Jemena Electricity Networks (Vic) Ltd

66kV Oil Filled Cable Replacement Program

Business Case

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66kV Oil Filled Cable Replacement Program

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1. Executive Summary

Synopsis

- There are several 66kV oil filled cables installed within the following sub-transmission network loops:
  - BLTS-YVE-NT
  - BLTS-TH
  - TTS-CS-CN
  - TTS-WT-NEL-NH-NEI
  - WMTS-FE-WGT
- The oil filled underground cables were installed from the mid 1960’s to the early 1970’s and are considered legacy installations that utilise pressurised oil as the insulating medium. This type of cable is near its design life with limited resources able to rectify any failures. This situation raises significant safety, environmental and security of supply risks.
- To manage these risks, three options were considered. The recommended option is to replace all at risk 66kV oil filled cables as a stand-alone program of works. Key items for replacement include:
  - Sub-transmission cable replacements across five zone substations
  - Seven kilometres of new 66kV sub-transmission cable
- The preferred solution is proposed for completion by the end of 2031 with an estimated total capital expenditure of $22.4 million (2024) with a positive NPV.

1.1 Business need

The 66kV oil filled cables form part of JEN sub-transmission network supplying approximately 98,300 JEN customers which is comprised of five separate 66kV sub-transmission loops that supply a total of seven JEN zone substations. There are approximately 7km of 66kV oil filled underground cables installed.

The 66kV oil filled cable are nearing end of life with rectification of repairs posing material risks to employee safety and reliability and security of customer supply. These assets require replacement with modern equivalents providing improved electrical and safety performance in accordance with JEN asset class strategies.

Issues associated with 66kV oil filled cable assets are described in Table 1-1.

Table 1-1: Current Issues with 66kV Oil Filled Cables

Issue No.	Description of Issue
1	**Asset condition** - The existing cables are 60 years old and near end of life. Historically there has been an increasing trend to failure and defects on these cables, interrupting supply to customers and resulting in single contingency network operations.
2	**Asset near obsolescence** - This type of cable is also no longer widely supported by manufacturers with maintenance and repair works requiring external resources and bespoke materials and equipment.
3	**Safety and network operational performance** - The technology used in this type of cable is based on a pressurised oil system which leads to inefficient maintenance and repair times in comparison to modern equivalents.
4	**Environmental impact** - The oil filled cables insulating medium can be detrimental to the environment should a cable failure or defect occur that results in oil leaking into the surrounding environment.

The following options addressing these issues have been considered:

1. **Do nothing.**
2. **Opportunistic replacement with other projects.**
3. **Dedicated staged replacement program.**
4. **Non-network solution.**

As per the Risk Assessment at Appendix B, the untreated risk ratings are High or Significant for the risks identified. This business case forms the rationale to initiate a project addressing the issues and risks associated with 66kV oil filled cable assets.

1.2 Recommendation

At 60 years old, the oil filled underground cables are nearing the end of their design life. The technology used in this type of cable and their condition has reached a point where safety, reliability and security of customer supply are compromised. Consequently, the replacement of this type of cable is recommended as a prudent and efficient investment.

It is further recommended to adopt Option 3 (Replacement Program). This involves replacing approximately 7km of 66kV oil filled cable, with modern equivalents that meet current JEN standards as a dedicated staged project. The new equipment will also conform to current Australian and industry standards, mitigating safety concerns and maintaining reliability of supply to customers.

This option is recommended as it addresses all identified condition issues whilst minimising the risk to network performance.

The total cost of this option is outlined in Table 1-2 and has a positive Net Present Value (**NPV**) as outlined in Table 1-3. This preferred solution is proposed to commence in 2027 with commissioning in 2031.

1.3 Regulatory considerations

The objective of the project is to determine the most appropriate strategy for the nominated assets to maintain customer supply reliability given their current asset condition.

Three options were explored in the options analysis outlined in Section 3.3 of this document to identify a recommendation. The options have been benchmarked against the risk assessment in Appendix B to ensure that health, safety and reliability issues are addressed. Risks, costs and economic values remain primary drivers.

JEN's investment decisions are ultimately guided by the National Electricity Objective (NEO). Additionally, JEN is required to meet the requirements of the National Electricity Rules (NER), Victorian Electricity Distribution Code of Practice (EDCoP), and public and industry expectations for distribution system performance, which require capital expenditure objectives to be achieved as discussed and outlined in Section 2.3.2.

1.4 Financial information

1.4.1 Forecast expenditure and budget summary

This project is required to be commissioned by the end of 2031. Table 1-2 provides the project budget by calendar year.

Table 1-2: Project Budget by Year, $2024

Year	Budget ($M)
2028	9.4
2029	4.4
2030	5.7
2031	2.9
Total Budget	**22.4**

Results of the economic evaluation for the preferred option is provided below.

Table 1-3: Economic Analysis Results Summary, $2024

Recommended option	($M)
Total Project Cost (capital):	22.4
NPV of Net Financial Benefit	22.7

2. Background

This document outlines the business case for the 66kV Oil Filled Cable Replacement, including its alignment with the JEN Asset Class Strategies.

The 66kV Oil Filled Underground Cable Replacement consists of:

- Nine circuit sections of oil filled cables to be replaced (one circuit has two oil filled cables in parallel YVENT A & B)
- Seven kilometres of new HDPE or XLPE cable to be installed
- Eighteen new cable terminations (cable ends and joins)
- Cable exit terminations at three zone substations
- Cable exit terminations at two terminal stations

2.1 Asset Details

The ST oil-filled cables installed in JEN sub-transmission network is described in Table 2-1, Figure 2-1 and Figure 2-2.

Table 2-1: 66kV ST Oil Filled Cable Details

Sub-transmission loop	Sub-Transmission Label	Conductor	Maximum Cyclic Rating (A)	Construction	Year	Length	Joints
Brooklyn Terminal Station – Yarraville – Newport BLTS-YVE-NT	YVENT A	3 single cores, 645mm^2, CU	1115	Direct buried	~1968	129m	0
	YVENT B	3 single cores, 645mm^2, CU	1115	Direct buried	~1968	129m	1
	YVENT C	3 single cores, 658mm^2, AL	1300	Direct buried / Conduit	~1974	185m	0
	BLTSNT	3 single cores, 658mm^2, AL	1140	Direct buried / Conduit	~1974	185m	0
Brooklyn Terminal Station – Tottenham BLTS-TH	BLTSTH	3 single cores, 811mm^2, AL	1710	Direct buried / Conduit	~1986	181m	0
Thomastown Terminal Station - Coburg South - Coburg North TTS-CS-CN	TTSCS	3 single cores, 658mm^2, AL	1350	Direct buried	~1976	241m	0
	CNCS	3 single cores, 658mm^2, AL	1350	Direct buried	~1976	133m	0

Sub-transmission loop	Sub-Transmission Label	Conductor	Maximum Cyclic Rating (A)	Construction	Year	Length	Joints
Thomastown Terminal Station – North Heidelberg - Nilsen TTS- NH-NEI	NEINH	3 single cores, 658mm^2, AL	1150	Direct buried	~1973	129m	3
	NELNH	3 single cores, 658mm^2, AL	1150	Direct buried	~1973	177m	0
West Melbourne Terminal Station – Footscray East WMTS-FE	WMTSFE1	3 single cores, 645mm^2, CU	1060	Direct buried	~1969	756m	4

Figure 2-1: 66kV ST Oil Filled Cable Head Pole (NEL-NH)

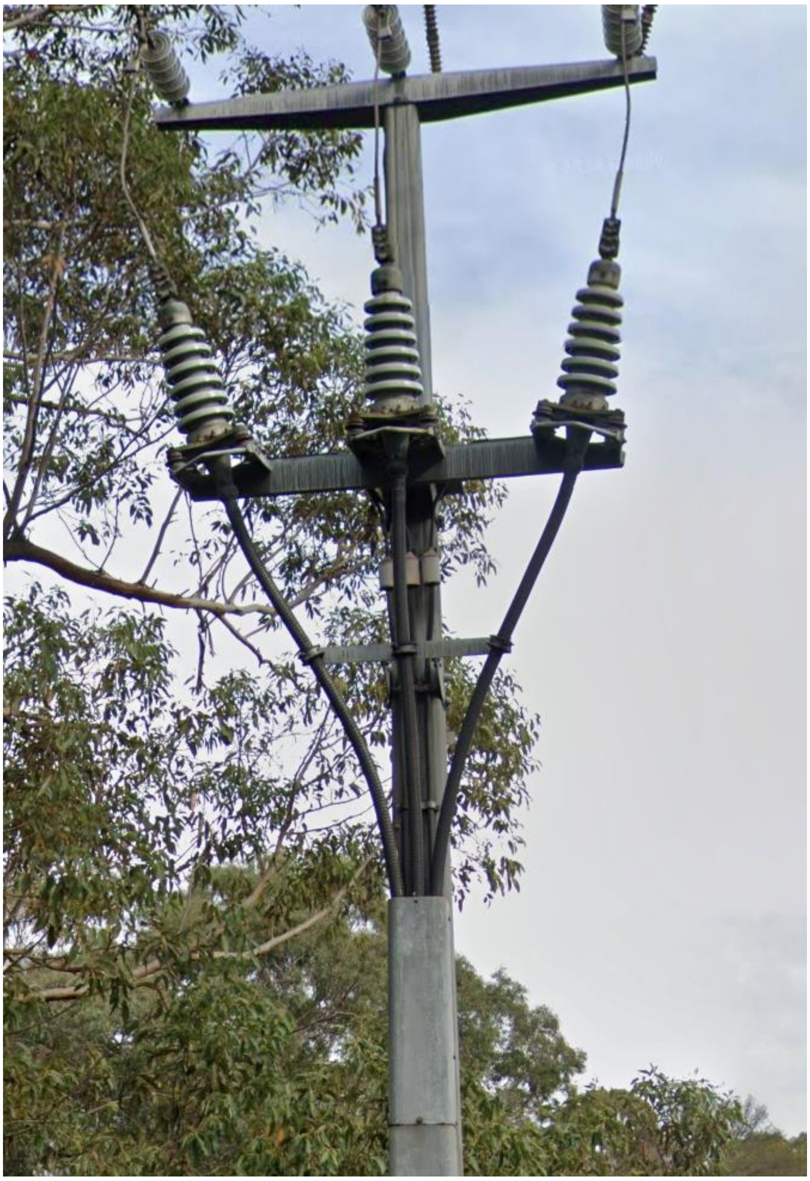


Figure 2-2 66kV ST Oil Filled Feeder Exit Cable at Newport (NT) Zone Substation (BLTS Feeder)

All JEN's 66kV sub-transmission oil filled cables are of the self-contained circular type, in which the oil is kept under pressure. One of the advantages of the oil filled cable is that all the free space between the core is available for the oil to flow and penetrate areas of the insulation leading to increased dielectric strength. Other benefits also include greater working temperature and ratings in relation to cable size.

This technology leads to complicated maintenance and repair works that is required to be completed by external parties. Such works have become challenging issues to resolve with ongoing risks becoming increasingly difficult to mitigate. For example, any joint repairs need to be completed by external oil filled cable specialists. Furthermore, when defects arise or faults occur, significant contingency planning is required due to the prolonged outage and response times.

A fault that occurred in 2016[1] with the WMTSFE1 oil-filled cable highlighted the impact a cable fault can have on JEN and its customers. Whilst the cause of the fault was due to physical disruption of the cable by a third party, the limited resources including specific skilled work crew, specific equipment and materials available to rectify the damages from the fault resulted in a prolonged outage of the cable and operation of the electricity distribution network on single contingency for 6 months. This meant for this duration of the outage, JEN was operating at a heightened risk level that could result in a significant number of customers off supply (approximately 13,900 customers at the time), should another fault occur on the remaining supply feeder. It is to be noted that Westgate Tunnel Zone Substation (WGT ZSS) has been added to the 66kV sub-transmission loop in 2018 increasing the risk of a prolonged oil filled cable outage. A history of faults and defects have been captured in

Table 2-2.

Due to technological advances in cable design and manufacturing, legacy oil filled cable technology has been progressively replaced with cross linked polyethylene (XLPE) insulated cables since the 1980s. Consequently, the aging technology has resulted in limited resources that are proficient in maintaining and repairing faults for these cables.

Table 2-2 66kV ST Oil Filled Cable Defects and Faults from 2010

Sub-Transmission Label	Defects / Faults	Year	Detail of fault and defect
YVENT B	Fault	2010	Blue phase sheath fault detected, located and repaired
	Fault	2015	Oil leak in gauge box. Required CitiPower resources to attend and repair gauge leak. Seven litres of oil required.
	Fault	2015	Red phase sheath fault detected, located and repaired
	Fault / Defect	2017	South side Red Phase Bushing cap blown out and repaired. Base of bushing damaged in same event and was cleaned up and placed back into service. Asset condition compromised and accelerated deterioration expected.
	Fault	2017	South side Red Phase stand-off insulator damaged and required to be replaced.
	Defect	2020	Oil pressure alarms Oil Pressure Alarm Stephen ST
BLTSTH	Fault	2012	Sheath fault identified and repaired. Cable outage taken and fault located close to terminal station fence.
TTSCS	Defect	Ongoing	CCPU chamber exhibiting rust and deterioration due to water ingress found under water on this occasion.
CNCS	Defect	Ongoing	CCPU chamber exhibiting rust and deterioration likely due to water ingress but found dry on this occasion.
NEINH	Defect	Ongoing	White phase bushing damaged with slow oil weeping. Sealant applied, ongoing monitoring.
	Defect	Ongoing	SVL pit at CHP has been found underwater regularly when undertaking maintenance.
	Defect	Ongoing	Oil leak at North Heidelberg zone substation end of NEI-NH cable
	Defect	2018	Thermal, 1_180802_NEI-NH_1
NELNH	Defect	Ongoing	Earth link pit in middle of football ground carpark found underwater regularly when undertaking maintenance. Showing signs of rust in the pit.
WMTSFE1	Defect	2015	WMTS-FE1, Dynon Rd Kensington, thermal
	Fault	2016	Third party had struck the cable when digging. Immediate response required CitiPower. Final repairs completed 6 months after cable struck due to the reliance on specialised external resources outside Victoria. Materials used were recently decommissioned cable from the CitiPower network and the jointing kits ordered from overseas.
	Fault	2023	Oil leak detected with repair works conducted after 9 months from detecting the fault due to reliance on specialised external resources outside Victoria.

2.2 Business and socio-economic context

The remaining 66kV oil filled underground cables were commissioned in the early 1970s and are part of five sub-transmission loops that supply [redacted] customers. A breakdown of these customers by customer class and location is captured in Table 2-3.

Table 2-3 Serviced Areas and Customers

Zone Substation	Suburbs Serviced	Customers (domestic)	Customers (business)
Yarraville	Yarraville, Spotswood and Maribyrnong	[redacted]	[redacted]
Newport	Newport and Williamstown	[redacted]	[redacted]
Tottenham	Tottenham and Brooklyn	[redacted]	[redacted]
Coburg South	Coburg, Coburg East, Moreland, Pascoe Vale and Pascoe Vale South	[redacted]	[redacted]
Coburg North	Coburg North, Fawkner, Reservoir and Preston	[redacted]	[redacted]
North Heidelberg	Yallambie, Viewbank, Macleod, Rosanna, Heidelberg Heights and Heidelberg West	[redacted]	[redacted]
Footscray East	Footscray, Footscray East, Yarraville and Spotswood	[redacted]	[redacted]

2.3 Asset risk (or opportunity) analysis

2.3.1 Short description of the affected assets

The key issues associated with the 66kV oil filled cables are age, condition, type and the onerous maintenance and repair works required to manage defects and faults. These considerations present a significant safety, environmental and security of supply risk due to the lack of skilled personnel, equipment and materials to conduct maintenance and resolve any faults or defects on what are now obsolete cable types.

All identified sub-transmission cables are of a similar age and construction type, therefore all original sections of this cable type will have degraded in the same way as the other cables due to age and in some cases the effects of electrolytic corrosion caused by the DC stray currents.

2.3.1.1 NTBLTS sub-transmission cable

The NTBLTS feeder exit cable at NT consists of 3 single 658mm^2 aluminium conductor, paper insulated, oil filled cables which are, for the most part a directly buried installation. [redacted]. The cable is near 60 years old with commissioning occurring when the NT zone substation building was created in 1970.

Figure 2-3 NTBLTS Cable route and Cable Head Pole

[redacted]

2.3.1.2 YVENT C sub-transmission cable

The SUB YVENT C feeder exit cable at NT consists of 3 single 658mm^2 aluminium conductor, paper insulated, oil filled cables which are, for the most part a directly buried installation. [redacted]. The cable is near 60 years old with commissioning occurring when the NT zone substation building was created in 1970.

Figure 2-4 YVENT C Cable route and Cable Head Pole

[redacted]

2.3.1.3 YVENT A & B sub-transmission cable

The YVENT A and B sub-transmission cables consists of 6 single 645mm^2 copper conductor paper insulated oil filled cables that is a directly buried installation. [redacted]. Given the asset is directly underneath a Victorian major road, it is likely additional coordination and works with VicRoads will be required to ensure any works are conducted without disruption to freeway commuters. The cable section is part of the original sub-transmission connection between the two zone substations create in 1970.

Figure 2-5 YVENT A & B Cable route and Cable Head Pole

[redacted]

2.3.1.4 BLTSTH Sub-transmission cable

The BLTSTH sub-transmission exit cable at BLTS consists of 3 single 811mm^2 aluminium conductor, paper insulated, oil filled cables. It is a directly buried installation. [redacted]. Given the asset is directly underneath a Victorian major road, it is likely additional coordination and works with VicRoads will be required in order to ensure works are conducted without disruption to freeway commuters. The cable is near 50 years old, with commissioning occurring in 1970s prior to the establishment of the current TH.

Figure 2-6 BLTSTH Cable route and Cable Head Pole

[redacted]

2.3.1.5 TTSCS sub-transmission cable

The TTS feeder exit cable at CS consists of 3 single 658mm^2 aluminium conductor, paper insulated, oil filled cables. It is directly buried in conduit installation. [redacted]. The cable is near 60 years old, with commissioning occurring when the CS zone substation building was created in 1972.

Figure 2-7 TTSCS Cable route and Cable Head Pole

[redacted]

2.3.1.6 CNCS sub-transmission cable

The CN feeder exit cable at CS consists of 3 single 658mm^2 aluminium conductor, paper insulated, oil filled cables. It is, for the most part, a directly buried installation. [redacted]. The cable is near 60 years old with commissioning occurring when the CS zone substation building was created in 1972.

Figure 2-8 CNCS Cable route and Cable Head Pole

[redacted]

2.3.1.7 NEINH sub-transmission cable

The NEI feeder exit cable at NH consists of 3 single 658mm^2 aluminium conductor, paper insulated, oil filled cables. It is, for the most part, a directly buried installation. [redacted]. The cable is near 60 years old with commissioning occurring when the CS zone substation building was created in 1973.

Figure 2-9 NEINH Cable route and Cable Head Pole

[redacted]

2.3.1.8 NELNH sub-transmission cable

The NEL feeder exit cable at NH consists of 3 single 658mm^2 aluminium conductor, paper insulated, oil filled cables. It is a directly buried installation. [redacted]. Given the asset also crosses directly underneath a rail corridor, it is likely additional coordination with Metro Trains Melbourne will be required to ensure works are conducted without disruption to rail operations. The cable is near 60 years old, with commissioning occurring when the NH zone substation building was created in 1973.

Figure 2-10 NELNH Cable route and Cable Head Pole

[redacted]

2.3.1.9 WMTSFE1 Sub-transmission cable

The WMTSFE1 sub-transmission exit cable at WMTS consists of 3 single 645mm^2 copper conductor, paper insulated, oil filled cables. It is a directly buried installation. [redacted]. The cable is near 60 years old, with commissioning occurring when the WMTS was created in 1970.

Figure 2-11 WMTSFE1 Cable route and Cable Head Pole

[redacted]

2.3.2 Risk assessment

JEN's sub-transmission network is designed to provide a secure and reliable supply to large numbers of customers with an N-1 level of redundancy. In the event of a sub-transmission network outage, planned or unplanned, the remaining capacity of the sub-transmission network is intended to maintain supply to customers without the need to load shed. Adopting this philosophy means that a loss to one end of a sub-transmission line or loop should not immediately impact supply to customers. However, should an oil filled cable fail on the other end of the sub-transmission loop, this could result in zone substation black for a longer duration. Furthermore, the prolonged N-1 condition expose JEN to higher probability of N-2 conditions which rotational customer load shedding may need to be implemented to prevent cascade failures. Consequences associated with this scenario can be categorised as follows:

- **Health and safety:** Severe damage to high-voltage (**HV**) apparatus or nearby infrastructure, potentially causing extreme HSE incidents to personnel, the community or environment
- **Operational**: Limits business operations of the distribution network, enforcing contingency plans that may not often be in place for prolonged periods due to load constraints and operation conditions of the distribution network.
- **Financial**: Loss of supply (outages) can result in financial losses to JEN through STPIS penalty and GSL payments. There would result in financial losses to the impacted customers.

JEN has applied an asset criticality score of Significant and Severe to the underground cable system which include sub-transmission oil filled cables. This is driven by the consequences associated with an underground cable failure and JEN's ability to respond to oil filled cable faults. Noting that if a cable fails in a sub-transmission loop where similar cables also exist, the loading will increase on the remaining at-risk oil filled cable leading to further stress on the poor condition asset.

The lack of maintenance and repair crews capable of repairing oil filled cables means prolonged outages and the operation of the electricity network on single contingency. At times, external specialist crews are required to carry out maintenance and repair works..

Additionally, the oil insulating medium is pressurised and requires extensive periods to test and repair faults leading to operating the electricity network on single contingency. The effect of oil leaks can also be detrimental to the environment.

Table 2-4 below describes the single contingency risk caused by the defects or faults in Section 2.1.

Table 2-4 Risk Impacts from Defects and Faults

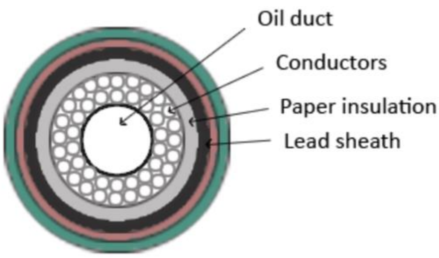
Sub-transmission loop	Sub-Transmission Label	Defect or Faults	Zone Substation at risk	MVA at risk (MD, 2024)	Customers at risk
Brooklyn Terminal Station – Yarraville – Newport BLTS-YVE-NT	YVENT B	5	Newport and Yarraville	71.3	[redacted]
Brooklyn Terminal Station – Tottenham BLTS-TH	BLTSTH	1	Tottenham	30	[redacted]
Thomastown Terminal Station - Coburg South - Coburg North TTS-CS-CN	TTSCS	1	Coburg South and Coburg North	100.6	[redacted]
	CNCS	1	Coburg South and Coburg North	100.6	[redacted]
Thomastown Terminal Station – North Heidelberg - Nilsen TTS- NH-NEI	NEINH	2	North Heidelberg and Nilsen	50.8	[redacted]
	NELNH	1	North Heidelberg, Nilsen and North East Link	50.8	[redacted]
West Melbourne Terminal Station – Footscray East WMTS-FE	WMTSFE1	2	Footscray East and West Gate Tunnel	33	[redacted]

The 66kV sub-transmission cables are aging oil impregnated, paper insulated, lead sheathed cables. The aging of the insulation system is driven by the presence of oxygen, moisture and heat. Failures of these cables are typically attributed to the deterioration of paper insulation or lead sheath.

Failure of paper insulation is due to oil migration over the life of the cable, leaving paper dry and brittle. This is particularly evident in existing cable joints or when new joints are installed. Due to the condition of the insulation in these cables, the risk of failure is significantly increased when cables are physically disturbed or handled.

Lead sheath fatigue and corrosion is caused by moisture ingress. The lead sheath provides the moisture barrier for the cable insulation as shown in Figure 2-12. Corrosion of the lead sheath can result from age-based deterioration and the type of installation (direct buried vs conduit). However, corrosion is commonly accelerated by electrolysis associated with DC traction systems.

Figure 2-12 Single Core Oil Filled Cable Cross Section



Single core conductor channel oil filled cable

Once the lead sheath has perforated or deteriorated, the rate of cable faults occurring increases. Consequently the reliability of these cables decreases. In some older cable systems, another layer of pitch impregnated cloth over the outside of the cable was installed as another barrier to mitigate the risk of lead sheath deterioration but over time the cloth also deteriorates rendering its presence ineffective.

A risk assessment, conducted in accordance with JEN's Risk Management Framework, has been undertaken and is provided in Appendix B of this document.

2.4 Project objectives and assessment criteria

2.4.1 Project objective

In line with the NEO, JEN's investment decisions aim to maximise the NPV to electricity consumers. The objective of this project is to maintain the reliability of supply to customers, given the current condition of the assets. This strategy must align with other JEN strategies and plans and the project must comply with associated regulatory requirements.

2.4.2 Regulatory considerations

JEN's investment decisions are ultimately guided by the NEO. Additionally, considerations such as the capital expenditure objectives set out in the NER (clause 6.5.7) are particularly relevant to JEN's investment decisions:

a) *A building block proposal must include the total forecast capital expenditure for the relevant regulatory control period which the Distribution Network Service Provider considers is required in order to achieve each of the following (the capital expenditure objectives):*

   (1) *Meet or manage the expected demand for standard control services over that period*

   (2) *Comply with all applicable regulatory obligations or requirements associated with the provision of standard control services*

   (3) *To the extent that there is no applicable regulatory obligation or requirement in relation to:*

      (i) *The quality, reliability or security of supply of standard control services; or*

      (ii) *The reliability or security of the distribution system through the supply of standard* *control services,*

to the relevant extent:

(iii) Maintain the quality, reliability and security of supply of standard control services

(iv) Maintain the reliability and security of the distribution system through the supply of standard control services.

(4) Maintain the safety of the distribution system through the supply of standard control services. [1]

Additionally, the EDCoP sets out provisions relevant to JEN's planning, design, maintenance, and operation of its network, most notably section 19.2 (Good Asset Management) and section 13.3 (Reliability of Supply):

Section 19.2 – Good Asset Management

A distributor must use best endeavours to:

a) *Assess and record the nature, location, condition and performance of its distribution system assets*

b) *Develop and implement plans for the acquisition, creation, maintenance, operation, refurbishment, repair and disposal of its distribution system assets and plans for the establishment and augmentation of transmission connections:*

   - *To comply with the laws and other performance obligations which apply to the provision of distribution services including those contained in this Code*
   - *To minimise the risks associated with the failure or reduced performance of assets*
   - *In a way which minimises costs to customers taking into account distribution losses.*

c) *Develop, test or simulate and implement contingency plans (including where relevant plans to strengthen the security of supply) to deal with events which have a low probability of occurring, but are realistic and would have a substantial impact on customers.*

Section 13.3 – Reliability of Supply

A distributor must use best endeavours to meet targets determined by the AER in the current distribution determination and targets published under clause 13.2.1 and otherwise meet reasonable customer expectations of reliability of supply.

When making decisions to invest, JEN must comply with these obligations.

2.5 Consistency with strategy and plans

This section describes how this project is consistent with JEN's objectives and strategies:

- **Provision of Service Levels and Reliability**: Ensuring service levels and reliability meet customer expectations.
- **Modern Capabilities**: Deployment of modern equivalent capabilities in the network to remain relevant to customers in the longer term.
- **Prudent and Efficient Expenditure**: Ensuring expenditure is prudent and efficient, aligning with customer expectations regarding affordability.

[1] NER, cll 6.5.6(a), 6.5.7(a).

JEN seeks to ensure that lifecycle costs are both efficient and effective. This business case is consistent with this requirement and aligns with the long term vision of the network, as set out in the Asset Management Plan (AMP) and annual planning reports.

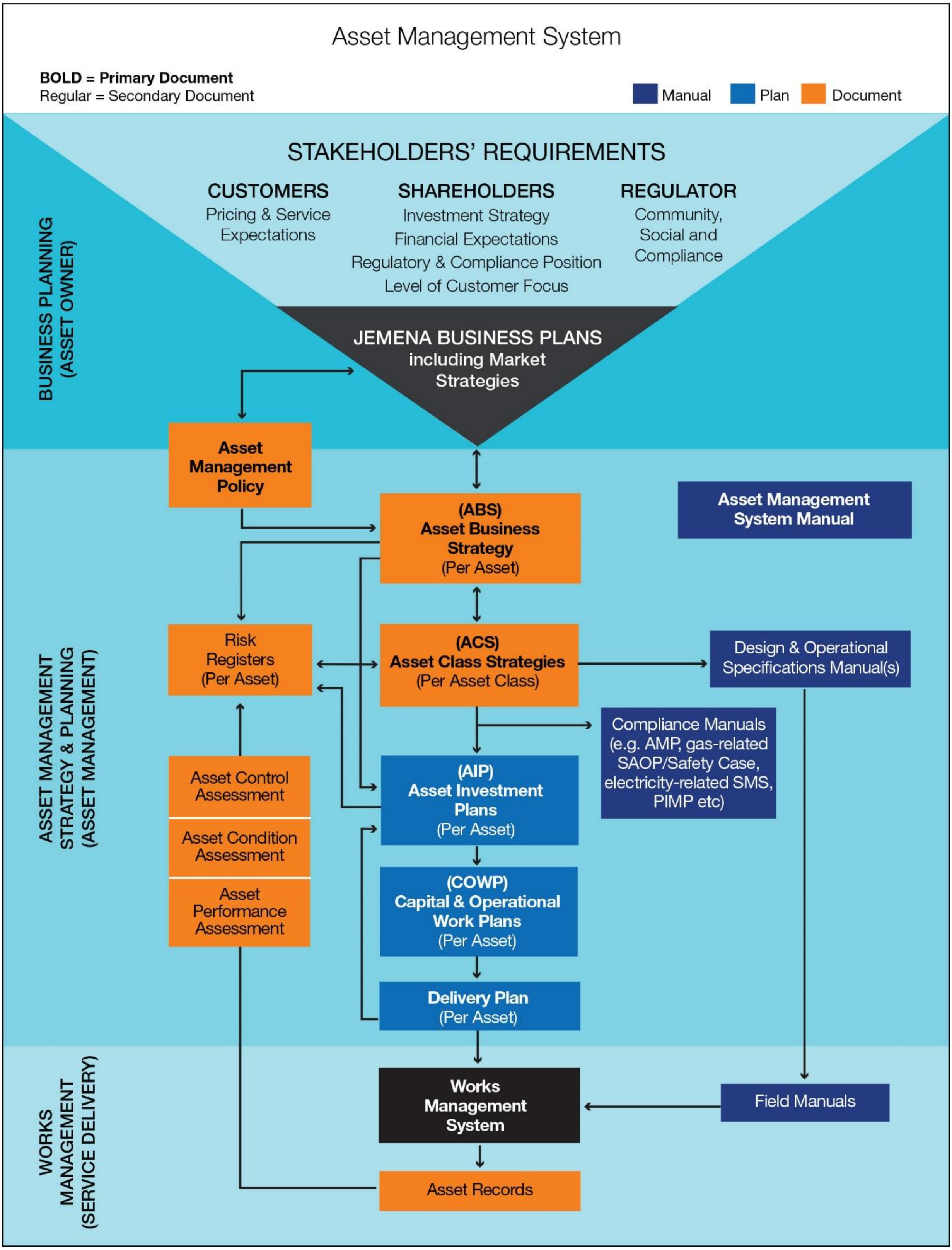
This proposal aligns with Asset Management Strategies, Plans and Policies contributing to a safe workplace for JEN employees and contractors. By addressing identified issues, JEN can reduce the risk of injury or environmental incident.

JEN abides by Australian asset and risk management industry standards (ISO 55001 and ISO 31000:2018) which is part of JEN's internal risk and asset management framework documents (ELE PL 0004 and JAA PO 0050).

Figure 2-13 outlines the Jemena Asset Management System and shows where the Asset Management Plan (AMP) is positioned within it. The AMP covers the creation, maintenance and disposal of assets, including investment planning to augment network capacity and replace degraded assets to maintain reliability of supply.

This strategic framework facilitates the planning and identification of business needs that require network investment documented via business cases.

Figure 2-13: The Jemena Asset Management System



3. Credible Options

3.1 Identifying credible options

The following options are available to address the business need, problem or opportunity.

- Option 1 – Do nothing.
- Option 2 – Opportunistic replacement with other projects
- Option 3 – Dedicated staged replacement program.
- Option 4 – Non-network solution

A preliminary assessment determined that Option 4 would not be considered further and has been excluded the options evaluation and subsequent sections. The key reasons for its exclusion are as follows:

- Most issues highlighted remain unresolved
- The condition of the asset that remains in service would lead to an unacceptable risk profile with heightened consequences
- Increased costs with no ability to realise delivery and operational efficiencies inherent in implementing standardised equipment and JEN asset strategies.
- Any non-network solution is likely to be unfeasible given the densely populated built-up environment in the areas served by the sub-transmission network. Servicing these areas would lead to an impractical cost to manage peak loads and customer demand.

3.2 Developing credible options

Table 3-1 shows the extent to which each option addresses the identified issues.

Table 3-1: Options Analysis

Issue	Option 1 Do Nothing	Option 2 Opportunistic replacement with other projects	Option 3 Dedicated staged replacement program
Issue 1 Asset condition	○	○	●
Issue 2 Asset near obsolescence	○	○	●
Issue 3 Safety and network operational performance	○	◑	●
Issue 4 Environmental impact	○	◑	●

●	Fully addressed the issue
◑	Partially addressed the issue
○	Did not address the issue

3.3 Options analysis

3.3.1 Option 1: Do nothing

The ‘do nothing’ option assumes business as usual, continuing current maintenance activities such as inspections, condition monitoring, preventive maintenance and defect repairs. However, this option does not address any of the identified condition issues. The probability of failure for this equipment would continue to increase over time, potentially leading to catastrophic failure while in service. Given the criticality of these issues and the lack of risk mitigation, this option is not considered credible.

3.3.2 Option 2: Opportunistic replacement with other projects

The ’Opportunistic replacement with other projects’ option is a reactive approach that implements changes once new projects arise. Whilst this approach partially addresses the key issues it does not fully address asset age and condition issues. The cable replacement is completely reliant on other project works occurring in the area which may not happen, essentially running the cables to failure. The outcome for cables in this scenario would resemble the ‘do nothing’ option. Additionally, no delivery efficiencies can be realised if other projects are independently driven by requirements that do not align with the requirements associated in replacing oil filled cables.

Until replacement works are completed, exposure to potential consequences and heightened risks would continue in the event a sub-transmission oil filled cable fails.

Given the residual unresolved issues, it is not recommended to pursue this option.

3.3.3 Option 3: Dedicated staged replacement program

The ‘Dedicated staged replacement program’ is a proactive approach that invests in the sub-transmission network of affected areas. Replacing the oil filled cables now mitigates all issues and risks associated with a failure of this type of asset. This is the recommended option and would involve installation of industry standard High-density polyethylene (HDPE) or Cross-Linked Polyethylene (XLPE) cable in parallel with the existing oil filled cables. The oil filled cables will then be retired and removed when the new cables have been cut over and commissioned.

Option 3 is the preferred option. This option resolves all identified issues while aligning with the JEN asset class and business strategies. The total capital cost of this option is forecasted as outlined in Table 1-2 based on the project commencing in 2027.

4. Option Evaluation

4.1 Economic evaluation

In line with the objective of the National Electricity Rules, JEN augmentation investment decisions aim to maximise the present value of the net economic benefit to all those who produce, consume and transport electricity in the National Electricity Market.

To assess benefits against this objective, JEN has undertaken a probabilistic cost-benefit assessment of replacement options. This assessment considers the likelihood and severity of critical network outages, evaluating the expected impact of asset failures and subsequent network outages on supply delivery. It combines this with the value that customers place on their supply reliability (VCR) and compares the result with the costs required to reduce the likelihood or impact of these supply outages. The benefits considered in this economic analysis relate to mitigating the increasing risk of failure of the sub-transmission oil filled cables. This includes the safety risks associated with Option 1 (do nothing) as described in section 3.3.1. The following table summarises the economic analysis undertaken.

Table 4-1: Economic Analysis Results Summary

($M)	Option 1	Option 2	Option 3
Total Expected costs	0	24.0	22.4
Total Expected market benefits	0	25.9	41.4
Net market benefits	0	7.0	22.7
Option ranking	3	2	1

4.1.1 Disposals

An assessment had been made on the equipment to be replaced as part of this project. The equipment has no written-down value due to its age and design life.

5. Recommendation

This business case proposes a total capital investment of Table 1-2.

It is recommended that Option 3 be adopted with all 66kV oil filled cables be replaced with new modern equivalents installed to current standards and philosophies.

This option maximises the net present value to JEN customers' and addresses all identified issues, therefore mitigating negative impacts on safety, reliability and security of customer supply.

It is recommended that the project commence in 2027 with completion in 2031.

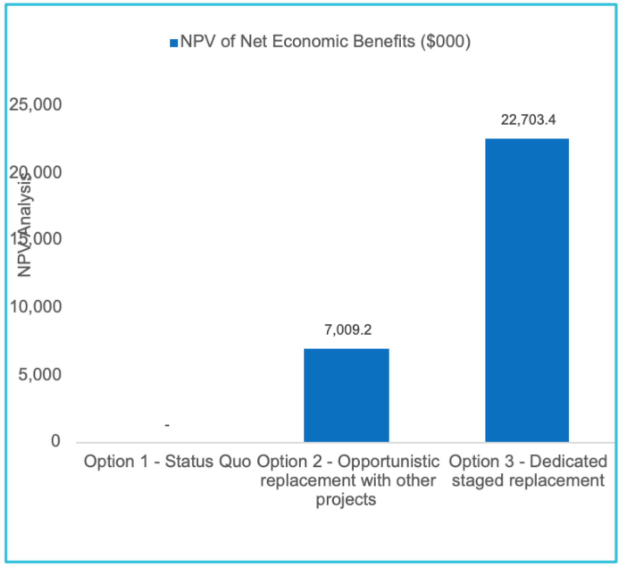
6. Exclusions

There are no exclusions within this business case.

Appendix A
Financial Evaluation Spreadsheets

A1. Financial Evaluation Spreadsheets

Overview of Options Analysis			
Options	**Option 1 - Status Quo**	**Option 2 - Opportunistic replacement with other projects**	**Option 3 - Dedicated staged replacement**
Recommended Option			✓
NPV of Net Economic Benefits ($000)	**-**	**7,009.2**	**22,703.4**
NPV of Total Economic Benefits ($000)	-	25,870.0	41,425.9
Avoided cost at asset failure	-	*383.0*	*868.1*
Improved energy reliability	-	*25,487.0*	*40,557.8*
Reduced energy losses	-	-	-
Other Economic Benefits	-	-	-
NPV of Incremental Total Costs ($000)	-	18,860.9	18,722.5
Total Incremental Net Capex	-	*18,860.9*	*18,722.5*
Total Incremental Opex - One-off	-	-	-
Total Incremental Opex - Ongoing	-	-	-
Sensitivity on Economic Benefit NPV ($000)			
Economic Benefits turn out to be 10% lower	-	4,422.2	18,560.8



Appendix B
Network Risk Assessment Summary

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B1. Network Risk Assessment Summary

Risk Register	66kV oil filled cable replacement					
Participants:	Alan Shu, Catherine Lee, Nicole Walker, Matthew Ch'ng, Jon Bernardo		**Workshop Date:**	9/10/2024	MS Teams	

S/No	Business Unit	Business Objective Category	Risk type	Risk Title	Risk Description	Root Causes Category	Root Causes - Description (Contributing Factors)	Risk Consequence Category	Risk Consequence - Description	Risk Owner	Untreated Consequence	Untreated Likelihood	Untreated Risk Rating	Current Controls	Control Assessment Frequency	Control Owner	Control Effectiveness	Overall Control Effectiveness	Current Consequence	Current Likelihood	Current Risk Rating	Risk Assessment Frequency	Risk Treatment Option	Acceptance Comment	Action Plan	Action Owner	Due Date	Status	Target Consequence	Target Likelihood	Target Risk Rating
1	Jemena Networks - Electricity	Sustainability	Safety risk	Working in the vicinity of live assets	Injury to employees or contractors working near or with this type of equipment. Many assets are near end of life with defects and faults increasing.	Resources – Assets, Cash, Equipment, Property	**Resources** - Oil filled cable and ancilliary equipment due to condition, age (end of life) and legacy equipment	Employee	- Injury to employees or contractors working in the vicinity of equipment - Regulatory investigations	M Ciavarella	Major	Possible	High	Asset Management System (ACS) including Asset Class Strategy.	6-monthly	M Ciavarella	Effective	Effective	Major	Unlikely	Significant	6-monthly	Treat		Project to replace the affected 66kV oil filled cables	N Walker	30/06/31	On Track	Major	Rare	Moderate
														VESI Switchgear Manual	6-monthly	M Gardiner	Effective														
														The VESI Green Book	6-monthly	M Gardiner	Effective														
														Emergency management plan	6-monthly	F Dunk	Effective														
														Job Safety Assessments (JSA), pre-start documentation and checks, associated pre-requisite procedures when completing site activities	6-monthly	L Cross	Effective														
2	Jemena Networks - Electricity	Sustainability	O-Business Continuty	Cable Failure	Failure of the oil filled cable to operate as intended.	Resources – Assets, Cash, Equipment, Property	**Resources** - Oil filled cable and ancilliary equipment due to condition, age (end of life) and legacy equipment. Third party damage.	Operational	- Unable to operate the oil filled cable as intended - Prolonged oil filled cable outage - Network operation of affected zone substation on single contingency for a prolonged duration - Network constraints leading to	M Ciavarella	Major	Possible	High	Distribution Asset Class Strategy	6-monthly	N Walker	Effective	Effective	Major	Unlikely	Significant	6-monthly	Treat		Project to replace the affected 66kV oil filled cables	N Walker	30/06/31	On Track	Major	Rare	Moderate
														VESI Switchgear Manual	6-monthly	M Gardiner	Effective														
														The VESI Green Book	6-monthly	M Gardiner	Effective														

Risk Register	66kV oil filled cable replacement		
Participants:	Alan Shu, Catherine Lee, Nicole Walker, Matthew Ch'ng, Jon Bernardo	Workshop Date: 9/10/2024	MS Teams

S/No	Business Unit	Business Objective Category	Risk type	Risk Title	Risk Description	Root Causes Category	Root Causes - Description (Contributing Factors)	Risk Consequence Category	Risk Consequence - Description	Risk Owner	Untreated Consequence	Untreated Likelihood	Untreated Risk Rating	Current Controls	Control Assessment Frequency	Control Owner	Control Effectiveness	Overall Control Effectiveness	Current Consequence	Current Likelihood	Current Risk Rating	Risk Assessment Frequency	Risk Treatment Option	Acceptance Comment	Action Plan	Action Owner	Due Date	Status	Target Consequence	Target Likelihood	Target Risk Rating
									adverse network resilience - Potential loss of supply to a high volume of customers - Fault current through the 66kV lines will be higher with the 66kV loop open (lines are not in parallel) which may result in CT saturation, causing protection maloperation with posibility of a station black. - Negative reputational impact - Regulatory investigations					Emergency management plan	6-monthly	F Dunk	Effective														
														Stakeholder/Customer engagement plan and procedures	6-monthly	J Ng	Effective														
														Job Safety Assessments (JSA), pre-start documentation and checks, associated pre-requisite procedures when completing site activities	6-monthly	L Cross	Effective														
3	Jemena Networks - Electricity	Sustainability	O-Business Continuity	Prolonged single contingency operation	Affected sub-transmission loop operating on single contingency for prolonged periods following an 66kV oil filled cable fault	People – Knowledge, Skills, RACI	**People** - Lack of resources and reliance on the availability of specialised external resources required to repair legacy oil filled cables	Operational	- high volume of customers supply at risk - large financial losses at risk - Negative reputational impact - Regulatory investigations - Fault current through the 66kV lines will be higher with the 66kV loop open (lines are not in parallel) which may result in CT saturation, causing protection maloperation with possibility of a station black. -Network constraints leading to adverse	M Ciavarella	Major	Possible	High	Distribution Asset Class Strategy	6-monthly	N Walker	Effective	Effective	Major	Unlikely	Significant	6-monthly	Treat		Project to replace the affected 66kV oil filled cables	N Walker	30/06/31	On Track	Major	Rare	Moderate
														VESI Switchgear Manual	6-monthly	M Gardiner	Effective														
														The VESI Green Book	6-monthly	M Gardiner	Effective														
														Emergency management plan	6-monthly	F Dunk	Effective														
														Stakeholder/Customer engagement plan and procedures	6-monthly	J Ng	Effective														

Risk Register	66kV oil filled cable replacement		
Participants:	Alan Shu, Catherine Lee, Nicole Walker, Matthew Ch'ng, Jon Bernardo	Workshop Date:	9/10/2024 MS Teams

S/No	Business Unit	Business Objective Category	Risk type	Risk Title	Risk Description	Root Causes Category	Root Causes - Description (Contributing Factors)	Risk Consequence Category	Risk Consequence - Description	Risk Owner	Untreated Consequence	Untreated Likelihood	Untreated Risk Rating	Current Controls	Control Assessment Frequency	Control Owner	Control Effectiveness	Overall Control Effectiveness	Current Consequence	Current Likelihood	Current Risk Rating	Risk Assessment Frequency	Risk Treatment Option	Acceptance Comment	Action Plan	Action Owner	Due Date	Status	Target Consequence	Target Likelihood	Target Risk Rating
									network resilience - Network constraints leading to no planned outages for opex (maintenance) and capex works					Job Safety Assessments (JSA), pre-start documentation and checks, associated pre-requisite procedures when completing site activities	6-monthly	L Cross	Effective														
4	Jemena Networks - Electricity	Sustainability	O-Business Continuty	Prolonged single contingency operation	Affected sub-transmission loop operating on single contingency for prolonged periods following an 66kV oil filled cable fault	Resources – Assets, Cash, Equipment, Property	**Resources** - lack of spare materials, tools and equipment	Operational	- high volume of customers supply at risk - Regulatory investigations - Fault current through the 66kV lines will be higher with the 66kV loop open (lines are not in parallel) which may result in CT saturation, causing protection maloperation with possibility of a station black. -Network constraints leading to adverse safety performance	M Ciavarella	Major	Possible	High	Distribution Asset Class Strategy	6-monthly	N Walker	Effective	Effective	Major	Unlikely	Significant	6-monthly	Treat		Project to replace the affected 66kV oil filled cables	N Walker	30/06/31	On Track	Major	Rare	Moderate
														VESI Switchgear Manual	6-monthly	M Gardiner	Effective														
														The VESI Green Book	6-monthly	M Gardiner	Effective														
														Emergency management plan	6-monthly	F Dunk	Effective														
														Stakeholder/Customer engagement plan and procedures	6-monthly	J Ng	Effective														
														Job Safety Assessments (JSA), pre-start documentation and checks, associated pre-requisite procedures when completing site activities	6-monthly	L Cross	Effective														

Risk Register	66kV oil filled cable replacement		
Participants:	Alan Shu, Catherine Lee, Nicole Walker, Matthew Ch'ng, Jon Bernardo	Workshop Date:	9/10/2024
			MS Teams

S/No	Business Unit	Business Objective Category	Risk type	Risk Title	Risk Description	Root Causes Category	Root Causes - Description (Contributing Factors)	Risk Consequence Category	Risk Consequence - Description	Risk Owner	Untreated Consequence	Untreated Likelihood	Untreated Risk Rating	Current Controls	Control Assessment Frequency	Control Owner	Control Effectiveness	Overall Control Effectiveness	Current Consequence	Current Likelihood	Current Risk Rating	Risk Assessment Frequency	Risk Treatment Option	Acceptance Comment	Action Plan	Action Owner	Due Date	Status	Target Consequence	Target Likelihood	Target Risk Rating
5	Jemena Networks - Electricity	Sustainability	O-Business Continuty	Oil spill	Cable failure or defect leads to oil contamination of nearby environment	Resources – Assets, Cash, Equipment, Property	**Resources** - cable failure or oil leak	Operational	- Prolonged customer outages and network constraints due to repair works, environmental clean up times and investigations	M Ciavarella	Severe	Likely	High	Distribution Asset Class Strategy	6-monthly	N Walker	Partially Effective	Partially Effective	Severe	Likely	High	6-monthly	Treat		Project to replace the affected 66kV oil filled cables	N Walker	30/06/31	On Track	[redacted]		
														Emergency management plan	6-monthly	F Dunk	Partially Effective														
														Environmental Management Plan	6-monthly	S Fourie	Partially Effective														
														Job Safety Assessments (JSA), pre-start documentation and checks, associated pre-requisite procedures when completing site activities	6-monthly	L Cross	Partially Effective														
														Sheath integrity and SVL tests	2-yearly	L Cross	Effective														
														Oil pressure checks	monthly	L Cross	Effective														
														SCADA alarms (reactive)	Continuous	D Bonavia	Partially Effective														

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