Overhead Links, Switches & Fuses Investment Case

Overhead Links, Switches and Fuses (OH Switchgear) provide isolation and connection of OH network segments as required by maintenance, load distribution and fault conditions. The Asset Class is a major contributor to cost, risk and performance particularly in the Network Risk component.
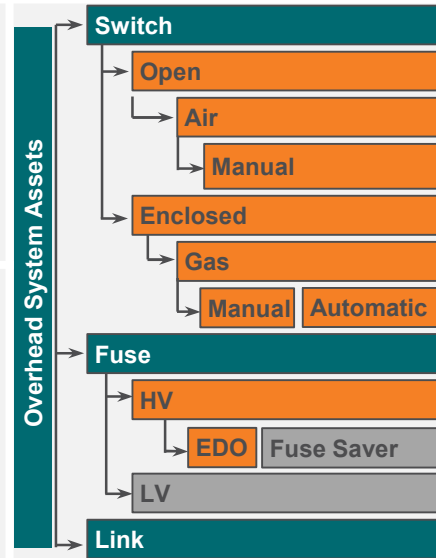
Scope

This investment case addresses OH Switchgear including Gas switches, Air Break Switches (ABS), LV and HV Links, and Expulsion Drop Out Fuses.

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 OH Switchgear forecast accounts for **1.89%** of the total Repex portfolio for FY25 to FY29.

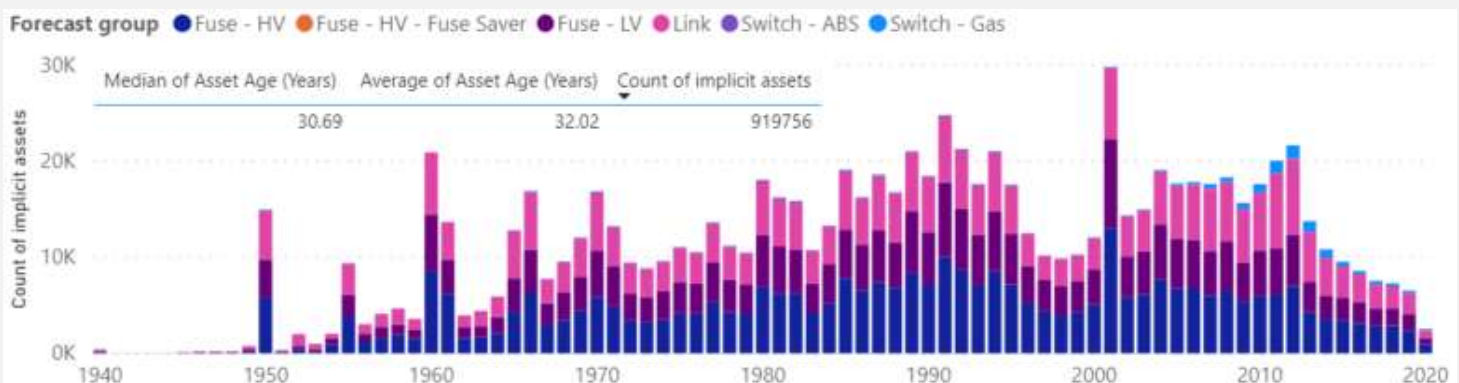| FY25	FY26	FY27	FY28	FY29
$4.1M	$4.3M	$4.3M	$4.3M	$4.3M

Asset Profile/Health

Asset Profile

Essential Energy's network includes approximately 920,000 OH Switchgear assets recorded either directly or implicitly through association with reactor, recloser, regulator, sectionaliser, or substation sites. Such implicit assets were assumed to have the same age as their explicit site. Note that sites often include multiple assets, counted separately for each phase in the case of links and fuses.

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

Forecast Group	Assets
Fuse - HV	352,757
Fuse – HV Fuse Saver	59*
Fuse - LV	260,624*
Link	290,060
Switch - ABS	4,344
Switch - Gas	11,912
Total	**919,756**

Risk Analysis

This section provides an overview of the OH Switchgear 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.
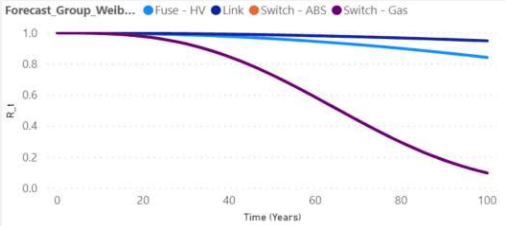
Probability of Failure (PoF)

Failure modes for OH Switchgear have been identified through a Failure Mode Effects Analysis (FMEA) with subsequent analysis focusing only on those failure modes with asset life ending consequence. Detail on the development and assumptions in the PoF Model are captured on Page 3 of this RMS. The resulting Weibull parameters are shown below.
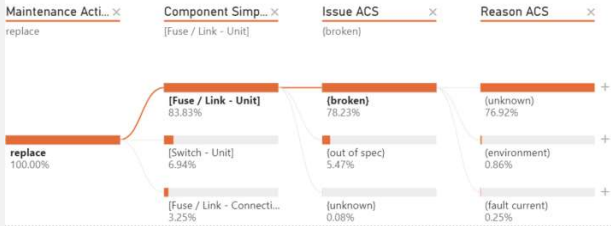
Analysis of historical Failure Database data from 2016 – 2019 identified 2,029 asset failures, the majority of which were attributable to HV Fuses. The component, issue, and reason for asset tasks were in general difficult to determine, due to lack of clarity in the dominant task and cause descriptions. An example is the lack of distinction between fuses and links in the descriptions, coupled with the task being raised against a Pole ID which may host multiple fuses and links. To overcome these issues SME input was utilised along with aggregation of failure modes across sub asset types to calculate Weibull parameters. Weibull parameters used in the risk model are shown below.

Weibull Parameters and reliability plot

PoF Model	Alpha	Beta
Switch - ABS	74.7	2.9
Switch - Gas	74.7	2.9
Link	416.8	2.1
Fuse - HV	223.2	2.2

Breakdown of tasks

Consequence of Failure (CoF)

The consequence of failure for an OH Switchgear asset describes the impact of a functional failure.

Consequences have been evaluated using the 6.03.03 Appraisal Value Framework. Consequence costs are dominated by Network costs.

Component	Total ($ billion)	Average ($ per asset)	Median ($ per asset)
Network	5.4	8,262	3,357.80
Safety	0.2	255	100.19
Environment	0.0	0.01	0.00
Bushfire	0.8	1,184	102.20
Financial	1.2	1,899	1,372.00

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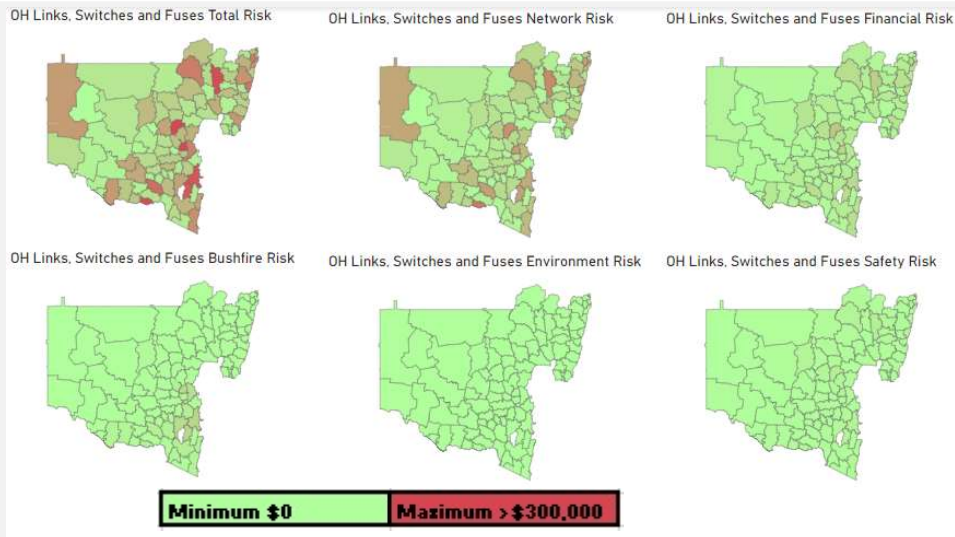
Model outputs have been calibrated against top-down performance figures. The table opposite compares the unscaled model outputs with the monetised top-down performance. For implementation, scaling factors are applied to risk model outputs, to align risk forecasts with realised performance.

Value Measure	Safety	Network	Bushfire	Financial	Total
Unscaled Model Outputs ($M)	0.3	8.2	1.2	1.9	11.5
Top-Down Performance ($M)	0.5	2.5	0.9	1.5	8.5

Risk Analysis

Risk Heatmap (Scaled)

The figure opposite displays the breakdown of the total (residual) risk for OH Links Switches and Fuses by depot area*. The primary differentiators of risk for these assets are the Network and Financial consequences, with remote radial fed sub-transmission assets having the highest Network consequence cost, alongside poles in high consequence bushfire areas.

* As of August 2022

OH Links, Switches and Fuses Total Risk
OH Links, Switches and Fuses Network Risk
OH Links, Switches and Fuses Financial Risk
OH Links, Switches and Fuses Bushfire Risk
OH Links, Switches and Fuses Environment Risk
OH Links, Switches and Fuses Safety Risk

Minimum $0   Maximum > $300,000

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 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 OH Switchgear consist of:

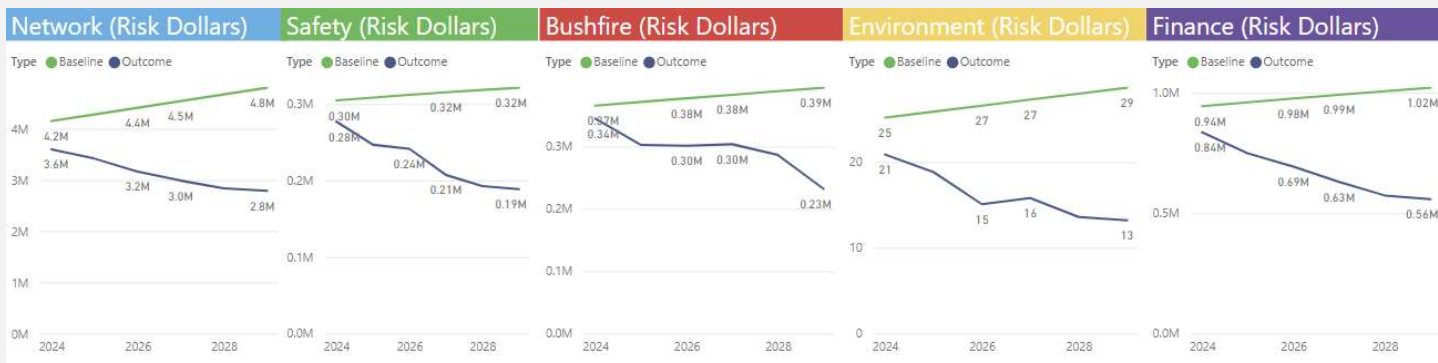1. Optimised risk-based replacements to maintain overall network risk values within defined objectives.

The above asset interventions utilise a probabilistic approach that has been developed through detailed analysis of historical asset performance to establish Weibull parameters (refer 6.03.03.07).

Forecast investment expenditure has been determined by multiplying the forecast replacement quantities of OH Services 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
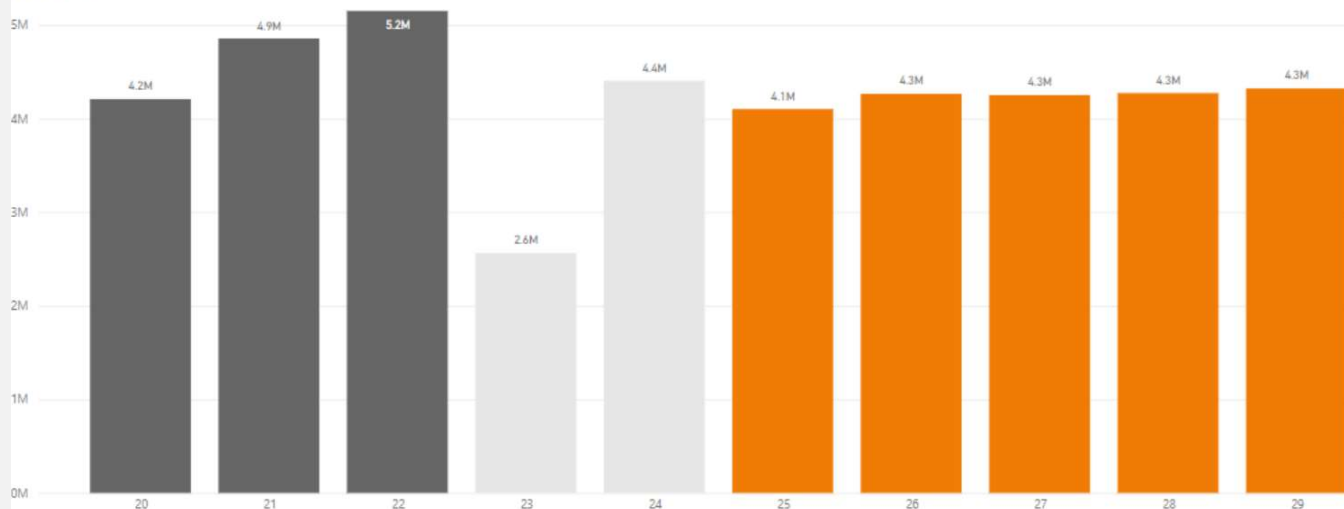
Risk Trend (2024-29 Optimised portfolio)

Over the 5 year regulatory window, total **baseline** monetised risk due to **functional** OH Switchgear failure is estimated to increase to $6.5M by 2030. The figure below depicts the **baseline** scenario and investment **outcomes** ($3.8M) of the optimised program for OH Switchgear.

Grouping

The OH Switchgear assets have been grouped into two 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;
2. **Functional** failure replacement - where the OH Switchgear is no longer able to perform its function due to damage and requires immediate replacement.

• 260,556 asset groups were loaded into 186 investments in Copperleaf to provide flexibility in portfolio optimisation

Investment Options

1. OH Switchgear replacement expenditure has been modelled on a replace with current standard 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.

• Non-network solutions are not considered when planning the replacement of this asset class.

Assumptions

• Attribution of tasks to specific assets was not possible in general. They are raised against a pole which may have many link / fuse assets or (in rarer cases) none. To approximate an age at task date for replacements, modelling assumed an installation date for the replaced asset equivalent to the installation date for the oldest OH Switchgear related asset present on the pole.
• 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 such as fuse cartridges being categorised as 'Repair'.
• 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). The Weibull parameters were based on analysis of all Replace tasks with no censoring applied. Due to the high volume of assets and tasks, particularly for links and fuses, random data sampling was used to accommodate the 150,000 row limit on the reliability fitting visuals. Each forecast group was calculated separately, allowing 150,000 rows per forecast group.
• 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.

Forecast replacement expenditure for Overhead Switchgear across the 2024-29 period is $21M, averaging $4.2M per annum. Actual/forecast expenditure for 19-24 period is $21M.

Real $FY24

Data source: Actuals: Internal delivery reports, Forecasts: Copperleaf
Note: All values are in FY2023-24 real dollar terms

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 include: maintaining present reliability levels for our customers; maintaining safety incidents at or below present levels; and reducing unassisted fire starts; and
- **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**: 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 OH Switchgear 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 Overhead Switchgear Repex expenditure for the 2024-29 period is $21M with no change from 2019-24 actual/forecast of $21M.

We shall

Strategic Direction

Acquisition

Selection Criteria

Fuses:
- Review potential use of spark-free fuses if bushfire consequence value is increased in future revisions of the Appraisal Value Framework.

Links:
- Maintain current selection criteria

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

Procurement
Refine estimates of annual usage of OH Switchgear assets using asset risk models, to provide greater clarity on internal cost allocation and greater certainty to suppliers (providing pathways to negotiation of reduced supply costs).

Supply Chain
Continue to work with EDO and link suppliers for new product opportunities, including spark free and spark less fuses.

Continue to maintain catalogue options for gas switches from multiple suppliers, to maintain diversity of supply.

Stock holdings:
Maintain current stock holding practices.

Ops & Maintenance

Preventative Maintenance (Inspections):
Continue to perform periodic inspections to identify failed or defective assets in accordance with *CEOM7005*.

Continue to visually check OH Switchgear prior to operation and include in HIRAC safety and risk measures during switching events.

Corrective Maintenance (Repairs):
Continue to manage OH switchgear defects in accordance with *CEOM7094 and CEOM7005*.

Breakdown Maintenance:
Continue to carry out breakdown maintenance on OH Switchgear assets in accordance with *CEOM7094 and CEOM7005*.

Interventions

Serviceability
Continue to assess and rectify asset serviceability in accordance with *CEOM7092*

Rate of Replacement

Air break switches:
- Maintain replacements on failure or if optimal replacement time is reached

Gas switches:
- Maintain replacements on failure or if optimal replacement time is reached
- Review the usage of smart, remotely operated switches as standard replacement.

Fuses & Links:
- Asses replacement of assets which are not the current standard (e.g. ceramic type) if field staff are on site for a related capital works activity and travel / de-energisation costs can be eliminated through bundling.

Prioritisation
Continue to prioritise replacements of switchgear by severity and risk in accordance with *CEOM7005*.

Reducing complexity
Reinforce and expand existing guidelines in *CEOM7092* detailing when to replace a switch with a link, or to remove an OH Switchgear function entirely, to enable further network simplification.

Continue to replace air break switches with alternatives, predominantly enclosed switches, based on criteria in *CEOM7092*.

Disposals

Individual Assets or Entire Asset Variants
Continue to investigate opportunities to re-use and recycle assets in accordance with *CECP8074*.

Hazardous Materials
Continue to manage hazardous materials including SF6 from enclosed switches in accordance with *CECM1000.10 and CECM1000.10d*.

Asset Support

Process & Information
Create individual records for OH Switchgear assets in the EAM system, so that work tasks can be raised against them directly. Adjust work practices accordingly to ensure that work being carried out on this asset class is captured accurately.

People & Training
Introduce SF6 hazardous material awareness training for field staff with potential for exposure on the OH network through gas switches.
Continue with current training practices, including awareness of fall-zones for operating OH Switchgear.