Jemena Electricity Networks (Vic) Ltd

2026-31 Electricity Distribution Price Review - Revised Regulatory Proposal

Supporting justification document

Undersized Neutral Replacement - Business Case

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Overview

This business case intends to provide self-supportive, rigorous documentation to substantiate the need and prudency of investments for both Jemena and its customers. The business case should assist in determining the strengths and weaknesses of a proposal, in comparison with its alternatives, systematically and objectively. The business case seeks endorsement and funding for the project from the appropriate Jemena stakeholders and approval from the relevant delegated financial authority.

1. Executive Summary

Synopsis

- There is approximately 633 km of known undersized neutral conductors installed across the mains and service distribution lines. Significant number of neutral conductor sizes are yet unknown.
- It was common practice to install neutral conductors smaller than phase conductors for a typical three phase balanced load. The neutral conductor was typically not expected to conduct high currents.
- With the changing characteristics of the electric grid, the neutral conductors now have higher currents flowing through them increasing risk of failure resulting in electric shocks, equipment damage and overall power quality degradation to the customers.
- To manage this risk, a few options were considered. The recommended option is to replace the undersized conductors in high-risk areas with LV ABC of suitable rating.
- The preferred solution is proposed for completion by end of 2031 with an estimated capital expenditure of $1.18 million.

1.1 Business need

The Undersized Neutral Replacement Project addresses a critical safety and reliability risk within the low voltage distribution network. Undersized neutral conductors, which are not adequately rated for their operating conditions, can lead to hazardous voltages, equipment damage, and compromised power quality. This project is driven by the need to mitigate these risks as well as improve network performance.

Issues associated with the undersized neutrals are listed below:

- Safety risks due to elevated touch voltages and stray currents.
- Customer equipment damage from voltage fluctuations and phase imbalance.
- Increased likelihood of electric shock during fault conditions.
- Poor power quality, including flicker, voltage instability, and harmonic distortion.

The following options addressing these issues have been considered:

- Option 1 – Do nothing.
- Option 2 – Perform targeted replacement of undersized neutral conductors in high-risk areas using appropriately rated LV ABC.
- Option 3 – Identify and replace all known undersized neutral conductors using appropriately rated LV ABC.
- Option 4 – Reconfigure the network to reduce current levels to impacted section of the reticulation.
- Option 5 – Rebalance the LV network.

1.2 Recommendation

It is recommended to proceed with Option 3 to perform targeted replacement of undersized neutral conductors in high-risk areas using appropriately rated LV ABC. This option offers a balanced and strategic approach to mitigating safety and reliability risks associated with undersized neutrals, while maintaining financial prudence.

By identifying critical locations, this option enables focused investment where the risk is highest, ensuring

efficient use of resources reducing the likelihood of electric shocks, equipment damage and power quality issues on vulnerable customers.

1.3 Regulatory considerations

The objective of the project is to improve customer safety, power quality and maintain customer supply reliability given their current asset condition. This strategy is consistent with other JEN strategies and plans such as the Electricity Distribution Class Asset Strategy and the project complies with associated regulatory requirements including the National Electricity Rules (NER) (clause 6.5.7) and, the Victorian Electricity Distribution Code (EDCoP).

JEN's investment decisions are guided by the National Electricity Objective (NEO). Additionally, JEN is required to meet the requirements of the NER, EDCoP, and public and industry expectations for distribution system performance, which require capital expenditure objectives to be achieved as discussed as outlined in Section **Error! Reference source not found.**.

1.4 Financial information

1.4.1 Forecast expenditure and budget summary

This project is required to be commissioned by the end of FY31. **Table 1–1** provides the project budget by calendar year.

Table 1–1: Project Budget by Year, $2024

Year	Budget ($'000)
2026-27	130.62
2027-28	261.25
2028-29	261.25
2029-30	261.25
2030-31	261.25
Total Budget	**1175.61**

The financial evaluation result is provided below.

Table 1-2: Financial Analysis Results Summary, $2024

Recommended option	($M)
Total Project Cost (capital):	1.18

2. Background

This document outlines the business case for the Undersized Neutral Replacement, including its alignment with the JEN Asset Class Strategies and broader network safety, power quality and reliability objectives.

An undersized neutral is any neutral not appropriately rated for the electrical conditions in which it operates. Such condition can be present across various asset types and pose significant risks to both customer safety and supply integrity. Issues arising from undersized neutrals include elevated touch voltages, stray currents, equipment damage, and increased likelihood of electric shock.

The proposed Undersized Neutral Replacement project consists of identification of high-risk areas and replacement of undersized neutral conductors with LV ABC of appropriate ratings. This approach ensures that efforts are focused where they are most needed, delivering safety, power quality and reliability benefits while maintaining cost efficiency.

The program supports JEN's strategic objectives by:

- Reducing condition-related failures and associated risks.
- Enhancing customer safety and power quality.
- Improving network resilience and operational performance by minimizing the network outages from neutral failures.

2.1 Business and socio-economic context

Some older electrical LV street circuits were constructed with smaller neutral conductors than phase currents, based on the theory that phase currents would cancel in the neutral so there was no need for full size neutral. Now the network has exported energy and non-sinusoidal loads that conflict with the original theory resulting in the neutral conductors being undersized for the currents flowing through them. This might lead to voltage rises, electric shocks and equipment failures that give rise to safety concerns as well as financial risks for the customer.

2.2 Asset risk (or opportunity) analysis

2.2.1 Short description of the affected Jemena assets

It was common practice to install neutral conductors smaller than phase conductors for a typical three phase balanced load. The neutral conductor was typically not expected to conduct high currents. However, with the evolution of electronically switched power supplies and exported energy with distributed solar, neutral currents have appreciably increased resulting in some overloaded neutrals. Undersized neutrals can cause poor supply quality, unsafe stray neutral/earth currents, and ultimately significant electrical and safety events upon failure.

Among the total installed service LV conductors, a portion of neutral conductors are undersized while a significant portion of neutral conductor size is unknown. A summary of the undersized neutral conductor quantity is given in Table 2-1

Table 2-1 Summary of undersized neutral conductor quantity

Neutral conductor size compared to phase conductor	Mains line length (km)	Service line length (km)
Unknown Size	893.50	1523.40
Undersized	630.02	3.27
Full Sized	972.52	1560.32

2.2.2 Risk assessment

An overloaded or high impedance neutral conductor poses serious risks to both safety and supply integrity. Elevated neutral impedance can lead to hazardous touch voltages and stray currents, which may travel through unintended paths such as water pipes or fibre optic catenary wires, turning otherwise non-conductive infrastructure into potential shock hazards.

Under fault conditions, particularly involving high-voltage (HV) faults, the effectiveness of MEN, CMEN, or ZCMEN systems in dissipating fault current is compromised. This can result in significant voltage rise at customer installations, increasing the likelihood of electric shock and damage to sensitive equipment.

In the event of neutral failure, single-phase customers may be exposed to phase-to-phase voltages, causing extensive damage to household appliances. Additionally, voltage instability, flicker, and harmonic distortion become more prevalent, especially in areas with high concentrations of electronically switched devices.

From a network performance perspective, poor neutral integrity contributes to increased technical losses and reduces the effectiveness of protection systems, undermining overall reliability and resilience.

Recent incidents have demonstrated the severity of these risks. A failed neutral event on 01/11/2018 at Barrington-Parnell Fault led to sustained supply interruptions affecting 99 customers, with approximately 50% reporting damage to electrical appliances. Similarly, on 2/7/2018 an failed neutral at Harrick-Translink led to an outage affecting 8 customers. These incidents highlight the urgent need for mitigation activities.

2.3 Project objectives and assessment criteria

2.3.1 Project objective

In line with the National Electricity Objective (**NEO**), JEN's investment decisions aim to maximise the net present value to electricity consumers. The primary objective of the undersized neutral replacement project is to increase safety of the customer and reduce risk of damage to customer's equipment. This strategy aligns with other JEN strategies and plans such as the Electricity Distribution Asset Class Strategy, and the project complies with associated regulatory requirements.

2.3.2 Regulatory considerations

JEN's investment decisions are ultimately guided by the National Electricity Objective (**NEO**). Additionally, the capital expenditure objectives set out in the NER (clause 6.5.7) are particularly relevant:

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.

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 relevantly 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.

2.4 Consistency with Jemena strategy and plans

This section describes how this project is consistent with Jemena'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.

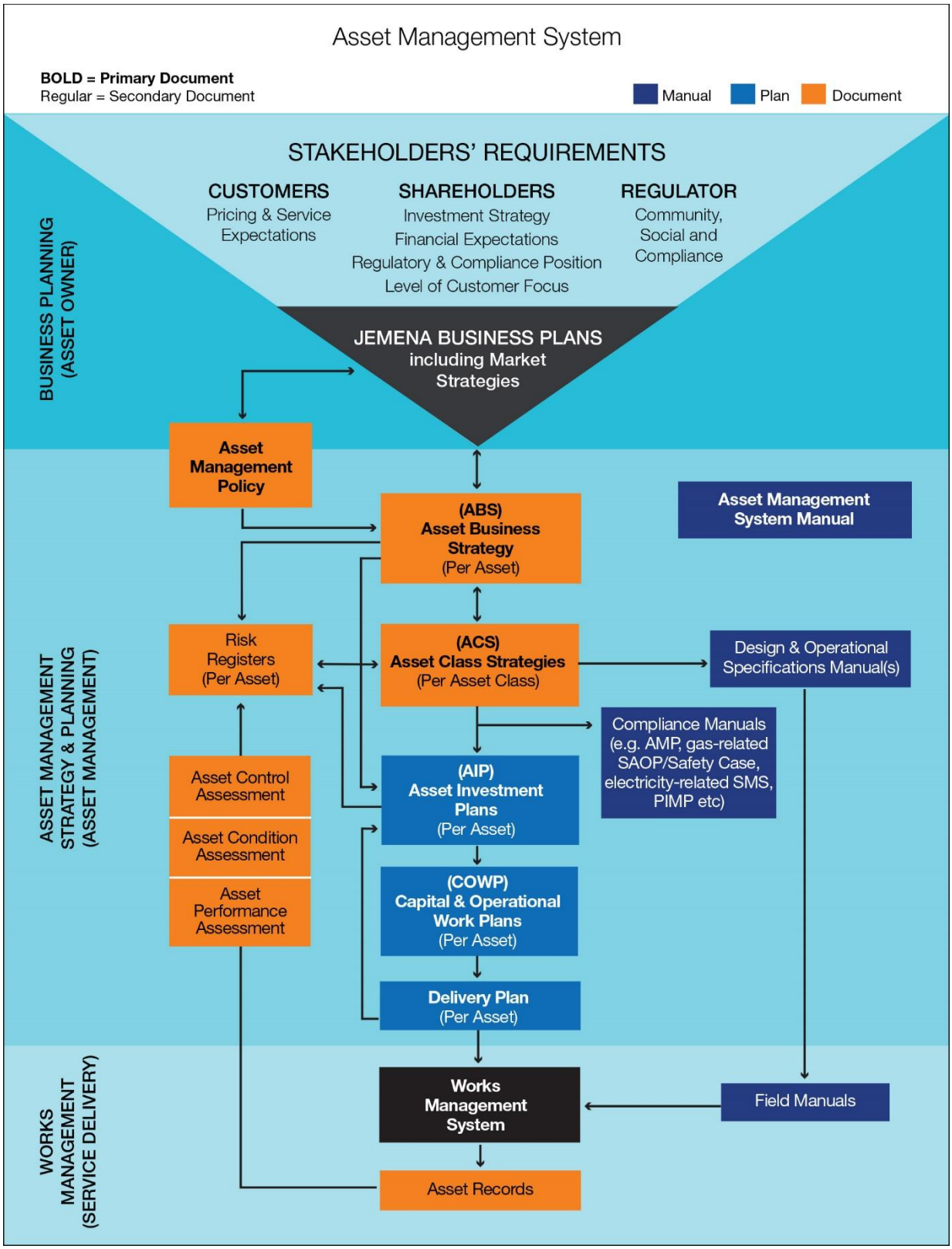
JEN seeks to ensure that lifecycle costs are both efficient and effective. This business case is consistent with this requirement and aligns with the long-term vision of the network, as set out in the Asset Management Plan (AMP) and annual planning reports.

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.

Figure 2–1 outlines the Jemena asset management system and where the Asset Management Plan (**AMP**) is positioned within it. The AMP covers the creation, maintenance and disposal of assets including investment planned to augment network capacity to meet increasing demand and to replace degraded assets to maintain reliability of supply to meet Jemena Business Plan requirements.

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

Figure 2–1: The Jemena Asset Management System



3. Credible Options

3.1 Identifying credible options

The following feasible options could be executed to address the business need, problem or opportunity.

1. Option 1 – Do nothing.
2. Option 2 – Perform targeted replacement of undersized neutral conductors in high-risk areas using appropriately rated LV ABC.
3. Option 3 –Identify and replace all known undersized neutral conductors using appropriately rated LV ABC.
4. Option 4 – Reconfigure the network to reduce current levels to impacted section of the reticulation.
5. Option 5 – Rebalance the LV network.

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 Perform targeted replacement of undersized neutral conductors in high-risk areas using appropriately rated LV ABC.	Option 3 Identify and replace all known undersized neutral conductors using appropriately rated LV ABC.	Option 4 Reconfigure the network to reduce current levels to impacted section of the reticulation	6. Option 5 7. Rebalance the LV network
Issue 1 Minimize Safety Risk	○	◑	◑	◑	◑
Issue 2 Cost Effectiveness	●	●	○	○	○
Issue 4 Minimize Impact on Network Performance	○	◑	◑	◑	●

●	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 involves maintaining the current state of the network without any intervention. However, this approach fails to address the existing safety, power quality and reliability concerns. Risks to customers such as potential electric shocks, equipment damage due to voltage fluctuations, and reputational harm remain unresolved. Additionally, there is costs associated with these risks. Given that this option does not mitigate the identified issues, it has been excluded from further consideration.

3.3.2 Option 2: Perform targeted replacement of undersized neutral conductors in high-risk areas using appropriately rated LV ABC.

This option involves identifying areas where impact of undersized neutral is high and upgrading existing conductors in those locations to appropriately rated LV ABC. By focusing on customers most affected by undersized neutrals, this approach improves safety, power quality and reliability while ensuring cost-efficiency. It provides an economic and scalable solution that addresses the issue where it matters most. This option is considered both practical and financially prudent and is therefore recommended. The cost of this option is approximately $1.18M.

3.3.3 Option 3: Identify and replace all known undersized neutral conductors using appropriately rated LV ABC.

This option proposes replacing all known undersized neutral conductors with appropriately rated LV ABC. While this would fully resolve the issue in identified areas and could be extended across the network, the scale and associated costs are substantial. The currently known length of undersized cables is approximately 633 km. So, the upfront investment required (approximately $99.23M) makes this option financially challenging and less efficient compared to a targeted approach. As a result, it is not recommended.

3.3.4 Option 4: Reconfigure the network to reduce current levels to impacted section of the reticulation

This option seeks to reduce current levels in impacted sections by reconfiguring the network rather than upgrading conductors. Although it addresses the issue at its source, the process is complex, time-consuming, and requires extensive planning and analysis. The implementation challenges and long lead times make this option impractical, and it has been excluded from further analysis.

3.3.5 Option 5: Rebalance the LV network

This “option seeks to rebalance the distribution network to improve load distribution and reduce stress on conductors. However, the scope of work involved is extensive, with high costs and significant complexity. The time and resources required to implement this option across the network are not justified given the available alternatives. Therefore, this option has been removed from further consideration.

4. Option Evaluation

4.1 Economic evaluation

The benefits of this project are primarily linked to mitigating the increasing risk of condition-related failure of neutral conductors. Such failures can lead to significant consequences, including damage to customer equipment, injury, and deterioration in power quality. These events carry both direct and indirect financial implications ranging from compensation claims and repair costs to reputational damage and regulatory penalties. By addressing these risks, the project aims to reduce the likelihood of costly incidents and improve overall network reliability, delivering long-term economic value.

4.2 Financial analysis

Cost comparison between the Option 3 and Option 4 of which refer to targeted replacement and overall replacement of undersized neutral conductors with suitably rated LV ABC respectively. The Table 4-1 below clearly shows significant cost differences between these options with Option 3 being recommended.

Table 4-1: Cost Comparison between Option 3 and Option 4 of the Initiative, $2024

Option	Estimated Cost M$	Estimated Replacement targets in km	Remarks
Option 2	1.18	7.5	Recommended
Option 3	99.23	633	

4.2.1 Disposals

An assessment has been made on the equipment which will be replaced as part of this project. This equipment shall be disposed of in accordance with JEM PO 1600 – Scrap Materials Policy.

5. Recommendation

This business case recommends option 2, which includes targeted replacement of undersized neutral conductors in high-risk areas using appropriately rated LV ABC fat a total capital investment of $1.18M. It covers approximately 7.5 km of undersized conductors.

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

It is recommended that the project commence in FY27 with completion in FY31.

6. Exclusions

There are no exclusions within this business case.