Final Report

New Large Network Asset
Ipswich Area Reinforcement

Report by Powerlink Queensland
25 July 2005

DOCUMENT PURPOSE

For the benefit of those not familiar with the National Electricity Rules (NER) and the National Electricity Market (NEM), Powerlink offers the following clarifications on the purpose and intent of this document:

1. The document is produced in accordance with the NER, which requires Powerlink to carry out forward planning, and to issue this type of document for "new large network assets" as defined in the NER.

2. The NER requires Powerlink to identify, evaluate and compare both network and non-network proposals to determine which can overcome future supply requirements at the lowest cost to electricity consumers. This document contains the results of this evaluation in accordance with NER requirements.

3. The purpose of this document is to recommend a proposal for a specific set of future issues, in time for the proposal to be implemented, and allow input by industry participants and other interested parties.

What the document does NOT mean:

A. It does NOT mean that the lights are about to go out. The identified supply requirements are expected to arise some years into the future, assuming that demand for electricity continues to grow. There is enough time between now and then to implement a solution.

B. It does NOT mean that Powerlink has been surprised, or that anything is "out of the ordinary". On the contrary, it is part of the normal, routine planning processes in the NEM.

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EXECUTIVE SUMMARY

Introduction

Electricity demand in the Ipswich Area is forecast to grow strongly at around 7% per annum in the next three years, due to significant residential, commercial and industrial development and the continued installation of domestic air conditioners. This area extends from Gatton in the west to Goodna in the east and from Abermain in the north to Ripley/Swanbank in the south.

This strong demand growth is forecast to increase loadings on the electricity transmission network supplying this area, such that the technical capability of the supply network will be fully utilised by the summer 2007/08. Augmentation will be required at this time to ensure customers continue to receive a reliable electricity supply.

Powerlink recognises the importance of maintaining a reliable electricity supply to its customers, and has undertaken an extensive planning investigation to identify feasible supply proposals to address the future requirements.

This Final Report has been prepared as part of a standard National Electricity Rules process for the approval of new large network assets. It contains the results of the planning investigation and economic assessment of feasible supply solutions. In accordance with the AER Regulatory Test, the supply solution that meets the reliability requirements at the lowest total present value cost is recommended for implementation.

Options Considered

Powerlink carried out consultation with industry participants and interested parties to identify feasible network and non-network options, to address the Ipswich Area future supply requirements. No feasible non-network solutions were identified within the study area.

In addition to the consultation process, alternative network augmentation options to address the future supply requirements were considered. Planning studies were carried out by Powerlink to evaluate these alternatives.

Three feasible network options were evaluated in detail to compare the present value of the costs to market participants, in accordance with the Regulatory Test. The augmentation options to address the Ipswich Area requirements are:

- Option 1 – Establish new 275/110kV substations at Goodna in 2007 and Abermain in 2008 (rebuild of Swanbank ‘A’ 110kV substation reduced and deferred).
- Option 2 – Establish a new 275kV substation at Abermain in 2007 with a full rebuild of Swanbank ‘A’ 110kV substation in 2007.
- Option 3 – Install a third transformer at Swanbank with a full rebuild of Swanbank ‘A’ 110kV substation in 2007.

Evaluation and Conclusion

The AER Regulatory Test requires that, for reliability augmentations, the recommended option represent the lowest present value cost in a majority of reasonable scenarios.

To allow comparison of options on an equivalent basis, the economic analysis was carried out over fifteen years, and included consideration of anticipated/modelled projects that are expected to be required in this period to meet forecast growth in electricity demand in the Ipswich Area. Market development scenarios and other analytical techniques were used to check the sensitivity of the outcome to changes in underlying assumptions.

The economic analysis in this paper identifies Option 1 as the least cost solution for the majority of credible scenarios considered over the fifteen-year analysis timeframe. Sensitivity analysis shows this result to be robust under a range of assumptions.

The option chosen, whilst being the least cost option, is also strategically the best long-term option because it also positions the transmission network to be able to respond effectively to the expected large load growth in the Ipswich Area.

Consequently, a draft recommendation to implement Option 1 to address the future supply requirements of the Ipswich Area from late 2007 was published in an Application Notice on 3 June 2005. The proposed new large network assets are:

- a new 275/110kV substation at Goodna, to be completed in late 2007, at an estimated capital cost of $18.3m in 2004/05 prices
- a new 275/110kV substation at Abermain, to be completed in late 2008, at an estimated capital cost of $19.6m in 2004/05 prices

No submissions were received in response to the draft recommendation.

Powerlink has therefore adopted the draft recommendation without change as its final recommendation and immediate steps will be taken to implement this recommendation.

1. INTRODUCTION

Electricity demand in the Ipswich Area is experiencing strong growth as a result of increasing population and significant housing and commercial development. This strong growth is forecast to continue, with significant areas identified for future development in the South East Queensland Regional Plan. For the purposes of this consultation, the "Ipswich Area" includes the area from Gatton in the west to Goodna in the east and from Abermain in the north to Ripley/Swanbank in the south. This area includes a mix of loads including residential, Ipswich CBD and scattered industrial load.

As part of its commitment to maintaining a reliable supply to customers in the area, Powerlink has undertaken routine planning studies to identify future supply requirements, taking into account proposed developments by Energex. Based on the forecast growth for this area, it has been determined that a planning decision is now required to enable works to be constructed by late 2007. This will ensure a reliable electricity supply in the Ipswich Area for the forecast 2007/08 summer peak loads.

This document has been prepared as part of a standard National Electricity Rules (NER) process for the planning of new large electricity network assets. Where a Network Service Provider proposes to establish a new large network asset, it is required to issue an 'Application Notice' under clause 5.6.6 of the National Electricity Rules. The NER then requires consideration of any submissions received in response to the Application Notice, and preparation of a Final Report.

This Final Report must contain information regarding:

- the reasons the augmentation is required, including, if relevant, why it is considered a "reliability augmentation" as defined in the NER;
- feasible options available to address the future supply requirements, including non-network alternatives;
- the recommended solution, including the timetable for implementation; and
- why the solution satisfies the Regulatory Test prescribed by the Australian Energy Regulator (AER); and
- a summary of submissions received from interested parties and the applicant's response to each submission.

This document contains a final recommendation for works to be undertaken to meet reliability of electricity supply obligations for the 2007/08 summer peak loads. This final recommendation is based on:

- the assessment that a planning decision is now required to maintain a reliable power supply in the Ipswich Area during single network contingencies for the 2007/08 peak load period;
- the consultation undertaken by Powerlink to identify potential solutions to address these future supply requirements;
- analysis of feasible options in accordance with the Regulatory Test prescribed by the AER; and
- the publication of an Application Notice containing a draft recommendation to address the future supply requirements to allow comment by interested parties.

The recommended solution minimises the present value of the costs to participants in the National Electricity Market while meeting the reliability standards in the National Electricity Rules and Powerlink's transmission licence.

2. REASONS AUGMENTATION IS REQUIRED

2.1 Supply to the Ipswich Area

2.1.1 Network Ownership

The two electricity network owners responsible for the supply of electricity to the Ipswich Area are:

- Powerlink Queensland (Transmission Network Service Provider) who is the owner and operator of the Queensland high voltage transmission grid, including the 275kV and a majority of the 110kV transmission network supplying the Ipswich Area.

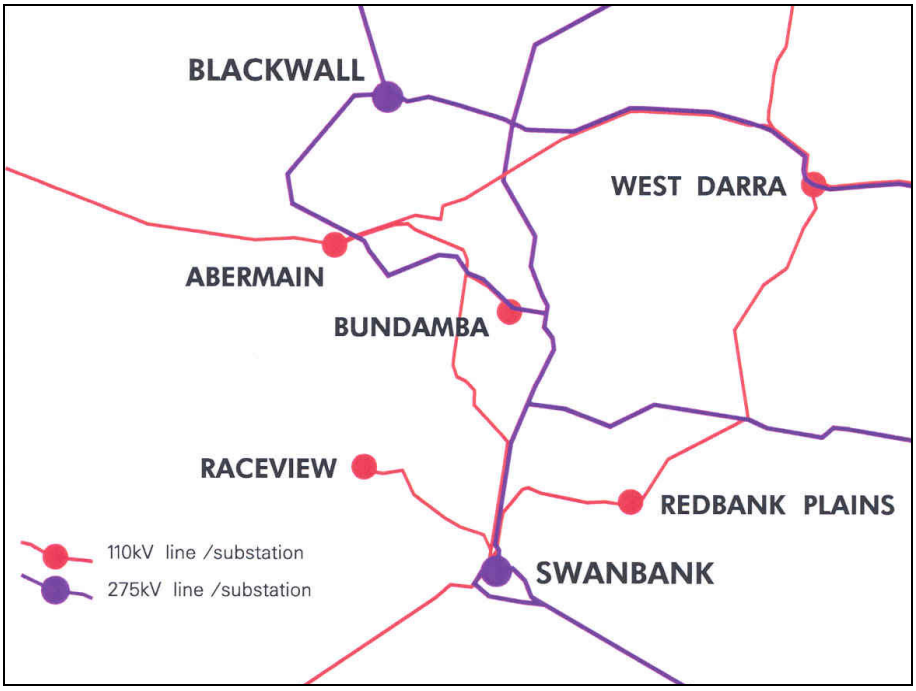
- Energex (Distribution Network Service Provider) who owns and operates the electricity distribution network in south-east Queensland, including the Ipswich Area.

2.1.2 Transmission Network

The 110kV network in the Ipswich Area supplies a number of Energex 110/33kV bulk supply substations, which transform electricity to voltages suitable to distribute to customers. This 110kV network is primarily supplied through two 275/110kV transformers at Swanbank, supported by 110kV interconnection via West Darra to Rocklea and South Pine.

Figure 2-1 shows the current transmission network that supplies the Ipswich area.

Figure 2-1: Existing Transmission Network in the Ipswich Area



A number of developments in the near future will change the way that this network operates. As a result of last year's Regulatory Test process and public consultation

culminating in the final report in December 2004[1], new 110kV substations are being established at Algester, Goodna and Sumner.

Forecast high load growth in the next few years will place extra demand on the 275/110kV transformers supplying the network, resulting in one of the Swanbank transformers overloading following the outage of the other. Network analysis has revealed that for summer peak conditions in 2007/08, the outage of either Swanbank transformer will result in a flow of around 360MVA through the other. Given that these transformers have cyclic ratings of 285 and 299MVA, reinforcement is necessary to avoid transformer overloads.

The following committed transmission network augmentations are already being implemented in response to the growing electricity usage in the Brisbane and Ipswich areas.

Table 2-1: Committed Transmission Network Augmentations

Project	Objective	Date to be Operational
Network Reconfiguration (West Darra/Belmont)	The 110kV network from West Darra to Belmont is being reconfigured to optimise the performance of the network.	Late 2005
Network Reconfiguration (Brisbane CBD)	Works to split the current 110kV "ring" that supplies the Brisbane CBD to optimise the performance of the network.	Late 2005
Algester 110/33kV Substation Establishment	Meet growing demand in the Energex distribution networks in South West Brisbane.	Late 2006
Goodna 110/33kV Substation Establishment	Meet growing demand in the Energex distribution networks in South West Brisbane.	Late 2006
Sumner 110/11kV Substation Establishment	Meet growing demand in the Energex distribution networks in South West Brisbane.	Late 2006

In addition to the works listed above, Swanbank 'A' 110kV substation is nearing the end of its technical life and will require rebuilding by late 2007 to address plant condition and fault level issues[2]. This will be very complex as any rebuild would need to be in-situ adjacent to live circuits. This results in higher risks throughout the planning and delivery of the project, which adds to the capital cost of the rebuild.

2.1.3 Distribution Network

Energex have significant programs of committed capital works within south-east Queensland to address load growth. While these works do not directly provide additional transfer capability into the Ipswich Area, all of the works have a cumulative impact on the power flows within the electricity supply system. They have therefore been considered in the planning analysis described in this document.

Committed works are detailed in Powerlink's Annual Planning Report and the Energex Annual Network Management Plan. However, more relevant works include 33kV and 11kV distribution works associated with the new 110kV substations at Algester, Goodna and Sumner and Energex's program of new transformer installations throughout its network to meet growing load growth.

[1] Proposed New Large Network Assets: South West Brisbane Area – Final Report, Powerlink & Energex, 17 December 2004.

[2] Short circuits on electricity networks can cause high fault currents to flow. These fault currents can be many times higher than normal load currents and the power network must be specially designed to withstand and interrupt the highest fault currents that are expected to occur.

2.2 Planning Criteria for Network Development

Powerlink's Transmission Authority requires Powerlink to plan and develop its network such that the power transfer available through the power system will be adequate to supply the forecast peak demand during the most critical single network element outage. Therefore, capacity is required to be provided to the Ipswich Area such that the forecast peak demand can be supplied with the most critical element out of service.

Powerlink, as a Transmission Network Service Provider (TNSP), must also comply with technical standards in the National Electricity Rules. In particular, requirements relating to reliability and system security contained in Schedule 5.1 of the NER must be met. Schedule 5.1 also includes details of credible contingencies and levels of redundancy to be considered in planning and operating the transmission network.

Additionally, the connection agreement between Powerlink and Energex includes obligations regarding the reliability of supply, as required under clause 5.1.2.2 of the NER.

Planning for augmentation of the interconnected 275kV and 110kV network is based on the ability to meet peak load following the worst single credible fault or contingency (sometimes referred to as "N-1").

Augmentation is required to ensure Powerlink will be able to meet these obligations for the forecast peak loads in the summer, therefore solutions to address the forecast supply requirements are classified as a reliability augmentation[3].

2.3 Future Supply Requirements

Powerlink carries out regular transmission system planning assessments and has identified that action is required to maintain a reliable electricity supply to the Ipswich Area in late 2007.

2.3.1 Future Supply Requirements – Transmission Network

Powerlink has carried out routine planning studies for the Ipswich Area, based upon the existing transmission network, the load forecasts described in section 3.2 and typical generation dispatch during summer peak periods[4]. Sensitivity analysis was carried out as part of the planning studies to examine sensitivity to changes in planning assumptions (refer section 8.2).

These studies have shown that if either one of the 275/110kV transformers at Swanbank is out of service, the adjacent transformer remaining in service would have insufficient capacity for summer 2007/08.

Consequently, supply augmentation is required by late 2007 to address this reliability of supply requirement and ensure that Powerlink meets its regulatory obligations, described in section 4.1.

[3] A transmission network augmentation that is necessitated solely by the inability to meet the minimum network performance requirements set out in schedule 5.1 or in relevant legislation, regulations or any statutory instrument of a participating jurisdiction.

[4] The output of embedded generation is included as a reduction to the forecast peak demand and hence has been incorporated in the studies.

Conclusion on Future Supply Requirements

The planning analysis above outlines the need for future action to reinforce supply to the Ipswich Area by late 2007 to ensure continued reliability of electricity supply. This is to avoid transformer overloads that are forecast to occur only if no action was to be taken. Because this reinforcement is necessitated solely to meet reliability of supply obligations, it is a 'reliability augmentation' as defined in the NER

3. RESPONSES TO THE CONSULTATION PROCESS

3.1 Submissions to Application Notice

Powerlink issued an Application Notice for Proposed New Large Network Assets on 3 June 2005, which contained a draft recommendation to address future supply requirements in the Ipswich Area. The recommended scope of works was as follows:

- Powerlink establish a new 275/110kV substation at Goodna, to be completed in late 2007, at an estimated capital cost of $18.3m in 2004/05 prices
- Powerlink establish a new 275/110kV substation at Abermain, to be completed in late 2008, at an estimated capital cost of $19.6m in 2004/05 prices

No submissions were received in response to the Application Notice.

4. OPTIONS CONSIDERED

4.1 Identification and Assessment of Options

Powerlink identified in its 2003 and 2004 Annual Planning Reports[5] an expectation that action would be required in this timeframe to address future 275/110kV transformer capacity requirements in the Moreton North and Moreton South zones, which includes the Ipswich Area. Powerlink has received no information relating to non-network options from industry participants in response to these requirements highlighted in the Annual Planning Reports.

Powerlink has also carried out planning studies to consider non-network and network options. This included load flow analysis and other technical assessment to determine the capability of potential options to supply future customer electricity needs in the Ipswich Area.

A summary of the consultation and planning outcomes, together with an outline of the options and anticipated/modelled projects considered, are contained in sections 4.2 to 4.4. Further details on feasible options to address the future supply requirements in the Ipswich Area are provided in section 5, with economic evaluation of options contained in Appendix 2.

4.2 Non-Network Options

The consultation process described above in section 4.1 provided information regarding the status of potential Demand Side Management (DSM) and generation options in the south-west Brisbane area. Powerlink has considered whether such potential options would address the Ipswich Area future supply requirements.

4.2.1 Demand Side Management

Demand Side Management initiatives involve reducing the amount of power that needs to be supplied through the electricity network. This can be achieved through agreements to interrupt customer electricity supply during peak periods, energy efficiency initiatives or use of alternative fuel sources such as gas.

Powerlink's demand and energy forecasts include all existing and foreseen DSM initiatives incorporated in Energex's load forecast for the Ipswich Area. These initiatives, which include routine hot water switching activities, are therefore already being used to defer augmentations as long as practical.

Powerlink is not aware of any new Demand Side Management initiatives in the Ipswich Area.

[5] Published in June 2003 and 2004 respectively.

4.2.2 New Local Generation

An allowance for potential cogeneration and renewable energy developments embedded[6] in the distribution network in the relevant area is already included in Energex's forecasts of electricity demand. Generation above the levels allowed would be required if local generation were to reduce demand on the transmission and distribution networks and defer the need for other forms of action.

To be considered as a viable option, a new generation proposal would need to be committed and operational prior to late 2007. The earlier consultation process for south-west Brisbane did not identify any parties or new generation proposals in the Ipswich Area capable of meeting this requirement. Powerlink has therefore concluded that there are no additional generation proposals that can be considered as a viable option to reduce the demand on the electricity network supplying the Ipswich Area prior to late 2007.

Conclusion on Non-Network Options

There are no viable non-network options to address the future supply requirements in the Ipswich Area. Demand side management initiatives are insufficient to offset one year's demand growth and there is no indication that sufficient new local generation could be developed by the required timeframe.

4.3 Network Options

Powerlink has carried out planning studies to determine the most appropriate network option to address the future supply requirements in the Ipswich Area. This planning process seeks to identify solutions that will ensure a reliable electricity supply at the lowest overall cost to customers.

4.3.1 Feasible Augmentation Options

An overview of feasible network options considered is provided below, with further details provided in section 5. A range of viable network options were considered, and the three that best met the requirements of the National Electricity Rules are presented in detail in this document.

Table 4-1: Feasible Network Augmentations

Feasible Network Augmentations	
Option 1	Establish new 275/110kV substations at Goodna in 2007 and Abermain in 2008 (rebuild of Swanbank 'A' 110kV substation reduced and deferred).
Option 2	Establish a new 275/110kV substation at Abermain in 2007 with a full rebuild of Swanbank 'A' 110kV substation in 2007.
Option 3	Install a third transformer at Swanbank with a full rebuild of Swanbank 'A' 110kV substation in 2007.

[6] An embedded generator connects directly to the distribution network. Output from such generators therefore reduces the expected energy that the transmission grid is required to deliver. Embedded generators may also reduce the demand the transmission grid is required to deliver, depending on their mode of operation.

It should be noted that the options described above deliver different increments in supply capacity to the Ipswich Area. These differences are taken into account in the economic comparison of options by considering future anticipated/modelled projects that are expected to be required under each option during the planning horizon.

Conclusions on Network Options

There are three alternative augmentations of the transmission network that would address the future supply requirements in the Ipswich Area. These options are considered further in section 5, in combination with anticipated/modelled augmentations, to address future supply requirements in the Ipswich Area in accordance with the National Electricity Rules and Powerlink's licence.

4.4 Anticipated/Modelled Projects

In accordance with the AER Regulatory Test, the economic analysis of options includes future anticipated/modelled projects[7] that may be required within the planning horizon. All options are expected to require a series of augmentations during the fifteen-year period analysed to meet the increasing demand forecast for the Ipswich Area over that period. Works required beyond 2008 are not recommended for approval in this Final Report, but are included to ensure the proposed augmentations are compared on an equivalent basis. The sensitivity of the analysis to these assumptions is tested through the use of market development and other reasonable scenarios.

Some anticipated/modelled projects are common to all of the options considered[8], with the scope of works and timing varying depending on what works are undertaken in the earlier years. Some augmentations provide a larger increment in network capability, and therefore provide for forecast load growth further into the future before additional action would be required.

It should be noted some of the anticipated/modelled projects for one option form part of the proposed augmentations in the other option (i.e. they will be necessary in 2007 rather than at a later time).

[7] The AER Regulatory Test defines anticipated projects as "projects … which have expected commissioning dates within five years" and 'modelled projects' as "other investments which are likely to be commissioned in response to growing demand…".

[8] Meaning that by the end of the fifteen-year period of analysis, the transmission network would look similar for most options.

5. FEASIBLE OPTIONS

This section provides an overview of the feasible proposed augmentation options identified, with full details of the economic analysis contained in Appendix 2.

The proposed network augmentations to address the future supply requirements of the Ipswich Area are:

- Option 1 – Establish new 275/110kV substations at Goodna in 2007 and Abermain in 2008 (rebuild of Swanbank 'A' 110kV substation deferred).
- Option 2 – Establish a new 275/110kV substation at Abermain in 2007 with a full rebuild of Swanbank 'A' 110kV substation in 2007.
- Option 3 – Install a third transformer at Swanbank with a full rebuild of Swanbank 'A' 110kV substation in 2007.

All of the proposed development options involve a series of projects to address the increasing electricity demand that is expected to occur in the Ipswich Area. Works required beyond 2008 are not recommended for approval in this Final Report, but are included to ensure the proposed augmentations are compared on an equivalent basis. The sensitivity of the analysis to these assumptions is tested through the use of market development scenarios.

Timings for anticipated/modelled projects are based on meeting future electricity supply requirements for the Ipswich Area based on the load forecast prepared by Energex in November 2004 and published in Powerlink's Annual Planning Report on 30 June 2005. Load forecasts are reviewed annually and actual timings of the anticipated/ modelled projects may change as a result of the ongoing review of load forecasts for the area during the fifteen-year planning horizon.

5.1 Option 1 – New 275kV Substations at Goodna & Abermain

Option 1 addresses the future supply requirements in the Ipswich Area by establishing two new 275/110kV substations. A key benefit of this option is that by establishing the two new 110kV infeeds at Goodna and Abermain, the scope of the rebuild of Swanbank 'A' 110kV substation is reduced and the timing deferred.

Table 5-1: Option 1 Proposed Augmentations

Date Required	Proposed Augmentations	Cost ($m, 04/05)
Late 2007	Establish Goodna 275kV substation and install one 375MVA 275/110kV transformer.	18.3
Late 2008	Establish Abermain 275kV substation and install one 375MVA 275/110kV transformer.	19.6

This option involves establishing a new 275kV substation in 2007 at Goodna adjacent to the existing 110kV site and the installation of one 375MVA 275/110kV transformer to supply Goodna 110kV substation. Additionally in 2008, a new 275kV substation at Abermain would be established adjacent to the existing 110kV site. The substation layout would be similar to Goodna, with one 375MVA 275/110kV transformer supplying Abermain 110kV substation.

This option eliminates the need for a dedicated 110kV cable in 2006 between Swanbank and the expected new large customer load, due to the improved load sharing following the establishment of a new 110kV injection point at Goodna.

Further works will be required beyond 2008 as the Ipswich Area continues to grow. The anticipated/modelled projects likely to be required in Option 1 based on current load forecasts are shown in the table below. The anticipated timings for these augmentations have been determined through planning studies, which examined when further action is required. Scenarios have been developed to test the sensitivity of the analysis to factors that might affect the assumptions regarding anticipated/modelled projects.

Table 5-2: Option 1 Anticipated/Modelled Projects

Date Required	Anticipated/Modelled Projects[9]	Cost ($m, 04/5)
Late 2009	Reduced-scope Swanbank 'A' rebuild.	13.3
Late 2011	Bundamba to Goodna 275kV Reinforcement[10].	7.0
Late 2014	Establish Upper Kedron 275kV substation and install two 375MVA 275/110kV Transformers.	24.9

As described in section 2.1.2, Swanbank 'A' 110kV substation is nearing the end of its technical life and will require rebuilding by late 2007 to address plant condition and fault levels issues. A full rebuild of the substation will be very complex and would incur considerable capital cost. However, establishing new 110kV infeeds at Goodna and Abermain with the installation of the new 275/110kV transformers, the scope of the rebuild of Swanbank 'A' 110kV substation is reduced and the timing deferred.

In late 2011, it is anticipated that a new double circuit 275kV overhead line will be required from Bundamba 'tee' to Goodna to meet reliability standards.

Together, the new substations at Goodna and Abermain also defer an anticipated major reliability augmentation in the wider western Brisbane area. Due to the specific site constraints at Upper Kedron, it is estimated that the costs for this project will be higher than the equivalent costs at Goodna and Abermain.

[9] Some future developments whose timing is common to all options have not been included, as they have no impact upon the relative ranking of options in the Regulatory Test analysis (refer section 7.4).

[10] This forms part of the expected reinforcement works between Bundamba and Larapinta. Only this section has been included in the Regulatory Test analysis because the timing of the remaining section between Goodna and Larapinta is common to all options.

5.2 Option 2 – New 275kV Substation at Abermain & Swanbank 'A' 110kV Substation Rebuild

Option 2 addresses the future supply requirements in the Ipswich Area by establishing a new 275/110kV substation at Abermain and fully rebuilding Swanbank 'A' 110kV substation to meet the increased fault level.

Table 5-3: Option 2 Proposed Augmentations

Date Required	Proposed Augmentations	Cost ($m, 04/05)
Late 2006	Separate 110kV cable from Swanbank to new customer load.	4.0
Late 2007	Establish Abermain 275kV substation and install one 375MVA 275/110kV transformer.	19.6
Late 2007	Full Swanbank 'A' in-situ rebuild.	19.4

This option allows for the installation of a dedicated 110kV cable in 2006 between Swanbank and the expected new large customer load, together with network connections. A new 275kV substation at Abermain would be established in 2007 adjacent to the existing 110kV site, with one 375MVA 275/110kV transformer supplying Abermain 110kV substation.

The age and condition of plant, and high fault levels at Swanbank 'A' 110kV substation result in the need to rebuild the substation in late 2007. This project allows for the full in-situ rebuild of the site, as Swanbank remains the main 110kV infeed for the whole of the Ipswich Area. Consequently, there is no opportunity to reduce the scope or defer the timing of the rebuild.

Further works will be required beyond 2008 as the Ipswich Area continues to grow. The anticipated/modelled projects likely to be required in Option 2 based on current load forecasts are shown in the table below. The anticipated timings for these augmentations have been determined through planning studies, which examined when further action is required. Scenarios have been developed to test the sensitivity of the analysis to factors that might affect the assumptions regarding anticipated/modelled projects.

Table 5-4: Option 2 Anticipated/Modelled Projects

Date Required	Anticipated/Modelled Projects[11]	Cost ($m, 04/05)
Late 2011	Establish Upper Kedron 275kV substation and install two 375MVA 275/110kV Transformers.	24.9
Late 2013	Bundamba to Goodna 275kV Reinforcement.	7.0

As can be seen in the table above, should this option be adopted the timing of the high capital cost Upper Kedron works on the transmission network is brought forward, compared to option 1.

[11] Some future developments whose timing is common to all options have not been included, as they have no impact upon the relative ranking of options in the Regulatory Test analysis (refer section 7.4).

5.3 Option 3 – Third Swanbank Transformer with Substation Rebuild

Option 3 addresses the future supply requirements in the Ipswich Area by installing a third 275/110kV transformer at Swanbank whilst rebuilding Swanbank 'A' 110kV substation to meet the increased fault levels due to the operation of three transformers together.

Table 5-5: Option 3 Proposed Augmentations

Date Required	Proposed Augmentations	Cost ($m, 04/05)
Late 2006	Separate 110kV cable from Swanbank to new customer load.	4.0
Late 2007	Full Swanbank 'A' in-situ rebuild and installation of third 375MVA 275/110kV transformer.	29.5

Similar to Option 2, this option allows for the full in-situ rebuild of Swanbank 'A' 110kV substation. However, this option would also deliver an additional 375MVA 275/110kV transformer at Swanbank, with associated 275kV and 110kV works.

Further works will be required beyond 2007 as the Ipswich Area continues to grow. The anticipated/modelled projects likely to be required in Option 3 based on current load forecasts are shown in the table below. The anticipated timings for these augmentations have been determined through planning studies, which examined when further action is required. Scenarios have been developed to test the sensitivity of the analysis to factors that might affect the assumptions regarding anticipated/modelled projects.

Table 5-6: Option 3 Anticipated/Modelled Projects

Date Required	Anticipated/Modelled Projects[12]	Cost ($m, 04/05)
Late 2008	West Darra to Abermain 2nd 110kV circuit.	5.0
Late 2008	Energex - Karalee 110/11kV (instead of 33/11kV).	3.0
Late 2009	Establish Upper Kedron 275kV substation and install two 375MVA 275/110kV Transformers.	24.9
Late 2010	Energex - Moggill 110/11kV (instead of 33/11kV).	7.0
Late 2013	Bundamba to Goodna 275kV Reinforcement.	7.0

The West Darra to Abermain 110kV second circuit project involves building a second 110kV line from West Darra to Abermain.

The construction of the second 110kV circuit from West Darra to Abermain requires Energex to build the anticipated zone substations at Karalee and Moggill at 110/11kV instead of the planned 33/11kV. This will mean Energex will incur additional costs in the construction of the substations, and the necessary new 110kV lines to connect the substations. These costs have been taken into consideration for the purposes of the Regulatory Test as they contribute to the overall cost of this option.

[12] Some future developments whose timing is common to all options have not been included, as they have no impact upon the relative ranking of options in the Regulatory Test analysis (refer section 7.4).

6. SCENARIOS CONSIDERED

6.1 Context for Evaluation of Options

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

- Commonwealth legislation has been in effect since 1 January 2001 to encourage increased generation from renewable energy sources. Powerlink has incorporated independent forecasts of additional renewable energy generation into the forecasts of demand and energy used in assessing future supply requirements; and
- NEMMCO's Statement of Opportunities (SOO) issued in July 2004 contained information on existing and committed generation developments in Queensland. There is currently a considerable margin between supply capacity and demand, with several large new generating units commissioned in Queensland in the past three years.

6.2 Assumed Market Development Scenarios

The AER Regulatory Test requires that options to address network requirements be assessed against a number of reasonable scenarios. These scenarios need to take account of:

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

The purpose of utilising this approach is to test the present value costs of the solutions being evaluated under a range of plausible scenarios.

6.2.1 Existing Network and Future Transmission Developments

No market development scenarios have been developed related to new network developments proposed by Powerlink outside the Ipswich Area. These are independent of the future supply requirements that are the subject of this report, and are considered to be common to all options analysed. Future network developments that are relevant to the Ipswich Area have been included as anticipated/modelled projects in the analysis.

6.2.2 Variations in Load Growth

Three scenarios have been developed to consider sensitivity to variations in forecast customer electricity demand:

Scenario	Forecast Electricity Demand Level
Scenario A	Low (lower economic growth and typical weather conditions)
Scenario B	Medium (medium economic growth and typical weather conditions)
Scenario C	High (higher economic growth and typical weather conditions)

These scenarios are based on typical weather (50% probability of exceedance) forecast for electricity usage, with varying levels of economic growth[13]. The forecasts include all known information about existing and planned demand side initiatives, and also include independent forecasts of local embedded generation developments.

The November 2004 forecast anticipates about 7% increase in demand per year for the next three years, and then about 3% for subsequent years. Scenarios A and C have been developed based on different levels of demand growth.

6.2.3 Existing and Committed Generators

As noted in section 4.2.2, there are no recently committed generators proposing to establish within the Ipswich Area prior to 2007. For this reason, no scenarios have been developed in which the output of existing and/or committed generators is increased.

6.2.4 Potential New Generation

NEMMCO's 2004 Statement of Opportunities indicated that additional investment in major generation may be required in the medium term. However, Powerlink is not aware of any well-advanced proposals for major new stand-alone generators in the Ipswich Area, hence no market development scenarios have been developed to consider the establishment of major new stand-alone generators in the Ipswich Area.

Smaller local generation or demand side developments may occur in the Ipswich Area, but these are unlikely to affect the required timing for network augmentation addressed by this Final Report.

[13] Scenario C (higher economic growth) is modelled by accelerating 3 years' forecast growth into 2 years. Similarly, Scenario A (lower economic growth) is modelled by decelerating 2 years' forecast growth into 3 years.

7. FORMAT AND INPUTS TO ANALYSIS

7.1 Regulatory Test Requirements

The requirements for the comparison of options to address future supply requirements are contained in the Regulatory Test prescribed by the Australian Energy Regulator (AER)[14].

The Regulatory Test requires that, for reliability augmentations[15], the recommended option be the option that "minimises the present value of costs, compared with a number of alternative options in a majority of reasonable scenarios".

The Regulatory Test contains guidelines for the methodology to be used to identify the lowest cost option. For example, information to be considered includes construction, operating and maintenance costs, the cost of complying with existing and anticipated laws and regulations, and reasonable forecasts of the 'efficient operating costs of competitively supplying energy to meet forecast demand'. 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.

7.2 Inputs to Analysis

A solution to address future supply requirements in the Ipswich Area as outlined in this document is required to satisfy reliability requirements linked to Schedule 5.1 of the National Electricity Rules, the requirements of the Queensland Electricity Act and Powerlink's Transmission Authority.

According to the 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 discounted cash flow model to determine the present value (PV) cost of the various options, are shown in section 8.1.

Cost inputs to the economic analysis are described below.

7.3 Cost of Network Augmentations

The cost to implement each of the feasible options and the anticipated/modelled projects outlined in section 5 have been estimated by Powerlink. Sensitivity studies have been carried out using variations in the capital cost estimates of plus or minus 15% (see section 8.2).

The financial analysis considers all foreseeable 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

[14] Powerlink is required to evaluate options for new transmission developments under the Regulatory Test in accordance with clause 5.6 of the National Electricity Rules.

[15] Where an option is necessitated solely by the inability to meet the minimum network performance requirements set out in schedule 5.1 of the NER or in relevant legislation, regulations or any statutory instrument of a participating jurisdiction.

on the assumption of typical load factor and an average cost of losses of $25/MWh[16]. Sensitivity studies have also been carried out on the assumed cost of losses.

7.4 Other Inputs to Analysis

While a solution must be adopted by late 2007 to address the future supply requirements, the economic analysis contains anticipated projects required to address long-term supply reliability requirements, excepting some future developments common to all options, which have been excluded. The sensitivity of the timing of these anticipated projects to load growth and generation development scenarios, and therefore the incidence of the capital expenditure, has been taken into account in the economic analysis.

Capital and operating costs for some items that are common to all options were not included in the analysis. These common costs include the capital and operating costs of other future works, where these costs are independent of the identified future supply requirements or where they are independent of the proposed augmentation. 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 financial analysis.

[16] Network losses are a function of the length and capacity of individual network elements, and the power being transferred through them. In heavily loaded systems, additional network elements reduce the amount of power that must be forced through the existing network, and therefore reduce total losses.

8. FINANCIAL ANALYSIS

The economic analysis undertaken considered the present value (PV) cost of alternative options over the fifteen-year period from 2005/06 to 2020/21. Full details of this analysis are contained in Appendix 2.

8.1 Present Value Analysis

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

Under the Regulatory Test, it is the ranking of the options that is important, rather than the actual present value results. This is because the Regulatory Test requires the recommended option to have the lowest present value cost compared with alternative projects.

The following table is a summary of the economic analysis contained in Appendix 2. It shows the present value cost of each alternative, and identifies the best ranked option, for the range of scenarios considered. The summary shows that Option 1 has the lowest present value cost under two of the three credible scenarios modelled. Importantly, it is the least cost option under the medium (anticipated) load growth scenario. It also has considerably less complexity than the next option, which involves significant construction and implementation risks due to carrying out a full rebuild of Swanbank 'A' substation in situ.

Table 8-1: Summary of Economic Analysis for the Three Scenarios

Summary *Discount rate = 10%*	**Option 1** **Goodna & Abermain**		**Option 2** **Abermain & Swanbank Rebuild**		**Option 3** **Swanbank 3rd Tx & Rebuild**	
Scenario A Low Load Growth	PV ($M) Rank	$18.76 1	PV ($M) Rank	$21.04 2	PV ($M) Rank	$28.77 3
Scenario B Medium Load Growth	PV ($M) Rank	$30.78 1	PV ($M) Rank	$31.63 2	PV ($M) Rank	$41.24 3
Scenario C High Load Growth	PV ($M) Rank	$40.85 2	PV ($M) Rank	$39.73 1	PV ($M) Rank	$50.29 3

8.2 Sensitivity Analysis

In addition to examining the impact of a range of reasonable 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[17]. The following table shows the parameters that

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

were investigated in the sensitivity analysis, the distribution that was assumed for each parameter and the range of values.

Table 8-2: Parameters Investigated in Sensitivity Analysis

Parameter	Distribution
Capital Cost of Transmission Augmentations	The capital cost of the proposed augmentations and anticipated/ modelled projects 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, 1000 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 a present value basis for the largest number of samples) and gives the frequency for which this option 'wins'.

In addition to the above sensitivity testing, 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' (option 1 or option 2) and the frequency for which it 'wins' for each scenario and discount rate across the range of parameters assessed.

Table 8-3: Results of Sensitivity Analysis for Varying Discount Rates

	Discount Rate		
	8%	10%	12%
Scenario A – Low Growth	1 (100%)	1 (100%)	1 (100%)
Scenario B – Medium Growth	1 (65%)	1 (75%)	1 (86%)
Scenario C – High Growth	2 (88%) 1 (12%)	2 (80%) 1 (20%)	2 (70%) 1 (30%)

As can be seen in this table, the results of the sensitivity analysis are consistent with the base case economic analysis, and the outcome is robust in terms of the variations in parameters assessed.

On the basis of the financial analysis and the sensitivity testing, Option 1 is the option that satisfies the Regulatory Test. Details of the scope of proposed works included in Option 1 are provided in Appendix 1.

8.3 Inter-Network Impact

Powerlink is required under the National Electricity Rules to assess whether a proposed new large network asset is reasonably likely to have a material inter-network impact. Powerlink has determined that the proposed new large network asset will not impose power transfer constraints or adversely impact on the quality of supply within the New South Wales network.

9. CONCLUSIONS

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

- There is no acceptable 'do nothing' option. If the identified future supply requirements are not addressed by the summer of 2007/08, power supply to customers in the Ipswich Area will be unable to be maintained during single contingencies. This situation is not consistent with reliability standards that Powerlink must comply with under its Transmission Authority and as a Transmission Network Service Provider in the National Electricity Market.
- Powerlink must plan new works now so that construction can commence in time to ensure continued reliable electricity supply to the Ipswich Area in the peak load period of 2007/08, and to position the area for future growth.
- Such action is necessary to comply with electricity reliability standards that Powerlink must meet. As the augmentations proposed in this document will prevent interruptions to supply during critical single contingencies in the transmission network supplying the Ipswich Area, they are 'reliability augmentations' as defined in the National Electricity Rules.
- Powerlink identified the requirements for additional 275/110kV transformer capacity in its APR and carried out a consultation process in order to identify any non-network solutions to address the Ipswich Area supply requirements. Planning studies were carried out by Powerlink to evaluate potential options to address the future supply requirements in the Ipswich Area. Following the consultation and planning process, Powerlink concluded that there were no viable non-network options. Three network augmentation options for late 2007 were evaluated in detail.
- Economic analysis carried out in accordance with the Regulatory Test has identified that proposed augmentation Option 1, new 275kV substations at Goodna & Abermain, is the least-cost solution over the fifteen-year period of analysis in the majority of credible scenarios considered. Sensitivity testing showed that the analysis is robust to variation in capital cost and other assumptions.
- No submissions were made in response to the publication of the Application Notice on 3 June 2005 and subsequent consultation period. Therefore, no new options were considered for this Final Report.
- As Option 1 is the lowest cost option in the majority of credible scenarios, Option 1 is considered to satisfy the Regulatory Test.

10. FINAL RECOMMENDATION

Powerlink did not receive any submissions in response to the Application Notice. It is therefore recommended that the draft recommendation for a 'new large network asset' be adopted without change. That is, it is recommended that the following action be implemented to address the future supply requirements in the Ipswich Area:

- Powerlink establish a new 275/110kV substation at Goodna, to be completed in late 2007, at an estimated capital cost of $18.3m in 2004/05 prices
- Powerlink establish a new 275/110kV substation at Abermain, to be completed in late 2008, at an estimated capital cost of $19.6m in 2004/05 prices

Powerlink will take immediate steps to implement the above final recommendation following the publication of this report.

APPENDIX 1: TECHNICAL DETAILS OF OPTION 1

For completion in late 2007:

Establish a new 275kV substation adjacent to the existing Goodna 110kV site, including all civil, construction and electrical works, and compliance with any special environmental requirements that may apply to the site.

Works to include:

- Installation of 5 x 275kV circuit breakers
- Installation of 1 x 375MVA (ODAF) 275/110kV transformer
- Installation of 1 x 110kV circuit breaker bay
- 275kV line modifications required for the cut-in of the 275kV overhead line and remote end secondary systems work

For completion in late 2008:

Establish a new 275kV substation adjacent to the existing Abermain 110kV site, including all civil, construction and electrical works, and compliance with any special environmental requirements that may apply to the site.

Works to include:

- Installation of 5 x 275kV circuit breakers
- Installation of 1 x 375MVA (ODAF) 275/110kV transformer
- Installation of 1 x 110kV circuit breaker bay
- 110kV line modifications
- 275kV line modifications required for the cut-in of the 275kV overhead line and remote end secondary systems work

APPENDIX 2: ECONOMIC ANALYSIS

Summary *Discount rate = 10%*	**Option 1** **Goodna & Abermain**		**Option 2** **Abermain & Swanbank Rebuild**		**Option 3** **Swanbank 3rd Tx & Rebuild**	
Scenario A Low Load Growth	PV ($M) Rank	$18.76 1	PV ($M) Rank	$21.04 2	PV ($M) Rank	$28.77 3
Scenario B Medium Load Growth	PV ($M) Rank	$30.78 1	PV ($M) Rank	$31.63 2	PV ($M) Rank	$41.24 3
Scenario C High Load Growth	PV ($M) Rank	$40.85 2	PV ($M) Rank	$39.73 1	PV ($M) Rank	$50.29 3

Development Options	**Scenario A**		**Scenario B**		**Scenario C**	
	FY	*Capex $M*	*FY*	*Capex $M*	*FY*	*Capex $M*
Option 1						
Goodna Substation & Transformer	09/10	18.76	07/08	18.76	06/07	18.76
Abermain Substation & Transformer	10/11	20.13	08/09	20.13	07/08	20.13
Proposed and modelled projects						
Reduced Swanbank Rebuild	12/13	13.63	09/10	13.63	07/08	13.63
Bundamba to Goodna 275 kV	15/16	7.18	11/12	7.18	08/09	7.18
Upper Kedron 2 x 275/110kV Tx	19/20	25.53	14/15	25.53	10/11	25.53
Option 2						
Dedicated 110kV Cable to New Customer Load	07/08	4.10	06/07	4.10	06/07	4.10
Abermain Substation & Transformer	09/10	20.13	07/08	20.13	06/07	20.13
Full Swanbank Rebuild	09/10	19.84	07/08	19.84	06/07	19.84
Proposed and modelled projects						
Upper Kedron 2 x 275/110kV Tx	15/16	25.53	11/12	25.53	08/09	25.53
Bundamba to Goodna 275 kV	18/19	7.18	13/14	7.18	09/10	7.18
Option 3						
Dedicated 110kV Cable to New Customer Load	07/08	4.10	06/07	4.10	06/07	4.10
Full Swanbank Rebuild & 3rd Tx	09/10	30.20	07/08	30.20	06/07	30.20
Proposed and modelled projects						
West Darra to Abermain 2nd 110 kV	10/11	5.13	08/09	5.13	07/08	5.13
Karalee 110/11kV (instead of 33/11kV)	10/11	3.08	08/09	3.08	07/08	3.08
Upper Kedron 2 x 275/110kV Tx	12/13	25.53	09/10	25.53	07/08	25.53
Moggill 110/11kV (instead of 33/11kV)	13/14	7.18	10/11	7.18	08/09	7.18
Bundamba to Goodna 275 kV	18/19	7.18	13/14	7.18	09/10	7.18

Scenario A		Low Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 1		**Goodna & Abermain**														
Goodna Substation & Transformer																
=> TUOS		0.000	0.000	0.000	0.000	2.068	2.041	2.013	1.986	1.958	1.931	1.903	1.875	1.848	1.820	1.793
==> PV of TUOS	$8.68															
Abermain Substation & Transformer																
=> TUOS		0.000	0.000	0.000	0.000	0.000	2.219	2.190	2.160	2.131	2.101	2.071	2.042	2.012	1.983	1.953
==> PV of TUOS	$8.05															
Proposed and modelled projects																
Reduced Swanbank Rebuild																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	1.503	1.483	1.463	1.443	1.423	1.403	1.383	1.363
==> PV of TUOS	$3.95															
Bundamba to Goodna 275 kV																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749
==> PV of TUOS	$1.13															
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		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	2.815
==> PV of TUOS	0.67															
Relative Losses																
* Losses $		0.000	0.000	-0.353	-0.543	-0.550	-0.577	-0.590	-0.606	-0.614	-0.763	-0.838	-0.860	-0.871	-0.895	-0.906
=> PV of Loss difference	-$3.72															
Total for Option 1	**$18.76**															

Scenario A		Low Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 2		**Abermain & Swanbank Rebuild**														
Swanbank to Paper Mill 110kV Cable																
=> TUOS		0.000	0.000	0.452	0.446	0.440	0.434	0.428	0.422	0.416	0.410	0.404	0.398	0.392	0.386	0.380
==> PV of TUOS	$2.49															
Abermain Substation & Transformer																
=> TUOS		0.000	0.000	0.000	0.000	2.219	2.190	2.160	2.131	2.101	2.071	2.042	2.012	1.983	1.953	1.923
==> PV of TUOS	$9.31															
Full Swanbank Rebuild																
=> TUOS		0.000	0.000	0.000	0.000	2.188	2.159	2.129	2.100	2.071	2.042	2.013	1.984	1.954	1.925	1.896
==> PV of TUOS	$9.18															
Proposed and modelled projects																
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.815	2.778	2.740	2.703	2.665
==> PV of TUOS	$4.02															
Bundamba to Goodna 275 kV																
=> TUOS		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	0.791	0.780
==> PV of TUOS	$0.40															
Relative Losses																
* Losses $		0.000	0.000													
=> PV of Loss difference																
Total for Option 2	**$21.04**															

Scenario A		Low Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 3		**Swanbank 3rd Tx & Rebuild**														
Swanbank to Paper Mill 110kV Cable																
=> TUOS		0.000	0.000	0.452	0.446	0.440	0.434	0.428	0.422	0.416	0.410	0.404	0.398	0.392	0.386	0.380
==> PV of TUOS	$2.49															
Full Swanbank Rebuild & 3rd Tx																
=> TUOS		0.000	0.000	0.000	0.000	3.330	3.285	3.241	3.197	3.152	3.108	3.063	3.019	2.975	2.930	2.886
==> PV of TUOS	$13.97															
Proposed and modelled projects																
West Darra to Abermain 2nd 110 kV																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.565	0.557	0.550	0.542	0.535	0.527	0.520	0.512	0.505	0.497
==> PV of TUOS	$2.05															
Karalee 110/11kV (instead of 33/11kV)																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.339	0.334	0.330	0.325	0.321	0.316	0.312	0.307	0.303	0.298
==> PV of TUOS	$1.23															
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.815	2.778	2.740	2.703	2.665	2.628	2.590	2.552
==> PV of TUOS	7.40															
Mogill 110/11kV (instead of 33/11kV)																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728
==> PV of TUOS	1.73															
Bundamba to Goodna 275 kV																
=> TUOS		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	0.791	0.780
==> PV of TUOS	$0.40															
Relative Losses																
* Losses $		0.000	0.000		0.006	0.156	0.028									
=> PV of Loss difference																
Total for Option 3	**$28.77**															

Scenario B		Medium Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 1		**Goodna & Abermain**														
Goodna Substation & Transformer																
=> TUOS		0.000	0.000	2.068	2.041	2.013	1.986	1.958	1.931	1.903	1.875	1.848	1.820	1.793	1.765	1.738
==> PV of TUOS	$11.38															
Abermain Substation & Transformer																
=> TUOS		0.000	0.000	0.000	2.219	2.190	2.160	2.131	2.101	2.071	2.042	2.012	1.983	1.953	1.923	1.894
==> PV of TUOS	$10.70															
Proposed and modelled projects																
Reduced Swanbank Rebuild																
=> TUOS		0.000	0.000	0.000	0.000	1.503	1.483	1.463	1.443	1.423	1.403	1.383	1.363	1.343	1.323	1.303
==> PV of TUOS	$6.31															
Bundamba to Goodna 275 kV																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728	0.717	0.707
==> PV of TUOS	$2.46															
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	2.815	2.778	2.740	2.703	2.665	2.628
==> PV of TUOS	5.05															
Relative Losses																
* Losses $		0.000	-0.353	-0.543	-0.577	-0.606	-0.763	-0.860	-0.895	-0.931	-0.969	-1.008	-1.048	-1.090	-1.133	-1.179
=> PV of Loss difference	-$5.11															
Total for Option 1	**$30.78**															

Scenario B		Medium Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 2		**Abermain & Swanbank Rebuild**														
Swanbank to Paper Mill 110kV Cable																
=> TUOS		0.000	0.452	0.446	0.440	0.434	0.428	0.422	0.416	0.410	0.404	0.398	0.392	0.386	0.380	0.374
==> PV of TUOS	$2.83															
Abermain Substation & Transformer																
=> TUOS		0.000	0.000	2.219	2.190	2.160	2.131	2.101	2.071	2.042	2.012	1.983	1.953	1.923	1.894	1.864
==> PV of TUOS	$12.21															
Full Swanbank Rebuild																
=> TUOS		0.000	0.000	2.188	2.159	2.129	2.100	2.071	2.042	2.013	1.984	1.954	1.925	1.896	1.867	1.838
==> PV of TUOS	$12.04															
Proposed and modelled projects																
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	2.815	2.778	2.740	2.703	2.665	2.628	2.590	2.552	2.515
==> PV of TUOS	$8.74															
Bundamba to Goodna 275 kV																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728
==> PV of TUOS	$1.73															
Relative Losses																
* Losses $		0.000														-1.325
=> PV of Loss difference																
Total for Option 2	**$31.63**															

Scenario B		Medium Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 3		**Swanbank 3rd Tx & Rebuild**														
Swanbank to Paper Mill 110kV Cable																
=> TUOS		0.000	0.452	0.446	0.440	0.434	0.428	0.422	0.416	0.410	0.404	0.398	0.392	0.386	0.380	0.374
==> PV of TUOS	$2.83															
Full Swanbank Rebuild & 3rd Tx																
=> TUOS		0.000	0.000	3.330	3.285	3.241	3.197	3.152	3.108	3.063	3.019	2.975	2.930	2.886	2.841	2.797
==> PV of TUOS	$18.32															
Proposed and modelled projects																
West Darra to Abermain 2nd 110 kV																
=> TUOS		0.000	0.000	0.000	0.565	0.557	0.550	0.542	0.535	0.527	0.520	0.512	0.505	0.497	0.490	0.482
==> PV of TUOS	$2.72															
Karalee 110/11kV (instead of 33/11kV)																
=> TUOS		0.000	0.000	0.000	0.339	0.334	0.330	0.325	0.321	0.316	0.312	0.307	0.303	0.298	0.294	0.289
==> PV of TUOS	$1.63															
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	0.000	0.000	2.815	2.778	2.740	2.703	2.665	2.628	2.590	2.552	2.515	2.477	2.440
==> PV of TUOS	11.81															
Mogill 110/11kV (instead of 33/11kV)																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728	0.717	0.707	0.696
==> PV of TUOS	2.87															
Bundamba to Goodna 275 kV																
=> TUOS		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728
==> PV of TUOS	$1.73															
Relative Losses																
* Losses $		0.000		0.006	0.028											
=> PV of Loss difference																
Total for Option 3	**$41.24**															

Scenario C		High Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 1		**Goodna & Abermain**														
Goodna Substation & Transformer																
=> TUOS		0.000	2.068	2.041	2.013	1.986	1.958	1.931	1.903	1.875	1.848	1.820	1.793	1.765	1.738	1.710
==> PV of TUOS	$12.93															
Abermain Substation & Transformer																
=> TUOS		0.000	0.000	2.219	2.190	2.160	2.131	2.101	2.071	2.042	2.012	1.983	1.953	1.923	1.894	1.864
==> PV of TUOS	$12.21															
Proposed and modelled projects																
Reduced Swanbank Rebuild																
=> TUOS		0.000	0.000	1.503	1.483	1.463	1.443	1.423	1.403	1.383	1.363	1.343	1.323	1.303	1.283	1.263
==> PV of TUOS	$8.27															
Bundamba to Goodna 275 kV																
=> TUOS		0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728	0.717	0.707	0.696	0.686	0.675
==> PV of TUOS	$3.81															
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	0.000	0.000	0.000	2.815	2.778	2.740	2.703	2.665	2.628	2.590	2.552	2.515	2.477
==> PV of TUOS	10.21															
Relative Losses																
* Losses $		-0.353	-0.570	-0.606	-0.786	-0.895	-0.956	-1.008	-1.076	-1.133	-1.179	-1.194	-1.194	-1.194	-1.194	-1.194
=> PV of Loss difference	-$6.58															
Total for Option 1	**$40.85**															

Scenario C		High Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 2		**Abermain & Swanbank Rebuild**														
Swanbank to Paper Mill 110kV Cable																
=> TUOS		0.000	0.452	0.446	0.440	0.434	0.428	0.422	0.416	0.410	0.404	0.398	0.392	0.386	0.380	0.374
==> PV of TUOS	$2.83															
Abermain Substation & Transformer																
=> TUOS		0.000	2.219	2.190	2.160	2.131	2.101	2.071	2.042	2.012	1.983	1.953	1.923	1.894	1.864	1.835
==> PV of TUOS	$13.87															
Full Swanbank Rebuild																
=> TUOS		0.000	2.188	2.159	2.129	2.100	2.071	2.042	2.013	1.984	1.954	1.925	1.896	1.867	1.838	1.809
==> PV of TUOS	$13.68															
Proposed and modelled projects																
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	0.000	2.815	2.778	2.740	2.703	2.665	2.628	2.590	2.552	2.515	2.477	2.440	2.402
==> PV of TUOS	$13.57															
Bundamba to Goodna 275 kV																
=> TUOS		0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728	0.717	0.707	0.696	0.686
==> PV of TUOS	$3.32															
Relative Losses																
* Losses $																-1.343
=> PV of Loss difference																
Total for Option 2	**$39.73**															

Scenario C		High Load Growth														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
		06/07	07/08	08/09	09/10	10/11	11/12	12/13	13/14	14/15	15/16	16/17	17/18	18/19	19/20	20/21
Option 3		**Swanbank 3rd Tx & Rebuild**														
Swanbank to Paper Mill 110kV Cable																
=> TUOS		0.000	0.452	0.446	0.440	0.434	0.428	0.422	0.416	0.410	0.404	0.398	0.392	0.386	0.380	0.374
==> PV of TUOS	$2.83															
Full Swanbank Rebuild & 3rd Tx																
=> TUOS		0.000	3.330	3.285	3.241	3.197	3.152	3.108	3.063	3.019	2.975	2.930	2.886	2.841	2.797	2.753
==> PV of TUOS	$20.81															
Proposed and modelled projects																
West Darra to Abermain 2nd 110 kV																
=> TUOS		0.000	0.000	0.565	0.557	0.550	0.542	0.535	0.527	0.520	0.512	0.505	0.497	0.490	0.482	0.475
==> PV of TUOS	$3.11															
Karalee 110/11kV (instead of 33/11kV)																
=> TUOS		0.000	0.000	0.339	0.334	0.330	0.325	0.321	0.316	0.312	0.307	0.303	0.298	0.294	0.289	0.285
==> PV of TUOS	$1.87															
Upper Kedron 2 x 275/110kV Tx																
=> TUOS		0.000	0.000	2.815	2.778	2.740	2.703	2.665	2.628	2.590	2.552	2.515	2.477	2.440	2.402	2.365
==> PV of TUOS	15.49															
Mogill 110/11kV (instead of 33/11kV)																
=> TUOS		0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728	0.717	0.707	0.696	0.686	0.675
==> PV of TUOS	3.81															
Bundamba to Goodna 275 kV																
=> TUOS		0.000	0.000	0.000	0.000	0.791	0.780	0.770	0.759	0.749	0.738	0.728	0.717	0.707	0.696	0.686
==> PV of TUOS	$3.32															
Relative Losses																
* Losses $																
=> PV of Loss difference																
Total for Option 3	**$50.29**															