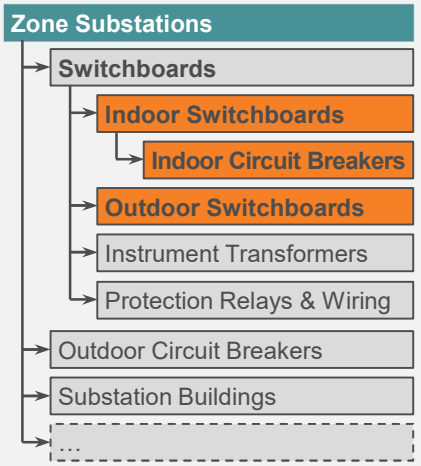
Switchboards Investment Case

Switchboards facilitate all switching and protection coordination functions required in the associated sub-transmission and high voltage distribution networks; and protect associated high voltage distribution assets by quickly clearing high current faults.

Scope

This investment case addresses switchboards located within zone substations, including circuit breakers that are integral to those switchboards.

The investment is required to meet the capital expenditure objectives (NER 6.5.7) for quality, reliability and security of electricity supply and to meet regulatory and legislative obligations for Standard Control Services.



Forecast $FY24

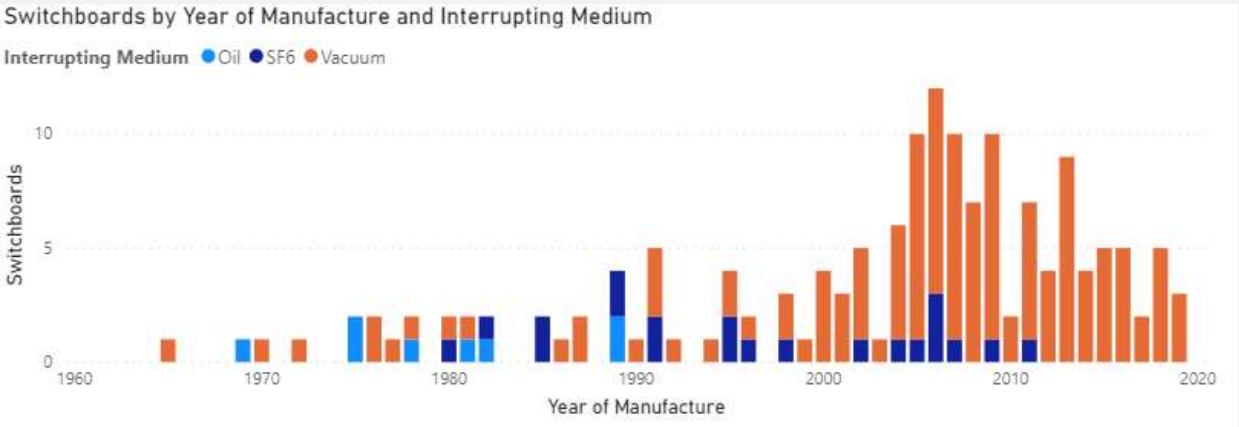
The Switchboard forecast accounts for 1.0% of the total Repex portfolio for FY25 to FY29.

FY25	FY26	FY27	FY28	FY29
$3.9M	$2.8M	$1.7M	$1.1M	$1.7M

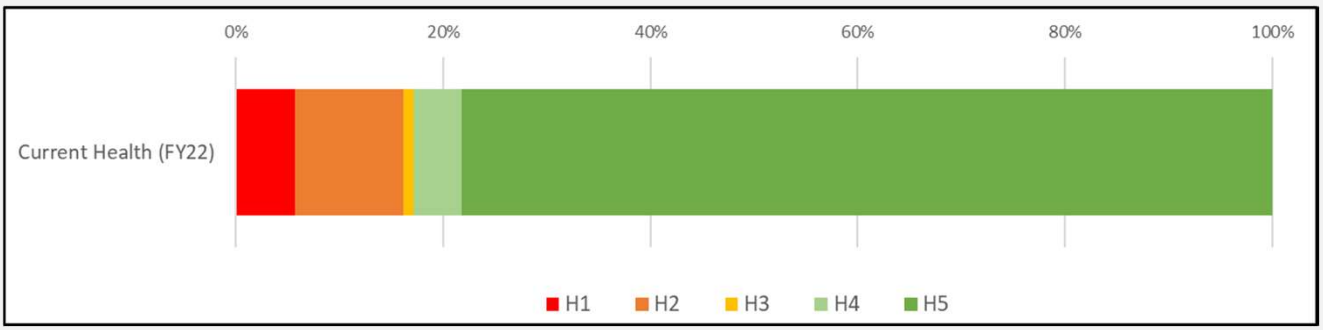
Asset Profile/Health

Asset Profile

Essential Energy currently has 158 zone substation switchboards in service, including 1,615 circuit breakers, with the oldest 51 years of age (Narrandera 11kV) and an average age across the entire population of 15.1 years. 82% of switchboards are 11kV, 8.4% are 22kV, and the remainder 33kV and 66kV.



Asset health is shown in the figure below.



AHI	Replacement Timeframe	Description
H1	0 to 3 years	Asset at or approaching end of life
H2	>3 to 7 years	High risk of failure, replace in short term
H3	>7 to 15 years	Elevated risk of failure, replace in medium term
H4	>15 to 25 years	Acceptable deterioration and condition
H5	>25 years	Low failure risk, asset in good condition

This risk section provides an overview of the Switchboard risk model. It is supported by documents and **6.03.02 Network Risk Management Manual, 6.03.03 Appraisal Value Framework and 6.03.04 System Capital Risk and Value Based Investment** methodology.

Probability of Failure (PoF)

Switchboard probability of failure is linked to the failure of circuit breakers that are an integral part of the switchboard. The switchboard PoF was modelled through summing the individual CB PoFs. An analysis of Essential Energy functional failure data was undertaken to determine a statistical fit to model CB failures. To ensure that an adequate number of failures were considered to reduce statistical uncertainty, this analysis encompassed all CBs (i.e. within switchboards and outdoor).
Weibull parameters used in the risk model are shown below:
Oil & Air: Beta = 4.14 and Alpha = 87

SF6 & vacuum: Beta = 4.14 and Alpha = 81

This Weibull was found to compare well against the Ofgem switchgear models, with the reduction in Alpha for SF6 and vacuum CBs analogous to the Ofgem reliability factor.

Consequence of Failure (CoF)

Consequence of failure models have been developed for catastrophic switchboard failure, due to each circuit breaker, evaluated using the 6.03.03 Appraisal Value Framework and ranked as shown opposite:

Consequence costs are dominated by Network costs.

Totals show the consequence cost should the entire switchboard fleet fail catastrophically and simultaneously.

Component	Consequence		
	Total ($ million)	Average ($ per SWB)	Median ($ per SWB)
Network	$294.9	$1,866,587	$1,1462,119
Financial	$13.0	$82,475	$76,800
Safety	$12.1	$76,838	$1,139
Bushfire	$0.4	$2,487	$327

Risk Model Calibration

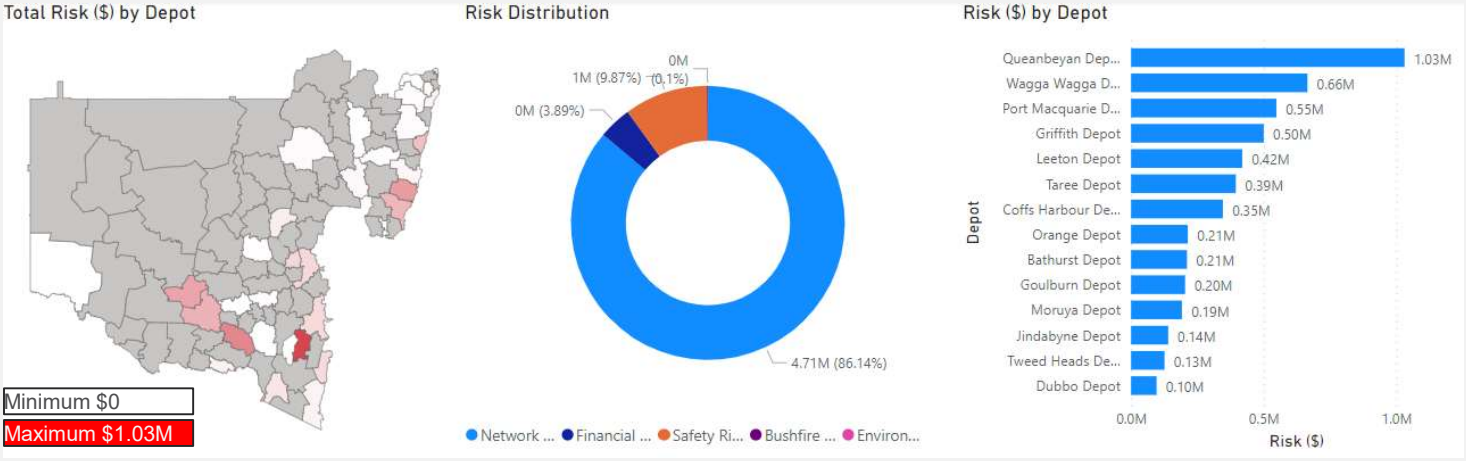
Asset risk is a function of the probability of failure and the consequence of failure.
The asset risk has been calibrated against top-down performance figures. The table to the right demonstrates the difference between the unscaled risk model output and the monetised top-down performance. Scaling factors are applied to the Model Outputs to equate the two methods.

Value Measure	Safety	Network	Bushfire	Financial	Total
Unscaled Model Outputs ($M)	0.54	4.71	0.01	0.21	5.47
Top-Down Performance ($M)	0.33	0.23	0.00	0.93	1.49

The modelling takes a bottom up probabilistic approach that has a number of estimates and assumptions to calculate across the population. This has been compared with a top down split of the actual recent events as valued by our Value Framework.

Risk Heatmap (Scaled)

The map below displays the network consequence for zone substation switchboards by nearest depot. The primary category of consequence for switchboards is the Network consequence, followed by Financial consequence.
The number of assets within a depot area, in conjunction with individual asset CoFs and PoFs, influence where the depot sits in the ranked list by depot.



Forecasting Approach

The replacement Capex forecast (FY25-FY29) has been calculated using Essential Energy's optimisation software (Copperleaf) which uses a risk based methodology to maximise the value of the investment portfolio within constraints established by Essential Energy that are consistent with our Corporate Risk Framework, Asset Management System, applicable standards, rules, regulations and licence conditions. To assure efficiency our portfolio has been constrained to meet customer and stakeholder expectations.

Objectives of the total replacement portfolio have been informed through extensive stakeholder engagement and consist of:

- Maintain reliability performance (network risk)
- Long term reduction of bushfire start risk by 20% over 20 years (2.5% FY25-29)
- Maintain safety performance

The replacement quantities of Switchboards consist of:

1. Optimised **risk-based replacements to maintain overall network risk values within defined objectives.**

The above asset intervention utilises a probabilistic approach that has been developed through detailed analysis of historical asset performance to establish Weibull parameters (refer 6.03.03.25)**.**

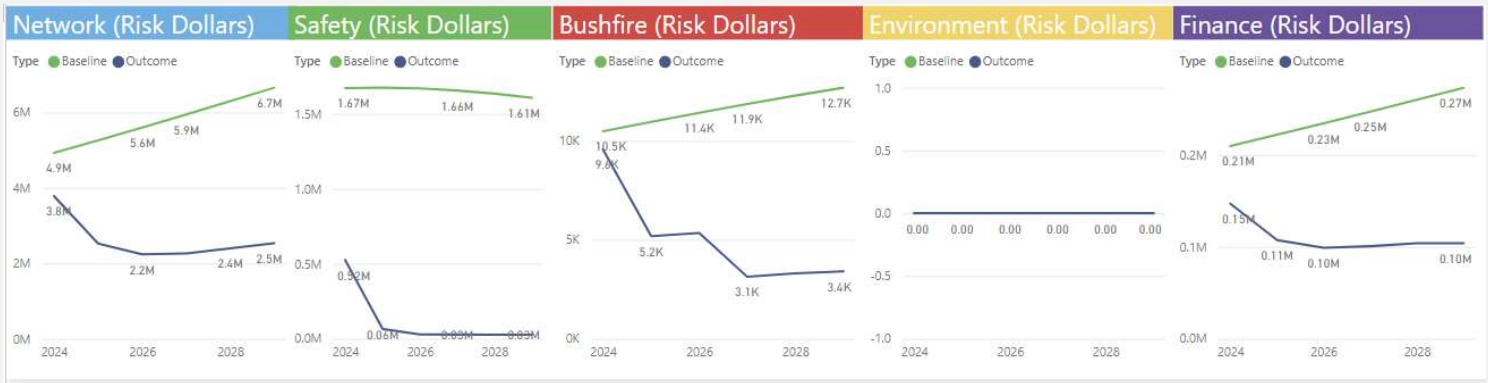
The probabilistic method has been tested and validated against historical volumes to ensure that it is accurate at the population level.

Forecast investment expenditure has been determined by multiplying the forecast replacement quantities of assets by SME defined unit rates.

Refer to **6.03.04 System Capital Risk and Value Based Investment** methodology for details on the **portfolio** wide optimisation planning approach and risk outcomes.

Optimised Portfolio Outcome

Risk Trend (2024-29 Optimised portfolio)
Over the 5 year regulatory window, total **baseline** monetised risk due to **functional** Switchboards failure is estimated to increase to $9.8M by 2030. The figure below depicts the **baseline** scenario and **investment** outcomes ($3.9M) of the optimised program for Switchboards.



Asset Grouping

The Switchboard assets have been grouped into one broad category for investment optimisation purposes:

1. **Risk-based** replacement - e.g. The risk attributed to an asset through its combination of probability of failure and consequence of failure is high and replacement is the prudent action to reduce this risk. Assets within this risk-based replacement group have been included in the optimisation process where they will have reached Equivalent Annualised Cost (EAC) positive by FY34.

- 51 asset groups were loaded into 51 investments in Copperleaf to provide flexibility in portfolio optimisation.

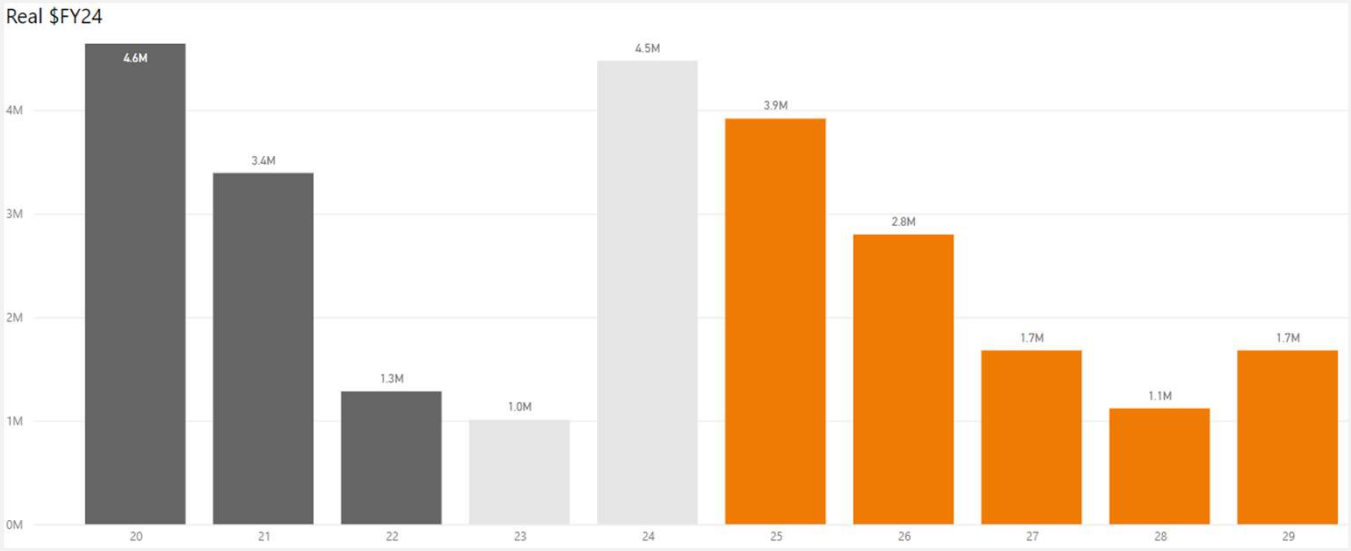
Options

1. Switchboard replacement expenditure has been modelled on a replace with current standard or like-for-like.
2. Risk based asset groupings are treated as additional optional investments for consideration in the total optimised portfolio to meet overall portfolio objectives.

- Non-network solutions are considered when planning the replacement of a specific asset.
- Value calculators determine the most prudent and efficient investment choice available at the time for a specific project. For example, options include: like-for-like replacement; replacement with different types or materials; or replacement of a feeder segment by a non-network solution.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for Switchboards across the 2024-29 period is $11.2M, averaging $2.2M per annum. Actual and projected expenditure for the remainder of the 2019-24 period is $14.8M. A slight reduction in expenditure is a result of the completion of a targeted replacement program for oil based switchboards in the current regulatory period (2019-24).



Data source: Actuals: Internal delivery reports, Forecasts: Copperleaf
Note: All values are in FY2023-24 real dollar terms

Justification

We are confident that our approach delivers an efficient and prudent level of investment as:

- **Clear drivers from Asset Management Objectives** for Reliability, Quality, Safety and Compliance (as detailed in **Attachment 10.01 Strategic Asset Management Plan**).
- **NER Capex Objectives:** form the basis of our proposal
- **Review and moderation:** Our forecasts have been tested and reviewed by our executive management and the Board, subject to top-down challenges (as detailed in **6.03.04 System Capital Risk and Value Based Investment**) and the forecasts moderated based on feedback and discussion.
- **Customer needs:** Through customer engagement, refer Chapter 4 of our Regulatory Proposal, customers indicated a desire to maintain current levels of safety and reliability, and increase expenditure for resilience based projects. This asset class does not explicitly have expenditure related to resilience and therefore has a flat forecast for replacements. The investment will contribute to maintaining safety and reliability, within the wider Repex portfolio (as per copperleaf forecast).

The major benefits from the proposed Switchboards investments (against the **change nothing** scenario) are:

- **Improved network risk and maintainability**: Investment in this asset class will reduce network risk through replacement of assets of degraded condition and/or in high risk locations with more resilient materials of acceptable condition; and
- **Improved service level outcomes:** management of asset health will result in fewer unplanned failures thus reducing unplanned outages and over time will improve network reliability.

Forecast Switchboard Repex expenditure for the 2024-29 period is $11.2M. The reduction from 2019-24 actual/forecast of $14.8M is due to Copperleaf optimisation selecting fewer investments than the total available to achieve the desired portfolio risk outcomes.

Assumptions

- The development of consequence of failure event trees aligned to the value framework have relied on SME estimates of probability of events, and accepted EE and industry parameters. Where data was unavailable, these were derived using SME informed assumptions.
- Asset data has been relied upon for the development of consequence of failure ($) for each switchboard, however, three switchboards do not exist (Moree, Narrabri & Cobar Peak) and as such these are not represented in the models.
- The lifecycle costs are dominated by the capital costs.
- Unit rates for this asset class are experiencing high volatility due to material supply costs. Volatility has been absorbed up to overall CPI rates, however pricing has well exceeded this value in the short term. Unit rates may require review prior to final submission as inflation and long term contracts are reviewed and finalised.

Strategic Direction

We shall

Acquisition

Selection Criteria
Continue to select air or SF6-insulated, vacuum interrupting switchboards (SWB) with AFLR arc-containment.
Supply as per period contract order for 11 and 22kV or detailed specification submitted with supply tender above 22kV.

Procurement
Continue the current period contract approach with vendors for 11 and 22kV switchboards.
Continue to order assets as required. Lead times vary by switchboard type and factory demand, however, lead times are typically in the range of 22 weeks.

Operations & Maintenance

General Site Inspections:
Continue as per *CEOP8011*.
- Visual inspection: 1/2/3 monthly based on site criticality and available SCADA monitoring.
- Annual thermographic survey
- Annual partial discharge testing.

Corrective Maintenance (Repairs):
Continue to replace or repair defective components.

Preventative Maintenance:
Continue as per *CEOP8011* :
- Circuit Breaker (CB) operational check scheduled 3 yearly
- Oil CBs also have operational checks following a calculated number of fault ops or no operations in a year.
- CB full maintenance scheduled 6 yearly for oil, 12 yearly for SF6/Vacuum.
- SWB full maintenance scheduled 12 yearly gas-insulated, 24 yearly air-insulated.

Breakdown Maintenance:
Continue to rectify failures with an economic viability assessment of repair or replacement, with larger investments undergoing a value calculation.

Interventions

Replacement programs
2019-2024: Replace remaining oil switchboards to address unacceptable safety risk.

2024-2029: Establishing a risk-valued replacement program to maintain acceptable risk level across the zone substation system as defined in this investment case.

Prioritisation
Continue to prioritise replacement projects with the value calculators and investment optimisation process.

Disposals

Individual Assets
Continue to dispose of SWB as per *CECP8074.01 Company Policy Asset Disposal*

Hazardous Materials
Continue to manage interactions with:
- SF6 as per *CECM1000.10d*
- Oil as per *CEOM2570*
- Asbestos as per *CECM1000.10a* and *CECM1000.10e*

Asset Support

Process & Information
Continue and improve EAM as central repository of asset information, preventative and corrective actions and test results.

Enhance asset risk-value assessments leveraging capabilities of new and existing software platforms.

People & Training
Continue to manage knowledge and skills regarding significant repairs.

Supply Chain
Continue to manage spares for unsupported CBs, resupplying via same model replacements.