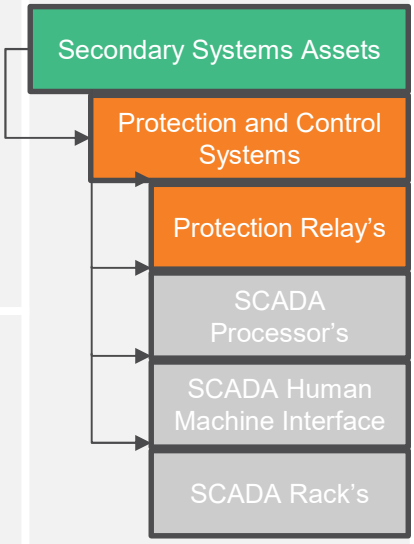
Protection and Control Systems Investment Case

Protection and Control systems are critical to the safe operation and control of Essential Energy's Distribution Network. The Protection system detects failed equipment or network faults and then isolates the affected equipment within stated clearance times. The Control System takes inputs from across the electrical network and provides control and remote visibility of critical parts of the electrical network.

Scope

This investment case addresses Protection and Control Systems assets located inside Zone Substations. Assets that are in scope but have not been fully addressed in this iteration are Scada Processors, Scada Human Machine Interfaces (HMI) and Scada Racks. These assets had issues around captured data related to populations, failures and work tasks and as such will be addressed in future iterations when the data becomes available.

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 Protection & Control Systems forecast accounts for 1.42% of the total Repex portfolio for FY25 to FY29.

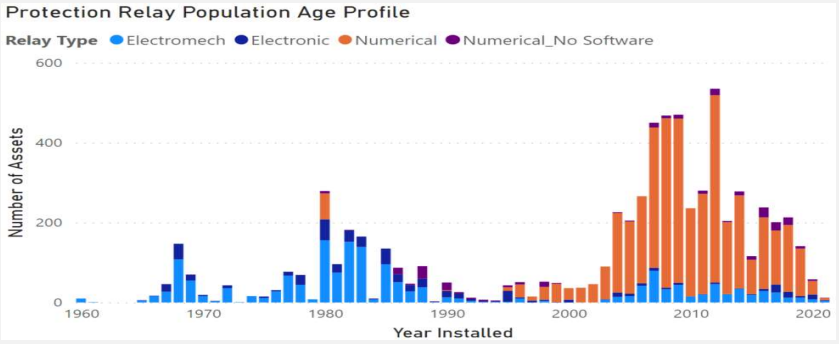
FY25	FY26	FY27	FY28	FY29
$3.2M	$3.2M	$3.1M	$3.2M	$3.2M

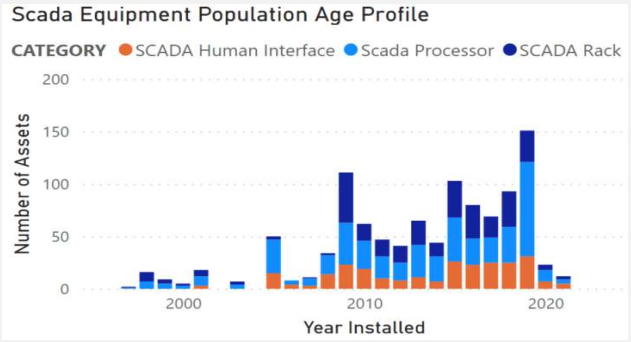
Asset Profile/Health

Asset Profile

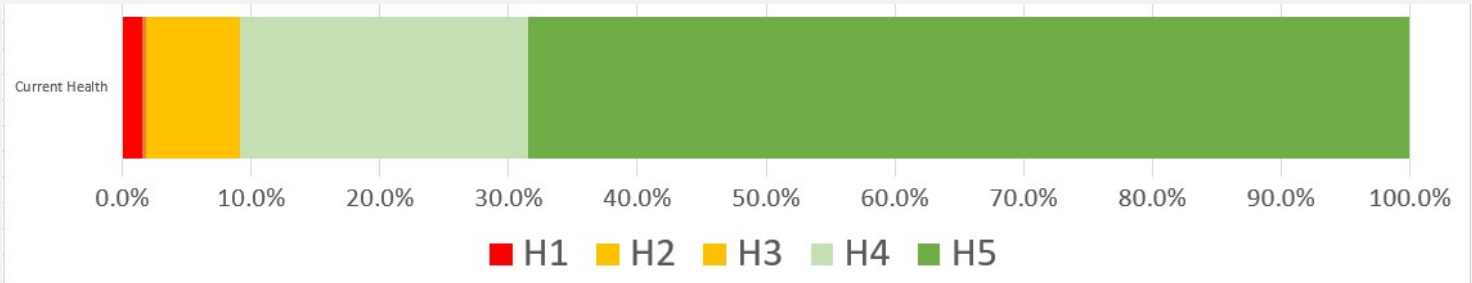
Essential Energy's Protection and Control System is responsible for approximately 8103 unique assets located at 314 Zone Substation sites across NSW. Each of these sites are exposed to various environments.

Asset Sub Class	Scada Processors	Scada HMI's	Scada Racks	Protection Relays
Number of Assets	517	265	330	6791





The majority of protection relays are of good health, using age as a proxy. However, there are some assets approaching end of life. The following graph shows the health of the numerical protection relay fleet.



AHI	PoF	Description
H1	x > 33%	Asset at or approaching end of life
H2	14% < x < 33%	High risk of failure, replace in short term
H3	7% < x < 14%	Elevated risk of failure, replace in medium term
H4	4% < x < 7%	Acceptable deterioration and condition
H5	x < 4%	Low failure risk, asset in good condition

This section provides an overview of the Protection & Control System 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

Failure modes for Protection and Control System assets have been identified through a Failure Mode Effects Analysis (FMEA) with subsequent analysis focusing only on those failure modes with asset life ending consequence. The resulting Weibull parameters are shown below.

Analysis of historical task data from 2001 – 2021 identified 216 asset failures and 4442 suspensions, however a large number of failure data gaps were identified which resulted in focus being put on the model for the SPAJ140 numerical relay that had low data gaps and was representative of the entire numerical relay fleet. The Weibull curve determined for this numerical relay will be used for the entire Numerical relay population.

Weibull Parameters and Failure Data

POF Model	Alpha	Beta
Numerical Protection Relays	32	3

Equipment Type	Failure	Suspension	Total
Numerical Protection Relays	10	41	51

Consequence of Failure

The consequence of failure for a Protection and Control System asset describes the impact of a functional failure.

Consequences have been evaluated using **6.03.03 Appraisal Value Framework**.

Consequence costs are mostly Compliance, Network and Financial, driven by the fact that Protection is critical to the safe and reliable function of the electrical network and as such this area is highly regulated.

The high level of redundancy in the protection system keeps the safety consequence low.

Component	Total	Average	Median
Safety	$ 6,306,707.32	$ 932.12	$ 932.12
Network	$ 174,255,573.24	$ 25,754.59	$ 25,754.59
Bushfire	$ 2,777,490.32	$ 410.51	$ 410.51
Environment	$ 339,358.34	$ 50.16	$ 50.16
Financial	$ 202,635,484.00	$ 29,949.08	$ 29,949.08
Compliance	$ 712.75	$ 0.11	$ 0.11

Risk calibration

Asset risk is calculated by applying the PoF and CoF models to individual assets. Asset risk is then aggregated to the total population level to determine the asset class risk.

Model outputs have been calibrated against top-down performance figures. The table opposite compares the unscaled model outputs with the monetised top-down performance. For implementation, scaling factors are applied to risk model outputs, to align risk forecasts with realised performance.

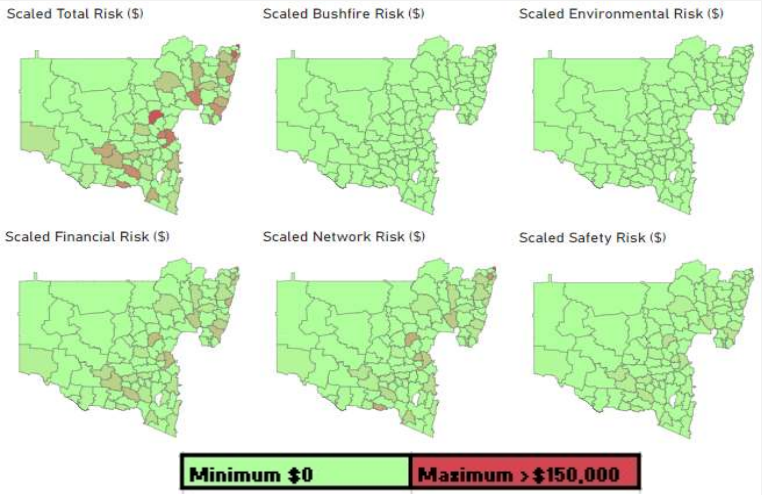
Value Measure	Safety	Network	Bushfire	Financial	Enviro	Compliance	Total
Unscaled Model Outputs ($M)	0.03	2.09	0.02	2.42	0.00	0.00	4.57
Top-Down Performance ($M)	0.33	0.85	0.02	0.83	0.00	0.00	2.01

To enable comparison with top-down performance figures, 'Unscaled model outputs' are calculated from a Maintain planned expenditure risk (change nothing) scenario that simulates the residual asset failures resulting from continued implementation of current asset maintenance and replacement strategies.

Risk Heatmap (Scaled)

The figure opposite displays the breakdown of the total (residual) risk for Protection Relays by depot area*. The primary differentiators of risk for these assets are the Financial and Network consequences, with areas with high concentration of assets and large loads having the highest risk.

* As of August 2022



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 ensure efficiency our portfolio has been constrained to meet customer and stakeholder expectations.

In line with NER capital objectives, the objectives of our 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 Protection and Control Systems consist of:

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

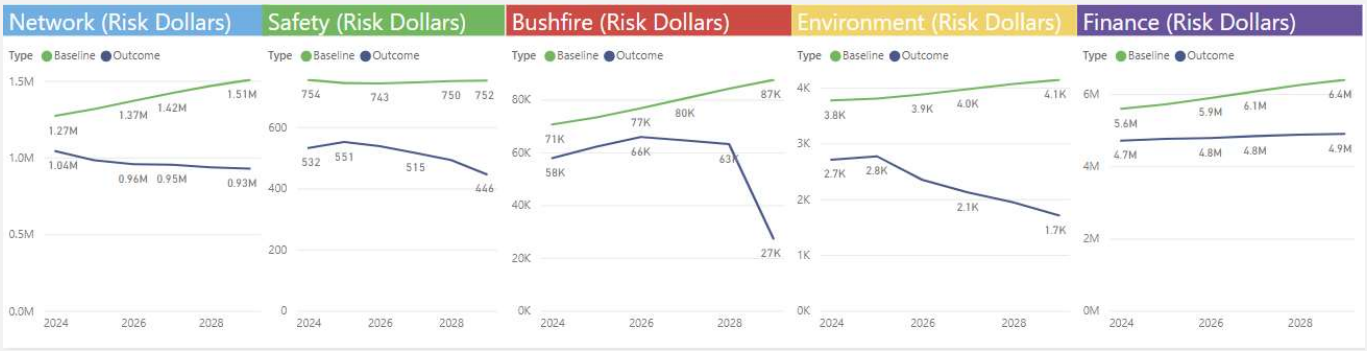
The above asset intervention utilises a probabilistic approach that has been developed through detailed analysis of historical asset performance to establish Weibull parameters.

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

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 SME defined unit rates.

Optimised Portfolio Outcomes

Risk Trend (2024-29 Optimised portfolio)
Over the 5 year regulatory window, total **baseline** monetised risk due to **functional** Protection & Control Systems failure is estimated to increase to $8M by 2030. The figure below depicts the **baseline** scenario and investment **outcomes** ($5.6M) of the optimised program for Protection & Control Systems.



Grouping

The Protection & Control Systems assets have been grouped for investment optimisation purposes.

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

- 3,939 asset groups were loaded into 157 investments in Copperleaf to provide flexibility in portfolio optimisation. Of the 157 investment groups, 47 were optimised into the portfolio for the 2024-29 regulatory period.

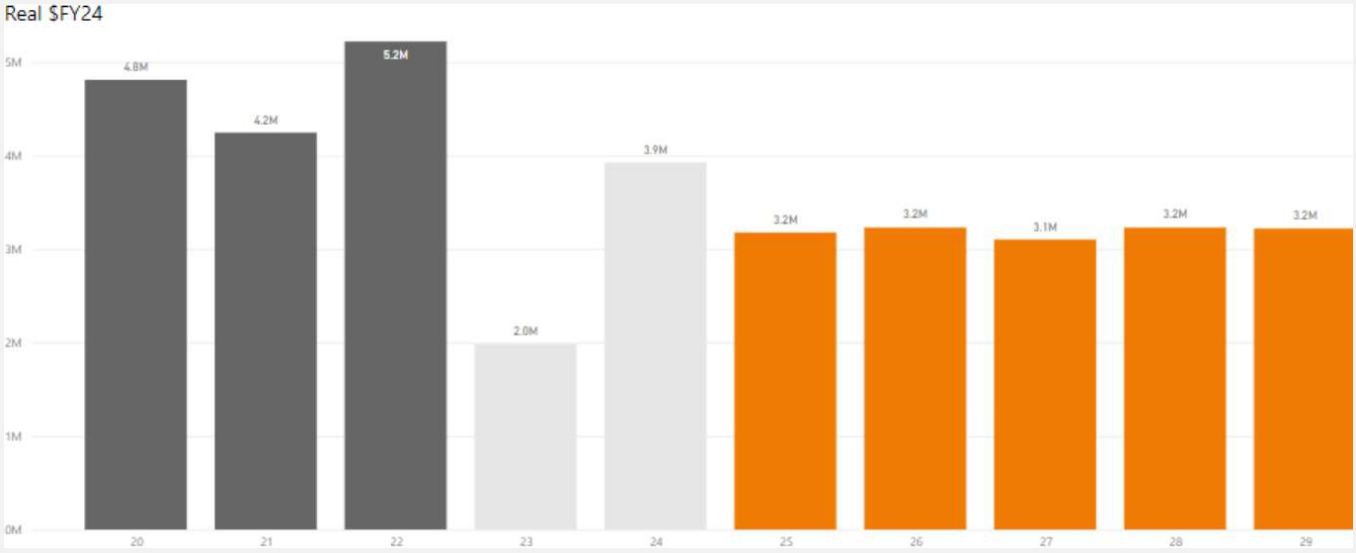
Investment Options

1. Protection & Control Systems replacement expenditure has been modelled on a replace with current standard or like-for-like, specifically replacement with a numerical protection relay.
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 not considered when planning the replacement of this asset class.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for Protection & Control Systems across the 2024-29 period is $16M, averaging $3.2M per annum. Actual and projected expenditure for the remainder of the 19-24 period is $20.2M.



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 because:

- **Clear, prudent drivers from Asset Management Objectives (detailed in Attachment 10.01 SAMP) for Reliability, Quality, Safety and Compliance:** Our forecast has been developed in line with the asset management objectives for this asset class including: maintaining present reliability levels for our customers and reducing unassisted fire starts.
- **NER Capex objectives**: form the basis of our proposal
- **Review and moderation:** Our forecasts have been tested and reviewed by our customers, our executive management and the Board, and the forecasts have been moderated based on feedback and discussion.
- **Deliverable:** Adequate resources are available to deliver the work.

The major benefits expected from these investments are:

- **Maintain network and safety risk and reduce bushfire risk**: through continuation of the Bulk Replacement program, we will proactively address locations of greatest risk across our overhead network, and in a manner that minimises costs; and
- **Maintain levels of service for our customers:** Maintaining the health of the OH Services fleet, and through addressing locations of highest risk, will result in fewer unplanned failures through asset degradation and therefore will enable us to maintain service reliability for customers.

Forecast replacement expenditure for Protection & Control Systems across the 2024-29 period is $16M,
The reduction from actual/forecast expenditure for 19-24 period of $20.29M is due to Copperleaf optimisation selecting fewer investments than the total available in order to meet the portfolio objectives.

Assumptions

- **Attribution of tasks** was very difficult due to large numbers of functional failures not being captured as failed relays were either repaired or replaced in the field as part of maintenance processes. This issue was particularly significant in the Electro mechanical relay subclass, however as these relays are being replaced with more capable numerical relays this issue will become less difficult over time.
- **Development of Weibull Parameters** occurred through a thorough analysis of captured failure information. The failure information used was of varying levels of quantity and quality across the wide range of in-service relays. This resulted in significant variations in the Weibull parameters that were determined through the available data. Weibull Parameters were further analysed using Subject Matter Expert feedback and comparisons with known failure information to determine which of the Parameters were the most reflective of real world performance.
- **Consequence models** were developed in accordance with 6.03.03 Appraisal Value Framework. Many data sources were used to develop the model to improve the accuracy of the model.

Strategic Direction

Lifecycle Stages

Acquisition

Selection Criteria

Protection Relays:

- Continue to select applicable period contract relays for the relevant protection schemes as per the developed standard relay allocation schedule..

SCADA RTU's and HMI's:

- Continue to select the most appropriate RTU and HMI's from the existing panel contract as per design requirements
- Complete market approach to identify suitable RTU's to replace existing RTU's which are coming to end of supply from manufacturers.
- In short term conduct a review to determine risks and benefits of having 1 or 2 in-service RTU's

Procurement

Protection Relays:

- Continue to use existing contracts to purchase appropriate Protection Relays as required to ensure simplification of Protection system.

RTU's:

- Continue to use existing approved suppliers to purchase appropriate RTU's.

HMI's:

- Continue to purchase approved HMI's from approved suppliers.

Stock holdings:

- In the medium term conduct a review of spares holding to limit impacts of failed Assets.

Supply Chain

- Continue to work with suppliers on opportunities around the improvement of the existing asset fleet include.

Ops & Maintenance

Preventative Maintenance (Inspections):

- Continue to perform periodic maintenance to identify failed or defective assets in accordance with *CEOP8011*
- In the medium term conduct a review of changes to Protection Relay maintenance process in CEOP8011 to ensure that benefits of the change are being achieved.

Corrective Maintenance (Repairs):

- Continue to perform Corrective maintenance in accordance with procedures defined in *CEOP8011.*

Breakdown Maintenance:

- Where an Electro Mechanical relay has failed and is not repairable it shall be replaced with a relay that meets the current standard.

Interventions

Serviceability

- In the medium term a review of Secondary Cabling is required to determine serviceability of the Cabling system.

Prioritisation

- Continue to prioritise replacement projects with the value calculators and investment optimisation process.
- We shall coordinate planning between primary and secondary plant to increase value of delivered investments.

Reducing complexity

- Continue to replace Non Numerical relays with Numerical relays to: Reduce numbers of protection relays, reduce maintenance overhead, derive safety & monitoring benefits, simplify protection systems and achieve reductions in bushfire risk through remote setting changes on total fire ban days

Cyber Security

- Short: Adjust Architecture and Design standards to incorporate new cyber security requirements.
- Medium: Implement designs as required to achieve compliance with CEOS7075 Cyber Security for Network devices

Disposals

Individual Assets or Entire Asset Variant

- Continue to investigate opportunities to re-use and recycle assets in accordance with CECP8074.
- SCADA RTU's should continue to use current disposal processes. In the short term this process needs to be documented to ensure consistency and reduce risk.

Hazardous Materials

- Continue to manage hazardous materials including Asbestos in accordance with *CECM1000.10a*

Asset Support

	Current Approach	Actions
Process & Information	Some asset data is contained within the existing EAM, however, much of it is still contained within various spreadsheets or other disconnected data sources.	• Short: Develop Suitable EAM data architecture for Protection Relays and for Scada Processors, Racks and HMI's. • Medium: Create Individual records for each asset within new EAM system. • Medium: Develop new system for storing , developing & approving Protection settings Advice (PSA) information.
People & Training	There are some risks with regards to skills gaps for some SCADA RTU's.	• Short: Conduct a skills analysis to determine skills coverage of existing SCADA RTU asset base • Short: Develop a plan to resolve identified skills coverage gaps