Chapter 4:
Future network development

4 Future network development

Key highlights

- Powerlink is responding to fundamental shifts in its operating environment by adapting its approach to investment decisions. In particular, assessing whether an enduring need exists for key assets and investigating alternate network reconfiguration opportunities and/or non-network solutions, where feasible, to manage asset risks.
- The Ross, Central West, Gladstone and Moreton zones have potential reconfiguration opportunities during the five-year outlook period from 2017 to 2022.
- Additional commitment of generating capacity in north or central west Queensland is expected to lead to a rise in congestion on the Gladstone or CQ-SQ grid sections. This will likely result in material constraint durations and levels for generators in north or central west Queensland.

4.1 Introduction

The National Electricity Rules (NER) (Clause 5.12.2(c)(3)) requires the Transmission Annual Planning Report (TAPR) to provide "a forecast of constraints and inability to meet the network performance requirements set out in schedule 5.1 or relevant legislation or regulations of a participating jurisdiction over one, three and five years". In addition, there is a requirement (Clause 5.12.2(c)(4)) of the NER to provide estimated load reductions that would defer forecast limitations for a period of 12 months and to state any intent to issue request for proposals for augmentation or non-network alternatives. The NER (clauses 5.12.2(c)(7) and 5.15.3(b)(1)) requires the TAPR to include information pertinent to transmission network replacements where the capitalised expenditure is estimated to be more than $6 million.

This chapter on proposed future network developments contains:

- discussion on Powerlink's integrated planning approach to network development
- information regarding assets reaching the end of their technical or economic life and options to address identified asset risks, including potential network reconfigurations, asset retirements or de-ratings
- identification of emerging future limitations[1] with potential to affect supply reliability including estimated load reductions required to defer these forecast limitations by 12 months (NER Clause 5.12.2(c)(4)(iii))
- a statement of intent to issue request for proposals for augmentation or non-network alternatives (NER Clause 5.12.2(c)(4)(iv))
- a table summarising the outlook for network limitations over a five-year outlook period and their relationship to the Australian Energy Market Operator (AEMO) 2016 National Transmission Network Development Plan (NTNDP)
- details of those limitations for which Powerlink Queensland intends to address or initiate consultation with market participants and interested parties
- a table summarising possible connection point proposals.

Where appropriate all transmission network, distribution network or non-network (either demand management or local generation) alternatives are considered as options for investment or reinvestment. Submissions for non-network alternatives are invited by contacting networkassessments@powerlink.com.au.

[1] Identification of forecast limitations in this chapter does not mean that there is an imminent supply reliability risk. The NER requires identification of limitations which are expected to occur some years into the future, assuming that demand for electricity grows as forecast in this TAPR. Powerlink regularly reviews the need and timing of its projects, primarily based on forecast electricity demand, to ensure solutions are not delivered too early or too late to meet the required network reliability.

4.1.1 Integrated approach to network development

Powerlink's planning for future network development focuses on optimising the network topology based on consideration of future network needs due to:

- forecast demand
- new customer supply requirements
- existing network configuration
- condition based risks related to existing assets.

This planning process includes consideration of a broad range of options to address identified needs described in Table 4.1.

Table 4.1 Examples of planning options

Option	Description
Augmentation	Increases the capacity of the existing transmission network, e.g. the establishment of a new substation, installation of additional plant at existing substations or construction of new transmission lines. This is driven by the need to meet prevailing network limitations and customer supply requirements.
Reinvestment	Asset reinvestment planning ensures that existing network assets are assessed for their enduring network requirements in a manner that is economic, safe and reliable. This may result in like-for-like replacement, network reconfiguration, asset retirement, line refit, operational refurbishment or replacement with an asset of lower capacity. Condition and risk assessment of individual components may also result in the staged replacement of an asset where it is technically and economically feasible.
Network reconfiguration	The assessment of future network requirements may identify the reconfiguration of existing assets as the most economical option. This may involve asset retirement coupled with the installation of plant or equipment at an alternative location that offers a lower cost substitute for the required network functionality.
Asset retirement	May include strategies to disconnect, decommission and/or demolish an asset and is considered in cases where needs have diminished or can be deferred in order to achieve long-term economic benefits.
Line refit	Powerlink also utilises a line reinvestment strategy called line refit to extend the technical life of a transmission line and provide cost benefits through the deferral of future transmission line rebuilds. Line refit may include structural repairs, foundation works, replacement of line components and hardware and the abrasive blasting of tower steelwork followed by painting.
Operational refurbishment	Operational refurbishment includes the replacement of a part of an asset which restores the asset to a serviceable level and does not significantly extend the life of the asset.
Additional maintenance	Additional maintenance is maintenance undertaken at elevated levels in order to keep assets at the end of their life in a safe and reliable condition.
Non-network alternatives	Non-network solutions are not limited to, but may include network support from existing and/or new generation or demand side management initiatives (either from individual providers or aggregators) which may reduce, negate or defer the need for network investment solutions.
Operational measures	Network constraints may be managed during specific periods using short-term operational measures, e.g. switching of transmission lines or redispatch of generation in order to defer or negate network investment.

4.1.2 Forecast capital expenditure

The energy industry is going through a period of transformation driven by fundamental shifts in economic outlook, electricity consumer behaviour, government policy and regulation and emerging technologies that have reshaped the environment in which Powerlink delivers its transmission services.

As a result Powerlink's capital expenditure program of work for the five-year outlook period is considerably less than that of previous years. The load driven capital expenditure originally forecast in the 2013/17 regulatory period will not be realised due to these fundamental shifts in Powerlink's business and operating environment which contributed to a downturn in commodity prices. This significantly reduced resource sector investment, underlying economic growth and the associated demand for electricity. Similarly distribution load demand remained relatively flat driven by consumer response to high electricity prices, increased focus on energy efficiency and the uptake of distributed solar PV installations.

In this changed environment, the reduction in forecast demand growth also had an impact on Powerlink's planned reinvestment program. Powerlink has adapted its approach to reinvestment decisions, with a particular focus on assessing whether there is an enduring need for key assets and seeking alternative investment options through network reconfiguration to manage asset condition and/or non-network solutions where feasible.

Also, Powerlink has taken a cautious approach in determining when it is appropriate to refit or replace ageing transmission line assets and how to implement these works cost effectively. This approach is aimed at delivering better value to consumers.

The five-year outlook period discussed in the 2017 TAPR runs from 2017/18 to 2022/23 and discusses potential transmission network projects where the estimated cost is over $6 million.

4.1.3 Forecast network limitations

As outlined in Section 1.6.1, under its Transmission Authority, Powerlink Queensland must plan and develop its network so that it can supply the forecast maximum demand with the system intact. The planning standard, which came into effect from July 2014, permits Powerlink to plan and develop the network on the basis that some load may be interrupted during a single network contingency event. Forward planning allows Powerlink adequate time to identify emerging limitations and to implement appropriate network and/or non-network solutions to maintain transmission services which meet the planning standard.

Emerging limitations may be triggered by thermal plant ratings (including fault current ratings), protection relay load limits, voltage stability and/or transient stability. Appendix E lists the indicative maximum short circuit currents and fault rating of the lowest rated plant at each Powerlink substation and voltage level, accounting for committed projects listed in Chapter 3.

Assuming that the demand for electricity remains relatively flat in the five-year outlook period, Powerlink does not anticipate undertaking any significant augmentation works during this outlook period other than those which could potentially be triggered from economic drivers and/or the commitment of mining or industrial block loads (refer to Table 4.2). In Powerlink's Revenue Determination 2017-2022, the projects that would be triggered by these large loads were identified as contingent projects. These contingent projects and their triggers are discussed in detail in Section 6.2.

Table 4.2: Potential contingent projects

Potential project	Indicative cost
Northern Bowen Basin area	$56m
Bowen Industrial Estate	$43m
Central to North Queensland reinforcement	$55m
Central West to Gladstone area reinforcement	$105m
QNI upgrade (Queensland component)	$67m
Queensland to South Australia interconnection (Queensland component)	$120m

In accordance with the NER, Powerlink undertakes consultations with AEMO, Registered Participants and interested parties on feasible solutions to address forecast network limitations through the Regulatory Investment Test for Transmission (RIT-T) process. Solutions may include provision of network support from existing and/or new generators, demand side management initiatives (either from individual providers or aggregators) and network augmentations.

4.2 Proposed network developments

As the Queensland transmission network experienced considerable growth in the period from 1960 to 1980, there are now many transmission assets between 35 and 55 years old. It has been identified that a number of these assets are approaching the end of their technical or economic life and reinvestment in some form is required within the five-year outlook period in order to manage emerging risks related to safety, reliability and other factors. Reinvestment in the transmission network to manage identified risks associated with these assets will form the majority of Powerlink's capital expenditure program of work moving forward.

In conjunction with condition assessments and risk identification, as assets approach their anticipated end of technical or economic life, possible reinvestment options undergo detailed planning studies to confirm alignment with future reinvestment and optimisation strategies. These studies have the potential to provide Powerlink with an opportunity to:

- improve and further refine options under consideration or
- consider other options from those originally identified which may deliver a greater benefit to customers and consumers.

Information regarding possible reinvestment alternatives is updated annually within the TAPR and includes discussion based on the latest information available at the time.

Proposed network developments within the five-year outlook period are discussed below. The developments are the most likely solution, but as mentioned may change with ongoing detailed analysis of asset condition and network requirements.

For clarity, an analysis of this program of work has been performed across Powerlink's standard geographic zones.

4.2.1 Far North zone

Existing network

The Far North zone is supplied by a 275kV transmission network with major injection points at the Chalumbin and Woree substations into the 132kV transmission network. This 132kV network supplies the Ergon Energy distribution network in the surrounding areas of Tully, Innisfail, Turkinje and Cairns, and connection to the hydro power stations at Barron Gorge and Kareeya.

Transmission network overview

There are no network limitations forecast to occur in the Far North zone within the five-year outlook period.

Transmission lines

Kareeya to Chalumbin 132kV transmission line

The 132kV transmission line was constructed in the mid 1980s and provides connection to the Kareeya Power Station from the Chalumbin Substation. It operates in an environmentally sensitive world heritage area in the Wet Tropics with extremely high humidity conditions impacting on the life of its galvanised components. After detailed assessment of the condition of the line and analysis of the available options, including consideration of the the inherent constraints of working within the Wet Tropics Management Authority area, Powerlink has committed an operational project to address corrosion on the structures of the transmission line by summer 2017/18.

Substations

Powerlink's routine program of condition assessments has identified primary plant and secondary systems assets within the Far North zone with emerging safety, reliability and obsolescence risks that may require reinvestment within the five-year outlook period. Planning analysis confirms these assets are required to provide a reliable supply into the future (except where potential retirement has been identified) and the related investment needs are outlined in Table 4.3.

Table 4.3 Possible reinvestment works in the Far North zone within five years

Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Substations					
Kamerunga Substation replacement	Full replacement of 132kV substation	Maintain supply reliability to the Far North zone	Summer 2019/20	Staged replacement of 132kV primary plant and secondary systems	$25m
Woree secondary systems replacement	Staged replacement of the 132kV secondary systems equipment	Maintain supply reliability to the Far North zone	Summer 2020/21	Full replacement of 132kV secondary systems	$10m
Retirement of one 132/22kV Cairns transformer	Retirement of one 132kV Cairns transformer including primary plant reconfiguration works (1)	Maintain supply reliability to the Far North zone	Summer 2021/22	Replacement of the transformer	$0.5m
Cairns secondary systems replacement	Full replacement of 132kV secondary systems	Maintain supply reliability to the Far North zone	Summer 2022/23	Staged replacement of the 132kV secondary systems equipment	$9m

Note:

(1) There may be additional works and associated costs required by Ergon Energy that need to be economically evaluated in relation to reconfiguration of the 22kV switchyard.

4.2.2 Ross zone

Existing network

The 132kV network between Collinsville and Townsville was developed in the 1960s and 1970s to supply mining, heavy commercial and residential loads. The 275kV network within the zone was developed more than a decade later to reinforce supply into Townsville. Parts of the 132kV network are located closer to the coast in a high salt laden wind environment leading to accelerated structural corrosion (refer to figures 4.1 and 4.2).

Figure 4.1 Northern Ross zone transmission network

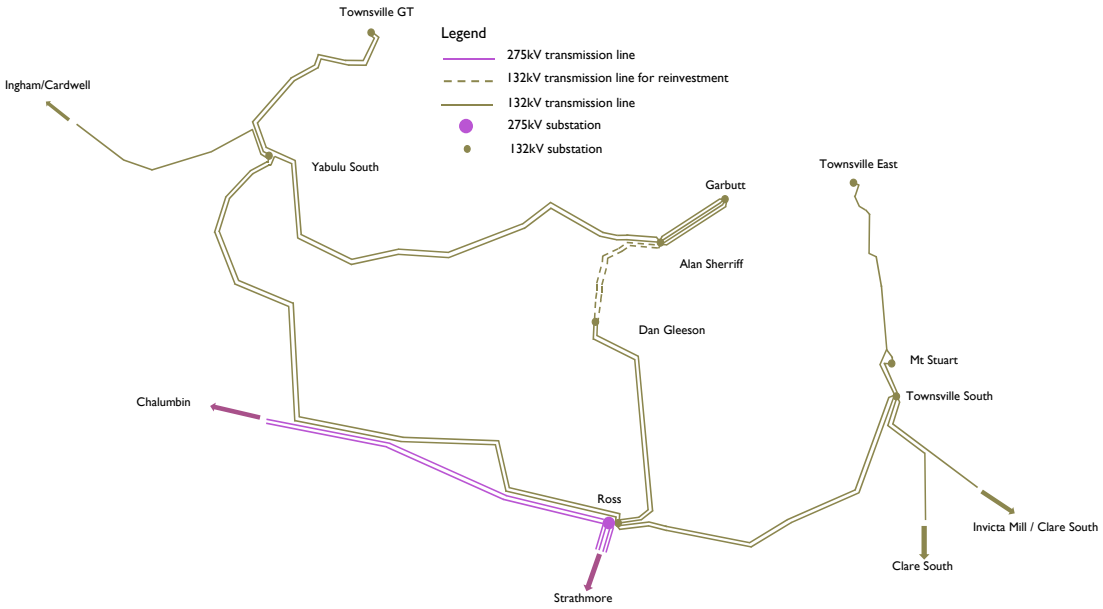
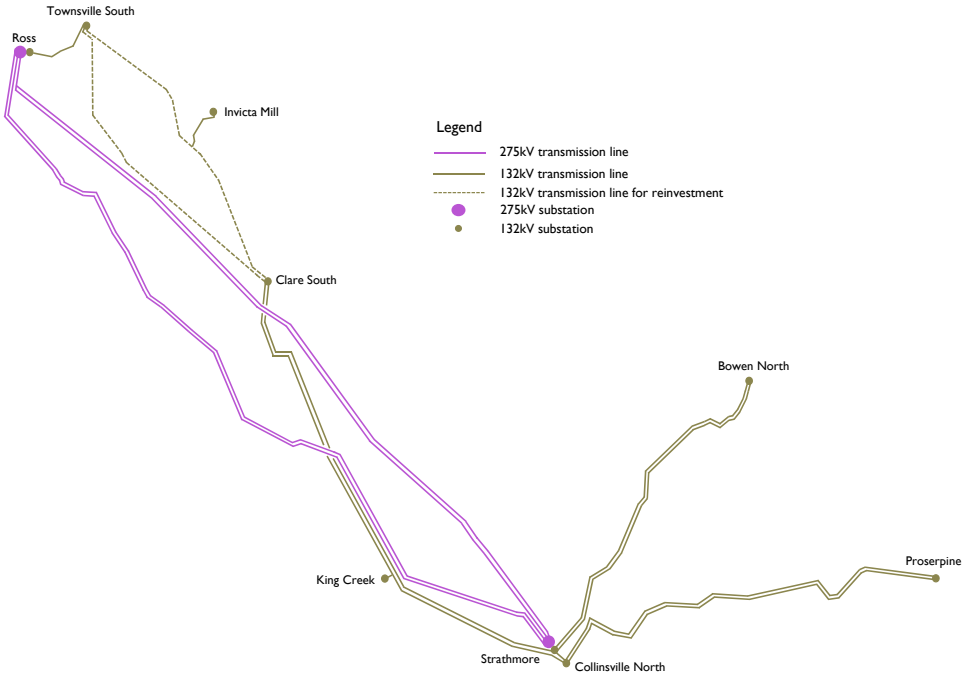


Figure 4.2 Southern Ross zone transmission network



Transmission network overview

There are no network limitations forecast to occur in the Ross zone within the five-year outlook period.

4 Future network development

Transmission lines

Dan Gleeson to Alan Sherriff 132kV transmission line

The 132kV line between Dan Gleeson and Alan Sherriff substations was constructed in the 1960s and is located in the south-western suburbs of Townsville. Foundation repair on this transmission line was completed in 2016 to allow the continued safe and economic operation of this line in the medium term. The condition assessment indicates moderate levels of structural corrosion and end of technical or economic life is expected within the next five to 10 years. Possible strategies for this transmission line may include line refit, replacement or retirement at the end of its technical life.

Clare South to Townsville South 132kV transmission lines

The 275kV and 132kV network which operates in parallel between Collinsville and Townsville has developed over many years. The 132kV lines are reaching end of technical or economic life within the next five to 10 years, while the earliest end of technical or economic life trigger for the 275kV lines is beyond the 10-year outlook of this TAPR.

Two 132kV lines traverse separate easements between Clare South and Townsville South substations, whereas a double circuit 132kV line connects Clare South to Collinsville North substations with one circuit switched at Strathmore Substation.

The inland Clare South to Townsville South transmission line consists of 230 structures and is approximately 69km in length. It is forecast that the above ground corrosion on these structures will require line refit in the five to 10-year outlook period.

The near term driver is to confirm the below ground condition that is particular to 156 structures with grillage foundations. Work is underway to conduct non-invasive testing on these grillage foundations, and based on this testing, it is expected that Powerlink will be able to confirm below ground conditions along this transmission line. Hence, reinvestment timing and scope is uncertain at this stage within the five-year outlook.

Once the below ground condition is known, Powerlink will consider a number of end of life strategies for this transmission line, whilst holistically considering future capacity requirements in the area. This will include an assessment of the cost associated with keeping this line in safe operation below and above the ground, and the costs and network requirements associated with removing it.

It has been identified that removal of this transmission line would require a substitute network or non-network solution to remain within mandated supply requirements. A possible solution to the voltage limitation could be the installation of a transformer at Strathmore Substation, network reconfiguration, network support or non-network alternative (refer to Section 6.3.1).

A condition assessment has confirmed that the coastal circuit has experienced higher rates of structural corrosion and as such, Powerlink is proposing to undertake line refit works on the coastal transmission line by around 2019/20. Once the below ground condition is known for the inland transmission line, the possible scope of works, reinvestment options and timing at the end of its technical life will be confirmed.

Collinsville North/Strathmore to Clare South 132kV transmission lines

The 132kV line between Collinsville North/Strathmore and Clare South was constructed in the 1960s and is located in the Houghton and Burdekin catchment basins, with the northern section dominated by sugar cane and cattle grazing pastures. A recent condition assessment identified levels of structural corrosion with end of technical or economic life expected to occur within the next five to 10 years.

As such, Powerlink is proposing to undertake line refit works on the transmission line commencing around 2022/23. Powerlink will consider a number of end of life strategies for this transmission line, whilst holistically considering future capacity requirements in North Queensland over the entire transmission corridor.

Substations

Powerlink's routine program of condition assessments has identified transformer, primary plant and secondary systems assets within the Ross zone with emerging reliability, safety and obsolescence risks that may require reinvestment within the five-year outlook period. Planning analysis confirms these assets are required to provide ongoing reliable supply and the related investment needs are outlined in Table 4.4.

Non-network solutions

In Powerlink's 2015 and 2016 TAPR a potential non-network solution was identified as an alternative option to the replacement of both of the 132/66kV transformers at Garbutt. In March 2016, Powerlink initiated a Non-network Solution Feasibility Study to provide non-network service providers and interested parties with technical information regarding Powerlink's requirements and for the purpose of inviting information, comment and discussion as part of the "concept" phase of project development. The information received from possible non-network solution providers during the study process supported the replacement of both of the 50/70MVA 132/66kV transformers at Garbutt as the lowest cost solution to address the need and deliver the lowest long run cost to consumers. The findings of the feasibility study were published on Powerlink's website in August 2016[2].

[2] Details of the Non-network Feasibility Study are available on Powerlink's website.

Table 4.4 Possible reinvestment works in the Ross zone within five years

Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Transmission lines					
Line refit works on the coastal 132kV transmission line between Clare South and Townsville South substations	Line refit works on steel lattice structures	Maintain supply reliability in the Ross zone	Summer 2019/20	Line refit works on 132kV transmission line between Townsville South and Invicta, and additional reinforcement at Strathmore. New 132kV transmission line.	$20m
Retirement of the inland 132kV transmission line between Clare South and Townsville South substations	Retirement of the transmission line including non-network support, voltage support or network reconfiguration in the Strathmore area (1) (2)	Maintain supply reliability in the Ross zone	Summer 2019/20	Targeted foundation repair on the 132kV transmission line, followed by line refit or decommissioning in five to 10 years. New 132kV transmission line.	$10m
Line refit works on the 132kV transmission line between Strathmore/ Collinsville North and Clare South substations	Line refit works on steel lattice structures	Maintain supply reliability in the Ross zone	Progressively from Summer 2022/23	Line refit works on 132kV transmission line Strathmore and King Creek, and additional reinforcement at Clare South. New 132kV transmission line.	$45m
Substations					
Dan Gleeson secondary systems replacement	Full replacement of 132kV secondary systems	Maintain supply reliability to the Ross zone	Summer 2019/20	Staged replacement of 132kV secondary systems equipment	$7m
Townsville South	Staged replacement of 132kV primary plant and secondary systems	Maintain supply reliability to the Ross zone	Summer 2021/22	Full replacement of 132kV primary plant and secondary systems	$16m

Note:

(1) Modification and installation of system integrity protection schemes may be required to manage system security during system normal and during outages. The retirement of these transmission lines may also require establishment of an alternate telecommunications network.

(2) Non-network solutions to remain within Powerlink's planning standard may include up to 10MW and 1,000MWh in the Proserpine or Collinsville area.

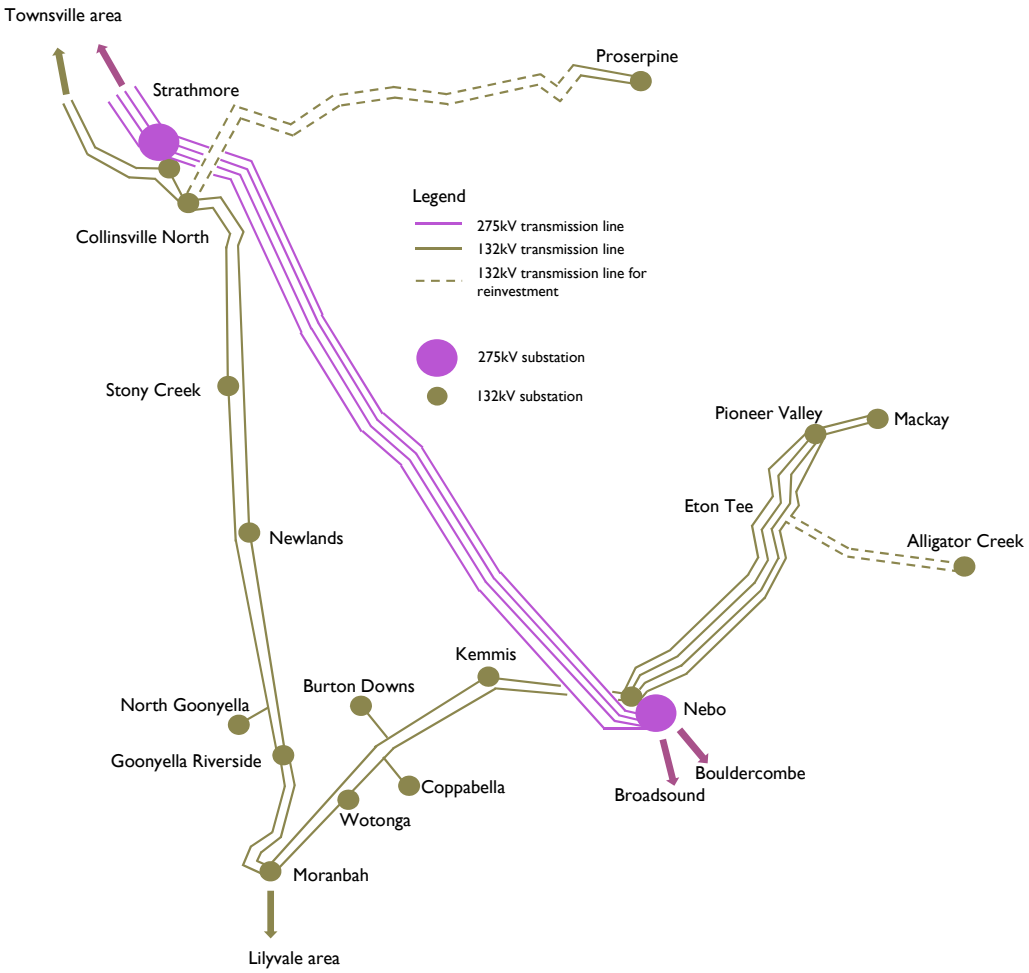
4.2.3 North zone

Existing network

Three 275kV circuits between Nebo (in the south) and Strathmore (in the north) substations form part of the 275kV transmission network supplying the North zone. Double circuit inland and coastal 132kV transmission lines supply regional centres and infrastructure related to mines, coal haulage and ports associated with the Bowen Basin mines (refer to Figure 4.3).

The coastal network in this zone is characterised by transmission line infrastructure in a corrosive environment which make it susceptible to premature ageing.

Figure 4.3 North zone transmission network



Transmission network overview

There are no network limitations forecast to occur in the North zone within the five-year outlook period.

The combination of increasing local demand in the Proserpine area, along with assets in the area reaching the end of their technical life, is expected to lead to some load at risk under Powerlink's planning standard within the five-year outlook period.

The critical contingency is an outage of the 275/132kV Strathmore transformer. Based on the medium economic forecast of this TAPR, this places load at risk of 10MW from summer 2020/21, which is within the 50MW and 600MWh limits established under Powerlink's planning standard (refer to Section 1.7).

Substations

Powerlink's routine program of condition assessments has identified transformer, primary plant and secondary systems assets within the North zone with emerging reliability, safety and obsolescence risks that may require reinvestment within the five-year outlook period. Planning analysis confirms these assets are required to provide ongoing reliable supply and the related investment needs are outlined in Table 4.5.

Table 4.5 Possible reinvestment works in the North zone within five years

Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Substations					
Kemmis 132kV secondary systems replacement	Full replacement of 132kV secondary systems	Maintain supply reliability to the North zone	Summer 2022/23	Staged replacement of 132kV secondary systems equipment	$8m

Supply to Bowen Basin coal mining area

The Bowen Basin area is defined as the area of 132kV supply north of Lilyvale Substation, west of Nebo Substation and south and east of Strathmore Substation.

In August 2013, Powerlink completed a RIT-T consultation to address voltage and thermal limitations[3] forecast to occur in the Bowen Basin coal mining area from summer 2013/14. As part of this process, Powerlink identified the installation of 132kV capacitor banks at Dysart, Newlands, and Moranbah substations, and entered into a non-network arrangement as the preferred option to address the emerging network limitations.

Powerlink has completed the installation of the capacitor banks at Moranbah, Dysart and Newland substations. However, the installation of a second capacitor bank at Moranbah Substation has been deferred in order to optimise project staging with other works planned at the substation (refer to Table 3.1). The Moranbah capacitor bank is expected to be commissioned by summer 2017/18. The non-network agreement that Powerlink entered following completion of the RIT-T process came to an end in December 2016.

There have been several proposals for new coal mining, coal seam gas (CSG) and port expansion projects in the Bowen Basin area whose development status is not yet at the stage that they can be included (either wholly or in part) in the medium economic forecast of this TAPR. These loads could be up to 80MW (refer to Table 2.1) and cause voltage and thermal limitations impacting network reliability. Possible network solutions to these limitations are provided in Section 6.2.1. The timing of any emerging limitations will be subject to commitment of additional demand.

4.2.4 Central West and Gladstone zones

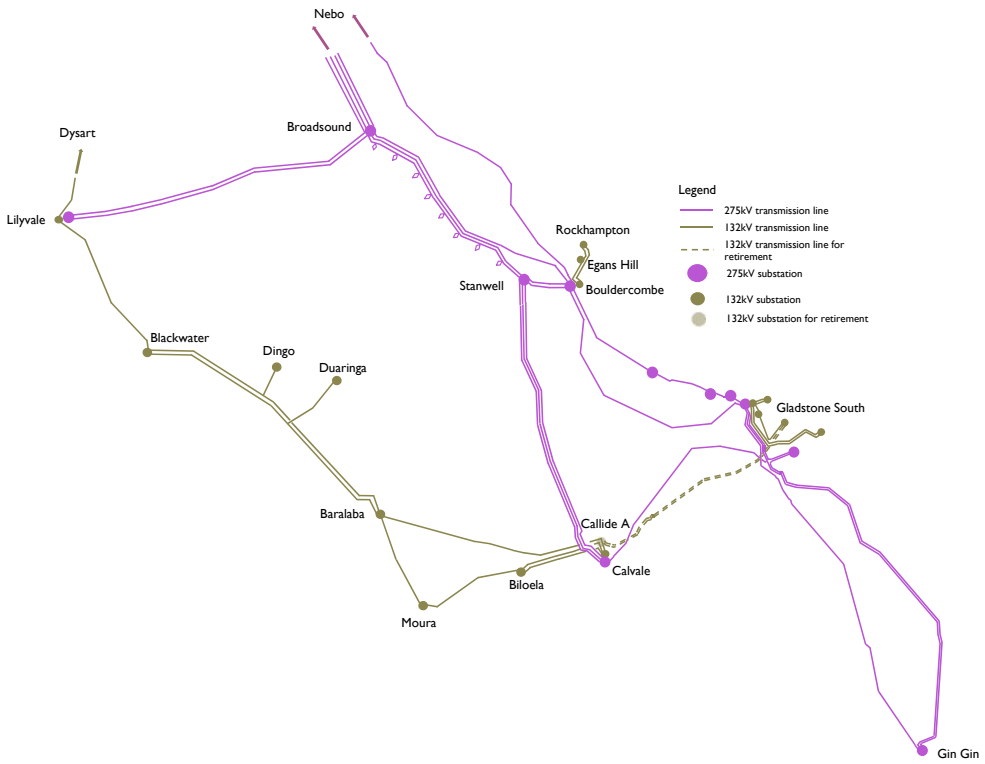
Existing network

The Central West 132kV network was developed between the mid 1960s to late 1970s to meet the evolving requirements of mining activity in the southern Bowen Basin. The 132kV injection points for the network are taken from Calvale and Lilyvale 275kV substations. The network is located more than 150km from the coast in a dry environment making infrastructure less susceptible to corrosion. As a result transmission lines and substations in this region have met (and in many instances exceeded) their anticipated technical life but will require replacement or rebuilding in the near future.

The Gladstone 275kV network was initially developed in the 1970s with the Gladstone Power Station and has evolved over time with the addition of the Wurdong Substation and supply into the Boyne Island smelter in the early 1990s (refer to Figure 4.4).

[3] Details of this consultation and the relevant technical information are available on Powerlink's website Maintaining a Reliable Electricity Supply to the Bowen Basin coal mining area

Figure 4.4 Central West and Gladstone transmission network



Transmission network overview

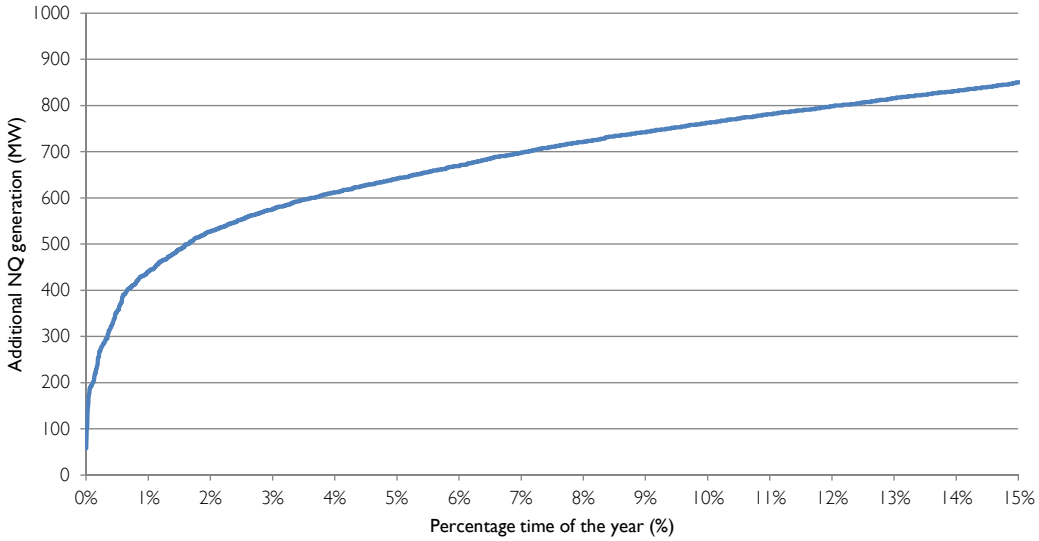
There are no network limitations forecast to occur in the Central West or Gladstone zones within the five-year outlook period.

In the NEM, generators compete for dispatch. Briefly, a generator's dispatch level depends on its bid in relation to other generators' bids, demand and available transmission capacity. Congestion occurs when transmission capacity prevents the optimum economic dispatch. Affected generators are said to be constrained by the amount unable to be economically dispatched. Forecast of constraint durations and levels are sensitive to highly uncertain variables including changes in bidding behaviour, environmental conditions, demand levels, etc. The use of historical conditions can serve to inform possible future outcomes.

Based on historical conditions and information on the expected operation of the committed generation, Powerlink's assessment indicates north and central west generators will continue to operate mostly unconstrained. However, additional generating capacity above committed levels in north or central west Queensland is expected to lead to a rise in congestion on the Gladstone or CQ-SQ grid sections. This will likely result in material constraint durations and levels for generators in north or central west Queensland. There is no load at risk associated with these constraints.

Figure 4.5 shows the percentage of time the Gladstone or CQ-SQ grid section could be congested as a function of the net increase of additional generation in north or central west Queensland above currently committed generation. Although high constraint times may not be indicative of the cost of market impact, they serve as a trigger for the analysis of the economics for overcoming the congestion.

Figure 4.5 Constraint outlook on Gladstone/CQ-SQ grid section for additional (above committed levels) NQ generation (based on 1 April 2016 to 31 March 2017 conditions)



Transmission lines

Egans Hill to Rockhampton 132kV transmission line

Rockhampton is supplied via a 132kV transmission line from Bouldercombe Substation. The section from Egans Hill to Rockhampton was constructed in the early 1960s and there is an ongoing need for this asset to supply the Rockhampton region. A recent condition assessment identified levels of structural corrosion with end of technical or economic life expected to occur within the next five years. Powerlink is proposing to undertake line refit works on the transmission line by around 2018/19.

Callide A to Moura 132kV transmission line

The 132kV transmission line was constructed in the early 1960s and there is an ongoing need for this asset to supply the Biloela and Moura substations. The condition assessment indicates moderate levels of structural corrosion, along with design limitations and degraded condition of the existing foundations, end of technical or economic life is expected to occur within the next five to 10 years. Detailed analysis is underway to evaluate foundation, repair and line refit or a staged replacement of this transmission line progressively from 2020 to 2025.

Callide A to Gladstone South 132kV transmission double circuit line

The 132kV transmission line was constructed in the mid 1960s to support the loads in the Gladstone area. A recent condition assessment identified high levels of structural corrosion with end of technical or economic life expected to occur within the next five years. Planning analysis has identified the possibility of reconfiguring the network in the area to achieve the lowest run cost of the 132kV reinvestment, and it is likely this line will be retired from service at the end of its technical life, expected within the next five to 10 years.

Substations

Powerlink's routine program of condition assessments has identified transformers, primary plant and secondary systems assets within the Central West and Gladstone zone with emerging safety, reliability and obsolescence risks that may require reinvestment within the five-year outlook period.

Powerlink has identified opportunities to reconfigure the network by summer 2018/19 to provide efficiencies and cost savings by:

- reducing the number of transformers within the zone, particularly at Lilyvale and Bouldercombe

- re-arrangement of the 132kV network around Callide A Substation by the establishment of a second transformer at Calvale Substation and retirement of Callide A Substation and the Callide A to Gladstone South transmission line. A committed project is underway to establish a second transformer at Calvale Substation.

The planning analysis also confirms the balance of substation assets are required to provide an ongoing reliable supply and the related investment needs are outlined in Table 4.6.

Table 4.6 Possible replacement works in the Central West and Gladstone zones within five years

Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Transmission lines					
Line refit of the 132kV transmission line between Egans Hill and Rockhampton substations	Line refit works on steel lattice structures	Maintain supply reliability in the Central West zone	Winter 2019	New 132kV transmission line	$18m
Line replacement of the 132kV transmission line between Callide A and Moura substations	Staged replacement of 132kV transmission line between Callide A and Moura substations on a new easement	Maintain supply reliability to Biloela and Moura in the Central West zone	Progressively from 2020	Foundation repair and line refit works	$68m
Substations					
Lilyvale transformers replacement	Replacement of two of the three 132/66kV transformers (1)	Maintain supply reliability in the Central West zone	Winter 2020	Replacement of three 132/66kV transformers. Retire two of three 132/66kV transformers and implement non-network solution. (2)	$10m
Lilyvale primary plant replacement	Staged replacement of 275kV and 132kV primary plant	Maintain supply reliability in the Central West zone	Summer 2020/21	Full replacement of 275/132kV substation	$8m
Bouldercombe primary plant replacement	Staged replacement of 275kV and 132kV primary plant	Maintain supply reliability in the Central West zone	Summer 2020/21	Full replacement of 275/132kV substation	$26m
Bouldercombe transformer replacement	Replacement of one 275/132kV transformer with a larger unit, and retirement of the other	Maintain supply reliability in the Central West zone	Summer 2022/23	Replacement of two 275/132kV transformers	$7m

Note:

(1) Due to the extent of available headroom, the retirement of this transformer does not bring about a need for non-network solutions to avoid or defer load at risk or future network limitations, based on Powerlink's demand forecast outlook.

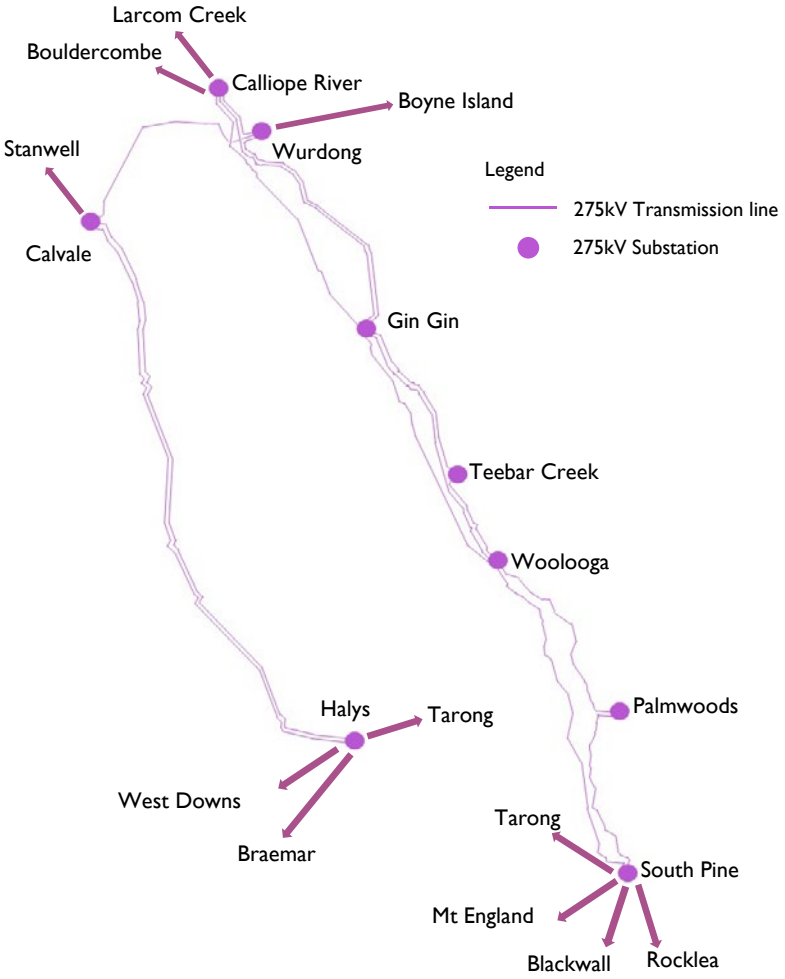
(2) Non-network solutions are not limited to, but may include network support from existing and/or new generation or demand side management initiatives (either from individual providers or aggregators).

4.2.5 Wide Bay zone

Existing network

The Wide Bay zone supplies loads in the Maryborough and Bundaberg region and also forms part of Powerlink's eastern CQ-SQ transmission corridor. This corridor was constructed in the 1970s and 1980s and consists of single circuit 275kV transmission lines between Calliope River and South Pine (refer to Figure 4.6). These transmisison lines traverse a variety of environmental conditions and as a result exhibit different corrosion rates and risk profiles.

Figure 4.6 CQ-SQ transmission network



Transmission network overview

There are no network limitations forecast to occur in the Wide Bay zone within the five-year outlook period.

Substations

Powerlink's routine program of condition assessments has identified primary plant and secondary systems assets within the Wide Bay zone with emerging safety, reliability and obsolescence risks that may require reinvestment within the five-year outlook period. Planning analysis confirms these substation assets are required to provide ongoing reliable supply and the related investment needs are outlined in Table 4.7.

Table 4.7 Possible reinvestment works in the Wide Bay zone within five years

Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Substations					
Gin Gin Substation rebuild	Staged replacement of 275kV and 132kV primary plant	Maintain supply reliability in the Wide Bay zone	Summer 2019/20	Full replacement of 275/132kV substation. In-situ replacement of the 275/132kV substation.	$18m

4.2.6 South West zone

Existing network

The South West zone is defined as the Tarong and Middle Ridge areas west of Postman's Ridge.

Transmission network overview

There are no network limitations forecast to occur within the South west zone within the five-year outlook period.

Substations

Powerlink's routine program of condition assessments has identified primary plant and secondary systems assets within the South West zone with emerging safety, reliability and obsolescence risks that may require reinvestment within the five-year outlook period. Planning analysis confirms these substation assets are required to provide ongoing reliable supply and the related investment needs are outlined in Table 4.8.

Table 4.8 Possible reinvestment works in the South West zone within five years

Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Substations					
Tarong secondary systems replacement	In situ staged replacement of secondary systems equipment	Maintain supply reliability in the South West zone	Summer 2021/22	Full replacement of 275kV secondary systems	$11m

4.2.7 Moreton zone

Existing network

The Moreton zone includes a mix of 110kV and 275kV transmission networks servicing a number of significant load centres in SEQ, including the Sunshine Coast, greater Brisbane, Ipswich and northern Gold Coast regions.

Future investment needs in the Moreton zone are substantially associated with the condition and performance of 110kV and 275kV assets in the greater Brisbane area. The 110kV network in the greater Brisbane area was progressively developed from the early 1960s and 1970s, with the 275kV network being developed and reinforced in response to load growth from the early 1970s. Multiple Powerlink 275/110kV injection points now interconnect with the Energex network to form two 110kV rings supplying the Brisbane CBD.

Transmission network overview

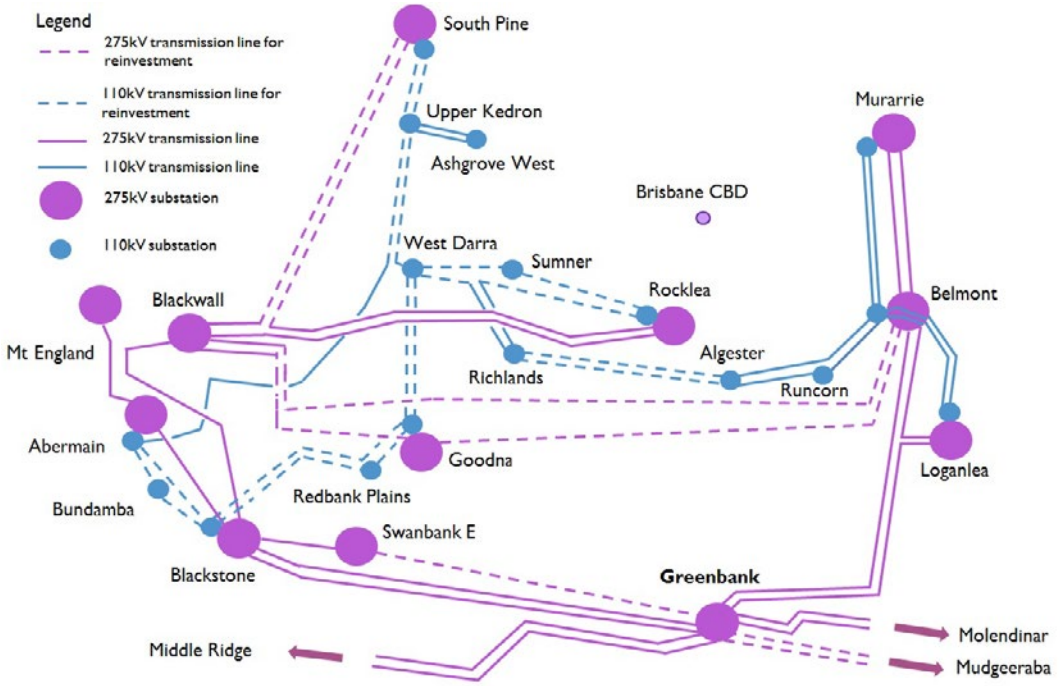
There are no network limitations forecast to occur in the Moreton zone within the five-year outlook period.

4 Future network development

Transmission lines

The 110kV and 275kV transmission lines in the greater Brisbane area are located between 20km and 40km from the coast, traversing a mix of industrial, high density urban and semi-urban areas. The majority of assets are reasonably protected from the prevailing coastal winds and are exposed to moderate levels of pollution related to the urban environment. These assets have, over time, experienced structural corrosion at similar rates, with end of technical or economic life for most transmission line assets expected to occur between 2020 and 2025. Figure 4.7 illustrates the assets that are approaching end of technical or economic life over this period.

Figure 4.7 Greater Brisbane transmission network



With the maximum demand forecast relatively flat in the five-year outlook period, and based on the development of the network over the last 40 years, planning studies have identified a number of 110kV and 275kV transmission line assets that could potentially be retired. Given the uncertainty in future demand growth, Powerlink proposes to implement low cost maintenance strategies to keep the transmission lines in-service for a reasonable period. Future decommissioning remains an option once demand growth is better understood. As such, detailed analysis will be ongoing to evaluate the possible retirement of the following transmission lines at the end of technical or economic life:

- West Darra to Upper Kedron
- West Darra to Goodna
- Richlands to Algester.

This ongoing review, together with further joint planning with Energex, may result in a future investment recommendation in the 2020s and would involve further consultation with impacted parties.

For the balance of transmission line assets with an enduring need, Powerlink is progressively analysing options and is proposing a program of line refit works between winter 2016 and summer 2020/21 as the most cost effective solution to manage the safety and reliability risks associated with these assets remaining in-service.

Substations

Powerlink's routine program of condition assessments has identified transformers, primary plant and secondary systems assets within the Moreton zone with emerging safety, reliability and obsolescence risks that may require reinvestment within the five-year outlook period. Planning analysis confirms these assets are required to provide ongoing reliable supply and the related investment needs are outlined in Table 4.9.

Table 4.9 Possible reinvestment works in the Moreton zone within five years

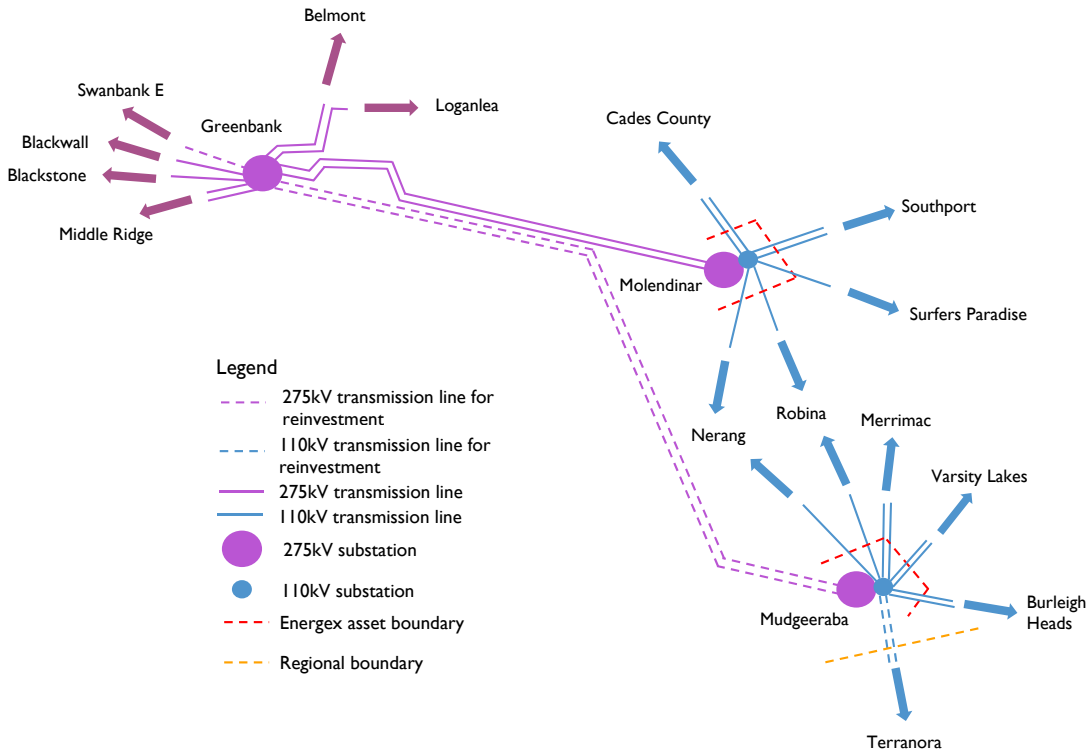
Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Transmission Lines					
Line refit works on 110kV transmission lines between South Pine to Upper Kedron	Line refit works on steel lattice structures	Maintain supply reliability in the CBD and Moreton zone	Summer 2021/22	New 110kV transmission line/s	$9m
Line refit works on 110kV transmission lines between Sumner to West Darra	Line refit works on steel lattice structures	Maintain supply reliability in CBD and Moreton zone	Summer 2021/22	New 110kV transmission line/s	$7m
Line refit works on 110kV transmission lines between Rocklea to Sumner	Line refit works on steel lattice structures	Maintain supply reliability in CBD and Moreton zone	Summer 2021/22	New 110kV transmission line/s	$9m
Line refit works on 275kV transmission lines between South Pine to Karana Tee	Line refit works on steel lattice structures	Maintain supply reliability in the Moreton zone	Summer 2022/23	New 275kV transmission line/s	$19m
Substations					
Ashgrove West Substation replacement	Full replacement of 110kV substation	Maintain supply reliability in the Moreton zone	Summer 2019/20	Staged replacement of 110kV primary plant and secondary systems	$13m
Abermain secondary systems replacement	Full replacement of 110kV secondary systems	Maintain supply reliability in the Moreton zone	Winter 2020	Staged replacement of 110kV secondary systems equipment	$7m
Palmwoods 275kV secondary systems replacement	Full replacement of 275kV secondary systems	Maintain supply reliability in the Moreton zone	Summer 2020/21	Full replacement of 275/132kV substation	$7m
Belmont 275kV secondary system replacement	Full replacement of 275kV secondary systems	Maintain supply reliability in the CBD and Moreton zone	Winter 2021	Staged replacement of 275kV secondary systems equipment	$9m

4.2.8 Gold Coast zone

Existing network

The Powerlink transmission system in the Gold Coast was originally constructed in the 1970s and 1980s. The Molendinar and Mudgeeraba substations are the two major injection points into the area (refer to Figure 4.8) via a double circuit 275kV transmission line between Greenbank and Molendinar substations, and two single circuit 275kV transmission lines between Greenbank and Mudgeeraba substations.

Figure 4.8 Gold Coast transmission network



Transmission network overview

There are no network limitations forecast to occur in the Gold Coast zone within the five-year outlook period.

Transmission lines

Greenbank to Mudgeeraba 275kV transmission lines

The two 275kV single circuit transmission lines were constructed in the mid 1970s and are exposed to high rates of corrosion due to proximity to the coast and the prevailing salt laden coastal winds. The extent of corrosion observed during condition assessments requires that Powerlink consider options for targeted line refit of these lines in the five to 10-year outlook period for continued safe operation. Due to outage impacts of removal of one or both lines, a staged approach will need to be considered. Alternatively a new transmission line would be required beyond the outlook of the TAPR (refer to Section 6.3.4). Planning studies have confirmed the need to preserve the 275kV injection into Mudgeeraba.

Mudgeeraba to Terranora 110kV transmission lines

The 110kV line was constructed in the mid 1970s and forms an essential part of the interconnection between Powerlink and Essential Energy's network in northern New South Wales (NSW), with 13km of the transmission line owned by Powerlink. The transmission line operates in a metropolitan/semi-coastal environment with moderate rates of atmospheric pollution impacting on the life of its galvanised components and is subject to prevailing salt laden coastal winds. Based on Powerlink's most recent condition assessment, line refit or replacement of the 13km transmission line section will be required beyond the five-year outlook period.

Substations

Powerlink's routine program of condition assessments has identified transformers, primary plant and secondary systems assets at Mudgeeraba with emerging safety, reliability and obsolescence risks that may require reinvestment within the five-year outlook period.

The condition of two 275/110kV transformers at Mudgeeraba Substation requires action within the five-year outlook period. A committed project is underway to replace one of these transformers and planning studies have identified the potential to subsequently retire the other transformer. This option is considered feasible under the current demand forecast outlook. However, the reliability and market impacts of this option under a broader range of demand forecast scenarios need to be analysed in further detail and Powerlink anticipates the commencement of a RIT-T consultation (refer to Section 4.4.2).

Planning analysis confirms the balance of assets in this zone are required to provide ongoing reliable supply and the related investment needs are outlined in Table 4.10.

Table 4.10 Possible replacement works in the Gold Coast zone within five years

Potential project	High level scope	Purpose	Possible commissioning date	Alternatives	Indicative cost
Transmission lines					
Targeted line refit works on sections of the 275kV transmission lines between Greenbank and Mudgeeraba substations	Line refit works on steel lattice structures	Maintain supply reliability to the Gold Coast zone	Progressively Summer 2021/22	New 275kV transmission line/s. Full line refit on one or both 275kV single circuit transmission lines.	$20m
Substations					
Retirement of one Mudgeeraba 275/110kV transformer	Retirement of the transformer (1)	Maintain supply reliability to the Gold Coast zone	Summer 2019/20	New 275/110kV transformer	$1.5m
Mudgeeraba 275kV secondary systems replacement	Full replacement of 275kV secondary systems	Maintain supply reliability to the Gold Coast zone	Summer 2021/22	Staged replacement of 275kV secondary systems equipment	$11m

Note:

(1) Due to the extent of available headroom, the retirement of this transformer does not bring about a need for non-network solutions to avoid or defer load at risk or future network limitations, based on Powerlink's demand forecast outlook of the TAPR.

4 Future network development

4.3 Summary of forecast network limitations

There are no network limitations forecast to occur in Queensland within the five-year outlook period.

4.4 Consultations

Network development to meet forecast demand is dependent on the location and capacity of generation developments and the pattern of generation dispatch in the competitive electricity market. Uncertainty about the generation pattern creates uncertainty about the power flows on the network and subsequently, which parts of the network will experience limitations. This uncertainty is a feature of the competitive electricity market and historically has been particularly evident in the Queensland region. Nothwithstanding the discussion in Section 4.2.4, Powerlink has not anticipated any material changes to network power flows which may require any major augmentation driven network development. This is due to a combination of several factors including a relatively flat energy and demand forecast in the five-year outlook period and Powerlink's planning criteria (refer to Chapters 1 and 2).

Proposals for transmission investments over $6 million to address forecast limitations are progressed under the provisions of Clause 5.16.4 of the NER. Accordingly, and where action is considered necessary, Powerlink will:

- notify of anticipated limitations within the timeframe required for action
- seek input, generally via the TAPR, on potential solutions to network limitations which may result in transmission network or non-network investments
- issue detailed information outlining emerging network limitations to assist non-network solutions as possible genuine alternatives to transmission investments to be identified
- consult with AEMO, Registered Participants and interested parties on credible options (network or non-network) to address anticipated constraints
- carry out detailed analysis on credible options that Powerlink may propose to address identified network constraints
- consult with AEMO, Registered Participants and interested parties on all credible options (network and non-network) and the preferred option
- implement the preferred option in the event an investment (network and non-network) is found to satisfy the RIT-T.

Alternatively, transmission investments may be undertaken under the "funded augmentation" provisions of the NER.

It should be noted that the information provided regarding Powerlink's network development plans may change and should therefore be confirmed with Powerlink before any action is taken based on the information contained in this TAPR.

4.4.1 Current consultations – proposed transmission investments

Proposals for transmission investments over $6 million that address limitations are progressed under the provisions of Clause 5.16.4 of the NER. Powerlink carries out separate consultation processes for each proposed new transmission investment by utilising the RIT-T consultation process.

There are currently no consultations underway.

4.4.2 Future consultations – proposed transmission investments

Powerlink anticipates the commencement of a RIT-T consultation for the replacement or removal of the Mudgeeraba 275/110kV transformer during 2018.

4.4.3 Summary of forecast network limitations beyond the five-year outlook period

The timing of forecast network limitations may be influenced by a number of factors such as load growth, industrial developments, new generation, the planning standard and joint planning with other network service providers. As a result of these variants, it is possible for the timing of forecast network limitations identified in a previous year's TAPR to shift beyond the five-year outlook period. However, there were no forecast network limitations identified in Powerlink's transmission network in the 2016 TAPR which fall into this category in 2017.

4.4.4 Connection point proposals

Table 4.11 lists connection works that may be required within the five-year outlook period. Planning of new or augmented connections involves consultation between Powerlink and the connecting party, determination of technical requirements and completion of connection agreements. New connections can result from joint planning with the relevant Distribution Network Service Provider (DNSP) or be initiated by generators or customers.

Table 4.11 Connection point proposals

Potential project	Purpose	Zone	Possible commissioning date
Mt Emerald Wind Farm	New wind farm near Atherton (1)	Far North	Quarter 2 2018
Clare Solar PV	New solar farm near Clare	Ross	Quarter 2 2017
Ross Solar PV	New solar farm near Ross	Ross	Quarter 2 2017
Genex Kidston Hydro/Solar PV	New hydro generator with solar PV near Kidston	Ross	Mid 2019
Whitsunday Solar PV	New solar farm near Strathmore	North	Quarter 1 2018
Hamilton Solar PV	New solar farm near Strathmore	North	Quarter 1 2018
Teebar Solar PV	New solar farm near Teebar Creek	Wide Bay	Quarter 1 2018
Lower Wonga Solar PV	New solar farm near Woolooga	Wide Bay	Quarter 4 2018
Coopers Gap Wind Farm	New wind farm near Halys	South West	Quarter 2 2018
Darling Downs Solar PV	New solar farm near Braemar	Bulli	Quarter 1 2018
Bulli Creek Solar PV	New solar farm near Bulli Creek	Bulli	Mid 2019

Note:

(1) When Powerlink constructs a new line or substation as a non-regulated customer connection (e.g. generator, renewable generator, mine or industrial development), the costs of acquiring easements, constructing and operating the transmission line and/or substation are paid for by the company making the connection request.

4.5 NTNDP alignment

The 2016 NTNDP was published by AEMO in December 2016. The focus of the NTNDP is to provide an independent, strategic view of the efficient development of the National Electricity Market (NEM) transmission network over a 20-year planning horizon.

Modelling for the 2016 NTNDP included as its starting point the completed and committed projects defined in Section 3.2. The NTNDP transmission development analysis was based on the 2016 National Electricity Forecasting Report (NEFR) and focused on assessing the adequacy of the main transmission network to reliably support major power transfers between NEM generation and demand centres (referred to as NTNDP zones).

4 Future network development

The NEFR forecasts slowing maximum demand growth. This is broadly aligned with Powerlink's medium economic forecast in Chapter 2. The slowing forecast maximum demand growth results in fewer network limitations in all regions. In fact, the 2016 NTNDP did not identify any emerging reliability limitations across the main transmission network within the Queensland region due to load growth. However, the NTNDP identified a potential reliability limitation when some Central Queensland black coal generating units are projected to retire in 2021[4] under the generation outlook in the neutral scenario. The Calvale to Wurdong 275kV line is projected to overload under some system normal conditions. The extent of the potential overload, and the economic impact, would depend on any changes to the generation dispatch pattern. This outlook is consistent with Powerlink's expectations under a similar generation scenario.

Consistent with the above, the 2016 NTNDP identified potential economic dispatch limitations across the Central West to Gladstone grid section under the neutral scenario. Again the trigger for this congestion is the retirement of some Central Queensland black coal generating units. As discussed in Section 6.2.5 Powerlink recognised the vulnerability of this grid section to the commitment of renewable generation in North Queensland and in general the dispatch of generation in the Queensland region.

The 2016 NTNDP also identified potential economic dispatch limitations across the South West Queensland and South East Queensland grid section under the neutral scenario. The trigger for this congestion is the retirement of some Central Queensland local black coal generating units and additional new generation in SWQ. The subsequent high power transfers from SWQ to SEQ potentially overload a 275kV circuit between Mt England to South Pine without constraining generation. This outlook is consistent with Powerlink's expectations under similar generation scenarios.

Both the NTNDP and this TAPR acknowledge that asset reinvestment will be the focus within the five-year outlook period and continue in the longer term. Planning for the future network will include optimising the network topology as assets reach the end of their technical and economic life so that the network is best configured to meet current and future needs.

The NTNDP and this TAPR also recognise there is a shift from large-scale, synchronous, centrally dispatched generation towards distributed and intermittent (or variable) non-synchronous generation, connected to the power system through inverter-based technology as the electricity industry transitions to a low carbon future. Transmission networks will increasingly be needed for system support services, such as frequency and voltage support, to maintain a reliable and secure supply.

The 2016 NTNDP projects that Australia's 2030 emissions reductions target[5] will be met mostly by large-scale variable renewable electricity (VRE) generation replacing coal generation as it withdraws from service. Gas powered generation will be required to support intermittent renewable generation unless alternate technologies become cost competitive.

[4] No such retirements have been announced or confirmed as at early June 2017.

[5] Australia committed at the 21st Conference of Parties to reduce greenhouse gas emissions (COP21). The Council of Australian Governments (CoAG) recommended that the NTNDP assume a 26% to 28% of emissions reduction below 2005 levels by 2030.

This energy transformation is likely to impact existing and future transmission needs. Transmission development will be required over the next 20 years to:

- connect up to 22GW of new large-scale wind and solar generation
- integrate this intermittent generation while maintaining a reliable and secure power system.

The transmission network was historically designed to transport electricity from large-scale synchronous generation to load centres located close to major energy reserves. In contrast, renewable generation is expected to connect to the transmission network from more remote areas which have access to high wind and solar resources. These outlying grid sections have been designed to supply only local load and consequently have a lower power transfer capability compared to other parts of the transmission network. For this reason, the specific locations and capacity of large scale renewable generation has the potential to impact the utilisation of grid sections within the Queensland region.

Further, concentration of generation in the same location may cause local transmission congestion due to network limitations. These outcomes will also be influenced by any subsequent withdrawal of thermal synchronous generation. This changing generation mix in the NEM may require new power system infrastructure to provide frequency control and network support services.

Powerlink will proactively monitor this changing outlook for the Queensland region and take into consideration the impact of emerging technologies, withdrawal of gas and coal-fired generation and the integration of VRE in future transmission plans. These plans may include:

- reinvesting in assets to extend their end of technical or economic life
- removing some assets without replacement
- determining optimal sections of the network for new connection (in particular renewable generation) as discussed in detail in Chapter 7
- replacing existing assets with assets of a different type, configuration or capacity or
- non-network solutions.

The NTNDP also presents results of analysis into the need for Network Support and Control Ancillary Services (NSCAS). NSCAS are procured to maintain power system security and reliability, and to maintain or increase the power transfer capabilities of the network. The 2016 NTNDP reported that no NSCAS gaps of any type were identified in the Queensland region over the next five years. However, both the NTNDP and this TAPR reported that operational strategies, including transmission line switching, may be required to manage high voltages under light load conditions in SEQ. AEMO and Powerlink will continue to monitor this situation.

4 Future network development