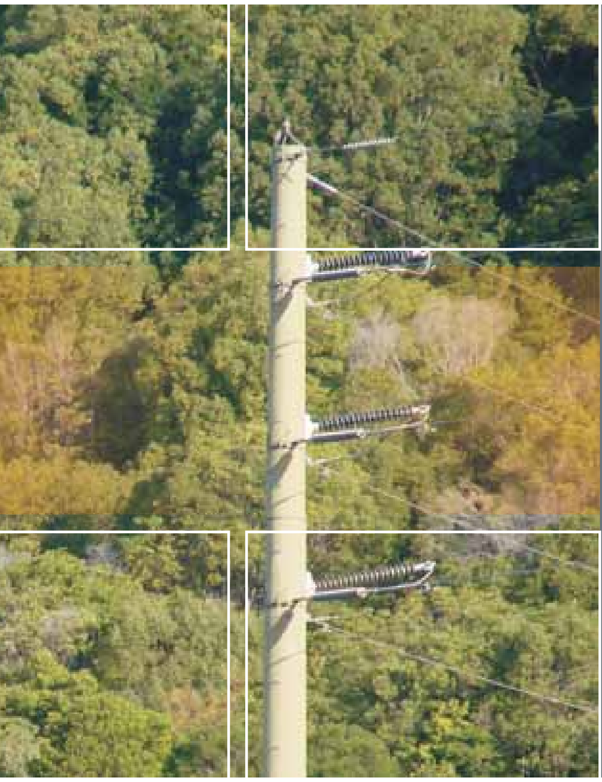

Annex O

Lismore to Mullumbimby Electricity Network Upgrade: Generic EMF Assessment of Upgrades of Zone Substation from 66kV to 132kV

(Connell and Wagner 18 September 2008)

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Lismore to Mullumbimby Electricity Network Upgrade: Generic EMF Assessment of Upgrade of a Zone Substation from 66kV to 132kV

Country Energy

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Table of Contents

1. Introduction

1.1 Background

In order to meet both existing and future electricity demand in the Lismore/Ballina/Byron region on the New South Wales upper north coast, Country Energy is undertaking a major upgrade of its network in the area.

The study area for the project is shown in Figure 1 below.

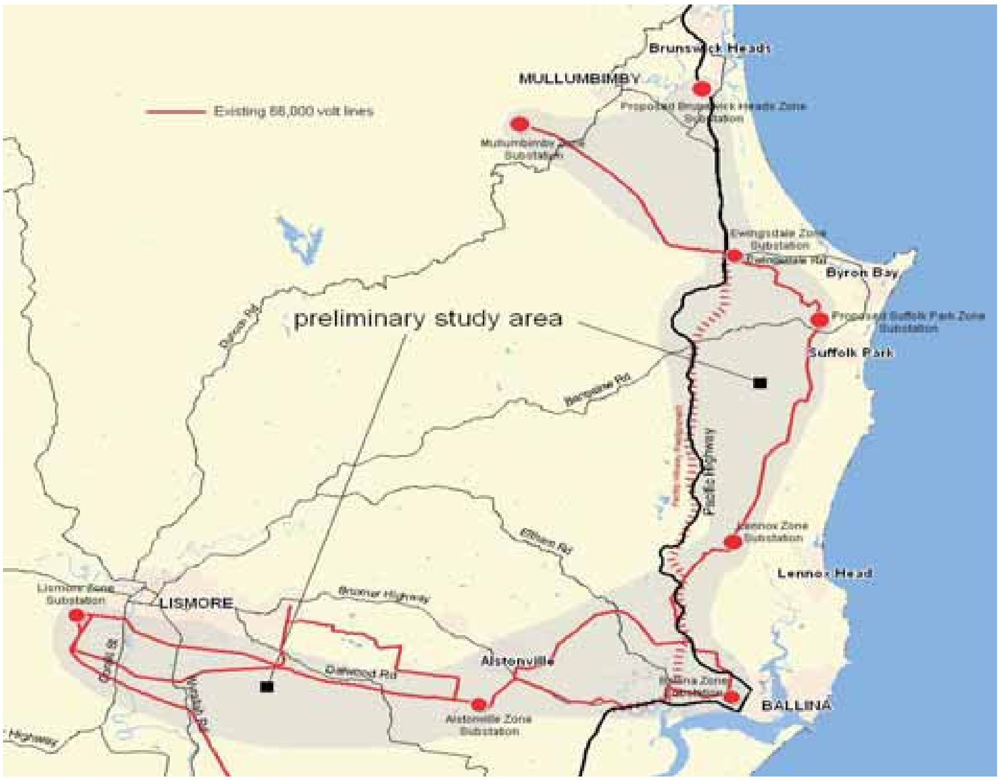


Figure 1: Area of assessment for proposed 132kV upgrade

Based on the outcome of social and environmental studies, the preferred option for the upgrade is the replacement of a number of existing 66,000 Volt (66kV) transmission lines with 132kV lines, the establishment of two new 132/11kV zone substations and the upgrading of three existing zone substations from 66/11kV to 132/11kV.

1.2 Connell Wagner Assignment

As part of Country Energy's overall assessment process in relation to the project, it has commissioned a number of reports and, in that context, Connell Wagner has been engaged to assess the generic electric and magnetic fields (EMF) implications of the upgrading of a typical 66/11kV substation to become a 132/11kV substation.

1.3 Structure of Report

Section 2 provides background information on the electric and magnetic fields associated with substations and Section 3 provides more specific information based on typical Country Energy design details. Brief conclusions are presented in Section 4.

2. Substation Electric and Magnetic Fields

2.1 General Description of Electric and Magnetic Fields

An **electric field** is a region where electric charges experience an invisible force. The strength of this force is related to the voltage, or pressure, which forces electricity along wires.

Electric fields are strongest close to their source, and their strength diminishes rapidly with distance from the source, in much the same way as the warmth of a fire decreases with distance. Many common materials - such as brickwork or metal - block electric fields, so they are readily shielded and, for all practical purposes, do not penetrate buildings. They are also shielded by human skin, such that the electric field inside a human body will be at least 100,000 times less than the external field.

Being related to voltage, the electric fields associated with electrical equipment in substations remain relatively constant over time, except where the substation voltage changes.

A **magnetic field** is a region where magnetic materials experience an invisible force produced by the flow of electricity or the current (amps). Because magnetic fields are related to the current rather than the voltage, high voltage equipment is not the only source of magnetic fields encountered in everyday life. In fact, modern life involves frequent contact with magnetic fields from a variety of sources such as appliances and electrical machinery.

The strength of a magnetic field depends on the size of the current (measured in amps), and decreases with distance from the source. While electric fields are blocked by many common materials, this is not the case with magnetic fields. This is one reason why power lines may contribute to the overall magnetic fields in the environment and why burying power lines will not necessarily eliminate these fields.

The magnetic field strength resulting from an electrical installation varies continually with time and is affected by a number of factors including:

- The total electrical load
- The size and nature of the equipment
- The design of the equipment
- The layout and electrical configuration of the equipment and its interaction with other equipment.

For an overhead line entering a substation or an overhead connection within a substation, the current flowing, the geometric configuration of the overhead conductors, the ground clearance and, where there are other circuits nearby, the "phasing" of the circuits in relation to one another determine the magnetic field. In the case of an underground cable entering, within or exiting a substation, the layout of the individual cables within the trench, the "phasing" of the individual circuits and the depth of burial can have a significant effect on the external magnetic fields.

2.2 Generic Principles Associated with Changing the Supply Voltage of a Substation

In order to enable large quantities of electrical energy to be transmitted from power stations or bulk electricity supply points to load centres such as towns, it is necessary to employ a relatively high voltage such as 66kV or 132kV. The purpose of a zone substation is to transform electricity from these higher voltages to a lower voltage (normally 11kV) for distribution to customers' premises or street distribution transformers.

2.3 Sources of Substation Electric Fields

Having regard to the principles outlined in Section 2.1, while in theory, any energized conductor within a substation is a potential source of electric fields, electric fields are readily shielded and, in the context of a substation, the sheaths of high voltage cables, metallic equipment enclosures, fencing and other structures act as shields. Accordingly, in practice, the only significant sources of electric fields within a zone substation are the exposed high voltage overhead conductors such as busbars. With the exception of the electric fields due to any high voltage overhead lines entering or leaving the substation, electric fields external to a substation are negligible.

2.4 Electric Field Implications of Supply Voltage Increase

When we increase the supply voltage from 66kV to 132kV, the internal electric fields associated with the exposed high voltage overhead conductors such as busbars and any high voltage overhead lines supplying the substation will approximately double. While the precise magnitude of the electric fields will vary depending on specific design configurations and dimensions, an indicative change is from 500volts/metre (0.5kV/m) to 1kV/m, or from 10% to 20% of the relevant health guideline value for the general public. Apart from the immediate vicinity of high voltage overhead lines entering the substation, electric fields external to a substation would remain negligible.

2.5 Sources of Substation Magnetic Fields

Having regard to the principles outlined in Section 2.1, every piece of substation equipment carrying an electric current (Amps) is a potential source of magnetic fields and these are not readily shielded. Potential sources of magnetic fields include:

- incoming and outgoing overhead lines or underground cables;
- busbars and other overhead or underground connections within the substation;
- transformers;
- switchgear; and
- reactive plant.

Because magnetic fields are caused by the amps rather than the volts, the 11kV connections are frequently the most significant source of fields associated with a substation, whether 66/11kV or 132/11kV.

2.6 Magnetic Field Implications of Supply Voltage Increase

To understand the magnetic field implications of an increase in the primary supply voltage, it is important to understand a few basic relationships and characteristics as follows:

- The total electrical load on a substation is generally expressed in terms of MVA.
- The load in MVA is equal to the voltage (kV) times the current (amps), divided by 1,000.
- The higher voltage (66kV or 132kV) side of a substation is characterised by higher volts but lower amps.
- The lower voltage (11kV) side of a substation is characterised by lower volts but higher amps.

Having regard to the foregoing, if we increase the supply voltage from 66kV to 132kV, while continuing to supply the same total load, the currents (Amps) on the supply side will halve, thereby reducing the magnetic fields. The magnetic fields on the 11kV side will remain unchanged.

Because, as noted in 2.5 above, the 11kV connections are frequently the most significant source of fields associated with a substation, it is more likely the case that an increase in the supply voltage will have little impact on the highest magnetic fields associated with the site.

Although beyond the scope of this generic report, in practice, a change in the primary supply voltage of a substation is sometimes implemented as part of a broader system rearrangement which can result in a step change, either increase or decrease in the substation load and this would also be reflected in the magnetic fields. In this context, Country Energy has advised that the principal driver for the Lismore to Mullumbimby Network Upgrade is limitations on the 66kV network external to the substations and, accordingly, the upgrade is not expected to cause any sudden increases in loadings on individual substations.

In addition, whether or not the supply voltage is changed, the loads on substations tend to grow over time and the magnetic fields will generally increase in line with such loading.

3. Assessment of Upgrade from 66kV to 132kV

3.1 Typical 66/11kV and 132/11kV Layouts

In order to relate this generic assessment more closely to the Lismore to Mullumbimby Network upgrade, Country Energy has provided details of standard 66kV and 132kV zone substation layouts. These are reproduced in Figures 3.1 and 3.2 respectively.

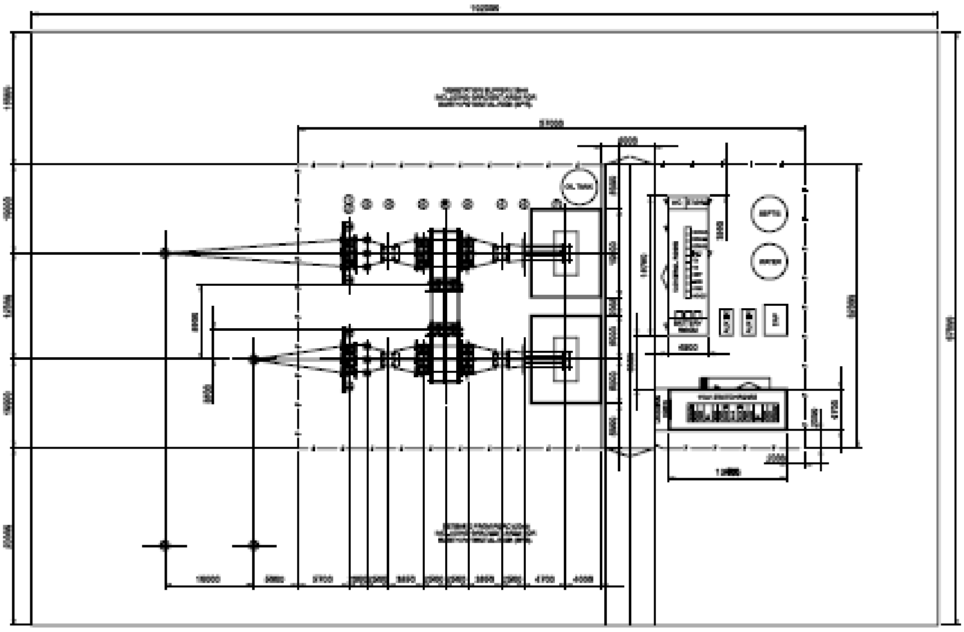


Figure 3.1: Typical 66/11kV, Two-Feeder Substation

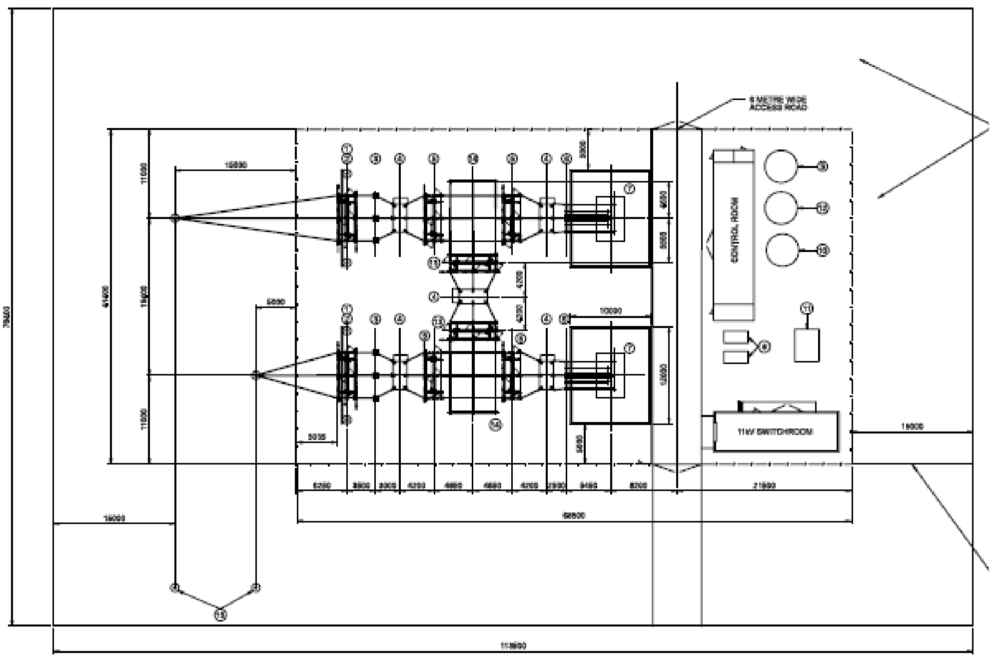


Figure 3.2: Typical 132/11kV, Two-Feeder Substation

Perusal of Figures 3.1 and 3.2, leads to the following observations:

- The 66 and 132kV layouts are broadly similar;
- The 11kV sides of both 66/11kV and 132/11kV substations are similar;
- The 66kV sites measure approximately 100 metres by 67 metres while the 132kV sites being slightly larger - 113 metres by 76 metres;
- Both layouts provide generous (15m) buffers between the high voltage enclosure and the site boundary;
- On the higher voltage (66 or 132kV) side, a clearance of at least 7 metres is provided between the busbars and the high voltage enclosure. This results in a total of 22 metres between the busbars and the site boundary;
- The 66kV phase to phase spacing is considerably less than the 132kV phase spacing. This would cause the magnetic fields from the overhead 66kV busbars to decrease more quickly with distance as one moves away from them. On the other hand, the 132kV busbars are normally higher than the 66kV, which tends to reduce the fields directly under them.

3.2 Indicative Magnetic Field Assessments

In order to provide some indicative perspective to the matters addressed in the previous Sections, a number of specific aspects have been assessed in more detail as follows:

3.2.1 Fields from Busbars

To provide some perspective on the respective fields from 66kV and 132kV busbars, each carrying the same load (10MVA), the results of indicative calculations are shown in Figure 3.1 below. It can be seen that, immediately under the busbars, the 66kV fields are more than twice those from an equivalent 132kV arrangement. However, as noted in Section 3.1, they drop off more rapidly with distance such that, at distances beyond 15 metres, there is little difference.

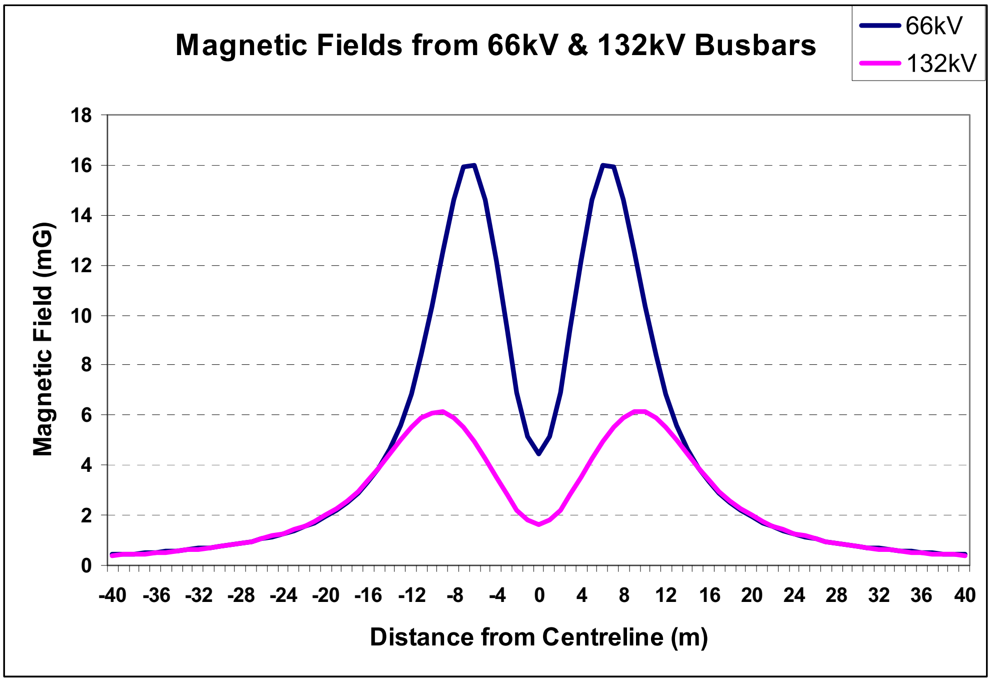


Figure 3.1: Predicted Magnetic Fields from 66kV & 132kV Overhead Busbars @ 10 MVA

3.2.2 Fields from Incoming and Outgoing Feeders

Indicative calculations have been performed to show the magnetic fields associated with 66kV and 132kV overhead lines, each carrying 10 MVA, and a bank of 4x11kV underground cables carrying a total of 10 MVA. The results are shown graphically in Figure 3.2.

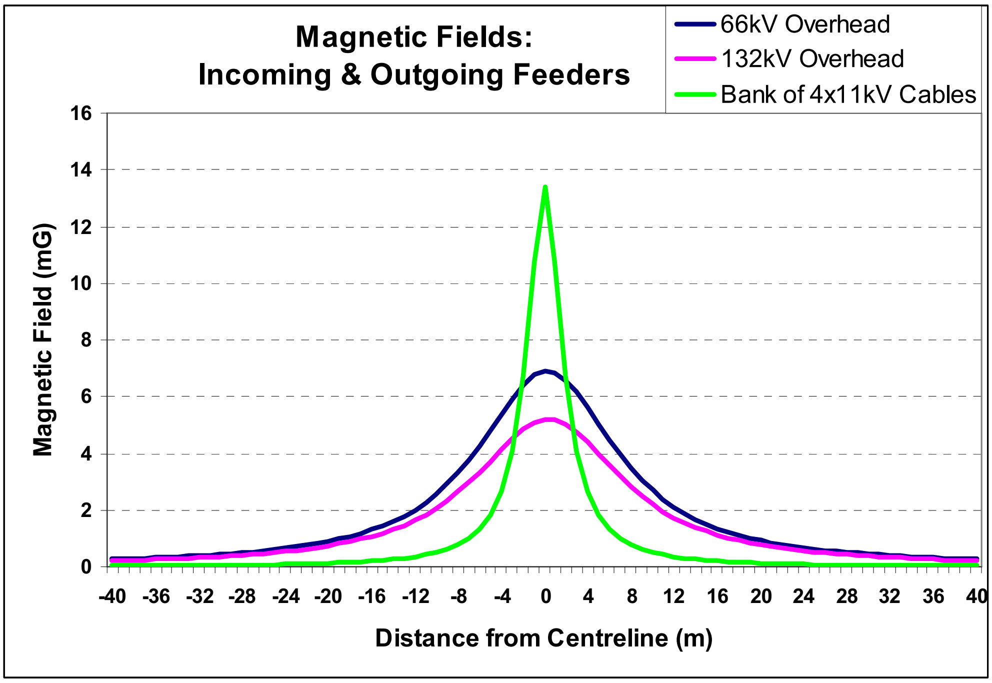


Figure 3.2: Predicted Magnetic Fields from 66kV & 132kV Overhead Feeders and 11kV Underground Cables, @ 10 MVA

It can be seen that the field directly below the 66kV line is over 30% higher than that directly below the 132kV line. However, beyond about 20 metres, both are less than 1 mG. As foreshadowed in Section 2.5, the field directly above the bank of 11kV cables is almost twice that below a 66kV line and 2.5 times that below a 132kV line. However, the field from the 11kV cables drops off very quickly with distance, becoming less than 1 mG within 7 metres. More importantly, in the context of the present assessment, the 11kV fields remain the same, whether the primary supply voltage is 66kV or 132kV.

3.2.3 Transformers

The creation of internal magnetic fields is an essential element of transformer operation. Accordingly, they are designed to minimise stray external magnetic fields which reduce their efficiency. While the actual performance will depend on the design of individual transformers, the magnetic field a few metres from a 132kV transformer is expected to be similar to or less than that from a 66kV to 11kV transformer supplying a similar load.

Due to the separation between the transformers and the substation boundaries, their contribution to the magnetic fields external to the substation is expected to be a few milligauss or less, both before and after upgrading from 66/11kV to 132/11kV.

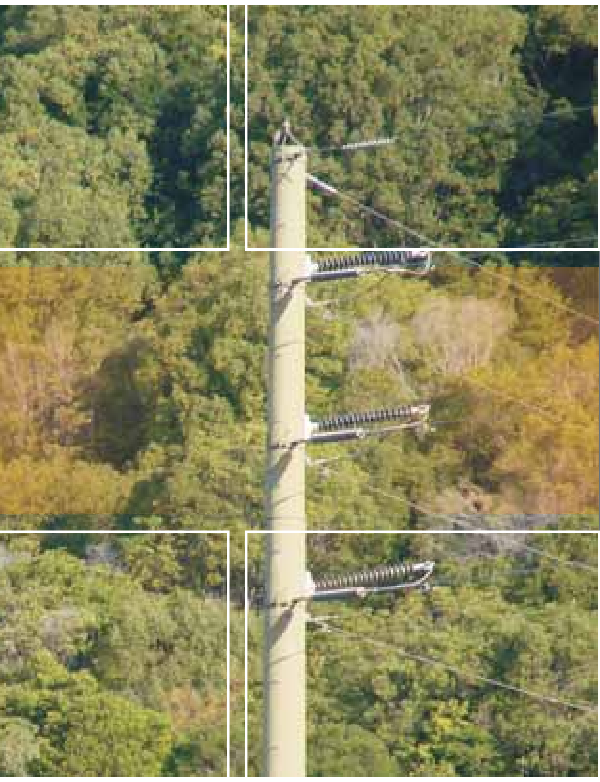
3.2.4 Fields from 11kV Busbars and Switchgear

Whether the primary supply voltage is 66kV or 132kV, the 11kV busbars and switchgear are expected to be similar. Accordingly, no change in external magnetic field levels is expected to result from the proposed upgrade from 66kV to 132kV.

4. Conclusions

The electric and magnetic field implications of an upgrade of a 66/11kV zone substation to 132/11kV have been examined generically and the findings are summarised below:

- The layouts of Country Energy's 66kV and 132kV substations are broadly similar;
- The 11kV sides of both 66/11kV and 132/11kV substations are similar;
- Both 66 and 132kV layouts provide considerable separation between the high voltage equipment and the high voltage enclosure, with further generous (15m) buffers between the high voltage enclosure and the site boundary;
- The internal electric fields associated with the exposed high voltage overhead conductors such as busbars and any high voltage overhead lines supplying the substation will approximately double, from about 0.5kV/m to 1kV/m, or from 10% to 20% of the relevant health guideline value for the general public.
- Apart from the immediate vicinity of high voltage overhead lines entering the substation, electric fields external to a substation would remain negligible.
- Because magnetic fields are caused by the amps rather than the volts, the 11kV connections are frequently the most significant source of fields associated with a substation, whether 66/11kV or 132/11kV.
- An increase the primary supply voltage from 66kV to 132kV will reduce the magnetic fields on the supply side, while those on the 11kV side will remain unchanged.
- Because the 11kV connections are frequently the most significant source of fields associated with a substation, it is likely that an increase in the supply voltage will have little impact on the highest magnetic fields associated with a substation site.



Annex P

Lismore to Mullumbimby Subtransmission Network Development

(Country Energy, 2005)

PLANNING REPORT

Lismore – Mullumbimby
Subtransmission Network development

General Manager Network Strategy approval:

Col Ussher

Far North Coast Regional General Manager approval:

Brian Glawson

Prepared by:

Ken Puchert

December 2005

CONTENTS

1 EXECUTIVE SUMMARY

The coastal area between Ocean Shores in the north and Ballina in the south is experiencing above average load growth and base on development information in the public domain (Council and Shire web sites), population growth statistics published by the Department of Infrastructure, Planning and Natural Resources (DIPNR) and Country Energy electrical trend data captured over several years, this growth is expected to continue in the medium to long term.

The existing electrical network is currently constrained under first level contingencies and with the predicted growth in electrical demand; the constraints will become progressively more risky and difficult to manage which will have a detrimental impact on service delivery standards.

The main constraints identified are:

- Low voltage on the Ewingsdale distribution network when the 66kV line from Mullumbimby – Ewingsdale trips at time of peak loads
- the thermal rating of several 66kV lines will be exceeded during system normal operation or first level contingency outages
- the thermal rating of several 66/11kV zone substation transformers will be exceeded under first level contingency outages
- the distribution network (11kV network) is voltage and thermally constrained in numerous areas and will require significant CAPEX to rectify.

Two high level solutions have been identified to address these network constraints.

- Augment the existing 66kV network, including
  - Four new 66/11kV zone substations
  - Additional 132/66/11.4kV transformer at Mullumbimby
  - New 66kV busbar at Mullumbimby with associated bays
  - Building of approximately 65 km's of new double circuit 66kV lines
  - Upgrade approximately 16km's of existing 66kV lines to increase capacity
  - Upgrading of transformers and equipment at several zone substations
- 132kV network upgrade, including
  - Three new 132/11kV zone substations
  - One new 66/11kV zone substation
  - Additional 132kV feeder bays at Mullumbimby and Lismore Bulk supply point
  - Rebuilding/re-insulate approximately 90 km's of 66kV lines to operate at 132kV
  - Upgrading Ewingsdale zone substation to 132/11kV
  - Add a 132kV busbar and 132/66kV transformer at Ballina zone substation
  - Relocating the 132/66/11.4kV Mullumbimby transformer to Ballina

Whilst both solutions provide an adequate network that will meet long term load forecast with appropriate reliability standards, the 66kV augmentation option requires significant additional 66kV circuits and associated easements and is expected to meet with public resistance. Additionally the 66kV augmentation solution will require major extensions to the space constrained Mullumbimby site and results in significant technical issues and high costs.

The 132kV network upgrade option will utilise existing 66kV line routes by upgrading the existing 66kV lines to 132kV. This upgrade is considered more achievable than acquiring several new line routes with associated easements as required for the 66kV augmentation option and is expected to meet with less public resistance.

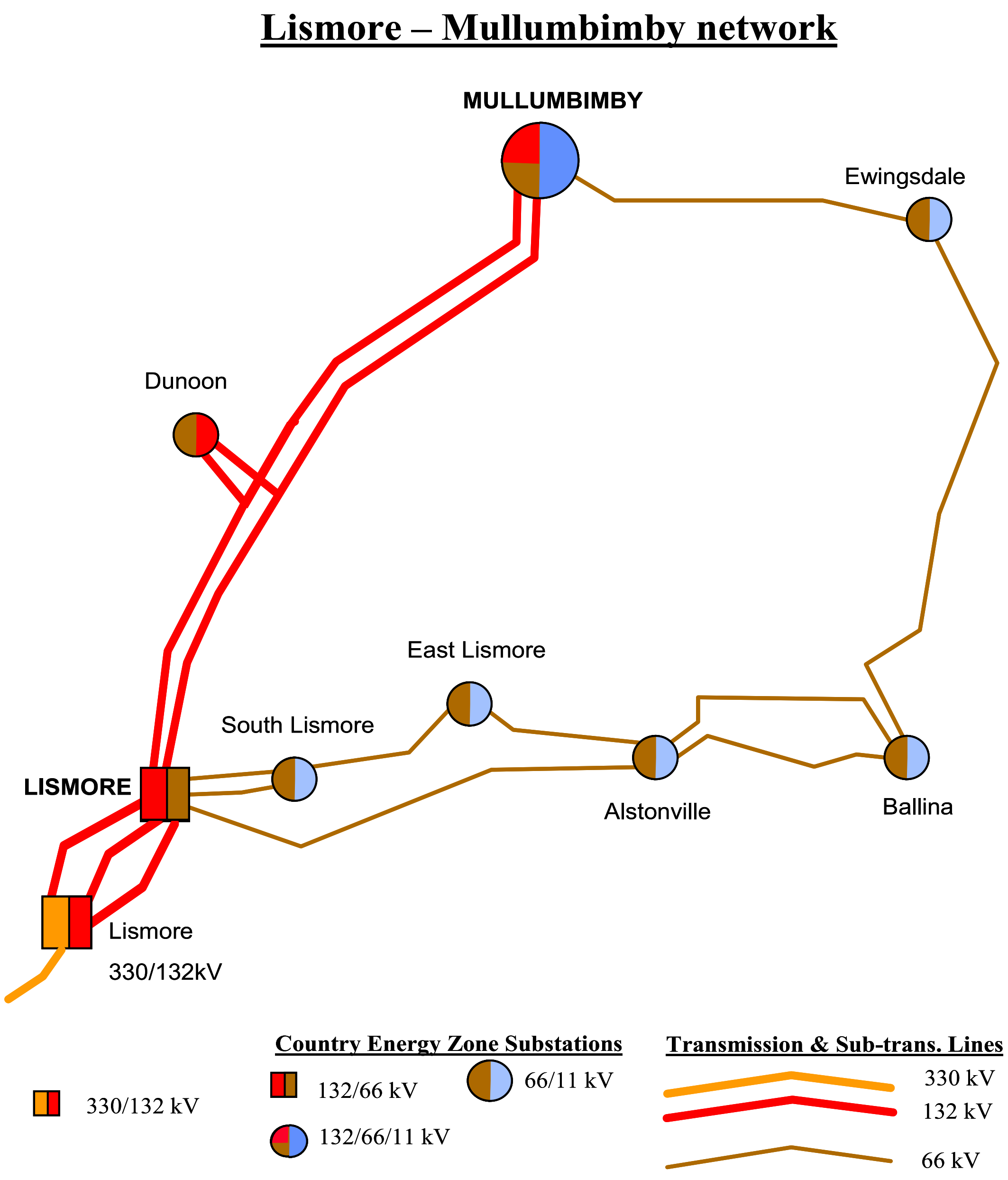
The analysis of these options using discounted cash flows indicates that the 132kV network upgrade option is marginally more expensive than the 66kV augmentation option, but is expected to meet with less public resistance and is therefore the preferred option. Additionally, the 132kV network upgrade option provides a network solution that is more appropriate to the long term load predictions and is less restrictive on the operation of DirectLink.

It is therefore recommended that the 132kV network upgrade option be approved. The capital works, spread over 8 years, that will be required to implement this network solution are attached in the appendix.

2 BACKGROUND

Lismore 330/132kV Bulk Supply Point (BSP), owned by Transgrid, supplies Lismore 132/66kV zone substation at Three Chain Road which in turn supplies Mullumbimby 132/66/11kV zone substation, Mullumbimby also provides a connection point for DirectLink.

Lismore BSP supplies several 66kV zone substations in the area and in conjunction with Mullumbimby zone substation supplies the Lismore-Mullumbimby 66kV ring as indicated by the simplified diagram below.



3 STUDY BOUNDRIES

Byron Shire is currently supplied from **Mullumbimby** and **Ewingsdale** zone substations and Ballina Shire is currently supplied from **Ballina** and **Alstonville** zone substations and Lismore City Council is currently supplied from **South Lismore, East Lismore** and **Dunoon** zone substations.

These zone substations, with the exception of Dunoon, are all connected to the Lismore – Mullumbimby 66kV network and any load growth in these areas will influence the network development.

Richmond Valley Council and Kyogle Shire are also supplied from the Lismore 132/66kV zone substation, but on independent circuits and do not impact on the Lismore – Mullumbimby 66kV network. Load growth in these areas is not considered in this report.

Tweed Shire to the north is not supplied from the Lismore network and therefore has no influence on the network development under investigation.

The map below indicates the Shire and Council boundaries.

Lismore City Council, Ballina Shire and Byron Shire are the areas supplied from the Lismore – Mullumbimby 66kV network.

4 LOAD GROWTH AND FUTURE MAXIMUM DEMAND

4.1 BYRON SHIRE

The Byron Shire, covering an area of 566 square kilometres, is located at Australia's eastern-most point, 180km south of Brisbane, 800km north of Sydney. There are a number of towns and villages in the shire, which has a population of 28 175 (Source: ABS, 2000), 30% living in rural areas.

Income is sourced largely from tourism and agriculture and an estimated 1.7 million tourists visit each year. Thriving home-based businesses focus on alternative, cultural and knowledge industries, with a growing population of artists, writers and filmmakers. The area is famed for its rural beauty and its beaches.

The Shire has an average population growth rate of 1.85% and by the year 2020 the population is expected to reach over 42,000[1].

4.2 LISMORE CITY COUNCIL AREA

Lismore is the regional centre of the Far North Coast of New South Wales and is a mixed urban and rural community covering an area of 1,267 square kilometres. Of the total population of 43,388 persons, some 28,000 reside in the town of Lismore itself with the remaining 15,000 people residing in the rural villages and environs. Lismore is located in the Far North Coast of New South Wales.
Excellent medical, professional and educational facilities and the main campus of the Southern Cross University attract residents and students from Australia and overseas. In addition, Lismore is a major centre for arts, sport and cultural activities.

The City Council has an average population growth rate of -0.3% and by the year 2020 the population is expected to be around 39,000[1].

4.3 BALLINA SHIRE

Ballina Shire is located on the New South Wales Far North Coast. The Shire is approximately 2.5 hours south of Brisbane, 9 hours north of Sydney or 1.5 hours fly time from Sydney. The shire is in a rural-coastal locality and enjoys a temperate to sub-tropical climate. It has an area of 487 square kilometres and an approximate population of 40,000 people. The Shire has a strong tourism and fishing industry, supported by a growing commercial centre with modern shopping complexes and a full range of community, sporting and social facilities. The Shire also produces Sugar, Macadamia nuts, Dairy, Beef, Avocado and Stone fruit.

Ballina, Lennox Head, Alstonville, Wollongbar and Wardell are the towns and villages in the Shire with an average population growth rate of 1.6% and by the year 2020 the population is expected to reach over 52,000[1].

[1] These population projections have been compiled by the Transport and Population Data Centre (TPDC), Department of Infrastructure, Planning and Natural Resources (DIPNR), on behalf of the NSW State Government. The projections have been compiled in consultation with the NSW Population Projections Group.

4.3.1 Growth areas in the Byron Shire

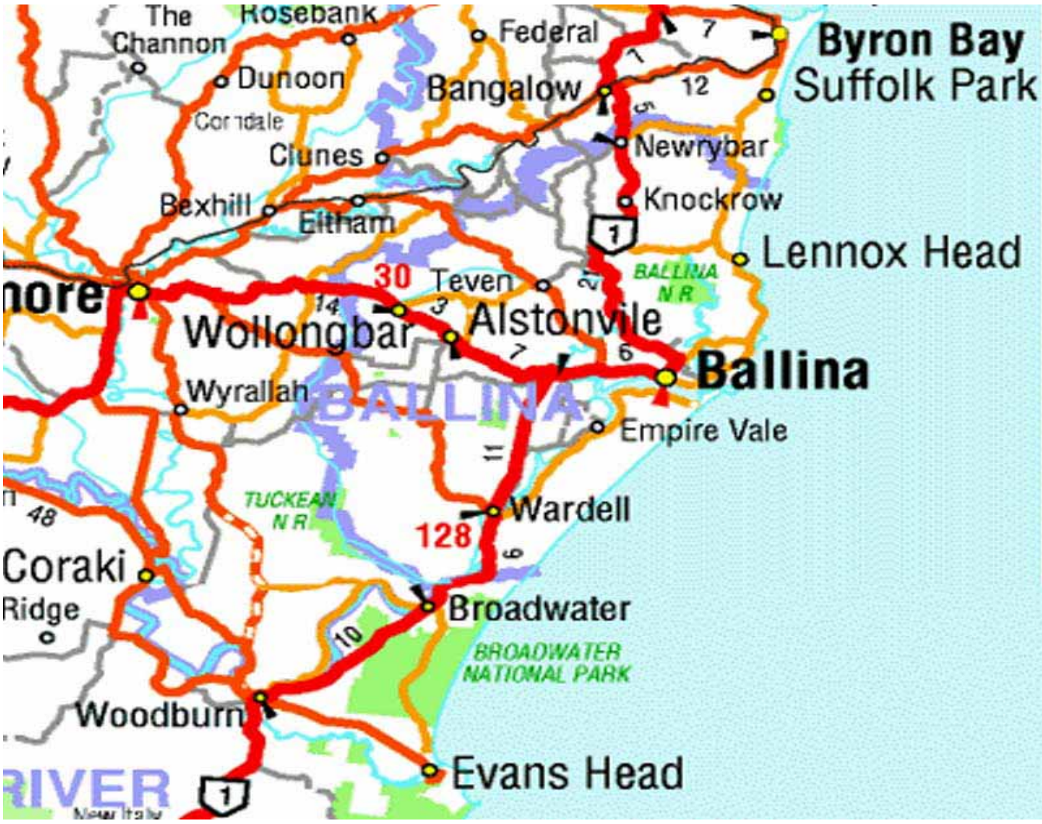
- Ocean Shores and Brunswick Heads – residential development
- Byron Bay – residential and commercial development
- Suffolk Park - residential development

The map below indicates the major roads and towns in the Byron Shire.

4.3.2 Growth areas in the Ballina Shire

- Lennox Head – residential development
- Ballina – residential and commercial development with a small growth in light industry

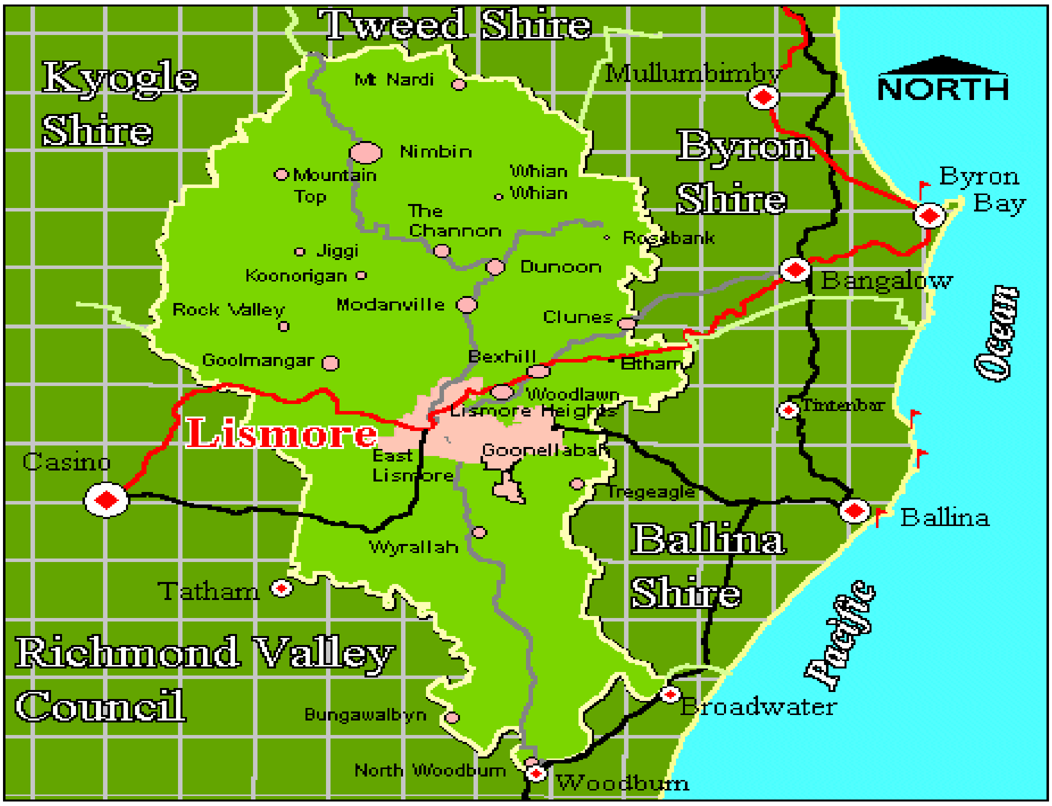
The map below indicates the major roads and towns in the Ballina Shire.



4.3.3 Growth areas in the Lismore City Council area

- Lismore city – Commercial, residential and light industrial growth
- Areas to the East of Lismore – residential and rural growth.

The map below indicates the major roads and towns in the Lismore City Council area and adjacent Shires.



4.3.4 Long term maximum demand

Based on the estimated future population and existing load growth rates at the existing zone substations, the long term maximum demand for Lismore Council, Byron Shire and Ballina Shire is expected to be between 195 and 221 MVA, depending on economic growth factors and population growth.

4.4 FUTURE MAXIMUM DEMAND

This load is broken down to the respective areas as follows:

High load growth scenario (load in MVA)

Area	2005	2010	2015	2020	2025
Byron Shire	34.4	39.70	45.7	50.6	60.5
Ballina Shire	43.4	51.80	60.1	67.6	72.8
Lismore Council	60.6	68.10	75.2	81.5	87.6
Total	138.5	159.60	181.0	199.7	220.9

Low load growth scenario (load in MVA)

Area	2005	2010	2015	2020	2025
Byron Shire	34.6	38.70	42.6	46.4	53.3
Ballina Shire	43.2	48.40	53.8	59.4	61.9
Lismore Council	58.5	63.90	69.0	74.4	79.8
Total	136.3	151.00	165.4	180.2	195.0

5 ZONE SUBSTATION MAXIMUM DEMANDS

The following tables indicate the summer and winter maximum demand for the zone substations supplying the Lismore Council area, Byron Shire and Ballina Shire.

SUBSTATION						HISTORY							FORECAST				
Summer Loads		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	MW	108.6	111.8	114.4	117.5	122.9	123.1	110.9	125.0	124.4	126.7	135.0	141.2	147.4	153.6	159.9	166.1
Lismore 132/66kV	MVAr	31.7	32.6	33.4	34.3	35.9	35.9	32.4	36.4	36.3	37.0	39.4	41.2	43.0	44.8	46.6	48.4
	MVA	**113**	**117**	**119**	**122**	**128**	**128**	**116**	**130**	**130**	**132**	**141**	**147**	**154**	**160**	**167**	**173**
	PF	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96	0.96
	MW								29.7	34.9	39.2	40.7	42.3	43.9	45.6	47.2	48.8
Mullumbimby	MVAr								9.8	11.5	12.9	13.4	13.9	14.4	15.0	15.5	16.0
132kV	**MVA**								**31.3**	**36.7**	**41.3**	**42.8**	**44.5**	**46.3**	**48.0**	**49.7**	**51.4**
	PF								0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	8.1	8.4	9.5	7.8	8.8	9.1	9.2	8.0	8.6	9.1	9.6	10.1	10.6	11.2	11.7	12.2
Alstonville	MVAr	2.7	2.8	3.1	2.6	2.9	3.0	3.0	2.6	2.8	3.0	3.2	3.3	3.5	3.7	3.8	4.0
	MVA	**8.5**	**8.8**	**10.0**	**8.2**	**9.3**	**9.6**	**9.7**	**8.4**	**9.0**	**9.6**	**10.1**	**10.7**	**11.2**	**11.7**	**12.3**	**12.8**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	18.1	19.0	18.5	21.1	20.5	21.3	21.6	25.7	25.8	31.0	31.7	29.8	31.3	32.9	34.5	36.1
Ballina	MVAr	5.9	6.2	6.1	6.9	6.7	7.0	7.1	8.4	8.5	10.2	10.4	9.8	10.3	10.8	11.4	11.9
	MVA	**19.0**	**20.0**	**19.5**	**22.2**	**21.6**	**22.4**	**22.7**	**27.0**	**27.2**	**32.6**	**33.3**	**31.3**	**33.0**	**34.7**	**36.4**	**38.0**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	19.0	19.5	20.0	21.7	22.2	22.2	18.1	20.6	20.1	25.1	25.3	26.6	27.9	29.2	30.5	31.8
Ewingsdale	MVAr	6.2	6.4	6.6	7.1	7.3	7.3	5.9	6.8	6.6	8.2	8.3	8.7	9.2	9.6	10.0	10.4
	MVA	**20.0**	**20.5**	**21.0**	**22.8**	**23.4**	**23.4**	**19.0**	**21.7**	**21.1**	**26.4**	**26.6**	**28.0**	**29.4**	**30.7**	**32.1**	**33.4**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	15.0	14.4	14.4	17.6	14.0	15.5	16.0	16.0	17.9	18.8	19.5	20.4	21.3	22.2	23.1	24.0
Lismore East	MVAr	4.9	4.7	4.7	5.8	4.6	5.1	5.3	5.2	5.9	6.2	6.4	6.7	7.0	7.3	7.6	7.9
	MVA	**15.8**	**15.2**	**15.2**	**18.5**	**14.7**	**16.3**	**16.8**	**16.8**	**18.8**	**19.8**	**20.5**	**21.5**	**22.4**	**23.4**	**24.3**	**25.3**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	25.7	26.2	26.4	26.2	26.2	27.6	27.8	29.5	33.3	30.7	33.3	34.5	35.6	36.8	38.0	39.1
Lismore South	MVAr	8.4	8.6	8.7	8.6	8.6	9.1	9.1	9.7	10.9	10.1	10.9	11.3	11.7	12.1	12.5	12.9
	MVA	**27.0**	**27.6**	**27.8**	**27.6**	**27.6**	**29.1**	**29.3**	**31.1**	**35.0**	**32.3**	**35.0**	**36.3**	**37.5**	**38.7**	**40.0**	**41.2**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW								5.3	7.0	7.1	7.3	7.4	7.6	7.7	7.9	8.0
Mullumbimby	MVAr								1.7	2.3	2.3	2.4	2.4	2.5	2.5	2.6	2.6
11kV	**MVA**								**5.6**	**7.3**	**7.4**	**7.7**	**7.8**	**8.0**	**8.1**	**8.3**	**8.4**
	PF								0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	4.6	3.8	4.0	4.5	4.4	3.9	4.7	4.4	4.1	5.1	4.8	4.9	5.0	5.1	5.2	5.3
Dunoon	MVAr	1.5	1.2	1.3	1.5	1.4	1.3	1.5	1.4	1.3	1.7	1.6	1.6	1.6	1.7	1.7	1.7
	MVA	**4.8**	**4.0**	**4.2**	**4.7**	**4.6**	**4.1**	**4.9**	**4.6**	**4.3**	**5.4**	**5.0**	**5.1**	**5.2**	**5.3**	**5.4**	**5.5**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

Byron Shire is currently supplied from **Mullumbimby** and **Ewingsdale** zone substations.

Ballina Shire is currently supplied from **Ballina** and **Alstonville** zone substations.

Lismore City Council is currently supplied from **Lismore South, Lismore East** and **Dunoon** zone substations.

Lismore 132/66kV and Mullumbimby 132/66kV demand forecast is included to indicate predicted loads at these supply points.

SUBSTATION						HISTORY							FORECAST				
Winter Loads		1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
	MW	124.4	126.8	125.7	127.7	127.2	98.4	99.4	119.2	116.4	117.0	126.5	132.0	137.6	143.1	148.6	154.2
Lismore 132/66kV	MVAr	31.2	31.8	31.5	32.0	31.9	24.6	24.9	29.9	29.2	29.3	31.7	33.1	34.5	35.9	37.2	38.6
	MVA	**128**	**131**	**130**	**132**	**131**	**101**	**102**	**123**	**120**	**121**	**130**	**136**	**142**	**148**	**153**	**159**
	PF	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97	0.97
	MW								38.5	38.7	49.0	48.9	50.6	52.3	54.1	55.8	57.5
Mullumbimby	MVAr								12.7	12.7	16.1	16.1	16.6	17.2	17.8	18.3	18.9
132kV	**MVA**								**40.6**	**40.7**	**51.6**	**51.5**	**53.3**	**55.1**	**56.9**	**58.7**	**60.6**
	PF								0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	10.0	9.9	11.0	10.5	9.7	10.3	10.3	9.3	11.6	11.6	12.1	12.7	13.2	13.7	14.3	14.8
Alstonville	MVAr	3.3	3.3	3.6	3.5	3.2	3.4	3.4	3.1	3.8	3.8	4.0	4.2	4.3	4.5	4.7	4.9
	MVA	**10.5**	**10.4**	**11.6**	**11.1**	**10.2**	**10.8**	**10.8**	**9.8**	**12.2**	**12.2**	**12.8**	**13.3**	**13.9**	**14.5**	**15.0**	**15.6**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	20.4	21.4	23.8	24.2	23.8	22.8	26.9	27.4	26.7	32.4	32.2	29.0	30.4	31.8	33.2	34.6
Ballina	MVAr	6.7	7.0	7.8	8.0	7.8	7.5	8.8	9.0	8.8	10.6	10.6	9.5	10.0	10.4	10.9	11.4
	MVA	**21.5**	**22.5**	**25.0**	**25.5**	**25.0**	**24.0**	**28.3**	**28.8**	**28.1**	**34.1**	**33.9**	**30.5**	**32.0**	**33.5**	**34.9**	**36.4**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	22.8	23.8	24.7	24.8	25.4	26.5	20.7	23.8	25.0	27.2	28.7	30.1	31.5	32.9	34.3	35.8
Ewingsdale	MVAr	7.5	7.8	8.1	8.1	8.3	8.7	6.8	7.8	8.2	8.9	9.4	9.9	10.4	10.8	11.3	11.8
	MVA	**24.0**	**25.0**	**26.0**	**26.1**	**26.7**	**27.9**	**21.8**	**25.1**	**26.3**	**28.7**	**30.2**	**31.7**	**33.2**	**34.7**	**36.2**	**37.6**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	18.2	16.8	18.8	17.0	18.6	17.1	17.1	17.8	19.3	20.2	20.8	21.7	22.5	23.3	24.2	25.0
Lismore East	MVAr	6.0	5.5	6.2	5.6	6.1	5.6	5.6	5.8	6.3	6.6	6.8	7.1	7.4	7.7	7.9	8.2
	MVA	**19.2**	**17.7**	**19.8**	**17.9**	**19.6**	**18.0**	**18.0**	**18.7**	**20.3**	**21.3**	**21.9**	**22.8**	**23.7**	**24.6**	**25.4**	**26.3**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	22.8	22.2	21.4	21.9	22.3	22.8	22.8	25.3	29.3	28.0	29.6	30.5	31.3	32.2	33.1	34.0
Lismore South	MVAr	7.5	7.3	7.0	7.2	7.3	7.5	7.5	8.3	9.6	9.2	9.7	10.0	10.3	10.6	10.9	11.2
	MVA	**24.0**	**23.4**	**22.5**	**23.1**	**23.5**	**24.0**	**24.0**	**26.6**	**30.9**	**29.5**	**31.1**	**32.1**	**33.0**	**33.9**	**34.8**	**35.8**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW								6.2	7.1	7.3	7.6	7.8	8.0	8.2	8.5	8.7
Mullumbimby	MVAr								2.0	2.3	2.4	2.5	2.6	2.6	2.7	2.8	2.9
11kV	**MVA**								**6.6**	**7.5**	**7.7**	**8.0**	**8.2**	**8.4**	**8.7**	**8.9**	**9.1**
	PF								0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
	MW	4.9	4.8	5.4	4.8	5.4	5.4	5.4	4.9	5.5	6.4	5.9	6.0	6.1	6.2	6.3	6.4
Dunoon	MVAr	1.6	1.6	1.8	1.6	1.8	1.8	1.8	1.6	1.8	2.1	1.9	2.0	2.0	2.0	2.1	2.1
	MVA	**5.2**	**5.1**	**5.7**	**5.1**	**5.7**	**5.7**	**5.7**	**5.2**	**5.8**	**6.7**	**6.2**	**6.3**	**6.4**	**6.5**	**6.6**	**6.7**
	PF	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95

Byron Shire is currently supplied from **Mullumbimby** and **Ewingsdale** zone substations.

Ballina Shire is currently supplied from **Ballina** and **Alstonville** zone substations.

Lismore City Council is currently supplied from **Lismore South, Lismore East** and **Dunoon** zone substations.

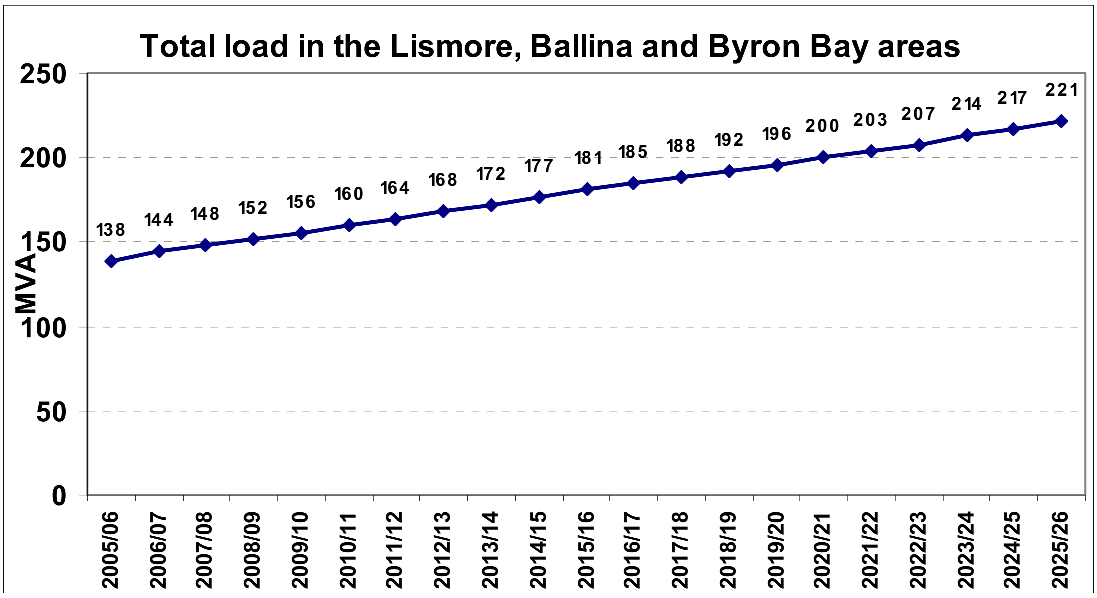
Lismore 132/66kV and Mullumbimby 132/66kV demand forecast is included to indicate predicted loads at these supply points.

6 ZONE SUBSTATION FUTURE MAXIMUM DEMANDS

Year	ALSTONVILLE	MULLUMBIMBY	EWINGSDALE	LENNOX HEAD	SUFFOLK PARK	BRUNSWICK HEADS	BALLINA	LISMORE SOUTH	LISMORE EAST	LISMORE UNI	DUNOON
2005/06	10.1	7.7	26.7	0.0	0.0	0.0	33.3	35.0	20.6	0.0	5.0
2006/07	10.7	7.8	28.2	8.0	0.0	0.0	26.4	36.3	21.7	0.0	5.1
2007/08	11.2	8.0	28.9	8.3	0.0	0.0	27.2	33.0	20.0	6.0	5.2
2008/09	11.7	8.1	21.2	8.6	8.5	0.0	28.1	30.6	20.5	9.0	5.3
2009/10	12.3	8.3	21.6	12.9	8.8	0.0	25.0	31.2	21.0	9.2	5.4
2010/11	12.7	8.5	22.1	13.3	9.1	0.0	25.8	31.8	21.4	9.5	5.5
2011/12	13.1	5.7	18.6	13.8	9.4	7.0	26.6	28.1	21.8	14.2	5.6
2012/13	13.5	5.8	19.0	17.3	9.7	7.3	24.4	28.6	22.3	14.6	5.7
2013/14	13.9	5.9	19.3	17.9	10.1	7.7	25.0	29.1	19.7	17.9	5.8
2014/15	14.3	6.0	19.7	18.5	10.6	8.1	25.7	29.5	20.0	18.6	5.8
2015/16	14.6	6.1	20.0	19.2	11.0	8.5	26.3	30.0	20.4	19.0	5.9
2016/17	15.0	2.2	20.4	19.9	11.3	12.7	26.9	25.9	20.6	23.9	6.0
2017/18	15.4	2.3	20.7	20.4	11.6	13.0	27.5	26.3	20.9	24.4	6.1
2018/19	15.8	2.3	21.1	24.9	11.9	13.4	24.1	26.7	21.1	25.0	6.2
2019/20	16.1	2.4	21.4	25.5	12.2	13.7	24.6	27.1	21.4	25.5	6.3
2020/21	16.4	2.4	21.7	26.1	12.5	14.0	25.1	27.5	21.6	26.0	6.4
2021/22	16.7	2.4	22.1	26.8	12.7	14.4	25.6	27.9	21.9	26.5	6.5
2022/23	17.0	2.5	22.4	27.5	13.0	14.7	26.0	28.3	22.2	27.1	6.6
2023/24	18.3	2.5	24.7	28.1	13.2	15.0	26.5	28.7	22.4	27.6	6.7
2024/25	18.6	2.6	25.1	25.8	16.5	15.3	27.0	29.0	22.7	28.0	6.8
2025/26	18.9	7.2	20.3	26.5	22.3	11.1	27.4	29.4	23.0	28.4	6.9

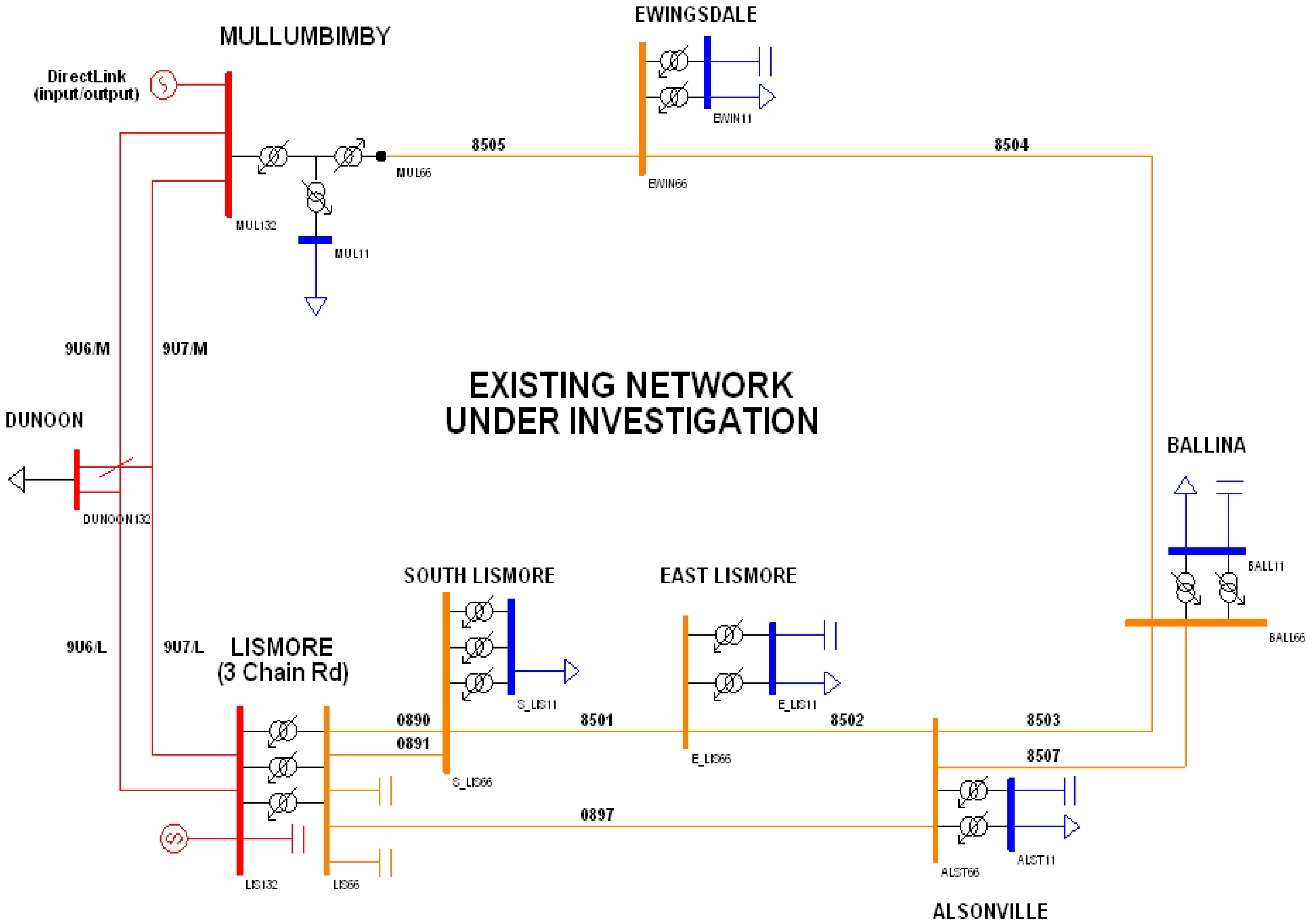
The summer MVA values in the table above are indicative, based on the best available data at the time, and have been used for load flow analysis of the options.
Load transfers between zone substations assume adequate 11kV network capacity and where the 11kV network is deficient, additional 11kV ties lines will be required.

The graph below indicates the long term load forecast trend.



7 EXISTING NETWORK DETAILS

The existing network supplying Lismore Council area, Ballina Shire and Byron Shire is indicated below. The yellow lines indicate 66kV circuits and the brown/red lines indicate 132kV circuits, blue indicates 11kV. Circuit numbers are included, as practicable, and are used to refer to a specific circuit. Line data, conductor type and design details are included in the Appendix.



7.1 LINE DATA

Line section	Summer Rating (MVA)	CURRENT	Winter Rating (MVA)	CURRENT	Comments
9U6/M & 9U7/M	107	469	141	616	NEON 19/3.75 AAAC @75°C
9U6/L & 9U7/L	107	469	141	616	NEON 19/3.75 AAAC @75°C
0890	21	187	53	462	PLUTO 19/3.75 AAC @50°C
0891	21	187	53	462	PLUTO 19/3.75 AAC @50°C
0897	39	341	48	416	DOG 6/.186+7/.062 SCA @85°C
8501	39	341	48	416	DOG 6/.186+7/.062 SCA @85°C
8502	21	187	53	462	PLUTO 19/3.75 AAC @50°C
8503	12	105	24	208	MINK 6/1/.144 SCA @50°C
8504	21	187	53	462	PLUTO 19/3.75 AAC @50°C
8505	62	546	77	675	PLUTO 19/3.75 AAC @85°C
8507	62	538	76	666	NEON 19/3.75 AAAC @85°C
Rating conditions					
Ambient	35 Degrees C		25 Degrees C		
Wind	0.5 m/s		0.5 m/s		

7.2 LINE ISSUES

The existing 66kV lines are required to maintain supply and the following table indicates issues associated with existing lines that will affect the network development.

66kV line section	Issue	Action
#0890 & #0891	Lines are critical for secure supply to South Lismore but have a very low rating based on existing conductor, design data and worst case weather conditions	Line must be retained. Survey line to determine thermal rating and undertake remedial work based on survey results
#0897	Line is required for secure supply to the larger 66kV ring but has some low rated sections where 1st contingency loads will exceed section rating	Line must be retained. Survey line to determine thermal rating and undertake remedial work based on survey results
#8501	Line is essential for firm supply (N-1) to East Lismore zone substation but has low rated sections where 1st contingency loads will exceed section capacity	Line must be retained. Survey line in 1 – 2 years to determine thermal rating and undertake remedial work based on survey results
#8502	Line is essential for firm supply (N-1) to East Lismore zone substation but has low rated sections where 1st contingency loads will exceed section capacity	Line must be retained. Survey line in 1 – 2 years to determine thermal rating and undertake remedial work based on survey results
#8503	Line is required for secure supply to the larger 66kV ring but has low rated sections where 1st contingency load will exceed section capacity	Line must be retained. Survey line to determine thermal rating and undertake remedial work based on survey results
#8504	Line is required for secure supply to the larger 66kV ring but has low rated sections where 1st contingency loads will exceed section capacity	Line must be retained. Survey line to determine thermal rating and undertake remedial work based on survey results
#8505	Line is essential for the firm supply to Ewingsdale zone substation.	Line must be retained.
#8507	Line is required for secure supply to the larger 66kV ring.	Line must be retained.

7.3 ZONE SUBSTATION TRANSFORMER DATA

SUBSTATION	TX.1	TRANSFORMER DESCRIPTION (MVA) TX.2	TX.3	Dynamic Tx Summer Rating %	MVA	Dynamic Tx Winter Rating %	MVA
Lismore 132/66kV	35/45/60	35/45/60	35/45/60	110%	132	120%	144
Mullumbimby 132/66kV[2]	60[3]			110%	66	120%	72
Alstonville	20	20		110%	22	120%	24
Ballina	15/19/23	15/19/23		110%	25.3	120%	27.6
Ewingsdale	15/19/23	15/19/23		110%	25.3	120%	27.6
Lismore East	17/22/24.5	15/20/25		110%	26.95	120%	29.4
Lismore South	17/22/24.5	17/19/23	20/25	110%	52.25	120%	57
Mullumbimby[1]	15			110%	16.5	120%	18
Dunoon	10	10		110%	11	120%	12

8 LOAD FLOW RESULTS

A network model was used to analyses the existing network with summer 2005 and winter 2005 maximum demand loads.

Results for summer 2005 loads:

Line section	Summer Rating (MVA)	Normal load (MVA)	0890	0891	0897	8501	8502	8503	8504	8505	8507
0890	21	**35**	0	**67**	**44**	18	**28**	**35**	**36**	**44**	**33**
0891	21	**35**	**67**	0	**44**	18	**28**	**35**	**36**	**44**	**33**
0897	39	26	27	27	0	**52**	36	25	30	**46**	24
8501	39	33	31	31	**53**	0	20	32	36	**53**	31
8502	21	13	11	11	**31**	20	0	12	16	**31**	11
8503	12	9	9	9	7	6	8	0	11	**21**	**24**
8504	21	7	7	7	13	16	10	7	0	**27**	12
8505	62	32	33	33	40	43	36	34	27	0	38
8507	63	20	20	20	15	13	18	27	24	45	0
Rating conditions											
Ambient	35 Degrees C										
Wind	0.5 m/s										

[2] Mullumbimby 132/66/11.4 is a single three winding transformer and is considered non-firm from a security of supply point of view.
[3] Rating of 66kV winding associated with 66kV load.

Loads in bold with grey shading indicate the contingent load in the line section and compared to the rating, gives an indication of the overload.

Results for winter 2005 loads:

Line section	Winter Rating (MVA)	Normal load (MVA)	0890	0891	0897	8501	8502	8503	8504	8505	8507
0890	53	34	0	**67**	45	15	27	34	36	45	32
0891	53	34	**67**	0	45	15	27	34	36	45	32
0897	48	28	29	29	0	**57**	40	28	31	**52**	26
8501	48	36	35	35	**57**	0	22	36	40	**58**	34
8502	53	14	13	13	34	21	0	14	17	35	12
8503	24	10	10	10	7	6	8	0	11	22	24
8504	53	6	6	6	14	16	9	7	0	31	12
8505	77	37	37	37	45	47	40	38	31	0	43
8507	76	20	20	20	15	13	18	29	25	49	0
Rating conditions											
Ambient	25 Degrees C										
Wind	0.5 m/s										

Loads in bold with grey shading indicate the contingent load in the line section and compared to the rating, gives an indication of the overload.

Zone Substation Transformer loading

SUBSTATION	Summer Firm Rating (MVA)	2005	2006	2007	2008	2009	2010
Lismore 132/66kV	132	**141**	**147**	**154**	**160**	**167**	**173**
Mullumbimby 132/66kV	66	43	45	46	48	50	51
Alstonville	22	10	11	11	12	12	13
Ballina	25.3	**33**	**31**	**33**	**35**	**36**	**38**
Ewingsdale	25.3	**27**	**28**	**29**	**31**	**32**	**33**
Lismore East	26.95	21	21	22	23	24	25
Lismore South	52.25	35	36	37	39	40	41
Mullumbimby	16.5	8	8	8	8	8	8
Dunoon	11	5	5	5	5	5	6
	Winter Firm Rating (MVA)						
Lismore 132/66kV	144	130	136	142	**148**	**153**	**159**
Mullumbimby 132/66kV	72	51	53	55	57	59	61
Alstonville	24	13	13	14	14	15	16
Ballina	27.6	**34**	**31**	**32**	**33**	**35**	**36**
Ewingsdale	27.6	**30**	**32**	**33**	**35**	**36**	**38**
Lismore East	29.4	22	23	24	25	25	26
Lismore South	57	31	32	33	34	35	36
Mullumbimby	18	8	8	8	9	9	9
Dunoon	12	6	6	6	7	7	7

Values in bold with grey shading indicate transformer firm capacity exceeded.

9 NETWORK CONSTRAINTS

Most significant constraints are:

- Load on feeder #0890 & #0891 currently exceeds ratings summer worst condition ratings
- Load on feeder #0897 exceeds some section ratings for an outage of #8501 or #8505
- Load on feeder #8501 exceeds some section ratings for an outage of #0897 or #8505
- Load on feeder #8502 exceeds some sections ratings for an outage of #0897 or #8505
- Load on feeder #8503 exceeds some section ratings for an outage of #8507 or #8505
- Load on feeder #8504 exceeds some section ratings for an outage #8505
- Ballina summer and winter load exceeds transformer firm capacity.
- Ewingsdale summer and winter load exceeds transformer firm capacity.
- Mullumbimby 132/66/11.4kV is a single transformer and an outage will have a significant impact on the network. This impact is the same as for 66kV line 8505 outage detailed above.
- 11kV voltage below Planning Reliability standards at Ewingsdale zone substation for an outage of #8505.

10 OPTION INVESTIGATED

Three main options that will eliminate the identified network constraints have been developed. All three options, to a greater or lesser extent, will cater for long term maximum demands as predicted in section 4 and provide the required network security as per current Planning Criteria.

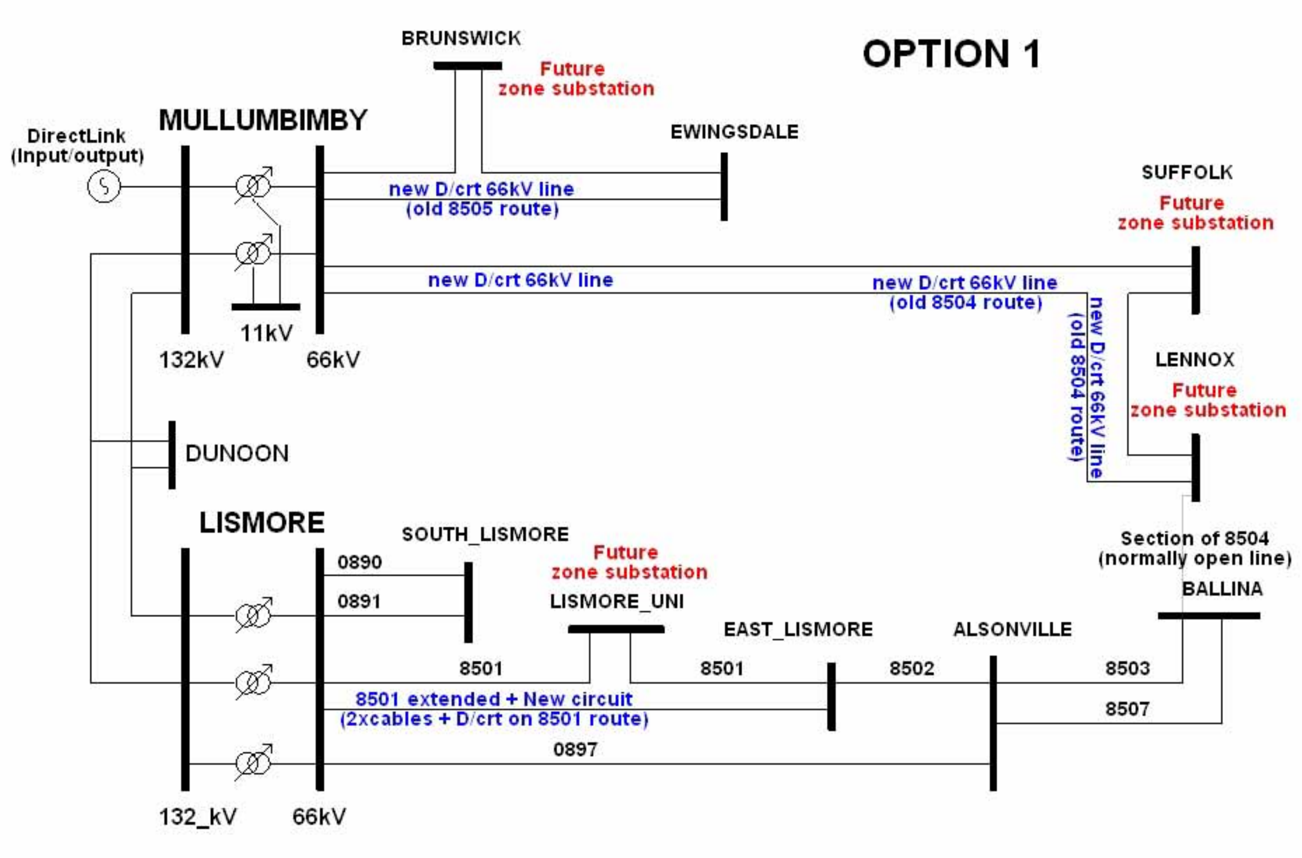
Option 1 – augment the existing 66kV network.
Option 2 – establish a new 132kV network ring supplied from Mullumbimby only.
Option 3 – establish a new 132kV network ring supplied from Mullumbimby and Lismore.

10.1 OPTION 1 – 66KV NETWORK AUGMENTATION

This option focuses on providing an adequate 66kV network to meet long term load predictions. The option requires significant additional 66kV feeder capacity, additional 132/66kV transformer capacity at Mullumbimby and additional 66/11kV zone substations to achieve this objective.

The intention of this option is to establish discreet 66kV rings, two 66kV rings supplied from Mullumbimby 66kV bus and two 66kV rings supplied from Lismore 66kV bus. The larger Lismore 66kV ring requires additional 66kV circuits to supply the future Lismore Uni zone substation and ensure security of supply to all 66kV zone substations supplied from this ring under N-1 contingencies.

The diagram below indicates the proposed network configuration for Option 1.



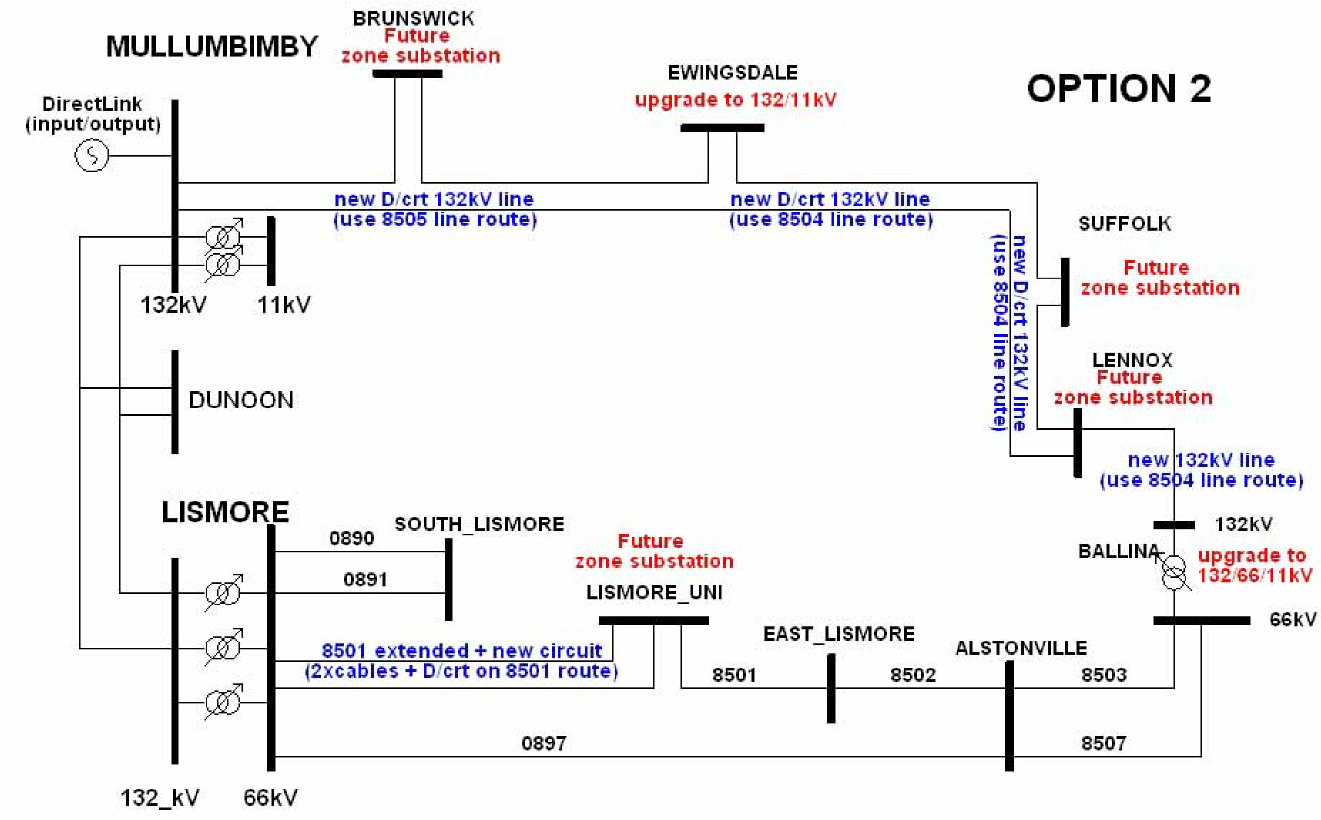
10.2 OPTION 2 – NEW 132KV DOUBLE CIRCUIT RING

This option focuses on providing an adequate 132kV network which replaces the existing 66kV network from Mullumbimby to Ballina zone substation. This will be a new 132kV ring network supplied from Mullumbimby 132kV busbar and will be adequate to meet long term load predictions. The option requires a new double circuit 132kV line from Mullumbimby to new Lennox Head zone substation, upgrading of Ewingsdale zone substation from 66/11kV to 132/11kV and additional 132/11kV zone substations.

The Lismore 66kV network requires additional 66kV circuits to supply the future Lismore Uni zone substation and ensure security of supply to all 66kV zone substations supplied from this ring under N-1 contingencies.

The intention of this option is to establish a 132kV ring supplied form Mullumbimby 132kV bus with a 132/66kV transformation point at Ballina that will reduce the loads on the Lismore 66kV meshed network and support the 66kV voltages in this ring under contingencies.

The diagram below indicates the proposed network configuration for Option 2.



10.3 OPTION 3 – NEW 132KV NETWORK SINGLE CIRCUIT RING

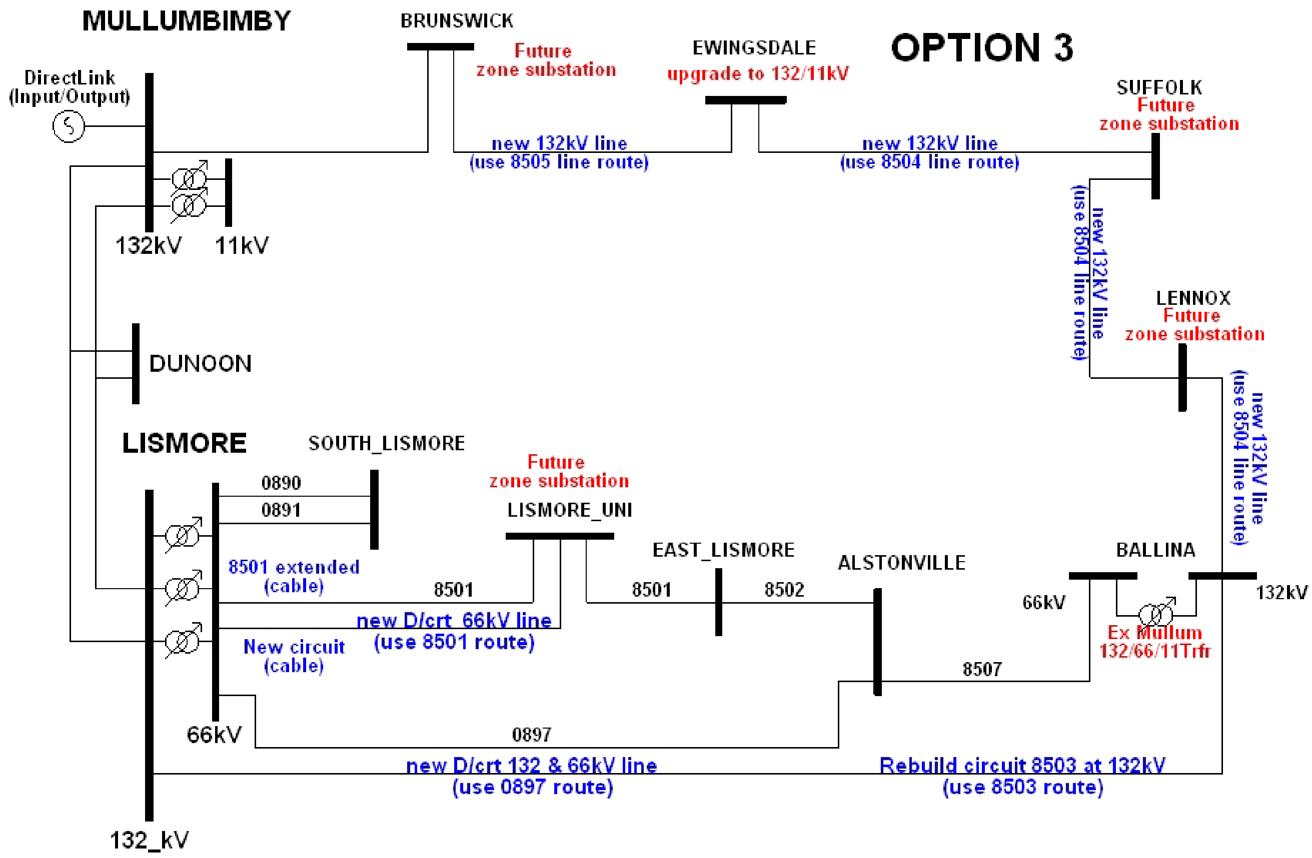
This option focuses on providing an adequate 132kV network which replaces the entire existing 66kV network north of Ballina and will be supplied from Mullumbimby 132kV bus in the north and Lismore 132kV bus in the south. This 132kV ring will be adequate to meet long term load predictions.

The option requires a new single circuit 132kV line from Mullumbimby to Ballina zone substation, upgrading of Ewingsdale zone substation from 66/11kV to 132/11kV and additional 132/11kV zone substations.

The Lismore 66kV network requires additional 66kV circuits to supply the future Lismore Uni zone substation and ensure security of supply to all 66kV zone substations supplied from this ring under N-1 contingencies.

The intention of this option is to provide a 132kV ring between Lismore and Mullumbimby with a 132/66kV transformation point at Ballina. This configuration significantly de-loads the Lismore 66kV network and improves security of supply to the overall network. It is proposed to build a new 132kV line from Lismore BSP to Alstonville and rebuild circuit 8503 (Alstonville – Ballina 66kV line) to create the new 132kV line.

The diagram below indicates the proposed network configuration for Option 3.



11 COST ESTIMATES

The cost estimates for the options are based on unit cost estimates and desktop analysis. Each option requires different timing of expenditure and therefore for comparison purposes, the Present Value of each option is calculated.
Present value calculations and per unit cost estimates are attached in the appendix.

Option 1
PV = $43.2 million

Option 2
PV = $42.4 million

Option 3
PV = $44.6 million

12 CONCLUSION

The options considered are high level network solutions that will address the existing constraints and network risks, but are fundamentally different.

- Option 1 is a 66kV network augmentation solution.
- Option 2 and 3 are new 132kV network solutions.

Each option will have distinct advantages and disadvantages, different prejudices, degrees of difficulty, varying costs and degrees of public resistance. The purpose of this planning report is to recommend the option that has the highest chance of success, will meet the long term load forecast with appropriate reliability standards and will be the most beneficial to Country Energy and the public.

Option 1 will require multiple 66kV feeders originating from Mullumbimby 66kV busbar and significant infrastructure changes and additions at Mullumbimby zone substation. Mullumbimby is a space constrained site with associated environmental and visual issues and any works undertaken at Mullumbimby can be expected to cost more than standard network augmentation. (Detailed cost estimates based on actual design for network augmentation have not been undertaken)

Additionally, obtaining approval to extend Mullumbimby is considered high risk due to possible environmental and visual impacts.

Option 1 is the second most expensive option based on preliminary cost estimates, and carries a high risk of public rejection due to the environmental and visual impact of multiple 66kV lines and the space constraints at Mullumbimby. Due to these issues, Option 1 is not a preferred option.

Option 2 will require significant 132kV double circuit lines and associated easements and additional 132kV feeder bays at the space constrained Mullumbimby zone substation. These space requirements are not as severe as in Option 1, but still need to be considered. The greatest risk with this option is acquiring 132kV double circuit easements because the easement compensation and easement availability are unknown and will have a significant impact on Option 2 cost and timing. It is expected that a full Environmental Impact Study (EIS) will be required for the 132kV lines and this will affect the project timing.

Based on preliminary cost estimates, Option 2 is the least expensive option but due to the risks associated with obtaining easements for a double circuit 132kV line, this is not a preferred option, but a reasonable second best option.

Option 3 will require a single circuit 132kV line and one additional 132kV feeder bay at the space constrained Mullumbimby zone substation. The impact of this single 132kV line bay at Mullumbimby is considered low. As in Option 2, the greatest risk with this option is acquiring 132kV easements, but this risk is considered to be marginally less than option 2 because the 132kV easements will be for a single circuit line and on the existing 66kV line routes. This option also requires a 132kV feeder bay at Lismore BSP (3Chain Road) and a 132kV line from Lismore to Ballina zone substation.

Option 3 is the most expensive option but delivers an excellent long term solution with a lower risk of public rejection.

Option 3 is the preferred option.

13 RECOMMENDATION

THAT Option 3 (new 132kV network ring) is approved as the preferred option for the long term network solution for the Lismore – Mullumbimby subtransmission network development.

APPENDIX

Line data

132kV Line sections	Line identifier	Conductor Length Total km	Conductor Length Section km	Conductor Type	Conductor Code	Design Temp. deg C.	Summer rating 35 C 0.5 m/s	Summer rating 35 C 1 m/s	Winter rating 25 C 0.5 m/s	Winter rating 25 C 1 m/s
Lismore 132kV to Dunoon T_1	**9U6/L**		16.9	19/3.75aaac	NEON	75	469	561	616	705
Dunoon T_1 to Mullumbimby	**9U6/M**	**34.37**	17.47	19/3.75aaac	NEON	75	469	561	616	705
Lismore 132kV to Dunoon T_2	**9U7/L**		16.9	19/3.75aaac	NEON	75	469	561	616	705
Dunoon T_2 to Mullumbimby	**9U7/M**	**34.37**	17.47	19/3.75aaac	NEON	75	469	561	616	705
66kV Line sections										
Lismore to South Lismore #1	**0890**	**2.25**	2.25	19/3.75aac	PLUTO	50	187	273	462	529
Lismore to South Lismore #2	**0891**	**2.23**	2.23	19/3.75aac	PLUTO	50	187	273	462	529
Lismore to Alstonville	**0897**		0.684	19/3.75aac	PLUTO	85	546	644	675	773
			2.071	30/7/3.00sca	LEMON	85	562	664	700	800
			9.851	6/.186 + 7/.062sca	DOG	85	341	403	416	478
			7.279	30/7/3.00sca	LEMON	85	562	664	700	800
			0.223	19/3.75aac	PLUTO	85	546	644	675	773
			0.984	30/7/3.00sca	LEMON	85	562	664	700	800
		22.30	1.21	30/7/3.00sca	LEMON	85	562	664	700	800
South Lismore to East Lismore	**8501**		7.712	30/7/.3.00acsr/gz	LEMON	85	562	664	700	800
		11.35	3.637	6/.186-7/.062acsr	DOG	85	341	403	416	478
Lismore East to Alstonville	**8502**		0.871	19/3.75aac	PLUTO	85	546	644	675	773
			0.725	19/3.75aac	PLUTO	50	187	273	462	529
			9.637	30/7/3.00acs/gz	LEMON	85	562	664	700	800
			0.082	19/3.75aac	PLUTO	50	187	273	462	529
			1.154	30/7/3.00acs/gz	LEMON	85	562	664	700	800
			0.048	19/3.75aac	PLUTO	50	187	273	462	529
		13.77	1.252	30/7/3.00acs/gz	LEMON	85	562	664	700	800
Alstonville to Ballina #1	**8503**		13.635	6/1/.144sca	MINK	50	105	140	208	240
		17.97	4.333	19/3.75aac	PLUTO	85	546	644	675	773
Alstonville to Ballina #2	**8507**	**14.54**	14.54	19/3.75aaac	NEON	85	538	635	666	762
Ballina to Ewingsdale	**8504**		4.485	19/3.75aac	PLUTO	85	546	644	675	773
			0.091	19/3.75aac	PLUTO	50	187	273	462	529
			1.159	19/3.75aac	PLUTO	85	546	644	675	773
			0.2	19/3.75aac	PLUTO	50	187	273	462	529
			4.35	30/7/3.00acs/gz	LEMON	85	562	664	700	800
			0.621	19/3.75aac	PLUTO	50	187	273	462	529
			0.767	30/7/3.00acs/gz	LEMON	85	562	664	700	800
			0.064	19/3.75aac	PLUTO	50	187	273	462	529
			7.197	19/3.75aac	PLUTO	85	546	644	675	773
			0.033	19/3.75aac	PLUTO	50	187	273	462	529
			7.11	19/3.75aac	PLUTO	85	546	644	675	773
			0.172	19/3.75aac	PLUTO	50	187	273	462	529
		33.69	7.443	19/3.75aac	PLUTO	85	546	644	675	773
Ewingsdale to Mullumbimby	**8505**		3.465	19/3.75aac	PLUTO	85	546	644	675	773
			9.91	30/7/3.00acsr/gz	LEMON	85	562	664	700	800
		13.42	0.049	19/3.75aac	PLUTO	85	546	644	675	773

OPTION 1 – 66kV network augmentation.

COST BENEFIT ANALYSIS - Country Energy
PROJECT : **Option 1: Multiple 66kV rings**
PROJECT LENGTH: **20 Years**
YEAR START **2006**
PRESENT VALUE **$ 43,262,255.10**
Maintenance cost 1.00%

Year	Cash Flow			Discounted Cash Flow		
	Capital	Annual Cost	Total	7.80%	9.80%	11.80%
Initial expenditure	($1,000,000)		($1,000,000)	($1,000,000)	($1,000,000)	($1,000,000)
Expenditure -Yr 1	($12,465,000)	($10,000)	($12,475,000)	($11,572,356)	($11,361,566)	($11,158,318)
Expenditure -Yr 2	($12,650,000)	($134,650)	($12,784,650)	($11,001,485)	($10,604,353)	($10,228,342)
Expenditure -Yr 3	($9,120,000)	($261,150)	($9,381,150)	($7,488,586)	($7,086,782)	($6,713,217)
Expenditure -Yr 4	($2,740,000)	($352,350)	($3,092,350)	($2,289,885)	($2,127,548)	($1,979,345)
Expenditure -Yr 5	($4,180,000)	($379,750)	($4,559,750)	($3,132,184)	($2,857,126)	($2,610,550)
Expenditure -Yr 6	($5,600,000)	($421,550)	($6,021,550)	($3,837,035)	($3,436,325)	($3,083,596)
Expenditure -Yr 7	($800,000)	($477,550)	($1,277,550)	($755,173)	($663,990)	($585,174)
Expenditure -Yr 8	$0	($485,550)	($485,550)	($266,246)	($229,835)	($198,930)
Expenditure -Yr 9	$0	($485,550)	($485,550)	($246,982)	($209,321)	($177,934)
Expenditure -Yr 10	$0	($485,550)	($485,550)	($229,111)	($190,638)	($159,153)
Expenditure -Yr 11	$0	($485,550)	($485,550)	($212,534)	($173,623)	($142,355)
Expenditure -Yr 12	$0	($485,550)	($485,550)	($197,155)	($158,127)	($127,330)
Expenditure -Yr 13	$0	($485,550)	($485,550)	($182,890)	($144,014)	($113,891)
Expenditure -Yr 14	$0	($485,550)	($485,550)	($169,657)	($131,160)	($101,871)
Expenditure -Yr 15	$0	($485,550)	($485,550)	($157,381)	($119,453)	($91,119)
Expenditure -Yr 17	$0	($485,550)	($485,550)	($145,994)	($108,792)	($81,501)
Expenditure -Yr 18	$0	($485,550)	($485,550)	($135,430)	($99,082)	($72,899)
Expenditure -Yr 19	$0	($485,550)	($485,550)	($125,631)	($90,238)	($65,205)
Expenditure -Yr 20	$0	($485,550)	($485,550)	($116,541)	($82,184)	($58,323)
Grand Totals	($48,555,000)	($7,863,600)	($56,418,600)	**($43,262,255)**	**($40,874,157)**	**($38,749,054)**

OPTION 2 – new 132kV network supplied from Mullumbimby 132kV bus only.

COST BENEFIT ANALYSIS - Country Energy
PROJECT : **Option 2: Mullumbimby - Lennox 132kV ring**
PROJECT LENGTH: **20 Years**
YEAR START **2006**
PRESENT VALUE **$ 42,474,531.75**
Maintenance cost 0.70%

Year	Cash Flow			Discounted Cash Flow		
	Capital	Annual Cost	Total	7.80%	9.80%	11.80%
Initial expenditure	($150,000)		($150,000)	($150,000)	($150,000)	($150,000)
Expenditure -Yr 1	($9,325,000)	($1,050)	($9,326,050)	($8,651,252)	($8,493,670)	($8,341,726)
Expenditure -Yr 2	($16,280,000)	($66,325)	($16,346,325)	($14,066,388)	($13,558,619)	($13,077,855)
Expenditure -Yr 3	($12,290,000)	($180,285)	($12,470,285)	($9,954,515)	($9,420,400)	($8,923,823)
Expenditure -Yr 4	($3,145,000)	($266,315)	($3,411,315)	($2,526,078)	($2,346,997)	($2,183,507)
Expenditure -Yr 5	($450,000)	($288,330)	($738,330)	($507,174)	($462,635)	($422,709)
Expenditure -Yr 6	($6,615,000)	($291,480)	($6,906,480)	($4,400,927)	($3,941,329)	($3,536,763)
Expenditure -Yr 7	($800,000)	($337,785)	($1,137,785)	($672,557)	($591,349)	($521,156)
Expenditure -Yr 8	$0	($343,385)	($343,385)	($188,292)	($162,541)	($140,685)
Expenditure -Yr 9	$0	($343,385)	($343,385)	($174,668)	($148,034)	($125,836)
Expenditure -Yr 10	$0	($343,385)	($343,385)	($162,029)	($134,821)	($112,555)
Expenditure -Yr 11	$0	($343,385)	($343,385)	($150,306)	($122,788)	($100,675)
Expenditure -Yr 12	$0	($343,385)	($343,385)	($139,430)	($111,829)	($90,049)
Expenditure -Yr 13	$0	($343,385)	($343,385)	($129,341)	($101,848)	($80,545)
Expenditure -Yr 14	$0	($343,385)	($343,385)	($119,983)	($92,757)	($72,044)
Expenditure -Yr 15	$0	($343,385)	($343,385)	($111,301)	($84,479)	($64,440)
Expenditure -Yr 17	$0	($343,385)	($343,385)	($103,248)	($76,939)	($57,638)
Expenditure -Yr 18	$0	($343,385)	($343,385)	($95,777)	($70,072)	($51,555)
Expenditure -Yr 19	$0	($343,385)	($343,385)	($88,847)	($63,817)	($46,114)
Expenditure -Yr 20	$0	($343,385)	($343,385)	($82,419)	($58,122)	($41,246)
Grand Totals	($49,055,000)	($5,552,190)	($54,607,190)	**($42,474,532)**	**($40,193,044)**	**($38,140,921)**

OPTION 3 – new 132kV ring network supplied from Mullumbimby 132kV bus and Lismore 132kV bus.

COST BENEFIT ANALYSIS - Country Energy
PROJECT : **Option 3: Mullumbimby - Lismore 132kV ring**
PROJECT LENGTH: **20 Years**
YEAR START **2006**
PRESENT VALUE **$ 44,625,368.51**
Maintenance cost 0.70%

Year	Cash Flow			Discounted Cash Flow		
	Capital	Annual Cost	Total	7.80%	9.80%	11.80%
Initial expenditure	($150,000)		($150,000)	($150,000)	($150,000)	($150,000)
Expenditure -Yr 1	($8,435,000)	($1,050)	($8,436,050)	($7,825,649)	($7,683,106)	($7,545,662)
Expenditure -Yr 2	($14,980,000)	($60,095)	($15,040,095)	($12,942,348)	($12,475,154)	($12,032,808)
Expenditure -Yr 3	($9,190,000)	($164,955)	($9,354,955)	($7,467,675)	($7,066,993)	($6,694,471)
Expenditure -Yr 4	($3,145,000)	($229,285)	($3,374,285)	($2,498,657)	($2,321,520)	($2,159,805)
Expenditure -Yr 5	($1,550,000)	($251,300)	($1,801,300)	($1,237,349)	($1,128,689)	($1,031,281)
Expenditure -Yr 6	($6,635,000)	($262,150)	($6,897,150)	($4,394,982)	($3,936,005)	($3,531,985)
Expenditure -Yr 7	$0	($308,595)	($308,595)	($182,414)	($160,388)	($141,350)
Expenditure -Yr 8	($1,235,000)	($308,595)	($1,543,595)	($846,415)	($730,659)	($632,410)
Expenditure -Yr 9	($10,935,000)	($317,240)	($11,252,240)	($5,723,611)	($4,850,851)	($4,123,469)
Expenditure -Yr 10	$0	($393,785)	($393,785)	($185,811)	($154,609)	($129,075)
Expenditure -Yr 11	$0	($393,785)	($393,785)	($172,366)	($140,810)	($115,451)
Expenditure -Yr 12	$0	($393,785)	($393,785)	($159,895)	($128,242)	($103,266)
Expenditure -Yr 13	$0	($393,785)	($393,785)	($148,325)	($116,796)	($92,367)
Expenditure -Yr 14	$0	($393,785)	($393,785)	($137,593)	($106,372)	($82,618)
Expenditure -Yr 15	$0	($393,785)	($393,785)	($127,637)	($96,878)	($73,898)
Expenditure -Yr 17	$0	($393,785)	($393,785)	($118,402)	($88,231)	($66,098)
Expenditure -Yr 18	$0	($393,785)	($393,785)	($109,835)	($80,356)	($59,122)
Expenditure -Yr 19	$0	($393,785)	($393,785)	($101,888)	($73,184)	($52,882)
Expenditure -Yr 20	$0	($393,785)	($393,785)	($94,515)	($66,652)	($47,300)
Grand Totals	($56,255,000)	($5,841,115)	($62,096,115)	**($44,625,369)**	**($41,555,495)**	**($38,865,319)**

Per unit cost estimates used to derive Option costs

Lines and cable	Detail	pu Cost
132kV D/C line	132kV double circuit line, concrete poles	$300,000
132kV line	Single Circuit 132kV line, rebuild existing 66kV line	$200,000
132kV & 66kV D/C line	Double circuit, dual voltage line (concrete poles)	$300,000
66kV line	Single Circuit 66kV line, reconductor existing 66kV line	$100,000
66kV D/C line	66kV double circuit line, wood poles	$220,000
66kV cable	66kV cable, trench and installation	$630,000
Transformers		
132/11kV transformer	132/11kV 20 MVA transformer	$600,000
132/11kV transformer	132/11kV 30 MVA transformer	$750,000
132/66/11.4 transformer	132/66/11.4kV 100 MVA auto transformer	$850,000
66/11kV transformer	66/11kV 30 MVA transformer	$650,000
Indoor equipment		
11kV indoor bay	11kV bus section	$30,000
11kV indoor bay	11kV feeders	$30,000
11kV indoor bay	Transformer LV incomers	$30,000
66kV indoor bay	66kV bus section	$425,000
66kV indoor bay	66kV feeder	$425,000
66kV indoor bay	Trfr 66kV HV	$425,000
Switchroom building	Building for 66kV indoor gis s/gear	$600,000
132kV equipment		
132kV bay	132kV bus section	$350,000
132kV bay	132kV feeder	$435,000
132kV bay	132kV trfr HV	$380,000
132kV busbar	Steel work, civils, conductor and insulators	$255,000
66kV equipment		
66kV bay	66kV bus section	$263,000
66kV bay	66kV feeder	$380,000
66kV bay	66kV Trfr HV	$325,000
66kV busbar	Steel work, civils, conductor and insulators	$200,000
General		
Site works	Mullumbimby civil works and site preparation for Option 1	$2,000,000
Building	Control building with 11kV switchroom	$400,000
Ancillary	DC supplies, SCADA and comms	$120,000
Yard	Fence, earth grid, trfr pads and oil sump	$300,000
Zone sub site	Land for new zone substation	$150,000

OPTION 3

Indicative timing and sequence of events

- MSProject GANTT Chart
- Slides indicating requirements and staged network development