Powerlink Queensland

Project Assessment Conclusions Report

10 October 2019

Maintaining reliability of supply in the Blackwater area

Document Purpose

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

1. The Rules require Powerlink to carry out forward planning to identify future reliability of supply requirements and consult with interested parties on the proposed solution as part of the Regulatory Investment Test for Transmission (RIT-T). This includes replacement of network assets in addition to augmentations of the transmission network.
2. Powerlink must identify, evaluate and compare network and non-network options (including, but not limited to, generation and demand side management) to identify the '*preferred option*' which can address future network requirements at the lowest net cost to electricity consumers. This assessment compares the net present value (NPV) of all credible options to identify the option that provides the greatest economic benefits to the market.
3. This document contains the results of this evaluation, and a final recommended solution to address the condition risks associated with the 132/66/11kV 80MVA transformers at Blackwater Substation by June 2022.

Contents

Executive Summary

Blackwater Substation, established in 1969 and located approximately 68km east of Emerald, plays a critical role in the provision of electricity to customers in Queensland's Central West area, providing supply to residential, mining and rail traction loads. Planning studies have confirmed there is a long-term requirement to continue to supply the existing electricity services provided by Blackwater Substation supporting the diverse range of customer needs in the area.

The substation's 132kV switchyard includes three 132/66/11kV transformers (2 x 80MVA and 1 x 160MVA) which provide connections to the Ergon Energy (part of the Energy Queensland Group) distribution network. The two 80MVA transformers were installed in 1978, and at over 40 years of age have significant condition and performance issues indicating that they are reaching the end of their technical service lives. The third transformer, rated at 160MVA, was installed in 2006 and is in good working condition.

The increasing likelihood of faults arising from the condition of the ageing 80MVA transformers at Blackwater remaining in service beyond June 2022, exposes customers to the risks and consequences of an increasingly unreliable electricity supply. There is a need for Powerlink to address these emerging risks. As the identified need for 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 National Electricity Rules (the Rules) and relevant jurisdictional obligations[1], it is classified as a 'reliability corrective action'[2].

This Project Assessment Conclusions Report (PACR) represents the final step in the RIT-T process prescribed under the Rules undertaken by Powerlink to address the condition risks arising from the two 80MVA transformers at Blackwater Substation. It contains the results of the planning investigation and the cost-benefit analysis of credible options compared to a non-credible Base Case where the emerging risks are left to increase over time. In accordance with the RIT-T, the credible option that maximises the net present value (NPV) of economic benefit, or minimises the costs, is recommended as the preferred option.

Credible options considered

Powerlink published a Project Specification Consultation Report (PSCR) to Registered Participants, the Australian Energy Market Operator (AEMO) and interested parties in May 2019 to address the risks arising from the condition of the ageing 80MVA transformers at Blackwater.

No submissions were received in response to the PSCR that closed on 27 August 2019. As a result, no additional credible options have been identified as a part of this RIT-T consultation.

Powerlink has developed three credible network options to maintain the existing electricity services, ensuring an ongoing reliable, safe and cost effective supply to customers in the area. Option 1 and 2 result in a changed substation configuration, with the final configuration consisting of two 132/66/11kV transformers (i.e. 2 x 160MVA transformers; one new and one existing transformer). Option 3 maintains the existing configuration consisting of three 132/66/11kV transformers (i.e. 2 x 100MVA new transformers and 1 x 160MVA existing transformer).

By addressing the condition risks, all options presented allow Powerlink to meet the identified need and continue to meet the reliability and service standards specified within Powerlink's Transmission Authority, Schedule 5.1 of the Rules and applicable regulatory instruments.

The Base Case is a non-credible option that reflects a state of the world in which the condition of the ageing asset is only addressed through standard operational maintenance activities, with escalating safety, financial, environmental and network risks.

The three credible network options, along with their net present values (NPVs) relative to the Base Case are summarised in Table 1. Option 2 is ranked first of the three credible options, with the highest NPV relative to the Base Case.

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

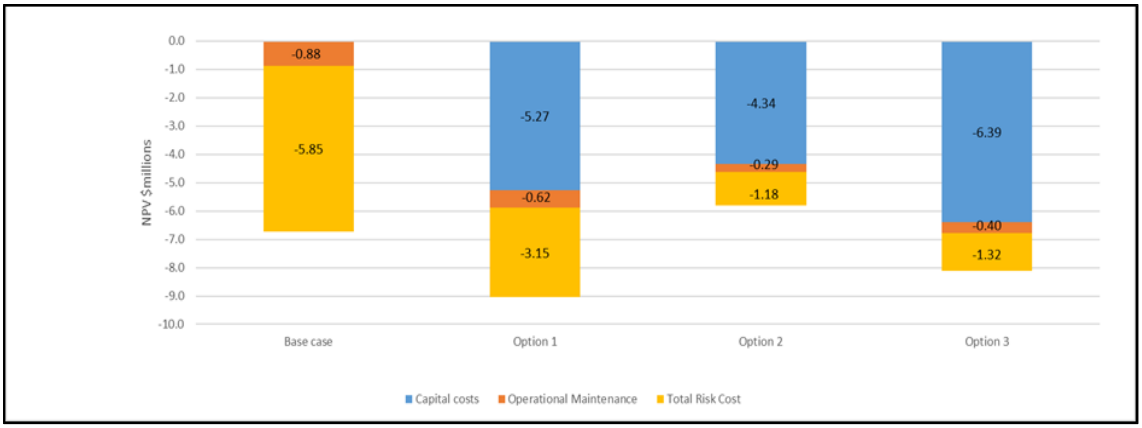
Table 1: Summary of credible network options

Option	Description	Total Cost ($m) 2018/19	NPV relative to Base Case ($m) 2018/19	Ranking
1	Repair oil leaks and replace selected components on the two at-risk 80MVA transformers to address corrosion and emerging reliability issues by June 2022 Replace both at-risk 80MVA 132/66/11kV transformers with a single 160MVA 132/66/11kV transformer by June 2027	3.50* 6.16†	-2.31	3
2	Replace both at-risk 80MVA 132/66/11kV transformers with a single 160MVA 132/66/11kV transformer by June 2022	6.16*	+0.91	1
3	Replace both at-risk 80MVA 132/66/11kV transformers with two 100MVA 132/66/11kV transformers by June 2022	9.09*	-1.39	2

*RIT-T Project
†Future modelled project

The absolute NPVs of the Base Case and the credible options are negative, shown graphically in Figure 1. All options reduce the total risk and maintenance costs arising from the ageing and obsolete assets at Blackwater remaining in service, with Option 2 having the largest reduction and reflecting a net economic benefit of $0.91 million compared to the Base Case.

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



Evaluation and Conclusion

The RIT-T requires that the proposed preferred option maximises the present value of net economic benefit, or minimises the net cost, to all those who produce, consume and transport electricity in the market.

In accordance with the expedited process for this RIT-T, the PSCR made a draft recommendation to implement Option 2. The RIT-T project for Option 2 involves replacing the two 132/66/11kV 80MVA transformers with one 132/66/11 kV 160MVA transformer by June 2022, at an estimated capital cost of $6.16 million in 2018/2019 prices. Under Option 2, design work will commence in late 2019, with installation of the new transformer completed by June 2022. Powerlink is the proponent of this network solution.

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

1. Introduction

This Project Assessment Conclusions Report (PACR) represents the final step of the RIT-T process[3] prescribed under the National Electricity Rules (the Rules) undertaken by Powerlink to address the condition risks arising from the two ageing 80MVA 132/66/11kV transformers at Blackwater Substation. It follows the publication of the Project Specification Consultation Report (PSCR) in May 2019.

The Project Specification Consultation Report (PSCR):

- described the identified need that Powerlink is seeking to address, together with the assumptions used in identifying this need
- set out the technical characteristics that a non-network option would be required to deliver in order to address the identified need
- described the credible options that Powerlink considered may address the identified need
- discussed specific categories of market benefit that in the case of this RIT-T assessment are unlikely to be material
- presented the Net Present Value (NPV) economic assessment of each of the credible options (as well as the methodologies and assumptions underlying these results) and identified the preferred option and that Powerlink was claiming an exemption from producing a Project Assessment Draft Report (PADR)
- invited submissions and comments, in response to the PSCR and the credible options presented, from Registered Participants, the Australian Energy Market Operator (AEMO), potential non-network providers and any other interested parties.

Powerlink identified Option 2, involving the replacement of the two 132/66/11kV 80MVA transformers with one 132/66/11 kV 160MVA transformer by June 2022, as the preferred option to address the identified need. The indicative capital cost of this option is $6.16 million in 2018/19 prices.

The Rules clause 5.16.4(z1) provides for a Transmission Network Service Provider to claim exemption from producing a PADR for a particular RIT-T application if all of the following conditions are met:

- the estimated capital cost of the preferred option is less than $43 million
- the preferred option is identified in the PSCR noting exemption from publishing a PADR
- the preferred option, or other credible options, do not have a material market benefit, other than benefits associated with changes in involuntary load shedding[4]
- submissions to the PSCR did not identify additional credible options that could deliver a material market benefit.

There were no submissions received in response to the PSCR that closed for consultation on 27 August 2019. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation. As the conditions are now satisfied, Powerlink has not issued a PADR for this RIT-T and is now publishing this PACR, which:

- describes the identified need and the credible options that Powerlink considers address the identified need
- discusses the consultation process followed for this RIT-T together with the reasons why Powerlink is exempt from producing a PADR

[3] This RIT-T consultation was commenced in May 2019 and has been prepared based on the following documents: National Electricity Rules, Version 121, 2 May 2019 and AER, Application guidelines, Regulatory investment test for transmission, December 2018.
[4] Section 4.3 Project assessment draft report, Exemption from preparing a draft report, AER, Application guidelines, Regulatory investment test for transmission, December 2018

- provides a quantification of costs and reasons why specific classes of market benefit are not material for the purposes of this RIT-T assessment
- provides the results of the net present value (NPV) analysis for each credible option assessed, together with accompanying explanatory statements
- identifies the preferred option for investment by Powerlink and details the technical characteristics and proposed commissioning date of the preferred option.

2. Customer and non-network engagement

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

2.1 Powerlink takes a proactive approach to engagement

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

2.2 Working collaboratively with Powerlink's Customer Panel

Powerlink's Customer Panel provides a face-to-face opportunity for customers and consumer representative bodies to give their input and feedback about Powerlink's decision making, processes and methodologies. It also provides Powerlink with a valuable avenue to keep customers 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.

2.3 Transmission Annual Planning Report (TAPR) – the initial stage of public consultation

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

2.3.1 Maintaining transfer capabilities and reliability of supply at Blackwater

- Powerlink identified in its TAPR from 2016, an expectation that action would be required at Blackwater Substation to maintain transfer capabilities and reliability of supply in the Central West transmission zone[5].
- The 2018 and 2019 TAPRs also discussed and provided technical information in relation to the identified need of this RIT-T.
- Members of Powerlink's Non-network Engagement Stakeholder Register (NNESR) were directly advised of the publication of the TAPR each year[6], including the accompanying compendium of potential non-network solution opportunities (Appendix F), which sets out

[5] This relates to the standard geographic definitions (zones) identified within the TAPR.
[6] More recently this also included the publication of a TAPR template containing detailed technical data for the connection point at Blackwater Substation.

the indicative non-network requirements to meet the identified need at Blackwater Substation. The NNESR were also advised of the publication of the PSCR for this RIT-T.

- The Customer Panel was advised of the upcoming RIT-T consultation for Blackwater Substation in December 2018.
- 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 TAPRs 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, 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. Powerlink welcomes feedback from all stakeholders to improve the RIT-T stakeholder engagement process.

3. Identified need

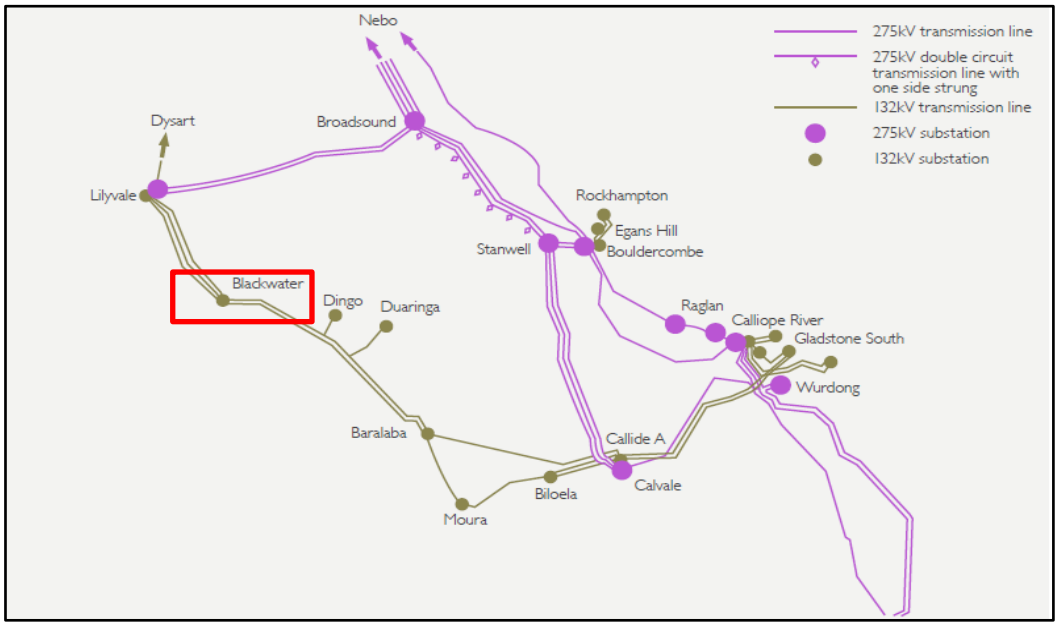
This section provides an overview of the existing arrangements at Blackwater Substation and describes the increasing risk to reliability of supply in the Central West area due to the assessed deteriorated condition of the ageing 80MVA transformers at the substation.

3.1 Geographical and network need

Blackwater Substation was established in 1969 to service the growing residential, mining and rail needs of Central West Queensland. The substation consists of 132kV (Powerlink) and 66kV (Ergon Energy) switchyards and hosts three 132/66/11kV transformers (2 x 80MVA and 1 x 160MVA) supplying the Ergon Energy load. It also facilitates the connection of seven 132kV feeders.

The Central West and Gladstone transmission zones are shown in Figure 3.1.

Figure 3.1: Central West and Gladstone transmission zones



3.2 Description of asset condition and risks

Powerlink has undertaken a comprehensive condition assessment of the transformers at Blackwater Substation.

Commissioned over 40 years ago, the two original 132/66/11kV transformers are exhibiting signs of age-related deterioration, particularly in the performance of their oil impregnated insulating paper and main tank bushing seals, as well as the corrosion of external fittings. Protective galvanised coatings have begun to break down on several components including radiators, connecting pipework, control system cabinets, bushing mountings and flanges.

The sealing integrity of numerous joints and valves has been compromised, resulting in an increased observation of oil leaks at radiators, bushings and conservator tanks. Analysis has also shown the transformers' winding paper insulation has deteriorated and is nearing the end of its technical service life, with approximately 3 to 5 years of reliable operation remaining.

The design of the winding clamping mechanism used in these older transformers also results in a loss of residual clamping pressure over time as the paper deteriorates, reducing the overall resilience of the transformers to future through faults. A failure of transformer insulation during a through fault can have major consequences to reliability of supply, safety and the environment because of the potential for oil loss and fire.

The transformers' porcelain bushings have also reached their manufacturers predicted design service life, increasing their likelihood of failure and presenting Powerlink with an unacceptable level of safety and network risks.

The age and design of the transformers means that replacements for key components are no longer available; hence, obsolescence has also become an issue with ongoing maintenance of the transformers.

The main condition-based risks of the transformers are summarised in Table 3.1.

Table 3.1: Blackwater transformer risks and consequences

Equipment	Condition/Issue	Consequence of failure
Power Transformers	• Degraded oil and paper insulation • Deteriorated cooling fans and radiators • Significant oil leaks. • Reduced clamping pressure due to clamp design • Loss of insulating paper strength • Limited availability of spares	• Increased susceptibility to power transformer failure during through faults leading to loss of supply with long return to service time. • Increased risk of fire and environmental damage.

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 to supply electricity in the area.

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

3.3 Description of identified need

With peak demand forecast to remain steady in the area for the next ten years[7], it is vital that Powerlink maintains supply to satisfy this demand and meet its reliability obligations under its Transmission Authority, the Electricity Act 1994 and the Rules[8]

It follows that the increasing likelihood of faults arising from the deteriorated condition of the 80MVA transformers remaining in service at Blackwater Substation compels Powerlink to take

[7] Powerlink Transmission Annual Planning Report 2019
[8] Transmission Authority Number T01/98, as amended 30 June 2014; Electricity Act 1994; The Rules, Schedule 5.1a System Standards and Schedule 5.1.2 Network Reliability

action if it is to continue to meet its regulatory obligations and the standards for reliability of supply set out in the Rules.

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[9].

In order to continue to meet the reliability standard within Powerlink's Transmission Authority, the services currently provided by the transformers at the Blackwater Substation are required for the foreseeable future to meet ongoing customer requirements.

Under the Electricity Act 1994, Powerlink is required to "operate, maintain (including repair and replace if necessary) and protect its transmission grid to ensure the adequate, economic reliable and safe transmission of electricity"[10]. The condition of the ageing 80MVA transformers at Blackwater requires Powerlink to take action to either repair, replace or remove them, while taking into consideration the enduring need for the services they provide, to ensure compliance with the Electricity Act 1994.

The Electrical Safety Act 2002 also requires Powerlink to operate its network in a manner that ensures electrical risk to a person or property has been eliminated, so far as is reasonably practicable; or if it is not reasonably practicable to eliminate electrical risk to the person or property, the risk has been minimised so far as is reasonably practicable[11].

As the proposed investment is to meet reliability and service standards specified within applicable regulatory instruments, and to ensure Powerlink's ongoing compliance with Schedule 5.1 of the Rules, it is classified as a "reliability corrective action", under the RIT-T[12].

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.

3.4 Rules, Jurisdictional and Legislative Compliance

The consequences of Blackwater's at-risk transformers remaining in service beyond 2022, without corrective action, would result in Powerlink being exposed to an unacceptable risk of breaching a number of its jurisdictional network, safety, environmental and Rules' obligations - resulting in poor customer, safety and environmental outcomes.

Safety and environmental obligations could theoretically be met by removing the 80MVA transformers from service, however to ensure Powerlink remains compliant with its Transmission Authority given the enduring electricity supply needs in the area, action must be taken to ensure the services provided by the 80MVA transformers are replicated either by credible network or non-network solutions.

By addressing the risks arising from the condition of the ageing 80MVA transformers at Blackwater, Powerlink is seeking to ensure it can safely deliver an adequate, economic, and reliable supply of electricity to its customers in the Blackwater area into the future.

[9] Transmission Authority No. T01/98, section 6.2(c)
[10] Electricity Act 1994, Chapter 2, Part 4, S34(1)(a)
[11] Electrical Safety Act 2002 sections 10 and 29
[12] The Rules clause 5.10.2, Definitions, reliability corrective action.

4. Submissions received

There were no submissions received in response to the PSCR that was open for consultation until the 27 August 2019[13]. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation.

5. Credible options assessed in this RIT-T

Powerlink has developed three credible network options to address the identified need for maintaining reliability of supply in the Blackwater area. All three options are designed to mitigate the risks to supply before the 80MVA transformers reach the end of their technical service lives and to ensure Powerlink maintains compliance with reliability and service standards specified in its Transmission Authority, Schedule 5.1 of the Rules and relevant jurisdictional instruments.

- Option 1: Life extension of the two at-risk 80MVA transformers by June 2022, followed by the replacement of both at-risk transformers with a single 160MVA transformer by June 2027. The RIT-T portion of this option would be completed by June 2022 at a cost of $3.5 million in 2018/19 prices.
- Option 2: Replacement of both at-risk 80MVA transformers with a single 160MVA transformer by June 2022, at a cost of $6.16 million in 2018/19 prices.
- Option 3: Replacement of both at-risk 80MVA transformers with two 100MVA transformers by June 2022, at a cost of $9.09 million in 2018/19 prices.

Table 4.1: Summary of credible options

Option	Description	Indicative project costs ($million, 2018/19)	Indicative annual average O&M costs ($million, 2018/19)
1	Repair oil leaks and replace selected components on the two at-risk 80MVA 132/66/11kV transformers to address corrosion and emerging reliability issues by June 2022 Replace both at-risk 80MVA 132/66/11kV transformers with a single 160MVA 132/66/11kV transformer by June 2027	3.50* 6.16†	0.04
2	Replace both at-risk 80MVA 132/66/11kV transformers with a single 160MVA 132/66/11kV transformer by June 2022	6.16*	0.02
3	Replace both at-risk 80MVA 132/66/11kV transformers with two 100MVA 132/66/11kV transformers by June 2022	9.09*	0.03

*RIT-T Project
†Future modelled project

All credible network options address the major risks resulting from the deteriorated condition of ageing transformers at Blackwater Substation. None of these options has been discussed by

[13] Members of Powerlink's Non-network Engagement Stakeholder Register were also advised of the PSCR publication.

the Australian Energy Market Operator (AEMO) in its most recent National Transmission Network Development Plan (NTNDP)[14].

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[15].

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 Transmission Network Service Provider (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 PACR, may impact the ranking of the credible options under consideration, or the relativity of the credible options to the Base Case, and that this class of market benefit could be material. These benefits have been quantified and included within the cost benefit and risk cost analysis as network risk.

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[16]. Other than market benefits associated with involuntary load shedding, Powerlink does not consider any other category of market benefits to be material, and had not estimated them as part of this RIT-T.

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

7. Base Case

7.1 Modelling a Base Case under the RIT-T

Consistent with the RIT-T Application Guidelines, the assessment undertaken in this PACR[17] compares the costs and benefits of credible options constructed to address the risks arising from an identified need, with a Base Case[18].

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.

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[14] Clause 5.16.4(b) (4) of the Rules requires Powerlink to advise whether the identified need and or solutions are included in the most recent NTNDP. The 2018 NTNDP is currently the most recent NTNDP.
[15] 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.
[16] AER, Application guidelines, Regulatory investment test for transmission, December 2018.
[17] The economic assessment was also presented in the PSCR.
[18] AER, Final Regulatory investment test for transmission application guidelines, December 2018.

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, over the same timeframe.

7.2 Blackwater 80MVA transformer 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[19] and has been used to calculate the risk costs of the Base Case for the two 80MVA Blackwater transformers. 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 two ageing 132/66/11kV 80MVA transformers at Blackwater, the following modelling assumptions specific to the Blackwater network configuration have been made:

- A suitable spare transformer is available as an emergency replacement in the event of non-repairable failure of one of the aged transformers.
- The downstream Ergon Energy 66kV distribution network supplying the greater Lilyvale and Blackwater area is available to provide a level of backup supply in the event of equipment failure.
- Embedded generation within the area operates while Blackwater substation remains energised to reduce the impacts of unserved energy in the event of equipment failures.
- Historical load profiles and embedded generation patterns have been used when assessing the likelihood of unserved energy under concurrent failure events.
- Peak demand for the greater Blackwater load area consistent with medium demand forecasts published within Powerlink's 2018 Transmission Annual Planning Report have been used[20].
- Unserved energy generally accrues under concurrent failure events, and consideration has been given to potential feeder trip events within the wider Blackwater area.
- The Blackwater Substation load comprises of a mix of load types, including open cut mining, underground mining, traction loads, and residential township. The network risk cost models have used the Queensland regional Value of Customer Reliability (VCR) published within AEMO 2014 Value of Customer Reliability Review Final Report ($39,710/MWh).
- Powerlink's business response to mitigating unserved energy under prolonged supply outage events has been incorporated within the risk cost modelling.

7.2.2 Base Case risk costs

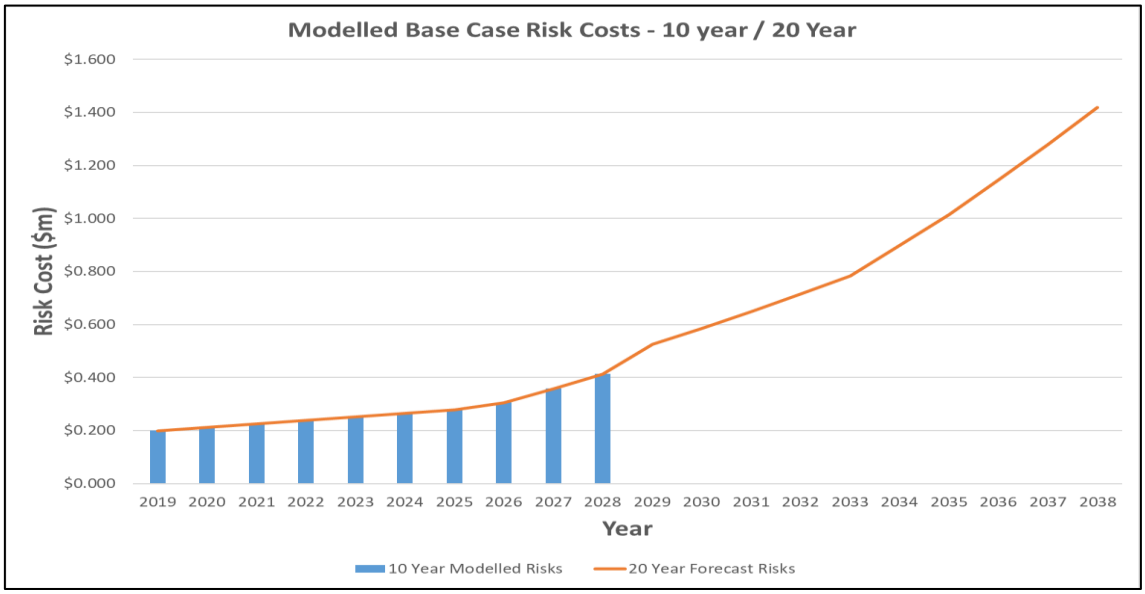
The main areas of risk cost are associated with network risks that involve reliability of supply through failure of the aged transformers modelled as probability weighted unserved energy and financial risk costs associated mostly with the replacement of failed assets in an emergency situation. Both of these risks increase over time as the condition of plant further deteriorates and the likelihood of failure rises.

Based upon the assessed condition of the ageing 80MVA transformers at Blackwater, total risk costs are projected to increase from $0.2 million in 2019 to $1.4 million in 2038.

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

[19] The risk costs are calculated using the principles set out in the Powerlink document, Overview of Asset Risk Cost Methodology, May 2019.
[20] The forecast remains unchanged in the 2019 TAPR.

Figure 7.1: Modelled Base Case risk costs



7.3 Modelling of Risk in Options

Each option is specifically scoped to mitigate the major risks arising in the Base Case and 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 2019 to 2038. A 20-year period takes into account the size and complexity of the proposed primary plant investments.

For all options, there will be remaining asset life by 2038, at which point a terminal value is calculated to correctly account for capital costs under each credible option.

8.2 Discount rate

Under the RIT-T, a commercial discount rate is applied to calculate the NPV of costs and benefits of the credible options. Powerlink has adopted a real, pre-tax commercial discount rate of 5.90%[21] 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%[22] and an upper bound discount rate of 8.33% (i.e. a symmetrical upwards adjustment).

[21] This indicative commercial discount rate has been calculated on the assumptions that a private investment in the electricity sector would hold an investment grade credit rating and have a return on equity equal to an average firm on the Australian stock exchange, as well as a debt gearing ratio equal to an average firm on the Australian stock exchange.

[22] A discount rate of 3.47 per cent is based on the AER's Final Decision for Powerlink's 2017-2022 transmission determination, which allowed a nominal vanilla WACC of 6.0 per cent and forecast inflation of 2.45 per cent that implies a real discount rate of 3.47 per cent. See AER, Final Decision: Powerlink transmission determination 2017-2022 | Attachment 3 – Rate of return, April 2017, p 9.

8.3 Description of reasonable scenarios

The RIT-T analysis is required to incorporate a number of different reasonable scenarios, which are used to estimate market benefits. The number and choice of reasonable scenarios must be appropriate to the credible options under consideration.

The choice of reasonable scenarios must reflect any variables or parameters that are likely to affect the ranking of the credible options, where the identified need is reliability corrective action[23].

Powerlink has considered capital costs and discount rate sensitivities individually and in combination and found that these variables do not affect the relative rankings of credible options or identification of the preferred option. As sensitivities (both individually and in combination) do not affect the ranking of the preferred option, Powerlink has elected to present one central scenario in Table 8.1.

Table 8.1: Reasonable scenario assumed

Key variable/parameter	Central scenario
Capital costs	100% of central capital cost estimate
Discount rate	5.90%

9. Cost benefit analysis and identification of the preferred option

9.1 NPV Analysis

Table 9.1 outlines the NPV and the corresponding ranking of each credible option relative to the Base Case.

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

Option	Description	Central Scenario NPV relative to Base Case ($m)	Ranking
1	Repair oil leaks and replace selected components on the two at-risk 80MVA 132/66/11kV transformers to address corrosion and emerging reliability issues by June 2022 Replace both at-risk 80MVA 132/66/11kV transformers with a single 160MVA 132/66/11kV transformer by June 2027	-2.31	3
2	Replace both at-risk 80MVA 132/66/11kV transformers with a single 160MVA 132/66/11kV transformer by June 2022	+0.91	1
3	Replace both at-risk 80MVA 132/66/11kV transformers with two 100MVA 132/66/11kV transformers by June 2022	-1.39	2

All three credible options will address the identified need on an enduring basis. Option 2 is ranked first of the three credible options, with the highest NPV relative to the Base Case.

[23] AER, Final Regulatory Investment Test for Transmission, June 2010, version 1, paragraph 16, p. 7

When compared to other credible options, Option 3 is $2.30 million and Option 1 is $3.22 million more expensive than Option 2 in NPV terms.

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

Figure 9.1: Central Scenario NPV component for each credible option (NPV $m, 2018/19)

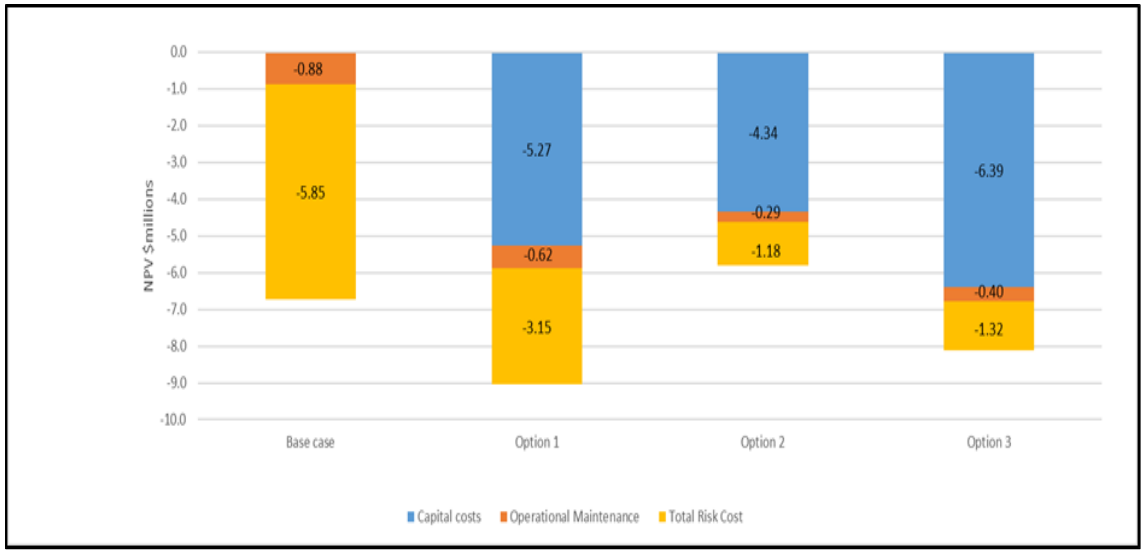


Figure 9.1 illustrates that all credible options will reduce the total risk cost and operational maintenance cost compared to the Base Case. Option 2 has the highest cost reduction benefit of the three credible options when compared with the Base Case.

Option 2 has the largest reduction in operational maintenance costs as the ultimate configuration consists of two 132/66/11kV transformers (1 new and 1 existing 160MVA transformer) at Blackwater from 2022.

Option 2 also has the largest reduction in total risk costs. This is due to the lower financial, network and safety risks associated with the ultimate two 132/66/11 kV transformer configuration to be commissioned from June 2022. Option 1 reaches the two transformer configuration at a later date in June 2027, while Option 3 retains the current three transformer configuration and has the highest residual total risk cost.

9.2 Sensitivity analysis

Powerlink has investigated the following sensitivities on key assumptions:

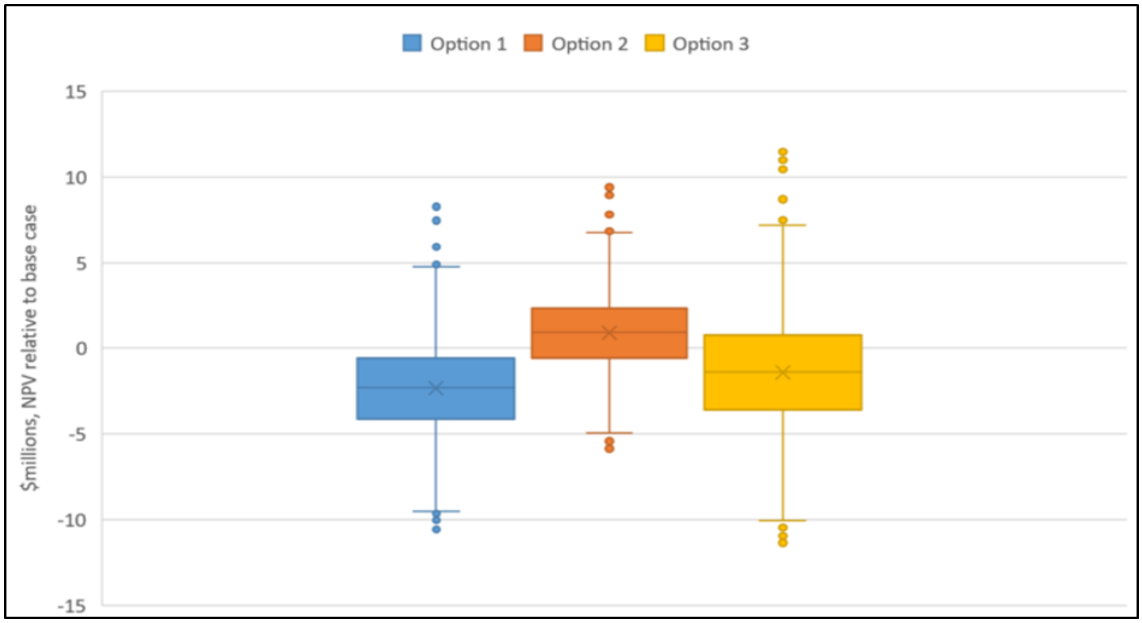
- a range from 3.47% to 8.33% for discount rate.
- a range from 75% to 125% of base capital expenditure estimates.
- a range from 75% to 125% of operational maintenance expenditure estimates.
- a range from 75% to 125% of total risk cost estimates.

Sensitivity analysis for the NPV relative to the Base Case shows that varying the discount rate, capital expenditure, operational maintenance expenditure and total risk costs has no impact on the option rank and the identification of the preferred option.

9.2.1 Sensitivity to multiple parameters

A Monte Carlo simulation was performed with multiple input parameters (including capital cost, discount rate, operational maintenance cost and total risk cost) generated for the calculation of NPV for each option. This process is repeated over 5000 iterations, each time using a different set of random variables from the probability function. The sensitivity analysis output is presented as a distribution of possible NPVs for each option, as illustrated in Figure 9.2.

Figure 9.2 NPV sensitivity analysis of multiple key assumptions relative to the Base Case



The Monte Carlo simulation results identify that Option 2 has the highest mean and median compared to the other credible options, while also exhibiting less statistical dispersion. This confirms Option 2 as the preferred option and shows it to be robust over a range of input parameters in combination.

10. Preferred option

Based on the conclusions drawn from the NPV analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the risks associated with the deteriorated condition of the two ageing 132/66/11kV 80MVA transformers at Blackwater Substation. Implementing this option will provide an ongoing safe and reliable electricity supply to customers in the area and ensure continued compliance with applicable regulatory instruments and the Rules.

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 requirements of the RIT-T and is the preferred option.

11. Conclusions

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

- Powerlink has identified condition risks arising from the two ageing 80MVA transformers at Blackwater Substation.
- TNSPs must maintain (including repair and replace if necessary) their transmission network to ensure the adequate, economic, reliable and safe transmission of electricity, including the ability to meet peak demand if a major element of the network was to fail.
- The increasing likelihood of faults associated with the condition of the ageing 80MVA transformers compels Powerlink to undertake reliability corrective actions at Blackwater Substation if it is to continue meeting the reliability standards set out in its Transmission Authority and to ensure ongoing compliance with the Rules and relevant jurisdictional obligations.

- Studies were undertaken to evaluate three credible options. The three credible options were evaluated in accordance with the AER's RIT-T.
- Powerlink published a PSCR in May 2019 requesting submissions from Registered Participants, AEMO and interested parties on the credible options presented, including alternative credible non-network options, which could address the condition risks associated with the 80MVA transformers at Blackwater Substation.
- The PSCR also identified the preferred option and that Powerlink was adopting the expedited process for this RIT-T, claiming exemption from producing a PADR as allowed for under the Rules Clause 5.16.4(z1) for investments of this nature.
- There were no submissions received in response to the PSCR, which was open for consultation until 27 August 2019. As a result, no additional credible options that could deliver a material market benefit have been identified as part of this RIT-T consultation. The conditions specified under the Rules for exemption have now been fulfilled.
- The result of the cost-benefit analysis under the RIT-T identified that Option 2 is the least cost solution, providing the greatest economic benefit, over the 20 year analysis period. Sensitivity testing showed the analysis is robust to variations in discount rate, capital expenditure, operational maintenance expenditure and risk cost assumptions. As a result, Option 2 is considered to satisfy the RIT-T.
- The outcomes of the economic analysis contained in this PACR remain unchanged from those published in the PSCR. Consequently, the draft recommendation has been adopted without change as the final recommendation and will now be implemented.

12. Final Recommendation

Based on the conclusions drawn from the NPV analysis and the Rules requirements relating to the proposed replacement of transmission network assets, it is recommended that Option 2 be implemented to address the risks associated with the condition of the ageing 80MVA transformers at Blackwater Substation. Option 2 allows Powerlink to continue to maintain compliance with Powerlink's Transmission Authority, Schedule 5.1 of the Rules and other applicable regulatory instruments.

Option 2 involves replacing both 132/66/11kV 80MVA transformers with one new 160MVA transformer by June 2022. This option minimises the number of outages and mobilisation costs, and reduces the overall future operational maintenance costs, as there are less transformers to maintain in the final substation configuration.

The indicative capital cost of the RIT-T project for Option 2 is $6.16 million in 2018/19 prices. Powerlink is the proponent of this network solution.

Design and procurement activities will commence in late 2019, with the RIT-T project works to be completed by June 2022.

Powerlink will now proceed with the necessary processes to implement this recommendation.

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