Powerlink Queensland

Project Assessment Conclusions Report

28 November 2019

Maintaining reliability of supply between Clare South and Townsville South

Document Purpose

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

1. The Rules require Powerlink to carry out forward planning to identify future reliability of supply requirements and consult with interested parties on the proposed solution as part of the Regulatory Investment Test for Transmission (RIT-T). This includes replacement of network assets in addition to augmentations of the transmission network.
2. Powerlink must identify, evaluate and compare network and non-network options (including, but not limited to, generation and demand side management) to identify the '*preferred option*' which can address future network requirements at the lowest net cost to electricity consumers. This assessment compares the net present value (NPV) of all credible options to identify the option that provides the greatest economic benefits to the market.
3. This document contains the results of this evaluation, and a final recommended solution to address the condition-based risks associated with the Clare South to Townsville South Transmission Lines.

Contents

Executive Summary

The 132kV network between Collinsville and Townsville was developed in the 1960s and 1970s to supply mining, commercial and residential loads. A parallel 275kV network was developed more than a decade later to reinforce supply into Townsville and far north Queensland.

The main function of the current 132kV infrastructure between Clare South and Townsville South is to provide connections to Invicta Mill and Clare South substations, and to support power transfers in the area, including from renewable generation. This infrastructure consists of two, 132kV single circuit transmission lines between Clare South Substation and Townsville South Substation, each traversing separate routes. The coastal line was established in 1967, and has a tee connection to Invicta Mill Substation. The inland line, established in 1963, carries critical telecommunications traffic for the transmission network via an optical ground wire. Due to their deteriorating condition, these 132kV transmission lines are now reaching the end of their technical service life.

There is a requirement for Powerlink to address the emerging condition risks on the 132kV Clare South to Townsville South Transmission lines. As the identified need for the proposed investment is to maintain compliance with the reliability and service standards set out in the National Electricity Rules (the Rules), Powerlink's Transmission Authority and applicable regulatory instruments[1], the proposed investment is classified as a 'reliability corrective action'[2].

This Project Assessment Conclusions Report (PACR) represents the final step of the RIT-T process prescribed under the Rules undertaken by Powerlink to address the condition risks arising from the ageing transmission lines between Clare South and Townsville South. It contains the results of the planning investigation and cost benefit analysis of credible options. In accordance with the RIT-T, the credible option that minimises the net present value of costs is recommended for implementation.

A non-credible Base Case was developed against which to compare credible options

Consistent with the December 2018 RIT-T Application Guidelines, the assessment undertaken compares and ranks the net present value of credible options to address the emerging risks to a Base Case. The Base Case is modelled as a non-credible option where the existing condition issues associated with an asset are managed via operational maintenance only, resulting in an increase in risk levels as the condition of the asset deteriorates over time. These increasing risk levels are quantified with a monetary value and added to the ongoing maintenance costs to form the Base Case. The Base Case is then used as a benchmark against which to compare and rank the credible options scoped to offset or mitigate the risks, and to ensure ongoing compliance with applicable regulatory and jurisdictional obligations.

Options considered

Powerlink published a Project Specification Consultation Report (PSCR) in November 2018, and a Project Assessment Draft Report (PADR) in August 2019 with respect to maintaining reliability of supply between Clare South and Townsville South. These documents invited submissions of credible non-network options to replicate the support, in full or in part, that the Clare South to Townsville South transmission lines provide Powerlink in meeting the Rule's and Powerlink's Transmission Authority's reliability obligations on an enduring basis.

Powerlink hosted a webinar for interested stakeholders in March 2019 to share key information contained in the PSCR, later than originally planned due to the unprecedented floods experienced by the Townsville community. The original closing date for PSCR submissions was also extended by one month until 18 April 2019.

Powerlink proposed four credible network options in the PSCR and PADR to address the identified condition driven need on the Clare South to Townsville South transmission lines. Option 1a and Option 1 involve retaining the existing 132kV lines between Clare South and Townsville South substations, utilising two alternative life extension strategies. Options 2 and 3 involve two life extension strategies of the coastal line along with decommissioning of the inland line, as well as the installation of an additional 375MVA transformer at Strathmore.

[1] Electricity Act 1994, Electrical Safety Act 2002 and Electricity Safety Regulation 2013
[2] The Rules clause 5.10.2, Definitions, reliability corrective action

Submissions from Origin Energy and Wilmar Sugar proposing potential non-network solutions were received in response to the publication of the PSCR. Following discussions with the proponents, and detailed analysis of their proposals, it was concluded that the solutions offered were not technically feasible due to their inability to meet the network's fault level and voltage control requirements for the area. As a result, they could not be considered as credible options in the PADR to meet the identified need under this RIT-T (refer Section 4 of this report for further detail).

An additional non-network submission was received from Vena Energy in response to the PADR, which closed on 27 September 2019. While there are some unresolved parameters with the proposed solution, the proposal is assumed to be technically feasible and has been assessed by Powerlink to the extent that it could provide a partial solution to the identified need. This non-network solution has been included as part of the new combined network / non-network options 4 and 5, and the cost benefit analysis in the PACR has been updated to reflect this change (refer Table 1).

All options extend the life of the 132kV network between Clare South and Townsville South through to 2040, at which time the area's 275kV lines are likely to have reached the end of their technical service life, thereby providing an opportunity to review the configuration of the complete network in the area. The six credible options, along with their net present values (NPVs) relative to the Base Case are summarised in Table 1. The absolute NPVs of the Base Case and the options are shown graphically in Figure 1.

Table 1: Summary of credible options

Option	Description	Total cost ($m) 2018/19	NPV relative to Base Case ($m) 2018/19	Ranking
Maintain existing	network topology theme			
Option 1a: 10 year life extension strategy of coastal and inland lines[3]	Repair or replace selected components on the coastal line by December 2021* and inland line by December 2022*****	40.83*	6.76	3
	Repair or replace selected components on the inland line by December 2025†	9.10†		
	Repair or replace selected components on the coastal line by December 2031† and inland line by December 2035†	17.04†		
Option 1: 20 year life extension strategy of coastal and inland lines	Repair or replace at risk components and paint all structures on the coastal line by December 2021,as well as repair/replace selected components on the inland line by December 2022*	54.81*	-6.52	4
	Repair or replace selected components and paint all towers on the inland line by December 2025†	24.87†		

[3] The Base Option contained in the Project Specification Consultation Report was relabelled Option 1a in the Project Assessment Draft Report subsequent to the release of the AER, Application guidelines, Regulatory investment test for transmission, December 2018

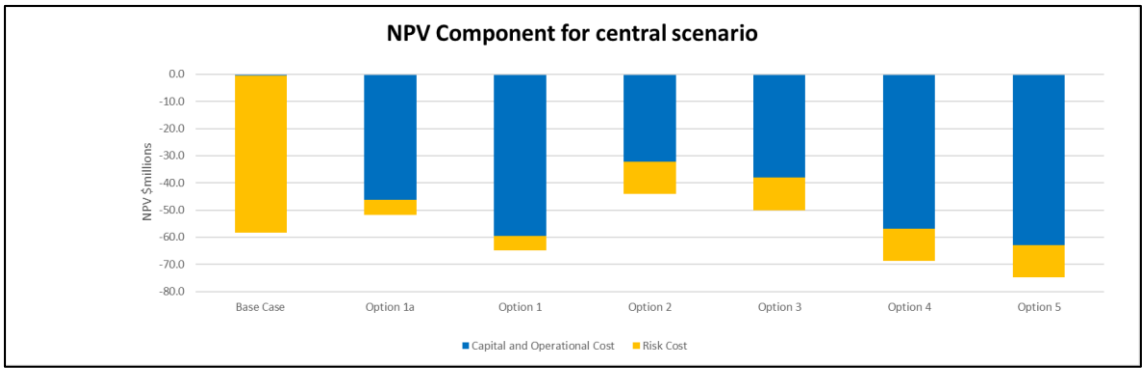
Option	Description	Total cost ($m) 2018/19	NPV relative to Base Case ($m) 2018/19	Ranking
Reconfigure network topology theme				
Option 2: 10 year life extension strategy of coastal line with network reconfiguration	Repair or replace selected components on the coastal line, and install a new transformer at Strathmore by December 2021*	28.34*	14.49	1
	Decommission the inland line by December 2022∞	8.22∞		
	Repair or replace selected components on the coastal line by December 2031†	8.43†		
Option 3: 20 year life extension strategy of coastal line with network reconfiguration	Repair or replace at risk components and paint all structures on the coastal line and install a new transformer at Strathmore by December 2021*	42.32*	8.46	2
	Decommission the inland line by December 2022∞	8.22∞		
Option 4 10 year life extension strategy of coastal line with network reconfiguration and non-network solution	Repair or replace selected components on the coastal line by December 2021*, and operate a non-network "Grid Firming Facility" at Collinsville from December 2021 to December 2026	Confidential~	-10.21	5
	Decommission the inland line by December 2022∞	8.22∞		
	Install a new transformer at Strathmore by December 2026*	14.53†		
	Repair or replace selected components on the coastal line by December 2031†	8.43†		
Option 5 20 year life extension strategy of coastal line with network reconfiguration and non-network solution	Repair or replace at risk components and paint all towers on the coastal line by December 2021* and operate a non-network "Grid Firming Facility" at Collinsville from December 2021 to December 2026	Confidential~	-16.25	6
	Decommission the inland line by December 2022∞	8.22∞		
	Install a new transformer at Strathmore by December 2026*	14.53†		

* Proposed RIT-T project
† Modelled capital project
∞ Operational project
~ Includes commercially sensitive costs, the details of which have been excluded to maintain confidentiality at the request of the non-network proponent

It should be noted that the options described in Table 1 result in different network configurations by December 2022. Options 1a and 1 maintain the existing network topology, while Options 2, 3, 4 and 5 result in the existing inland line being decommissioned.

All options and their resulting network configurations, continue to meet system standards and provide the required services, to the Townsville South, Clare and Proserpine areas.

Figure 1: NPV of Base Case and Options ($m, 2018/19)



Note: Capital and operational costs have been combined to maintain confidentiality with the non-network proponent

Figure 1 shows the breakdown of the absolute NPV of the Base Case and the six credible options calculated over a 20 year analysis period. The Base Case and options all have a negative NPV. All options reduce the risk costs arising from the ageing and obsolete assets remaining in service (as occurs in the Base Case) with Options 1a, 2 and 3 resulting in a net economic benefit when compared to the Base Case. The remaining options, Option 1 and the combined network / non-network Options 4 and 5, were found to be less cost effective than the preferred network option, Option 2.

Taking into account capital, operational maintenance and risk costs, Option 2 delivers the greatest net economic benefit, providing a $14.49 million reduction in the overall costs in NPV terms when compared to the Base Case over the 20 year analysis period.

Evaluation and conclusion

The RIT-T requires that the proposed preferred option maximises the present value of net economic benefit, or for a reliability corrective action minimises the cost, to all those who produce, consume and transport electricity in the market. In accordance with the RIT-T process, the PADR published in August 2019 made a draft recommendation to implement Option 2 as it:

- satisfies the RIT-T based on the cost benefit analysis (i.e. lowest cost in NPV terms with consideration for estimating accuracy)
- reduces the risk to supply and public safety arising from the inland line remaining in service beyond December 2022
- optimises the life of the coastal line while maintaining system strength and stability
- allows Powerlink to maintain compliance with the Rules, Powerlink's Transmission Authority and applicable regulatory instruments, ensuring reliability of supply and service standards are maintained for customers.

Option 2 involves the repair or replacement of selected components on the coastal 132kV line from Clare South to Townsville South, and the installation of a new 375MVA 132/275kV transformer at Strathmore by December 2021, with a separate operational project to decommission the inland line by December 2022.

The indicative capital cost of the RIT-T project for the preferred option is $28.34 million in 2018/19 prices and it delivers a $14.49 million net economic benefit in NPV terms relative to the Base Case. Under this option, design will commence in late 2019 and construction in early 2020. Installation of the new transformer at Strathmore and the life extension of the coastal transmission line will be completed by December 2021.

As the outcomes of the economic analysis contained in this PACR remain unchanged from those published in the PADR, the draft recommendation has been adopted without change as the final recommendation, and will now be implemented.

1. Introduction

This Project Assessment Conclusions Report (PACR) represents the final step of the RIT-T process[4] prescribed under the National Electricity Rules (the Rules) undertaken by Powerlink to address the condition risks arising from the ageing transmission lines between Clare South and Townsville South. It follows the publication of the Project Specification Consultation Report (PSCR) and the Project Assessment Draft Report (PADR) in November 2018 and August 2019 respectively.

The Project Specification Consultation Report (PSCR):

- described the identified need that Powerlink is seeking to address, together with the assumptions used in identifying this need
- set out the technical characteristics that a non-network option would be required to deliver in order to address the identified need
- described the credible options that Powerlink considered may address the identified need
- discussed specific categories of market benefit that in the case of this RIT-T assessment are unlikely to be material
- invited submissions and comments, in response to the PSCR and the credible options presented, from Registered Participants, The Australian Energy Market Operator (AEMO), potential non-network providers and any other interested parties.

The Project Assessment Draft Report (PADR):

- described the identified need that Powerlink is seeking to address, together with the assumptions used in identifying this need
- described the credible options that Powerlink considered may address the identified need
- analysed the submissions received in response to the PSCR and in consultation with the proponents concluded they were unable to meet the technical requirements of the network
- discussed why Powerlink does not expect certain classes of market benefits to be material for this RIT-T[5]
- presented the Net Present Value (NPV) economic assessment of each of the credible options (as well as the methodologies and assumptions underlying these results) and identified the preferred option.
- invited submissions and comments from Registered Participants, AEMO, potential non-network providers and other interested parties in response to the PADR.

Powerlink identified Option 2, the repair or replacement of selected components on the coastal 132kV line from Clare South to Townsville South, and the installation of a new 375MVA 132/275kV transformer at Strathmore by December 2021 as the preferred option to address the identified need. The indicative capital cost of the RIT-T project for the preferred option is $28.34 million in 2018/19 prices.

Powerlink is now undertaking the final stage of the RIT-T process and is publishing this PACR, which:

- describes the identified need and the credible options that Powerlink considers address the identified need
- discusses the consultation process followed for this RIT-T
- provides a quantification of costs and reasons why specific classes of market benefit are not material for the purposes of this RIT-T assessment
- provides the results of the net present value (NPV) analysis for each credible option assessed, together with accompanying explanatory statements

[4] This RIT-T consultation was commenced in September 2018 and has been prepared based on the following documents: *National Electricity Rules, Version 112*, 18 September 2018 and AER, *Final Regulatory Investment Test for Transmission Application Guidelines*, September 2017.
[5] As required by clause 5.16.1(c)(iv) of the Rules.

- identifies the preferred option for investment by Powerlink and details the technical characteristics and proposed commissioning date of the preferred option.

2. Customer and stakeholder engagement

Delivering electricity to almost four million Queenslanders, Powerlink recognises the importance of engaging with a diverse range of customers and stakeholders who have the potential to affect, or be affected by, Powerlink's activities and/or investments.

2.1 Powerlink takes a proactive approach to engagement

Powerlink regularly hosts a range of engagement forums and webinars, sharing information with customers and stakeholders in the broader community. These engagement activities help inform the future development of the transmission network and assist Powerlink in providing services that align with the long-term interests of customers. Feedback from these activities is also incorporated into a number of publicly available reports.

2.2 Working collaboratively with Powerlink's Customer Panel

Powerlink's Customer Panel provides a face-to-face opportunity for customers and consumer representative bodies to give their input and feedback about Powerlink's decision making processes and methodologies. It also provides Powerlink with a valuable avenue to keep customers and stakeholders better informed, and to receive feedback about topics of relevance, including RIT-Ts.

The Customer Panel is regularly advised on the publication of Powerlink's RIT-T documents and briefed quarterly on the status of current RIT-T consultations, as well as upcoming RIT-Ts. This provides an ongoing opportunity for the Customer Panel to ask questions and provide feedback to further inform RIT-Ts, and for Powerlink to better understand the views of customers when undertaking the RIT-T consultation process.

2.3 Transmission Annual Planning Report – the initial stage of formal public consultation

Powerlink utilises its Transmission Annual Planning Report (TAPR) as a primary vehicle to engage and understand broader consumer, customer and industry views on key topics as part of the annual Transmission Network Forum (TNF) and to inform its business network and non-network planning objectives. TNF participants encompass a diverse range of stakeholders including customers, landholders, environmental groups, Traditional Owners, government agencies, and industry bodies.

2.4 RIT-T Engagement

Powerlink identified in its TAPRs from 2015 to 2019, an expectation that action would be required on the Clare South to Townsville South transmission lines to maintain transfer capabilities and reliability of supply in the southern Ross transmission zone[6]. The 2018 TAPR also highlighted that Powerlink anticipated the commencement of a RIT-T within the next 12 months, while the 2019 TAPR reflects that the RIT-T is in progress.

Members of Powerlink's Non-network Engagement Stakeholder Register (NNESR) were directly advised of the publication of the TAPR and the accompanying compendium of potential non-network solution opportunities (Appendix F), which set out the indicative non-network requirements to meet the identified need between Clare South and Townsville South.

In April 2017, Powerlink held an engagement forum in Townsville with regional area stakeholders to discuss and gather strategic input on local issues and other factors to consider when planning transmission reinvestments in north Queensland. Matters raised by forum participants included:

- focussing on reliability and cost for customers and stakeholders when considering reinvestment or reconfiguration of the transmission network

[6] This relates to the standard geographic definitions (zones) identified within the TAPR.

- the importance of network resilience and that any future strategy should preserve the operating capability of the transmission network, particularly given the challenge of the area's exposure to significant weather events
- other challenges specific to the area such as the increased high level of penetration of renewables, new or potential expansion of existing customer loads and the operating capability of the network, in particular system security, power quality, quality of supply and availability
- the potential to achieve mutually beneficial outcomes when developing future strategies for the transmission network through wider collaboration with generators and industry
- the opportunity for Powerlink to improve engagement practices to be better informed on regional stakeholder needs.

Powerlink has taken these matters into consideration as part of the development of the credible options presented in the RIT-T documents by:

- focussing on maximising value for customers
- optimising the use of existing assets
- ensuring the transmission network provides the most value and flexibility for our stakeholders moving forward.

The Customer Panel was advised of the upcoming RIT-T consultation for the North Queensland transmission lines between Clare South and Townsville South in September 2018.

A webinar on the PSCR was held for interested parties on 25 March 2019 to discuss the details of the RIT-T process, the credible options currently under consideration and to invite submissions from non-network proponents. Following the webinar, further discussions were held with two parties who subsequently made submissions on possible non-network solutions.

Powerlink's webpage includes copies of all submissions received as well as the consultation documentation.

2.5 Powerlink applies a consistent approach to the RIT-T stakeholder engagement process

Powerlink undertakes a considered and consistent approach to ensure an appropriate level of stakeholder engagement is undertaken for each individual RIT-T. Please visit Powerlink's website for detailed information on the types of engagement activities that may be undertaken during the consultation process. These activities focus on enhancing the value and outcomes of the RIT-T process for customers, stakeholders and non-network providers. Powerlink welcomes feedback from all stakeholders to further improve the RIT-T stakeholder engagement process.

3. Identified need

To maintain compliance with the reliability and service standards set out in the Electricity Act 1994[7], Powerlink's Transmission Authority[8] , the Rules[9], and applicable regulatory instruments[10], Powerlink must address the emerging condition risks on the 132kV Clare South to Townsville South transmission lines.

3.1 Geographical and network overview

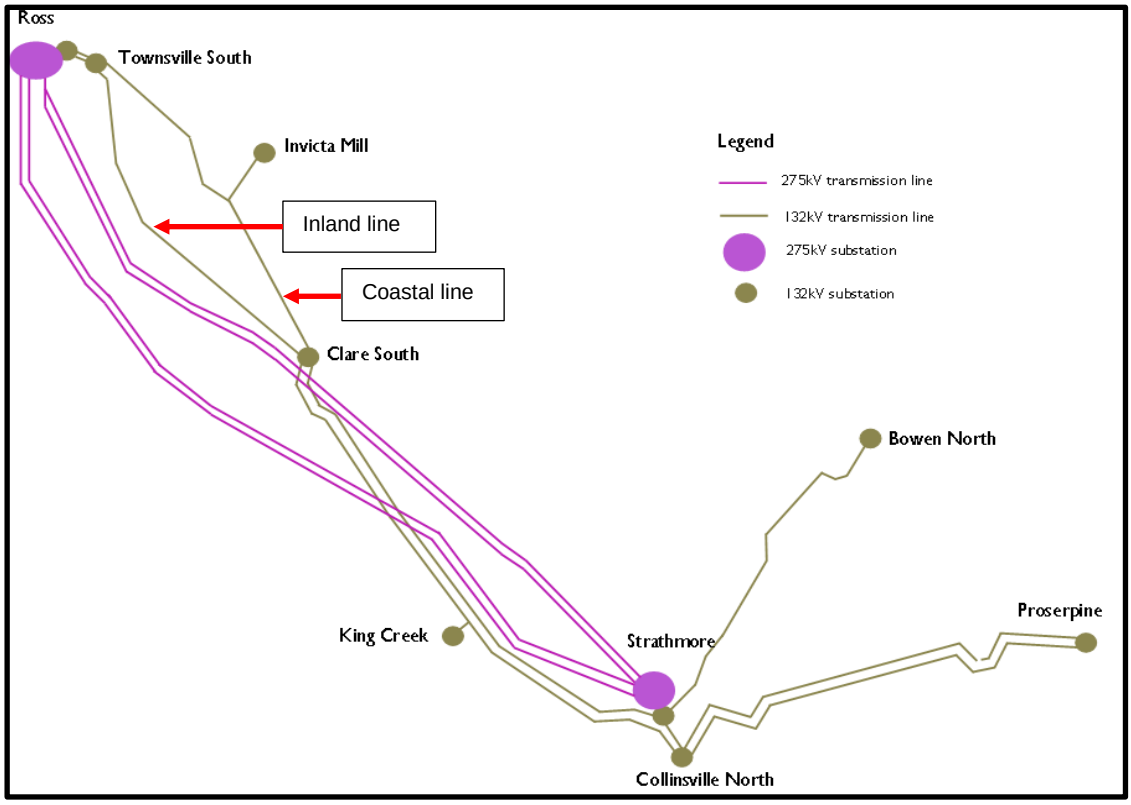
Two 132kV single circuit transmission lines exist between Clare South Substation and Townsville South Substation, each traversing separate geographical routes. The two lines consist of 407 structures with a combined route length of around 135 kilometres, and form part of the Southern Ross transmission network in the Ross transmission zone[11]. The original 132kV transmission network has since been reinforced by a 275kV network.

[7] Electricity Act 1994, Chapter 2, Part 4, S34(1)(a)
[8] Queensland Transmission Authority T01/98, section 6.2
[9] The Rules Schedule 5.1a and Schedule 5.1.
[10] The Rules, Chapter 10, Glossary, Applicable regulatory Instruments (5) Queensland
[11] This relates to the standard geographic definitions (zones) identified within the Powerlink's Transmission Annual Planning Report, (TAPR) which is published annually by 30 June.

The coastal circuit was established in 1967, has a tee connection to Invicta Mill Substation and traverses the Haughton and Burdekin catchments. Sugar cane farming dominates the southern portion of the line while the northern section crosses the Bowling Green National Park and Sister Mountains.

The inland circuit, established in 1963, carries critical telecommunications traffic for the transmission network via an optical ground wire (OPGW) and traverses the Burdekin, Ross and Haughton catchments, with land use dominated by improved pastures, dry land cattle grazing and sugar cane.

Figure 3.1: Southern Ross zone transmission network



3.2 Description of asset condition and risks

The 132kV Clare South to Townsville South transmission lines were commissioned in 1963 and 1967 to help service a growing need for electricity supply in far north Queensland. The transmission lines are located in a tropical environment, with the coastal line also subject to the influence of salt-laden easterly winds.

Advanced corrosion to the grillage foundations of the inland line has resulted in significant loss of underground metal, adversely impacting the structural integrity of the transmission towers. This has elevated the risk of tower failure (including the likelihood of cascading effects on adjacent structures) particularly in cyclonic and storm conditions. A small number of foundations on this line have already had remedial micro-piling work completed to help mitigate the emerging risks.

While the major risk on the inland line is failure of the grillage tower foundations, the tower nuts and bolts are also exhibiting degradation, with advanced corrosion resulting in loss of steel cross section and strength predicted by 2022.

On the coastal line, the sacrificial galvanised coating on several low lying foundation interfaces have completely broken down, exposing the underlying steel to the environment. If not addressed, this exposed steel will corrode at an accelerated rate, losing cross-sectional area and structural strength. This ultimately makes the foundation interfaces far more susceptible to failure during cyclonic wind conditions. The line is also displaying higher levels of advanced corrosion to cross-arm-tips and hanger brackets, as well as the nuts and bolts on the tower superstructures and main bodies.

The current insulator mounting arrangement on the lines do not satisfy revised standards for tower attachment, which are being progressively implemented to reduce the susceptibility to failure in cyclonic wind conditions. A decoupling of an insulator can lead to a conductor drop with a resultant transmission failure and high risk safety consequences. Climbing step bolts are also exhibiting corrosion on both circuits and fail to meet current requirements as an attachment point for fall arrest devices.

In addition, the overhead earth wire (OHEW) along the coastal circuit is exhibiting corrosion, which reduces the wire's strength and increases the risk of failure.

The consequence of not addressing these condition-based risks is that the asset condition will continue to decline at an accelerated rate. In the short term, this leads to additional works to rectify the condition and address the resulting risks. Under the worst case scenario, components of the asset will ultimately fail presenting serious risk to public safety and network reliability.

Appendix 1 details the key electrical safety legislation, in addition to the Electrical Act 1994, governing the need to address the condition of the 132kV transmission lines between Clare South and Townsville South, and provides further detail on the main at-risk components and the consequences of their failure.

3.3 Reliability and service standards

With peak demand forecast to remain steady in the area for the next ten years[12], it is vital that supply is maintained to satisfy this demand, and for Powerlink to meet its reliability of supply obligations under the Electricity Act 1994, it's Transmission Authority and the Rules.

Under the Electricity Act 1994, Powerlink is required to "operate, maintain (including repair and replace if necessary) and protect its transmission grid to ensure the adequate, economic reliable and safe transmission of electricity"[13]. The condition of the 132kV transmission lines between Clare South and Townsville South requires Powerlink to take action to either repair, replace or remove these lines, while taking into consideration the enduring need for the services they provide, to ensure compliance with the Electricity Act 1994.

Powerlink's Transmission Authority requires it to plan and develop the transmission network "in accordance with good electricity industry practice, having regard to the value that end users of electricity place on the quality and reliability of electricity services". It allows load to be interrupted during a critical single network contingency, provided:

> *"the power transfer available through the power system will be such that the forecast of electricity that is not able to be supplied during the most critical single network element outage will not exceed:*
>
> *(i) 50 megawatts at any one time; or*
>
> *(ii) 600 megawatt-hours in aggregate."*[14]

Planning studies have confirmed an enduring demand for transmission services from customers in the area, as well as an ongoing requirement to provide supply to Townsville South, and voltage support to Strathmore for an outage of the single 275/132kV transformer at Strathmore or the 132kV line between Strathmore and Collinsville South Substations.

In order to continue to meet the reliability standard within Powerlink's Transmission Authority, the services currently provided by the Clare South to Townsville South 132kV transmission lines are required for the foreseeable future to meet ongoing customer requirements.

3.3.1 Impact of line removal on reliability and service standards

Removal of both 132kV feeders between Clare South and Townsville South (without any network changes or a non-network solution) will result in Powerlink being unable to comply with the following Rules and Transmission Authority requirements.

The power system must be able to be operated in a satisfactory state, as defined in the Rules 4.2.2(b), (c) and (d). Failure to do so would result in non-compliance with the Rules S5.1.12.

[12] Powerlink Transmission Annual Planning Report 2019
[13] .Electricity Act 1994, Chapter 2, Part 4, S34(1)(a)
[14] Transmission Authority No. T01/98, section 6.2(c)

The power system must also be able to be operated in a secure operating state, as defined in the Rules 4.2.4. Failure to do so would result in non-compliance with the Rules S5.1.12.

The load shedding required to comply with S5.1.12 even before a credible contingency in this scenario would result in breaches of Powerlink's Transmission Authority T01/98 clause 6.2 (c).

If one of the two 132kV feeders between Clare South and Townsville South is retained (without any network changes or a non-network solution) Powerlink will still be unable to comply with certain Rules and Transmission Authority requirements as detailed below.

Following a credible contingency event the power system must be able to land in a satisfactory operating state (as defined in the Rules 4.2.2(b), (c) and (d)). Consequently, load shedding would be required following the credible contingency to ensure that the system is able to be operated without breaching the following clauses of the Rules:

- S5.1.5 – Voltage fluctuations. Under outage conditions, the voltage fluctuations may exceed the levels stipulated in accordance with the provisions of clause S5.1a.5 of the system standards.
- S5.1.4 – Magnitude of power frequency voltage. The system must be operated such that voltages are between 95% and 105% of the target voltage, except in the case of a credible contingency event. Following a credible contingency event, the voltage can fall to zero (0) for any period, however within 30 minutes the network must be restored so as to restore a secure operating state.

The load shedding required to comply with S5.1.5 and S5.1.4 would result in breaches of Powerlink's Transmission Authority T01/98 clause 6.2 (c).

In addition, the inland line carries an OPGW to provide critical telecommunications for the high voltage transmission network control and protection systems, which if removed without replacement would breach AEMO's Power System Data Communication Standard and Power System Security Guidelines.

3.4 Summary of Compliance Obligations

Due to the condition of the 132kV Clare South to Townsville South transmission lines, Powerlink is obligated to take corrective action to continue to meet safety, reliability and service standard obligations under key electrical safety legislation (see Appendix 1), the Rules and its Transmission Authority. Safety obligations could theoretically be met by removing the transmission lines from service, however, to ensure Powerlink remains compliant with the Rules and its Transmission Authority, the action taken must ensure the services provided by the 132kV Clare South to Townsville South lines are replicated either by credible network or non-network options.

Removal of both or either one of the 132kV transmission lines, without additional network investment or a non-network solution, is not a technically feasible option.

4. Submissions received

Powerlink published a PSCR in November 2018 seeking submissions from Registered Participants, the Australian Energy Market Operator (AEMO) and interested parties on the credible options presented. It also sought submissions on any alternative credible network and non-network options that could replicate some or all of the support that the Clare South to Townsville South transmission lines provides Powerlink in meeting the Rule's reliability obligations on an enduring basis. Due to the unprecedented floods experienced by the Townsville community in early 2019, the original closing date for submissions on the PSCR was extended by one month to 18 April 2019.

Two submissions, from Origin Energy and Wilmar Sugar, were received in response to the PSCR request for network support options to enable the inland line to be removed. Both options were evaluated against the technical requirements of the network, following removal of the inland line with the results published in the PADR.

An additional submission was received from Vena Energy following the publication of the PADR. Summaries of all three proposals and their evaluation are given below.

4.1 Origin Energy Proposal

Origin Energy submitted a non-network solution consisting of three generating units connected to the 132kV network in the Townsville area.

4.1.1 Origin Energy Proposal Evaluation

For the removal of the Clare South to Townsville South 132kV inland circuit the generation proposed by Origin Energy was unable to meet the 10MW supply requirement in the Proserpine, Clare or Collinsville area, or restore the fault level (system strength) to that prior to the removal of the inland circuit. Similarly, the plant is not able to provide the same level of voltage control that the inland circuit provides. This is after accounting for all three generating units operating at the proponent's site.

It was concluded that the proposed generation solution offered was not technically feasible due to its inability to meet the network's supply, fault level or voltage control requirements for the area. As a result, it was not considered as a credible option to meet the identified need under this RIT-T.

4.2 Wilmar Sugar Proposal

Wilmar Sugar submitted a non-network solution consisting of two generating units connected to the Energy Queensland 66kV network out of Clare South.

4.2.1 Wilmar Sugar Proposal Evaluation

Wilmar Sugar's initial submission involved the use of one generator in the Clare region to provide network support. While Wilmar Sugar's generator is able to meet the supply requirement by being able to provide greater than 10MW in the Proserpine, Clare or Collinsville area, the offer does not meet the criteria to be considered a feasible non-network solution due largely to the impedance of the 66kV network between the proponent's location and Clare South. For the removal of the Clare South to Townsville South 132kV inland circuit, the proposed generator is not able to restore the fault level to that prior to the removal of the inland circuit. Similarly, the generator is not able to provide the same level of voltage control that the inland circuit provides.

The proposal was subsequently revised to include consideration of a second unit operating as a synchronous condenser. With both machines in service, there is an improvement to the fault level and the 132kV voltage at Clare South, however it is not sufficient to address the limitation.

It was concluded that the proposed generation solution offered was not technically feasible due to its inability to meet the network's fault level and voltage control requirements for the area. As a result, it was not considered as a credible option to meet the identified need under this RIT-T.

4.3 Vena Energy Proposal

Vena Energy submitted a non-network proposal for a grid firming facility to be connected at its site in Collinsville.

4.3.1 Vena Energy Proposal Evaluation

Vena Energy's submission proposed the establishment of a "Grid Firming Facility" at its site in Collinsville, connected via a short transmission line to Powerlink's 132kV Collinsville North Substation. The "Grid Firming Facility" would incorporate diesel power generation and a Battery Energy Storage System to be commissioned by 2021.

The technical parameters of this non-network proposal have not yet been fully tested and resolved. However, the proposal is assumed to be technically feasible and has been assessed by Powerlink to the extent that it could provide a partial solution to the identified need, deferring by five years the requirement to install a second transformer at Strathmore Substation, as proposed in Options 2 and 3. The provision of a "Grid Firming Facility", as proposed by Vena Energy, has now been included as part of two new combined network / non-network Options 4 and 5. As a result, and subsequent to the publication of the PADR, the cost benefit analysis has been updated in the PACR to reflect this change.

5. Potential credible options to address the identified need

Subsequent to the Vena Energy non-network proposal, as discussed in section 4, Powerlink has developed six credible options under two main themes to address the identified need for maintaining the reliability of supply between Clare South and Townsville South. All options extend the life of the 132kV line(s) through to 2040, at which time the area's 275kV lines are likely to have reached their end of technical service life, thereby providing an opportunity to review the configuration of the wider network in the area.

Theme 1: Maintain existing network topology

Theme 1 involves retaining the existing lines between Clare South and Townsville South substations, with the formulation of two alternative life extension strategies.

- Option 1a: 10 year life extensions of coastal and inland lines.
- Option 1: 20 year life extension of coastal and inland lines.

Theme 2: Reconfigure network topology

Theme 2 involves two life extension strategies of the coastal line along with decommissioning of the inland line[15]. Removal of the inland line requires reconfiguration of the network to maintain system reliability, system strength and voltage control.

- Option 2: 10 year life extension of the coastal line with network reconfiguration including an additional transformer at Strathmore.
- Option 3: 20 year life extension of the coastal line with network reconfiguration including an additional transformer at Strathmore.
- Option 4: 10 year life extension of the coastal line with network reconfiguration, including the operation of a 5 year non-network "Grid Firming Facility" at Collinsville, followed by an additional transformer at Strathmore in 2026.
- Option 5: 20 year life extension of the coastal line with network reconfiguration, including the operation of a 5 year non-network "Grid Firming Facility" at Collinsville, followed by an additional transformer at Strathmore in 2026.

Under Options 2 and 3, system reliability, system strength and voltage control are maintained through the addition of a transformer at Strathmore Substation in 2021, while installation of the transformer is delayed until 2026 under Options 4 and 5.

[15] The inland circuit was selected for decommissioning based upon the additional costs to remediate the advanced degradation of its foundations, along with the need to provide a continuing connection to Invicta Mill via the coastal circuit for both the supply and export of electricity over the network.

Table 5.1: Summary of Credible Options

Option	Description	Indicative cost ($million, 2018/19)	Indicative annual O&M costs ($million, 2018/19)
Maintain existing network topology theme			
Option 1a: 10 year life extension strategy of coastal and inland lines	Repair or replace selected components on the coastal line by December 2021* and the inland line by December 2022*	40.83*	0.21
	Repair or replace selected components on the inland line by December 2025†	9.10†	
	Repair or replace selected components on the coastal line by December 2031† and the inland line by December 2035†	17.04†	
Option 1: 20 year life extension strategy of coastal and inland lines	Repair or replace at risk components and paint all towers on the coastal line by December 2021, as well as repair or replace selected components on the inland line by December 2022*	54.81*	0.11
	Repair or replace selected components and paint all towers on the inland line by December 2025†	24.87†	
Reconfigure network topology theme			
Option 2: 10 year life extension strategy of coastal line with network reconfiguration	Repair or replace selected components on the coastal line, and install a new transformer at Strathmore by December 2021*	28.34*	0.14
	Decommission the inland line by December 2022∞	8.22∞	
	Repair or replace selected components on the coastal line by December 2031†	8.43†	
Option 3: 20 year life extension strategy of coastal line with network reconfiguration	Repair or replace at risk components and paint all towers on the coastal line and install a new transformer at Strathmore by December 2021*	42.32*	0.08
	Decommission the inland line by December 2022∞	8.22∞	

Option	Description	Indicative cost ($million, 2018/19)	Indicative annual O&M costs ($million, 2018/19)
Option 4 10 year life extension strategy of coastal line with network reconfiguration and non-network solution	Repair or replace selected components on the coastal line by December 2021*, and operate a non-network "Grid Firming Facility" at Collinsville from December 2021 to December 2026	Confidential ~	
	Decommission the inland line by December 2022∞	8.22∞	
	Install a new transformer at Strathmore by December 2026*	14.53*	
	Repair or replace selected components on the coastal line by December 2031†	8.43†	
Option 5 20 year life extension strategy of coastal line with network reconfiguration and non-network solution	Repair or replace at risk components and paint all towers on the coastal line by December 2021*, and operate a non-network "Grid Firming Facility" at Collinsville from December 2021 to December 2026	Confidential ~	
	Decommission the inland line by December 2022∞	8.22∞	
	Install a new transformer at Strathmore by December 2026*	14.53*	

* Proposed RIT-T project
† Modelled capital project
∞ Operational project
~ Includes commercially sensitive costs, the details of which have been excluded to maintain confidentiality at the request of the non-network proponent

The work to be committed under each option as a result of this RIT-T is identified as a 'proposed RIT-T project'; whilst future planned projects included in the economic analysis to provide a complete view of the options are identified as 'modelled capital projects' and 'operational projects'.

All of the credible options address the major risks resulting from the deteriorating condition of the ageing 132kV transmission lines between Clare South and Townsville South by removing, replacing or repairing the deteriorated assets, while ensuring system strength and voltage control are maintained. All options also allow Powerlink to meet its safety, reliability of supply and service standard obligations under the Rules, its Transmission Authority, the Electricity Act 1994 and other applicable regulatory instruments. They are technically and economically feasible, addressing the identified need in a timely manner, avoiding a situation where corrective maintenance of ageing assets is no longer practical.

None of these options has been discussed by the Australian Energy Market Operator (AEMO) in its most recent National Transmission Network Development Plan (NTNDP)[16].

[16] Clause 5.16.4(b)(4) of the Rules requires Powerlink to advise whether the identified need and or solutions are included in the most recent NTNDP. The 2018 NTNDP is currently the most recent NTNDP.

Additional options that have been considered but not progressed, for technical or economic reasons, were identified in the PSCR.

5.1 Material inter-network impact

Powerlink does not consider that any of the credible options being considered will have a material inter-network impact, based on AEMO's screening criteria[17].

6. Materiality of Market Benefits

The AER has recognised that if the proposed investment will not have an impact on the wholesale market, then a number of classes of market benefits will not be material in the RIT-T assessment, and so do not need to be estimated[18].

6.1 Market benefits that are material for this RIT-T assessment

Powerlink considers that changes in involuntary load shedding (i.e. the reduction in expected unserved energy) between options and the Base Case, set out in this PACR, may impact the ranking of the credible options under consideration, or the relativity of the credible options to the Base Case, and that this class of market benefit could be material. These benefits have been quantified and included within the cost reduction benefit and risk cost analysis as network risk.

6.2 Market benefits that are not material for this RIT-T assessment

None of the replacement options will have an impact on wholesale market outcomes. The Australian Energy Regulator (AER) has recognised that if the proposed investment will not have an impact on the wholesale market, then a number of classes of market benefits will not be material in the RIT-T assessment[19] and will not need to be estimated. Other than market benefits associated with involuntary load shedding, Powerlink does not consider any other category of market benefits to be material, and had not estimated them as part of this RIT-T.

More information on consideration of individual classes of market benefits can be found in the PSCR.

7. Base Case

7.1 Modelling a Base Case under the RIT-T

Consistent with the RIT-T Application Guidelines the assessment undertaken in this PADR compares the costs and benefits of credible options to address the risks arising from an identified need, with a Base Case[20].

As characterised in the RIT-T Application Guidelines, the Base Case itself is not a credible option to meet the identified need. Specifically, the Base Case reflects a state of the world in which the condition of the ageing asset is only addressed through standard operational activities, with escalating safety, financial, environmental and network risks.

To develop the Base Case, the existing condition issues associated with an asset are managed by undertaking operational maintenance only, which results in an increase in risk levels as the condition of the asset deteriorates over time. These increasing risk levels are assigned a monetary value that is used to evaluate and compare the credible options scoped to offset or mitigate these risk costs. The Base Case therefore includes the costs of work associated with operational maintenance and the risk costs associated with the irreparable failure of the asset. The costs associated with irreparable failures are modelled in the risk cost analysis and are not included in the maintenance costs.

[17] In accordance with Rules clause 5.16.4(b)(6)(ii). AEMO has published guidelines for assessing whether a credible option is expected to have a material inter-network impact.
[18] AER, *Final Regulatory Investment Test for Transmission Application Guidelines,* September 2017, version 2, page 13.
[19] AER, *Final Regulatory Investment Test for Transmission Application Guidelines,* September 2017, version 2, page 13.
[20] AER, Application guidelines, Regulatory investment test for transmission, December 2018

The Base Case acts as a benchmark and provides a clear reference point in the cost benefit analysis to compare and rank the credible options against over the same timeframe.

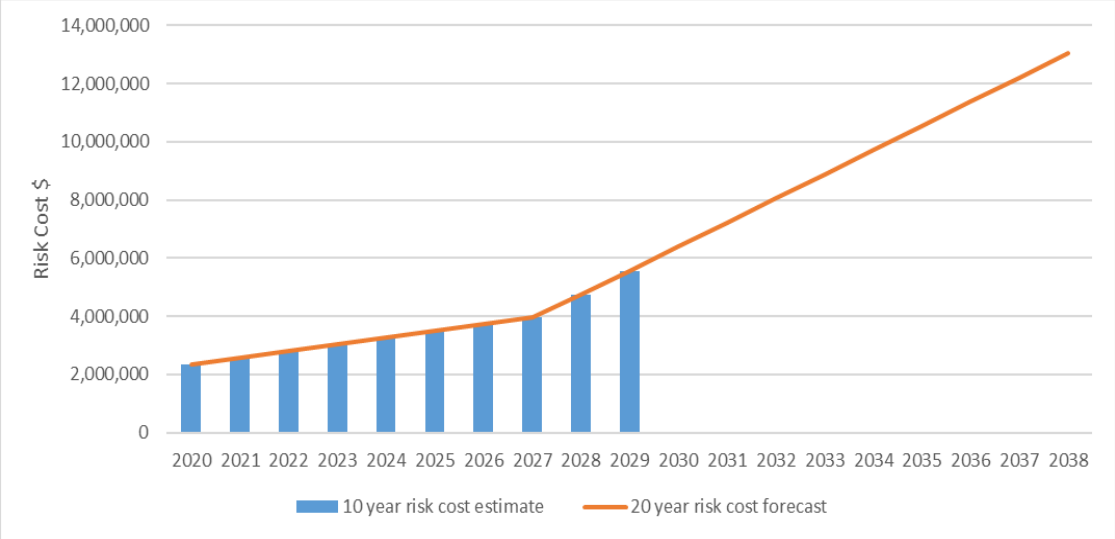
7.2 Clare South – Townsville South base case risk costs

Powerlink has developed a risk modelling framework consistent with the RIT-T Application Guidelines. An overview of the framework is available on Powerlink's website[21] and this has been used to calculate the risk costs of the Clare South to Townsville South Base Case. The framework includes the modelling methodology and general assumptions underpinning the analysis.

In calculating the risk cost arising from failure of the transmission lines, consideration has been given to the nature of the network and locality that the overhead lines traverse. For example, safety risk costs are higher where transmission line spans traverse roads. The financial risks have incorporated costs associated with restoration of overhead line structures and conductors in an emergency manner where these have failed in an irreparable manner. The network risk costs have taken into account the availability of adjacent transmission circuits that are able to mitigate the impacts of extended circuit outages. The calculation of the risk costs is considered to be conservative, as in the case of tower failures, the financial consequences include the impact of a single tower failure and not the impact of cascading tower failures.

The 20-year forecast of risk costs[22] for the Base Case is shown in Figure 7.1.

Figure 7.1: Modelled Base Case risk costs



Based upon the assessed condition of the transmission lines between Clare South and Townsville South, the risk costs are projected to increase from $2.3 million in 2019 to $13.0 million in 2038. The main areas of risk cost are attributed to financial risks associated with the replacement of failed assets in an emergency, and safety risks. These risks increase over time as the condition of the lines further deteriorates and the likelihood of failure rises.

7.3 Modelling of Risk in Options

Each option is specifically scoped to mitigate the major risks arising in the Base Case in order to maintain compliance with all statutory requirements and to ensure the safe, reliable and cost effective supply of electricity to customers. The residual risk is calculated for each option based upon the individual implementation strategy of the option. This is included with the capital and operational maintenance cost of each option to develop the NPV inputs.

[21] The risk costs are calculated using the principles set out in the Powerlink document, Overview of Asset Risk Cost Methodology, May 2019

[22] Where network risk costs arise, unserved energy is modelled using the Queensland regional Value of Customer Reliability (VCR) consistent with that published by AEMO in their Value of Customer Reliability Review, Final Report, September 2014 (i.e. $39,710/MWh).

8. General modelling approach adopted to assess net benefits

8.1 Analysis period

The RIT-T analysis has been undertaken over a 20 year period, from 2019 to 2038. There will be varying residual values by 2038 under each option, at which point a terminal value is calculated to correctly account for capital costs under each credible option.

8.2 Discount rate

Under the RIT-T, a commercial discount rate is applied to calculate the NPV of costs and benefits of credible options. Powerlink has adopted a real, pre-tax commercial discount rate of 5.90%[23] as the central assumption for the NPV analysis presented in this report. Powerlink has tested the sensitivity of the results to changes in this discount rate assumption, and specifically to the adoption of a lower bound discount rate of 3.47%[24] and an upper bound discount rate of 8.33% (i.e. a symmetrical upwards adjustment).

8.3 Description of reasonable scenarios

The RIT-T analysis is required to incorporate different reasonable scenarios to estimate market benefits. The scenarios must be appropriate to the credible options under consideration.

The choice of reasonable scenarios must reflect any variables or parameters that[25]:

- are likely to affect the ranking of the credible options, where the identified need is reliability corrective action
- are likely to affect the ranking of the credible options, or the sign of the net economic benefits of any of the credible options, for all other identified needs.

Powerlink has considered capital cost, maintenance cost, risk cost and discount rate sensitivities individually and in combination and found that these variables do not affect the ranking of the preferred, least cost option. Consequently, Powerlink has elected to present one central scenario defined in Table 8.1 below.

Table 8.1: Reasonable scenario assumed

Key variable/parameter	Central scenario
Capital costs	100% of baseline capital cost estimate
Discount rate	5.90%
Risk Cost	100% of baseline risk cost estimate

[23] The indicative commercial discount rate is calculated on the assumption that a private investment in the electricity sector would hold an investment grade credit rating, a return on equity and a debt-gearing ratio equal to an average firm on the Australian stock exchange.
[24] A discount rate of 3.47% is based on the AER's Final Decision for Powerlink's 2017-2022 transmission determination, which allowed a nominal vanilla WACC of 6.0% and forecast inflation of 2.45% that implies a real discount rate of 3.47%. See AER, Final Decision: Powerlink transmission determination 2017-2022 | Attachment 3 – Rate of return, April 2017, p 9.
[25] AER, Final Regulatory Investment Test for Transmission, June 2010.

9. Cost benefit analysis and identification of the preferred option

9.1 Net present values

Table 9.1 summarises the NPV for the Base Case and each credible option.

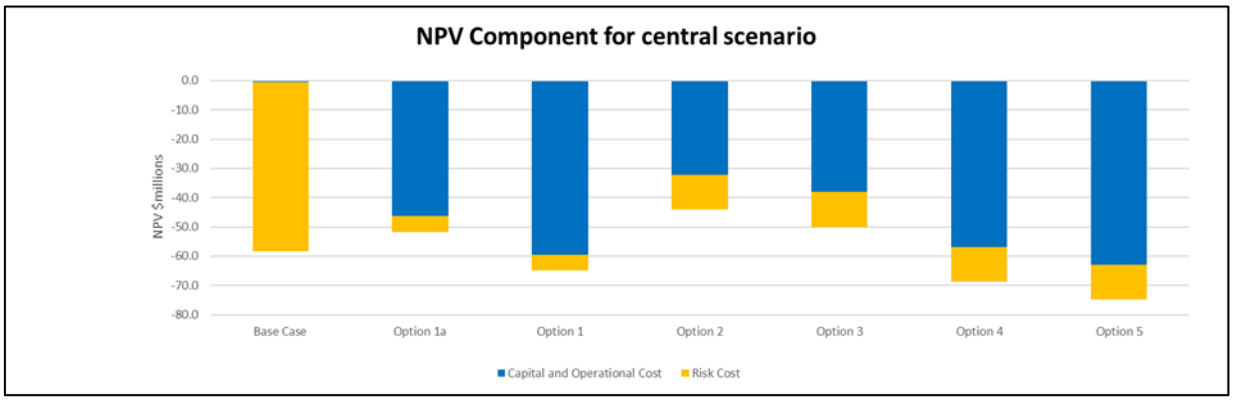
Table 9.1: NPV for the Base Case and each credible option ($m, 2018/19)

Option	Central Scenario NPV ($m)	Central Scenario NPV relative to Base Case ($m)	Ranking
Base Case	-58.45	-	
Option 1a	-51.69	6.76	**3**
Option 1	-64.97	-6.52	**4**
Option 2	-43.96	14.49	**1**
Option 3	-49.99	8.46	**2**
Option 4	-68.66	-10.21	**5**
Option 5	-74.70	-16.25	**6**

All six options will address the identified need on an enduring basis. Of the six credible options, Option 2 has the highest NPV relative to the Base Case and is ranked first.

Figure 9.1 sets out the breakdown of the combined capital, operational maintenance and decommissioning costs where applicable, and risk cost for each option in NPV terms under the central scenario. Note that the non-credible Base Case consists of operational maintenance and risk costs and does not include any capital expenditure.

Figure 9.1: NPV of Base Case and Options ($m, 2018/19)



Note: Capital and operational costs have been combined to maintain confidentiality with the non-network proponent

9.2 Sensitivity analysis

Powerlink has investigated the following sensitivities on key assumptions:

- a range from 3.47% to 8.33% discount rate.
- a range from 75% to 125% of baseline capital expenditure estimates.
- a range from 75% to 125% of baseline risk cost estimates.

Sensitivity analysis, documented in Figures 9.2, 9.3 and 9.4, shows that varying the discount rate, capital cost and risk cost has no impact on the ranking of the preferred option. Option 2 is the preferred option under all scenarios tested.

Figure 9.2 Discount rate sensitivity

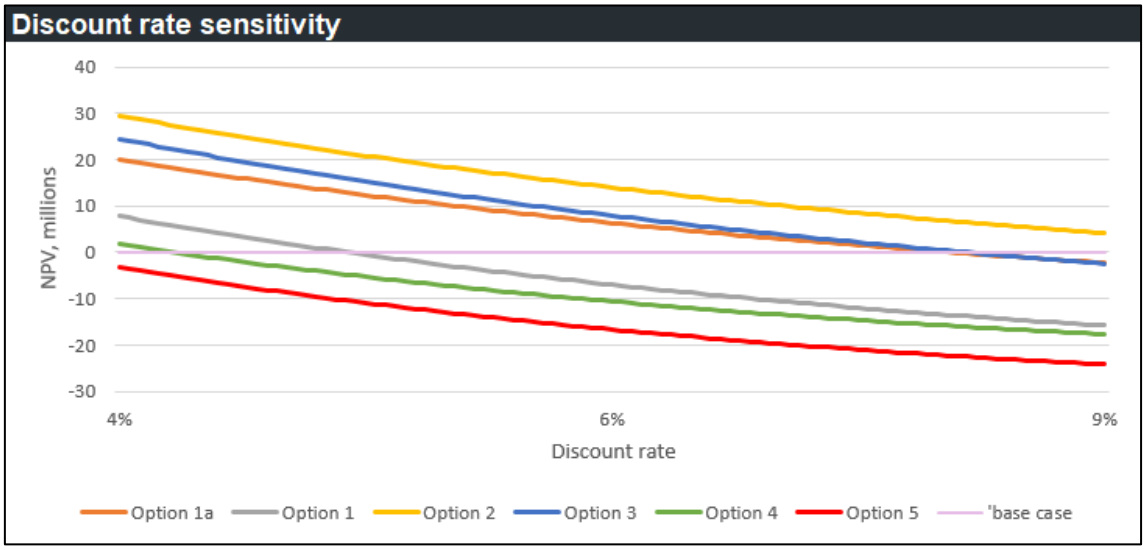


Figure 9.3 Capital cost sensitivity

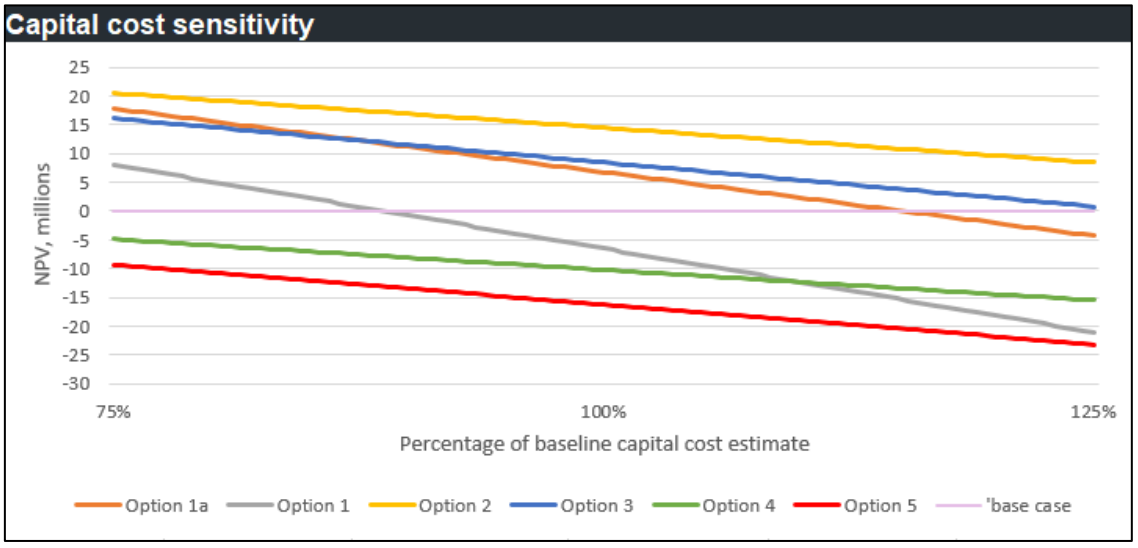
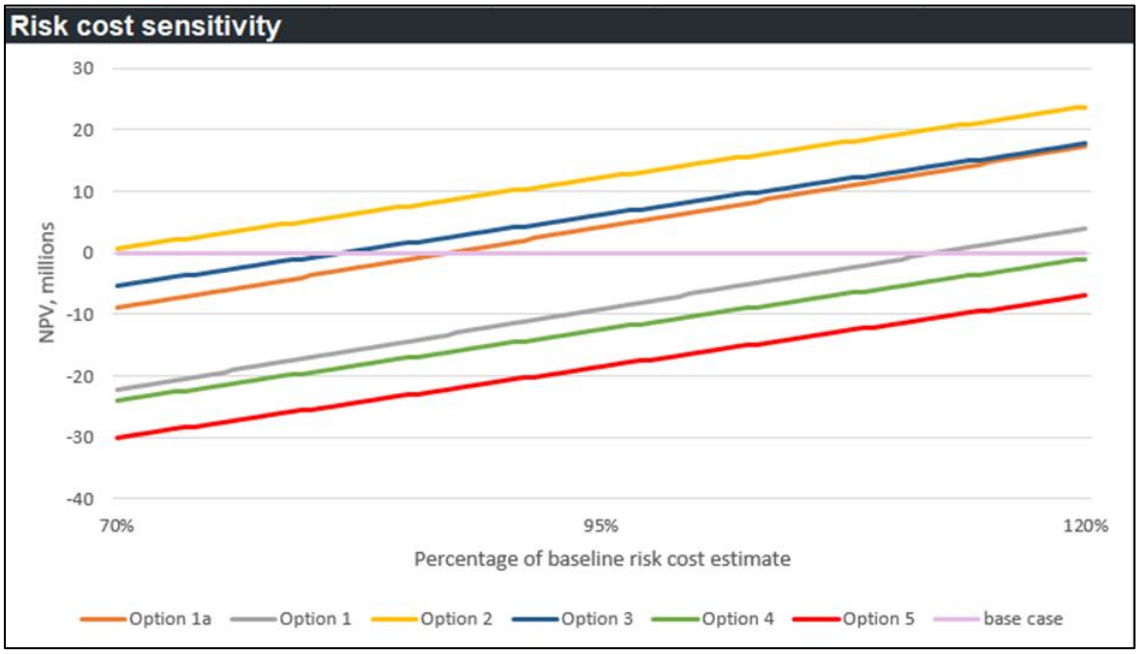


Figure 9.4 Risk cost sensitivity

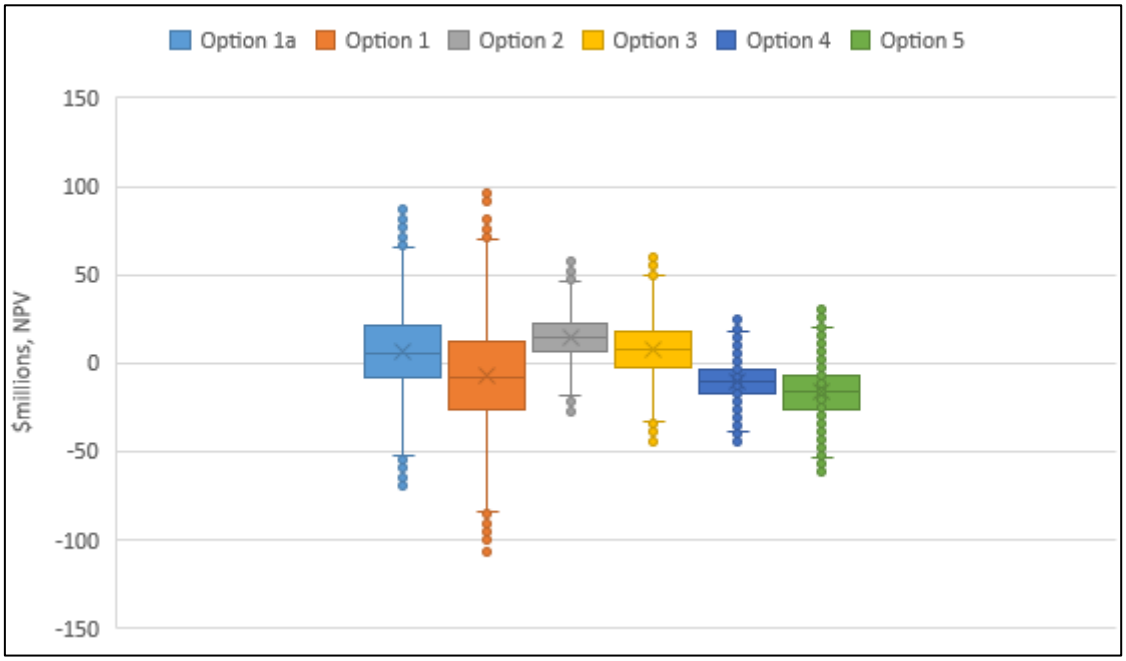


9.3 Sensitivity to multiple key assumptions

A Monte Carlo Simulation was performed with multiple input parameters (including capital cost, discount rate, maintenance costs and risk costs) generated for the calculation of the NPV for each option. This process is repeated over 5000 iterations, each time using a different set of random variables from the probability function. The sensitivity analysis is presented as a distribution of possible NPVs for each option, as illustrated in Figure 9.5.

The Monte Carlo simulation results identify that Option 2, has less statistical dispersion in comparison with the other credible options and its mean and median is the highest of the four credible options. This confirms that the preferred option is robust over a range of input parameters in combination.

Figure 9.5: NPV sensitivity analysis of multiple key assumptions relative to the Base Case



10. Preferred option

Based on the conclusions drawn from the NPV analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the risks associated with the condition of the Clare South to Townsville South transmission lines.

Sensitivity testing shows that the analysis is robust to variations in discount rates, capital costs and risk costs.

Option 2 is therefore considered to satisfy the requirements of the RIT-T and is the preferred option.

11. Conclusions

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

- Powerlink has identified condition risks arising from the ageing transmission lines between Clare South and Townsville South requiring action.
- TNSPs must maintain (including repair and replace if necessary) their transmission grid to ensure the adequate, economic, reliable and safe transmission of electricity, including the ability to meet peak demand if a major element of the network was to fail.
- The increasing likelihood of faults associated with the ageing Clare South to Townsville South transmission lines compels Powerlink to undertake reliability corrective actions if it is to continue meeting the reliability and service standards set out in the Rules, Powerlink's Transmission Authority and relevant regulatory instruments.
- Powerlink published a PSCR in November 2018 requesting submissions from Registered Participants, AEMO and interested parties on the credible options presented, including alternative credible non-network options, which could address the condition risks on the Clare South to Townsville South transmission lines.
- Two submissions were received in response to the PSCR, which was open for consultation until 18 April 2019. Following consultation with the proponents, and detailed network analysis, it was concluded that these options were unable to satisfy the technical requirements, particularly those relating to system strength and voltage control.
- A third submission was received in response to publication of the PADR, which was open for consultation until 27 September 2019 and has been assessed by Powerlink to the extent that it could provide a partial solution to the identified need, deferring the requirement to install a second transformer at Strathmore Substation for five years. This non-network proposal was included in the PACR's final analysis as part of two new combined network / non-network options.
- Studies were undertaken to evaluate six credible options that address the identified need; all six credible options were evaluated in accordance with the RIT-T.
- The result of the cost benefit analysis under the RIT-T identified that Option 2 provides the least negative net present value solution (and most positive relative to the Base Case) over the 20 year analysis period. Sensitivity testing shows that the analysis is robust to variations in the discount rate, capital cost and risk cost assumptions.

As a result, Option 2 is considered to satisfy the RIT-T and is the preferred option.

12. Final Recommendation

Based on the conclusions drawn from the NPV analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the risks arising from the condition of the ageing Clare South to Townsville South transmission lines. Implementing Option 2 allows Powerlink to maintain compliance with the Rules, Powerlink's Transmission Authority and applicable regulatory instruments, ensuring ongoing reliability of supply and the maintenance of service standards for customers.

The RIT-T project for Option 2 involves the repair or replacement of selected components on the coastal 132kV line from Clare South to Townsville South, and the installation of a new 375MVA 132/275kV transformer at Strathmore by December 2021. (This allows a separate operational project to decommission the inland line to be completed by December 2022).

The indicative capital cost of the RIT-T project for the preferred option is $28.34 million in 2018/19 prices and delivers a $14.49 million net economic benefit in NPV terms relative to the Base Case.

Powerlink is the proponent of this network solution.

Under this option, design will commence in late 2019 and construction in early 2020. Installation of the new transformer at Strathmore and the life extension of the coastal transmission line will be completed by December 2021.

The staged approach of this option allows for a further review of the risks arising from the condition of the coastal line remaining in service, prior to undertaking the subsequent life extension stage currently forecast to be required by December 2031. This will confirm if the need for remedial action is still required at that point in time.

Powerlink will:

- review and refine the timing of subsequent stages of this option, if required, based on future condition assessments of the risks arising from these lines remaining in service
- review and realign the strategy of the anticipated subsequent stages of this option, if required, based on future network topology requirements to meet forecast demand in the Townsville South, Clare and Proserpine areas and
- undertake any necessary additional regulatory consultations at the appropriate time for future investments if required.

As the outcomes of the economic analysis contained in this PACR remain unchanged from those published in the PADR, the draft recommendation has been adopted without change as the final recommendation, and will now be implemented.

Appendices

Appendix 1: Summary of the main limiting condition, key legislation and consequences of failure

Table A1 indicates the key legislation, in addition to the Electrical Safety Act 1994, governing the need to address the condition of the 132kV transmission lines between Clare South and Townsville South. The Table also identifies the key limiting items of equipment and the potential consequences of their failure.

Table A1 Summary of main limiting condition, key legislation and consequences of failure

Main Limiting Condition	Key Legislation In addition to the Electricity Act 1994	Main Deteriorated Element	Consequence of failure
Inland Line			
Structural integrity	Electrical Safety Act 2002, section 29 Electrical Safety Regulation 2013, section 198(a) Electrical Safety Regulation 2013, section 198(d)	Steel (grillage) foundations - significant loss of underground metal adversely impacting structural strength Structure bolts - advanced corrosion with loss of steel cross section and strength by 2021	Advanced corrosion or degradation of structural components can lead to mechanical failure under normal operating conditions, worsened by adverse weather events, which can lead to failure of the structure (including cascading effects on adjacent structures) with significant safety risks and loss of supply.
Conductor support hardware integrity	Electrical Safety Act 2002, section 29 Electrical Safety Regulation 2013, section 198(a) Electrical Safety Regulation 2013, section 198(b) Electrical Safety Regulation 2013, section 198(d)	Insulator 'cold' end hardware - advanced corrosion with loss of steel cross section and strength Insulator ' hot' end hardware - polymeric insert of conductor clamp deteriorating causing strain and wear on the conductor	Advanced corrosion or degradation of the hardware can lead to mechanical failure potentially resulting in a conductor drop, which can lead to significant safety risks and loss of supply. Wear on the conductor resulting from deterioration of the clamp polymer will lead to conductor damage and consequential breakage of conductor strands, which can lead to significant safety risks, reduced performance of the conductor and potentially loss of supply.
Coastal Line			
Structural integrity	Electrical Safety Act 2002, section 29 Electrical Safety Regulation 2013, section 198(a) Electrical Safety Regulation 2013, section 198(d)	Structure leg / foundation interface - advanced corrosion with loss of steel cross section and strength by 2021 Structure bolts - advanced corrosion with loss of steel cross section and strength by 2021	Advanced corrosion or degradation of structural components can lead to mechanical failure under normal operating conditions, worsened by adverse weather events, which can lead to failure of the structure (including cascading effects on adjacent structures) with significant safety risks and loss of supply

Main Limiting Condition	Key Legislation In addition to the Electricity Act 1994	Main Deteriorated Element	Consequence of failure
Conductor support hardware integrity	Electrical Safety Act 2002, section 29 Electrical Safety Regulation 2013, section 198(a) Electrical Safety Regulation 2013, section 198(d)	Hanger bracket bolts / hardware - advanced corrosion with loss of steel cross section and strength by 2021. Accelerated corrosion of the fasteners supporting the conductor weight to the tower.	Advanced corrosion or degradation of the bolts /hardware can lead to mechanical failure potentially resulting in a conductor drop, with significant safety risks and loss of supply

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