united energy

ASSET CLASS OVERVIEW

ZONE SUBSTATION SWITCHGEAR

UE BUS 4.09 – PUBLIC

2026–31 REGULATORY PROPOSAL

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1. Overview

The management of our zone substation switchgear is critical to our ability to maintain network reliability and minimise safety risk as far as practicable.

We manage these assets on a least lifecycle cost basis, underpinned by the continuous refinement of our risk analysis and understanding of the asset condition and performance. We adjust our asset replacement and maintenance timing as inputs to our risk evaluation changes such as asset cost, reliability, failure consequence such as loss of supply.

Our zone substation switchgear forecast is based on detailed risk analysis. It enables the identification of the highest net benefit solution to manage the substation, based on the identified failure modes of our switchgear and the corresponding probabilities, likelihoods, and consequences of failures.

Our approach is consistent with the AER's asset replacement planning application note, and modelling accepted by the AER in previous regulatory decisions.

In total, our zone substation switchgear forecast represents a decrease in expenditure from the current 2021–26 regulatory period.

A summary of our forecast projects and corresponding capital expenditure is shown in table 1.

TABLE 1 ZONE SUBSTATION SWITCHGEAR EXPENDITURE ($M, 2026)

EXPENDITURE	FY27	FY28	FY29	FY30	FY31	TOTAL
EW switchboard replacement	3.8	1.9	-	-	-	**5.7**
Defective switches	1.1	1.1	1.1	1.1	1.1	**5.7**
Total	**4.9**	**3**	**1.1**	**1.1**	**1.1**	**11.4**

Note: Expenditure reported in this category in our Reset RIN is lower than this amount, as major plant replacement works (such as switchboard replacements) are allocated across multiple RIN categories to reflect the nature of the work undertaken.

2. Background

Zone substation circuit breakers are mechanical switching devices designed to protect electrical circuits and associated components from damage caused by an overload or a fault, whilst ensuring continued service to unaffected circuits. Zone substation circuit breakers can be standalone, mounted in a gas insulated switchgear pressure vessel or in an indoor switchboard.

Circuit breaker operation is generally initiated by a signal from the protection and control system and can be operated remotely. When a circuit breaker operates, it disconnects a circuit and causes an arc to form, which is quenched by the circuit breaker insulating medium. Circuit breaker insulating medium can be mineral oil, air, sulphur hexafluoride (SF6) or vacuum.

This section provides an overview of our zone substation switchgear asset class, including a high-level summary of our compliance obligations, asset population and age profile.

2.1 Compliance obligations

We operate under a combination of national and state legislation which establish our obligations and the regulatory framework under which we operate.

The National Electricity Rules sets out reliability and safety obligations and the Electricity Distribution Code of Practice include performance requirements. We must also manage our network assets in accordance with the Electricity Safety Act 1998, the Electricity Safety (Management) Regulations 2019, the Electricity Safety (Bushfire Mitigation) Regulations 2023 and the Victorian Environment Protection Act 2017.

These obligations can be summarised as follows:

- Electricity Safety Act 1998 – requires us to minimise safety risk 'as far as practicable' including bushfire danger
- Electricity Distribution Code of Practice – requires us to manage our assets in accordance with principles of good asset management and to minimise the risks associated with the failure or reduced performance of assets
- National Electricity Rules – requires us to forecast expenditure to maintain the quality, reliability and security of supply of our networks and maintain the safety of the distribution system
- Victorian Environment Protection Act (2017) – requires us to reduce the risk of harm from our activities to human health and the environment and from pollution or waste.

In short, we must maintain reliability, minimise safety risk 'as far as practicable' including bushfire danger arising from our network, and reduce the risk of harm to the environment.

2.2 Asset population

Our zone substation switchgear asset class comprises circuit breakers at multiple voltages and insulating mediums. As shown in table 2, most of our circuit breakers are 11kV and 22kV vacuum circuit breakers.

The majority of our 6.6kV, 11kV and 22kV circuit breakers are indoor switchboard types. Our 66kV circuit breakers are predominately outdoor circuit breakers.

TABLE 2 ZONE SUBSTATION CIRCUIT BREAKER POPULATION

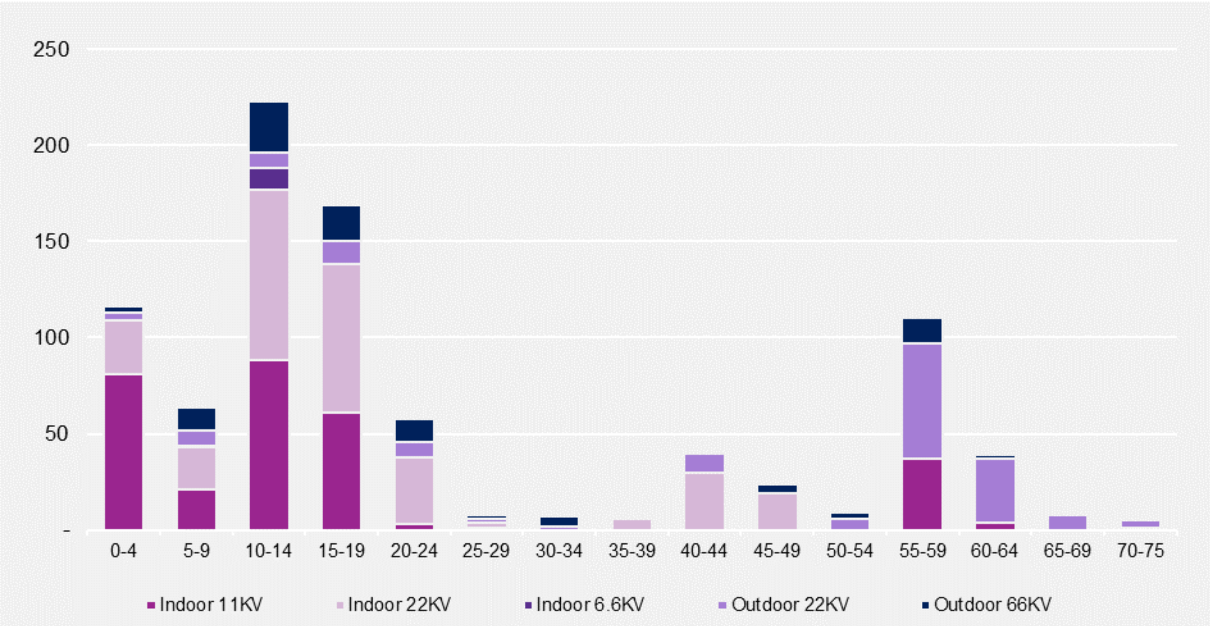
VOLTAGE TYPE	OIL	SF6	VACUUM	AIR (OUTDOOR)	TOTAL
6.6kV	0	0	12	0	**12**
11kV	44	0	253	0	**297**
22kV	129	56	276	13	**474**
66kV	25	79	1	0	**105**
Total	**198**	**135**	**542**	**13**	**888**

2.3 Asset age profile

Our zone substation circuit breakers have an average life of 60 years. Average life is the average life span of a circuit breaker, after which the asset is likely to be less reliable and require replacement. However, some circuit breakers require replacement before the average life due to type issues, environmental issues or deteriorated condition.

Figure 1 shows the age profile of our zone substation circuit breakers, with 52 of our critical breakers having exceeded this age today. Without intervention, this will likely increase to circa 171 by the end of the 2026–31 regulatory period.

FIGURE 1 NUMBER OF ZONE SUBSTATION CIRCUIT BREAKERS BY AGE (YEARS)



3. Identified need

The performance of our zone substation switchgear may impact our network service level, as failure may lead to a loss of supply for customers, pose safety risks to our personnel and the public and potentially catch on fire. This may also result in significant unplanned expenditure to restore supply to our customers.

The identified need, therefore, is to manage our zone substation switchgear asset class to maintain reliability and minimise safety risks as far as practicable, consistent with our regulatory and legislative obligations.

This section outlines the historical performance of our zone substation switchgear, which has informed how we assess (and respond, as required to) to this identified need.

3.1 Historical asset performance

We monitor the following two key indicators to inform our approach to meet the identified need:

- failures, which are functional failures that occur while the asset is in service
- high priority defects, which indicate deteriorating condition and are leading indicators of future failures.

As we have replaced our circuit breakers over the last few regulatory periods, our defects are low.

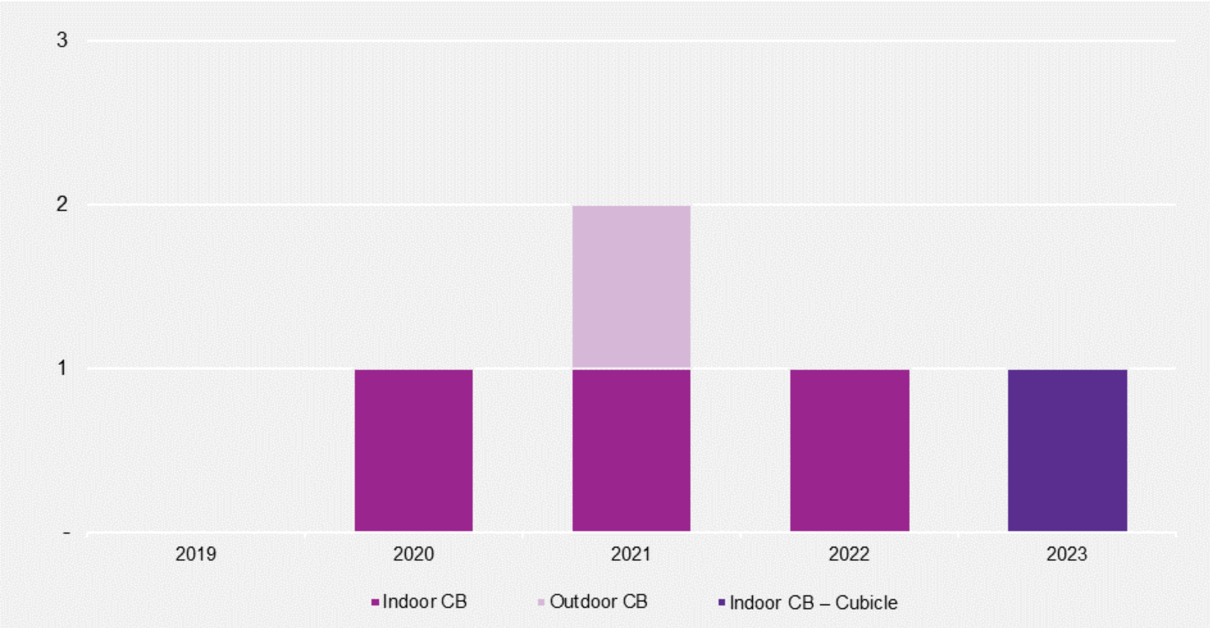
We use our historical asset performance, substation particulars and consequence information to inform and refine our risk evaluation for this asset class.

3.1.1 Historical asset failures

Zone substation switchgear are traditionally very reliable as evidenced by the low annual number of failures. However, we have experienced circuit breaker failures annually since 2020 as shown below in figure 2.

The potential consequences associated with zone substation circuit breaker failures can range from minor to catastrophic depending on zone substation and network configurations.

FIGURE 2 ZONE SUBSTATION CIRCUIT BREAKER FAILURES



4. Forecast interventions

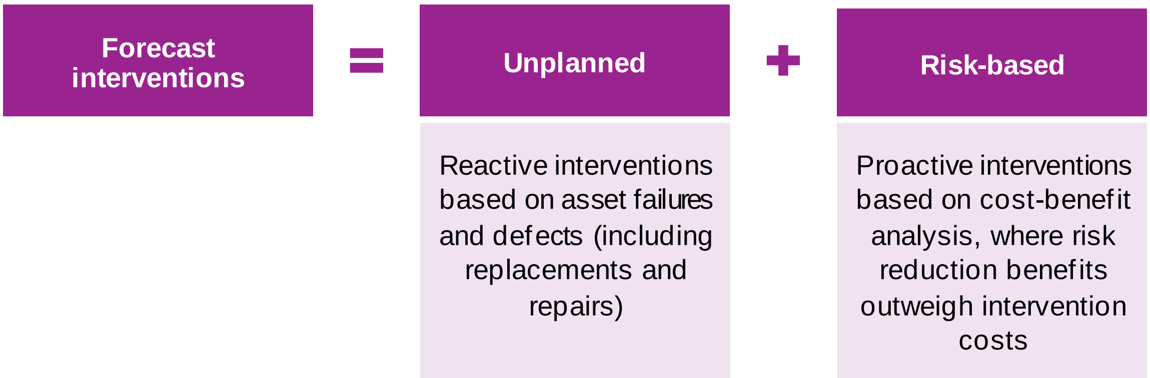
Our current asset management approach for our zone substation switchgear includes multiple options to meet our required service levels, consistent with our compliance obligations. Specifically, these options include the following:

- ongoing planned, preventative maintenance
- targeted replacement of specific components where technically feasible
- defer replacement of circuit breakers through online monitoring systems or other mitigation controls, including asset refurbishment
- asset replacement based on condition and risk assessments, including the impact of common-cause failures.

We constantly revise our plans based on the latest information regarding cost, reliability and risk of these assets to ensure that we are meeting our obligations. As these inputs and understandings change, our forecast will fluctuate accordingly. Our forecast is based on the two categories, as shown in figure 3.

- unplanned interventions are responses to asset failures and defects, which include replacements and repairs. These repairs are considered capital expenditure as they extend the life of the asset
- risk-based interventions are determined by a cost benefit analysis, where risk reduction benefits outweigh the intervention costs.

FIGURE 3 FORECAST CATEGORIES



4.1 Unplanned interventions

We forecast our unplanned interventions based on historical average of the previous five years. These typically comprise minor station works of low materiality.

4.2 Risk-based interventions

Our risk-based interventions comprise our typical risk-based switchgear replacements. This section explains our assessment methodology, with site specific assessments set out in appendix A.

These forecasts are developed based on sophisticated risk modelling, consistent with the AER's asset replacement planning note and modelling that was accepted by the AER in previous regulatory decisions.[1] This modelling is attached with our regulatory proposal and supported by our asset risk quantification guide.[2]

4.2.1 Forecast methodology

Our risk evaluation method assesses risk at the zone substation level instead of the individual circuit breaker. Assessing risks at zone substation level recognises the unique characteristic of circuit breakers and their impact on the network and customers. It considers the following:

- probability of circuit breaker failure
- joint and conditional probability based on similarity of circuit breaker at the zone substation
- available redundancy and load transfer capability at the zone substation
- zone substation load forecast, including the energy facilitated by the network
- number of transformers offline in the event of a circuit breaker failure
- length of the outage caused by the circuit breaker failure
- increased station risk until circuit breaker is replaced or repaired.

Our risk assessment is underpinned by a risk monetisation approach summarised in figure 4. This approach ensures we invest only when the cost of replacing existing infrastructure exceeds the total value of the underlying risks.

FIGURE 4 RISK MONETISATION APPROACH

Probability of failure

Several factors contribute to the deterioration and subsequent failure of circuit breakers. In the first instance, we have used our historical asset failure data to determine the probability of failure. Where required, this data is supplemented by failure type ratios from relevant industry surveys (e.g. such as those published by Ofgem).

Consequence of failure

Our approach to monetising risk compares the total cost (including risk) of technically feasible options. The preferred option(s) is that which provides the maximum benefit compared to costs.

Figure 5 shows an overview of how we determine the total cost of each option. It identifies the most beneficial solution to manage the substation, based on the identified failure modes for an asset, and the corresponding probabilities, likelihoods and consequences of failures.

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1 See, for example, the AER's final decision for our United Energy network; AER, United Energy distribution determination 2021 to 2026, Attachment 5, April 2021. This modelling approach has since been incorporated to support the asset management of our zone substation program across our three networks, including CitiPower.

2 UE MOD 4.04 - Parallel risk model - Jan2025 - Public; and UE ATT 4.01 – Asset risk quantification guide – Jan2025 – Public.

FIGURE 5 CONSEQUENCE OF FAILURE

The determination of these consequences is summarised below:

- network performance risk (energy at risk) – we quantify circuit breaker failure risk based on the overall risk at the zone substation. That is, we use a joint and conditional probability model to calculate the energy at risk cost for the substation. This considers available redundancy, load transfer capability at the substation, response times for different investments and the cost of multiple interventions that affect overall system reliability, rather than focusing on the condition of a singular asset. This is particularly important in zone substations as they are redundant systems, and the consequence of failure can vary throughout the year. The value of energy at risk is based on the AER's determined value of customer reliability.

- safety risks to our staff are determined based on the likelihood of a person present when the failure occurs, and the likelihood of an injury or death as a result. Our safety risks also consider the outcome of our switchboard arch flash assessment and the subsequent short and medium term controls in response (e.g. in 2022, Energy Safe Victoria (ESV) updated the Code of Practice on electrical safety for work on or near high voltage electrical apparatus, to include specific requirements for the risk of arc flash to be managed as far as reasonably practicable. ESV and Worksafe published their expectations on carrying out an arc flash / fault study or assessment, to IEEE 1584 or similar, and conducting a risk assessment, considering workers interacting with switchgear). The value of safety risks are based on the value of a statistical life from the Australian Government and injury values informed by Safe Work Australia

- financial risks comprise unplanned replacement and unplanned repair impacts respectively. For the purpose of monetising the risk of circuit breaker failures, we categorise these failures as either significant or major (or both, with a likelihood ratio assigned based on experience). Significant failures are those that are repairable, whereas major failures require the replacement of the asset. The corresponding costs are based on observed history.

With respect to financial risks, we note that zone substation assets are subject to a high level of management oversight, which results in low failure rates. However, as condition monitoring technology and asset understanding improves over time the occurrence of clear wear-out characteristics do not always materialise. This is particularly pertinent to complex, maintainable systems like power transformers and circuit breakers (whereas simpler assets do more typically demonstrate a defined end-of-life). As a result, the focus of our risk analysis tends to be on the consequence associated with failure, not just the condition. In addition, where the likelihood of failure due to condition tends to drop as a result of management or prevention of failures due to management techniques, the proportion of other failure causes increases and becomes the higher risk that needs to be managed.

The above is particularly important for older, obsolete assets that do not align with modern equipment specifications and can include maintenance-related failures due to lack of parts or skillsets to maintain, as well as systemic underlying failures (referred to as common-cause failures). We have experienced issues that are common to multiple assets at the same time, including the following:

- concurrent 11kV current transformer faults in the switchboard at our MP zone substation

- concurrent offload voltage selector switch failures at our C zone substation (due to reaching end life)

- high duty feeder circuit breakers, such as regularly switched capacitor bank circuit breakers, experiencing metal fatigue cracking around the solenoid gland plates.

These occurrences demonstrate that this kind of risk is real and needs to be considered alongside other risk factors, such as condition, in a comprehensive risk analysis. These are all included in our analysis.

4.2.2 Options considered

Table 3 lists all the potential credible zone substation circuit breakers intervention options. The suitability of these options, however, depends on the zone substation.

TABLE 3 RISK-BASED INTERVENTION OPTIONS

OPTION	DESCRIPTION
Do-nothing different	No change to existing practices and no planned replacement
Online monitoring	Install online monitoring on the circuit breaker or switchboard
Revised maintenance program	This option updates our maintenance practice and timing on each circuit breaker or switchboard bus
Simultaneous replacement of circuit breakers or switchboard and relays	Replace the circuit breakers or entire switchboard and relays simultaneously
Separate replacement of circuit breakers or switchboard and relays	Replace the relays first (because new circuit breakers can only interface with modern digital relays), followed by the replacement of the circuit breakers or switchboard (noting this will entail some re-work on the relays)

We also considered the following intervention options, but these have been assessed as not credible and thus not subject to economic assessment:

- replacement of only one bus of an aged switchboard – this will not reduce the probability of failure on the remaining buses and associated circuit breakers, and raises physical and integration challenges with different switchgear technologies
- refurbishment of the switchboard – this is not technically practicable and in any event, would provide immaterial benefits
- non-network solutions – we are not aware of non-network solutions that will be able to replace the functionality of a zone substation circuit breaker. Our zone substation circuit breaker replacements are listed in our annual distribution asset planning report (DAPR) and to date, we have not received any non-network proposals for circuit breaker asset replacement.

4.2.3 Forecast risk-based interventions

Based on the risk monetisation approach summarised above, we assessed individual zone substations for potential interventions in the 2026–31 regulatory period. These sites were then reviewed against our broader station works portfolio to identify overlaps and synergies.

This further reviewed identified the following:

- synergies were identified with our protection relay replacements, whereby it is efficient to deliver both circuit breaker and relay replacements simultaneously. These synergies were identified for our zone substation switchboard, and as such, these relay replacements have been removed from our protection forecasts
- adjustments to project timing were made to align with other proposed works at the station to ensure efficient and practical sequencing of projects.

Our 2026–31 zone substation circuit breaker intervention assumes Shoreham zone substation will be built in the 2026–31 regulatory period, which will reduce the risk in and therefore replacement intervention required.

A summary of our proposed zone substation circuit breaker replacements is set out in table 4. Further site-specific assessments are provided in appendix A.

TABLE 4 ZONE SUBSTATION SWITCHGEAR: FORECAST EXPENDITURE ($M, 2026)

EXPENDITURE	FY27	FY28	FY29	FY30	FY31	TOTAL
EW switchboard replacement	3.8	1.9	-	-	-	**5.7**

Note: Corresponding circuit breaker volumes are reported in our Reset RIN on an as-commissioned basis (i.e. in the last year of expenditure).

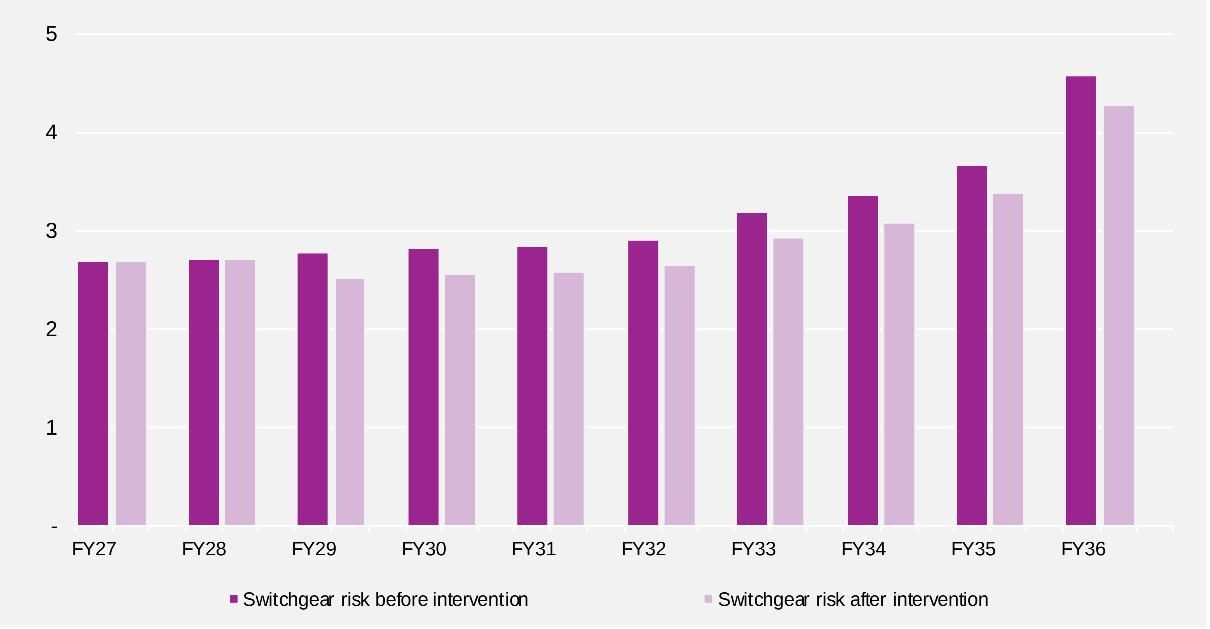
Top-down portfolio review

In addition to the review of overlaps and synergies identified above, we also assessed the change in zone substation circuit breaker risks, and that at the zone substation overall (i.e. the sum of circuit breaker, transformer and protection risks).

A central theme of our stakeholder engagement program was reliability, with customers consistently highlighting the importance of a maintaining a reliable energy supply. This view was explored in the context of our customers' increasing dependence on electricity given forecast electrification. Our replacement program and asset management practices are critical to ensure reliability outcomes for customers as well as maintaining trust throughout the energy transition for our customers to electrify.

As shown in figure 6, overall, our zone substation switchgear risks are expected to increase by FY31 without our proposed interventions.

FIGURE 6 ZONE SUBSTATION RISK: SWITCHGEAR ($M, 2026)



A EW transformer replacement

Elwood (EW) zone substation supplies the beachside suburb of Elwood, parts of St Kilda and Elsternwick. It has a two bus 11kV switchboard with 14 panels housing J18 oil-filled circuit breakers. These assets were commissioned in 1969 and are near their service life at 55 years old.

A.1.1 Identified need

Switchboards with J18 oil-filled circuit breakers have a history of failing catastrophically as evidenced by previous failures at WD and K zone substations prior to switchboard replacements. As the switchboard was not designed to contain arc, hot gasses will be expelled in the room in the event of an internal switchboard fault, which poses a safety risk to personnel. In addition, it is increasingly difficult to source components to refurbish the switchboard, which can result in extended outages.

The continued operation of the switchboard will increase the risk of disruption to customer supply and pose an increasing network reliability and safety risk. Hence, there is a need to arrest the growing network reliability risk and minimise safety risks as far as practicable at EW zone substation switchboard.

Further, the existing 11kV bus residual protection schemes need to be replaced with new high impedance protection schemes to provide optimal protection for the new switchboard. To minimize execution risk and reduce installation and interfacing costs, the least cost approach is to install new feeder and CB management relays within the switchboard LV compartment. This strategy will also ensure a smooth and efficient transition from the old switchboard to the new switchboard.

A.1.2 Options analysis

When we replaced the switchboard at K zone substation, we repurposed the online monitoring system at K zone substation to EW zone substation switchboard. As such, the base case considers the continued usage of online monitoring at EW zone substation switchboard.

Given the switchboard age, improved or increased maintenance was not considered a credible option.

The results of our analysis, relative to a do-nothing base case, are shown in table 5.

TABLE 5 OPTIONS EVALUATION RELATIVE TO BASE CASE ($M, 2026)

OPTION		PV COSTS	PV BENEFITS	NET BENEFITS
2	Simultaneous replacement of circuit breakers or switchboard and relays	3.4	3.7	0.3
3	Separate replacement of circuit breakers or switchboard and relays	3.4	2.6	-0.9

A.1.3 Preferred option

The preferred option is to simultaneously replace switchboard and relays (Option two) because it is economic under the central scenario.[3] Replacing the 11kV switchboard will reduce the failure risk of

[3] UE MOD 4.04 - Parallel risk model - Jan2025 - Public; and UE MOD 4.01 - EW transformer - Jan2025 – Public.

11kV switchboard and hence, reduce network reliability and safety risk. It will also reduce the high maintenance costs associated with maintaining aged equipment.

Sensitivity analysis was also used to test the robustness of the central scenario result to potential variations in costs and benefits. The preferred option remained economic under all scenarios.

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