Draft Recommendation

Emerging Network Limitations -

Gold Coast 110kV Ring & Mudgeeraba 275kV Transformer Capacity

February 2002
Joint Report by Powerlink and Energex

1.0 Executive Summary

Powerlink Queensland and Energex have identified emerging limitations in the transmission and distribution networks within the Gold Coast region.

Energex's main supply network on the Gold Coast, a 110kV 'ring' between Mudgeeraba, Robina, Nerang, Molendinar, Southport, Surfers Paradise and Broadbeach, distributes power from 275kV injection points at Mudgeeraba and (indirectly) Belmont to local 33kV supply substations. Technical studies have identified that, from late 2003, an outage within this network between Mudgeeraba and Surfers Paradise will cause loss of supply to customers.

A second emerging network limitation has been identified at Powerlink's 275kV substation at Mudgeeraba. From late 2003, if one of the three transformers is out of service, the remaining transformers will become overloaded. Without corrective action, customer supply would need to be automatically interrupted to ensure that safe operation of the power system can be maintained.

Action is required to overcome these limitations before late 2003 to allow Powerlink and Energex to meet their obligations under the Electricity Act and technical standards in the National Electricity Code. There is no acceptable 'do nothing' option, because if no action is taken power supply to customers on the Gold Coast will not be able to be maintained during single network contingencies.

Powerlink and Energex carried out joint planning to assess potential solutions to the limitations outlined above. Three possible alternatives were identified:

- **Option 1** involves an initial augmentation to address the 110kV ring issues by strengthening 110kV supply from the Beenleigh area to the northern end of the Gold Coast. This does not overcome the Mudgeeraba transformer limitations. It is assumed the transformer issues could be initially addressed by procuring grid support from the privately-owned Directlink market network service provider.

- **Option 2** involves an initial augmentation which brings 275kV supply directly into the northern end of the Gold Coast "Ring" by creating a tee connection from Molendinar to an existing 275kV feeder to the Gold Coast. This immediately addresses both the 110kV ring and transformer issues.

- **Option 3** involves an initial augmentation of the underground cables between Merrimac and Broadbeach to address the 110kV ring issues. Like Option 1, this does not overcome the transformer issues, which are assumed could be initially addressed by procuring grid support from Directlink.

In all three options, a series of further augmentations is required during the fifteen-year period analysed to meet the very high demand forecast for the Gold Coast area.

Other alternatives involving demand side management initiatives or local generation options may be capable of addressing the identified network limitations. Powerlink and Energex are not aware of any such initiatives of sufficient magnitude to address the emerging limitations. Industry participants are invited to offer any relevant information in response to this draft recommendation.

Financial analysis was carried out to calculate and compare the Net Present Value (NPV) of the costs to market participants of the three feasible options identified, in accordance with the ACCC Regulatory Test. The analysis included evaluation of the options under three scenarios of varying load growth (High, Medium and Low load growth forecasts). The sensitivity of the financial analysis to assumptions about capital cost, cost of network losses and discount rate was also assessed.

The ACCC Regulatory Test requires that for reliability requirements (as is the case for the Gold Coast limitations), the recommended option be the option with the lowest net present value cost.

The economic analysis in this paper identified that Option 2 is the least-cost solution over the fifteen-year period of analysis. Sensitivity analysis showed this outcome to be very robust, with the option rankings insensitive to variations in critical parameters used in the analysis.

Consequently, this report contains a draft recommendation to adopt the following course of action to address the identified network limitations at Mudgeeraba substation and in the Gold Coast 110kV Ring:

- Powerlink to construct a 275kV transformer ended feeder between Maudsland and Molendinar by October 2003 at a cost of $22.9M.

- Energex to rearrange the 110kV feeder connections and associated protection schemes at Molendinar substation by late 2003 at a cost of $1.0M

- Energex to carry out a minor capacity upgrade of the Beenleigh-Cades County 110kV feeder by late 2003 at a cost of $0.5M.

- Other network augmentations included in “Option 2” over the 15 year period analysed to be assessed at a later date according to National Electricity Code and ACCC regulatory requirements. No commitment is to be made to these subsequent augmentations at this time.

Powerlink and Energex invite submissions from Code Participants and interested parties on this draft recommendation. The closing date for submissions is Friday 8th March 2002.

****

This report deals only with issues related to Mudgeeraba 275kV transformer capacity and the Gold Coast 110kV network ie to network limitations WITHIN the Gold Coast area. In addition to these anticipated limitations, Powerlink has identified emerging issues with the transfer capability BETWEEN major power generation sources and the Gold Coast/Tweed area. As outlined in the 2001 Annual Planning Report, the 275kV network between Swanbank and Mudgeeraba is reaching voltage stability limits. Action will be required in the near future to maintain a reliable power supply to customers in the Gold Coast/Tweed area. Market participants and interested parties are advised that emerging limitations with the 275kV transfer capacity INTO the Gold Coast will be the subject of a separate consultation process to evaluate potential solutions. This process may be initiated during 2002.

2.0 INTRODUCTION

This report contains a draft recommendation to address the following emerging electricity network limitations **within** the Gold Coast area in south-east Queensland :

1) overloading of the 110kV network on the Gold Coast, and
2) transformer capacity limitations at the Mudgeeraba 275/110kV substation.

The draft recommendation is based on:

- the consequences of the identified network limitations in terms of maintaining reliable power supply to customers from the existing transmission and distribution grids. It has been identified that the existing network will be unable to supply forecast electricity demand with a single network element out of service from late 2003 onwards.
- A joint technical assessment by Powerlink and Energex of potential solutions available to address the emerging network limitations, and
- An economic analysis of feasible options in accordance with the Regulatory Test prescribed by the Australian Competition and Consumer Commission (ACCC).

The recommended option is technically feasible and satisfies reliability requirements at the least cost to the market and therefore to end-use customers.

2.1 Other Emerging Network Limitations

This report deals only with issues related to Mudgeeraba 275kV transformer capacity and the Gold Coast 110kV network. i.e network capability **within** the Gold Coast area. In addition to these anticipated limitations, Powerlink has identified emerging issues with the transfer capability **between** major power generation sources and the Gold Coast/Tweed area. As outlined in the 2001 Annual Planning Report, the 275kV network between Swanbank and Mudgeeraba is reaching voltage stability limits, and action will be required in the near future to maintain a reliable power supply to customers in the Gold Coast/Tweed area.

Market participants and interested parties are advised that emerging limitations with the 275kV transfer capacity **into** the Gold Coast will be the subject of a separate consultation process to evaluate potential solutions. This process may be initiated during 2002.

3.0 EMERGING NETWORK LIMITATIONS

3.1 Electricity Demand

Electricity demand in the Gold Coast/Tweed zone[1] is growing at one of the fastest rates in Queensland – an average demand growth of 4.7% p.a. is predicted for the next ten years[2]. This fast growing demand for power is placing considerable stress on the existing electricity supply system **within** the Gold Coast area.

Summer demand is the most critical in terms of the capacity of the local supply network. Peak demand on the Gold Coast is actually higher in winter, but the capability of the electricity system is also higher at this time. In summer, the potential operating capability of equipment is reduced[3] due to higher summer temperatures. Peak usage also persists for long periods during the day in summer, placing greater stress on electrical plant.

3.2 Existing System

Most of the power consumed on the Gold Coast is produced at power stations to the west and north of Brisbane. It is transferred into the Gold Coast area across Powerlink's two 275kV transmission circuits between Swanbank (near Ipswich) and Mudgeeraba. A smaller amount of power is injected into the Gold Coast area via the network which extends from the major 275kV substation at Belmont in southern Brisbane[3] via the 110kV sub-transmission system between Loganlea and Molendinar.

Under certain electricity market conditions, the privately-owned "Directlink" – a network connection between Terranora and Mullumbimby – may deliver power into the Gold Coast area from New South Wales. Northward power flows across Directlink are transferred from the Country Energy 110/66/33kV substation at Terranora to Mudgeeraba via two 110kV transmission circuits.

Once power reaches the Gold Coast area, it is transferred to local supply points via the Energex 110kV network. Most of this network is referred to by electricity system planners as the "Gold Coast 110kV Ring", as it consists of 110kV connections forming a 'ring' between Mudgeeraba, Robina, Nerang, Molendinar, Southport, Surfers Paradise and Broadbeach (see figure 3.1). There is also a radial line between Mudgeeraba and Burleigh.

[1] The Gold Coast/Tweed zone is the area south of Beenleigh to the Gold Coast, and includes the Tweed Shire of NSW
[2] Refer to forecast information contained in Powerlink's 2001 Annual Planning Report, July 2001.
[3] and from early 2002, a 275kV substation at Loganlea

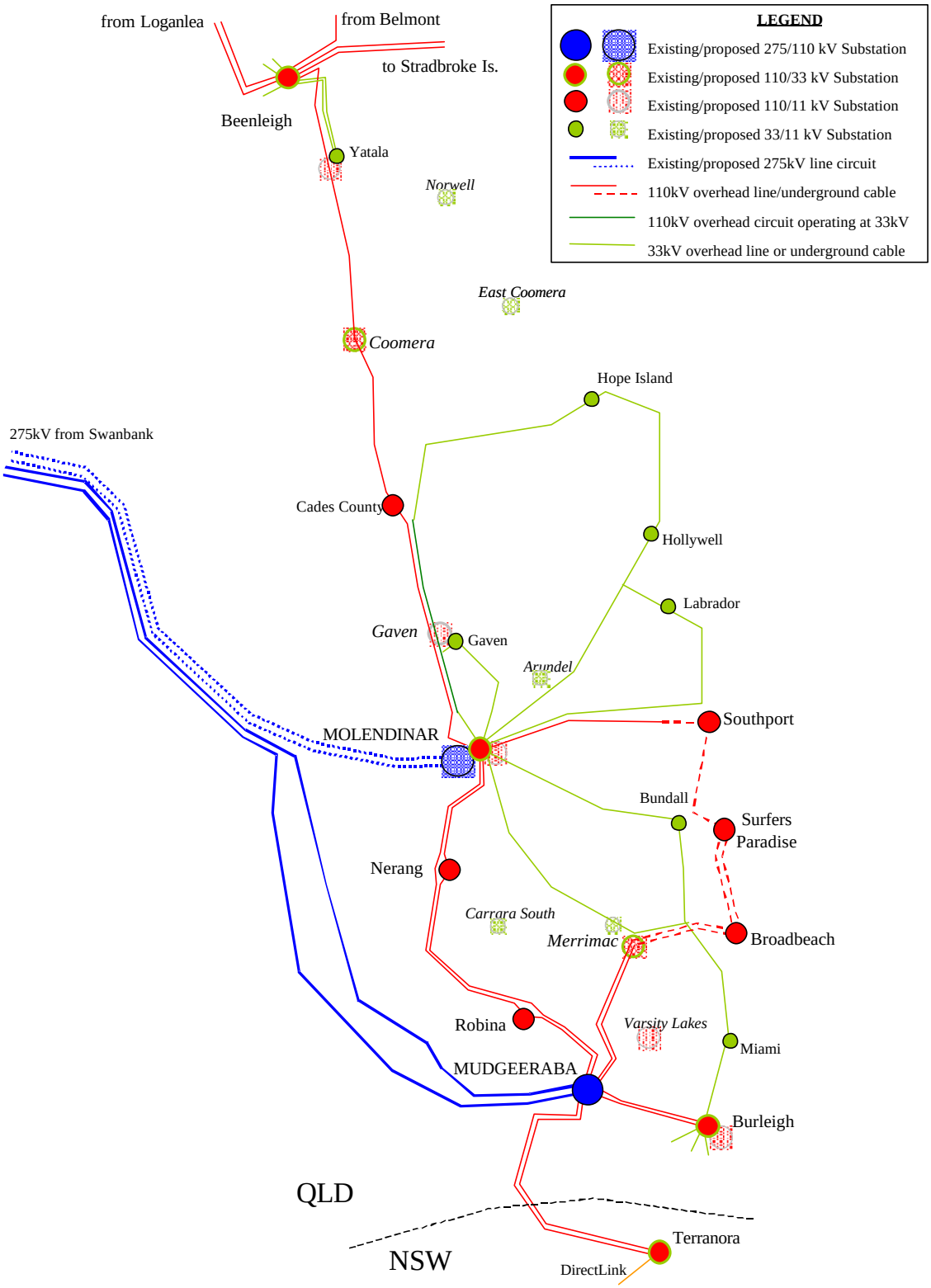

Figure 3.1 – Gold Coast Supply Network

3.3 Emerging Limitations: Gold Coast 110kV "Ring"

As outlined above, Energex's main supply network on the Gold Coast consists of the Gold Coast 110kV "ring" (Mudgeeraba, Robina, Nerang, Molendinar, Southport, Surfers Paradise, and Broadbeach) and a radial supply to Burleigh. This network distributes power from 275kV injection points at Mudgeeraba and (indirectly) Belmont to local 33kV supply substations around the Gold Coast region.

Limitations in the capacity of the Gold Coast 'ring' have been identified, mostly associated with the way power is transferred to the northern end of the Gold Coast. With all network elements in service the majority of power presently flows 'anti-clockwise' on the ring from Mudgeeraba to Southport via Broadbeach.

During an outage of one of the 110kV circuits between Mudgeeraba and Surfers Paradise, the remaining circuit in this part of the ring becomes overloaded (in the 110kV underground cable section between Merrimac and Broadbeach). This occurs now during high load periods even when all elements of the power system are in service, but is presently managed by Energex through operational measures such as 'load shifting'[4].

However, technical studies have identified that, due to increasing load growth, such operational strategies will not be able to effectively deal with outages of the 110kV network between Mudgeeraba and Surfers Paradise from the summer of 2003/04 onwards[5]. Studies have also identified that unacceptable overloads of the Merrimac-Broadbeach cables will also occur if an outage occurs in the 'ring' between Molendinar and Southport from late 2006 onwards. Unless these issues are addressed, customer loadshedding will be required during the relevant single contingencies to allow the electricity system to be operated safely[6].

3.4 Emerging Limitations: Mudgeeraba Transformer Capacity

Another emerging supply limitation has been identified at Powerlink's 275kV substation at Mudgeeraba. If a fault or contingency occurs so that one 275/110 kV transformer unit at Mudgeeraba is out of service, the remaining transformers in service at the substation become overloaded by summer 2003/04[7]. Load flow studies show the following transformer loadings during a single transformer contingency at the time of local summer peak demand:

Mudgeeraba 275/110kV Transformers (summer normal/emergency cyclic ratings)	Summer 2001/02	Summer 2002/03	Summer 2003/04
245/295 MVA	274MVA	289MVA	305MVA

It is clear that loadings are already well above the 'summer normal' thermal rating of the remaining transformers if only two of the three transformers are in service. Both remaining transformers will be operating close to their short-term emergency rating in such circumstances. Operation at such high loads accelerates the aging of power transformers and a degradation in reliability.

[4] During high load times, the Southport 110kV bus section is operated open to 'shift' the way power is transferred around the ring. This operational measure results in some load that would normally flow to Southport via Broadbeach being supplied instead from Molendinar.

[5] Base case studies assume medium load growth forecasts.

[6] That is, to avoid unacceptable line overloads when a single 110kV network element is out of service

[7] Base case studies assume zero flow on Directlink, medium load growth forecasts and 100% of Energex local capacitor banks in service.

As electricity demand increases, loadings on the transformers also increase. By the summer of 2003/04, acute capacity limitations would arise during a contingency. The existing Powerlink system would not be able to withstand a single outage of a transformer at Mudgeeraba without loss of supply to customers, because the actual loading on the remaining transformers would exceed summer emergency ratings. Operation above the emergency rating is not acceptable due to the increased risk of catastrophic failure. From late 2005, an outage of a single Mudgeeraba transformer during peak periods will also result in overloading of the Beenleigh-Cades County 110kV line[8].

3.5 Conclusion re Emerging Network Limitations

This report concludes that the existing Gold Coast supply system is not expected to be able to maintain secure and reliable supply to customers during either single 110kV contingencies or Mudgeeraba transformer contingencies from the summer of 2003/04 onwards[9].

Powerlink and Energex consider that 'N-1' (that is, the ability to supply all load with any single network element out of service) is the appropriate planning criterion for the Gold Coast to meet their current obligations under the Electricity Act and technical standards in the National Electricity Code.

Augmentation to overcome the Gold Coast 110kV network and the Mudgeeraba transformer limitations is therefore required before late 2003.

[8] The emergency rating of this line would be exceeded.
[9] Based on demand forecasts for average weather conditions and moderate economic growth.

4.0 OPTIONS CONSIDERED

4.1 Identification and Assessment of Options

As required under the National Electricity Code, Energex and Powerlink have undertaken joint planning regarding emerging 110kV supply limitations on the Gold Coast. The Code requires that the transmission and distribution networks be planned as a single network. The joint planning process therefore examined the networks as a single 'supply chain', with load flow analysis and other technical assessment being carried out to determine the overall capability of the transmission and distribution networks supplying the Gold Coast area.

After the capability of the networks was analysed, system planners assessed potential solutions, both network solutions and non-network solutions, including local generation and demand side management, to overcome the 110kV network and Mudgeeraba transformer limitations as follows:

4.1.1. Local Generation:

Only existing and committed projects which will be operational prior to October 2003 are considered to be viable solutions to address the emerging network limitations. If uncommitted project proposals are relied upon, and are not developed by the summer of 2003, significant interruptions to customer power supply could result. This risk is not considered acceptable in an area of high density residential, commercial and tourism importance such as the Gold Coast.

Powerlink and Energex are not aware of any existing local generation, or committed projects that will be in service by October 2003, capable of addressing the emerging limitations outlined in this paper. Powerlink's Annual Planning Reports issued in 2000 and 2001 both identified that capacity augmentation might be required to address Gold Coast supply issues, but the only sizeable generator to be developed in the area recently is the Rocky Point Sugar Mill cogenerator (an expansion of an existing small cogeneration facility).

Rocky Point has a registered capacity of 28MW. This generator will have minimal impact on the network limitations in the 110kV ring and Mudgeeraba transformer capacity issues. Its output is relatively small in comparison to the Gold Coast load and it is located in the Beenleigh area - too far north to address the emerging network limitations outlined in this paper[10].

Powerlink has also noted media reports about a proposal to develop a cogeneration facility at the Condong Sugar Mill in the Tweed area of NSW. At this stage, Powerlink has received no advice about this proposed project, and it has not been accounted for in load growth forecasts. Market participants are invited to provide information about this, or other generation projects in the Gold Coast area, in response to this draft recommendation. Interested parties are advised that:

- Projects would need to inject power directly into the 110kV substations at Broadbeach, Surfers Paradise or Southport (or reduce the power supplied from these substations) to overcome issues associated with the Energex 110kV network.

[10] The Rocky Point sugar mill generator is embedded in the distribution network, and results in a reduction in the amount of load which must be supplied from the transmission grid. The output of Rocky Point has been accounted for in the load growth forecasts used in the joint planning analysis carried out by Powerlink and Energex.

- Sizeable new generation located anywhere in the Gold Coast/Tweed Zone could potentially assist in overcoming the transformer capacity limitations at Mudgeeraba.[11]

4.1.2. Demand Side Management (DSM):

Existing demand side management programs on the Gold Coast, and routine hot water switching activities, have been included in the demand forecasts used in the joint planning process. Powerlink and Energex are unaware of any other possible arrangements to reduce or curtail electricity usage in the target area capable of addressing the emerging network limitations outlined in this paper.

In a similar way to that outlined in the section on local generation, any new demand side management initiatives need to directly offload Energex 110/11kV connection points at Broadbeach, Surfers Paradise or Southport if they are to address the 110kV Ring issues. General load reductions in the broader Gold Coast/Tweed zone may assist in addressing the transformer capacity limitations at Mudgeeraba substation. However, to be effective, any programs would need to be able to offset annual growth in electricity loading on the Mudgeeraba transformers (20-30MW initially in 2003/04, plus a further 20-30MW each subsequent year). A DSM program may involve customers agreeing to voluntarily 'switch off' during a network contingency. If this is the case, an automatic and immediate system would be required to interrupt power supply to participants in the program immediately following a contingency to prevent more widespread loadshedding.

4.1.3. Directlink

Directlink effectively links the Queensland and NSW electricity grids, and therefore can provide a connection between NSW power generators and customers in the Gold Coast area through the NSW transmission and distribution systems[12]. Importing power into Queensland across Directlink reduces the Terranora load that must otherwise be supplied from Mudgeeraba. Operation of Directlink in a northerly direction therefore unloads the Mudgeeraba transformers and can assist in relieving the anticipated transformer capability limitations at Mudgeeraba. It is assumed that a commercial arrangement would need to be in place between Powerlink and the owners of Directlink for this type of support to be available when required (ie – electricity market bidding outcomes may not result in Directlink flowing northward during periods of transformer limitations at Mudgeeraba).

Directlink cannot assist in addressing the limitations within the Gold Coast 110kV Ring. Directlink injects power into or draws power from the southern end of the ring via Terranora and Mudgeeraba. When Directlink is flowing north into Queensland, it increases the flows on the critical Energex 110kV circuits north from Mudgeeraba. This increases the level of potential overloads on these lines during contingencies. During a 'broken ring' scenario, this worsens the overloads likely to be experienced on Merrimac-Broadbeach 110kV cables. On the other hand, when Directlink exports power from Queensland, this results in an increase in the flows on the Energex 110kV circuit south from Beenleigh to Cades County, and can result in potential overloads in this part of the 110kV network during contingencies and increased loadings on the Mudgeeraba transformers.

The analysis in this paper assumes zero flow across Directlink except where it has been assumed to provide grid support to assist in offloading the Mudgeeraba transformers (see options 1 & 3 in section 4.2). No scenario has been assumed where Directlink operation would lead to customer loadshedding

[11] New generation would need to reduce contingency flows across the Mudgeeraba transformers (during a transformer outage or an outage of the Beenleigh-Cades County line) by at least one year's load growth to have any impact on the need to augment supply capacity. It is estimated that approximately 30MW of new generation would be required to achieve this.

[12] While Directlink is rated at 188MW, limitations in the Country Energy 132kV network north of Lismore, and the TransGrid transmission network in northern NSW, may limit the available contribution to the Gold Coast area in the critical peak load periods to well below the design capacity of Directlink. For example, during a 330kV network contingency in northern NSW at high load times, no northerly flow across Directlink is possible.

during single network contingencies. In practice, Directlink flow would be limited to avoid the risk of loadshedding.

4.1.4. Network Augmentation:

Energex and Powerlink investigated various transmission and distribution network augmentation options to determine the capability of such options to address the identified 110kV "ring" and transformer network limitations.

Powerlink and Energex conducted planning studies to identify several solutions that would be technically capable of alleviating the identified network limitations. Detailed feasibility analysis and field work has been carried out on the high voltage transmission solution.

In addition, high level planning investigations were carried out by both Energex and Powerlink to determine works that are likely to be required in the longer term to enable supply to specific future growth areas identified in Energex's strategic development plan.

4.2 Feasible Options:

The outcome of the planning assessments is that three options have been compared as possible alternatives to address the issues outlined in section 3.0:

- **Option 1** involves an initial augmentation to address the 110kV ring issues by strengthening 110kV supply from the Beenleigh area to the northern end of the Gold Coast. This does not overcome the Mudgeeraba transformer limitations.

  - It is assumed the transformer issues could be initially addressed by procuring grid support from the Directlink market network service provider. A valid alternative to such grid support would be the installation of a fourth 275/110kV transformer at the existing Mudgeeraba substation. However, only preliminary consideration was given to this method of addressing the transformer limitations as it was not found to be cost-effective (see section 6.2.2).

- **Option 2** involves an initial augmentation which brings 275kV supply directly into the northern end of the Gold Coast "Ring" by creating a tee connection from Molendinar to an existing 275kV feeder to the Gold Coast. This immediately addresses both the 110kV ring and transformer issues.

- **Option 3** involves an initial augmentation of the underground cables between Merrimac and Broadbeach to address the 110kV ring issues. Like Option 1, this does not overcome the transformer issues, which are assumed could be addressed by procuring grid support from Directlink.

These three approaches all satisfy the emerging 110kV Ring issues and Mudgeeraba transformer limitations. However, the augmentations outlined above deliver different supply capabilities. In all cases, further augmentation will be required during the fifteen-year analysis period to ensure that the transmission and distribution networks can meet the very high demand growth forecast for the Gold Coast area (expected to increase by 50% above current levels in the next eight years alone[13]).

[13] Actual demand in 2000/01 was 498MW, and this is forecast to grow to 751MW by 2009/10.

A meaningful comparison of the options is only possible if differences in subsequent network development are taken into account. Powerlink and Energex have therefore identified a series of subsequent augmentations so that each option has the technical capability to meet Gold Coast power requirements within the 15-year timeframe. The sensitivity of these assumptions to different scenarios is discussed in section 5.0. An overview of the options based on a medium load growth forecast is provided below, with full details and the impact of other load growth scenarios contained in the financial analysis in Appendix 1. Proposed works with timing common to all options have not been included as they have no impact on the economic comparison of alternatives.

Overview of Option 1 – Strengthen 110kV Supply from Loganlea Area

Date Reqd	Augmentation	Capital Cost
Oct 2003	Rebuild Beenleigh to Cades County 110kV feeder as a double circuit line	$12.2M
	Convert Cades County to Molendinar to double circuit 110kV operation	$ 0.9M
	Coomera substation work and 33kV network upgrades	$4.1M
	Gaven substation work	$3.8M
Oct 2004	Establish 2nd 275/110kV transformer at Loganlea	$6.0M
Oct 2006	Establish new 110kV line/cable between Molendinar and Surfers Paradise	$11.5M
Oct 2007	Establish Molendinar 275kV substation. Tee connection to existing lines	$22.9M
	Rearrange 110kV feeder connections and protection schemes at Molendinar	$1.0M

- Directlink grid support required to offload Mudgeeraba transformers during peak periods from 2004 to 2007

(a) Addressing the Gold Coast 110 kV ring limitation

The initial works proposed in Option 1 increase the capacity of the 110kV lines which feed power into the Gold Coast '110kV ring' from the north via Beenleigh and Cades County. This would overcome overloads in the 'ring' because it would result in less power being transferred to the northern end of the Gold Coast from Mudgeeraba via Broadbeach and Surfers Paradise.

Energex is finalising construction of a new 110kV line between Loganlea[14] and Beenleigh. This line is designed to supply increasing electricity demand in the fast-growing Beenleigh area. However, the new 110kV line also means that there is sufficient network capacity for the next few years to carry additional power from Loganlea to the northern end of the Gold Coast if the 110kV network between Beenleigh, Cades County and Molendinar is upgraded. Energex and Powerlink have determined that this can be achieved by:

- rebuilding the 110kV feeder between Beenleigh and Cades County to a double circuit line
- converting the Cades County –Molendinar feeder to a double circuit 110kV line (presently operating one circuit at 110kV and one circuit at 33kV)

[14] New 275/110kV substation under construction – to be completed in early 2002.

- carrying out 33kV works in the Cades County area by establishing a new substation at Coomera and upgrading the 33kV network in the area between Molendinar and Coomera[15].
- Advancing the establishment of a second 275/110kV transformer at Loganlea to 2004.

Technical studies show that this augmentation of supply from the north will solve the overload problems in the Gold Coast 110kV ring for approximately three years. At this time, other limitations in the '110kV ring' will be reached. Studies show that an additional 110kV circuit will be needed from Molendinar to Surfers Paradise in late 2006[16].

(b) Addressing the Mudgeeraba transformer capacity limitation

Strengthening the 110kV supply to the Gold Coast from the Loganlea area reduces the loadings on the Mudgeeraba transformers. However, it does not reduce the loadings sufficiently to prevent emergency transformer ratings being exceeded by late 2004 during single transformer contingencies.

Therefore, additional action is required to address the Mudgeeraba transformer limitations in option 1. Several measures are possible, but in option 1 it is assumed that grid support can be procured from Directlink[17]. Northerly flows on Directlink reduce the customer load which needs to be supplied from Mudgeeraba, and therefore reduces the loadings on the relevant transformers. As the flows on Directlink occur in response to market conditions, it is anticipated that option 1 would involve a contractual arrangement for grid support between the owners of Directlink and Powerlink (see section 6.2.3 for a discussion of grid support assumptions).

In the base case scenario, it is anticipated that grid support will not be required from Directlink beyond late 2007. At this time, it is assumed that significant network upgrades will be commissioned to address thermal limitations on the main 275kV network supplying the Gold Coast[18]. The works assumed in Option 1 (common to all options in this paper but with different commissioning timeframes) include the establishment of a 275/110kV substation at Molendinar in late 2007 at a cost of $22.4M, and associated 110kV feeder rearrangements at Molendinar.

[15] The conversion of the Cades County – Molendinar line to double circuit 110kV will require the construction of new 33kV connections and substations at Coomera and Gaven to be advanced.

[16] Proposal is to establish a new 110kV line/underground cable between Molendinar and Surfers Paradise

[17] Directlink operation may be limited by transmission network limitations in NSW. For the purposes of this analysis, it has been assumed Directlink support will be available as and when required. This assumption would need to be confirmed.

[18] In the short to medium term, the Gold Coast 275kV transfer limitations are associated with voltage stability issues. Addressing these issues will be the subject of a separate consultation process as outlined earlier. However, based on current medium load growth forecasts which include forecasts of the development of local power sources, the 275kV circuits between Swanbank and Mudgeeraba are expected to reach their thermal limits (maximum current carrying capacity) in late 2007. Major network augmentation is likely to be necessary to overcome this thermal limitation, so as to maintain a reliable power supply to Gold Coast customers. Section 5.0 examines the sensitivity of this assumption to varying load growth scenarios. For example, in option 1 under a low load growth scenario, major network augmentation is not anticipated to be required until late 2009 and Directlink grid support is assumed to be necessary until this time. It should be noted that a major network augmentation to overcome the Gold Coast transfer limit would comprise a series of major works - only works not common to each option (ie - the establishment of Molendinar 275/110kV substation) are included in the comparison in this paper.

Overview of Option 2 – Early Molendinar 275kV Establishment		
Date Reqd	Augmentation	Capital Cost
Oct 2003	Establish Molendinar 275kV substation. Tee connection to existing lines Rearrange 110kV feeder connections and protection schemes at Molendinar Minor capacity upgrade of Beenleigh-Cades County 110kV feeder	$22.9M $1.0M $0.5M
Oct 2004	Rebuild Coomera-Cades County at double circuit 110kV – one side at 33kV Further 33kV works in Coomera area	$2.8M $0.9M
Oct 2006	Establish new 110kV line/cable between Molendinar and Surfers Paradise	$11.5M
Oct 2009	Establish 2nd 275/110kV transformer at Loganlea	$6.0M
Oct 2011	Strengthening of 110kV & 33kV network in Beenleigh/Coomera/Gaven area	$15.7M

The initial works proposed in Option 2 involve the advancement of works to establish a new 275kV injection point at Molendinar substation on the northern end of the Gold Coast in late 2003.

In this option, a 275kV transformer-ended feeder, approximately 12km long, would be constructed between existing 275kV circuits to the Gold Coast and a site adjacent to the existing Energex 110kV/33kV substation at Molendinar near Nerang (see figure 4.1). This line would be a tee connection into Powerlink's existing 275kV circuits between Swanbank and Mudgeeraba at a point known as Maudsland. Some associated rearrangements of 110kV feeder connections and protection schemes would also be required at Energex's Molendinar substation.

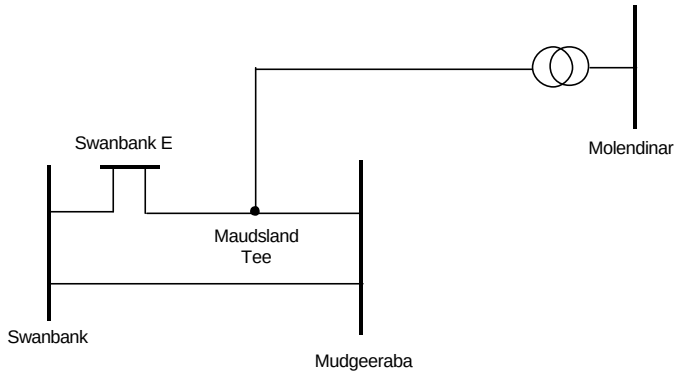

Figure 4.1: Maudsland Tee Option

The Maudsland-Molendinar 275kV tee line overcomes the 110kV ring issues by reducing the requirement for existing ring elements to transfer power from Mudgeeraba to the northern end of the Gold Coast via Broadbeach. It provides an additional path for power flow by establishing an additional injection point into the northern end of the 110kV ring. The establishment of a 300MVA 275/110kV transformer at Molendinar will also offload the existing transformers at Mudgeeraba, reducing load flows during contingencies to below the normal ratings of these transformers.

In late 2004, some reinforcement of the 110kV and 33kV network in the Coomera is required. In addition, as with Option 1, supply augmentation between Molendinar and Surfers Paradise will be required in late 2006.

These augmentations are capable of meeting most long-term supply needs within the Gold Coast area, and defer the establishment of a second 275/110kV transformer at Loganlea until 2009. However, in 2011, it is anticipated that the 110kV network from the north will need to be upgraded in a similar way to the initial augmentations recommended in Option 1. This will be required to address local capacity issues that will arise in the Cades County area. A double circuit 110kV connection will be needed between Beenleigh and Molendinar and the 33kV network in the Coomera/Cades County area will need to be upgraded at a total estimated cost of $15.7M[19].

Overview of Option 3 – Initial 110kV Cable Upgrade

Date Reqd	Augmentation	Capital Cost
Oct 2003	Upgrade underground 110kV cables – Merrimac to Broadbeach	$9.0M
	Minor capacity upgrade of Beenleigh-Cades County feeder	$0.5M
Oct 2004	Rebuild Coomera-Cades County at double circuit 110kV – one side at 33kV	$2.8M
	Further 33kV works in Coomera area	$0.9M
Oct 2005	Establish 2nd 275/110kV transformer at Loganlea	$6.0M
Oct 2007	Establish Molendinar 275kV substation. Tee connection to existing lines	$22.9M
	Rearrange 110kV feeder connections and protection schemes at Molendinar	$1.0M
Oct 2008	Establish new 110kV line/cable between Molendinar and Surfers Paradise	$11.5M
Oct 2011	Strengthening of 110kV & 33kV network in Beenleigh/Coomera/Gaven area	$15.7M

- Directlink grid support required to offload Mudgeeraba transformers during peak periods from 2003 to 2007

(a) Addressing the Gold Coast 110 kV ring limitation

Option 3 addresses the 110kV ring issues by replacing and upgrading the 110kV underground cables between Merrimac and Broadbeach (see map in section 3.2).

At present, load flows across this segment of the "ring" are the most difficult for Energex to manage using operational measures. Without action, the emergency capacity of these cables will be exceeded during outages from late 2003 onwards. Upgrading the capability of these cables, along with works in the Coomera area in late 2004, will address overload limitations within the Energex 110kV ring for approximately four years. After this time, loading on other elements of the ring during 110kV outages will need to be addressed.

(b) Addressing the Mudgeeraba transformer capacity limitation

Upgrading the cables between Merrimac and Broadbeach does not overcome the transformer capacity limitations at Mudgeeraba. As in Option 1, Option 3 assumes that the transformer limitations can be addressed through the procurement of grid support from Directlink to ensure that customer supply can be maintained during transformer contingencies.

[19] Anticipated works are slightly different in 2011 to those proposed in 2003 in Option 1. Option 2 includes works in 2011 to rebuild Beenleigh to Coomera as a double circuit 110kV line, conversion of the line between Coomera and Molendinar to double circuit 110kV, and 33kV substation work at Coomera and Gaven.

As with Option 1, in the base case scenario, it is anticipated that there will be no need for Directlink support beyond summer 2007/08 because significant network upgrades will be required at that time to address thermal limitations on the main 275kV network supplying the Gold Coast. However, option 3 requires other network augmentations to ensure that the growing Gold Coast electricity demand can be met. Under option 3, a new 110kV cable between Molendinar and Surfers Paradise will be required in late 2008 at a cost of $11.5M. Works will also be required to upgrade the 110kV and 33kV network in the Coomera/Cades County area in 2011 at a cost of $15.7M[20].

All three options deliver comparable network capability over the 15 year period, thereby enabling a direct comparison of the NPV costs of the Options.

[20] See detail of works in option 2 – footnote 21

5.0 MARKET DEVELOPMENT SCENARIOS

5.1 Context for Evaluation of Options

All feasible solutions to the identified network constraints must be viewed in the context of wider developments in the National Electricity Market:

- NEMMCO's Statement of Opportunities (SOO) issued in March 2001 contained information on existing and committed generation developments in Queensland. Approximately 2500MW of new generation capacity is committed for commissioning in Queensland within the next three years.

- The new Commonwealth Government legislation to encourage increased generation from renewable energy sources came into effect on 1st April, 2001. Powerlink has incorporated independent forecasts of additional renewable energy generation into the forecasts of demand and energy used in assessing the expected incidence of future network constraints.

- The Queensland Government published the Queensland Energy Policy in May 2000. Recent steps have been taken towards implementation of policy initiatives, such as the requirement for Queensland energy retailers to source 13% of their energy from gas-fired generation from 1 January 2005.

5.2 Assumed Market Development Scenarios

The ACCC Regulatory Test requires that options to address a network limitation be assessed against a number of plausible market development scenarios. These scenarios need to take account of:

- the existing system
- future network developments.
- variations in load growth
- committed generation and demand side developments
- potential generation and demand side developments

The purpose of utilising this approach is to test the NPV costs of the options being evaluated under a range of plausible scenarios.

5.2.1. Existing Network and Future Transmission Developments:

No market development scenarios have been developed related to new transmission works proposed by Powerlink outside the Gold Coast area. These are independent of the identified network limitations that are the subject of this report, and are considered to be common to all options analysed.

5.2.2. Variations in Load Growth:

Powerlink and Energex carry out the majority of their detailed planning using a medium economic growth, typical weather forecast for electricity usage. These forecasts include all known information about existing and planned demand side initiatives, and also include independent forecasts of local embedded generation developments.

Three market development scenarios have been developed to simulate the impact of variations in customer load growth:

Scenario A	Medium load growth forecast (medium economic growth and typical weather conditions)
Scenario B	High load growth forecast (higher economic growth and typical weather conditions)
Scenario C	Low load growth forecasts (lower economic growth and typical weather conditions)

As noted above, the overview of options and timing of the series of anticipated network augmentations outlined in section 4.0 was based on medium load growth forecasts (Scenario A). The financial analysis in Appendix 1 highlights how the timing of required augmentations varies for Scenario B & C (higher and lower load growth assumptions).

Higher or lower load growth could occur due to actual conditions not matching assumptions about economic growth and electricity consumption patterns, or could reflect the impacts of demand side initiatives and/or output from embedded generators. However, no regard has been given to the cause or source of different electricity load forecasts. The purpose of the scenarios is to test the robustness of the option comparison, so the cause is not relevant to the outcome of the economic analysis.

5.2.3. Existing and Committed Generators:

Analysis of potential solutions in this paper is not considered sensitive to the generation pattern of existing and committed generators. Major existing and committed generators are located a considerable distance from the Gold Coast area. Variations in market bidding behaviour by these generators are expected to have minimal impact on the relevant network flows through the Mudgeeraba transformers and/or the Gold Coast 110kV Ring. For this reason, market development scenarios have not been developed to test assumptions about different operational patterns of existing and committed generators.

5.2.4. Potential Generation Developments:

Recent additional generation capacity commitments within Queensland mean that a healthy electricity supply-demand balance is anticipated over the medium term. New generation is only likely to be developed where developers identify commercial opportunities, rather than being developed in response to load requirements. Large generation developments outside the immediate area (eg – such as proposals for major new generation in north Queensland or at Kogan Creek) will have minimal impact on the Gold Coast limitations, and are therefore not significant factors in this study.

Smaller generation developments may occur in the Gold Coast-Tweed zone in response to government initiatives to encourage the development of renewable energy generation and generation from gas-fired power sources. Powerlink and Energex are not aware of any well-advanced new generation proposals in the immediate area where the network limitations exist. However, it is plausible that such a generation development could occur. To avoid bias due to assuming a specific location for a hypothetical generator, Powerlink instead believes that Scenario C most appropriately reflects the impact of additional local generation. If an embedded generator approximately 30MW in size was developed and connected to the Energex distribution system at one of the relevant connection points on the Gold Coast, it would reduce the forecast load needing to be supplied via the transmission and distribution network. The impact on the existing network could therefore be considered equivalent to a lower load growth assumption such as that in Scenario C.

6.0 FORMAT AND INPUTS TO ANALYSIS

6.1 Regulatory Test Requirements

The requirements for the comparison of options to address an identified network limitation are contained in the Regulatory Test prescribed by the Australian Competition and Consumer Commission (ACCC).

The Regulatory Test requires that the recommended option be the option that "maximises the net present value of the market benefit having regard to a number of alternative projects, timings and market development scenarios". To satisfy the Test, a proposed augmentation must achieve a greater market benefit in most, but not necessarily all, credible scenarios.

The Regulatory Test contains guidelines for the methodology to be used to calculate the net present value (NPV) of the market benefit. For example, where an augmentation is required to satisfy objectively measurable reliability standards, the methodology published by the ACCC defines "market benefit" as the total net cost to all those who produce, distribute and consume electricity in the National Electricity Market. That is, the option with the lowest net present value cost maximises the market benefit.

Information to be considered includes the 'efficient operating costs of competitively supplying energy to meet forecast demand' and the cost of complying with existing and anticipated laws. However, the Regulatory Test specifically excludes indirect costs, and costs that cannot be measured as a cost in terms of financial transactions in the electricity market.

6.2 Inputs to Analysis

A solution to address emerging network limitations within the Gold Coast area as outlined in this document is required to satisfy reliability requirements linked to Schedule 5.1 of the National Electricity Code and the requirements of the Queensland Electricity Act[21].

According to the ACCC Regulatory Test, this means that the costs of all options must be compared, and the least cost solution is considered to satisfy the Regulatory Test. The results of this evaluation, carried out using a cash flow model to determine the Net Present Value (NPV) of the various options, are shown in section 7.0.

Cost inputs to the NPV analysis are described as follows:

[21] Powerlink's transmission authority includes a responsibility "… to ensure as far as technically and economically practicable, that the transmission grid is operated with enough capacity (and if necessary, augmented or extended to provide enough capacity) to provide network services to persons authorised to connect to the grid or take electricity from the grid." (Electricity Act 1994, S34.2). As noted in section 3.5, without action, Powerlink and Energex will be unable to maintain supply during single contingencies affecting the Mudgeeraba 275/110kV transformers, or single contingencies on the Gold Coast 110kV Ring .

6.2.1. Cost of Network Augmentations:

The cost of the network augmentations outlined in the options in section 4.0 have been estimated by Powerlink and Energex.

Sensitivity studies have been carried out for both Energex and Powerlink augmentations using variations in the capital cost estimates of plus or minus 15% (see section 7.3).

The financial analysis considers all cost impacts of the proposed network augmentations to market participants as defined by regulatory processes. The estimated saving in the cost of network losses for each option has been included based on the assumption of typical Gold Coast load factor and an average cost of losses of $25/MWh [22]. Sensitivity studies have also been carried out on the assumed cost of losses (see section 7.3).

The incidence of the capital expenditure (ie – the assumed timing of the augmentations) was determined jointly by Powerlink and Energex based on load flow analysis. As outlined in section 5.0, sensitivity of timing assumptions to high, medium and low load growth forecasts has been taken into account through the use of three scenarios.

6.2.2. Grid Support Costs:

Grid support refers to an arrangement whereby a market participant operates its plant in a particular way to meet the needs of a network owner. For example, the National Electricity Code allows a transmission network owner to enter into a commercial arrangement with a generator to operate in a way that avoids exceeding transmission grid power transfer limits. This can, in some circumstances, be a feasible alternative to augmenting the network, or an economic means of deferring a network augmentation.

In the Gold Coast situation, northerly flow across the Directlink market network service provider could assist in addressing anticipated future transformer limitations at Mudgeeraba. The actual cost of obtaining this grid support from Directlink would be dependent on the cost of energy (price per MWh) negotiated between Powerlink and the owners of Directlink. The total grid support cost would also depend on actual electricity demand and the generation pattern at the time support was required.

Negotiations for a grid support arrangement with Directlink have not been progressed even though it is a technically feasible option to address some of the identified emerging network limitations. This is because the results of the economic analysis indicated that options involving grid support would not satisfy the Regulatory Test.

As shown in Appendix 1, the financial analysis assumes that grid support costs are zero (ie – Directlink is assumed to provide the grid support at no cost to Powerlink). This is the lowest possible cost outcome for grid support, and was used to test the comparative economic costs of options to address the emerging network limitations. On this basis, and therefore in all situations where grid support costs might be greater than $0, the relevant options did not satisfy the Regulatory Test.

[22] Network losses are a function of the length and capacity of individual network elements, and the power being transferred through them. Additional network elements reduce the amount of power that must be forced through the existing network, and therefore reduce total losses.

7.0 FINANCIAL ANALYSIS

7.1 Description of Financial Analysis Approach

The economic analysis undertaken considered the net present value (NPV) costs of alternative options over the fifteen year period from 2002 to 2016. Full details of this analysis are contained in Appendix 1.

7.2 Net Present Value Analysis

Financial analysis was carried out to calculate and compare the Net Present Value (NPV) of the costs to market participants of each option under the range of assumed market development scenarios.

A fifteen year analysis period was selected, as an appropriate period for financial analysis. A discount rate of 10% was selected as a relevant commercial discount rate, and sensitivity analysis was conducted to test this assumption.

Capital and operating costs for items which are common to all options were not included in the analysis. These common costs include the capital and operating costs of other transmission and distribution works that Powerlink and Energex are proposing in the relevant area, where these costs are independent of the identified network constraints. As such, they have no impact on the relative ranking of options resulting from the analysis. Where the timing of common works is affected by the proposed options, the cost of the other works proposed has been included in the NPV analysis.

Under the Regulatory Test, it is the ranking of the options which is important, rather than the actual net present value results. This is because the Regulatory Test requires the recommended option to have the lowest net present value cost under most but not necessarily all plausible scenarios.

The following table is a summary of the economic analysis contained in Appendix 1. It shows the net present value of each alternative, and identifies the best ranked option, for the range of scenarios considered.

Discount rate 10%	**Scenario A** *Medium load growth*		**Scenario B** *High load growth*		**Scenario C** *Low load growth*	
	NPV ($M)	**Rank**	**NPV ($M)**	**Rank**	**NPV ($M)**	**Rank**
Option 1 From North First	$29.39	3	$31.30	2	$26.23	3
Option 2 Early Molendinar	$25.65	1	$28.33	1	$22.68	1
Option 3 Cable Upgrades Defer Molendinar	$29.10	2	$32.07	3	$23.95	2

7.3 Sensitivity Analysis:

In addition to examining the impact of varying load growth scenarios, the sensitivity of the option ranking to other critical parameters was also examined.

The effect of varying these parameters over their credible range was investigated using standard Monte Carlo techniques.[23] The following table shows the parameters that were investigated in the sensitivity analysis, the distribution that was assumed for each parameter and the range of values.

Parameter	Distribution
Capital Cost of Transmission and Distribution Network Components	The capital cost of all the network components was tested for sensitivity to variations of plus or minus 15% from the expected value. The variation in each cost was modelled as a triangular distribution with the assumption that the costs are statistically independent. This means that the cost of each network component is allowed to vary within plus and minus 15% independently of the over or underspend of the other components.
Cost of losses	The sensitivity to the average cost of losses was tested by allowing this parameter to vary randomly between $20/MWh and $30/MWh using a triangular distribution with a mode of $25/MWh.

The Monte Carlo analysis assigns a value to each of the above parameters according to its distribution and then ranks the options. This simulation is done many times (in this case, 1,000 times) to cover a large number of combinations of parameters. The analysis identifies which option is the best ranked option (the option that has the lowest cost on an NPV basis for the largest number of samples) and gives the frequency for which this option 'wins'.

In addition to the above sensitivities, the sensitivity of the ranking of options to the discount rate assumption was also investigated by repeating the above analysis with a discount rate of 8%, 10% and 12%. The following table shows the 'winning option' and the frequency for which it 'wins' for each scenario and discount rate across the range of parameters assessed.

	Discount Rate		
Scenario	8%	10%	12%
A – Medium load growth	2 (100%)	2 (100%)	2 (100%)
B – High load growth	2 (100%)	2 (100%)	2 (100%)
C – Low load growth	2 (99%)	2 (98%)	2 (96%)

As can be seen in this table, Option 2 is the best-ranked option in all scenarios. This outcome is robust in terms of all of the variations in parameters assessed.

[23] Using the @Risk add-in for Microsoft Excel.

8.0 DISCUSSION OF RESULTS

The following conclusions have been drawn from the analysis presented in this report:

- There is no acceptable 'do nothing' option. If the emerging network limitations are not addressed by the summer of 2003/04, power supply to customers on the Gold Coast will be unable to be maintained during single 110kV "ring" contingencies. Reliability of supply is also likely to be impacted during single Mudgeeraba 275/110kV transformer contingencies from the summer of 2003/04. This situation is not consistent with reliability standards which Powerlink and Energex, as the local transmission and distribution network service providers, must meet.

- Powerlink and Energex are unaware of any demand side management initiatives or local generation options capable of addressing the identified network limitations. Industry participants are invited to offer information in response to this draft recommendation, should they have any information about such alternatives.

- Of the three options assessed, only the advancement of a new 275kV injection point at Molendinar (near Nerang) is capable of immediately addressing both the 110kV ring and transformer limitation issues identified in this paper.

- The emerging network issues anticipated in late 2003 can also be addressed by two options involving a combination of 110kV augmentations and the procurement of grid support from the privately-owned market network service known as Directlink.

- Economic analysis has identified that Option 2 in this paper is the least-cost solution over a fifteen year period of analysis, thereby satisfying the ACCC Regulatory Test. Initial works in Option 2 to be completed by late 2003 include:
  - a new 275/110kV substation at Molendinar with a tee connection into existing 275kV lines at Maudsland
  - associated 110kV feeder and protection scheme rearrangements at Molendinar substation
  - Minor capacity upgrade of the Beenleigh-Cades County 110kV feeder.

- Sensitivity analysis showed this outcome to be very robust, with the option rankings insensitive to variations in critical parameters used in the analysis.

- The Regulatory Test requires that a transmission network service provider optimise the timing of any proposed network augmentation that is justified under the Regulatory Test. It is evident from the analysis that action is required prior to October 2003 in order to maintain a reliable power supply to customers. Any deferral of timing beyond late 2003 will result in unacceptable system reliability.

9.0 DRAFT RECOMMENDATION

Based on the conclusions drawn from the analysis, the following course of action is recommended to address the identified network limitations at Mudgeeraba substation and in the Gold Coast 110kV Ring:

Draft Recommendation:

- Powerlink to construct a 275kV transformer ended feeder between Maudsland and Molendinar by October 2003 at a cost of $22.9M.
- Energex to rearrange the 110kV feeder connections and associated protection schemes at Molendinar by late 2003 at a cost of $1.0M
- Energex to carry out a minor capacity upgrade of the Beenleigh-Cades County 110kV feeder by late 2003 at a cost of $0.5M
- Other network augmentations included in "Option 2" to be assessed at a later date according to Code and ACCC regulatory requirements. No commitment is to be made to these subsequent augmentations at this time.

Powerlink and Energex invite submissions from Code Participants and interested parties on this draft recommendation. Submissions are requested by Friday 8th March 2002.

Please address submissions to:

Alison Gray
Manager Network Assessments
PO Box 1193
Virginia QLD 4014
Tel: (07) 3860 2300
Fax: (07) 3860 2388
Agray@powerlink.qld.gov.au

Following consideration of the submissions, Powerlink expects to publish a final recommendation by late March 2002.

Summary

Discount rate 10%	Scenario A *Medium load growth* NPV ($M)	Rank	Scenario B *High load growth* NPV ($M)	Rank	Scenario C *Low load growth* NPV ($M)	Rank
Option 1 From North First	$29.39	3	$31.30	2	$26.23	3
Option 2 Early Molendinar	$25.65	1	$28.33	1	$22.68	1
Option 3 Cable Upgrades Defer Molendinar	$29.10	2	$32.07	3	$23.95	2

Development Options	**Scenario A** *Medium load growth*	**Scenario B** *High load growth*	**Scenario C** *Low load growth*
Option 1			
Rebuild Cades County-Beenleigh DC 110kV	03/04	03/04	03/04
Coomera 2nd 110/33 Transformer & 33kV Connection	03/04	03/04	03/04
Molendinar-Cades County DC 110kV	03/04	03/04	03/04
Gaven 110/11 2CBs & Transformer	03/04	03/04	03/04
Loganlea 2nd 275/110 Transformer	04/05	04/05	05/06
Molendinar-Surfers Paradise 110kV	06/07	05/06	07/08
Molendinar 275/110 Transformer & Tee Connection	07/08	06/07	09/10
Molendinar 110 kV feeder rearrangements	07/08	06/07	09/10
Option 2			
Molendinar 275/110 Transformer & Tee Connection	03/04	03/04	03/04
Molendinar 110 kV feeder rearrangements	03/04	03/04	03/04
Beenleigh-Cades County Thermal Upgrade	03/04	03/04	03/04
Rebuild Coomera-Cades County 110kV & 33kV	04/05	04/05	05/06
Extra Coomera 33kV Works	04/05	04/05	05/06
Molendinar-Surfers Paradise 110kV	06/07	05/06	07/08
Loganlea 2nd 275/110 Transformer	09/10	07/08	11/12
Energex 110kV & 33kV Strengthening	11/12	09/10	14/15
Option 3			
Upgrade Merrimac-Broadbeach Cable	03/04	03/04	03/04
Beenleigh-Cades County Thermal Upgrade	03/04	03/04	03/04
Rebuild Coomera-Cades County 110kV & 33kV	04/05	04/05	05/06
Extra Coomera 33kV Works	04/05	04/05	05/06
Loganlea 2nd 275/110 Transformer	05/06	05/06	06/07
Molendinar 275/110 Transformer & Tee Connection	07/08	06/07	09/10
Molendinar 110 kV feeder rearrangements	07/08	06/07	09/10
Molendinar-Surfers Paradise 110kV	08/09	07/08	10/11
Energex 110kV & 33kV Strengthening	11/12	09/10	14/15

2

Scenario A		*Medium load growth*														
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
		02/03	**03/04**	**04/05**	**05/06**	**06/07**	**07/08**	**08/09**	**09/10**	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**	**15/16**	**16/17**
Option 1		**From North First**														
Rebuild Cades County-Beenleigh DC 110kV																
Coomera 2nd 110/33 Transformer & 33kV Connection																
Molendinar-Cades County DC 110kV																
Gaven 110/11 2CBs & Transformer																
=> DUOS		0.000	0.000	2.310	2.279	2.248	2.217	2.187	2.156	2.125	2.094	2.063	2.033	2.002	1.971	1.940
==> NPV of DUOS	$12.71															
Loganlea 2nd 275/110 Transformer																
=>TUOS		0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609	0.600	0.591	0.582	0.573	0.564
==> NPV of TUOS	$3.19															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150	1.133	1.116
==> NPV of DUOS	$4.60															
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	2.635	2.600	2.565	2.530	2.494	2.459	2.424	2.389	2.354
==> NPV of TUOS	$8.18															
Relative Losses																
* Losses $		0.000	0.245	0.216	0.181	0.266	0.099	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Losses	$0.71															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 1	**$29.39**															
Option 2		**Early Molendinar**														
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
Beenleigh-Cades County Thermal Upgrade																
=> TUOS/DUOS		0.000	0.000	2.690	2.654	2.618	2.582	2.547	2.511	2.475	2.439	2.403	2.367	2.331	2.296	2.260
==> NPV of TUOS/DUOS	$14.80															
Rebuild Coomera-Cades County 110kV & 33kV																
Extra Coomera 33kV Works																
=> DUOS		0.000	0.000	0.000	0.402	0.397	0.392	0.386	0.381	0.376	0.370	0.365	0.359	0.354	0.349	0.343
==> NPV of DUOS	$1.94															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150	1.133	1.116
==> NPV of DUOS	$4.60															
Loganlea 2nd 275/110 Transformer																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609
==> NPV of TUOS	$1.45															
Energex 110kV & 33kV Strengthening																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.725	1.702	1.679	1.656	1.633
==> NPV of DUOS	$2.46															
Relative Losses																
* Losses $		0.000	0.000	0.000	0.000	0.000	0.204	0.324	0.204	0.047	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Losses	$0.40															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 2	**$25.65**															
Option 3		**Cable Upgrades Defer Molendinar**														
Upgrade Merrimac-Broadbeach Cable																
Beenleigh-Cades County Thermal Upgrade																
=> DUOS		0.000	0.000	1.047	1.033	1.019	1.005	0.992	0.978	0.964	0.950	0.936	0.922	0.908	0.894	0.880
==> NPV of DUOS	$5.76															
Write off existing Merrimac- Broadbeach cables	$2.93	0.000	0.000	3.900	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rebuild Coomera-Cades County 110kV & 33kV																
Extra Coomera 33kV Works																
=> DUOS		0.000	0.000	0.000	0.402	0.397	0.392	0.386	0.381	0.376	0.370	0.365	0.359	0.354	0.349	0.343
==> NPV of DUOS	$1.94															
Loganlea 2nd 275/110 Transformer																
=> TUOS		0.000	0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609	0.600	0.591	0.582	0.573
==> NPV of TUOS	$2.78															
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	2.635	2.600	2.565	2.530	2.494	2.459	2.424	2.389	2.354
==> NPV of TUOS	$8.18															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150
==> NPV of DUOS	$3.33															
Energex 110kV & 33kV Strengthening																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.725	1.702	1.679	1.656	1.633
==> NPV of DUOS	$2.46															
Relative Losses																
* Losses $		0.000	0.380	0.558	0.470	0.529	0.286	0.152	0.152	0.050	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Losses	$1.71															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 3	**$29.10**															

3

Scenario B		*High load growth*														
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
		02/03	**03/04**	**04/05**	**05/06**	**06/07**	**07/08**	**08/09**	**09/10**	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**	**15/16**	**16/17**
Option 1		**From North First**														
Rebuild Cades County-Beenleigh DC 110kV																
Coomera 2nd 110/33 Transformer & 33kV Connection																
Molendinar-Cades County DC 110kV																
Gaven 110/11 2CBs & Transformer																
=> DUOS		0.000	0.000	2.310	2.279	2.248	2.217	2.187	2.156	2.125	2.094	2.063	2.033	2.002	1.971	1.940
==> NPV of DUOS	$12.71															
Loganlea 2nd 275/110 Transformer																
=>TUOS		0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609	0.600	0.591	0.582	0.573	0.564
==> NPV of TUOS	$3.19															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150	1.133	1.116	1.099
==> NPV of DUOS	$5.32															
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
=> TUOS		0.000	0.000	0.000	0.000	0.000	2.635	2.600	2.565	2.530	2.494	2.459	2.424	2.389	2.354	2.319
==> NPV of TUOS	$9.55															
Relative Losses																
* Losses $		0.000	0.245	0.216	0.181	0.067	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Losses	$0.53															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 1	**$31.30**															
Option 2		**Early Molendinar**														
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
Beenleigh-Cades County Thermal Upgrade																
=> TUOS/DUOS		0.000	0.000	2.690	2.654	2.618	2.582	2.547	2.511	2.475	2.439	2.403	2.367	2.331	2.296	2.260
==> NPV of TUOS/DUOS	$14.80															
Rebuild Coomera-Cades County 110kV & 33kV																
Extra Coomera 33kV Works																
=> DUOS		0.000	0.000	0.000	0.402	0.397	0.392	0.386	0.381	0.376	0.370	0.365	0.359	0.354	0.349	0.343
==> NPV of DUOS	$1.94															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150	1.133	1.116	1.099
==> NPV of DUOS	$5.32															
Loganlea 2nd 275/110 Transformer																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609	0.600	0.591
==> NPV of TUOS	$2.05															
Energex 110kV & 33kV Strengthening																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.725	1.702	1.679	1.656	1.633	1.610	1.587
==> NPV of DUOS	$3.78															
Relative Losses																
* Losses $		0.000	0.000	0.000	0.000	0.204	0.324	0.204	0.047	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Losses	$0.44															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 2	$28.33															
Option 3		**Cable Upgrades Defer Molendinar**														
Upgrade Merrimac-Broadbeach Cable																
Beenleigh-Cades County Thermal Upgrade																
=> DUOS		0.000	0.000	1.047	1.033	1.019	1.005	0.992	0.978	0.964	0.950	0.936	0.922	0.908	0.894	0.880
==> NPV of DUOS	$5.76															
Write off existing Merrimac- Broadbeach cables	$2.93	0.000	0.000	3.900	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rebuild Coomera-Cades County 110kV & 33kV																
Extra Coomera 33kV Works																
=> DUOS		0.000	0.000	0.000	0.402	0.397	0.392	0.386	0.381	0.376	0.370	0.365	0.359	0.354	0.349	0.343
==> NPV of DUOS	$1.94															
Loganlea 2nd 275/110 Transformer																
=> TUOS		0.000	0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609	0.600	0.591	0.582	0.573
==> NPV of TUOS	$2.78															
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
=> TUOS		0.000	0.000	0.000	0.000	0.000	2.635	2.600	2.565	2.530	2.494	2.459	2.424	2.389	2.354	2.319
==> NPV of TUOS	$9.55															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150	1.133
==> NPV of DUOS	$3.94															
Energex 110kV & 33kV Strengthening																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.725	1.702	1.679	1.656	1.633	1.610	1.587
==> NPV of DUOS	$3.78															
Relative Losses																
* Losses $		0.000	0.380	0.558	0.470	0.237	0.152	0.152	0.050	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Losses	$1.39															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 3	$32.07															

4

Scenario C		*Low load growth*														
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*	*13*	*14*	*15*
		02/03	**03/04**	**04/05**	**05/06**	**06/07**	**07/08**	**08/09**	**09/10**	**10/11**	**11/12**	**12/13**	**13/14**	**14/15**	**15/16**	**16/17**
Option 1		**From North First**														
Rebuild Cades County-Beenleigh DC 110kV																
Coomera 2nd 110/33 Transformer & 33kV Connection																
Molendinar-Cades County DC 110kV																
Gaven 110/11 2CBs & Transformer																
=> DUOS		0.000	0.000	2.310	2.279	2.248	2.217	2.187	2.156	2.125	2.094	2.063	2.033	2.002	1.971	1.940
==> NPV of DUOS	$12.71															
Loganlea 2nd 275/110 Transformer																
=>TUOS		0.000	0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609	0.600	0.591	0.582	0.573
==> NPV of TUOS	$2.78															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150	1.133
==> NPV of DUOS	$3.94															
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.635	2.600	2.565	2.530	2.494	2.459	2.424
==> NPV of TUOS	$5.78															
Relative Losses																
* Losses $		0.000	0.245	0.368	0.216	0.181	0.201	0.266	0.099	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Losses	$1.04															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 1	**$26.23**															
Option 2		**Early Molendinar**														
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
Beenleigh-Cades County Thermal Upgrade																
=> TUOS/DUOS		0.000	0.000	2.690	2.654	2.618	2.582	2.547	2.511	2.475	2.439	2.403	2.367	2.331	2.296	2.260
==> NPV of TUOS/DUOS	$14.80															
Rebuild Coomera-Cades County 110kV & 33kV																
Extra Coomera 33kV Works																
=> DUOS		0.000	0.000	0.000	0.000	0.402	0.397	0.392	0.386	0.381	0.376	0.370	0.365	0.359	0.354	0.349
==> NPV of DUOS	$1.69															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183	1.166	1.150	1.133
==> NPV of DUOS	$3.94															
Loganlea 2nd 275/110 Transformer																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626
==> NPV of TUOS	$0.94															
Energex 110kV & 33kV Strengthening																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.725	1.702
==> NPV of DUOS	$0.86															
Relative Losses																
* Losses $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.204	0.324	0.333	0.204	0.047	0.000	0.000	0.000
=> NPV of Losses	$0.45															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 2	$22.68															
Option 3		**Cable Upgrades Defer Molendinar**														
Upgrade Merrimac-Broadbeach Cable																
Beenleigh-Cades County Thermal Upgrade																
=> DUOS		0.000	0.000	1.047	1.033	1.019	1.005	0.992	0.978	0.964	0.950	0.936	0.922	0.908	0.894	0.880
==> NPV of DUOS	$5.76															
Write off existing Merrimac- Broadbeach cables	$2.93	0.000	0.000	3.900	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Rebuild Coomera-Cades County 110kV & 33kV																
Extra Coomera 33kV Works																
=> DUOS		0.000	0.000	0.000	0.000	0.402	0.397	0.392	0.386	0.381	0.376	0.370	0.365	0.359	0.354	0.349
==> NPV of DUOS	$1.69															
Loganlea 2nd 275/110 Transformer																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.662	0.653	0.644	0.635	0.626	0.617	0.609	0.600	0.591	0.582
==> NPV of TUOS	$2.40															
Molendinar 275/110 Transformer & Tee Connection																
Molendinar 110 kV feeder rearrangements																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.635	2.600	2.565	2.530	2.494	2.459	2.424
==> NPV of TUOS	$5.78															
Molendinar-Surfers Paradise 110kV																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.268	1.251	1.234	1.217	1.200	1.183
==> NPV of DUOS	$2.27															
Energex 110kV & 33kV Strengthening																
=> DUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.725	1.702
==> NPV of DUOS	$0.86															
Relative Losses																
* Losses $		0.000	0.380	0.569	0.558	0.470	0.429	0.529	0.286	0.152	0.158	0.152	0.050	0.000	0.000	0.000
=> NPV of Losses	$2.26															
Grid Support Costs																
* Grid Support $		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
=> NPV of Grid Support	$0.00															
Total NPV for Option 3	$23.95															