Network Overloaded Feeders (NOL)

Regulatory Business Case (RBC) 2024-29

PowerWater

Contents

1. Summary

This business case has been prepared to support the 2024-29 Regulatory Proposal. The business case demonstrates that Power and Water has undertaken appropriate analysis of the need and identified a full suite of credible options that will resolve the need, to ensure that Power and Water continues to meet the National Electricity Objectives and manage the network prudently and efficiently.

The project/program identified in this business case will undergo further assessment and scrutiny through Power and Waters normal governance processes prior to implementation.

This business case addresses the management of underground cables forecast to be overloaded in the 2024-29 Regulatory Control Period ('the next RCP').

1.1 Business need

Power and Water is required to comply with the Network Technical Code and Network Planning Criteria ('the Network Technical Code') as it relates to first contingency conditions, steady state voltage levels, and feeder overloads.

To achieve the organisational objectives and meet the requirements of the Asset Management Policy, Power and Water has, under the Network Overloaded Feeders (NOL) program, identified seven 11kV, CBD and Urban feeders where older assets reduce the flexibility and load transferability of the network.

Investments are required to provide interconnectivity within a single feeder system and improved switching capability to transfer loads during contingency conditions on impacted CBD and urban, 11kV distribution networks.

1.2 Options analysis

The options considered to resolve this need are shown in Table 1.

Table 1: Summary of credible options

Option No.	Option Name	Description	Recommended Option
1	Do Nothing	Do not invest in addressing network constraints during the 2024-29 regulatory period	No
2	Continue the NOL program	Continue the NOL during the 2024-29 regulatory period	**Yes**

As part of a holistic assessment, non-network solutions, capex/opex trade-offs and retirement or derating were considered, but none of these options cost-effectively addressed the underlying network issues.

1.3 Recommendation

The recommended option is Option 2 - Continue the NOL program in the 2024-29 regulatory period at an estimated cost of $3.6 million (real 2021/22).

Table 2 shows a summary of the expenditure requirements for the next RCP.

Table 2: Annual capital and operational expenditure ($'000, real FY22)

Item	FY25	FY26	FY27	FY28	FY29	Total
Capex	0.72	0.72	0.72	0.72	0.72	3.60
Opex	-	-	-	-	-	-
Total	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**3.60**

2. Identified need

This section provides the background and context to this business case, identifies the issues that are posing increasing risks to Power and Water and its customers, describes the current management program, highlights challenges and emerging issues, and provides a risk assessment of the inherent risk if no investment is undertaken.

2.1 Background

Power and Water must comply with the Network Technical Code requirements to maintain the network security, reliability, and quality of supply to network users.

To achieve the organisational objectives and meet the requirements of the Asset Management Policy, Power and Water investigated the adequacy of the ratings of the 11kV feeders across the network. These feeders cover predominantly CBD and Urban areas, are generally interconnected, and allow for switching to alternative sources of supply during contingency conditions to help avoid load loss or to help with rapid supply restoration.

Analysis was undertaken by modelling each feeder under the feeder's standard N-1 configuration[1] for the 2021-2022 peak load and reviewing for any component overloads or voltage issues. Where issues were noted, potential solutions were also modelled with an emphasis on identifying alternate configurations to respond to N-1 outages to avoid or minimise the need for capital investment.

This review has identified seven 11kV CBD and urban feeders for which some assets reduce the operational flexibility and circuit utilisation due to constraints.

The Network Overloaded Feeders program (NOL) consequently includes minor network augmentations to provide interconnectivity within feeders and improved switching capability to transfer loads during contingency conditions on the impacted CBD and urban 11kV distribution networks.

2.2 Planning criteria

Power and Water is required to adhere to time limits for power restoration during contingency events. The 'supply contingency criteria' are defined in section 14 of the Network Technical Code. There are essentially three parts:

- The definition of load types (i.e. CBD, Urban, Non-urban, and Remote, in Figure 12)
- The study parameters, including equipment ratings (section 14.3), first and second contingencies (section 14.2) and
- The supply contingency criteria themselves for the different load types, Class of supply (A-F), and contingency events (credible N-1 or N-2) in Figures 14 (CBD and Urban) and Figure 15 (Non-urban and Remote).

For example, for urban load types with between 5MVA and 50MVA of demand, Power and Water has 60 minutes to restore supply (to avoid a penalty). Typically this will involve utilising distribution transfer capacity to contiguous feeders and/or substations to assist with restoration.

---

[1] Standard N-1 configuration consists of transferring the entire load of one feeder to an adjacent feeder or feeders via the closing and opening of two or more switches.

These planning criteria have been applied to the distribution feeders to develop the current and forecast feeder augmentation activities necessary to comply with the supply contingency criteria.

2.3 Historical and current programs

This program of works was previously included under the Overloaded Feeders / Distribution Augmentation ('NFO') program for the 2019-24 Regulatory Control Period ('current RCP'). Average annual capex of $1.2 million was allowed by the AER in its Final Determination.

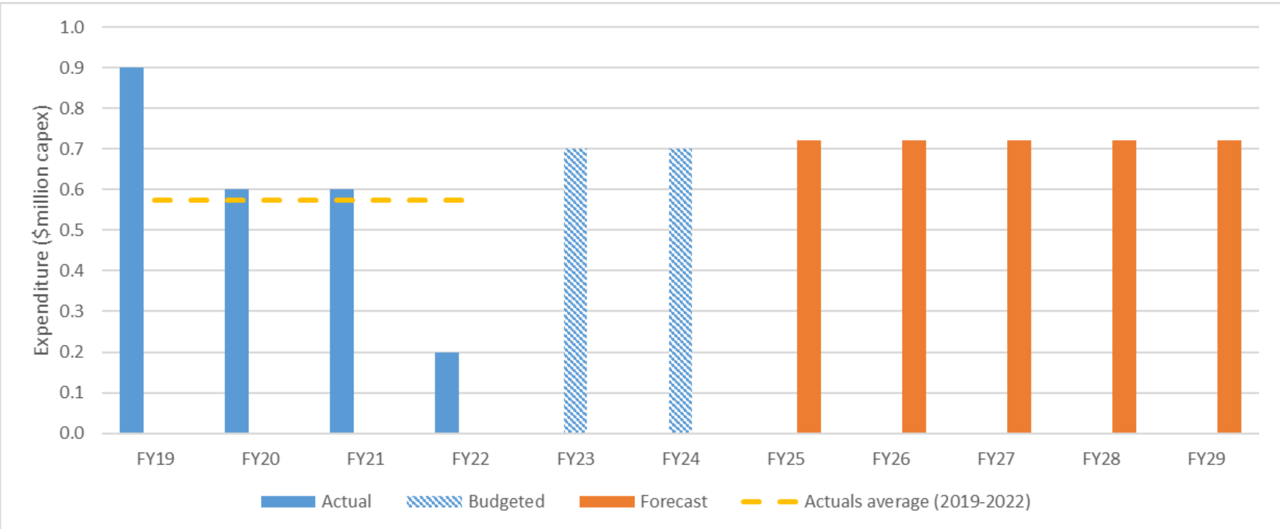
Since then, the NFO program has been split into two programs:

- Network Design Planning (NDP) program – for augmentations required at zone substation premises
- Network Overloaded Feeders (NOL) program– for augmentation of distribution feeders.

During the current RCP, seven NOL projects have been completed and one project is currently in progress. Historically, investment covered by the program includes activities such as improving the capacity of the network to transfer load across the distribution network (i.e. distribution transfer capacity, 'DTC') which is typically called-upon following contingency events. The projects address limiting factors such as undersized network cables, as well as inadequately specified switches, allowing for higher transfers.

The NOL program implemented from July 2019 to June 2022 has incurred $2.2 million to address NOL issues (i.e. an average of $0.73 million annually). Power and Water forecast to spend an additional $1.6 million during FY23 and FY24 to address network overloading issues. Actual expenditure under the NOL program has informed the forecast expenditure for the next RCP, as shown in Figure 1. The dip in expenditure in FY22 was due to the effects of the COVID-19 pandemic.

Figure 1 - NOL program historical and forecast capital expenditure[2] ($m, real 2022)



The forecast costs are based on identified cable upgrades required in the next RCP, the unit rates derived from recent similar projects, and a small allowance for currently unidentified issues and risk associated that are likely to arise during the next RCP.

[2] Note one project in 2020/21 was categorised under the NOL program and later changed to the NMF program.

2.4 Overloaded feeders in the next RCP

2.4.1 Overloaded cable sections

The 11kV Urban[3] load type feeders listed in the table below pose a heightened level of risk during the next RCP due to the highly sensitive commercial areas they service. Each include underground cable sections. The limited capacity of the installed cable assets will result in overloading, which in turn will restrict the flexibility and resilience of the network during a contingency event on each of the feeder systems.

The at-risk feeders requiring augmentation have been identified in priority order in the table below.

Table 3: Prioritised feeders requiring augmentation

#	Feeder
1.	Casuarina ZSS –11CA23 Moil
2.	Casuarina ZSS –11CA25 Brinkin
3.	Woolner ZSS – 11WO02 Fannie Bay
4.	Woolner ZSS – 11WO24 Parap
5.	Casuarina ZSS –11CA24 Parar
6.	Leanyer ZSS – 11LE04 Tambling
7.	Leanyer ZSS – 11LE08 Parkside

Many of the cables in the identified feeders are more than 40 years old with no water blocking measures, which can lead to water ingress, increased likelihood of failure, and restricted load transferability. In the event of a cyclone, many overhead conductors can be damaged, with poles destroyed and repairs taking days or weeks, leading to greater reliance on the underground feeder assets listed in the table above. Switching even small amounts of additional load to the cables listed in the table above would likely result in non-compliance with the restoration requirements of the Network Technical Code for urban areas.[4] By replacing these assets Power and Water will eliminate the non-compliance, increase the load that can be transferred onto these feeder systems, and provide greater network flexibility.

2.4.2 Steady state voltage limits

The scope of the steady state voltage level investments involves the installation of adjustable voltage support equipment on the impacted 22kV feeders. As no 22kV feeders were identified as having steady state voltage issues, no augmentation of feeders has been identified to address this issue in the next RCP.

2.5 Risk assessment

The risk posed by the identified cable assets to the network has been quantified by applying Power and Water's Risk-Quantification Procedure. This procedure has been developed based on good electricity

[3] Pg. 125, Clause 14.1 a) Network Technical Code and Planning Criteria, Power and Water Corporation, 30 March 2020.
[4] Power and Water, Network Technical Code and Planning Criteria, Clause 14.6, Figure 14

industry practice and taking into account the recent guidelines and determinations made by the AER, the ISO 31000 Risk Management Standard, and other professional publications.

The consequences related to restoring power in area supplied by inadequately rated cable after a nearby failure are Direct Financial Cost and Service Delivery value dimensions in Power and Water's Risk Quantification Procedure[5] and 'typical consequence areas' identified by the AER[6].

A simple probabilistic risk-based analysis is included in Appendix B.

2.6 Summary

The at-risk underground cable assets identified have the potential to compromise the maintenance of supply to several sensitive regions in Darwin.

Risk analysis of the asset fleet liable to overload has quantified the risk posed by the asset fleet identified in the NOL Network Planning Report. This business case is focused on the management of cable assets at-risk of overload. The proactive upgrade of at-risk assets and augmentation of the network maintenance works is covered by the NOL program.

Section 3 discusses the options that will efficiently manage these risks.

[5] Power and Water Risk Quantification Procedure RevB4, June 2022

[6] Australian Energy Regulator, Industry practice application note: Asset replacement planning 2019

3. Options analysis

This section describes the various options that were analysed to address the increasing risk to identify the recommended option. The options are analysed based on ability to address the identified needs, prudency and efficiency, commercial and technical feasibility, deliverability, benefits and an optimal balance between long term asset risk and short-term asset performance.

3.1 Comparison of credible options

Credible options are identified that address the identified need, are technically feasible and can be implemented within the required timeframe. The following options have been identified:

- Option 1 – Do Nothing. This option is based on no further investment in the NOL program in the next RCP.
- Option 2 - Continue NOL Program. This option proposes to continue investment in the NOL program to address feeder sections which could lead to non-compliance with the Network Technical Code.

A comparison of the two identified credible options and the issues they address in the identified need is depicted in the table below. A detailed discussion of each option is provided below.

The basis for the cost estimate for Option 2 is included in Appendix A.

Table 4: Summary of options analysis

Assessment metrics	Option 1	Option 2
NPV ($m, real 2022)	0.0	-3.15
Capex ($m, real 2022)	0.0	3.60
Meets customer expectations	0.0	●
Aligns with Asset Objectives	○	●
Technical Viability	○	◕
Deliverability	○	●
Preferred	✗	✓

● Fully addresses the issue ◕ Adequately addresses the issue ◑ Partially addresses the issue ○ Does not address the issue

Notes:

- The table above excludes the expenditure forecast for the remainder of the current period but allows for the non-compliance reduction achieved as it is a continuation of the existing program.

- The NPV and Capex was calculated over a 30 year regulatory period. Option 1 – Do nothing (Base Case).

3.1.1 Option 1 – Do Nothing (Base Case)

This option is based on no further investment in the NOL program in the next RCP.

The advantage of this option is that there may be no capital cost incurred during the next RCP to address the non-compliant feeders.

The disadvantages of this option are that:

- Based on technical analysis, there will be a number of non-compliant feeders in the next RCP (refer to Table 3)
- One or more of the feeders may fail in service due to overloading or condition defects[7] and the direct and indirect cost to rectify the failure would be significant – a simple probabilistic risk-based analysis is included in Appendix B.

This option does satisfy the reasonable expectations of customers and other stakeholders for Power and Water to be a prudent network operator by, among other things, proactively planning to address likely technical non-compliance issues and related cost and reliability risks.

Similarly, this option does not align with Power and Water's asset management objectives and strategies, which among other things requires identified non-compliance with the network Technical Code to be addressed, taking into account the risk posed in determining the solution and timing.

This option is not recommended.

3.1.2 Option 2 – Continue the NOL program

This option proposes to continue investment in the NOL program to address feeder sections which could lead to non-compliance with the Network Technical Code. A risk-based approach has identified seven feeders which are very likely to require augmentation to relieve overloading in the next RCP. The proposed scope of work will provide intra-feeder interconnectivity and improved switching capability to transfer loads within a feeder system during contingency conditions on impacted CBD and urban 11kV networks

The approximate total cost for all projects listed in Table 3 to be completed under this option would require capex of $3.6 million over the next RCP.

As a customer centric organisation, Power and Water aims to address network issues as early as feasible before customers are affected. The reliance of this option on proactive processes is aligned with Power and Water providing sustainable long term solutions for the network and significantly mitigating the risk associated with asset overload.

The disadvantage of this option is that it is more expensive than Option 1. However, unlike Option 1, this option is likely to satisfy the reasonable expectations of customers and other stakeholders that Power and Water act in accordance with good industry practice to proactively identify and correct high risk non-compliant feeder overloads.

[7] E.g. water ingress – refer to the discussion in section 2

3.2 Non-Credible Options

Our analysis also identified options found to be non-credible. These options are described below and were not taken through to detail analysis for the reasons provided.

3.2.1 Non-Network alternatives

Supply and demand management through the control of distributed energy resources (DER) such as solar PV and energy storage devices (batteries) are currently being investigated by Power and Water as part of its future network strategy.

This initiative is likely to be developed and implemented in a staged approach with benefits only starting to be realised towards the end of the next regulatory period. It is not considered a reasonable alternative for offsetting the immediate needs of the network.

The approaches may involve substituting opex for capex.

4. Recommendation

The recommended option is Option 2 - Continue the NOL program at an estimated cost of $3.6 million (real 2021/22) to be most prudent and cost effective approach to meet the identified needs.

The proposed program is consistent with the National Electricity Rules Capital Expenditure Objectives as the expenditure is required to maintain the quality, reliability, and security of supply of standard control services and maintain the safety of the distribution system.

4.1 Strategic alignment

The "Power and Water Corporation Strategic Direction" is to meet the changing needs of the business, our customers and is aligned with the market and future economic conditions of the Northern Territory projected out to 2030.

This proposal aligns with Asset Management System Policies, Strategies and Plans that contributes to the D2021/260606 "Power and Water Strategic Direction" as indicated in the table below.

Table 5 Alignment with corporate strategic focus areas

No.	Strategic Direction Focus Area	Strategic Direction Priority
1	Living within our means	Cost Prudency
2	Customer and the community at the centre	Enhance Customer Experience and Engagement
3	Customer and the community at the centre	Trusted Partner

4.2 Dependencies

There are no known projects or other network issues that are dependent on the resolution of this network issue.

4.3 Deliverability

The proposed works are equivalent to the similar activities to be completed in the current RCP. No delivery risks have been identified.

4.4 Customer considerations

As required by the AER's Better Resets Handbook, in developing this program Power Services has taken into consideration feedback from its customers.

Feedback received through customer consultation undertaken at the time of writing this business case, has demonstrated strong support amongst the community for appropriate expenditure to enable long term maintenance of the network to ensure continued reliability, maintainability, and safety of supply.

4.5 Expenditure profile

This cost estimate is based on continuing the NOL program. The table below shows a smoothed expenditure profile over the next RCP. A smoothed expenditure profile is assumed as an approximation because the work is likely to be spread out over several years due to changes in priorities and works scheduling during the delivery stage to improve efficiencies with the use of internal and external resources.

Table 6 Annual capital and operational expenditure ($m, real FY22)

Item	FY25	FY26	FY27	FY28	FY29	Total
Capex	0.72	0.72	0.72	0.72	0.72	3.60
Opex	-	-	-	-	-	-
Total	**0.72**	**0.72**	**0.72**	**0.72**	**0.72**	**3.60**

4.6 High-level scope

The scope of this program involves 11kV network augmentations to support the switching and load transfer capability of the feeders during first contingency conditions. Six 11kV distribution cable assets are required to be upgraded to improve the capacity of these assets. The installation of one new 11kV distribution cable asset has been identified to strengthen the feeder network in the event of an adjacent contingency event. The approximate length of each asset to be replaced or install is detailed in Table 6.

Appendix A. Cost estimates for feeder augmentations 2024-29

Table 7 Prioritised feeder augmentation and associated costs

Feeder	Required augmentation	Replacement / installation cost
Casuarina ZSS –11CA25 Brinkin	Upgrade from 95 mm^2 Aluminium (Al) cross linked polyethylene (XLPE) to 240 mm^2 Al XLPE Approx. 740m	Material[8]: $97,206 Labour: $93,270 Civil works: $244,837 Total: $435,314
Leanyer ZSS – 11LE04 Tambling	Upgrade 95 mm^2 Al XLPE to 240 mm^2 Al XLPE Approx. 2,600km	Material: $341,536 Labour: $327,705 Civil works: $860,239 Total: $1,529,480
Woolner ZSS – 11WO24 Parap	Upgrade 95 mm^2 Al XLPE to 240 mm^2 Al XLPE Approx. 550m	Material: $72,248 Labour: $69,322 Civil works: $181,974 Total: $323,544
Woolner ZSS – 11WO02 Fannie Bay	Upgrade 50 mm^2 Cu to 240 mm^2 Al XLPE Approx. 40m	Material: $5,254 Labour: $5,042 Civil works: $13,234 Total: $23,530
Leanyer ZSS – 11LE08 Parkside	New 400 mm^2 Al XLPE Approx. 1000m	Material: $131,360 Labour: $126,040 Civil works: $330,861 Total: $588,262
Casuarina ZSS –11CA23 Moil	Upgrade 300 mm^2 Al PL to 400 mm^2 Al XLPE Approx. 550m	Material: $72,248 Labour: $69,322

[8] Includes cable and 150 mm^2 conduit costs.

		Civil works: $181,974 Total: $351,746
Casuarina ZSS –11CA24 Parar	Upgrade 300 mm^2 Al Paper Lead to 400 mm^2 Al XLPE Approx. 500m	Material: $65,680 Labour: $63,020 Civil works: $165,431 Total: $319,769

Appendix B. Risk assessment

The risk posed by the identified cable assets to the network has been quantified by applying Power and Water's Risk-Quantification Procedure. This procedure has been developed based on good electricity industry practice and taking into account the recent guidelines and determinations made by the AER, the ISO 31000 Risk Management Standard, and other professional publications.

B.1 Quantified consequences of failure

The consequences related to restoring power in area supplied by inadequately rated cable after a nearby failure are Direct Financial Cost and Service Delivery value dimensions in Power and Water's Risk Quantification Procedure[9] and 'typical consequence areas' identified by the AER[10].

B.1.1 Direct financial cost

Direct financial costs incurred by Power and Water that result from an asset failure are the cost of asset replacement. The cost of replacing distribution underground cable has been calculated using historical expenditure data for three core Cross-Linked Polyethylene (XLPE) cables replaced in Power and Water's network from July 2020 to June 2022. The estimated cost per cable system is $124k p.a.

B.1.2 Value of Lost Load

Value of lost load (VoLL) quantifies the economic impact of loss of supply to customers. The consequence of failure in this value dimension is calculated as follows:

$$Value\ of\ Lost\ Load = PoF\ \times \sum_{1}^{i} (EAR_i\ \times VCR_i)$$

The Probability of Failure (PoF) is the likelihood of the event occurring per year and was calculated as the number of failures that would lead to the overloading of the cables identified in a year. The number of failures per year that would cause a feeder to overload is calculated as a linear extrapolation of the overall number of failures recorded for the whole 11kV underground cable network multiplied by the ratio of 11kV underground cable identified to the overall 11kV underground cable in network. Therefore, using figures provided in the Power and Water's Regulatory Information Notices (RINs) from July 2013 to June 2022 for $> 1kV, \leq 11kV$ cables:

$$Average\ annual\ failures = \frac{Average\ annual\ cable\ failures^{11}}{Average\ cable\ network\ length^{12}} = \frac{29}{671}\left[\frac{Failures}{km}\right]$$

Energy At Risk[13] (EAR) is the total amount of energy that would not be supplied to customers if the event occurs and was calculated based on the average load affected in an event multiplied by the sum of the

[9] Power and Water Risk Quantification Procedure RevB4, June 2022

[10] Australian Energy Regulator, Industry practice application note: Asset replacement planning 2019

[11] Average failures per year for the July 2013 to June 2022 period.

[12] Average length of cable type network for the July 2013 to June 2022 period.

[13] It must incorporate the demand that is off supply for each stage of the fault: the initial response time and each stage of the repair/restoration process.

switching and restoration time required to re-establish load. Affected load is assumed to be equivalent to 50% loading[14] of the installed capacity of the distribution transformers connected to each of the identified assets and switching time and restoration time were conservatively assumed to be 2 hours and 8 hours[15] respectively.

The Value of Customer Reliability (VCR) is published by the AER annually and describes the dollar value per kilowatt hour (kWh) disaggregated across multiple customer demographics, including customer type and location. The VCR was calculated using the AER VCR Annual Adjustment[16] for the values of the Northern Territory using an 80:20 commercial to residential ratio as the identified cables predominantly supply commercial customers:

$$VCR = \$\,40,740\;per\;MWh$$

Without intervention, in a business as usual scenario, the annual cost of residual risk associated with the identified cable assets is $49k.

B.2 Risk assessment

The assessment has been undertaken based on the business-as-usual case, that is, on the basis that Power Services does not undertake any proactive mitigation measures to address the emerging risk. The modelling is based on the following key assumptions:

- There is 4.61k km of 11kV underground cable identified by Power and Water as at risk of overload.
- Based on 11kV cable failure data for FY 2013-14 to FY2020-21 reported in Power and Water's Category Analysis RIN Responses[17], we have assumed:
  - 0.0431 failures per year per kilometre throughout the 11kV cable network, scaled up to 0.2415 failures per year for the 4.61km of cable identified as at-risk assets.
  - An outage has an economic impact of $205k based on the load calculated to be affected and the switching and restoration time requirements of the Network Planning Criteria
  - Under the base case, cables that are overloaded are assumed to be replaced, resulting in the decreasing risk profile decreasing to zero.

The assumptions are conservative and based on the best information available. The risk is approximately 72% direct financial cost and 28% service delivery, which appears to be a reasonable outcome considering the failure modes and historical interruption data. There is also a small net risk cost associated with investigation and litigation as well as safety and property risk should a failure in the cable assets result in fire, however, this is a comparatively small cost.

The reduction in risk that is achieved by different credible mitigation options, along with the cost of those options and any other direct financial cost savings.

---

[14] 50% of installed rated distribution transformer capacity is Power and Water standard approach to maximum load modelling.

[15] See Figure 14, pg.129, Network Technical Code and Network Planning Criteria v4, 30 March 2020, Power and Water Corporation.

[16] 2021 VCR Annual Adjustment, December 2021, Australian Energy Regulator.

[17] Table 2.2.1 Asset Failures by Asset Category, Power and Water Corporation – RIN responses (link)

Figure 2: Current risk with base case scenario

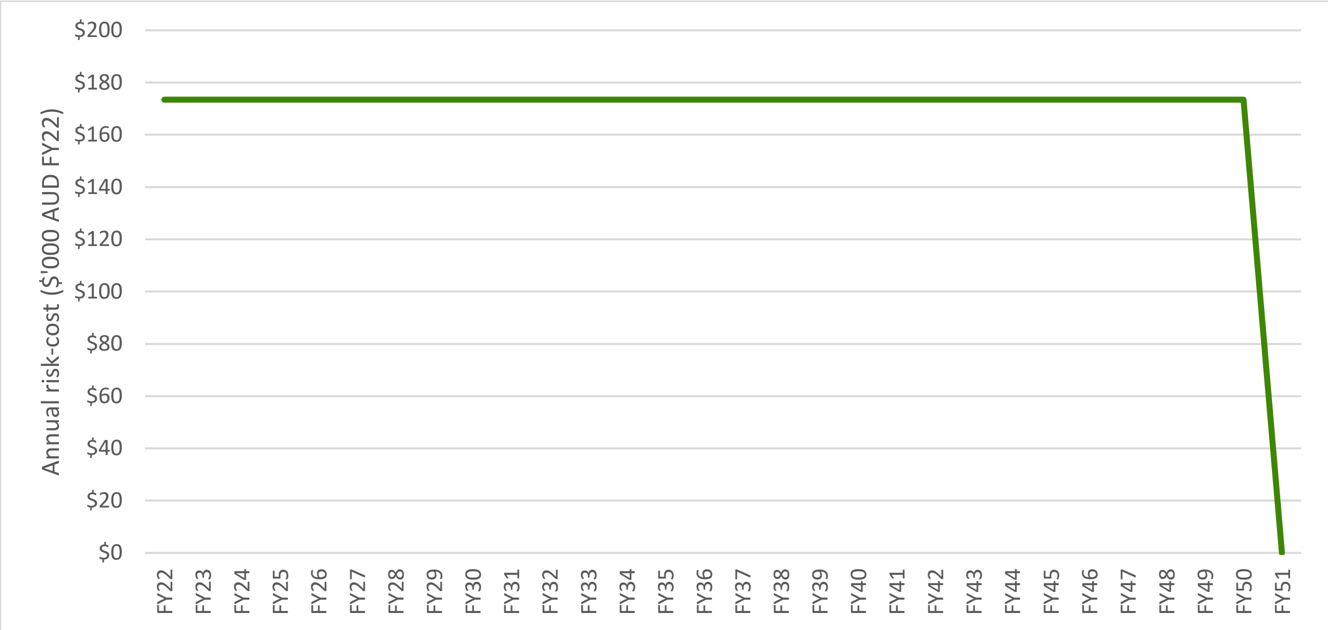
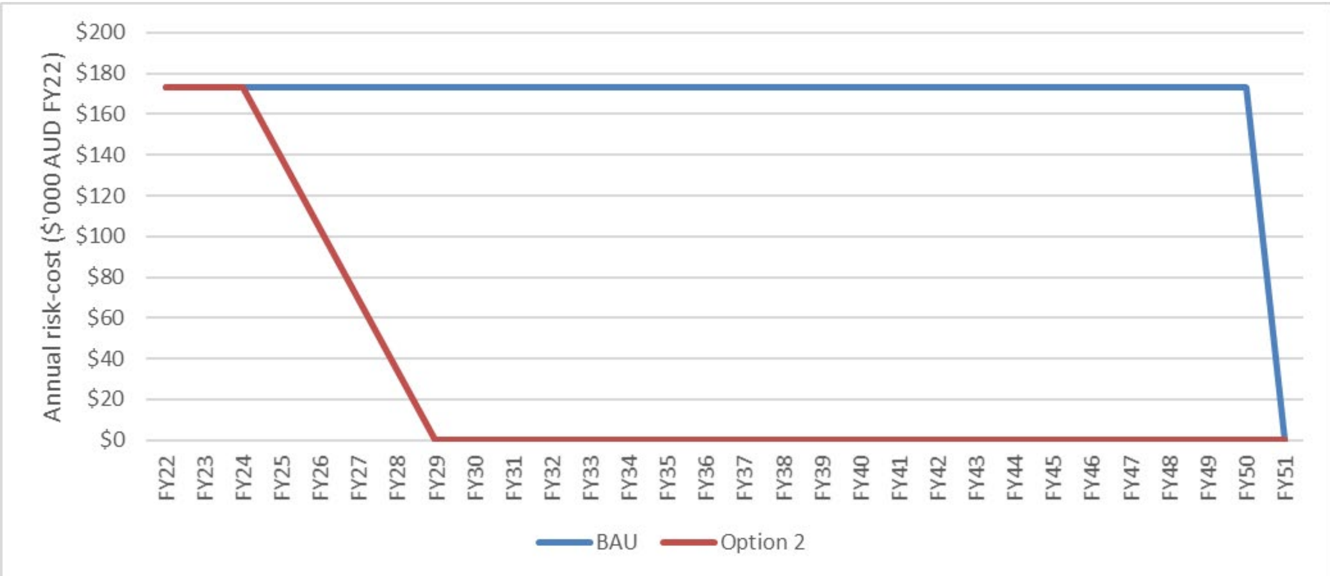


Figure 3 below shows the calculated reduction in risk attributable to upgrading and replacing the identified assets compared to Option 1, business as usual.

Figure 3 Risk reduction achieved by implementing Option 2



Appendix C. Annual network failures for 11kV underground cable

The following data has been collected from Power and Water RIN responses submitted to the AER.

Table 8 Annual asset failures and network length for 11kV underground cable

RIN Year[18]	Number of Failures[19]	Network Underground Cable (km)[20]	Failure per km
20-21	27	700	0.039
19-20	27	692	0.039
18-19	30	694	0.043
17-18	44	684	0.064
16-17	32	678	0.047
15-16	35	668	0.052
14-15	15	635	0.024
13-14	21	614	0.034
Average	29	671	0.043

[18] All past Power and Water RIN Reponses can be found on the AER's Performance Reporting database (link)
[19] The number of failures experienced throughout Power and Water's network for each given regulatory year is taken from Power and Water's Economic Benchmarking RIN Reponses – Table 2.2.1 - Replacement Expenditure, Volumes and Asset Failures by Asset Category – Asset Failures for asset category Underground Cables (> 1 kV & < = 11 kV).
[20] The length of underground cable in Power and Water's network for each given regulatory year is taken from Power and Water's Economic Benchmarking RIN Reponses – Table 3.5.1.2 - Underground network circuit length at each voltage for asset category Underground 11 kV.

Contact

Power and Water Corporation

55 Mitchell Street, Darwin NT 0800

Phone 1800 245 092

powerwater.com.au

PowerWater