Overhead Network System Strategy Executive Summary

Current State

Purpose

The purpose of the System Strategy is to outline a 10-year strategy for a discrete asset system. It provides a description of the investment, performance, key risks and intervention strategies associated with the asset system. The strategy also describes how the system is managed to achieve the network objectives and Endeavour Energy's key goals.

Context

Our regulatory asset base (RAB) is managed via discrete asset systems and subsequent classes within each system. The Overhead Network has a population of 1.90 million assets making up 67% of the total asset count across the RAB. Assets within the Overhead Network contribute 56% of the BAU risk across the RAB. This system strategy covers Endeavour Energy's overhead network assets. The Overhead Network assets include the following classes.

- Structures
- Switchgear
- Services
- Pole Top Assemblies
- Conductors
- Public Lighting

Current Practice

Management of the Overhead Network is driven by achieving the Overhead Network Objectives. Historic asset performance data is utilised to quantify current performance of the asset fleet against the Overhead Network performance targets. Historic failure data is utilised to inform the quantification of current and forecast asset risk. Risk is quantified in categories which are aligned to the Overhead Network Objectives. Intervention options are then assessed and selected based on their NPV and effectiveness in addressing the asset risk categories, Network Objectives and Overhead System Objectives. Constraints are applied to optimise the list of proposed interventions. Ongoing monitoring of performance trends is undertaken to confirm effectiveness of proposed interventions and alignment with Network Objectives

Proposed Strategy

Targets

Performance targets for the Overhead Network are categorised as safety, reliability and bushfire. Specific performance targets include;

- Reduce 5-year rolling average of total incidents (excluding general hazards)
- Reduce 5-year rolling average of customer minutes interrupted
- Reduce 5-year rolling average of fire starts

Strategy Options

To achieve performance targets and mitigate asset risk a range of intervention options have been considered including the below.

- Operational Controls
- Reduced Load
- Non-network
- Additional maintenance
- Reactive repair/ replacement
- Staged removal / Replacement

Strategy Selection

A combination of reactive repair/replacement and risk based interventions are the preferred options for both asset classes. Risk based intervention does not provide sufficient value for public lighting or service mains.

The strategies presented in this report include:

- BAU
- Risk Based

1. Baseline – Business as usual (BAU).
2. Unconstrained – Inclusive of BAU plus risk based investments identified when they reach their maximum NPV (Risk Based).
3. Optimised – Inclusive of BAU plus unconstrained investments with all constraints and comparisons to other potential investments applied.

- Structures
- Switchgear
- Services
- Pole Top Assemblies
- Conductors
- Public Lighting

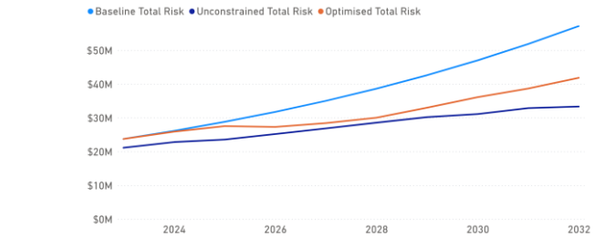
Forecast Outcomes

Performance Forecast

Risk Forecast

Over the next 10 years, proposed intervention strategies are forecast to mitigate Overhead Network risk as summarised below.

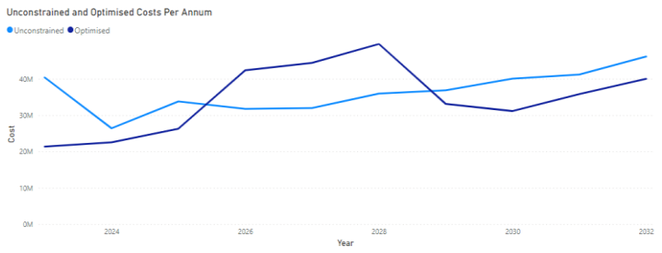
Unconstrained and Constrained Risk per Annum



Cost Forecast

To deliver the proposed Overhead Network intervention strategy, required investment over the next 10 year planning period is summarised below.

Unconstrained and Optimised Costs per Annum



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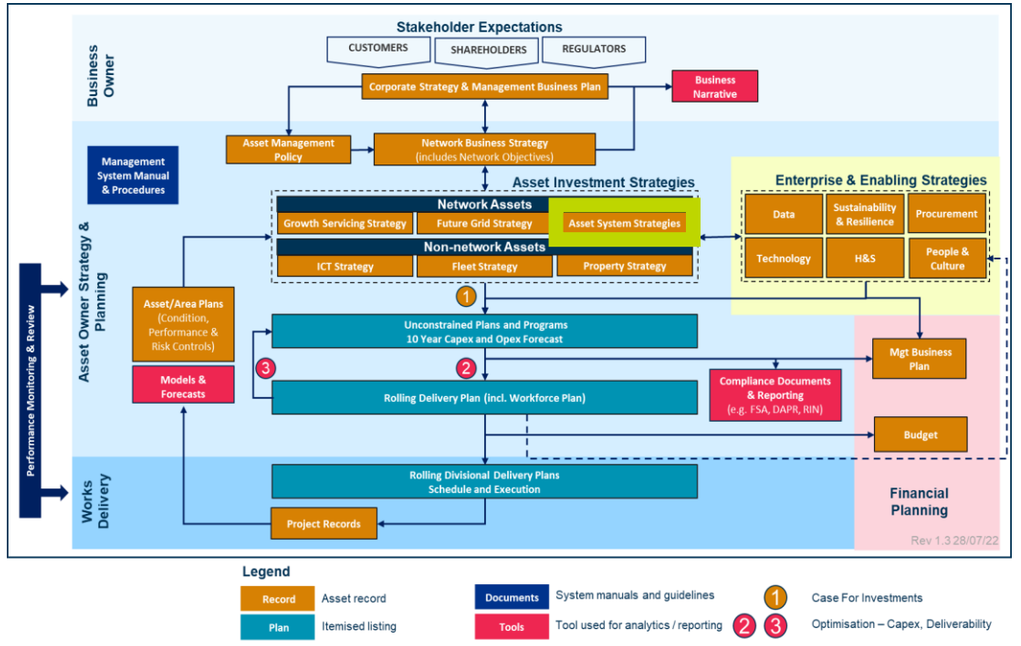
Introduction

Version	Date	Comments
1.0	November 2022	Initial release

The purpose of this document is to outline current and proposed asset management practices for Overhead (OH) Network assets, and define a 10-year strategic plan for the system based on risk and cost. The 10-year plan seeks to use all current knowledge of the system in context with the whole network to establish Key Performance Indicators (KPI) to assist in understanding and monitoring ongoing performance.

The relationship between this System Strategy and other artefacts within the Asset Management Framework (AMF) is illustrated below.

Asset Management Framework



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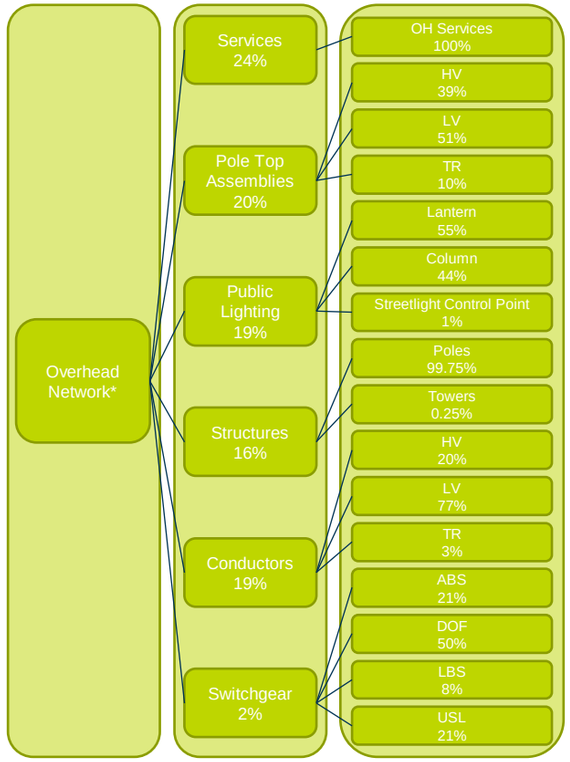
Overview

A 10-year strategy for the Overhead (OH) Network system has been defined, driven by the risk associated with the ageing population of the asset class. The forecasted risk, strategy, cost breakdown, and performance metrics are outlined in this report and include asset classes within the Overhead Network scope. The strategies presented in this report include:

1. Baseline – Business as usual
2. Unconstrained – Inclusive of business as usual plus risk based investments identified when they reach their maximum NPV.
3. Optimised – Inclusive of BAU plus unconstrained investments with all constraints and comparisons to other potential investments applied.

Scope

The Endeavour Energy RAB is managed via discrete systems and subsequent classes within each system. The scope of this document includes the Overhead Network system.



*by asset count

67% Assets within the Overhead Network make up 67% of the **asset count** across the regulated asset base[1].

56% Assets within the Overhead Network make up 56% of the **BAU risk** across the regulated asset base.

61% Assets within the Overhead Network make up 61% of unconstrained **cost** over the next 10 years across the regulated asset base.

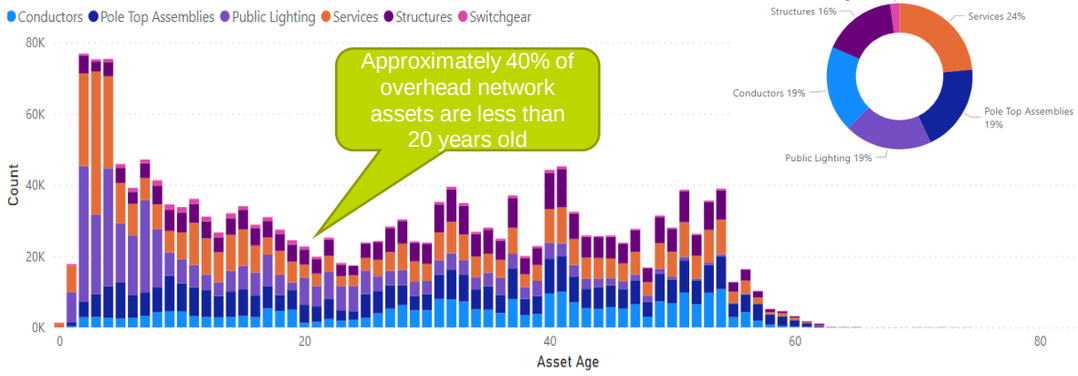
Density of Overhead Assets

Approximately 40% of overhead network assets are located in 3 depots: Hoxton Park, Kings Park, Penrith

LOW
MEDIUM
HIGH

1. *Based on counts of discrete assets per asset class plan breakdowns. Linear assets are counted based on GIS FID.Public lighting assets summarised as "bracket" or "lantern" rather than sub types articulated in the ACP.*

AGE PROFILE



BY ASSET CLASS

Method

Age profile

↓

System Performance Objectives selected in alignment with Network Objectives and historical trends identified

↓

Historical performance data identified for each consequence category

↓

Failure modes identified and probability of failure modelling undertaken

↓

Risk modelling undertaken to determine the quantum of risk relating to each category

↓

Intervention options assessed at system level and asset class level

↓

Economic assessment of intervention options undertaken to identify optimum balance of performance, risk and cost

↓

Future performance forecasts calculated (in development)

↓

Line of sight to Network Objectives to ensure targets are met (in development)

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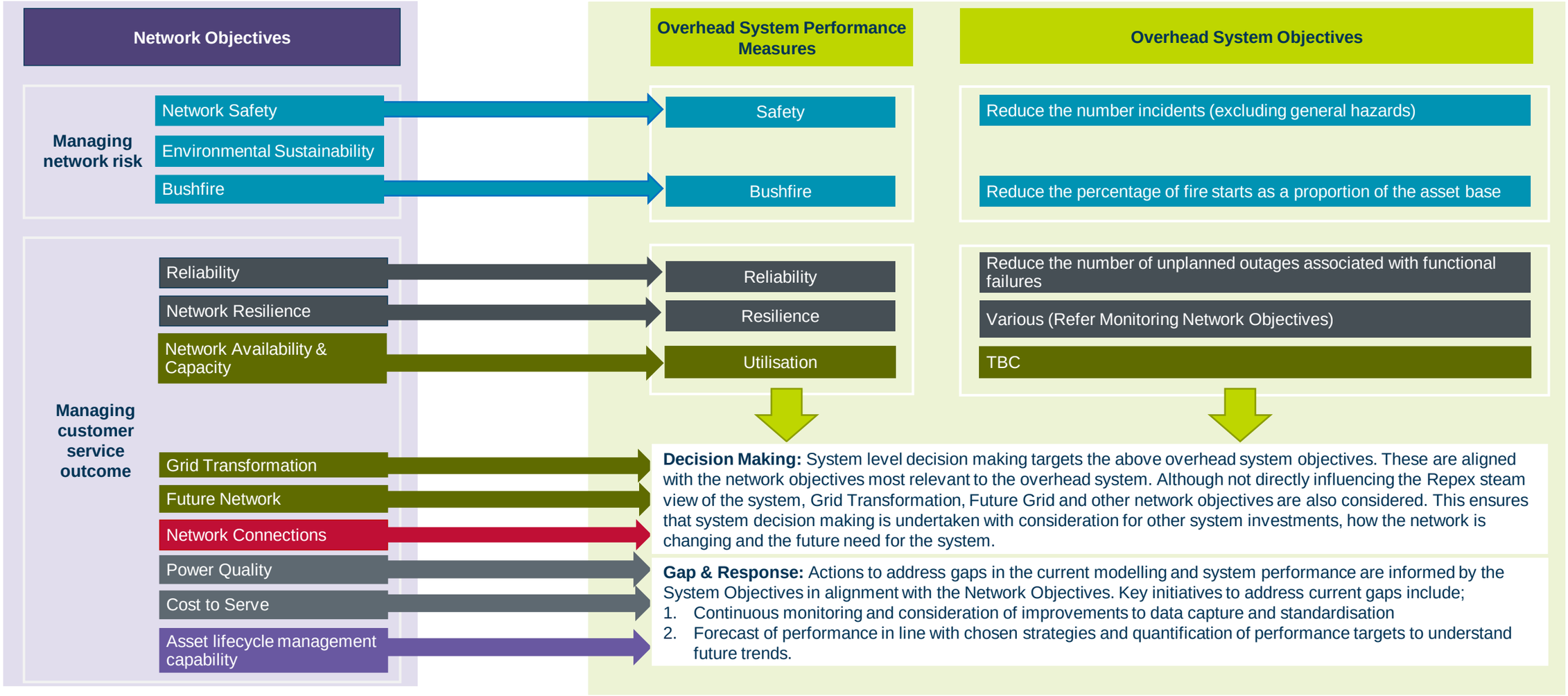
Network Objectives

Twelve network objectives have been identified to drive prudent investments to deliver against customers, shareholders, and regulators' expectations. Monitoring these objectives provides oversight against critical investments themes, allowing Endeavour Energy to manage appropriate trends and levels of investment into the future. As illustrated in the figure below, this System Strategy facilitates line of sight from the Network Objectives to the system performance targets and objectives.



Monitoring Network Objectives

Performance Category	Objective	Performance Measure	Asset Class	Current Performance	Performance Target	Status	Trend *
Utilisation	TBC						TBC
Safety	Reduce the number incidents (excluding general hazards)	5-year rolling average of total incidents (excluding general hazards)	Conductors	1.6	Reduce in line with forecasts	●	—
			Pole Top Assemblies	23.9		●	—
			Public Lighting	17.4		●	▲
			Services	10		●	▼
			Structures	5.8		●	▲
			Switchgear	5.8		●	—
Reliability	Reduce the customers minutes interrupted during unplanned outages associated with unassisted functional failures	5-year rolling average of customer minutes interrupted	Conductors	1.75 M	Reduce in line with forecasts	●	—
			Pole Top Assemblies	2.59 M		●	▼
			Public Lighting	0.88 M		●	▼
			Services	0.11 M		●	▲
			Structures	0.18 M		●	—
			Switchgear	3.78 M		●	—
Resilience	TBC						TBC
Bushfire	Reduce the percentage of fire starts as a proportion of the asset base	5-year rolling average of fire starts	Conductors	4.2	Reduce in line with forecasts	●	—
			Pole Top Assemblies	0.4		●	—
			Services	2.6		●	—
			Structures	2.8		●	▲
			Switchgear	7.8		●	▼

Our response to achieving system performance targets?

- It is noted that only historical trends have been considered to date.
- Across all asset classes, risk based interventions proposed for the overhead system are expected to reduce risk and reliability incidents resulting from the ageing asset fleet.

A main contributor to safety events is pole top assemblies. To further minimise the number of safety incidents continued monitoring and review of performance and risk modelling will be considered across all asset classes. Refined categorisation of safety incident data on MySafe will also be considered.

The largest contributors to reliability events are switchgear and pole top assemblies. 80% of pole top assembly outages are due to defects in HV and LV crossarms and service connections. To further minimise the number of functional failures, pole top assemblies and switchgear will continue to monitor reliability events. Further, a review of data capture and failure root causes across the network will also be considered to ensure failure data is correctly attributed to asset classes.

To target improved system resilience for switchgear, ongoing monitoring of outage impacts to customers will be considered. Development of new KPI's to quantify the impact of automated switching capability will also be considered. To target improved system resilience for structures, combustible poles within bushfire prone areas will be replaced with non-combustible poles.

The largest contributor to fire start events is switchgear. To further minimise controllable bushfire risk, HV OH Switchgear will consider possible improvements in the capture of data associated with actual network fire events (e.g. the comparison of the actual consequence with modelled consequence).

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Performance

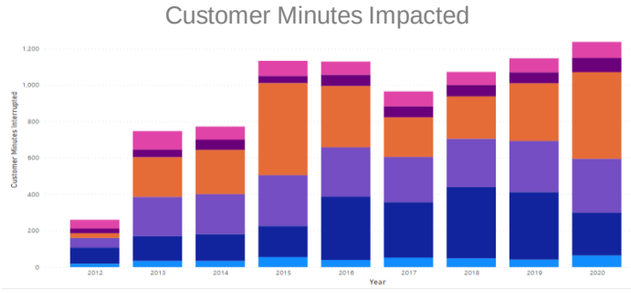
Historical performance of assets over the last 10 years has been used to inform consequence of failure modelling and can be linked to the network objectives to enable the measurement of performance against targets set. Data for safety incidents, reliability outages, bushfire starts, resilience and utilisation is presented to identify the trend of incidents and compare asset class performance.

Safety

- The largest proportion of safety incidents can be attributed to public lighting, however this is driven by general hazards and near misses (90%). Asset classes with the highest number of major injuries are Pole Top Assemblies and Structures (10%).
- Over the last five years, safety incidents have been trending up when considered holistically. This is driven by an increasing trend in general hazards, with spikes in 2017 and 2019. Major and minor injuries have been trending down in this period and near misses have been steady.
- These trends should be monitored to ensure the increase in general hazards does not translate to an increase incident severity and may be a function of improved reporting / visibility.

Reliability

- Outages have been increasing over the last 5 years, with pole top assemblies and services contributing the most customer minutes impacted.

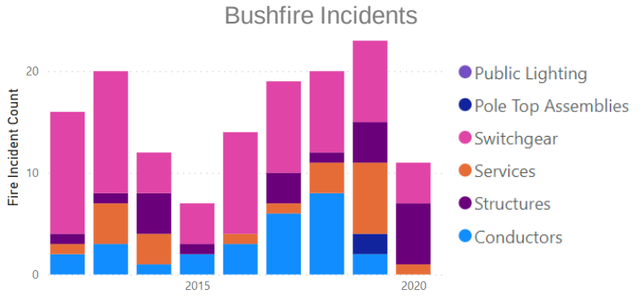


Resilience

Under development

Bushfire

- Count of fire starts (independent of severity) trended up between 2015 and 2019 across all asset classes listed, with switchgear contributing the most incidents.



Utilisation

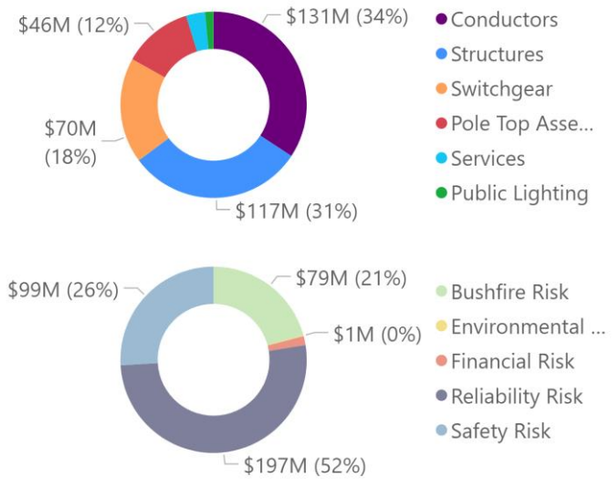
Under development

Risk

Failures of assets within the Overhead Network system may lead to Bushfire, Environmental, Financial, Reliability, and Safety consequences. Risk measures are calculated to quantify these consequences at an asset level as per the current value framework. Endeavour Energy's risk forecast considers two scenarios which are compared to the baseline. The baseline and these two scenarios are defined as following:

Baseline: A risk forecast considering assets are replaced reactively as per the BAU and no planned interventions take place
Unconstrained: A risk forecast considering assets are replaced reactively as per the BAU + identified risk based interventions assuming no business constraints
Optimised: Inclusive of BAU plus unconstrained investments with all constraints and comparisons to other potential investments applied.

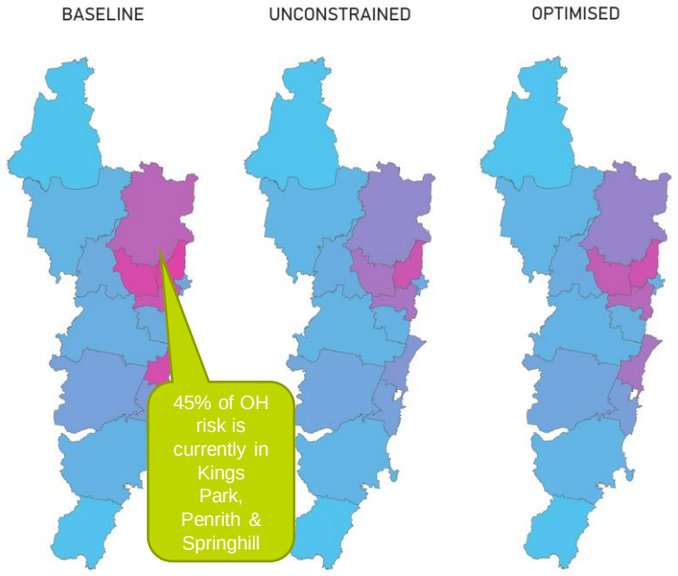
What's driving risk?



The baseline risk associated with the overhead network over the next 10 years is mostly driven by conductors and structures (which include poles and towers), representing over half the total risk.

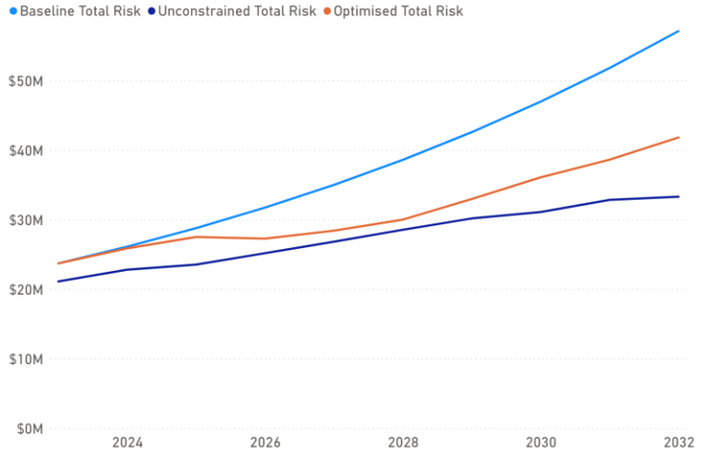
This risk is primarily composed of Reliability and Safety, representing approximately 80% of total risk.

Where's the risk?



The total risk associated with the overhead network over the next 10 years is concentrated in higher density residential / CBD areas as the risk is predominantly driven by network reliability. The proposed investment strategies aim to decrease this risk in a more uniform manner.

What's the risk going forward?



The baseline risk associated with the overhead network is projected to approximately increase to $60M if no action is taken.

The proposed unconstrained investment profile if carried out results in a relatively steady risk profile at $30M at the end of the 10-year forecast period.

Optimisation of the investment profile results in a steady yet slightly higher risk profile at $40M at the end of the 10-year forecast period.

Investment Strategy

What did we consider?

Legend: Not feasible or applicable | Selected Intervention | Partial Address Objectives

Asset Class	Non-network	Additional Maintenance	Reactive repair /replacement	Operational Controls	Reduced Load	Staged removal /replacement
Conductors			Selected			Selected
Switchgear			Selected	Partial		Selected
Public Lighting			Selected	Partial		Partial
Structures			Selected	Partial		Selected
Services			Selected	Partial		Partial
Assemblies			Selected	Partial		Selected

The credible intervention options considered for this system are summarised above. Operational controls are effective in addressing safety performance but do not contribute sufficiently to other performance objectives. Reactive repair and replacement programs are justified for all asset classes. Staged removal and risk based replacement programs effectively address the performance objectives for conductors, switchgear, pole top assemblies and structures, but not provide sufficient value for selection as the preferred intervention for public lighting and services.

Conductors Intervention Strategy: Proactive intervention was considered to provide highest overall value in addressing risk and performance across 1,489 conductors. Reactive replacement programs have been proposed to address residual failure risk.

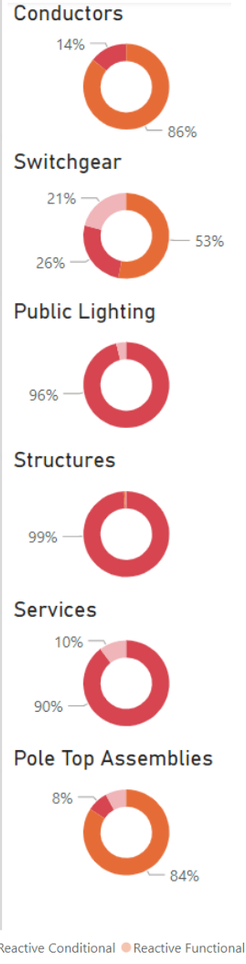
Switchgear Intervention Strategy: Proactive intervention was considered to provide highest overall value in addressing risk and performance for overhead switchgear. Reactive replacement programs have been considered to address residual failure risk.

Public Lighting Intervention Strategy: A proactive intervention strategy was found not to provide sufficient value within the FY22-FY32 planning period. A reactive strategy has been proposed to mitigate risk for the low risk profile across public lighting assets.

Structures Intervention Strategy: Proactive intervention was considered to provide highest overall value in addressing risk and performance across 71 tower assets. Reactive programs have been proposed for poles and towers to address residual failure risk.

Services Intervention Strategy: Proactive intervention was considered to provide highest overall value. A primarily reactive strategy has however been proposed to address asset risk. This provided better cost balance given the geographic spread of the defective assets.

Pole Top Assemblies Intervention Strategy: Proactive intervention was considered to provide highest overall value in addressing risk and performance across 6,393 assemblies. Reactive replacement programs have been proposed to address residual failure risk.



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Investment Strategy

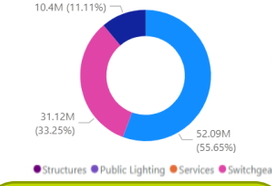
How have investments been identified?

The risked based replacement program has identified assets within the Overhead Network that are justified for a risk-based intervention in the upcoming regulatory period.

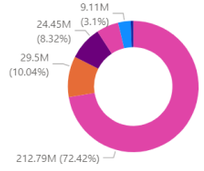
Assets that reach their maximum NPV are illustrated in the unconstrained scenario. A number of other assets will have reached the point of being NPV positive, however these will be considered as part of the portfolio optimisation process.

Total replacement volumes are comprised of risk based as well as reactive functional and conditional replacements based on the strategy selected for each asset class. Across FY25-29, the total unconstrained cost of risk based investments is $43.2M and reactive investments is $143.26M. Charts below reflect 10 year forecasts.

Risk Based by Asset Class



Reactive by Asset Class



Whilst Pole Top Assembly replacements drive the *volume* of risk based investments, Conductor replacements are driving the *cost* of risk based investments.

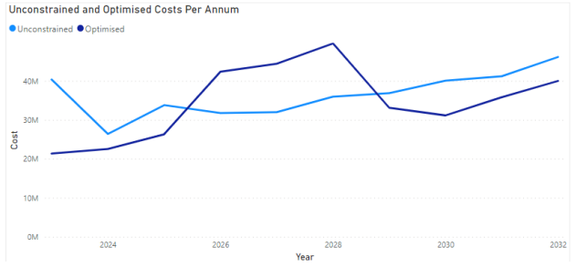
50% of OH risk based investments are in Windsor, Penrith and Spring Hill

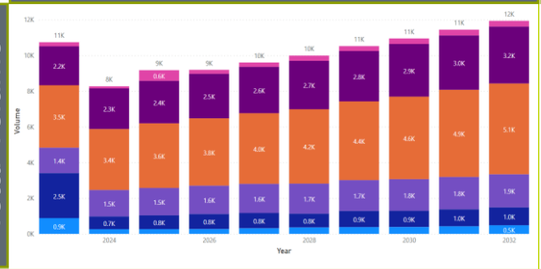
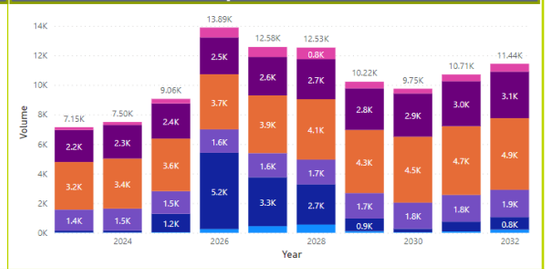
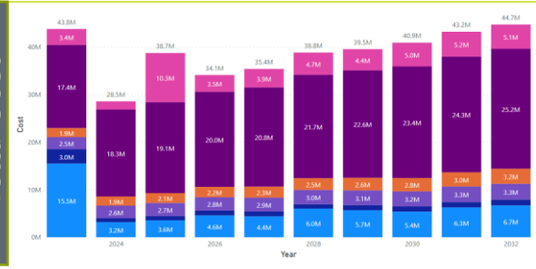
Comparison between unconstrained and optimised

The proposed unconstrained investment profile is calculated from FY23; however, it is difficult to efficiently introduce these additional replacements into the FY23 and FY24 periods without impacting existing strategies. Optimisation has been applied to these proposed investments, considering factors such as labour, outage availability etc.

Optimisation results in a proportion of assets identified for intervention in FY23 and FY24 being shifted into the next regulatory period.

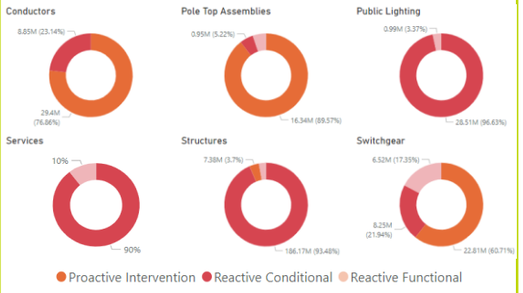
Unconstrained and Optimised Costs per Annum



	Unconstrained	Optimised
Total Volume		
Total Cost		

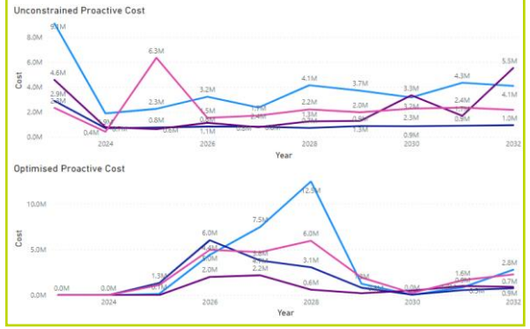
So What?

Cost of Optimised Risk Based and Reactive Investments



Asset classes with risk based investments include Conductors, Switchgear, Pole Top Assemblies and Structures. Once optimised, the proactive spend across these asset classes has reduced in FY23-24 and increased in FY25-29. This is primarily evident for Conductors.

Cost of Unconstrained and Optimised Proactive Investments by Asset Class



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Asset Lifecycle

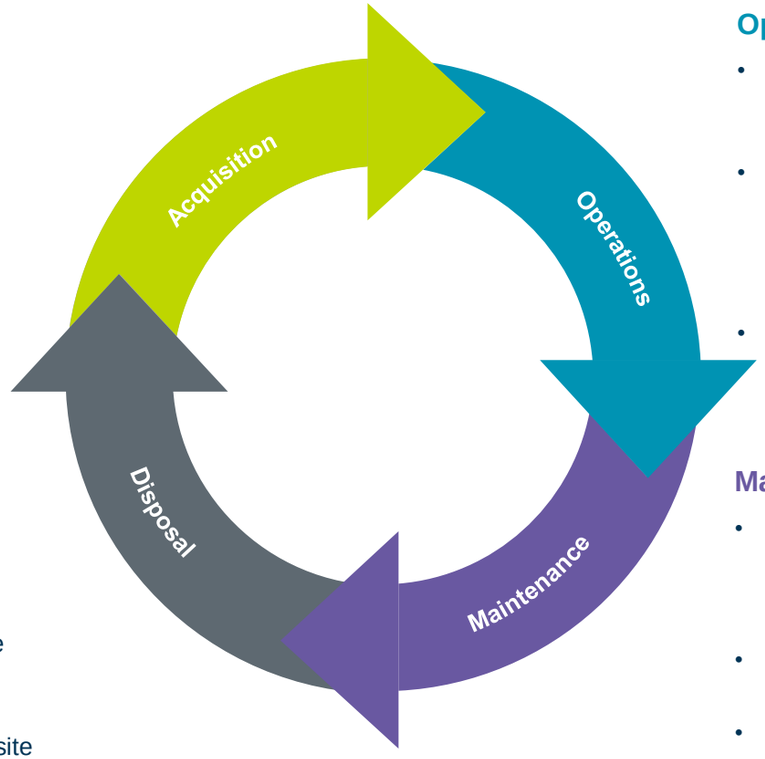
Historical performance of assets over the past 10 years has shown that many operation and maintenance processes pose safety and reliability risks and this been seen due to their existing condition or type of material. Current/future initiatives of replacing assets with a modern equivalent will reduce the overall risk across the network.

Acquisition

- All assets vary in size, type and configuration and ETS standards define the technical criteria.
- In public lighting assets, SLCP with Zellweger is used across brownfield sites but new sites will have photoelectric control for automatic switching.
- In service mains, new lines within existing Overhead areas can be overhead, unless underground lines are cost or environmentally justified.
- Towers identified for replacement are typically replaced with a steel pole structures and composite poles have been installed as a trial as an alternative pole type.
- Poor condition steel mains and hard drawn copper conductors pose a high risk in bushfire prone areas which will be reduced with the introduction of CCT.

Disposal

- All assets continued to be disposed off in accordance with the Endeavour Energy Waste Management Standard EMS 0007.
- No recycling programs exist for concrete and composite poles an crossarms due to the low number of retirements seen each year but should be considered going forward as the populations of these asset types increase and continue to age.
- Relays are stored at designated locations at Hoxton Park Field Services Centre (FSC) until an appropriate disposal facility is established.



Operations

- The operating performance of assets can be largely influenced by the environmental conditions, age profile of assets and the type of material.
- Automatic switching will reduce the need for staff to attend the site to operate the asset such as HV Overhead Switchgear, Overhead Assemblies. This shift is expected to decrease the safety risk as well as the number of assets.
- Continued clearances to be maintained between network assets and vegetation in accordance with Vegetation Maintenance Common Requirements (VMCR) or MMI 0013.

Maintenance

- **OLI/GLI** (scheduled every 5.5 years) **and PSBI** (scheduled every 1 year) of Overhead Conductors, HV Overhead Switchgear, Overhead Assemblies, OH Structures and Service Mains
- **Thermovision Survey** of HV Overhead Switchgear and Service Mains scheduled every 3 to 4 years
- **Earth Resistance Test** of Overhead Conductors and HV Overhead Switchgear scheduled every 10 to 12 years
- **TLI** of HV Overhead Switchgear and Overhead Structures scheduled every 3 to 5 years
- **Bulk Lamp Replacement Program** (scheduled every 3 to 4 years) **and Annual and Strom Patrols** of Public lighting assets
- The *DS422 – High voltage distribution bushfire mitigation* (2020 - 2023) program have been carried out by the organisation to manage the risk posed by OH conductors on the network.

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Support Systems & Continuous Improvement

Support Systems

Ellipse Database

Used for historical (2010-2021) asset nameplate details, routine maintenance scheduling, defect workorder recording and management

OMS

Used for historic (2012-2021) asset related reliability incidents

ADMS

To be used in future as the primary data source for: Reliability, Resilience, Utilisation metrics.

GIS

Used for historic (2012-2021) geo-spatial locations for linear assets.

SAP

Used for recent (2021-Current) asset nameplate details, routine maintenance scheduling, defect workorder recording and management

FireStart

Used for historic (2005-2021) asset related firestart incidents

MySafe

Used for historic (2012-2021) asset related safety incidents categorised by severity

Continuous Improvement

Data Capture and Completeness

- Improvements in the capture of data associated with actual network fire events.
- Improvement in data capture methods for reliability data to ensure events are recorded against asset class and asset type, and easily aligned to asset identification numbers in SAP.
- The safety data captured on MySafe does not categorize the safety incidents based on the asset type, which can be improved on in the next regulatory period with the use of SAP.

Alignment with Network Business Strategy

- Continuous monitoring and review of risk and performance modelling across all performance objectives and asset classes.
- Interpretation of risk forecasts for selected strategies to forecast performance trends by measure and asset class.
- Development of targets in alignment with Network Objectives to improve the quantification of system performance.

Performance Based /Forecasting

- Development of methods to target performance-based investments to ensure performance targets are achieved.

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