Powerlink Queensland

Project Specification Consultation Report

6 April 2022

Maintaining power transfer capability and reliability of supply at Redbank Plains

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 the 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 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, identification of the preferred option, technical characteristics of non-network options, and categories of market benefits impacting selection of the preferred option. 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).

Contents

Executive Summary

The condition of transformers and primary plant at Redbank Plains Substation requires Powerlink to take action

Redbank Plains Substation, located approximately 27km southwest of the Brisbane CBD, was established in 1985 as a bulk-supply injection point to the Energex (part of the Energy Queensland group) distribution network. It also provides additional switching capability for alternative power transfer between Blackstone and Goodna.

A recent condition assessment indicates that both power transformers, along with a number of primary plant items are nearing the end of their respective service lives and are displaying a number of condition-based issues.

Planning studies have confirmed there is a long-term requirement to continue to supply the existing electricity services provided by Redbank Plains Substation. Powerlink must therefore take action to avoid the increasing likelihood of unserved energy arising from failure of the ageing transformers and primary plant at Redbank Plains, and ensure customers are provided with a reliable and safe supply of electricity.

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

As the identified need of the proposed investment is to meet reliability and service standards specified in the Rules, Powerlink's Transmission Authority and applicable jurisdictional instruments, it is classified as a "reliability corrective action"[2].

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

Powerlink has adopted the expedited process for this RIT-T[4], as the preferred option is below $46 million and is unlikely to result in any material market benefits other than those arising from a reduction in involuntary load shedding. The reduction in involuntary load shedding under the credible network options is catered for in the risk cost modelling and consequentially represented in the economic analysis of the options.

This Project Specification Consultation Report (PSCR) discusses and ranks the potential credible network options, which incorporate cost effective measures over the long-term, to achieve the required service levels.

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

Consistent with the Australian energy Regulator's (AER's) RIT-T Application Guidelines[5] the assessment undertaken in this PSCR compares and ranks the net present value (NPV) of credible network options designed to address the emerging risks, relative 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 assigned 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 designed to offset/mitigate the risks, and to ensure ongoing compliance with regulatory and jurisdictional obligations.

Four credible network options have been developed to address the identified need

Powerlink has developed four credible network options, to maintain the existing electricity services, ensuring a reliable, safe and cost effective supply to customers in the area.

[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

[5] AER, *Application guidelines, Regulatory investment test for transmission,* August 2020

The four credible network 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 RIT-T network options ($m, real 20/21)

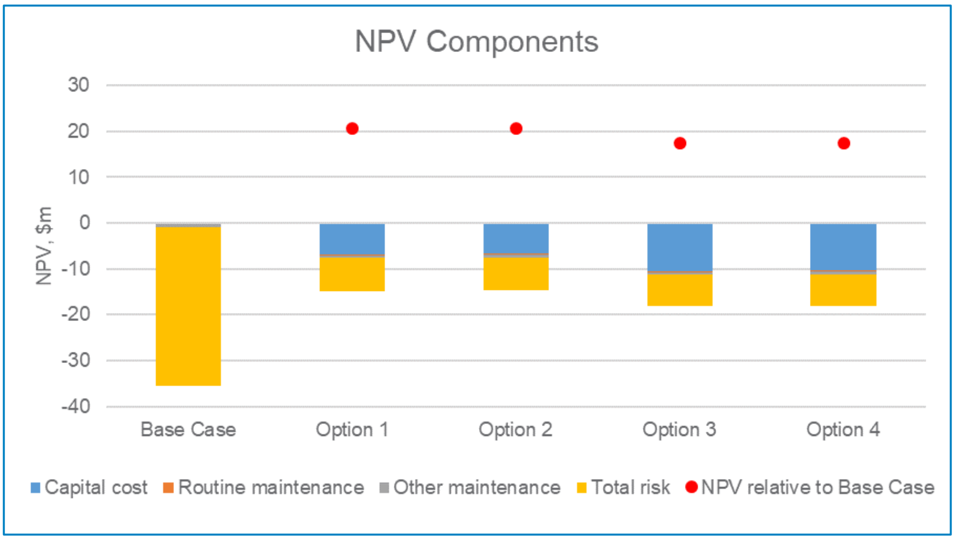
Option	Description	Total Cost	NPV relative to Base Case	Ranking
1	Refit and life extend transformers by 2024, and replace selected feeder and bus bay primary plant by 2025	7.22*	20.63	2
	Replace isolators and earth switches by 2029	2.06†		
	Replace transformers by 2039	8.69†		
2	Refit and life extend transformers by 2024, and replace all feeder bay and bus bay primary plant by 2025	8.45*	20.74	1
	Replace transformers by 2039	8.69†		
3	Replace transformers by 2024 and replace selected feeder and bus bay primary plant by 2025	13.97*	17.40	4
	Replace isolators and earth switches by 2029	2.06†		
4	Replace transformers by 2024, and replace all feeder bay and bus bay primary plant by 2025	15.20*	17.51	3

*RIT-T Project
†Future modelled projects (operational and capital)

All credible options address the major risks resulting from the deteriorated condition of ageing transformers and primary plant at Redbank Plains Substation.

Figure 1 shows the breakdown of the central scenario NPV of the Base Case and the four credible options. All options reduce the total risk costs arising from the ageing assets at Redbank Plains remaining in service and being managed via operational maintenance only (as in the Base Case), and hence reflect a net economic benefit when compared to the Base Case.

Figure 1: Central scenario NPV component of Base Case and Options ($m, real 20/21)



Option 2 has been identified as the preferred network option.

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. The economic analysis demonstrates that Option 2 provides the highest net economic return relative to the Base Case of the four credible options and is therefore the preferred option.

Option 2 involves the refit of the two 110/11kV 25MVA transformers to extend their service life and the replacement of all feeder bay and bus bay primary plant by 2025. The indicative capital cost of the RIT-T project for the preferred option is $8.45 million in 2020/21 prices excluding future model project costs.

Under Option 2, procurement of new plant would commence in 2022, with refurbishment of the existing transformers and replacement of selected primary plant completed by 2025.

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

Powerlink welcomes submissions from proponents who consider that they could offer a credible non-network option that is both economically and technically feasible by June 2024, on an ongoing basis.

A non-network option that avoids the proposed replacement of ageing primary plant and refit of transformers would need to replicate, in part or full, the support that Redbank Plains Substation delivers to customers in the area on a cost effective basis.

Lodging a submission with Powerlink

Powerlink is seeking written submissions on this *Project Specification Consultation Report* by Monday, 11 July 2022, particularly on the credible options presented[6].

Please address submissions to:

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[6] 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[7], optimizing performance and efficiently managing assets through the whole asset life cycle[8].

The transformers and primary plant at Redbank Plains Substation are nearing the end of their technical service lives and are increasingly at risk of failure due to their deteriorated condition.

Planning studies have confirmed there is a long-term requirement to continue to supply the existing electricity services currently provided by Redbank Plains Substation to customers in the Greater Brisbane area.

The proposed credible network options maintain the current electricity services to customers in the area by addressing the increasing likelihood of faults arising from the condition of Redbank Plains Substation's ageing transformers and primary plant. When developing the credible options, Powerlink has focussed on implementing cost effective solutions that ensure a reliable and safe supply, delivering positive outcomes for customers.

1.2 RIT-T Overview

The identified need referred to in this RIT-T, to maintain power transfer capability and reliability of supply at Redbank Plains, 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*[9].

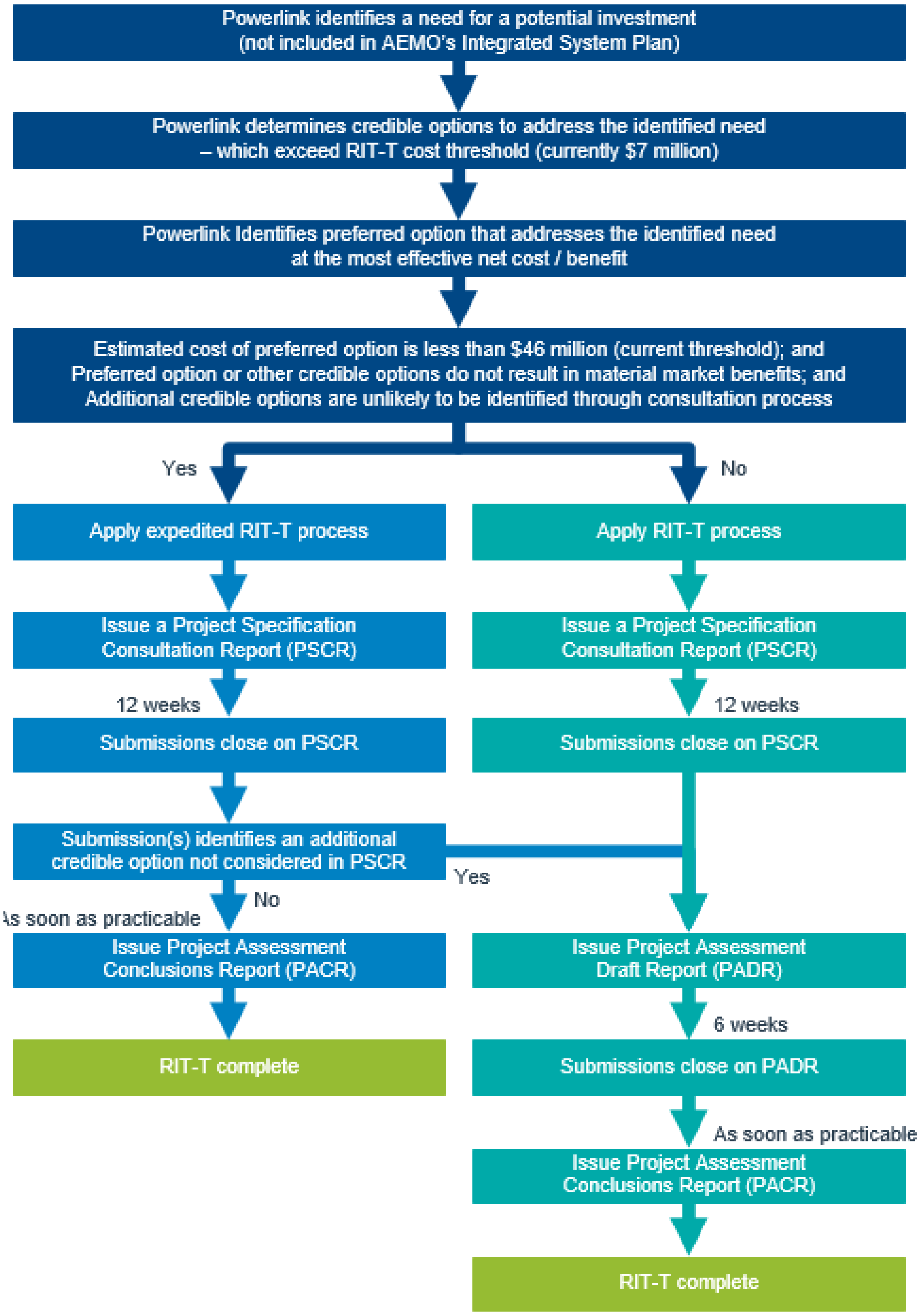
This Project Specification Consultation Report (PSCR) is the first step in the RIT-T process[10]. It:

- 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 options that Powerlink currently considers address the identified need
- discusses why Powerlink does not expect specific categories of market benefit to be material for this RIT-T[11]
- presents the Net Present Value (NPV) assessment of each of the credible options compared to a Base Case (as well as the methodologies and assumptions underpinning these results)

[7] 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*.
[8] 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
[9] Refer to Clause 5.16.2 of the NER.
[10] This RIT-T consultation has been prepared based on the following documents: *National Electricity Rules, Version 179,* 10 March 2022 and AER, *Application guidelines, Regulatory investment test for transmission,* August 2020.
[11] As required by Clause 5.16.1(c)(iv) of the Rules.

- identifies and provides a detailed description of the credible option that best satisfies the RIT-T, and is therefore the preferred option
- describes how customers and stakeholders have been engaged regarding the identified need
- provides stakeholders with the opportunity to comment on this assessment so that Powerlink can refine the analysis (if required) as part of the Project Assessment Conclusions Report (PACR).

Figure 1.1: RIT-T Process Overview: Need not identified as an *actionable ISP project*



Powerlink has adopted the expedited process for this RIT-T, as allowed for under the National Electricity Rules (the Rules) for investments of this nature[12]. Specifically, Powerlink will publish a Project Assessment Conclusions Report (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 $46 million
- none of the credible options have material market benefits, other than benefits associated with changes in involuntary load shedding
- Powerlink has identified its preferred option in this PSCR (together with the supporting quantitative cost-benefit analysis)
- Powerlink does not envisage that additional credible options, which could deliver material market benefits, will be identified through the submission process, given the nature of this primary plant replacement project.

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 more cost efficient outcome for customers.

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.

[12] In accordance with clause 5.16.4(z1) of the Rules

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 Transmission Annual Planning Report (TAPR) and TAPR templates (available via the TAPR portal), 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 Maintaining power transfer and reliability of supply at Redbank Plains

Powerlink identified in its 2019-2021 TAPRs, an expectation that action would be required to address the emerging power transfer and reliability of supply issues in the Moreton transmission zone[13]. 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.

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 comprises approximately 9% of the total cost of the residential electricity bill (refer to Figure 2.1).

Figure 2.1: Components of 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.

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

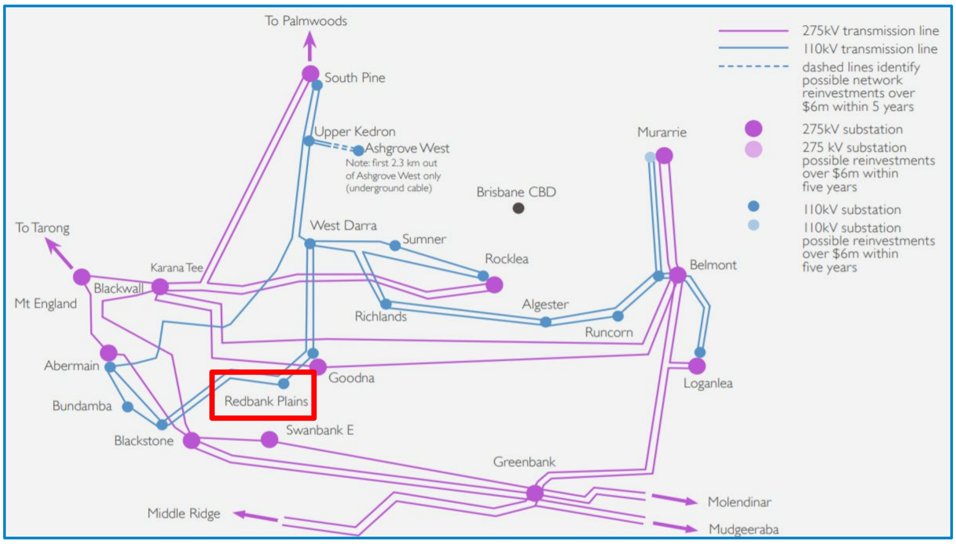
3 Identified need

This section provides an overview of the existing arrangements at Redbank Plains Substation 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

Redbank Plains Substation was established in 1985 as a bulk- supply injection point to the Energex distribution network. It has direct connections to the Blackstone and Goodna Substations and forms part of Powerlink's meshed network in the Greater Brisbane area.

Figure 3.1: Greater Brisbane transmission network



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[14].

Planning studies have confirmed that in order to continue to meet the reliability standard within Powerlink's Transmission Authority, the services currently provided by Redbank Plains Substation are required into the foreseeable future to meet ongoing customer requirements.[15]

As the proposed investment is for meeting reliability and service standards arising from Powerlink's Transmission Authority and to ensure Powerlink's ongoing compliance with Schedule 5.1 of the Rules, it is a 'reliability corrective action' under the Rules[16]

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.

[14] Transmission Authority No. T01/98, section 6.2(c)
[15] *Powerlink's Transmission Annual Planning Report 2021*
[16] The Rules clause 5.10.2, Definitions, reliability corrective action.

3.3 Assumptions and requirements underpinning the identified need

Powerlink's condition assessment of the ageing transformers and primary plant assets at Redbank Plains Substation has highlighted that many assets are nearing the end of their technical service lives and are operating in a deteriorated condition.

The consequences of these at-risk transformers and primary plant remaining in service beyond 2024, without corrective action, would result in Powerlink being exposed to potential risk of catastrophic failure. This would lead to a breach of Powerlink's obligations under the *Electrical Safety Act and Regulations, Work Health and Safety Act* and *Environmental Protection Act*, as well as its service standards under the *Electricity Act* and *Regulations* and its *Queensland Transmission Authority*[17].

The failure of the circuit breakers to operate or clear faults in sufficient time to avoid damage to the power system may leave Powerlink unable to meet its public safety and supply obligations to its customers. Corrective action is also required to prevent the failure of deteriorated current transformers (CTs) and voltage transformers (VTs), in order to ensure the safety of personnel and that the plant operates as designed in accordance with the requirements of the *Electrical Safety Regulations 2013 Part 1 Section 3 and Part 9 Section 198*.

The catastrophic failure of oil filled, porcelain housed CTs would result in a breach of Powerlink's Primary duty of care obligations under the *Work Health and Safety Act 2011*[18]. Under the requirements of the Act, Powerlink must "so far as is reasonably practicable" address the risk.

Removing the deteriorated assets from service will in many cases eliminate the risk of breaching these safety obligations. However, removing the assets from the Powerlink network without a suitable network or non-network alternative will result in Powerlink not complying with the Rules or its Transmission Authority, as detailed below.

The removal of the power transformers or any of the circuit breakers, or other affected primary plant, at Redbank Plains will result in the need for load shedding to ensure that the system is able to be operated without breaching clause 4.2.2(d) of the Rules:

> *"all other plant forming part of or impacting on the power system is being operated within the relevant operating ratings (accounting for time dependency in the case of emergency ratings) as defined by the relevant Network Service Providers in accordance with schedule 5.1."*

The load shedding requirement under an intact system, as well as for a credible contingency, would result in breaches of Powerlink's Transmission Authority T01/98 clause 6.2 (c), where Powerlink must plan and develop its transmission network such that:

> *"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."*

By addressing the risks arising from the condition of ageing and obsolete assets at Redbank Plains, Powerlink is seeking to ensure a safe, adequate, economic, and reliable supply of electricity to its customers into the future.

3.4 Description of asset condition and risks

Powerlink has undertaken a comprehensive condition assessment of the transformers and primary plant at Redbank Plains Substation. This has identified that a significant amount of equipment is exhibiting age-related deterioration issues and reaching the end of its technical service life, with an increasing risk of failure.

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[17] *Section 29, Electrical Safety Act 2002*; *Part 1, Section 3, and Part 9, Section 198, Electrical Safety Regulations 2013; Section 19, Work Health and Safety Act 2011*; *Chapter 7, Part 1, Division1 Section 319(1), Environmental Protection Act 1994*; *Section 34 (1)a Electricity Act 1994*; Queensland Transmission Authority T01/98 (See Appendix 2 for further detail)

[18] Work Health and Safety Act 2011, Division 2 Primary Duty of Care, Section 19

Notwithstanding the assessed condition of the asset, Powerlink's ongoing operational maintenance practices are designed to monitor plant condition and ensure any emerging safety risks are proactively managed.

Power Transformers

Commissioned 35 years ago, the original 110/11kV transformers are exhibiting signs of age-related deterioration, in particular, the HV bushings are past the nominal 25 years suggested by the original equipment manufacturer, with an estimated 3-5 years until end of life.

The sealing integrity of numerous joints and valves have been compromised, resulting in an increased observation of oil leaks at radiators and bushings as well as the appearance of oil in the transformer's cable box. The transformers' overall anti-corrosion system is in reasonable condition, with a full repaint of the transformers and their cooling systems sufficient to provide a further 10 -15 year's protection.

As the consequences of a major failure of a power transformer are high, the asset management strategy employed is to plan and execute reinvestment before an actual failure occurs, given an ongoing future need.

Primary Plant

At-risk primary plant comprises circuit breakers, current and voltage transformers, isolators, earth switches and surge arrestors.

Circuit Breakers

Installed in the 1980s, the substation's ageing circuit breakers are no longer supported by their manufacturers and sourcing spare parts has become a major issue. Low air pressure in the breakers' compressor systems has resulted in a number of seals being replaced. The close/trip times on these older circuit breakers has also begun to trend upwards in the past 5-10 years.

An in-service failure of any of these aged circuit breakers would put load at risk for long periods, as considerable civil work is required to modify the foundations to accept any new replacement model.

With limited spares available from the manufacturers, it is also becoming increasingly difficult for Powerlink to service this ageing population of circuit breakers across the Powerlink transmission network.

Current and Voltage Transformers

At almost 35 years of age, insulation breakdown and oil leaks pose the biggest risk to the ongoing operation of the current and voltage transformers at Redbank Plains Substation. The ageing process impacts the integrity of the transformer seals, leading to moisture ingress and breakdown of the insulating oil. As the oil breaks down it releases a combination of combustible gases and loses its insulating properties.

The moisture also migrates into the paper insulation causing its rapid degradation. This degradation of the insulating paper combined with the continuing breakdown of the oil ultimately results in arcing, which in the presence of highly combustible gases, increases the probability of catastrophic failure. Under these conditions, the transformers' porcelain housings can rupture on failure, resulting in safety risks, reliability of supply impacts, and potential damage to adjacent equipment and plant, requiring lengthy repairs and incurring significant costs.

Analysis of catastrophic failures within Powerlink's fleet of oil filled, porcelain housed CTs shows a marked increase in the likelihood of failure after 36 years of service. Historical failure rates in excess of 30% after 25 years of service for the obsolete, at-risk VTs also leaves Powerlink at risk of breaching its metering obligations.

Earth Switches and Isolators

While earth switches and isolators remain in reasonable operable condition at present, they will require replacement within the next 10 years to ensure the ongoing reliable isolation of primary plant.

3.5 Consequences of Redbank Plains transformer and primary plant failures

Poor asset condition increases the risk and frequency of faults, while obsolescence increases the time needed for Powerlink to undertake any necessary repairs, prolonging the return to service time. Due to the substation's configuration, utilising the same breakers for feeder and transformer protection, the slow operation of the feeder breakers or explosive failure of a CT would result in the loss of a feeder and transformer.

The potential in-service failure of ageing transformers and primary plant at Redbank Plains presents Powerlink with a range of unacceptable safety, network and financial risks, and the inability to meet legislative obligations and customer service standards.

The condition and consequences of failure of the main at-risk items of equipment is summarised in Table 3.1.

Table 3.1: Redbank Plains: at-risk assets and consequences of failure

Equipment	Condition	Consequence of failure
Power Transformers	• Aged HV bushings at end of technical service life • Emerging gasket failures • Repeated moisture exchange, increased oil acidity and presence of oxygen • Leaking and corroded cooling banks	• Increased susceptibility of power transformer failure during through faults leading to loss of supply with long return to service time • Risk of fire and environmental damage
Circuit Breakers	• Loss of pneumatic pressure • Limited availability of spares	• Failure to operate or slow clearance times resulting in safety and supply risks • Extended time to restore supply to customers due to a limited availability of spares • Environmental impacts from SF6 gas release • Increased maintenance resulting in less reliable and more costly supply to customers
Voltage Transformers	• Degraded oil and paper insulation inside porcelain housings • Oil leaks and overheating	• Significant safety, financial, environmental and loss of supply risks • Potential for explosive failure modes leading to damage of other equipment and loss of supply • Loss of protection signals resulting in disconnection of supply • Breach of metering requirements[19]
Current Transformers	• Degraded oil and paper insulation inside porcelain housings • Oil leaks	• Significant safety, financial, environmental and loss of supply risks • Potential for explosive failure modes leading to damage of other equipment and extended loss of supply

[19] Chapter 7, Part D, Metering Installation and Schedule 7.2 Metering Provider, AER

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.

Powerlink identified in its TAPRs from 2019 to 2021, an expectation that action would be required at Redbank Plains Substation to maintain reliability of supply requirements in the Moreton transmission zone[20]. Powerlink has considered the operation of the existing embedded generation in the region in establishing this requirement.

Powerlink has consulted with Registered Participants, Powerlink's Non-Network Engagement Stakeholder Register and interested parties on the proposed investment at this substation as part of the TAPR publication and associated engagement activities.

No submissions proposing credible and genuine non-network options were received from prospective solution providers in the normal course of business or in response to the TAPRs. As a result, Powerlink is currently not aware of any non-network options that could be adopted, but will investigate the feasibility of any potential non-network option proposed or otherwise identified.

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

A non-network option that assists in minimising the overall investment could provide either a full solution that replicates the functionality of the primary plant and the two transformers, or a partial solution that provides support to replace one of the transformers at risk.

A non-network option that avoids replacement of ageing transformers, and associated primary plant, would need to provide injection or demand response at Redbank Plains of 25MW and up to 400MWh per day at peak from June 2024.

The exact requirements are in addition to existing embedded generation that operates in the area, and is dependent on the nature of the network support, including how quickly any response can be initiated. A non-network solution must also maintain/restore fault level (system strength) and voltage control.

Powerlink has identified the following common criteria that must be satisfied if proposed network support services are to meet supply requirements[21].

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.

[20] This relates to the standard geographic definitions (zones) identified within the Powerlink's Transmission Annual Planning Report, which is published annually by 31 October.
[21] 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- agreement.

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[22].
- 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, protection schemes, equipment to support maintenance outages, these costs form part of the scope of a non-network option and will be included in the overall cost of a non-network option as part of the RIT-T cost-benefit analysis.

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 Rules, its Transmission Authority and connection agreements to ensure supply reliability is maintained to its customers. 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 condition risks arising from ageing transformers and primary plant at Redbank Plains Substation.

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 four credible network options to address the identified need for maintaining power transfer capabilities and reliability of supply at Redbank Plains Substation.

Options 1 and 2 seek to optimise the service life of the transformers through the selective upgrading of components, thereby delaying replacement until 2039, while options 3 and 4 seek to minimise mobilisation costs and outages by replacing the transformers in 2024, with the bulk of other works.

Options 1 and 3 further seek to optimise the service life of the earth switches and isolators by delaying their replacement until 2029, while options 2 and 4 seek to minimise mobilisation costs and outages by replacing them at the same time as all other primary plant in 2025.

[22] The National Electricity Rules prevent a generator that is providing network support from setting the market price.

Table 5.1: Summary of credible options – capital and maintenance costs ($m, real 20/21)

Option	Description	Total Cost	Annual Operational Maintenance Cost
1	Refit and life extend transformers by 2024, and replace selected feeder and bus bay primary plant by 2025	7.22*	0.07
	Replace isolators and earth switches by 2029	2.06†	
	Replace transformers by 2039	8.69†	
2	Refit and life extend transformers by 2024, and replace all feeder bay and bus bay primary plant by 2025	8.45*	0.07
	Replace transformers by 2039	8.69†	
3	Replace transformers by 2024 and replace selected feeder and bus bay primary plant by 2025	13.97*	0.07
	Replace isolators and earth switches by 2029	2.06†	
4	Replace transformers by 2024, and replace all feeder bay and bus bay primary plant by 2025	15.20*	0.07

*RIT-T Project
†Future modelled projects (operational and capital)

Powerlink is the proponent of all of the credible network options presented. All credible options address the major risks resulting from the deteriorated condition of ageing primary plant at Redbank Plains Substation. None of these options has been discussed by the Australian Energy Market Operator (AEMO) in its most recent Integrated System Plan (ISP)[23].

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

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[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 (or categories) is unlikely to be material.

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 the options, set out in this PSCR, may impact the ranking of the credible options under consideration and that this class of market benefit could be material. Consequently, these benefits have been quantified and included within the cost-benefit and risk cost analysis as network risk.

[23]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 ISP. The most recent ISP was published in July 2020
[24] 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.

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[25].

A discussion of each market benefit under the RIT-T is discussed below.

- **Changes patterns of generation dispatch**: replacement under the credible options does not by itself materially affect transmission network constraints or affect transmission flows that would change patterns of generation dispatch. It follows that changes in patterns of generation dispatch are not material to the outcome of the RIT-T assessment.
- **Changes in voluntary load curtailment**: replacement under the credible options does not by itself affect prices in the wholesale electricity market. It follows that changes in voluntary load curtailment will not be material for the purposes of this RIT-T.
- **Changes in costs for other parties**: the effect of replacing the ageing assets under the credible options considered are localised to the substation they are located at and do not affect the capacity of transmission network assets and therefore is unlikely to change generation investment patterns (which are captured under the RIT-T category of 'costs for other parties').
- **Differences in the timing of expenditure**: credible options for asset replacement do not affect the capacity of transmission network assets, the way they operate, or transmission flows. Accordingly, differences in the timing of expenditure of unrelated transmission investments are unlikely to be affected.
- **Changes in network losses**: credible options are not expected to materially provide any changes in network losses.
- **Changes in ancillary services cost**: there is no expected change to the costs of Frequency Control Ancillary Services (FCAS), Network Control Ancillary Services (NCAS), or System Restart Ancillary Services (SRAS) due to credible options under consideration. These costs are therefore not material to the outcome of the RIT-T assessment.
- **Competition benefits:** 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.
- **Option value**: Powerlink does not consider that the identified need for the options considered in this RIT-T is affected by uncertain factors about which there may be more clarity in future. As a consequence, option value is not a relevant consideration for this RIT-T.

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 material, these will be quantified as part of the RIT-T assessment of these options.

[25] AER, *Application guidelines, Regulatory investment test for transmission,* August 2020, page 29.

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 credible options 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. 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 the credible options designed to offset or mitigate these risk costs.

The Base Case therefore includes the costs of work associated with operational maintenance (i.e. routine, condition-based and corrective 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 corrective maintenance costs.

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 each other over the same timeframe.

7.2 Redbank Plains 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[27] and this has been used to calculate the risk costs of the Redbank Plains Base Case. The framework includes the modelling methodology and general assumptions underpinning the analysis.

7.2.1 Base Case assumptions

In calculating the potential unserved energy (USE) arising from a failure of the ageing primary plant and transformers at Redbank Plains, the following modelling assumptions specific to the Redbank Plains network configuration have been made.

- Historical load profiles and embedded generation patterns have been used when assessing the likelihood of unserved energy under concurrent failure events.
- Unserved energy generally accrues under concurrent failure events, and consideration has been given to potential feeder trip events within the wider Redbank Plains area.
- Redbank Plains Substation supplies a mixture of residential and commercial types. Historical load data has been analysed to approximate the ratio of residential to commercial load, resulting in a VCR of $26,038/MWh. The most relevant residential and commercial VCR values published within the AER's Value of Customer Reliability Annual Adjustment (updated in 2021) and have been used to determine this VCR.
- Powerlink's business response to mitigating unserved energy under prolonged supply outage events has been incorporated within the risk cost modelling.

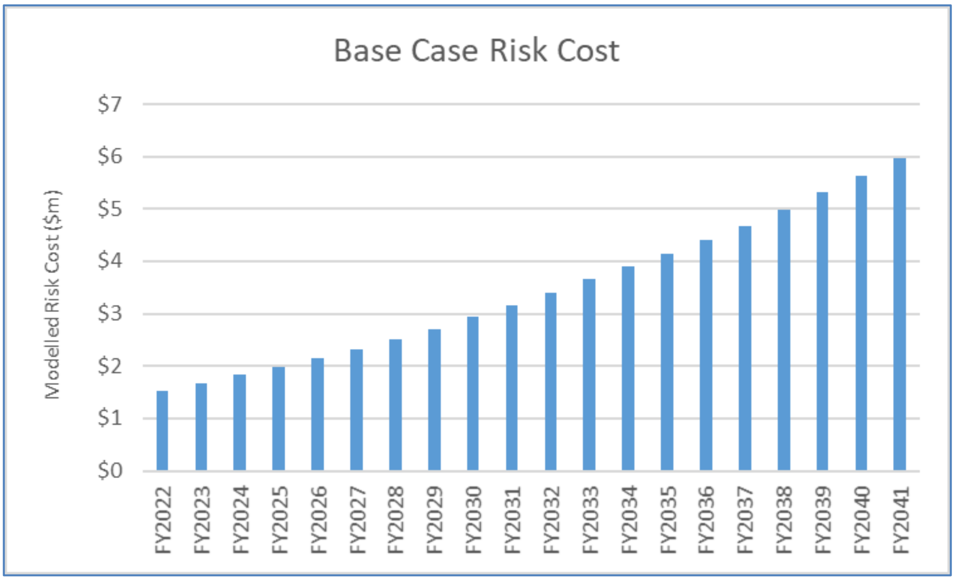
[26] AER, *Application guidelines, Regulatory investment test for transmission,* August 2020

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

7.2.2 Base Case risk costs

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

Figure 7.1: Modelled Base Case risk costs ($m, real 20/21)



Based upon the assessed condition of the ageing primary plant and transformers at Redbank Plains, the total risk costs are projected to increase from $1.53 million in 2022 to $5.96 million in 2041.

The main areas of risk cost are safety risk arising from the failure of equipment, financial risk related to the replacement of damaged equipment and failed items of primary plant and transformers, as well as network risk, involving reliability of supply through the failure of deteriorated primary plant and transformers, modelled as probability weighted unserved energy[28]. These risks increase over time as the condition of plant further deteriorates and the likelihood of failure rises.

7.3 Modelling of Risk in Options

Each option is specifically scoped to manage the major risks arising in the Base Case in order to maintain compliance with all statutory requirements. 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.

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 2022 to 2041. A 20 year period sufficiently takes into account the size and complexity of the replacement primary plant and transformer investment.

As there will be remaining asset life in 2041, a terminal value[29] is calculated to account for any future benefits that would accrue over the balance of the asset's life.

[28] Unserved Energy is modelled using a Value of Customer Reliability (VCR) consistent with that published by AER in their *Value of Customer Reliability Annual Adjustment (updated in 2021)*.
[29] Terminal value was calculated based on remaining asset value using straight-line depreciation over the capital asset life.

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 5.5%[30] 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 2.2%[31] and an upper bound discount rate of 8.8% (i.e. a symmetrical upwards adjustment).

8.3 Description of reasonable scenario

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[32].

The detailed modelling of scenarios based upon AEMO's 2020-21 Inputs, Assumptions and Scenarios Report would represent a disproportionate cost in relation to the scale of the proposed network investment and the minor differences in residual risk between the options.

As discount rate, capital cost, maintenance cost and risk cost sensitivities do not impact the option rankings and identification of the preferred option, Powerlink has elected to present a central scenario consistent with the requirements for reasonable scenarios in the RIT-T instrument and in accordance with the provisions of the RIT-T Application Guidelines.

As noted above in Section 7, unserved energy costs are modelled as part of the Base Case Risk costs for comparative purposes with and between the options.

Table 8.1: Reasonable scenario assumed

Key parameter	Central scenario
Capital cost	100% of base capital cost estimate
Maintenance cost	100% of base maintenance cost estimate
Discount rate	5.5%
Risk cost	100% of base risk cost forecast

[30] This indicative commercial discount rate of 5.5% is based on the AEMO 2021 Inputs, Assumptions and Scenarios Report, p105.

[31] A discount rate of 2.2% pre-tax real Weighted Average Cost of Capital is based on the AER 2023-27 Powerlink Queensland revised revenue proposal, p21.

[32] AER, Final Regulatory Investment Test for Transmission, July 2020, version 2, Section 23

9 Cost-benefit analysis and identification of the preferred option

9.1 NPV Analysis

Table 9.1 outlines the net present value for each credible option and the corresponding ranking of each credible option, relative to the Base Case.

Table 9.1: NPV of credible options ($m, 2020/21)

Option	Description	Central Scenario NPV relative to Base Case	Ranking
1	Refit and life extend transformers by 2024, and replace selected feeder and bus bay primary plant by 2025*	20.63	2
	Replace isolators and earth switches by 2029†		
	Replace transformers by 2039†		
2	Refit and life extend transformers by 2024, and replace all feeder bay and bus bay primary plant by 2025*	20.74	1
	Replace transformers by 2039†		
3	Replace transformers by 2024 and replace selected feeder and bus bay primary plant by 2025*	17.40	4
	Replace isolators and earth switches by 2029†		
4	Replace transformers by 2024, and replace all feeder bay and bus bay primary plant by 2025*	17.51	3

*RIT-T Project
†Future modelled projects (operational and capital)

All credible options will address the identified need on an enduring basis.

Of the four credible options, Option 2 has the highest of net present value relative to the Base Case, with Option 1 not materially different, being $0.09 million more expensive compared to Option 2 in NPV terms.

Option 2 provides additional benefit of reducing repeat mobilisation of key resources.

Figure 9.1 sets out the central scenario NPV components of capital cost, maintenance cost and risk cost for the Base Case and each credible option. Note that the non-credible Base Case consists of operational maintenance and total risk costs and does not include any capital expenditure.

Figure 9.1: Central scenario components of Base Case and credible options ($m, real 20/21)

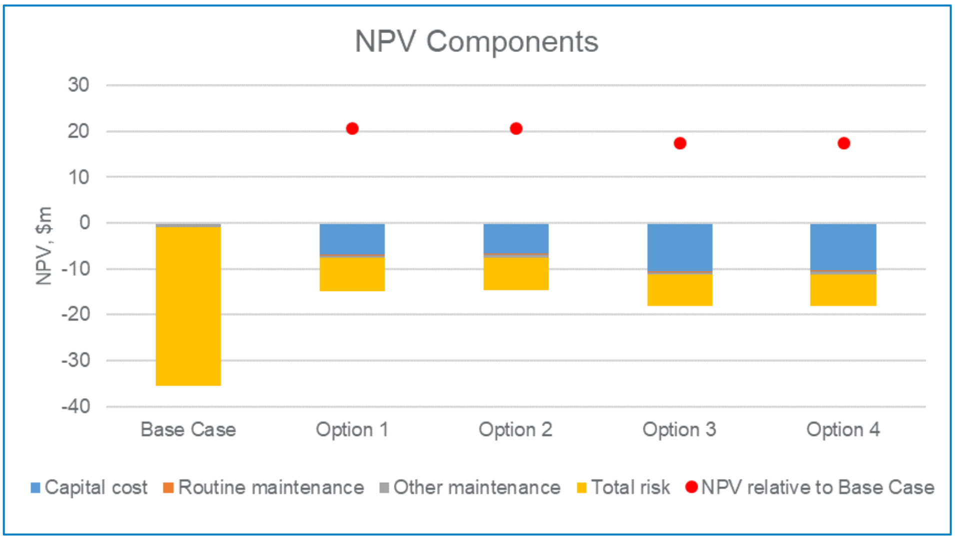


Figure 9.1 illustrates that the capital investment for the four credible options that address risks associated with the primary plant and transformers at Redbank Plains Substation will result in benefits from a reduction in risk costs, as well as a reduction in operational maintenance costs when compared to the Base Case. Option 2 results in less financial and safety risks compared to the transformer replacement options (3 and 4) and the partial primary plant options (1 and 3).

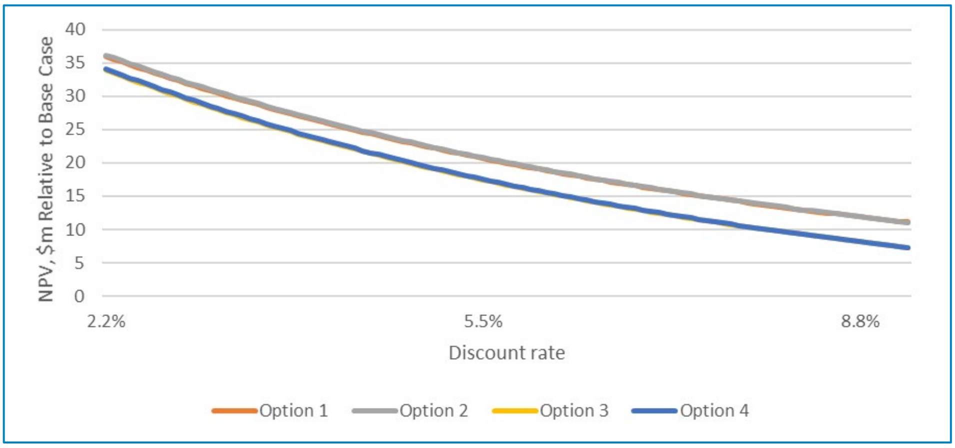
9.2 Sensitivity analysis

Powerlink has investigated the following sensitivities on key assumptions:

- a range from 2.2% to 8.8% for discount rate[33]
- a range from 75% to 125% for capital expenditure estimates
- a range from 75% to 125% for operational maintenance expenditure estimates
- a range from 75% to 125% for total risk cost estimates.

As illustrated in Figure 9.2 – 9.4, sensitivity analysis for the NPV relative to the Base Case shows that varying the discount rate, capital expenditure, operational maintenance cost and risk cost has no impact on the identification of the preferred option. Option 2 is the preferred option under all sensitivities tested.

Figure 9.2 Discount rate sensitivity



33 A discount rate of 2.2% pre-tax real Weighted Average Cost of Capital is based on the AER 2023-27 Powerlink Queensland revised revenue proposal, p21.

Figure 9.3 Capital cost sensitivity

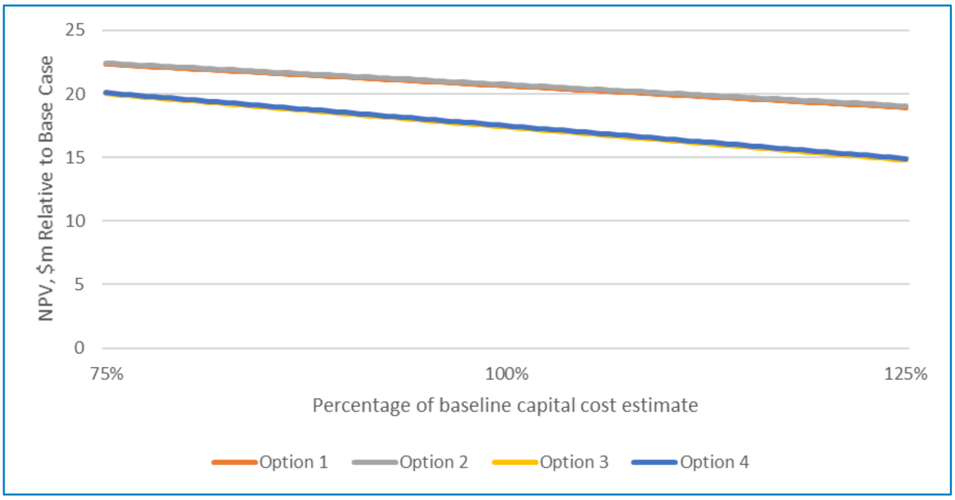


Figure 9.4 Risk cost sensitivity

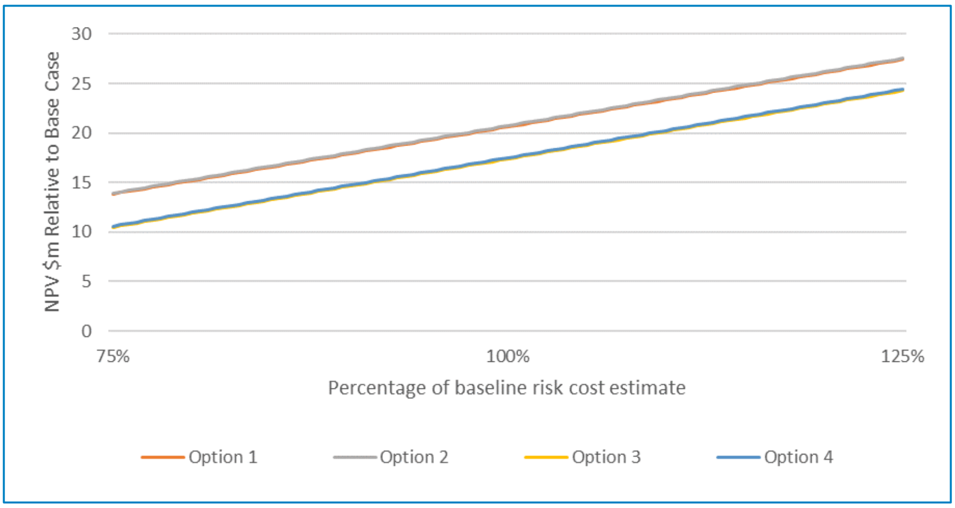
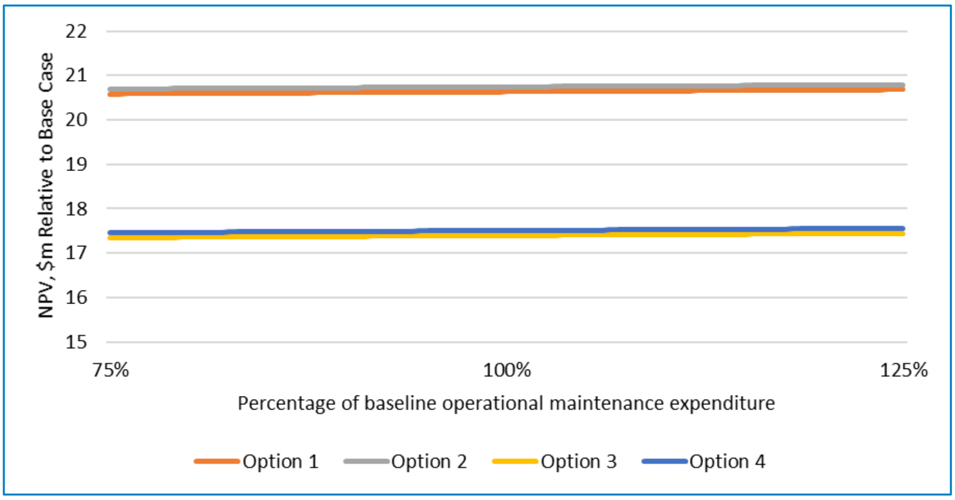


Figure 9.5 Maintenance cost sensitivity



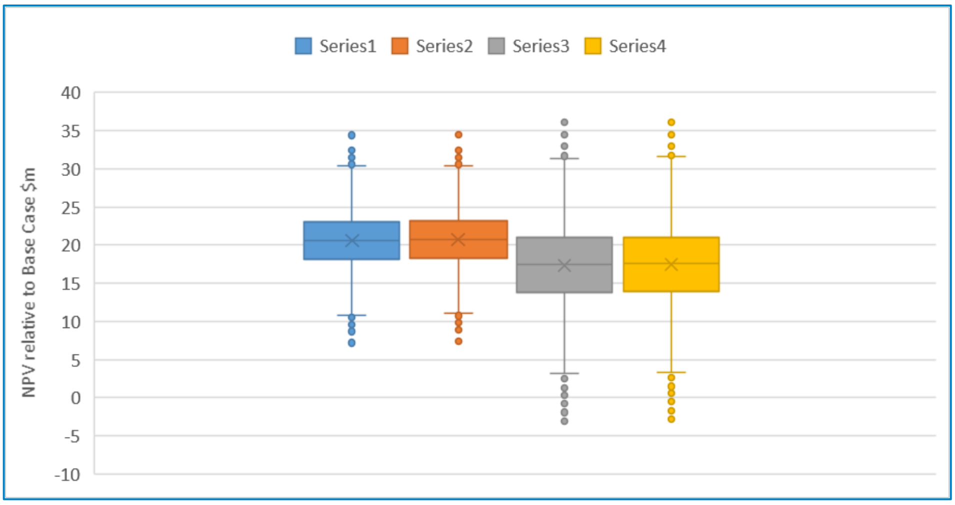
9.2.1 Sensitivity to multiple key assumptions

Monte Carlo Simulation was performed with multiple input parameters (including capital cost, discount rate, operational maintenance cost, corrective maintenance cost and total risk costs) generated for the calculation of NPV for each option. This process is repeated over 5000 iterations, each time using a different set of random variable from the probability function.

The output is presented as a distribution of possible NPVs for each option, as illustrated in the boxplot presented in Figure 9.6.

It can be seen that the preferred option, Option 2, has similar statistical dispersion in comparison with other credible options and its mean and median is the highest of the four options. This confirms that the preferred option 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



9.3 Conclusion

The result of the cost-benefit analysis indicates that Option 2 has the highest net economic benefit over the 20 year analysis period. Sensitivity testing shows that the analysis is robust to variations in the capital cost, operational maintenance cost, discount rate and risk cost assumptions.

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

10 Draft 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 associated with the deteriorated condition of the ageing primary plant and transformers at Redbank Plains Substation.

Option 2 involves the refit of the two 110/11kV 25MVA transformers to extend their service life and the replacement of all feeder bay and bus bay primary plant by 2025. The indicative capital cost of the RIT-T project for the preferred option is $8.45 million in 2020/21 prices, excluding future model project costs.

Design and procurement activities will commence in 2022, with onsite work to be completed by 2025.

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 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 RIT-T Application Guidelines
- 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 supply requirements:

Part 1	PSCR Publication	6 April 2022
Part 2	Submissions due on the PSCR Have your say on the credible options and propose potential non-network options.	11 July 2022
Part 3	Publication of the PACR Powerlink's response to any further submissions received and final recommendation on the preferred option for implementation.	September 2022

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).

Appendices

Appendix 1: Options considered but not progressed

As part of its joint-planning activities with Energex (part of the Energy Queensland Group), Powerlink investigated the option of reconfiguring Redbank Plains into a 33/11kV Substation as part of the distribution network for the area. Details of this option are described in Table A1.

Table A1: Options considered but not progressed

Option description	Reason for not progressing option
Reconfiguration of Redbank Plains to a 33/11kV substation as part of the local distribution network. • 5km of double-circuit, underground 33kV feeders and two 25MVA 33/11kV transformers to connect to the existing 11kV switchgear on site. • Upgrade to the Goodna bulk supply substation with a new 33kV switchboard to enable connection to the new 33kV feeders. • Decommissioning of Powerlink primary plant, secondary systems and lines	In the short-term, the two new feeders are able to be transformer-ended, however as loads grow a 33kV switchboard would need to be established to enable connection of a third 33/11kV transformer. Overall, while technically feasible, the reconfiguration of the 110/11kV transmission substation to a 33/11kV distribution substation is well in excess of twice the cost of the other network options assessed and as such is not considered economically viable in this instance.

Appendix 2: Summary of the main limiting equipment and key legislation

Table A2 indicates the key legislation, in addition to the Electrical Safety Act 1994, governing the need to address the condition of the transformers and primary plant at Redbank Plains. The Table also identifies the key limiting items of equipment.

Table A2 Summary of main limiting equipment and key legislation

Equipment	Key Legislation in addition to the Electricity Act 1994	Main Deteriorated Element
Power transformers and bushings	• Transmission Authority • Work Health and Safety Regulation 2011 • Electrical Safety Act 2002 • Electrical Safety Regulation 2013 • Environmental Protection Act 1994 • Electrical Safety Act 2002	• Oil and paper insulation • Cooling fans and radiators • Mechanical clamping mechanism • HV Bushings • Gaskets
Circuit breakers and instrument transformers (CTs & VTs)	• Transmission Authority • Work Health and Safety Regulation 2011 • Electrical Safety Act 2002 • Electrical Safety Regulation 2013 • Environmental Protection Act 1994 • Electrical Safety Act 2002	• Seals and operating mechanism • Degraded oil and paper insulation inside porcelain housings • Oil leaks and overheating

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