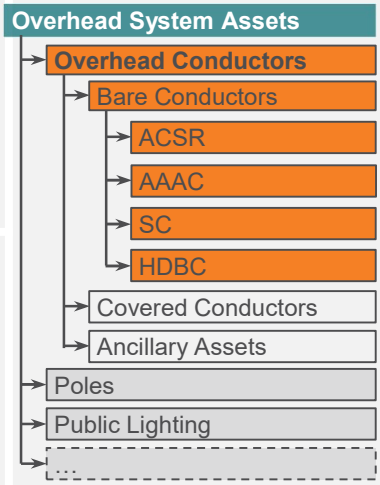
Overhead Conductor Investment Case

Overhead Conductors (OHC) are one of the most visible asset classes across Essential Energy's network and a major contributor to cost, risk and performance. The primary function of conductors, as well as associated fittings and hardware, is the transfer of electrical energy. As such, conductors are live, i.e. energised at between 240V and 132,000V, and the clearance between the conductors or equipment and other objects must be maintained in order to avoid inadvertent contact or unintentional discharge of electricity or bushfire start. Secondly, the continuity of conductor systems is essential to ensure electrical supply, and a break in continuity is likely to mean a loss of supply to customers.

Scope

This investment case for Overhead Conductors, ties, connections to directly support their installation, safety, and maintainability.

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 Overhead Conductor forecast accounts for **3.84%** of the total Repex portfolio for FY25 to FY29.

FY25	FY26	FY27	FY28	FY29
$8.5M	$8.5M	$8.8M	$8.6M	$8.6M

Asset Profile/Health

Asset Profile

Essential Energy network comprises of ~184,500 km of OHC (primarily of five types):

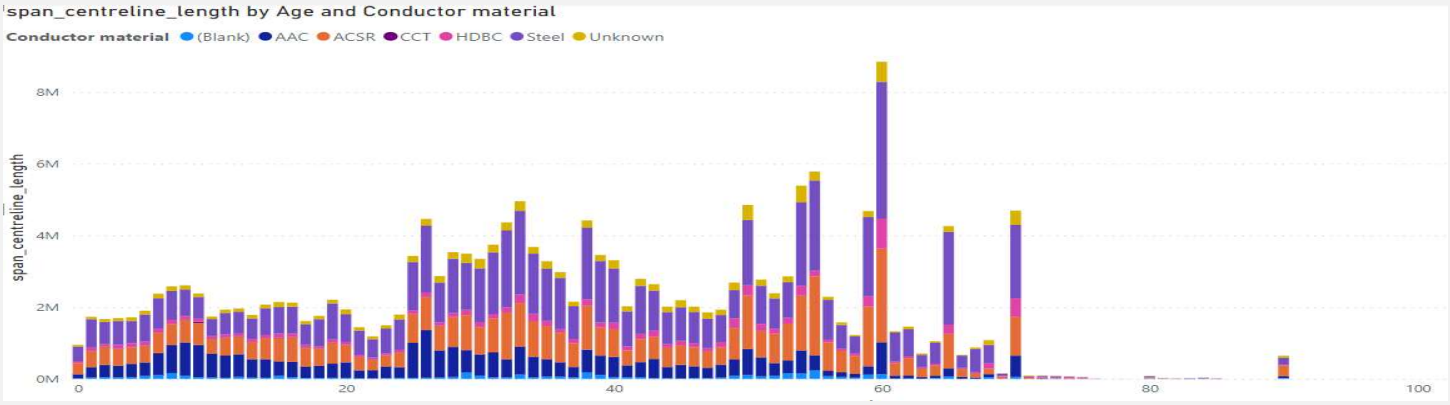
- Steel Conductor (SC, including SC/GZ or SC/AC, 42.2%),
- Aluminium Conductor Steel Reinforced (ACSR, 27.3%),
- Aluminium and Aluminium-Alloy Conductors (AAC and AAAC, collectively 16.9%),
- Hard Drawn Copper Conductor (HDBC, 5.2%), legacy conductor type which will be replaced by ACSR and SC.
- 8% approx. of conductors are uncertain

Material selection is driven by design requirements based on geographical factors (e.g. distance from coast and length of span), current load carrying capacity and financial constraints.

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

The figure and tables show the conductor asset profile by material type, nominal length and age.

Conductor material	span_centreline_length	%GT span_centreline_length	Average of Age
Steel	78028644	42.26%	38.86
ACSR	50391617	27.29%	38.06
AAC	31245193	16.92%	32.82
Unknown	10875099	5.89%	38.95
HDBC	9615423	5.21%	40.90
	4257834	2.31%	36.04
Total	**184658976**	**100.00%**	**37.16**



Risk Analysis

This section provides an overview of the OHC 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)

The failure modes for OHC have been identified through the Failure Mode Effects Analysis (FMEA) with subsequent analysis focusing only on those failure modes that can lead to a functional failure. Analysis of historical data resulted in differentiating this asset class by sub-conductor type and distance to coast for PoF modelling.

The OHC risk model currently in use was calibrated using "unassisted" probabilities of failure. Weibull parameters used in the risk model are shown on the right.

Weibull Unassisted Functional Failure Parameters

Conductor	Coastal dist. (km)	5	10	20	>30
ACSR	α	160	190	200	200
	β	1.87	1.6	1.6	1.6
HDBC	α	95	120	120	120
	β	1.3	1.3	1.3	1.3
Streel	α	80	160	160	160
	β	1.8	1.5	1.5	1.5
AAC	α	160	216	216	174
	β	1.55	1.47	1.47	1.55

Consequence of Failure (CoF)

The consequence from failure of OHC describes the impact of a functional failure.

Consequences have been evaluated using the 6.03.03 Appraisal Value Framework.

The consequence categories have been ranked based on consequence cost assuming all conductor, in the network will fail (i.e. Total Consequence).

The primary differentiator of criticality for conductors is the Network consequence. Radial fed sub-transmission OHC the highest consequence.

Event Trees combining the likelihood of consequence and cost of consequence have been developed at an individual asset level to determine the key contributors to consequence criticality associated with each asset. The OHC consequence modelling has been developed using a combination of data where available and Subject Matter Expert (SME) elicitation where insufficient data was available.

Value Measure	Consequence		
	Total $B	Average ($ per asset)	Median ($ per asset)
Network	$66.6	$43.9k	$7.7k
Safety	$7.6	$5.0k	$5.9k
Bushfire	$7.3	$4.8k	$0.5k
Environment	$0.05	$0	$0
Financial	$6.9	$4.6k	$3.7k

Risk Calibration

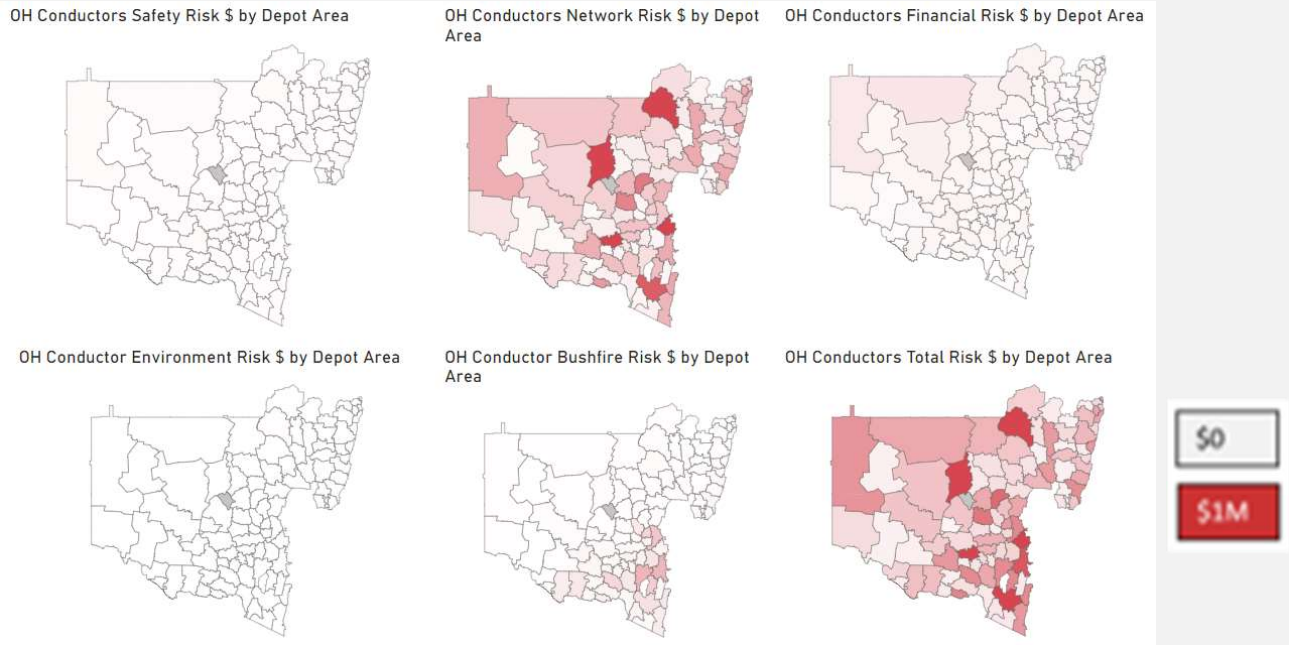
Asset risk is calculated by applying the PoF and CoF models to individual assets. Asset risk is then aggregated to the total population level to determine the asset class risk.

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	Bushfire	Financial	Total
Unscaled Model Outputs ($M)	2.7	23.2	2.5	2.8	31.1
Top-Down Performance ($M)	0.8	17.3	3.1	2.5	23.79

Risk Heatmap (Scaled)

The figure opposite displays the breakdown of the (residual) risk for OH Conductors by depot area and value measure. The primary differentiators of risk for OH Conductors are the Network and Bushfire consequences, with remote radial fed sub-transmission poles having the highest Network consequence cost, alongside poles in high consequence bushfire areas.



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 OHC consists 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.

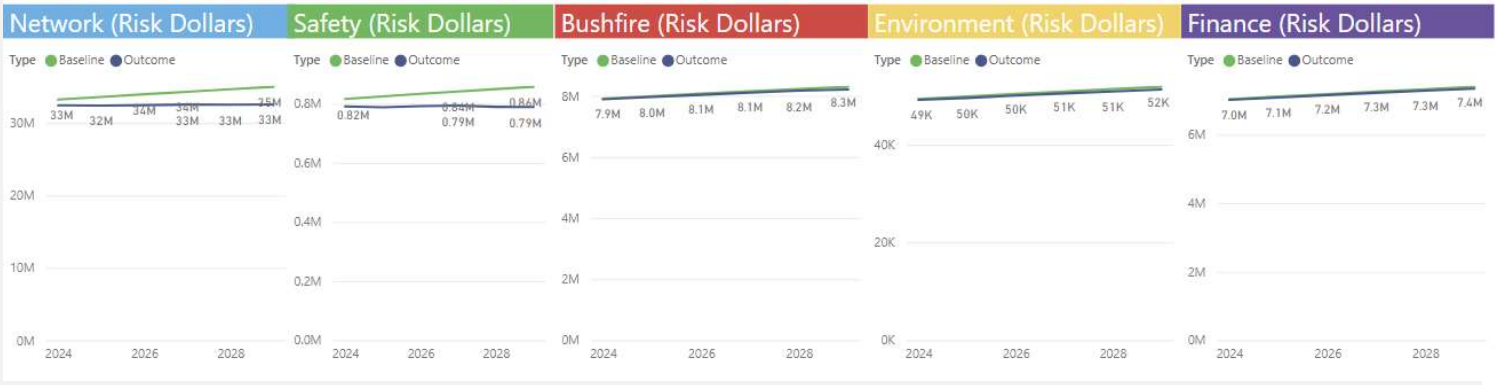
Forecast investment expenditure has been determined by multiplying the forecast replacement quantities of OHC assets by applicable unit rates.

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** OHC failure is estimated to increase to $52.7M by 2030. The figure below depicts the **baseline** scenario and investment **outcomes** ($49.8M) of the optimised program for OHC.



Asset Grouping

The OHC 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 OHC is no longer able to perform its function due to damage and requires immediate replacement.

- 38,707 asset groups were loaded into 720 investments in Copperleaf to provide flexibility in portfolio optimisation.

Options

1. OHC replacement expenditure has been modelled on a replace with like-for-like, except for Hard Drawn Copper Conductors . These are a legacy material and will be replaced by Aluminium Conductor Steel Reinforced or Steel Conductor.
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 considered when planning the replacement of a specific asset.
- 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 OHC elements with different types or materials; or replacement of a feeder segment by a non-network solution.

Key Assumptions

Probability of Failure

- Probability of Failure Weibull parameters generated using survival analysis of historical data from 2015-2019 with an adjustment made to address missing failure data

Consequence of Failure

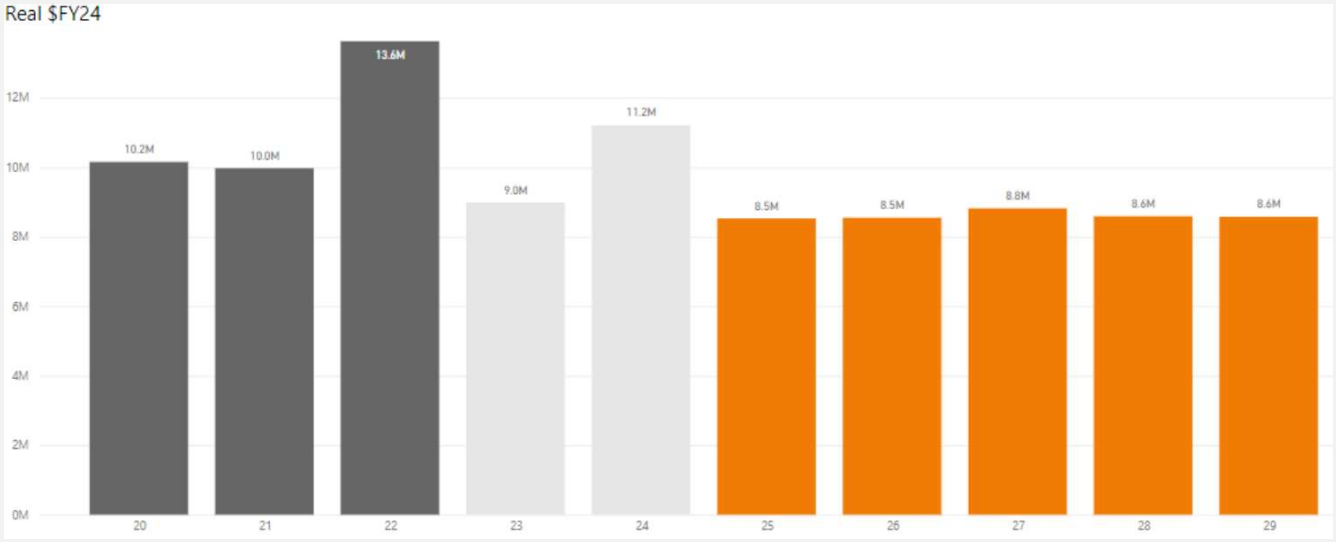
- Developed in accordance with 6.03.03 Appraisal Value Framework

Risk Calculation

- Application of scaling factors for Safety, Network and Bushfire risk in line with actual performance data where available, in conjunction with SME input.

10 Year Replacement Capex Forecast

Forecast replacement expenditure for Overhead Conductor across the 2024-29 period is $43.1M, averaging $8.6M per annum. Actual and projected expenditure for the remainder of the 19-24 period is $54M.



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.
- **Critical Environmental Factors:** Risk associated with OHC due to factors such as geography and climate. This investment will provide the ability to replace conductors with appropriate materials based on environment, or consider alternative solutions such as undergrounding, or non-network solutions.
- **Customer needs:** Through customer engagement, refer Chapter 4 of our Regulatory Proposal, customers indicated a desire to maintain current levels of safety and reliability, and increase expenditure for resilience based projects. This asset class does not explicitly have expenditure related to resilience and therefore has a flat forecast for replacements. The investment will contribute to maintaining safety and reliability, within the wider Repex portfolio (as per copperleaf forecast).

The major benefits from the proposed OHC investments (against the **change nothing** scenario) are:

- **Improved network risk and maintainability**: Investment in this asset class will reduce network risk through replacement of OHC 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 Overhead Conductor Repex expenditure for the 2024-29 period is $43.1M. The reduction from 2019-24 actual/forecast of $54M is due to:

- Reduced volume of overall conductor replaced due to focus on high risk areas (through optimisation process) and some additional undergrounding

.

Strategic Direction

We shall:

Acquisition

Selection Criteria

Continue to select conductor and fitting specifications for new installations as per relevant guidelines (CEOM7097, CEOM7081 and overhead distribution and sub-transmission construction manuals), in the short term.

Continue to drive replacement decisions by lab testing results on the remaining strength on conductors.

Prioritise replacement of non-compliant legacy installations (material type and location) with recommended alternatives by assessing the risk trade-off, in the short and medium term.

Procurement

Continue to utilise current procurement function for depots request conductors.

Investigate opportunities to forecast procurement volumes based on population risk.

Conductor stock holdings

Continue to hold stock at all depots and larger stockpile at the warehouses, and 20% of Essential Energy's annual demand (based on historical usage) at the suppliers in the short term.

Review stock holdings at the warehouses and suppliers based on the projected asset demand from the risk model.

Ops & Maintenance

Preventative Maintenance (Inspections)

Continue to perform defect identification and categorisation as per CEOP2446 and CEOM7005 in the short term (inspection interval at 4.5 years).

Investigate opportunities to review inspection intervals and enhance inspection techniques for high risk segments, preferably with measurable outcomes.

Investigate opportunities to utilise systems (e.g. DAM) to enhance collection of conductor attribute (type, age) and condition data to inform conditional probability of failure models, in the medium term.

Corrective and Breakdown Maintenance

Continue to perform corrective maintenance and breakdown repairs as per the relevant guidelines (CEOM7094, CEOM7005, CEOP2446 and NAHC) in the short term.

Investigate opportunities to forecast quarterly maintenance and resource demand in the medium term, by combining conductor condition data with probability of failure models.

Interventions

Serviceability

Continue to determine threshold for conductor serviceability by network improvement requests, fault reporting, feeder studies, demand issues, in the short term.

Replace unserviceable OHC, including adjacent conductor fittings/ancillaries, as per the relevant guidelines (CEOP7097, CEOM7081, CEOM7094, CEOM7005, CEOP2446, NAHC),

Disposals

Hazardous Materials

N/A for conductors.

Entire Asset Variant

Develop disposal plan, in the short term, for legacy conductor variants (as per CEOP8074), to ensure support systems and data are appropriately managed out of service.

Investigate opportunities to retire legacy conductor variants in the medium term.

Individual Assets

Continue to dispose conductor segments (as per CEOP8074), and gather revenue awarded from metal recycling.

Asset Support

Process & Information

Continue to remediate gaps in asset performance data (e.g. attributes, condition and failures) and leverage the EAM system upgrade to address inaccuracies & inconsistencies.

Introduce the functionality in EAM to record conductor segments as unique assets and accurately capture location of failures (with the associated remedial efforts/costs).

Investigate opportunities to link safety, fire-start and reliability events to unique conductor segments in the EAM system, in the medium term.

Investigate opportunities to incorporate OHC risk models and databases interfaces in Power Lines Pro, in the medium term.

People & Training

Investigate opportunities to align future personnel training program with the demand forecast in undertaking conductor maintenance.

Supply Chain

Investigate opportunities to mitigate potential supply chain risk by implementing demand forecasting and inventory allowance tools using asset risk models.