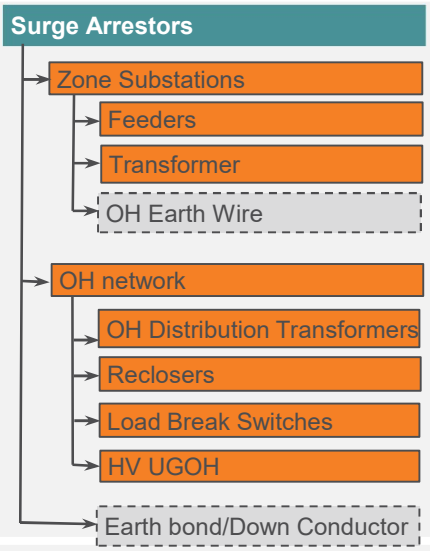
Surge Arrestors Investment Case

Surge diverters provide the HV network with an increased level of reliability by minimising the impact of over-voltages that result from transient conditions. Damage to critical energised infrastructure can result if sufficient surge protection is not provided leading to an increase in network outages and repair costs.

Scope

This investment case addresses surge arrestors located within zone substations and the overhead network.

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 Surge Arrestor forecast accounts for 0.05% of the total Repex portfolio for FY25 to FY29.

FY25	FY26	FY27	FY28	FY29
$0.11M	$0.11M	$0.12M	$0.12M	$0.11M

Asset Profile/Health

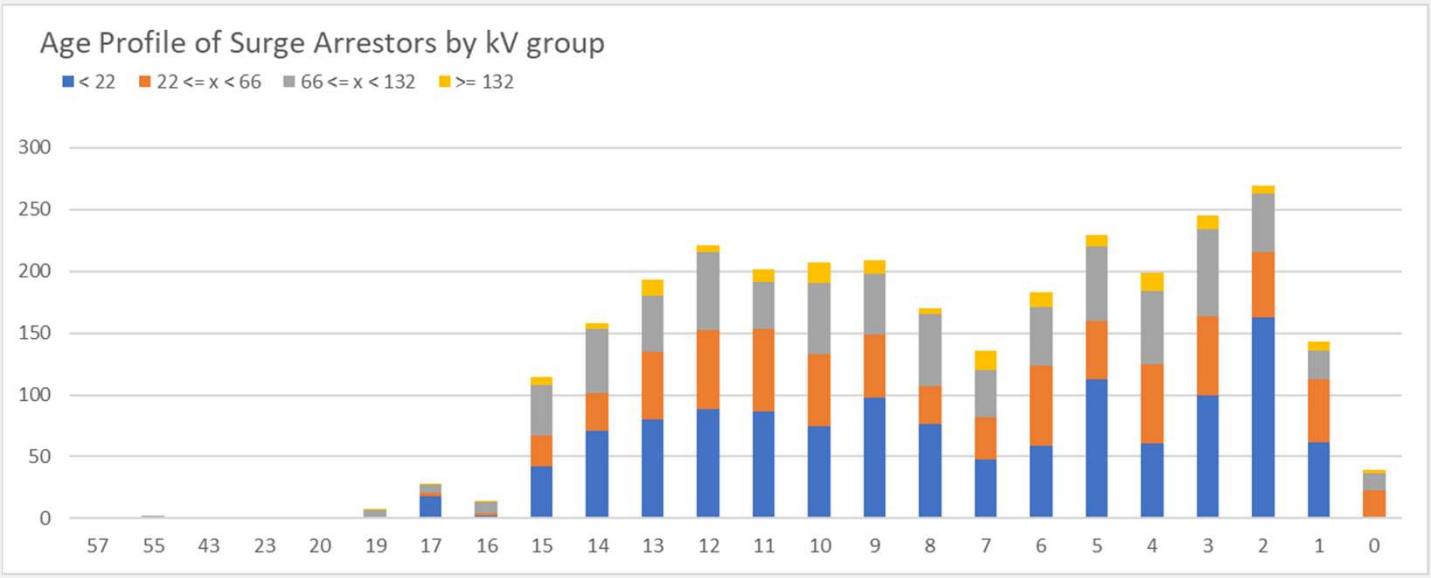
Asset Profile

Essential Energy's network recorded data either directly or implicitly through association with zone substations, distribution transformers, reclosers, load break switches and HV UG/OH connections includes:

- 8,106 in service ZS Surge Arrestors
- 284,278 in service OH Surge Arrestors

Note: HV UGOH Cable Connections missing from count

The age profile of surge arrestors asset class is shown in the following figure and used as proxy for asset health



This risk section provides an overview of the Surge Arrestor 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)

Failure modes for Surge Arrestors have been identified through a SME elicitation focusing only on major failure modes with asset life ending consequence. The parameters have been applied by Voltage, reflective of the design and stresses on the asset. The generalised Weibull parameters are shown on the right.

The data analysis of the Zone Substation Surge Arrestors from 2006 – 2021 identified 2,876 completed tasks. These tasks where further filtered for task code and commissioning dates. Due the function of the asset, the failures are generally shown during voltage transient conditions. This introduces a random shape failure mode to the conventional aging failure models. Due to the random nature of the assisted failure mode, preventative replacements are influenced more by the consequence and risk to the network.

The Weibull curve has been modified to reflect the feedback from the manufacturers who expect a life of 30-50 years. Weibull parameters used in the risk model are shown on the right.

Subsystem	Component	Failure Mode
Surge Arrestors	• End Fitting/electrodes • Resistor (Metal Oxide)/MOV Disks • Wrap (Epoxy/Fiberglass) • Silicon Rubber Sheds • Mounting • Earth Lead	• {Moisture Expansion} • {Flash Over/Contaminated} • {Flash Over/Fauna • {Thermal Runaway} • {Exceeding design Capacity} • {Mechanical Loading}

Surge Arrestor Data (all):

shape(b) = 1.8 , characteristic age(a) = 22.6

Surge Arrestor OEM:

shape(b) = 4 , characteristic age(a) = 40

Consequence of Failure

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

Consequence costs are dominated by Network impacts.

Totals show the consequence cost should the entire surge arrestor fleet fail catastrophically.

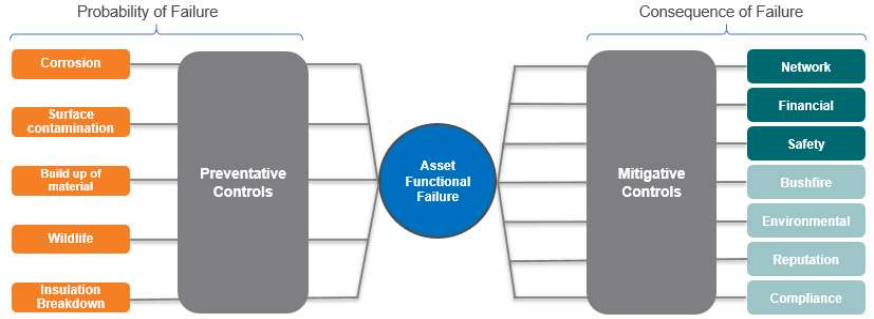
Bushfire, Environment and Reputational risks have been deemed insignificant as the units are all located within zone substation yards.

Component	Consequence (ZS)		
	Total ($ million)	Average ($)	Median ($)
Network	$495.87	$166,793	$55,761
Financial	$74.76	$25,145	$10,429
Safety	$11.78	$3,962	$3,154
Bushfire	$0	$0	$0
Environment	$0	$0	$0

Totals show consequence cost should the entire fleet fail.

Network Risk

Asset risk is a function of the probability of failure and the consequence of failure. The risk model has been developed using the Asset Risk Management framework. and represents the relationship between the drivers of the probability of functional failures and the consequence of failure.



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 Surge Arrestors consist of:
1. Optimised **risk-based replacements to maintain overall network risk values within defined objectives.**

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

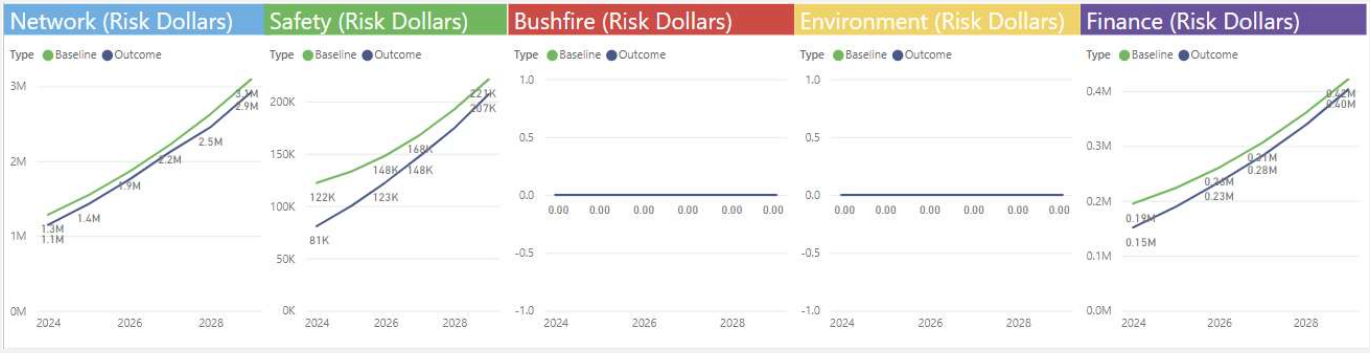
The above asset intervention utilises a probabilistic approach that has been developed through detailed analysis of historical asset performance to establish Weibull parameters.

Forecast investment expenditure has been determined by multiplying the forecast replacement quantities of Surge Arrestors 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 Outcomes

Risk Trend (2024-29 Optimised portfolio)
Over the 5 year regulatory window, total **baseline** monetised risk due to **functional** Surge Arrestors failure is estimated to increase to $3.7M by 2030. The figure below depicts the **baseline** scenario and investment **outcomes** ($3.5M) of the optimised program for Surge Arrestors.



Asset Grouping

The Surge Arrestor assets have been grouped into one 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.

- 2,708 asset were loaded into 40 investments in Copperleaf to provide flexibility in portfolio optimisation.

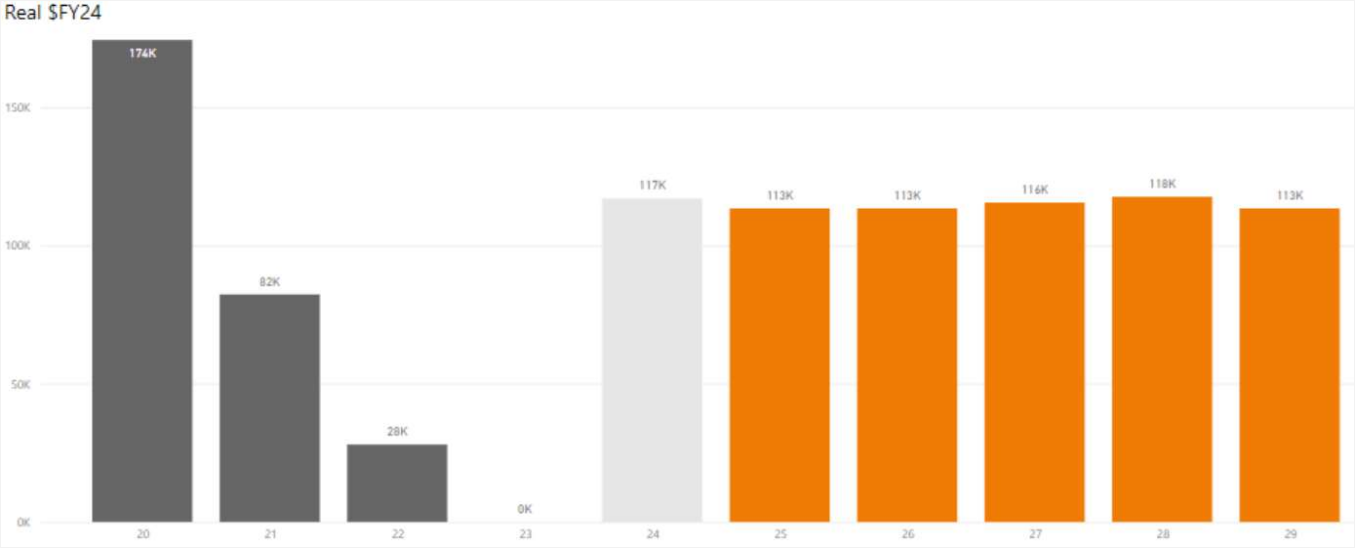
Options

1. Surge Arrestor 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.

- Non network solutions are not considered for this asset class.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for Surge Arrestors across the 2024-29 period is $0.57M, averaging $0.11M per annum. Actual and projected expenditure for the remainder of the 19-24 period is $0.4M.



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**).
- **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:** Risk associated with Surge Arrestors due to factors such as geography and climate.
- **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 Surge Arrestor investment (against the **change nothing** scenario) are:

- **Improved network risk and maintainability**: Investment in this asset class will reduce network risk through replacement of Surge Arrestors 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 Surge Arrestor Repex expenditure for the 2024-29 period is $0.57M. The change from 2019-24 actual/forecast of $0.4M is due to:

- Slight increase in volume of replacements to achieve risk outcomes.

Key Assumptions

- **Attribution of Asset Age to Task**
  - **Zone Substation:** asset fleet is relative young (Average 7.85 years) as a replacement program was initiated to remove the high risk silicon carbide porcelain arrestors. Failures have been tracked against asset but there is limited historical data.
  - **Overhead Network:** OH Surge Arrestors are not recorded as individual assets and tasks are raised against the protected asset. Modelling the OH Network Surge Arrestors will occur in future iterations.
- **Categorisation of task maintenance activity** was performed in a task code mapping spreadsheet. Replace tasks were categorised based on their task group, task description, and cause description.
- **Weibull Parameters** were developed by curve fitting in Power BI. The population was subdivided by location (ZS or OH). Future iterations to look at further sub-population analysis (Type, voltage level and kVA).
- **Calibration of Weibull Parameters** was achieved by comparing failures predicted for a given set of Weibull parameters to historical failures recorded in the Network Failure Database between 2016-2019.
- **Consequence models** were developed in accordance with 6.03.03 Appraisal Value Framework.
- **Overhead Network:** conditional replacements are applied in each preventative scenario inline with the Overhead System Strategy and identified through asset inspections.

Strategic Direction

Lifecycle Stages

Acquisition

Selection Criteria
Continue to select polymer metal oxide surge arrestors.

Maintain selection of station class arrestors for ZS feeder and transformer (selection based on over voltage transients (lightning/switching).

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

Procurement
Review current period contract approach with vendors to ensure compliance (previous issue with transformer turning up with unfit for purpose surge arrestors)

ZS: Lead times are typically in the range of 4 – 8 weeks for surge arrestors. Continue to order assets as required with appropriate consideration of spares requirements.

Apply asset criticality assessment to Spares Strategy.

Ops & Maintenance

Preventative Maintenance (Inspections):
OH: Continue visual inspections for 'conditional failed' surge arrestors as part of pole asset Inspections.

ZS: Conduct sample lab testing to simulate arrestor aging in Network conditions to verify aging functional failure types and end of life expectance (Polymer degradation).

Note: There is no current inspection program for ZS surge arrestors

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

Breakdown Maintenance:
Continue to replace on failures.

Interventions

Serviceability
- OH Network Surge arrestors are run to failure.
- ZS: As part of ZS upgrade projects continue to review and modify surge arrestor mounting locations (elevated) to maintain protection while reduce outage (cut away) and replacement times.

Prioritisation
Continue to prioritise replacement projects with the value calculators and investment optimisation process.
- Track and implement the removal of remaining porcelain silicon carbide surge arrestors in the 2019-24 regulatory period
- Upgrade of UGOH connections to remove mechanical loading on Surge Arrestors

Replacement Programs
Establish a risk-valued replacement program to maintain acceptable risk level across the Zone Substation and Overhead Network systems in line with this document

Continue to leverage knowledge from other DNSPs to inform maintenance and replacement programs.

Disposals

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

Hazardous Materials
Continue to manage interactions with:
- 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.
- Update EAM data to include Asset information for Overhead Network Surge Arrestors.

People & Training
- OH Network: Continue with other current training practices, including awareness of associated conditional failure when inspecting or maintaining assets.
- OH Network: Continue to manage knowledge and skills (Earth grid dependence, down conductors, Overhead Earth wire)
- ZS: Continue to manage knowledge and skills (Earth bonding, effectively earthed and non effectively earthed systems, class types)

Supply Chain
- Continue to manage spares at the depot level for F&E replacements