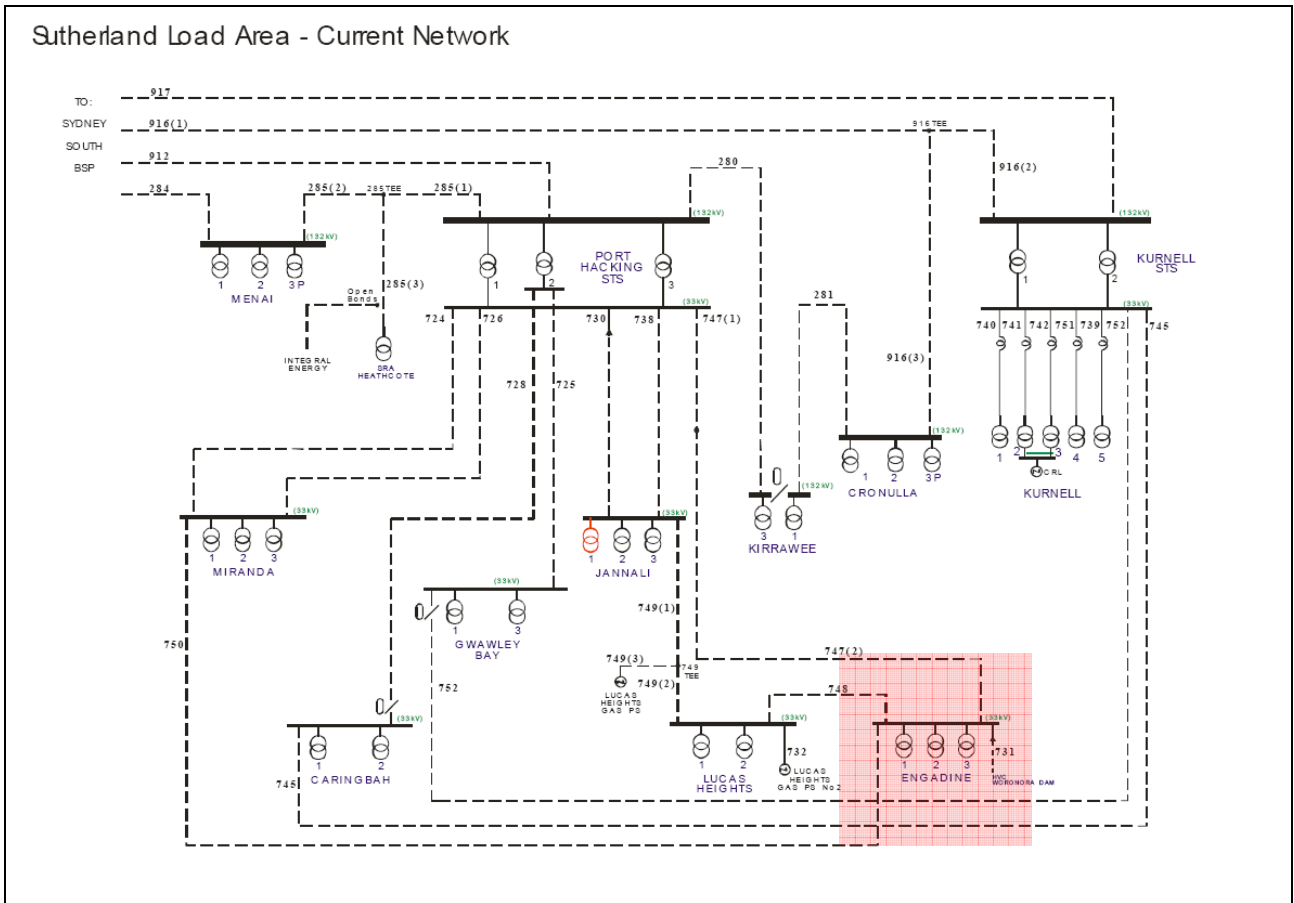


Figure 2: Sutherland supply area 132kV and 33kV diagram

## **2. IDENTIFICATION OF NEED FOR AUGMENTATION**

### **2.1. Applied Service Standard**

EnergyAustralia is required to comply with service standards that are specified in the 'Design, Reliability and Performance Licence Conditions' (Licence Conditions), which were imposed on NSW distributors by the Minister for Energy on 1 October 2007. The design planning criteria are specified in Schedule 1 of the Licence Conditions and reliability standards are specified in Schedules 2 and 3. For existing network, a distributor must be as compliant as practicable with these requirements by 1 July 2014 and fully compliant by 1 July 2019. All new network elements must comply with these requirements.

The service standards that are applicable to a consideration of supply constraints affecting the Engadine load area are summarised below. For further details refer to the Licence Conditions or to EnergyAustralia's Network Management Plan.

#### **2.1.1. Subtransmission Substations (Urban/Non-Urban)**

With all elements in service, the thermal capacity is required to meet at least 115% of forecast demand.

For a failure of a single critical element (i.e. N-1 conditions) within a subtransmission substation, the forecast demand is not to exceed the thermal capacity. Recovery of load should be within one minute.

#### **2.1.2. Zone Substations And Subtransmission Network (Urban/Non-Urban)**

With all elements in service, the thermal capacity is required to meet at least 115% of forecast demand.

Following a failure of a single critical element (i.e. N-1 conditions), the network must be designed to recover supply within one minute for systems supplying >10MVA, and otherwise, within best practice repair times. For systems that supply >10MVA, the forecast demand of a zone substation or overhead feeder network may exceed the N-1 capacity for up to 1% of the year i.e. a total aggregate time of 88 hours per annum, up to a maximum of 20% above the N-1 capacity; and the forecast demand of an underground feeder network may not exceed the N-1 capacity.

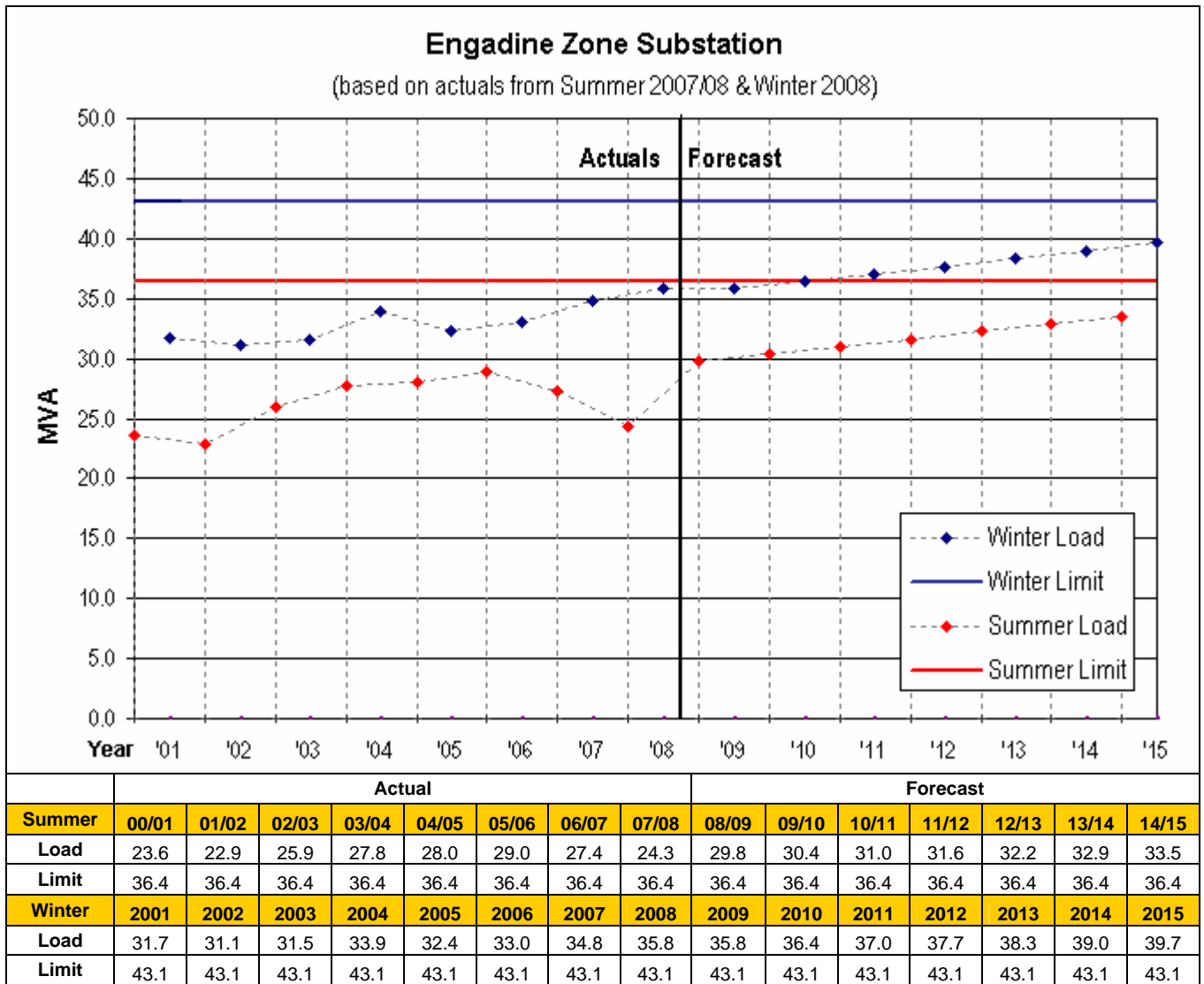
## **2.2. Description of Network Constraints**

### **2.2.1. Capacity Issues**

#### **Engadine Zone Substation**

Engadine 33/11kV zone substation was commissioned in 1964 and is presently equipped with one 10MVA and two 19MVA transformers. The zone has a firm capacity of 31.7MVA in summer and 35.9MVA in winter, restricted by the rating of the 33/11kV transformers. Engadine is supplied by three 33kV overhead feeders from Port Hacking STS, one direct feeder (747), one feeder via Miranda zone (750) and another feeder via Lucas Heights zone (748). This is illustrated in above figure 2.

The licence capacity for Engadine zone is 36.4MVA in summer limited by the daily rating of transformers and 43.1MVA in winter limited by 120% of the firm capacity of the zone. The peak load forecast at Engadine zone substation is shown in Table 1 below. The peak load was 24.3MVA in summer 2007/08 and 35.8MVA in winter 2008. Engadine zone is not forecast to exceed licence capacity in the current forecast period.



**Table 1: Peak load forecast at Engadine zone substation**

### Port Hacking STS

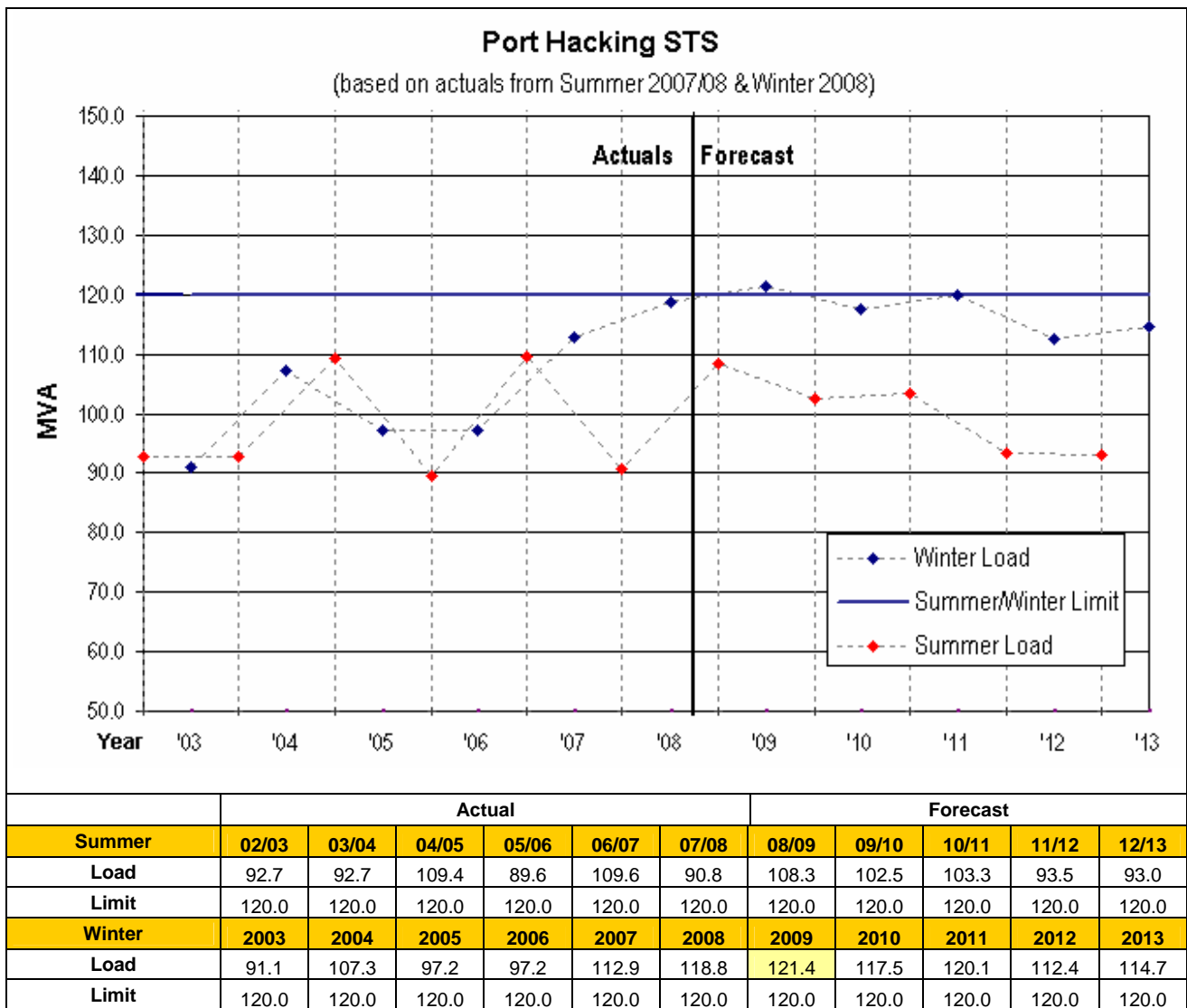
Supply to the existing Engadine zone substation is normally provided from Port Hacking STS.

Port Hacking STS is supplied directly from TransGrid's Sydney South BSP via the 132kV feeder 912 and from Menai 132/11kV zone substation via the 132kV feeder 285. Port Hacking is equipped with three 60MVA 132/33kV transformers and has a firm capacity of 120MVA in summer and winter.

The peak load forecast at Port Hacking STS is shown in Table 2 below.

Port Hacking STS is forecast to exceeds its winter licence capacity in 2009. A load transfer from Jannali 33/11kV zone (presently supplied by Port Hacking STS) to Kirrawee 132/11kV zone is proposed and will provide short term relief for Port Hacking. However, Port Hacking STS will be constrained again in winter 2011. At this time, a separate future project to convert the existing Gwawley Bay 33/11kV zone substation to 132kV operation is planned and will serve to alleviate the constraint at Port Hacking STS from 2011 onwards\*.

\* Although the system needs date for the Gwawley Bay 132kV conversion is winter 2011, it is anticipated that Demand Management can achieve a one year deferral due to the low MVA requirement for the initial deferral. Once Gwawley Bay is converted to a 132/11kV substation, it may then be possible to defer the conversion of Engadine to coincide with the replacement deadline of the 11kV switchgear in 2014.



**Table 2: Peak load forecast at Port Hacking STS**

### 2.2.2. Asset Condition Issues

A significant portion of substation equipment is approaching the end of its serviceable life and requires replacement within 5 years:

- The 11kV switchgear at Engadine zone substation is prioritised for replacement between 2012 and 2014;
- Three 33kV circuit breakers are bulk oil type and are at the end of service life and require replacement in the short term; and

### 2.2.3. Geographic Constraints

Engadine zone substation is located in a relatively remote area with limited 11kV connections to adjacent zones. The only 11kV interconnections at Engadine are to Jannali zone substation. Jannali, however, is currently approaching its capacity limit.

Engadine zone substation is 9km from Port Hacking STS and the existing 33kV feeder 747 that supplies Engadine zone from Port Hacking STS is more than 11km in length. Due to such geographic remoteness, any additional 33kV feeder from Port Hacking STS will be of similar length and subsequent high cost.

#### **2.2.4. 132kV Network**

The 132kV network supplying Port Hacking STS from Sydney South BSP is reaching capacity limitations due to the rating of the Port Hacking busbar. Under the present forecast, this limit is expected to be reached in winter 2012. Reconfiguration of feeders 912, 284 and 285 are required in the medium term to address this issue. This reconfiguration will require an additional busbar in the 132kV network to facilitate the necessary connections.

The supply option designated as "Option 1" described in section 3 below addresses these constraints.

#### **2.3. Consideration of Demand Side Management**

A Demand Management investigation has been initiated to ascertain the ability to defer the Engadine project. The results of any Demand Management deferral will be incorporated into the supply solution for the Engadine supply area.

#### **2.4. National Electricity Rules Requirements**

Engadine zone substation and its associated feeders are classified as distribution system assets by the National Electricity Rules (the Rules).

The Rules (Clauses 5.6.2(e) and (f)) requires that, where analysis indicates that any relevant technical limits of a distribution system will be exceeded, that the Distribution Network Service Provider (DNSP) must notify any affected Participants of these limitations and of the expected time for corrective action and consult with affected Participants and interested parties on the possible options to address the projected limitations of the relevant distribution system. The proposed options for the Engadine load area (to address the projected limitations of the system) include new distribution network asset options that involve expenditure in excess of \$10 million. These options are classed as new large network assets and consequently Energy Australia has an obligation to consult on these options.

EnergyAustralia has previously published details of its load forecasts and the timing of loads exceeding technical limits of the system in its Annual Electricity System Development Reviews of 2004, 2005, 2006 & 2007.

Clause 5.6.2(g) of the Rules requires DNSPs to include the economic analysis of possible options in their consultation on options. This paper has been prepared to consult on identified options which satisfy the regulatory test and meet the network performance standards set out in Schedule 5.1 of the Rules and limb (a) of the regulatory test must be applied to determine the option that satisfies the regulatory test. Under limb (a) of the regulatory test, the option that meets the test is the one that minimises the present value of costs compared with a number of alternative options in the majority of reasonable scenarios.

### **3. OPTIONS**

The options considered are described below.

#### **3.1. Option 1 – Convert Engadine Zone Substation to 132/11kV Operation**

Option 1 proposes to convert Engadine zone substation to a 132/11kV zone substation in 2012<sup>†</sup>, using vacant land owned by EnergyAustralia west of the existing zone. After the commissioning of the new 132kV zone, the existing 33/11kV Engadine zone will be decommissioned. This option also involves associated 33kV and 132kV network reconfiguration.

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<sup>†</sup> The completion date for the Engadine project may be deferred by up to 2 years to 2014 due to Demand Management. Refer to section 2.3 for further details.

The new substation would be developed as a standard 2x37.5MVA zone substation supplied from the reconfigured 132kV feeders 285 and 912. Three short overhead 132kV sections are required to link the new Engadine zone to these feeders.

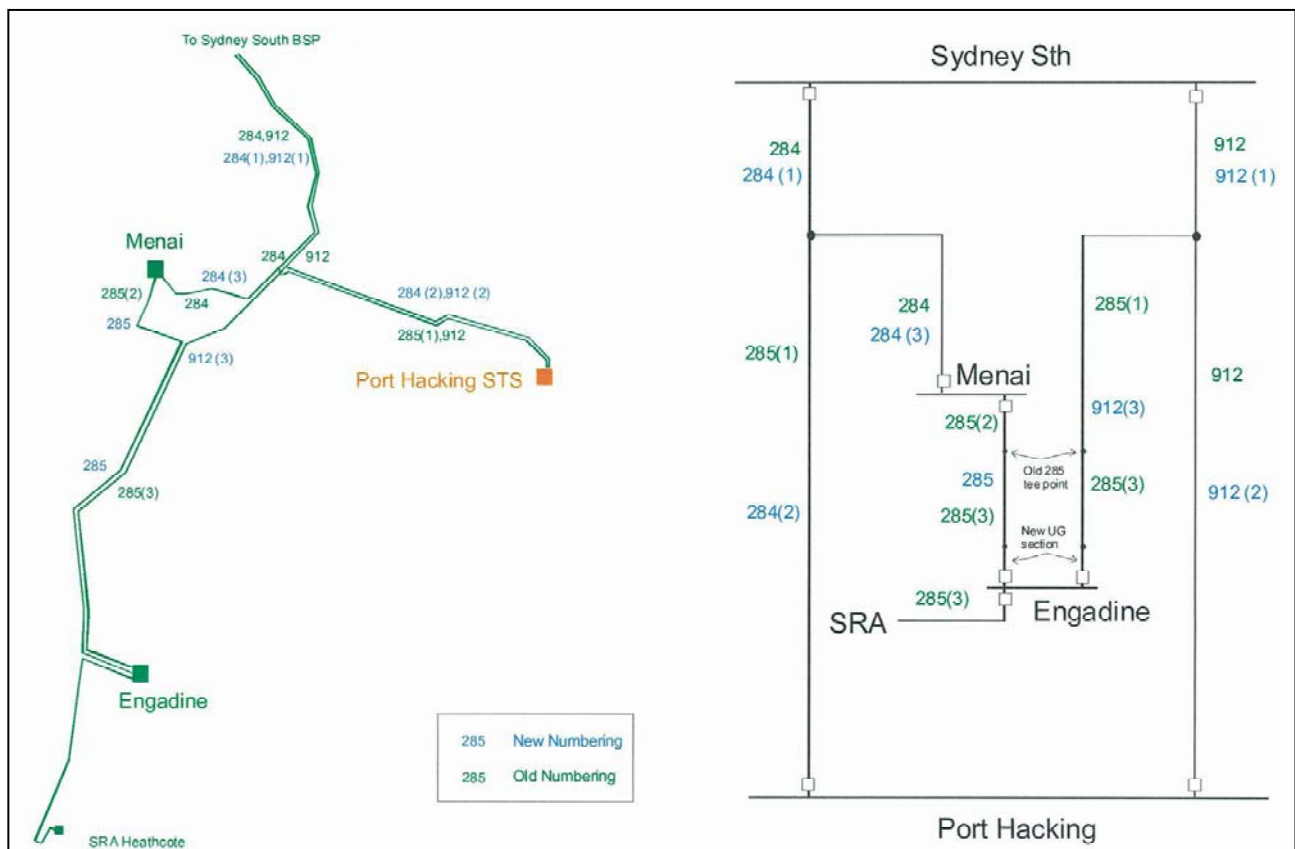
The three existing 33kV feeders that supply Engadine 747, 750 and 748 form an interconnected feeder ring that includes Miranda zone, Lucas Heights zone, Jannali zone, Port Hacking STS as well as the Lucas Heights landfill generators. The ring also supplies Woronora Dam via the existing Engadine zone. Under this option, reconfiguration of the 33kV network around Engadine, following decommissioning of the existing 33/11kV zone, will be required to ensure continued supply to Woronora Dam and ensure N - 1 security of supply to Lucas Heights zone.

In summary, this option consists of the following components;

- Conversion of existing 33/11kV Engadine zone substation to 132/11kV operation
- Construction of three short 132kV underground feeder sections to Engadine zone substation
- Reconfiguration of 132kV feeder network (feeders 285 and 912)
- Decommissioning of the 33/11kV Engadine zone substation
- Reconfiguration of 33kV feeder network

This option addresses the asset condition issues at Engadine and will reduce loading at Port Hacking STS.

**The estimated capital cost of this option is \$42.5M.**



**Figure 3: Proposed 132kV connections under Option 1**

### 3.2. Option 2 – Refurbish Existing Engadine Zone Substation at 33/11kV

Option 2 involves the refurbishment and expansion of Engadine zone at 33kV. This will require upgrading to 3x33MVA transformers, and an additional 33kV feeder to cater for emerging 33kV network constraints. The 11kV switchgear at Engadine zone substation and a number of oil-filled 33kV circuit breakers will require replacement.

This option includes 33kV feeder work and zone refurbishment, but excludes the cost for subtransmission development work, such as the up-rating of the Port Hacking STS transformers and switchgear.

***The estimated capital cost of this option is \$48.1M.***

## 4. APPLICATION OF THE REGULATORY TEST

A preliminary economic analysis has been carried out for the period 2007/08 to 2019/20. This analysis involves the comparison of options on an economic basis by carrying out NPC analysis for the two options considered.

EnergyAustralia has included a range of issues in comparison of options such as change in discount rates and variations in costs.

### 4.1. Base Case Analysis

In terms of increasing cost the options considered are ranked in the following order considering 8.5% discount rate as the base case:

Options	Total Capital Cost (\$M)	NPC (\$M)	Ranking
Option 1 – Convert Engadine zone substation to 132/11kV operation	42.5	31.8	1
Option 2 – Refurbish Engadine zone substation at 33/11kV	48.1	34.4	2

Detailed analysis is provided in Section 7.0 Appendix – A.

The analysis above indicates that under base case conditions, the NPC of Option 1 is the least cost solution.

### 4.2. Sensitivity Analysis

Sensitivity Analysis was carried out to consider the impact of different discount factors and equipment cost scenarios on the NPC of each option. The base case and the range of sensitivity checks conducted are listed below:

Parameter	Base Case Value	Sensitivity Checks at
Discount Rate	8.5%	7% and 10%
132kV Feeder Cost	100%	75% and 125%
132/11kV Zone Substation Cost	100%	75% and 125%
11kV Feeder Cost	100%	75% and 125%
33kV Feeder Cost	100%	75% and 125%
33/11kV Zone Substation Cost	100%	75% and 125%

Since the Engadine project is primarily driven by asset condition issues, sensitivity to load growth will not impact on the preferred outcome.

The results of sensitivity analysis are provided in the following table:

<b>Sensitivity Factor</b>	<b>NPC (\$M) Option 1</b>	<b>NPC (\$M) Option 2</b>
Base Case 8.5% Discount Rate	<b>31.8</b>	34.4
7% Discount Rate	<b>33.7</b>	36.7
10% Discount rate	<b>30.0</b>	33.7
25% increase in 132kV feeder cost	34.9	<b>34.4</b>
25% decrease in 132kV feeder cost	<b>28.7</b>	34.4
25% increase in 132/11kV ZS cost	36.6	<b>34.4</b>
25% decrease in 132/11kV ZS cost	<b>26.9</b>	34.4
25% increase in 11kV feeder cost	<b>31.8</b>	34.4
25% decrease in 11kV feeder cost	<b>31.7</b>	34.4
25% increase in 33kV feeder cost	<b>31.8</b>	40.2
25% decrease in 33kV feeder cost	31.7	<b>28.6</b>
25% increase in 33/11kV ZS cost	<b>31.8</b>	37.2
25% decrease in 33/11kV ZS cost	31.8	<b>31.6</b>

Option 1 is the least cost option under the majority of analysed scenarios.

## 5. CONCLUSION

The upgrade of Engadine zone substation from 33/11kV to 132/11kV operation is the least cost option under the majority of analysed sensitivity scenarios. Accordingly, subject to comments received during consultation, EnergyAustralia favours Option 1.

## 6. CONTACT DETAILS

Comments on this Consultation Paper, including proposals for alternative options must be in the form of written submissions, which may be in hard copy or suitable electronic format and must be provided within 40 business days of the issue date of this paper. Proposals or other enquiries should be directed to the contact listed below:

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## 7. APPENDIX A – ECONOMIC ANALYSIS OF BASE CASE

**Discount Factor**                      **8.5%**

### Option 1 – Convert Engadine Zone Substation to 132/11kV Operation

Description	HPC (\$M)	CAPEX (\$M)	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20
132kV feeder reconfiguration	12.08	17.21	-	-	-	0.23	10.73	6.26	-	-	-	-	-	-	-
new 132/11kV substation	18.13	24.69	-	-	0.36	6.81	14.94	2.58	-	-	-	-	-	-	-
11kV feeder work	0.20	0.30	-	-	-	-	0.02	0.28	-	-	-	-	-	-	-
33kV feeder reconfiguration	0.16	0.22	-	-	0.00	0.03	0.12	0.07	-	-	-	-	-	-	-
Decommission	0.08	0.11	-	-	0.00	0.03	0.07	0.01	-	-	-	-	-	-	-
<b>Total</b>	<b>30.65</b>	<b>42.54</b>	-	-	<b>0.36</b>	<b>7.10</b>	<b>25.88</b>	<b>9.19</b>	-	-	-	-	-	-	-
<b>O&amp;M</b>	<b>1.13</b>	-	-	-	-	-	-	<b>0.31</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>
<b>Grand Total</b>	<b>31.79</b>	<b>42.54</b>	-	-	<b>0.36</b>	<b>7.10</b>	<b>25.88</b>	<b>9.50</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>	<b>0.27</b>

### Option 2 – Refurbish Existing Engadine Zone Substation at 33/11kV

Description	HPC (\$M)	CAPEX (\$M)	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20
33/11kV zone substation work	10.41	15.59	-	-	-	-	0.76	14.83	-	-	-	-	-	-	-
33kV feeder work	22.52	32.49	-	-	-	-	16.19	16.29	-	-	-	-	-	-	-
<b>Total</b>	<b>32.93</b>	<b>48.08</b>	-	-	-	-	<b>16.95</b>	<b>31.12</b>	-	-	-	-	-	-	-
<b>O&amp;M</b>	<b>1.44</b>	<b>0.00</b>	-	-	-	-	<b>0.00</b>	<b>0.20</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>
<b>Grand Total</b>	<b>34.37</b>	<b>48.08</b>	-	-	-	-	<b>16.95</b>	<b>31.32</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>	<b>0.38</b>

Note: The estimates are based on 2007/08 real dollars