Powerlink Queensland

Project Specification Consultation Report

8 October 2020

Managing voltage control in Central Queensland

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[1] 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. More information on the RIT-T process and how it is applied to ensure that safe, reliable and cost effective solutions are implemented to deliver better outcomes to customers is available on Powerlink's website.
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 customers.
3. The main purpose of this document is to provide details of the identified need, credible options, technical characteristics of non-network options, and categories of market benefits addressed in the assessment. In particular, it encourages submissions from potential proponents of feasible non-network options to address the identified need.

[1] Such requirements include, but are not limited to, addressing any emerging reliability of supply issues or relevant *ISP actionable projects* identified in the Australian Energy Market Operator's (AEMO) latest Integrated System Plan (ISP), for which Powerlink has responsibility as the relevant Transmission Network Service Provider (TNSP).

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Executive Summary

Changing electricity generation and consumption patterns in Central and Northern Queensland require Powerlink to take action

Minimum transmission flows between Central and Northern Queensland have been decreasing over the past 5 years, with this trend forecast to continue into the future.

The main driver of this change has been the progressive displacement of traditional generation in Central Queensland with increasing amounts of large scale variable renewable energy (VRE) generation in the North, coupled with a reduction in minimum daytime demand due to the uptake of small scale rooftop PV systems. This has led to an increase in the reactive charging of 275kV lines in the Central Queensland area, resulting in a growing potential for sustained over-voltage events.

Over-voltage events can result in equipment damage, loss of supply and safety issues.

The Rules specify allowable over-voltage limits and require Powerlink to take action to ensure these limits are not exceeded in order to maintain the power system in a secure state.

Current reactive plant is at capacity and Powerlink is increasingly having to manage these limits via the switching out of feeders. This operational solution is now at its technical limit and is not considered an effective sustainable strategy. Switching out of feeders on an on-going regular basis impacts system strength and reliability of supply, while increasing transmission losses and accelerating the ageing of primary plant.

Insufficient reactive capacity in the Central Queensland section of the grid is also making it increasingly difficult to obtain outages for maintenance purposes, increasing the likelihood of Powerlink breaching its responsibilities as a Transmission Network Service Provider (TNSP) under the Rules, as well as its Transmission Authority reliability and service standards.

Powerlink is required to apply the RIT-T to this investment

The identified need to manage voltages within allowable limits requires Powerlink to apply the RIT-T.

The proposed investment is to meet reliability and service standards specified within Powerlink's Transmission Authority and to ensure Powerlink's ongoing compliance with Schedule 5.1 of the Rules, and is classified as a 'reliability corrective action'[2].

As the identified need is not discussed in the most recent Integrated System Plan (ISP), it is subject to the application and consultation process for RIT-T projects not defined as *actionable ISP projects*[3].

Powerlink has presented three credible network options in this Project Specification Consultation Report (PSCR) to maintain the existing electricity services, ensuring an ongoing reliable, safe and cost effective supply to customers in the area.

All options presented are below $43 million, with the only material market benefit being changes in fuel costs, which are identical for each option. As there are no market benefits that change the ranking of the options, Powerlink has adopted the expedited process for non-ISP projects for this RIT-T[4]. The changes in fuel costs have been included in the economic analysis of the options.

A non-credible Base Case has been developed against which to compare the credible options

Consistent with the Australian Energy Regulator's (AER's) RIT-T Application Guidelines for non-ISP projects, the assessment undertaken in this PSCR compares the net present value (NPV) of the credible network options identified to address the emerging risk-costs of a "do-nothing" Base Case.

[2] The Rules clause 5.10.2, Definitions, reliability corrective action.
[3] Refer to Clause 5.16.2 of the NER.
[4] In accordance with clause 5.16.4(z1) of the Rules and S4.1 AER Regulatory investment test for transition application guidelines, August 2020

The Base Case is modelled as a **non-credible** option where the emerging issue of non-compliant over voltage events is managed via the despatching of off-line generators to provide voltage support to the network. The additional fuel costs of despatching these generators forms the market costs of the "do nothing" Base Case.

Proposed network options to address the identified need

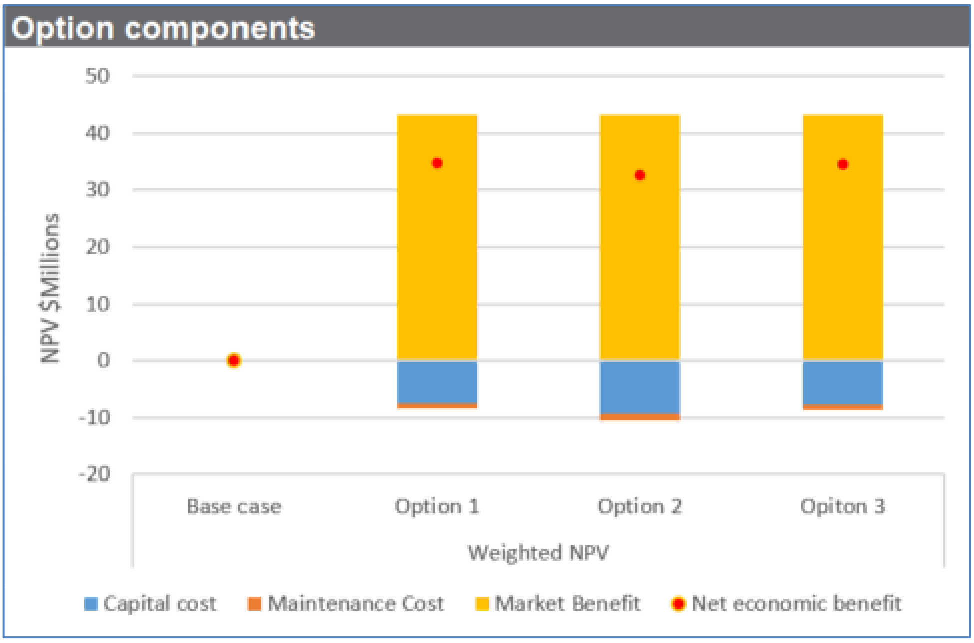
The credible network options, along with their NPVs relative to the Base Case are summarised in Table 1. The absolute NPVs of the Base Case and the credible network options are shown in Figure 1.

Table 1 illustrates that the three credible network options have a net economic benefit relative to the non-credible Base Case.

Table 1: Summary of the credible network options

Option	Description	Total costs ($m) 2020/21	Net Economic Benefit ($m)
1	Establish 1x 150MVAr 300kV bus reactor at H020 Broadsound by June 2023	9.63	34.80
2	Establish 2x 300kV line reactors at H020 Broadsound by June 2023	12.04	32.61
3	Establish 1x 150MVAr 300kV 2bus reactor at H011 Nebo by June 2023	9.89	34.48

Figure 1: NPV of Base Case and Credible Network Options



The Base Case is not a credible option, in that it does not allow Powerlink to continue to maintain compliance with the requirements of relevant regulatory instruments and the Rules. As the investment is classified as a 'reliability corrective action' under the Rules, the purpose of the RIT-T is to identify the credible option that minimises the total cost to customers.

Taking into account capital, operational maintenance and market benefits, Option 1 delivers the greatest net economic benefit, providing a $34.80 million net economic benefit in NPV terms when compared to the Base Case over the 20-year analysis period.

Option 1 has been identified as the preferred network option

The preferred network option involves establishment of a 275kV bus connected shunt reactor at the Broadsound Substation by June 2023. Powerlink is the proponent of this network option.

Under this option, installation and commissioning of the reactor will be completed by June 2023.

Powerlink welcomes the potential for non-network options to form part or all of the solution

Powerlink welcomes submissions, from proponents who consider they could offer a potential non-network solution by January 2021.

A non-network option that avoids the proposed installation of the new shunt reactor would need to replicate, in part or full, the support that the reactor delivers to the network in the Central Queensland area, on a cost effective and ongoing basis.

Lodging a submission with Powerlink

Powerlink is seeking written submissions on this Project Specification Consultation Report on or before Friday, 8 January 2021, particularly on the credible option presented[5].

Please address submissions to:

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PO Box 1193
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Tel: (07) 3860 2328

Submissions can be emailed to: networkassessments@powerlink.com.au

[5] Powerlink's website has detailed information on the types of engagement activities, which may be undertaken during the consultation process. These activities focus on enhancing the value and outcomes of the RIT-T engagement process for customers and non-network providers.

1 Introduction

1.1 Powerlink Asset Management and Obligations

Powerlink Queensland is a Transmission Network Service Provider (TNSP) in the National Electricity Market (NEM) that owns, develops, operates and maintains Queensland's high-voltage electricity transmission network. This network transfers bulk power from Queensland generators to electricity distributors Energex and Ergon Energy (part of the Energy Queensland Group), and to a range of large industrial customers.

Powerlink's approach to asset management includes a commitment to sustainable asset management practices that ensure Powerlink provides valued transmission services to its customers by managing risk[6], optimising performance and efficiently managing assets through the whole of asset life cycle[7].

Planning studies have confirmed there is a long-term requirement to continue to supply electricity services to customers in Central and Northern Queensland.

Declining transmission flows between Central and Northern Queensland, the progressive displacement of traditional synchronous generation[8] with asynchronous or VRE generation[9], and declining minimum demand, are increasing the likelihood of non-compliant over-voltage events. The current strategy of switching out selected feeders to ensure ongoing compliance with the Rules' "*voltage* of *supply* at a *connection point"*[10], is at the limit of its technical effectiveness. Continued reliance on increasingly onerous reconfigurations of the network will result in higher market costs, reduced system resilience, and compromised system security, and is not an effective sustainable strategy.

Powerlink must therefore take action to ensure compliance with management of voltages in its transmission network.

As the proposed credible options to address the identified need include a potential investment in excess of $6 million, Powerlink must assess these options under the RIT-T.

When developing the credible options, Powerlink has focussed on implementing cost effective solutions that ensure a reliable supply, delivering positive outcomes for customers.

1.2 RIT-T Overview

The identified need referred to in this RIT-T, managing the over voltage risks in Central Queensland, is not discussed in the most recent Integrated System Plan (ISP). As such, it is subject to the application and consultation process for RIT-T projects not defined as *actionable ISP projects*[11].

This Project Specification Consultation Report (PSCR) is the first step in the RIT-T process[12]. It:

- describes the reasons why Powerlink has determined that investment is necessary (the 'identified need'), together with the assumptions used in identifying this need
- provides potential proponents of non-network options with information on the technical characteristics that a non-network solution would need to deliver, in order to assist proponents in considering whether they could offer an alternative solution
- describes the credible option that Powerlink currently considers may address the identified need

[6] Risk assessments are underpinned by Powerlink's corporate risk management framework and the application of a range of risk assessment methodologies set out in AS/NZS ISO31000:2018 Risk Management Guidelines.
[7] Powerlink aligns asset management processes and practices with AS ISO55000:2014 Asset Management – Overview, principles and terminology to ensure a consistent approach is applied throughout the life cycle of assets
[8] For example hydro, thermal coal and thermal gas generation
[9] Such as wind turbine and solar generation.
[10] National Electricity Rules, Version 148, 21 August 2020, Schedule 5.1a.4 Power frequency voltage
[11] Refer to Clause 5.16.2 of the NER.
[12] This RIT-T consultation has been prepared based on the following documents: National Electricity Rules, Version 148, 21 August 2020 and AER, Regulatory investment test for transmission application guidelines, August 2020.

- discusses why Powerlink does not expect specific categories of market benefit to be material for this RIT-T[13]
- presents the NPV assessment of the credible option compared to a Base Case (as well as the methodologies and assumptions underlying these results)
- identifies and provides a detailed description of the credible option that satisfies the RIT-T, and is therefore the preferred option
- describes how customers and stakeholders have been engaged with regarding the identified need
- provides stakeholders with the opportunity to comment on this assessment so that Powerlink can refine the analysis (if required)

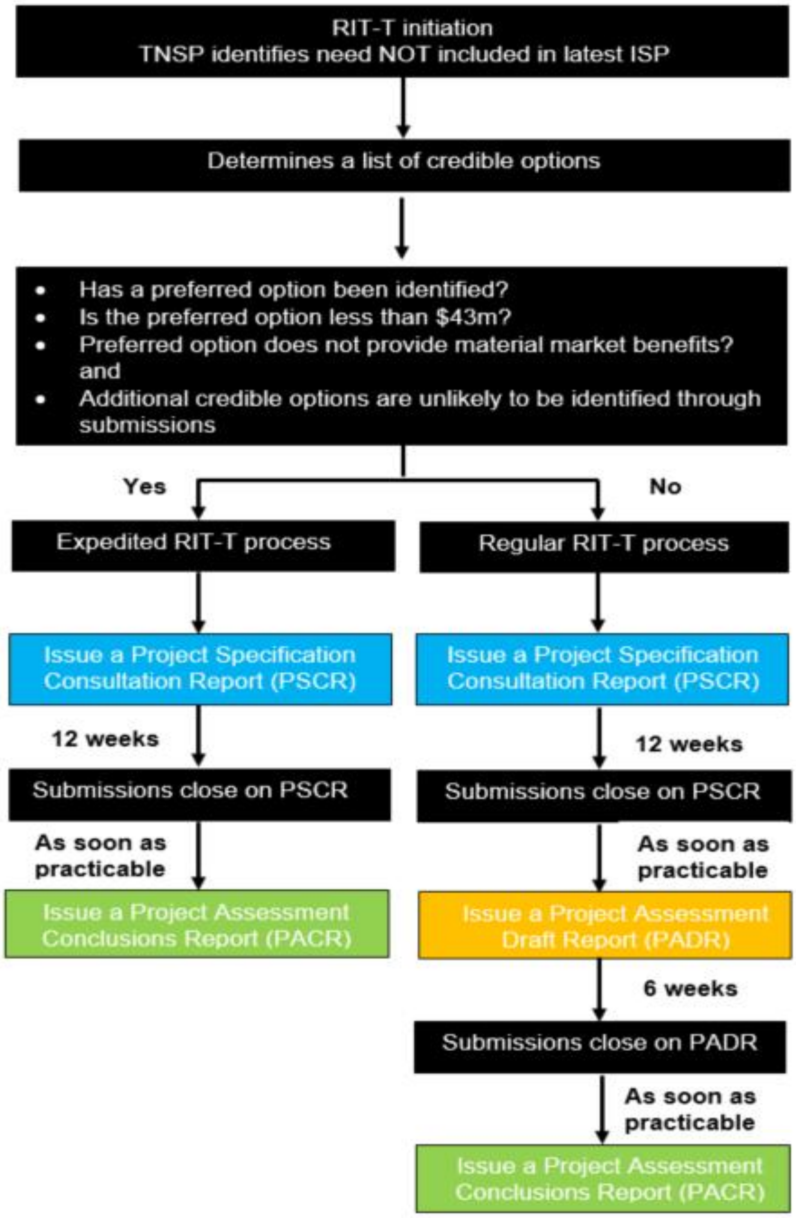
Powerlink has adopted the expedited process for this RIT-T, as allowed for under the Rules for investments of this nature[14]. Specifically, Powerlink will publish a PACR following public consultation on this PSCR and apply the exemption from publishing a Project Assessment Draft Report (PADR) as:

- the preferred option has an estimated capital cost of less than $43 million
- market benefits arising from the credible options do not impact the ranking of options or the selection of the preferred option[15]
- Powerlink has identified its preferred option in this PSCR (together with the supporting quantitative cost-benefit analysis)
- Powerlink is currently not aware of any non-network options that could be adopted. This PSCR provides a further opportunity for providers of feasible non-network options to submit details of their proposals for consideration.

Powerlink will however publish a PADR if submissions to this PSCR identify other credible options that have not yet been considered and which could provide a material market benefit.

[13] As required by clause 5.16.1(c)(iv) of the Rules.
[14] In accordance with clause 5.16.4(z1) of the Rules
[15] Section 4.3 Project assessment draft report, Exemption from preparing a draft report, AER, Regulatory investment test for transmission application guidelines, August 2020

Figure 1.1: RIT-T Process Overview for projects that are not *actionable ISP Projects*



2 Customer and non-network engagement

With five million Queenslanders and 236,000 Queensland businesses depending on Powerlink's performance, 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 activities and/or investments. Together with our industry counterparts from across the electricity and gas supply chain, Powerlink has committed to The Energy Charter.

2.1 Powerlink takes a proactive approach to engagement

Powerlink regularly hosts a range of engagement forums and webinars, sharing effective, timely and transparent information with customers and stakeholders within the broader community.

Powerlink's annual Transmission Network Forum (TNF) is a primary vehicle used to engage with the community, understand broader customer and industry views and obtain feedback on key topics.

It also provides Powerlink with an opportunity to further inform its business network and non-network planning objectives. TNF participants include customers, landholders, environmental groups, Traditional Owners, government agencies, and industry bodies.

Engagement activities such as the TNF 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, providing an ongoing opportunity for:

- the Customer Panel to ask questions and provide feedback to further inform RIT-Ts
- Powerlink to better understand the views of customers when undertaking the RIT-T consultation process.

Powerlink will continue providing updates to and request input from the Customer Panel throughout the RIT-T consultation process.

2.3 Transparency on future network requirements

Powerlink's annual planning review findings are published in the TAPR and TAPR templates, providing early information and technical data to customers and stakeholders on potential transmission network needs over a 10-year outlook period. The TAPR plays an important part in planning Queensland's transmission network and helping to ensure it continues to meet the needs of Queensland electricity consumers and participants in the NEM. Powerlink undertakes engagement activities, such as a webinar and/or forum, to share with customers and stakeholders the most recent TAPR findings and respond to any questions that may arise.

In addition, beyond the defined TAPR process, Powerlink's associated engagement activities provide an opportunity for non-network alternatives to be raised, further discussed or formally submitted for consideration as options to meet transmission network needs, well in advance of the proposed investment timings and commencement of regulatory consultations (where applicable).

2.3.1 Voltage control in Central Queensland

Powerlink identified in its 2019 TAPR, an expectation that action would be required to address the emerging voltage control issues in Central Queensland[16].

Powerlink advised members of its Non-network Engagement Stakeholder Register (NNESR) of the publication of the TAPR.

No submissions proposing credible and genuine non-network options have been received from prospective non-network solution providers in the normal course of business, in response to the publication of the TAPR or as a result of stakeholder engagement activities.

2.4 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.

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

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.

2.5 The transmission component of electricity bills

Powerlink's contribution to electricity bills reduced by a third from July 2017 and comprises approximately 8% of the total cost of the residential electricity bill (refer to Figure 2.1).

Figure 2.1: Components of end user bills

Generator Charges (41%) + Transmission Charges (8%) + Distribution Charges (36%) + Retail Charges (5%) + Green Policies (5 %) = End User Bills

Detailed information on transmission pricing, including discussion on how Powerlink is actively engaging with customers and stakeholders on transmission pricing concerns, is available on Powerlink's website.

3 Identified need

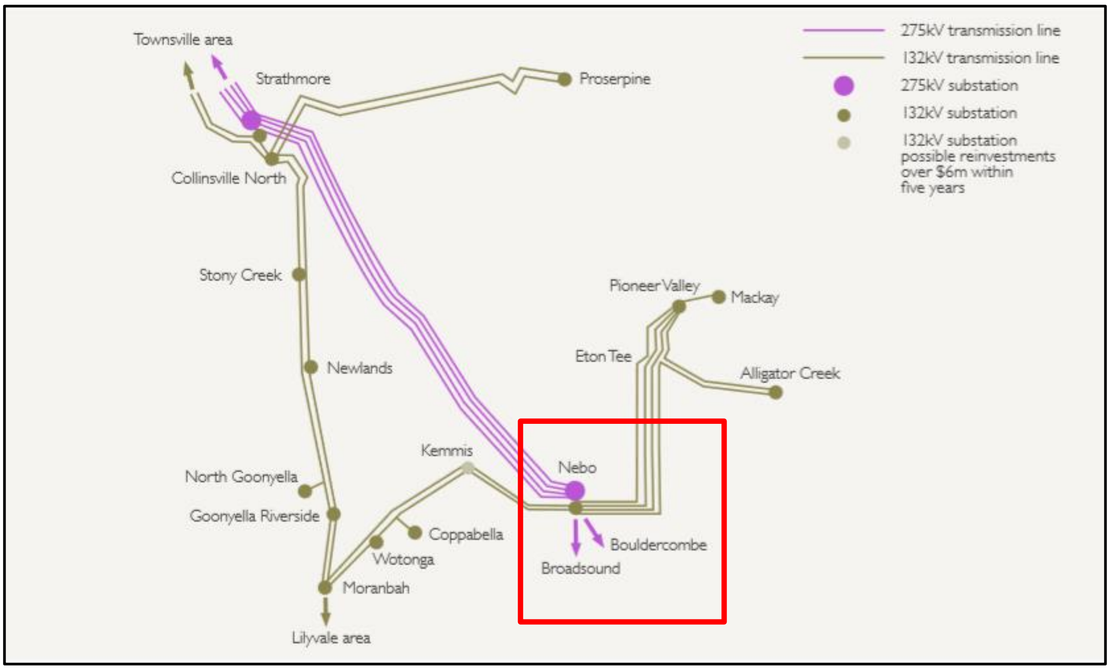
This section provides an overview of the existing voltage control arrangements in Central Queensland and describes the increasing risk to Powerlink of being unable to maintain compliance with relevant standards, applicable regulatory instruments and the Rules, which are designed to ensure Powerlink's customers continue to receive safe, reliable and cost effective electricity services.

3.1 Geographical and network need

The main grid section connecting Central and Northern Queensland consists of four 275kV feeders between Nebo and Broadsound Substations, with planning studies confirming there is an enduring need for the supply of bulk electricity to Central Queensland and for the transfer of power between northern, Central and Southern Queensland[17].

The Northern and Central transmission networks are shown in Figures 3.1 and 3.1a

Figure 3.1: Northern transmission network



[17] Transmission Annual Planning Report 2019, Appendix A – Compendium_ Forecast of connection point maximum demand

Figure 3.1a Central transmission network

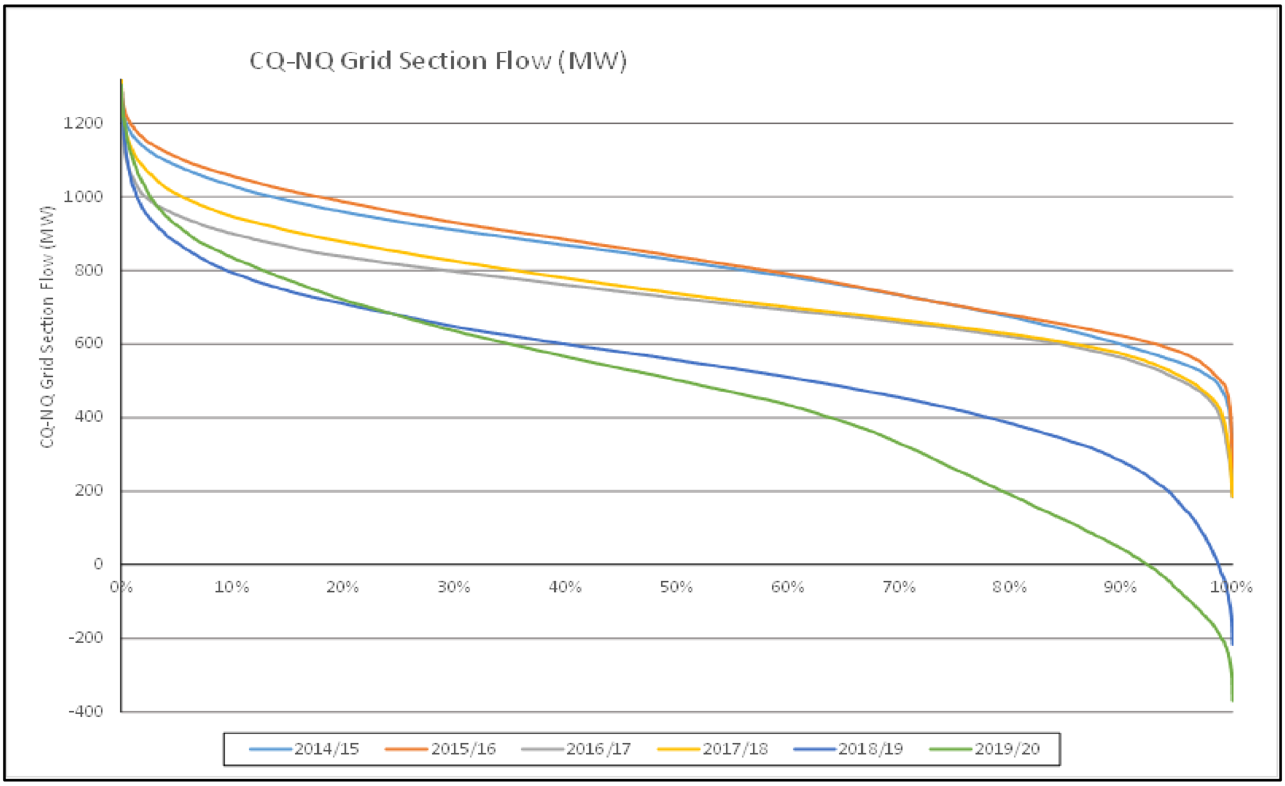
3.1.1 Increasing voltage risks associated with a rapidly transitioning energy system

An increase in the amount of large scale renewable generation in the northern zone, combined with lower minimum daytime demand, particularly since 2018/2019 has produced a declining electricity flow across the CQ-NQ grid section, (see Figure 3.2). This has resulted in an increase in the reactive charging of 275kV lines in Central Queensland, in turn producing an increase in the maximum voltages being experienced at Nebo, Broadsound and Lilyvale substations, with a sustained trend of voltages exceeding Powerlink's maximum operating voltages at Nebo.

Whilst the renewable generation in the northern zone provides additional voltage control during its operating period, its remote location relative to Broadsound and Nebo means it is unable to offset the reactive charging of the 275kV transmission lines in the area.

The rapid increase in small scale rooftop PV systems has also increased the likelihood of over-voltage events in the distribution network by reducing the minimum demand. The recent reduction of the nominal low voltage level from 240V to a 'preferred operating range' of 230 volts +6/-2% further confirms that this trend towards lower minimum demand levels will continue into the future.

Figure 3.2 CQ- NQ Flows 2014/15 – 2019/20



This combination of an increasing displacement of traditional generation, declining minimum demands and reducing transfers means the network's current ability to operate within the voltage limits prescribed in the Rules[18] is rapidly declining.

Good electricity industry practice is to maintain sufficient headroom in the system to be able to manage disturbances so that voltages do not exceed allowable safe limits. Under system normal conditions, the dynamic reactive plant (SVC) at Nebo is increasingly operating at its limit, where it would become ineffective in responding to network disturbances. The instances when the SVC is at maximum MVArs absorption have more than doubled between 2018 and 2019. With the SVC at Nebo functioning near capacity, the allowable 275kV operational voltage limits will be exceeded under key reactive plant outages.

3.2 Description of identified need

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 maximum load and energy:

- will not exceed 50MW at any one time; or
- will not be more than 600MWh in aggregate[19].

Planning studies have confirmed that in order to continue to meet the reliability standard within Powerlink's Transmission Authority, the connection points at Nebo, Broadsound and Lilyvale substations are required into the foreseeable future to meet ongoing customer requirements.

[18] The Rules, Schedule 5.1a.4 Power frequency voltage
[19] Transmission Authority No. T01/98, section 6.2(c)

Schedule 5.1a of the Rules sets minimum standards for network service providers that:

(a) are necessary or desirable for the safe and reliable operation of the *facilities* of *Registered Participants*

(b) are necessary or desirable for the safe and reliable operation of equipment

(c) could reasonably be considered *good electricity industry practice*

S5.1a.4 states that under system normal conditions, the voltage at a connection point must not exceed 1.1 per unit. Following a credible contingency, the voltage at a connection point must be able to be restored to less than 1.1 per unit in less than 1 second. The SVC at Nebo is, in the existing system, utilised to the point that it would be unable to respond to credible network disturbances following a credible contingency, resulting in non-compliant over voltages at Nebo Substation.

S5.1.2.1 of the Rules also states "*Network Service Providers must plan, design, maintain and operate their transmission networks….to allow the transfer of power from generating units to Customers ….*" With reactive plant at capacity, obtaining outages for maintenance work is becoming increasingly difficult. Switching out lines during low load and/or low power transfer periods, to help gain access for reactive plant maintenance, reduces system strength and constrains the dispatch of renewable generation in North Queensland. Gaining access for maintenance during peak load conditions is also problematic, as these same dynamic reactive power devices are required to maintain voltage stability under high power transfer into North Queensland.

There is a need for Powerlink to address this emerging issues to ensure ongoing compliance with Schedule 5.1 of the Rules and applicable regulatory instruments, which are designed to ensure Powerlink's customers continue to receive safe, reliable and cost effective electricity services.

The proposed investment addresses the need to meet operational safety, reliability and service standards arising from Powerlink's Transmission Authority and to ensure Powerlink's ongoing compliance with Schedule 5.1 of the Rules and is categorised as 'reliability corrective action' under the Rules[20].

A reliability corrective action differs from that of an increase in producer and consumer surplus (market benefit) driven need in that the preferred option may have a negative net economic outcome because it is required to meet an externally imposed obligation on the network business.

3.3 Assumptions and requirements underpinning the identified need

Under current system normal conditions, peak operating voltages are at or near Powerlink's operational limits, while dynamic reactive plant is at its limit. Studies indicate that the current reactive capacity of the grid in this region would be unable to provide the necessary management of voltages under the forecast declines in electricity flows, resulting in over-voltages on the network following a credible contingency.

To help manage this issue, 275kV feeders in the area are increasingly being switched out for short periods, however, switching the backbone 275kV feeders to manage over voltage events in Central Queensland impacts the system strength available in North Queensland.

Under the AEMO defined minimum fault levels[21], Powerlink is obliged to maintain 1300MVA on the 275kV bus at Ross, however this is based on the intact system and loss of a critical network element. Where a prior outage is taken, the network (and connected plant) must be able to withstand the next credible contingency. As such, in order for line switching to be utilised there would be constraints on VRE generation in North Queensland.

[20] The Rules clause 5.10.2 ,Definitions, reliability corrective action

[21] [21] https://www.aemo.com.au/-/media/files/electricity/nem/security_and_reliability/system-security-market-frameworks-review/2020/2020-notice-of-queensland-system-strength-requirements-and-ross-node-fault-level-shortfall.pdf?la=en

4 Required technical characteristics for non-network options

The information provided in this section is intended to enable interested parties to formulate and propose genuine and practicable non-network solutions such as, but not limited to, local generation and Demand Side Management (DSM) initiatives.

This PSCR provides a further opportunity for providers of feasible non-network options to submit details of their proposals for consideration.

4.1 Criteria for proposed network support services

Under system normal conditions, network support would need to provide voltage control equivalent to the proposed reactor at or near Nebo or Broadsound substations, being 126MVAr at the 275kV bus. Reactive support would be required to be available on a continuous basis, and not be coupled to generation output.

The network support must continue to operate as per system normal for planned and unplanned outages. Outages of the network support must be coordinated to ensure that Powerlink is able to maintain system security at all times.

The location(s) of any proposed non-network solution will determine the exact levels of support required and will be considered on a case by case basis.

Powerlink has identified the following common criteria that must be satisfied if proposed network support services are to meet supply requirements[22].

Size and location

- Proposed solutions must be large enough, individually or collectively, to provide the size of injection or demand response set out above. However, the level of support is dependent on the location, type of network support and load forecasts.
- Due to the bulk nature of the transmission network, aggregation of sub 10MW non-network solutions will be the sole responsibility of the non-network provider.
- Notwithstanding the location of any solution, each proposal would require assessment in relation to technical constraints pertinent to the network connection, such as impacts on intra-regional transfer limits, fault level, system strength, maintaining network operability and quality of supply.

Operation

- A non-network option would need to be capable of operating continuously 24 hours per day over a period of years.
- If a generation service is proposed (either standalone or in conjunction with other services), such operation will be required regardless of the market price[23].
- Proponents of generation services are advised that network support payments are intended for output that can be demonstrated to be additional to the plant's normal operation in the NEM.
- Where there are network costs associated with a proposed non-network option, including asset decommissioning, these costs will form part of the option economic assessment.

Reliability

- Proposed services must be capable of reliably meeting electricity demand under a range of conditions and, if a generator must meet all relevant National Electricity Rules requirements related to grid connection.
- Powerlink has obligations under the National Electricity Rules, its Transmission Authority and connection agreements to ensure supply reliability is maintained to its customers.

[22] Powerlink's Network Support Contracting Framework has been developed as a general guide to assist potential non-network solution providers. This framework outlines the key contracting principles that are likely to appear in any non-network support agreement.
[23] The National Electricity Rules prevent a generator that is providing network support from setting the market price.

Failure to meet these obligations may give rise to liability. Proponents of non-network options must also be willing to accept any liability that may arise from its contribution to a reliability of supply failure.

Timeframe and certainty

- Proposed services must be able to be implemented in sufficient time to meet the identified need, using proven technology and, where not already in operation, provision of information in relation to development status such as financial funding and development timeline to support delivery within the required timeframe must be provided.

Duration

- The agreement duration for any proposed service will provide sufficient flexibility to ensure that Powerlink is pursuing the most economic long run investment to address the voltage control issues in Central Queensland.

Powerlink welcomes submissions from potential proponents who consider that they could offer a credible non-network option that is both economically and technically feasible.

5 Potential credible network options to address the identified need

Powerlink has developed three credible network options to address the identified need for additional voltage control capacity in the CQ-NQ grid section. All are technically and economically feasible and address the identified need in a timely manner.

Table 5.1 Summary of the credible network option

Option	Description	Total costs ($m) 2020/21	Net Economic Benefit ($m)
1	Establish 1x 150MVAr 300kV bus reactor at H020 Broadsound by June 2023	9.63	34.80
2	Establish 2x 300kV line reactors at H020 Broadsound by June 2023	12.04	32.61
3	Establish 1x 150MVAr 300kV 2bus reactor at H011 Nebo by June 2023	9.89	34.48

All options are designed to:

- Maintain voltages within operational and design limits and keep the power system in a secure operating state,
- Reduce the impact on network reliability resulting from de-energising the 275kV transmission lines, and
- Reduce potential market constraints on generation resulting from de-energising the 275kV transmission lines.

The forecast timing for implementation of the solution to address the over-voltage limitation identified in the 2019 TAPR was December 2021. Subject to the outcome of this RIT-T consultation, the earliest likely timing for the completion of works is June 2023 due to the impacts of the restrictions of the COVID-19 pandemic. The network risk associated with this limitation is being managed through a range of short-term operational measures including rescheduling of outages and the selective switching out of lines as required, until the most economical solution can be implemented.

Additional options that have been considered but not progressed, for technical or economic reasons, are listed in Appendix 1.

5.1 Option 1 - Establish 1x 150MVAr 300kV bus reactor at H020 Broadsound by June 2023

Under this option, a 275kV bus reactor would be establish at Broadsound Substation. The reactor, which would nominally be specified as 150MVAr at 300kV (126MVAr at 275kV), would be connected to the 275kV 2 bus by a dedicated reactive plant bay.

Table 5.2: Shunt reactor at Broadsound: Post N-1 events, per unit voltage values and SVC status

Existing system	**Intact**	**Trip Nebo Reactor**	**Trip Broadsound Line Reactor**	**Trip Nebo SVC**
Broadsound	1.055	1.058	1.064	1.057
Lilyvale	1.066	1.068	1.07	1.067
Nebo	1.066	1.071	1.068	1.07
Nebo SVC (MVArs)*	-28.4	-80	-56.9	0

*SVC Reactive Limit = -80MVars

The reactor at Broadsound has significant impacts on reducing steady state voltages at Broadsound, Nebo and Lilyvale, as well as significantly reducing the utilisation of the Nebo SVC.

5.2 Option 2 - Establish 2x 300kV line reactors at H020 Broadsound by June 2023

Line reactors would be installed on the following 275kV feeders

- Feeder 8831 Stanwell – Broadsound – 25MVAr @ 300kV (21MVAr @ 275kV)
- Feeder 834 Broadsound – Nebo – 35MVAr @ 300kV (39.4MVAr @ 275kV)

The reactors would both be installed at Broadsound with each 275kV reactor required to have a dedicated 275kV reactor circuit breaker.
In order to limit resonance on the 275kV feeder, each reactor must be less than 50% of the charging of the feeder to which they are connected to, and the reactors are sized as such.

Table 5.3: Line reactors at Broadsound: Post N-1 events, per unit voltage values and SVC status

Existing system	**Intact**	**Trip Nebo Reactor**	**Trip Broadsound Line Reactor**	**Trip Nebo SVC**
Broadsound	1.064	1.07	1.082	1.069
Lilyvale	1.071	1.073	1.08	1.072
Nebo	1.069	1.078	1.076	1.076
Nebo SVC (MVARs)*	-59.6	-80	-80	0

*SVC Reactive Limit = -80MVars

5.3 Option 3 - Establish 1x 150MVAr 300kV 2bus reactor at H011 Nebo by June 2023

Under this option, it is proposed to establish a 275kV bus reactor at H011 Nebo. The reactor, which would nominally be specified as 150MVAr at 300kV (126MVAr at 275kV), would be connected to the 275kV 2 bus by a dedicated reactive plant bay.

Table 1: Shunt reactor at Nebo: Post N-1 events, per unit voltage values and SVC status

Existing system	Intact	Trip Nebo Reactor	Trip Broadsound Line Reactor	Trip Nebo SVC
Broadsound	1.067	1.069	1.075	1.066
Lilyvale	1.071	1.073	1.076	1.071
Nebo	1.063	1.068	1.066	1.062
Nebo SVC (MVARs)*	10.2	-47.5	-18.8	0

*SVC Reactive Limit = -80MVars

The reactor at Nebo has significant impacts on reducing steady state voltages at Broadsound and Nebo, and has a greater effect than the Broadsound reactor on reducing the utilisation of the Nebo SVC. The reactor at Nebo, however, does not have as significant an effect on the voltages at Lilyvale.

5.4 Material inter-network impact

Powerlink does not consider that the credible option under consideration will have a material inter-network impact, based on AEMO's screening criteria[24].

6 Materiality of market benefits

The rules require that all categories of market benefits identified in relation to a RIT-T be quantified, unless the TNSP can demonstrate that a specific category is unlikely to be material to the option rankings.[25]

6.1 Market benefits modelled in this RIT-T assessment

Powerlink considers that changes in fuel costs, arising from the need to dispatch off-line generators into the market will have the potential to impact the NPV values of the options relative to the Base Case. However, this does not change the identification of the preferred option under this RIT-T as the ranking of options remains unchanged. These benefits have been quantified and included within the cost benefit analysis.

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

The AER has recognised a number of classes of market benefits may not be material in the RIT-T assessment and so do not need to be estimated.

A discussion of each market benefit under the RIT-T that is considered not material is presented below:

- **changes in voluntary and involuntary load curtailment:** while the installation of additional reactive power plant will mitigate against the need to de-energise lines, the impact is not considered material to the selection of the preferred option
- **changes in costs for parties, other than the RIT-T proponent**: All three credible network options result in the same fuel cost savings, with the start-up, operating and maintenance costs arising from delivering the savings immaterial to the quantum of the savings and therefore the ranking and sign of the options
- **differences in the timing of expenditure**: As all three options offer a substantially similar outcome, any potential transmission investment at a future date for the purposes of voltage control will not change the ranking of the options
- **changes in network losses**: The proposed credible options will have only a marginal impact on network losses. Additionally all three options have the same impact and so there is no material influence on selection of the preferred option from network losses
- **changes in ancillary services cost**: there are no Frequency Control Ancillary Services (FCAS), Network Control Ancillary Services (NCAS), or System Restart Ancillary Services (SRAS) contracts in place to address the over-voltage issue therefore changes in these costs are not material to the outcome of the RIT-T assessment
- **competition benefits:** Due to the localised nature of the voltage issues**,** Powerlink does not consider that any of the credible options will materially affect competition between generators, and generators' bidding behaviour and, consequently, considers that the techniques required to capture any changes in such behaviour would involve a disproportionate level of effort compared to the additional insight it would provide

[24] In accordance with Rules clause 5.16.4(b)(6)(ii). AEMO has published guidelines for assessing whether a credible option is likely to have a material inter-network impact.
[25] S3.6.1 Material classes of market benefits, AER, Regulatory investment test for transmission application guidelines, August 2020

- **option value**: The estimation of any option value benefit over and above that already captured via the scenario analysis in the RIT-T would require significant modelling, which would be disproportionate to any additional option value benefit that may be identified. No additional option value has therefore been estimated for this RIT-T
- the negative of **any penalty** paid or payable: Powerlink does not consider the reactive plant proposed will in any material way impact its obligation to meet any relevant government-imposed instruments

6.3 Consideration of market benefits for non-network options

Powerlink notes that non-network options may impact the wholesale electricity market (for example by displacing generation output). Accordingly, it is possible that several of the above classes of market benefits will be material where there are credible non-network options, depending on the specific form of the option.

Where credible non-network options are identified as part of the consultation process on this PSCR, Powerlink will assess the materiality of market benefits associated with these options. Where the market benefits are considered material, these will be quantified as part of the RIT-T assessment of these options.

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 PSCR compares the costs and benefits of the credible options developed to address the risks arising from an identified need, with a Base Case[26].

As characterised in the RIT-T Application Guidelines, the Base Case itself is not a credible option to meet the identified need. In developing the Base Case, the emerging over-voltage issues in Central Queensland are managed by reducing the output from VRE generators in north Queensland and despatching off-line synchronous generators in Central Queensland to provide the necessary reactive power in the system.

Accordingly, the Base Case provides a clear reference point in the cost-benefit analysis to compare any credible options (network or non-network).

7.2 Base Case assumptions

In calculating the costs required to dispatch off-line generators to address the over-voltage events, the following modelling assumptions have been made:

- To maintain Central Queensland voltages within acceptable limits, utilising existing reactive support, northerly flows would need to be maintained at a minimum of 200MW.
- historical load profiles have been used when assessing the amount of renewable generation that would need to be curtailed (substituted) in MWh, to achieve a minimum of 200MW northerly flow
- the models have used a differential 2020 fuel cost of $25/MWh.

Based upon historical load flows, the average annual cost of curtailing renewable generation in North Queensland and substituting it with suitable generation close to the over-voltage connection points, is $5.1m.

8 General modelling approach adopted for net benefit analysis

8.1 Analysis period

The RIT-T analysis has been undertaken over a 20-year period, from 2020 to 2039. A 20-year period takes into account the size and complexity of the additional reactive plant.

[26] AER, Regulatory investment test for transmission application guidelines, August 2020

There will be remaining asset life by 2039, at which point a terminal value[27] is calculated to account for any future benefits that would accrue over the balance of the asset's life.

8.2 Discount rate

Under the RIT-T, a commercial discount rate is applied to calculate the NPV of the costs and benefits of credible options. Powerlink has adopted a real, pre-tax commercial discount rate of 5.90%[28] 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%[29] and an upper bound discount rate of 8.33% (i.e. a symmetrical upwards adjustment).

8.3 Description of reasonable scenarios and sensitivities

The RIT-T analysis is required to incorporate a number of different reasonable scenarios, which are used to estimate market benefits and rank options. The number and choice of reasonable scenarios must be appropriate to the credible options under consideration and reflect any variables or parameters that are likely to affect the ranking of the credible options, where the identified need is reliability corrective action[30].

8.3.1 Reasonable Scenarios

The detailed market modelling of future generation and consumption patterns based upon the substitution of existing asynchronous generation with utility-scale renewables and changing consumer behaviour, represents a disproportionate cost in relation to the scale of the proposed network investment, and will not materially impact the ranking of options.

Given the specific and localised nature of the over-voltage limitation, the ISP scenarios from the most recent Input Assumptions and Scenario Report are not relevant to this RIT-T[31]. Powerlink has chosen to present two reasonable scenarios consistent with the requirements for reasonable scenarios in the RIT-T instrument [32] and in accordance with the provisions of the RIT-T Application Guidelines[33].

Scenario 1: Powerlink has factored a 10% likelihood of additional reactive power capacity from renewable grid connections in the Central Queensland area becoming available to help address the over-voltage issue during the period of analysis.

Scenario 2: No additional reactive power from new connections in the area becomes available, resulting in higher fuel costs from the need to dispatch additional generation. This scenario was given a weighting of 90%.

[27] Terminal value was calculated based on remaining asset value using straight-line depreciation over the capital asset life.
[28] This commercial discount rate on is based on AEMO's **2019** forecasting and planning scenarios, inputs, and assumptions report in accordance with AER, RIT-T, August 2020 paragraphs 18-19 .
[29] 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.
[30] AER, Regulatory investment test for transmission, August 2020, Section 23
[31] AER, Final: RIT–T, August 2020, sub-paragraph 20(b)
[32] AER, Final: RIT–T, August 2020, sub-paragraph 22
[33] S3.8.1 Selecting reasonable scenarios, RIT-T Application Guidelines, August 2020

Table 8.1: Reasonable scenario assumed

Key variable/parameter	Scenario 1 – Potential Renewable Generation near Broadsound	Scenario 2 – Without Potential Renewable Generation near Broadsound
Capital costs	100% of central capital cost estimate	100% of central capital cost estimate
Discount rate	5.90%	5.90%
Market Benefit from reduction in fuel consumption from generation dispatch	0	$5.1m p.a.
Weighting	10%	90%

9 Cost benefit analysis and identification of the preferred option

9.1 NPV Analysis

Table 9.1 outlines the NPV of the credible network options relative to the Base Case.

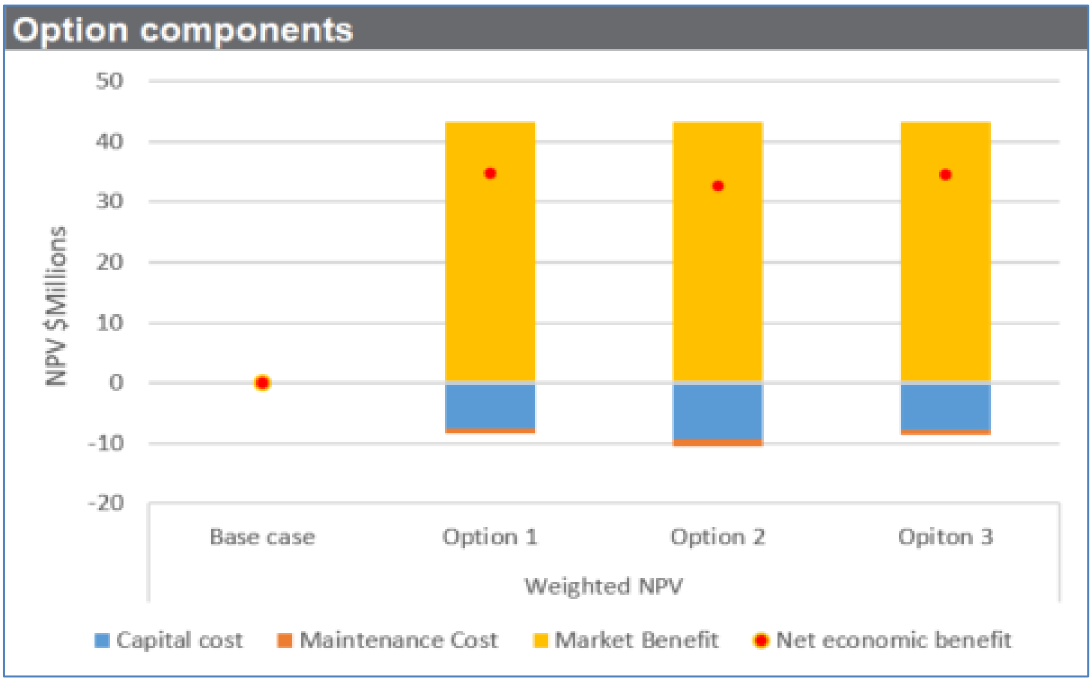
Table 9.1: NPV of the credible network options relative to the Base Case ($m, 2020/21)

Option	Description	Net Economic Benefit ($m)	Ranking
1	Establish 1x 150MVAr 300kV bus reactor at H020 Broadsound by June 2023	34.80	1
2	Establish 2x 300kV line reactors at H020 Broadsound by June 2023	32.61	3
3	Establish 1x 150MVAr 300kV 2bus reactor at H011 Nebo by June 2023	34.48	2

The credible network options address the identified need on an enduring basis by installing additional reactive capacity.

Figure 9.1 sets out the breakdown of capital cost, operational maintenance cost and market benefit of the credible options, as well as the net economic benefit in weighted NPV terms. All credible options have positive net economic benefits compared to the Base Case.

Figure 9.1: NPV of the Base Case and credible option (NPV $m)



9.2 Sensitivity analysis

Sensitivity analysis was carried out to test the robustness of the analysis resulting in the preferred option and to determine if any factors would change the order of the credible options assessed:

The following sensitivities on key assumptions were investigated:

- a range from 3.47% to 8.33% discount rate
- a range from 75% to 125% of base capital expenditure estimates.
- a range from 75% to 125% of base maintenance expenditure estimates.

Figures 9.2 to 9.5 show the impacts of varying the discount rate, capital expenditure and operational maintenance expenditure on the NPV relative to the Base Case. Option 1 is the preferred option under all scenario tested.

Figure 9.2: Discount Rate Sensitivity

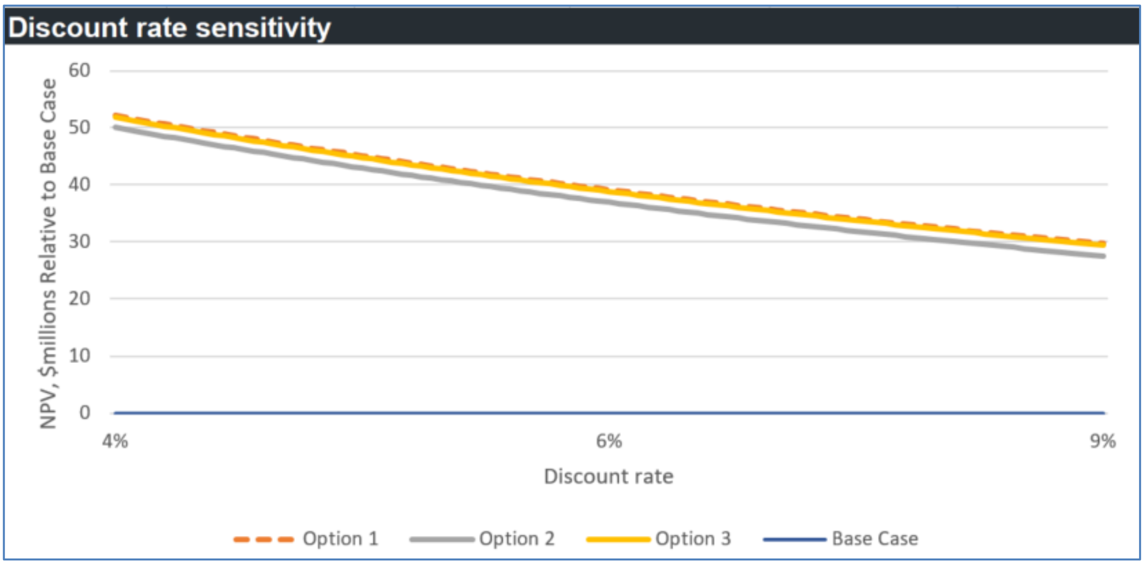


Figure 9.3: Capital Cost Sensitivity

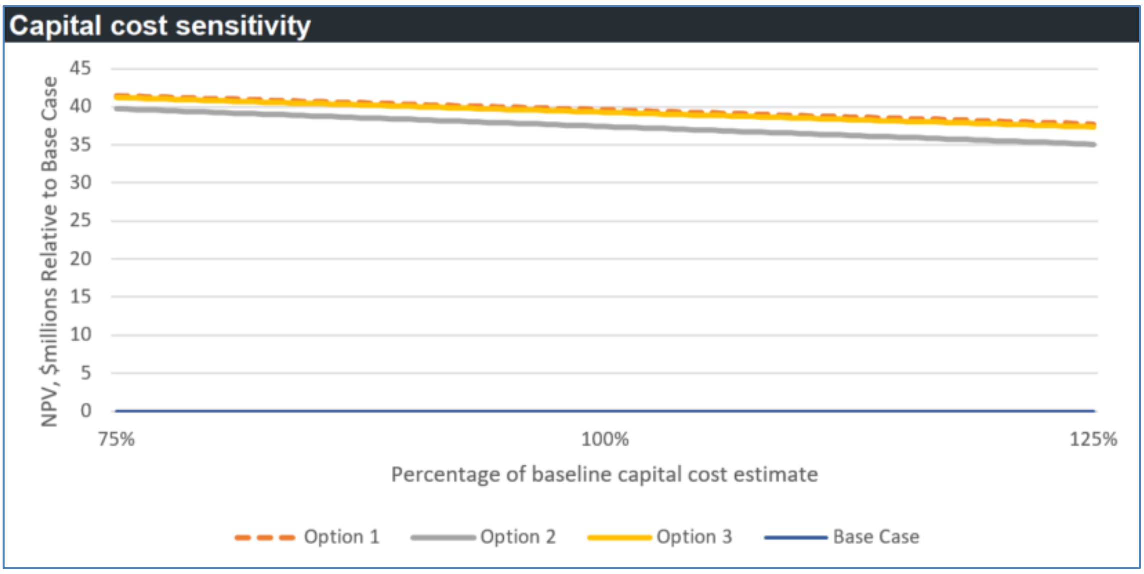
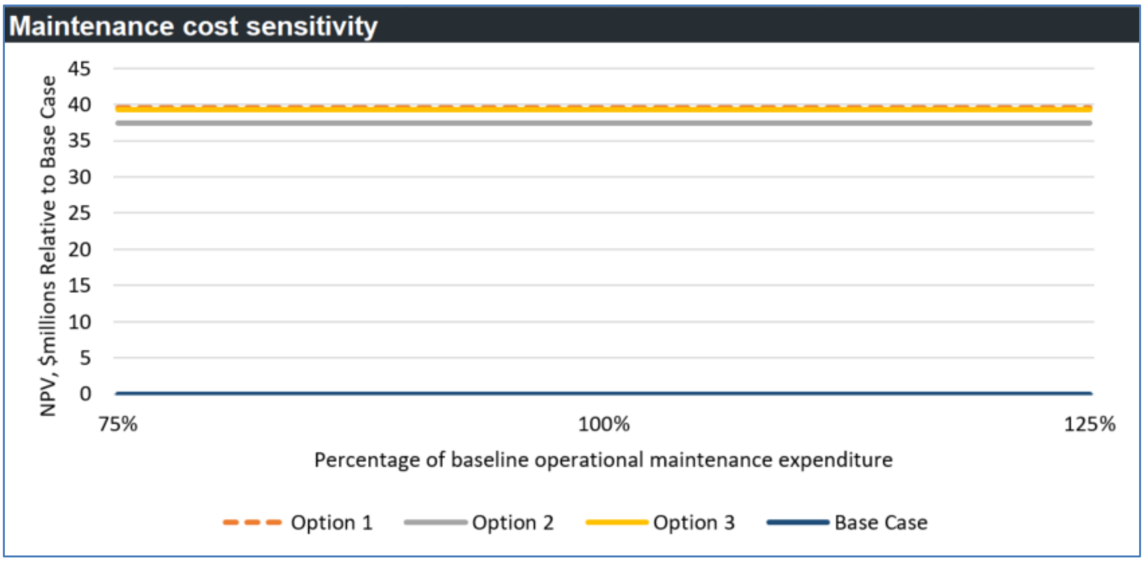


Figure 9.5: Maintenance Cost Sensitivity



9.3 Sensitivity to multiple parameters

A Monte Carlo simulation was performed with multiple input parameters (including capital cost, discount rate, operational maintenance cost) generated for the calculation of the NPV for the credible network option. This process is repeated over 5000 iterations, each time using a different set of random variables from the probability function. The sensitivity analysis output is presented as a distribution of possible NPVs for the credible option, as illustrated in Figure 9.6.

The Monte Carlo simulation results identify that Option 1 has less statistical dispersion in comparison to Options 2 and 3 and has a higher mean compared to these Options. This confirms that the preferred option, Option 1, is robust over a range of input parameters in combination.

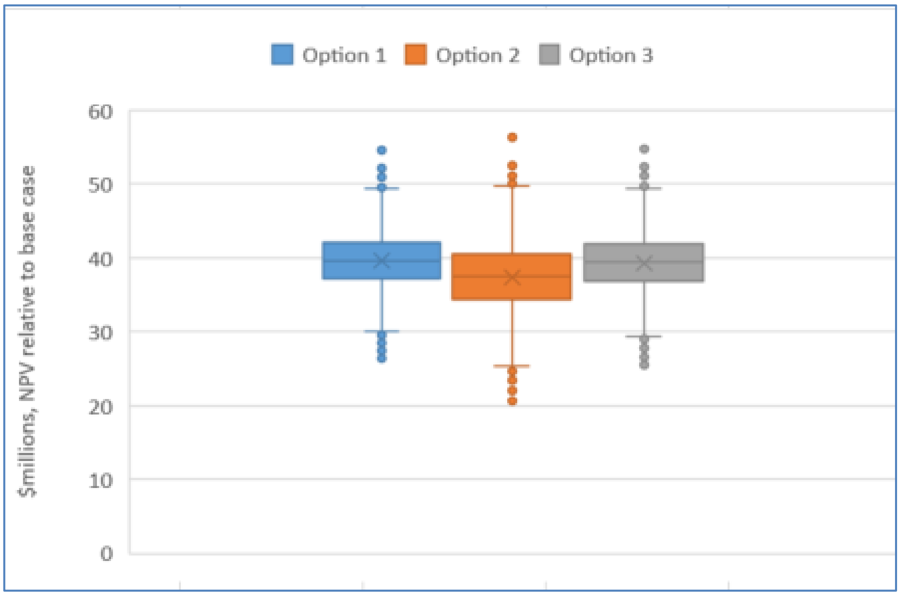


Figure 9.6: NPV sensitivity analysis of multiple key assumptions relative to the Base Case

9.4 Conclusion

The Base Case is not a credible option, in that it does not allow Powerlink to continue to maintain compliance with relevant standards, applicable regulatory instruments and the Rules. As the investment is classified as a 'reliability corrective action' under the Rules, the purpose of the RIT-T is to identify the credible option that minimises the total cost to customers.

Installing a 150MVAr 300kV bus reactor at Broadsound Substation presents the highest net economic benefit to customers and is considered to satisfy the RIT-T.

10 Draft recommendation

Based on the conclusions drawn from the economic analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that proposed network Option 1 be implemented to address over-voltage issues in Central Queensland. Implementing this option will also ensure ongoing compliance with relevant standards, applicable regulatory instruments and the Rules.

Option 1 involves the installation of a 150MVAr 300kV bus reactor at Broadsound Substation at an indicative capital cost of $9.63 million in 2020/21 prices.

Under this option, installation and commissioning of the reactor will be completed by June 2023.

11 Submissions requirements

Powerlink invites submissions and comments in response to this PSCR from Registered Participants, AEMO, potential non-network providers and any other interested parties.

Submissions should be presented in a written form and should clearly identify the author of the submission, including contact details for subsequent follow-up if required. If parties prefer, they may request to meet with Powerlink ahead of providing a written response.

11.1 Submissions from non-network providers

This is not a tender process – submissions are requested so that Powerlink can fulfil its regulatory obligations to analyse non-network options. In the event that a non-network option appears to be a genuine and practicable alternative that could satisfy the RIT-T, Powerlink will engage with that proponent or proponents to clarify cost inputs and commercial terms.

Submissions from potential non-network providers should contain the following information:

- details of the party making the submission (or proposing the service)
- technical details of the project (capacity, proposed connection point if relevant, etc.) to allow an assessment of the likely impacts on future supply capability
- sufficient information to allow the costs and benefits of the proposed service to be incorporated in a comparison in accordance with AER RIT-T guidelines for non-ISP projects
- an assessment of the ability of the proposed service to meet the technical requirements of the Rules
- timing of the availability of the proposed service
- other material that would be relevant in the assessment of the proposed service.

As the submissions will be made public, any commercially sensitive material, or material that the party making the submission does not want to be made public, should be clearly identified. It should be noted that Powerlink is required to publish the outcomes of the RIT-T analysis. If parties making submissions elect not to provide specific project cost data for commercial-in-confidence reasons, Powerlink may rely on cost estimates from independent specialist sources.

11.2 Assessment and decision process

Powerlink intends to carry out the following process to assess what action, if any, should be taken to address future voltage management requirements:

Part 1	PSCR Publication	8 October 2020
Part 2	Submissions due on the PSCR Have your say on the credible options and propose potential non-network options.	8 January 2021
Part 3	Publication of the PACR Powerlink's response to any further submissions received and final recommendation on the preferred option for implementation.	May 2021

Powerlink reserves the right to amend the timetable at any time. Amendments to the timetable will be made available on the Powerlink website (www.powerlink.com.au).

12 Appendix 1: Options considered but not progressed

Table A1: Options considered but not progressed

Option description	Reason for not progressing option
Establish 1x 150MVAr 300kV reactor with transfer bus at H011 Nebo	Extensive on site construction and testing made this option economically unviable. The 120MVAr Cap 3 will have to be moved back 3m to allow for the replacement of the independent earth switch to be replace with an isolator. A purpose-built special custom beam will have to be designed and fitted from the old rack structures to the new with different attachment heights for the beam, different offsets and different size to either of the existing units. A firewall to T6 and T2 will be required. A noise wall will be required. Outages of T6 and T2 will be required together to install these beams and strung bus and quite possibly for the delivery of the reactor. Cap 3 cannot be replaced with the reactor as it would have to be lifted over the =C6 strung bus at 20m high. Additional works by SIEMENS to modify SVC Q-Opt logic to ‘inform’ SVC if CB5832 is currently controlling a ‘reactor’ or ‘cap bank’. Consideration of control system philosophy (two panels controlling one bay) e.g. interlocking. The Q optimiser logic will be unique and require extensive testing.
Establish 1x 150MVAr 300kV reactor at H020 Broadsound using an existing diameter by 2023	The reactor would only be able to be energised by the CB in the new bay within the diameter To switch the reactor in (or out) of service, it will be necessary to open the CB in the coupler bay, open the CB in the new bay, close (or open) the motorised disconnector on the reactor, then close the CB in the new bay followed by the coupler CB. This switching action would be required – on average – twice a day (once in, once out) The number switching operations required from both a plant and an operational perspective, are too high for a connection of this nature.
Establish a synchronous condenser at Broadsound	Capable of meeting voltage control requirements, however at a significantly higher cost than shunt reactors.

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