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POWERLINK QUEENSLAND REVENUE PROPOSAL

Supporting Document

Powerlink Queensland
Asset Management Plan
(Volume 3 - Area Plans)

Delivering better value

ASSET MANAGEMENT PLAN 2015

Volume 3 – Area Plans

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Investment and Planning
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DISCLAIMER

This Asset Management Plan has been produced to provide general information about the development of Powerlink's network and is a summary of the best view of asset investment strategies at the time of writing. In many cases, the projects listed in the Asset Management Plan have been selected from a large number of future scenarios and are the result of preliminary investigations.

As well as the need for future analysis to evaluate system and asset conditions and alternatives, there are processes described in the National Electricity Rules that need to be followed before projects can be approved. It is possible that projects listed here may change in scope or timing, be replaced by other projects or deemed unnecessary. Business decisions and actions should not be made solely on the basis of information contained here. The Asset Management Plan does not replace any current business or approval processes.

Risk costs continue to be enhanced and at this stage should not be used to solely prioritise projects or prioritise projects between asset classes as currently not all risks have been modelled which leads to some risk costs being understated. Similarly some asset risks are based on desktop analysis at an asset fleet level rather than based on individual asset condition, depending on the timing of the anticipated investment need.

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Issued	[redacted]	Senior Asset Planning Engineer		
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ABBREVIATIONS

AMP	Asset Management Plan
AEMC	Australian Energy Market Commission
AEMO	Australian Energy Market Operator
AER	Australian Energy Regulator
TAPR	Transmission Annual Planning Report
BCS	Business Continuity Site
CVT	Capacitor Voltage Transformer
DC	Direct Current
DWDM	Dense Wavelength Division Multiplexing
EMF	Electric and Magnetic Field
EMS	Energy Management System
EOL	End of Life
FNQ	Far North Queensland
GIS	Gas Insulated Substation
GOC	Government Owned Corporation
IEC	International Electro technical Commission
iPASS	Intelligent Plug and Switch System
kV	Kilovolt
LNG	Liquefied Natural Gas
MVAr	Megavolt Ampere Reactive
NEFR	National Electricity Forecasting Report
NEL	National Electricity Law
NEM	National Electricity Market
NER	National Electricity Rules
OPGW	Optical Ground Wire
OHEW	Overhead Earthwire
OSS	Operational Support System
OTN	Operational Telephone Network
PV	Photovoltaic
QNI	Queensland to New South Wales Interconnector
RIT-T	Regulatory Investment Test for Transmission
SCADA	Supervisory control and data acquisition
SDM	Substation design standard
SVC	Static VAr Compensator
TNSP	Transmission Network Service Provider

1. OVERVIEW

Powerlink develops Area Plans for collective groupings of assets to co-optimise future network capability requirements with end of life and condition related issues. For example, an integrated approach is considered where there are opportunities for optimising or consolidating the network where changing load consumption and/or generation patterns, coupled with how the network has developed over time, have changed the forecast network capability requirements.

Where reinvestment drivers are identified, strategies including extended maintenance, asset decommissioning, replacement with lower rated plant, or consolidation of existing assets to improve utilisation are considered (depending on the circumstances).

The volume contains the following area plans:

- Cairns Area Plan
- North Queensland (NQ) Area Plan
- Mackay Area Plan
- Central West Area Plan
- Gladstone Area Plan
- Central to South Queensland (CQ-SQ) Area Plan
- Tarong Area Plan
- Greater Brisbane (Metro) Area Plan
- Gold Coast Area Plan.

The network boundary definitions which comprise the area plans are shown in Figure 1.1. These boundary definitions outline the grouping of network assets which may have some form of inter-dependency in terms of network capability, and where there may be opportunities for consolidation and optimisation for those plant items reaching end of life so that the network is best configured to meet current and future capacity needs.

Figure 1.1: Area Plan Definitions

[redacted]

2. CAIRNS

2.1 Introduction

2.1.1 Background

Over the last few decades the Cairns area has displayed one of the highest maximum demand growth rates in the state at 3 to 4% p.a. This rate of growth was expected to continue. Through joint planning processes, long term strategies for augmentation and reinvestment in this region had been developed on this basis which proposed extensive network augmentation to supply this level of expected load.

In consideration of projections of a relatively flat demand growth outlook, and changes in the service standards governing how Powerlink plan and operate the transmission network, future reinvestment strategies in this region have been reviewed.

Powerlink owns a significant number of substation and transmission line assets in the Cairns area that were constructed in the 1960s. It is expected these assets will approach the end of economic or technical life in the 10 year outlook of the Asset Management Plan (AMP). Although the majority of these assets are somewhat independent in terms of investment drivers, due to the geographic locality, shared stakeholders and potential broader impacts they have been considered as one area plan.

In the medium term, the Kamerunga supply area is expected to require reinvestment that will need to be considered collectively with potential network expansion plans. This includes the Woree to Kamerunga 132kV double circuit transmission line, and the majority of the secondary systems and primary plant equipment at Kamerunga Substation. Since 132kV supply to this area was originally planned and constructed, further developments have taken place to meet load growth in both Powerlink and Ergon Energy's networks. It has also been identified that a possible future block load commitment in this area may require the existing transmission and distribution systems to be materially augmented requiring an external regulatory consultation.

Reinvestment of Powerlink's existing assets in the Cairns area needs to collectively meet the existing network requirements and be resilient to potential future growth.

2.1.2 Description of Existing Network

The geographic area referred to as the "Cairns area" includes the Cairns central business district and surrounding area from Kamerunga in the north to Innisfail in the south.

Powerlink Queensland owns and operates the 275kV and 132kV transmission network supplying the Cairns area. Ergon Energy owns and operates the electricity distribution network, and the 132kV transmission network directly feeds the 22kV distribution system with no intervening sub-transmission network, which is unique to other parts of the state.

Primary electricity supply into the Cairns area is provided via Powerlink's double circuit 275kV transmission network which runs from Ross Substation near Townsville to Woree Substation near Cairns, via Chalumbin Substation. Woree 275/132kV Substation is the principal marshalling point for 132kV circuits in Cairns forming the hub for circuits to the following areas:

- Kamerunga area which comprises of 132kV double circuit transmission line to Powerlink's Kamerunga 132/22kV Substation and 132kV connection to the Barron Gorge Power Station. The load predominantly consists of a mix of low density residential blocks inland and resorts, hotels and apartments along the coast;
- Cairns CBD which comprises of Powerlink's Cairns 132/22kV Substation and provides 132kV connection for Ergon Energy's Cairns North and Cairns City 132/22kV substations. This area comprises of the commercial/industrial and main residential areas, with Cairns City Substation supplying the main commercial centre including the airport, seaport and tourist accommodation; and
- Edmonton 132/22kV Substation which was established to off-load Cairns Substation and support growing load in the southern suburbs of Cairns. It is supplied from one side of the coastal 132kV double circuit that supports the Far North region from the Townsville area.

The original 132kV assets in Cairns were established during the late 1950s to provide electricity to the expanding far north Queensland communities when the demand increased beyond the local network capacity. For many years the Cairns Substation provided connection to the hydro generator at Barron Gorge and a 132kV transmission network linked to Innisfail and the hydro generators at Tully Falls.

Barron Gorge hydro-electric Power Station was established in 1963 and is the only generator within the immediate Cairns area. The registered capacity of Barron Gorge is 60MW, but limited water supply allows full output only during the wet season (January to March) or for short periods such as system emergencies. During a typical summer day, there is usually only sufficient water for one unit to provide up to 15MW, while the other unit generates reactive power (for voltage support) only.

Kamerunga Substation was established in 1976 to supply the rapidly growing area to the north of Cairns. Woree Substation was established in 2002 to provide an injection point for 275kV transmission into Cairns. Woree Substation also provided an alternative site for replacement of the 132kV switching functions to the aged Cairns Substation. Edmonton Substation was established in 2004 in the southern suburbs of Cairns.

There are a total of five existing 132/22kV zone substations in the Cairns area as detailed in Table 2.1:

Table 2.1: 132k/22kV zone substation in Cairns

Substation	Capacity
T051 Cairns (Hartley Street)	2x65 + 1x50 [PQ]
Cairns City	2x80 [EE]
T053 Kamerunga	2x50 [PQ]
T129 Edmonton	2x65 [PQ]
Cairns North	2x63 [EE]

Note: PQ: Powerlink own the transformers
EE: Ergon Energy own the transformers

Along with these zone substations, there are two Ergon Energy 22kV switching stations that supply the far north and far south regions of the Cairns area. Kewarra Beach 22kV switching station is located to the far north and is supplied by three 22kV feeders from Kamerunga. Gordonvale 22kV switching station is located at Gordonvale south of Edmonton and is supplied by three 22kV feeders from Edmonton.

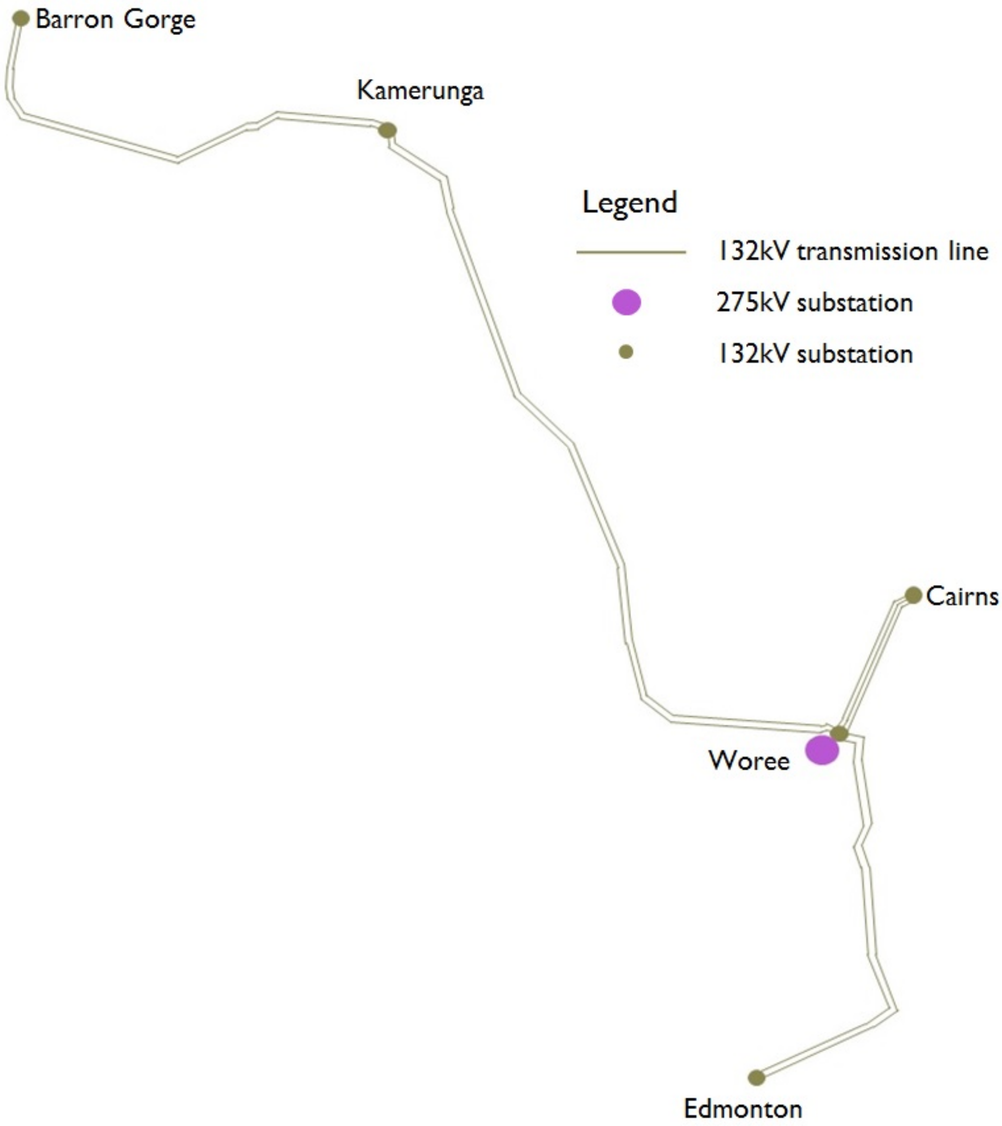
The electricity system in the Cairns Area is shown in Figure 2.1.

The 275kV and 132kV transmission network and major developments in the Cairns area to date are shown in Table 2.2.

Table 2.2: Development of the transmission network in the Cairns area

Period	Substations	Lines
Late 1950s	Cairns 132kV Substation and No.1 and No.2 132/22kV 20MVA transformer	Woree to Cairns 132kV Transmission Line (originally part of the 132kV coastal supply)
Early 1960s		Woree to Kamerunga 132kV Transmission Line and Kamerunga to Barron Gorge 132kV Transmission Line (originally connected Cairns to Barron Gorge)
Late 1960s		Cairns to Woree 132kV Transmission Line
1970s	Kamerunga Substation and No.1 132/22kV 20MVA transformer	
1980s	Kamerunga No.2 132/22kV 10MVA transformer Barron Gorge Power Station PS Switchyard Cairns No.3 and No.4 132/22kV 50MVA transformer	
1990s	Kamerunga No.1 and No.2 132/22kV 50MVA transformer	Chalumbin to Woree 275kV Transmission Line (operating at 132kV)
2001	Cairns No.1 132/22kV 50MVA transformer (and decommission 2 x 20MVA)	
2002	Woree 275/132kV Substation (including No.1 275/132kV 375MVA transformer)	Chalumbin to Woree operating at 275kV
2005	Edmonton 132/22kV Substation including No.1 and No.2 132k/22kV 50MVA transformers Woree 275kV SVC	
2009 and 2010	Woree No.2 275/132kV 375MVA Transformer Cairns Rebuild and Woree 132kV Substation Expansion (switching functions established at Woree and Cairns redeveloped as three transformer ended substation)	Decommission Turkinje to Cairns 132kV transmission line

Figure 2.1: Powerlink 132kV system in the Cairns area



Greater Far North Queensland Area

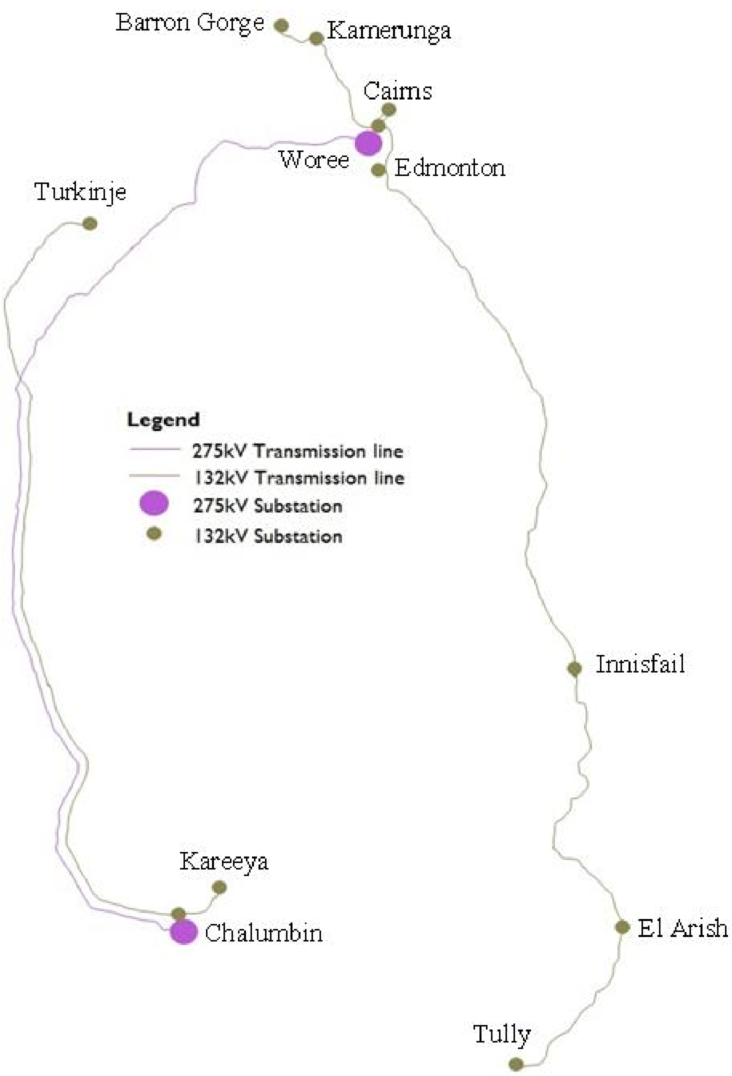
The coastal 132kV transmission lines from Townsville to Cairns via Ingham, Cardwell, Tully, Innisfail and Edmonton provide supply to coastal communities between Townsville and Cairns and support to the Cairns area in the event of a contingency on the 275kV lines supplying Far North Queensland (FNQ). Originally these 132kV coastal transmission lines, along with the Chalumbin to Turkinje and Turkinje to Cairns transmission lines, supplied the Cairns area before the 275kV injection into Woree was established.

This backup supply function became more significant once the Turkinje – Cairns line was decommissioned, as required by the conditions agreed with the Wet Tropics Management Authority in obtaining the easement for construction of the 275kV Chalumbin – Woree line in 1995.

The 132kV coastal lines were originally constructed in the late 1950s and were replaced in several stages between 2006 and 2013 by a 275/132kV double circuit dual voltage line along the coastal route from Townsville GT switchyard (near Yabulu) to Edmonton (just south of Cairns) via Ingham, Cardwell, Tully and Innisfail. The line is currently operated at 132kV and there are no augmentation or reinvestment drivers for these assets in the 10 year outlook. The original Kareeya – Tully and Kareeya – Innisfail lines were decommissioned and recovered.

The transmission system in greater FNQ is shown in Figure 2.2.

Figure 2.2: Transmission system in greater Far North Queensland



The Chalumbin to Turkinje 132kV transmission line was constructed in 1986 and reinvestment decisions are beyond the 10 year outlook of the AMP. However, the establishment of a 275/132kV substation at or near Turkinje would allow this transmission line to be decommissioned when it reaches end of technical or economic life. If this option is to be pursued, adequate lead-time should be ensured to secure the necessary land and easement requirements.

[redacted]

2.2 Asset Condition

The following sections summarise the condition of the transmission assets in the Cairns area that are being considered for reinvestment within the 10 year outlook.

2.2.1 Lines

Woree to Cairns 132kV Transmission Line

The Woree to Cairns double circuit transmission line (Feeder 7225/7226, built section 1255) was originally commissioned in July 1957. This 1km 132kV double circuit transmission line comprises three double circuit steel towers.

The transmission line operates in an aggressive tropical coastal environment. A condition assessment confirmed these assets have approximately 55% of the tower surfaces with advanced corrosion of the galvanised components and several steel members were deemed to need replacement in addition to the tower bolt sets.

It was identified that a line refit and paint, or complete replacement, of the transmission line was required to address the deteriorated condition and safety issues related to the risk if this asset remained in service. A project is underway, CP.2632 Woree to Cairns Line Refit, which is due for completion by October 2016. The project scope is to replace corroded nuts, bolts and tower members then blast, clean and paint the towers to extend the life of the transmission line for a further 20 years.

Woree to Kamerunga 132kV Transmission Line

The 132kV double circuit transmission line (Feeder 7141/7142, built section 1252) between the Woree and Kamerunga substations is the primary supply to the Northern Beaches area and provides connection to the Barron Gorge Power Station. It is approximately 14km in length with 42 tower structures. The line was commissioned in 1963 and tower structures are now over 50 years old.

A significant proportion of the transmission line traverses built up residential, encroached development and there are a number of major and minor road crossings.

In July 2011 a medium term line refit project to extend the asset life by seven to 10 years was recommended. The refit work had three components, which were foundations, structures and members, and insulators and hardware. The grillage foundation repair work utilising the micro-piling installation was completed in late 2012, which was designed to extend the life of the foundations for a further 10 years. The remainder of the project was completed in 2015.

Powerlink’s asset management strategy is to monitor the condition of this line asset and it is expected it may require major reinvestment just beyond the 10 year outlook of the AMP to manage the condition driven risks associated with its ongoing operation. Powerlink will consider strategies involving increased maintenance or foundation repair to economically defer significant line reinvestment if technically feasible.

Woree to Edmonton 132kV Transmission Line

The 132kV double circuit transmission line (Feeder 7284/7139/7301, built section 1615 and 1236 between the Woree and Edmonton substations was commissioned in 1998 and forms part of the 132kV coastal supply to Cairns, and to Edmonton substation.

The transmission line is located adjacent to the environmentally sensitive Trinity Inlet Marine Park, and close to other tidal waterways. Access to each tower has been upgraded with local Environmental and Resource Management approval, however working in areas at each tower site are subject to the management requirements of the marine park. The area has high humidity and increased exposure to heavy rates of air-borne salt deposition, causing accelerated levels of corrosion.

The original Cairns to Innisfail transmission line was constructed in the 1950s (and has since been replaced in part by Feeder 7284). Corrosion and maintenance records from the original line confirmed that galvanised bolts were exhibiting extensive Grade 2 corrosion after 11 years, light members after 18 years and heavy members at 29 years.

A condition assessment conducted for the Woree to Edmonton transmission line confirmed nuts, bolts and splice plates on the upper sections of the structures and cross arms were already experiencing advanced Grade 2 corrosion, consistent with historical records.

Powerlink’s asset management strategy involves early life tower painting within the 10 year outlook to extend the life of this asset and defer a major refit project that would require blasting techniques. This involves applying a cold galvanised coating to the towers before further breakdown of the hot galvanising. It is expected that this refurbishment strategy would further delay the effects of corrosion and defer further reinvestment by an additional 10 years.

Kamerunga to Barron Gorge 132kV Transmission Line

The Kamerunga to Barron Gorge 132kV transmission line (Feeder 7143/7184, built section 1233) was commissioned in 1963 and is located in the Barron Gorge National Park and the overlaps the Wet Tropics World Heritage Area. The transmission line provides access to Barron Gorge Power Station.

In 2002, work was completed that involved upgrading of tower access, construction of new tower foundations, painting of all towers, the replacement of all conductor support assemblies and the installation of new tower accessories.

Recent inspections have shown evidence of further breakdown of the paint coating system, which may require localised painting in the 10 year outlook.

2.2.2 Substations

Edmonton 132/22kV Substation

Edmonton Substation was established in 2005 and the high voltage equipment is in relatively good condition, and the secondary systems are mid-life. It is not expected that there will be any major reinvestment requirements at this site driven by primary plant condition in the 10 year outlook. It is expected that the secondary systems will need to be considered for reinvestment towards the end of the 10 year outlook to manage the condition driven risks associated with ongoing operation.

Cairns 132/22kV Substation

The Cairns Substation was established in the mid to late 1950's and was the principal marshalling point for all 132kV circuits in the Cairns area until the establishment of the Woree Substation in 2002. It comprises of three 132k/22kV transformers, with No.2 and No.3 rated at 70MVA and No.4 rated at 61MVA. However, each transformer is limited by the bay ratings to 59.4MVA, which in this instance is the 132kV series reactors connected to the primary side of each transformer to limit fault levels on the 22kV distribution system.

A condition assessment for the No.4 Transformer has identified that based on the condition driven risks associated with the transformer bushings, oil leaks and degradation of the insulation it is expected that reinvestment needs to be considered towards the end of the 10 year outlook.

Kamerunga 132/22kV Substation

The Kamerunga Substation was established in 1976 and consists of two buses and one bus coupler bay (disconnectors only), two transformer bays with two 132/22kV power transformers, two 132kV feeder bays to Woree and two 132kV feeder bays to the Barron Gorge Power Station. The majority of the original equipment, consisting of two 132kV feeder bays and one transformer bay and the associated solid and strung busbars is still in service. The second transformer was installed in 1984. Both No.1 and No.2 132/22kV transformers have subsequently been replaced in 1990 and 1996 respectively by 50MVA transformers.

A condition assessment was completed at Kamerunga Substation for the 132kV switchyard including structural components and secondary systems. It identified emerging condition and obsolescence issues, which if not addressed, will present an increasing related risk for continued operation of these assets within the 10 year outlook.

The site condition assessment identified condition issues over the next one to five years for the following assets:

- Location and flood considerations –
  - existing switchgear and control building below 50 year flood level;
  - the site is located in a flood prone area that will be inundated with water depths estimated to be 1.25m and 1.6m for one in 100 and one in 200 years respectively. The worst impacted area of the substation is at the north east side where water is predicted to rise above secondary terminal boxes of current transformers and circuit breaker mechanism boxes;
  - the site is in close proximity to residential development;

- Inherent design issues - insufficient clearances around two disconnectors; 5A secondary CTs that are not standard design; hold down bolt corrosion due to the poor drainage; and a single 125V DC system;

- Concerns associated with selective primary plant including circuit breakers, porcelain CVTs and surge arrestors in one transformer bay;
- Secondary systems
  - the protection and control relays installed for the transformer, including the transformer earthing protection, are obsolete with limited manufacturer support and no spares;
  - the protection and control relays installed for the feeder protection panels are obsolete with limited manufacturer support and spares; and
  - obsolete local control and remote control equipment.

2.3 Network requirements

2.3.1 Edmonton

There are no limitations forecast in the Edmonton area that would require augmentation to the existing transmission network within the 10 year outlook of the AMP.

2.3.2 Kamerunga and Northern Beaches

The electricity supply for the Kamerunga area is supplied from the Woree 275/132kV Substation via a 132kV double circuit transmission line to Kamerunga 132/22kV Substation. Powerlink owns the two 132/22kV transformers that supply the 22kV bus owned by Ergon on the same site. The 22kV network supplies Yorkey's Knob, Smithfield, Trinity Beach, Kewarra Beach, Clifton Beach and Palm Cove. The Kewarra Beach 22kV switching station is fed by tie feeders from Kamerunga Substation. There are limited opportunities for 22kV corridors between Kamerunga and the Ergon owned site at Smithfield. Significant load is already supplied from the 22kV network around Smithfield and north of Smithfield.

In addition to the three demand scenarios based on the observed load and 2015 TAPR forecast levels, the proposed Aquis between Yorkey's Knob and Holloways Beach north of Cairns was considered as an additional scenario. Aquis is intended to be Australia's largest integrated resort [redacted] This project has received federal and state approval and is planning construction to begin in 2018, if it proceeds. It is plausible it may be operational by 2020.

Planning studies have shown that during the 10 year outlook for the load scenarios studied:

- firm capacity of the Kamerunga Substation may be exceeded, with some scenarios predicted to breach the 600MWh limit; and
- firm capacity of the Woree to Kamerunga 132kV transmission line is not exceeded.

There are no forecast augmentation requirements for the Kamerunga area based on observed loads. Should load incrementally increase in this area, installation of fans on the transformers at Kamerunga may be a credible alternative to address the transformer limitations, but may not mitigate limitations on the 22kV network.

Fault Levels

There are no emerging fault level issues in Kamerunga area.

Generation Development

There are no proposed new generators in the Northern Beaches area. In the longer term, Powerlink has identified several plausible future wind farm and solar developments north of Cairns that may change power flows on the transmission network. These generation scenarios are currently under review.

Strategic Joint Planning (10 years+)

Powerlink's existing transmission network is capable of meeting the mandated reliability of supply obligations based on observed loads.

During peak load times, approximately 10 MVA can be transferred from Kamerunga Substation to the adjacent Cairns and Cairns North substations under contingency. The installation of fans on the existing transformers at Kamerunga further alleviates thermal constraints in the short term.

However there may be a future requirement for network augmentation of the transmission and distribution networks for new block loads and longer term load growth in the Northern Beaches.

It is proposed the ultimate development of the Kamerunga Substation is to remain as a two transformer site. The substation will need to provide an allowance for an additional two 132kV feeder bays to allow expansion of the 132kV transmission network to the north of Cairns.

[redacted]

The Woree to Kamerunga 132kV transmission line is presently loaded to approximately 70% of its firm capacity. However it is expected that in the longer term as the areas north of Cairns develops, the thermal capacity of this line may be exceeded. If a new transmission is constructed it is recommended with increased thermal capabilities of up to 200MVA.

2.3.3 Cairns

Cairns No.4 Transformer (T4) is likely to require reinvestment within the 10 year outlook. The ratings of these transformers are shown in Table 2.7. Each transformer is limited by the bay ratings, which in this instance are limited by the 132kV series reactors connected to the primary side of each transformer.

Table 2.7: Asset ratings

Transformer	Bay Rating	Normal Cyclic	Emergency Cyclic
T2	59.44MVA	68MVA	70MVA
T3	59.44MVA	68MVA	70MVA
T4	59.44MVA	55MVA	61MVA

10 year outlook

The current load forecast for this substation shows little to no growth over the next 10 years. For this reason, the headroom under each option was calculated instead, to the amended planning standard.

Leaving transformer 4 in service allows for at least 80% headroom, and removing it provides for less than 20% before the 600MWh limit could be breached (load could be at risk for more than 5%). Removing transformer 4 and uprating the bays to the ratings of transformers 2 and 3 provides for somewhere between 30% and 35% headroom.

Planning studies have shown that based on the existing load forecast Cairns No.4 transformer can be decommissioned at end of life.

Through joint planning it has been identified 22kV cables supplying the Cairns 22kV bus need to be rearranged to ensure that bus outages would not impact supply. A review of the transformer cables is also to be carried out to ensure that adequate rating is available.

Removal of T4 will reduce the fault level on the 22kV bus significantly, and it may be necessary to reconfigure the 22kV capacitor banks to avoid excessive switching voltage step changes on the 22kV bus. An alternative to this may be to remove the 132kV reactors. If a third transformer were to be reinstalled at a later date, it may be necessary to re-install the reactors should they be removed.

[redacted]

[redacted]

[redacted]

2.3.4 Market and regulatory considerations

Non-network alternatives

Ergon have advised that there is potential for an additional 6MW to the existing Demand Side Management (DSM) in the Kamerunga area.

Non –network solutions within the Northern Beaches may be available to defer or remove potential thermal limitations on the Kamerunga transformers.

Generation

Barron Gorge Hydro, located 20 kilometres north west of Cairns in Far North Queensland and commissioned in 1963, and can generate approximately 60MW of capacity. It is expected that the generation will remain in service well outside the outlook period of the AMP.

Barron Gorge is connected to the 132kV bus at Kamerunga, and cannot support the load locally for an outage of the 132/22kV transformers. The operation of Barron Gorge, or any other generation that may operate in the area, could be a credible alternative to defer or remove thermal limitations on the Woree – Kamerunga 132kV feeders under high growth scenarios.

2.4 Other considerations

2.4.1 Environment

A major constraint for access and construction in the Cairns Area is the environmentally sensitive location in the Wet Tropics World Heritage Area (WHA) which completely surrounds the coastal area from Cairns to Cardwell. The restrictions imposed due to the WHA, means that special consideration needs to be given for all projects to provide capacity for the longer term in the region to ensure best use of easements and lands, and the type of construction methods that can be used.

2.4.2 Operational telecommunications

In the Cairns area, Powerlink's telecommunications network assets consist of the following:

- OPGW;
- ADSS fibre between Cairns and Kamerunga substations;
- microwave communication links between Cairns Substation and Barron Gorge Power Station;
- Ergon fibre between Cairns and Woree and between Woree and Edmonton substations; and
- PLC.

[redacted]

Legacy microwave and PLC systems have low capacity and are maintenance intensive. Powerlink's telecommunications asset management strategy has been, where practicable and cost effective, to consider migration of the telecommunications circuits off these legacy systems to higher capacity fibre network which is more secure and reliable. To facilitate this strategy, any new or rebuilt transmission lines should have OPGW installed as the earth wire and where practical earth wire replacement projects should include OPGW as the preferred overhead earth wire.

Cairns area specific

The fibre between Cairns and Kamerunga is ADSS (All Dielectric Self Supporting) and installed on wooden poles. Maintenance of this cable is extensive and it has been damaged several times in the past. Any future rebuild or refit of the Woree to Kamerunga line should consider the installation of OPGW.

PLC associated with the feeders at Turkinje should be decommissioned as part of secondary system rebuilds.

The microwave link between Barron Gorge and Wrights Lookout may require replacing in the 10 year outlook.

Cairns area general

It is proposed that the following be considered:

- the Operational Telephone Network will be replaced at all sites;
- DWDM equipment will be replaced at effected sites; and
- telecommunication services will be migrated to IP where effective to do so.

2.5 Investment outlook

2.5.1 Strategic investment strategy

The investment outlook for the Cairns area will require a broader consideration of the interaction between individual assets, their condition, network requirements and other factors.

Previous reinvestment strategies for the 132kV assets in the Kamerunga area were integrated with the expected augmentation requirements to meet the forecast increase in load resulting in significant distribution network expansion and requirement for higher continuous current ratings to meet the high demand growth.

Reinvestment decisions for meeting both the asset reinvestment and future network requirements that are expected in the 10 year outlook need to achieve the following:

- ensuring a reliable service to the Cairns northern beaches area;
- achieving alignment between the end of life of the towers and tower structural components (foundations, conductor, OPGW);
- achieving alignment between the end of life of equipment in the Kamerunga Substation;
- achieving a balance between cost efficiency and reliability of supply through selection of the most feasible option identified for the asset.

2.5.2 Targeted investment strategy

A number of strategies for meeting both reinvestment and potential future network requirements have been developed and analysed for the following assets:

- Woree to Kamerunga 132kV transmission line
- Kamerunga 132kV Substation and
- Cairns No.4 transformer.

Each is discussed in turn below.

Woree to Kamerunga 132kV transmission line

The Woree to Kamerunga 132kV transmission line was constructed in 1963 and it is approaching the end of its technical or economic life. It is expected major reinvestment may be required just beyond the 10 year outlook.

There is an ongoing need to maintain 132kV connection to Barron Gorge Power Station and 22kV connection to Ergon at Kamerunga Substation. The existing easement is only 20 metres in width and there is no capacity to rebuild along this easement unless the existing transmission line is dismantled first, which is not technically feasible.

Cairns city has undergone significant development over the last two decades, which has been accompanied by a progressive urban sprawl. Some sections of the existing easement have been subjected to encroachment of urban development and residential dwellings to surround towers. The encroachment has limited access to the transmission line and has a significant impact on its maintenance and operation.

The declining condition of the transmission line has meant extensive life extension works have been undertaken over the last two years. These works were required to ensure the existing line reached its technical or economic life around 2023. However, invasive structural repairs techniques such as painting and blasting are not technically feasible due to the presented easement constraints and any further repairs will only offer incremental extension of life due to the condition of the grillage foundations.

The end of life decisions for the Woree to Kamerunga 132kV transmission line are currently under review and are being assessed under 3 option themes:

- Option 1 - Line Refit on the existing easement;
- Option 2 - Line Replacement on existing easement;
- Option 3 - Line Replacement on new easement
    - o Further refurbishment to defer replacement incrementally, followed by line replacement;
    - o Overhead line construction; and
    - o Partial underground construction, potentially via the Redlynch transition site.

It is considered likely that in the longer term the only feasible solution involves line replacement. The deferral benefit or costs associated with another incremental refurbishment cannot be determined at this point in time, however will be considered as part of the end of life assessment.

[redacted]

[redacted]

Kamerunga 132kV Substation

The future reinvestment strategy of the Kamerunga 132kV Substation has considered the following plant and load driven issues as follows.

- Network requirements:
  - o There are no thermal or voltage limitations forecast for Kamerunga without additional development, and there is an ongoing need to maintain 132kV connection to Barron Gorge Power Station and 22kV connection to Ergon. Should load further increase in the area, then installation of fans on the transformers at Kamerunga could be used to defer any thermal limitation, however may not address limitations on the 22kV network.
  - o The eventual establishment of future zone substations at Smithfield and Kewarra Beach would de-load the Kamerunga transformers.
  - o The original development at Kamerunga was planned as a two transformer site. There are space restrictions with residential development surrounding the property. Installation of a third 132/22kV transformer would require rearrangement of the 132kV bus. Increasing transformer capacity would require the installation of series reactors to control fault levels on the distribution network. This option would also require significant augmentation of the 22kV distribution network.
  - o Ergon currently has a two-bus 22kV building at Kamerunga. Increasing the transformation at Kamerunga would require the extension of the 22kV building. There are limited opportunities for new 22kV corridors between Kamerunga and Smithfield, and expansion of the 22kV distribution network would likely require undergrounding which will be cost prohibitive.
  - o Under the subdued load growth outlook, it is not expected an additional zone substation between Woree and Kamerunga would be required in the next 20 years for augmentation requirements, [redacted]
  - [redacted] Two additional 132kV feeder bays may be required [redacted]
- Site and location:
  - o Initial development in 1976 at Kamerunga was for three x 132kV bays associated with one transformer and Feeders 7184, 7143, 7141 and 7142. Subsequent development during the period 1980 to 2009 included addition and replacement of the transformers, circuit breakers and instrument transformers.
  - o The 132kV yard is an H bus arrangement, without a circuit breaker in the bus section bay. It is a single breaker system, with circuit breakers on the two transformers and two 132kV feeders to Barron Gorge. This configuration reduces switching flexibility and consideration should be given to installing a bus coupler circuit breaker and circuit breakers on the 132kV feeders from Woree to improve operability and flexibility.
  - o This site is located in flood prone area and will be inundated with water depths estimated to be 1.25 m and 1.6 m for one in 100 and one in 200 years respectively. Kamerunga Substation is surrounded by residential development. The area surrounding the substation is residential along the flood plain of the Barron River. Storm surge and flood plain modelling indicate that the site and building will be subject to extensive inundation should a major coincident flood event occur.
  - o Site access issues also exist in relation to obtaining circuit routes out of Kamerunga Substation in the future, and this may be further constrained with any additional 22kV feeders (as well as the potential requirement for 132kV connections in future).
- Primary plant:
  - o The condition assessment of Kamerunga primary plant revealed risks associated with deteriorated condition of two circuit breakers, issues with disconnectors, and selected

instrument transformers. There are inadequate section clearances that require management in the short term;
  - o The existing current transformers with 5A secondary rating (requiring interposing CT's for modern relays,);

- Secondary systems:
  - o The original secondary systems equipment is now over 30 years old. To increase the security of the feeder protection to Barron Gorge Power Station, a current differential protection scheme was installed on associated feeders. This has caused a mixture of secondary systems equipment from the early 1980s through to the 2000s. The original secondary systems equipment have network risks associated with obsolescence, no spares and reliability of aging equipment associated with the earthing transformers, and original electronic relays and CVT monitoring relays in all feeder bays.
  - o The condition of the panel wiring and marshalling kiosks has approximately a further 10 years before requiring full replacement.

- The communications systems are OPGW based, located in the communications room. Existing communications systems can accommodate the requirements of the substation and are suitable for continued use.

- The proposed arrangements will need to be discussed and confirmed with Ergon and Barron Gorge Power Station owners, as being major customers with an interest in this substation.

There is a continuing need for a 132kV switchyard in the Kamerunga area in the long term to meet reliability of supply obligations to the Northern Beaches area under all demand projections. The majority of primary plant and secondary systems equipment at the Kamerunga Substation is approaching end of technical or economic life within 10 to 15 years and accordingly consideration is being given to their reinvestment strategies.

The end of life of life drivers that are currently being assessed under four option themes are as follows:

- Option 1 - converting Kamerunga to a hard teed arrangement.
- Option 2 - progressive replacement of selective equipment at Kamerunga Substation.
- Option 3 - full replacement of substation at Kamerunga
  - o staged replacement
  - o upfront replacement.
- Option 4 - full replacement of the substation at Redlynch location.

These reinvestment strategies are currently under review and the high level summary of the benefits and issues with each option is detailed in Table 2.9.

Table 2.9: High level review of reinvestment options at Kamerunga

Options	Pros	Cons
Option 1 Hard teed arrangement	Lowest upfront cost	Transformers will be exposed to generator faults Significantly reduced flexibility and reliability. Operational constraints on Barron Gorge. No provision for future 132kV supply from Kamerunga [redacted] Ongoing flood risk to equipment
Option 2 Progressive replacement	Lower upfront costs Reduce significant risks	Ongoing flood risk to equipment

Options	Pros	Cons
Option 3 Full replacement at Kamerunga -staged or upfront	Lowest risk Flood risk reduced with GIS This would enable maintenance to return to routine levels, enabling good management of available resources. Under this option, it is then expected that no major works will be required for the next 20 years with the exception of secondary systems and DC supply system, which are likely to require replacement within that period.	Higher upfront cost
Option 4 Full replacement at Redlynch	Lowest risk Flood risk reduced with GIS Maintenance benefits as above	Higher upfront cost – potentially additional costs associated with establishing 22kV supply Site is also below the Q100 flood level and exit/entries are constrained by urban development

After considering the benefits and risks of each option, it is considered likely that Option 3 that involves a full replacement of equipment at Kamerunga Substation over the next 10 years will be economic and adequately address the risks associated with the equipment remaining in service.

Option 3 can be implemented as the full substation replacement in three to five years, or the staged replacement of the secondary systems and selective primary plant in three to five years, followed by a full replacement of the 132kV switchyard in 10 years. The ongoing flood risk will be reduced once the entire switchyard is replaced to the Q100 standard.

Cairns No.4 Transformer

The Cairns No.4 transformer (T4) is approaching end of technical or economic life in 7 to 10 years and accordingly high level consideration is being given to the reinvestment strategy.

Planning studies have shown that based on the existing load forecast T4 could be decommissioned at end of life. From a loading perspective, there is no immediate requirement to replace T4 provided that the 22kV cables are adequately uprated and that T3 can be relocated. Powerlink will also need to consider whether a new 22kV station service (or obtain a second supply) as it is currently supplied from the 22kV side of T4.

Any works associated with the removal of T4 (including cable upgrades, bus reconfigurations, and capacitor bank re-configuration) must be considered in assessing whether T4 should be decommissioned or replaced.

2.6 Conclusions

The Cairns Area Plan has been undertaken to examine a number of different strategies for managing the end of life of the existing network assets and future capacity requirements in the area over the 10 year outlook of the AMP.

The recommended reinvestment strategy for the Cairns Area over the next five year outlook is as follows:

1 to 5 years

Possible reinvestment for the Cairns network over the one to five year outlook is as follows:

- Full replacement of the Kamerunga Substation
  - Option 1 – upfront replacement; or
  - Option 2 – staged replacement of full secondary systems and selective primary plant, deferring full switchyard replacement for 10 years.

5 to 10 years

- [redacted]
- Decommission No.4 transformer at Cairns Substation
- Cairns Secondary Systems replacement
- Kamerunga feeder bays for Smithfield

Beyond 10 years

- Kamerunga 132kV feeder bays for Smithfield or Kewarra Substation
- Chalumbin to Turkinje Line Replacement [redacted]
- Construct a new Woree to Kamerunga 132kV transmission line, decommission the existing line.

Individual capital and operational projects within this strategy will be subject to justification and approval at an appropriate time and are shown in Table 2.10.

Table 2.10: Proposed investment in the Cairns area (10 year outlook)

Project Number	Description	Indicative timing
CP.02617	Kamerunga Substation Rebuild	2019
CP.01664	Kamerunga 132kV Feeder Bays for Smithfield	2021
[redacted]	[redacted]	[redacted]
CP.PROV	Cairns Secondary Systems Replacement	2023

3. NORTH QUEENSLAND (NQ)

3.1 Introduction

3.1.1 Area Plan Overview

In the North Queensland area many of the substation and line assets constructed in the 1950s, 1960s and 1970s are approaching the end of technical or economic life in the 10 year outlook of the Asset Management Plan (AMP).

All the 132kV transmission assets between Townsville and Collinsville are forecast to approach end of life in 5 to 15 years. The 275kV single circuit transmission lines between Strathmore and Ross are forecast to approach end of life in 15 to 20 years. In response to these condition and age drivers, Powerlink has investigated a number of strategies to optimise the end of life decisions for the 132kV network assets that require reinvestment in the 10 year outlook, whilst holistically considering future capacity requirements and reinvestment requirements in North Queensland. The 132kV single circuit transmission lines between Townsville South and Clare South substations require reinvestment decisions in the one to five year outlook. Removal of the inland line between Townsville South and Clare South substations, whilst the coastal line remains in service, would not meet Powerlink's reliability obligations. Powerlink has identified that the installation of additional reactive support in the Proserpine area, or equivalent network support, represents a lower cost to meeting Powerlink's reliability obligations. Options that involve full replacement or extended operation of the inland line by extensive grillage foundation repairs were discounted as they are not economic.

Powerlink owns a significant number of substation and line assets in the Townsville area that are approaching the end of technical or economic life in the 10 year outlook of the AMP. These investments have been considered on an individual basis, but due to the geographic locality, shared stakeholders and potential operational impacts they have been considered in this area plan.

Powerlink has been progressively investigating strategies to ensure the condition based risks related to these assets remaining in service are acceptable, including ongoing maintenance, asset retirement, life extension and rebuild. With the current subdued demand forecast outlook, there are a number of technically feasible options for the retirement of certain transmission line assets within this area that have been investigated as part of this area plan.

3.1.2 Description of the network

The geographic area referred to in the North Queensland Area Plan includes two areas:

- Townsville Central Business district; and
- 275kV and 132kV transmission supply assets from Collinsville and Strathmore substations.

Powerlink Queensland owns and operates the 275kV and 132kV transmission network supplying North Queensland. Primary electricity supply is provided via Powerlink's three 275kV transmission lines which run from Strathmore Substation to the Ross Substation. One of these lines comprises of two single circuit lines which have been paralleled, with the older of these two single circuit lines constructed in 1978, and the other in 1985. The other two 275kV transmission lines between Strathmore and Ross are a double circuit construction that was constructed in 2010. There is presently a single 275/132kV transformer at Strathmore, and three 275/132kV transformers at Ross.

The 132kV network in North Queensland was once the only network. It comprises of a double circuit line between Collinsville and Clare South constructed in 1967, and two SCST lines on different alignments between Clare South and Townsville South which were both constructed in 1963.

There is presently one DCST 132kV line between Townsville South and Ross. The second DCST line was removed in 2015, with the remaining line unparalleled.

Townsville is supplied by a 132kV transmission network to the south and west of the greater load area injecting into an interconnected 66kV distribution system owned and operated by Ergon. Connection points are located at the Townsville South 132/66kV, Dan Gleeson 132/66kV, Garbutt 132/66kV, and Alan Sherriff 132/11kV substations.

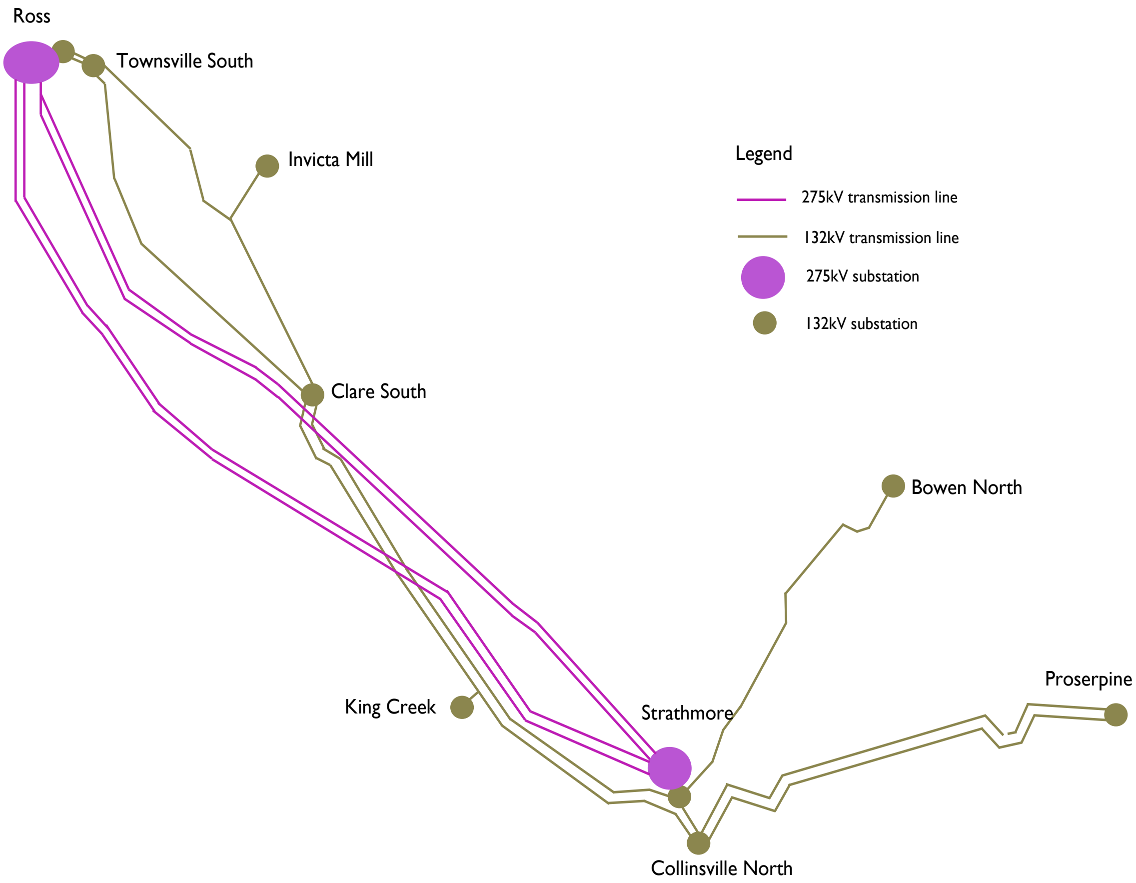
The 132kV sub-transmission network is supplied primarily by the Ross 275/132kV injection point. However, the system is also inter-linked to Strathmore 275/132kV injection point to the south of the Townsville load area, the Townsville (Yabulu) Power Station and the coastal 132kV network to the north of the Townsville load area.

The Townsville 66kV distribution network provides a strong and dynamic link between the connection points injecting into the Townsville area. Local generation dispatch at either Yabulu or Mt Stuart can change the loading balance between these connection points. Similarly, contingency conditions can also alter the power loading balance between these connection points due to the changed effective feeder impedances of the network.

The development of the North Queensland Area is detailed in Table 3.1.

The 275kV and 132kV transmission system between Strathmore and Ross is shown in Figure 3.1.

Figure 3.1: The 275kV and 132kV transmission system between Strathmore and Ross



The electricity system in the Townsville Area is shown in Figure 3.2.

Figure 3.2: Townsville Area Transmission System

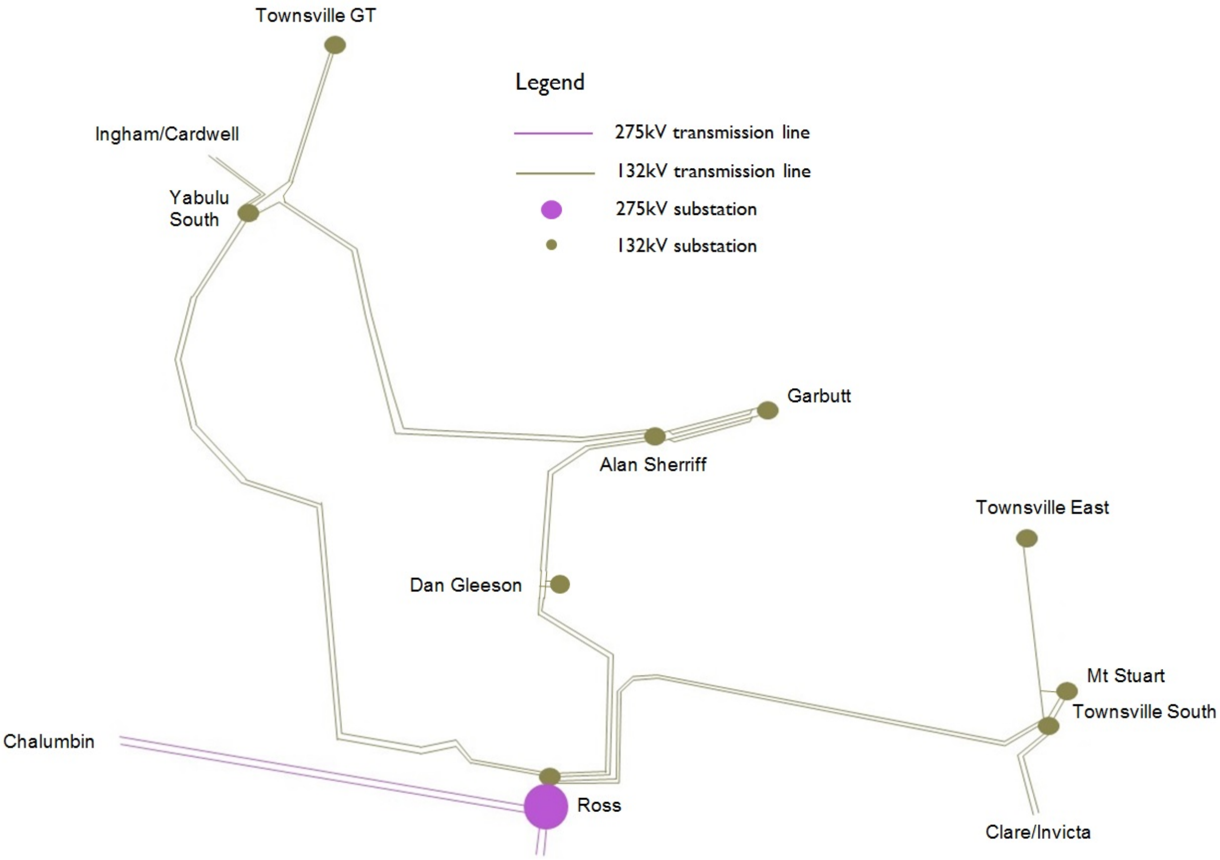


Table 3.1: Development of the transmission system in the North Queensland Area

Period	Substations	Lines
1950s	Garbutt Substation Establishment (including No.1 and No.2 132/66kV transformers)	Garbutt to Alan Sherriff 132kV Transmission Line
1960s		Dan Gleeson to Alan Sherriff 132kV Transmission Line Clare South to Townsville South 132kV Transmission Line (inland) Collinsville to Strathmore 132kV Transmission Line Clare South to Townsville South 132kV Transmission Line (coastal)
1970s	Townsville South Substation Establishment Garbutt No.1 and No.2 132/66kV transformer replacement	Ross to Dan Gleeson 132kV Transmission Line Strathmore to Collinsville South 132kV Transmission Line Strathmore to Ross 1st 275kV SCST Transmission Line
1980s	Ross 275/132kV Substation Establishment including No.1 275/132kV transformer	Townsville to Ross 132kV Transmission line Strathmore to Ross 2nd 275kV Transmission Line Ross to Townsville South 132kV Transmission Line Strathmore to Ross 275kV SCST Transmission Line
Early 1990s	Ross No.2 275/132kV transformer	
Late 1990s	Invicta Mill Substation Establishment Dan Gleeson Substation Establishment including No.1 132/66kV transformer Townsville Zinc Substation Establishment including No.1 132/66kV transformer Mt Stuart GT Switchyard Establishment Townville GT PS and Switchyard Establishment Ross No.3 and No.4 275/132kV Transformer	
Early 2000s	Strathmore 275/132kV Substation Establishment including No.1 275/132kV Transformer Alan Sherriff Substation Establishment Townsville South No.2 132/66kV Transformer replacement Dan Gleeson No.2 132/66kV Transformer	Strathmore to Clare South 132kV Transmission Line Dan Gleeson to Ross 132kV Transmission Line Alan Sherriff to Garbutt 132kV Transmission Line Alan Sherriff to Dan Gleeson 132kV Transmission line
Late 2000s	Townsville East Substation Establishment including No.1 132/66kV Transformer Clare South Substation Establishment including No.1 and No.2 132/66kV Transformers	Ross to Townsville South 132kV Transmission Line Ross to Strathmore 275kV DCST Transmission Line
2015	Collinsville North Substation Establishment including No.1 and No.2 132/66kV Transformers	Ross – Townsville South 132kV line decommissioned

3.2 Asset condition

The following sections summarise the condition of the transmission assets in the North Queensland area that have reinvestment requirements within the 10 year outlook.

3.2.1 Lines

Townsville South to Clare South inland 132kV transmission line

The inland Townsville South to Clare South single circuit transmission line (Feeder 7131, built section 1219) was commissioned in 1963. This line consists of 230 galvanized steel lattice towers and is approximately 69km in length. It operates in a relatively high rainfall area with average 66% humidity, and due to this aggressive environment will have significantly accelerated rate of corrosion compared to lines of similar age located in less corrosive environments.

A condition assessment was undertaken in May 2014 which also took into consideration the information gathered by a site inspection of 29 towers. The condition assessment confirmed that the corrosion levels on the nuts and bolts, as well as tower members, were consistent with the aggressive microclimatic conditions and age of the structures (52 years). For the most part the towers' exposed galvanised members exhibited Grade 2 corrosion, with 5% at the soil interface exhibiting Grade 3, while the nuts and bolts showed a predominance of Grade 3 corrosion.

A high level summary of the identified line condition is provided as follows:

Estimated investment timing	1 to 5 years
Structures	The galvanised tower members and fixings have started to lose their protective galvanised coating. For the most part the towers' exposed galvanised members exhibited Grade 2 corrosion, with 5% at the soil interface exhibiting Grade 3, while the nuts and bolts showed a predominance of Grade 3 corrosion.
Conductors	The conductors are in good condition, and show no significant signs of deterioration. It is estimated the conductor has another 20 years remaining life.
Earthwires	The earthwire and hardware are in generally good condition, and show no significant signs of deterioration.
Insulators	The insulator string hardware and associated hardware are in generally good condition, and show no significant signs of deterioration.
Foundations	The line has a significant number of grillage foundations, discussed further below.

Tower members in direct contact with soil have been identified as a major risk to the structural integrity. [redacted] During maintenance in 2012 and 2013, twenty structures required their footings to be repaired or treated urgently due to unacceptable levels of degradation.

The condition assessment confirmed that the corrosion levels on the nuts and bolts, as well as tower members, were consistent with the aggressive microclimatic conditions and age of the structures (52 years) and confirmed that:

- the line is positioned in a relatively high rainfall area with an average of 66% humidity. Exposed carbon steel in this environment (C4: including tropical with medium pollution) is expected to corrode at between 50 to 80 micrometres per annum, which is 25 to 40 times faster than galvanised coatings;
- there are 156 structures with grillage foundations. Excavation and removal of grillage foundations of similar age and in similar operating environments has demonstrated beyond 50 years:
  - corrosion can be present at depths of greater than 1m, while metal just below the surface is in serviceable condition. i.e. structures with observed levels of Grade 2 corrosion on their exposed members, severe corrosion at depth can be occurring (Grade 4 or more) with grillage foundation;
  - the foundations are highly susceptible to extensive below ground corrosion in poorly drained soils and aggressive elements in the soil; and

- o the corrosion rates and the extent of loss of metal cross-section vary enormously such that the condition of adjacent tower foundations, or the legs on the same tower, can be in quite different condition.

Corrosion problems at depth are difficult to assess with accuracy, short of full excavation. However, the expense of full excavation is prohibitive and excavation work exposes the foundations to atmospheric conditions that will further accelerate degradation. Consequently, the condition of buried steelwork has been assessed indirectly in view of the observed condition of grillage foundations inspected, the operating environment and observations of each tower site.

The line is located approximately 40km from the coast in far north Queensland and traverses the Houghton, Ross and Burdekin catchment basins in predominantly improved pasture and dry land cattle farming.

It is recommended that remedial action be performed to ensure safe operation of Powerlink's electricity infrastructure, and to address the anticipated condition driven risks as follows:

- grillage foundations have approximately five years of serviceable life remaining, beyond which the potential risks would be higher. If the asset is not decommissioned foundation repairs should be undertaken at the highest risk locations (15 to 17 towers located by design review of route angle points and road crossings). The risk would represent a significant to high risk beyond a further 10 years and it is recommended that all grillage foundations be repaired, or the entire transmission line be replaced or decommissioned no later than 2023; and
- structural components (including members and tower bolts) would have approximately 5 to 10 years of serviceable life remaining, beyond which the potential risks would be higher. If the asset is not decommissioned, life extension of the transmission line by way of increased maintenance or refit should be undertaken to prevent occurrence of significant levels of Grade 4 degradation resulting in loss of steel exceeding acceptable limits for design strength.

Townsville South to Clare South coastal 132kV transmission line

The coastal Townsville South to Clare South single circuit transmission line (Feeder 7130, built section 1209) was commissioned in 1967. This line consists of 177 galvanized steel lattice towers and is approximately 68km in length. It operates in a relatively high rainfall area with average 66% humidity, and due to this aggressive environment will have significantly accelerated rate of corrosion compared to lines of similar age located in less corrosive environments.

A condition assessment of the transmission line was undertaken in October 2015. A high level summary of the identified line condition is provided as follows:

Estimated investment timing	5 to 10 years
Structures	The galvanised tower members and fixings have started to lose their protective galvanised coating. For the most part the towers' exposed galvanised members exhibited Grade 2 corrosion, with 5% at the soil interface exhibiting Grade 3, while the nuts and bolts showed a predominance of Grade 3 corrosion. Grade 3 was present on all anti-climbing barriers, on most sheltered parts of the x-arm tips, and nuts and bolts exhibiting on 50% the superstructure and 80% on the tower body.
Conductors	The conductors are in good condition, and show no significant signs of deterioration. It is estimated the conductor has another 20 years remaining life.
Earthwires	The earthwire and hardware are in generally good condition, and show no significant signs of deterioration.
Insulators	The insulator string hardware and associated hardware are in generally good condition, and show no significant signs of deterioration.
Foundations	The foundations are in generally good condition, and show no significant signs of deterioration.

Significant repairs were undertaken on eight towers in 2008 and 2013. The condition assessment confirmed that the corrosion levels on the nuts and bolts, as well as tower members, were consistent with the aggressive microclimatic conditions and age of the structures (48 years).

The line traverses the Houghton and Burdekin catchment basins. The southernmost 30km of the line is dominated by sugar cane farming. The middle section traverses the Bowling Green National Park while the remainder is predominately located within the Sister Mountains and Dys Prison Farm. The line does not cross any major highways.

It is recommended that remedial action be performed to ensure safe operation of Powerlink's electricity infrastructure, and to address the anticipated condition driven risks as follows:

- structural components (including members and tower bolts) would have approximately 5 to 10 years of serviceable life remaining, beyond which the potential risks would be higher. If the asset is not decommissioned, life extension of the transmission line by way of increased maintenance or refit should be undertaken to prevent occurrence of significant levels of Grade 4 degradation resulting in loss of steel exceeding acceptable limits for design strength.

Collinsville/Strathmore to Clare South coastal 132kV DCST transmission line

A condition assessment of Collinsville/Strathmore to Clare South single circuit transmission line (Feeder 7208/7128 and 7127/7128, built section 1215 and 1260) was undertaken in 2014. A high level summary of the identified line condition is provided as follows:

Estimated investment timing	5 to 10 years
Structures	The galvanised tower members and fixings have started to lose their protective galvanised coating. For the most part the towers' exposed galvanised members exhibited Grade 2 corrosion, with 5% at the soil interface exhibiting Grade 3, while the nuts and bolts showed a predominance of Grade 3 corrosion. Grade 3 was present on all anti-climbing barriers, 30% x-arm tips, and nuts and bolts exhibiting on 20% on the tower body.
Conductors	The conductors are in good condition, and show no significant signs of deterioration. It is estimated the conductor has another 20 years remaining life.
Earthwires	The earthwire and hardware are in generally good condition, and show no significant signs of deterioration.
Insulators	The insulator string hardware has lost some of the protective galvanised coating and instances of minor metal loss have been observed.
Foundations	The foundations are in generally good condition, and show no significant signs of deterioration.

The condition assessment confirmed that the corrosion levels on the nuts and bolts, as well as tower members, were consistent with the aggressive microclimatic conditions and age of the structures (48 years).

The line traverses the Houghton and Burdekin catchment basins and the northern section is dominated by sugar cane and cattle grazing pastures.

It is recommended that remedial action on BS1215 and 1260 be performed to ensure safe operation of Powerlink's electricity infrastructure, and to address the anticipated condition driven risks as follows:

- insulator replacement in the one to five year outlook;
- structural components (including members and tower bolts) would have approximately five to 10 years of serviceable life remaining, beyond which the potential risks would be higher. If the asset is not decommissioned, life extension of the transmission line by way of increased maintenance or refit should be undertaken to prevent occurrence of significant levels of Grade 4 degradation resulting in loss of steel exceeding acceptable limits for design strength.

Garbutt to Alan Sherriff coastal 132kV DCST transmission line

The two 132kV double circuit transmission lines (Feeder 7277/7276, built section 1610) between Garbutt and Alan Sherriff substations were built in the late 1950s and early 1960s, and the subsequent deviation of the landing span in the mid-2000s. Both lines are 3.8km in length. Each of the original line sections is 3.2km in length with 10 tower structures.

The line route commences from the Alan Sherriff Substation, crosses a section of the Bruce Highway and follows the Dalrymple Road Reserve to the Garbutt Substation. Both lines operate in an aggressive tropical environment within 10km of the Coral Coast.

A condition assessment was undertaken in 2011, which identified that the condition of the foundations, structures and hardware associated with the original line sections has reached a stage where replacement is required. Primary defects identified include:

- advanced corrosion of grillage foundations, earthing, structure and cross arm steel members, structure nuts and bolts; and
- accelerated deterioration of line hardware and overhead earthwire.

It was identified that full replacement of the transmission line was required to address deteriorated condition and safety issues related to the risk if this asset remains in service. A project is underway, CP.1091 Garbutt to Alan Sherriff Transmission Line replacement, which is due for completion by June 2017. This transmission line is located within close proximity to the Townsville airport, and the project has been delayed due to issues regarding height restrictions. The scope involves replacement of the southern 132kV double circuit line with a new 132kV steel pole line, and recovery of the northern 132kV double circuit line. The second new 132kV line is to be constructed should the capacity need arise.

Dan Gleeson to Alan Sherriff coastal 132kV DCST transmission line

The Dan Gleeson to Alan Sherriff 132kV transmission line (Feeder 1223, built section 1223) consists of 21 double circuit steel lattice towers and was constructed in 1963. Two double circuit steel poles (built section 1611) were commissioned in 2004 to connect into Alan Sherriff Substation.

This line was originally, along with the Alan Sherriff – Garbutt line, as part of the Ross – Garbutt 132kV line, with the Ross – Dan Gleeson section rebuilt to allow for the Ross – Townsville South transmission line in the 1980's, and subsequently Alan Sherriff Substation connected into the line in 2004.

A condition assessment of Dan Gleeson to Alan Sherriff transmission line was undertaken in 2011. The line's topography is generally flat and follows a formed drainage canal for approximately half its length. At least 3 structures have access compromised by residential developments located along the route.

The condition assessment confirmed that the corrosion levels on the nuts and bolts, tower members, earthing, conductor and other hardware were consistent with the aggressive microclimatic conditions, proximity to the coast and age of the structures (51 years). The majority of components of the towers' members exhibited Grade 2 corrosion to Grade 3 corrosion, with nuts and bolts exhibiting Grade 3 corrosion. A high level summary of the identified line condition is provided as follows:

Estimated investment timing	0 to 5 years
Structures	The galvanised tower members and fixings have started to lose their protective galvanised coating. For the most part the towers' exposed galvanised members exhibited Grade 2 corrosion, with 5% at the soil interface exhibiting Grade 3, while the nuts and bolts showed a predominance of Grade 3 corrosion. Grade 3 was present on all anti-climbing barriers, 30% x-arm tips, and nuts and bolts exhibiting on 20% on the tower body.
Conductors	The conductors are in good condition, and show no significant signs of deterioration. It is estimated the conductor has another 20 years remaining life.
Earthwires	The earthwire and hardware are in generally good condition, and show no significant signs of deterioration.
Insulators	The insulator string hardware has lost some of the protective galvanised coating and instances of minor metal loss have been observed.
Foundations	The line has grillage foundations, discussed further below.

The Dan Gleeson to Alan Sherriff transmission line is located less than fifteen kilometres from the coast and, with the prevailing weather; towers are subject to constant wetting and drying cycles. The line is positioned in a relatively high rainfall area with an average of 66% humidity. Exposed carbon steel in this environment (C4: including tropical with medium pollution) is expected to corrode at between 50 to 80 micrometres per annum, which is 25 to 40 times faster than galvanised coatings.

Nearly all structures have grillage foundations. Excavation and removal of grillage foundations of similar age and in similar operating environments has demonstrated beyond 50 years:

- corrosion can be present at depths of greater than 1m, while metal just below the surface is in serviceable condition. i.e. structures with observed levels of Grade 2 corrosion on their exposed members, severe corrosion at depth can be occurring (Grade 4 or more) with grillage foundation;
- the foundations are highly susceptible to extensive below ground corrosion in poorly drained soils and aggressive elements in the soil; and
- the corrosion rates and the extent of loss of metal cross-section vary enormously such that the condition of adjacent tower foundations, or the legs on the same tower, can be in quite different condition.

Corrosion problems at depth are difficult to assess with accuracy, short of full excavation. However, the expense of full excavation is prohibitive and excavation work exposes the foundations to atmospheric conditions that will further accelerate degradation. Consequently, the condition of buried steelwork has been assessed indirectly in view of the observed condition of grillage foundations inspected, the operating environment and observations of each tower site. It is recommended that remedial action be performed to ensure safe operation of Powerlink’s electricity infrastructure, and to address the anticipated condition driven risks as follows:

- grillage foundations would expect to have approximately one to three years of serviceable life remaining, beyond which the potential risks would be higher. The risk to the public due to tower failure is unacceptable beyond 5 to 7 years. If the asset is not decommissioned foundation investigations or repairs should be immediately undertaken; and
- structural components (including members and tower bolts) would have approximately 5 to 10 years of serviceable life remaining, beyond which the potential risks would be higher. If the asset is not decommissioned, life extension of the transmission line by way of increased maintenance or refit should be undertaken to prevent occurrence of unacceptable levels of Grade 4 degradation resulting in loss of steel exceeding acceptable limits for design strength.

3.2.2 Substations

Ross 275/132kVSubstation

Ross Substation is located in North Queensland and has 275/132kV operating voltages in one yard. Ross Substation is supplied predominantly by four 275kV feeders from Strathmore and Chalumbin substations and provides an essential switching station for 275kV power transfer into North and Far North Queensland. Three 275/132kV bulk supply transformers provide connection to the 132kV switchyard. The 132kV switchyard provides supply to Townsville and surrounding areas through eight 132kV feeders connected from the Townsville South, Millchester, Alan Sherriff, Kidston and Yabulu South substations.

Ross Substation was established in 1985. The majority of secondary systems equipment is the original installation and is now over 25 years old. Subsequent secondary system changes were made to the 275kV diameters associated with the feeders to Strathmore and Chalumbin substations in 2001 and the 150MVAr SVC in 2012. Two additional 132kV diameters were constructed in early 2010 to provide connection to the Yabulu South Substation. This has resulted in a mixture of secondary systems equipment from the original electromechanical relays in 1985 to microprocessor based relays in 2001 and the early 2010s.

A condition assessment of the secondary systems equipment at the Ross Substation was undertaken in 2008 and reviewed in 2013. It has identified that the original equipment is required to be replaced to address condition and obsolescence risks. A project is underway, CP.1293 Ross Secondary Systems Replacement, which is due for completion by June 2018.

A condition assessment of primary plant is underway. It is expected that selective equipment will require replacement towards the end of the 10 year outlook.

Alan Sherriff Substation

Alan Sherriff Substation was built in 2002 as a two transformer 132/11kV substation, and replaced the 132kV switching functions at Garbutt in 2004. A condition assessment of the secondary systems is currently underway. The main concerns are obsolescence of the C50 RTU control systems.

At this stage it is expected the condition driven risks associated with original secondary systems equipment will exceed an acceptable risk profile requiring decommissioning or replacement of assets at the end of the 10 year outlook.

Garbutt Substation

Garbutt Substation was built in the late 1950s as a 132/66kV bulk supply and transformation point to the distribution network. In early 1960s three bays were added to the substation, and in 1978 two power transformers replaced the previous units. In 2004, the substation was rebuilt as transformer ended, with the switching function established at Alan Sherriff. The secondary systems were replaced during the substation rebuild in 2004

The 132/66kV 71MVA (ONAF) transformers 1 and 2 at Garbutt Substation were manufactured in 1977 by General Electric, and installed in 1978. The condition of these transformers is routinely assessed to assist with determining the appropriate strategies for maintenance, refurbishment and reinvestment.

Both transformers were the subject of a midlife refurbishment project in 2004 that repaired oil leaks on the HV and LV bushings, replaced gaskets, steam clean and removal of surface rust and full repaint of all surfaces. The rectification work was required to ensure the continued reliable performance of the units.

A condition assessment was completed in March 2015 which considered the results of an on-site inspection of T1 and T2 in January 2015, desktop analysis of historical oil and insulation test data, maintenance history and through fault data history where available. Given the similarities between the transformers manufacture, location and loading over their lifetime, it is reasonable to assume that they will have generally weathered in a common mode. Due to collective consideration of the condition and obsolescence issues, and the related risk of both transformers remaining in service, reinvestment in the next five years is recommended.

The secondary systems were replaced during the substation rebuild in 2004. A condition assessment will be completed early 2016. At this stage the condition driven risks associated with original secondary systems equipment are expected to exceed an acceptable risk profile requiring decommissioning or replacement beyond the end of the 10 year period.

Dan Gleeson Substation

Dan Gleeson Substation consists of one yard of 132kV operating voltage and Ergon 66kV enclosed by the one perimeter fence. There is a single building housing all facilities. The Dan Gleeson Substation was built in 1998 to provide local supply to south western suburban area of Townsville.

Dan Gleeson is supplied by two tees, one each off the Ross – Alan Sherriff 132kV DCST line, feeders 7144 and 7151. The two teed feeders are transformer ended with no bus coupler. Powerlink owns two 66kV capacitor banks connected to Ergon's 66kV bus.

The original secondary systems equipment is expected to require replacement in the next five years. A condition assessment of the secondary systems equipment at the Dan Gleeson Substation was undertaken in 2010 with the main issue obsolescence of the secondary systems equipment.

Townsville South Substation

Townsville South Substation was established in 1978 to replace the 132kV equipment at Mt Stuart substation. It is a major substation supplying the city of Townsville, a major industrial load of Sun Metals Zinc Refinery and serving as a connection point for the Mt Stuart Power Station. Initial development included two 132kV transformer bays and two 132kV feeder bays. Extensions from 1980 up to 1998 included two 66kV capacitor banks, a 132kV bus coupler and two 132kV feeder bays. Further expansion since 1998 include six 132kV feeder bays and two 132kV capacitor banks.

Based on desktop assessment it is expected the condition driven risks associated with selective primary plant will exceed an acceptable risk profile requiring decommissioning or replacement of assets in the 10 year outlook.

A secondary systems replacement of the original installation was completed in 2007. A condition assessment is currently underway and it is expected that the remaining equipment will require replacement in the next five years due to the following:

- The secondary systems of four feeders (2 x Zinc Smelters, 2 x Mt. Stuart PS) are 17 years old. They are expected to start experiencing declining reliability in the next three years and have high criticality supplying major loads;
- The No.2 Transformer secondary system has old technology PLC since 2003 and Powerlink's strategy is to progressively replace when practicable;
- Feeder 7130 – Clare South to Townsville South supplies the Invicta Mill, and after the proposed decommissioning of the inland circuit, its availability will provide critical back up supply and operational flexibility for the 132kV and 66kV network. The secondary systems was installed in 2003 and is expected to start experiencing declining reliability in the next three to five years; and
- Pending obsolescence of the C50 RTU control systems.

3.3 Network requirements

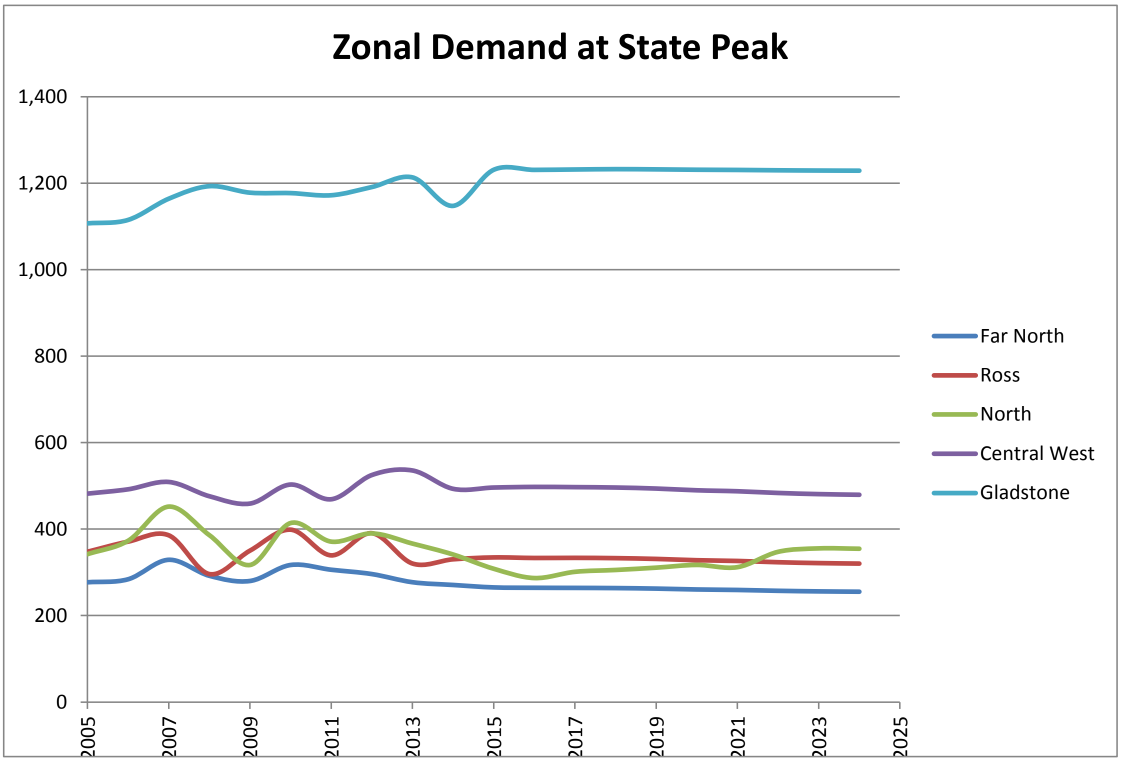
3.3.1 Demand and energy forecasts

The demand forecast at time of state peak for the Far North, Ross, North, Central West and Gladstone Zones is shown below. The contribution to state peak of the demand in the Far North, Ross and Central West zones are forecast to be relatively flat.

At the time of North Queensland peak, the forecast load for Far North and Ross zones is forecast to be relatively flat.

Note that the demand forecast shown here is at State Peak; at a local level some pockets of growth are expected.

Figure 3.3: Zonal demand at State peak



3.3.2 Load characteristics

The load in the North and Gladstone zones are dominated by mining and minerals processing, and are subject to fluctuation as a result. The North Queensland area as defined by this area plan is in the Ross zone. There is significant mining and mineral processing load in this zone with the balance being agriculture and residential. Townsville Zinc is a major industrial load in Ross zone. The mining and minerals processing loads is subject to market conditions, and can be volatile. The network in this region is sensitive to changes in load and changes in network topology.

3.3.3 Generation development

The output of the Townsville GT has significant influence on the Townsville area network. Mt Stuart generation has been assumed offline for studies. All planning studies are conducted with Townsville (132kV) both on and offline.

[redacted]

3.3.4 Existing network capability

Strathmore to Ross

Main Grid Capability

The existing network configuration between Strathmore and Ross, but with feeder 7131 assumed removed from service is adequate to supply current forecast load levels (2014/15 North Queensland 10% PoE load – the "base case"). The 275kV backbone can support load levels 30% higher than the base case studied. Generally, for the existing network, transient stability limits are limiting, with voltage stability limits able to be overcome (with adequate shedding of load), and thermal ratings not exceeded.

The main grid can support load levels of +35% and +40% without any thermal constraints, and can meet voltage stability criteria if 50 MW of load is able to be shed quickly after the fault. Above loadings of +40%, transient instability problems exist. A loading of +35% meets transient stability criteria, but only if Townsville GT is constrained off. This is not considered a reasonable position for a high loading scenario. Therefore, overall, the main grid can support approximately +30% of additional load.

132kV Network Capability

The existing 132kV network between Townsville and Collinsville is able to support the Clare, Invicta and King Creek loads. However, for loss of the single 275/132kV transformer at Strathmore, this network provides significant support to the 132kV loads out of Collinsville and Strathmore (in particular Proserpine).

Following the decommissioning of the Mackay – Proserpine circuits (approved project) in 2015, it is expected that should an outage of the Strathmore transformer occur at time of peak that there will need to be load shed to maintain satisfactory voltages at Proserpine. Analysis indicates that, based on 2013/14 observed loads, this is currently below the 50MW / 600MWh cap specified in Powerlink's Transmission Authority ('the cap'), and that no augmentation is economic.

Results are shown in Table 3.2 below.

Table 3.2: Load at risk (MWh), existing configuration

Scaling	100%	105%	110%	115%
Existing	350	774	1650	
Existing + 14MVAr Cap at T039	16	64	243	698

It was determined that a 14MVAr capacitor bank could be switched at Proserpine. The installation of such a capacitor bank was modelled and the results included in Table 2.

As can be seen, the 600MWh limit set in Powerlink's Transmission Authority is breached by a 5% load increase under this existing configuration, and if a capacitor bank is installed at Proserpine, the limit is breached at some point between 10% and 15% load increase.

Townsville Area

The base load scenario considered applied the historic MW loadings for all sites from October 2013 to March 2014 ("base case"). The load at risk was assessed and where the base case was viable loading increases of 5% were applied. The 132kV transmission system in the Townsville area can supply load levels 15% higher than the base case.

3.3.5 Forecast network performance

Strathmore to Ross

The headroom on the main grid was assessed with a variety of network and system configurations, being:

- Older section of feeder 879 either retained or removed from service
- 132kV network around Clare one of four configurations:
  - "as is" with 7131 removed;
  - Clare supplied from the South only;
  - Clare supplied from the North only; or
  - Clare supplied via 275kV injection
- Townsville GT either on or offline.

The load at risk was assessed and where the base case was viable loading increases of 5% were applied. The 275kV transmission network between Strathmore and Ross can supply load levels 30% higher than the base case with BS1219 retired.

Under base case for a contingency of a Strathmore transformer, the existing 132kV transmission network (with BS1219 in service) has less than 5% headroom to remain within Powerlink's jurisdictional reliability standards and comply with the National Electricity Rules. By retiring BS1209, this effective network reconfiguration would require the installation of a 132kV capacitor bank at Proserpine Substation, or equivalent network support of approximately 800MWhr to meet the reliability standard. The network support could be load management schemes or embedded generation in the Proserpine area, and would need to operate over peak periods regularly for a number of weeks.

Townsville Area

With two Garbutt transformers in service, the retirement of BS1223 increases the available headroom on the local 132kV and 66kV networks under system normal conditions and N-1 contingency conditions to 25% to 30%.

The Garbutt transformers are approaching end of life decisions. One option is to decommission one of the Garbutt transformers and secure network support for contingency conditions for an outage of the single Garbutt transformer. Under this option, the retirement of BS1223 will change the balance of flows on the 66kV distribution system under contingency, resulting in somewhat higher requirement for network support at Garbutt for this option.

3.3.6 Market considerations

Under certain contingency conditions and BS1219 removed from the network, there may be operational constraints under outage conditions to the Ergon 66kV distribution network requiring high speed run-back or trip schemes [redacted]

[redacted]

3.3.7 Other factors

Clare Substation is currently supplied by four 132kV circuits (2 single circuits from Townsville South and one double circuit from Strathmore / Collinsville). Decommissioning and removal of any of these circuits may reduce the access to outages. Should two of the circuits be decommissioned and removed, the load at Clare would be able to be supplied to the standards set out in Powerlink's Transmission Authority, however during outages load would be at risk. Consideration should be given to whether any extended outages are required prior to the decommissioning and removal of any circuits.

The removal of the older section of feeder 879 will reduce the potential window of outages on the 275kV network.

3.4 Other considerations

3.4.1 Telecommunications

In the North Queensland area, Powerlink's telecommunications network assets consist of the following:

- OPGW;
- Numerous microwave communication links between Ingham and Clare South;
- PLC communication; and
- The use of Ergon fibres between T145 Townsville GT and T046 Garbutt and between Ergon Garbutt Control Centre and T094 Townsville East.

Legacy PLC systems have low capacity and are maintenance intensive. Powerlink's telecommunications asset management strategy has been, where practicable and cost effective, to migrate the telecommunications circuits off these legacy systems to higher capacity fibre network which is more secure and reliable. To facilitate this strategy and provide a second independent fibre optic link in the North Queensland area, any new or rebuilt transmission lines should have OPGW installed as the earth wire and where practical earth wire replacement projects should include OPGW as the preferred overhead earth wire.

North Queensland Area Specific

Alternative fibre paths must be provisioned prior to any transmission line decommissioning where existing OPGW is affected

With the exception of the links between Kelly Mountain and Invicta Mill, and between Townsville East and Townsville Zinc Refinery, all microwave links will be decommissioned under Townsville Microwave Rationalisation and Northern Region Microwave Decommissioning projects.

No new telecommunications equipment is to be installed in the Ergon Control Centre at Garbutt. Any secondary Systems work at Garbutt Substation should consider the removal of legacy equipment in the Control Centre

North Queensland Area General

It is proposed that the following be considered;

- The Operational Telephone Network will be replaced at all sites;
- DWDM equipment will be replaced at effected sites; and
- Telecommunication services will be migrated to IP where economic.

3.4.2 Easements

The easements between Townsville South and Clare South are 132kV easements, with a single 132kV circuit on each. The easement on which 7130 runs on (the coastal circuit) is narrower, and traverses Bowling Green National Park.

The easement on which 7131 runs on (the inland circuit) is wider, and skirts the national park, however it would be necessary to establish a new easement (and circuit), of at least 12km in length, from the inland alignment the Invicta Tee should the coastal circuit be removed in full.

Both lines traverse the Houghton, Ross and Burdekin catchment basins. The southernmost sections dominated by sugar cane farming, while the remainder is predominately improved pasture and dry land cattle farming.

The easement for the Alan Sherriff to Dan Gleeson line is generally flat and follows a formed drainage canal for approximately half its length. At least 3 structures have had their access compromised by residential developments located along the route.

3.5 Investment Outlook

3.5.1 Strathmore to Ross - Strategic Investment Strategy

The investment outlook for the Strathmore to Ross 275kV and 132kV transmission will require a broader consideration of the interaction between individual assets, their condition, network requirements and other factors.

Strategies for meeting both the asset end-of-life and future network requirements are required for the following assets that are expected to have reinvestment decisions in the 10 year outlook and beyond.

Powerlink has collectively investigated a number of different network development strategies to optimise reinvestment decisions of the existing 132kV network assets and longer term supply requirements into North Queensland as follows:

- Theme 1 – Maintain the existing configuration;
- Theme 2 – 132kV rationalisation and split 132kV network; and
- Theme 3 – 132kV rationalisation and maintain connectivity.
  - o Utilising existing 132kV lines; or
  - o Reconfigure 275kV lines.

Based on network requirements, NPVs and cost/benefits analysis the proposed strategy is Theme 3 which involves maintaining the 132kV network connectivity by the proposed capital works outlined below.

<table>
<tr><td rowspan="4">Stage 1</td><td>2018</td><td colspan="3">Refit F7130 Coastal 132kV single circuit Townsville Sth to Clare South</td></tr>
<tr><td rowspan="3">2018-2019</td><td colspan="3">Installation of 132kV capacitor bank at Proserpine</td></tr>
<tr><td colspan="3">Install new Communication Path Townsville Sth to Clare (previously on 7131)</td></tr>
<tr><td colspan="3">Decommission F7131 Inland 132kV single circuit (following cap bank and OPGW commissioning)</td></tr>
<tr><td>Stage 2</td><td>2022-2025</td><td colspan="3">Refit F7208/1 Collinsville to King Creek 132kV double circuit</td></tr>
<tr><td rowspan="6">Stage 3</td><td>Decision for Stage 3 to be made in 2020 in conjunction with end of life decisions for 275kV</td><td>Theme 3 (maintain 132kV connectivity)</td><td>Theme 3a (maintain 132kV connectivity alternative option)</td><td>Theme 3b (maintain 132kV connectivity alternative option)</td></tr>
<tr><td>2022-2025</td><td>Refit remainder F7208/7128</td><td></td><td></td></tr>
<tr><td rowspan="4">2027</td><td></td><td>Decommission King Creek to Clare</td><td>Construct new DCST between Clare and Strathmore</td></tr>
<tr><td></td><td>Turn in 275kV cct at Clare and Strathmore/ Ross and construct new 132kV DCST</td><td></td></tr>
<tr><td></td><td>May advance transformer at Strathmore (*trigger will be dependent on load at that time)</td><td></td></tr>
<tr><td></td><td>New communication path King Creek to Clare</td><td></td></tr>
</table>

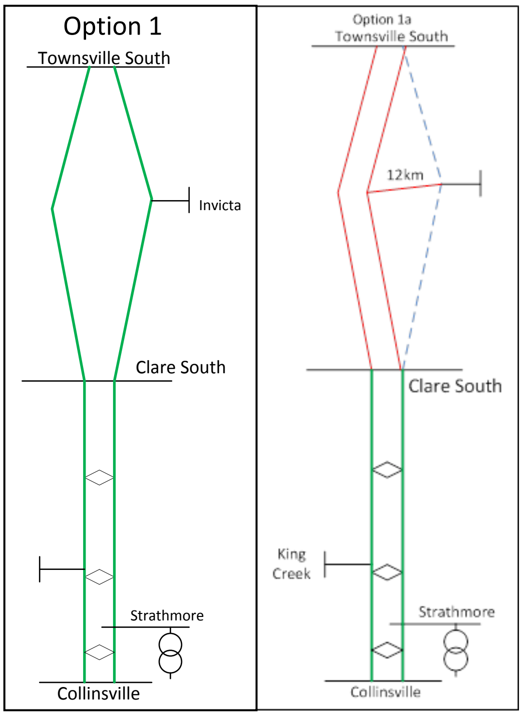
With the current relatively flat demand forecast outlook it has been identified that the inland single circuit transmission line (BS1219) can be retired at end of life, with the coastal single circuit (BS1209) in service. A reconfiguration solution has been identified involving installation of a capacitor bank at Proserpine and an alternative OPGW path. BS1209 can remain in service for a further 15 to 20 years through structural refit and painting at low cost. Hence options in Theme 1 which involve a new double circuit construction on the inland easement or extended operation of BS1219 by extensive grillage foundation repairs are not economic in the first stage. However, new double circuit construction on the inland easement should be reassessed in subsequent stages; hence Powerlink should maintain this easement.

Theme 2 is comparable in terms of NPV with Theme 1; however the network reliability and operational impacts are significant. [redacted] In order to maintain route diversity into North Queensland in subsequent stages would require continued operation of the 275kV single circuits that are coming are predicted to reach end of technical or economic life around 10 to 20 years.

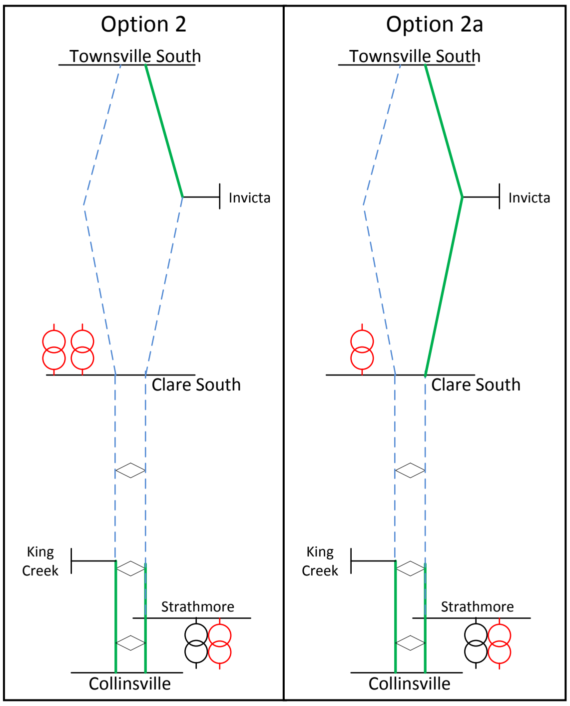
The proposed strategy, Theme 3, involves maintaining the connectivity of the 132kV coastal transmission lines as a backup supply in the first stages on the basis that it provides:

- The lowest NPV cost strategy for majority of sensitivity studies and long term loading scenarios;
- Maintenance of geographic diversity of supply into North Queensland; and
- Alignment of all subsequent EOL drivers for NQ Area 275kV and 132kV SCSTs within 2028-2035 and provides greatest flexibility for optimisation.

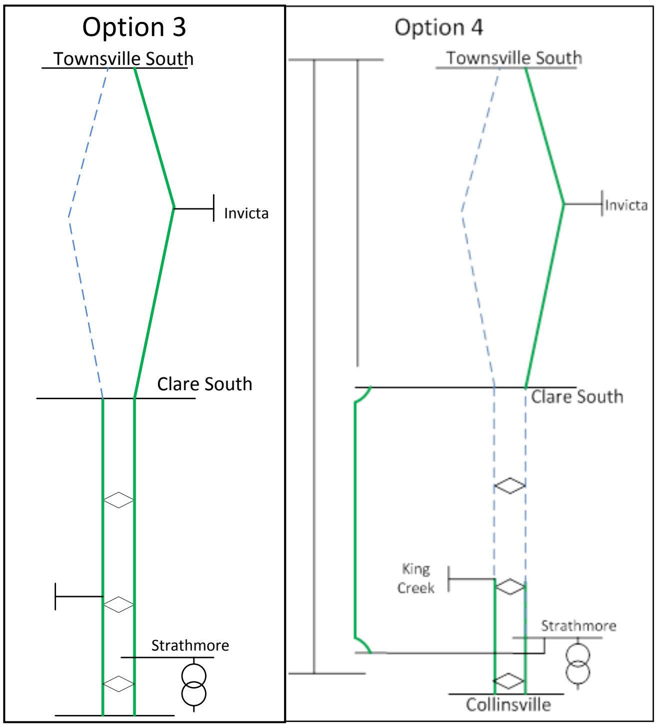
Theme 1 - Maintain the existing configuration



Theme 2 - 132kV rationalisation and split 132kV network



Theme 3 - 132kV rationalisation and maintain connectivity



It is recommended BS1209 (7130, coastal circuit) be considered for structural refit and paint in the next five years. Due to the lengthy outages required to refit BS1209, it is recommended that BS1219 remain in service to facilitate the outages required and BS1219 (7131, inland circuit) be decommissioned in the next five years once all impacted parties have been consulted and it is assessed at end of technical life. Retirement of BS1219 would also require establishing a second OPGW communication path in order to maintain two geographic diverse fibre paths between Strathmore and Ross substations.

The decommissioning of BS1219 may impact the reliability of supply to Ergon, Mt Stuart Power Station and Townsville Zinc under N-2 outage conditions, which may result in load at risk under planned outages or run-back and trip schemes. This would require consultation with the affected parties, and any additional expenditure would need to be considered further as part of the economic justification for decommissioning along with any other relevant feedback.

An inspection of one grillage foundation on each of 7 structures of BS1219 is underway to determine the suitability of BS1219 to remain in service in the short term. This is to facilitate outages required to refit the coastal single circuit BS1209, and to complete pre-requisite works to establish a second OPGW communication path and installation of a capacitor bank at the Proserpine Substation.

Dan Gleeson to Alan Sherriff

With the current relatively flat demand forecast outlook it has been identified that the Dan Gleeson to Alan Sherriff transmission line can be retired at end of life, resulting in Alan Sheriff and Garbutt substations being supplied from Yabulu South Substation via the 132kV double circuit transmission line constructed in 2008.

There is no enduring network requirement for BS1223 to meet Powerlink's reliability obligations. Hence, options that involve full replacement or extended operation of the existing line by extensive grillage foundation repairs have not been considered as they are not economic.

Following removal of BS1223, the 132kV network may have load at risk for contingencies during outages; however there is headroom on the 66kV network to support outages during periods of low loads. This will require consultation with the affected parties as part of the approval process.

Garbutt 132/66kV Transformers

Refurbishment activities on transformer 1 and 2 at Garbutt Substation such as bushing and oil replacement are possible. However, these activities are considered high risk as they place the existing paper insulation under stress and make the transformer more susceptible to faults and terminal failure. Further, the replacement of the bushings and oil will not substantially improve the reliability of the transformer as the inherent condition / moisture content of the insulation paper is the major contributor to a transformer's reliability.

As a result, two options are being considered to manage the risks associated with the Garbutt transformers:

- replacement of both transformers with two new transformers;
- network reconfiguration to supply through a single transformer in conjunction with a non-network alternative in the Townsville area. Non-network alternatives may include but are not limited to:
  - load curtailment of customer's electricity consumption during times of peak demand on the network (individual providers or aggregators); or
  - existing embedded and or/new generation.

The amount of demand to be supplied by proposed non-network solutions for summer 2018/2019 is currently forecast to be up to 10MW or 500MWh (this is the demand above Powerlink's mandated reliability standard of N-1-600MWh). However, the level of support is dependent on the location, type of network support and load forecasts. The location of the demand side management would need to generally align with the location of the load to defer the need.

Any options in relation to the replacement of the 132/66kV transformers at Garbutt must:

- address the identified need;
- be commercially and technically feasible; and
- be implemented in sufficient time to meet the identified need.

Powerlink is currently working through a feasibility study process to determine the (technical and economic) capability of the market to provide a non-network solution to meet the requirements of the Garbutt transformers. It is intended that the results of the findings will be made publically available.

Other substations

The Ross 275/132kV Substation and Townsville area bulk supply substations have transmission assets that are reaching end of technical and economic life within the 10 year outlook. These substations will continue to provide essential switching for power transfer into North Queensland and essential 132kV bulk supply to the Townsville area. Ergon will continue to take supply from the network connected to these substations and the stranding risk associated with any proposed reinvestment is therefore low.

Ross is a central node in the Townsville 132kV network, with two circuits each to Yabulu South, Townsville South and Dan Gleeson / Alan Sherriff, as well as supply to Ergon's Millchester and Kidston substations. There is little opportunity for consolidation of assets in this substation without reducing the reliability and operational flexibility of the substation.

3.6 Conclusions

The North Queensland Area Plan has been undertaken to examine a number of different strategies for managing the end of life of the existing network assets and future capacity requirements in the area over the 10 year outlook of the AMP. These strategies consider the condition based risks related to these assets remaining in service, geographic matters, asset criticality, and existing load and future network requirements.

The recommended reinvestment strategy for the North Queensland Area over the next five year outlook is as follows:

One to five years

- Replace insulators on the Strathmore/Collinsville to Clare South transmission line;
- Full replacement of the secondary systems at Ross substation;
- Replace the Alan Sherriff to Garbutt two DCST transmission lines with one DCST transmission line;
- Decommission the Dan Gleeson to Alan Sherriff transmission line (this should precede the secondary system replacements at each substation);
- Installation of an alternative OPGW fibre path between Alan Sherriff and Dan Gleeson substations;
- Life extension works on the Townsville South to Clare South transmission line (7130, coastal circuit);
- Decommission the Townsville South – Clare South 132kV transmission line (7131, inland circuit)
- Installation of 132kV capacitor bank at Proserpine substation;
- Installation of an alternative OPGW fibre path between Clare South and Townsville South;
- Garbutt 132/66kV transformer replacement;
- Selective replacement of the primary plant at Ross;
- Selective replacement of the secondary systems at Townsville South;
- Full replacement of the secondary systems at Dan Gleeson (following the decommissioning BS1223).

Possible reinvestment for the North Queensland Area over the 5 to10 year outlook is as follows:

Five to 10 years

- Life extension works on the Strathmore/Collinsville to Clare South transmission line
- Selective replacement of primary plant at Townsville South;
- Full replacement of the secondary systems at Alan Sherriff;
- Ross Substation Primary Plant Replacement.

Individual capital and operational projects within this strategy will be subject to justification and approval at an appropriate time and are shown in Table 3.3.

Table 3.3: Proposed investment in the North Queensland Area (10 year outlook)

Project Number	Description	Indicative timing
CP.01091	Garbutt - Alan Sherriff T/L Replacement	2017
CP.2646	Dan Gleeson to Alan Sherriff Fibre Easement	2017
CP.02019	Townsville South - Clare South F7130 T/L Life Extension (1209)	2018
CP.02516	Garbutt 132/66kV Transformers Replacement	2018
CP.01293	Ross Secondary Systems Replacement	2018
CP.PROV	Dan Gleeson to Alan Sherriff Communication Path	2018
CP.02410	Proserpine 132kV Capacitor Bank (T039)	2019
CP.PROV	Townsville South Secondary Systems Replacement Stage 1 (T056)	2019
CP.02640	Townsville South to Clare South Communication Path	2019
CP.01640	Dan Gleeson Secondary Systems Replacement (T092)	2019
CP.PROV	Ross Primary Plant Replacement	2023
CP.PROV	Townsville South Primary Plant Replacement (T056)	2021
CP.02304	Collinsville/Strathmore to Clare Line Refit (1215,1260)	2022

Project Number	Description	Indicative timing
CP.PROV	Alan Sherriff Secondary Systems Replacement (T150)	2024
CP.PROV	Garbutt Secondary Systems Replacement	2025
CP.02631	Ross-Dan Gleeson TL Refit (1257)	2029

4. MACKAY

4.1 Introduction

4.1.1 Background

Mackay is recognised as the gateway to the Bowen Basin coal mining reserves of Central Queensland.

The region is the location of choice for mining service companies that supply and consult to the mine operators and is strategically located within close proximity to the mines, major highways and train lines, and the Hay Point coal terminals. On the back of higher coal prices, Mackay has experienced a significant population influx and a growth rate of more than 5% per annum in the Mackay region between 2007/8 and 2012/13. The slowing down of the resources sector has flattened growth prospects.

At present, in consideration of projections of a more subdued demand growth outlook and changes in the planning standards governing how Powerlink plans the transmission network, future reinvestment strategies in this region are being reviewed.

Powerlink owns a substantial amount of assets in the Mackay area that have been developed since the early 1970s. As load requirements have grown additional substation and capacity have been added. The transmission network supplying the Mackay area is in close proximity to the coast and exposure to salt laden winds has led to an increased degradation of galvanising, and in some cases, tower components (including bolts and members). As a result, the region is characterised by transmission line infrastructure that has prematurely aged when compared to assets in less saline environments.

Reinvestment of Powerlink's existing assets in the Mackay area needs to collectively meet the existing network requirements and be resilient to potential future growth.

4.1.2 Description of Existing Network

The geographic area referred to as the "Mackay area" includes the Mackay central business district and surrounding area south to Sarina, north to Proserpine and west to Nebo.

Powerlink Queensland owns and operates the 275kV and 132kV transmission network supplying the Mackay area. Ergon Energy owns and operates the electricity distribution network, and the 132kV transmission network directly feeds the 66kV and 33kV distribution system.

Primary electricity supply into the Mackay area is provided via Powerlink's 275kV Nebo Substation. Nebo Substation was originally established in 1977 and is located 75km south west of Mackay. It is an essential 275kV switching station for power supply into Northern Queensland and 275/132kV bulk supply point for the 132kV network in the Moranbah and Mackay areas. Four 132kV circuits run north east from Nebo, with an additional two 132kV circuits providing additional support from the 275kV substation Collinsville North – teed with T039 Proserpine Substation. There are three 132kV bulk supply substations in the region:

- T065 Alligator Creek - Alligator Creek Substation is located approximately 22km south of Mackay. The substation provides supply to the Ergon distribution network (directly from the substation, but also at Louisa Creek), and Aurizon (at Oonooie and Mackay Ports substation). The line supplies the coal handling facility and the electrification of the coal haulage trains from the mines in the Bowen Basin. It provides direct supply to the town of Sarina (at 33kV) and also to smaller townships further south along the Bruce Highway. A 33kV feeder connection between T038 Mackay and T065 Alligator Creek also exists that enables South Mackay 33/11kV Substation to be transferred onto T065 Alligator Creek Substation for network maintenance and during emergencies.
- T141 Pioneer Valley – The Pioneer Valley Substation is located approximately 20km West South West of Mackay and has four 132kV supply circuits (two to Nebo, one to Alligator Creek, and one to Mackay). Two 132/66kV transformers (135.8/146.4 MVA and 128.8/139 MVA NC/EC) transformers supply Ergon's 66kV network that includes the 2 x 132kV constructed circuits to Glenella (currently operated at 66kV). In addition to supplying the Glenella 66/33/11kV substation, the 66kV network supplies the area north, south and west that include the townships of Seaforth, Eton, Marian, Mirani and Pinnacle.

- T038 Mackay – The Mackay Substation is located within Mackay city and is currently supplied via four circuits, one from H011 Nebo, one from T141 Pioneer Valley and two from Collinsville/Proserpine to the North. The substation has three transformers (86.9/90 MVA, 91.9/101.4 MVA, and a 123.5/134.2 MVA NC/EC) supplying Ergon Energy at 33kV. The 33kV network supplies the Mackay harbour, city and the west and south Mackay residential / industrial areas.

Figure 4.1: Geographical overview of the transmission network in the Mackay Area

[redacted]

The Mackay Substation was established in 1968 via a northerly 132kV connection from the Collinsville Power Station. This was followed by additional 132kV reinforcement from the Nebo Substation in the west in the late 1970s. The Alligator Creek Substation was developed in the early 1980s to facilitate a supply to the ports and coal haulage. Pioneer Valley was established in the late 1990s to support load into the Mackay region. Additional transformer capacity has been progressively installed since the early 2000's to support the load growth in the region.

There are two significant sized generators within the Mackay Area: Mackay Gas Turbine and Race Course Road Mill. Mackay GT is a peaking plant connected to Mackay's 33kV bus that rarely runs, and as a result of its age and condition is likely to be decommissioned in the near future. The Race Course Road Mill is connected into the 66kV network out of Pioneer Valley, and is designed to burn bagasse and coal. It has the facility to store bagasse from other local sugar mills in the area, theoretically allowing it to generate the whole year around. This generator is relatively new and little information is known on its operational behaviour and whether it would alleviate peak load periods.

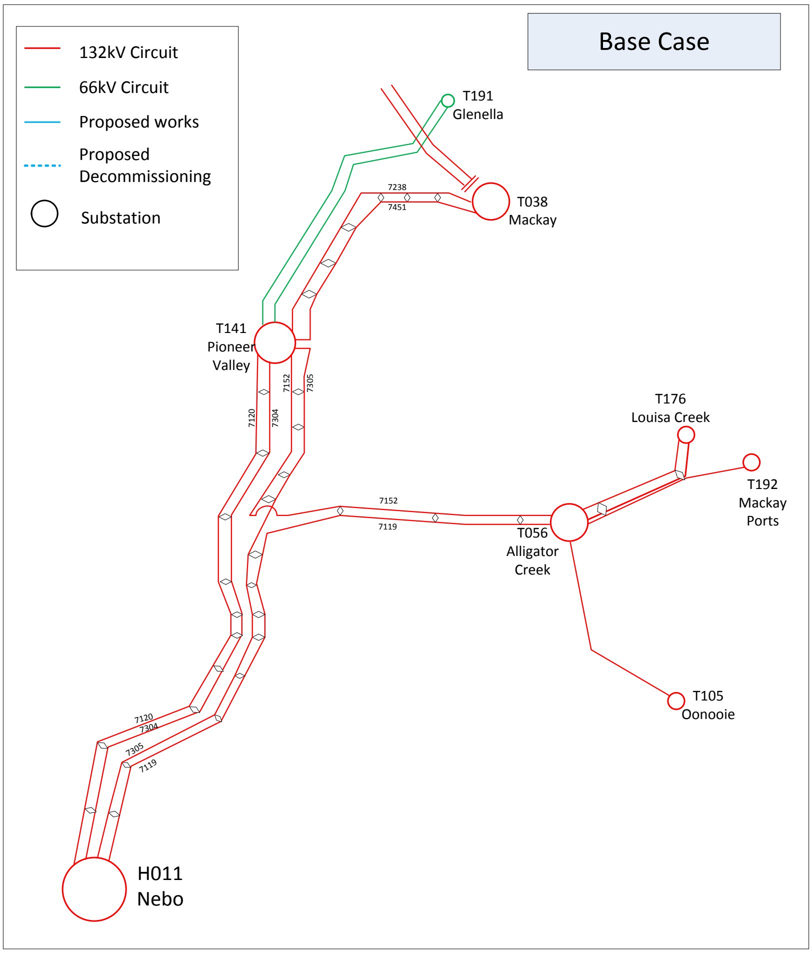
The five existing zone substations in the Mackay area along with their respective transformer and Static Var Compensator capacity is shown in Table 4.1 below.

Table 4.1: Age and Characteristics of Transformers at Zone Substations in the Mackay Area

Site Name	#	Voltage	Capacity	Start from
T065 Alligator Creek	T3	132/33/11kV	100MVA	2008
	T2	132/33/11kV	100MVA	2008
	1	132/16KV	SVC	2009
T038 Mackay	T3	132/33/11kV	40/60/80MVA	1994
	T1	132/33/11kV	80MVA	2002
	T2	132/33/11kV	30MVA	2014
H011 Nebo	T3	132/11kV	5MVA	1982
	T4	132/11kV	5MVA	1983
	T5	275/17.7kV	SVC	1987
	T6	275/132/19.1kV	250MVA	2005
	T1	288/138/19.1KV	375MVA	2013
	T2	275/132/19.1k	200MVA	2014
T141 Pioneer Valley	T2	132/66/11kV	100MVA	2004
	T1	132/66/11kV	100MVA	2013
T039 Proserpine	T1	132/66/11kV	80MVA	1997
	T2	132/66/11kV	60/80/100MVA	2003

The electricity network in the Mackay Area is shown in Figure 4.2.

Figure 4.2: Single Line Diagram of the Electricity Network in Mackay



Ergon Energy operates a 33kV network that interconnects between Powerlink's T038 Mackay, T065 Alligator Creek substations, and T141 Pioneer Valley via Ergons 66/33kV substation at Glenella. Additionally Ergon operates a 66kV network out of T141 Pioneer Valley that runs up the coast to the area supplied via Powerlink's T039 Proserpine Substation. Ergon utilises open points on their 33kV and 66kV networks and has some limit transfer capability.

Powerlink's transmission network supplies the Aurizon network to support coal haulage from the Bowen Basin. The five sites are typically supplied via a single 132kV feeder from either Nebo or Alligator Creek. The transformers on site are owned and operated by Aurizon.

The 275kV and 132kV transmission system and major transmission network developments in the Mackay area to date are shown in Table 4.2.

Table 4.2: 275kV and 132kV transmission system and major transmission network developments in the Mackay area

Period	Substations	Transformers	Lines
Late 1960s	Mackay 132kV Substation		132kV Collinsville to Mackay (built section 1201)
1972	Establishment of Proserpine Substation		Cut in of Proserpine to the 132kV Collinsville to Mackay feeder
Late 1970s	Establishment of Nebo Substation with two 275kV/132kV transformers, two 275kV feeder bays and four 132kV feeder bays		
1977			132kV from Nebo to Mackay (built section 1204, 1241 and 1242)
1982			Eton Tee to Alligator Creek (built section 1205)
1983	Establishment of Alligator Creek Substation		
1986			Establish 132kV Alligator Creek to Oonooie (built section 1206)
1986	Establishment of Wandoo Substation		
1987	Establishment of Oonooie substation		
1999	Establishment of Pioneer Valley substation		Cut in Pioneer Valley to the 132kV Nebo to Mackay feeders (built section 1256)
2002		Replacement of Transformer 1 at Mackay	
2003		Transformer 2 at Proserpine	
2004		Transformer 2 at Pioneer Valley substation	
2005		Transformer 6 at Nebo	
2007	Establishment of Mindi Substation		
2008		Replacement of Transformer 3 and 4 at Alligator Creek	Additional 132kV Nebo to Pioneer Valley Circuit (built section 1626)

Period	Substations	Transformers	Lines
2009	Establishment of Bollingbroke Substation	SVC at Alligator Creek	
2010	Establishment of Mackay Ports Substation		132kV Circuit from Alligator Creek to Louisa Creek / Mackay Ports (built section 1646, 1647 and 1648)
2013		Replacement of Transformer 1 at Pioneer Valley Replacement of Transformer 1 at Nebo	
2014		Replacement of Transformer 2 at Mackay Replacement of Transformer 2 at Nebo	

4.2 Asset Condition

The following sections summarise the condition of the transmission assets in the Mackay area that have reinvestment requirements within the 10 year outlook.

4.2.1 Transmission Lines

The 132kV network supplying Mackay was established in the late 1970's and early 1980's. The proximity of the transmission lines in an aggressive tropical coastal environment has led to increased degradation of galvanising and in some cases, tower components (including bolts and members).

132kV Eton Tee to Alligator Creek transmission line (built section 1205, feeder 7152, 7119)

The Alligator Creek to Eton Tee (built section 1205) is a double circuit 132kV transmission line (containing feeders 7152 and 7119), originally commissioned in 1982. The 22km transmission line consists of 10 steel tension towers and 52 steel suspension towers. Feeder 7119 is supplied from Nebo Substation and feeder 7152 is supplied from Pioneer Valley.

The transmission line is currently strung with Lime conductor and has sufficient electrical capacity to meet existing long term supply requirements of the region. Planning studies have highlighted an ongoing need for the transmission line to supply the port and coal haulage infrastructure associated with the Mackay ports.

The transmission line is in close proximity to the coast and is exposed to highly corrosive, salt laden winds.

Several condition assessments, including a 2015 detailed climbing inspection as well as a desktop analysis of SAP data and photographic evidence have been conducted over the last five years.

Table 4.3: Demonstrates all transmission line hardware across the built section exhibits some degree of Grade 3 and 4 corrosion

	Half Closest to Alligator Creek (31 Towers)	Half Closest to Eton Tee (31 Towers)	Entire Built Section (62 Towers)
% of bolts with Cat 3 or 4 corrosion	5.51%	1.69%	3.5%
% of members with Cat 3 or 4 corrosion	1.05%	0.26%	0.65%
Number of Towers with Cat 3 or 4 bolts > 10%	7	0	7
Number of Towers with Cat 3 or 4 members > 2.5%	4	0	4
Insulators	0	24	24
Line Hardware	30	31	61

Table 4.3 above demonstrates that all transmission line hardware across the built section exhibits some degree of Grade 3 and 4 corrosion. It can be seen that heterogeneous deterioration of bolts, members and insulators exists across the built section, with the half closest to Alligator Creek presenting greater deterioration of bolts and members.

Increased levels of maintenance work have occurred in the last three years, rectifying critical Grade 3 and 4 corrosion on insulators and conductor hardware. This increase in maintenance costs is an indication that the asset is approaching its end of life.

The suspension insulators were replaced in 1999, however, the majority of the original tension insulators still remain.

The reinvestment outlook based on the condition of the transmission line is determined by the Alligator Creek end of the line and estimated to be within the next five years. Given this heterogeneous corrosion performance, future investment will need to consider the potential to stage works. Further, the investment outlook may be extended further into the future if the minor percentage of Grade 3 (and above) corrosion is addressed separately.

Taking into consideration the effective age (moderated for condition) and location of the tower, risk modelling identifies a need to invest in the transmission line to mitigate potential risk associated with a tower collapse within the next five years. This timing aligns with the condition assessment of the transmission line.

132kV Eton Tee to Pioneer Valley transmission line (built section 1241, feeder 7120, 7304)

The Eton Tee to Pioneer Valley (built section 1241) is a double circuit 132kV transmission line (containing feeders 7304 and 7120), originally commissioned in 1977 (as part of the transmission line between Nebo and Mackay substations). Initial development was only one circuit, followed by the second circuit on the original structures in 1981. The establishment of Alligator Creek Substation resulted in one circuit in and out at the Eton Tee point in 1982, followed by a reconfiguration in 1998 when Pioneer Valley Substation was established.

The 14km transmission line consists of six steel tension towers and 36 steel suspension towers and runs parallel to and approximately 20km inland from the coast. Both feeders are supplied from Nebo substation.

Significant works under taken on this built section include the following:

- Suspension insulators replaced on structures 1701 to 1740 during 2000.
- Signage upgrade in 2009.

A desktop condition assessment conducted in 2015 highlighted:

- Cross arm, superstructure and body tower members are exhibiting some early evidence of Grade 2 corrosion, although none have yet suffered a total loss of their galvanised coatings.

- Approximately 10% of the superstructure and cross arm tip nuts and bolts are displaying early Grade 2-3 corrosion, based for the most part on their sheltered location on the structure.
- It appears as though up to 10% of the old earth strap attachment points on the tower peaks are exhibiting early Grade 3 corrosion.

The conductors are in sound condition and are considered to have at least another 25 years remaining life.

Taking into consideration the effective age (moderated for condition) and location of the tower, risk modelling highlights that there are no risks associated with a tower collapse, conductor or earthwire drop for the next 10 years. The reinvestment outlook for the transmission line is therefore expected to fall within the next 10 to 20 years.

Given the location of the built section in a harsh saline environment, the transmission line will require close monitoring to assess the progress of the corrosion on the structures.

132kV Nebo to Eton Tee transmission line (built section 1242, feeder 7304 and 7120)

The Nebo to Eton Tee (built section 1242) is a double circuit 132kV transmission line (containing feeders 7304 and 7120), originally commissioned in 1977 (as part of the transmission line between Nebo and Mackay substations). Built as part of the same development as built section 1241, the initial development was only one circuit, followed by the second circuit on the original structures in 1981. The establishment of Alligator Creek Substation resulted in one circuit in and out at the Eton Tee point in 1982, followed by a reconfiguration in 1998 when Pioneer Valley Substation was established.

The 54km transmission line consists of 25 steel tension towers and 108 steel suspension towers and transmission traverses west over the Eton Range to Nebo substation.

Significant works under taken on this built section include the following:

- Suspension insulators replaced on structures 1745 to 1854 during 2000 and 2001.
- Signage upgrade in 2009.

A desktop condition assessment conducted in 2015 identified the following conditions:

- Cross arm, superstructure and body tower members are exhibiting some early evidence of Grade 2 corrosion, although none have yet suffered a total loss of their galvanised coatings.
- Approximately 10% of the superstructure and cross arm tip nuts and bolts are displaying early Grade 2 corrosion, based for the most part on their sheltered location on the structure.
- It appears as though up to 10% of the old earth strap attachment points on the tower peaks are exhibiting early Grade 3 corrosion.
- The conductors are in sound condition and are considered to have at least another 25 years remaining life.

Based on the observed condition, the reinvestment outlook of the transmission line falls within the next 10 to 20 years. This is consistent with the risk modelling that highlights that there are no identifiable risks associated with a tower collapse, conductor or earthwire drop out in the (ten year) outlook period.

132kV Mackay to Proserpine (built section 1201, feeder 7125 and 7126)

The 132kV Mackay to Proserpine transmission line is 114km in length and consists of 294 double circuit steel lattice towers. The asset was commissioned in 1967 as the initial supply into Mackay and the majority of the towers show severe signs of corrosion, both of bolts and steel members.

A condition assessment in 2004 found that it was uneconomic to refurbish or replace the whole asset, resulting in a project to refurbish 23 towers between Mackay and the Glenella area (tower 1201-STR-0272) so as to extend their life and allow for a future connection to an Ergon Substation at Glenella. As such, these 23 towers and associated line hardware are to remain in situ for future use.

However, the remaining 271 towers of the transmission line have reached the end of their life and require decommissioning and removal. An approved project is in progress to decommission this section of transmission line, dismantle and recover all transmission line assets.

132kV Mackay to Pioneer Valley (built section 1204, feeder 7305 and 7238)

The Pioneer Valley to Mackay 132kV double circuit transmission line, BS1204, was commissioned in 1977, and carries feeders 7305 and 7238. The line length is approximately 19km, consisting of 51 double circuit 132kV transmission structures.

The transmission line structures were recently refitted and painted extending the life of the structures on the built section to 2035. However, condition assessment reports indicated:

- Grade 4 corrosion exists on conductor hardware; and
- the existing OHEW's, and conductor hardware have been identified degraded condition displaying Grade 2 or greater corrosion.

In order to ensure the life of the transmission line is achieved, a project has been approved to replace original insulators, vibration dampers and hardware by July 2016.

4.2.2 Substations

Mackay 132/33kV Substation

Condition assessments (of the primary plant and secondary systems equipment) at the Mackay Substation undertaken in 2007 and reviewed in 2013 identified that replacement is required to address condition and obsolescence issues. Major defects identified are outlined below:

- Secondary systems:
    - o the protection and control relays and RTUs are obsolete with limited manufacturer support and limited or nil spares;
- Transformer 2:
    - o degrading HV insulation;
    - o high water and PCB content of the oil (including the presence of corrosive sulphur);

Note: Transformer 2 was replaced in 2014 as part of the first stage of the Mackay Rebuild project.

- Circuit Breakers:
    - o the circuit breakers in seven of the nine bays have condition issues with hydraulic oil leaks, worn components; and
    - o there is limited or no manufacturer support and limited spare parts available from decommissioned equipment;
- Instrument Transformers:
    - o the instrument transformers have deteriorated insulation and increased moisture levels, with corroded tanks and fuse boxes on all voltage transformers and six of the ten current transformer sets;
    - o Isolators – the isolators have increased contact resistance, hot spots and corroded components.

Major components of every primary plant bay require replacement. In the event of failure of the equipment, Powerlink's ability to restore and maintain reliable supply to the Mackay area will be reduced. This is due to the lack of spares and increased probability of failure of various and numerous critical elements, which would potentially leave load at risk until the failure is rectified. As a result, corrective action is considered necessary.

The existing bays and ring bus are laid out in such a way as to require all of the 132kV primary plant to be demolished to accommodate the proposed replacement bus within the available land. A project is approved and underway, to replace both primary and secondary system equipment. This will mitigate the risks identified above while maintaining supply within Powerlink's amended Planning Standard.

Pioneer Valley 132/66kV Substation

Bay Reconfiguration

As noted above, an OR project will remove the two 132kV feeders between Mackay and Proserpine substations from service in July 2016 due to condition. The Mackay Substation will then have supply from the Pioneer Valley and Nebo substations only. Planning studies have shown that, following removal of the Mackay to Proserpine 132kV lines from service, a voltage limitation on the transmission network will occur during an outage of the 132kV feeder which supplies the Mackay Substation from Pioneer Valley. Corrective action will be required by summer 2015/16 to enable Powerlink to meet its reliability of supply obligations.

The most economic option was determined to be to install two 132kV feeder bays at the Pioneer Valley Substation and connect the 132kV feeder between Nebo and Mackay substations. A project, CP.02145 Pioneer Valley 132kV Feeder Bays, to undertake these works was completed in November 2015.

This now allows the feeders to be sectionalised and reduce the network impact during the critical feeder outages. This option would also provide increased operational flexibility by allowing outages for any of the circuits to the Pioneer Valley Substation and the Mackay Substation. The security of supply is increased and due to the increased strength on the network, power quality is improved in the area.

Secondary Systems

A condition assessment undertaken in 2010 of the secondary systems equipment at the Pioneer Valley Substation confirmed that the secondary systems installed prior to 2008 require replacement to address condition and obsolescence issues.

Primary defects identified with the pre-2008 equipment include:

- protection relays, transducers, local substation control, RTU, metering Datagate and OpsWAN facilities are obsolete technology with no or limited manufacturer support and limited spares; and
- substation AC and DC distribution boards have reached their full capacity with limited spare circuits for reconfiguration in a fault event.

The life of the secondary systems assets cannot feasibly be extended due to the proprietary nature of the system. While some elements of the secondary systems could be replaced with new standard equipment, they cannot be interfaced to the rest of the existing system without creating a full interface between the new standard equipment and old proprietary equipment. Such an approach is considered to be technically difficult and would require use of scarce (hence costly) technical resources.

In the event of failure of the secondary systems, Powerlink's ability to maintain reliability of supply to the Mackay area will be reduced and would potentially leave load at risk until the failure is rectified. As a result, corrective action is considered necessary.

CP.01972, Pioneer Valley Secondary Systems is approved and underway. The project will implement a full secondary systems rebuild to mitigate the risks associated with obsolescence and interfacing configuration issues.

275/132kV H011 Nebo Substation

The Nebo Substation contains the following primary plant assets which are protected and controlled by the secondary systems equipment:

- 275kV switchyard: 6 feeder bays, two capacitor bank bays, two reactor bays and one SVC bay; and
- 132kV switchyard: 9 feeder bays and five transformer bays.

Secondary Systems Replacement

Approximately half of the secondary systems equipment is the original installation and is now over 35 years old. Subsequent additions were made to the site in the 1980s, 1990s and 2000s. This has resulted in a mixture of secondary systems equipment from the original electromechanical and electronic protection relays in 1977 and 1980s, to microprocessor based and digital relays in later extensions.

A condition assessment of the secondary systems equipment at the Nebo Substation was undertaken in 2008 and reviewed in 2012. It has identified that the original equipment installed before 2002 is required to be replaced to address condition and obsolescence issues.

Primary defects identified include:

- Protection relays, transducers, local substation control, RTU, metering and OpsWAN facilities are obsolete technology with no or limited manufacturer support and limited spares;

- Protection and control relays and interface modules have experienced increased failure rates with increased equipment age;
- Local control facilities are via the large wallboard mimic panels and have no capacity for expansion and there are no spares for this equipment; and
- The SCADA system is proprietary technology that is unique to the Nebo Substation and is obsolete technology with limited manufacturer support.

As with the primary plant, in the event of failure of the secondary systems, Powerlink's ability to support transfers into North Queensland and to maintain reliability of supply into the Moranbah and Mackay areas will be reduced and would potentially leave load at risk until the failure is rectified. As a result, corrective action is considered necessary.

A project, CP.01016, Nebo Secondary Systems Replacement is underway and is expected to be finalised in 2018.

Transformer 1 and 2 Replacement

Transformers 1 and 2 at Nebo Substation are over 32 years old and recent inspection found that there are several defects, which are impacting on the continued reliable performance of these units. The Nebo 275/132kV transformers supply the 132kV network between Moranbah and Mackay and this requirement will continue into the foreseeable future.

Condition assessment of the transformers has revealed that they have suffered accelerated ageing of the insulation, which limits the cost effectiveness of substantial ongoing refurbishment. Other defects that are present on these units include:

- oil leaks;
- rust on the cooling bank radiators and structures, and rust and loss of paint coating from main tank and conservator;
- insulation failure on control and supply cables to all fans and pumps; and
- failed cooling fans.
- Consequently, refurbishment work on these transformers at this time is not considered a feasible option for the long-term management of these assets and their replacement is necessary.

Transformer 1 and 2 are to be replaced with 375MVA units in-situ with location offset. This requires the establishment of a new transformer bay behind the existing transformer with an overhead connection to the 132kV switchyard. The location offset from the existing unit will provide adequate clearance to construct the new bay and install the new transformer before disconnection of the existing unit. This will require some staging for the cut-over work during outages to maintain supply reliability.

Transformer 1 was commissioned under CP.01397 in August of 2015 and Transformer 2 is planned to be commissioned under CP.01396 by the end of 2015.

Transformer 3 and 4 Replacement

Transformers 3 and 4 at Nebo Substation are 32 years old. A condition assessment has been performed towards the transformers "end of life" including an on-site visual assessment combined with a desktop analysis of historical oil and insulation test data, maintenance history and through fault data history where available. A summary of the condition assessment is included below:

- The transformer has been repainted in its life and while showing oxidation, only minor corrosion exists on the outside of the transformer;
- The winding paper is estimated to have 10 and 15 years remaining for transformer 3 and 4 respectively;
- The clamping structures contributing to the transformers winding mechanical stability are an old design which may lead to increased rates of moisture exchange with the oil;

- The HV bushings are 32 years old, well past the nominal 25 years suggested by the OEM. Regardless, they are expected to have between 5 to 10 years life remaining. The LV bushings are in a serviceable condition;
- The acidity of the insulating oil is starting to get high and it has a service life of approximately five years remaining;
- The radiators are hot dipped galvanised and have 10 years remaining; and
- The transformers are exhibiting very minor leaks which can be addressed under normal maintenance.

The assessment has revealed that even though transformer 4 has more residual life in the cellulose insulation (winding paper) then transformer 3, both transformers suffer from similarly aged oil which tends to limit both transformers residual life "as-is" to the same 5+ years. Based on the condition assessment and risk modelling, the transformers are expected to require reinvestment in the 5 to 10 year outlook.

4.3 Network Requirements

4.3.1 Demand forecast

Figure 4.3: Mackay Area peak load demand – historical and forecast

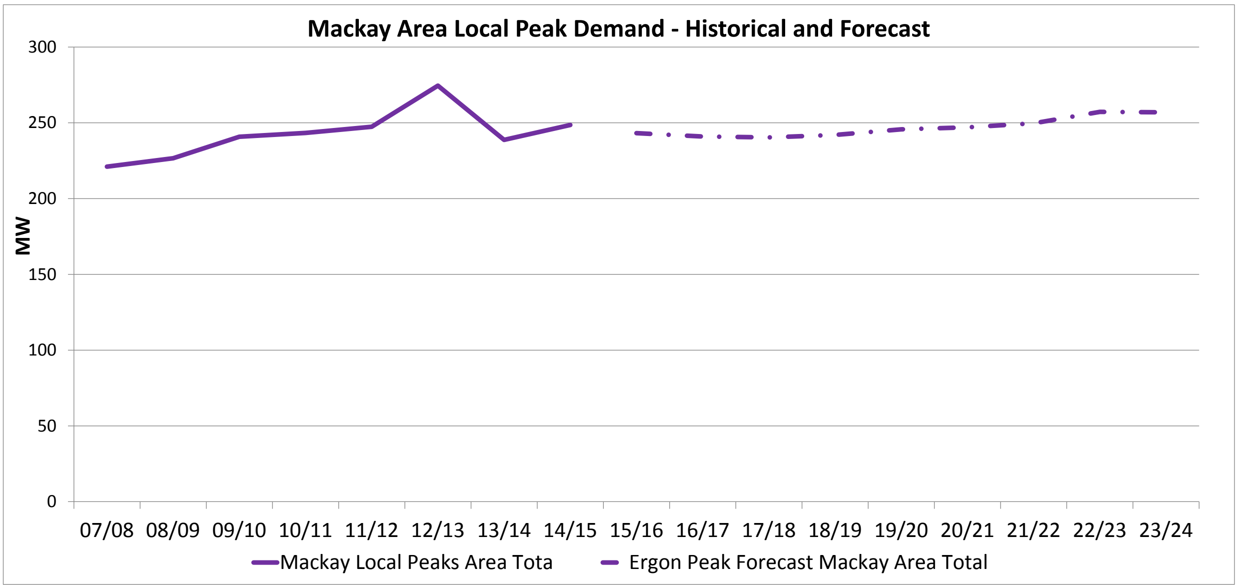


Figure 4.3 reflects a growth rate of more than 5% per annum in the Mackay region between 2007/8 and 2012/13. However since 2012/13, a downturn in the resources sector has resulted in a subdued demand and a relatively flat forecast over the next ten year outlook. Consequently, the existing network is capable of supporting current and forecast demand with no trigger to augment capacity over the balance of the forecast period.

4.3.2 Market and Regulatory Considerations

Joint Planning – Ergon Energy

Major work in the last five years within the 132kV network in the Mackay area has involved: replacement of the 132/66kV transformer at Pioneer Valley; replacement of Transformer 2 at Mackay, and the refurbishment of towers between Pioneer Valley to Mackay and between Mackay to Proserpine (but only to a point just north of Ergon's Glenella Substation).

4.4 Other Considerations

Operational Telecommunications

In the Mackay area, Powerlink's telecommunications network assets consist of the following:

- Limited OPGW;
- Microwave communication links between Nebo and Mackay and between Alligator Creek and Mount Blackwood; and
- PLC communication.

A fibre optic cable is also utilised through an operational agreement with Ergon between Pioneer Valley and Ergon's Glenella Substation.

Legacy microwave and PLC systems have low capacity and are maintenance intensive. Powerlink's telecommunications asset management strategy has been, where practicable and cost effective, to migrate the telecommunications circuits off these legacy systems to higher capacity fibre network which is more secure and reliable. To facilitate this strategy and provide higher capacity to the Mackay region, any new or rebuilt transmission lines should have OPGW installed as the earth wire and where practical earth wire replacement projects should include OPGW as the preferred overhead earth wire.

The Mackay region is the least area serviced by OPGW and relies heavily on 4 microwave links between Nebo and Mackay. These microwave links are due to be replaced in 2024. Alligator Creek, Louisa Creek and Mackay Ports are supported by a microwave link and PLC which severely restricts the communication capability in this area and any rebuilds to these substations may be limited due to the limitations in telecommunications capacity. Installation of OPGW should be considered as part of any rebuild work

Proserpine Substation is serviced purely by PLC and any substation or secondary systems rebuild will be impacted by the lack of communications. Installation of OPGW should be considered as part of any rebuild work.

In general, it is proposed that, where practicable and economic to do so:

- the Operational Telephone Network will be replaced at all sites;
- DWDM equipment will be replaced at effected sites; and
- Telecommunication services will be migrated to IP.

4.5 Investment Outlook

Targeted Investment Strategy

The nature of the condition of the assets and requirements of the Mackay area network results in limited opportunity for network optimisation. Given this, each investment is considered on an individual basis but is contained within this area plan as there are shared stakeholder interests and a potential impact on future portfolio delivery.

The following projects are approved, in progress and have spend in the next five year outlook.

Table 4.4: Approved projects in the Mackay Area

Category	Title	Commissioning Date
Lines	CP.02642 Install OPGW on 1204 and Refit Transmission Line Insulation	2016
Substation	CP.01128 Mackay Substation Rebuild	2017
Secondary Systems	CP.01972 Pioneer Valley Secondary Systems	2016
Secondary Systems	CP.01016 Nebo Secondary Systems Replacement	2018

Table 4.5 below outlines the projects have been recently completed in the Mackay Region.

Table 4.5: Recently completed projects in the Mackay region

Category	Project
Substation	CP.02145 Pioneer Valley 132kV Feeder Bay
Substation	CP.01397 Nebo Transformer 1 Replacement
Substation	CP.01396 Nebo Transformer 2 Replacement

The following needs are currently being considered to manage Powerlink's risk profile.

Eton to Alligator Creek 132kV transmission line

Three options to address the risk associated end of life issues were identified, which included:

1. An Operational Refurbishment project to address the most deteriorated components followed by a program of painting, refit, easement acquisition and rebuild;
2. A Transmission Line Refit project including painting, followed by a program of painting, easement acquisition and rebuild; and
3. Easement acquisition and Transmission Line Rebuild project followed by a program of painting.

Staged alternatives for the Refit and Rebuild Options (2 and 3) were also assessed. Each of the above options was considered against a range of criteria to identify the most suitable action to address the end of life drivers for this transmission line. These included economic assessment and analysis of the timings between future investments which take into account the harsh environment in which the line is located; risks related to ongoing operation of the assets; and Powerlink's legal and compliance obligations.

Powerlink's preferred option is to undertake a Full Transmission Line Refit (including painting), implemented in the next five years.

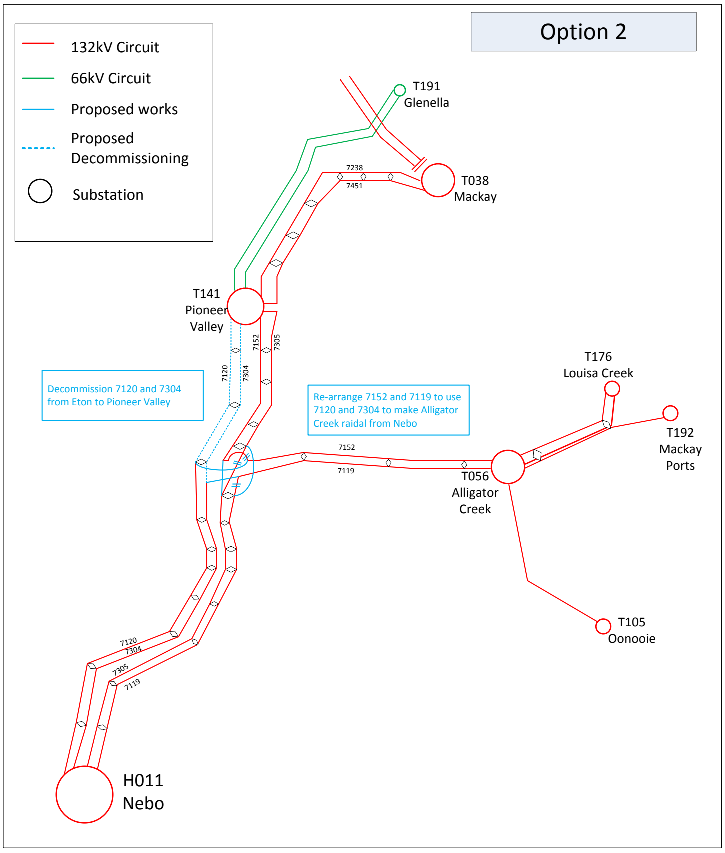
Eton to Pioneer Valley 132kV transmission line

Planning studies have highlighted there is an opportunity to rationalise the network around Mackay by retiring the northerly sections of 7304 and 7120. This could be achieved by:

- Decommissioning the northerly sections of feeders 7304 and 7120;
- Reconfigure the remaining sections of 7120 and 7304 with 7119 and 7152 Eton to Alligator Creek sections to create a double circuit lime radial line from Nebo to Alligator Creek; and
- Reconfigure the remaining sections of 7304, 7119 and 7120 to create a double circuit single phosphorus line from Nebo to Pioneer Valley.

This approach provides the flexibility to head towards a double tee connection to Alligator Creek in the longer term, while retaining easement to reinstate the second double circuit between Nebo and Pioneer Valley should this be required. The reconfiguration is shown diagrammatically in Figure 4.4 below.

Figure 4.4: Eton to Pioneer Valley 132kV transmission line rationalisation



Powerlink's current preferred option is to retire the transmission line in the 10 to 20 year outlook period. However, further detailed planning studies (with the most up to date demand forecast) and condition assessments will be required to evaluate other potential options which may include a potential refit or reconfiguration of the existing network.

Nebo Transformer 3 and 4

Two options were considered to manage the risk levels associated with the transformers 3 and 4 at Nebo.

The first option assessed was to replace the existing transformers with two new transformers. Under this option the 2 x 5MVA transformers would be replaced with two new 132/11kV transformers. This option provides adequate N-1 capacity and ensures that Powerlink's reliability obligations under its Transmission Authority are met.

The second option examined whether it was possible to replace the existing transformers with a single transformer. Under this option the 2 x 5MVA transformers would be replaced with a single 132/11kV transformer. This option would not meet Powerlink's obligations under its Transmission Authority, as more than 600MWh of load would be shed for the loss of the single remaining transformer. However, in combination with network support, this option could potentially be feasible and non-network solutions would be sought via Powerlink's Non-network Feasibility Study Process closer to the need timing. The required network support would need to be operational within 5 days and be able to provide up to 5MW.

Based on current analysis and notwithstanding the opportunity for potential non-network support, the current network reinvestment alternative is option 1, replacement with two new 132/11kV transformers in the five to 10 year outlook. This option is recommended on the basis that it meets reliability obligations and represents the most economic and efficient investment decision.

4.6 Conclusions

The Mackay Area Plan has been undertaken to examine a number of different strategies for managing the end of life of the existing network assets and future capacity requirements in the area over the 10 year outlook of the AMP.

The recommended reinvestment strategy for the Mackay Area over the next five year horizon period is as follows:

- 1 to 5 years
  - o Completion of the following approved projects:
    - Glenella Transmission Line Decommissioning;
    - Mackay Substation Rebuild;
    - Pioneer Secondary Systems; and
    - Nebo Secondary System.
  - o Transmission Line Refit of the 132kV Eton Tee to Alligator Creek transmission line
- 5 to 10 years
  - o Mackay Region Microwave Replacement in 2024
  - o Replacement of 132/11kV transformer 3 and 4 at Nebo substation.
- Beyond 10 years
  - o Rationalisation of the 132kV feeders between Eton Tee and Pioneer Valley around 2025
  - o Management of risks associated with the 132kV Eton Tee to Nebo transmission line

Individual capital and operational projects within this strategy will be subject to justification and approval at an appropriate time and are shown in Table 4.6.

Table 4.6: Proposed investment in the Mackay Area (10 year outlook)

Project Number	Description	Indicative Timing
CP.02642	Install OPGW on 1204 and Refit Transmission Line Insulation	2016
CP.02629	Alligator Creek - Eton TL Refit (1205)	2018
CP.02305	Pioneer Valley - Eton 132kV TL Line Refit (1241)	2025
CP.02306	Nebo - Eton 132kV TL Refit (1242)	>2025
CP.01128	Mackay Substation Replacement (T038)	2017
CP.02351	Nebo Primary Plant Replacement (H011)	2018
CP.PROV	Mackay Region Microwave Replacement	2024
CP.01016	Nebo Secondary Systems	2018
CP.01972	Pioneer Valley Secondary Systems	2016

5. CENTRAL WEST

5.1 Introduction

5.1.1 Area plan overview

The 132kV network between Callide and Blackwater was developed between the mid-1960’s and the late 1970’s. Initial developments coincided with the establishment of the Callide A Power Station and supplied the nearby towns of Biloela and Moura. The network was subsequently extended to Gladstone in 1966 and Blackwater via Baralaba in 1968. An additional circuit between Callide and Blackwater, via Baralaba, was constructed in 1977 to support the increased mining activity in the Central West Queensland (CWQ) area.

The QR connection to Dingo and the Callide B connection was established in 1986, while Duaringa was tee-connected into feeder 7113 in 2012 to meet the expansion of Aurizon. The Biloela substation was substantially rebuilt in 2006.

Selected 110kV primary plant and secondary system components at the Callide A, Moura and Baralaba substations will require investment in the next five years. Plans are currently in place to replace these assets or retire them from service depending on identified network needs.

The 132kV transmission line between Callide – Biloela – Moura was constructed in the mid-1960’s. Whilst the above ground structures were assessed to be in relatively good condition (given the age of the structure) the line was constructed with grillage foundations which require a separate, detailed condition assessment. The nature of grillage foundations is such that metal just below the surface may be in serviceable condition, while corrosion can be present at depths of greater than 1m.

Powerlink’s asset management strategy is to monitor the condition of the transmission line assets between Callide and Baralaba, and Moura to Baralaba and investigate all line management strategies to ensure that condition based risks related to these assets remaining in service are acceptable. These include strategies that provide for an extension of life through line refit works such as structural repairs, foundation reinforcement works and replacement of line components and hardware. It is likely that these transmission lines will need to be considered for a line refit project within the 10 year outlook of the AMP to economically defer a line rebuild, or complete rebuild when life extension works are economically unjustifiable.

This Central West Area Plan has been developed to examine a number of different strategies for managing the lifecycle risks and consequential reinvestment strategies of the existing network assets and future capacity requirements in the area. These strategies consider the condition based risks related to these assets remaining in service, geographic matters, asset criticality, existing load and future network requirements for the area.

5.1.2 Description of Existing Network

Powerlink's transmission supply network in the Central West consists of 132kV single circuit connections between Callide A and Baralaba, Baralaba and Moura and a single circuit tee connection between Moura and the double circuit between Callide A and Biloela. There are two single circuit connections between Baralaba and Blackwater, each of which services an Aurizon rail traction load connection point. Additionally, there is a 132kV double circuit between Callide A and Gladstone South.

The electricity supply network in the Central West is shown geographically in Figure 5.1.

Figure 5.1: Electricity supply network in the Central West

[redacted]

The loads at Moura and Biloela consist predominantly of mining load and are serviced by a single 275/132kV transformer at Callide. Limited support is received from Gladstone South and Blackwater in the event of an outage of the Callide transformer.

Since this network was originally planned and constructed, further network developments have taken place to meet load growth, including 275kV supply at Lilyvale, Gladstone and Callide. These subsequent developments mean that the services to be provided by the CWQ 132kV network are likely to be very different now and in the future, compared to prevailing needs at the time this network was originally established.

5.2 Asset condition

5.2.1 Substation assets

Callide A Substation

T022 Callide A 132/11kV substation was built in the early 1960's, predominantly to enable connection of Callide A Power Station to the 132kV transmission grid. Since then as power station development occurred in this area, this substation has developed to become a significant 132kV switchyard. It provides a major connection point for all 132kV supply network in the central west part of Queensland. There is a complementary 275kV injection and switching station at H024 Calvale, located less than 1km south west from Callide A.

Although some generation equipment is still located at this site the majority of that equipment is de-energised and not in service. Only two transformers are still energised.

The substation layout is based on a double bus disconnector selectable configuration with transfer bus, bus coupler and two bus section bays with disconnectors.

This substation consists of four generator transformer bays, nine 132kV feeder bays, one bus coupler bay and two bus sections.

The majority of the original 1960's equipment remains in service. Additional development occurred in mid-1980's when the connections to Callide B Power Station and Calvale were added.

The condition assessment of Callide A Substation revealed issues related to the corrosion of hold down bolts being part of footings (foundations) on most structures in the yard. In addition, the majority of the equipment has reached or exceeded their full expected service life, circuit breakers and instrument transformers in particular are costly to maintain and unreliable due to the lack of adequate spares, expertise and manufacturer support. They are also operating with an increasing probability of failure. A number of bays and associated equipment are redundant. It was identified that reinvestment in the substation is required to address the deteriorated condition issues related to the risk of these assets remaining in service.

Moura Substation

Site Description

Moura 132/66kV substation was established in 1962 predominantly to provide supply for the local coal mine. Nowadays it also provides supply to local area utilising connection to 66kV and 11kV Ergon switchgear located at the same site. Ergon load is supplied from secondary and tertiary of two 132/66/11kV, 60MVA power transformers. The existing substation layout is based on double bus disconnector selectable configuration with transfer bus and without bus coupler or bus section bay. A 132kV, 20 MVAr capacitor bank was added in 2010 and is connected to Bus 1 only.

This substation consists of two transformer bays with two 132/66/11kV, 60MVA power transformers, two feeder bays and one capacitor bay.

At the present there is no network planning trigger for additional transformer capacity at Moura. Planning studies have confirmed the requirement for the capacitor bank to be maintained as a long term requirement for voltage support.

The majority of the original 1960's equipment, including solid and strung busbars is still energised and maintained. Power transformers, instrument transformers and surge arresters in 66kV and 11kV bays were replaced in 1986.

The recent condition assessment of Moura substation revealed issues related to deteriorated plant condition, unavailability of spares (and therefore inability to maintain the existing equipment), some structural and AC supply design inadequacies, presence of asbestos containing materials, a redundant building, inadequate roads and drainage. It was identified that reinvestment in the substation is required to address the deteriorated condition issues related to the risk of these assets remaining in service.

Baralaba Substation

Baralaba is a 132kV switching station established in 1977 in conjunction with the development of the 132kV network between Callide A PS and Blackwater substation.

The equipment is now reaching a phase where manufacturer support and reliability (especially for oil filled instrument transformers) become a risk.

The four feeder bays and one bus coupler bay (with no circuit breaker) at Baralaba were installed during 1977 to 1983. There are no power transformers and no capacitor banks at this site.

Most of the originally installed primary equipment (including circuit breakers, current transformers, voltage transformers, disconnectors and line traps) are still in service.

The condition assessment of Baralaba Substation revealed issues related to deteriorated AC and DC supply systems, fence, substation access road, substation roadways, switchyard lighting and associated cabling, surge arrestors, 30+ year old instrument transformers and one circuit breaker.

In order to bring the equipment at Baralaba substation up to a condition suitable for a further 20 years of service, a modest reinvestment in the next five years to replace a circuit breaker, some instrument transformers and surge arrestors and the AC and DC supply system is recommended.

5.2.2 Transmission Line Assets

Callide – Biloela – Moura 132kV DCST/SCST transmission line

The 132kV transmission line between Callide A – Biloela – Moura (built section 1157, 1110/feeders 7109, 7110) was constructed in the mid-1960's. The section of line consists of 128 structures and is 47.86km in length. The line operates in a rural mining environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components.

Whilst the above ground structures were assessed to be in relatively good condition (given the age of the structure) the line was constructed with grillage foundations which require a separate, detailed condition assessment. An assessment has been scheduled to determine the condition of the grillage foundations on this line, which will provide an indication of the remaining service life of the entire structure. In general, repair of grillage foundations combined with a refit of the above ground tower structure is considered uneconomical in comparison to a replacement of the transmission line.

The condition assessment conducted in 2015 and a high level summary of the identified line condition is provided as follows:

- The galvanised tower members and fixings have lost their protective coating consistent with the estimated reinvestment within five-ten years time.
- The conductors are in satisfactory condition, they show no significant signs of deterioration relative to its age.
- The earthwire and hardware are in generally good condition, and show no significant signs of deterioration.
- All insulator and earthwire hardware are generally in good condition, and show no significant signs of deteriorating insulator pins.
- The above ground structures appear to be in relatively good condition however this line was constructed with grillage foundations which require a separate assessment. A detailed condition assessment of the foundations is scheduled for early 2016. The result of this assessment will be used to determine the future of this asset with a reinvestment outlook between five to ten years.

It is estimated that built sections 1157 and 1110 will exceed an acceptable risk profile in the next five to ten years.

Callide A to Baralaba 132kV SCST transmission line

The Callide A to Baralaba transmission line (built section 1103, 1146, 1147, feeders 7111 and 7114) was originally commissioned in 1977. The section of line consists of 175 structures and is 78.11km in length. The line operates in a rural mining environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components.

It is estimated that built section 1103, 1146 and 1147 will exceed an acceptable risk profile and require reinvestment in the next 15 – 20 years.

Moura to Baralaba 132kV SCST transmission line

The Baralaba to Moura transmission line (built section 1156, feeder 7112) was originally commissioned in 1968. The section of line consists of 113 structures and is 41.4km in length. The line operates in a rural mining environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components.

The condition of the transmission line is consistent with estimated reinvestment timing in 10-15 years time Feeder 7113: Baralaba – Blackwater tee Duaringa

The Blackwater to Baralaba tee Duaringa transmission line (built section 1109/1527) was originally commissioned in 1968, with the Duaringa tee section added in 2012. The section of line consists of 431 structures in total and is 161.38km total in length. The line operates in a rural mining environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components.

The condition of the transmission line is consistent with estimated reinvestment timing in 10-15 years' time.

Baralaba to Blackwater tee Dingo 132kV DCST/SCST transmission line

The Blackwater to Baralaba tee Dingo transmission line (built section 1147/1148/1149/1105) was originally commissioned in 1977 with the Dingo section added in 1986. The section of line owned by Powerlink consists of 331 structures in total and is 145.33km in length. The line operates in a rural mining environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components.

It is estimated that the built sections associated with feeder 7114 will exceed an acceptable risk profile and require reinvestment in the next 10 – 15 years.

Callide A to Gladstone South 132kV DCST transmission line

The Callide A to Gladstone South transmission line (built section 1102, feeder 7104 and 7105) was originally commissioned in 1966. The section of line consists of 228 structures and is 86.63km in length. The line operates in a rural mining environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components. The transmission line's structure closest to the coast is located 2.5km from the coast and is therefore subject to salt laden coastal winds.

A condition assessment was conducted in 2015 and a high level summary of the identified line condition is provided as follows:

- Nuts and bolts experiencing moderate to high corrosion (Grade 3). The galvanised tower members and fixings have experienced loss to their protective coating consistent with a reinvestment timing of five to ten years' time.
- The conductors are in satisfactory condition, but show signs of deterioration.
- The earthwire and hardware are in generally satisfactory condition, but are starting to show signs of deterioration.
- All insulator and earthwire hardware, as well as deteriorating insulator pins that will require action.
- The foundations are in generally good condition.

The CWQ network comprises the 132kV transmission line and substation assets from Callide A to Blackwater and includes the 132kV double circuit between Callide A and Gladstone South.

The transmission line and substation assets which impact reinvestment decisions in the CWQ area are listed in Table 5.1 and Table 5.2 below.

Table 5.1: Transmission line assets which impact reinvestment decisions in the CWQ area

Built Section No.	Feeder No	Built section name	Route length (km)	No. of Strs	Build year
1102	7105_7104	Gladstone South to Callide A	86.6	228	1966
1103	7111_EX7106	Callide A to STR-0003	0.6	3	1963
1105	7114/3	Dingo Tee - Dingo	13.0	38	1986
1109	7113	Baralaba to Blackwater	133.4	352	1968
1110	7110/3	Biloela to Moura	47.9	128	1965
1146	7111	Baralaba - Callide A	78.0	174	1977
1148	7114/1	Baralaba - Dingo Tee	75.1	167	1977
1149	7114/2	Dingo Tee - near Blackwater	57.2	126	1977
1156	7112	Moura to Baralaba	41.4	113	1968
1157	7109_7110	Callide A to Biloela	16.2	57	1963
1529	7113/3	Duaringa Tee - Duaringa	27.8	79	2012

Table 5.2: Substation assets which impact reinvestment decisions in the CWQ area

Code	Substation	Established
T022	Callide A	1962
T026	Biloela	1963
T027	Moura	1962
T031	Baralaba	1981
T098	Dingo	1986
T210	Duaringa	2012

5.3 Network requirements

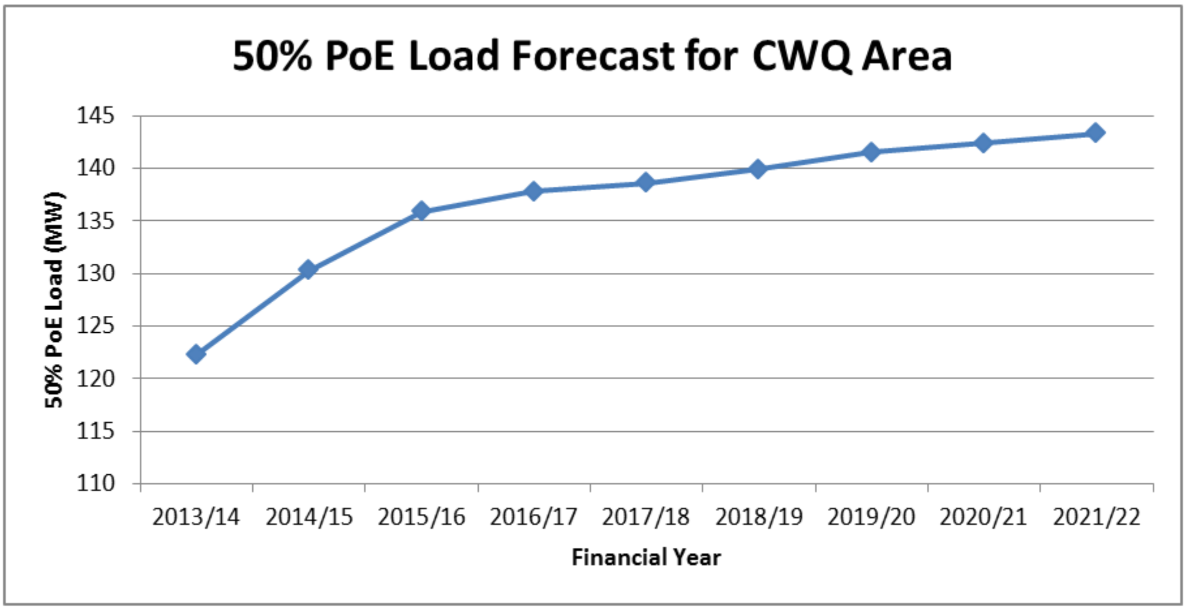
5.3.1 Load forecast

The loads most relevant to this area are the Ergon loads at Biloela and Moura, as well as the Aurizon loads Duaringa and Dingo to the north of Baralaba.

Callide B Power Station auxiliaries are also supplied from Callide A.

Figure 5.2 displays the assumed load forecasts for the CWQ area.

Figure 5.2: Assumed load forecast for the relevant substations



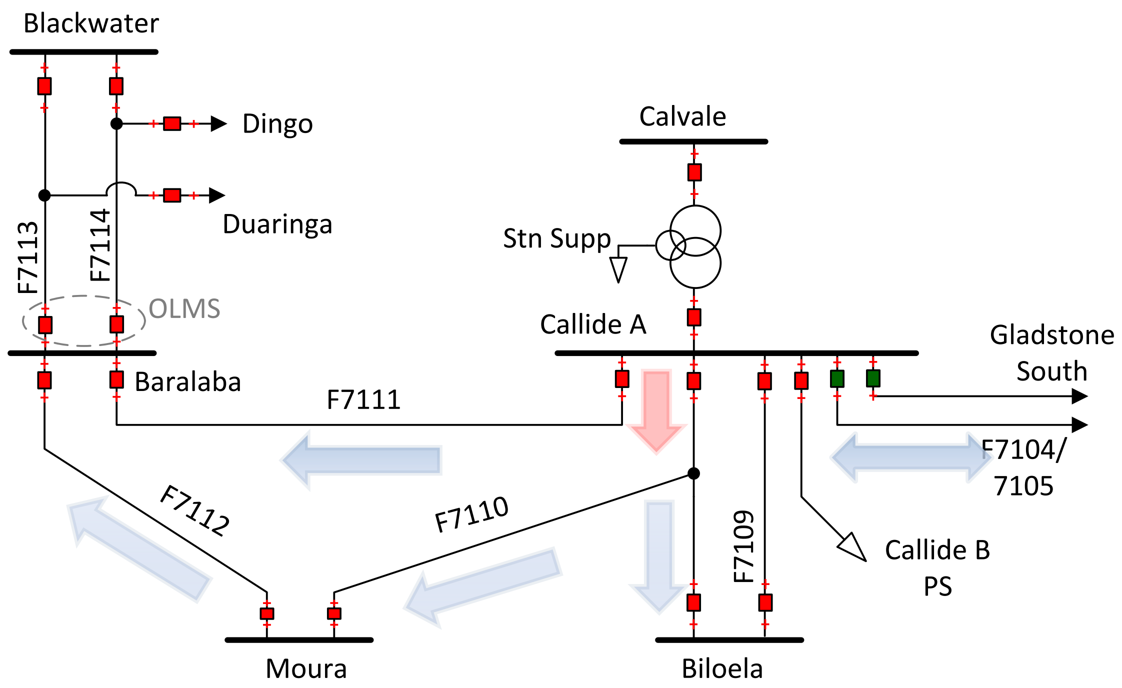
Historically, demand in the CWQ region has enjoyed a steady growth due to mining activity in the area. However a downturn in the resources sector has resulted in subdued demand levels and a relatively flat forecast over the ten year outlook. Consequently, the existing network is capable of supporting current and forecast demand with no trigger to augment capacity over the balance of the forecast period. Reinvestment needs are therefore related to asset condition.

5.3.2 CWQ network operation

The CWQ network experiences a complex mix of power flows, including several limitations which are managed independently. Generation dispatch, undulating load levels, prior network outages and plant availability influence these limitations to varying degrees.

The Callide A Substation receives supply from a single transformer at Calvale and provides connectivity for feeders south, east and west of the substation. With all lines in service, power flow is in the direction from Callide to Baralaba, Biloela and Moura, and northward on to Blackwater. Power also flows from Callide towards Gladstone South.

Figure 5.3: CWQ existing network



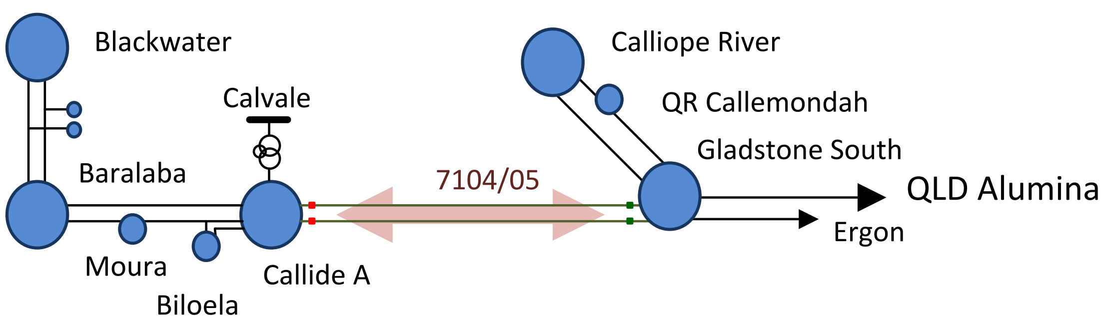
Currently, the section of feeder between Callide A and the tee-point on feeder 7110 sets the thermal limit of supportable load at Moura and Biloela for the loss of feeder 7112. However, the loss of feeder 7110 results in the Moura load being supplied via feeders 7111 and 7112, resulting in a weak network with poor voltage regulation at Moura.

In the event of losing either F7111 or F7109, the feeder section between Callide A and the tee-point will overload due to the combined Biloela and Moura loads, as well as the through flow towards Blackwater. This issue is currently managed with an overload management scheme (OLMS) in service at Baralaba, programmed to trip the circuit breakers north of Baralaba for the loss of either F7109 or F7111.

Callide A to Gladstone South feeders 7104 & 7105

Transmission supply to the Gladstone South substation consists of a double circuit 132kV line from Calliope River substation (one circuit via QR Callemondah) and a double circuit 132kV line from Callide A substation. The Gladstone South substation supplies Ergon Energy and Queensland Alumina Limited (QAL).

Figure 5.4: Callide A to Gladstone South feeders



The feeders between Callide and Gladstone South (7104/7105) are operated normally open to address potential fault level limitations at Callide A and overload of the Calvale 275/132kV transformer following a contingency event. The feeders are placed in service during outages of circuits between Calliope River and Gladstone South, or during bus outages at Gladstone South to secure for the next event. This operational flexibility enhances the reliability of supply to Gladstone South following any planned/unplanned outage of one of the above circuits or to facilitate bus maintenance works. In this arrangement power flow is in the direction from Callide A to Gladstone South.

Similarly, these circuits are closed in service for an outage of the single Calvale transformer to provide reliability of supply to the CWQ loads of Biloela and Moura. In this arrangement, power flow is in the direction from Gladstone South to Callide A.

If a second transformer is commissioned at Calvale, these circuits will no longer be required to support loads in the CWQ network and could conceivably be retired from service with no breach of mandated reliability standards. However, removal of these feeders from service will remove the operational flexibility currently available to secure bus outages (at short notice) at Gladstone South for planned maintenance works.

5.4 Investment outlook

A number of strategies for meeting both the asset risk, and future network requirements, have been developed and analysed for the assets in the region that are expected to have reinvestment needs over the 10 year outlook. The Central West network reinvestment strategy addresses the following transmission assets approaching end of life:

- Callide A Substation (excluding transformer replacement)
- Moura Substation (excluding transformer replacement)
- Baralaba switchyard
- Callide A to Gladstone South 132kV double circuit

Whilst the area planning approach is based on meeting mandated reliability standards, to network reinvestment focuses on optimising the network topology based on consideration of existing and future network needs. This is driven by forecast demand, new customer supply requirements, existing network configuration, condition based risks related to existing assets and mandated reliability standards.

5.4.1 Overview

Within the current outlook, the network redevelopment strategy for the area consists of two distinct phases:

a) interim network development phase

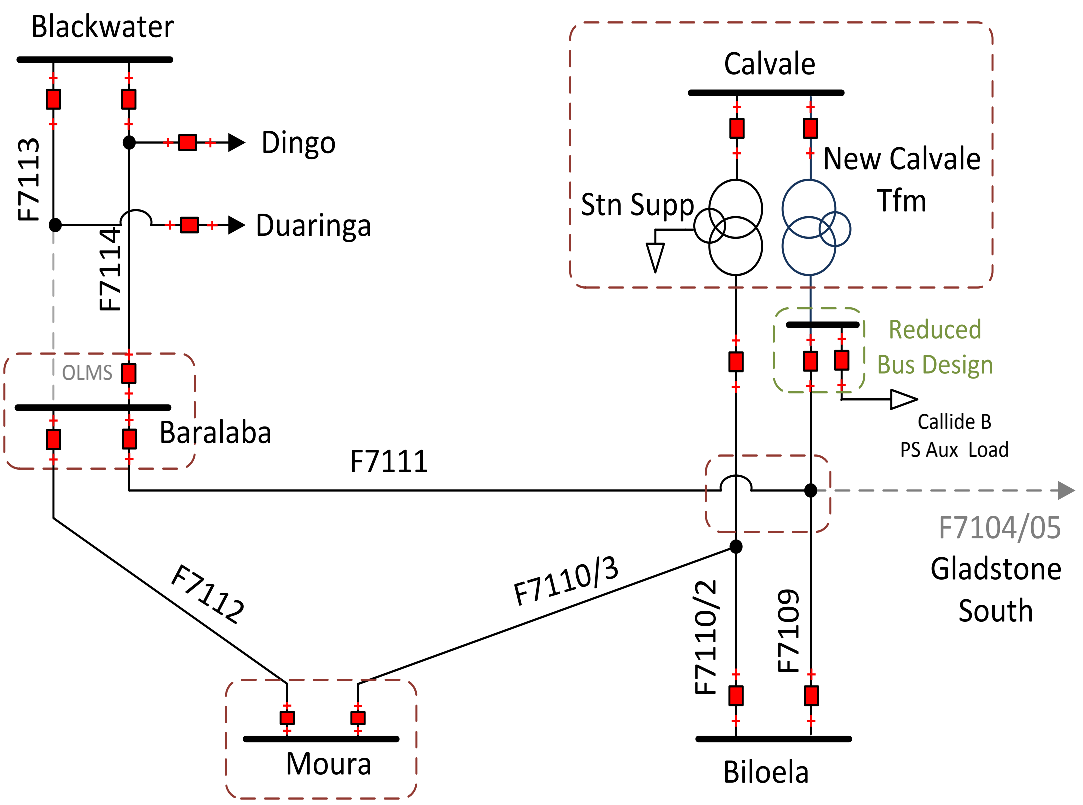
b) final network development phase.

A high level summary of works proposed in the initial network development phase as shown in Table 5.3.

Table 5.3: Summary of works proposed in the initial network (0-5 years) development phase

Moura Substation	• replacement of the 132kV bus, primary plant and secondary systems to retain existing switching functionality
Callide A Substation	• bypassing the Callide substation and removal of feeder switching functionality • commission to service the second 275/132kV transformer at Calvale • selective tee connection of outgoing feeders to two transformers at Calvale (creating two sets of transformer ended 132kV feeders) • create provision to supply the Callide B Power Station auxiliary load via a “reduced bus” with individual feeder switching capability
Callide A to Gladstone South Feeders	• retire from service the 132kV double circuit transmission line between Callide A and Gladstone South • Reconfiguration of the Callide A to Gladstone South feeders at Gladstone South to create bus tie connectivity
Baralaba Substation	• reduce the scope of the secondary systems replacement works at Baralaba by reducing the number of feeder entries to the bus down to 3
Duaringa Substation	• Configure the Aurizon traction load at Duaringa to operate as a single radial connection from Blackwater
Callide – Biloela – Moura Transmission Line	• assess the integrity of the grillage foundations on the Callide – Biloela – Moura transmission line through a detailed condition assessment (this investigation will provide an indication of the remaining life of the structure, and identify potential to extend the service life of the asset)

Figure 5.5: Summary of works proposed in the interim network development phase



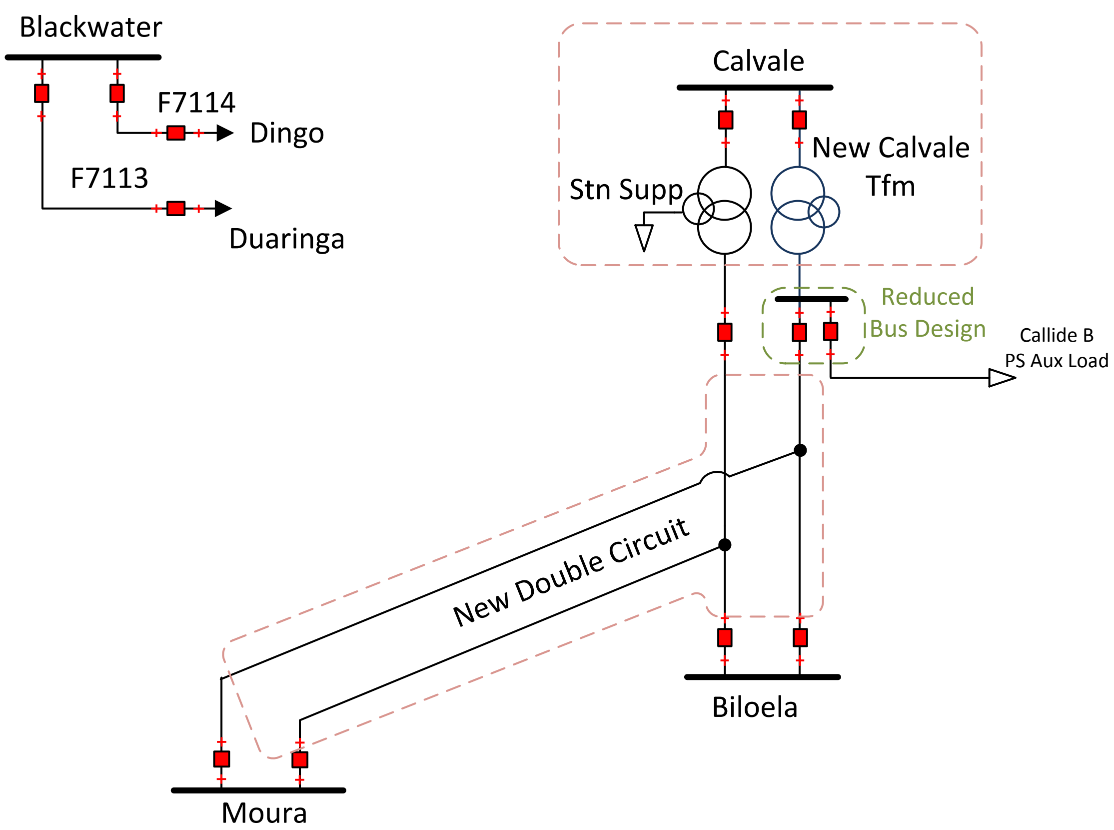
As part of a long term strategy for the area, the CWQ 132kV network will gradually transition from its current arrangement to a radial, more simplified configuration. Redevelopment would occur as assets reach their end of life from a technical and economic perspective.

A high level summary of works proposed in the final network development phase is as follows:

Table 5.5: A high level summary of works proposed in the final network (5-20 years) development phase

Transmission line construction	• Establish new 132kV double circuit transmission line between Calvale and Moura configured in a transformer ended arrangement at Calvale
Biloela Substation	• Tee-connect the Biloela substation into the new Calvale – Moura transmission line
Baralaba Substation	• Decommission the Baralaba substation and retire all feeders and feeder assets at Baralaba
Dingo Substation	• Configure the Aurizon traction load at Dingo to operate as a single radial connection from Blackwater

Figure 5.6: A high level summary of works proposed in the final network development phase



Both the initial and final proposed networks are able to meet the current and forecast future load requirements, ultimately with fewer circuit kilometres of transmission line.

It is assumed that new easements will be required to allow replacement of the existing Callide A-Biloela-Moura circuits. In addition the installation of a second 275/132kV transformer at Calvale replaces the support provided by the Callide A to Gladstone South circuits.

This strategy results in 132kV single circuit lines being removed between Callide A, Baralaba and Blackwater

5.4.2 Summary of feasible options considered

This section presents a subset of the options that were considered in developing the CWQ area plan. It presents only the options which were considered to be technically and economically feasible i.e. it does not include options which at a high level, did not align with corporate expectations.

Callide A Substation reinvestment strategy

Asset condition drivers and obsolescence issues have triggered a need to replace the Callide A Substation

Two options have been identified to address asset condition issues at the Callide A Substation:

- full replacement of primary plant and secondary systems
- install second Calvale Transformer and bypass Callide A switchyard.

Table 5.10: Callide A Substation reinvestment strategy option 1

Callide A Substation Reinvestment Strategy	
Option 1	• Replacement strategy
Option overview	• This option entails replacement of primary plant and secondary systems components of the Callide substation on a new Powerlink site (greenfield) to the south of the existing substation. • Rationalisation of a feeder bay to accommodate either a new transformer or a single feeder from Gladstone South. • Parallel feeders 7104/05 into a single 132kV bay at Callide A
Benefits of option	• Retains switching capability • Provides expansion capability to accommodate new connections • Offers reliability to remaining connections during planned and unplanned outages • Greater operational flexibility during maintenance outages
Drawbacks of option	• High upfront cost • Risk of surplus capacity dependent on future load development
Operational flexibility	• High level of flexibility to manage outages and maintenance in the future
reliability	• Retains high level of reliability due to switching capability associated with individual feeders
Load support	• Maximum capability for load support due to increased fault levels
Critical contingency	• Retention of switching capability ensures that individual outages do not impact adjacent feeders, however the single Calvale transformer remains as the critical contingency in the area.

Figure 5.11: Callide A Substation reinvestment strategy option 1

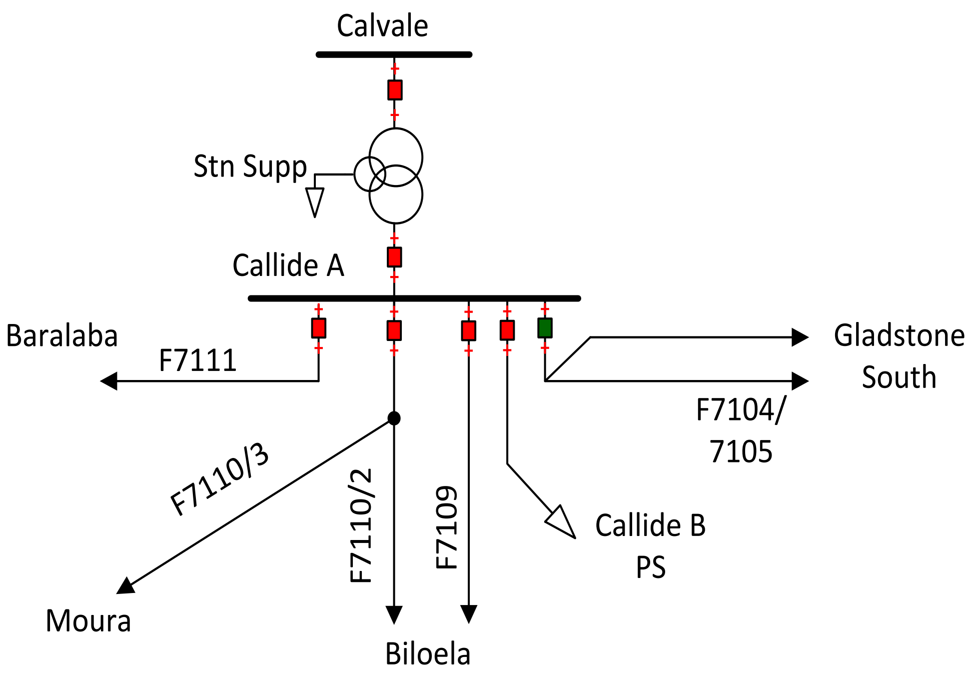
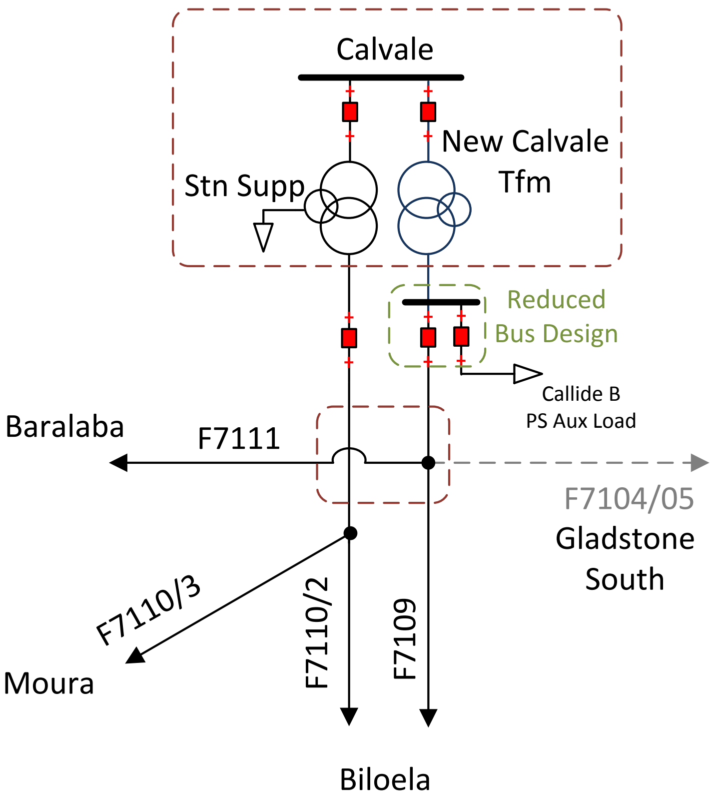


Table 5.11 Callide A Substation reinvestment strategy option 2

Callide A Substation reinvestment strategy	
Option 2	• Bypass strategy
Option overview	This option entails: • bypass the Callide Substation and removal of switching capability • commission the second 275/132kV transformer at Calvale to create two sets of transformer ended feeders operating at 132kV • selective tee connection of existing feeders to maintain network connectivity • maintain supply to the Callide B Power Station auxiliary load from a 132kV reduced bus established at Calvale • removal of the Callide to Gladstone South 132kV feeders from service
Benefits of option	• Low upfront cost • Reduces risk of overinvestment and asset stranding
Drawbacks of option	• Limited opportunity to expand site to accommodate new connections • Establishes an additional tee connection
Operational flexibility	• Reduces flexibility to manage outages due to teed feeder arrangement • May require extended outages for maintenance
Reliability	• Reduces reliability due to increased exposure of teed feeder sections
Load support	• Marginal reduction in load support
Critical contingency	• This option does not introduce a new critical contingency, however greater exposure of feeders due to tee-connections will result in multiple elements removed from service for the same event.

Figure 5.12 Callide A Substation reinvestment strategy option 2



The preferred option is Option 2 – Bypass strategy – as it meets all requirements at lower cost

Moura Substation reinvestment strategy

Asset condition drivers and obsolescence issues have triggered a need to replace the Moura Substation.

Two options have been identified to address asset condition issues at the Moura Substation:

- full replacement of primary plant and secondary systems
- removal of 132kV bus switching functionality and transformer end the substation.

Table 5.12: Moura Substation reinvestment strategy option 1

Moura Substation reinvestment strategy	
Option 1	• Replacement strategy
Option overview	• This option involves full replacement of primary plant and secondary systems components of the Moura substation on the existing site.
Benefits of option	• retains switching functionality • provides opportunity for expansion to accommodate new connections • significant operational flexibility • increased reliability of supply to the load at Moura • improved quality of supply in the local network • retains existing load support capability • allows an even distribution of load across both transformers at Moura • provides operational flexibility during network maintenance outages • provides flexibility to support staged rebuilds of transmission line and substation assets in the area • supports consolidation of transmission line and substation assets in the area
Drawbacks of option	• marginally higher upfront cost than the transformer ended option
Operational flexibility	• High level of flexibility to manage outages and maintenance in the network
Reliability	• Retains high level of reliability due to switching capability associated with individual feeders
Load support	• Maximum capability for load support due to increased fault levels
Critical contingency	• Retention of switching capability ensures that individual outages do not impact adjacent feeders.

Figure 5.13: Moura Substation reinvestment strategy option 1

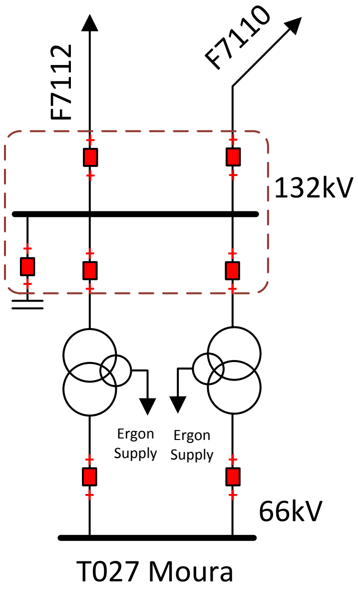
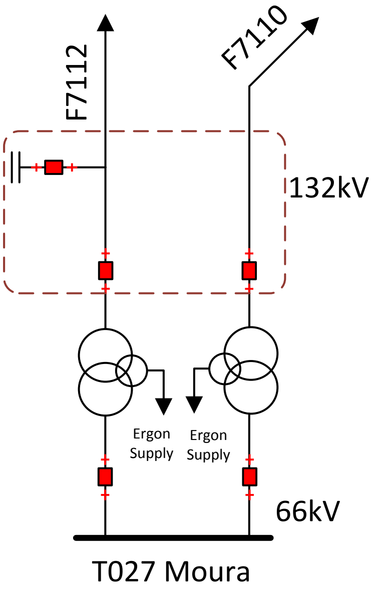


Table 5.13: Moura Substation Reinvestment Strategy Option 2

Moura Substation reinvestment strategy	
Option 2	Transformer end strategy
Option overview	This option entails: • Removal of the 132kV bus and associated switching functionality at Moura • Connection of the existing 20Mvar capacity bank to F7112 • Operating the Moura substation in a transformer ended arrangement
Benefits of option	• Marginally lower upfront cost than full replacement option • Reduces risk of overinvestment and asset stranding
Drawbacks of option	• Does not meet Powerlink's N-1-50 Planning criteria • limited opportunity to expand site to accommodate new connections • A reduced ability to supply load at the Moura substation • A reduced fault level which triggers power quality impacts • Limited future load connection and augmentation capability • Earlier future network augmentation • Reduced ability to install shunt reactive support • Reduced reliability • Reduced operational flexibility
Operational flexibility	• Reduces flexibility to manage outages due to the number of assets impacted by single outage • May require extended outages for maintenance
Reliability	• Reduced reliability due to disconnection of multiple assets for a single event
Load support	• Reduction in load support capability
Critical contingency	• Capacitor bank and feeder outage for a single event

Figure 5.14: Moura Substation reinvestment strategy option 2



The preferred option is Option 1 as Option 2 does not meet the mandated reliability standard.

Baralaba Substation reinvestment strategy

Asset condition drivers and obsolescence issues have triggered a need to replace the Baralaba substation and as a consequence, a project was approved to provide for the complete in situ replacement of Baralaba. Recent developments in the external environment have afforded Powerlink the opportunity to reconsider the network development plans for the area. As a result, the replacement project was suspended to allow a review of the approved works with the intention of identifying and considering potential alternative network development strategies for the CWQ network.

Two options have been identified to address asset condition issues at the Baralaba substation:

- Full replacement of primary plant and secondary systems
- Reduced scope replacement with removal of 1x132kV feeder bay to Blackwater
  - secondary systems support to three circuit breakers at Baralaba
  - reconfigure the Aurizon load at Duaringa to operate as a radial connection from Blackwater.

Table 5.14: Baralaba Substation reinvestment strategy option 1

Baralaba Substation reinvestment strategy	
Option 1	• Full replacement strategy
Option overview	• This option involves full replacement of secondary systems components and selected primary plant at the Baralaba substation
Benefits of option	• Retains switching functionality • Provides opportunity for expansion to accommodate new connections
Drawbacks of option	• High upfront cost • Risk of surplus capacity dependent on future load development
Operational flexibility	• High level of flexibility to manage outages and maintenance in the future
Reliability	• Retains high level of reliability due to switching capability associated with individual feeders
Load support	• No impact to load capability
Critical contingency	• Retention of switching capability ensures that individual outages do not impact adjacent feeders.

Figure 5.15: Baralaba Substation reinvestment strategy option 1

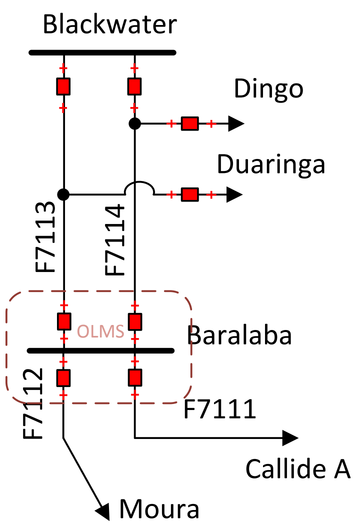
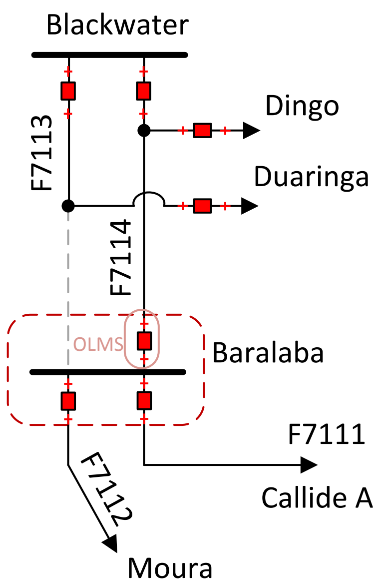


Table 5.15: **Baralaba Substation reinvestment strategy option 2**

Baralaba Substation reinvestment strategy	
Option 2	• Three circuit breaker option
Option Overview	• This option entails: • Removal of 132kV feeder 7113 (Baralaba – Blackwater tee Duaringa) bay at Baralaba • Undertake reduced secondary systems replacement works for the three remaining feeder bays • Presents opportunity to avoid the primary plant replacement works depending on the feeder selected for decommissioning • Operate the Aurizon load at Duaringa as a radial connection from Blackwater.
Benefits of Option	• Reduced cost due to reduction in scope of secondary systems replacement works • Opportunity to reduce cost of primary plant replacement works depending on the feeder targeted for decommissioning • Reduces potential sunk cost once the network transitions to the final configuration and the substation is decommissioned • Begins early transition to the final network configuration • Reduces risk of overinvestment associated with asset stranding
Drawbacks of Option	• Reduces operational flexibility in the Lilyvale network since there is a reliance on load support from Calvale (via Blackwater) for maintenance outages in the Lilyvale network
Operational Flexibility	• Marginal reduction in operational flexibility to manage outages in the Lilyvale network
Reliability	• Marginal reduction in reliability
Load Support	• Marginal reduction in load support during maintenance outages
Critical Contingency	• Retention of switching capability ensures that individual outages do not impact adjacent feeders.
Network Limitation	• Introduces a marginal network limitation during maintenance outages in the Lilyvale network

Figure 5.16: **Baralaba Substation reinvestment strategy option 2**



The preferred Option is Option 2 as it meets all requirements at lower cost

5.4.3 Proposed outlook for Callide A to Gladstone South feeders

Feeders 7104 and 7105 between Callide A and Gladstone South were originally established to supply the Gladstone area from Callide A Power Station. However the gradual development of the higher capacity 275kV network has resulted in a reduced reliance on these feeders for load support. In more recent times, feeders 7104/05 have been used as a contingency measure to provide backup support for the east and west networks during plant outages.

Within the context of the Central West area network development plan, these feeders are no longer required to provide mandated levels of network reliability and hence may be retired from service. The establishment of a second transformer at Calvale makes provision for N-1-50 reliability in the Central West network to be met locally.

Table 5.6 below summarises the short term operational constraints and longer term network requirement for feeders 7104 and 7105.

Table 5.6: Short term operational constraints and longer term network requirement

Configuration	Feeders 7104 and 7105 – Current and Future Needs
Existing Network	• Feeders operated normally open to address potential fault level issues at Callide A substation and overload of the Calvale transformer. • Placed in service to support loads at Gladstone South for feeder outages between Calliope River and Gladstone South or Callemondah. • Placed in service to support loads in the CWQ network for an outage of the single Calvale transformer.
Interim Network	• Feeders are no longer required to support loads in the Central West network once the second Calvale transformer is commissioned. • Removing these feeders will not result in breach of the shared grid reliability standard of N-1-50; however the flexibility to maintain N-1-50 at Gladstone South for certain plant outages will be removed. • Additional reinvestment will be required at Callide A to accommodate the additional connection if these feeders are retained. • Feeders may be retired from service.
Final Network	• Same as for Interim Network. • Feeders may be retired from service.

The proposed solution for the Callide A and Gladstone South feeder is to remove them from service when the Callide A substation is bypassed in the next 5 years.

5.5 Conclusion

The Central West area plan has been developed to examine a number of potential strategies for managing the end of life of the existing network assets and future capacity requirements in the area over the 10 year outlook of the Asset Management Plan.

The recommended reinvestment strategy for the Central West area seeks to minimise reinvestment through partial rebuilds, network reconfiguration, and asset retirement where achievable.

A reduced scope of work has been proposed for the Callide A substation which removes bus switching functionality and creates transformer ended feeders. A reduced scope of work has been proposed for the Baralaba substation which reduces a 132kV feeder bay and associated works, while the Moura substation is proposed to undergo a full like for like replacement (excluding transformer replacement).

The 132kV transmission line assets between Callide and Baralaba and Moura to Baralaba will not require reinvestment within the ten year outlook of the asset management plan. However, the transmission line between Callide and Moura was constructed with grillage foundations and whilst the above ground structures appear to be in reasonable condition, a detailed condition assessment is required to determine the state of the grillage foundation structures. A condition assessment of the foundations is scheduled for early 2016 which will provide an indication of the remaining service life of the entire structure.

The 132kV double circuit between Callide and Gladstone South is expected to be removed from service once the second transformer is commissioned at Calvale.

The Central West transmission assets are regulated network assets. There are presently no regulatory requirements for participant consultation on the proposed replacement or reconfiguration of these aged assets. However, Powerlink will consult with all stakeholders in the area on the proposed strategy and any replacement or reconfiguration works identified, All proposed projects will be included in publication in the TAPR in order to provide information to interested parties and proponents of non-network solutions.

Table 5.7: Summary of proposed reinvestment strategy

Timeframe	Strategy
1 to 5 years	• Moura Substation rebuild to full scope reinstating 132kV switching functionality • Commission to service the second 275/132kV transformer at Calvale • Callide A Substation bypass with selective tee connection of outgoing feeders • Create provision to supply the Callide B Power Station auxiliary load via a "reduced bus" with individual feeder switching capability • Callide A to Gladstone South feeders removed from service • Reconfiguration of the Callide A to Gladstone South feeders at Gladstone South to create bus tie connectivity • Replace the Baralaba Substation secondary systems with a reduced scope replacement by reducing the number of feeder entries to the bus. Provision for secondary systems replacement works for three feeder bays down from four. • Reconfigure the Aurizon rail traction load at Duaringa to operate as a radial connection from Blackwater • Assess the integrity of the grillage foundations on the Callide – Biloela – Moura transmission line by undertaking a detailed condition assessment of the foundation structures
5 to 10 years	• Undertake routine transmission line maintenance including life extension works to maximise the remaining service life of tower structures • Undertake detailed assessment of ageing assets to determine the remaining service life of tower structures and substation components
Beyond 10 years	• Establish a new double circuit transmission line between Calvale and Moura with a tee connection to Biloela. • Decommission the Baralaba substation and remove from service the remaining feeders 7111, 7112 and 7114 between Baralaba and the Dingo tee point • Reconfigure the Aurizon rail traction load at Dingo to operate as a radial connection from Blackwater

Individual capital and operational projects within this strategy will be subject to justification and approval at an appropriate time and are shown in Table 5.8.

Table 5.8: Proposed investment in the Central West Area (10 year outlook)

Project Number	Description	Indicative Timing
CP.01146	Blackwater Primary Plant Replacement (T032)	2016
CP.01549	Moura Switchyard Replacement (T027)	2016
CP.01457	Baralaba Secondary Systems Replacement	2017
CP.01151	Calvale & Callide B Secondary Systems Replacement (H024 and H030)	2017
CP.PROV	Calvale 2nd 275/132kV Transformer	2018
CP.01647	Biloela - Moura 132kV T/L Replacement (1110)	2020
CP.01649	Callide - Biloela 132kV T/L Replacement (1157)	2020
CP.02369	Blackwater Transformer 1T 2T Replacement	2021
CP.PROV	Blackwater Secondary Systems Replacement (T032)	2022
CP.PROV	Biloela Secondary Systems Replacement (T026)	2025

6. GLADSTONE

6.1 Introduction

6.1.1 Area Plan Overview

The area around the town of Gladstone is a heavy industrial area which can be described as energy intensive and includes industry of high economic significance to Queensland. This commenced with the establishment of the alumina smelter in 1967 and then Gladstone Power Station in 1976. Gladstone Power Station supported the industrial development of central Queensland but played a major role suppling load to south east Queensland via the 275kV network connecting Central Queensland.

This area is expected to continue to be a heavy industrial area with the addition of new industries and the expansion of existing facilities. Recently coal seam gas compression and export facilities have established in the Gladstone area.

The Transmission Annual Planning Report defines the Gladstone zone as the area south of Raglan, north of Gin Gin and east of Calvale as shown in Figure 6.1.

Figure 6.1: Gladstone area

[redacted]

6.1.2 Description of network

The Gladstone 275kV network grew in the mid 1970's following the establishment of the Gladstone Power Station switchyard which formed the northern part of the CQ-SQ 275kV intra-connection providing supply to the South East. In the early 1990s Wurdong Substation and the 275kV supply to Boyne Island were also established.

The major developments of the transmission system within the Gladstone area are listed in Table 6.1. Boyne Island aluminium smelter, Queensland Alumina Limited (QAL) and Rio Tinto Alcan's (RTA) Yarwun alumina refineries make up the majority of the load in the Gladstone area and these loads are directly connected to the Powerlink network. The 275/132kV transformers at Boyne Island also help supply the major smelter load and these are Boyne Island assets. Railway loads are direct connected to the Powerlink network at Raglan and Callemondah. The Distribution Network Service Provider (DNSP) supplies other load in the area from Gladstone, Gladstone North, Gladstone South and Yarwun substations, with Yarwun supplying Boat Creek Substation.

Central Queensland is a net exporter of electricity. Export of electricity is predominantly via the 275kV network from Calvale and Gladstone. In late 2009, Powerlink established the Larcom Creek 275/132kV Substation in the Gladstone State Development Area (GSDA) in response to ongoing load growth in the Gladstone zone. This substation supplies the RTA Yarwun Alumina Refinery and Ergon's Boat Creek Substation.

The major 132kV injection point in the Gladstone Area sub-transmission system is Calliope River 275/132kV Substation. A 132kV sub-transmission system provides supply to bulk supply points within the Gladstone area.

Figure 6.2: Gladstone area single line diagram

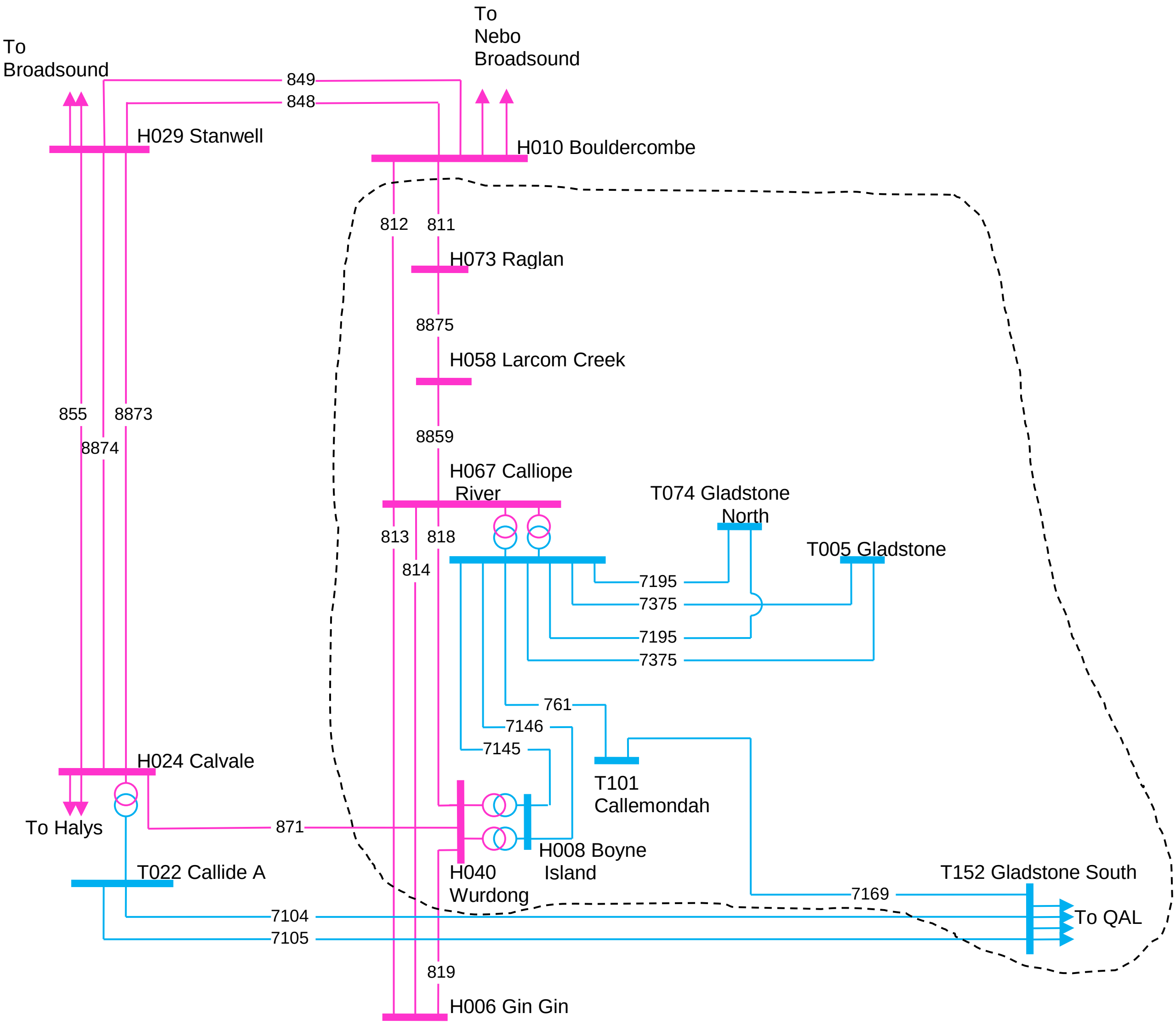


Table 6.1: Major developments of the 275kV transmission system in the Gladstone area

Period	Substations	Lines
1973-1976	Gin Gin 275kV Substation established Gladstone 275kV Substation established	Feeder 813(1973) Gladstone - Gin Gin Single Circuit Transmission Line (135.6km) Feeder 814(1976) Gladstone - Gin Gin Single Circuit Transmission Line (151.7km)
1977	Bouldercombe 275kV Substation established	Feeder 811(1977) Bouldercombe - Gladstone Single Circuit Transmission Line (81.4km) Feeder 820(1977) Bouldercombe - Broadsound Single Circuit Transmission Line (143.4km)
1980-1981		Feeder 812(1980) Bouldercombe to Gladstone Single Circuit Transmission Line (97.7km) Feeder 818/819(1981) Gladstone to Gin Gin Single Circuit Transmission Line (152.2km) Feeder 821(1980) Bouldercombe to Nebo Single Circuit Transmission Line (291.7km)
1987	Calvale 275kV Substation establishment	Feeder 871(1987) Calvale to Bouldercombe-Gladstone Tee Single Circuit Transmission Line (55.4km)
1990	Wurdong 275kV Substation establishment	
1992	Stanwell 275kV Substation establishment	Feeder 855(1992) Stanwell to Calvale Single Circuit Transmission Line (101.34km) Feeder 856(1992) Stanwell to Broadsound Single Circuit Transmission Line (127.31km)
1993-1994		Feeder 848(1993) Stanwell to Bouldercombe Single Circuit Transmission Line (17.1km) Feeder 849(1993) Stanwell to Bouldercombe Single Circuit Transmission Line (17.0km)
1998		Feeder 871(1998) Midpoint to Wurdong Tee Single Circuit Transmission Line (36.7km)
2012-2014	Gladstone rebuilt as Calliope River Substation	
2013		Feeder 8873/8874(2013) Stanwell to Calvale Transmission Line DoubleCircuit (101.34km)

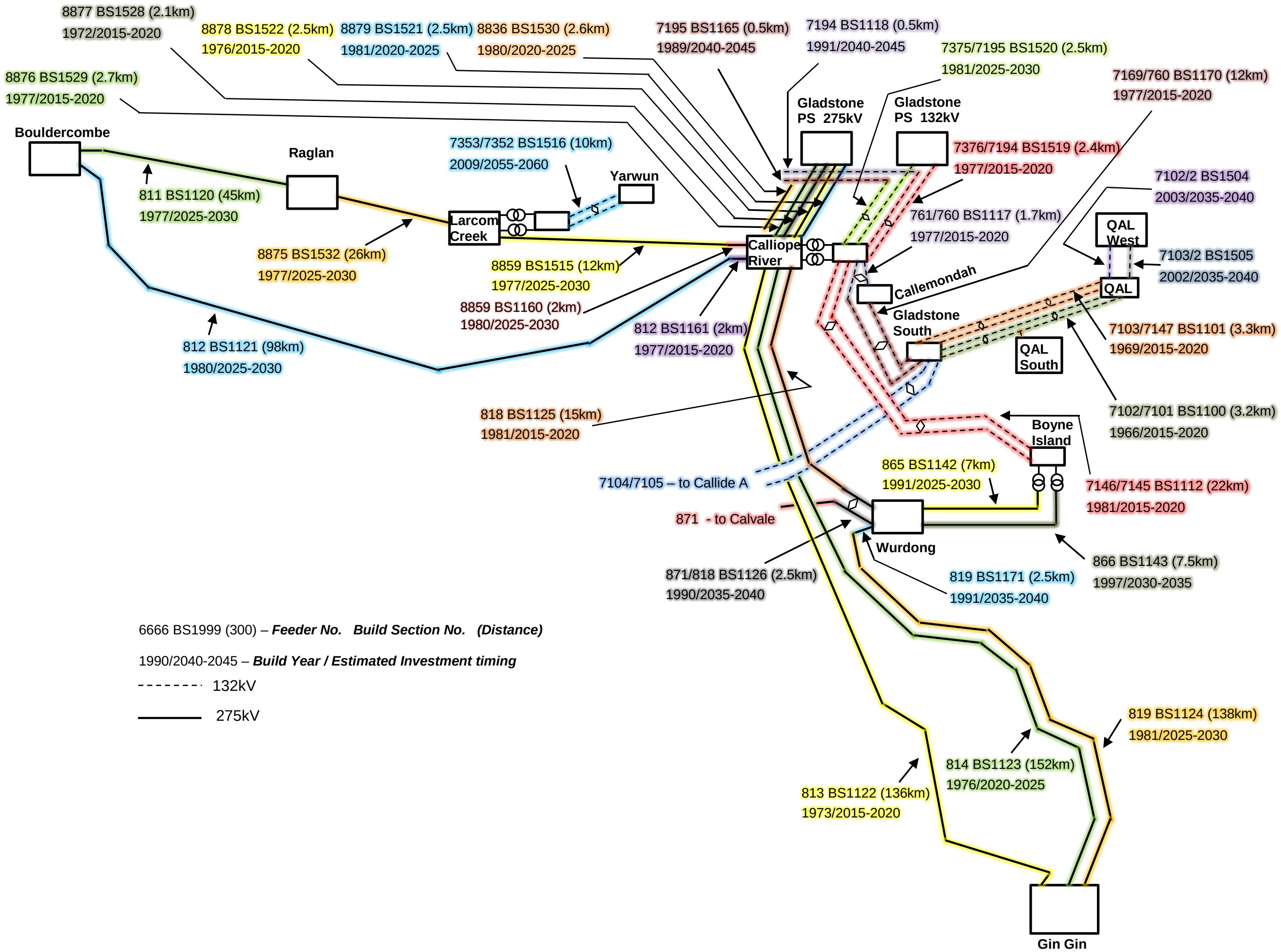
6.2 Asset Condition

The 275kV network in the Gladstone area was built in the 1970s with the exception of the supply to Boyne Island via Wurdong which was built in the 1990s. All the 1970s lines are expected to require reinvestment within the next 10 years unless the line is later rebuilt or no longer required.

The 132kV lines from Calliope River to Boyne Island, Calliope River to Gladstone, Calliope River to Gladstone North and Calliope River to Gladstone South were built prior to 1982. The 132kV lines from Gladstone South to QAL were built prior to 1970. All of these lines are expected to require reinvestment within the next five years, unless the line is no longer required.

Figure 6.3 outlines the assets in the Gladstone area and immediate surrounds.

Figure 6.3 Assets in the Gladstone area



6.2.1 Transmission lines

Gladstone South to QAL 132kV DCST transmission line

The Gladstone South to QAL 132kV double circuit lines were built in the late 1960's. Built section 1100 (feeders 7101 and 7102) consists of 12 galvanized steel lattice towers strung with Tiger conductor and is approximately 3km in length. One earthwire is OPGW installed in 2002 and the other is steel cored - aluminium conductor 7/3.25 installed in 1966. Built section 1101 (feeders 7103 and 7147) consists of 13 galvanized steel lattice towers strung with Tiger conductor and is approximately 3km in length. One earthwire is OPGW installed in 2002 and the other is an aluminium type Tennis conductor installed in 2002.

A condition assessment undertaken in 2012 showed Grade 3 and Grade 4 corrosion on some towers. All towers exhibited some corrosion though the three towers located within the QAL plant have a heavy build-up of bauxite, which makes accurate assessment of their condition difficult.

A project to refurbish BS1100 and BS1101 is approved and currently underway and will extend the life of the line to at least 2025.

Calliope River to Boyne Island 132kV DCST transmission line

The Calliope River to Boyne Island built section 1112 (feeders 7146 and 7145) double circuit line was built in 1981. The line consists of 55 galvanized steel lattice towers strung with Diving conductor and is approximately 22km in length. Both earthwires are aluminium type conductor installed in 1981.

A condition assessment was undertaken in 2013 and exhibited high levels of corrosion, particularly at the power station and smelter ends of the line.

[redacted]

A project to refurbish this circuit by 2017 is proposed, and will postpone future investment on the built section outside a 10 year period.

Calliope River to Callemondah – Gladstone South 132kV DCST transmission line

The Calliope River to Callemondah to Gladstone South double circuit line was built in 1977. Built section 1117 (feeders 760 and 761) runs between Calliope and Callemondah and consists of five galvanized steel lattice towers strung with Goat conductor and is approximately 2km in length. Built section 1170 (feeders 760 and 7169) consists of 28 galvanized steel lattice towers strung with Goat conductor and is approximately 12km in length. One earthwire is OPGW installed in 2012 and the other is an aluminium type Opal conductor installed in 2009.

A detailed condition assessment completed on built section 1117 in 2011 found this section has experienced accelerated rates of corrosion as a result of its location in a tidal marine environment adjacent to a coal fired power station and within 5km of several metal processing plants. It is estimated that many of the light members and bolts will soon lose, or have lost, their structural integrity and that these components can no longer be restored and will require replacement within the next one to two years.

A project to refurbish built section 1117 by 2017 is underway, and will extend the reinvestment outlook of the transmission line outside the next 10 years.

Currently there is no detailed condition assessment for BS1170 and the overhead earthwire has fault level issues. To accommodate these requirements a structural upgrade including insulators and hardware replacement is estimated to be required in the five to ten year outlook.

Gladstone / Gladstone North to Calliope River 132kV DCST transmission line

The Calliope River to Gladstone built section 1519 (feeders 7376 and 7194) and built section 1520 (feeders 7195 and 7375) double circuit lines were built in 1977. Each line consists of nine galvanized steel lattice towers strung with Goat conductor and is approximately 2km in length. One earthwire is OPGW installed in 2012 and the other is an aluminium type Opal conductor installed in 2009. Each line has one circuit from Calliope to Gladstone Power Station and one circuit from Calliope to Gladstone North.

A detailed condition assessment completed in 2011 found these sections have experienced accelerated rates of corrosion as a result of their location in a tidal marine environment adjacent to a coal fired power station and within 5km of several metal processing plants. It estimated that many of the light members and bolts will soon lose, or have lost, their structural integrity and that these components can no longer be restored and will require reinvestment within the next five years.

A project to refurbish built section 1519 and built section 1520 by 2016 is underway, and will extend the life of the line to at least 2025.

Gladstone to Calliope River 275kV SCST transmission line

These built sections 1521 (feeders 8878 and 8877), 1522 (feeders 8878, 8877), 1528 (feeder 8879), 1529 and 1530 (feeders 8876 and 8836) run between Calliope River and Gladstone and were built beween 1972 and 1981. Each built section is approximately 3km in length and has between five and eight galvanized steel lattice towers. Four of the five built sections connect 275kV machines at Gladstone Power Station to Calliope River.

A project to refurbish these circuits is proposed, and will postpone the reinvestment outlook outside the next 10 years.

Calliope River to Larcom Creek 275kV SCST transmission line

This single circuit line was built in the late 1970's. Built section 1160 (feeder 8859) consists of five galvanized single circuit towers strung with Paw Paw conductor and is approximately 2km long. Built section 1515 (feeder 8859) consists of 21 galvanized single circuit towers strung with Paw Paw conductor and is approximately 11km long. One earthwire is OPGW installed and the other is an aluminium type Pearl conductor, both installed in 2008.

A detailed condition assessment completed in 2011 and found:

- The line's concrete reinforced foundations remain in good condition. The pile foundations of the tower located near Calliope River will require remedial work to maintain their on-going structural integrity.
- Structural tower steel is generally sound, exhibiting deterioration of the galvanising only, with little metal loss.
- Insulator hardware is original and nearing the end of its service life.

It is estimated that built section 1160 and 1515 will reach an unacceptable risk profile in the next 10 to 20 years.

Raglan to Bouldercombe 275kV SCST transmission line

This single circuit line runs from Raglan to Bouldercombe built section 1120 (feeder 811) and was built in 1977. The line consists of 118 galvanized single circuit towers strung with Paw Paw conductor and is approximately 44km long. One earthwire is OPGW installed in 2008 and the other is an aluminium type Volleyball conductor installed in 2008.

A detailed condition assessment was completed in 2011 and found:

- The tower concrete foundations are in sound condition and show no significant signs of deterioration. All galvanised tower members, nuts and bolts are also exhibiting early evidence of Grade 2 corrosion, with little metal loss.
- Suspension insulators were replaced in 2008 while the tension and bridging insulators range in age from one to 33 years, with the older units and their associated hardware suffering extensive Grade 2 and 3 corrosion being observed on 5% of the towers.
- The line's OPGW/OHEW and conductors are all in good condition, as is the earthwire hardware.

It is estimated that built section 1120 will reach an unacceptable risk profile in the next 10 to 20 years.

Built section 1121 and 1161, feeder 812 – Calliope River to Bouldercombe

This single circuit line runs from outside Calliope River to Bouldercombe and was built in the late 1970's. The line consists of 217 galvanized single circuit towers strung with Paw Paw conductor and is approximately 100km long. Both earthwires on BS1121 are steel and were installed in 1980, whilst both earthwires on BS1161 are an aluminium type Opal conductor installed in 2009.

Built section 1532, feeder 8875 – Raglan to Larcom Creek

This single circuit line runs from Raglan to Larcom Creek and was built in 1977. The line consists of 68 galvanized single circuit towers strung with Paw Paw conductor and is approximately 26km long. One earthwire is OPGW installed in 2008 and the other is an aluminium type Volleyball conductor installed in 2008.

A detailed condition assessment was completed in 2011 and found the condition similar to the Raglan - Bouldercombe line.

Rationalisation of the circuits between Calliope River Substation and Bouldercombe Substation

The two single circuits between Calliope River Substation and Bouldercombe Substation (one via Larcom Creek and Raglan) will require some reinvestment in the 10 year outlook. High level assessments indicate it would be more appropriate to replace these circuits in the late 2020's by a new double circuit line between Calliope River and Bouldercombe that is cut into Larcom Creek and Raglan. Load aspects of these circuits are discussed in Section 6.6

Other built sections in the area

The 132kV Callide A - Gladstone South transmission line is discussed in the Central West area plan, while the 275kV circuits south of Calliope Substation are discussed in the CQ-SQ area plan.

6.2.2 Additional assets reaching end of life

Within this area, there are also a range of other substation equipment and secondary systems assets with a predicted end of life within the 10 year outlook period of the AMP. The discussion presented within this area plan confirms an enduring need for the majority of these assets, and as such the condition driven risks of maintaining these assets in service will be considered on a case by case basis as part of future investment decisions.

The following is a description of substation related items that are likely to result in significant expenditure that falls within the next 10 years.

H008 Boyne Island

The majority of the secondary systems at Boyne Island Substation have been in service for more than 20 years. Secondary systems will require investment within the next five years due to the conditions and obsolescence of secondary system equipment and the significance of the load.

H040 Wurdong

The majority of the secondary systems at Wurdong Substation have been in service for more than 20 years. Control systems including C225 RTUs have become obsolete and there are only limited spares available. The secondary systems will subsequently require reinvestment within the next five years.

T101 Callemondah

The secondary systems at Callemondah Substation were commissioned in the late 1980s and would require some reinvestment within five years. Initial indications are refurbishment works could defer a large reinvestment in the next five to ten year period.

6.3 Network requirements

6.3.1 Demand forecasts and load characteristics

The Gladstone load profile is comprised of primarily industrial load. Load reduction in the future would primarily be driven by closure of industrial facilities and supporting industries. The summer peak forecast demand at time of state peak for the Gladstone zone is shown in Figure 6.4. Figure 6.5 outlines the Gladstone load duration curves.

Figure 6.4: Gladstone zone demand forecast

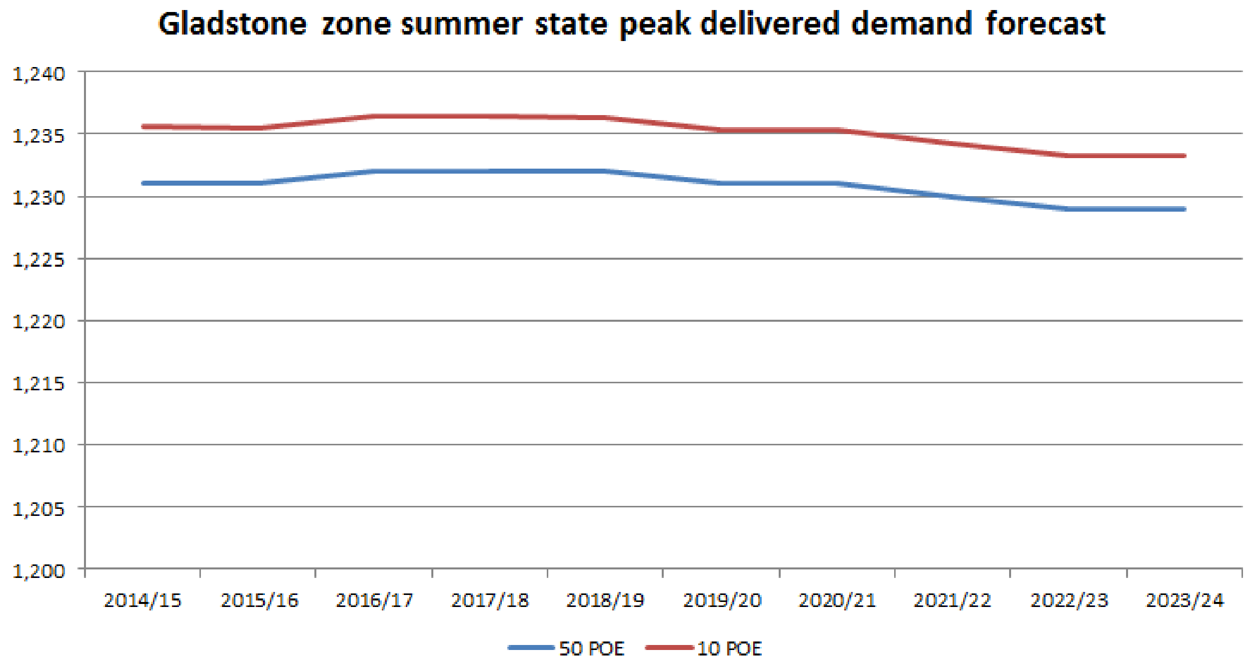
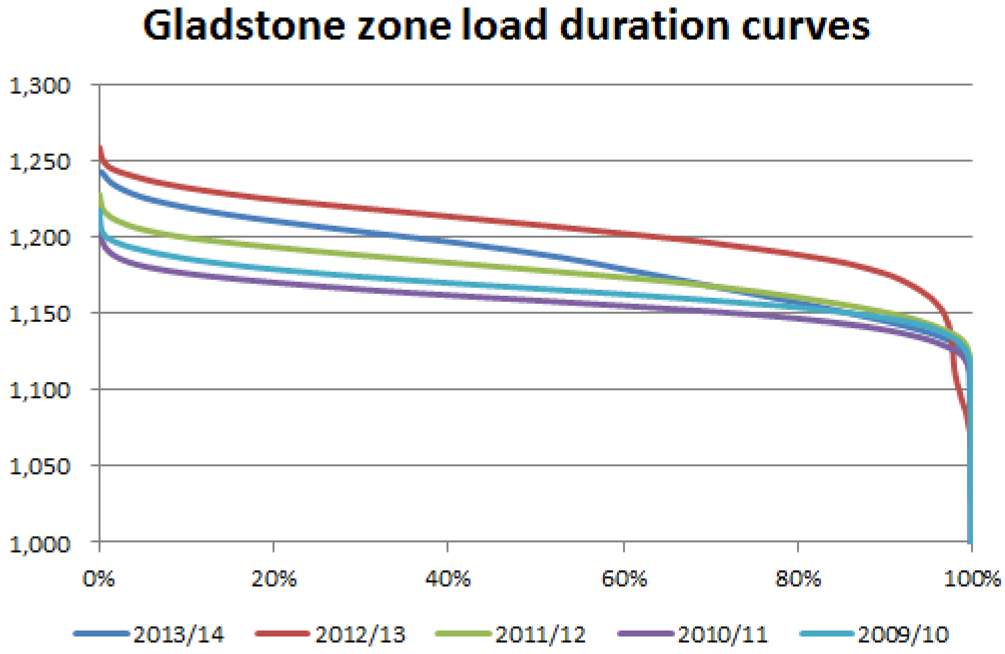


Figure 6.5: Gladstone area load duration curves



It can be seen that Gladstone is generally flat around 1200MW for a large proportion of time. It is expected that demand will be maintained at these levels for the foreseeable future.

6.3.2 Generation Development

Gladstone Power Station comprises six coal fired steam turbines with a combined generating capacity of 1,680MW. It is one of the older power stations being commissioned between 1976 and 1981. Four of the Gladstone generators (units 1, 2, 5 and 6) are connected to the 275kV system and two (units 3 and 4) are connected to the 132kV system. The systems are connected by two 275/132kV transformers located at Calliope River.

The Comalco Alumina Refinery (CAR) Stage 2 project, connected to the 132kV network at Yarwun Substation, incorporates a 160MW combined cycle gas fired cogeneration plant as the refinery's primary fuel source.

Table 6.2:

Generator	Capacity (Winter/Summer MW)	Commissioning Date
Gladstone	1680	1976
Yarwun	160/155	2010

There are no new entrants presently announced for the Gladstone area and there are no announced closures. Gladstone currently tends to rotate one unit out of service.

6.3.3 Existing Network Capability

Calliope River to Bouldercombe

The maximum power transfer across the Gladstone grid section is set by the thermal rating of the Calvale to Wurdong (feeder 871), the Bouldercombe to Raglan (feeder 811), the Larcom Creek to Calliope River 275kV circuits (feeder 8859), or the Calvale 275/132kV transformer. As power transfers increase between Central and Southern Queensland, loading increases on this grid section. If the rating would otherwise be exceeded following a critical contingency, generation is re-dispatched to alleviate power transfers. Powerlink also implements network switching and support strategies when transfers reach the capability of this grid section.

The Larcom Creek to Yarwun double circuit line has been constructed partly within an existing easement earmarked for future 275kV circuits. Hence, this part of the line was built for 275kV operation, with a new 132kV supply to Yarwun to be constructed when 275kV is required between Larcom Creek and Calliope River substations.

There is a strong argument to maintain two circuits between Bouldercombe and Calliope River. If there is only one circuit then for the loss of this circuit AEMO would need to dispatch substantial Gladstone generation to prevent the Calvale to Wurdong (feeder 871) from overloading. In this situation, the feeder would share the supply of Boyne and eastern CQ-SQ with the Gladstone generators. For example, if CQ-SQ requires 500MW and Boyne 1200MW then Gladstone would require 4 units operating at Gladstone.

For these reasons there is a requirement to maintain two Calliope to Bouldercombe circuits. As there is also a requirement to supply Larcom Creek and Raglan, it would be prudent to replace these with double circuits sharing the load across the two circuits.

Calliope River to Boyne Island

The following discussion assumes the aluminium smelter will remain in production at its present capacity.

The three options for continued supply to the aluminium smelter are to:

1. Refit 7145/76,
2. Rebuild 7145/76; or
3. Install a third 275/132kV transformer at Wurdong along with an additional feeder from Wurdong to Boyne Island.

At present the planned work for 7145/76 consists of replacement of a few substantially corroded towers adjacent to Boyne Island and a partial refit of the remaining towers as needed. This extent of work is expected to postpone the reinvestment requirement of these lines for 10 years. At that stage a decision on what happens after that can be deferred in the short term, and subsequent refit and tower painting could further postpone reinvestment for an additional 15 or more years.

Forecast Network Performance

Central Queensland has significant reactive reserves in the 275kV network from the large generation centres of Callide, Stanwell and Gladstone. Large parts of the network were built in the late 70s and early 80s in low capacity single Paw Paw conductor coinciding with the establishment of the Gladstone generators. Subsequent builds between Calvale and Gladstone/Wurdong were developed in the late 80s and early 90s coinciding with the Callide B generators and the establishment of Wurdong substation. Although these lines have a higher rating, due to the substantial generation and interconnection within Central Queensland, the most significant issue for the Gladstone Area continues to be thermal limitations.

6.4 Conclusion

The timing of major transmission line reinvestment in the Gladstone area is beyond the ten year timeframe of the AMP. The existing built sections can be life extended or refurbished to take them beyond this timeframe.

The recommended reinvestment strategy for the Gladstone Area over the next 10 years is as follows:

- 0-5 years
  - Bouldercome to Stanwell Tension Suspension and Bridging Insulator Replacement
  - Structural Repairs to Towers in Close Proximity to Calliope River
  - Stanwell to Bouldercombe Tension Insulator Replacement
  - Callipe River to Boyne Island Transmission Line Refit
  - Wurdong Secondary Systems Replacement
  - Boyne Island Secondary Systems Replacement.
- 5-10 years
  - Callemondah to Gladstone South Structural Upgrade
  - Refurbishment of Towers at Calliope Island
  - Gladstone South Secondary Systems Replacement.
- 10+ years
  - Rationalisation of the Calliope River to Bouldercombe Transmission Line.

At the end of life of existing single circuits between Calliope River and Bouldercombe, it is proposed to replace them with a new double circuit line. This will most likely occur in the last half of the 2020-30 decade.

In addition there are a number of secondary system replacements that need to be undertaken in the next ten years and various minor substation works.

Individual capital and operational projects within this strategy will be subject to justification and approval at an appropriate time and are shown in the table below.

Table 6.4: Proposed investment in the Gladstone area (10 year outlook)

Project Number	Description	Indicative Timing
CP.02344	Calliope River to Boyne Island BS1112 Transmission line refit	2017
CP.01148	Wurdong Secondary Systems Replacement	2018
CP.PROV42	Gladstone South Secondary Systems Replacement	2022
CP.02531	Boyne Island Secondary Systems Replacement	2018

7. CENTRAL TO SOUTH QUEENSLAND (CQ-SQ)

7.1 Introduction

7.1.1 Area Plan overview

In the coastal area between Calliope River and South Pine, there are a number of single circuit 275kV transmission lines constructed in the 1970s and 1980s that based on condition assessment and risk analysis will require some form of reinvestment from now to 2030s. In response, Powerlink has been progressively investigating strategies to ensure the risks related to these assets remaining in service are acceptable, including ongoing maintenance, asset retirement, life extension and rebuild. With the current demand forecast and reduced reliance on the CQ-SQ corridor that has occurred over the last five years due to additional generation in southern Queensland, there are a number of technically feasible options for the retirement of certain transmission line assets within this area that have been investigated as part of this area plan.

7.1.2 Description of network

Powerlink's eastern Central to South Queensland (CQ-SQ) transmission corridor consists of single circuit 275kV transmission lines between Calliope River and South Pine, supplying Wurdong, Gin Gin, Teebar Creek, Woolooga and Palmwoods 275kV substations. This transmission corridor is a major component of the CQ-SQ grid section and provides supply to Boyne Island, Wide Bay and the Sunshine Coast. An important aspect worth noting is that the lines are all single circuit construction.

The CQ-SQ 275kV network was established shortly after the first 275kV transmission line in Queensland (a double circuit between Swanbank and South Pine). This intraconnection provided supply to the South East from the newly constructed Gladstone Power Station via a single circuit 275kV transmission line and provided the means to address reliability of supply concerns for an outage of the Swanbank to South Pine 275kV double circuit. A second single circuit was constructed about 5 years later, followed by a third circuit to Woolooga, as more units were added to Gladstone Power Station supplying an increasing load.

Demand growth in southern Queensland continued to outpace that of local generation. The commissioning of Stanwell Power Station was closely followed by the Calvale - Tarong double circuit 275kV transmission line in 1998, completing today's CQ-SQ grid section. At 333km, these became the longest circuits in Powerlink's network, the loss of one of these circuits defined the maximum supportable transfer.

As the reliance on power flows increased, a series of capacitor banks and SVCs were commissioned addressing stability limits.

The electricity supply system forming the CQ-SQ grid section is shown in Figure 7.1.

Figure 7.1: CQ-SQ single line diagram

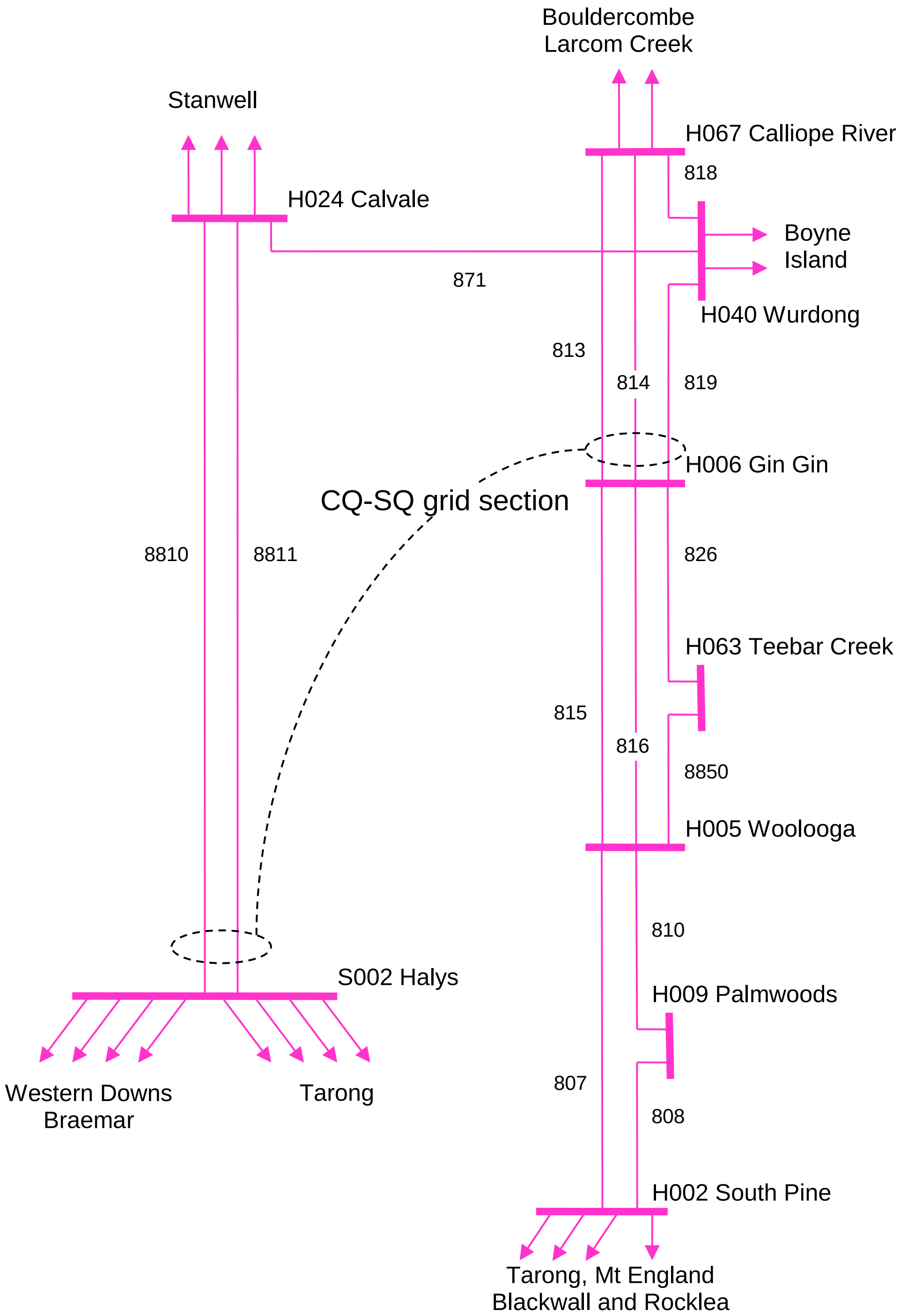


Table 7.1 lists the major developments of this transmission system.

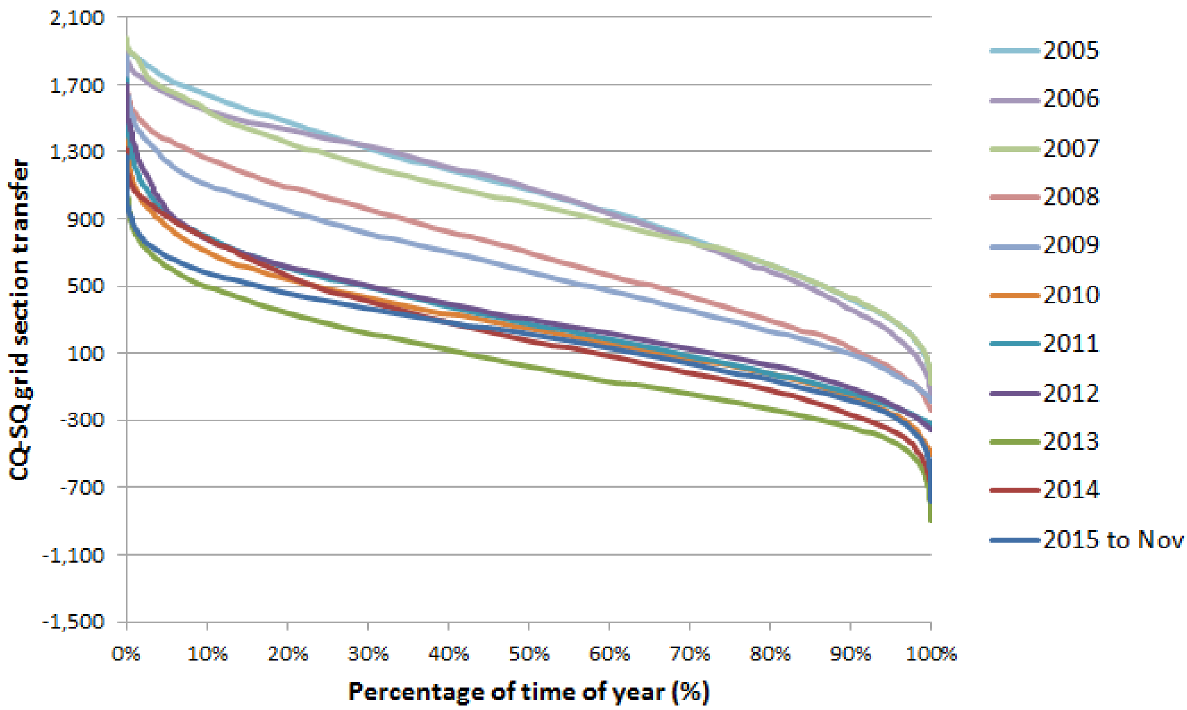
Table 7.1: Development of the transmission system in the CQ-SQ area

Period	Substations	Lines
1970-75	H005 Woolooga 275kV Establishment H006 Gin Gin 275kV Establishment H007 Gladstone 275kV Establishment	807 South Pine - Woolooga 275kV Single Circuit Transmission Line (approx. 159.6km) 815 Woolooga – Gin Gin 275kV Single Circuit Transmission Line (approx. 148.9km) 813 Gin Gin – Gladstone 275kV Single Circuit Transmission Line (approx. 135.6km)
1976-80	H009 Palmwoods 132kV Establishment	808/810 South Pine – Woolooga 275kV Single Circuit Transmission Line (approx. 163.8km) 816 Woolooga – Gin Gin 275kV Single Circuit Transmission Line (approx. 149.9km) 814 Gin Gin – Gladstone 275kV Single Circuit Transmission Line (approx. 151.7km)
1980-85		818/819 Gin Gin – Gladstone 275kV Single Circuit Transmission Line (approx. 152.2km) 826/8850 Gin Gin – Woolooga 275kV Single Circuit Transmission Line (approx. 149.9km)
1986-90	H040 Wurdong 275kV Establishment	818/819 Gin Gin – Gladstone is turned into Wurdong
1991-95	H009 Palmwoods 275kV Establishment H002 South Pine 1st and 2nd 120MVAr Capacitor Banks H040 Wurdong 1st 120MVAr Capacitor Bank	808/810 South Pine – Woolooga is turned into Palmwoods
1996-2000	H007 Gin Gin 1st 120MVAr Capacitor Bank H005 Woolooga 1st 120MVAr Capacitor Bank	8810/8811 Calvale – Tarong 275kV Double Circuit Transmission Line (approx. 333.5km)
2001-05	H009 Palmwoods 275/132kV 375MVA Transformer H005 Woolooga 275/132kV 200MVA Transformer H009 Palmwoods 1st 120MVAr Capacitor Bank H040 Wurdong 2nd 120MVAr Capacitor Bank	
2006-10	H040 Wurdong 3rd 120MVAr Capacitor Bank H063 Teebar Creek 275kV Establishment H002 South Pine SVC H002 South Pine 3rd and 4th 120MVAr Capacitor Banks H008 Woolooga SVC	
2011-	H067 Calliope River 275kV Establishment (H007 Gladstone Replacement) H005 Woolooga 275/132kV 250MVA Transformer	

Following interconnection with New South Wales in 2001, significant generation capacity was located in South West Queensland. Approximately 4,000MW of new generation was developed in southern Queensland between 2001 and 2010.

A number of generators have been withdrawn due to subdued forecast loading and economic conditions since the Global Financial Crisis (refer to Section 7.3.3). Notwithstanding, there is sufficient generation in Central and North Queensland to stress CQ-SQ to its limits. At the same time, there is not only sufficient generation in southern Queensland to render these lines *unnecessary* (for CQSQ flows, still required to supply intermediate substations) at any time of the year, but to also reverse the power flows from southern Queensland to central Queensland. Figure 7.2 illustrates the wide range of flows experienced over the past decade.

Figure 7.2: CQ-SQ load duration curves



The utilisation of CQ-SQ is expected to increase with the ramping of the Surat LNG load. This is expected to be partly offset by the return of the withdrawn south Queensland generators.

In its current form, CQ-SQ offers a great deal of flexibility for possible generation dispatches, seldom imposing any constraints to market operation. Further, it allows Powerlink to remove circuits from service, e.g. during maintenance, without large impacts to the market and without the risk of load shed for a subsequent credible event.

7.2 Asset condition

The 275kV corridor between Calliope and South Pine was progressively developed in the 1970s and 1980s. A number of these transmission lines are expected to require some form of reinvestment within the next 10 year outlook period.

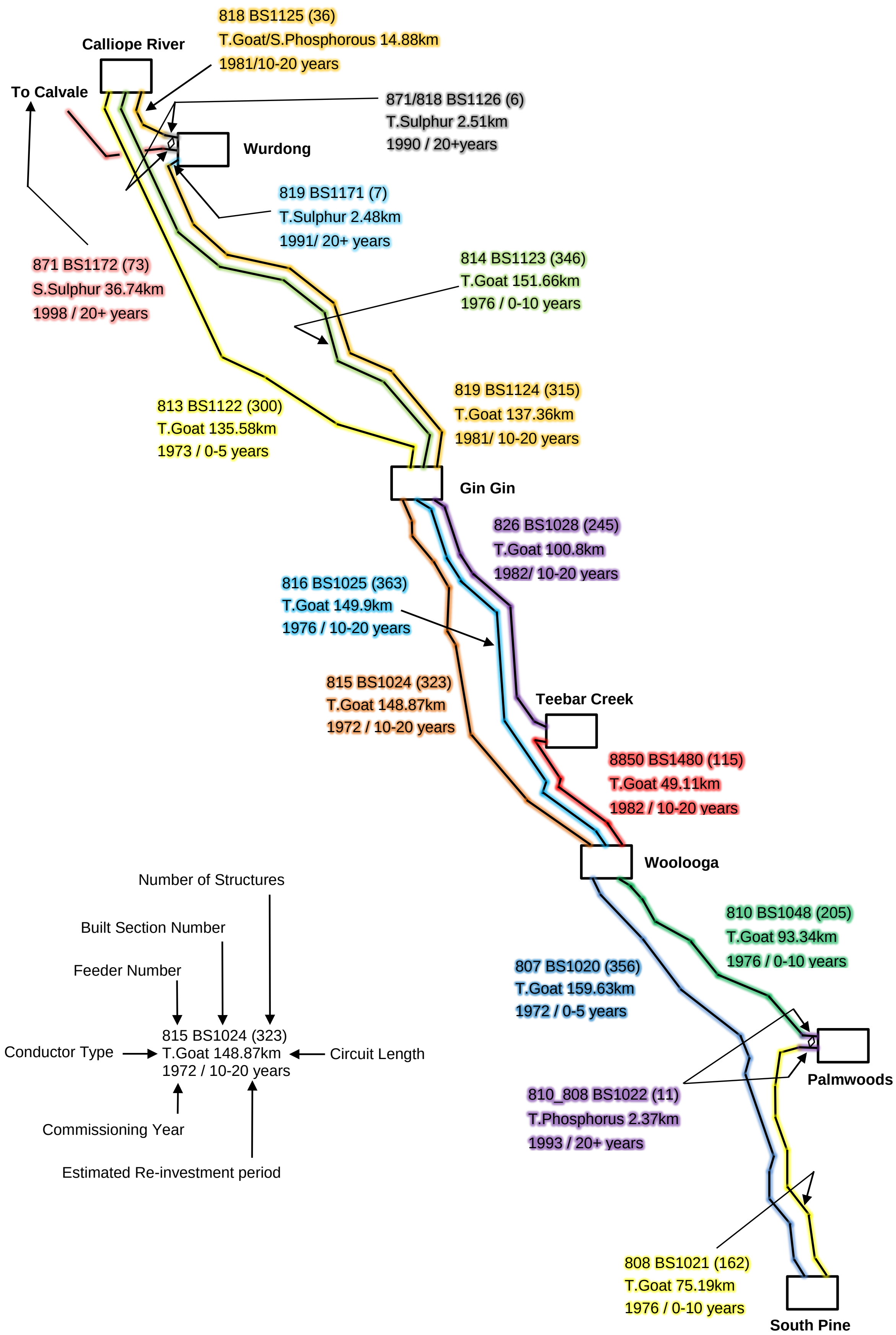
These transmission lines are subject to different environmental and atmospheric conditions and thus have, over time, experienced structural degradation at different rates, with the predicted useful life of the assets ranging from 43 to 55 years. Some assets have unique condition drivers and risks relating to the state of line components and hardware that need to be addressed in the medium term (either discretely or in conjunction with a larger scope of reinvestment works related to an asset) that may also influence the timing of reinvestment.

Initial condition assessments identified the 275kV transmission lines between South Pine to Woolooga and Palmwoods to Woolooga are tracking to a higher rate of corrosion and will exceed acceptable risk levels in the next five years. The higher rate of corrosion is due to a localised wet weather environment in the hinterland regions of Mapleton and Maleny. These sustained periods of wetting contribute to the premature degradation of galvanising on the steel transmission structures.

Additionally, the 275kV lines at the northern end of the CQ-SQ coastal corridor (near Calliope River) are currently tracking to higher rate of corrosion and it is expected that the risks associated with these lines will exceed acceptable levels in the next five years. This higher rate of corrosion is due to the proximity to the coast and exposure to salt laden coastal winds. The Calliope River to Wurdong line also traverses two tidal crossings and operates in a heavily polluted industrial area.

Of the 2,766 single circuit towers within the corridor, more than 2,000 of the towers are anticipated to require some form of reinvestment within the next five to 20 years. Figure 7.3 outlines the respective circuit lengths of the transmission line, the number of towers, commissioning date and estimated refit and technical end of life timing.

Figure 7.3: Geographic diagram with transmission line estimated reinvestment period



7.2.1 275kV lines

Table 7.2: Summary condition and risk profile of 275kV single circuit transmission lines

Built Section	Built Section Name	Estimated Reinvestment Period (years)
BS1125	Calliope River – Wurdong Tee	10-20
BS1123	Calliope River – Gin Gin	0-10
BS1122	Calliope River – Gin Gin	0-5
BS1124	Wurdong Tee – Gin Gin	10-20
BS1024	Gin Gin - Woolooga	10-20
BS1025	Gin Gin - Woolooga	10-20
BS1028	Gin Gin – Teebar Creek	10-20
BS1480	Teebar Creek – Woolooga	10-20
BS1020	Woolooga – South Pine	0-5
BS1048	Woolooga – Palmwoods	0-10
BS1021	Palmwoods – South Pine	0-10

Calliope River to Wurdong Tee 275kV SCST Transmission Line

The Calliope River to Wurdong Tee 275kV single circuit transmission line (built section 1125, feeder 818) was commissioned in 1977. The line consists of 21 suspension towers and 20 tension towers and is 17km in length.

A desktop condition assessment was undertaken utilising photographic evidence from 2010 to 2015, SAP Notifications and SAP Measuring Documents.

The towers' concrete foundations are in sound condition and show no significant signs of deterioration. An invasive inspection of three tower foundations in 2012 found them all to be in sound condition.

Structural tower steel is generally sound, exhibiting minor deterioration of the galvanising only, with no metal loss to date. Structure 6978, on the banks of the Calliope River, has a small amount of Grade 3 on some light members.

Most nuts and bolts on the line have experienced moderate corrosion and apart from those exceptional cases of Grade 3 corrosion on the cross arms, conductor attachment plates and OHEW Peaks of a small number of towers, mostly concentrated at the Calliope River end of the line, will not require replacement in the next 10-15 years.

All V-string and suspension insulators were replaced in 2000, and along with their associated hardware, remain in good condition. Tension insulators are the original 1980 units and estimated to require replacement in the short to mid term.

The conductors are in sound condition and are considered to have at least another 25 years remaining life.

Both A and B earthwires were restrung in 2011 and are in sound condition.

It is expected that reinvestment will be required on built section 1125 (without significant maintenance or refurbishment) in the next 10 to 20 years.

Calliope River to Gin Gin 275kV SCST Transmission Line

The Calliope River to Gin Gin 275kV single circuit transmission line (built section 1123 Feeder 814) was commissioned in 1976. The line consists of 346 original galvanized steel lattice towers and is approximately 152km in length. This line is also fitted with OPGW and provides the primary communication path between Calliope River and Gin Gin.

The structural tower steel is generally sound, exhibiting deterioration of the galvanising only, with no visible metal loss. Nuts and bolts on the line have started to show Grade 2 corrosion. The tower concrete foundations are in sound condition and show no significant signs of deterioration except for typical minor corrosion at the concrete - tower leg interface.

Structures in the Calliope region may require further detailed condition assessment as the rate of corrosion in this region may be greater than the other sections of the feeder.

Suspension insulators have been replaced between 2002 and 2008 and remain in a sound condition. Insulators replaced in 2002 are beginning to show Grade 2 corrosion. Insulator hardware is beginning to show Grade 2 corrosion. Tension Insulators and Bridging Insulators have been replaced in 2013 and remain in good condition. The hardware associated with the suspension and tension insulators as well as the earth wire hardware was installed in 1976 and shows some minor deterioration and corrosion.

The climbing step bolts and anti-climbing barriers have started to show Grade 3 corrosion and no longer meet present day Powerlink standards. The warning and asset identification signs were replaced in 2012 and are in good condition.

On average across the built section towers are suffering approximately 14% Grade 2 degradation of nuts and bolts. On conductor attachment plates approximately 20% bolts and nuts show Grade 2. Approximately 7% of steel members on the tower are exhibiting Grade 2 corrosion.

Without any increased maintenance or refurbishment, built section 1123 has an expected reinvestment requirement in the next ten years. This is primarily due to the condition of structures at Calliope River, with the remainder of the line in a better condition. This remainder has an estimated remaining service life between 10 to 20 years.

Calliope River to Gin Gin 275kV SCST Transmission Line

The Calliope River to Gin Gin 275kV single circuit transmission line (built section 1122 Feeder 813) was commissioned in 1972. The line consists of 300 original galvanized steel lattice towers and is approximately 136km in length.

The towers' concrete foundations are in sound condition and show no significant signs of deterioration.

Structural tower steel is generally sound, exhibiting minor deterioration of the galvanising only, with no metal loss to date.

From the photographs available, and notifications lodged, most nuts and bolts on the line have experienced very little corrosion, with less than 20 recorded examples of 25% or more Grade 2 corrosion. The most widespread Grade 2 corrosion appears on the superstructure of towers located within 5kmof either the Gladstone Power Station or the Boyne Aluminium Smelter settlement ponds, with up to 10% Grade 3 on some of these structures.

The majority of V-string insulators were replaced in 2004 and 2009, and remain in good condition. Tension insulators are the original 1972 units and require replacement in the short term. Associated hardware is showing greater than 10% Grade 3 on the final four towers at the lines northern end. Most suspension insulators were replaced in 2009 (with a smaller number replaced in 2000 and 2004). Bridging and restraint bridging insulators were changed out between 2000 and 2015.

The conductors are in sound condition and are considered to have at least another 25 years remaining life.

The original 1972 A and B earth wires remain, with at least 4 spans displaying Grade 3 corrosion near the northern end of the built section. The OHEW is captured in a supported trunnion clamp arrangement on most Suspension towers; with this arrangement known to shorten the life of the wire due to the rocking motion of the clamp when the wire is buffeted by high winds.

The estimated reinvestment outlook of built section 1122 (without additional maintenance or refurbishment) is expected to be in the next five years with the superstructure bolt and suspension hardware corrosion at the northern end of the line being the critical determinant of this estimate.

Wurdong Tee to Gin Gin 275kV SCST Transmission Line

The Wurdong Tee to Gin Gin 275kV single circuit transmission line (built section 1124 Feeder 819) was commissioned in 1981. The line consists of 315 original galvanized steel lattice towers and is approximately 137km in length.

Photographic evidence as well as SAP notification reporting indicate that the transmission line is performing well when compared against corrosion modelling data, with 1% of structural members and 3% of tower bolts observed to have lost all galvanising (Grade 3 corrosion). The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The insulators and OHEW were replaced in the last 10 years, but the conductor hardware, dampers and spacers are showing levels of deterioration that require replacement in the medium term.

The tower concrete foundations are in sound condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

It is estimated that built section 1124 will exceed an acceptable risk profile and require investment in a 10 to 20 year period.

Gin Gin to Woolooga 275kV SCST Transmission Line

The Gin Gin to Woolooga 275kV single circuit transmission line (built section 1024, Feeder 815) was commissioned in 1972. The line consists of 323 original galvanized steel lattice towers and is approximately 149km in length. It follows a more inland route.

Although no condition assessment report is currently available at this stage, routine inspection photographic evidence as well as SAP notification reporting indicates grade 2 corrosion on 25% to 40% of bolts and 10% of members.

The suspension and bridging insulators were replaced in last 5 years (2010 and 2014 respectively). The original tension insulators (with the associated hardware and hanger brackets) remain, are in a fair condition and are scheduled in be replaced in 2019. Similarly, the original OHEW is in place and has Grade 2 corrosion, but is in good condition.

It is estimated that built section 1024 will exceed an acceptable risk profile and require investment in the next 10 to 20 years.

Gin Gin to Woolooga275kV SCST Transmission Line

The Gin Gin to Woolooga 275kV single circuit transmission line (built section 1025 Feeder 816) was commissioned in 1976. The line consists of 363 original galvanized steel lattice towers and is approximately 150km in length. It follows a more coastal route via Teebar Creek. This line was fitted with OPGW in 2007 to provide the communication path between Gin Gin, Teebar Creek and Woolooga.

Photographic evidence as well as SAP notification reporting indicates that the transmission line has approximately 40% Grade 2 corrosion on bolts and less than 10% Grade 2 corrosion on members.

The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The suspension insulators, dampers and OHEW were replaced in the last 10 years, but the tension insulators, conductor hardware and spacers are in degraded condition due to corrosion and will also require replacement in the medium term.

It is estimated that built section 1025 will exceed an acceptable risk profile and require investment in the next 10 to 20 years.

Woolooga to South Pine 275kV SCST Transmission Line

The Woolooga to South Pine 275kV single circuit transmission line (built section 1020, Feeder 807) was commissioned in 1972. The line consists of 356 original galvanized steel lattice towers and is approximately 160km in length.

In 2012, climbing inspections of every tower in the built section detailed the level of corrosion across the feeder. This inspection found that all galvanised tower members, nuts and bolts are beginning to exhibit evidence of Grade 2 corrosion, with instances of Grade 3 and Grade 4 confined to specific geographic locations such as the Obi Obi Valley and the Maleny Hinterland.

Recent maintenance work in 2014 targeted areas identified from the climbing inspections with Grade 3 and 4, replacing highly corroded bolts/nuts and other components.

The climbing step bolts on all towers no longer meet present day Powerlink WH&S standard and any future refurbishment work will require the step bolts to be upgraded.

Insulators on suspension structures were replaced in 2008 & 2012 and bridging insulators have been gradually replaced from 2012 – 2014, with the remainder to be replaced in 2015.

A sample of the SC/GZ overhead earth wire was removed in 2014 and although there was significant surface rust, the internal strands of the earth wire did not exhibit the same level of corrosion. In 1997, a major refurbishment of suspension hardware due to internal strand breakages was carried out. The problem was attributed to excessive vibration caused by incorrect hardware. It is expected that overhead earth wire replacement will be required to ensure extended service life.

All warning and asset identification signs have also been progressively replaced over the past 4 years.

The ACSR/GZ conductors are in sound condition and are considered to have at least another 25 years remaining life.

It is estimated that the built section 1020 will require investment in the next five years, with the potential requirement for a program of targeted maintenance in the interim. This assessment is driven primarily on the condition of the structures in the Maleny and Montville regions.

Woolooga to Palmwoods275kV SCST Transmission Line

The Woolooga to Palmwoods 275kV single circuit transmission line (built section 1048, Feeder 810) was commissioned in 1976. The line consists of 205 original galvanized steel lattice towers and is approximately 93km in length. This line is also fitted with OPGW and provides the communication path between Woolooga and Palmwoods.

A condition assessment conducted in 2015 highlighted the following:

- Structural tower steel is sound, but exhibiting deterioration of the galvanising with surface rust visible in specific locations along the built sections and an increasing proportion of nuts and bolts with grade 3 corrosion. Deterioration of the galvanising of members and bolts can be found throughout the built section and is highest in the areas between Montville to Mapleton and west of Gympie.
- The tower foundations are reinforced concrete type in generally sound condition although there is some evidence of corrosion at the concrete - tower leg interface, primarily due to localised drainage issues.
- The suspension and bridging insulators were replaced between 2008 and 2010. The original tension insulators are still installed (1976) and have grade 2 corrosion. All structures have the original hardware installed and are showing evidence of 35% grade 2 and between 15-30% grade 3 corrosion and will require attention in the next 5 years.
- Overhead earth wire hardware was retrofitted with OPGW and Volleyball OHEW in 2010. These are in good condition with at least another 25 years of service life remaining.
- The conductors are in sound condition and are considered to have at least another 25 years remaining life.

Taking into account the existing condition and location of the built section, the expected reinvestment outlook for built section 1048 is in the next 10 years (if no additional investment is undertaken). This assessment is driven primarily on the condition of the structures in the Maleny and Montville regions.

Palmwoods to South Pine 275kV SCST Transmission Line

The Palmwoods to South Pine 275kV single circuit transmission line (built section 1021 Feeder 808) was commissioned in 1976. The line consists of 162 original galvanized steel lattice towers and is approximately 75km in length. This line is also fitted with OPGW (installed in 2010) and provides the primary communication path between Palmwoods and South Pine.

Climbing inspections were carried out on all structures on the built section in 2013. The inspections found that:

- the condition of all structures was generally good with Grade 2 corrosion between 5% to 20% of all bolts. There were instances of Grade 3 and 4 bolts; however these were on a small number of structures and totalled less than 1% of all bolts.

- Structural members were in good condition with only Grade 2 corrosion observed on less than 10% of all members.

Suspension and bridging insulators were changed between 2005 and 2009. The associated suspension hardware and hanger brackets remaining are in fair condition and will requirement replacement in the short to mid-term. Tension insulators and the associated hardware (including conductor hardware, dampers and spacers) were installed in 1976 and are in a fair condition considering their age, but should be considered for replacement in the mid-term.

It is estimated that built section 1021 (without significant maintenance or refurbishment) will exceed an acceptable risk profile and require investment in the next 0 to 10 years.

Additional assets reaching end of life

Within this area, there are also a range of other substation and secondary systems assets with a predicted end of life within the outlook period of the AMP. The discussion presented within this area plan confirms an enduring need for the majority of these assets, and as such the condition driven risks of maintaining these assets in service will be considered on a case by case as part of future investment decisions.

7.3 Network requirements

7.3.1 Demand and energy forecasts

Eastern Central Queensland to South Queensland supplies Boyne Island smelter, Wide Bay and typically Southern Queensland (at times flows may reverse, see Figure 7.2, in these situations loads on the north coast and into the Wide Bay zone are supplied from South Pine Substation). The demand for electricity in Wide Bay zone and South Queensland is highest during summer. Summer is also the season with lowest network capacity due to lower thermal ratings and load power factors. Summer is therefore the relevant season for assessment of demand reliability.

Delivered energy and to a lesser extent delivered demand have been significantly affected by recent behaviours, trends and technological improvements. Wide Bay and South Queensland are not expected to be immune to these as reflected by forecasts. The summer peak historical and forecast delivered demand at time of state peak for the Wide Bay zone and South Queensland zones are shown in figures 7.4 and 7.5. The Surat zone is responsible for the large initial growth depicted in Figure 7.5.

Figure 7.4: Wide Bay historical and forecast delivered summer peak demand

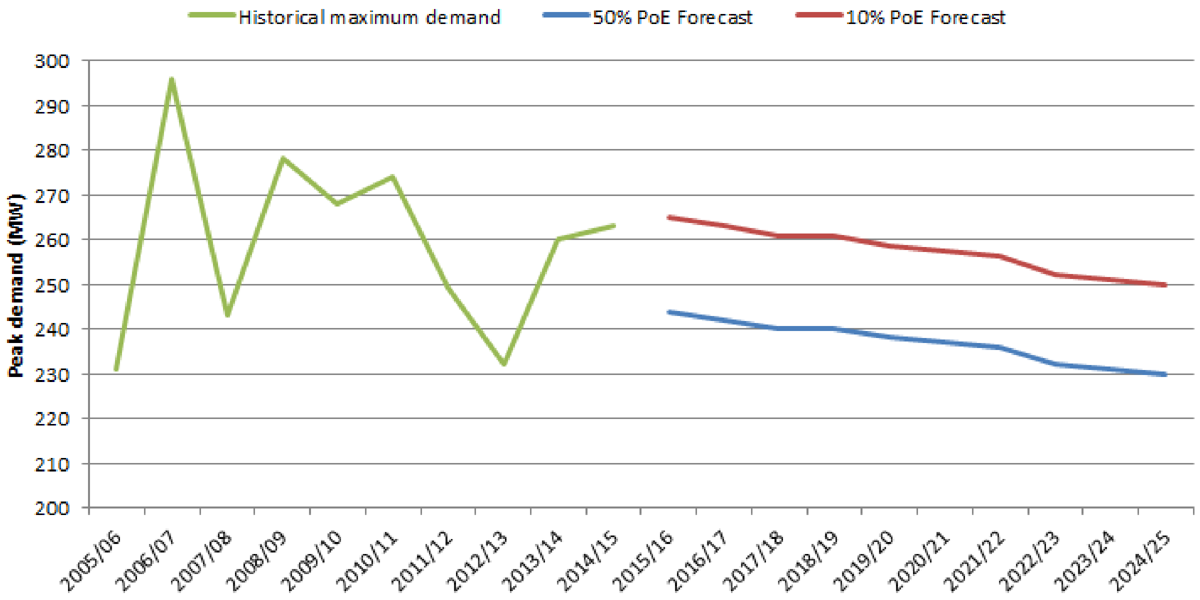
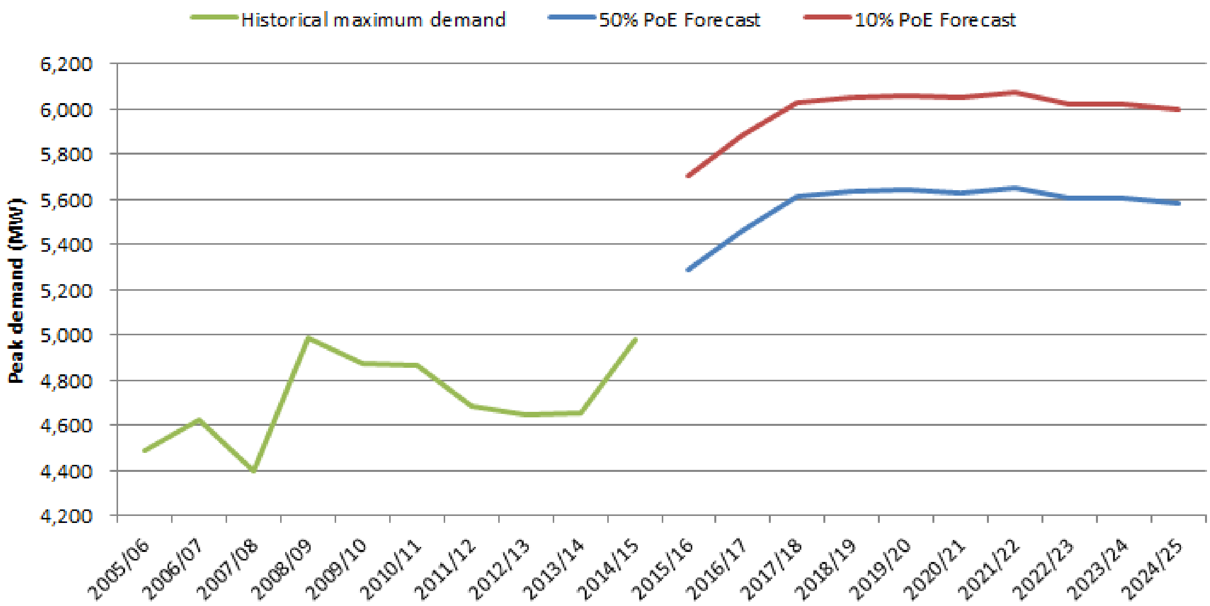


Figure 7.5: South Queensland historical and forecast delivered summer peak demand



7.3.2 Load characteristics

The normalised maximum delivered demand profile and annual delivered load duration curves for the Wide Bay zone and South Queensland comparing load shapes across the last five years are shown in figures 7.6, 7.7, 7.8 and 7.9.

Figure 7.6: Wide Bay normalised maximum delivered demand profile

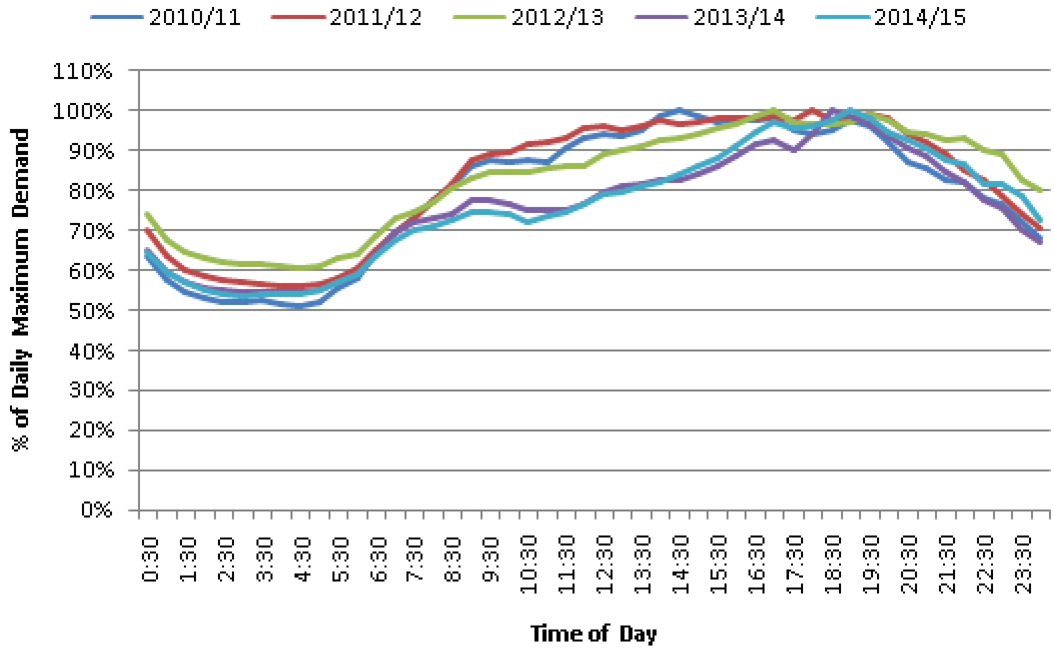


Figure 7.7: Wide Bay normalised annual delivered load duration curves

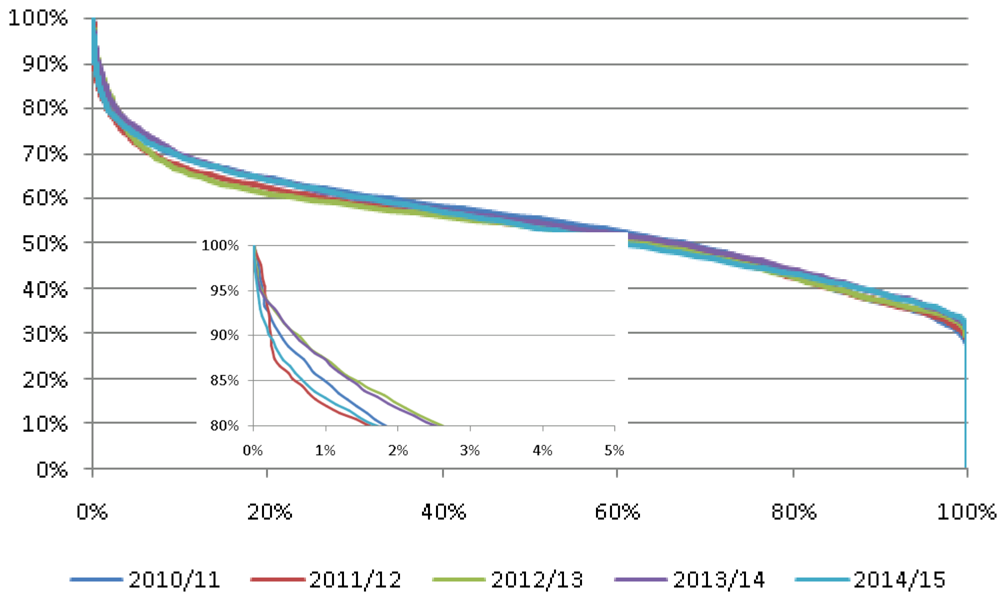


Figure 7.8: South Queensland normalised maximum delivered demand profile

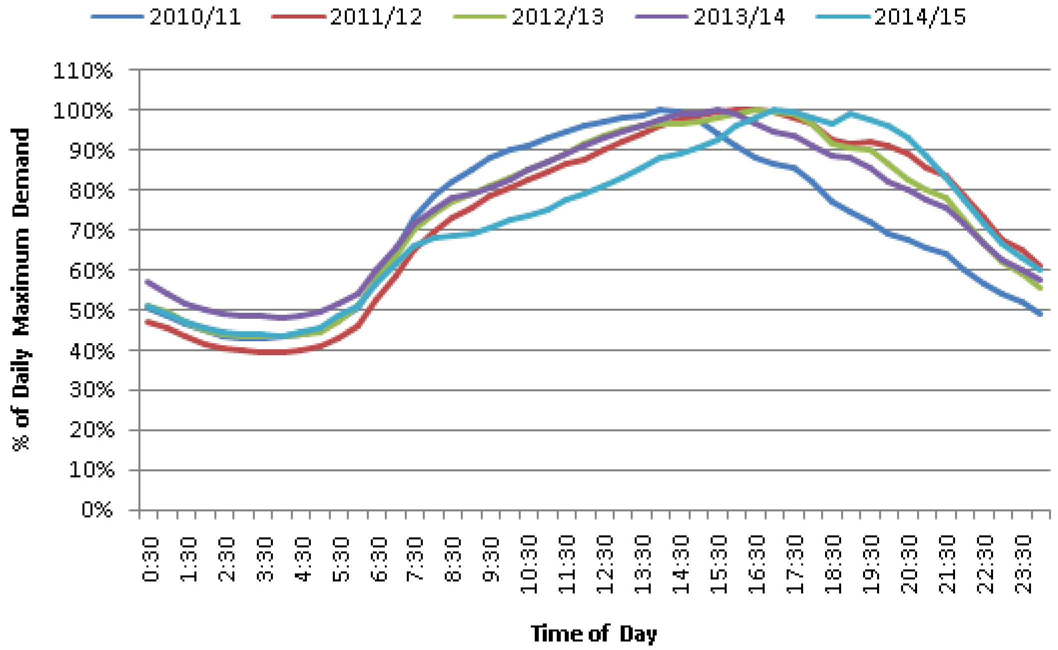
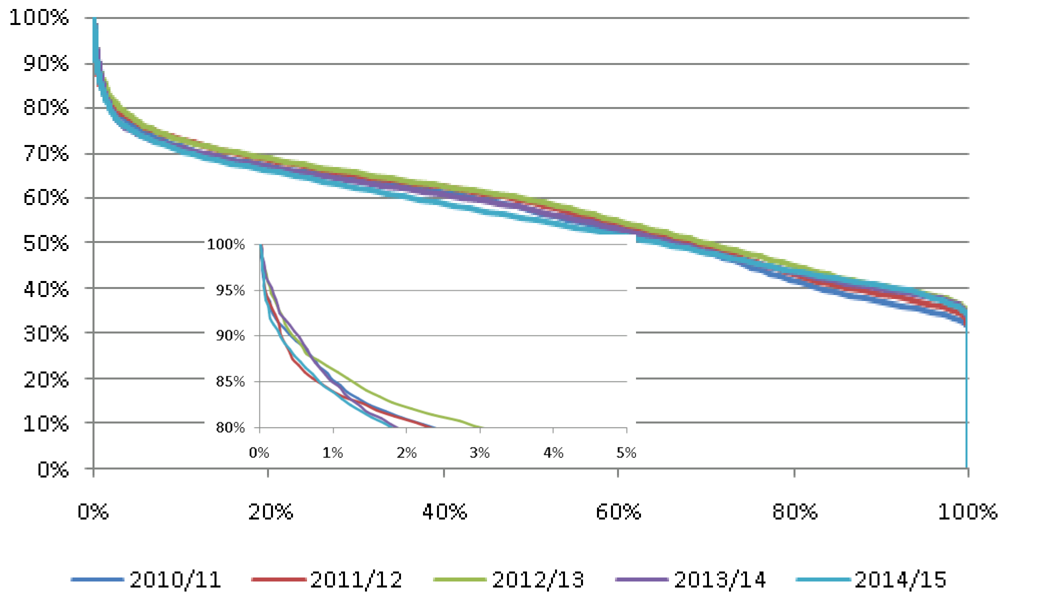


Figure 7.9: South Queensland normalised annual delivered load duration curves



Peak demands have trended to occur later in the day, when PV has little to no impact. Load durations curves have not significantly altered in the last 4 years.

Electrical load in these zones is predominantly urban residential, but also includes large components of large and small industrial, farming, commercial and rural residential.

7.3.3 Generation development

South Queensland has traditionally been a net importer of electricity making use of CQ-SQ and later QNI and Directlink to supply its net demand. Table 7.3 provides a breakdown of the generation and peak load by area. Currently there is sufficient generation in North and Central to provide 2,789MW to South Queensland even at times of highest load conditions. The capacity of CQ-SQ at the current maximum level of 2,100MW would prohibit these southerly transfers. Figure 7.2 illustrates that such high transfers are not found to be economical in practice.

Table 7.3: Breakdown by area of Queensland transmission connected and scheduled generators and summer peak load

Area	2015/16 Generation Capacity (MW)†	2015/16 State Peak Demand (MW)	2015/16 Generation Surplus (MW)
North	806	1,151	-345
Central	4,929	1,795	3,134
South	5,853	5,530	323

† excludes QNI/Directlink and network losses/generator auxiliary
Source: TAPR 2015

Stanwell Corporation withdrew two units at Tarong Power Station from service in October and December 2012 respectively. The units remain registered with the Australian Energy Market Operator (AEMO). Stanwell Corporation announced in February 2014 its intention to withdraw Swanbank E Power Station for up to three years from 1 October 2014, and Tarong unit 4 to be returned to service later in 2014, and Tarong unit 2 to be returned in mid‑2015. Tarong unit 4 was returned to service in July 2014 and Swanbank E was mothballed in December 2014. Tarong unit 2 has not yet been returned to service. Table 7.4 summarises this short term generator capacity withdrawal.

Table 7.4: South Queensland power station withdrawal

Generator	Capacity (Winter/Summer MW)	Period Withdrawn
Tarong Unit 2	350	2012-2015(+)
Tarong Unit 4	350	2012-2014
Swanbank E	370/350	2014-2017(+)

Generation in South Queensland is predominantly located in the west, making use of the South West and Tarong grid sections to supply the South East. There is interdependency between CQ-SQ and the Tarong grid section. A reduced CQ-SQ eastern injection places higher loading on the Tarong grid section.

Powerlink notes that while there have been generator connection enquiries in south east Queensland, none of these proposals have committed in recent years. In the same period there have been a large number of new generators establish in the south west. One reason for this may be that including gas transport costs, as well as environmental and town planning constraints, it is more cost effective for plant to locate in the south west area.

The following factors impact the practicality of future power stations in and around urban and sensitive areas:

- The Queensland Government strategy for improving air quality by reducing combustion-based industrial plant within SEQ;

- Growth in Queensland cities and town planning activities which have constrained land use, and this has eliminated many opportunities for power stations in urban areas;
- Lack of localised fuel sources or access to remote sources of fuel where existing transportation infrastructure is fully committed and the scale of investment needed to increase capacity is significant;
- Emerging fault level constraints in parts of the network practically impacting the plausibility for the connection of future generators;
- Market competition from new generators entering the market, beyond demand and reserve capacity levels in relation to co-opted emerging industries such as LNG, resulting in earlier than predicted retirement of older less efficient generators;
- Demonstrated community opposition to previously proposed power stations;
- Lack of committed generator projects, lack of evidence of future generator prospects and lack of interest by proponents across some areas; and
- Federal Government regulations pertaining to locating of infrastructure, such as control of developments in the vicinity of defence force assets, national parks, world heritage areas, rail corridors, major highways, and height restrictions and exhaust flume around airports.

Table 7.5 lists known South Queensland generator proposals.

Table 7.5: South Queensland power station proposals

Generator	Fuel Type	Unit Status	Nameplate Capacity (MW)	Proposed Start Date
Braemar 3	Gas	Publically Announced	550	TBA
Braemar 4	Gas	Publically Announced	495	TBA
Coopers Gap	Wind	Publically Announced	350	TBA
Crows Nest	Wind	Publically Announced	200	TBA
Darling Downs Stage 2	Gas	Publically Announced	500	TBA
Kogan Creek	Solar	Committed	44	2016
Westlink Power Project	Gas	Publicly Announced	up to 1000 in three stages	TBA

Source: AEMO Generation Information, http://kogansolarboost.com.au/.

Sources of coal-fired generation within South West Queensland comprise the Tarong and Tarong North power stations. The Tarong Power Station comprises four steam turbines with a combined generating capacity of 1,400MW. It was one of the first stations commissioned in the area progressively commissioned between 1984 and 1986.

The Tarong North Power Station was commissioned at the same location in 2002 and comprises a super-critical boiler design and steam turbine of 443MW capacity. Oakey Power Station comprises two gas turbine open cycle units with a total capacity of 282MW.

Condamine combined cycle power station (144MW) and Roma Power Station (54MW) are connected to the 132kV network from Tarong and to the 275kV network via Columboola.

The Bulli zone includes Millmerran, Kogan, Darling Downs, Braemar 1 and 2 power stations.

Local generation available to supply the Moreton area was reduced following the closure of Swanbank B Power Station in 2012.

The major remaining sources of generation within the Moreton zone is the Swanbank E combined cycle gas fired generator (350MW currently mothballed) and Wivenhoe power station. Wivenhoe is a pumped storage hydro generating station with an installed capacity of 500MW. Energy limitations exist at Wivenhoe due to the need to pump water for later generation and the capacity of the Splityard Creek upper dam.

Table 7.6 lists South Queensland generator development and current capacity factors.

Table 7.7 lists South Queensland generator retirements.

There are no major sources of local generation within the Wide Bay area. However, several small sugar mill co-generation facilities embedded within the Ergon distribution network are located within this zone. The effects of these embedded generators are taken into account within the summer and winter peak forecasts.

Table 7.6: Existing South Queensland power station development

Generator	Fuel Type	Capacity (Winter/Summer MW)	Commissioning Date	2014/15 Capacity Factor (1)
Wivenhoe	Hydro	500	1984	0%
Tarong	Black coal	1400	1984-86	46%
Roma	Natural gas	68/54	1999	30%
Oakey	Natural gas	340/282	2000	20%
Millmerran	Black coal	852/760	2002	89%
Tarong North	Black coal	443	2002	50%
Swanbank E	Natural gas	370/350	2002	28%
Braemar	Natural gas	504/465	2006	50%
Kogan Creek	Black coal	744/730	2007	88%
Condamine	Natural gas	144	2009	62%
Braemar 2	Natural gas	519/495	2009	57%
Darling Downs	Natural gas	630/580	2010	77%

Source: (1) AEMO 2015 NEM Historical Market Information.

Table 7.7: South Queensland power station Retirements

Generator	Capacity (Winter/Summer MW)	Decommissioning Date
Middle Ridge Gas Turbine	52/44	2002
Swanbank C	28/25	2002
Swanbank A	408	2002
Swanbank B	480	2012

7.3.4 Existing network capability

The capability of CQ-SQ under intact system conditions is set by the requirement to maintain transient or voltage stability following a Calvale to Halys 275kV circuit contingency.

Transfer capability across the grid section varies with different system operating conditions. Such transfer limits are not generally amenable to definition by a single number. CQ-SQ transfer capability can be set by insufficient reactive power reserves in the Central West and Gladstone zones following a contingency. More generating units online in these zones increase reactive power support and therefore transfer capability. The transfer capability ranges between 1,550MW and 2,100MW.

For the purposes of this area plan a system condition aligned with the latest time for reinvestment has been assessed. This system condition attempts to maximise the transfer capability (by locating generation close to the intra-connector) whilst minimising the power transfer (by modelling a reliable amount of South East Queensland generation on), in a reliable fashion, for a given load. Under this system condition the CQ-SQ limit for the existing system is 2,100MW.

It is important to note that in determining transfer limits, the system is stressed by modifying load and generation. The diversity of the load plays an important role in the final limit. Higher demand in Wide Bay versus south Queensland than assumed will result in a different CQ-SQ limit as the flows between the western and eastern parts of this corridor redistribute accordingly.

Similarly, the location of new generators and other modelled projects will affect the ultimate calculation of limit and headroom. Limits quoted in this area plan are based on this assumed reliability trigger scenario unless qualified otherwise.

The coastal CQ-SQ provides the major injection points at Gin Gin, Teebar Creek, Woolooga and Palmwoods 275/132kV for the Wide Bay and Sunshine coast areas. The Ergon Energy 132kV and Energex 132/110kV sub-transmission systems supply bulk supply points in these areas. From these bulk supply points, a 66kV or 33kV distribution system supplies the various zone substations. These 132kV and 110kV sub-transmission systems typically run in parallel with the 275kV network. Accordingly, there is some component of CQ-SQ transfer that flows through the parallel sub-transmission system. High CQ-SQ transfer may therefore exacerbate 132kV network loadings. Under outage conditions the sub-transmission network may have to be split to avoid overload for a subsequent event.Thermal ratings can limit power transfer under planned or unplanned outage conditions. These CQ-SQ coastal circuits were constructed using twin Goat conductor (except for short twin Phosphorus turn into Palmwoods and twin Sulphur into Wurdong). Table 7.8 lists relevant summer thermal ratings.

Table 7.8: Coastal CQ-SQ feeder ratings

Feeder	Normal Summer Rating (MVA)	Emergency Summer Rating (MVA)
813 Calliope River to Gin Gin	798	866
814 Calliope River to Gin Gin	798	866
818 Calliope River to Wurdong	798	866
819 Wurdong to Gin Gin	798	866
815 Gin Gin to Woolooga	763	857
816 Gin Gin to Woolooga	763	857
826 Gin Gin to Teebar Creek	763	857
8850 Teebar Creek to Woolooga	763	857
807 Woolooga to South Pine	798	866
810 Woolooga to Palmwoods	798	866
808 Palmwoods to South Pine	798	866

7.3.5 Forecast Network Capability

The scenario analysed is based on:

- existing generation with mothballed units returned to service if needed
- committed Surat load (2023/24 forecast level)
- new 300MW generator in the Surat zone
- 10% PoE summer 2014/15 state peak conditions.

In assessing *headroom*, the approach taken is consistent with the traditional reliability trigger conditions. These conditions attempt to maximise the transfer capability whilst minimising the power transfer, in a reliable fashion, for a given load. In terms of CQ-SQ, the reliability trigger dispatch is summarised as:

- Kogan Creek out of service (most impacting unit)
- QNI 300MW northerly transfer
- Wivenhoe at 150MW (energy limited)
- all other south Queensland generators at maximum output
- five Gladstone units at maximum output.

Loads are scaled in steps of 5% until a limitation is found. If no operational limitation exists, this becomes the latest time (or maximum supportable load) before a load driven investment is needed. The increase from the base load level defines the headroom for the option.

Under the 2015 TAPR, forecast loads in Wide Bay are not expected to exceed the base (0%) level over the next 10 years. A network delivering positive headroom under these conditions is therefore expected to provide the planned level of reliability over the medium term. Relative headroom can be used to compare capacity between Options. Headroom alone, can assist in calculating number of years before requiring further action (under such a scenario). However, headroom is affected by:

- diversity of growth
- location of generation to supply the additional load.

The analysis presented does not forecast depleting the headroom and alternative solutions when this occurs. For example, if headroom is depleted due to transfer into SQ alternative solutions may include

- QNI augmentation
- Western CQ-SQ augmentation
- Eastern CQ-SQ augmentation.

The timing of such an augmentation will be dependent on the location (and the type) of new generation.

Section 3.5 discusses forecast network capability for the options analysed under this scenario.

7.3.6 Market and regulatory considerations

Non-network alternatives

Potential non-network solutions that will reduce load within the south Queensland area may assist in further managing the risk related to a future decision that brings about larger scale retirement of 275kV network assets and a reduction in network capability that creates the potential for load shedding in accordance with Powerlink's reliability standard.

Non-network solutions may include:

- Broad based load aggregation schemes within the south Queensland area, location depending on the nature of asset retirement;

- demand side management initiatives, in addition to that already assumed in the delivered demand forecast. This may include customers agreeing to voluntarily 'switch off' during a network contingency or operating embedded generation to manage short term rating exceedances of plant at peak periods. If this is the case, an automatic system would be required to interrupt power supply to participants in the program immediately following a contingency to prevent more widespread load shedding.

Powerlink's strategy over the next three to five years is to develop costings and viability of network and DSM alternatives through joint planning activities.

External consultation

Regardless of the future investment recommendation, the CQ-SQ limit and subsequent transfer capability will likely be reduced. This may constitute a "material impact" under the National Electricity Rules and require Powerlink to consult and perform a Regulatory Investment Test (RIT-T). The timing for this RIT-T will be dependent on the physical reduction of transfer capability, realised by the end of the technical and economic life of the relevant transmission lines.

Market considerations

The flow across the CQ-SQ grid section is limited by a set of voltage and transient stability constraint equations in the National Electricity Market Dispatch Engine. The transient stability constraint sets the upper limit and voltage stability constraints provide other operational limits down to a minimum of 1,550MW. Network changes in and around CQ-SQ impact both these transfer limits, consequently imposing different levels of constraints on market dispatch resulting in market costs or benefits.

The market impact mainly comprises out-of-merit generation fuel cost and under unfavourable situations unserved energy cost associated with limited transmission capacity. However, this market cost depends on many uncertain parameters such as:

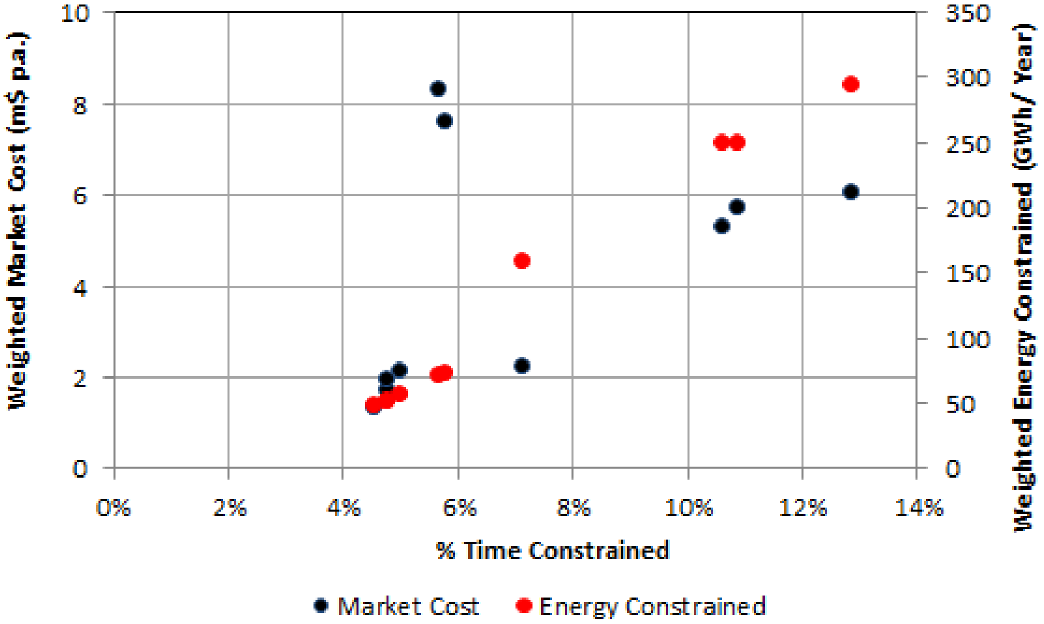
- system demand
- generator bidding strategies
- fuel costs
- water values
- plant retirements
- new entrants
- planned generator outages
- forced generator outage rates
- network limits

AEMO's 2014 NTNDP market model database has been used as the starting point for this analysis. The demand forecast was closely aligned with Powerlink's 2014 TAPR forecast. The 2015 TAPR forecast for south Queensland is approximately 10% higher for the 10% PoE and 5% higher for the 50% PoE. Therefore (all else being equal) a greater market is expected impact under this revised outlook.

Figure 7.10 provides an overview of the variability of expected market impacts caused by a reduction in CQ-SQ capability to 1,200MW. Each point represents the expected market impact over a year between 2016 and 2025. Variable energy costs and cost of unserved energy make up the market impact, variable energy cost being the larger of the two components. As is common practice with this type of future analysis, numerous simulations are repeated varying some of the uncertain parameters (demand, bidding and forced outages) and results are summarised by weighting each result by a probability measure. It is important to note that there is a wide distribution surrounding both the expected market impact (achieved values greater than $25 m p.a.) and the time constrained variables (achieved values 20%) and only the expected value of this distribution is plotted and used in net present value analysis.

It should be noted that although the market cost is modest, the time constrained can be very large (much larger than any Queensland intra connector). This is typical of a system with surplus generation capacity, or one where the fuel cost of the new marginal generator is comparable to the constrained generator. If the incremental cost for additional transmission capacity beyond what is needed to meet reliability of supply requirements is comparatively large, there will be no economic case for reinvesting for that level of CQSQ capacity.

Figure 7.10: Market cost and energy constrained relationships

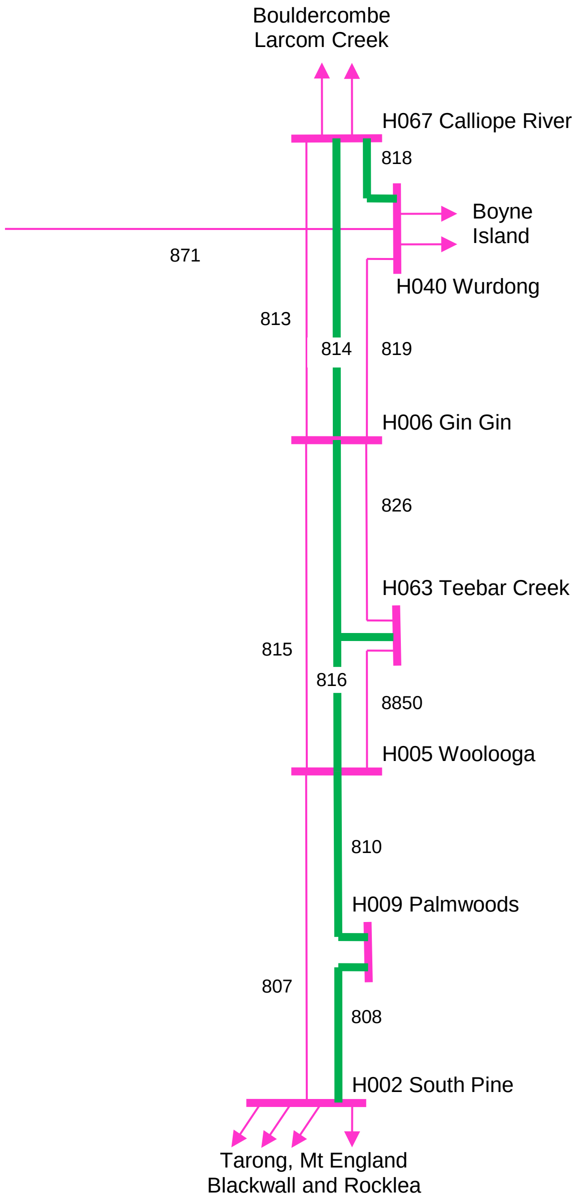


7.4 Other considerations

7.4.1 Telecommunications

There is a continuous fibre optic network established between Calliope River and South Pine using Optical Fibre Ground Wire (OPGW) fitted to selected overhead transmission lines. With this established fibre route Powerlink will decommission the legacy microwave system running between South Pine and Table Mountain over the next 18 months. Figure 7.11 illustrates circuits in green colour fitted with OPGW. Analysis of options that involve retirement of these 275kV assets includes the costs associated with establishing new bearer networks and the relocation of the associated traffic.

Figure 7.11: CQSQ OPGW route



7.4.2 Easements

It is not envisaged that any future investment will require the acquisition of additional easements.

Table 7.9 below outlines the average corridor width for the CQ-SQ intra-connector.

Table 7.9: Average Corridor Width for built sections on CQSQ

Built Section	Average Corridor Width (metres)	Comments
1122	80	
1123	60	Built sections 1123 and 1124 run parallel to each other. It is therefore possible to keep one single circuit in service and rebuild the other as a double circuit feeder (if required).
1124	60	
1125	50	
1024	76	
1025	60	Built sections 1025 and 1028, 1025 and 1480 run parallel to each other. It is therefore possible to keep one single circuit in service to rebuild the other as a double circuit feeder (if required).
1028	60	
1480	60	
1020	71	
1048	120	Both built sections 1048 and 1021 are a double width and could support a double circuit rebuild if the other was to remain in service.
1021	112	

Two of the coastal single circuits run adjacent to each other from Calliope River to Woolooga, and are built on a double width easement. The inland single circuit is built on a narrower single width easement. The number of circuits and their corresponding easements located in parallel along the coastal route presents the opportunity to rebuild at either single or double circuit construction while the other circuit remains in service.

South of Woolooga, the existing coastal circuits are located on a double width easement.

As such, it is believed that either rebuilding or life-extending any of these circuits would be achievable from an easement perspective.

7.4.3 Strategic joint planning – Ergon Energy and Energex

It is expected that any future investment recommendation that involves retirement of 275kV network assets and associated reduction in network capability will require joint planning and consultation of impact on power constraints and power quality in the networks owned by Ergon and Energex.

It is anticipated that both network configuration options investigated in this area plan would not materially impact Ergon or Energex and their ability to supply their load.

7.4.4 Stakeholder engagement

Background

Powerlink held an interactive forum with a number of stakeholders on the 14th of October 2015 to discuss the redevelopment of the 275kV coastal transmission lines from Central Queensland to Southern Queensland. A number of investment criteria were outlined including lowest long run cost, asset condition, importance of transfer capability and future operability of the network. Participants were also asked to identify any additional criteria that should be considered.

Two themes were presented as reinvestment examples to prioritise and assess the criteria. It was emphasised that Powerlink are still in the early stages of the reinvestment process and there was no predetermined outcome.

Themes presented

The first theme presented was a single circuit refit of approximately 1200 towers. This has the impact of reducing transfer capability, headroom and places a considerable level of load at risk during planned outages (load centres including Bundaberg, Maryborough, Hervey Bay, Gympie and the Sunshine Coast). It would result in a substantial reduction (700km) in transmission line length. Construction works for this option would be required prior to the end of technical life (within the next five years) to ensure sufficient strength remains in the structures to carry out these activities.

The second theme presented was the rebuild with a 275kV double circuit transmission line on an existing easement. This theme preserved, to a large extent, the transfer capability and headroom of the intra-connector and had minimal market impact and operability issues. It would result in some reduction of transmission line (300km), with construction required at the end of technical life (expected to be within the next 7 to 15 years). The two themes have comparable long run costs.

Key learnings

The key learnings of the stakeholder engagement sessions are summarised as follows:

- Participants did not think historical network investments have resulted in positive market outcomes for consumers. As a result, consumers are unlikely to be comfortable in selecting an option that may offer additional future benefits at a higher upfront cost;
- The participants were keen to see Powerlink adopt an incremental approach to investment such that future alternative options were not eliminated.
- Some participants were comfortable with a larger load at risk. There were thoughts that a loss of a number of regional centres may not be unpalatable in the current environment.
- The participants felt that while reducing the cost of future investment was important, it should not come at the detriment of network reliability. Following from this, the level of reliability currently delivered by Powerlink's network was considered to offer a suitable service to consumers.

7.5 Investment outlook

As highlighted earlier, in response to these preliminary condition assessments and ongoing importance of CQ-SQ, Powerlink has been progressively investigating long term strategies to ensure the condition based risks related to these assets remaining in service are acceptable, including ongoing maintenance, asset retirement, life refit (and extension) and rebuild.

The future CQ-SQ reinvestment strategy needs to balance economic cost whilst preserving a transfer capability that delivers appropriate market benefits. Taking into consideration stakeholder feedback, it should ensure transmission line reconfiguration occurs at the optimal time to deliver efficient market outcomes and reliability of supply to south Queensland for a wide range of generation and load scenarios.

Consideration is also being given to options to rationalise the number of 275kV transmission line circuits in the network from three down to two or one.

7.5.1 Description of long term options

This section will review strategic themes that will meet the network and asset requirements. It will undertake economic analysis on a holistic basis to determine the lowest investment outlook for the region.

Three option are being considered as part of the longer term strategy of the area plan:

- Base Case which maintains the current network topography;
- Option 1 – Refit selected single circuit lines to form a reduced single circuit corridor between South Pine and Calliope River, with a refit of two single circuits between Calliope River and Wurdong; and
- Option 2 – Rebuild selected single circuit lines to form a double circuit corridor between South Pine and Calliope River, with an additional double circuit connection between Calliope River and Wurdong.

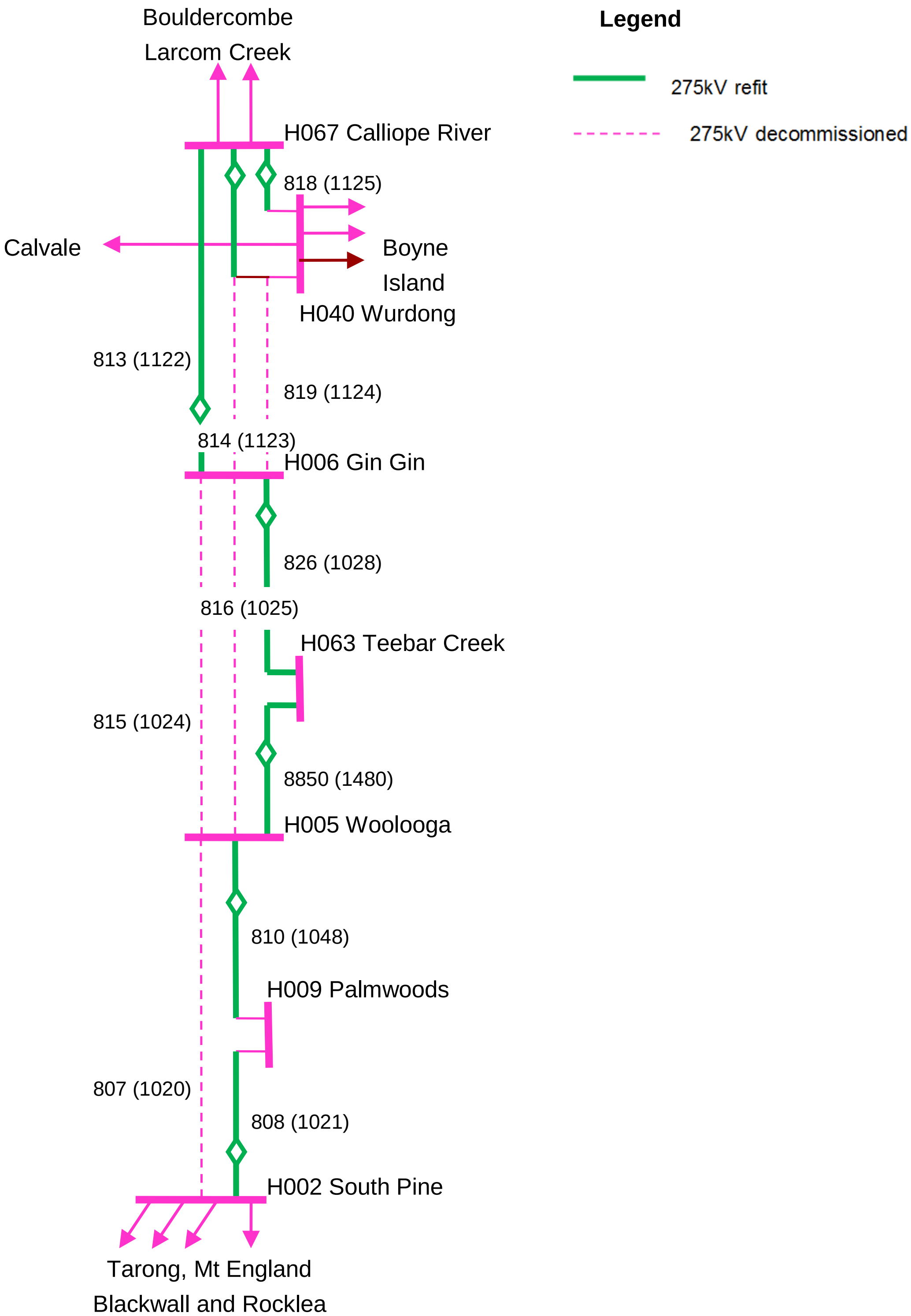
7.5.2 Base case

The base case option maintains the current topology and replaces/refits the existing transmission lines as and when the risk level requires it to do so. However bearing in mind that all the lines are single circuit, it would seem reasonable to assume that maintaining the current topology would be prohibitively expensive and unnecessary considering the subdued forecast as well as reduced reliance on maintaining high CQ-SQ transfer capabilities.

On this basis this option has not been further considered, apart from the concept of base case headroom and transfer capabilities as reference for other options.

7.5.3 Option 1 – single circuit life extension refit theme

The figure below outlines the final topology of Option 1 including the relevant lines requiring decommissioning.



The table below provides a summary of Option 1.

<table>
<tr><td rowspan="2">Option Overview
(Note – The timing of these projects will be optimised as Powerlink complete condition assessments and confirm end of life.)</td><td>0-10 years</td><td>Circuit 813 (built section 1122) is retained through transmission line life extension

Circuit 810 (built section 1048) is retained through transmission line life extension

Circuit 807 (built section 1020) is retired

Circuit 814 (built section 1123) first 15km from Calliope River is retained through transmission line life extension

Remaining section of circuit 814 (built section 1123) is retained through transmission line life extension

Circuit 818 (built section 1125) is retained through transmission line life extension</td></tr>
<tr><td>10-20 years</td><td>Circuit 808 (built section 1021) is retained through transmission line life extension

Circuit 826 and 8850 (built section 1028 and 1480) is retained through transmission line life extension

Circuit 815 and 816 (built section 1024 and 1025) is retired</td></tr>
<tr><td rowspan="3">Assumptions</td><td>0-10 years</td><td>Gin Gin rebuild assumes that a single bay will be made available for circuits 815/816. At this point these circuits and 813/814 are paralleled.</td></tr>
<tr><td>10-20 years</td><td>Potential construction of 3rd Wurdong – Boyne Island 275/132kV transformer ended supply as an alternative to the 132kV supply into Boyne Island.</td></tr>
<tr><td colspan="2">Level of load at risk under a planned outage is acceptable.
Costs of reducing capacitor bank sizes and emergency control schemes to manage 132kV flows are small.</td></tr>
<tr><td>Benefits of Option</td><td colspan="2">Lower initial costs.

No risk of excess capacity since this is the minimal build to supply existing loads with the required reliability standard.</td></tr>
<tr><td>Drawbacks of Option</td><td colspan="2">Lower CQ-SQ southerly limit of 1,200MW, imposing greater constraints to the market. Northerly limit is also reduced but not expected to result in market impacts.

Transmission capacitor banks will need to be resized due to the lower fault levels. Distribution network will experience higher voltage changes when switching their reactive devices. Potential impacts on power quality at distribution level.

Larger than assumed growth in the Wide Bay area versus the rest of SQ has a large impact on headroom reducing spare for zonal transfer (lower utilisation of Calvale-Halys).

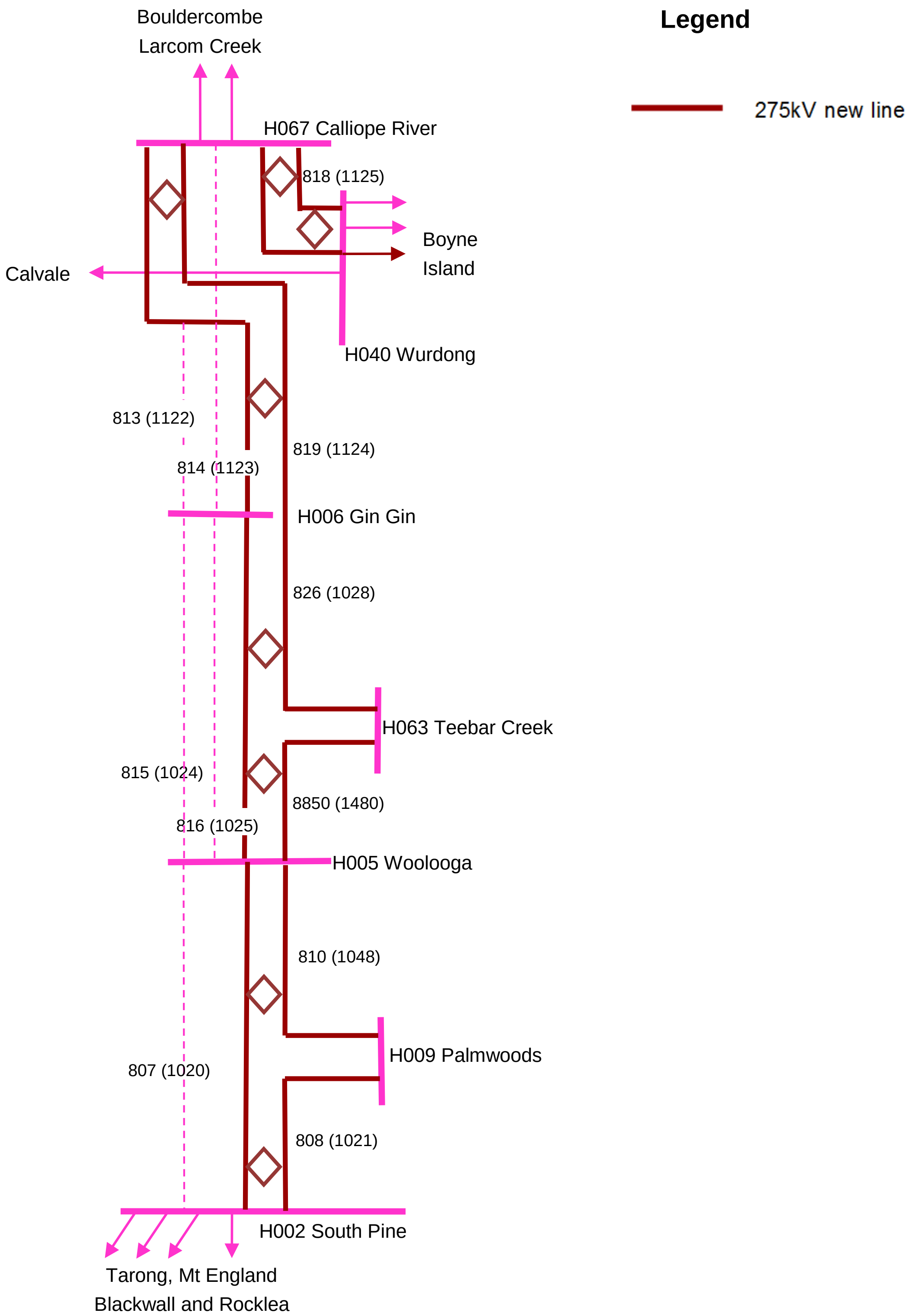
Safety considerations when working on towers may extend the construction period to complete all necessary refit works on the line.

Greater Operating Expenditure.</td></tr>
<tr><td>Market Impact</td><td colspan="2">Expected market impacts estimated between $5m and $10m p.a. However,</td></tr>
</table>

	the pool price impacts are expected to be much higher than this.
Operational Flexibility	A single circuit outage places greater levels of residential and small industry loads at risk (for the next event) than current topology. System Integrity Schemes may be required during maintenance of plant, such as the Woolooga SVC, to avoid wide spread propagation of voltage instability.
Demand Scenario	15% headroom before reliability constraints (current headroom ~30%).
Critical Contingency	2 phase to ground fault on the Calliope River end of the Calliope River – Gin Gin circuit. Loss of Calvale – Halys 275kV circuit
Network Limitation	Transient instability of central and north Queensland generators. Thermal overload of Calliope River – Gin Gin 275kV.

7.5.4 Option 2 – double circuit rebuild theme

The figure below outlines the final topology of Option 2 including the relevant lines that require decommissioning.



The table below provides a summary of Option 2.

Option Overview (Note – The timing of these projects will be optimised as Powerlink complete condition assessments and confirm end of life.)	0-10 years	Ongoing targeted maintenance of circuits 807 and 810 (built section 1020 and 1048) to align with end of life of 808 (built section 1021)
	10-20 years	The construction of a double circuit transmission line on existing easement from South Pine to Woolooga with one circuit connecting into Palmwoods. Retirement of circuits 807, 808 and 810 (built section 1020, 1021 and 1048). The construction of double circuit transmission line on existing easement from Woolooga to Gin Gin with one circuit connecting into Teebar Creek. Retirement of circuits 815, 816, 826 and 8850 (built section 1024, 1025, 1028 and 1480). The construction of double circuit transmission line from Calliope River to Wurdong. Retirement of circuit 818 (built section 1125) The construction of double circuit transmission line from Calliope River to Gin Gin. Retirement of circuit 813 and 814 (built section 1123 and 1124).
Assumptions	10-20 years	Potential construction of 3rd Wurdong – Boyne Island 275/132kV transformer ended supply as an alternative to the 132kV supply into Boyne Island.
	It is more economical to increase transfer into SEQ via the eastern side of CQ-SQ than via other means (such as QNI or the western part of CQ-SQ). Easement of existing line can be used for rebuild.	
Benefits of Option	Higher CQ-SQ southerly limit of ~1,750MW (and northerly limit) providing a smaller decrease from today's 2,100MW capacity limit (very small market cost). A modern double circuit transmission line. Fewer transmission towers. Less reduction in fault levels from current topology. Improved quality of supply. Less impact to size of capacitor banks (only Gin Gin capacitor banks impacted). Greater resilience to Wide Bay load increases.	
Drawbacks of Option	Higher initial cost. Introduces a high likelihood non-credible contingency event (loss of the double circuit). Risk of surplus capacity dependent on future generation (e.g. closure of Gladstone power station, new generation in Southern Queensland) and load development (e.g. Galilee, or low growth in Southern Queensland).	
Market Impact	Expected market impacts have been estimated at less than $1m p.a.	
Operational Flexibility	Reduction of load at risk during a single network outage. Longer outage windows available.	
Demand Scenario	25% headroom before reliability constraints comparable to current headroom of 30%.	
Critical Contingency	2 phase to ground fault on the Halys end of a Calvale – Halys 275kV circuit. Loss of Calliope River – Gin Gin 275kV.	
Network Limitation	Transient instability of central and north Queensland generators. Thermal overload of Calliope – Teebar Creek 275kV.	
Mitigation Measures		

7.5.5 Scenarios and sensitivities

Price sensitivity

Uncertainty currently exists around a number of inputs that can influence the economic assessment of the identified options. This uncertainty can be mitigated by assessing the options across a range of values.

Analysis was undertaken to compares the NPV of Option 1 to Option 2. Figure 7.12 below shows the variation of relative NPVs as a function of rebuild and refit costs. It utilises the differential of the relative NPV to identify the least cost option.

Figure 7.12: Graph of relative NPV for Option 1 and 2 with varying rebuild and refit costs

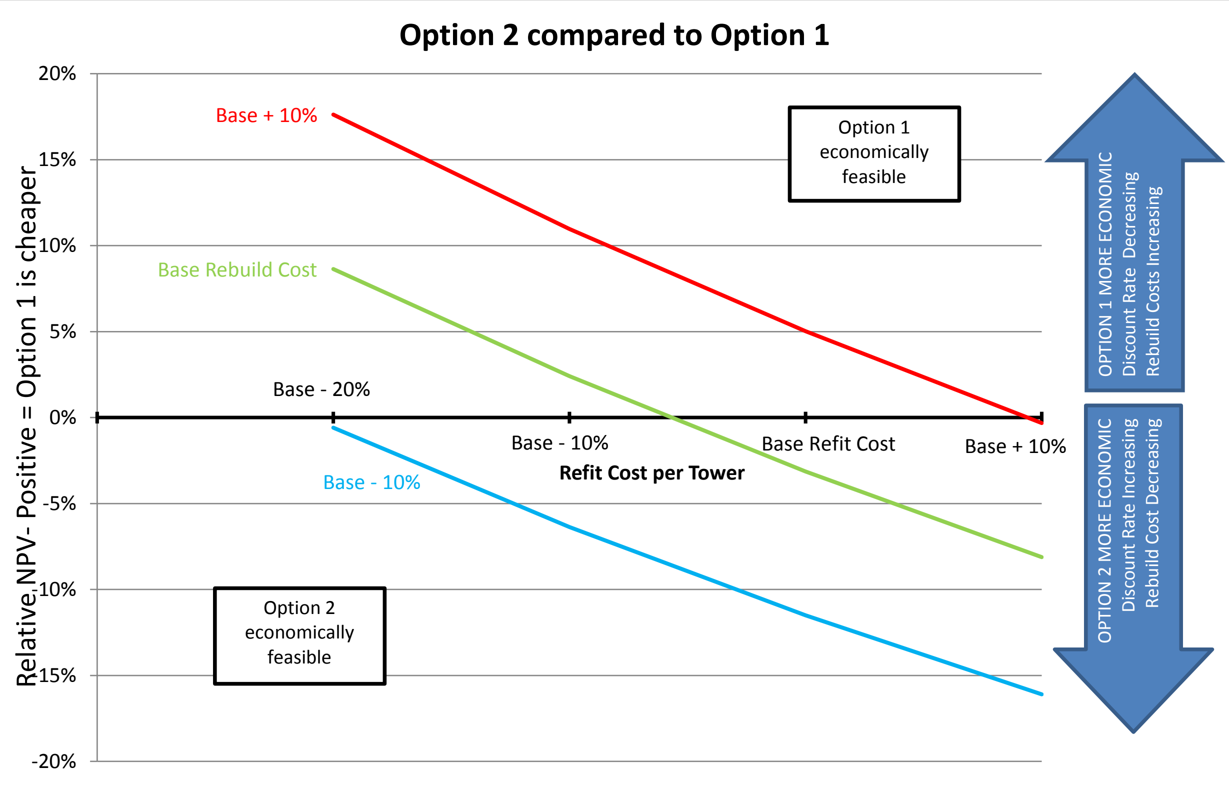


Figure 7.12 highlights more cost scenarios under Option 1 will become economically feasible as the discount rate decrease and rebuild costs increase. Conversely, Option 2 becomes more economic as the discount rate increase and the rebuild cost decrease.

At a minimum, the refit cost must be approximately 20% per tower lower than Powerlink's base cost for Option 1 to be the least cost alternative across all rebuild cost scenarios.

7.5.6 Short term outlook

In the short term, based on the prevailing asset condition and risks identified in Section 3.2, there are two potential strategies to manage the existing assets between South Pine, Woolooga and Palmwoods. Detailed condition assessments are scheduled for early 2016 to obtain more information to better understand the risk profile of these lines.

The first short term option will look to immediately decommission the 275kV transmission line between South Pine and Woolooga. This will have the impact of potentially constraining the market as a result of the lower CQ-SQ transfer capability and restrict operational flexibility and require network outages between Woolooga, South Pine and Palmwoods to be taken in the winter months. Savings may be realised through the reduction of maintenance on the transmission line.

The second short term option will manage the unacceptable risk profile of the existing assets between South Pine and Woolooga with increased levels of targeted maintenance. This maintenance will continue to align with the end of life of the 275kV Palmwoods to Woolooga transmission line. While not impacting the CQ-SQ transfer capability or NEM flows, additional costs will be incurred for the increased maintenance.

Economic analysis (across a range of values) has shown there is marginal difference between the two short terms options.

7.6 Conclusions

Taking into consideration the variability of future generation and load patterns, the economic net present value analysis of each of the two options is comparable. Given this, Option 2, utilising increased targeted maintenance is the preferred short term solution as it will permit greater operational flexibility and maintain transfer capability at little or no additional cost. It also has the benefit of offsetting a large amount of capital investment to provide time to better understand and formulate a strategy to address the prevailing market requirements.

This is consistent with the feedback provided by stakeholders in relation to the incremental approach to transmission investment. It has the benefit of reducing the risk of asset stranding (as more information on the generation and load profiles will be understood) and maintains the flexibility of adopting a range of future investment options.

The outcomes of the condition assessment and subsequent risk analysis will inform the expected end of life of these transmission lines. A RIT-T will then be required to determine the appropriate reinvestment is implemented. This may include ongoing maintenance, asset retirement, life refit (and extension) or rebuild.

Individual capital projects within this strategy will be subject to justification and approval at an appropriate time and are shown in Table 7.10.

Table 7.10: Proposed investment in the CQ-SQ Area (10 year outlook)

Project Number	Description	Indicative Timing
	Additional targeted maintenance on Woolooga-South Pine and Calliope River-Gin Gin circuits	2016-2020
CP.PROV	Woolooga - South Pine Modified Refit (1020)	2021
CP.PROV	Calliope River - Gin Gin Rebuild (First 15km) (1122)	2021
CP.PROV	Calliope River - Wurdong Tee (1125)	2021
CP.PROV	Gin Gin - Woolooga Modified Refit (1025)	2021
CP.PROV	Wurdong Tee - Gin Gin Rebuild (1124)	2023
CP.PROV	Woolooga - Palmwoods 275kV Rebuild (1048)	2024

8. TARONG

8.1 Introduction

8.1.1 Area plan overview

Following the commissioning of the 275kV network to supply the Surat Basin North West area, it is expected that the 132kV double circuit line between Tarong and Chinchilla is no longer critical to meet reliability obligations in this area. However, these circuits currently offer operational flexibility to manage potential fault level violations for the Tarong 275/66kV transformers. These transformers are expected to be at the end of their technical life in early to mid-2020s. Following the replacement or decommissioning of these transformers the fault level mitigation strategy would be no longer required.

The 132kV transmission corridor between Tarong, Chinchilla and Columboola substations offers the benefits of geographic diversity, operational flexibility and backup supply to the critical loads in the Surat Basin and local generation, and Ergon loads at Roma and Chinchilla. Powerlink has also received connection enquiries focused on connection to these 132kV transmission assets. It is recommended that until major reinvestment is required for its continued operation, that this 132kV transmission corridor remains in service to provide these benefits and to accommodate potential new loads and generation.

The Chinchilla Substation 132kV primary plant and Tarong 275/132kV transformers are expected to require major reinvestment in the 10 to 15 year outlook, when it is expected that these assets could be decommissioned. Chinchilla Substation could be reconfigured as a radial supply from Columboola via two transformer ended circuits with no 132kV bus.

Accordingly, over the 10 year outlook, Powerlink is currently giving consideration to all reinvestment and maintenance strategies that involve minimising expenditure associated with continued operation of the 132kV transmission corridor between Tarong and Chinchilla substations.

Reinvestment of Powerlink's existing assets in the Tarong area needs to collectively meet the existing network requirements and resilient to potential new loads and generation connections.

8.1.2 Description of existing network

[redacted] The substation is also the connection point for the Tarong and Tarong North base load coal fired power stations, and step down transformation point to supply local rural and mining loads.

The Tarong Substation was established in conjunction with the Tarong Power Station in 1982. The substation consists of one switchyard of 275kV operating voltage and one switchyard of 132kV and 66kV operating voltages. Powerlink owns the 275kV, 132kV and 66kV assets on site.

Initial development included two 275/66kV transformers and it was designed for an ultimate fault level of 31.5kA. In order to meet the growing demand in the Chinchilla area, transformer capacity at the station was augmented a few years later to include two 275/132kV transformers. Subsequent extension for the development of Tarong North Power Station and network augmentation to South East Queensland was carried out in the 1990s.

The 132kV and 66kV switchyards at Tarong Substation provide bulk supply for Ergon to the Kingaroy and Chinchilla areas in South West Queensland and auxiliary supply to the power stations. The switchyard is comprised of two 132kV feeder bays, six 66kV feeder bays, two 66kV transformer bays and 66kV bus section breaker.

Subsequent development at Tarong Substation, and more generally within the South West and Bulli zones, resulted in the fault levels on all busbars increasing above the original design parameters. This increased fault level (33.6kA at 275kV) has driven the replacement of primary plant items over the last decade due to infringement of plant ratings.

The 132kV system between Columboola, Chinchilla and Tarong substations and including the 132kV switchyard at Chinchilla and Columboola was transferred from Ergon to Powerlink on 1st July of 2012.

The Condamine and Roma gas fired power stations are also supplied via the 132kV transmission system through Chinchilla and Columboola substations.

Chinchilla Substation consists of one yard of 132/110/33kV operating voltage enclosed by the one perimeter fence. There is one control building and one communication building housing all Powerlink and Ergon facilities. Ergon have property rights and own the site and building infrastructure, including the panels that house the Powerlink owned secondary systems. The transformers are owned by Ergon and there is one 132/110kV 30MVA transformer supplying two 110/33kV 20MVA transformers, and a 60MVA 132/33kV transformer. Currently the load supplied by Chinchilla Substation is approximately 20MVA, with minor growth on the network.

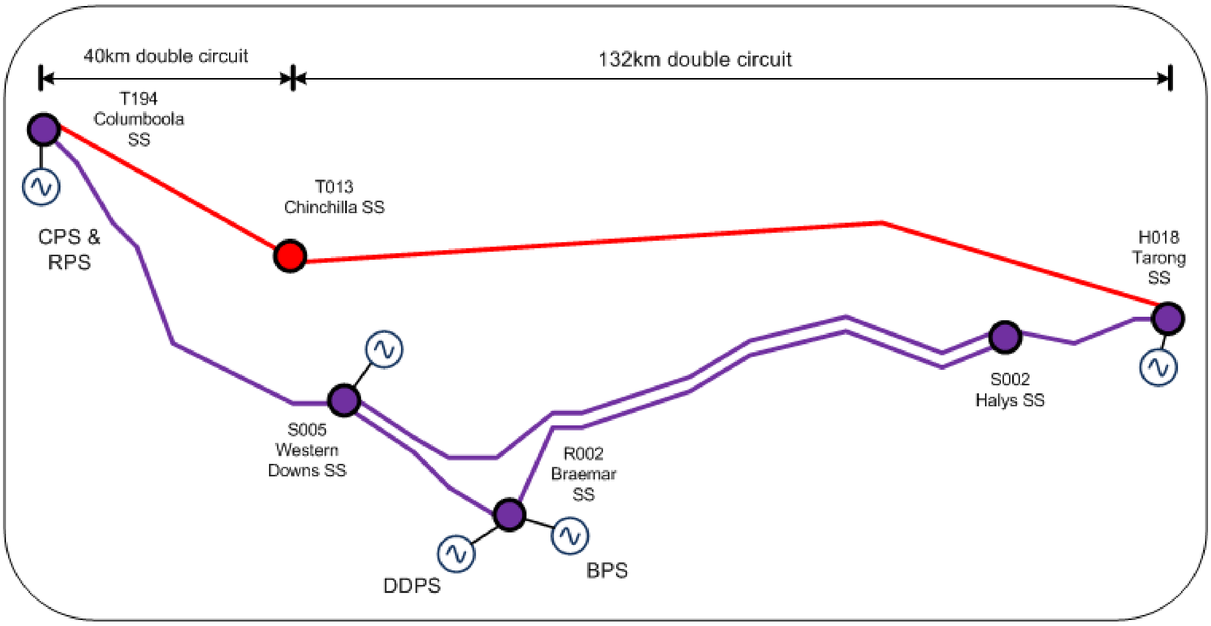
Chinchilla Substation consists of the following assets:

- 2 x 132kV bus bays (transferred to Powerlink from Ergon);
- 4 x 132kV feeder bays (transferred to Powerlink from Ergon);
- 110 and 33kV bays (Ergon assets); and
- The 132kV feeder 7183 and 7168 is connected with H018 Tarong while two 132kV feeders 7149 and 7350 are connected to T194 Columboola.

Columboola Substation has recently been upgraded to 275kV to meet the growing load requirements in the Surat Basin. This substation consists of a 275kV and 132kV switchyards and provides supply to Ergon's Roma Substation and provides the connection point for the Condamine power station.

The existing network configuration of the Tarong and Chinchilla area is shown in Figure 8.1.

Figure 8.1: Tarong area plan network configuration



8.2 Asset condition

The following sections summarise the condition of the transmission assets in the Tarong to Chinchilla area that have reinvestment requirements within the 10 year outlook.

8.2.1 Lines

Tarong to Chinchilla 132kV Transmission Line and Chinchilla to Columboola 132kV Transmission

The Tarong to Chinchilla double circuit transmission line (Feeders 7168 and 7183, built section 2412), and the Chinchilla to Columboola double circuit transmission line (Feeders 7349 and 7350, built section 2413), were constructed in 1986 and owned by Ergon. The transmission line is approximately 132km in length. A major insulator replacement project was completed in 2006 by Ergon, after a number of failures had been observed on this transmission line. Ownership including all easement and property rights was transferred to Powerlink in 2012. Works were completed to install additional hardware to allow live line replacement work in the future, replacement of the earth wire hardware, identification signs and tower earthing upgrades.

The transmission line is generally in good condition congruent with its age and geographic location. Within the 10 year outlook of the AMP, there are no expected major reinvestment works above normal maintenance.

8.2.2 Substations

Tarong 275/132/66kV switchyard

At Tarong Substation there are five 275kV bays associated with generation, 10 x 275kV bays connecting critical 275kV transmission lines, two 132kV feeders to Chinchilla and four 66kV bulk supply feeders to local loads.

Subsequent development at Tarong Substation, and more generally within the South West and Bulli zones, resulted in the fault levels on all busbars increasing above the original design parameters. This increased fault level has driven the replacement of primary plant items over the last decade due to infringement of plant ratings. As a result, the majority of the switchyard bays have been refurbished, and it is not expected that there will be any major reinvestment requirements at this site driven by primary plant condition in the 10 year outlook, with exception to the power transformers.

Transformer 1 90MVA 275/132/19.1kV

This transformer was constructed in 1986 and has normal and emergency cyclic loadings of 96 MVA and 105 MVA, respectively and 2 hour and 10 min are 118 and 135 MVA, respectively. It is designed to withstand 31.5 kA @1 s fault current. Historically mild oil overheating is detected in oil samples and it has tested positive for corrosive sulphur and been passivated. The expected technical and economic end of life of this transformer is around 10 years.

Transformer 2 90MVA 295/69/11kV

This transformer was constructed in 1982 and has normal and emergency cyclic loadings of 90 MVA and 111 MVA, respectively and 2 hour and 10 min are 130 and 135 MVA, respectively. It is designed to withstand 31.5 kA @1 s fault current. Historically mild oil overheating is detected in oil samples and it has tested positive for corrosive sulphur and been passivated. It has major oil leaks from the main tank lid, top header valve and radiators. Provided the issue with oil leaks are able to be addressed, it is expected to require reinvestment in the next five to 10 years.

Transformer 3 90 MVA 295/69/11 kV

This transformer was constructed in 1983 and has normal and emergency cyclic loadings of 90 MVA and 111 MVA, respectively and 2 hour and 10 min are 130 and 135 MVA, respectively. It is designed to withstand 31.5 kA @1 s fault current. Historically it has tested positive for corrosive sulphur and has been passivated.

This transformer has a significant oil leak causing oil pooling on the surrounding concrete, but there are a range of smaller leaks distributed over the transformer and cooler bank. There is corrosion resulting in loss of steel emerging under the base plate of the cooler bank ‘A’ frame structural supports. The other minor identified issues could be addressed during scheduled maintenance. Provided the issues surrounding the oil leak and corrosion can be addressed economically, it is expected to require reinvestment in the next five to 10 years.

Transformer 4 90 MVA 275/132/19.1 kV

This transformer was constructed in 1991 and has normal and emergency cyclic loadings of 99 MVA and 108 MVA, respectively and 2 hour and 10 min are 118 and 135 MVA, respectively. It is designed to withstand 31.5 kA @1 s fault current. Historically it has tested positive for corrosive sulphur and has been passivated. It was refurbished in 2002, but has since had an oil leak around bushing turrets detected in 2003.

As would be expected, this transformer being the youngest should appear to be in the best condition. As observed there are no major issues other than suffering from paint delamination off the main tank only. Provided this transformer is repainted, it is expected that it has a technical life beyond the 10 year outlook in this AMP.

Chinchilla 132kV Substation

Chinchilla Substation consists of one yard of 132/110/33kV operating voltage enclosed by the one perimeter fence. The 132kV system between Tarong and Columboola substations was transferred from Ergon to Powerlink on 1st July of 2012. The Chinchilla Substation was built in 1984 to provide supplies for mines and pastoral industries around Chinchilla. The original equipment is now 23 years old. There is one control building and one communication building housing all Powerlink and Ergon facilities that are both owned by Ergon. It is expected that any major reinvestment requirements at this site driven by primary plant condition will be beyond the 10 year outlook.

A condition assessment of the secondary systems identified that reinvestment or removal of the majority of equipment needs to be considered in the next five years to address condition and obsolescence risks related to these assets remaining in service. The main issue is the obsolescence of secondary systems equipment, in particular the bus protection, and THR and GE electro-mechanical relays have become obsolete, and the pending obsolescence of the control system. An assessment of the associated condition driven risks over the one to five year outlook is moderate increasing to significant. It is expected the original secondary systems equipment will need to be considered for reinvestment in the one to five year outlook.

8.3 Network requirements

Maximum power transfer of Tarong-Chinchilla 132kV Corridor

The post contingent thermal rating of the 132kV circuits over Columboola-Chinchilla-Tarong 132kV corridor is 84MVA per circuit, which is the maximum power transfer before load shedding may be required. The Chinchilla load is circa 25MVA and the power flow between Chinchilla and Tarong is voltage limited to 50MVA, after which load shedding may be required to maintain satisfactory voltages.

There are no emerging network limitations that would require augmentation to increase the transfer capacity into Tarong to Chinchilla 132kV transmission network in the 10 year outlook.

Maximum power transfer of Tarong transformers

There are no emerging network limitations that would require augmentation to increase the transfer capacity of the Tarong transformers in the 10 year outlook.

Fault levels

The 275/132kV and 275/66kV transformers (T1-T4) have a fault level design rating of 31.5kA. In Powerlink's 2015 TAPR the fault levels at the 275kV Tarong Substation bus are expected to exceed[1] the design rating of these transformers.

Fault level infringement issues are generally mitigated by applying either of the following measures:

- upgrade the plant to appropriate fault level rating; or
- reduce the fault level to within plant rating.

The 275/66kV transformers (T2 and T3) may infringe fault level design ratings when operated unparalleled (i.e. with the 66kV bus coupler open or with either transformer removed from service). This is generally the configuration during transformer or network maintenance, a faulted transformer etc. During normal parallel operation, fault current through each 275/66kV transformer is lower than design ratings for faults on the 66kV bus. With one 275/66kV transformer out-of-service the potential fault level violation of the in-service transformer may be addressed by opening the circuit breakers and back-feeding the 66kV bus from Chinchilla[2].

[1] 3 phase fault level – 32.8kA; single phase to ground fault level – 34.5kA
[2] Chinchilla is a significantly lower fault level source.

The 275/132kV transformers (T1 and T4) infringe fault level design ratings under normal operation and when one transformer is out-of-service. If F7168 and F7183 are in-service under normal system operation then the fault level violation may be addressed by paralleling / bridging the 132kV circuits between Tarong and Chinchilla substations.

Establishing this parallel / bridge on the 132kV circuits has the same effect as the 66kV bus has for the 275/66kV transformers. However, as for the 275/66kV transformers if one 275/132kV transformer is out-of-service the fault level violates the rating of the remaining in-service transformer. This fault level violation of the in-service transformer may be addressed, without impacting reliability of supply obligations, by removing this transformer from service.

In general, fault levels are expected to increase as networks expand and develop; however, declining growth or generator closures can lead to a reduction in fault levels. In 2012, Stanwell Corporation Limited (Stanwell) announced the temporary retirement of two of four 350MW generators connected at Tarong. The temporary closure of these two generator units resulted in fault levels reducing below the maximum fault level rating (31.5kA) of transformers. In 2014, Stanwell announced that both mothballed units would be returned to service around from 2015. However early 2015, Stanwell advised that the return to service of Unit 2 is postponed until at least 2016, depending on market conditions. Whilst this unit is offline, there are no expected fault level violations under the conditions described above.

In recent years, Powerlink has commissioned a new 275kV network to supply the Surat Basin North West area. This network extension consists of a 275kV double circuit line between Western Downs and Columboola substations and a 275kV double circuit line between Columboola and Wandoan South substations. Following the establishment of this network, reliability of supply to the Chinchilla load can be met solely from the 132kV double circuit line between Columboola and Chinchilla substations.

For the foreseeable load forecasts, no need has been identified that requires the Tarong to Chinchilla 132kV double circuit line (F7167 and F7183) to remain in-service for Powerlink to meet its reliability of supply obligations to the Surat Basin north west area.

In the longer term it is expected that the load at Chinchilla can be fed radially from the Columboola Substation via two transformer ended circuits, with no 132kV bus at Chinchilla Substation required.

8.3.1 Market and regulatory considerations

Generation

Tarong Power Station

The load supplied from the 66kV bus at Tarong is approximately 35MVA and consists of a mixture of Ergon Energy customer load, Pacific Coal, and Tarong Energy PS auxiliary supplies. [redacted]

[redacted]

[redacted]

8.4 Other considerations

8.4.1 Operational Telecommunications

In the Tarong area, Powerlink's telecommunications network assets consist of the following:

- OPGW;
- microwave communication links between Warra and Western Downs; and

- PLC communication between Tarong and Chinchilla and between Chinchilla and Columboola.

Legacy PLC systems have low capacity and are maintenance intensive. Powerlink's telecommunications asset management strategy has been, where practicable and cost effective, to migrate the telecommunications circuits off these legacy systems to higher capacity fibre network which is more secure and reliable. To facilitate this strategy and provide a second independent fibre optic link in the Tarong area, any new or rebuilt transmission lines should have OPGW installed as the earth wire and where practical earth wire replacement projects should include OPGW as the preferred overhead earth wire.

Tarong Area Specific

The PLC between Tarong and Chinchilla is provided by Fujitsu equipment. This equipment is obsolete and no longer supported; it is recommended that this PLC be considered for replacement with a modern equivalent as part of any rebuild works at these substations.

The microwave links between Warra and Western downs will be considered for replacement as part of a telecommunications project when they are due for reinvestment.

Tarong Area General

It is proposed that the following reinvestment be considered-

- the Operational Telephone Network will be replaced at all sites;
- DWDM equipment will be replaced at effected sites; and
- telecommunication services will be migrated to IP where effective to do so.

8.5 Investment outlook

The investment outlook for the Tarong area requires a broad consideration of the interaction between individual assets, their condition, network requirements and other factors.

8.5.1 Strategic investment strategy

Strategies for meeting both the asset end-of-life and future network requirements are required for the following assets that are expected to have reinvestment decisions in the 10 year outlook:

- 275/66kV and 275/132kV transformers at Tarong; and
- Chinchilla secondary systems.

This section will review a number of strategic themes that will meet the network asset requirements and approach economic analysis on a holistic basis to achieve the lowest investment outlook for the region.

The 132kV transmission corridor between Tarong, Chinchilla and Columboola substations offers the benefits of geographic diversity, operational flexibility and backup supply to the critical loads in the Surat Basin and local generation, and Ergon loads at Roma and Chinchilla. Powerlink has also received connection enquiries focused on connection to these 132kV transmission assets. It is recommended that until major reinvestment is required for its continued operation, that this 132kV transmission corridor remains in service to provide these benefits and to accommodate potential new loads and generation.

Table 8.1 shows the expected end of technical or economic life of the following assets associated with continued operation of the 132kV transmission corridor:

Table 8.1: Expected reinvestment outlook

Line	Asset ID	Commissioned Date	Indicative Reinvestment Timing
Tarong – Chinchilla	F7168 / F7183	1986	2030-2035
Chinchilla – Columboola	F7349 / F7350	1986	2030-2035
Chinchilla primary plant		1986	2025-2030
Tarong 275/132kV	T2 / T3	1986	2025-2030
Tarong 275/66kV (fault limits)	T1 / T4	1982	2020-2025

The Chinchilla Substation primary plant and Tarong 275/132kV transformers are expected to require reinvestment in the 10 to 15 year outlook. At end of technical or economic life it is expected that these assets could be decommissioned. Chinchilla Substation could be reconfigured as a radial supply from Columboola via two transformer ended circuits with no 132kV bus.

Accordingly, over the 10 year outlook, Powerlink is giving consideration to all reinvestment and maintenance strategies that involve minimising expenditure associated with continued operation of the 132kV transmission corridor.

A number of strategies for meeting both the asset end-of-life, and future network requirements, have been developed and analysed for the following assets that are expected to have reinvestment decisions in the 10 year outlook:

- 275/66kV and 275/132kV transformers at Tarong; and
- Chinchilla secondary systems.

Each strategy is discussed in turn below.

Transformers

Power transformers T1-T4 at Tarong Substation were identified to potentially be operating at fault levels above design rating. To address this issue, a project was raised to replace the 275/66kV transformers T2 and T3 with adequately rated units and to recover the 275/132kV transformers T1 and T4, once the 275kV committed augmentation between Western Downs and Columboola substations was completed in winter 2014.

However, this recommendation has been revisited for the following reasons:

- the two 275/66kV transformers at Tarong (T2, T3) are unique within the Queensland transmission system in terms of their voltage ratio. Purchase of new 275/66kV transformers would promote further investment in non-standard equipment;
- transformers T1 and T4 are not yet at end of technical or economic life; and
- the temporary reduction in the number of generator units at Tarong reduced fault levels to within transformer design ratings.

Whilst the existing 275/66kV transformers remain in-service, the 132kV double circuit line between Tarong and Chinchilla substations may be used to manage fault level violations arising when one of these transformers is out-of-service.

The 275/66kV transformers are approaching end of technical or economic life in 5 to 10 years and accordingly high level consideration is being given to the reinvestment strategy.

The high level strategies being assessed are as follows:

- Option 1 – Replace the 275/66kV transformers and decommission 275/132kV transformers;
- Option 2 – Install 132/66kV transformers, advance replacement of both 275/132kV transformers and decommission 275/66kV transformers; and
- Option 3 – Replace one 275/132kV transformer and both 275/66kV transformers.

Planning studies have shown that based on the existing load forecast, following the replacement of the 275/66kV transformers there has been no long term network requirement identified to retain this double circuit line between Tarong and Chinchilla substations to meet reliability of supply obligations. On this basis, it is considered likely that Option 1 is the preferred strategy.

Chinchilla Secondary Systems

The majority of secondary systems require reinvestment in the one to five year outlook. There is a continuing need for a 132kV Substation at Chinchilla to meet reliability of supply obligations. However, in the longer term it is expected that the load at Chinchilla could be fed radially from the Columboola Substation. This radial connection at Chinchilla Substation could be via two transformer ended circuits with no 132kV bus. Accordingly, Powerlink is currently giving consideration to secondary system replacement strategies that involve minimising expenditure on assets with no enduring need.

8.6 Conclusions

The Tarong Area Plan has been undertaken to examine a number of different strategies for managing the end of life of the existing network assets and future capacity requirements in the area over the 10 year outlook of the AMP.

The recommended reinvestment strategy for the Tarong Area over the next 10 year outlook is as follows:

One to Five years

- Columboola to Tarong 132kV transmission line as a source to back energise the 66kV bus at Tarong, be implemented to address the transformer fault rating issue Tarong Substation when the Tarong No.2 generating unit returns to service; and
- Full replacement of secondary system bays associated with Chinchilla to Columboola transmission lines and control system at Chinchilla substation, and selected relay replacements in the two secondary system bays associated with the feeders to Tarong.

Five to 10 years

- Replace two 275/66kV transformers at Tarong.
- Tarong secondary system replacement.

Beyond 10 years

- Decommission two 275/132kV transformers at Tarong.

Individual capital and operational projects within this strategy will be subject to justification and approval at an appropriate time and are shown in Table 8.2.

Table 8.2 – Proposed investment in the Tarong area (10 year outlook)

Project Number	Description	Indicative Timing
CP.02584	Tarong 275/66/11kV Transformers Replacement	2024
CP.02170	Chinchilla Secondary System Replacement	2018
CP.01999	Tarong Secondary Systems Replacement Stage 2 (H018)	2022

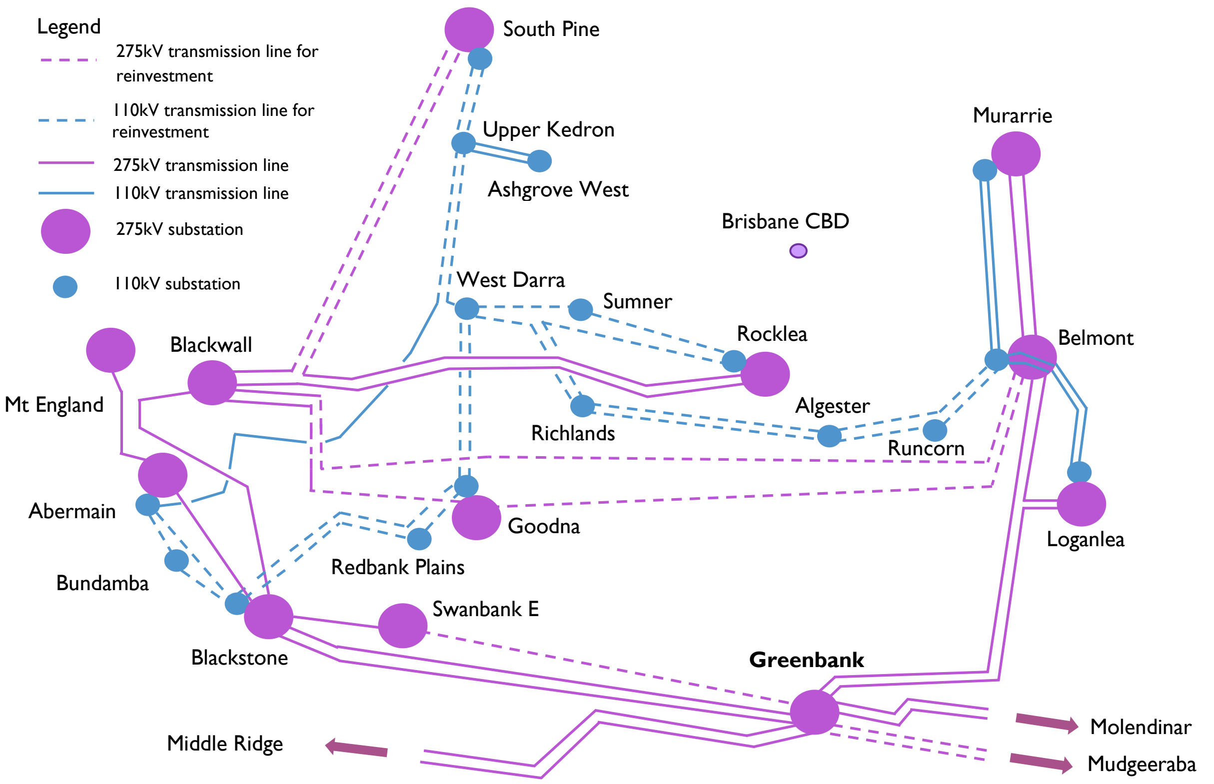
9. GREATER BRISBANE (METRO)

9.1 Introduction

9.1.1 Area plan overview

In the Greater Brisbane area, there are a number of 110kV and 275kV transmission lines constructed in the 1960s and 1970s (denoted in as dashed lines in Figure 9.1) that based on condition assessment are expected to reach the end of their technical or economic life over the period to the mid-2020s. In response to these assessments, Powerlink has been progressively investigating strategies to ensure the condition based risks related to these assets remaining in service are acceptable, including ongoing maintenance, asset retirement, life extension and rebuild. With the current subdued demand forecast outlook and extent of reinforcement of the 275kV network into the metropolitan area, there are a number of technically feasible scenarios for the retirement of certain transmission line assets within this area that have also been investigated as part of this area plan.

Figure 9.1: Transmission line assets requiring reinvestment in the10 year outlook



Over the outlook period of the AMP, there is also a requirement to consider reinvestment decisions related to a number of transformers, primary plant and secondary system installations within the Greater Brisbane area. The area plan focuses particularly on transformer site capacity required to meet the more subdued forecast demand growth anticipated in the future.

9.1.2 Description of network

In 1963, the Southern Electric Authority (a predecessor of Powerlink) developed the first 110kV double circuit steel lattice transmission line in south east Queensland between Bulimba and South Pine, providing the means for transmission of power generated from the 120MW Tennyson power station, to areas in south, south-west and north of Brisbane.

As demand increased in the Greater Brisbane area, the SEA identified the need to develop further generating assets, culminating in the commissioning of the Swanbank A Power Station in 1967. Further 110kV transmission line assets were commissioned in 1968 between Swanbank A - Abermain and Swanbank A – West Darra to reinforce supply into Ipswich and the metropolitan Brisbane area.

At this stage West Darra had become a significant hub for 110kV transmission and in 1971 additional 110kV transmission line assets were constructed between West Darra and Belmont to reinforce electricity supply into the south east and bayside suburbs of Brisbane.

The 480 MW Swanbank B Power Station was commissioned in 1971 and 275kV transmission lines commissioned between Swanbank and South Pine in 1971, followed by 275kV transmission lines between Swanbank and Belmont in 1972. The establishment of 275/110kV injection points at both locations by 1972 precipitated a rebalancing of flows on the 110kV power system and set the scene for progressive network developments that have reduced the reliance on the meshed 110kV network over time.

While South Pine and Belmont remain as significant 275kV injection points into the greater Brisbane area, Powerlink has in more recent times commissioned a number of new 275/110kV injection points that have reinforced the Greater Brisbane area and in turn further de-loaded the meshed 110kV network, including:

- Rocklea 1st Transformer 1993
- Rocklea 2nd Transformer 2001
- Goodna 1st Transformer 2006
- Murarrie 1st Transformer 2006
- Murarrie 2nd Transformer 2008
- Abermain Transformer 2009

With these developments completed, the Brisbane CBD is currently supplied by two 110kV rings, the Western ring and the Eastern ring. Powerlink's South Pine and Rocklea injection points are paralleled together through Energex's network to form the Western 110kV ring. Powerlink's Murarrie and Belmont injection points are paralleled together through Energex's network to form the Eastern 110kV ring.

9.2 Asset condition

The condition of 110kV and 275kV transmission lines in the Greater Brisbane area is of most significance to this area plan and is discussed in detail below. There are a number of additional reinvestment needs related to transformers, primary plant and secondary system installations in this area that are also within the outlook of the AMP.

9.2.1 Lines

110kV transmission

The 110kV meshed network in the Greater Brisbane area was progressively developed between 1963 and 1971.

The 110kV transmission lines in the Greater Brisbane area are subject to similar environmental and atmospheric conditions and have over time experienced structural degradation at similar rates, with the predicted end of life for most assets in the early to mid-2020s. Some assets have unique condition drivers and risks relating to the state of line components and hardware that need to be addressed in the medium term (either discretely or in conjunction with a larger scope of reinvestment works related to an asset) that will also influence the timing of reinvestment.

In total, there are approximately 265 original galvanised steel lattice structures in the 110kV transmission system in the Greater Brisbane area with a predicted end of life within the 10 year outlook of the AMP.

Given the relatively homogenous nature of 110kV line condition issues in the Greater Brisbane area, the priority and timing of reinvestment in these assets is substantially a function of the risks related to maintaining these assets in service over time (eg. extent of road crossings, proximity to residential and commercial areas and importance in supplying load into the future).

South Pine to Upper Kedron 110kV transmission line

The South Pine to Upper Kedron 110kV transmission line (Built Section 1000, feeders 721 and 722) was constructed in 1963 and consists of 33 original galvanised steel lattice towers and one concrete pole over a 12.5km route. The line is within 20kms of the coast and is reasonably protected from any prevailing coastal winds by virtue of its alignment through undulating forestry, semi-rural and residential areas.

Condition assessment has indicated that the transmission line is performing well when compared against corrosion modelling data, with 1% of structural members and 3% of tower bolts observed to have Grade 3 corrosion. The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The tower concrete foundations are in sound condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Specific components of the transmission line are exhibiting corrosion and will require replacement in the medium term, particularly the OHEW.

All line insulators were replaced in 2013, as well as all associated hardware on tension structures, and all suspension hardware showing levels of Grade 3 corrosion.

The conductors on this transmission line are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1000 is likely to exceed an acceptable risk profile and require investment in the next five to 10 years.

Upper Kedron to West Darra 110kV transmission line

The Upper Kedron to West Darra 110kV transmission line (Built Section 1036, 1037, feeder 776 and 7258) was constructed in 1963 and consists of 42 original galvanised steel lattice towers and one concrete pole over a 17.5km route. The line is within 30kms of the coast and is reasonably protected from any prevailing coastal winds by virtue of its alignment through undulating forestry, semi-rural and residential areas.

Condition assessment has indicated that the transmission line is performing well against modelled data, with 1% of structural members and 1% of tower bolts observed to have Grade 3 corrosion. The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The tower concrete foundations are in sound condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Specific components of the transmission line are exhibiting corrosion and will require replacement in the medium term, particularly the OHEW, line insulators and associated hardware, all of which are showing Grade 3 corrosion.

The conductors on this transmission line are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1036 and 1037 is likely to exceed an acceptable risk profile and require investment in the next five to 10 years.

Rocklea to Sumner to West Darra 110kV transmission line

The Rocklea to West Darra 110kV transmission line (Built Section 1038, 1039, feeders 707, 708, 709 and 7292) was constructed in 1963 and consists of 35 original galvanised steel lattice towers over a 10km route. The line is within 20kms of the coast and subject to higher levels of pollution related to the industrial and urban environment in which it operates.

Condition assessment has indicated that the transmission line is degrading in line with modelled data, with 2% of structural members and 10% of tower bolts observed to have Grade 3 corrosion. The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The tower concrete foundations are in sound condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Specific components of the transmission line are exhibiting corrosion and will require replacement in the medium term. The OHEW is subject to Grade 3 corrosion and is not appropriately rated to carry the level of fault current modelled under the current network configuration. Line insulation and hardware exhibit high levels of Grade 3 corrosion.

The conductors on this transmission line are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1038 is likely to exceed an acceptable risk profile and require investment in the next five to 10 years.

Belmont to Runcorn to Algester 110kV transmission lines

The Belmont to Runcorn to Algester 110kV transmission lines (Built Sections 1473, 1007, feeders 762, 749 and 7293) were constructed in 1971 and consist of 46 galvanised steel lattice towers and poles over a 12.2km route. The lines are within 20kms of the coast and subject to higher levels of pollution related to the industrial and urban environment in which it operates.

Condition assessment has indicated that the transmission lines are performing well against modelled data, with 1% of structural members and 3% of tower bolts observed to have Grade 3 corrosion. The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The tower concrete foundations are in sound condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Line insulation and hardware on the section of transmission line between Belmont and Runcorn is also exhibiting Grade 3 corrosion.

The conductors on this transmission line are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1007 and 1473 is likely to exceed an acceptable risk profile and require investment in the next five years.

Algester to Richlands 110kV transmission line

The Algester to Richlands 110kV transmission line (Built Section 1043, feeders 709 and 7294) was constructed in 1967, and consists of 30 double circuit steel lattice towers as well as 6 concrete and 4 steel poles, over a 7.79km length.

The line passes through southern suburbs of Brisbane, including residential developments, sports fields, sand extraction and light industry. The line is approximately 24km from the coast and is reasonably well protected from prevailing coastal winds; however it is exposed to constant wetting and drying cycles, and air borne pollutants from several major roads.

The condition assessment of the line shows that buried legs and leg corrosion at foundation interface level is a significant issue on several structures and further investigation will be required to determine the extent of the corrosion throughout the built section. In addition to this corrosion damage, a number of structures have bent members at the K point that were caused by impacts.

Cross arm, superstructure and body tower members are exhibiting some early evidence of Grade 2 corrosion, although none have yet suffered a total loss of their galvanised coatings.

Approximately 10% of the superstructure and cross arm tip nuts and bolts are displaying Grade 2 corrosion, based for the most part on their sheltered location on the structure.

The conductors are in sound condition and are considered to have at least another 25 years remaining life.

It is estimated that built section 1043 is likely exceed an acceptable risk profile and require investment in the next five years.

Richlands to Sumner Tee 110kV transmission lines

The Richlands to Sumner Tee 110kV transmission line (Built Section 1001, feeders 707 and 709) was constructed in 1967 and consists of 15 galvanised steel lattice towers route.

A transmission line refit is being carried out on the line, due for completion in 2016.

Swanbank A to West Darra 110kV transmission line

The 110kV transmission lines between Swan bank A, Redbank Plains, Goodna and West Darra (Built Sections 1004, 1474 and 1042, feeders 717, 718, 791, 7295 and 7296) were constructed in 1968 and consist of 61 original galvanised steel lattice structures over a 16.2km route. The lines are within 40kms of the coast and are reasonably protected from any prevailing coastal winds. The lines traverse a mix of industrial, urban and Brisbane River flood plain areas.

Condition assessment has indicated that the transmission lines are performing well when compared against corrosion modelling data, with 1% of structural members and 3% of tower bolts observed to have Grade 3 corrosion. The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The tower concrete foundations are in sound condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

The overhead earth-wire (OHEW) on these lines was replaced in 2006 and is in good condition; however, hardware providing for connection to the structure is exhibiting signs of Grade 2 and 3 corrosion and will need to be addressed in the medium term.

Line insulation and hardware is exhibiting Grade 3 corrosion. These issues are being addressed through operational refurbishment and as such the drivers on reinvestment for these assets are substantially linked to the extent of corrosion on structural members and tower bolts.

The conductors on these transmission lines are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built sections 1004, 1042 and 1473 are likely to exceed an acceptable risk profile and require investment in the next five to 10 years.

Swanbank A to Abermain 110kV transmission line

The 110kV transmission line between Swanbank and Abermain (Built Section 1003, feeders 715, 716 and 7324) was constructed in 1968 and consists of 48 original galvanised steel lattice structures over a 13.2km route. The line is within 40kms of the coast and is reasonably protected from any prevailing coastal winds. The line traverses a mix of industrial, urban and Brisbane River flood plain areas.

This line was the subject of major refurbishment works in 2005, providing for the replacement of line insulators, hardware and step bolts, in conjunction with the repair of corrosion at the tower leg/foundation interface. Original OHEWs were also replaced in 2000 and 2006.

Condition assessment has indicated that the transmission line is performing well when compared against corrosion modelling data, with 1% of structural members and 3% of tower bolts observed to have Grade 3 corrosion. The balance of structural components still retain some level of galvanising (Grade 2 corrosion) and are considered suitable for painting and life extension.

The conductors on this transmission line are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1003 is likely to exceed an acceptable risk profile and require investment in the next five to 10 years.

Table 9.1: Summary of 110kV transmission lines

Built Section	Built Section Name	Indicative Reinvestment Period (years)
1000	South Pine – Upper Kedron	5-10
1036 1037	West Darra – Upper Kedron	5-10
1039	Rocklea – Sumner	5-10
1038	Sumner – West Darra	5-10
1007	Belmont – Runcorn	0-5
1043 1473	Runcorn – Algester – Sumner Tee	0-5
1001	Sumner Tee – Richlands	0-5
1004 1474 1042	Swanbank A – West Darra	5-10
1003	Swanbank A - Abermain	5-10

275kV Transmission Lines

There are a number of 275kV transmission lines constructed in the early 1970s that underpinned the first stage of 275kV reinforcements into the Greater Brisbane area, bringing power from the newly commissioned 480MW Swanbank B power stations to newly established 275kV transmission nodes at South Pine and Belmont.

Blackstone to Bergins Hill 275kV Transmission Line

The 275kV transmission line between Blackstone to Bergins Hill (Built Section 1014, feeder 801 and 803) was constructed in 1971 and consists of 14 original galvanised steel lattice structures over a 4.8km route. The line is around 40km from the coast and traverses a mix of industrial and semi-rural areas, historically impacted by pollution from the operation of the Swanbank power station

Condition assessment has indicated that the transmission line is performing well against modelled data, with the majority of structural components retaining some level of galvanising (Grade 2 corrosion) and considered suitable for painting and life extension.

The tower concrete foundations are in good condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Specific components of the transmission line are exhibiting corrosion and will require replacement in the medium term. The OHEW and insulator hardware is subject to Grade 3 corrosion, while line insulation is showing advanced Grade 2 corrosion.

The conductors on this transmission line are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1014 is likely to exceed an acceptable risk profile and require investment in the next five to 10 years.

Bergins Hill to Goodna to Belmont 275kV transmission line

The 275kV transmission lines between Bergins Hill, Goodna and Belmont (Built Section 1015, 1067, 1068 and 1475, feeders 817, 8842 and 8826) were constructed in 1972 and consist of 105 original galvanised steel lattice structures over a 36.8km route. The lines are between 20 and 40kms of the coast and traverse a mix of industrial and urban areas, crossing the Gateway and Logan Motorways on 3 occasions each, with additional single crossings of the Lindsay and Centenary Highways.

Condition assessment has indicated that the transmission lines are performing well against modelled data, with the majority of structural components retaining some level of galvanising (Grade 2 corrosion) and considered suitable for painting and life extension.

The tower concrete foundations are in good condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Specific components of the transmission lines are exhibiting corrosion and will require replacement in the medium term. The OHEW and insulator hardware is subject to Grade 3 corrosion, while line insulation is showing advanced Grade 2 corrosion.

The conductors on this transmission line are in good condition and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1015, 1067, 1068 and 1475 will exceed an acceptable risk profile and require investment in the next five to 10 years.

Bergins Hill to Karana Downs 275kV transmission line

The 275kV transmission lines between Bergins Hill and Karana Downs (Built Section 1046, 1066, feeders 817 and 8819) were constructed in 1970 and consist of 17 original galvanised steel lattice structures over a 5.6km route. The line is approximately 40kms of the coast and traverses a mixture of urban and semi-rural areas. It also crosses the Bremer and Brisbane Rivers.

Condition assessment has indicated that the transmission lines are performing well against modelled data, with the majority of structural components retaining some level of galvanising (Grade 2 corrosion) and considered suitable for painting and life extension.

The tower concrete foundations are in good condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Specific components of the transmission line are exhibiting corrosion and will require replacement in the medium term. The OHEW and, conductor hardware and tension insulator hardware is subject to Grade 3 corrosion, while line insulation is in variable condition (Grade 1–3) given selective replacement of insulators over previous years.

The conductors on these transmission lines are in sound condition with a remaining service life of at least 25 years and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1046 and 1066 will exceed an acceptable risk profile and require investment in the next five to 10 years.

Karana Downs to South Pine 275kV transmission line

The 275kV transmission lines between Karana Downs and South Pine (Built Section 1047, feeders 838 and 809) was constructed in 1970 and consists of 80 original galvanised steel lattice structures over a 32.3km route. The line is between 10 and 40kms from the coast and is dominated by forest reserve and continual changes in elevation. At its lowest point (South Pine Substation) the line is only 20m above sea level but rises to 250m behind the Enoggera Reservoir.

Condition assessment has indicated that the transmission line is performing well against modelled data, with the majority of structural components retaining some level of galvanising (Grade 2 corrosion) and considered suitable for painting and life extension.

The tower concrete foundations are in good condition and show no significant signs of deterioration except for typical corrosion at the concrete - tower leg interface.

Specific components of the transmission line are exhibiting higher levels of corrosion and will require replacement in the medium term. The OHEW and, conductor hardware and tension insulator hardware is subject to Grade 3 corrosion, while line insulation is in variable condition (Grade 1 to 3) given selective replacement of insulators over previous years.

The conductors on this transmission line are in sound condition with a remaining service life of at least 25 years and are appropriately rated when considered against the current demand forecast.

It is estimated that built section 1047 will exceed an acceptable risk profile and require investment in the next five to 10 years.

Swanbank – Greenbank 275kV transmission line

The 275kV single circuit transmission lines between Swanbank E and Greenbank (Built Section 1466 and 1467) were constructed in 1974/5 and consist of 38 original galvanised steel lattice structures over an 18km route. The lines are 40kms from the coast and traverses industrial areas adjacent to the power station, forest reserves and dense urban development in the last five kilometre approach to Greenbank.

A more detailed condition assessment for this asset is yet to be undertaken given the predicted end of life timing is on the boundary of the outlook period of the AMP.

The predicted reinvestment period for this asset is 10-15 years.

Table 9.2: Summary of 275kV transmission lines.

Built Section	Built Section Name	Indicative Reinvestment Period - years
1014	Blackstone – Bergins Hill	5-10
1015 1067 1068 1475	Bergins Hill – Goodna - Belmont	5-10
1046 1066	Bergins Hill – Karana Downs	5-10
1047	Karana Downs – South Pine	5-10
1466 1467	Swanbank E - Greenbank	10-15

Additional assets reaching end of life

Within this area, there are also a range of other substation, secondary systems and UG cable assets with a predicted end of life within the outlook period of the AMP. The discussion presented within this area plan confirms an enduring need for the majority of these assets, with the exception of Belmont No.2 and No.3 275/110kV Transformers, and as such the condition driven risks of maintaining these assets in service will be considered on a case by case as part of future investment decisions.

275/110kV Transformation

Belmont No.2 and No.3 275/110kV transformer replacement

Underground Cables

Upper Kedron to Ashgrove West 110kV underground cable

Primary Plant

- Ashgrove West 110kV
- Loganlea 110kV
- Belmont No.2 and No.4 275/110kV transformer bays
- Redbank Plains 110kV

Secondary Systems

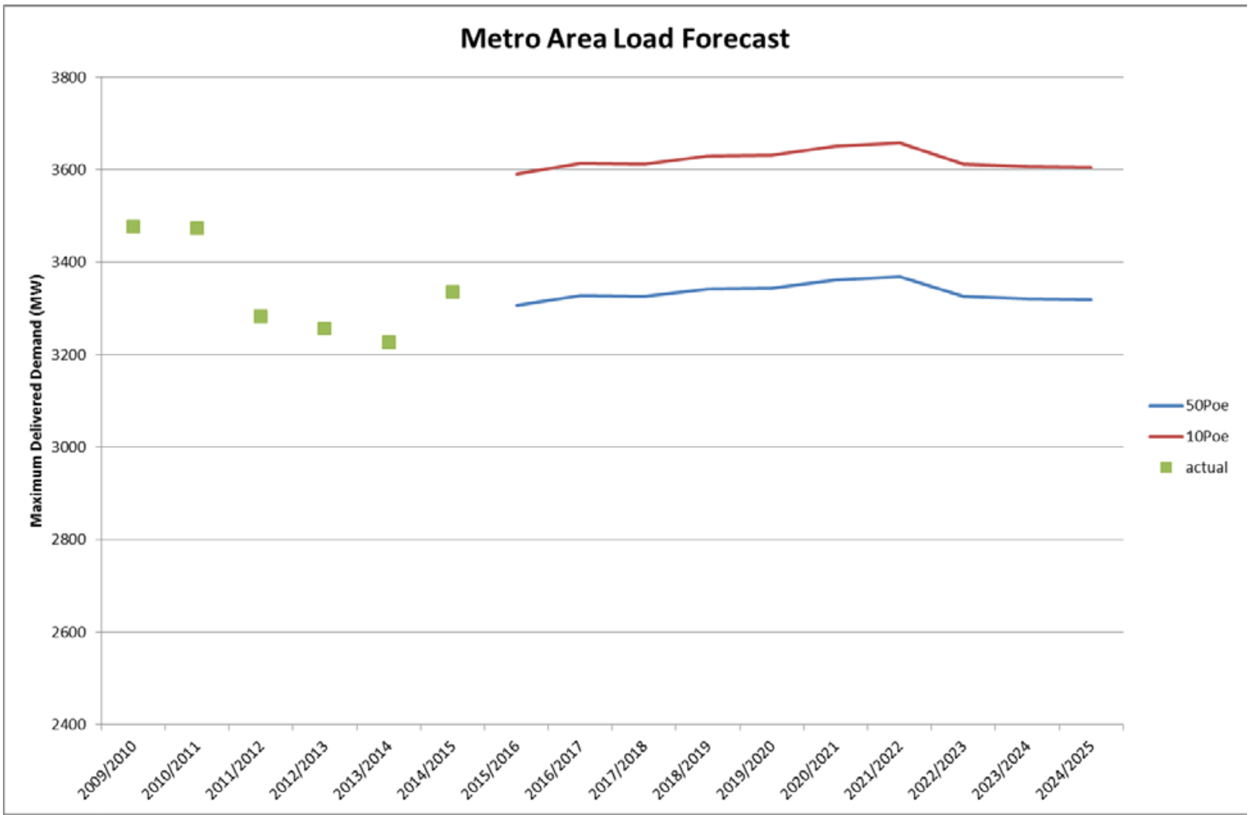
- Abermain Secondary Systems
- Belmont 275kV Secondary Systems

9.3 Network requirements

9.3.1 Demand and energy forecasts

The 2015 TAPR has forecast that the Demand and Energy for the Greater Brisbane area is relatively flat over the 10 year planning horizon. The 2015 TAPR demand and energy forecasts for the Greater Brisbane area are shown in Figure 9.2

Figure 9.2: Demand forecast – Greater Brisbane area



While there will be new customer loads connecting within the Greater Brisbane area during the 10 year planning horizon, from new residential, industrial and commercial buildings, no major additional loads are expected [redacted]

9.3.2 Load characteristics

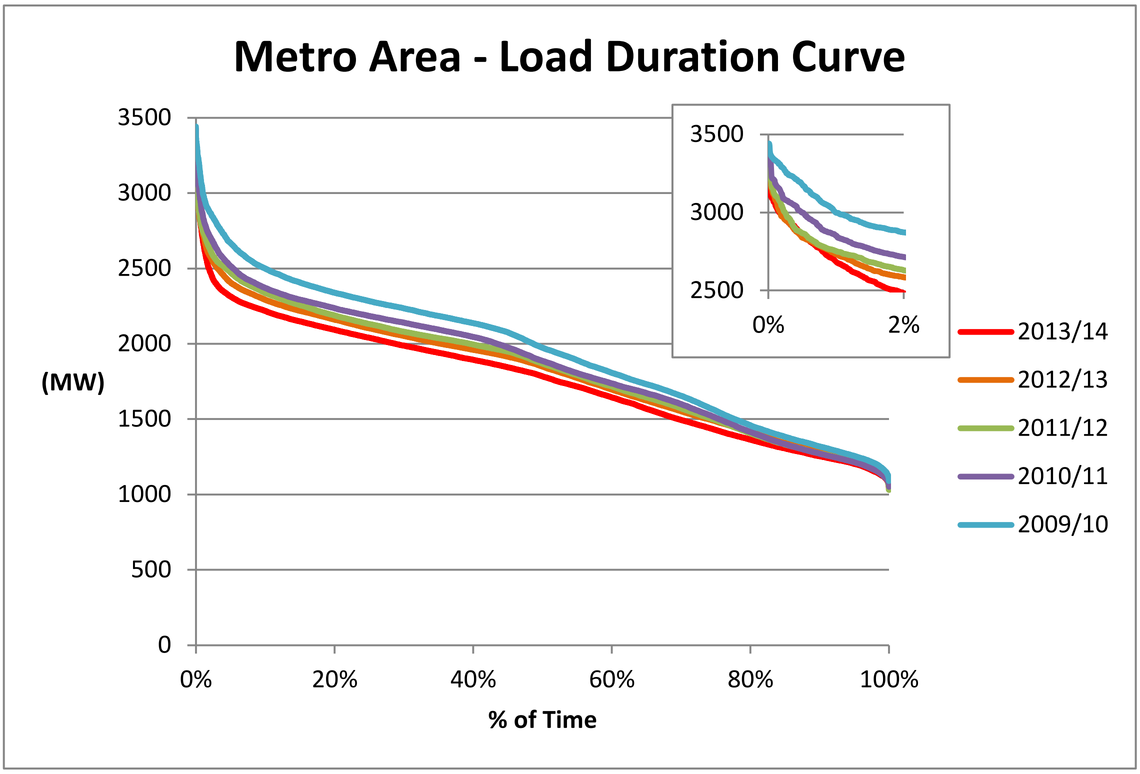
The Greater Brisbane area which includes the Brisbane CBD is predominantly made up of Residential and Commercial loads. However the Greater Brisbane area also includes the Brisbane airport and some industrial areas.

Load duration curves

The Load Duration curves for the past five fiscal years can be seen in Figure 9.3.

The Load Duration curves show that the Greater Brisbane area load has been dropping over the last five years. The general shape of the Load Duration Curve also shows the load is getting peakier in nature. This may lead to opportunities for non-network solutions should demand start to increase in the future.

Figure 9.3: Load duration curves by financial year



Reactive demand and compensation

Currently there are no reactive deficiencies within the Greater Brisbane area and as a result there are no plans for additional SVCs or capacitor banks within the 10 year planning horizon.

9.3.3 Generation development

Existing generation

Swanbank E Gas Power Station is the only existing scheduled generating unit in the Greater Brisbane area. The power station is owned by Stanwell Corporation Limited and has a capacity of 385MW (combined cycle gas turbine) using coal seam methane gas as fuel. Swanbank E was withdrawn from service from December 2014. Stanwell Corporation, however, has stated that Swanbank E PS will return to service once market conditions becomes more favourable.

Future generation enquires

Currently Powerlink does not have any generation connection enquiries within the Greater Brisbane area.

Embedded generation

There are a number of generators that are embedded within the distribution network - most of these generators are standby generators for CBD buildings and hospitals. The following is a list of the significant embedded generators that are expected to be generating on a peak summer day;

Generator	Connection Point	5 year rolling average
Ti Tree	Abermain 33 kV	2.1 MW
Bromelton	Loganlea 110 kV	18.7 MW
Stapyton	Loganlea 110 kV	0.9 MW
Rochedale LFG	Belmont 33 kV	3.9 MW
Browns Plains LFG	Loganlea 110 kV	1.6 MW
Wivehoe Small	Abermain 110 kV	3.9 MW
New Chum	Blackstone 110 kV	1.0 MW
Rocky Point	Loganlea 110 kV	25.3 MW
Total		57.4 MW

9.3.4 Existing network capability

Limitations on the meshed 110 and 275kV network within the Greater Brisbane area are associated with the thermal ratings of assets being exceeded under various critical contingencies. While the demand forecast for the Greater Brisbane area is relatively flat (refer to Section 3.1), the existing network can cope with additional load growth given how the network has developed over the last 40 years and recent changes to Powerlink's reliability standard. At higher loading, Powerlink's reliability standard is exceeded for the loss of a South Pine to Upper Kedron feeder causing the remaining South Pine to Upper Kedron feeder to exceed its emergency rating.

The existing 275kV network, with the possible exception of the Swanbank to Greenbank single circuit transmission lines (discussed in subsequent sections), is required into the future in order to support the forecast demand.

9.3.5 Forecast network capability

Total capability of existing network

Since load is largely flat in the 2015 TAPR 10PoE forecast, the total headroom capability of the Greater Brisbane network is forecast to remain flat over time. Powerlink's analysis has concluded there are no emerging network limitations that would require augmentation of the network in the 10 year outlook. The prospect of a reduction in demand in the Greater Brisbane area will also influence the reinvestment strategies adopted for transmission line assets.

There is also potential to further improve overall network capability through a range of operational measures being investigated through joint planning with Energex.

9.4 Other considerations

9.4.1 Telecommunications network

There is an extensive fibre optic network established in the Greater Brisbane area using Optical Fibre Ground Wire (OPGW) retrofitted to existing overhead transmission lines. The communications network diagram in Figure 9.6 illustrates how a significant portion of the existing meshed 110kV network includes OPGW. Analysis of options that involve retirement of 110kV assets includes the risks and costs associated with establishing new bearer networks and the relocation of the associated traffic.

Figure 9.6: Fibre optic bearer network – Greater Brisbane area

[redacted]

9.4.2 Easements

The long term strategic benefit of retaining and having access to easements in the Greater Brisbane area is a significant issue when considering options associated with reinvestment or retirement of 110 and 275kV transmission line assets.

Many of the 110kV transmission lines within the Greater Brisbane area traverse a mix of heavily populated semi-rural, residential and light industrial/commercial areas, with development up to and in some instances encroaching on existing easements. Easements widths are relatively narrow (up to 50 metres) and are typically highly constrained in terms of the opportunity to widen or undertake works in situ. Many transmission lines in this area are also subject to quite challenging ground access conditions and cross significant road, rail and motorway infrastructure.

Within this area there is also a risk that rights to existing easements (if not occupied due to the retirement of a transmission line asset) would be progressively eroded through continued urban development. Under circumstances where Powerlink needs to develop new infrastructure on an existing vacant easement, such developments would require quite complex and extended community infrastructure designation processes to obtain future works approvals.

The risks to retaining use of a vacant easement increase proportionally with increased uncertainty on future use and the period of time over which it is left vacant.

Taking into account the factors discussed above, in conjunction with the high degree of uncertainty regarding external factors influencing the future growth or otherwise of demand on Powerlink's network, there is significant merit in leaving existing transmission line assets on existing easements for as long as cost effective to do so.

9.4.3 Market and regulatory considerations

Non-network alternatives

Potential non-network solutions that will reduce load within the Greater Brisbane area may assist in further managing the risk related to a future decision that brings about selected retirement of 110kV network assets and a reduction in network capability that creates the potential for load shedding in accordance with Powerlink's reliability standard.

Non-network solutions may include:

- Broad based load aggregation schemes within the Greater Brisbane area and CBD, location depending on the nature of asset retirement;
- demand side management initiatives, in addition to that already assumed in the delivered demand forecast. This may include customers agreeing to voluntarily 'switch off' during a network contingency or operating embedded generation to manage short term rating exceedances of plant at peak periods. If this is the case, an automatic system would be required to interrupt power supply to participants in the program immediately following a contingency to prevent more widespread load shedding.

Powerlink's strategy over the next three to five years is to develop costings and viability of network and DSM alternatives through joint planning activities, subject to the extent of asset retirement pursued under this area plan.

External consultation

It is expected that any future investment recommendation that involves retirement of 275 and 110kV network assets and associated reduction in network capability in the Greater Brisbane area will require consultation with impacted parties, subject to the extent of impact on transmission network users exceeding materiality thresholds contemplated under the Rules.

At the 2015 Powerlink Transmission Forum held in July 2015, the Metro area was used as an example on delivering value through network optimisation. Feedback received at this forum is discussed later after exploration of the options presented at the forum.

9.5 Investment outlook

9.5.1 Description of options

The existing 110kV network of the Greater Brisbane area is shown in Figure 9.7. The Brisbane CBD is currently supplied by two 110kV rings, the Western ring and the Eastern ring. Powerlink's South Pine and Rocklea injection points are paralleled together through Energex's network to form the Western 110kV ring. Powerlink's Murarrie and Belmont injection points are paralleled together through Energex's network to form the Eastern 110kV ring.

With a significant number of 110 and 275kV transmission lines reaching end of life in the early to mid-2020s, there is an opportunity to consider options that involve retiring aged assets from service (noting that retiring an asset may involve demolition, or a reduced scope of works to disconnect the asset and make safe).

For the purposes of this area plan, a number of technically feasible options were studied to illustrate the effect of progressively retiring 110kV transmission line assets on network capability, while also considering the economic benefit and qualitative risks of doing so over time. These options were include:

- Retention and reinvestment in all 110kV transmission line assets
- Retirement of Richlands – Algester 110kV transmission line
- Retirement of Richlands – Algester and Upper Kedron – West Darra 110kV transmission line
- Retirement of Richlands – Algester, Upper Kedron – West Darra and Goodna – West Darra 110kV transmission line.

Network diagrams outlining each option above are illustrated in subsequent sections.

Other potential asset retirements

Planning studies have also confirmed that for all options noted above, there were additional opportunities to retire a number of other transmission assets within the Greater Brisbane area that can occur without further significantly reducing the capability of the network to withstand load growth in the future, particularly:

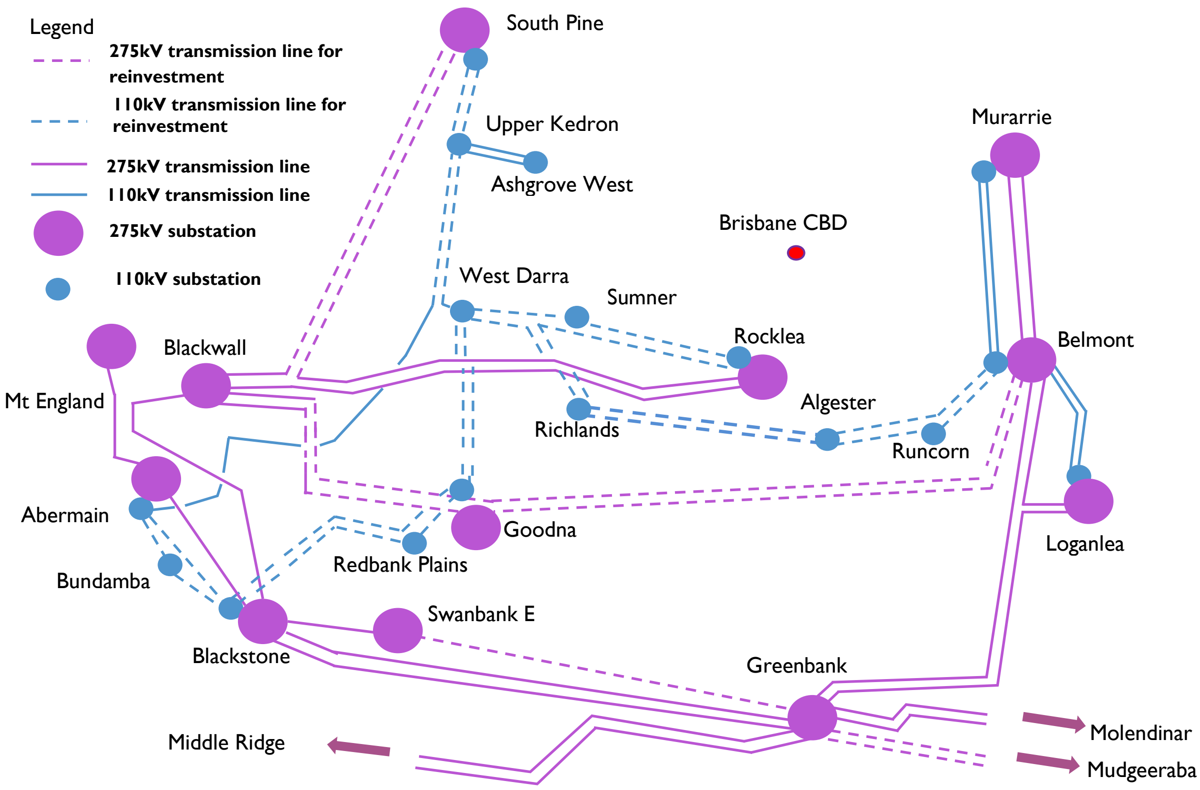
- No.2 and/or No.3 275/110kV transformer at Belmont;
- 275kV single circuit steel lattice transmission lines (currently paralleled) between Swanbank E and Greenbank;
- Partial 110kV transmission line sections between Belmont – Loganlea; and
- Partial 110kV transmission line sections between Tingalpa Tee and Murrarie;

Some assets identified in the planning study, such as the Belmont transformers and Swanbank E – Greenbank transmission lines, are the subject of a reinvestment decision in the 10 year outlook of the AMP and it has been assumed for planning purposes that these assets will be retired. Future and more detailed investment options analysis for these projects will consider and validate retirement as the preferred option.

9.5.2 Retention and reinvestment in all 275 and 110kV transmission line assets

The option presented in Figure 9.7 involves retaining and progressively reinvesting in all of the existing 110 and 275kV transmission line assets in the Greater Brisbane area through a strategy of structural upgrades, tower painting and full rebuild in the longer term.

Figure 9.7: Retention and reinvestment in all 275 and 110kV transmission line assets

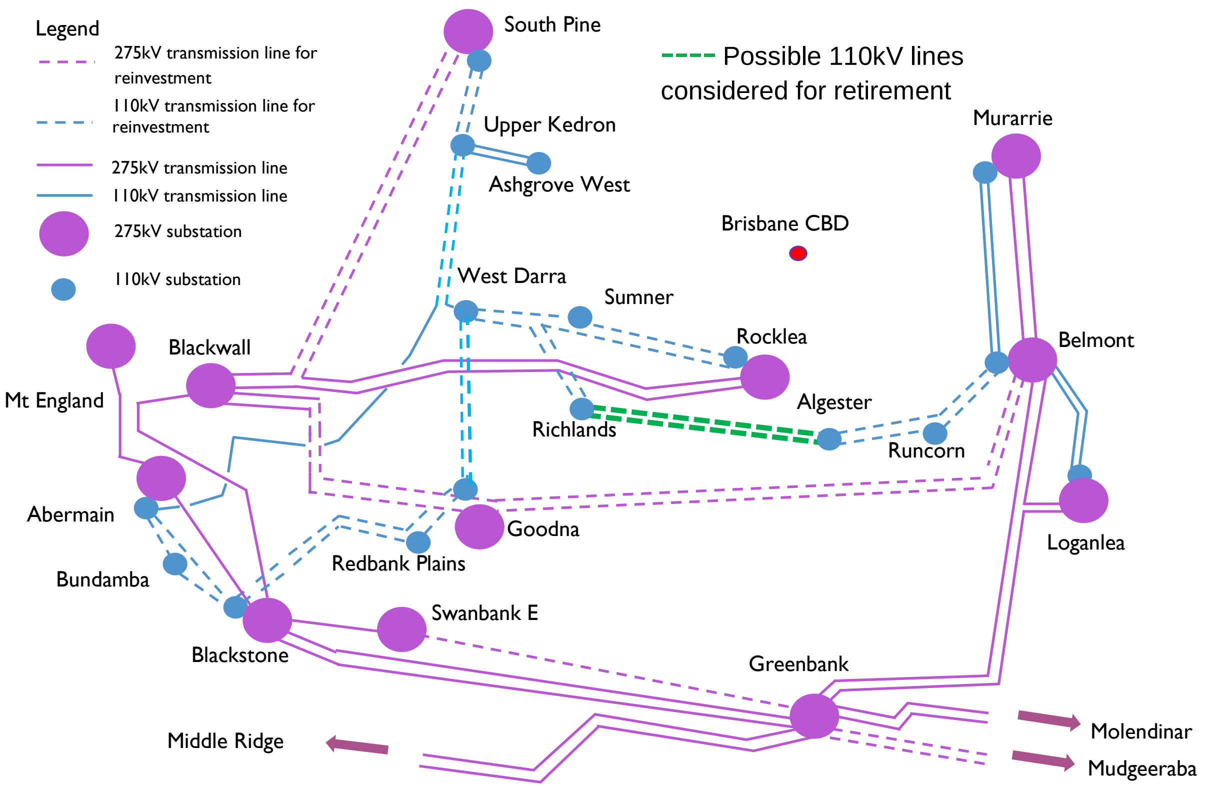


9.5.3 Retirement of Richlands – Algester 110kV transmission line

The option presented in Figure 9.8 involves retiring from service the 7.8km section of 110kV transmission line between Richlands and Algester and requires the existing OPGW on this transmission line to be rerouted (either direct buried on the existing easement or the establishment of alternative fibre optic bearers).

The balance of 110 and 275kV transmission line assets in the Greater Brisbane area are retained through a strategy of structural upgrades, tower painting and full rebuild in the longer term.

Figure 9.8: Retirement of Richlands – Algester 110kV transmission line

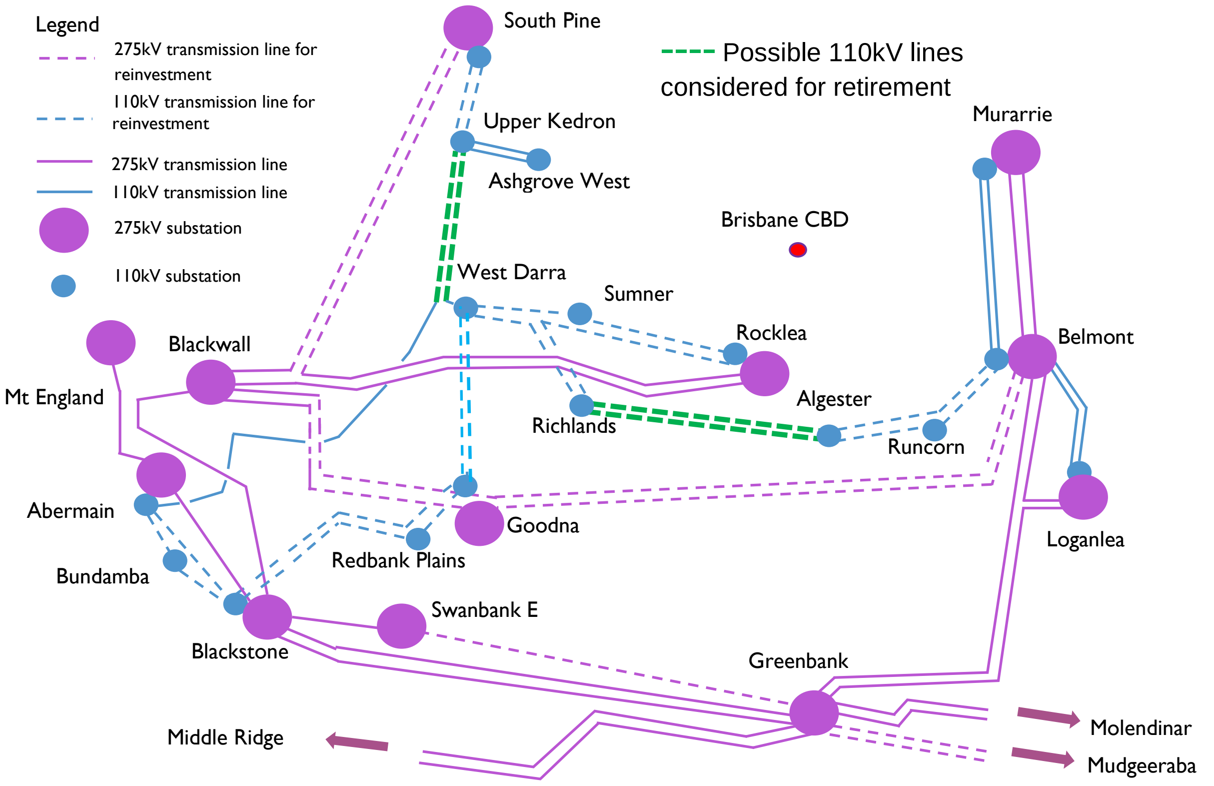


9.5.4 Retirement of Upper Kedron – West Darra and Richlands – Algester 110kV transmission lines

The option presented in Figure 9.9 involves retiring from service the 23.2km sections of 110kV transmission lines between Richlands – Algester and Upper Kedron – West Darra. Existing OPGW on the Richlands – Algester transmission line needs to be rerouted (either direct buried on the existing easement or the establishment of alternative fibre optic bearers).

The balance of 110 and 275kV transmission line assets in the Greater Brisbane area are retained through a strategy of structural upgrades, tower painting and full rebuild in the longer term.

Figure 9.9: Retirement of Upper Kedron – West Darra and Richlands Algester 110kV

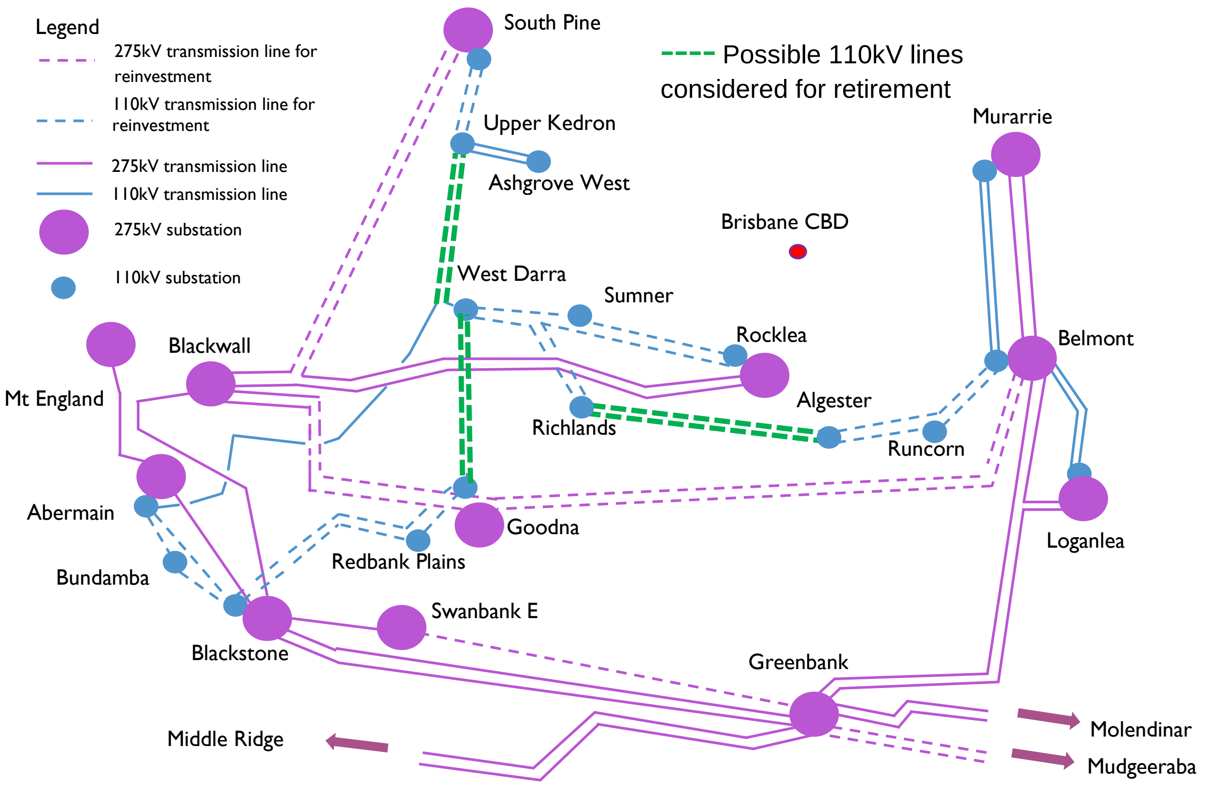


9.5.5 Retirement of Richlands – Algester, Upper Kedron – West Darra and Goodna – West Darra 110kV transmission line

The option presented in Figure 9.10 involves retiring from service the 31km sections of 110kV transmission line between Richlands – Algester, Upper Kedron – West Darra and Goodna – West Darra. The existing OPGW on Richlands – Algester and Goodna – West Darra is to be rerouted (either direct buried on the existing easement or the establishment of alternative fibre optic bearers).

The balance of 110 and 275kV transmission line assets in the Greater Brisbane area are retained through a strategy of structural upgrades, tower painting and full rebuild in the longer term.

Figure 9.10: Retirement of Richlands – Algester, Upper Kedron – West Darra and Goodna – West Darra 110kV



9.5.6 Summary of Options

Table 9.3 summarises technical, economic and qualitative factors relating to each option presented above. Three key observations to note in the comparison of options are:

- all options would comply with Powerlink's varied reliability standard. However, as more assets are retired, the current and future potential for load at risk in the Greater Brisbane area increases;
- options that involve retirement of transmission line assets result in a lower long run cost outcome under all load growth scenarios considered, with annualised demand growth needing to exceed 2% per annum to completely erode the long run cost benefits of retiring transmission line assets in accordance with the options presented; and
- under options that retire more than the Richlands – Algester 110kV line, the risks relating to the future use of easements made vacant through asset retirement and of a credible contingency causing load shedding needs to be considered.

Table 9.3: Summary of options

Greater Brisbane Option Analysis – Summary	Retain and reinvest in all assets (BASE CASE)	Retire Richlands-Algester 110kV	Retire Richlands – Algester and Upper Kedron West Darra	Retire Richlands - Algester, Upper Kedron – West Darra and Goodna-West Darra
Line length retired (km)	0	7.8	23.2	31
0% pa load growth scenario				
NPV for 0% load growth	$73.61M	$69.13M	$64.20M	$59.71M
% difference from Base case NPV		-6.1%	-12.8%	-18.9%
2%pa Load Growth Scenario				
NPV for 2% load growth	$75.72M	$71.24M	$71.09M	$70.12M
% difference from Base Case NPV		-6.0%	-6.0%	-7.0%
Qualitative Risks	Assessed in accordance with Corporate Risk Framework			
Future use of existing vacant easement constrained or infeasible Risk Category: • Financial/Contractual • Stakeholder	Low • All assets retained on existing easements.	Moderate • Limitations on supply of existing load triggered at +40% growth would be managed by operational measures and augmentation of South Pine – Upper Kedron 110kV transmission line. •	Significant • Limitations on supply of existing load triggered at +20% growth would be managed by operational measures and augmentation of South Pine – Upper Kedron 110kV transmission line •	Significant • Limitations on supply of existing load triggered at +10% growth would be managed by operational measures and augmentation of South Pine – Upper Kedron 110kV transmission line •
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]

Greater Brisbane Option Analysis – Summary	Retain and reinvest in all assets (BASE CASE)	Retire Richlands-Algester 110kV	Retire Richlands – Algester and Upper Kedron West Darra	Retire Richlands - Algester, Upper Kedron – West Darra and Goodna-West Darra
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]
	[redacted]	[redacted]	[redacted]	[redacted]
Further Context				
[redacted]	[redacted]			[redacted]

Greater Brisbane Option Analysis – Summary	Retain and reinvest in all assets (BASE CASE)	Retire Richlands-Algester 110kV	Retire Richlands – Algester and Upper Kedron West Darra	Retire Richlands - Algester, Upper Kedron – West Darra and Goodna-West Darra
				[redacted]

9.5.7 Powerlink 2015 Transmission Forum feedback

At the Forum, Powerlink presented the intact case and compared it to Option 3 of removing three circuits and sought feedback and input on three key themes:

Network Resilience

How should Powerlink take account of factors that have the potential to impact the resilience of our network in the future?

Strategic value of land

Is retaining access to easements to provide increased resilience to demand growth in the greater Brisbane area of value?

Stakeholder impact

How should Powerlink balance the lowest cost approach to retiring assets with factors such as landholder impacts, reputation and public safety?

Key feedback was as follows:

- With existing and forecast population growth Powerlink should be taking a longer term view when considering reduce network resilience, as growth will continue in Brisbane. Powerlink should also be mindful of the forecasting uncertainty.
- Many participants felt that Powerlink would lose the opportunity to use easements in the future if transmission lines were decommissioned or that the future costs and risks of obtaining access to these easements for construction would be prohibitive.
- Given the uncertainty in future demand growth, participants suggested that Powerlink apply low cost innovative maintenance techniques to keep the transmission lines going for a reasonable period. Future decommissioning remains a possibility once demand growth is better understood.

9.6 Conclusions

The Greater Brisbane area plan has been undertaken to examine a number of different strategies for managing the end of life of the existing network assets and future capacity requirements in the area over the 10 year outlook of the AMP. These strategies consider the condition based risks related to these assets remaining in service, geographic matters, asset criticality, and existing load and future network requirements.

The 110 and 275kV transmission lines in the Greater Brisbane area are subject to similar environmental and atmospheric conditions and have over time experienced structural degradation at similar rates, with the predicted end of life for most assets expected to occur between 2020 and 2025, correlating with structural refit and painting of those same assets being technically feasible between 2015 and 2020. It should also be noted that some assets have unique condition drivers and risks relating to the state of line components and hardware that need to be addressed in the medium term (either discretely or in conjunction with a larger scope of reinvestment works related to an asset) that will also influence the timing of reinvestment. The priority and timing of reinvestment in these assets proposed is substantially a function of risks related to maintaining these assets in service over time (eg. extent of road crossings, proximity to residential and commercial areas and importance in supplying load into the future) discussed in Section 4.2.1.

Planning studies have also been undertaken to examine the criticality of 110 and 275kV assets in the Greater Brisbane area. For the purposes of this area plan a number of options were studied to determine the effect of progressively retiring assets on network capability, while also considering the economic benefit and qualitative risks of doing so over time. A particular focus of the study involved options for retirement of 110 and 275kV transmission lines, the outcomes which are detailed in Section 4.5.6 and summarised below:

- All technically feasible options to retire 110kV transmission line assets would comply with Powerlink's varied reliability standard; however, as more assets are retired the current and future potential for load at risk in the Greater Brisbane area increases.

- Options that involve retirement of transmission line assets result in a lower long run cost outcome, with annualised demand growth needing to exceed 2% to completely erode the long run cost benefits of retiring transmission line assets in accordance with the options presented.
- Under options that retire more than the Richlands – Algester 110kV line, the risks relating to the future use of easements made vacant through asset retirement and of a credible contingency causing load shedding need to be considered.

Taking into account the discussion above, this area plan therefore supports a reinvestment strategy in the Greater Brisbane area based on the following approach:

- For those 110 and 275kV transmission line assets that have the potential to be retired, defer structural refit and painting, and retain the assets in service until the balance of higher priority transmission line reinvestment has been completed. This will enable Powerlink to monitor and re-evaluate the risks and uncertainty associated with demand forecast growth and the future requirement for use of easements identified in Section 4.5.6;
- For the balance of transmission line assets where there is high certainty of being required into the future, implement a program of structural refit and painting. In general, this is the most economic option to provide for an extension of life of a transmission line, noting that individual reinvestment decisions will identify and analyse a range of options and timings to validate this approach.
- Reinvest in the balance of primary plant and secondary systems in the Greater Brisbane area, with exception of both Belmont No.2 or No.3 transformers.

The recommended reinvestment strategy for the Greater Brisbane Area over the outlook is as follows:

Project Number	Description	Indicative Timing
CP.01653	Sumner Tee - Richlands 110kV Transmission Line	2016
CP.01654	Richlands - Runcorn 110kV Transmission Line	2017
CP.01655	Runcorn - Belmont 110kV Transmission Line	2017
CP.02508	West Darra - Sumner 110kV Transmission Line	2022
CP.02509	Rocklea - Sumner 110kV Transmission Line	2022
CP.02533	South Pine - Upper Kedron 110kV Transmission Line	2021
CP.01648	Swanbank-Redbank Plains- Goodna 110kV Transmission Line	2021
CP.02292	Blackstone-Abermain 110kV Transmission Line	2023
CP.02565	Karana Downs to South Pine 275kV Transmission Line	2025
CP.02532	Bergins Hill-Goodna-Belmont 275kV Transmission Line	2021
CP. PROV	Algester – Richlands 110kV Transmission Line	2022
CP.02189	West Darra - Upper Kedron 110kV Transmission Line	2022
CP.02355	Ashgrove West Primary Plant	2019
CP.PROV	Redbank Plains Primary Plant	2020
CP.01635	Abermain Secondary Systems	2020
CP.02319	Belmont 275kV Secondary Systems	2021

10. GOLD COAST

10.1 Introduction

10.1.1 Background

In the Gold Coast area many of the substation and line assets constructed in the 1970s and 1980s are approaching the end of technical or economic life in the 10 year outlook of the AMP.

Over the next one to five year outlook Mudgeeraba Substation No.2 275/110kV transformer and selected 110kV primary plant and secondary systems are reaching the end of technical or economic life.

Over the next five to 10 year outlook, the Mudgeeraba Substation No.3 275/110kV transformers, 275kV secondary systems, remaining 110kV primary plant and 110kV secondary systems are expected to reach the end of technical or economic life.

The Greenbank to Mudgeeraba 275kV single circuit transmission lines and the Mudgeeraba to Terranora 110kV double circuit transmission lines were constructed in the 1970s and it are estimated that under normal maintenance the structural components of these lines have approximately 10 years of technical life remaining. Powerlink's asset management strategy is to monitor the condition of these assets and investigate all line management strategies to ensure the condition based risks related to these assets remaining in service are acceptable. This includes strategies that provide for an extension of life through line refit works such as structural repairs, foundation enforcement works and replacement of line components and hardware. It is likely that these transmission lines will need to be considered for a line refit project within the 10 year outlook of the AMP to economically defer a major line rebuild.

Since this network was originally planned and constructed in the 1970s and 1980s, further developments have taken place to meet load growth, including a 275kV double circuit supply to Molendinar Substation, reinforcement of Energex's 110kV distribution network and establishment of the Directlink interconnector. This progressive reinforcement of the Gold Coast has the potential to impact on the reliance on historical individual assets to maintain Powerlink's supply reliability obligations. As these assets reach the end of technical or economic life their enduring requirement needs to be tested in the context of a more subdued demand growth outlook and changes in the service standards governing how Powerlink plans and operates the transmission network.

The Gold Coast Area Plan has been undertaken to examine a number of different strategies for managing the end of life of the existing network assets and future capacity requirements in the area. These strategies consider the condition based risks related to these assets remaining in service, geographic matters, asset criticality, and existing load and future network requirements.

10.1.2 Description of Existing Network

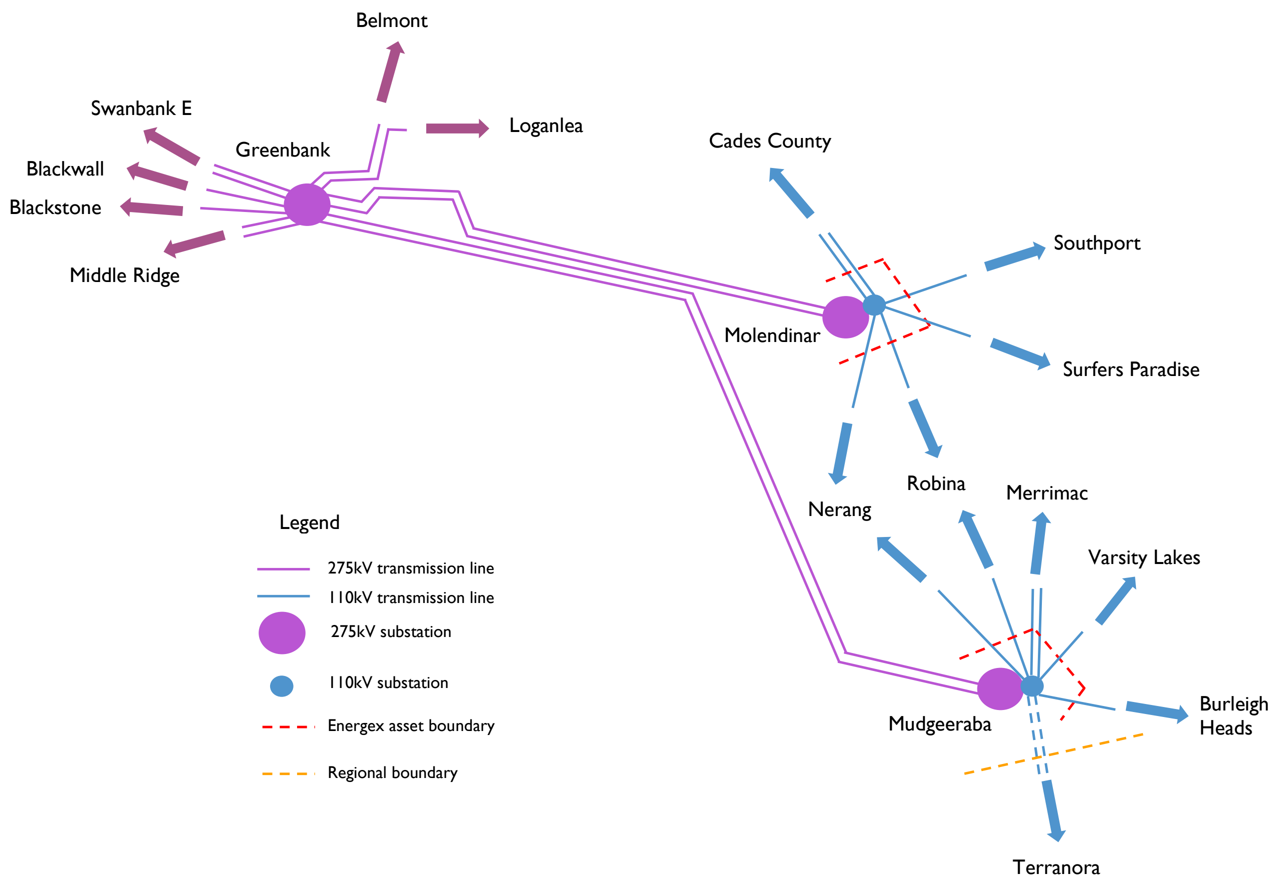
The Powerlink transmission system in the Gold Coast consists of a double circuit 275kV transmission line between Greenbank to Molendinar, and two single circuit 275kV transmission lines between Greenbank to Mudgeeraba substations. The Molendinar and Mudgeeraba substations are the major injection points into the area. Molendinar Substation is located within the northern end of the zone and Mudgeeraba Substation is located towards the southern end.

The Gold Coast electricity supply system is shown in Figure 10.1

The Mudgeeraba Substation is supplied from Greenbank Substation by two 275kV single circuit transmission lines. Initially these lines originated from Swanbank and were configured as transformer ended feeders through to 275kV circuit breakers. A 275kV fully switchable bus arrangement at Mudgeeraba Substation was established in 2001 with three 275/110kV power transformers (each having a normal rating of 250MVA).

The Molendinar Substation was established in 2003 and is supplied from Greenbank Substation by a 275kV double circuit transmission line. Initially these lines originated from Swanbank until the establishment of Greenbank Substation in 2006. There is currently no 275kV bus, with two 275/110kV transformers supplied transformer ended and each having a normal rating of approximately 420MVA.

Figure 10.1: Gold Coast Network



Prior to the 1970s, electricity supply to the Gold Coast was via 110kV lines from Beenleigh substation, located almost mid-way between Brisbane and the Gold Coast. The southern Gold Coast area was supplied via Molendinar and Burleigh substations with 33kV transmission lines. That network has been progressively reinforced by the establishment of the 275kV transmission system and major developments to date are shown in Table 1.1.

Other electricity network owners relevant to the supply of electricity to the Gold Coast Area comprise:

- Energex is the DNSP (Distribution Network Service Provider) who owns and operates the electricity distribution network in South-East Queensland, including the Gold Coast Area. This provides additional supply from Loganlea to Beenleigh, Coomera and Cades County substations. The 110kV network from Molendinar to Mudgeeraba links the coastal bulk supply points at Southport, Surfers Paradise and Broadbeach via an underground cable network. An inland overhead 110kV network supplies Robina and Nerang substations;
- Essential Energy (Distribution Network Service Provider) owns and operates the electricity distribution network in Northern NSW, up to the Queensland – NSW state border; and
- Directlink was approved as a regulated network service provider in late 2005, with the regional boundary changed to the Queensland and NSW border. The 180MW HVDC connector links the Essential Energy Lismore 132kV network to the Tweed 110kV system.

There are currently no committed or under construction transmission or distribution projects within the Gold Coast area.

Table 10.1: Development of the Transmission System in the Gold Coast Area

Period	Substations	Lines
1971	Mudgeeraba 110kV Substation establishment – six 110kV bays associated with a bus coupler, Beenleigh (1), Burleigh (2) and Terranora (2)	
Mid 1970s	Mudgeeraba 1st (No.2) 275/110kV 200MVA Transformer Mudgeeraba 2nd (No.3) 275/110kV 200MVA Transformer	Swanbank-Mudgeeraba 275kV Single Circuit Transmission Lines (approx. 65.2km) Mudgeeraba to Terranora border 110kV Transmission Line (approx. 13.1km)
1980s	Mudgeeraba 110kV Feeder bays 779, 780, 794 Mudgeeraba No.1 110kV 50MVAr capacitor	
1990s	Mudgeeraba 3rd (No.1) 275/110kV 250MVA Transformer Mudgeeraba No.2 and No.3 110kV 50MVAr capacitor	
2001	Mudgeeraba 275kV Bus Establishment Mudgeeraba 110kV Feeder bay Varsity Lakes	
2002	Mudgeeraba No.1 275kV 120MVAr capacitor bank	
2003	Molendinar No.1 275/110kV 375MVA transformer	Maudsland tee – Molendinar 275kV DCST transmission line (approx.18.2km)
2006	Greenbank 275kV Establishment Molendinar No.2 275/110kV 375MVA transformer	Greenbank to Maudsland tee 275kV DCST transmission line (approx. 39km)
2007	No.4 Mudgeeraba 110/33kV transformer	

10.2 Asset Condition

The following sections summarise the condition of the transmission assets in the Gold Coast area.

10.2.1 Lines

275kV Transmission

The Greenbank to Mudgeeraba 275kV single circuit transmission lines (Built section 1018 and 1019 Feeders 835/836) were commissioned in December 1974 and January 1975. These lines are approximately 65km in length and each consist of 162 original galvanized steel lattice towers and 3 concrete poles.

The Greenbank and Mudgeeraba substations are located approximately 40km and 8km respectively from the coast. It can be expected that the southern end of the line has been subjected to higher rates of corrosion due to the prevailing salt laden coastal winds. The lines operate in a metropolitan/semi-coastal environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components.

The condition assessment conducted in 2011 and a high level summary of the identified line condition is provided as follows:

- The galvanised tower members and fixings have started to lose their protective coating consistent with expected corrosion modelling. Nuts and bolts experiencing moderate corrosion (Grade 2 and 3).

- The conductors are in good condition, and show no significant signs of deterioration. It is estimated the conductor has another 20 years remaining life.

- The earthwire and hardware are in generally good condition, and show no significant signs of deterioration.

- The insulator string hardware in general has lost some of their protective coating, and instances of minor metal loss have been observed. There are some cases of eroded insulator and earthwire hardware, as well as deteriorating insulator pins that will require action in the short term.

- The foundations are in generally good condition, and show no significant signs of deterioration.

The transmission lines traverse built up residential and commercial areas, and there are a number of major and minor road crossings.

The condition assessment confirmed that these transmission lines are currently tracking to a standard rate of corrosion and it can be expected that the condition of these lines will exceed an acceptable risk profile and require major reinvestment in approximately 10 years.

Within the 10 year outlook of the AMP it is likely these transmission line assets will require selective insulator replacements and need to be considered for increased maintenance or line refit to prevent further deterioration of the underlying steel components to economically defer a major line rebuild.

110kV Transmission

The Mudgeeraba to Terranora double circuit transmission line (built section 1009) was originally commissioned in May 1976. The section of line owned by Powerlink consists of 33 structures and is 13.11km in length. The line operates in a metropolitan/semi-coastal environment exposing the line to moderate rates of atmospheric pollution, impacting on the life of its galvanised components. The transmission line is located between 6 and 12 kilometres from the coast and is therefore subject to prevailing salt laden coastal winds.

The condition assessment conducted in 2010 and a high level summary of the identified line condition is provided as follows:

- The galvanised tower members and fixings have started to lose their protective coating consistent with the estimated end of life. Nuts and bolts experiencing moderate corrosion (Grade 2 and 3).

- The conductors are in good condition, and show no significant signs of deterioration. It is estimated the conductor has another 20 years remaining life.

- The earthwire and hardware are in generally good condition, and show no significant signs of deterioration.

- All insulator and earthwire hardware, as well as deteriorating insulator pins will require action in the short term.

- The foundations are in generally good condition, and show no significant signs of deterioration.

The transmission lines traverse built up residential and commercial areas, and there are a number of major and minor road crossings.

The condition assessment confirmed these transmission lines are currently tracking to a standard rate of corrosion and it can be expected that the condition of these lines will exceed an acceptable risk profile and require major reinvestment in approximately 10 years.

Within the 10 year outlook of the AMP it is likely that these transmission line assets will require selective insulator replacements and need to be considered for increased maintenance or line refit to prevent further deterioration of the underlying steel component to economically defer a major line rebuild.

Previous property investigations have identified encroachments along the easement from Mudgeeraba to the NSW border, and that line replacement on the existing easement is not viable. Other alternatives would involve underground construction on a new easement. It is considered likely that if the connection between Mudgeeraba and NSW border is required, continued operation of BS1009 through increased maintenance or line refit will be economic.

10.2.2 Substations

Molendinar Substation

Molendinar 110kV switchyard was rebuilt in 2003 and the high voltage equipment is in relatively good condition. It is not expected that there will be any major capital reinvestment requirements at this site driven by primary plant or secondary systems condition in the 10 year outlook.

There are two 275/110kV 375MVA transformers and three 110/33kV 100MVA transformers. All transformers have just past the infant stage of their service lives and are in good condition.

Mudgeeraba 275kV Switchyard

The 275kV switchyard and associated secondary systems at Mudgeeraba Substation were partially established in 1992 and expanded again in 2002 with the establishment of the 275kV bus.

Based on the condition monitoring data it is not expected that the condition of primary plant and structures would require significant capital reinvestment in the 10 year outlook.

Mudgeeraba 275kV Secondary Systems

A condition assessment of the secondary systems conducted in 2014 identified that reinvestment or removal of the majority of equipment is required in the 10 year outlook to address condition and obsolescence risks related to these assets remaining in service.

A high level summary of the identified secondary systems condition and risks are provided in Table 10.2.

Table 10.2: High level summary of the identified secondary systems condition and risks

		Indicative timing (years)
Feeder protection	The majority of transformer protection relays were installed in 2000 to 2005 and failure rates are increasing. Manufacturer support has ceased and spares are projected to be consumed within three to five years.	5-10
Bus protection	The electro-mechanical bus zone protection relay 1 Bus Y (DAD3) has been in service for more 24 years. Manufacturer support has ceased and there are no spares. In the event of failure of the relay, replacement will require major logic modification and wiring circuitry modification. The remaining bus zone protection relays were installed in 2002.	5-10 DAD3 – 0-5
Transformer protection	The majority of transformer protection relays were installed in 2000 and failure rates are increasing. Manufacturer support has ceased and spares are projected to be consumed within three to five years.	0-5
275kV Capacitor Bank	This protection panel was installed in 2002 on a swing frame panel. The relays have manufacturer support and spares are available. The relays are providing reliable service.	5-10
Other asset risks	Corridor construction type panels - These panels are of construction with separate protection and auxiliary panels. This type of construction is vulnerable to human error on causing protection system operation when maintenance is conducted and it is also expensive to modify because of the inter panel wiring.	

An assessment of the associated condition driven risks for the 275kV secondary systems over the next three to five year outlook is moderate. At this stage it is expected the condition driven risks will exceed an acceptable risk profile requiring decommissioning or replacement in the five to 10 year outlook.

Mudgeeraba 110kV Switchyard

A program of primary plant replacement occurred at Mudgeeraba 110kV Substation in 2006. The scope involved the upgrade of 110kV circuit breakers and other switchgear in order to address critical fault rating and continuous current rating limitations. Selected primary plant was replaced using the existing structures and foundations. The majority of the primary plant replaced being from the original installation in the 1970s.

A condition assessment of Mudgeeraba 110kV switchyard was completed in 2014. It identified emerging condition and obsolescence issues, which if not addressed, will present an increasing related risk for continued operation of these assets. A high level overview of potential condition driven timings for the bay, or selected elements within the bay, is shown in Table 10.3.

Table 10.3: High level overview of potential condition driven timings for the bay, or selected elements within the bay

Bay Description	Indicative timing (years)
110kV 3 Capacitor Bay	0-5
110kV 1 Capacitor Bay	0-5
110kV 3-4 Bus Coupler Bay	0-5
706 Nerang 110kV Bay	0-5
779 Feeder Bay	0-5
780 Feeder Bay	0-5
Spare 110kV Bay	5-10
110kV 1 Transformer Bay	5-10
110kV 2-4 Bus Section Bay	5-10
110kV 3 Transformer Bay	5-10
754 Feeder Bay	5-10
110kV 1 Bus	5-10
110kV 2 Bus	5-10
110kV 3 Bus	5-10
110kV 4 Bus	5-10
275kV 2 Transformer Bay	10-15
275kV 3 Transformer Bay	10-15
110kV 2 Capacitor Bay	10-15
755 Feeder Bay	10-15
758 Feeder Bay	10-15
757 Feeder Bay	10-15

The site condition assessment identified condition issues for a number of assets that will need to be addressed over the next one to five years.

110kV Secondary systems

A condition assessment of the secondary systems conducted in 2014 identified that reinvestment or removal of the majority of equipment is required in the 10 year outlook to address condition and obsolescence risks related to these assets remaining in service.

A high level summary of the identified secondary systems condition and risks is provided in Table 10.4.

Table 10.4: High level summary of the identified secondary systems condition and risks

		Indicative timing (years)
Control	Local control and OPSWAN are suffering from no or limited manufacturer support and limited spares and increased failure rates in line with equipment age. A virtualized solution is being developed to replace this obsolete Sun Workstation equipment throughout the state.	0-5
Feeder protection	Feeders 706, 754, 755, 757 and 758 Pilot wire relays have experienced reliability issues and manufacturers have ceased to provide technical support and supply. There are only limited system spares for these relays and it will be expected these spares will be consumed in three years. Replacement with a modern relay will require major logic and wiring modification resulting in a longer outage window.	0-5
	Feeders 779, 780, 794, 7838, 7839 Majority of equipment was installed in the late 2000's. Its condition has been assessed as fair, manufacturer support and spares are also available.	5-10
Bus protection	Majority of protection devices were installed in 1992 have become obsolete, limited spares and experiencing high failure rates. The master-check design is not fully redundant (non-compliance with current NER). Failure of the check scheme will cause all bus zone protection schemes to block and to clear a bus fault will rely on remote end distance protection with slow clearance time (non-compliance with current NER) resulting in the entire 110kV bus being switched out. Replacement with a modern relay will require major logic and wiring modification resulting in longer outage window.	0-5
Transformer protection	Majority of protection devices were installed in the early 2000s have become obsolete, limited spares and experiencing high failure rates. Manufacturer support has ceased and spares are projected to be consumed within three to five years.	0-5
110kV Capacitor Bank	Majority of protection devices were installed in mid to late 1990s have become obsolete, limited spares and experiencing high failure rates.	0-5
Other asset risks	DC Supply Circuitry - All 110kV protection and control are supplied by "X" DC system. Failure of X DC supply will result in increased risk of loss of all protection and control functions on all 110kV systems. Corridor construction type panels - These panels are of construction with separate protection and auxiliary panels. This type of construction is vulnerable to human error on causing protection system operation when maintenance is conducted and it is also expensive to modify because of the inter panel wiring.	

An assessment of the associated condition driven risks for the 110kV secondary systems over the next one to five year outlook is moderate increasing to significant. At this stage the condition driven risks associated with original secondary systems equipment is expected to exceed an acceptable risk profile requiring decommissioning or replacement in one to five years.

The overall condition of the remaining 110kV secondary systems equipment (approximately 50% of total equipment) at Mudgeeraba has been assessed as fair. The majority of this equipment was installed during expansion of the site in the 2000s and is relatively new with replacement to be considered towards the end of the 10 year outlook.

No.2 and No.3 275/110kV 250MVA Transformers

No.2 and No.3 275/110kV transformers at Mudgeeraba were manufactured in 1974. These transformers were built as 160/200 MVA ONAN/OFDAN units and uprated to 250 MVA with the installation of fans some years ago. The condition of these transformers is routinely assessed to assist with determining the appropriate strategies for maintenance, refurbishment and replacement.

No.2 Transformer has all the original oil paper impregnated bushings. This transformer was the subject of a diverter switch refurbishment in 2005 and a midlife refurbishment project in 2006. These projects were to ensure that a reliable service life of 40 years could be achieved.

No.3 Transformer was refurbished in 2002. The diverter switch was refurbished in 2005 and a midlife refurbishment project was completed in 2006. These projects were to ensure that a reliable service life of 40 years could be achieved.

A condition assessment was conducted in 2014 and a high level summary of the identified condition and risks is shown in Table 10.5.

Table 10.5: High level summary of the identified condition and risks

Insulation	The history of oil test results indicate aged paper insulation. This may be caused by high temperatures due to the heavy loads it was subjected prior to the installation of fans and the third transformer.
Oil Quality and Tap Changer	The oil was filtered as part of the midlife refurbishment project in 2006. However, the oil is again contaminated, likely due to inadequate sealing between tap changer and main tank.
Clamping	The internal inspection in 2006 indicated that the transformer core and winding assemblies appeared secure. However, the winding clamping arrangement with the screwed clamping pads represents an inherent design concern, in that sufficient axial winding pressure may not be maintained throughout the life of the transformer to withstand short circuit forces. This would need to be routinely manually adjusted to maintain the design pressure on the windings and compensate for insulation shrinkage of winding insulation. Such adjustments require removal of oil and de-tanking off site.
Bushings	The electrical test results conducted in 2013 for No.2 Transformer indicated that DLA measurements for all primary high voltage bushings are outside acceptable limits for bushings of this type, and should be considered for replacement.
External Inspection	An external inspection of the transformers identified a number of condition issues including areas of paintwork deterioration and corrosion, presence of oil leaks, and crazing of the outer sheath of control cabling. Firewalls have structural issues and cracks.

Due to collective consideration of the condition issues, and the related risk of the No.2 transformer remaining in service, continued operation beyond the five year outlook is not recommended. The associated risks solely related to No.2 transformer are higher than No.3 transformer based on the poorer oil quality, higher furan age and accelerated aged deterioration of paper insulation, and operational issues with the tap changer. The No.2 transformer has all original oil impregnated bushings with the likelihood of one of these failing much higher than for bushings on No. 3 transformer which has only one original OIP bushing (all others are synthetic and had been replaced previously).

Due to collective consideration of the condition issues, and the related risk of the No.3 transformer remaining in service, continued operation beyond five to 10 years is not recommended. The additional years in service can be achieved with minor civil repairs and is based on the assessment that the aged condition of No.3 transformer is slightly healthier than No.2 transformer due to the sound condition of the bushings, lower furan age, and lower levels of accelerated corrosion and oil leaks.

10.3 Network Requirements

10.3.1 Demand and Energy forecast

The demand for electricity in the Gold Coast is highest during summer. The maximum demand in winter can still exceed 90% of the summer maximum demand. Figure 10.2 shows the per unitised daily load profile for the peak load days from 2008/9 to 2013/14. Over these five years the maximum demand occurred during mid to late afternoon. Some reduction in day-time demand has been observed as a consequence of PV installations, but this is unlikely to materially impact the 18:00 peak demand. The effect of growing PV penetration can be observed in the load duration curve in Figure 10.3. The plot demonstrates that over time, the load during the day has reduced. However, at peak times the load has not changed. Likewise, during overnight periods when the load is lowest, there is no significant change.

Figure 10.2: Load profile on top five days of maximum demand

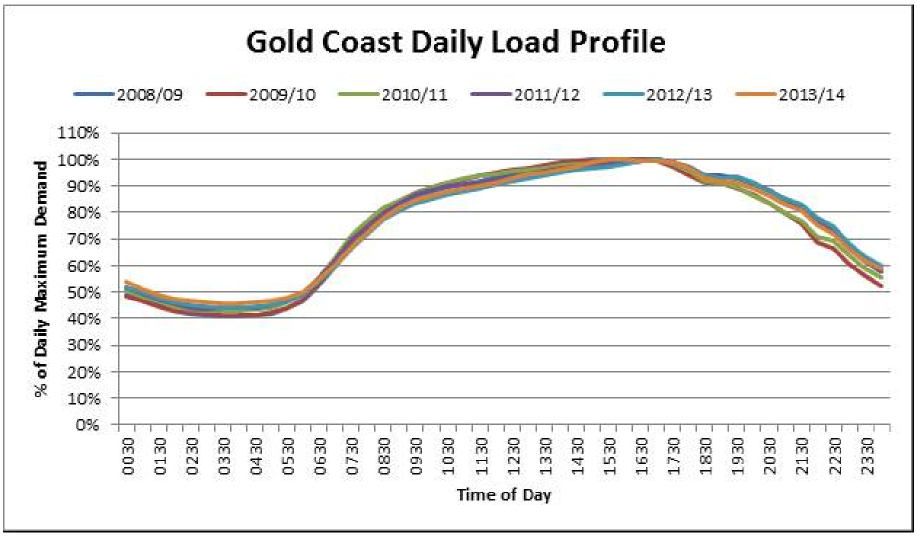
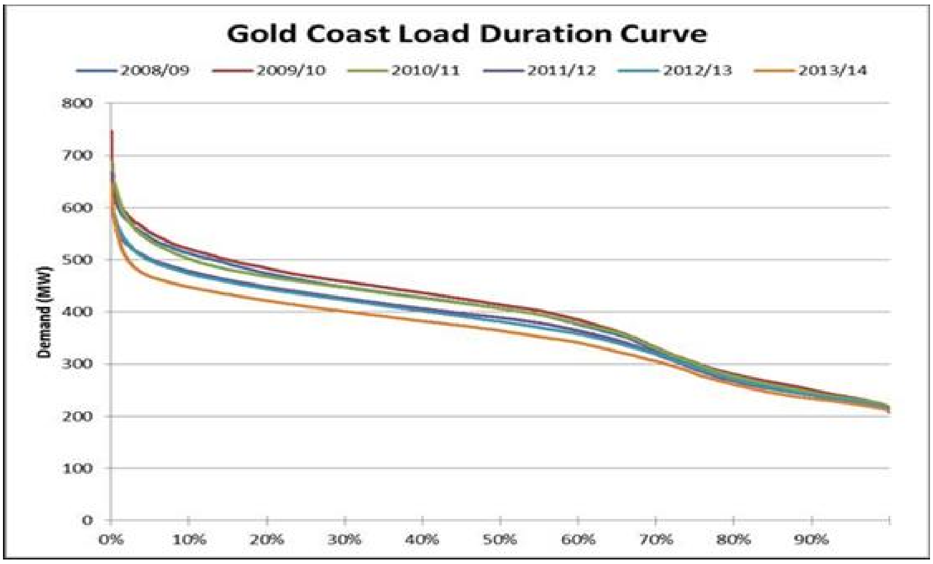
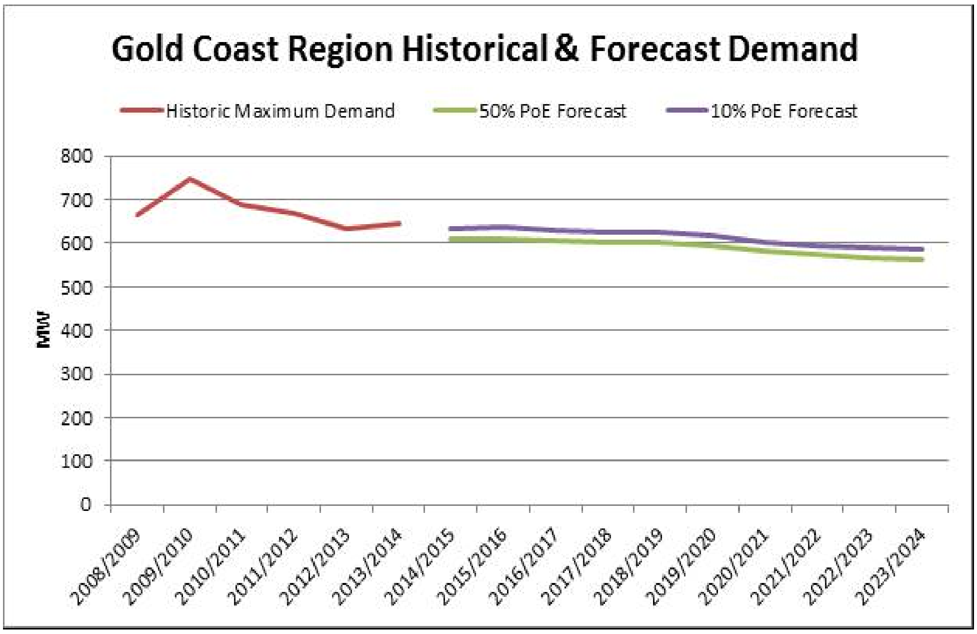


Figure 10.3: Load duration curve (summer)



The historical maximum demand and Powerlink's forecast of future maximum demand in the Gold Coast zone is shown in Figure 10.4.

Figure 10.4: Maximum demand forecast



10.3.2 Load Characteristics

Electrical load in the Gold Coast is characterised by:

- commercial (tourist based) loads located in Broadbeach, Surfers Paradise, Southport, Burleigh Heads, Tallebudgera, Palm Beach, Currumbin, Tugun, Bilinga, Kirra, Coolangatta;
- urban residential loads located in Burleigh Heads, Tallebudgera, North Palm Beach, Palm Beach, Elanora, Currumbin, Currumbin Waters, Tugun, Bilinga, Kirra, Coolangatta; and
- rural residential loads located in Bonogin and Tallebudgera Valley.

10.3.3 Generation Development

There are no committed new generators in the Gold Coast area.

Under certain electricity market conditions, the privately-owned "Directlink" may deliver power into the Gold Coast area from New South Wales. The power from Directlink is transferred from the Essential Energy 110/66/33kV substation at Terranora to Mudgeeraba via two 110kV transmission circuits. Importing power into Queensland across Directlink reduces the Terranora load that must otherwise be supplied from the Mudgeeraba 275/110kV Transformers.

In recent years, flow on the Terranora interconnector has been affected by disruptions to Directlink. In August 2012 a fire resulted in one 60MW converter being removed from operation and it has only recently been returned to service. The remaining two converter stations were taken offline in late 2013 whilst precautionary repairs were conducted. They returned to service late 2014.

10.3.4 Existing Network Capability

Maximum power transfer to the Gold Coast is set by voltage stability associated with the loss of Swanbank E generating unit west of Brisbane, an outage of a Greenbank to Molendinar 275kV circuit (and associated 275/110kV transformer), or an outage of a Greenbank to Mudgeeraba 275kV circuit.

The Gold Coast 275kV and 110kV existing network has sufficient capacity under a single contingency to supply actual and forecast load levels (2014/15 Gold Coast 10% PoE load – the "base case"). The firm capability of the 275kV lines into the Gold Coast zone is assessed to be approximately 1200MW.

10.3.5 Forecasted Network Requirements

Demand scenarios

The central forecast for demand on the Gold Coast transmission system is based on the 2014 TAPR forecast. Three demand scenarios have been considered as follows:

- 2014 TAPR 10% PoE forecast (flat);
- Demand growing at 1% per annum; and
- Demand growing at 3% per annum.

Demand for the 2014 TAPR 10% PoE and the 1% low growth scenario trend at a lower rate than the forecast population growth in SEQ. These scenarios are aligned with government policies that suppress electricity demand growth and increase roof-top PV installations.

The 3% load growth scenario is considered to be an upper limit for load growth within the Gold Coast zone and is based on the following possible factors that could lead to the higher growth scenario:

- Increase in tourism, high density living or migration to the coast
- High uptake of electrical vehicles
- Reduction in the uptake of roof-top PV installations or energy efficiency initiatives.

It should be noted that the 2014 Energex 50% PoE forecast had a starting point 50MW higher than the Powerlink 2014 TAPR 10% PoE forecast.

Total transfer capacity of existing network

Since load reduces slightly in the 2014 TAPR 10% PoE forecast, the spare capacity in the firm power transfer capability will increase accordingly over time. This is shown in Figure 10.5. The starting headroom is approximately 500MW based on the amended planning standard. It can be seen that under all demand scenarios (with Directlink out-of-service) there are no emerging network limitations that would require augmentation to increase the transfer capacity into the Gold Coast in the 10 year outlook.

Transfer capacity of Greenbank to Mudgeeraba 275kV circuits

Under the 2014 10% PoE TAPR forecast the Greenbank to Mudgeeraba lines have capacity without any power transfer on Directlink (as described above).

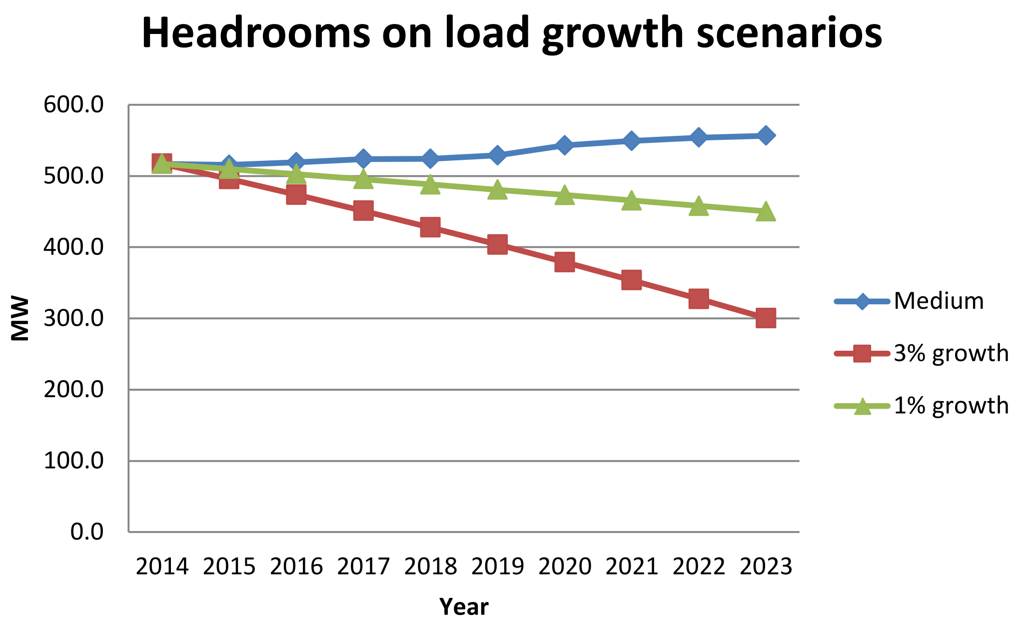
Under a scenario where both Greenbank to Mudgeeraba circuits are retired at the end of their technical life (~2025), the firm total transfer capacity into the Gold Coast zone would be limited by the emergency rating of a Greenbank to Molendinar circuit (918 MVA). However, due to the feeder-transformer configuration, the firm transfer capacity is further reduced to the emergency rating of a Molendinar 275/110kV transformer (455 MVA). The Gold Coast zone summer peak load is currently over 700MW. The power flow from Molendinar towards Mudgeeraba may be further limited by the 110kV network capacity.

[redacted]

[redacted]

On this basis there is a requirement to preserve 275kV circuit injection into Mudgeeraba Substation to provide reliable supply to the Gold Coast.

Figure 10.5: Total transfer limit spare capacity with Directlink 0MW



Transfer capacity of Mudgeeraba 275/110kVtransformers

Analysis was conducted to assess the impact, under the three load growth scenarios, of removing one or both of the two transformers at Mudgeeraba at the end of their technical life.

With the existing three 275/110kV transformers configuration at Mudgeeraba Substation there is no load at risk during the 10 year outlook for all three load growth scenarios, including maximum southerly flow on Directlink, under a critical transformer contingency.

With a two 275/110kV transformer configuration, maximum south bound flows on Directlink can be impacted under the 3% load growth scenario.

If both transformers are retired at end of technical life, the loss of the remaining transformer would result in loss of all 275kV injection into Mudgeeraba. The transfer capability into the Gold Coast can be limited by the ratings of the 110kV network and Molendinar 275/110kV transformer rating as described previously.

In order to land at a *satisfactory state,* using the 2014/15 Gold Coast observed peak load and with no power transfer across Directlink, the following would be required:

- Pre-contingent load shedding of up to 45MW would be required within the Gold Coast zone to avoid distribution assets immediately exceeding their short term rating following the critical contingency. A SPS would be required to avoid this pre-contingent load shedding.
- Load reduction of up to 125MW would be required to manage flows within the continuous rating of these assets ;or
- Significant upgrade of the 110kV network.

Even with the implementation of a SPS to avoid pre-contingent load shedding, load shedding of up to 125MW would be required for the Gold Coast network to land in a *satisfactory state.* This is a violation of the required supply reliability standard. On this basis there is a requirement that Mudgeeraba will remain a two or three transformer site to satisfy the required supply reliability with the existing load in the Gold Coast. If Mudgeeraba was to revert to a single transformer site then significant investment would need to occur on the 110kV network to meet the required supply reliability standard.

In the longer term, further reduction and redistribution of the Gold Coast load, may lend itself to the option to rationalise to a single 275kV connection and one 275/110kV transformer at Mudgeeraba

Substation. Under this configuration there would be ongoing reduced security and customer impacts that will need to be assessed. This option would likely have significant market impacts [redacted] The strategies for reinvestment for all 275kV and 110kV lines in the Gold Coast zone that are expected to reach end of technical or economic life in 10 to 20 years will be evaluated by Powerlink and Energex through joint planning and will consider the network impact and economic benefit of all reconfiguration options regardless of asset boundaries.

Voltage Stability

Under all demand scenarios, and varying assumptions on the modelled number of capacitor banks on the Mudgeeraba 110kV bus, the reactive margins exceed the minimum levels required for voltage stability at summer peak periods.

Fault levels

There are no emerging fault level issues in the Gold Coast zone. However, the available fault rating headroom at Mudgeeraba 110kV is limited.

Planned outages

Planned outages of the existing network configuration are likely to involve constraints on Directlink southerly capability. This could potentially be addressed through system protection schemes. There may potentially be some risks evident with extended transformer outages during the summer period; however this can be mitigated through operational control schemes or northerly flow on Directlink.

10.4 Other Considerations

10.4.1 Market and Regulatory Considerations

Non-Network Alternatives

Potential non-network solutions that will reduce load within the Gold Coast zone, particularly towards the southern end that are available on a firm basis, may remove or defer the requirement to maintain a three transformer configuration at Mudgeeraba Substation, or reduce the 275kV transmission line thermal transfer requirements into the Mudgeeraba and Molendinar substations.

Non-network solutions may include:

- sizeable generation anywhere in the Gold Coast/Tweed zone; or
- demand side management initiatives, in addition to that already assumed in the delivered demand forecast. This may include customers agreeing to voluntarily ‘switch off’ during a network contingency. If this is the case, an automatic system would be required to interrupt power supply to participants in the program immediately following a contingency to prevent more widespread load shedding.

Powerlink’s strategy over the next one to two years is to develop costings and viability of network and DSM alternatives through joint planning activities with Energex and Essential Energy and external consultation with market participants.

Market Impact

The Queensland and NSW regions are linked via the Terranora 110kV Interconnector and Directlink HVDC interconnector. Any proposed reinvestment works in the Gold Coast zone that are deemed to have a material inter-network impact on another Transmission Service Provider’s network or significant change in power constraints across network boundaries will require full consultation with all affected parties.

Reconfiguration options involving the circuits out of Greenbank or into Mudgeeraba, or consolidation of the transformers at Mudgeeraba Substation, will potentially have market impacts. Those scenarios that involve a system configuration of one 275kV circuit into Mudgeeraba or result in one 275/110kV transformer at the Mudgeeraba Substation are expected to have significant material impact under the 2014 TAPR forecast requiring broad consultation.

External consultation

The Gold Coast 275kV and 110kV transmission assets are regulated network assets. There are presently no regulatory requirements for participant consultation on the replacement of aged assets.

Any replacement works identified in this Gold Coast Area Plan in the five year outlook are to be published in the TAPR in order to provide information to interested parties and proponents of non-network solutions.

It is expected that any future investment recommendation that involves consolidation of the 275kV network assets and associated reduction in network capability in the Gold Coast will require:

- joint planning and consultation of impact on power constraints and power quality in the networks owned by Energex, Essential Energy and Transgrid; and
- consultation with AEMO and Directlink due to the inter-network power transfer capability of Directlink being impacted more than the minimum of 3% of maximum transfer capability or 50MW.

Any consultation would need to be completed before project approval for reinvestment in the 275kV transmission lines between Greenbank and Mudgeeraba Substation, and the reinvestment of the second 275/110kV transformer at Mudgeeraba Substation. It is expected consultation would be finalised by late 2017.

10.4.2 Operational Telecommunications

In the Gold Coast zone, Powerlink's telecommunications network assets consist of the following:

- OPGW
- Microwave communication links between Mudgeeraba and Mt Gravatt
- PLC communication between Mudgeeraba and Terranora

A fibre optic cable is also utilised through external commercial arrangement and follows the railway route from Tennyson, through Robina into Mudgeeraba. Historically this link has significant reliability and availability issues.

Legacy microwave and PLC systems have low capacity and are maintenance intensive. Powerlink's telecommunications asset management strategy has been, where practicable and cost effective, to migrate the telecommunications circuits off these legacy systems to higher capacity fibre network which is more secure and reliable. To facilitate this strategy and provide a second independent fibre optic link into the Gold Coast, any new or rebuilt transmission lines should have OPGW installed as the earth wire and where practical earth wire replacement projects should include OPGW as the preferred overhead earth wire.

Gold Coast Area Specific

[redacted]

[redacted]

Gold Coast Area General

It is proposed that the following reinvestment be considered-

- The Operational Telephone Network will be replaced at all sites;

- DWDM equipment will be replaced at effected sites; and
- Telecommunication services will be migrated to IP where effective to do so.

10.4.3 Easements

The Greenbank to Mudgeeraba 275kV transmission line easement includes a mix of urban development, small lot rural subdivision and forest reserve.

For the first 2km out of Greenbank Substation and the final 6.5km into Mudgeeraba Substation the transmission lines pass through, or are within 100m, of established urban development. These sections are highly visible and accessible from several urban streets. The easement itself in these locations provides unhindered access for all vehicle types, including EWPs. [redacted]

The remaining majority of the Greenbank to Mudgeeraba easement is located within the Jimboomba, Eagle Heights and North Tamborine forest reserves. This section is reasonably well protected from any prevailing coastal winds and poses a number of access issues due to its undulating nature. It also contains a number of heavily vegetated spans with a medium to high fire risk, potential to impact tower access and outage performance.

The Mudgeeraba to Terranora border 110kV transmission line easement crosses the main Pacific Highway just after leaving the Mudgeeraba Substation. Its northern section then runs along the western boundary of an emerging residential development at Reedy Creek, while it's central and southern section's pass through natural vegetation and grazing land.

[redacted]

10.4.4 Commonwealth Games

The Commonwealth Games will be held on the Gold Coast in April 2018. Project staging and outage coordination must ensure supply availability and reliability during this period.

10.4.5 Joint Planning Considerations

Energex

Major work over the past five years on the 110kV network in the Gold Coast has involved reconfiguration between Molendinar, Southport and Surfers Paradise substations. The scope involved establishing two new 110kV underground cables from Molendinar Substation to cut into the existing 110kV circuit between Southport to Surfers Paradise near Bundall zone Substation and was completed in 2011.

Essential Energy

The Mudgeeraba to Terranora line is shared with Essential Energy. In the previous five years works have been undertaken by Essential Energy under a heavy maintenance program, including replacement of all insulators due to corrosion and resolution of limiting section clearance line spans, which will extend the life of their section of the shared transmission line beyond 2025.

10.5 Investment Outlook

Strategic investment strategy

The investment outlook for the Gold Coast area will require a broader consideration of the interaction between all stakeholders, individual assets and their condition, future network requirements and other factors.

Powerlink's strategy over the next one to two years is to:

- Develop costings and viability of network and non-network alternatives through joint planning activities with Energex and Essential Energy and external consultation with market participants.
- Determine load shedding options with Energex (Tweed load) and Essential Energy (Terranora);
- Refine end of life timings for Powerlink and Energex transmission line assets, and refine understanding of Powerlink 275kV transmission line condition to determine if exhibits continuous deterioration rates of components ; and
- Finalise external stakeholder consultation and develop long term strategic plan for the Gold Coast zone.

Targeted investment strategy

A number of strategies for meeting both the asset end-of-life, and potential future network requirements, have been developed and analysed for the following assets that are expected to have reinvestment decisions in the 10 year outlook:

- 275kV Transmission Line Reinvestment Strategy - 275kV Mudgeeraba to Greenbank transmission lines;
- 275/110kV Transformer Reinvestment Strategy - Mudgeeraba 275/110kV Transformers;
- 110kV Transmission Line and Substation Reinvestment Strategy - 110kV Mudgeeraba to Terranora transmission line and Mudgeeraba 110kV Substation.

Each strategy is discussed in turn below.

10.5.1 275kV Transmission Line Reinvestment Strategy

Given the very long life of transmission line assets, changes in technology, cost of structures, regulatory requirements and network requirements are experienced between the initial construction and the time at which reinvestment in the line is required. It is therefore likely that many reinvestment options can be considered beyond like for like replacement.

The end of technical life drivers for the Greenbank to Mudgeeraba 275kV transmission lines were considered for the following option themes:

- Rebuild both single circuit steel tower (SCST) lines to a single double circuit steel tower (DCST) line;
- Life extension – refit (in part or whole) one or two of the Greenbank to Mudgeeraba single circuit lines; and
- Maudsland Teed Connection - refit or rebuild options modified to connect Greenbank to Molendinar transmission line supplying Mudgeeraba Substation via a teed connection point at Maudsland.

Based on the load growth scenarios considered and on a high level review of the risks and benefits, it is considered likely that Powerlink would maintain the existing connectivity of two 275kV circuits from Greenbank to Mudgeeraba.

Powerlink's asset management strategy is to monitor the condition of these line assets and to determine if the transmission line exhibits continuous deterioration rates of components or if there is an atypical trend due to geographic diversity. Within the 10 year outlook of the AMP it is likely these transmission line assets will require selective insulator replacements and to be considered for increased maintenance or line refit to prevent further deterioration of the underlying steel component to economically defer a major line rebuild that would be required beyond the 10 year outlook. It is expected that a life extension (in part or whole) within the next one to five years is likely to be the most economic option.

10.5.2 Rebuild Theme

Figure 10.6: Network configuration for Rebuild Theme

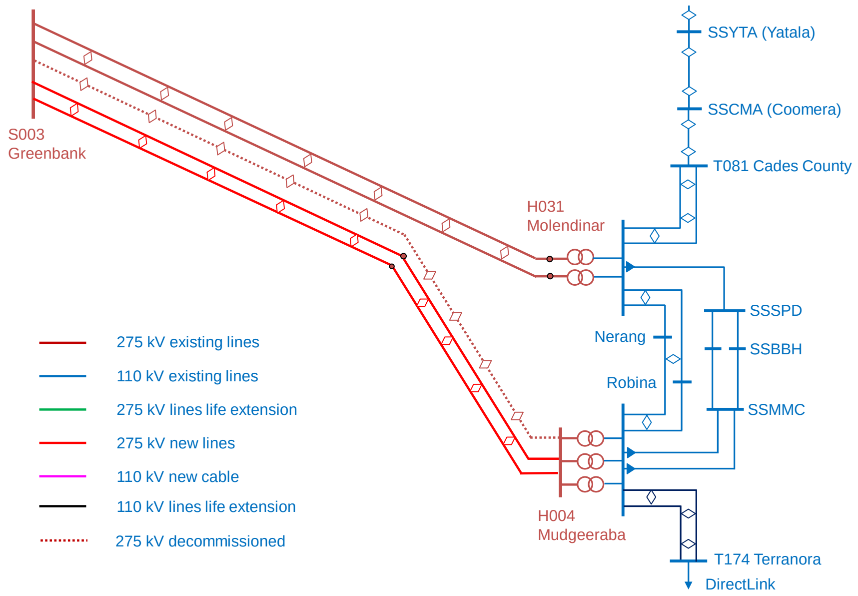

SSYTA (Yatala)
SSCMA (Coomera)
T081 Cades County
S003
Greenbank
H031
Molendinar
SSSPD
Nerang
SSBBH
Robina
SSMMC
H004
Mudgeeraba
T174 Terranora
DirectLink
275 kV existing lines
110 kV existing lines
275 kV lines life extension
275 kV new lines
110 kV new cable
110 kV lines life extension
275 kV decommissioned

Table 10.7: High level option analysis for Rebuild Theme

Option Overview	Demolish F836 and rebuild a 275kV double circuit line between Greenbank and Mudgeeraba on the easement of F836
Assumptions	Easement of the existing line can be used for rebuild Outage windows can be managed due to the risk of loss of other circuit
Benefits of Option	High capacity Lower NPV if refit costs > approximately 50% of rebuild costs New OPGW link to coast Existing network configuration has capability to supply future 275kV injection into Yarabilba
Drawbacks of Option	High upfront cost Taller towers and higher current rating conductor Risk of surplus capacity dependent on future load development
Market Impact	No impact on Directlink operation
Operational Flexibility	High level of flexibility to manage outages and maintenance in the future
Demand Scenario	High load growth, more than 3% per year for at least 10 years
Network Limitation	110kV network and Molendinar transformation capacities during rebuild
Mitigation Measures	Selecting construction in winter period and or 110kV network split on contingency

10.5.3 Life Extension Theme – a line refit of either one or both SCST

Figure 10.7: Network configuration for Refit Theme

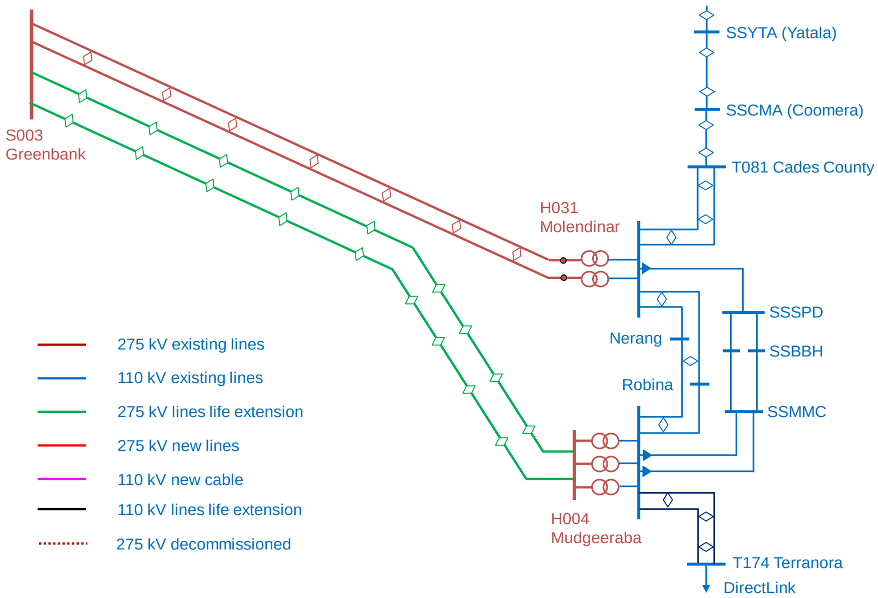


Table 10.8: High level option analysis for Refit Theme

Option Overview	Line refit works to extend the life of the transmission line – one or both transmission lines, in part or whole
Assumptions	Less easement or community issues Outage windows can be managed due to the risk of loss of other circuit during line refit work
Benefits of Option	Lower upfront cost Sufficient capacity and provides flexibility moving forward Allows for targeted and reduced scope of works if atypical condition profile of the line to reduce asset risk and targeted life span extension (either with or without Maudsland Tee) Lowest community and environmental impact New OPGW link to coast Existing network configuration has capability to supply future 275kV injection into Yarabilba
Drawbacks of Option	Not economic if line refit costs >50% than new build costs and offers less thermal headroom and shorter life span compared with rebuild Consolidation to one circuit requires 110kV reinforcement and advances network requirement for the 3rd Molendinar transformer and associated 275kV bus establishment
Market Impact	Operational impact on Directlink transfer capability under consolidation to one circuit
Operational Flexibility	Decreased level of flexibility to manage outages and maintenance in the future under consolidation to one circuit
Demand Scenario	3% per year for at least 10 years under existing configuration Flat or 1% per year for at least 10 years for consolidation to one circuit
Network Limitation	110kV network (under existing network configuration this would only be during the outage windows required for refit)
Mitigation Measures	Automatic bus split upon critical contingency and post contingent load shedding Pre-contingent load curtailment and post-contingent load shedding Reinforcing the 110kV network between Molendinar, Surfers Paradise and Broadbeach (new underground cable installation)

10.5.4 Maudsland Tee theme – reconfiguration of one or both circuits as a teed connection

Figure 10.8: Network configuration for Reconfiguration Theme

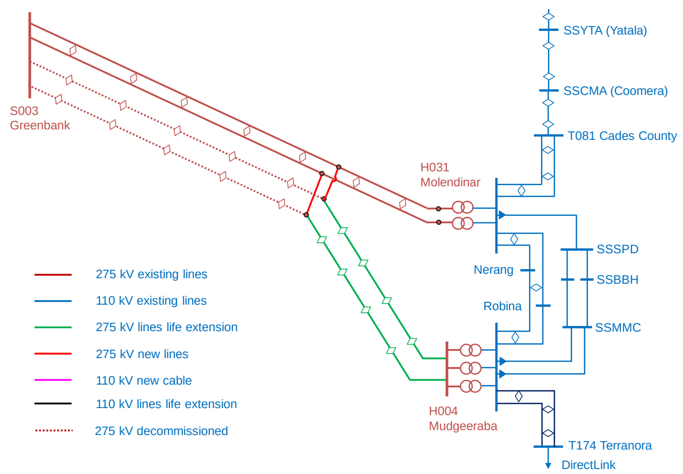


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Table 10.9: High level option analysis for Reconfiguration Theme

Option Overview	Life extension or rebuild one or two Greenbank to Mudgeeraba circuits between Maudsland Tee and Mudgeeraba and making a teed connection to

	a Greenbank to Molendinar circuit and decommissioning the remainder of the circuit of either one or both lines
Assumptions	Less easement or community issues Outage windows can be managed due to the risk of loss other circuit
Benefits of Option	Lower upfront cost and reduced ongoing maintenance Opportunity for consolidation under flat or reducing load growth Allows for targeted and reduced scope of works if atypical condition profile of the line to reduce asset risk and targeted life span extension Lowest community and environmental impact This could facilitate a staged approach to any rebuild or refit options
Drawbacks of Option	Total supply into Gold Coast limited by emergency rating of single Greenbank to Molendinar circuit with two circuits into the Gold Coast. However a hybrid option of 3 circuits into the Gold Coast offers significantly more headroom (only one teed connection) With only two circuits into the Gold Coast – double circuit outage total loss of supply of Gold Coast and supply to Tweed Significantly reduced transfer capacity with two circuits into the Gold Coast Potential market impacts and impacts on other networks Maintaining future use of spare easement
Market Impact	Operational impact on Directlink operation
Operational Flexibility	Decreased flexibility to manage outages and maintenance in the future
Demand Scenario	Flat or 1% load growth
Network Limitation	Existing configuration - EC rating of Greenbank to Molendinar circuit Consolidation to one circuit - Under critical contingency, Gold coast is solely supplied through a single 275/110kVtransformer at Molendinar (EC 455MVA). However, peak load is currently 710 MW.
Mitigation Measures	Automatic bus split upon critical contingency Pre-contingent/post-contingent load shedding Reinforcing the 275kV at Molendinar and/or 110kV network between Surfers Paradise and Molendinar.

10.5.5 Mudgeeraba 275/110kV Transformer Reinvestment Strategy

No.2 and No.3 Mudgeeraba 275/110kV transformers are now approaching end of technical or economic life and accordingly consideration was given to the reinvestment options.

Under the 2014 TAPR 10% PoE forecast Mudgeeraba can convert to a two transformer site in the short to medium term and meet reliability of supply obligations to the Gold Coast zone.

There is an increased risk of in-service failure of No.2 and No.3 Mudgeeraba 275/110kV 250MVA transformers due to the following condition and design issues:

- The oil tests for both transformers indicated aged paper insulation, oil contamination and external corrosion/oil leaks with an increased risk of moisture ingress;
- There are aged condition and design concerns that clamping pressures will not be adequate to restrict axial movement of windings; and
- The No.2 275/110kV transformer bushings tested outside acceptable limits.

Both transformers were refurbished in 2006 to ensure that a reliable service life of 40 years could be achieved. Another significant refurbishment of either transformer has not been further considered as an option on the basis that it would have an increasing level of ongoing asset based risk and may require removal of oil and detanking the transformer. Risks associated with transformer failure or rupture due to breakdown of insulation strength and clamping could not be addressed economically. Any measures that may potentially address the other condition driven risks would result in significant additional reinvestment costs in the transformers and possibly introduce new condition risks moving forward.

The Commonwealth Games will be held on the Gold Coast in April 2018. Project staging and outage coordination must ensure supply availability and reliability during this period.

Due to collective consideration of the condition issues, and the related risk of these assets remaining in service, the continued operation of No.2 transformer beyond one to three years and No.3 transformer beyond five to seven years is not recommended. Three options to address the end of technical life drivers have been developed, that offer various levels of investment risk and cost. The reinvestment options considered include:

1. Decommission No.2 transformer in 2017 and replace No.3 transformer in 2019;
2. Replace No.2 transformer in 2017 and decommission No.3 transformer in five to seven years (or replace subject to external consultation); and
3. Replace No.2 and No.3 transformers in 2017.

The recommended option is to:

- replace No.2 transformer within three years;
- defer reinvestment in No.3 transformer, with the recommendation to decommission it within five to seven years dependent on load requirements; and
- the decommissioning of No.3 transformer should align with the 275kV secondary systems replacement.

10.5.6 110kV Transmission Line Reinvestment Strategy

Mudgeeraba to Terranora 110kV Transmission Line

The Tweed region in Northern NSW is supplied by the 110kV Mudgeeraba to Terranora transmission line and the Directlink HVDC link to Lismore. Otherwise, there is only a very modest distribution connection, only sufficient for partial backup.

Directlink does not presently have 'black start' capability meaning that it cannot function as the sole source of supply to the Tweed region. The Mudgeeraba to Terranora transmission line, together with Directlink, function as an interconnector. Outages on or removal of any of these circuits will have market impacts.

Previous property investigations have identified encroachments along the easement from Mudgeeraba to the NSW border. A review of easement use indicates that re-building along the existing easement was unlikely to be viable. Through joint planning, the lowest-cost alternative solution identified required the use of underground cable and was estimated to cost above $100 million.

Powerlink's asset management strategy is to monitor the condition of these line assets and to determine if the transmission line exhibits continuous deterioration rates of components or if there is an atypical trend due to geographic diversity. Within the 10 year outlook of the AMP it is likely these transmission line assets will require selective insulator replacements and to be considered for increased maintenance or line refit to prevent further deterioration of the underlying steel component to economically defer a major line rebuild that would have been required beyond the 10 year outlook. If Powerlink is to continue to supply the Tweed region, life extension of the existing lines is likely to be the most economic option.

10.5.7 110kV Mudgeeraba Substation Reinvestment Strategy

Previous strategies for the reinvestment of the 110kV switchyard were integrated with the expected augmentation requirements to meet the forecast increase in the Gold Coast load (resulting in higher fault levels and continuous current rating requirements). However on the basis of subdued load growth, the age profile throughout the switchyard, and site specific considerations as above, these options were discounted. Further, these solutions did not allow the flexibility to align to future end of technical life replacement options, i.e. locking Mudgeeraba to partial equipment replacement strategies into the future, nor do they allow the future opportunity to optimise the number of transformers, bus sections and ongoing requirement for bus selectability.

The future reinvestment strategy of the Mudgeeraba 110kV switchyard has considered the following plant and load driven issues.

Load driven issues

- Planning analysis has shown there is a continuing long term need for the 110kV switchyard at Mudgeeraba to meet reliability of supply obligations to the Gold Coast load centre under the load growth scenarios considered. It provides critical supply to the electricity networks of Energex and Essential Energy and provides 110kV connection to Directlink.
- At this stage, the long term 110kV ultimate layout requirements are not known as it will depend on the reinvestment strategy for the end of life drivers for the Gold Coast 275kV network to be addressed around 2025. However the present viewpoint is that the existing 110kV configuration would be sufficient for the subdued load growth outlook in the TAPR 2015 load forecast. There may be a future opportunity to reduce the number transformers, bus sections and ongoing requirement for bus selectability.
- The minimum plant fault rating is 25kA with the existing fault level at 23kA. It is not expected that the fault levels will exceed the minimum plant ratings under the 2014 TAPR load forecast. In the future, operational measures may be available to manage fault levels within equipment rating to some degree. However, to ensure safe operation of plant during faults the fault level ratings need to be considered in any long term redevelopment strategy.
- The overhead strung bus sections have been assessed to be in fair condition and the minimum rating of 2000 Amps is adequate on the basis of actual load and the current TAPR 2014 load forecast which is flat.
- The Commonwealth Games will be held on the Gold Coast in April 2018. Project staging and outage coordination must ensure supply availability and reliability during this period.
- The installation of GIS technology has been evaluated in consideration of the advantages of this technology over conventional AIS switchgear relevant to the aforementioned constraints of this site. It is recommended that the use of GIS technology be considered as an option for a future rebuild on this site.

Primary Plant Strategy

There is a continuing need for the 110kV switchyard at Mudgeeraba in the long term to meet reliability of supply obligations to Gold Coast load under all medium and high economic demand projections.

Three options to address end of life drivers have been developed which offer various levels of investment benefits, risk and cost of works:

1. Selective bay reinvestment in 2017, followed by full rebuild in 2025
2. Selective bay level reinvestment in 2017, followed by full rebuild in 2025
3. Selective bay level reinvestment in 2017, followed by a staged rebuild in 2025 and 2030.

After considering the benefits and risks of each option it is recommended that Option 1, involving selective replacement of equipment in 2017 followed by a full substation rebuild in 10 to 15 years dependent on the assessment of the plant condition at that time and project justification.

Option 1 provides minimal initial capital cost outlay and results in deferral of the large capital expenditure associated with the full substation replacement options, while managing the majority of the condition drivers and asset risks in the identified bays for the next five years; it provides flexibility to deal with future 110kV switchyard requirements and it aligns major reinvestment with broader substation drivers in 10 to 15 years.

Secondary Systems Strategy

Due to collective consideration of the condition and obsolescence issues, and the related risk of these assets remaining in service, the following 110kV secondary system reinvestment strategies have been considered as shown.

Three options to address the end of technical life drivers have been developed, that offer various levels of investment risk and cost. The reinvestment options considered include:

1. Minimal relay replacement;
2. Partial replacement;

3. Full replacement.

Having taking into consideration

- the NPV results which identify Option 1 as the most economic option, but having the highest level of risk and a significant risk during commissioning;
- greater reliability benefits of Option 2 compared to option 1, and lower NPV and upfront costs compared to Option 3; and
- operational capability in accordance with the National Electricity Rules.
- Option 2, Partial Panel level replacement in 2017, is the preferred option for implementation.

10.6 Conclusions

The Gold Coast Area Plan has been undertaken to examine a number of different strategies for managing the end of life of the existing network assets and future capacity requirements in the area over the 10 year outlook of the AMP. These strategies consider the condition based risks related to these assets remaining in service, geographic matters, asset criticality, and existing load and future network requirements.

The recommended reinvestment strategy for the Gold Coast Area over the next 10 year outlook is shown in Table 10.10.

Table 10.10: Summary of proposed reinvestment strategy

Timeframe	Strategy
1 to 5 years	Transmission Lines • Undertake detailed condition assessment to determine the remaining service life of tower structures and line components. • Life extension works on 110kV Mudgeeraba to Terranora double circuit. • Life extension works on both 275kV Greenbank to Mudgeeraba single circuits or rebuild as a double circuit at a later date. Mudgeeraba Substation • Replace all ABB 275kV Twin Leg CTs. • Replace No.2 275/110kV 250MVA transformer at Mudgeeraba. • Merrimac Bays - partial bay replacement excluding the disconnectors. • Decommission No.1 and No.3 capacitor bank bays and capacitors. • The new 110kV transformer bay in existing No.1 Cap Bank bay to minimise outages. • New perimeter fencing and replace DC batteries. • Selective replacement of the VTs in the following bays - 2 Cap, 2 Tx, 3-4 Bus, 2/3/4 Bus. • Replacement of the CT in 3-4 Bus Bay. • Replace all the secondary system panels associated with the bus zone protection and Feeders 706, 754, 755, 757 and 758.
5 to 10 years	• Undertake detailed assessment of ageing assets to determine the remaining service life of Mudgeeraba substation components. • Decommission No.3 275/110kV Transformer at Mudgeeraba. • Full replacement of Mudgeeraba 275kV secondary systems.
Beyond 10 years	• Mudgeeraba 110kV substation replacement - significant scope of replacement works including foundations and structures. Consideration of the application of GIS technology due to space constraints. • Mudgeeraba 110kV secondary system replacement of the remaining bays in new building.

Individual capital projects within this strategy will be subject to justification and approval at an appropriate time and are shown in Table 10.11.

Table 10.11: Proposed investment in the Gold Coast (10 year outlook)

Project Number	Description	Indicative timing
CP.01679	Mudgeeraba 110kV Rebuild (Partial rebuild of two bays only)	2017
CP.PROV003	Mudgeeraba 110kV Secondary Systems Replacement Stage 1	2017
CP.01543	Mudgeeraba 275/110kV No.2 Transformer Replacement	2017
CP.01690	Greenbank to Mudgeeraba Easement Clearance	2018
CP.02415	Greenbank - Mudgeeraba 275kV T/L Life Extension	2019
CP.02272	Mudgeeraba 275kV Secondary System Replacement	2021
CP.PROV	Greenbank - Mudgeeraba BS1018 275kV Line Refit F835	2019
CP.PROV	Mudgeeraba to STR-1731 (NSW Boarder Terranora) Line Refit	2018
CP.PROV049	Mudgeeraba 275kV and 110kV Primary Plant Replacement	2025