AUGMENTATION

FAULT LEVEL MITIGATION

PAL BUS 3.03 – PUBLIC

2026–31 REGULATORY PROPOSAL

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1. Overview

A fault is an event where an abnormally high current occurs caused by a short circuit somewhere in our network. A fault may involve a single or multiple phases and/or ground. In a ground/earth fault, charge flows into the earth, along a neutral or earth-return wire.

This business case focuses on addressing increasing fault levels in the Ballarat, Altona, Ford, Laverton and Koroit areas where fault level limit exceedance is forecast in sections of the network during the 2026–31 regulatory period.

Addressing fault level limit compliance breaches will reduce the chance of severe electric shocks when faults have occurred or lines have fallen to the ground, improving safety for our staff and the general public.

Augmentations at Ballarat North, Altona Chemicals, Ford North, Laverton and Koroit are proposed to meet fault level compliance limits.

The type of works proposed include installing neutral earthing resistors, auto close schemes, reactors and circuit breakers. The total capital investment costs for the business case are outlined in table 1.

TABLE 1 EXPENDITURE FORECASTS FOR PREFERRED OPTION ($M 2026)

CAPITAL EXPENDITURE FORECAST	FY27	FY28	FY29	FY30	FY31	TOTAL
Augment BAN by installing a new neutral earthing resistor	0.6	-	-	-	-	**0.6**
Augment AC by installing a normally open auto close scheme	0.3	-	-	-	-	**0.3**
Augment FNS by installing a normally open auto close scheme	-	-	-	-	0.3	**0.3**
Augment LVN by installing series reactor	1.3	-	-	-	-	**1.3**
Replace the KRT23 22kV feeder circuit breaker	-	-	-	-	0.5	**0.5**
Capital expenditure	**2.1**	**-**	**-**	**-**	**0.8**	**3.0**

2. Background

A fault is an event where an abnormally high current occurs caused by a short circuit somewhere in our network. A fault may involve a single or multiple phases and/or ground. In a ground/earth fault, charge flows into the earth, along a neutral or earth-return wire.

We calculate prospective fault current to ensure it is within allowable regulatory limits, limits of the electrical equipment installed and to enable the selection and setting of the protective devices that can detect a fault condition. Devices such as circuit breakers, automatic circuit reclosers, sectionalisers and fuses can act to interrupt the fault current to protect the electrical plant and avoid significant and sustained outages as a result of plant damage.

Fault levels are determined according to several factors including:

- generation of all sizes
- impedance of transmission and distribution network equipment
- load, including motors
- voltage level.

Fault level mitigation programs are becoming increasingly common on our network through increasing transmission fault levels and as the level of embedded generation being directly connected to the network increases.

3. Identified need

Under Clause 5.13.1 of the National Electricity Rules (NER), we have an obligation to identify and mitigate limitations on our network where design fault levels will be exceeded. Generally, where no other limitation exists, our design fault levels are consistent with the limits included in the Electricity Distribution Code of Practice (EDCoP) and shown in table 2.

Failure to mitigate fault level exceedance can result in catastrophic asset failures (either our asset or our customers' asset) and ‘step and touch' safety risks for site staff and the general public due to faults or fallen overhead lines and equipment.

'Step' potential occurs when there is a voltage difference between a person’s feet while standing or walking near a fault, potentially causing a dangerous current to flow through the body. 'Touch' potential arises when a person touches an energised object while standing on the ground, creating a voltage difference between the hand and feet, which can also result in a harmful current flow. Both scenarios can lead to severe electric shocks.

Neutral earthing resistors and neutral earthing reactors are plant added to the transformer neutral earthing system to restrict earth fault currents.

The need to address fault level issues is compliance driven.

TABLE 2 DISTRIBUTION SYSTEM FAULT LEVELS

VOLTAGE LEVEL (KV)	SYSTEM FAULT LEVEL (KA)
66	21.9
22	13.1
11	18.4
6.6	21.9
<1	50

We annually evaluate the three phase and phase to ground fault levels at each zone substation and compare them to the lowest of plant rating, any connection agreement and our design fault level.

Under our distribution system augmentation planning policy, when zone substation fault levels are predicted to exceed the limits detailed in table 2, mitigation strategies need to be employed.

A strategy that can be employed quickly and relatively cheaply is the implementation of a normally open auto close (NOAC) scheme. A NOAC scheme is the first option considered when assessing fault level mitigation strategies. If a NOAC scheme cannot mitigate the risk, augmentation options such as neutral earthing resistors, neutral earthing reactors, line reactors, and higher impedance transformers are then considered.[1]

The forecast fault level exceedance for each substation in the program of works is detailed in Table 3.

TABLE 3 FORECAST FAULT LEVEL EXCEEDANCE

ZONE SUBSTATION	IDENTIFIED NEED	YEAR OF EXCEEDANCE
BAN	Fault level on the BAN 22kV bus has reached the limit of 13.1 kA and impacting connection of new embedded generation.	2028
AC	Fault level on the AC 11kV bus is forecast to reach the limit of 18.4 kA.	2028
FNS	Fault level on the FNS 22kV bus will reach the limit of 13.1 kA.	2032
LVN	Fault level on the LVN 22kV bus has reached the limit of 13.1 kA.	2028
KRT-KRT23	The existing KRT23 circuit breaker has a rupture rating of only 6.6 kA. The 3-phase fault level is reaching 5.1 kA and 1-phase-to-ground fault level is reaching 5.9 kA. Forecast Fault Level exceedance of the circuit breaker is impeding connection of additional generation in the area.	2032

As a compliance requirement, the selection of fault level mitigation options is determined on a least-cost, technically feasible basis.

1 Neutral earthing resistors and neutral earthing reactors are plant added to the transformer neutral earthing system to restrict earth fault currents.

4. Ballarat North

The identified need is to mitigate limitations on our network where design fault levels will be exceeded. Fault levels on the Ballarat North (BAN) 22kV bus are forecast to reach the limit of 13.1 kA in 2028, impacting the connection of new embedded generation.

4.1 Assessment of credible options

Several options were considered to meet the identified compliance need, and a summary of the costs calculated for feasible options is provided in table 4.

TABLE 4 OPTIONS CONSIDERED AND COST SUMMARY ($M 2026)

DESCRIPTION OF WORKS	ASSESSMENT	PV COST
Option 1 (base case): no capital investment or change to existing practices.	The forecast fault levels on the BAN 22kV bus will exceed limits in the 2026–31 regulatory period. This option fails to address the identified need to meet our fault level compliance obligations.	-
Option 2: augment BAN by installing a new neutral earthing resistor.	This option addresses the fault level non-compliance issue of the BAN 22kV bus by installing new 22kV common neutral earthing resistor and integrating it with the existing REFCL system. This is the least-cost option for maintaining fault level compliance.	-0.6
Option 3: installing series reactors to limit the fault level	This option addresses the fault level non-compliance through the installation of series reactors increasing the impedance and reducing the fault level	-1.0

4.2 Preferred option

The preferred option to address the identified need is option 2, as this is the least-cost to comply.

The forecast expenditure for option 2 is shown in table 5.

TABLE 5 EXPENDITURE FORECASTS FOR PREFERRED OPTION ($M 2026)

EXPENDITURE FORECAST	FY27	FY28	FY29	FY30	FY31	TOTAL
Augment BAN by installing a new neutral earthing resistor	0.6	-	-	-	-	0.6

5. Altona chemicals

The identified need is to mitigate limitations on our network where design fault levels will be exceeded. Fault levels on the Altona Chemicals (AC) 11kV bus are forecast to reach the limit of 18.4 kA in 2028, impacting the connection of new embedded generation.

5.1 Assessment of credible options

Several options were considered to meet the identified compliance need, and a summary of the costs calculated for feasible options is provided in table 6.

TABLE 6 OPTIONS CONSIDERED AND COST SUMMARY ($M 2026)

DESCRIPTION OF WORKS	ASSESSMENT	PV COST
Option 1 (base case): no capital investment or change to existing practices.	The forecast fault levels on the AC 11kV bus will exceed limits in the 2026–31 regulatory period. This option fails to address the identified need to meet our fault level compliance obligations.	-
Option 2: augment AC by installing an NOAC scheme.	This option addresses the fault level non-compliance issue of the AC 11kV bus by: Installing a NOAC scheme on one of the two transformer 11kV circuit breakers. The second transformer will then be kept on 'hot standby', which can seamlessly transition into operation in case the other transformer fails, minimising disruption to power supply This is the least-cost option for maintaining fault level compliance.	-0.3
Option 3: Installing series reactors to limit the fault level	This option addresses the fault level non-compliance through the installation of series reactors increasing the impedance and reducing the fault level	-0.7

5.2 Preferred option

The preferred option to address the identified need is option 2, as this is the least-cost to comply.

The forecast expenditure for option 2 is shown in table 7.

TABLE 7 EXPENDITURE FORECASTS FOR PREFERRED OPTION ($M 2026)

EXPENDITURE FORECAST	FY27	FY28	FY29	FY30	FY31	TOTAL
Augment AC by installing a NOAC scheme	0.3	-	-	-	-	0.3

6. Ford North

The identified need is to mitigate limitations on our network where design fault levels will be exceeded. Fault levels on the Ford North (FNS) 22kV bus are forecast to reach the limit of 13.1 kA in 2032, impacting the connection of new embedded generation.

6.1 Assessment of credible options

Several options were considered to meet the identified compliance need, and a summary of the costs calculated for feasible options is provided in table 8.

TABLE 8 OPTIONS CONSIDERED AND COST SUMMARY ($M 2026)

DESCRIPTION OF WORKS	ASSESSMENT	PV COST
Option 1 (base case): no capital investment or change to existing practices.	The forecast fault levels on the FNS 22kV bus will exceed limits in the 2026–31 regulatory period. This option fails to address the identified need to meet our fault level compliance obligations.	-
Option 2: augment FNS by installing an NOAC scheme.	This option addresses the fault level non-compliance issue of the FNS 22kV bus by: Installing a NOAC scheme on one of the three transformer 22kV circuit breakers. The second transformer will then be kept on 'hot standby' in case the one of the other two transformers fail. This is the least-cost option for maintaining fault level compliance.	-0.3
Option 3: installing series reactors to limit the fault level	This option addresses the fault level non-compliance through the installation of series reactors increasing the impedance and reducing the fault level.	-1.1

6.2 Preferred option

The preferred option to address the identified need is option 2, as this is the least-cost to comply. The forecast expenditure for option 2 is shown in table 9.

TABLE 9 EXPENDITURE FORECASTS FOR PREFERRED OPTION ($M 2026)

EXPENDITURE FORECAST	FY27	FY28	FY29	FY30	FY31	TOTAL
Augment FNS by installing a NOAC scheme	-	-	-	-	0.3	0.3

7. Laverton

The identified need is to mitigate limitations on our network where design fault levels will be exceeded. Fault levels on the Laverton (LVN) 22kV bus are forecast to reach the limit of 13.1 kA in 2028, impacting the connection of new embedded generation.

7.1 Assessment of credible options

Several options were considered to meet the identified compliance need, and a summary of the costs calculated for feasible options is provided in table 10.

TABLE 10 OPTIONS CONSIDERED AND COST SUMMARY ($M 2026)

DESCRIPTION OF WORKS	ASSESSMENT	PV COST
Option 1 (base case): no capital investment or change to existing practices.	The forecast fault levels on the LVN 22kV bus will exceed limits in the 2026–31 regulatory period. This option fails to address the identified need to meet our fault level compliance obligations.	-
Option 2: augment LVN by installing series reactor.	This option addresses the fault level non-compliance issue of the LVN 22kV bus by: Installing either 22kV or 66kV reactors at LVN substation, depending on space availability. This is the least-cost option for maintaining fault level compliance.	-1.3
Option 3: primary equipment replacement	This option requires the replacement of all primary plant and equipment at LVN that is not adequately rated.	-15.0

7.2 Preferred option

The preferred option to address the identified need is option 2, as this is the least-cost to comply.

The forecast expenditure for option 2 is shown in Table 11.

TABLE 11 EXPENDITURE FORECASTS FOR PREFERRED OPTION ($M 2026)

EXPENDITURE FORECAST	FY27	FY28	FY29	FY30	FY31	TOTAL
Augment LVN by installing series reactor	1.3	-	-	-	-	1.3

8. Koroit

The identified need is to mitigate limitations on our network where design fault levels will be exceeded. Fault levels on the Koroit (KRT) circuit breaker are forecast to reach their 6.6kA limit in 2032, impacting the connection of new embedded generation.

8.1 Assessment of credible options

Several options were considered to meet the identified compliance need, and a summary of the costs calculated for feasible options is provided in table 12.

TABLE 12 OPTIONS CONSIDERED AND COST SUMMARY ($M 2026)

DESCRIPTION OF WORKS	ASSESSMENT	PV COST
Option 1 (base case): no capital investment or change to existing practices.	The forecast fault levels on the KRT 22kV bus will exceed limits in the 2026–31 regulatory period. This option fails to address the identified need to meet our fault level compliance obligations.	-
Option 2: replace the KRT23 22kV feeder circuit breaker.	This option addresses the fault level non-compliance issue of the KRT 22kV bus by: Replacing the KRT23 22kV feeder circuit breaker with a circuit breaker rated for a minimum rupture capacity of 13.1 kA. This is the least-cost option for maintaining fault level compliance.	-0.5
Option 3: installation of series reactors	This option addresses the fault level non-compliance through the installation of series reactors increasing the impedance and reducing the fault level.	-1.1

8.2 Preferred option

The preferred option to address the identified need is option 2, as this is the least-cost to comply.

The forecast expenditure for option 2 is shown in table 13.

TABLE 13 EXPENDITURE FORECASTS FOR PREFERRED OPTION ($M 2026)

EXPENDITURE FORECAST	FY27	FY28	FY29	FY30	FY31	TOTAL
Replace the KRT23 22kV feeder circuit breaker	-	-	-	-	0.5	0.5

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