Jemena Electricity Networks (Vic) Ltd

JEN - RIN - Support - CN ZSS Redevelopment - Business Case - 20250131

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1. Executive Summary

Synopsis

- The primary and secondary equipment at Zone Substation Coburg North (CN) is at risk of failure due to its age and poor condition. This situation raises significant safety and security of supply concerns.
- To manage these risks, five options have been considered. The recommended option is to redevelop the zone substation by installing current Jemena Electricity Network (JEN) standardised equipment to replace at-risk assets. Key items include:
  - Three 66kV circuit breakers
  - Three 20/33MVA 66/22kV transformer
  - Three modular 22kV switchboards
  - An earth fault management system
  - New protection and control equipment
- The project is proposed for completion in 2028 with an estimated total capital expenditure of $47.6 million (nominal) with a positive NPV.

1.1 Business need

Zone Substation Coburg North (CN) supplies around 24,000 JEN customers and consists of:

- three 66/22kV power transformers,
- three 66kV circuit breakers,
- three capacitor banks, and
- eleven 22kV feeders

The outdoor 22kV switchgear, 22kV pin and cap insulators, two 66kV circuit breakers, No.1 and 2 transformers and all protection and control schemes have reached their end of life and pose material risks to employee safety, 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.

In addition, an earth fault management system and 66kV line circuit breakers are proposed to achieve current public safety, network supply quality and reliability requirements:

The issues associated with CN assets are described below in Table 1-1. Refer to Section 2 for a detailed overview of CN assets, associated faults and degree of alignment to JEN Primary Plant and Secondary Asset Class Strategies.

Table 1-1: Current Issues with CN Assets

Issue No.	Description of Issue
1	The current 1-2 66kV bus tie Circuit Breaker (CB) is a type with a history of mechanical failure and catastrophic bushing failure. This CB type (LG4C) is also no longer supported by any manufacturer with spares unavailable.

Issue No.	Description of Issue
2	The 2-3 66kV ASEA HLC bus tie circuit breaker is oil filled and maintenance intensive. It also has a nitrogen gas leak and is no longer supported by the manufacturer.
3	The No.1 and 2 transformers are at end of life, being over 60 years old by the time of replacement. The No.1 and 2 transformers have a very high moisture in paper level, and No. 2 is leaking oil. Repairing these transformers is impractical. Consequently, they will be replaced to ensure ZSS CN remains operational. Subsequently the No.3 transformer will be replaced and later relocated and installed as the No.3 transformer at ZSS Coburg South (CS) as part of a future planned redevelopment of CS. No further capital expenditure on ZSS CN transformers is anticipated in the next 20 years.
4	All transformer high voltage (HV) bushings have been identified for replacement due to type with historic failures and catastrophic consequences of failure (risk of fires destroying the total transformer for example). Bushing replacement also requires HV Current Transformer (CT) replacement, affecting the turrets and transformers and requiring extensive testing before returning to service.
5	The outdoor 22kV oil filled circuit breakers (type 345GC) are nearly 60 years old and their condition is degraded. This family of breakers also have a history of mechanical failure at this age, including catastrophic bushing failure. The switchgear is also no longer supported by the manufacturer and mechanism/bushing spare parts are depleted.
6	The 345GC switchgear has a history of oil leaks from the circuit breaker and internal isolator compartments and this requires increased operating expenditure (OPEX) to manage.
7	The 3AF 22kV circuit breakers were originally designed for indoor (metal clad) operation. However, the 3AF units at ZSS CN were installed within individual outdoor cubicles. In addition, the manufacturer no longer supports these breakers, and mechanism spare parts, including vacuum interrupter spares, are depleted.
8	The 3AF switchgear does not comply with current switchgear standards for electrical internal arc fault containment (IAC), which presents a health and safety risk to JEN personnel.
9	The failure mechanism of pin and cap type insulators is known within the industry. Moisture ingress and subsequent corrosion at the point where the steel pin is cemented into the insulator causes the porcelain to fracture under pressure. These HV connections are no longer supported and HV faults are common following the failure of this type of insulator.
10	The existing feeder exit cables are mainly paper lead and are 57 years old. Historically there has been an increasing trend to failure on these cables, interrupting supply to customers. This type of cable is also not suitable for the REFCL technology application. In addition, animal proofing on non-standard legacy cable head pole construction has proven ineffective.
11	Most protection relays are legacy electromechanical and do not have real-time monitoring. These relays are used to protect major primary plants. The electro-mechanical relays at CN are 50 years old, with a design life of 40 years. Without monitoring, failure of these relays can remain undetected, exposing the network to reliability and safety risks. Additionally, Analogue Electronic and Digital relays at CN are also nearing their design life.

Issue No.	Description of Issue
12	The DC supply system is deteriorated and is at risk of failure. Most batteries are beyond their 15-year design life and are deteriorated. This is a critical system and is used to supply auxiliary power to protection relays, control and communication circuits, and trip/close HV circuit breakers. Failure of a DC system would leave the zone substation unprotected and inoperable. This in turn creates a serious safety risk for the public and JEN personnel, as well as increased risk of asset damage and loss of supply to customers.

The following options addressing these issues have been considered:

1. **Do nothing.**
2. **Increased maintenance and monitoring.**
3. **Redevelop the zone substation.**
4. **Staged replacement of assets**
5. **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 network assets at CN.

1.2 Recommendation

At 60 years old, the 22kV bus, switchgear and transformers (No.1 and No.2) have reached or exceeded their design life, as evidenced in Section 2 and the CBRM health index. Their condition has degraded to a point where safety, reliability and security of customer supply are compromised. Additionally, the secondary equipment at the zone substation is at end-of-life, further increasing the risk of failure. Consequently, the replacement of both primary and secondary equipment is recommended as a prudent and efficient investment.

After consideration of all alternatives, it is recommended to adopt Option 3 (Redevelop the zone substation, explained in detail in Section 3.3). This involves replacing all outdoor equipment including the 66/22kV transformers and all secondary equipment with modern equivalents that meet current JEN standards. The new equipment will also conform to current Australian and industry standards and be based on a modular concept, mitigating safety concerns and improving the reliability and security of customer supply concerns. Implementation of modular equipment also ensures that cost efficiencies are realised by incorporating design elements that reduce the amount of work required to carry out any construction, commissioning or operational activity with the equipment.

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

The total cost of this option is $47.6M (outlined in Table 1-2) and has a positive Net Present Value (NPV) of $132.2M[1] (outlined in Table 1.3). This preferred solution is proposed to commence in 2026 with commissioning in 2028.

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 at CN given their current asset condition.

[1] Refer to Coburg North (CN) Redevelopment Costs and Benefits Analysis Model.xlsb for detailed calculations.

Four 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.

In preparing this business case, JEN have considered and closely followed relevant AER assessment guidelines. This includes, but is not limited to, the Better Resets Guideline and Expenditure Forecast Assessment Guideline.[2]

1.4 Customer considerations

In addition to regulatory considerations, the expectation from our customers is to implement the most appropriate option that addresses all asset condition issues whilst maintaining customer supply reliability in the most efficient way.

The scope of the asset replacement options include the use of modular equipment. As outlined in section 3.3, the modular approach meets customer requirements by:

- Specifying and designing equipment based on a building block approach
- Selecting equipment available from a wide range of manufacturers
- Installing equipment which can be applied for a variety of configurations
- Installing equipment that can be easily repaired or replaced reducing outage time
- Reducing customised solutions and procedures applicable throughout the project and during the life of the asset

In preparing options for this business case, JEN have considered established philosophies and practices in zone substation asset replacements.

1.5 Economic evaluation and project cost

1.5.1 Forecast expenditure and budget summary

This business case proposes a total capital investment of $47.6M. Further detail of the total capital investment can be found in Appendix B.

This project is based on commissioning in 2028. Table 1-2 provides the project budget by financial year.

Table 1-2: Project Expenditure by Year, $2024[3]

Year	Expenditure ($M)
FY27	22.6
FY28	25.0
Total Budget	**47.6**

2 In Appendix A of Attachment JEN Att 05-01 Capital expenditure, we have also set out how our proposed capital expenditure, which includes the Coburg North Redevelopment, is compliant with the requirements of the NER.

3 Refer to Coburg North (CN) Redevelopment Costs and Benefits Analysis Model.xlsb for detailed calculations .

Results of the economic evaluation for the preferred option is provided below and in **Error! Reference source not found.**.

Table 1-3: Economic Analysis Results Summary, $2024[4]

Recommended option	($M)
Total Project Cost (capital):	47.6
NPV of Net Financial Benefit:	132.2

[4] Refer to Coburg North (CN) Redevelopment Costs and Benefits Analysis Model.xlsb for detailed calculations.

2. Background

The purpose of this document is to set out the business case for the Coburg North (CN) zone substation redevelopment project, including its alignment with JEN Primary Plant and Secondary Asset Class Strategies and how our customers will benefit from the project over the long term. [5]

CN consists of:

- two 66/22kV 20/30 MVA rated power transformers,
- one 66/22kV 20/33 MVA rated power transformer,
- one 66kV AEI LG4C circuit breaker,
- one 66kV ASEA HLC circuit breaker,
- one ABB EDF SK1-1 circuit breaker,
- three 22kV buses and eleven 22kV feeders.

The outdoor 22kV switchgear consist of 345GC build oil and Siemens 3AF vacuum circuit breakers.

Most protection relays are legacy electromechanical types without real-time monitoring, protecting major primary plants such as power transformers and 66kV and 22kV Buses. These relays, over 50 years old, have exceeded their 40 year design life, posing network reliability and safety risks.

Figure 2-1 Coburg North Zone Substation Layout

[5] Refer to JEN Primary Plant (ELE-999-PA-IN-008) and Secondary (ELE-999-PA-IN-010) Asset Class Strategies.

Asset Details

66kV switchgear

The 66kV switchgear installed at CN is described in Table 2-1 below and Figure 2-2 on the previous page.

Table 2-1: CN 66kV Bus Tie CB Details

Designation	Make	Type	Voltage	Current	SECV Spec No.	Year of Manufacture
1-2 66kV Bus Tie CB	AEI	LG4C	66kV	1,600 A	64-65/199	1967
2-3 66kV Bus Tie CB	ASEA	HLC 72.5	66kV	1,600 A	82/389	1990
SUB CS FDR	ABB	EDF SK1-1	66kV	2,000 A	-	1990

Figure 2-2: CN 1-2 66kV Bus Tie CB

No recorded defects have been found on the 1-2 66kV bus tie circuit breaker; however, 66kV circuit breakers of this type and age have a history of defects and catastrophic failures.

The 2-3 66kV bus tie CB, an ASEA HLC72.5, suffers from water in oil issues. This is due to its “free-breathing” design where moisture is able to penetrate the circuit breaker in humid weather. This can result in the accumulation of ‘free’ water (i.e. water below the oil) that must be drained from the circuit breaker stacks at each maintenance outage.

22kV switchgear

The 22kV switchgear installed at CN is briefly described in Table 2-2 and Figure 2-3. The 345GC CBs are outdoor dead tank bulk oil CBs. The load break mechanism is via heavy copper contacts that are suspended via wood pull rods. The 345GC CBs are installed at zone substations AW (Airport West), BD (Broadmeadows) and CN (Coburg North).

Table 2-2: CN switchgear Details

Designation	Make	Type	Voltage	Current	SECV Spec No.	Year of Manufacture
NO.1 TRANS, NO.2 TRANS, NO.1 CAP BANK, NO.2 CAP BANK, 1-2 BUS TIE, FDRs CN2, CN3, CN4, CN5, CN6, CN7, CN8	EMAIL	345GC	22kV	1,200A	64-65/58 65-66/390	1967
NO.3 TRANS, NO.3 CAP BANK, 2-3 BUS TIE, FDRs CN1, CN9, CN10	Siemens	3AF	22kV	1,250A, 630A, 1250A, 630	83/532 86/503	1986 1991
FDR CN11	Crompton Greaves	30-SFGP-25A	22kV	1,250A	Q98830232	1998

Figure 2-3: CN 22kV Switchgear

There have been 26 recorded defects associated with the CN Email 345GC 22kV switchgear. In addition, 32 defects have occurred at ZSS AW (Airport West) and 24 defects have been reported for ZSS BD (Broadmeadows). AW, BD and CN all have the Email 345GC switchgear on the JEN Network. AW also has the Crompton Greaves 30-SFGP-25A CBs. Neither AW nor BD have the Siemens 3AF CBs.

Historically, the 345GC CBs suffer from several issues, the predominant issue being bushing defects. The bushings sometimes leak pitch. A program was initiated to refurbish all bushings on the 345GC CBs on the JEN. In more recent years the main contact pull rods have experienced failures. These pull rods were made from Permali wood, which is no longer available. In 2014 a project was initiated to replace pull rods with fibre glass pull rods on all transformer and cap bank CBs on JEN.

There have been no recorded defects on the Siemens 3AF CBs. However, due to excessive switching duties on the cap bank CBs they have needed interrupters replaced.

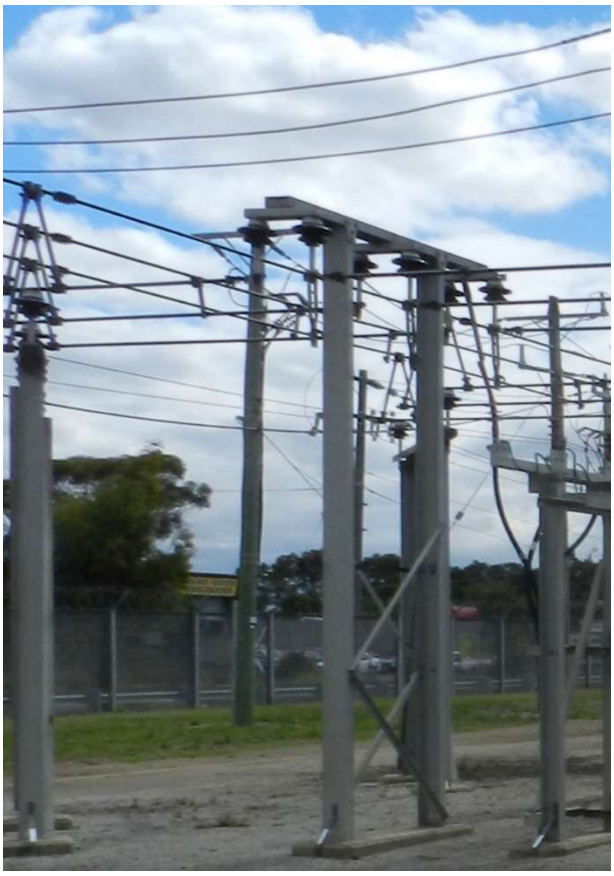
The Crompton Grieves CBs have a history of ongoing issues, with the main issue related to SF6 leaks from the interrupter poles. Several CBs on JEN have had their interrupters refurbished. This is an ongoing issue and will only be resolved with the replacement of the CBs.

The 22kV Transfer Bus installed at CN is briefly described in Table 2-3 and Figure 2-4.

Table 2-3: CN 22kV Transfer Bus Details

Designation	Make	Voltage	Current	SECV Spec No.	Year of Manufacture
22kV Transfer Bus and Connections	SECV	22kV	995A	N/A	1967

Figure 2-4: CN 22kV Transfer Bus



There have been two recent incidents associated with the failure of 22kV pin and cap type insulators within Victoria (Refer to the Electricity Primary Plant Asset Class Strategy[6] for further information) as follows:

1. In a circumstance with the arrangement in Figure 2-4, an insulator had sheared from the pin, and resulted in the bus dropping to 1m above ground level. The bus remained alive and was found by an employee.
2. An isolator was opened using a HV switch stick when an insulator had sheared from the pin. The live conductor then fell onto an employee's shoulder.

<u>Transformers</u>

The transformers at CN are briefly described in Table 2-4 and

Figure 2-5. The No.1 and No.2 AEI transformers are naturally cooled, while the No.3 Wilson transformer can be fan-cooled, leading to a slightly higher capacity. No.1 transformer moisture level in oil is currently fair. This will be monitored and prioritised from a Trojan dry-out. Results from 2016 indicate both No.1 & No.2 transformers have high moisture & acid levels. This increases the likelihood of catastrophic failure with transformers in operation at the end of their design life.

Table 2-4 Transformer Details

Designation	Make	Voltage Ratio	NER Installed	Capacity	SECV Spec No.	Year of Manufacture
TRANSF NO1	AEI	66/22kV	Y	20/30MVA	63-64/246	1967
TRANSF NO2	AEI	66/22kV	Y	20/30MVA	63-64/246	1967
TRANSF NO3	WILSON	66/22kV	Y	20/33MVA	85/474	1990

Figure 2-5 Transformer No.1

[6] Refer to JEN Primary Plant (ELE-999-PA-IN-008) Asset Class Strategy.

2.1 Consumer engagement

2.1.1 Overview of consumer sentiment and relationship to this business case

CN was commissioned in 1967 and is located to the north of the Melbourne CBD in an industrial zone on Newlands Road, Coburg North. The zone substation supplies approximately 24,000 customers in the Coburg North, Fawkner, Reservoir and Preston areas.

Following an extensive customer engagement program[7] with residential customers, small and medium businesses and large commercial customers located within the JEN Network, we received strong feedback that customers want to ensure our assets are maintained and upgraded to ensure a safe, and reliable electricity network. In terms of our overarching customer engagement program, customer feedback on the Draft Plan highlighted that our consumer engagement has met or exceeded expectations.[8]

Over 150 residential customers from across North-Western Melbourne, including customers from Coburg, Reservoir and Preston, provided feedback on how we can prepare our network for a more sustainable energy future while meeting customer and community needs today. When asked for feedback on the pace and scale of investment we should make on network assets, they told us to strengthen the network to ensure our assets don't compromise the reliability of the network.[9]

This feedback also highlighted the importance of exploring non-augmentation and non-network solutions, which was subsequently explored in this business case. Feedback recommended:

- Exploring non-augmentation solutions such as local energy systems (e.g., batteries, substation improvements) to enhance reliability and resilience.
- Evaluating the trade-offs between cost and benefits to achieve desired reliability levels.
- Considering solutions beyond current regulatory frameworks, like community batteries or aggregator models.

In addition, surveying 1,000 residential customers across JEN's electricity network, reliability and the maintenance of the network was the most important priority to customers. Customers surveyed identified network reliability, defined as 'the ability of the electricity network to perform its function adequately for the period of time intended' as of high importance (97 per cent of surveyed customers placed important on this issue).

This business case for the Coburg North zone substation redevelopment intends to give effect to the consumer preference for network reliability and safety.

2.1.2 Jemena's People Panel

The People's Panel, a Citizen's Jury made of up to 50 residential customers, also provided a recommendation for JEN to focus on network reliability, "Jemena needs to prioritise investing in reliability by assessing, building and maintain the network to meet changes in operating conditions and withstand network failures."

The People's Panel rationale for this recommendation was that it is important to invest in network infrastructure with a focus on:

- Improving and maintaining service standards and customer experience
- Reduced frequency in power outages

[7] Refer to Attachments JEN – Att 02-01 – Engagement Strategy – 20230601 – Public; JEN – Mosaic Lab Att 02-22 – Customer deep Dive outcomes report – 20241209 – Public; JEN – Sagacity Research Att 02-08 Customer priorities research report – 20241308 – Public.

[8] Refer to Attachment JEN – Att 02-18 Draft Plan Feedback Report - 20240924.

[9] Refer to Attachment JEN – Att 02-23 Energy Reference Group Report - 20240312.

- Continue to invest in upgrading the network's ability to "self-heal"
- Flexibility to accommodate network growth and demand

For context, the People's Panel is an iterative consultation mechanism which was formed to represent customers from across JEN's network and to help us understand how we can prepare for a sustainable energy future, while meeting customer and community needs today. The People's Panel is a diverse selection of JEN's customers, incorporating all walks of life - cultural diversity, age, gender and geographic location. For reference, the People's Panel spent five Saturdays together over six months, learning about the role we play in the electricity supply network.

2.1.3 AER expectations for consumer engagement

Better Resets Handbook		Alignment to this business case
Nature of engagement	Sincerity of engagement	• We engaged with customers through multiple channels, allowing diverse opinions and recommendations for JEN investment priorities. • Independent facilitators and researchers, such as MosaicLab and Sagacity Research were utilised.
	Consumers as partners	• We partnered with consumers directly through our People's Panel. Recommendations from this panel explicitly recognised the need for network reliability.
	Equipping customers	• Engagement materials briefed customers on key concepts, including (but not limited to) how the electricity supply chain works, an overview of JEN's operating environment, megatrends in the energy market, the regulatory context, and a snapshot of our customer base.
	Accountability	• Independent facilitators and researchers, such as MosaicLab and Sagacity Research were utilised.
Breadth and depth of engagement	Accessible, clear and transparent engagement	• We engaged with customers through multiple channels, allowing diverse opinions and recommendations for JEN investment priorities. • Engagement materials briefed customers on key concepts, including (but not limited to) how the electricity supply chain works, an overview of JEN's operating environment, megatrends in the energy market, the regulatory context, and a snapshot of our customer base.
	Multiple channels of engagement	• We engaged with customers through multiple channels, allowing diverse opinions and recommendations for JEN investment. This included through direct feedback, consumer surveys, and our People's Panel. • Our full regulatory proposal outlines our consumer engagement program and initiatives in detail.
	Consumers influence on the business case	• Engagement highlighted the importance of prioritise investing in reliability by assessing, building, and maintaining the network to meet changes in operating conditions and withstand network failures

Better Resets Handbook		Alignment to this business case
Clearly evidenced impact	Business case linked to consumer preferences	• This business case for zone substation redevelopment at Coburg North specifically supports the consumer preference for network reliability – given the risks and consequences of undertaking non-preferred options.
	Independent consumer support from the business case	• The independent Sagacity Research report concludes that: *When ranked, network reliability comes to the fore, followed by network resilience*

The alignment of our consumer engagement program with AER expectations has been detailed further in our broader regulatory proposal.

2.2 Asset risk (or opportunity) analysis

2.2.1 Short description of the affected assets

66kV Equipment

Switchgear 1-2 66kV Bus Tie CB (type LG4C)

This family of breakers has a history of failure, including catastrophic insulation failure, impacting employee safety and security of customer supply. Notable incidents include:

- 2015: Bushing failure on the 1-2 66kV bus tile CB at ZSS FE due to insulation degradation
- 2023: Bushing failure at Brooklyn Terminal Station on the 2-3 66kV bus tie
- CB controls are rated for 240V DC, but are required to operate at 110V DC to align with the standard secondary systems DC system discussed in the JEN Secondary plant asset class strategy. [10]

Switchgear 2-3 66kV Bus Tie CB (type HLC)

The 2-3 66kV ASEA HLC bus tie CB at ZSS CN is oil filled, and maintenance intensive. It has a nitrogen gas leak and is no longer supported by any manufacturer. To mitigate employee safety and security of customer supply risks, this project proposes to replace this circuit breaker with a modern equivalent.

CB controls are rated for 240V DC, but are required to operate at 110V DC to align with the standard secondary systems DC system discussed in the JEN Secondary plant asset class strategy.

22kV Equipment

Email 345GC

The outdoor 22kV oil filled circuit breakers (type 345GC) are more than 57 years old and in a degraded condition. The switchgear is no longer supported by the manufacturer and mechanism/bushing spare parts are depleted.

The 22kV Email 345GC circuit breaker is an outdoor CB located within various zone substations. There are many issues recorded as follows:

- History of compound leaks from the bushings, and explosive failure (Other distribution businesses).
- Main contact pull rod failures.

10 Refer to JEN Secondary Plant (ELE-999-PA-IN-010) Asset Class Strategy .

- Maintenance intensive with maintenance frequency increased from 12 years to 6 years.
- Worn Pull Rod guides.

There is evidence that new failure modes are emerging as the asset continues to age beyond its design life. Failure of some existing components can be mitigated by engineering new components, but this process is costly and does not mitigate emerging age-related failure of other components within the CB. Arc flash hazards and risks of catastrophic failure continue to increase over time.

Siemens 3AF

The 3AF CBs were originally designed for indoor (metal clad) operation. However, the 3AF units at CN were installed within individual outdoor cubicles and are no longer supported by the manufacturer and mechanism spare parts including vacuum interrupters spares are limited. Several 3AF CBs installed within outdoor cubicles at CN have experienced delayed tripping resulting in upstream protection operating. Although corrective action and modifications have taken place, these remain short term solutions. Failure to trip in accordance with the design trip time for a genuine fault remains a significant risk for safety. This also impacts wider customer supply, including life support customers. The 3AF switchgear is non arc fault rated and is planned for replacement.

Switchyard

22kV ‘Pin and Cap’ insulators

The failure mechanism of pin and cap-type insulators is well-known within the industry. Moisture ingress and subsequent corrosion at the point where the steel pin is cemented into the insulator, causes the porcelain to fracture under pressure and HV connections are no longer supported. HV faults have occurred following the failure of this type of insulator.

During early 2020 a similar 66kV ‘pin and cap’ porcelain insulator sheared and caused a HV fault (at ZSS BD). Arcing discharge and surface tracking has been witnessed on the 66kV brown pin and cap insulators at another site, warranting their replacement. All 22kV pin and cap type insulators at CN (installed on buses, feeders, capacitor banks) are of a similar age and condition and well beyond their design life.

Transformers

The No.1 and 2 Transformers at CN are past their design life and will be over 60 years old when replaced. The No.1 and 2 transformers have high moisture in paper levels, with No. 2 leaking oil. It is not economical to repair these transformers as the work involved would require rebuilding the internal core of the transformer essentially resulting in a transformer with new internals components whilst utilising the same existing shell. These works cannot be completed onsite and can only be completed at a transformer manufacturing plant leading to extended periods without an in-service transformer given the transformer will need to be temporarily relocated and sent to a transformer manufacturer to be rebuilt before finally being sent back to site for installation and recommissioning. A rebuilt transformer will also be subject to reduced warranty periods in comparison to a newly built and supplied transformer. It is proposed the No.3 transformer be replaced and later relocated and installed as the No.3 transformer at zone substation Coburg South (CS) as part its future proposed redevelopment.

Feeder Cables

The existing feeder exit cables are mostly paper lead and near 60 years old. There have been several historical failures on these cables, interrupting supply to customers. This type of cable has shown an increasing failure trend in recent years. In addition, animal proofing on non-standard legacy cable head pole construction has proven ineffective. Therefore, all feeder exit cables should be replaced from the new switchgear directly to the cable head poles with standard construction, including new surge diverters and animal-proofing. Feeder HV cable (3 phase cable) screens will be bonded to the CMEN and Zone Substation earth grid to establish a ZCMEN system and will be labelled accordingly at both ends at the switchgear and CHP. The 22kV feeder exit underground cables will be designed to achieve the cyclic rating of 375A using JEN-approved standard cables[11].

Protection and Control Equipment

[11] 22kV 3/C 300mm2 Copper XLPE cable is non-standard. Refer to Tech Alert ELE-FTC 0191 for details

There have been 32 recorded defects since 2013 associated with Protection, Control, Supervisory Control and Data Acquisition (SCADA) and Communications equipment at CN. The defects are occurring at an average of 2.7 per year with the trend increasing. The cause of these defects predominantly relates to the age and condition of the equipment.

Relays

Many protection relays are legacy electromechanical without the ability to real-time monitor. These relays protect major primary plants. Consequently, their failure may remain undetected, exposing the network to safety risk. These electromechanical relays are also at the end of their design life.

DC system

Batteries and chargers are a critical system with the latter nearing the end of their design life. Failure of the DC system leaves the zone substation unprotected posing serious safety, asset and loss of supply risk.

SCADA and Communications

Specific issues include:

- **C50 RTU**: This RTU has been in service for over 20 years, and is well beyond its design life, requiring an increased maintenance regime to manage failure risk. The current RTU cannot facilitate Digital Substation portfolio objectives and requires replacement with compatible equipment to incorporate the required functionality.

- **Communications System**: This legacy system doesn't have the ability to achieve the modern functionality required by the JEN Secondary System Asset Class Strategies.

2.2.2 Risk assessment

A network asset risk assessment has been completed for assets installed at CN. The risk assessment results have highlighted that the current condition of assets and controls implemented exceed JEN risk appetite and require further treatment. The current condition of assets at CN are driving key safety and business continuity risks. Further details of the network assets risk assessment are shown in Appendix B.

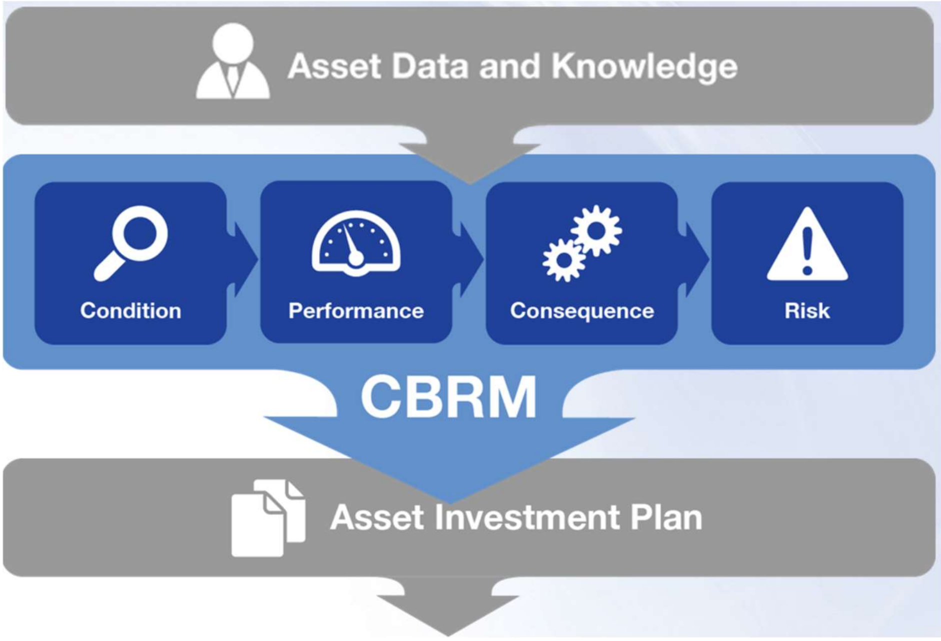
Primary Equipment

JEN applies Condition Based Risk Management (CBRM) modelling for switchgear and transformer assets to assist in developing asset investment plans using existing asset data and other information. A detailed description of how the CBRM model works can be found in the Guideline - Condition Based Risk Management (CBRM)[12].

The CBRM model is a structured process that combines asset information, engineering knowledge and practical experience to define future condition, performance and risk for network assets. An overview of the CBRM asset management process is outlined in Figure 2-6.

[12] Refer to ELE GU 0005 Guideline - Condition Based Risk Management (CBRM).

Figure 2-6 Overview of CBRM Asset Management Process



The CBRM model process can be summarised by a series of sequential steps as follows:

1. **Define asset condition.** 'Heath indices' for individual assets are derived and built for different asset groups. Current health indices are measured on a scale beginning from 0 to greater than 7, where 0 indicates the best condition and values above 7 the worst.

2. **Link current condition to performance.** Health indices are calibrated against relative probability of failure (**PoF**). The health index/PoF relationship for an asset group is determined by matching the health index profile with the recent failure rate.

3. **Estimate future condition and performance.** Knowledge of degradation processes are used to 'age' health indices. The ageing rate for an individual asset is dependent on its initial health index and operating conditions such as high pollution areas and distance to coastal environments. Future failure rates can then be calculated from aged health index profiles and the previously defined health index/PoF relationship.

4. **Evaluate potential interventions in terms of PoF and failure rates.** The effect of potential replacement, refurbishment or changes to maintenance regimes can then be modelled and the future health index profiles and failure rates modified accordingly.

5. **Define and weight consequences of failure (CoF).** A consistent framework is defined and populated in order to evaluate consequences in significant categories such as network performance, safety, financial and environmental. The consequence categories are weighted to relate them to a common monetary ($) unit.

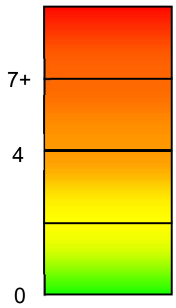
6. **Build risk model.** For an individual asset, its probability and consequences of failure are combined to quantify risk. The total risk associated with an asset group is then calculated as the sum of the risk of the individual assets.

7. **Evaluate potential interventions in terms of risk.** The effect of potential replacement, refurbishment or changes to maintenance regimes can then be modelled to quantify the potential risk reduction associated with different strategies.

8. **Review and refine information and process.** Building and managing a risk-based process on the basis of asset specific information is not a one-off process. The initial application will deliver results based on available information and, crucially, identify opportunities for ongoing improvement that can be used to progressively build an improved asset information framework.

The key element of the CBRM model is the Health Index which it outputs for each asset which corresponds to a scale representative of the assets condition, remnant life and probability of failure. As noted above, Health index values begin at zero and can be greater than seven. Values greater than seven represent serious deterioration and the need to plan for replacement before failure occurs. The health index is described in Table 2-5.

Table 2-5 Asset Health Index



Condition	Health Index	Remnant Life	Probability of Failure
Bad		At EOL (<5 years)	High
Poor		5 - 10 years	Medium
Fair		10 - 20 years	Low
Good		>20 years	Very low

The CBRM modelling results are summarised in Table 2-6. The results indicate the CBs are in a severely deteriorated condition. By 2029, the CBRM health index indicates a high probability of failure should no action be taken.

Table 2-6 Primary Equipment CBRM

	2024		2029	
Primary Equipment	**Average**	**Maximum**	**Average**	**Maximum**
66kV Bus Tie CB	7.67	-	8.92	-
No. 1 and No. 2 Transformers	7.05	-	8.21	-
22kV CBs	7.38	9.72	8.93	11.47
22kV transfer bus	8.34	9.1	11.78	12.78

If these assets were to fail in the next regulatory period, the failure or maloperation of primary equipment can lead to major consequences, which can be categorised as follows:

- **Health and safety**: Severe damage to HV apparatus and loss of supply (outages), potentially causing extreme HSE incidents to personnel, the community or environment
- **Operational**: Limits business operations of the distribution network, enforcing contingency plans due to the loss of supply (outages)
- **Financial**: Loss of supply (outages) can result in financial penalties based on frequency of occurrence, duration and number of customers affected
- **Reputation**: Negative perception from industry and customer stakeholders if reliability and safety performance is reduced
- **Regulatory**: Breaches of obligations under legislation, regulation, rules and codes.

The investment outlined in this business case seeks to address these requirements and risks.

Secondary Equipment

Protection and control systems are designed to detect the presence of faults or other abnormal operating conditions and to automatically isolate the faulted network by opening appropriate high voltage circuit breakers. Interruptions to customers from faulty protection and control equipment are generally caused by either:

- Failure of the protection relay to act upon a genuine fault
- Mal-operation of the protection relay under system normal conditions

The secondary equipment at CN is operating at end-of-life with increasing risk of asset failure. Like the primary equipment, all risks for secondary equipment are identified and managed in Omnia which is Jemena's Risk and Compliance Management System. Failure or maloperation of protection relays lead to the same 'Major' consequences previously described.

The investment outlined in this business case seeks to address these requirements and risks.

2.3 Project objectives and assessment criteria

2.3.1 Project objective

In line with the NEO, JEN's investment decisions aim to maximise the net present value 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.

2.3.2 Regulatory considerations

JEN's investment decisions are ultimately guided by the National Electricity Objective (**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.* [13]

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

Additionally, the Victorian Electricity Distribution Code of Practice (**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.

2.3.3 AER assessment criteria

In preparing this business case, JEN have considered and closely followed relevant AER assessment guidelines. This includes, but is not limited to, the Better Resets Guideline and Expenditure Forecast Assessment Guideline.[14]

[14] In Appendix A of Attachment JEN 0 Att 05-01 Capital expenditure, we have also set out how our proposed capital expenditure, which includes the Coburg North Redevelopment, is compliant with the requirements of the NER.

2.4 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 that 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.
- **Optimised Investment Profile**: Driving an investment profile that optimises regulatory allowances and provides expected returns to shareholders.

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.

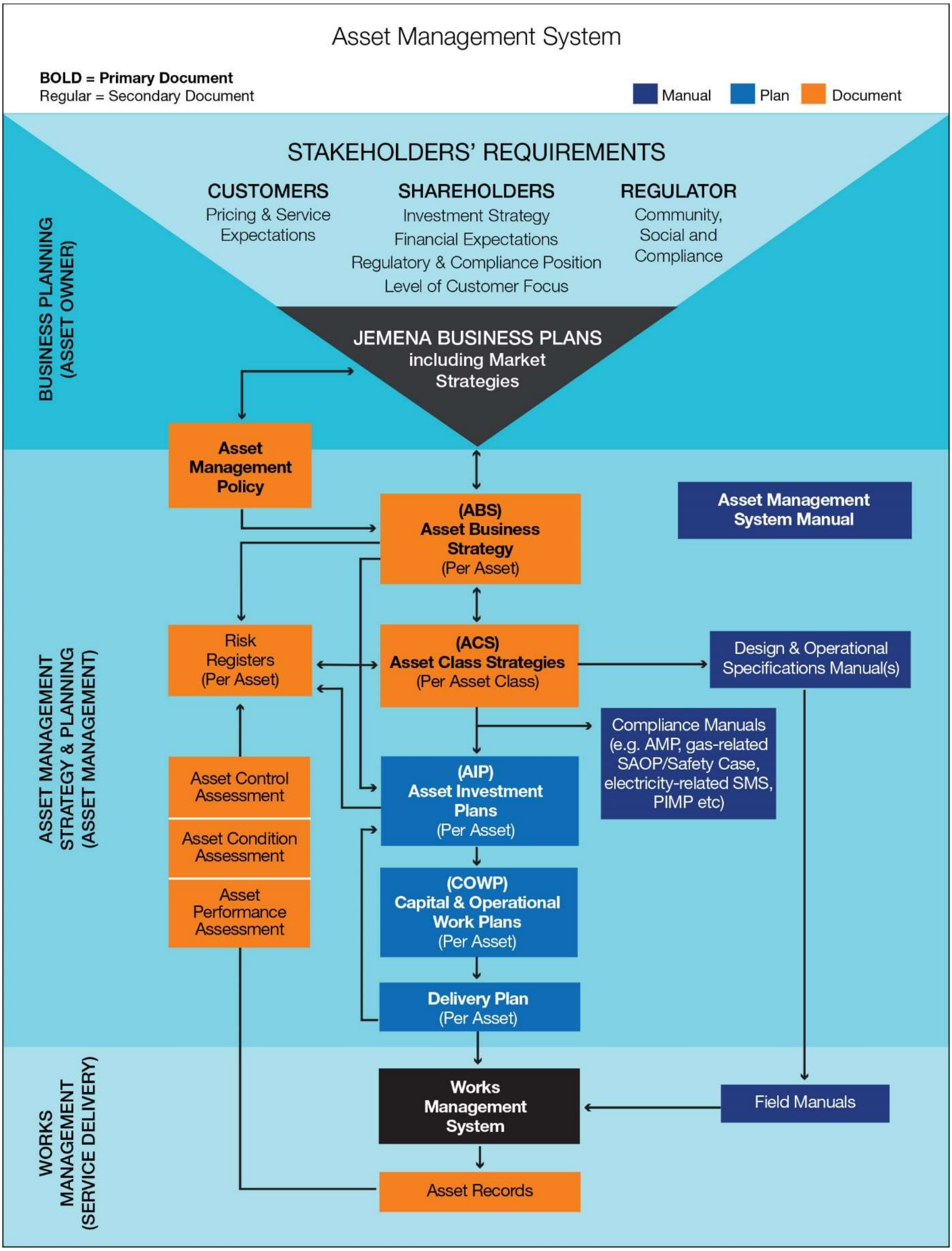
This proposal aligns with Asset Management Strategies, Plans and Policies contributing to a safe workplace for JEN employees and contractors. By addressing identified issues, JEN can reduce the risk of injury to its staff or members of the public.

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 2-7 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 2-7: The Jemena Asset Management System



3. Credible Options

3.1 Identifying credible options

The following options were identified to address the business needs, problems or opportunities.

- Option 1 – Do nothing.
- Option 2 – Increased maintenance and monitoring.
- Option 3 – Redevelop the zone substation.
- Option 4 – Staged replacement of assets
- Option 5 – Non-network solution

A preliminary assessment determined that Option 5 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 will 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.

The preliminary assessment of the non-network solution is further described in Appendix C.

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 Increased maintenance and monitoring	Option 3 Redevelop the zone substation	Option 4 Staged replacement of assets
Issue 1 66kV switchgear obsolete	○	○	●	◑
Issue 2 66kV switchgear condition	○	◑	●	◑
Issue 3 Transformer condition	○	○	●	●
Issue 4 Transformer CT requirements	○	○	●	●
Issue 5 22kV switchgear obsolete	○	○	●	◑
Issue 6 22kV switchgear condition	○	◑	●	◑
Issue 7 Switchgear lack of spares	○	○	●	◑
Issue 8 22kV switchgear not arc fault rated	○	○	●	◑
Issue 9 Legacy Pin and Cap insulators	○	○	●	◑
Issue 10 Feeder cables	○	○	●	◑
Issue 11 Legacy Secondary system	○	○	●	◑
Issue 12 DC system condition	○	○	●	◑

●	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, particularly the switchgear and transformer. For instance, all primary plant equipment in Table 2-6 has a CBRM health index average rating greater than 7.0 indicating that the equipment condition is bad, at end of life (<5 years) and has a high probability of failure now. 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: Increased maintenance and monitoring

This option involves closer monitoring of the switchgear and transformers, with a two-fold increase in the frequency of condition testing. Despite this, the ultimate failure of the CBs and transformers cannot be prevented if they remain in-service. The condition of the primary equipment will continue to deteriorate, impacting reliability and safety with anticipation of failure within 5 years as per the CBRM modelling results. [15] Similarly, increasing maintenance and monitoring of secondary systems will not prevent failure or avoid the risk of equipment mal-operation.[16] Additionally, increasing maintenance and monitoring will require taking equipment out of service, increasing supply reliability risks. Given this option does not resolve majority of the issues described in Table 3-1, this option is not recommended as it is more likely to resemble the ‘do nothing’ option.

3.3.3 Option 3: Redevelop the zone substation

This option involves decommissioning legacy items and deteriorated equipment. This will see most of the zone substation equipment replaced with new standardised equipment. This will enable the substation to operate in accordance with the strategies and philosophies described in JEN Asset Class and Business Strategy documentation. Redeveloping the zone substation also addresses all issues identified including safety, reliability and security of customer supply. Major assets to be installed include:

- Three new 66/22kV 20/33MVA transformers.
- New 66kV equipment: busbars, insulators, circuit breakers, voltage transformers, current transformers, motorised double break disconnectors, earth switches and surge arrestors.
- A new earth management system including arc suppression coil (ASC), ASC bypass CB, neutral earthing resistor (NER) and associated secondary systems.
- Two new 22kV/433V station service transformers (kiosk type).
- Three identical new modular switch room buildings, each housing one standardised indoor 22kV switchboard consisting of busbars, insulators, circuit breakers, voltage transformers, current transformers, disconnectors, earth switches and surge arrestors.
- Two new 22kV 12MVAr containerised capacitor banks. The 1st step is 4 MVAr with a step CB connecting to the 2nd step (4MVAr), and a third step CB connecting to the 3rd step (4MVAr). The Cap Banks will have floating neutrals with VAr control and neutral earth switch.
- Civil and structural works associated with new or decommissioned equipment including earth grid works.

15 Refer to Section 2 for CBRM modelling results.

16 Internal Costs and Benefits Analysis modelling suggests $2.05M AUD in additional incremental costs to increase maintenance and monitoring. Refer to Coburg North (CN) Redevelopment Costs and Benefits Analysis Model.xlsb for detailed calculations.

- One new modular control room building consisting of new modular secondary equipment required to complete protection, control, communications and auxiliary supply functions required for the zone substation.

In line with JEN initiatives to provide a safe working, cost effective and efficient asset management of network assets, this option proposes to adopt a modular concept approach for all equipment installed on site. JEN intends to adopt modular equipment for all new asset installations at greenfield and brownfield sites when a significant amount of works are required, or space allows for modular equipment be installed and cutover accordingly i.e. in situ replacements can be avoided.

The principle of the modular concept utilises a building block approach and enables a complex system to be broken up into smaller independent units called modules. In the case of zone substation asset, these key modules take the form of switchgear, buildings and secondary systems. Modular equipment is standardised and incorporates opportunities for improvement during the specification and design phase that reduce construction, commissioning and operating costs. Furthermore, modular equipment is widely available from manufacturers and provides additional benefits in asset flexibility/configurations, reliability, scalability and safety which are essential in ensuring JEN business and customer objectives are met.

Option 3 is the preferred option. This option resolves all identified issues while aligning with the JEN asset class and business strategies and the implementation of modular building concepts that aim to realise benefits in lower construction, commissioning and operational costs. The total cost of this option is $47.6M as outlined in Table 1-2 and has a positive NPV of $135.3M. [17] This preferred solution is proposed to commence in 2026.

3.3.4 Option 4: Staged replacement of assets

This option involves decommissioning legacy items and deteriorated equipment in a two-staged manner. This will see most of the zone substation equipment eventually replaced with new standardised equipment. This will ultimately enable the substation to operate in accordance with the strategies and philosophies described in JEN Asset Class and Business Strategy documentation. Only at completion of the second stage of replacement works will all issues associated with safety, reliability and security of customer supply be addressed. A staged replacement of major assets to be installed include:

<u>Stage 1: 2026 - 2030</u>

- Two new 66/22kV 20/33MVA transformers including new secondary equipment required for the operation of the transformers

- Civil and structural works associated with new or decommissioned equipment including earth grid works.

<u>Stage 2: 2031 - 2035</u>

- One new 66/22kV 20/33MVA transformers

- New 66kV equipment: busbars, insulators, circuit breakers, voltage transformers, current transformers, motorised double break disconnectors, earth switches and surge arrestors.

- A new earth management system including arc suppression coil (ASC), ASC bypass CB, neutral earthing resistor (NER) and associated secondary systems.

- Two new 22kV/433V station service transformers (kiosk type).

- Three identical new modular switch room buildings, each housing one standardised indoor 22kV switchboard consisting of busbars, insulators, circuit breakers, voltage transformers, current transformers, disconnectors, earth switches and surge arrestors.

17 Refer to Coburg North (CN) Redevelopment Costs and Benefits Analysis Model.xlsb for detailed calculations.

- Two new 22kV 12MVAr containerised capacitor banks. The 1st step is 4 MVAr with a step CB connecting to the 2nd step (4MVAr), and a third step CB connecting to the 3rd step (4MVAr). The Cap Banks will have floating neutrals with VAr control and neutral earth switch.

- One new modular control room building consisting of new secondary equipment required to complete protection, control, communications and auxiliary supply functions required for the zone substation. Secondary works to include relocation of stage 1 secondary works into the new modular control room building.

- Civil and structural works associated with new or decommissioned equipment including earth grid works.

The staged replacement approach prioritises the resolution of issues based on the condition and criticality of the assets. The transformers are considered a critical asset due to the high replacement costs, impacts on customer supply, long lead time for repair or replacement and occupational health, safety and environmental impacts that can occur from a defect or failure.

The CBRM health index indicates the No.1 and No.2 transformers are in bad condition and at a high risk of failure (within 5 years) therefore resolving the issues associated with these assets are proposed to be completed in the first stage of works. Whilst replacing the No.1 and No.2 transformers in the first stage of work fully addresses the transformer issues identified, most of the issues identified remain unresolved until the second and final stage of works are completed. This means a high volume of assets in a bad condition will remain in service between the two stages of asset replacement works. This results in the same level of energy (MWh) at risk until project completion however at a slightly lower probability of occurrence. For these reasons, most of the issues are partially addressed as shown in Table 3-1.

Option 4 will eventually address all issues upon completion of the second stage however is not the preferred option. The consequences described in Section 2.2 remain a risk too great for JEN to leave untreated. The staged asset replacement works does not align with JEN asset class and business strategies with the CBRM health index for most of the assets greater than 7 (indicative failure within 5 years).

The conclusion of this assessment is that replacing the primary plant and secondary assets using a staged approach will result in an estimated increase in total project cost of approximately 20%. This is due to the introduction of the following inefficiencies:

- the new secondary systems would need to be wired to the existing primary plant and then later re-wired to the new primary plant.

- testing and commissioning the new secondary systems and primary plant would need to be performed twice rather than once had all of the assets been replaced at the same time.

- two instances of site mobilisation / demobilisation rather than one which involves site construction facilities, inductions, project management establishment.

- two sets of review of the secondary design drawings and protection settings rather than one.

- twice as many planned outages to be planned, scheduled and switched out.

In addition, mobilising to a site on two occasions and completing the project as a staged approach introduces the following risks:

- Twice as many occurrences of planned outages during construction, testing and commissioning which increases the potential for health and safety incidents.

- Overall duration of the project is increased which increases the disruption duration for customers and to the local community. This would have an impact of increasing local traffic movements, increasing noise, and reducing pedestrian access.

- Potential for the unavailability of personnel and therefore intellectual property associated with the first stage of the project, ultimately leading to re-work and inefficiencies in the second stage.

- Potential changes in technology in the intervening 3-5 year period which would result in some re-work of Stage 1 to make the secondary system compatible with the primary plant.

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.[18] JEN undertook this assessment using its Cost and Benefits Analysis Model, 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)[19] (where the cost of risk = (network performance + capex + opex) x probability), 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 transformers, 22kV circuit breakers and 66kV circuit breaker. 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, $2024[20]

($M)	Option 1	Option 2	Option 3	Option 4
Total Expected costs	0	0	47.6	57.2
Total Expected market benefits	0	0	173.6	152.6
Net market benefits	0	0	132.2	105.9
Option ranking	4	3	1	2

4.1.1 Disposals

An assessment has been made on the equipment which will be replaced as part of this project. This equipment has no written-down value due to its age.

18 Refer to Coburg North (CN) Redevelopment Costs and Benefits Analysis Model.xlsb for detailed calculations

19 ibid

20 ibid

5. Recommendation

This business case proposes a total capital investment of $47.6M ($2024) .

It is recommended that Option 3 be adopted. The scope of works include replacement of all transformers, switchgear and secondary systems with new modern equivalents installed to current standards and philosophies.

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

It is recommended that the project commence in 2026 with completion in 2028.

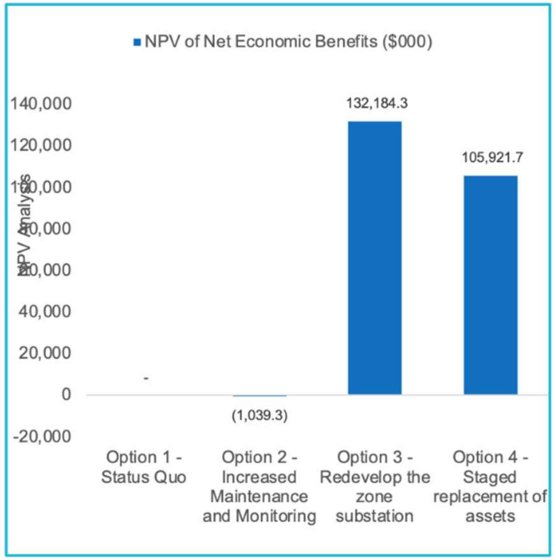
6. Exclusions

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 - Increased Maintenance and Monitoring**	**Option 3 - Redevelop the zone substation**	**Option 4 - Staged replacement of assets**
Recommended Option			✓	
NPV of Net Economic Benefits ($000)	**-**	**(1,039.3)**	**132,184.3**	**105,921.7**
NPV of Total Economic Benefits ($000)	-	-	173,642.8	152,585.2
Avoided cost at asset failure	-	-	*5,145.9*	*1,613.8*
Improved energy reliability	-	-	*168,496.9*	*150,971.4*
Reduced energy losses	-	-	-	-
Other Economic Benefits	-	-	-	-
NPV of Incremental Total Costs ($000)	-	1,039.3	41,458.5	46,663.5
Total Incremental Net Capex	-	-	*41,458.5*	*46,663.5*
Total Incremental Opex - One-off	-	-	-	-
Total Incremental Opex - Ongoing	-	*1,039.3*	-	-
Sensitivity on Economic Benefit NPV ($000)				
Economic Benefits turn out to be 10% lower	-	(1,039.3)	114,820.0	90,663.2



Appendix B
Network Risk Assessment Summary

B1. Network Risk Assessment Summary

Risk Register	BAA-RSA-800067_Coburg North (CN) Redevelopment		
Participants:	Alan Shu, Matthew Ch'ng, David Bonavia, Jon Bernardo	Workshop Date: 14/6/2024	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 contractor working near or with outdoor equipment in the switchyard. Many assets are near end of life with potential for explosive failures of bushings, insulators and tank raptures.	Resources – Assets, Cash, Equipment, Property	**Resources** - Outdoor Primary Plant due to condition and age (end of life).-	Employee	- Injury to employees or contractors working in the vicinity of outdoor equipment in the switchyard - Regulatory investigations	M Ciavarella	Major	Possible	High	Asset Management System (ACS) including Asset Class Strategy.	6-monthly	M Ciavarella	Effective	Effective	Major	Possible	High	6-monthly	Treat		Initiate project to replace the affected pin and cap insulators, transformer and switchgear	M Chng	01/01/26	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	BAA-RSA-800067_Coburg North (CN) Redevelopment		
Participants:	Alan Shu, Matthew Ch'ng, David Bonavia, Jon Bernardo	Workshop Date: 14/6/2024	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
2	Jemena Networks - Electricity	Sustainability	O-Business Continuty	Circuit Breaker Failure	Failure of the circuit breaker to operate as intended.	Resources – Assets, Cash, Equipment, Property	**Resources** - Circuit breaker due to condition and age (end of life)	Operational	- Unable to operate the breaker as intended - Autoreclose and manual close control of the breaker are compromised. - Loss of supply to a high profile HV customer and residential 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 possibility of a station black. - Negative reputational impact - Regulatory investigations	M Ciavarella	Severe	Likely	High	Primary Asset Class Strategy	6-monthly	M Chng	Effective	Effective	Severe	Likely	High	6-monthly	Treat		Initiate project to replace the affected circuit breakers	M Chng	01/01/26	On Track	Severe	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	BAA-RSA-800067_Coburg North (CN) Redevelopment		
Participants:	Alan Shu, Matthew Ch'ng, David Bonavia, Jon Bernardo	Workshop Date: 14/6/2024	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
3	Jemena Networks - Electricity	Sustainability	O-Business Continuity	Transformer failure	Failure of the transformer to operate as intended.	Resources – Assets, Cash, Equipment, Property	**Resources** - Defective Transformer due to condition and age (end of life)	Operational	- Unable to operate the transformers intended - Loss of supply to a high profile HV customer and residential 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 possibility of a station black. - Negative reputational impact - STIPIS financial penalties - Regulatory investigations	M Ciavarella	Severe	Likely	High	Primary Asset Class Strategy	6-monthly	M Chng	Effective	Effective	Severe	Possible	Significant	6-monthly	Treat		Initiate project to replace the affected transformers	M Chng	01/01/26	On Track	Severe	Rare	Moderate
														VESI Switchgear Manual	6-monthly	M Gardiner	Effective														
														The VESI Green Book	6-monthly	M Gardiner	Effective														
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														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	BAA-RSA-800067_Coburg North (CN) Redevelopment		
Participants:	Alan Shu, Matthew Ch'ng, David Bonavia, Jon Bernardo	Workshop Date: 14/6/2024	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
4	Jemena Networks - Electricity	Sustainability	O-Business Continuity	Feeder cable failure	Failure of legacy paper lead cables.	Resources – Assets, Cash, Equipment, Property	**Resources** - Defective cables due to condition and age (end of life)	Operational	- Loss of supply to a high profile HV customer and residential customers. - Negative reputational impact - STIPIS financial penalties - Regulatory investigations	M Ciavarella	Serious	Likely	Significant	Primary Asset Class Strategy	6-monthly	M Chng	Effective	Effective	Serious	Possible	Moderate	6-monthly	Treat		Initiate project to replace the affected paper lead cables	M Chng	01/01/26	On Track	Serious	Rare	Low
														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	BAA-RSA-800067_Coburg North (CN) Redevelopment		
Participants:	Alan Shu, Matthew Ch'ng, David Bonavia, Jon Bernardo	Workshop Date: 14/6/2024	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 Continuity	Secondary Systems failure	Failure of legacy Secondary Systems	Resources – Assets, Cash, Equipment, Property	**Resources** - Defective Protection, Control, DC systems, SCADA and Communications equipment due to legacy design, condition and age (end of life)	Operational	- Unable to operate the Secondary Systems intended - Loss of supply to a high profile HV customer and residential customers. - Negative reputational impact - STIPIS financial penalties - Regulatory investigations	M Ciavarella	Severe	Likely	High	Secondary Asset Class Strategy	6-monthly	D Bonavia	Effective	Effective	Severe	Possible	Significant	6-monthly	Treat		Initiate project to replace the affected Secondary Systems	D Bonavia	01/01/26	On Track	Serious	Rare	Low
														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														

Appendix C
Preliminary Options Assessment

C1. Option 5 - Non-network solution

This option involves non-network or standalone power systems (SAPS) that typically address existing or emerging network capacity limitations in our network. Should network capacity limitations be caused by the condition or serviceability of one or more zone substation asset, a non-network solution can be considered as an alternative to mitigate the consequential risks associated with the affected asset.

Non-network and SAPS solutions could be delivered through embedded generation, storage, or demand-side management programs (or combination thereof), to defer or reduce in scope, traditional network augmentation solutions or asset replacement. Such solutions need to have a sufficient number of proponents participating, to provide the aggregate level of dispatchable capacity needed. This could then mitigate the consequential risks of continuing to operate at risk assets.

The aim when defining potential credible non-network and SAPS options, is to test whether non-network or SAPS solutions (or combination of) is a viable way to avoid or reduce the scale of a network investment, in a way that efficiently addresses the identified need. The criteria we use to assess the potential credibility of non-network or SAPS solutions includes:

- **Addressing the identified need**: being able to reduce or eliminate the supply reliability risk (EUE) associated with the identified need.
- **Technically feasible**: there being no constraints or barriers that prevent an option from being delivered to address the identified need.
- **Economically feasible**: the economic viability is commensurate or potentially better than the preferred network option.
- **Timely**: can be delivered in a timescale that is consistent with the timing of the identified need.

Notwithstanding our approach to seeking efficient solutions to project augmentation, we have undertaken a high-level assessment of non-network options by considering the benefits of deferring expenditure by one year against a plausible alternative of procuring capacity from the market based on recent RIT-D responses. Applying this methodology to distributed storage solutions, we determined that the installed costs[21] of $73.4M is greater than the $47.6M installed costs of the preferred option. Therefore, a non-network option is not the preferred approach based on program-wide network benefits alone.

[21] Installed cost of $500/kWh x $132.2M present value reliability benefit ÷ $45.006/kWh VCR ÷ 20 years analysis period = $73.4M

Appendix D
Cost Breakdown

D1. Cost Breakdown

Cost Summary

CN ZSS Redevelopment Cost Breakdown

Item	Total Budget	
Direct Labour, Subcontract, Preliminaries and Plant		
66kV Lines	38,923	
High Voltage Lines	49,627	
High Voltage Underground Cables	904,316	
Stations Subtransmission Primary	1,120,988	
Stations Transformer Primary	1,674,022	
Stations HV Primary	1,076,118	
REFCL System	770,679	
Earth Grid	74,927	
General Earthworks	375,285	
Roadworks	189,210	
Drainage	126,500	
Trenches / Conduits	52,654	
Fire Protection Systems	36,977	
Lighting	71,359	
Security Fencing	98,065	
Buildings	4,182,622	
Protection & Control Systems	971,458	
SCADA System	309,872	
Metering Systems	81,414	
Auxiliary Supplies	153,422	
Communication Systems	87,037	
Civil Contractor On-Costs	698,239	
Operator Switching, etc	84,658	
Planning, Design, Construction	3,574,015	
Engineering, Project Management	2,644,900	
Design Subcontract	1,565,686	
Project and Site Preliminaries	922,588	
Total Direct Labour, Subcontract, Preliminaries and Plant	**21,935,562**	*46.1% of Total Costs*
Materials		
Materials	5,476,600	
Jemena FIM	7,792,700	
Total Materials	**13,269,300**	*27.9% of Total Costs*
Risk Allocation		
Total Risk Allocation	**5,092,204**	*10.7% of Total Costs*
Overheads		
Total Overheads	**7,335,614**	*15.4% of Total Costs*
Total Costs	**47,632,680**	