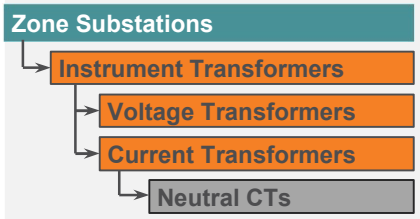
Instrument Transformers Investment Case

Outdoor Instrument Transformers measure voltage or current for protection and control functions required in the associated subtransmission and high voltage distribution networks.

Scope

This investment case addresses outdoor instrument transformers located within zone substations; this includes both voltage transformers (VT) and current transformers (CT).

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

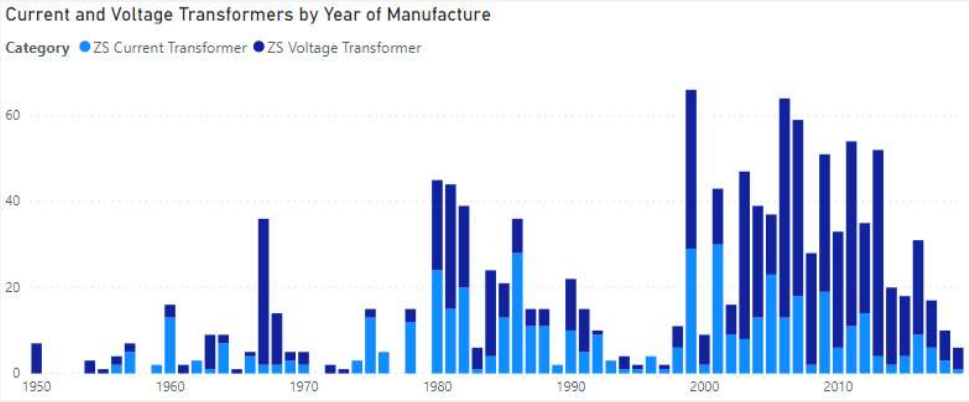
The Instrument Transformer forecast accounts for 1.49% of the total Repex portfolio for FY25 to FY29.

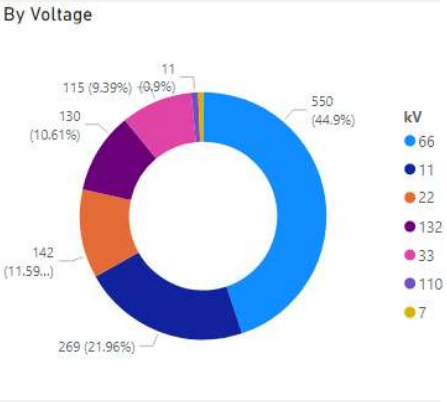
FY25	FY26	FY27	FY28	FY29
$2.9M	$3.8M	$3.4M	$1.4M	$5.3M

Asset Profile/Health

Asset Profile

Essential Energy currently has 488 sets of current transformers and 768 sets of voltage transformers. These assets have an average age of 30 and 24 years respectively.





Risk Analysis

This risk section provides an overview of the Instrument Transformer 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

Population level probability of failure (PoF) was developed for this asset strategy. This was performed by determining a statistical fit through a Weibull model.

Due to limited functional failure data, the PoF was developed by utilising replacements recorded. This data includes replacements due to external factors. Steps were taken to compare and identify the aging/stress failure characteristics. There is also evidence of early-life type fault failures that are not typical of the population and not included in the risk forecasts.

Weibull parameters used in the risk model are shown below.

Instrument transformers: **Beta = 6 , Alpha = 80**

Epoxy instrument transformers: **Beta = 6 , Alpha = 66**

Subsystem	Component	Failure Mode
Instrument Transformers	• Housing • Insulation – external • Insulation – internal • Control / Indication - Cubicle • Control / Indication • Support Structure	• {broken} • {contaminated} • {damaged} • {leaking} • {loose} • {loss of dielectric strength} • {surface contamination}

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 impacts.

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

Bushfire and Environment risks have been deemed insignificant as the units are all located within zone substation yards.

Component	Consequence		
	Total ($ million)	Average ($ per IT)	Median ($ per IT)
Network	$401.0	$322,000	$233,644
Financial	$32.4	$29,308	$47,845
Safety	$32.9	$26,886	$27,525
Bushfire	$0	$0	$0
Environment	$0	$0	$0
Total	**$433.0**	**$353,872**	**$309,014**

Risk Model Calibration

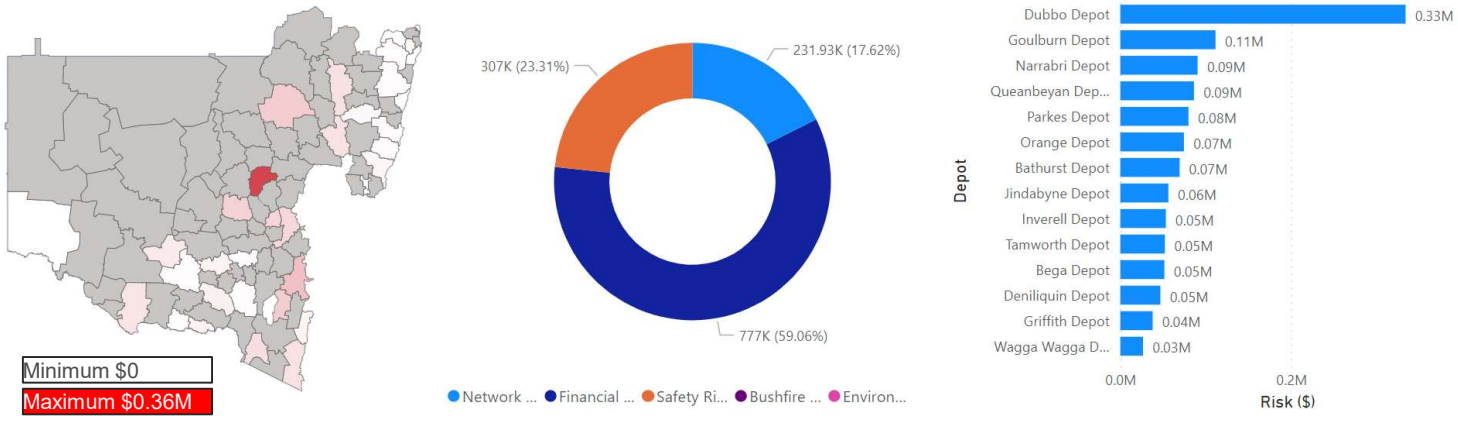
Asset risk is a function of the probability of failure and the consequence of failure.

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 ($M)	0.12	1.92	0	0.15	2.19
Top-Down Performance ($M)	0.31	0.23	0	0.78	1.32
Commentary	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 instrument transformers by nearest depot. The primary risk category is Network risk. 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.
The Dubbo depot has resulted in a higher risk due in part to large loads on a radial feeder and long travel times from Dubbo depot to the zone substations further west.



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, 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 Instrument Transformers 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 6.03.03.19).

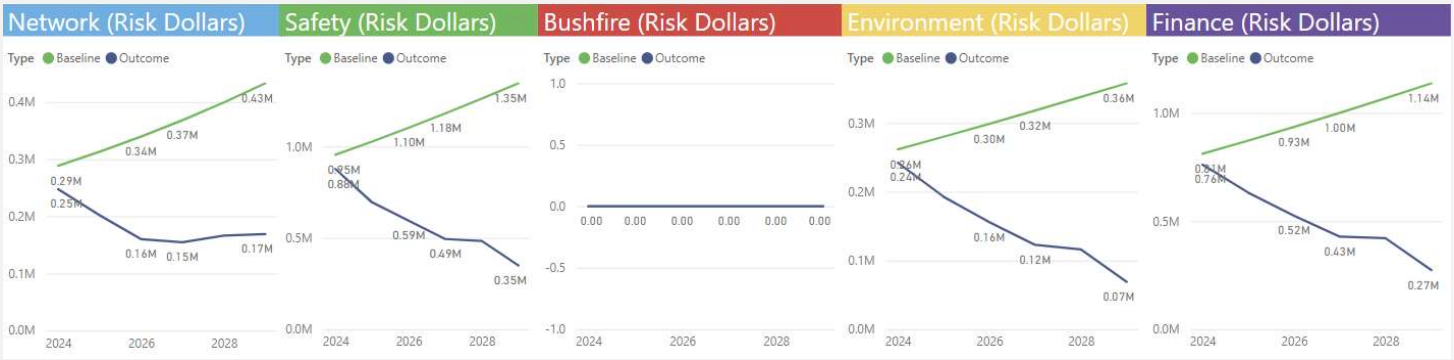
The probabilistic method has been tested and validated against historical volumes to ensure that it is accurate at the population level.

Forecast investment expenditure has been determined by multiplying the forecast replacement quantities of assets by 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** Instrument Transformers failure is estimated to increase to $3.5M by 2030. The figure below depicts the **baseline** scenario and investment **outcomes** ($1.1M) of the optimised program for Instrument Transformers.



Asset Grouping

The Instrument Transformer 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.

- 789 asset groups were loaded into 86 investments in Copperleaf to provide flexibility in portfolio optimisation.

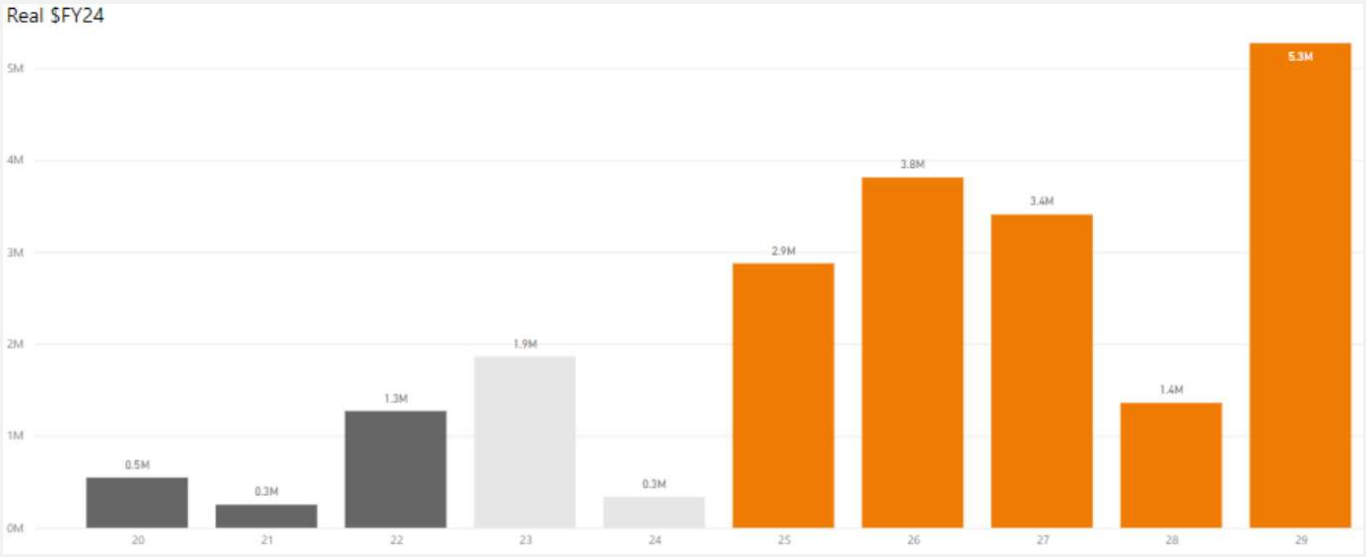
Options

1. Instrument Transformer replacement expenditure has been modelled on a replace with 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.

- 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 of different types or materials; or replacement of a feeder segment by a non-network solution.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for Instrument Transformers across the 2024-29 period is $16.7M, averaging $3.3M per annum. Actual and projected expenditure for the remainder of the 19-24 period is $4.3M.



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. The investment will contribute to maintaining safety and reliability, within the wider Repex portfolio (as per copperleaf forecast).

The major benefits from the proposed Instrument Transformers 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
- **Maintain levels of service for our customers:** Maintaining the health of Instrument Transformers 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 Instrument Transformer Repex expenditure for the 2024-29 period is $16.7M. The increase from 2019-24 actual/forecast of $4.3M (and allocation of approx. $8.4m) is due to:

- Copperleaf optimisation selecting investments required in order to achieve the portfolio objectives.
- Type faults associated with several models of voltage and current transformers requiring replacement.

Assumptions

- Risk-value replacement schedule assumed the replacement of all oil Instrument Transformers in the short term.
- Development of consequence of failure event trees aligned to **6.03.03 Appraisal 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. The Network consequence assumes a typical layout, improved accuracy requires a dedicated analysis.
- Instrument transformer early and mid life replacements were removed from the Weibull analysis. This was due to external replacement drivers from associated circuit breaker and protection upgrades or type faults that are not typical of the whole population.
- Application of scaling factors for Safety, Network and Bushfire risk in line with actual performance data where available, in conjunction with SME input.

Strategic Direction

We shall

Acquisition

Selection Criteria
Continue to select instrument transformers that are oil-filled, polymer housing with pressure relief technology

Maintain awareness of alternate supplier designs and trial when commercial and technical viable.

Procurement
Continue the current period contract approach with vendors.

Lead times are typically in the range of 20 – 30 weeks for instrument transformers. Continue to order assets as required with appropriate consideration of spares requirements.

Apply asset criticality assessment to Spares Strategy.

Operations & Maintenance

General Site Inspections:
Continue to inspect instrument transformers 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 to maintain instrument transformers as per *CEOP8011*:

- Current transformers;
  - 3 yearly oil sample
  - 6 yearly full maintenance
- Voltage transformers;
  - 6 yearly oil sample
  - 12 yearly full maintenance
- Epoxy instrument transformers 12 yearly full maintenance.

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

Operations:
Implement secondary monitor where viable.

Interventions

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

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 instrument transformers.