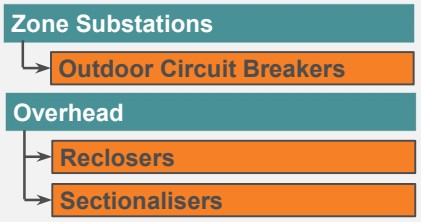
Circuit Breakers Investment Case

Outdoor circuit breakers and reclosers facilitate switching and protection coordination functions required in the associated subtransmission and high voltage distribution networks; and protect associated high voltage distribution assets by quickly clearing high current faults. Sectionalisers, used in conjunction with reclosers, isolate faulty network segments.

Scope

This investment case addresses outdoor circuit breakers located within zone substations, in addition to reclosers and sectionalisers irrespective of location.

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



Forecast $FY24

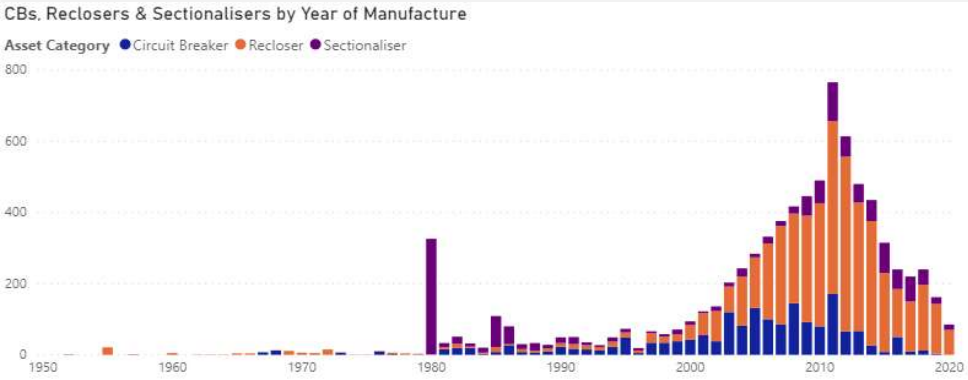
The Circuit Breaker forecast accounts for **1.92**% of the total Repex portfolio for FY25 to FY29.

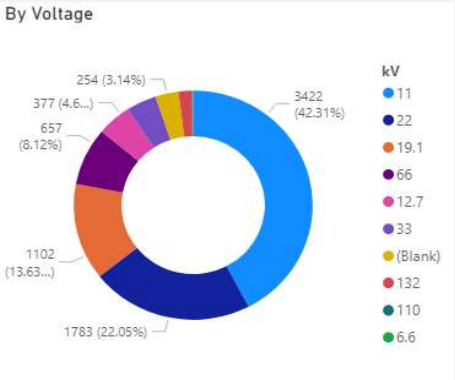
FY25	FY26	FY27	FY28	FY29
$2.9M	$5M	$4.5M	$4.1M	$5M

Asset Profile/Health

Asset Profile

Essential Energy currently has 1810 circuit breakers, 4806 reclosers and 1472 sectionalisers. These assets have an average age of 17, 11 and 21 years respectively.





Asset age has been used as a proxy for asset health for this asset class.

This section provides an overview of the Circuit Breakers 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)

The Outdoor Circuit Breaker PoF model was developed for catastrophic functional failure, using failure records and asset records with good data quality. Population PoF model (Weibull distribution) parameters were determined as:

Circuit Breakers: Beta = 4.38, Alpha = 74.9

Circuit Breakers with type faults were accorded a reduced alpha by 8 years to emulate the OFGEM reliability modifier. Reclosers were similarly modelled with an increased alpha by 10 years due to minimal recorded failures in the ZS setting.

Subsystem	Component	Failure Mode
Circuit Breaker	• Bushing • Control / Indication - Cubicle • Control / Indication • Housing • Insulation • Mechanism - Motor • Mechanism - Trip Coil • Mechanism • Primary Contacts • Support Structure	• {broken} • {contaminated} • {damaged} • {high resistance} • {leaking} • {loose} • {loss of dielectric strength} • {misaligned} • {replace}

Consequence of Failure

Consequence of failure models have been developed for catastrophic asset failure, evaluated using the *6.03.03 Appraisal Value Framework* and ranked as shown opposite.

Consequence costs are dominated by Network and Financial costs.

Totals show the consequence cost should the entire Circuit Breaker fleet fail catastrophically.

Component	Consequence		
	Total ($ million)	Average ($ per CB)	Median ($ per CB)
Network	$2,636	$1,456,613	$1,369,340
Financial	$243	$134,265	$115,000
Safety	$67	$36,741	$36,700
Bushfire	$4	$244	$470
Environment	$0.1	$50	$50

Risk Model Calibration

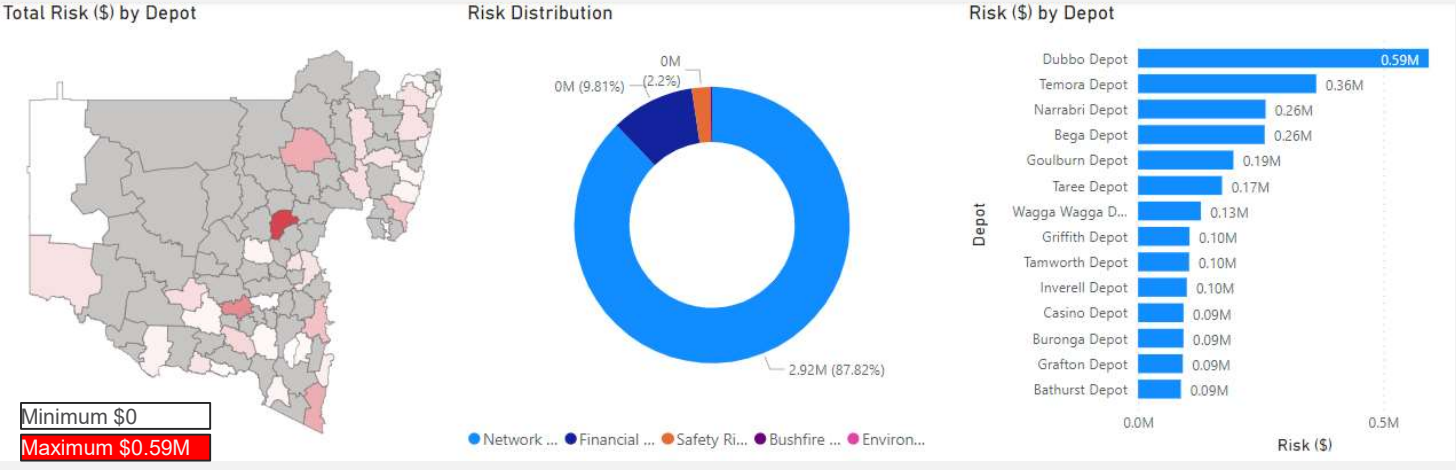
Asset risk is a function of the probability of failure and the consequence of failure.
The asset risk has been calibrated against top-down performance figures. The table to the right demonstrates the difference between the unscaled risk model output and the monetised top-down performance. Scaling factors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

Value Measure	Safety	Network	Bushfire	Financial	Total
Unscaled Model Outputs ($M)	0.07	2.92	0.01	0.33	3.32
Top-Down Performance ($M)	0.38	2.78	0.01	0.98	4.15

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 risk for Circuit Breakers by nearest depot. The primary category of risk for is the Network risk, followed by Financial risk.
The number of assets within a depot area, in conjunction with individual asset PoFs and CoFs, 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.

In line with NER capital objectives, 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 Circuit Breakers consist of:

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

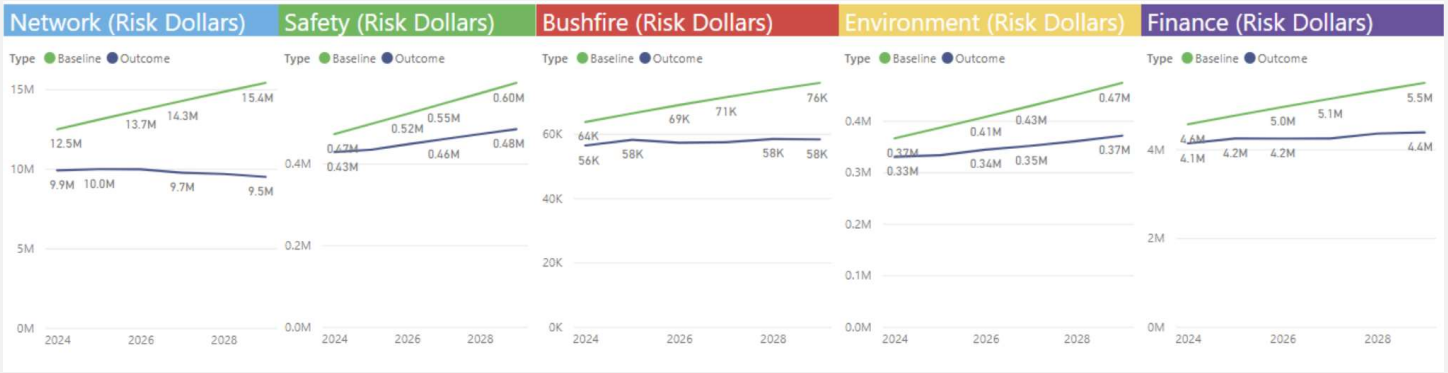
The above asset intervention utilises a probabilistic approach that has been developed through detailed analysis of historical asset performance to establish Weibull parameters (refer 6.03.03.16).

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

Forecast investment expenditure has been determined by multiplying the forecast replacement quantities of Circuit Breakers assets by applicable 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, and **10.01.04 Capital Unit Rates** for unit rates.

Optimised Portfolio Outcome

Risk Trend (2024-29 Optimised portfolio)
Over the 5 year regulatory window, total **baseline** monetised risk due to **functional** Circuit Breakers failure is estimated to increase to $22M by 2030. The figure below depicts the **baseline** scenario and investment **outcomes** ($14.8M) of the optimised program for Circuit Breakers.



Asset Grouping

Circuit Breaker assets have been grouped into three broad categories for investment optimisation purposes according to the different modes of replacement:

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.

- 726 asset groups were loaded into 175 investments in Copperleaf to provide flexibility in portfolio optimisation.

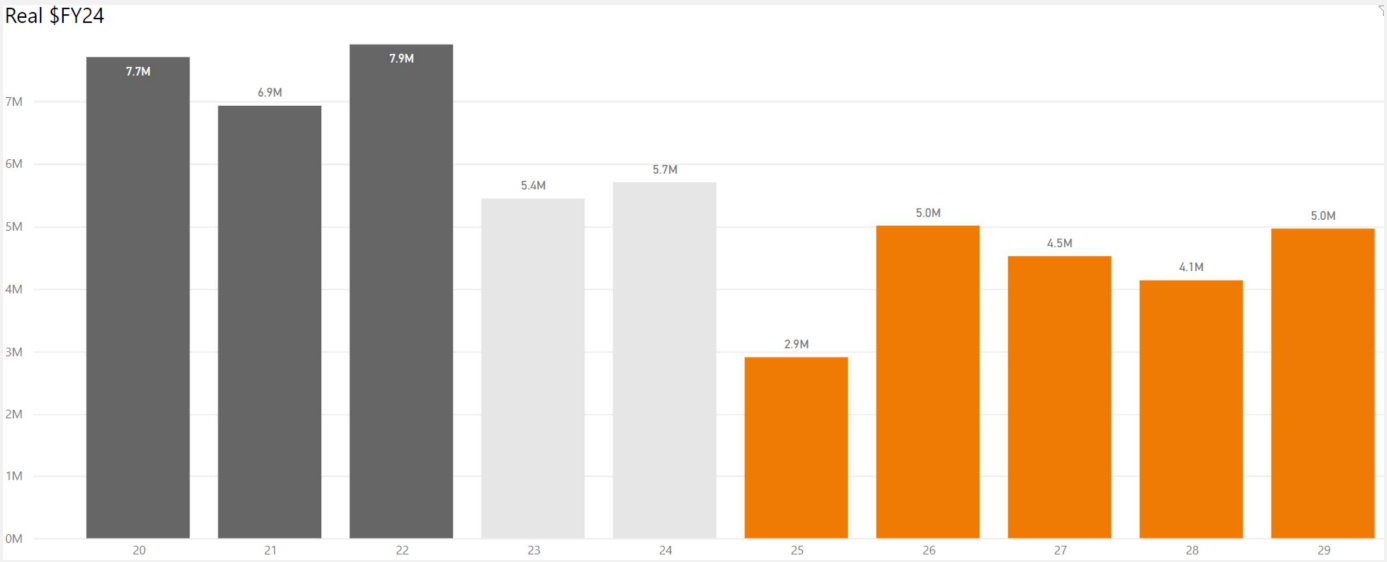
Options

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

- 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; or replacement of a live tank circuit breaker by dead tank type (or vice versa); or replacement of a circuit breaker by a less expensive recloser. Retirement of the asset, feeder or zone substation may be considered if load and network constraints permit.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for Circuit Breakers across the 2024-29 period is $21.6M, averaging $4.3M per annum. Actual and projected expenditure for the remainder of the 19-24 period is $33.7M.



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.
- **Critical Environmental Factors:** There is increased risk associated with Circuit Breakers due to factors such as oil containment.
- **Customer needs:** Through customer engagement, refer Chapter 4 of our Regulatory Proposal, customers indicated a desire to maintain current levels of safety and reliability. The investment will contribute to maintaining safety and reliability, within the wider Repex portfolio.

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

- **Improved network risk and maintainability**: Investment in this asset class will reduce network risk through replacement of Circuit Breakers of degraded condition and/or in high risk locations with more resilient materials of acceptable condition; and
- **Maintain levels of service for our customers:** Maintaining the health of assets through addressing locations of highest risk, will result in fewer unplanned failures from asset degradation and therefore will enable us to maintain service reliability for customers.

Forecast Circuit Breakers Repex expenditure for the 2024-29 period is $21.6M. The reduction from 2019-24 actual/forecast of $33.7M is due to:

- Reduced volume of replacements required to achieve portfolio risk targets.

Key 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.
- In lieu of failure data for overhead distribution reclosers and sectionalisers, date removed from service was used. This incorporates preventative and failure replacements.
- Type faults were included in the risk and cost modelling by applying a reduction in the Weibull characteristic age (alpha) by 8 years. This meant that in the network risk forecast, type fault assets were given additional priority when determining replacements at the population level.
- Reclosers were modelled with an increased Weibull characteristic age (alpha) by 10 years due to a track record of minimal failures and increased age profile within zone subs, compared to the OH distribution network assets.
- Consequence models were developed in accordance with 6.03.03 Appraisal Value Framework

Strategic Direction

We shall

Acquisition

Selection Criteria
Continue to select circuit breakers at 33kV and below that are vacuum interrupting and SF6 insulating. At 66kV and above, SF6 interrupting and insulating.

Continue selecting reclosers that are vacuum interrupted and solid insulation, sectionalisers that are SF6 insulating.

Maintain awareness of supplier developments in SF6-free alternative switches, and trial when appropriate for commercial and technical viability.

Procurement
Continue the current period contract approach with vendors.

Lead times are typically in the range of 20 – 40 weeks for circuit breakers and 8-12 weeks for reclosers and sectionalisers. Continue to order assets as required with appropriate consideration of spares requirements.

Maintain awareness of obsolescence issues and availability of critical components.

Operations & Maintenance

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

Continue inspecting reclosers as per *CEOP8009:*
- Visual inspection by Asset Inspectors.

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

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

Continue maintaining reclosers and sectionalisers as per *CEOP8009*
- 4 yearly minor maintenance.
- Recloser only, 8 yearly full calibration.

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
Continue to deliver a risk-valued replacement program to maintain acceptable risk level across the zone substation system.

Evaluate benefits of upgrading non-telemetry reclosers.

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

Disposals

Individual Assets
Continue to dispose of assets 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 circuit breakers.