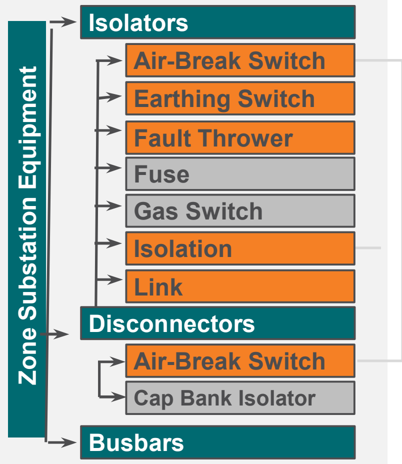
Zone Substation Outdoor Busbar, Isolators and Disconnectors Investment Case

Busbars, isolators and disconnectors within a Zone Substation provide a safe and effective means of transmitting and switching electrical energy around an outdoor switchyard. These assets play a key role in the operation, performance and reliability of Essential Energy's sub-transmission network.

Scope

This investment case addresses Zone Substation – Outdoor Busbars, Isolators and Disconnectors (OBID) which directly support their installation, safety, and maintainability.

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 ZS OBID forecast accounts for **0.91%** of the total Repex portfolio for FY25 to FY29.

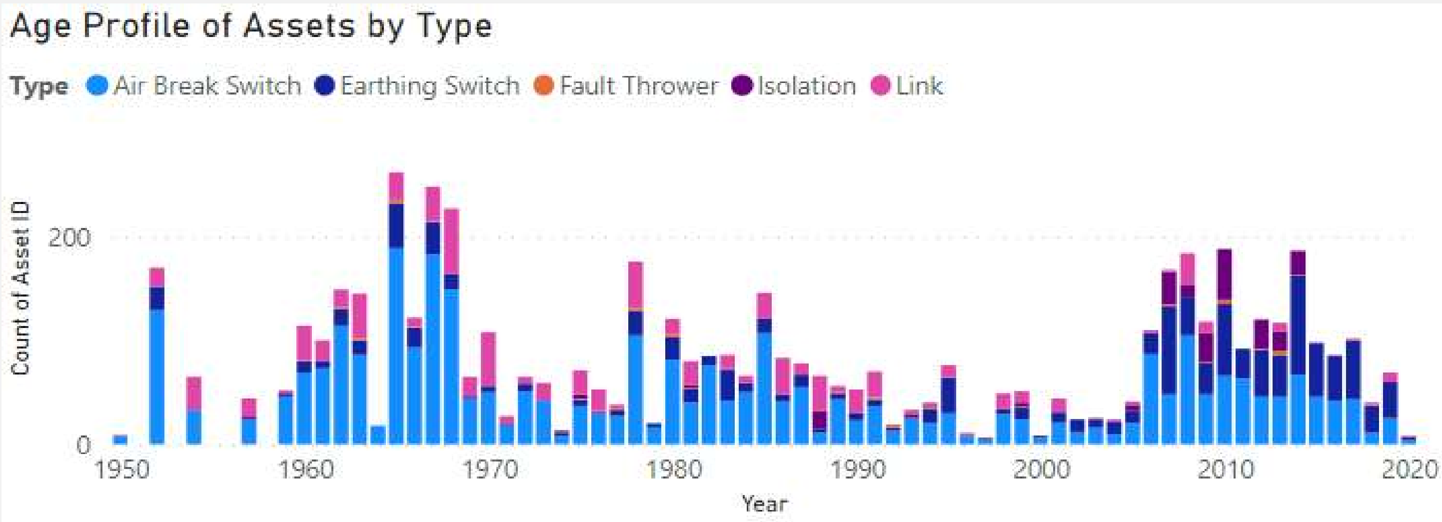
FY25	FY26	FY27	FY28	FY29
$2.2M	$2.6M	$2.6M	$1M	$1.9M

Asset Health/Profile

Asset Profile

Essential Energy currently has 7,012 in service assets recorded. For the analysis, sub-asset types of 'Air Break Switches' and 'Isolation' were combined; analysis of earthing switches and links were also included. These sub-asset types have an average age of 39, 27, and 45 years respectively.

Due to the combination of asset volume, failure modes, and replacement costs, asset age has been used as a proxy for asset health for this asset class.



Asset Type	Air-Break Switch	Earthing Switch	Fault Thrower	Isolation	Link	Total
# of Assets	4002	1521	54	272	1163	**7012**

Risk Analysis

This risk section provides an overview of the OBID 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 ZS OBID have been identified through a Failure Mode Effects Analysis (FMEA) with subsequent analysis focusing only on those failure modes with asset life ending consequence. 4,456 tasks (from 2005-2021) were analysed to inform the Weibull analysis. Task categories in this dataset did not provide a clear indicator of end-of-life / failed assets due to issues with current practices in classification of information. The limited availability and consistency of data also made it difficult to classify failures as repair or replace – therefore, only end of life replacement failures are considered in the analysis. A conservative total of 439 failure tasks and 182 maintenance tasks were mapped to assets. The majority of failures were from Isolators / Air Break Switches. Weibull parameters used in the risk model are shown below.

Air Break Switch: Beta = 2.71; Alpha = 115.17	**Link:** Beta = 3.83; Alpha = 92.14	**Earthing Switch:** Beta = 2.02; Alpha = 198.5

Consequence of Failure (CoF)

The consequence of failure for these assets describes the impact of a functional 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 in the adjacent table:

Consequence costs are dominated by Network costs with significant contributions also from Safety and Financial costs. Bushfire, Environment and Reputational risks have been considered but deemed insignificant, primarily due to assets being located within zone substation yards.

Component	Consequence		
	Total ($ million)	Average ($ per asset)	Median ($ per asset)
Safety	$57.54	$8,269	$6,097
Network	$1,656.38	$238,992	$56,333
Financial	$213.39	$30,668	$28,600
Bushfire	$0	$0	$0
Environment	$0	$0	$0

Risk Calibration

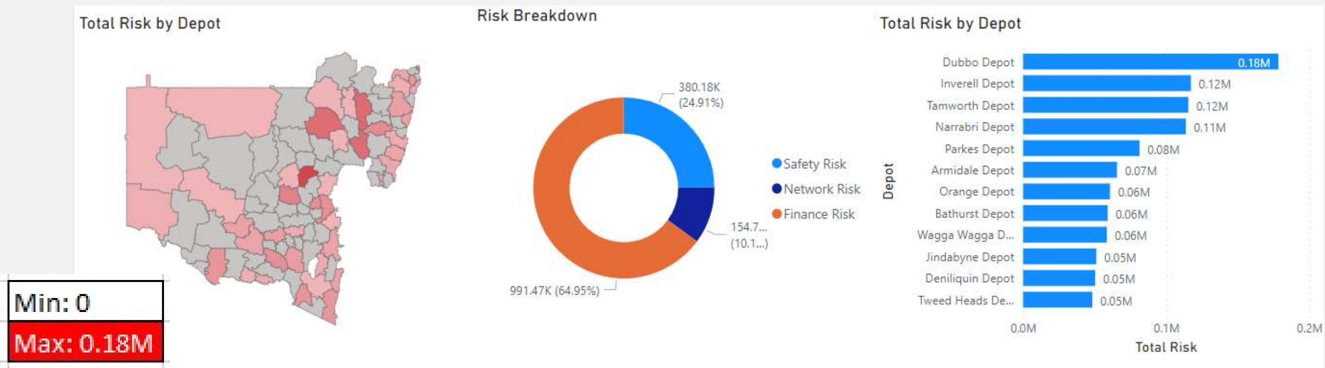
Asset risk is calculated by applying the PoF and CoF models to individual assets. Asset risk is then aggregated to the total population level to determine the asset class risk.

Model outputs have been calibrated against top-down performance figures for unassisted failures. 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	Bush fire	Financi al	Total
Unscaled Model Outputs ($M)	0.31	3.32	1.51	0	5.14
Top-Down Performanc e ($M)	0.38	0.15	0	0.98	1.52

Risk Heatmap (Scaled)

The images below display a summary of asset risk (quantified by the total risk per asset failure) for ZS Outdoor Busbars, Isolators and Disconnectors by depot. 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. Dubbo is the depot with highest criticality assets. The primary category of risk for this model is the Financial risk, followed by Safety and Network risk.



Forecasting Approach

The replacement Capex forecast (FY25-FY29) has been calculated using Essential Energy's optimisation software (Copperleaf). It utilises 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 OBID 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 6.03.03.26).

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** ZS Outdoor Busbar failure is estimated to increase to $13.5M by 2030. The figure below depicts the **baseline** scenario and investments **outcomes** ($11.1M) of the optimised program for ZS Outdoor Busbar.

Grouping

The OBID assets have been grouped into one broad categories 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.

- 3,059 asset groups were loaded into 173 investments in Copperleaf to provide flexibility in portfolio optimisation.

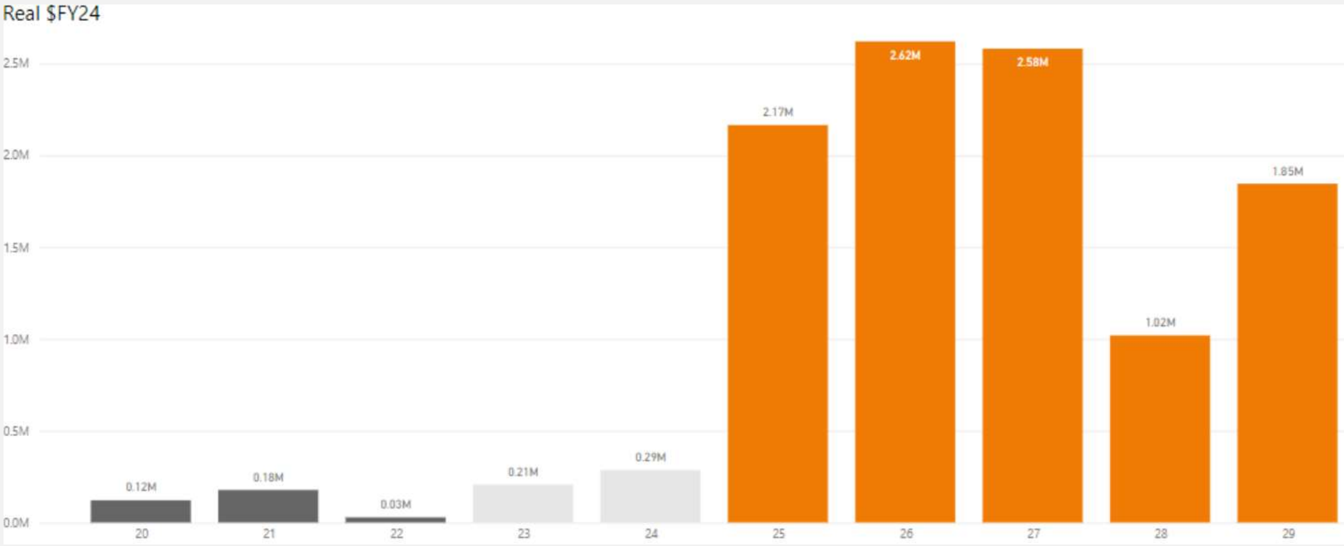
Investment Options

1. OBID replacement expenditure has been modelled on a replace with current standard (composite) 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.

- 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 asset elements with different types or materials; or replacement of a feeder segment by a non-network solution. To maximise value achieved in replacing assets, consideration of concurrent replacement of adjacent and/or related assets as part of a bundled project.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for Zone Substation Outdoor Busbars across the 2024-29 period is $10.2M, averaging $2M per annum. Actual/forecast expenditure for 19-24 period is $0.8M, well under the allocation.



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

The major benefits from the proposed Zone Substation Outdoor Busbars, Isolators & Disconnectors investments (against the **change nothing** scenario) are:

- **Improved network risk and maintainability**: Investment in this asset class will reduce network risk through replacement of OBID of degraded condition and/or in high risk locations with more resilient materials of acceptable condition; and
- **Maintained service level outcomes:** management of asset health will result in better control of unplanned failures thus will maintain network reliability.

Forecast Zone Substation Outdoor Busbar, Isolators & Disconnectors Repex expenditure for the 2024-29 period is $10.2M. The increase from 2019-24 actual/forecast of $0.8M (and decrease from allocation of approximately $14.6M) is due to:

- Risk and probabilistic modelling improvements since the 2019-2024 regulatory submission has allowed for this asset class to be evaluated as part of portfolio risk optimisation;
- Volume increase to address the inherent risks and age of this asset class identified during developed of the asset class strategy.

Key Assumptions

- **Attribution of tasks to specific assets** was not possible in general. To approximate an age at task date for replacements, modelling assumed an installation date for the replaced asset equivalent.
- **Categorisation of task maintenance activity** was performed in a task code mapping spreadsheet. Tasks were categorised (Replace, Repair, Inspect, Install, Modify) based off their task group, task description, and cause description. The 'Replace' category was reserved for replacement of an entire assembly, with minor component replacements being categorised as 'Repair'.
- **Age profile** was determined using the asset installation date where available. Where this information was not available the Zone Substation age was used, however due to incomplete Zone Substation age data, some assumptions were made for sites without this information.
- **Development of Weibull Parameters** occurred through fitting within Power BI, relying on user-selected filtering and censoring of the categorised data (tasks and in-service asset ages). Adjustment of these selected controls was informed by the calibration process described below. The final Weibull parameters were based on analysis of all Replace tasks with no censoring applied.
- **Calibration of Weibull Parameters** was achieved by comparing failures predicted in 2020 by a given set of Weibull parameters to historical failures recorded in the Failure Database between 2016-2019.
- **Consequence models** were developed in accordance with **6.03.03 Appraisal Value Framework**.
- **Historical cost of managing assets was estimated**. Due to incomplete information captured on current spends of assets included in this strategy, historical data was used from the Regulatory Period 2015-2019. The actual accrued costs by activity type were not available for analysis as part of this strategy. Instead SME input used to amend values from the historical data. This does not take into account costs for different activity types (e.g. maintenance vs inspection), but rather has assumptions on the costs based on the asset type.

Lifecycle Stages

Strategic Direction

Acquisition

Selection Criteria
- Air Break Switches: Maintain current selection criteria.
- Isolators: Maintain current selection criteria.
- Fault Throwers: Maintain current selection criteria.
- Links: Maintain current selection criteria.

Maintain awareness of alternate supplier designs and trial where commercially and technically viable.

Investigate viability of replacing failures with gas switches where applicable.

Procurement
- Continue to replace insulators with glass/porcelain as the primary insulating material, with composite polymer insulators.
- Continue the current period contract approach with vendors.
- Maintain awareness of obsolescence issues and availability of critical components.

Supply Chain
- Continue to work with suppliers for new product opportunities.
- Continue to maintain catalogue options for ZS isolators and disconnectors from multiple suppliers, to maintain diversity of supply.

Ops & Maintenance

Preventative Maintenance (Inspections):
- Continue to use bird proofing, fauna guard installation and redesigning of busbars, insulators and isolators to minimise the risk of failures due to bird and vermin strike.
- Continue to do visual inspections to detect signs of surface tracking and loose / broken assets
- Continue with Partial Discharge and Thermographic testing to identify potential failures before reaching critical point
- Continue to inspect assets as per *CEOP8011 Substation Inspection:*
  - Routine Inspection High Risk Sites – 1 month intervals
  - Routine Inspection Medium Risk Sites – 2 month intervals
  - Routine Inspection Low Risk Sites – 3 month intervals

  Thermographic Survey – 1 year interval
  Partial Discharge Survey – 1 year interval

Corrective Maintenance (Repairs):
- Remove the root cause of insulation failures due to mechanical issues by tuning mechanisms and readjusting the alignment of contacts.
- Continue on-condition corrective maintenance where financially viable and spares readily available.

Breakdown Maintenance:
- Continue to carry out breakdown maintenance on zone substation outdoor busbars, isolators and disconnector assets with an economic viability assessment of repair or replacement. Larger investments will undergo and require demonstration of a positive value calculation.

Interventions

Replacement Programs
- 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.
- Update *CEOP8032 Transmission and Zone Substation Design Guidelines* to include design recommendations for indoor switchboards when outdoor switchgear need to be replaced (environmental damage outdoors).

Disposals

Individual Assets
- Continue to investigate opportunities to re-use and recycle assets in accordance with *CECP8074.*
- Continue to dispose of assets as per *CECP8074.01 Company Policy Asset Disposal.*

Entire Asset Variant
- Continue to dispose of assets as per *CECP8074.01 Company Policy Asset Disposal.*

Hazardous Materials
- Continue to manage hazardous materials in accordance with *CECM1000.10.*

Asset Support

Process & Information
- Improve use of EAM as the central repository of asset information, preventative and corrective actions and test results.
- Create records for busbars and their failures to capture asset profile.
- Enhance asset risk-value assessments leveraging capabilities of new and existing software platforms.
- Continue to follow *CEOM7074 Operational Manual: Entry into electrical stations* for safety directions for employees working in Zone Substations.

People & Training
- Continue with other current training practices, including awareness of fall-zones for operating Zone Substation isolators and disconnector assets.
- Continue to manage knowledge and skills regarding significant repairs.

Supply Chain
- Continue to manage spares for unsupported ZS Isolators and disconnector assets.