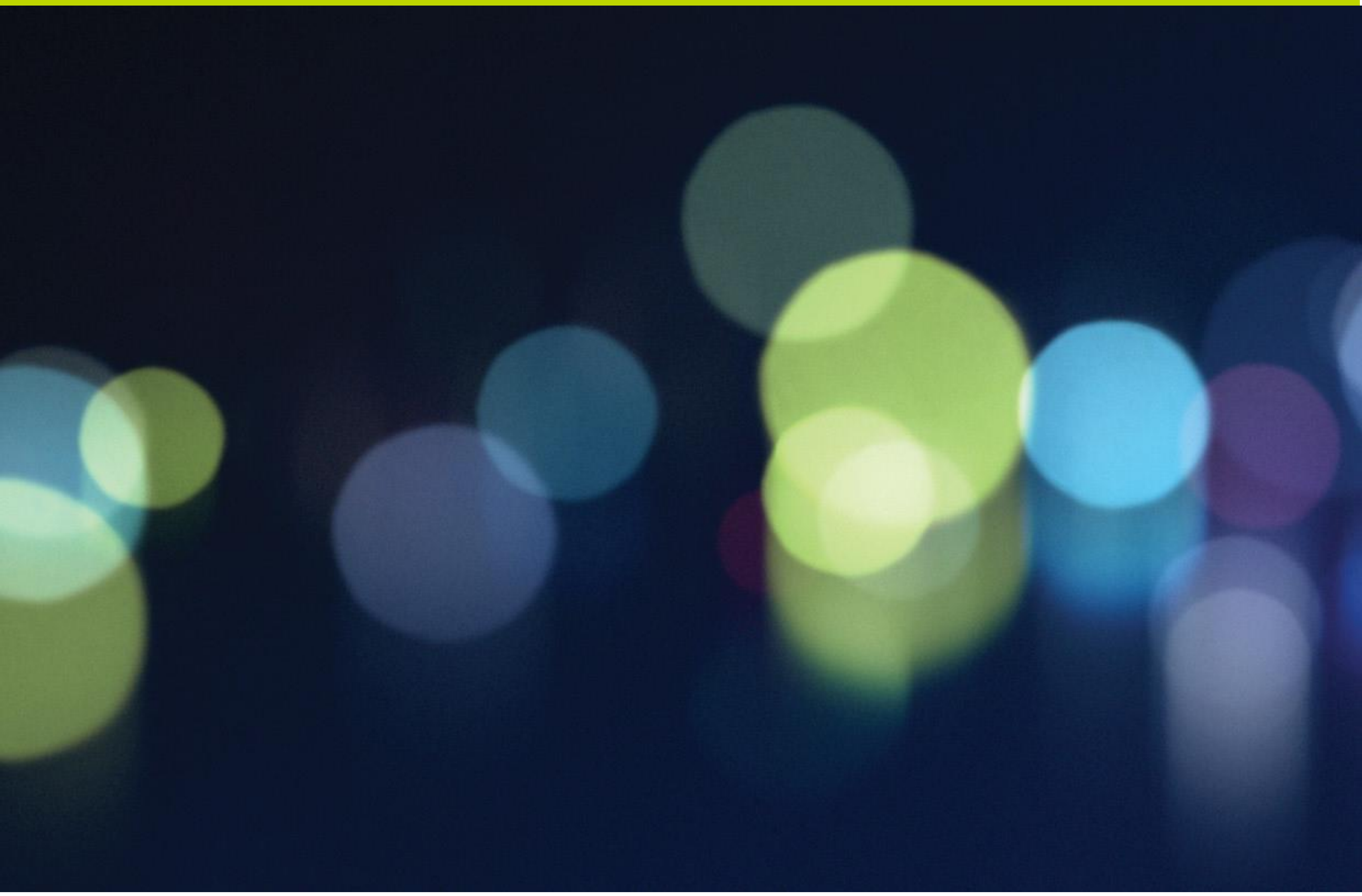
Overhead Structures Asset Class Plan

Mains Assets

October 2022



Endeavour Energy

Version control

Version	Date	Comments
1.0	2/09/2022	Initial draft for review

Contents

1. Executive Summary

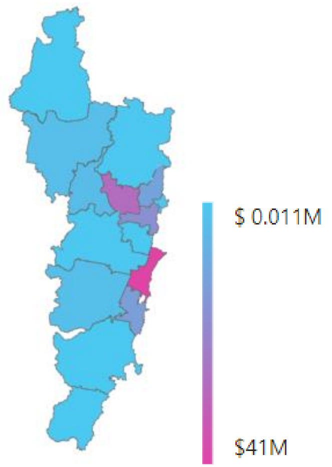
A 10-year strategy for overhead structures has been defined driven by the risk associated with the aging population of the asset class. The forecasted risk, strategy cost breakdown, and performance metrics are outlined below and include all Endeavour Energy owned poles and towers within the transmission and distribution network.

Risk Forecast

The failure of overhead structures may lead to Safety, Reliability, Financial, Environmental or Bushfire consequences.

These consequences are quantified in $'s and coupled with statistical modelling to determine the risk associated with the fleet of in-service poles and towers.

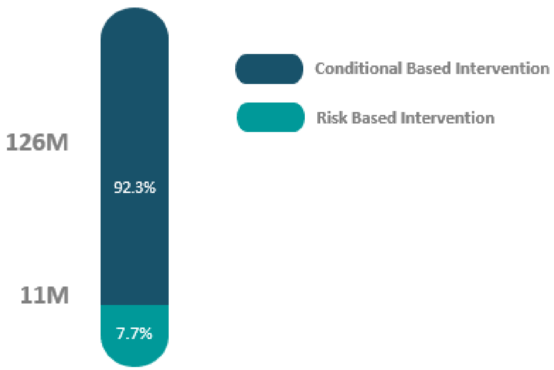
As the age of these assets increase, the risk associated with their failure also increase and this is geographically represented.



Strategy and Cost

The selected intervention option to address the risk associated with transmission and distribution poles and towers includes a condition-based program including the replacement and reinstatement of these assets.

The total cost of this strategy for the 2023-2029 period is $137M and is categorised based on the intervention type.



Key Performance Indicators

The performance of poles and towers is defined based on the following performance categories and objectives.

For all asset types, the targets for these objectives are either already met, or cannot currently be measured. In these cases, monitoring systems are to be setup to allow for appropriate data collection to determine if objectives are being achieved.

All objectives are forecasted to be improved or achieved based on the 10-year strategy proposed in this asset class plan.

Performance Category	Objective	Performance Target	Status
Asset Utilisation	Optimise use and penetration of assets in the network to decrease management costs, improve utilisation and inform future network standards	To be determined	— —
Safety	Reduce the number incidents (excluding general hazards)	Reduce in line with forecasts	🟠 🟢
Reliability	Reduce the number of unplanned outages associated with functional failures	Reduce in line with forecasts	🟢 🟢
Resilience	Monitor and reduce the number of combustible poles within bushfire prone land	Reduce in line with forecasts	🟢 🟢
Bushfire	Maintain the percentage of fire starts as a proportion of the asset base	Reduce in line with forecasts	🟠 🟢
Financial	Monitor the financial impacts associated with the functional failure of overhead structures	To be determined	— —
Environmental	Minimise risk to the environment So Far as is Reasonably Practicable (SFAIRP).	To be determined	— —

2. Overview

2.1 Purpose

The purpose of this document is to outline previous, current and proposed asset management practices for poles and towers and define a 10-year strategic plan for the asset class based on the asset's risk and cost.

The 10-year plan seeks to use all current knowledge of the asset in context with the whole network to establish Key Performance Indicators (KPI) to assist in understanding and monitoring the ongoing performance of the asset. The adopted levels of service for poles and towers are based on risk / benefit trade-offs versus cost options, legislative requirements, customer expectations, and strategic goals set by Endeavour Energy.

This document is intended to function as part of the "Performance Monitoring and Review Process" as established in the Asset Management System (AMS) outlined in Section 8 of this report. The document plays a key role in ensuring:

- A continuous feedback loop is established between the performance of the individual assets and the performance of the more macro level Asset Class
- Monitoring of the performance of the asset class against Key Performance Indicator (KPI's) set
- Changes in the performance or risk (positive or negative) are identified as early as possible
- Communicating the historic, current and proposed balance of risk and cost (as shown via the number of asset replacements caused by functional failures, condition-based replacements and risk-based replacements).

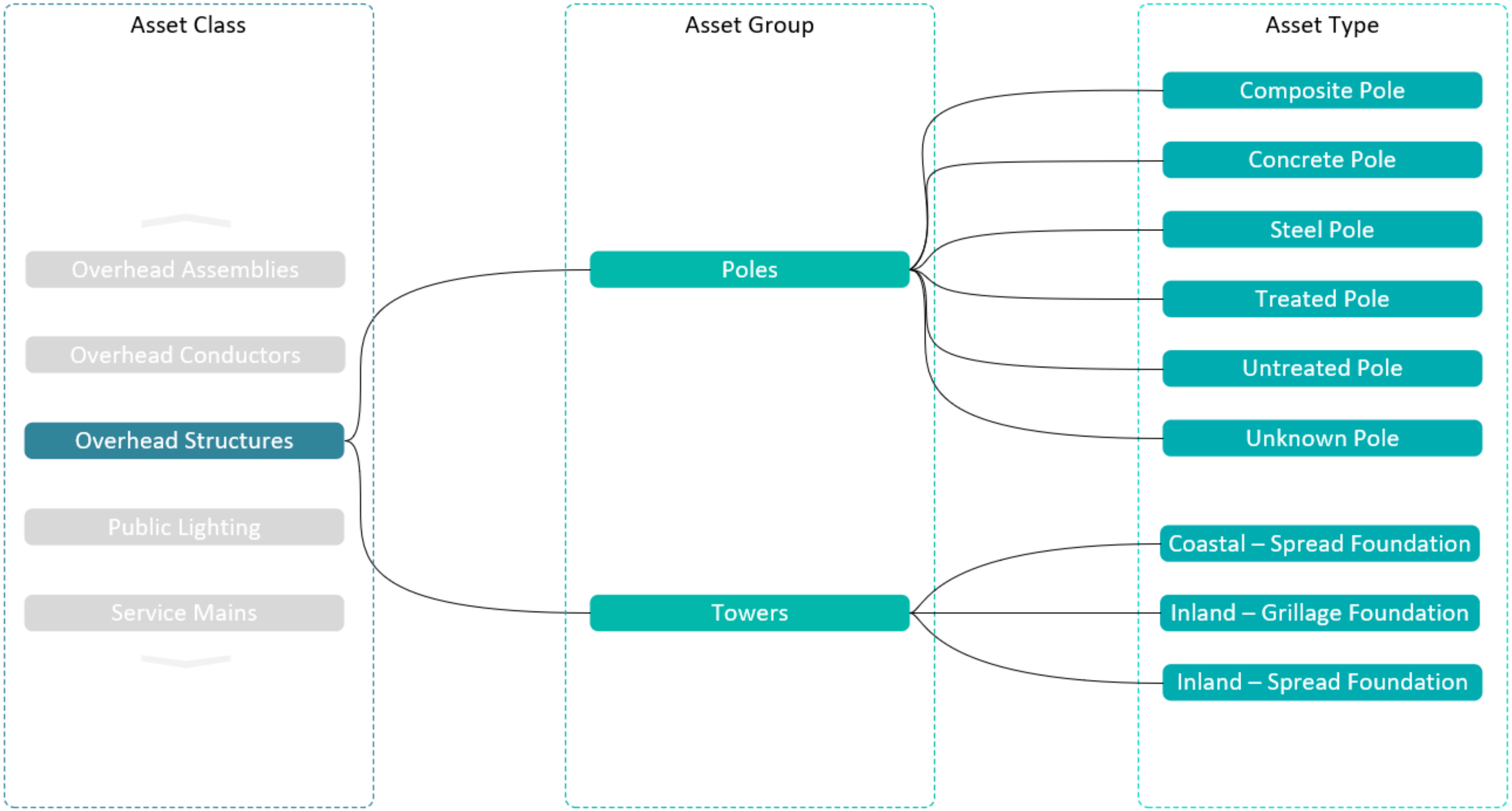
The document will highlight and discuss historical trends and future forecasts for three primary asset management strategies:

- Risk Based asset replacements (e.g. those proposed to be completed on a risk / cost justification basis)
- Condition Based asset replacements (e.g. asset triggered for replacement due to a inspection and/or maintenance program)
- Functional asset failures (e.g. assets replaced post an asset failure whilst in service)

The forecasted "outcome" risk projections (for safety, reliability, resilience, bushfire etc) throughout this document are based on the optimal investment profiles proposed in the Case for Investments (CFI's) as well as the continuation of the existing maintenance strategies. The "baseline" risks outlined throughout this document represent the natural increase in risk without an asset replacement program.

2.2 Scope

This report covers all Endeavour Energy owned overhead structures including poles and towers with their relevant asset types as seen below:



3. Asset Portfolio

3.1 Asset Function

Overhead structures act as support structures for overhead conductors, their main function is to support overhead electrical conductors to ensure adequate safety clearance is maintained from the ground (including vegetation, structures, buildings and other services) to mitigate the risk of inadvertent contact with live conductors.

Additionally, poles facilitate the installation of a wide range of pole mounted network assets to assist in safe and reliable delivery of power throughout the network (including transformers, switches, reclosers and third-party assets).

The general requirements for overhead lines and their support structures are underpinned by Company Policy 9.2.5 Network Asset Design. This policy outlines the public safety measures relating to earthing of conductive structures, approved pole types for use on the network and the suitable locations for each pole type.

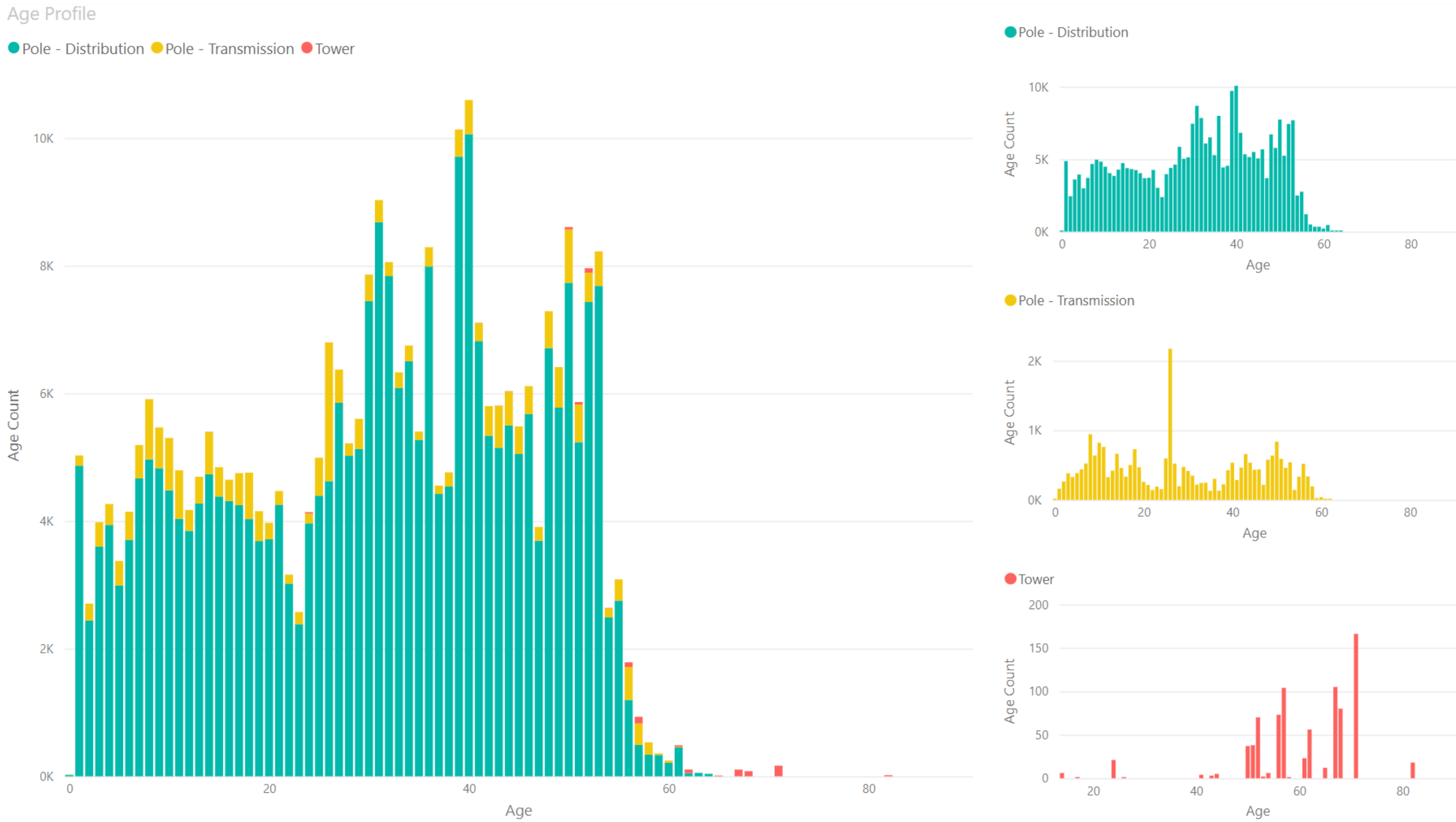
Design parameters such as the location, heights, clearances and mechanical loading are outlined in Mains Design Instruction MDI 0031 *Overhead line design* and the construction requirements are outlined in Mains Construction Instruction MCI 0005 *Overhead construction standards manual*. While steel tower lines are not specifically addressed in MCI 005, the requirements, parameters and principles are generally applicable, in addition to the requirements of AS/NZS 7000 *Overhead line design* and AS 4100 *Steel structures*.

The breakdown of risks that are attributed to this asset class are shown in section 4 to illustrate performance measures and key drivers.

3.2 Asset Population

Endeavour Energy has approximately 311,000 poles and 839 steel towers currently in-service within the transmission and distribution overhead network. The total number of poles in the distribution and transmission network has increased over the previous 10 years due to extensions within non-urban areas of the network where underground reticulation is not practical, and this is expected to continue whereas the number of steel towers within the network is expected to reduce over time, as towers identified for replacement are replaced with steel pole structures.

The age profile of overhead structures is summarised in the below figure.



4. Asset Performance

This section quantifies the risks and asset performance measures associated with the fleet of overhead structures. The weighting for different risk categories illustrates the areas of focus for managing the maintenance, life cycle and intervention options for this asset class. These are further broken down into performance measures that enable clear relationships to be drawn between risk and the asset performance.

The level of risk (by risk category) is determined for each individual asset, based on its location in the network and probability of failure (as per the risk-based replacement review). The following table summarises the risk categories and provides an overview of the average risk contribution made by each risk category (e.g. safety, reliability bushfire etc), this illustrates the primary risk drivers for the asset class.

The largest risk for this asset class is associated with safety risk, which can be attributed to Towers and their close proximity to residential developments and roadways. Safety risk outweighs reliability risk as the short outage times associated with repairs of poles and towers help to lower the reliability risk associated with overhead structures.

Risk Category	Consequence	Risk Contribution
Safety	- Injury to public due to structure falling on building, roadway or high pedestrian area - Injury to workers during linework in the immediate vicinity of a structure failure - Risk of electric shock due to fallen conductors	60%
Reliability	- Clashing or fallen conductors resulting in extended loss of supply while network is re-configured to isolate, sectionalise and repair the affected area	22%
Bushfire	- Conductors making contact with the ground or other structures may ignite a bushfire due to arcing of live conductors	4%
Financial	- Additional costs associated with clean-up after a failure including damage to property, livestock and vehicles - Not replacing the asset before a failure may lead to capital expenditure related to reactive replacement	13%
Environmental	- Damage to environmentally sensitive areas during repair/replacement/clean-up	1%

The table below summarises the asset performance service level and objectives across the fleet of overhead structures.

Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Asset Utilisation	Optimise use and penetration of assets in the network to decrease management costs, improve utilisation and inform future network standards	Not currently measured	Poles	-	To be determined	—	—
			Towers	-		—	—
Safety	Reduce the number incidents (excluding general hazards)	5-year rolling average of total incidents (excluding general hazards)	Poles	5.6	Reduce in line with forecasts	●	▲
			Towers	0.2		●	—
Reliability	Reduce the number of unplanned outages associated with functional failures	5-year rolling average of unplanned outages	Poles	7.0	Reduce in line with forecasts	●	—
			Towers	0.0		●	—
Resilience	Monitor and reduce the number of combustible poles within bushfire prone land	Percentage of combustible structures within bushfire prone land	Poles	85%	Reduce in line with forecasts	●	▼
			Towers	0%		●	—
Bushfire	Maintain the percentage of fire starts as a proportion of the asset base	5-year rolling average of fire starts	Poles	2.8	Reduce in line with forecasts	●	▲
			Towers	0.0		●	—
Financial	Monitor the financial impacts associated with the functional failure of overhead structures	Not currently measured	Poles	-	To be determined	—	—
			Towers	-		—	—
Environmental	Minimise risk to the environment So Far as is Reasonably Practicable (SFAIRP).	Not currently measured	Poles	-	To be determined	—	—
			Towers	-		—	—

4.1 Asset Utilisation

4.1.1. Objective

To monitor and understand asset utilisation across each asset type and network wide to inform topology standards and maximise the utilisation of the existing asset base.

4.1.2. Performance

There is no current measure for the utilisation of transmission and distribution poles, however a proposed measure includes the comparison of calculated mechanical load against the rated load of the pole. Bulk calculation of mechanical load on every Endeavour Energy owned pole in the network is not possible at present, however the introduction of new technology may help to achieve this.

The digital twin is a 3D virtual model of Endeavour Energy's network being developed. The digital twin will be capable of performing pole load calculations, however at this stage it is unknown whether the digital twin can perform these calculations on a large-scale across the network.

Performance Category	Objective	Performance Measure	Current Performance	Performance Target	Status	Trend
Asset Utilisation	Optimise use and penetration of assets in the network to decrease management costs, improve utilisation and inform future network standards	Not currently measured	-	To be determined	—	—

4.1.3. Gap

As no measure of utilisation currently exists for this asset class, there is no gap in the measured performance.

4.1.4. Response

Utilisation of transmission and distribution poles has not traditionally been monitored, however emerging technology and the establishment of KPI's will help ensure the ongoing performance of the asset class.

4.2 Safety

4.2.1. Objective

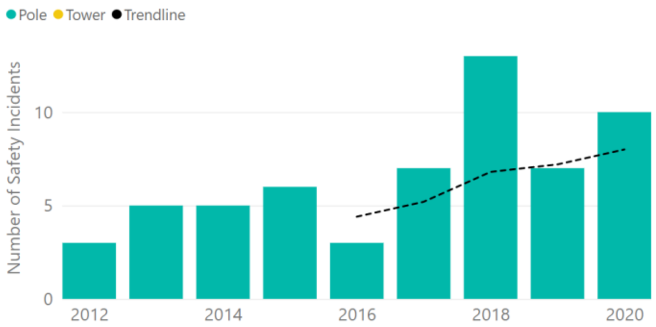
Stabilise, monitor, and maintain safety risk across the asset base over the next 10-years.

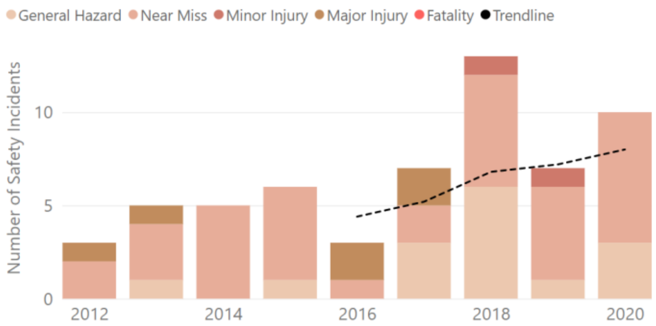
4.2.2. Performance

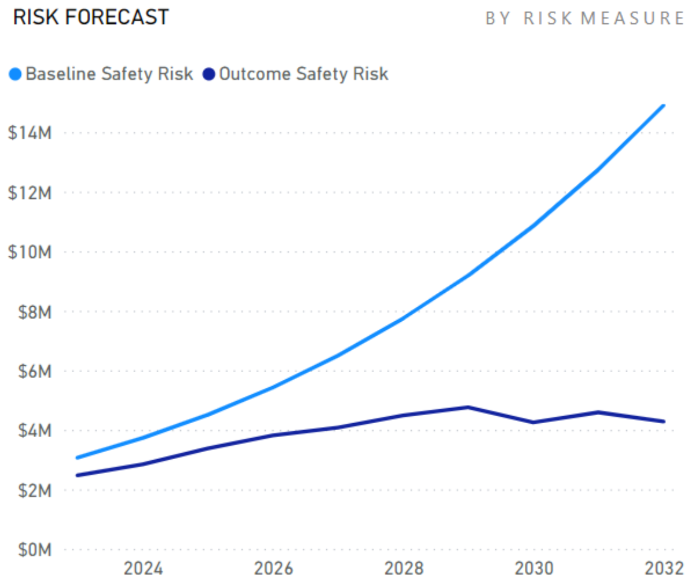
Safety incidents are categorised by severity and include general hazards, near misses, minor injuries, major injuries, and fatalities. The number of the safety incidents associated with poles and towers has varied over the last 10 years, with an increasing trend evident over the last 5 years. This trend should be continued to be monitored.

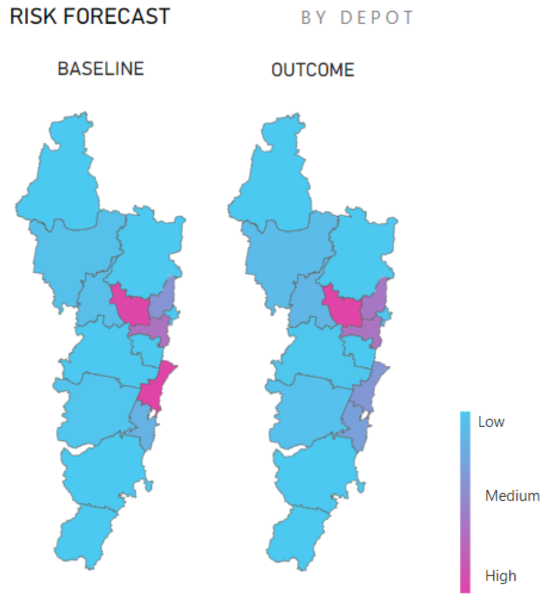
The majority of safety incidents in relation to this asset class are due to poles. This can be attributed to the large population of poles, their close proximity to public places as well as increased level of maintenance and operational activities.

The proposed asset strategies (refer to Section 6) are expected to decrease both the frequency of events as well as the total organisational safety risk associated with the asset class.









Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Safety	Reduce the number incidents (excluding general hazards)	5-year rolling average of total incidents (excluding general hazards)	Poles	5.6	Reduce in line with forecasts	● (amber)	▲ (amber)
			Towers	0.0		● (green)	— (green)

4.2.3. Gap

Safety is the biggest contributor to the overall risk associated with overhead structures and it is forecast to improve based on the current condition and risk based strategies of intervention. The granularity of safety reporting data is expected to improve with the introduction of SAP, which will in turn assist in the monitoring of safety risk for this asset class.

4.2.4. Response

Safety risk will continue to be monitored and risk modelling reviewed as new external factors are identified / occur to improve future forecasts.

4.3 Reliability

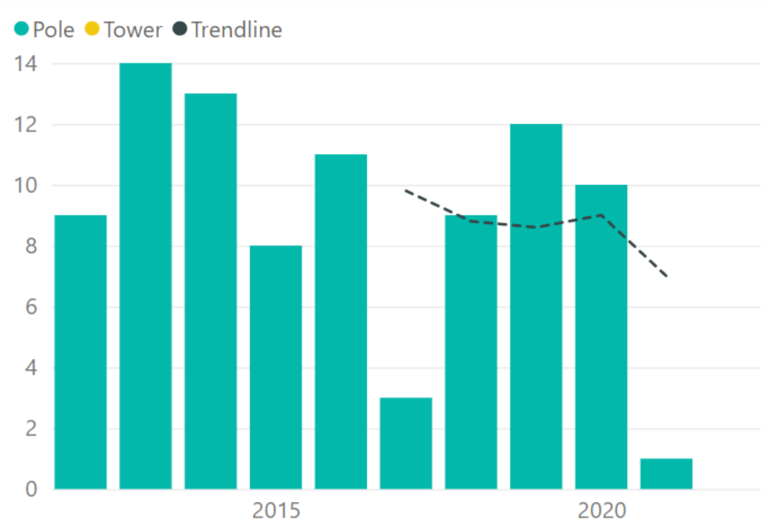
4.3.1. Objective

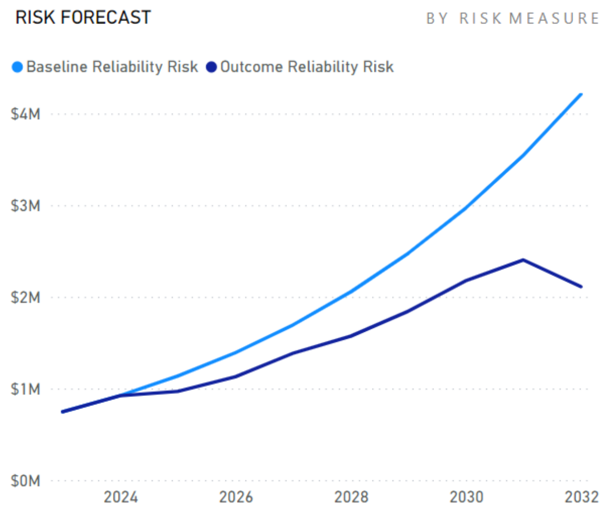
Maintain the level of network reliability risk and number of outages caused by unassisted asset failures associated with overhead structures.

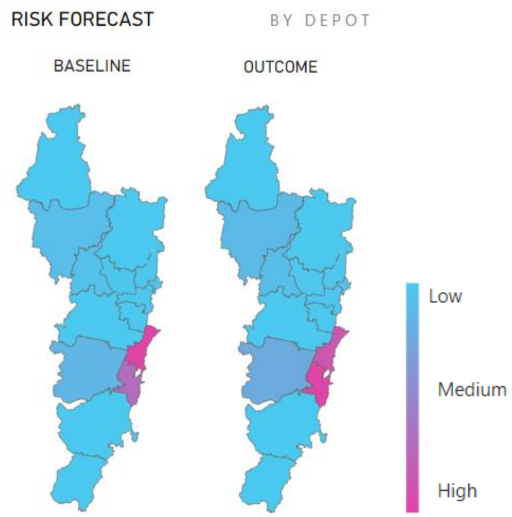
4.3.2. Performance

The number of functional failures associated with overhead structures has been relatively stable over the past 10 years. All recorded functional failures within the overhead structure asset class are attributed to poles as there have been no functional failures of towers within Endeavour Energy's network to date.

The low number of functional failures associated with poles is expected to remain stable over the next regulatory period due to the condition based intervention strategy implemented for this asset type.







Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Reliability	Reduce the number of unplanned outages associated with functional failures	5-year rolling average of unplanned outages	Poles	7.0	Reduce in line with forecasts	●	—
			Towers	0.0		●	—

4.3.3. Gap

No gaps are currently identified in the reliability risk associated with overhead structures.

4.3.4. Response

The current proposed asset management strategy indicates a steady risk profile and a steady number of functional failures. Continued monitoring of both metrics will be performed to ensure this continues to hold true.

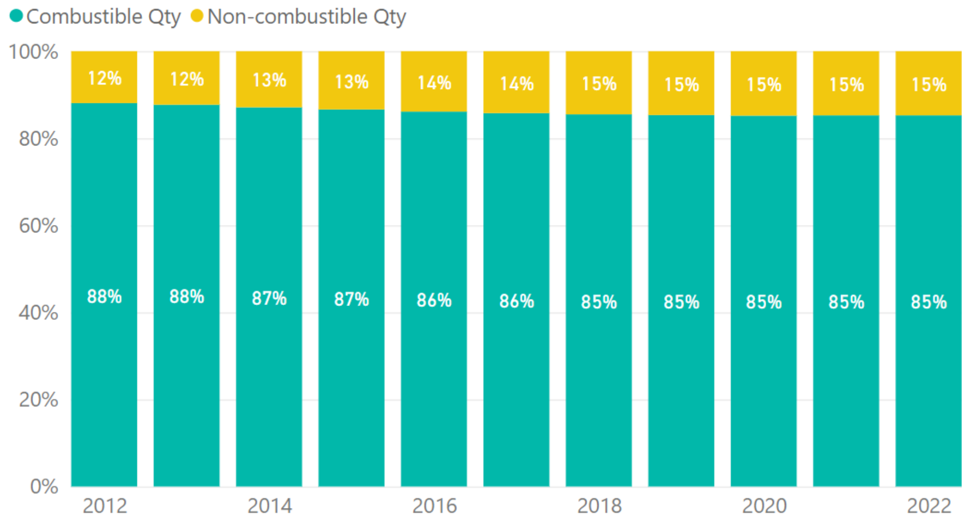
4.4 Network Resilience

4.4.1. Objective

To monitor and reduce the number of combustible structures within bushfire prone land to lessen the damage on the network caused by a major bushfire event.

4.4.2. Performance

At present, any pole that is identified for condition based intervention within a bushfire prone area is assessed for a suitable non-combustible replacement pole, such as concrete or steel. Limitations include earthing requirements for pole substations or enclosed switches.



Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Resilience	Monitor and reduce the number of combustible poles within bushfire prone land	Percentage of combustible structures within bushfire prone land	Poles	85%	Monitor	●	▼
			Towers	0%		●	—

4.4.3. Gap

No gaps are currently identified in the resilience performance associated with overhead structures.

4.4.4. Response

Continued condition based interventions of poles within bushfire prone land will see greater numbers of combustible poles installed within these areas having a positive impact on network resilience.

4.5 Bushfire

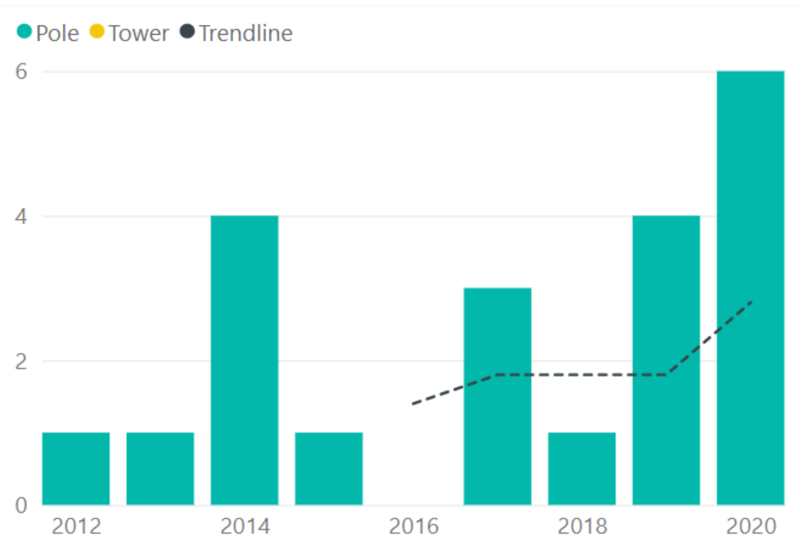
4.5.1. Objective

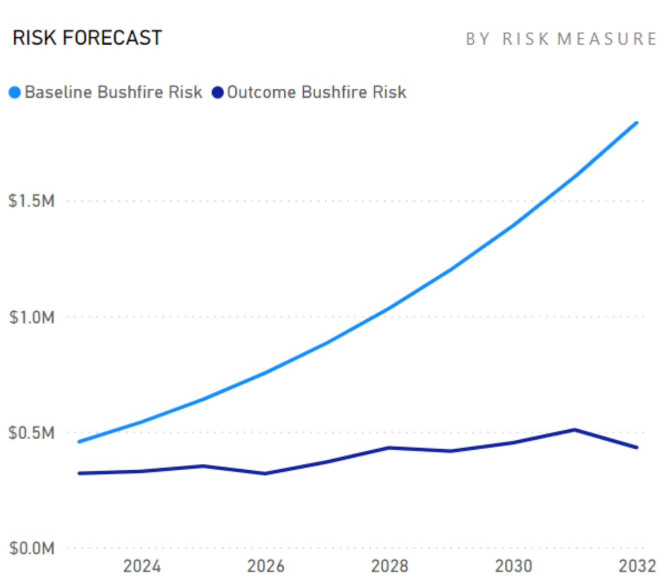
To reduce the number of functional failures and therefore the likelihood component of bushfire risk associated with overhead structures.

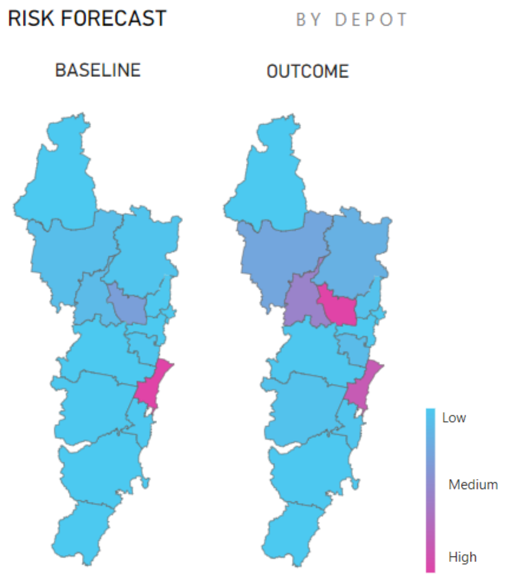
4.5.2. Performance

Bushfire performance is measured by monitoring the quantity and severity of fire starts that are initiated by asset failures across our network. There have been no recorded fire starts associated with towers in the last 10 years, however, there is an increasing trend in fire starts caused by poles. This should continue to be monitored but is expected to remain stable.

Limitations in the fire start data prevent further analysis to determine the severity of these fire starts, however anecdotal experience over this period indicated no major events have occurred, which is reflective of the relatively low proportion of bushfire risk attributed to overhead structures.







Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Bushfire	Maintain the percentage of fire starts as a proportion of the asset base	5-year rolling average of fire starts	Poles	2.8	Reduce in line with forecasts	●	▲
			Towers	0.0		●	—

4.5.3. Gap

Bushfire performance, as monitored by first starts is expected to remain stable as older, higher risk assets are replaced under existing replacement programs. Although fire-starts remain stable, the severity of these starts is not adequately monitored to align real world events with the organisation's bushfire risk model.

4.5.4. Response

To further minimise controllable bushfire risk for overhead structures, possible improvements include the capture of data associated with actual network fire events (e.g the comparison of the actual consequence with modelled consequence).

Bushfire risk will also be monitored at a network wide level to ensure investment is conducted in the most appropriate areas to ensure appropriate investment / prioritisation decisions are made.

4.6 Financial

4.6.1. Objective

Monitor the financial impacts associated with the functional failure of overhead structures.

4.6.2. Performance

The financial risk associated with overhead structures relates to the potential damage to third party property caused by the functional failure of poles and towers as well as the reactive costs associated with the replacement of these assets.

<table>
<tr><th>Performance Category</th><th>Objective</th><th>Performance Measure</th><th>Asset Type</th><th>Current Performance</th><th>Performance Target</th><th>Status</th><th>Trend</th></tr>
<tr><td rowspan="2">Financial</td><td rowspan="2">Monitor the financial impacts associated with the functional failure of overhead structures</td><td rowspan="2">Not currently measured</td><td>Poles</td><td>-</td><td rowspan="2">To be determined</td><td>—</td><td>—</td></tr>
<tr><td>Towers</td><td>-</td><td>—</td><td>—</td></tr>
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4.6.3. Gap

There is currently no performance measure identified for financial risk relating to overhead structures as there is no data being recorded on the financial costs to third party property after the functional failure of asset.

4.6.4. Response

In order to minimise controllable financial risk for overhead structures, a means to record and monitor financial impacts to third party property must be established.

4.7 Environmental

4.7.1. Objective

Minimise risk to the environment So Far as is Reasonably Practicable (SFAIRP).

4.7.2. Performance

Environmental risk for overhead structures only applies to towers, in particular, the potential of causing damage to sensitive areas during the repair or replacement of conditionally or functionally failed towers.

Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Environmental	Minimise risk to the environment So Far as is Reasonably Practicable (SFAIRP).	Not currently measured	Poles	-	To be determined	—	—
			Towers	-		—	—

4.7.3. Gap

There is currently no performance measure identified for environmental risk relating to overhead structures as there is no data being recorded to quantify the impact that repairs relating to this asset class has on the environment.

4.7.4. Response

To further minimise controllable environmental risk for overhead structures, possible improvements include the capture of data associated with the repair and/or replacement of overhead structures in environmentally sensitive areas. Work practices should also be altered to minimise the impact on such areas.

5. Asset Lifecycle

This section discusses overhead structures throughout the asset lifecycle and brings to light key factors that currently (or may) impact the asset class performance.

5.1 Acquisition

The three types of poles approved for use within Endeavour Energy's network are timber, concrete and steel and whilst Endeavour Energy's network largely consists of timber, concrete and steel poles, a small quantity of composite poles have been installed for the purpose of a trial. Design criteria for transmission and distribution poles are outlined in MDI 0031 and approved pole types including their applications is outlined in Company Policy 9.2.5 Network Asset Design.

The acquisition of poles is largely driven by the reactive replacement of the existing population upon failure as well as extensions within non-urban areas of the network where underground reticulation is not practical, particularly in the transmission network.

The most common form of intervention for towers involves replacing structural members or refurbishment of the tower's foundation, however if a tower is identified for replacement it is usually replaced with a steel pole structure.

The continued monitoring of the asset class will allow further refinement of technology mix and network configurations options being implemented.

The current technical criteria for this asset class are defined in Equipment Technical Specifications (ETS) as listed in Section 8.1. Asset types have largely been defined based on the technology type, however as performance data indicated the current asset types will continue to be further subdivided.

5.2 Operations

Overhead structures are not considered operational assets as their primary function is to support overhead conductors and apparatus, however, certain operational restrictions are related to poles. These operational restrictions include:

- Condemned poles and reinstated poles shall not be climbed by field staff.
- Poles with substations or switches cannot be reinstated/nailed.
- A reinstated/nailed pole should be adequately supported before changing the head loading of the pole.

5.3 Maintenance

An overview of the current maintenance activities being performed on overhead structures are summarised below. These maintenance activities result in the current asset performance (e.g. risk and number of unassisted / conditional asset failures). The condition-based replacement strategy is based on the results of the following maintenance strategy and assist in controlling the underlying risk associated with this asset class.

5.3.1. Inspections & Preventative Maintenance

The following table summarises the frequency of different inspection programmes and preventative maintenance applicable to poles.

	Programme Name		Interval (Years)	Poles			Towers	Reference
				Timber	Concrete	Steel		
Inspections	OLI/GLI[1]		5.5	✓[1]	✓[2]	✓[2]	-	SMI 101 MMI 0001
	TLI	Non-Critical Feeders	5	✓	✓	✓	✓ [4]	MMI 0001 MMI 0012
		Critical Feeder	3	✓	✓	✓	✓ [4]	
	PSBI[3]		1	✓	✓	✓	✓	SMI 101 MMI 0034
	Steel structure climbing inspection		6				✓	MMI 0012
	Step and potential test		12	✓ [5]	✓ [5]	✓ [5]	✓ [5]	MMI 0012

1. OLI only until 22 year and OLI/GLI every 5.5 years thereafter
2. OLI every 5.5 years, no GLI required
3. Applicable to only assets that fall within the defined bushfire prone area
4. All 132kV steel tower lines are subject to full overhead line inspection every 3 years
5. Step and potential test only applicable for structures in special locations, refer MMI 0012 section 6.7

5.3.2. Essential Spares

The requirement for an essential spare's strategy is governed by the criticality of the equipment's function in the network and is dependent on the lead time for acquisition.

Given the availability of various suppliers, the ease of procuring items and the level of inventory maintained for poles there is no existing essential spares strategy for this asset class.

Endeavour Energy's procurement and logistics section is responsible for the on-going sourcing strategy of poles including its supply chain security.

5.4 Disposal

All overhead structures should be disposed of in accordance with the Endeavour Energy Waste Management Standard EMS 0007.

A recycling program for timber poles removed from the network exists which involves returning suitable poles to a field service centre, where they are stored temporarily on pole racking before being collected by our recycling partner. Untreated timber poles can be processed for agricultural use, where treated timber poles are processed to produce process engineered fuel (PEF), which is a practical and sustainable energy source.

Suitability requirements for timber pole recycling are outlined in Endeavour Energy's Environmental Guidelines Handbook.

No recycling programs exist for concrete and steel poles, however both materials can be recycled on an as required basis. This is not expected to change due to the low number of concrete and steel pole retirements seen each year.

6. Intervention Options

A range of options have been considered as possible intervention options to address the risk presented by transmission and distribution poles. These options are initially considered as an asset type / class level to determine if they are technical feasible and/or practical. Intervention options deemed to be a viable option are then considered at an asset level to determine the most appropriate option for each individual asset.

Intervention Type	Option	Assessment of effectiveness	Credibility
Non-Network Based	-	Due to the nature of the asset class and its primary functionality being support structures for overhead conductors, there are no credible non-network solutions which could replace their functionality.	Not A Feasible Solution
Condition Based	Additional maintenance to extend the life of the existing asset	Maintenance procedures are unable to further extend the life of overhead structures. The ongoing management and maintenance of overhead structures typically involves routine inspections for defects.	Not A Feasible Solution
	Reactive replacement of overhead structures after conditional or functional failure	Reactive replacement includes replacement of overhead structures or structural members based on condition as well as the reinstatement of timber poles. This forms part of Endeavour Energy's business-as-usual practice, however unidentified conditional failures may lead to functional failures.	Technically feasible solution but does not always effectively mitigate risk of future failures
Risk Based	Reduce the load on the asset through network reconfiguration, network automation or demand management	The risk of failure is independent of supply load. A minor reduction in the consequences of failure could be achieved by transferring load from any one substation / feeder to another, however this is not a practical option in reality and would result in little if any positive benefit.	Not A Feasible Solution
	Implementing operational controls such as limiting access, remote switching protocols etc	These controls are in place to limit the safety risks presented by this equipment to workers, but the principal risk that drives the need for intervention is safety to the public and reliability, neither of which can be affected by practicable controls.	Controls only safety risk for workers
	Staged refurbishment or replacement of tower structures	Replacement or refurbishment of aged assets would reduce the likelihood of bushfire, environmental, financial, reliability and safety risk.	Feasible Option

6.1 Non-Network Based Interventions

No non-network based interventions have been identified to replace the primary function of this asset class.

6.2 Condition Based Interventions

The inspections and preventative maintenance programs outlined in 5.3 Asset Maintenance results in the following condition-based repairs, replacements, and defects on overhead structures. The objective of the condition-based maintenance is to identify functional asset failures prior to them occurring, however as close as possible to the assets technical / economic end of life.

Defects are directly linked to an asset's failure mode(s) and aim to identify issues with the defect that will result in it being unable to perform its primary intended function. Defects are currently prioritised based on a qualitative assessment of the likelihood the defect will result in a functional failure.

Endeavour Energy determines what constitutes a defect based on Failure Modes Effects and Criticality Analysis (FMECA). FMECA is an analytical process that is derived from an assessment of an asset's ability to sustain technical function and purpose and relies on information relating to failure modes, their probability and consequences of failure. FMECA establishes a condition-based approach to asset maintenance that enables a risk-based determination of the maintenance requirements for assets.

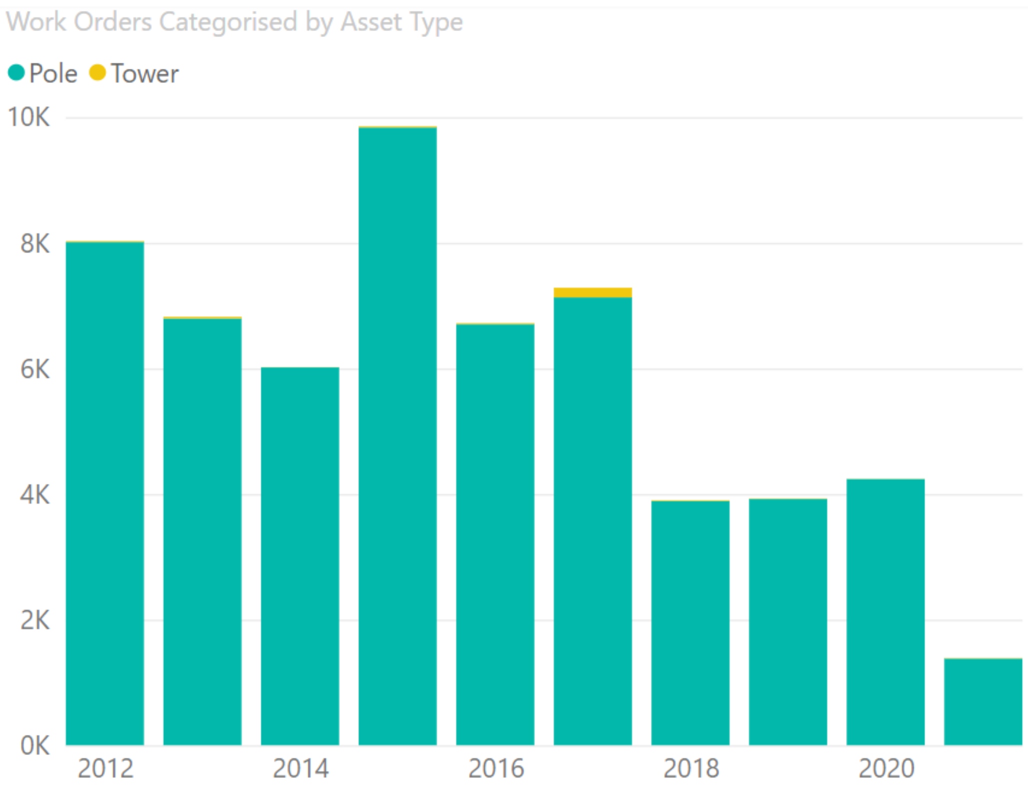
MMI 0002 and SMI 124 provide further detail on what is to be recorded as a defect, the required actions, and the corresponding priority for each failure mode, the table below provides an overview of applicable defects associated with overhead structures.

Structure Type	Standard Job No.	Repair / Replacement	Standard Job Description
Pole	POLGAA	Replacement	Sub/Recloser / Volt Reg Pole Replacement GD
	POLGAB	Replacement	LBS / ABS Pole Replacement (Includes LV) GD
	POLGAC	Replacement	HV Pole Term / UGOH Replacement (Includes LV) GD
	POLGAD	Replacement	HV Pole Pin Replacement GD
	POLGAE	Replacement	HV Pole Shackle Replacement GD
	POLGAF	Replacement	LV Pole Pin Replacement GD
	POLGAG	Replacement	LV Pole Shackle/Term Replacement GD
	POLGAH	Replacement	HV / LV Pole Pin Replacement GD
	POLGAI	Replacement	HV / LV Pole Shackle Replacement GD
	POLGAJ	Replacement	HV / LV Pole Termination Replacement GD
	POLGAK	Replacement	Service / Stay / SL Pole Replacement GD
	POLHBA	Replacement	Sub/Recloser / Volt Reg Pole Replacement HD
	POLHBB	Replacement	LBS / ABS Pole Replacement (Includes LV) HD
	POLHBC	Replacement	HV Pole Term / UGOH Replacement (Includes LV) HD
	POLHBD	Replacement	HV Pole Pin Replacement HD
	POLHBE	Replacement	HV Pole Shackle Replacement HD
	POLHBF	Replacement	LV Pole Pin Replacement HD
	POLHBG	Replacement	LV Pole Shackle/Term Replacement HD
	POLHBH	Replacement	HV / LV Pole Pin Replacement HD
	POLHBI	Replacement	HV / LV Pole Shackle Replacement HD
	POLHBJ	Replacement	HV / LV Pole Termination Replacement HD

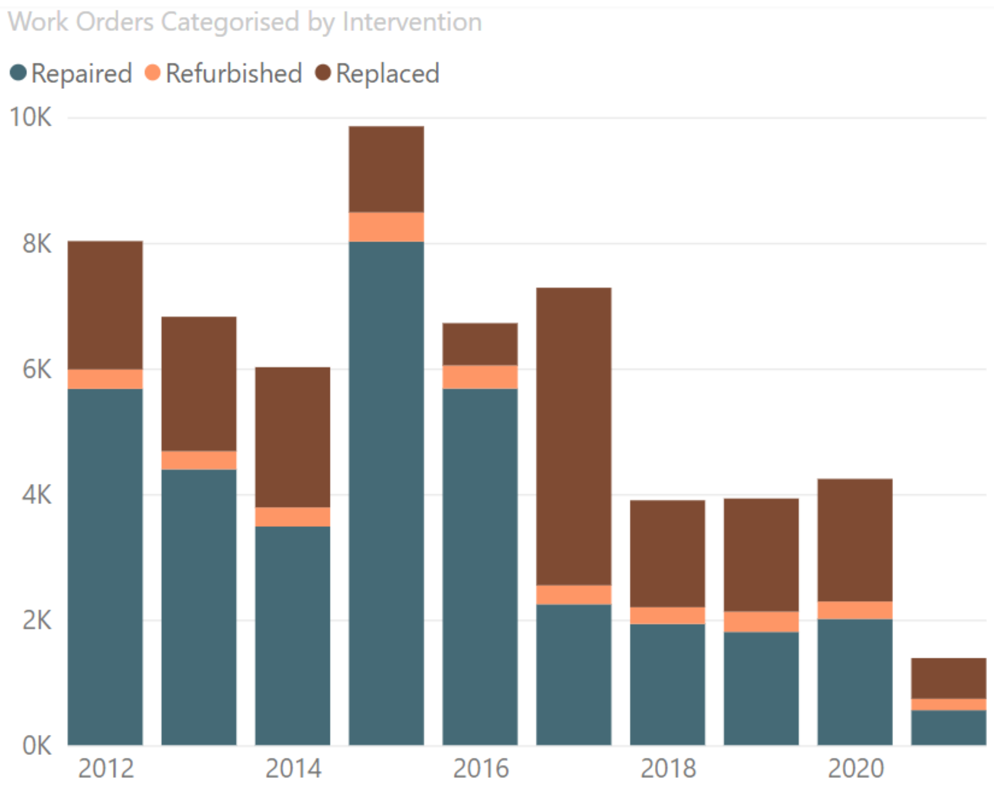
Structure Type	Standard Job No.	Repair / Replacement	Standard Job Description
	POLHBK	Replacement	Service / Stay / SL Pole Replacement HD
	1POLE	Replacement	Replace Condemned Pole
	1FPOLE	Replacement	Replace Naturally Failed Pole
	EOLPLN	Replacement	Replace Nailed Pole
	1PLREI	Refurbishment	Reinstate Pole
	1PCAPH	Repair	Replace Pole Cap
	1PCAPM	Repair	
	1PLCAP	Repair	
	1PLLEA	Repair	Repair Leaning Pole
	1BPOLE	Repair	Repair Burnt CCA Pole
	1PLBAN	Repair	Replacement of Pole Bands
	1PLSAP	Repair	Desap Pole
	1PLSRT	Repair	Soft Rot
Tower	1BEMEM	Refurbishment	Replace Bent Member
	1TWFOO	Refurbishment	Repair Tower Footing
	1BARBW	Repair	Repair/Replace Barb Wire
	1PAINT	Repair	Paint
	1RUSCO	Repair	Inspect Rust/Corrosion

At present poles are creating the majority defects in the overhead structures asset class, however the overall volume has been reducing (improving) over the past five years, indicating an improvement in the condition of the asset base and therefore a reduction in the likelihood of failure. The interventions from the maintenance inspection programs are also predominantly asset repairs and not asset replacements, again the number of asset replacement initiated based on a conditional asset failure has been reducing over the last five years.

The number of repair work orders is largely driven by minor defects on poles such as missing pole caps and poles requiring a desap. Refurbishment defects include the nailing of timber poles, as well as structural and foundation refurbishment of steel towers.



Work Orders Categorised by Asset Type
Pole
Tower
10K
8K
6K
4K
2K
0K
2012
2014
2016
2018
2020



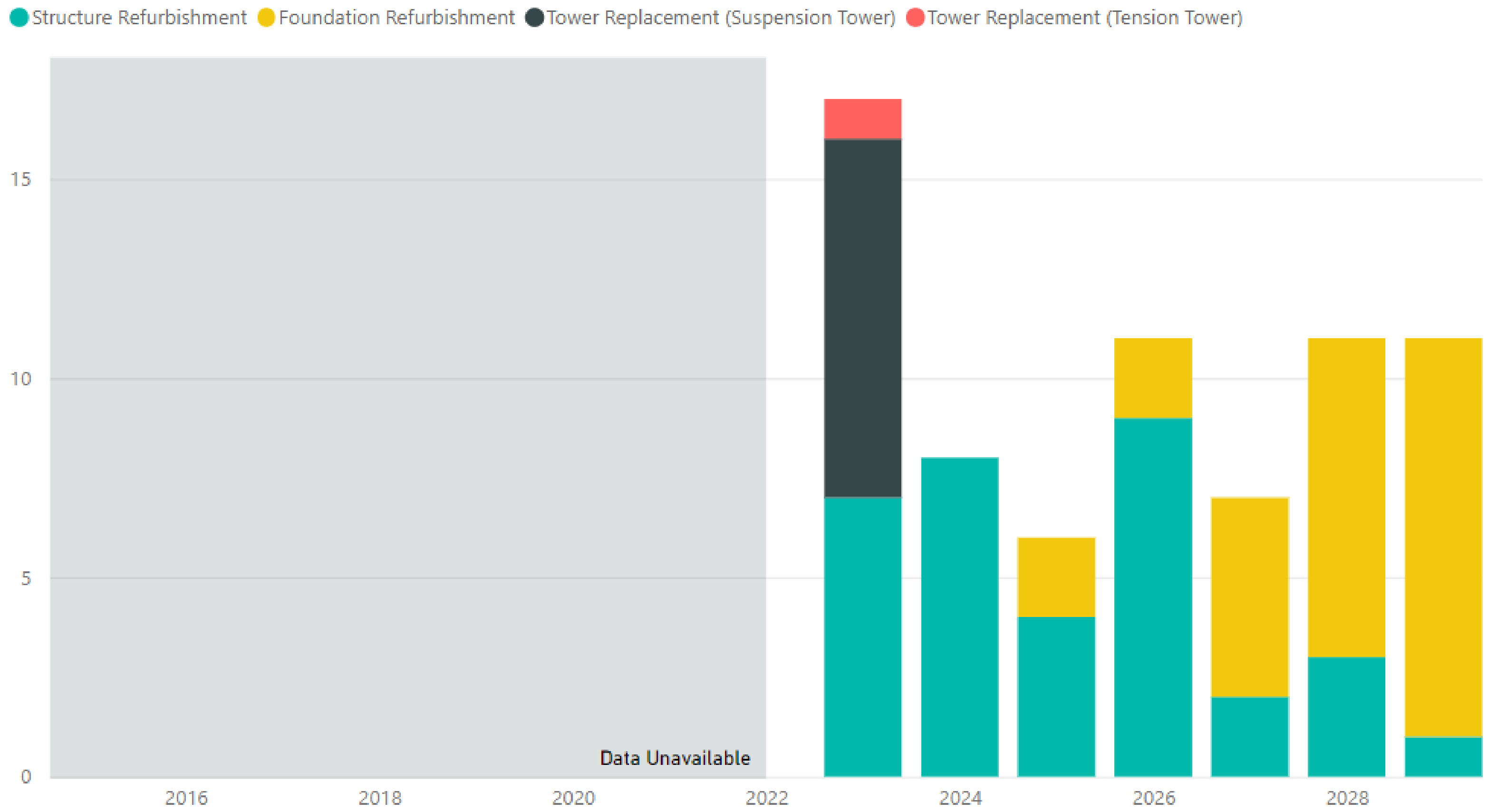
Work Orders Categorised by Intervention
Repaired
Refurbished
Replaced
10K
8K
6K
4K
2K
0K
2012
2014
2016
2018
2020

6.3 Risk Based Interventions

Risk based intervention options considered as possible feasible intervention options have been further considered to address the risk presented by overhead structures at the asset class level. The customer benefit achieved by the proposed intervention option is compared with the cost of the proposed intervention(s) to determine if the option is economically viable and in the customer's interest. This approach generates a cost to benefit ratio / NPV for every asset and intervention option being considered.

The assessment into the risk-based intervention of overhead structures only yielded economically feasible interventions for towers, there are no economically feasible interventions identified for poles.

The following volume of forecasts / breakdown between options are based on the results of the CFI associated with towers.

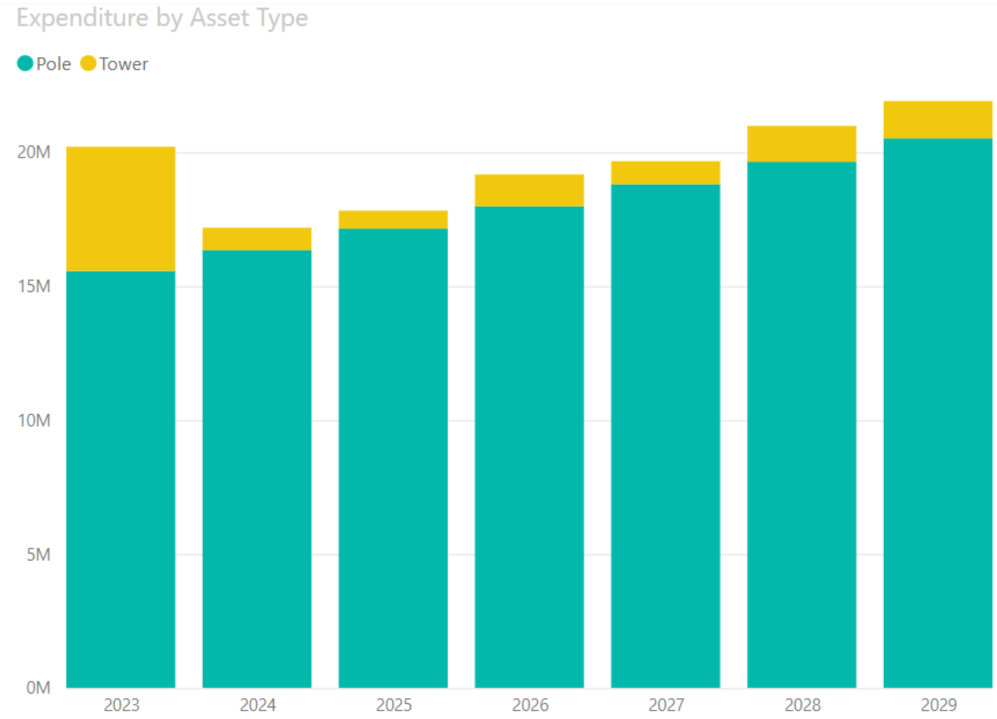


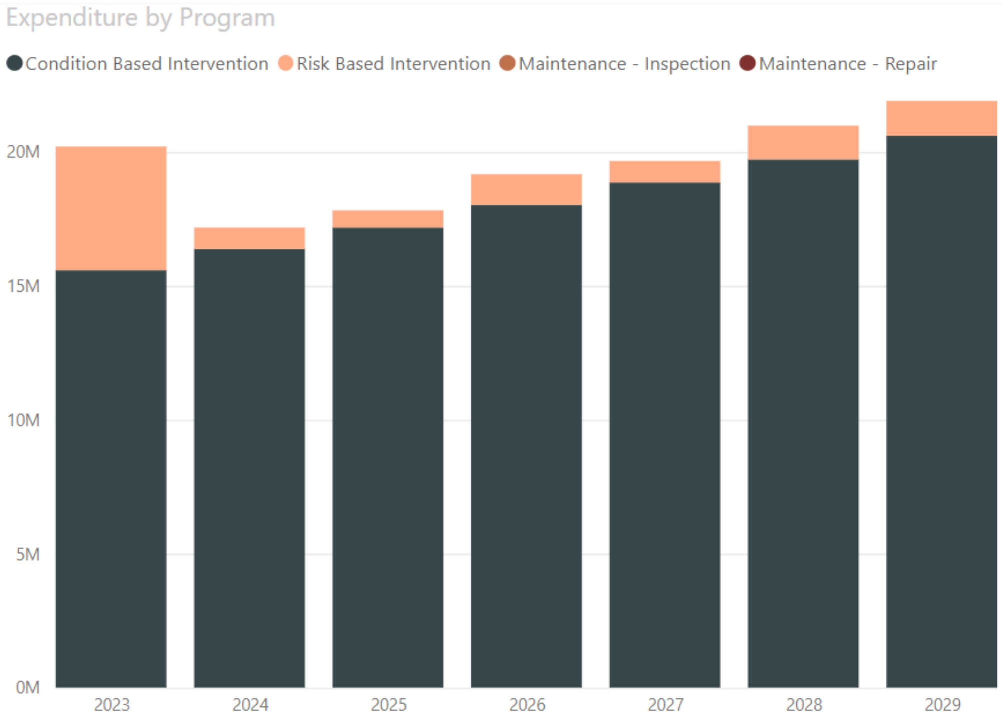
7. Forecasts

7.1 Cost

The expenditure for overhead structures in the FY23-29 period totals $136.89 million which comprises of $10.52 million worth of investment into the risk-based asset intervention of towers that will reach their maximum NPV within the FY23-29 period as well as a further $126.36 million for the condition-based intervention of both poles and towers that are expected to conditionally or functionally fail within the FY23-29 period.

There is a peak in investment costs for overhead structures in FY23 due to 10 towers being identified for complete replacement as part of the assessment into risk based intervention of towers. Investment costs for this asset class drop slightly in FY24 before steadily increasing towards FY29.



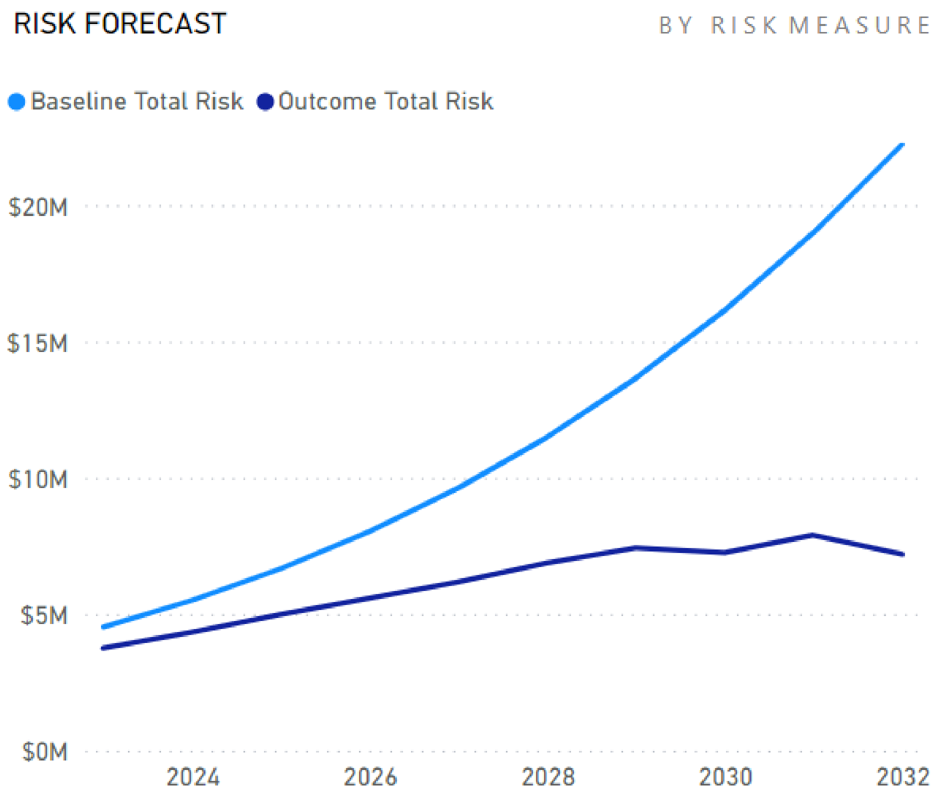


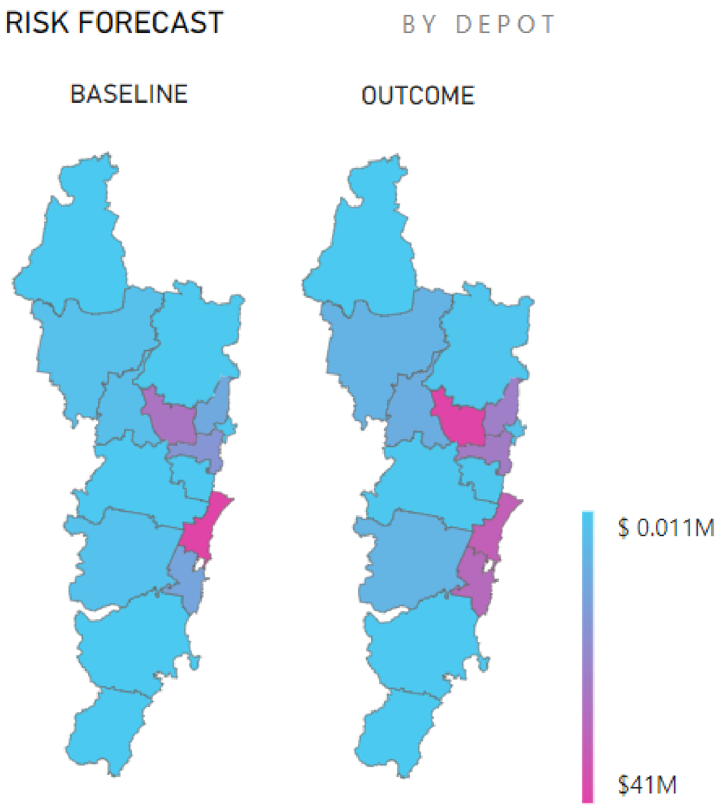
7.2 Risk

Network risk associated with overhead structures has been calculated as per the current value framework. The total risk in this asset class is made up from Reliability (60%), Safety (22%), Financial (13%), Bushfire (4%), and Environmental (1%).

The baseline risk (no intervention) associated with this asset class is projected to approximately reach $22 million if no action is taken. The outcome risk based on the proposed intervention profile is however projected to remain steady at $7 million over the following ten-year period.

It can also be seen that the total risk will become much more uniform across the network with the majority of the investment focused in higher density residential / CBD areas, as the risk is predominantly driven by network reliability.

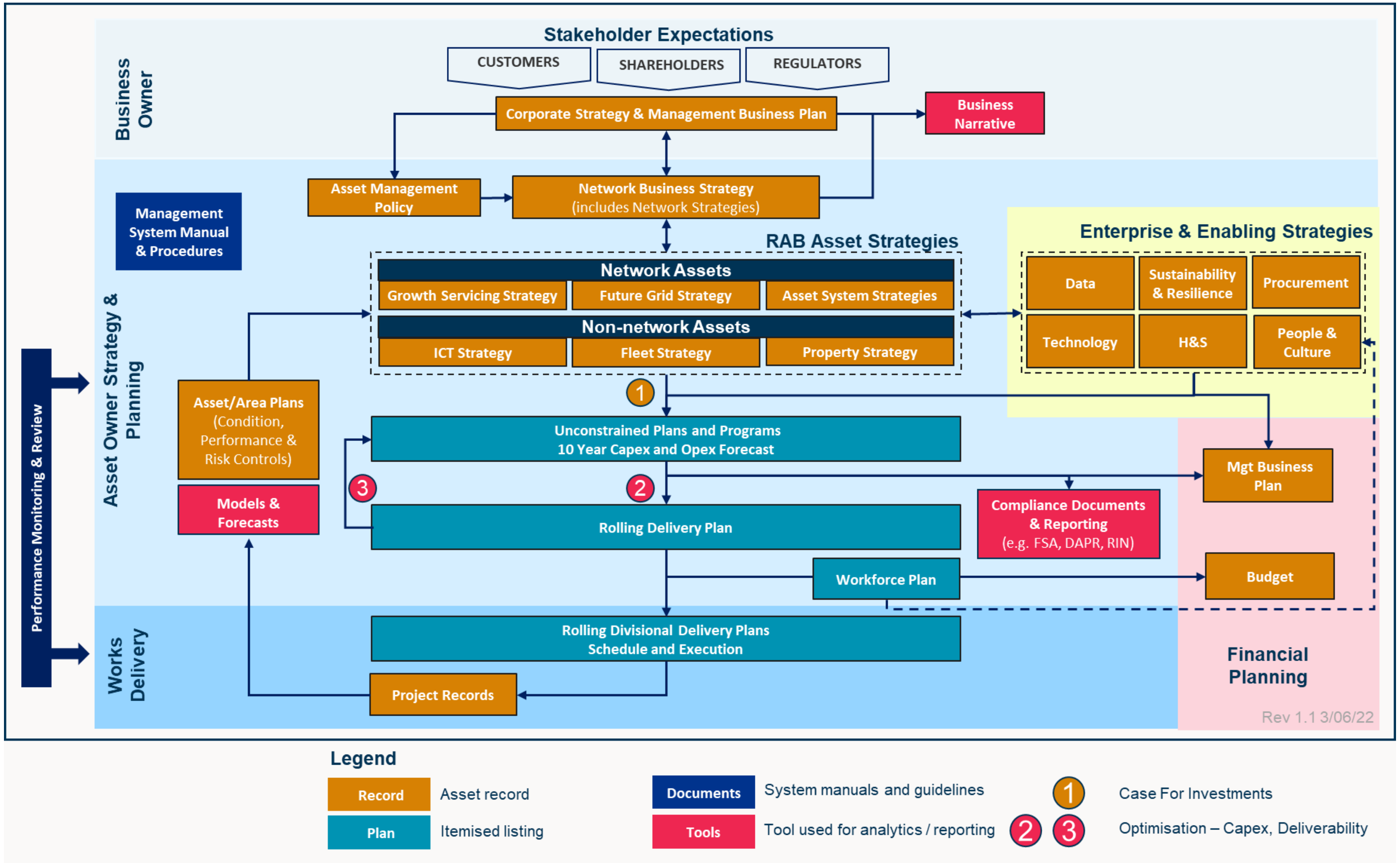




8. Asset Management Systems

This section identifies the strategies, practices and guidelines supporting the management of this asset class. A detailed description of Endeavour Energy's asset management system and its constituent parts is available in the Asset Management System Manual and the Asset Management System Guidelines.

The relationship between this document and the other artefacts within Endeavour Energy's asset management system is illustrated below:



8.1 Standards, Guidelines & Policies

Endeavour Energy's asset management practises are governed and guided by numerous legislative requirements, guidelines, and industry best practises throughout Australia and Internationally. Endeavour Energy's manuals, procedures and workplace policies are all underpinned by these key documents as documented in 'GQY 1190 Policy and Procedure Framework' and demonstrated in the adjacent figure. Legislation, regulations, and high-level Australian Standards applicable to HV network operations are detailed in the Endeavour Energy Asset Management System.

Endeavour Energy has developed the following documentation to specifically guide the life-cycle management of overhead structures:

Company Policies

9.1.6	Approved Materials List
9.1.7	Commissioning network Electrical Assets
9.1.9	Network Technical Compliance
9.2.1	Network Planning
9.2.2	Network Protection
9.2.5	Network Asset Design
9.7.1	Network Asset Construction
9.8.3	Network Operations
9.9.1	Network Asset Maintenance
9.9.2	Essential Spares

Approved Materials Lists & Specifications

ETS 0052	Timber Poles
ETS 0057	Pole Nails
ETS 0104	Steel Poles

Design Instructions

MDI 0031	Overhead Line Design
SDI 518	Support Structures

Construction & Commissioning Standards

MCI 0005	Overhead Construction Standards Manual

Maintenance & Operations Standards

MMI 0001	Pole and Line Inspection and Treatment Procedures
MMI 0002	Distribution Overhead Defect Handbook
MMI 0012	Overhead Transmission Line Routine Inspection
MMI 0034	Pre-summer Bushfire Inspections
SMI 101	Minimum Requirements for Maintenance of Distribution Equipment

8.2 Asset Management Tools

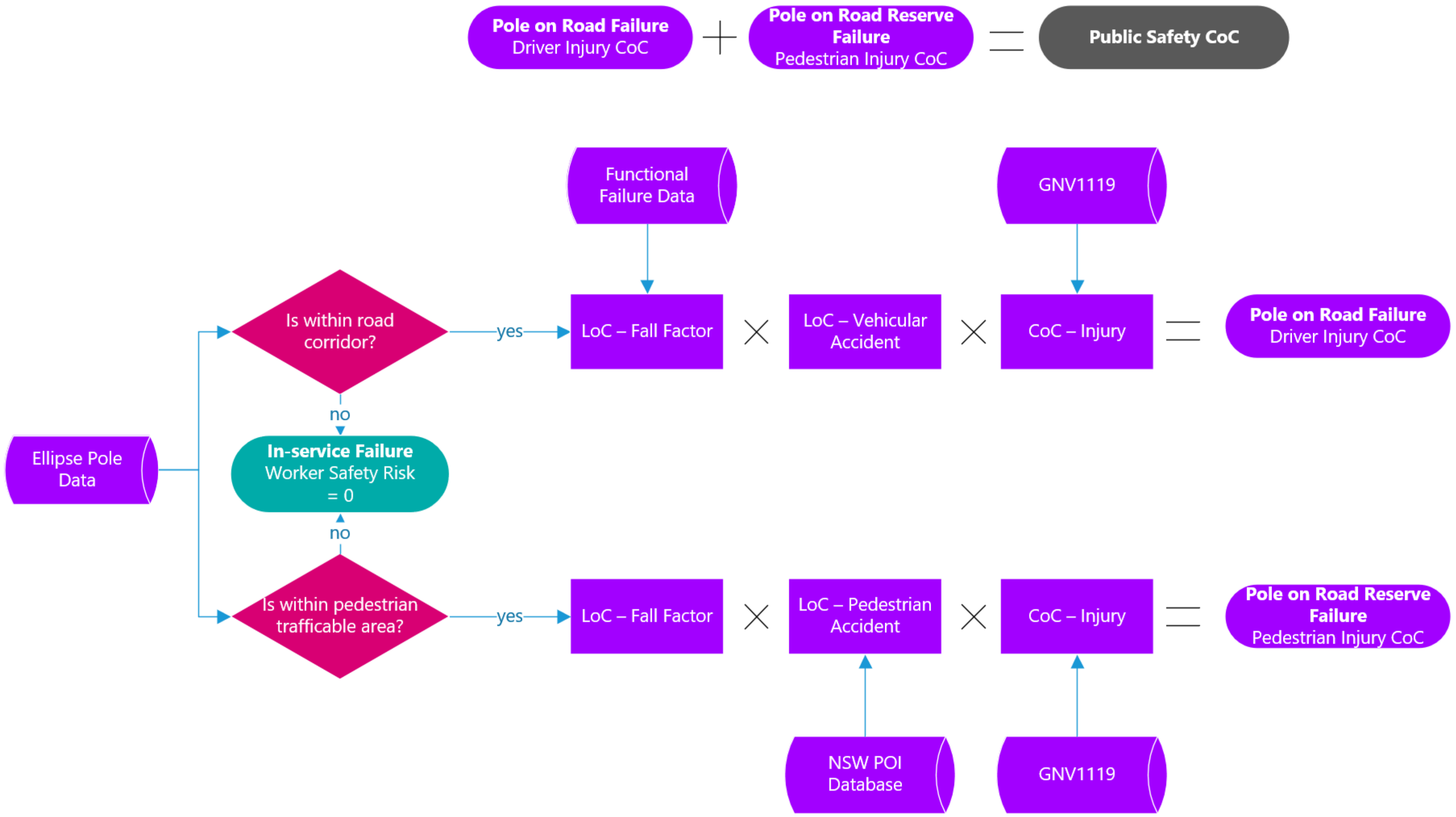
Endeavour Energy use numerous integrated data-base and geographical information system related tools to aid in the management of overhead structures.

Key tools used for the management of overhead structures include:

Tools	Current Purpose	Future Purpose
Ellipse Database	Used for historical (2010-2021) asset nameplate details, routine maintenance scheduling, defect workorder recording and management	Superseded by SAP
SAP	Used for recent (2021-Current) asset nameplate details, routine maintenance scheduling, defect workorder recording and management	To be used as the primary data source for: • Asset characteristics • Financials • Safety – safety incidents are to be categorised by asset class, asset type, and severity • Bushfire – bushfire incidents are to be categorised by asset class, asset type, and severity • Environmental – environmental incidents such as SF6 gas leaks are to be captured and categorised by asset class, asset type, and severity
ADMS	Not currently used	To be used as the primary data source for: • Reliability – reliability incidents are to be categorised by asset class, asset type, and include SAIDI and SAIFI contributions. • Resilience – Benefits from network automation to be quantified • Utilisation – switching events are to be categorised by asset class and asset type.
SwitchIt	Used to determined switch utilisation in terms of switching frequency	Superseded by ADMS
OMS	Used for historic (2012-2021) asset related reliability incidents	Superseded by ADMS
FireStart	Used for historic (2005-2021) asset related firestart incidents	Superseded by SAP
MySafe	Used for historic (2012-2021) asset related safety incidents categorised by severity	Superseded by SAP

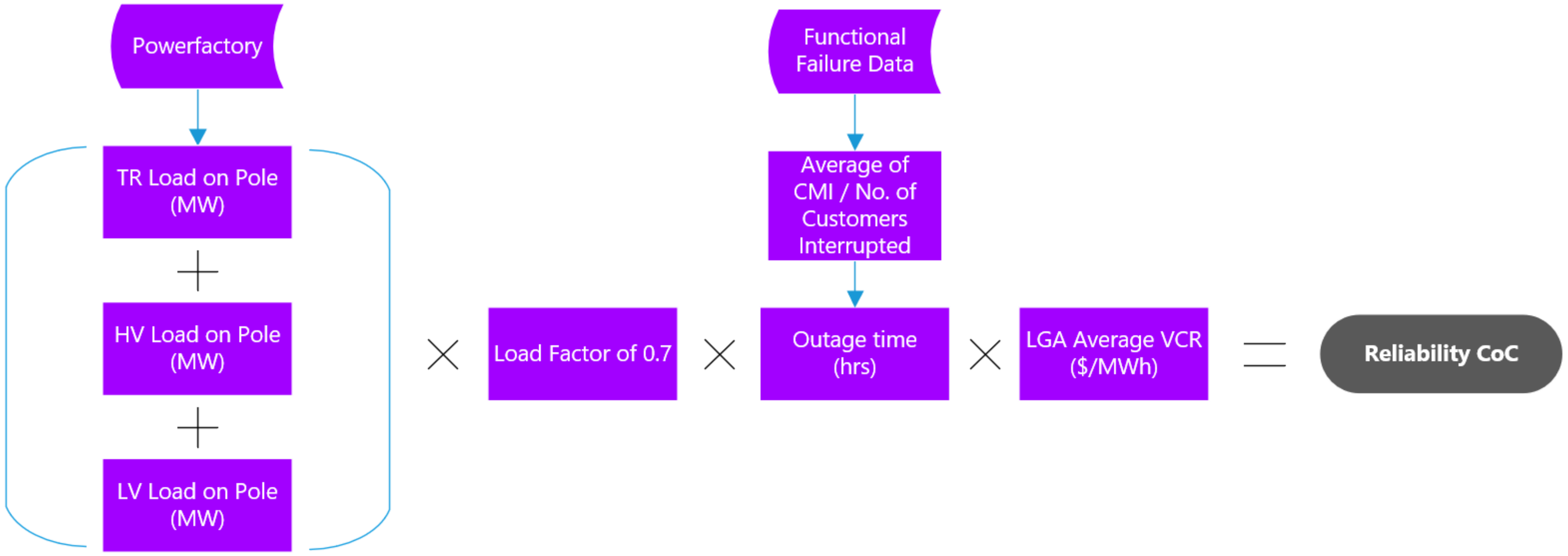
Appendix A – Cost of Consequence

Poles - Safety



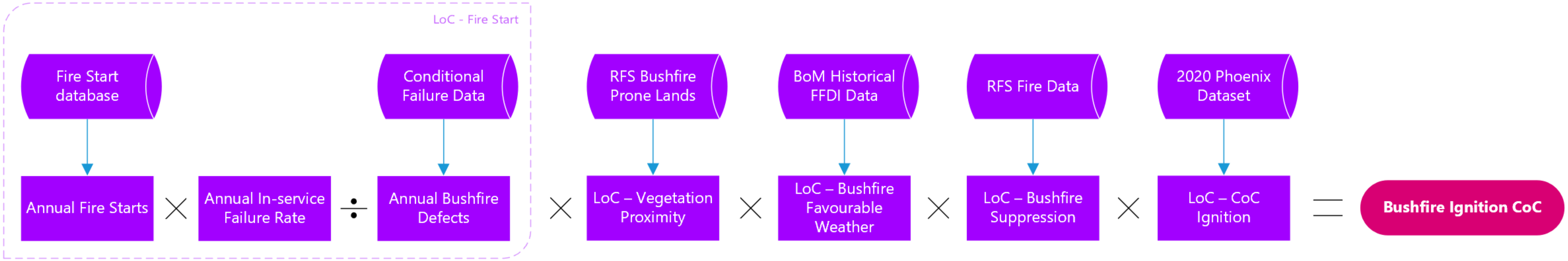
Parameter	Value	Description	Source/Assumptions
LoC – Fall Factor	0.0044	Likelihood that a failure will relate to a safety incident	Endeavour Energy's defect data via Ellipse workorders
LoC – Vehicular Accident	0.01	Likelihood that a safety incident will result in an injury	Endeavour Energy's historical Safety Incidents via MySafe database
LoC – Pedestrian Accident	0.0333	Likelihood of a pole falling and impacting a pedestrian in a high traffic area	Based on classification, calculated exposure probability
	0.00556	Likelihood of a pole falling and impacting a pedestrian in a medium traffic area	Based on classification, calculated exposure probability
	0.000116	Likelihood of a pole falling and impacting a pedestrian in a low traffic area	Based on classification, calculated exposure probability
CoC - Fatality	$5,100,000	Value of statistical life (VoSL)	Office of Best Practice Regulation
CoC – Injury	$255,000	5% of VoSL	Office of Best Practice Regulation

Poles - Reliability



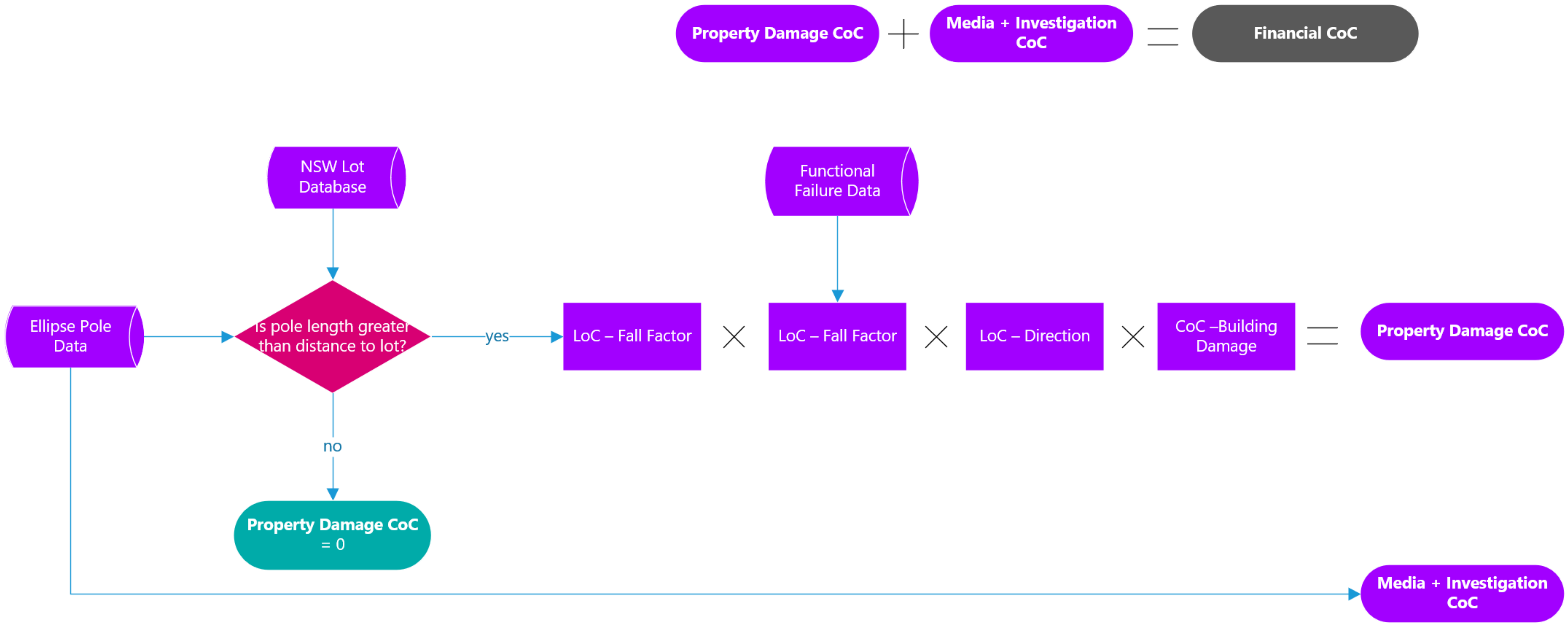
Parameter	Value	Description/justification	Source/assumptions
Load on pole	TR – Varies by pole	50% of maximum transmission feeder load multiplied by 5% due to feeder back-up	EE transmission feeder loads
	HV – Varies by pole	Load of HV feeder	Power Factory load flow simulations
	LV – Varies by pole	Load of closest distribution substation	EE distribution substation loads
VCR	Varies by pole	Based on HV feeder	AER published values
Duration of interruption	4 hours	Duration of time until affected customers are restored	Based on historical data from EE's Outage Management System

Poles - Bushfire



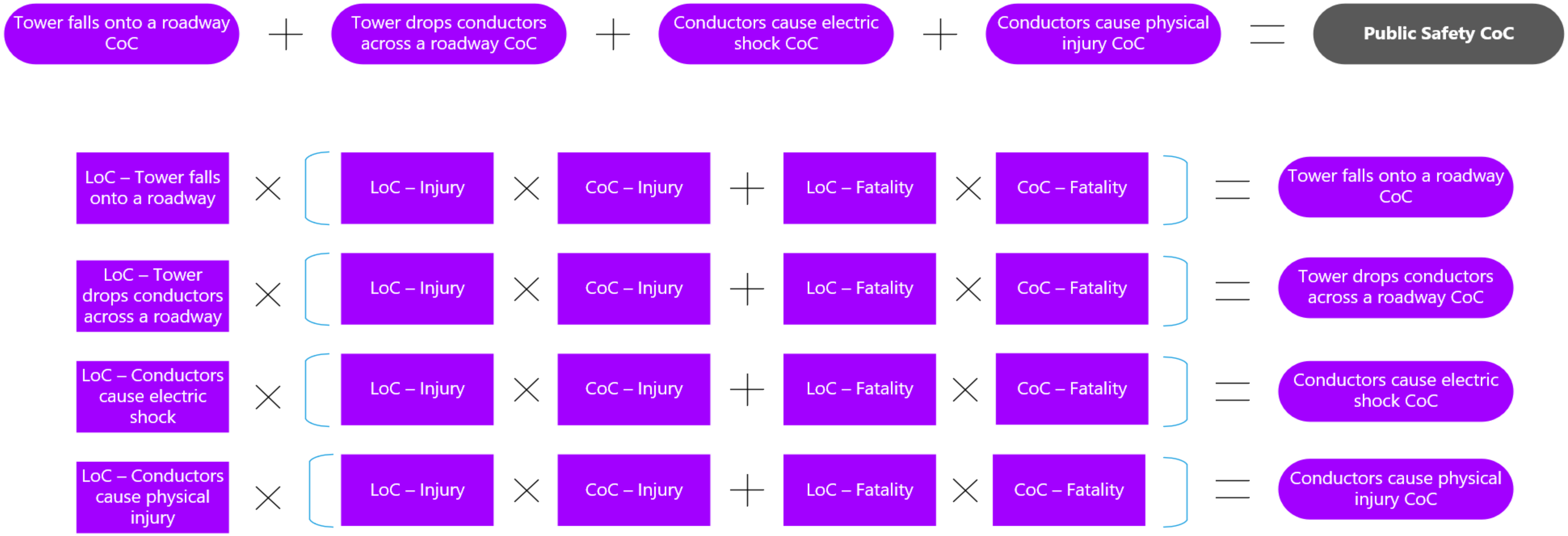
Parameter	Value	Description/Justification	Source/Assumptions
LoC – Fire Start	Varies by asset	Likelihood that a failure will create a fire	Endeavour Energy's defect data via Ellipse workorders Endeavour Energy's historical fire database
LoC – Vegetation	Varies by asset	Risk reduction factor based on the asset's spatial location and its proximity to vegetation fuel sources	RFS bushfire prone land maps
CoC – Bushfire	Varies by asset	Cost of a bushfire including costs associated with fatalities, houses lost, residential contents lost, vineyards lost, plantations lost, crops lost, powerlines lost.	Ignition simulation via Phoenix software

Poles - Financial



Parameter	Value	Description/justification	Source/assumptions
Pole length	Varies by pole	Length of pole	Based on voltage classification of pole and the average pole lengths used for each voltage classification
Lot distance	Varies by pole	Distance from pole to property	NSW Lot Database
Direction - LoC	0.25	Likelihood of pole falling in the direction of property	Estimated value
Building Damage - CoC	$78,018	10% of average cost of buildings within EE franchise area	Estimated value
Media + Investigation - CoC	$18,000	Financial costs arising due to media response and investigation	Estimated value

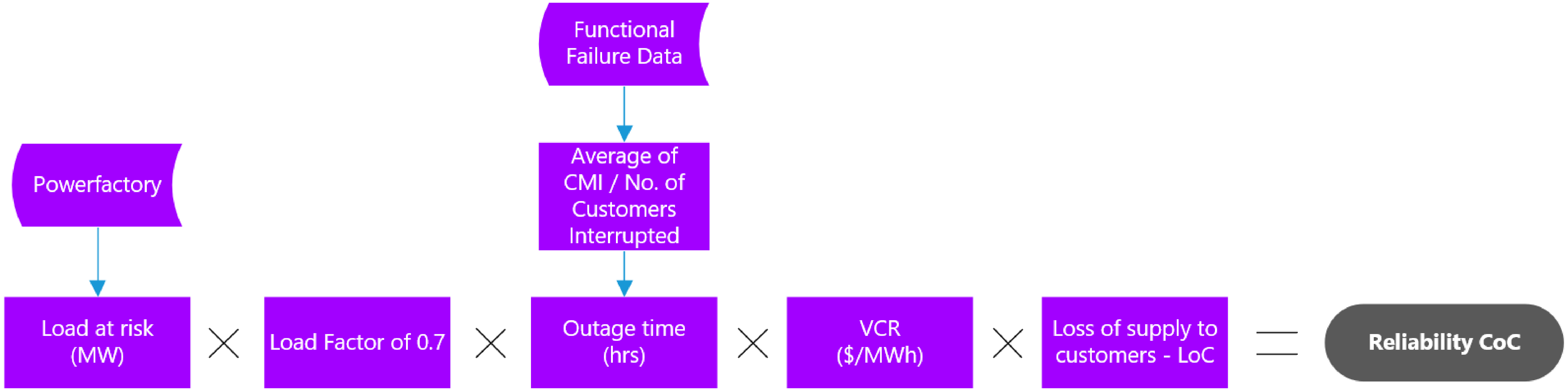
Towers - Safety



Parameter	Value	Description/justification	Source/assumptions
Value of a fatality	$5,100,000	Value of statistical life (VoSL)	EE Copperleaf Value Model – based on Office of Best Practice Regulation published values
Value of a serious injury	$2,249,000	44.1% of VoSL	GNV1119
Tower falls onto a roadway - LoC	5%	Likelihood of causing a fatality if falls onto a road, subject to number of persons exposed	Estimate "Roadway_impact" input variable
	15%	Likelihood of causing a serious injury if falls onto a road, subject to number of persons exposed	Estimate "Roadway_impact" input variable
	Varies by tower	Falls across roadway and number of persons likely to be present	Calculated by spatial analysis in FME. 40m buffer around the tower centreline touches/intersects with road data from *RoadSegmentEndeavourDec2020* shapefile.
Tower drops conductors across a roadway – LoC	5%	Likelihood of causing a fatality if persons present	Estimate "Roadway_impact" input variable
	15%	Likelihood of causing a serious injury	Estimate "Roadway_impact" input variable
	Varies by tower	Falls across roadway and number of persons likely to be present	Calculated by spatial analysis in FME given the location of the tower and its neighbour in the same line, in relation to roads, and the type of road. Find "nearest towers" in the same line. Find conductor segments between the towers. Find where touch/intersect with a road segment from ESRI shapefile *RoadSegmentEndeavourDec2020*. Some line segments in GIS span multiple towers. To compensate for this, all towers greater than 400m from road/conductor intersection were excluded. Number of road users likely to be present for each type of road provided by the roads shapefile.

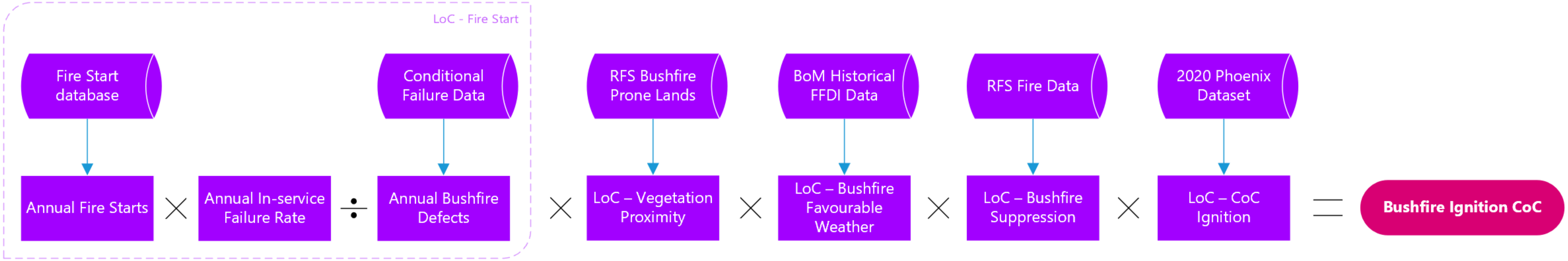
Parameter	Value	Description/justification	Source/assumptions
Conductors cause electric shock – LoC (based on falling onto buildings)	50%	Nominal likelihood of conductors falling onto or near to the ground such that they could cause a shock to persons in the vicinity. Tower failure near ground level.	Estimate "Persons_impact" input variable
	5%	Likelihood of causing a shock hazard resulting in a fatality if persons present	RiskCAT generalised value for exposure "Persons_impact" input variable
	15%	Likelihood of causing a shock hazard resulting in serious injury if persons present	Estimate "Persons_impact" input variable
	1	Number of persons affected if present	Estimate "Persons_impact" input variable
	Varies by tower	Number of persons likely to be present	Calculated by spatial analysis in FME given the location of **buildings** within 40m buffer area around tower. Buildings type and location from ESRI shapefile *BuildingsDec2020*.
Conductors cause physical injury – LoC (based on falling onto buildings)	1%	Likelihood of falling onto a person and causing a fatality	Estimate "Persons_impact" input variable
	9%	Likelihood of falling onto a person and causing a serious injury	Estimate "Persons_impact" input variable
	1	Number of persons affected if present	Estimate "Persons_impact" input variable
	Varies by tower	Number of persons likely to be present	Calculated by spatial analysis in FME given the location of **buildings** within 40m buffer area around tower. Buildings type and location from ESRI shapefile *BuildingsDec2020*.

Towers – Reliability



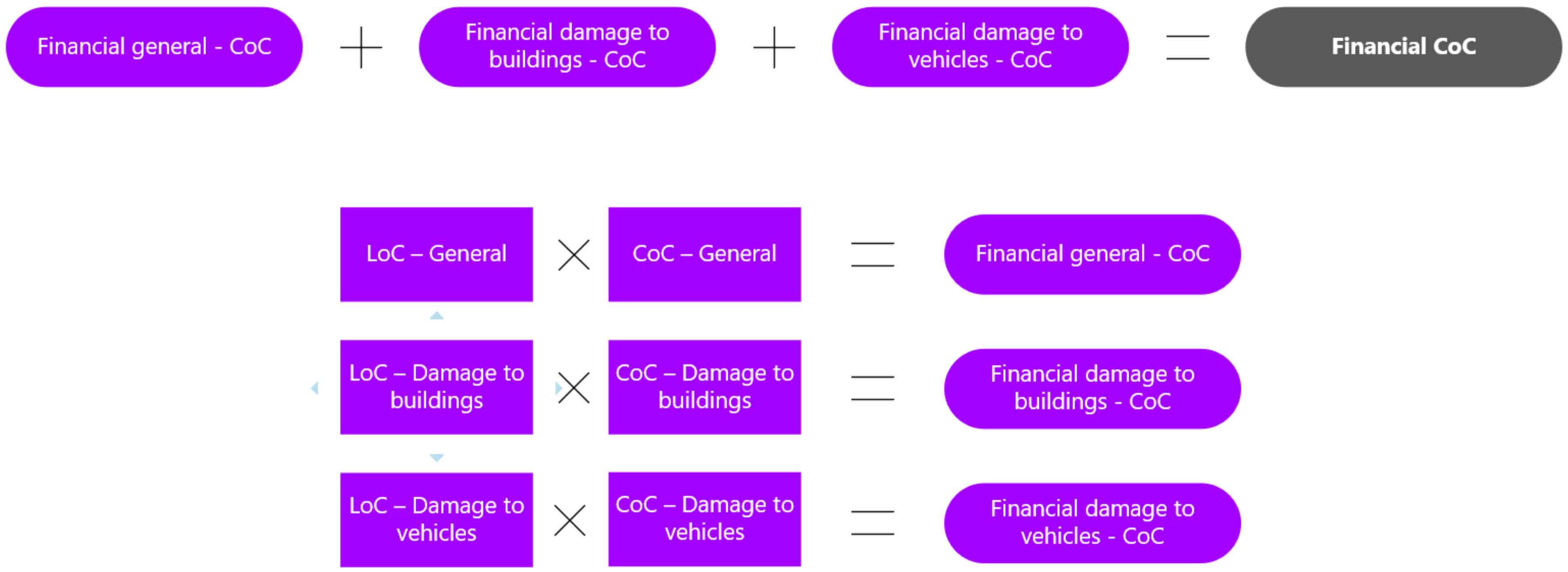
Parameter	Value	Description/justification	Source/assumptions
Loss of supply to customers - LoC	1% generally 100% for specific cases	1% likelihood of loss of load when N-1 supply security is available 100% likelihood of loss of load for the failure of a double circuit tower which provides the sole supply to a substation	RisCAT - 1% likelihood the alternate supply path will not be available due to maintenance, or failure. 100% is applicable to towers in the following lines: 980/981 – Bellambi TS 985/989 – Outer Harbour TS 940/941 – North Katoomba TS 930/931 – Carlingford TS Source – Network topology/SOPS
Load impacted	Varies based on the substations supplied by the lines the towers support	The summer maximum demand of the substation	Spreadsheets based on 2020 Summer Maximum Demand planning report
Load factor	70%	Load assumed to be lost is 70% of the summer maximum demand value for the supplied substation(s)	Source – studies of network faults by Protection Manager.
VCR	$34,340/MWh of unserved energy	Value of customer reliability for an occasional short-term outage	Generalised value across the network from Copperleaf Value Model, based on values published by the AER (Note, value published by Network Planning Manager is $35,811)
Duration of interruption	4 hours	4 hours assumed interruption until alternate arrangements are made for supply through switching the network	A generalised value based on a range of outages of transmission assets. Assumes off-loading to reinstate supply through a combination of SCADA and manual switching.

Towers – Bushfire



Parameter	Value	Description/justification	Source/assumptions
Bushfire - LoC	50%	Estimated value based on standardised EE value of 20% for "TR Conductor".	20% for "TR Conductor" based on the recorded quantity of fires started to failures observed across the specific set of assets. Value increased to 50% on the basis that a tower collapse will cause multiple conductors to clash and/or contact the ground with a greater likelihood of starting a fire than a single conductor down. Input the Bushfire model.
Bushfire - CoF	Total Bushfire Risk Cost	Likelihood and consequence of bushfire start evaluated by the Bushfire Model based on the Phoenix RapidFire simulation prepared for EE's network by The University of Melbourne in 2020.	Tower spatial information input into the Bushfire FME model. The model assesses the CoC of a bushfire started by each tower. Other inputs to the model: - Vegetation LoC - CoC for Low, High, Very High, Severe, Extreme, Catastrophic fire risk days - LoC adjustment for Bushfire severity days to produce the "All Annual Risk Cost (Total)" value for reading back into the Towers FME workflow

Towers – Financial



Parameter	Value	Description/justification	Source/assumptions
Financial general - CoC	$100,000	Switching to restore supply/supply security, clean-up, any temporary diversion works, investigation, media management costs	Estimate, based on typical clean-up and investigation costs
Financial general - LoC	100%	Likelihood of general financial risks being realised on failure	Will always be realised to an average extent.
Financial – damage to buildings – CoC	$750,000	Value of damage if tower falls on a building	Nominal value of building repair/replacement - $750,000. Average house construction cost in NSW. Sourced from media published values.
Financial – damage to buildings – LoC	12.5%	Likelihood of a tower collapse near a building falling onto and causing damage to the building	"Buildings_impact" input variable. Estimate – based on 25% likelihood of a tower collapse being in the direction of the adjacent building and 50% likelihood of the collapse in the direction of the building reaching the ground and causing damage to the building Number of buildings likely to be impacted is derived from the ESRI shapefile *BuildingsDec2020*
Financial – damage to vehicles if tower falls onto road OR drops conductors across a road – CoC	$20,000	Value of vehicles impacted if tower falls onto or drops conductors across a road	Nominal value of vehicle repair/replacement - $20,000. Average vehicle value in NSW. Sourced from media published values. (Note - this has increased to $35,000 during 2021/22 due to Covid influences)
Financial – damage to vehicles if tower falls onto road OR drops conductors across a road – LoC	50%	Likelihood of vehicles being impacted by a tower falling onto a road or dropping a conductor across a road	"Roadway_impact" variable. Estimate based on 50% likelihood of a collapse resulting in the tower or conductors reaching the ground. Number of vehicles likely to be impacted is calculated by the type of road information derived from the ESRI shapefile *RoadSegmentEndeavourDec2020*

Towers - Environmental

Parameter	Value	Description/justification	Source/assumptions
Environmental - CoF	High sensitivity - $100,000 Medium sensitivity - $25,000 Low sensitivity - $10,000	CoC assigned based on the land use around each tower.	The land use around each tower evaluated from the ESRI shapefile *LanduseEndeavourDec2020*. Sensitivity assigned based on landuse: "High" – National Parks, state forests, wetlands etc "Medium" – Cropping, high value agriculture "Low" – All others Values of consequence are estimates based on clean-up and compensation costs.
Environmental - LoC	100%	Likelihood of the above environmental impact occurring on a tower failure	LoC assumed to be = 1

Appendix B – Weibull Parameters

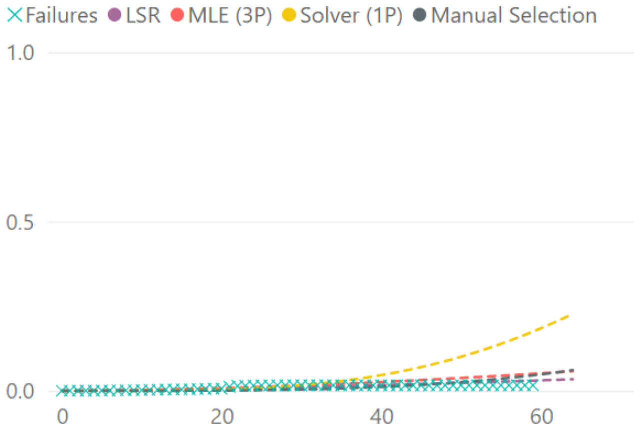
Conditional Weibull Parameters

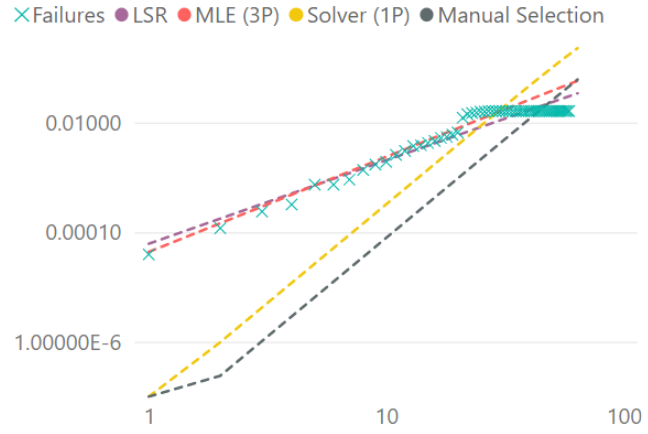
Poles

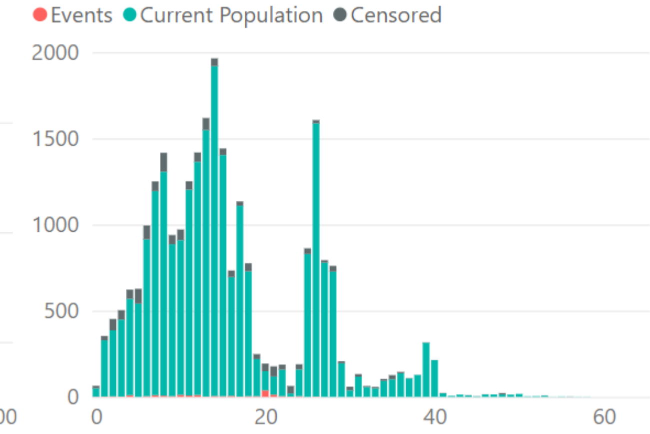
Concrete

Parameters	LSR	MLE	Solver	Selected
Shift	0	0	0	0
Shape	1.52	1.73	3.6	3.6
Scale	581.46	325.63	93	138
Predicted average failure age	524	290	84	124
Predicted no. of failures p.a.	9	13	16	4

Input Data Statistics	Value
Mean failure age	14
Population size	23774
Avg number of historical annual failures	16
Age Earliest Failure	0
Age Oldest Asset	58



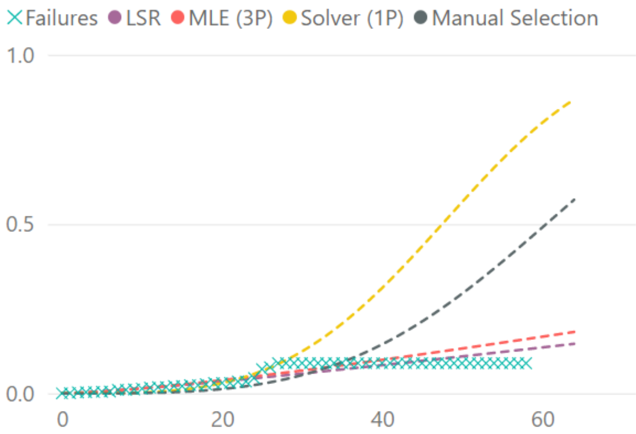


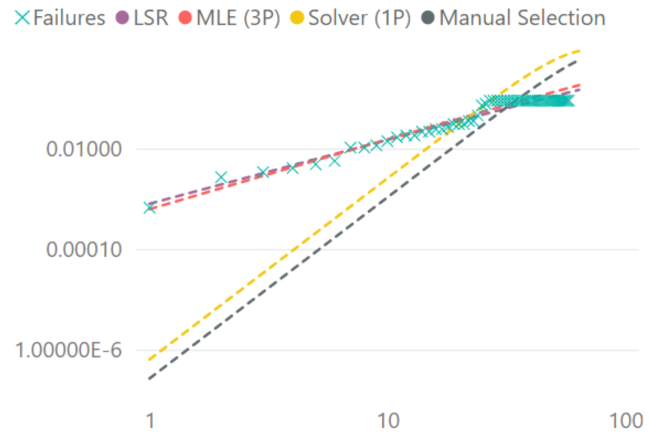


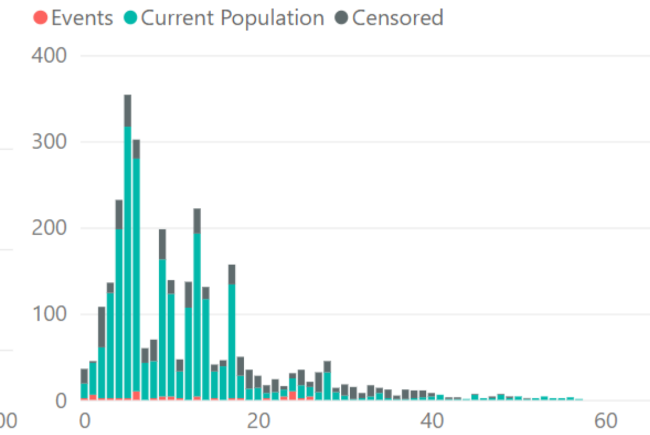
Steel

Parameters	LSR	MLE	Solver	Selected
Shift	0	0	0	0
Shape	1.27	1.39	3.6	3.6
Scale	272.49	203.7	53	67
Predicted average failure age	253	186	47	60
Predicted no. of failures p.a.	4	5	7	3

Input Data Statistics	Value
Mean failure age	13
Population size	2272
Avg number of historical annual failures	7
Age Earliest Failure	0
Age Oldest Asset	57



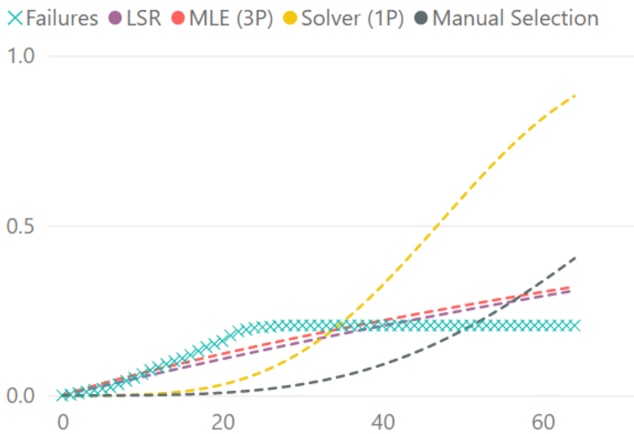


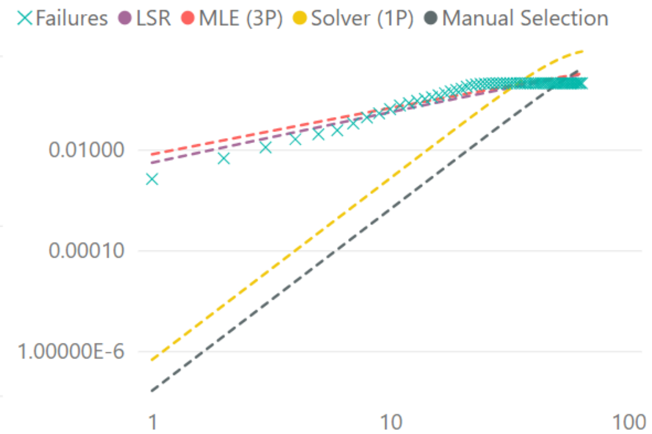


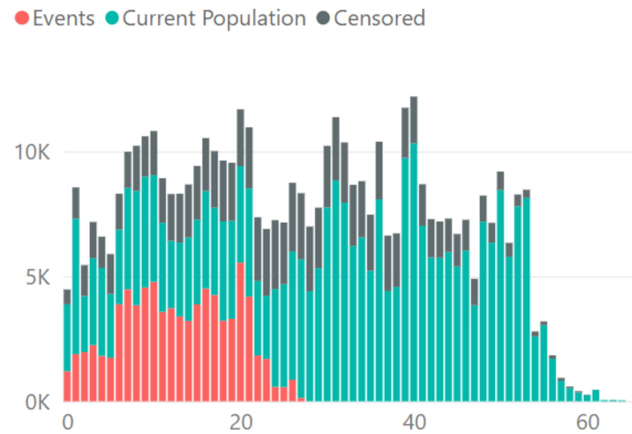
Timber

Parameters	LSR	MLE	Solver	Selected
Shift	0	0	0	0
Shape	1.01	0.93	3.6	3.6
Scale	171.32	178.23	52	76.9
Predicted average failure age	170	184	47	69
Predicted no. of failures p.a.	1650	1712	8098	2002

Input Data Statistics	Value
Mean failure age	13
Population size	286730
Avg number of historical annual failures	8098
Age Earliest Failure	0
Age Oldest Asset	64





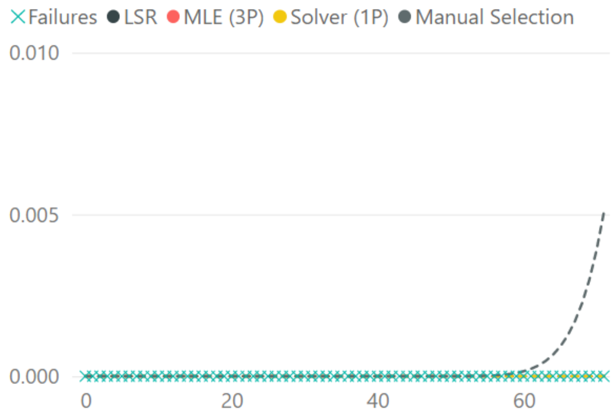


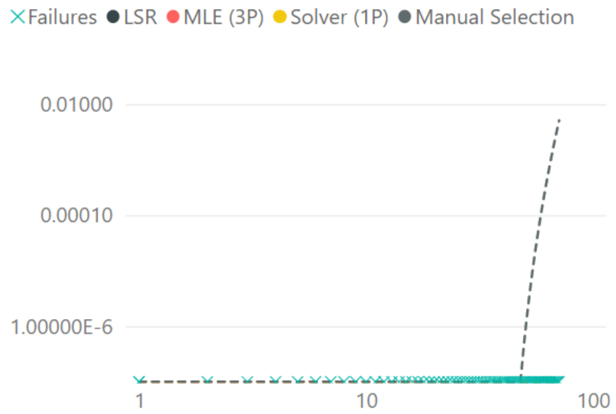
Towers

All

Parameters	LSR	MLE	Solver	Selected
Shift	-	-	-	40
Shape	-	-	-	8
Scale	-	-	-	60
Predicted average failure age	-	-	-	97
Predicted no. of failures p.a.	-	-	-	0.7

Input Data Statistics	Value
Mean failure age	-
Population size	832
Avg number of historical annual failures	-
Age Earliest Failure	-
Age Oldest Asset	85





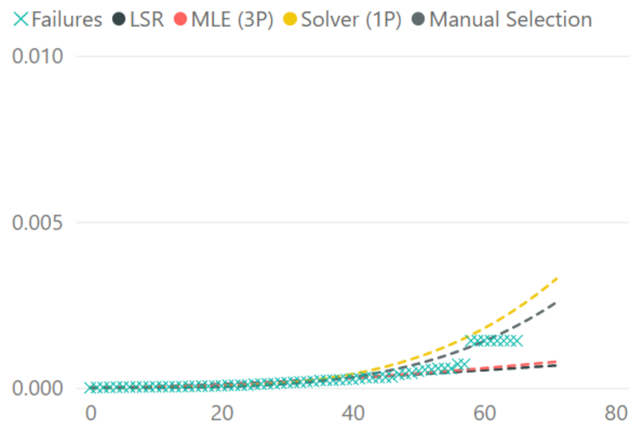
Functional Weibull Parameters

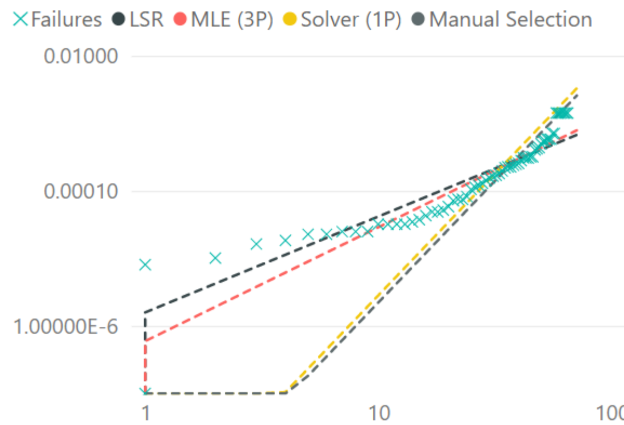
Poles

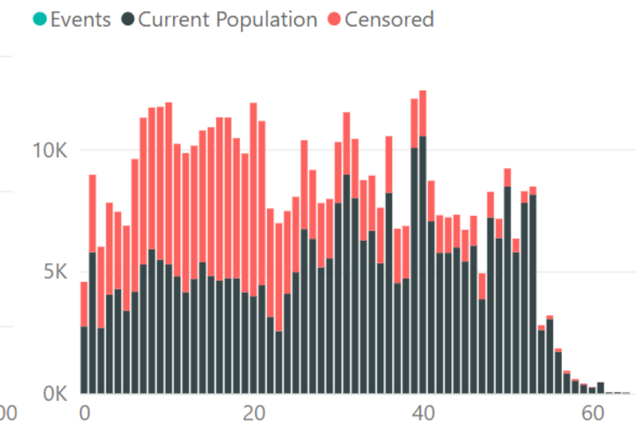
All

Parameters	LSR	MLE	Solver	Selected
Shift	0	0	0	0
Shape	1.42	1.69	3.6	3.6
Scale	12178.79	4936.68	348	372
Predicted average failure age	11076	4407	313	335
Predicted no. of failures p.a.	3	3	9	7

Input Data Statistics	Value
Mean failure age	28
Population size	312772
Avg number of historical annual failures	9
Age Earliest Failure	0
Age Oldest Asset	64





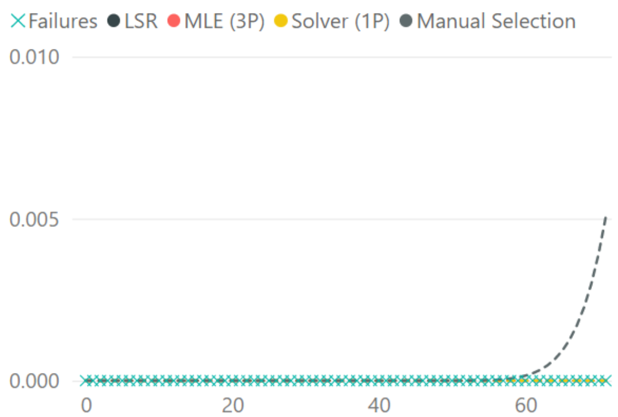


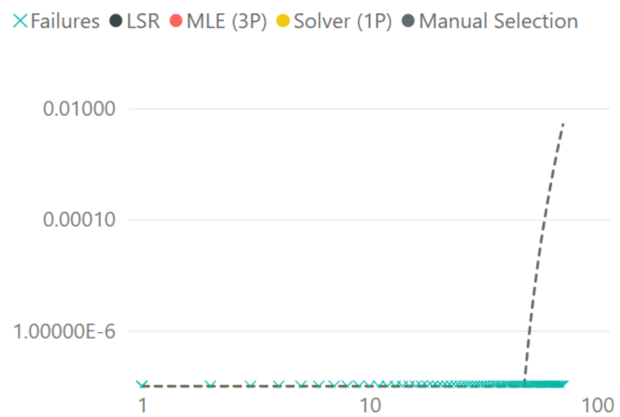
Towers

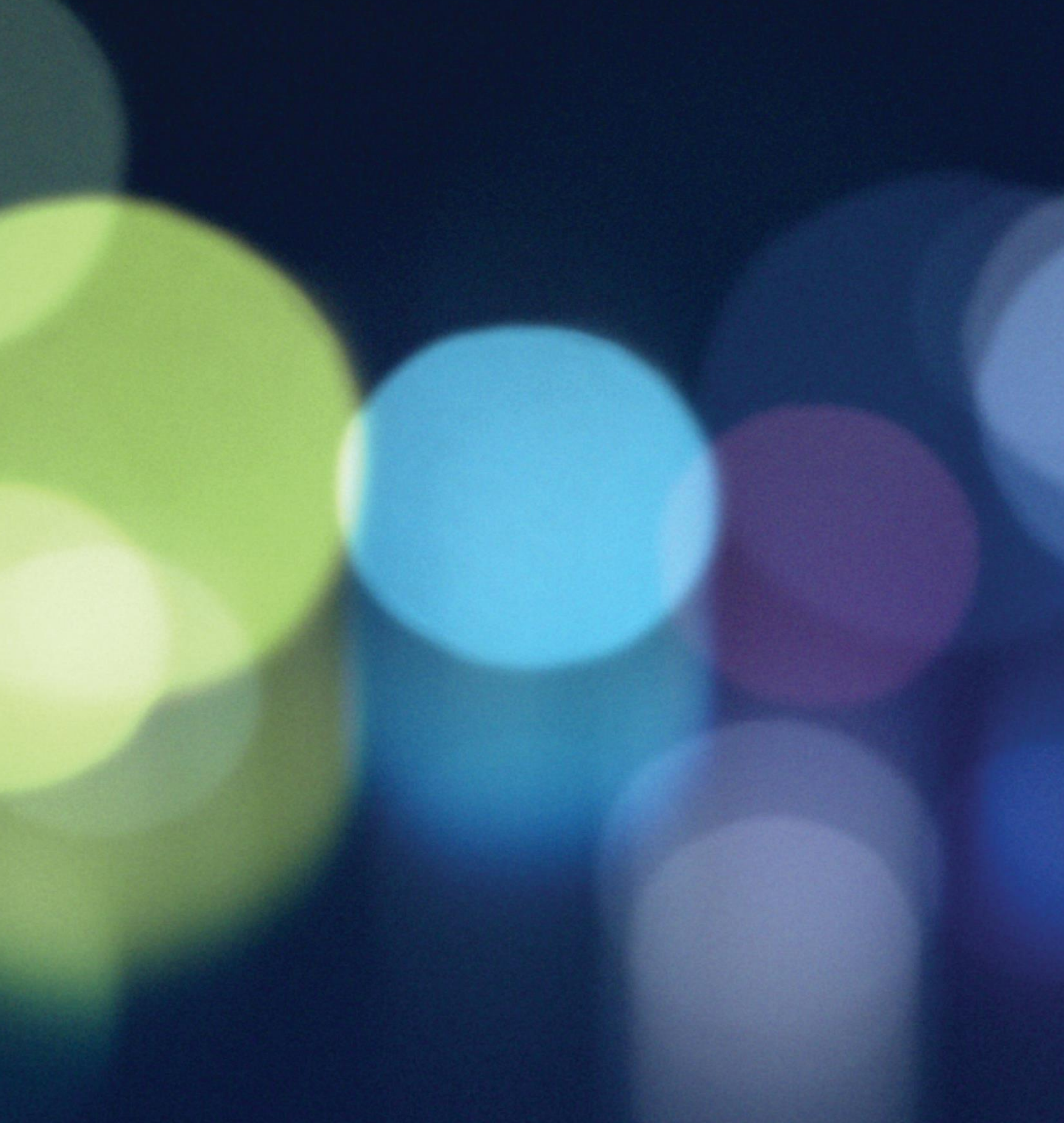
All

Parameters	LSR	MLE	Solver	Selected
Shift	-	-	-	40
Shape	-	-	-	8
Scale	-	-	-	60
Predicted average failure age	-	-	-	97
Predicted no. of failures p.a.	-	-	-	0.7

Input Data Statistics	Value
Mean failure age	-
Population size	832
Avg number of historical annual failures	-
Age Earliest Failure	-
Age Oldest Asset	85







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