HV Overhead Switchgear Asset Class Plan

Mains Assets

October 2022

Endeavour Energy

Version control

Version	Date	Comments
1.1	20/10/2022	Initial release

Contents

1. Executive Summary

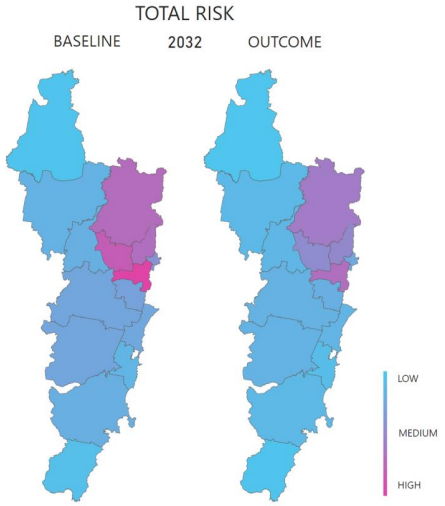
A 10-year strategy for HV Overhead (OH) Distribution Switchgear has been defined driven by the risk associated with the aging population of the asset class. The forecasted risk, strategy cost breakdown, and performance metrics are outlined below and include Air Break Switches, Under Slung Links, Drop Out Fuses, and Load Break Switches.

Risk Forecast

The failure of HV OH Switchgear may lead to Safety, Reliability, Financial, 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 HV Overhead Switchgear.

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

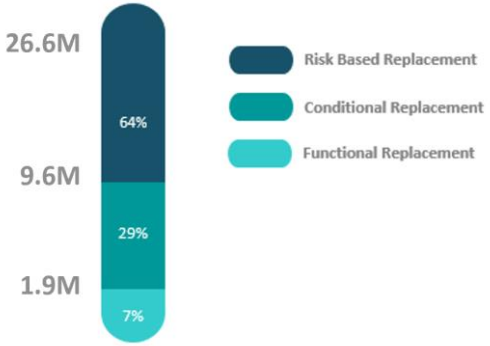


Strategy and Cost

The selected intervention option to address the risk associated with HV OH Switchgear includes a mix of reactive replacement and proactive replacement.

Continued maintenance is also to be applied however the cost associated with this cannot be broken down to this level at this stage.

The total cost of this strategy for the 2023-2029 period is $26.6M and is categorised based on the intervention type.



Key Performance Indicators

HV OH Switchgear performance 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	Status
Asset Utilisation	Optimise use and penetration of assets in the network to decrease management costs, improve utilisation and inform future network standards	●
Safety	Reduce the number incidents (excluding general hazards)	●
Reliability	Reduce the number of unplanned outages associated with functional failures	●
Resilience	Monitor the average number of customers impacted during an unplanned outage	—
	Monitor the average number of customers impacted during a planned outage	—
	Reduce need / risk associated with manual switching	●
Bushfire	Maintain the percentage of fire starts as a proportion of the asset base	●

2. Overview

2.1 Purpose

The purpose of this document is to outline previous, current and proposed asset management practices for HV Overhead (OH) Distribution Switchgear 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 HV OH Distribution Switchgear 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).

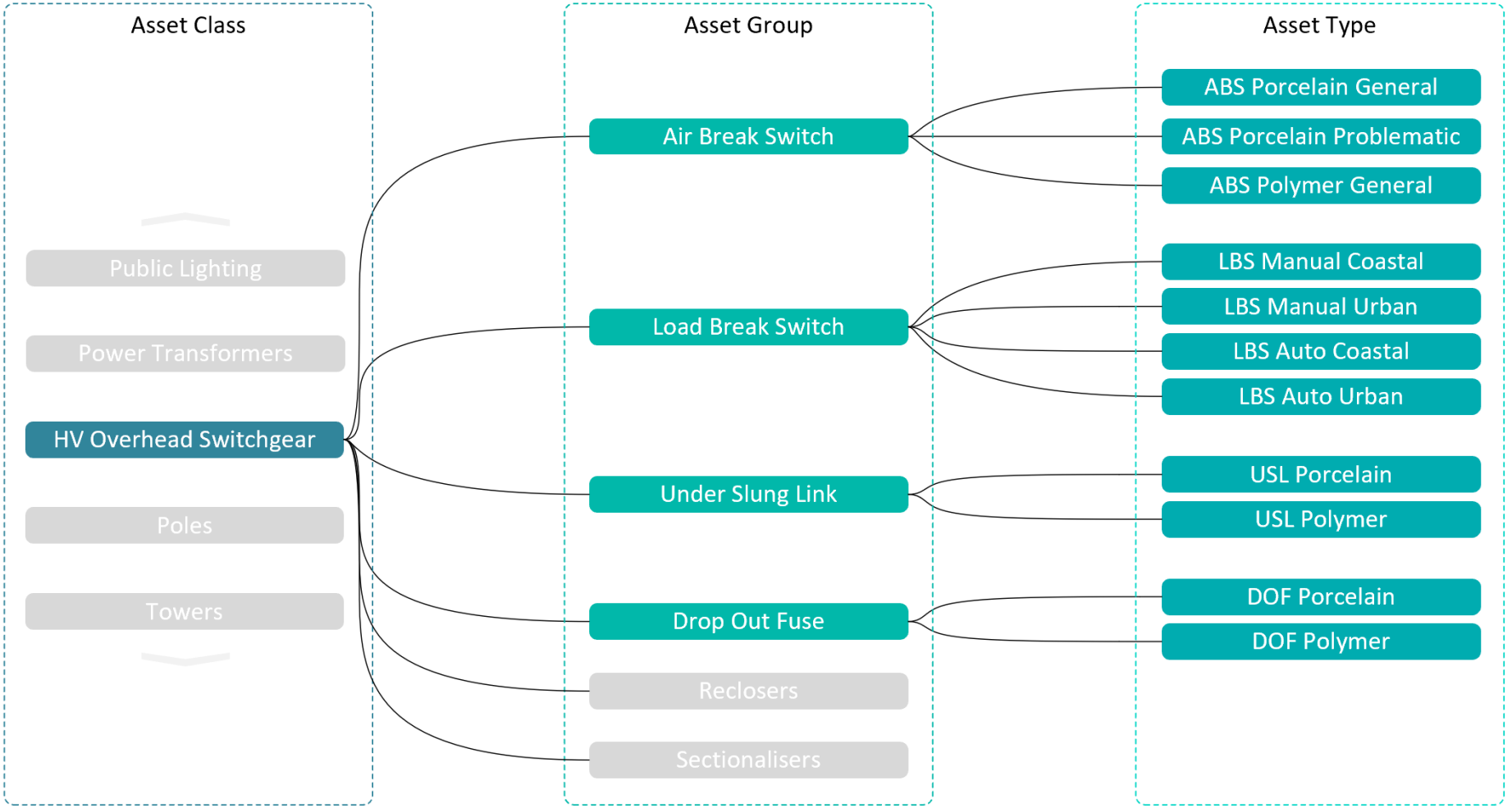
The document will highlight and discuss historical trends and future forecasts for three primary asset management strategies:

- 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 through out this document represent the natural increase in risk without an asset replacement program.

2.2 Scope

This report covers all Endeavour Energy owned HV OH Distribution Switchgear which includes the following highlighted assets:



3. Asset Portfolio

3.1 Asset Function

HV OH Switchgear currently perform two primary functions, allowing current to flow and isolation / segmentation of the network for the following purposes:

1. To facilitate re-energisation of the network, post a fault event (e.g. restore supply to customers).
2. Facilitate isolation for faulted sections of the network or for planned outages and maintenance/repair of equipment.
3. Automatic and centralised operation of switchgear (through replacement of retired ABS & USL assets with SCADA enabled LBS), to promote operational efficiency.

The current role and minimum performance measures for OH switchgear in the distribution network is underpinned by Company Policy 9.2.5 Network Asset Design. This policy states:

"Isolation points must be installed at appropriate locations in the network to facilitate the effective operation, maintenance, fault isolation, supply restoration and repair of the network so as to reduce the duration and the area of planned and unplanned interruption of supply to customers."

The policy also specifies design parameters for the number of substations or amount of load allowed between isolation points. The procedure to implement and achieve this policy is outlined in MDI 0026.

As the capability of switches (and supporting infrastructure such as ADMS) become more advanced (e.g. load break capability, network fault detection, communications and the introduction of "Fault location, isolation, and service restoration" (FLISR), the functionality and purpose of HV OH switches will continue to change and mature. This asset class will increase in significance / importance in the performance of the network as these technologies are gradually introduced into the network and the maturity of systems develop.

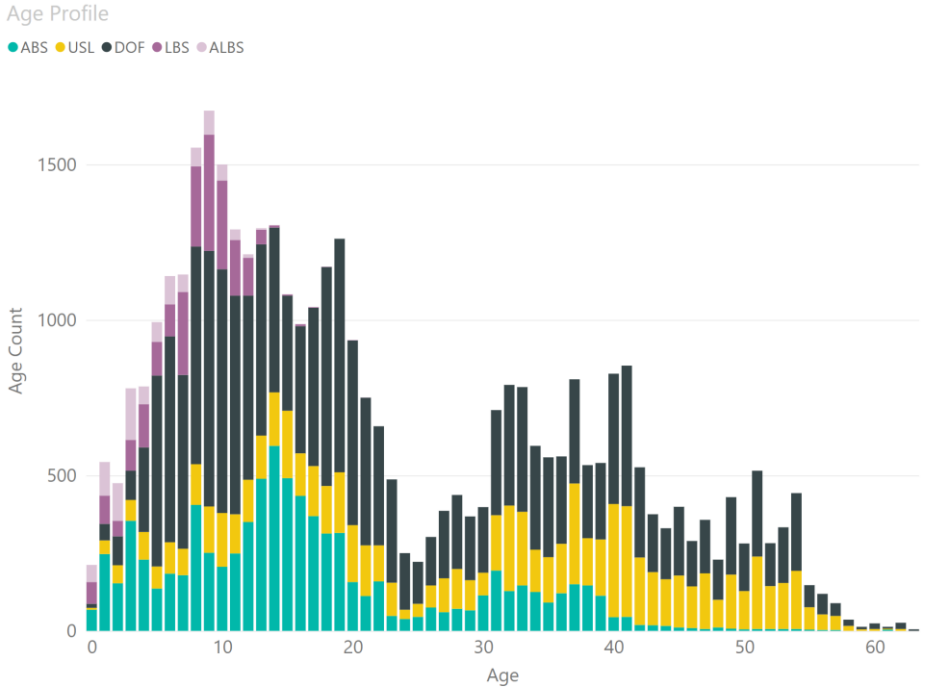
The breakdown of risks that are attributed to this asset class are shown in section 4 to illustrate performance measures and key drivers.

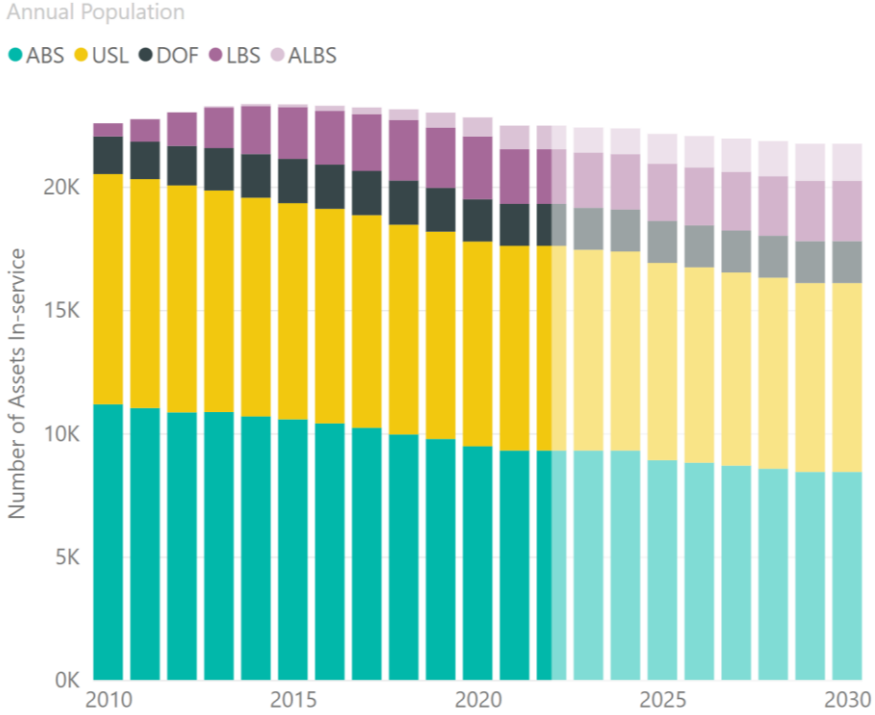
3.2 Asset Population

Endeavour has approximately 22,600 HV Overhead Switches in service in the distribution network.

The total number of assets in the network is relatively consistent over the previous 10 years as most network extensions are in the underground network. A continued overall reduction in the number of assets in this class is expected in years to come (and can already be witnessed) due to further undergrounding of the distribution systems and a shift to automated switches resulting in the need for less switches overall.

A decrease in ABS's and USL's is expected in the coming regulatory period(s) as asset utilisation is assessed and these components are removed from service or replaced by LBS's.





Note: this age profile includes DOF's dedicated for transformer protection. These assets are not reflected in the Annual Population graph shown on the right.

4. Asset Performance

This section quantifies the risks and asset performance measures associated with the fleet of HV OH Switchgear. 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 by for this asset class is associated with reliability.

Risk Category	Consequence	Risk Contribution
Safety	- Damaged insulators falling to the ground during switching striking operators - Faulty insulation creating tracking currents - Combustible gas creating debris from explosive failures which may strike operators	20%
Reliability	- Damaged insulators causing faults and loss of supply on the HV network - Misaligned or jammed contacts prohibiting switching and extending outages or network maintenance	60%
Bushfire	- Arcing of live contacts and damaged insulation may create sparks and initiate a bushfire	5%
Environmental	- No significant environmental consequences have been experienced or are anticipated and are therefore not considered a risk to be managed - Switches using SF6 gas may impose environmental risks in the future, however this is dependent on carbon tax laws	0%
Financial	- Not replacing the asset before a failure may lead to capital expenditure related to reactive replacement	15%

The table below summarises the asset performance service level and objectives across the fleet of HV OH Switchgear.

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	% of switches with at least 1 operation over 10 years	ABS	64%	Stable or Increasing	●	▲
			USL	47%		●	▲
			DOF	15%		●	—
			LBS	66%		●	▲
		Number of switches per km OH line	All	0.98 / per km	Stable	●	—
Safety	Reduce the number incidents (excluding general hazards)	5-year rolling average of total incidents (excluding general hazards)	ABS	2.0	Reduce in line with forecasts	●	—
			USL	1.4		●	—
			DOF	2.2		●	—
			LBS	0.2		●	—
			All	5.8		●	—
Reliability	Reduce the number of unplanned outages associated with functional failures	5-year rolling average of unplanned outages	ABS	28.6	Reduce in line with forecasts	●	—
			USL	26.4		●	—
			DOF	17.0		●	—
			LBS	3.6		●	—
			All	75.6		●	—
Resilience	Monitor the average number of customers impacted during an unplanned outage	Average number of customers disconnected during an unplanned outage (post utilisation of ALBS's)	All	210 customers	Monitor	—	—
	Monitor the average number of customers impacted during a planned outage	Average number of customers disconnected during a planned outage	All	333 customers	Monitor	—	—
	Reduce need / risk associated with manual switching	Percent of total switching operations performed remotely	All	22%	Increase	●	▲
Bushfire	Maintain the percentage of fire starts as a proportion of the asset base	5-year rolling average of fire starts	ABS	4.2	Reduce in line with forecasts	●	—
			USL	2.0		●	▼
			DOF	1.6		●	▼
			LBS	0.0		●	—
			All	7.8		●	—

4.1 Asset Utilisation

4.1.1. Objective

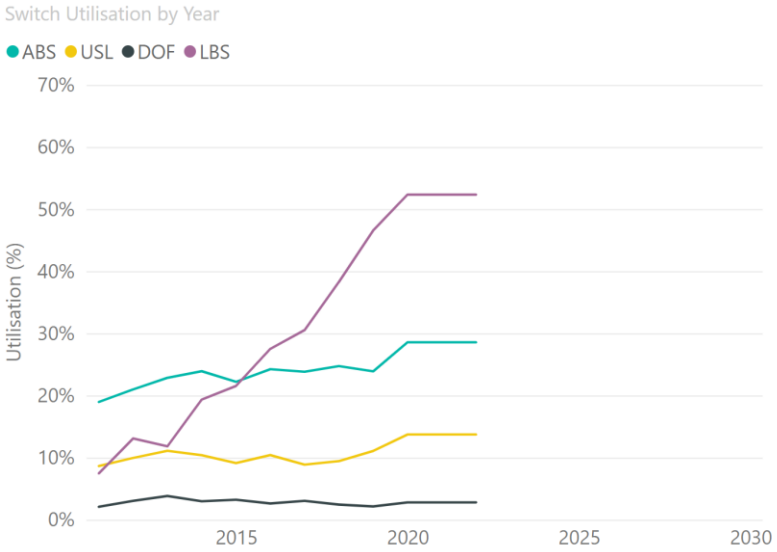
To monitor and understand asset utilisation across each asset type and network wide to inform topology standards and maximise the utilisation of the existing asset base.

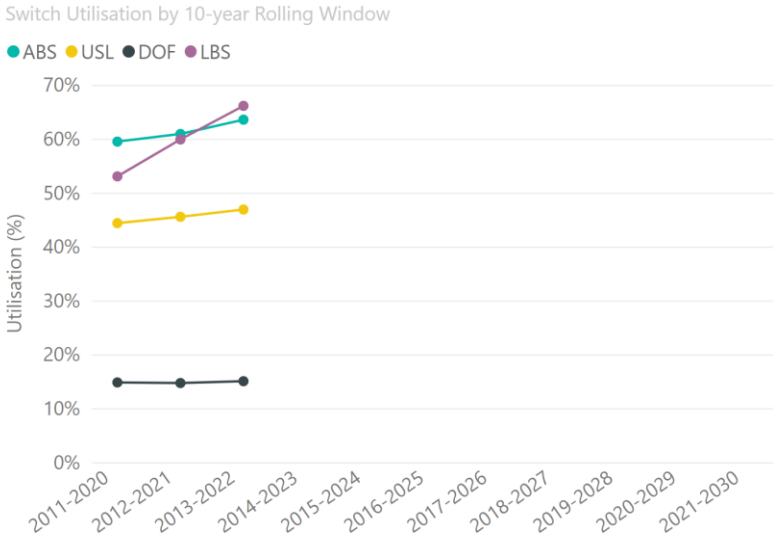
4.1.2. Performance

Utilisation of HV OH Switchgear is defined by the frequency of switching events (open or close of a switch). However, as the primary function of switches is to provide network isolation during network faults, augmentation, maintenance and load transfers, the non-operation of an asset in any one year (or over a short period) should not be considered as under-utilisation.

Both a yearly and rolling 10-year window are monitored for the utilisation of HV OH switches and this data illustrates that the utilisation of each asset type as well as the asset group is continuing to improve. The short term (i.e. yearly) utilisation of LBS's is significantly higher than any other asset type, this is predominantly due the locations in the network they have been installed and their capability to switch line current (which other asset types within this class do not have).

No formal utilisation targets have been established for HV OH Switchgear; however, in line with our objective we want to maximise the value provided by existing assets and only install new assets where the increased level of service they provide justifies the whole of life cost. We aim to maintain or increase the annual utilisation of assets.





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	% of switches with at least 1 operation over 10 years	ABS	64%	Stable or Increasing	●	▲
			USL	47%		●	▲
			DOF	15%		●	—
			LBS	66%		●	▲
		Number of switches per km OH line	Total	0.98 / per km	Stable	●	—

4.1.3. Gap

Value of Utilisation, total network risk is increasing so the value of network isolation is expected to increase over the next 20 years, increasing the reliability value of HV OH Switchgear. These switches contribute to our level of service; however, negatively impact traditional KPIs for utilisation. Improved performance measures need to be developed to accurately reflect the value of these assets and set appropriate targets.

4.1.4. Response

Utilisation of HV OH switches have not traditionally been monitored and the establishment of KPI's will help ensure the ongoing performance of the asset class. All current KPI's indicate that the network topology described in MDI 0026 is effective and being implemented appropriate to allow an increase in asset utilisation of HV OH switches.

4.2 Safety

4.2.1. Objective

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

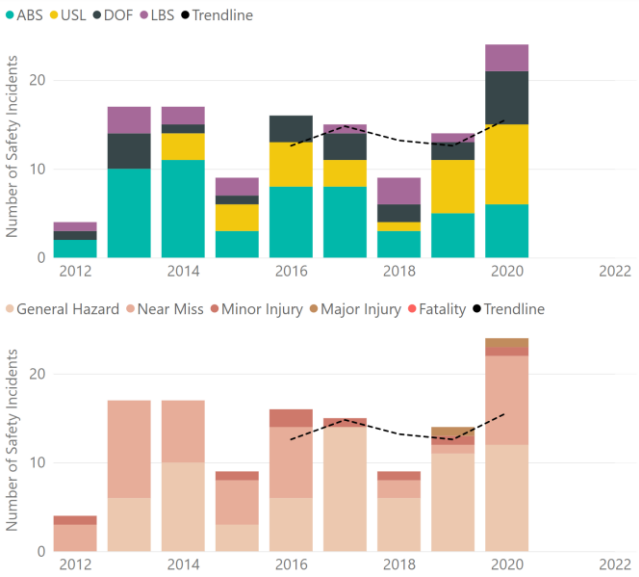
4.2.2. Performance

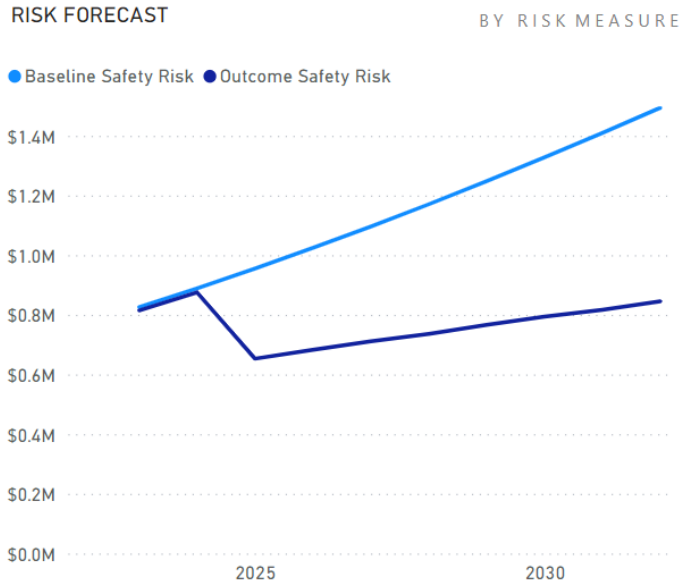
Safety incidents are categorised by severity and include general hazards, near misses, minor injuries, major injuries, and fatalities.

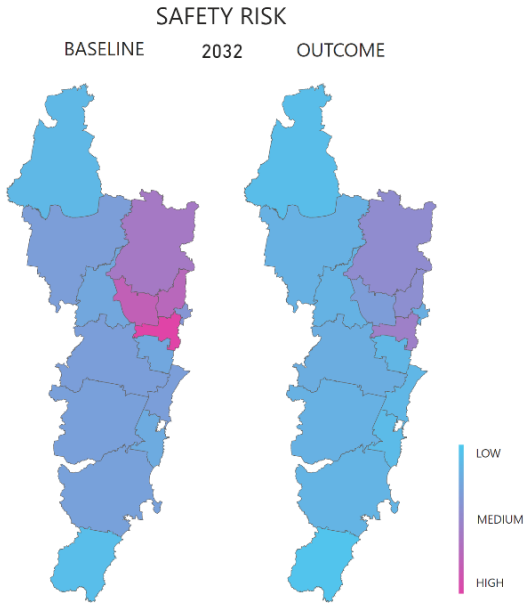
The current asset management strategy is expected to improve safety performance across the fleet of assets as assets at higher risk of failure, which are utilised more often are prioritised for intervention.

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.

The Safety Risk Concentration indicates that at present particular areas of the network have a higher normalised safety risk profile, the proposed program (refer to Section 6) will facilitate balancing the normalised safety risk across the network.







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)	ABS	2.0	Reduce in line with forecasts	●	—
			USL	1.4		●	—
			DOF	2.2		●	—
			LBS	0.2		●	—
			All	5.8		●	—

4.2.3. Gap

Previous investment strategies were unable to separate out safety as an individual risk. Whilst safety makes up a relatively small portion of the overall risk associated with HV OH switches, it is forecast to reduce (improve) based on the current proposed strategy.

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

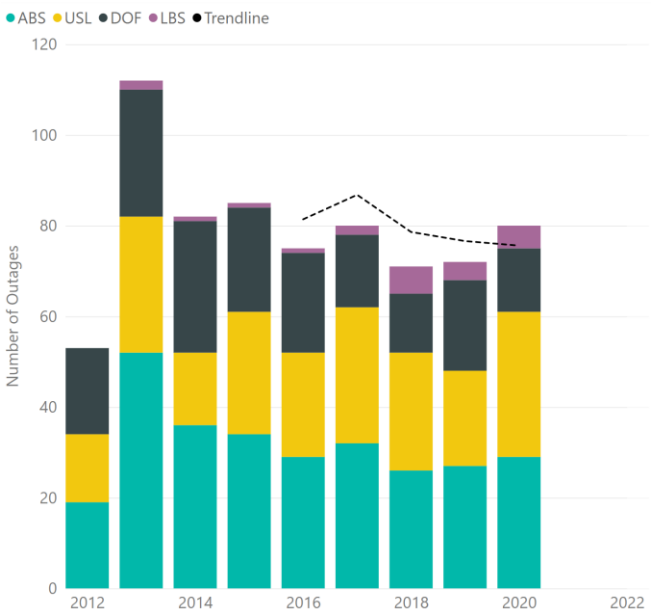
4.3.1. Objective

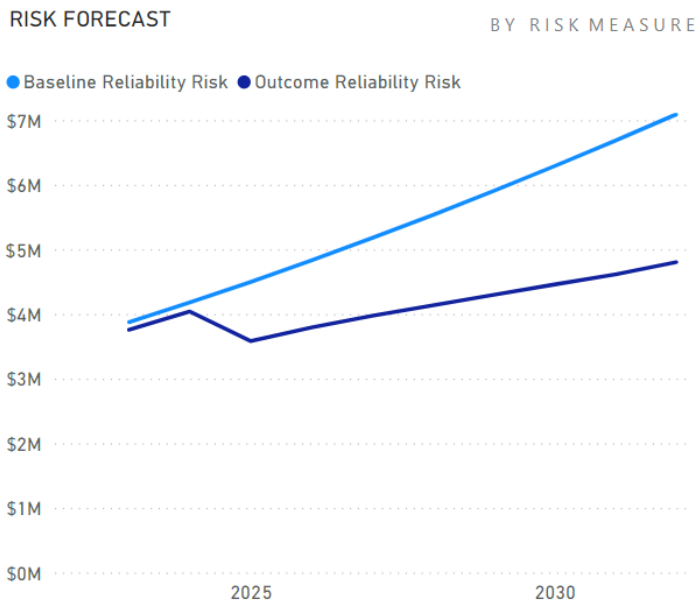
Maintain the level of network reliability risk and number of outages caused by unassisted asset failures associated with HV OH Switches

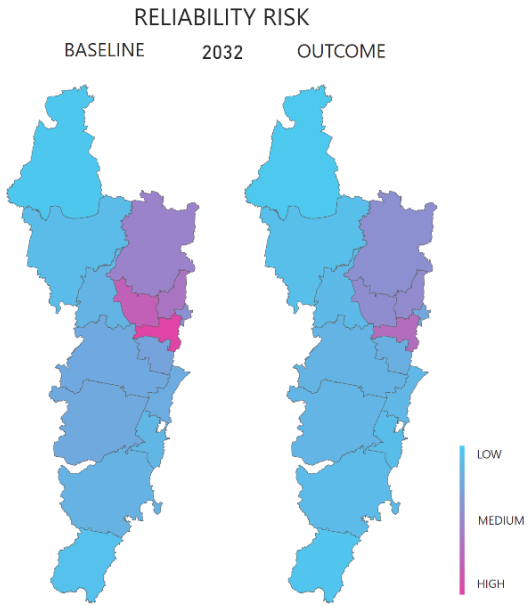
4.3.2. Performance

The number of functional failures associated with HV OH switches has been relatively stable over the past 10 years, the move to an asset level understanding of both probability of failure and reliability risk is expected to create a step change (improvement) in the number of functional failures, however overall reliability risk is expected to remain relatively steady. This steady reliability risk profile is a significant advancement considering the asset bases increasing probability of failure.

The normalised risk concentration across the network is not currently uniform, however is expected to improve over the coming regulatory period.







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	ABS	28.6	Reduce in line with forecasts	●	—
			USL	26.4		●	—
			DOF	17.0		●	—
			LBS	3.6		●	—
			All	75.6		●	—
	Reduce the assets contribution to SAIDI	5-year rolling average of SAIDI contribution	-	-	-	-	-
	Reduce the assets contribution to SAIFI	5-year rolling average of SAIFI contribution	-	-	-		-

4.3.3. Gap

No Gaps are currently identified in the reliability risk associated with HV OH switchgear

4.3.4. Response

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

4.4 Network Resilience

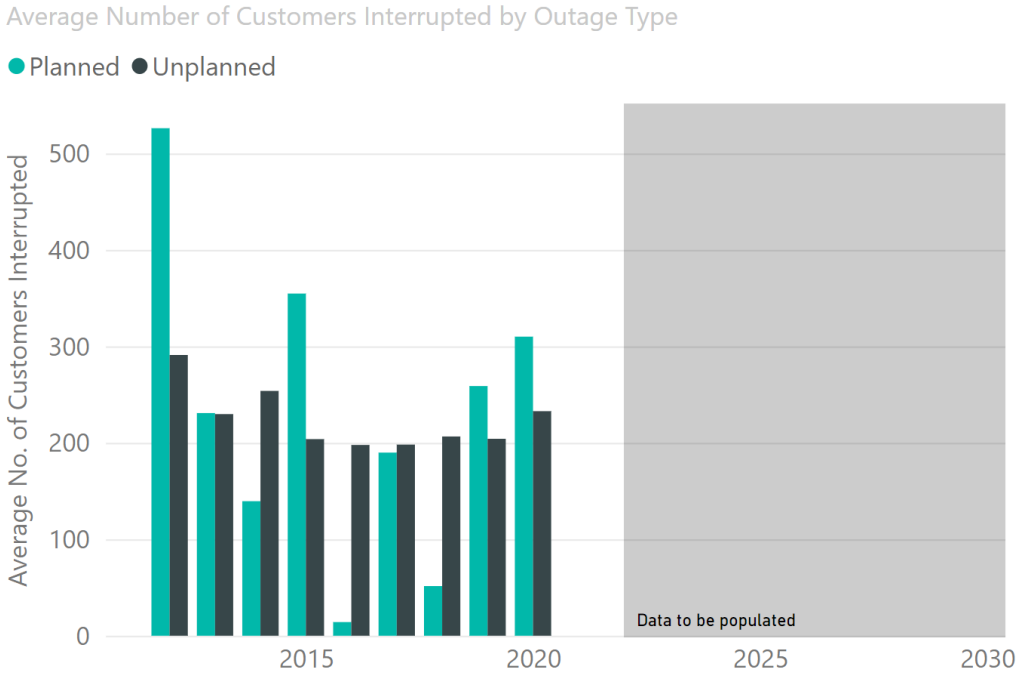
4.4.1. Objective

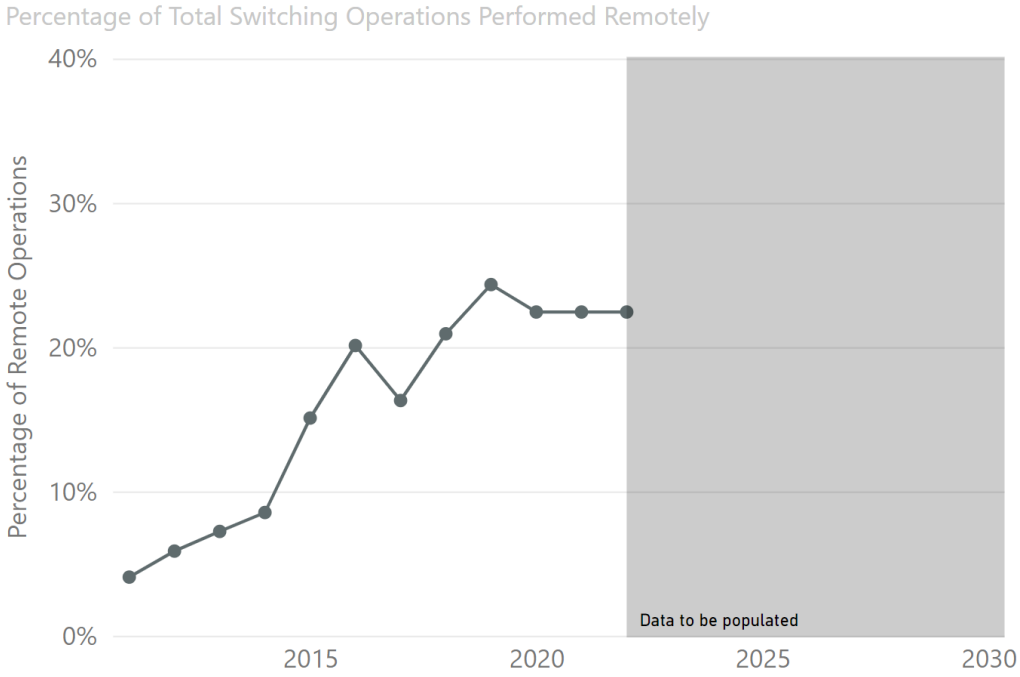
To monitor the network wide installation of automated load break switches across the network and ensure the asset levels decisions being made are reflected once viewed from the network perspective.

4.4.2. Performance

The primary purpose of HV OH switches is to allow switching of the network to allow isolation of faults and/or access to the network for augmentation / maintenance. Network Resilience can significantly be impacted (positively or negatively) by the number, location, and functionality of HV OH switches across the network.

The performance of HV OH Switchgear is determined by the impact it has on outage management, during unplanned and planned interruptions and how efficiently field services can complete network switching activities. At present the number of customers impacted for unplanned outages remains steady, whilst the number of customers for planned outages appears to be increasing. With the low volumes of ALBS's within the network this is expected, however needs to be continued to be monitored.





Performance Category	Objective	Performance Measure	Asset Type	Current Performance	Performance Target	Status	Trend
Resilience	Monitor the average number of customers impacted during an unplanned outage	Average number of customers disconnected during an unplanned outage (post utilisation of ALBS's)	Total	210 customers	monitor	—	—
	Monitor the average number of customers impacted during a planned outage	Average number of customers disconnected during a planned outage	Total	333 customers	monitor	—	—
	Reduce need / risk associated with manual switching	Percent of total switching operations performed remotely	All	22%	increasing	●	▲
	Monitor operational performance	Average time to isolate customers (time needed by district operators to perform a switching plan)	Total	-		●	—

4.4.3. Gap

Whilst the asset level replacement decision framework is sound, measurable impacts cannot yet be seen at the asset class level. This is expected to be driven by two primary factors:

- The current low volumes of ALBS's across the network and the short period of time they have been present.
- Current KPI's / measurements not specifically designed to monitor network resilience and the improvements to customers from automated switching capability

4.4.4. Response

Continued work on developing new KPI's / measurements to better quantify the network wide impacts of automated switching capability.

4.5 Bushfire

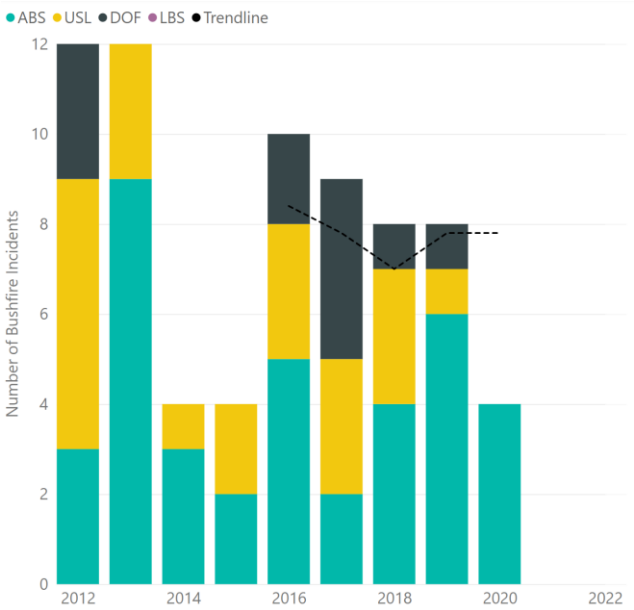
4.5.1. Objective

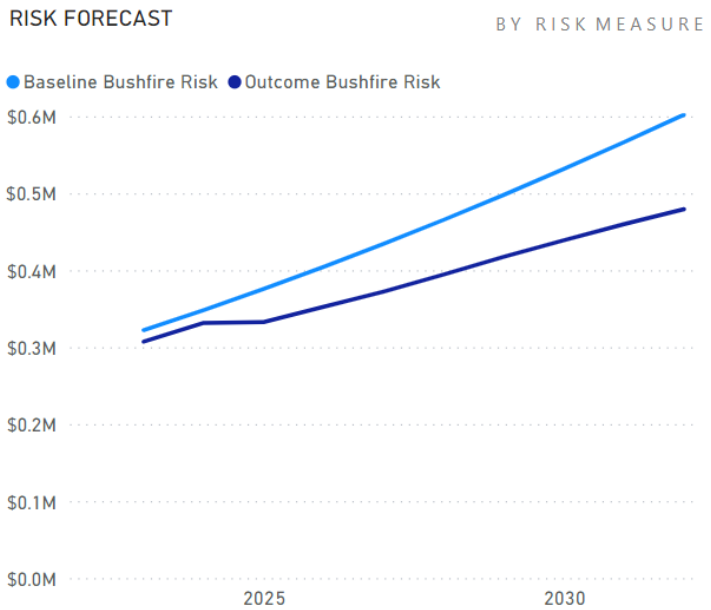
To reduce the number of functional failures and therefore the likelihood component of bushfire risk associated with HV OH switches.

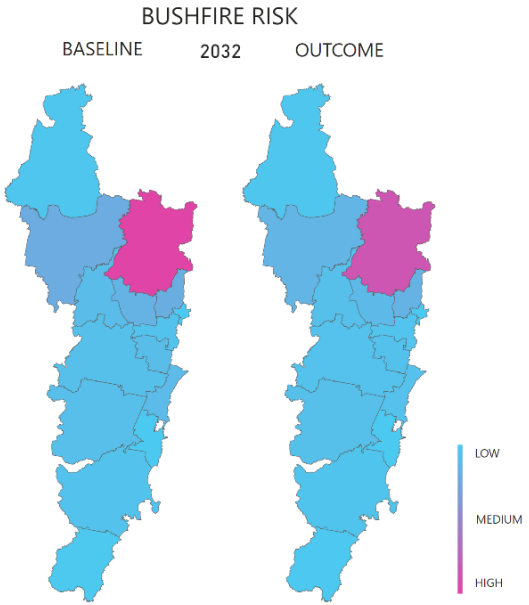
4.5.2. Performance

Bushfire performance is measured by monitoring the quantity and severity of fire starts that are initiated by asset failures across our network. Fire starts caused by HV OH Switchgear remained stable with an average of 9 fire starts per annum. 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 HV OH switches.

The proposed asset management strategy is forecasting a reduction in failure events / fire starts, however overall bushfire risk with HV OH switches is forecast to increase by approximately 20% over the next regulatory period. This increase is predominantly driven by an increased likelihood of asset failure and a forecasted increase in high fire danger weather events.







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	ABS	4.2	Reduce in line with forecasts	●	—
			USL	2.0		●	▼
			DOF	1.6		●	▼
			LBS	0.0		●	—
			All	7.8		●	—

4.5.3. Gap

Bushfire performance, as monitored by fire 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, 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).

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

Not applicable to this asset class.

Only reactive replacement costs associated with functional failures of HV OH switches are considered.

4.7 Environmental

Not applicable to this asset class.

5. Asset Lifecycle

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

5.1 Acquisition

The location and type of HV OH Switchgear is determined by the isolation requirements currently defined in MDI 0026. Historically, a mix of technologies (e.g. DOF's, USL's, ABS's, LBS's etc) and different network configurations have been utilised across the network, resulting in wide spread of asset utilisation levels and network capability.

The introduction of LBS's (in approximately 2010) and ALBSs (in 2020) as a new technology options has significantly improved the network capability (in the areas they are introduced) as well as allowed for the number of switches overall to start declining.

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

The operation (e.g. switching needs) of HV OH Switchgear is generally driven by network requirements (e.g. asset maintenance, asset failures, network augmentation etc). Currently most switches are not rated to break load (e.g. USL's and ABS's) and should only be used for equipment / line isolation and not for breaking continuous current.

Additionally, most assets are manual switches and require staff to attend site to operate the asset. With the introduction of automated switches, the networks need for switches across the network has been re-evaluated (as per MDI 0026) and an increase in automated and nonautomated LBS's is expected with a decrease in other switch types as they are replaced and/or made redundant.

Overall, this should see an increase in asset utilisation (e.g. switching frequency per switch), with an overall reduction in the total number of switches per line length.

The historical installation / operation of assets not adequately rated to break load (e.g. ABS's) being used for such operations (due to a lack of suitable alternative technologies) have led to an increase in the deterioration of some assets. With the introduction of LBS's (due to an increased reduction in their costs) this limitation is beginning to be removed from the network.

Reducing manual operation of the switchgear fleet also reduces the safety risk associated with the asset class as switching operators are not physically exposed in the event of a failure resulting from falling parts.

The following table lists the operational restrictions and location of use for each switch.

Asset Group	Operational Restrictions	Location & Use
ABS	• Not rated for breaking fault or load current • Not to be installed in coastal locations due to corrosion issues	• 11kV and 22kV network • Stand-alone equipment (mid-pole or pole-top mounted)
USL	• Not to be used as isolation points on distribution transformers (due to the risk of ferroresonance leading to failure of distribution transformers) • Each phase is singly operated using a link stick	• Single phase units that may be configured for 1, 2 or 3 phase isolations • Stand-alone equipment (mid-pole or pole-top mounted) • With Reclosers • With Regulators
DOF	• Not indented for interrupting nominal system load currents.	• 11kV network with low fault levels • High fault level 11kV areas • all 22kV (incl. SWER) areas
LBS	• Not to be used or operated when low-gas indicator has been raised.	• 11kV and 22kV network • Stand-alone equipment (mid-pole or pole-top mounted)

5.3 Maintenance

An overview of the current maintenance activities being performed on HV OH Switchgear are summarised below. These maintenance activities result in the current asset performance (e.g. risk and number of unassisted / conditional asset failures). The shift to an asset level risk-based replacement strategy is expected to provide a step change (improvement) in risk during the FY25-FY29 regulatory period, however the underlying risk will continue based on the following maintenance strategy.

5.3.1. Inspections & Preventative Maintenance

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

	Programme Name		Interval (Years)	ABS	USL	DOF	LBS	Reference
Inspections	OLI/GLI[1]		5.5	✓	✓	✓	✓	SMI 101 MMI 0001
	TLI	Non-Critical Feeders	5	✓			✓	MMI 0001 MMI 0012
		Critical Feeder	3	✓			✓	
	PSBI[2]		1	✓	✓	✓	✓	SMI 101 MMI 0034
	Transmission ABS Inspection		0.5	✓	✓			SMI 100
	Recloser Inspection[3]		0.5					SMI 100 SMI 207 MMI 0001
	Thermovision[4]		3	✓	✓	✓	✓	SMI 100 SMI 101 MMI 0032
Preventative Maintenance	ABS Major Overhaul[1]	All ABS's	-	✓				SMI 101 SMI 204
		Problematic ABS's ≥ *5km coast*[5]	8	✓				
		Problematic ABS's < *5km coast*[5]	4	✓				
	Earth Resistance Tests		10				✓	SMI 101 EDI 0005
	Recloser Battery Check		4					SMI 100 SMI 102 PMI 4120
	LBS Minor Overhaul		4				✓	SMI 207

1. Applicable to only distribution assets
2. Applicable to only assets that fall within the defined bushfire prone area
3. Only applicable to reclosers associated with ZS and TS
4. Typically applied to the first seven switches out from the zone or transmission substation
5. Applicable to specific manufacturer model ABS's identified as problematic (Essante HS641, Taplin D571 and AK Power A24)

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 overhead switches there is no existing essential spares strategy for overhead switches.

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

5.4 Disposal

There are no unique requirements governing the disposal of the majority of the HV OH Switchgear asset class, with the exception of the LBS asset type as these contain SF6. The number of LBS replacements at this point are very low (due to their age), however all SF6 from replaced assets is captured and recycled.

Metrics for the monitoring of SF6 holdings, leakage and disposal are currently being created to support the organisations objectives associated with environmental management.

6. Intervention Options

A range of options have been considered as possible intervention options to address the risk presented by HV Overhead Switchgear. These options are initially considered as an asset type / class level to determine if they are technically feasible and/or practical. Intervention options deemed to be a viable options 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 substantial load that each switch carries on a continual basis and the asset's primary functionality being to isolate / switch the network, 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	**Air Break Switch -** A maintenance program, which was initially introduced in 2005, has had negligible effect on the defect rate for ABS's. Since 2015 maintenance of the general population ABS's was ceased whereas maintenance on problematic ABS's has currently continued. However, given that the primary causes of failure are age related or problematic insulator designs (both of which cannot be addressed via maintenance), re-introducing maintenance on the general population or funding additional maintenance on the problematic population will not be effective in managing risk or extending asset life.	Not A Feasible Solution
		Load Break Switch - Routine inspections are currently performed on all LBS's (manual and automated) via the OLI, TLI, PSBI and thermovision programs. Whilst these inspection programs are effective in identifying assets close to end of life, few options currently existing to maintain or refurbish load break switches.	
		Under Slung Links and Drop Out Fuses - USLs and DOFs do not have any scheduled maintenance activities dedicated purely to the asset. Inspection of these assets are carried out as part of other inspection programs such as the OLI program, PSBI, and thermovision. The frequencies of these inspection programs range from yearly to every 5 years. However, given that the primary causes of failure are on-event failures (e.g. failure when switching is attempted) (which cannot be adequately identified via maintenance), funding additional maintenance on the population will not be effective in managing risk.	
Risk Based	Reduce the load on the asset through network reconfiguration, network automation or demand management	The risk of failure is independent of 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. The primary function of this asset class is to facilitate flexibility in switching of the overhead distribution network to minimise the extent of customer outages and the duration of outages during planned and unplanned works on the network. Load transfers would ultimately reduce this flexibility and provide a negative results to customers in the medium to long term.	Not A Feasible Solution
	Implementing operational controls such as limiting access, remote switching protocols etc	Operating controls are already in place for the operation of all HV Overhead Switches. 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 reliability, which is not affected by practicable controls.	Controls only safety risk for workers
	Staged removal or replacement of HV Overhead Switchgear.	On replacement, risk associated with a switch will be reduced to the risk associated with the replacement option. On removal, risk associated with a switch will be effectively illuminated as any operating risks are no longer present.	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 (e.g. switching capability in the network).

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 HV Overhead Switchgear. 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.

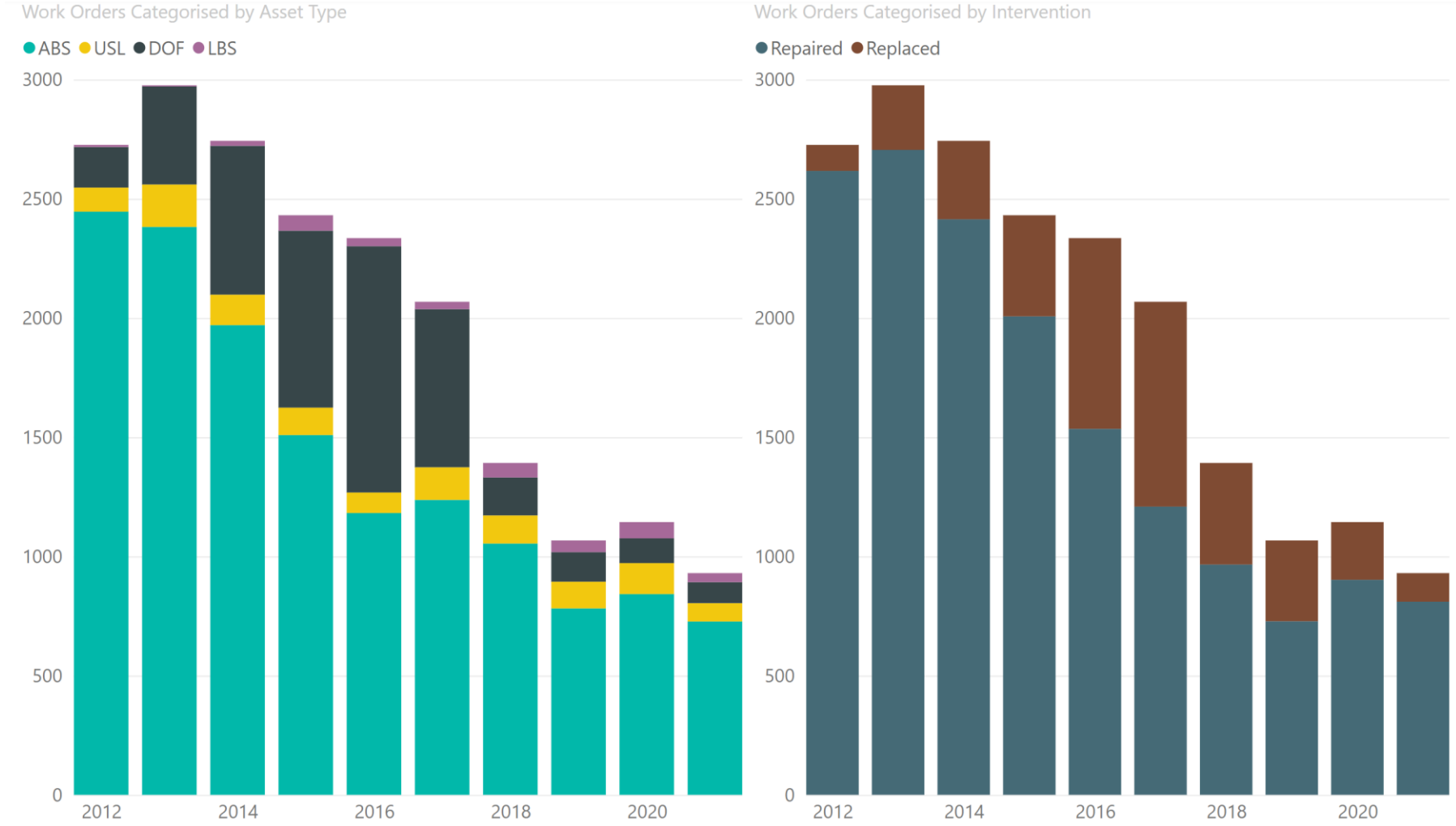
Endeavour Energy determines what constitutes a defect based on Failure Modes Effects and Criticality Analysis (FMECA). FMECA is an analytical process that is derived from an assessment of an asset's ability to sustain technical functionality and relies on information relating to failure modes, their probability and consequences of failure.

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 HV OH switches.

Switch Type	Defects	Repair / Replacement	Standard job description
ABS	1ABSAD	Repair	Adjustments made to re-align ABS to fully close - can be at the assembly/handle
	1ABSAH	Repair	Repair/ replace arcing horn due to misalignment or due to burning/ wear and tear
	1ABSBL	Repair	Repairs/ replacement of damaged ABS blade caused by incorrect operation/ fault
	1ABSOH	Repair	Repairs/ replacement of ABS operating handle. (incl relocating handle higher)
	1ABSOR	Repair	Replace ABS operating rods
	1ABSSW	Replace	Replace ABS assembly. Can include operating rods and operating handle.
	1EARBA	Repair	Replace earth batten on a pole including substations, UGOH poles, ABS poles
DOF	1DOFCA	Repair	Replace DOF carrier.
	1DOFSW	Replace	Replace complete DOF
	1LVLIN	Replace	Replace LV links installed on overhead, including substations
USL	1USL	Replace	Replace defective under slung link
LBS	1LBSSW	Replace	Replace LBS Unit
GENERAL	1LOCK	Repair	Repair locks on equipment that are hard to open or replace missing/damaged locks
	1FAULT	-	For storms and major events or can be used when another standard job is not suitable

At present ABS's are creating the majority defects in the HV OH switchgear assert class, however the overall volume has been reducing (improving) over the past five years, indicated 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.



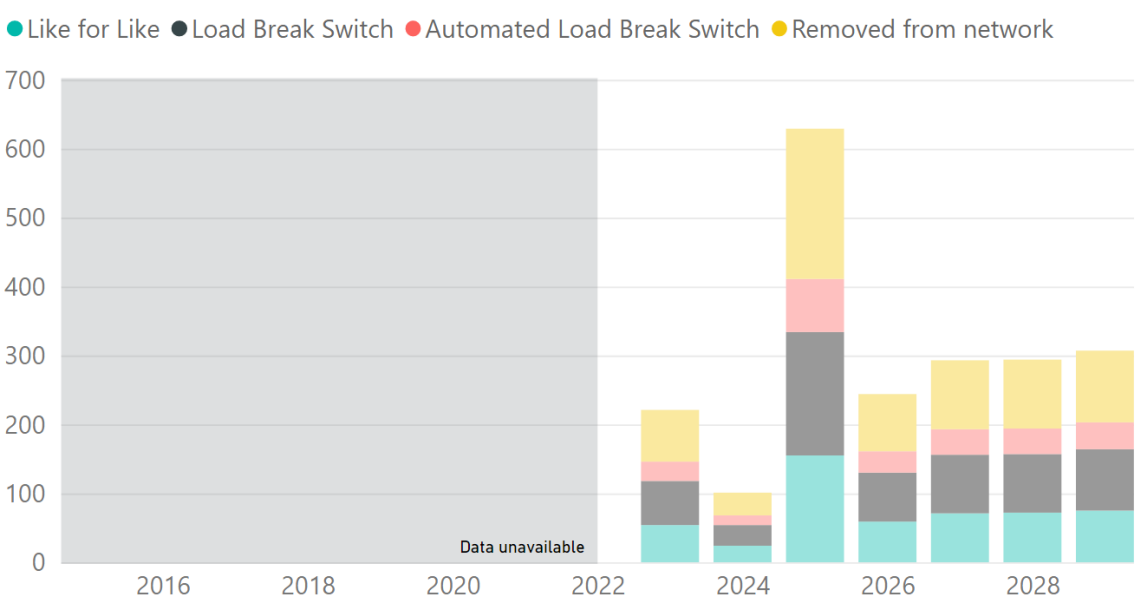
6.3 Risk Based Interventions

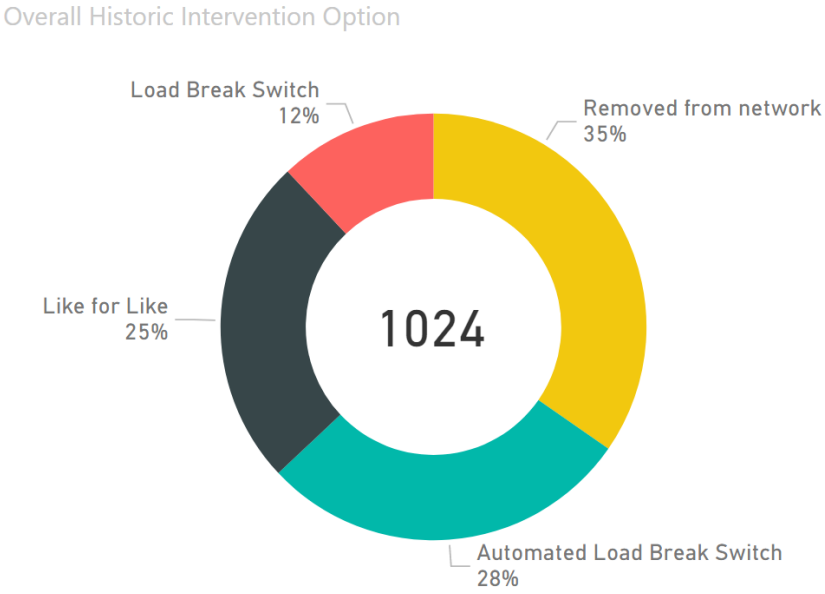
Risked based intervention options considered as possible feasible intervention options have been further considered to address the risk presented by HV Overhead Switchgear at the asset level. The customer benefit achieved by the proposed intervention option is compared with the cost of the proposed intervention(s)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

Endeavour Energy Mains Design instruction MDI 0026 provides instructions for the minimum isolations requirements and sets out in detail both the location and the type of isolation points to be installed. For each asset proposed to have an intervention (as specified in the CFI's), the two options are considered:

- Removal/Lockout of the switch: If it is assessed that the functionality of a retired switch is no longer required, then it is locked out and removed from service.
- Replacement of the switch: If it is assessed that the functionality of a retired switch is still required, then it is replaced by either a like-for-like switch, an LBS or an automated LBS which is connected to the SCADA network for remote and/or automated operation.

The following volume of forecasts / breakdown between options are based on the results of the CFI's associated with this asset class.





7. Forecasts

7.1 Cost

The risked based replacement program has identified assets within this asset class that are currently justified for a risk-based asset intervention over the upcoming regulatory period. Asset that reach their NPV maximum point are illustrated in the images below. A number of other assets will have reached the point of being NPV positive (e.g. risk are higher than intervention costs), however these will be considered as part of the portfolio optimisation process. The proposed investment profile is relatively flat from FY23, however it is difficult to efficiently introduce these additional replacements into the FY23 and FY24 periods (without impact existing strategies). A proportion of assets identified for intervention over these two periods have been shifted to FY25 as this is the first practical opportunity they will be completed. This has resulted in a peak in investment costs in FY25 as indicated in the expenditure profiles, however additional constraints (e.g. labour, outage availability etc) will likely see this peak flattened over the regulatory period.

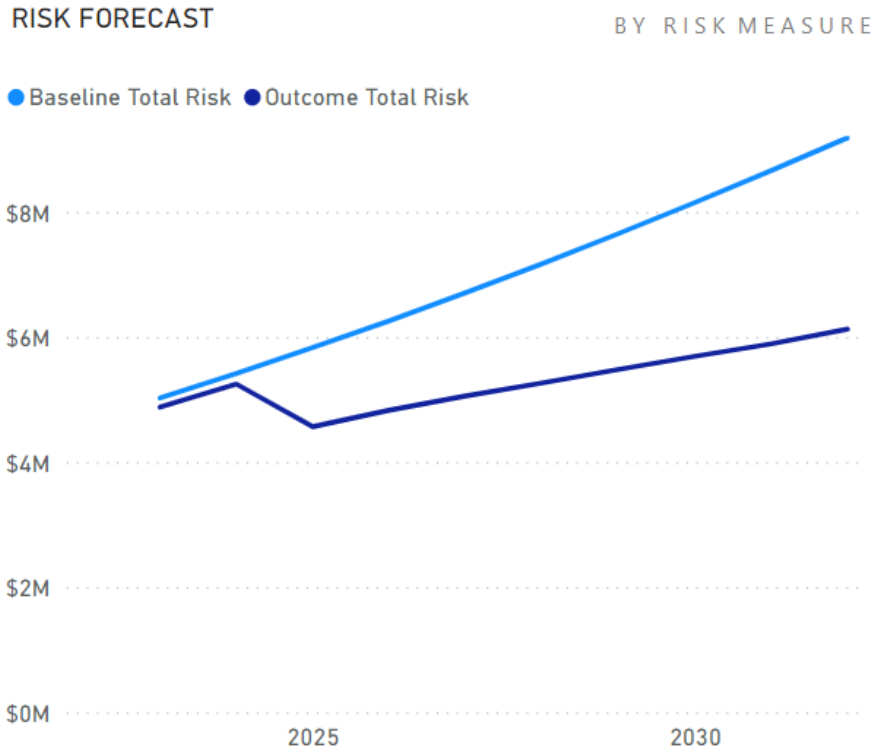
Over the next 5 years, inspection and maintenance spend is expected to remain stable.

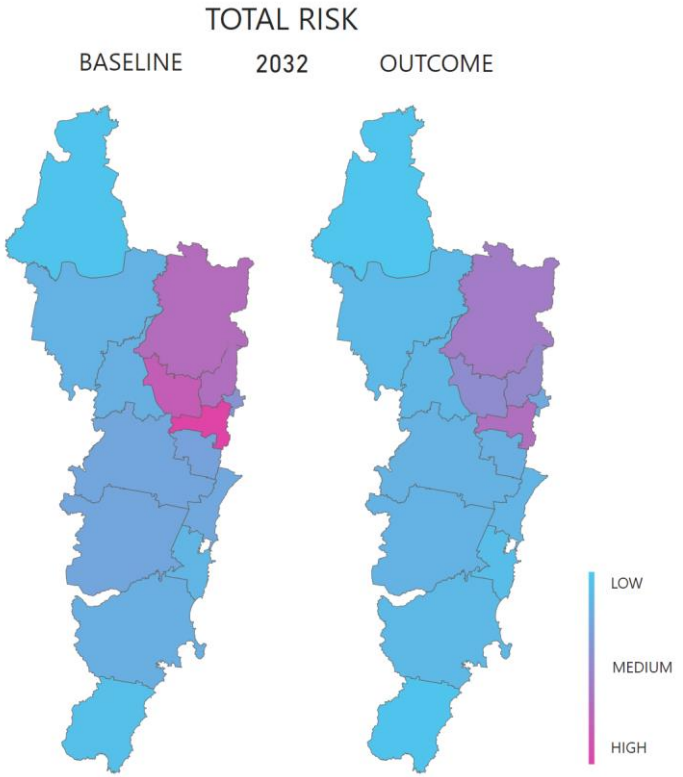
7.2 Risk

Network risk associated with HV OH switches has been calculated as per the current value framework. The total risk in this asset class is made up from Reliability (60%), Safety (20%), Bushfire (5%), and Financial (which for this asset class is purely Reactive Replacement costs / functional asset failures (15%).

The baseline risk (no intervention) associated with this asset class is projected to approximately double to $9 million if no action is taken. The outcome risk based on the proposed intervention profile is however projected to remain steady at $5.2 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.

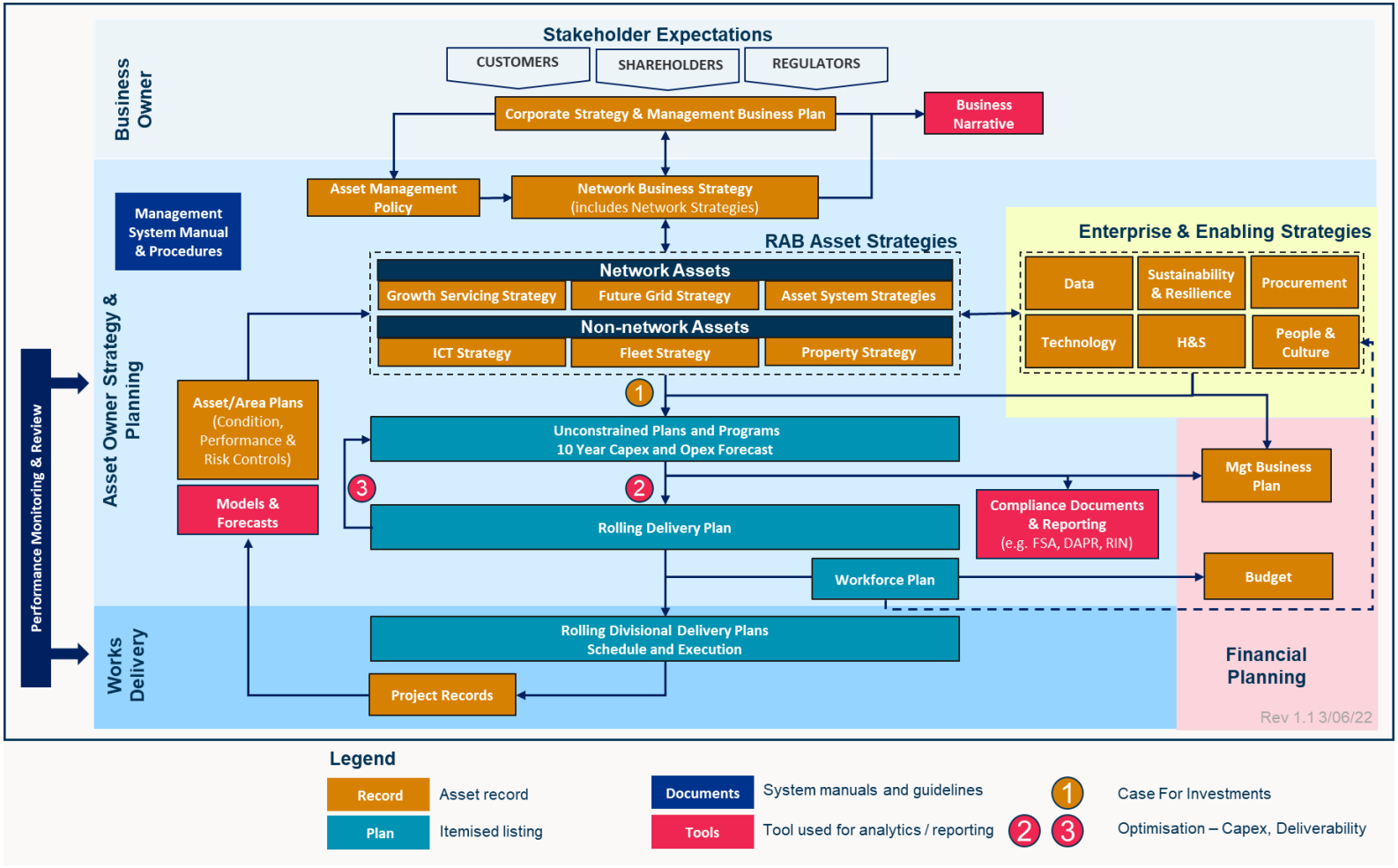




8. Asset Management Systems

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.

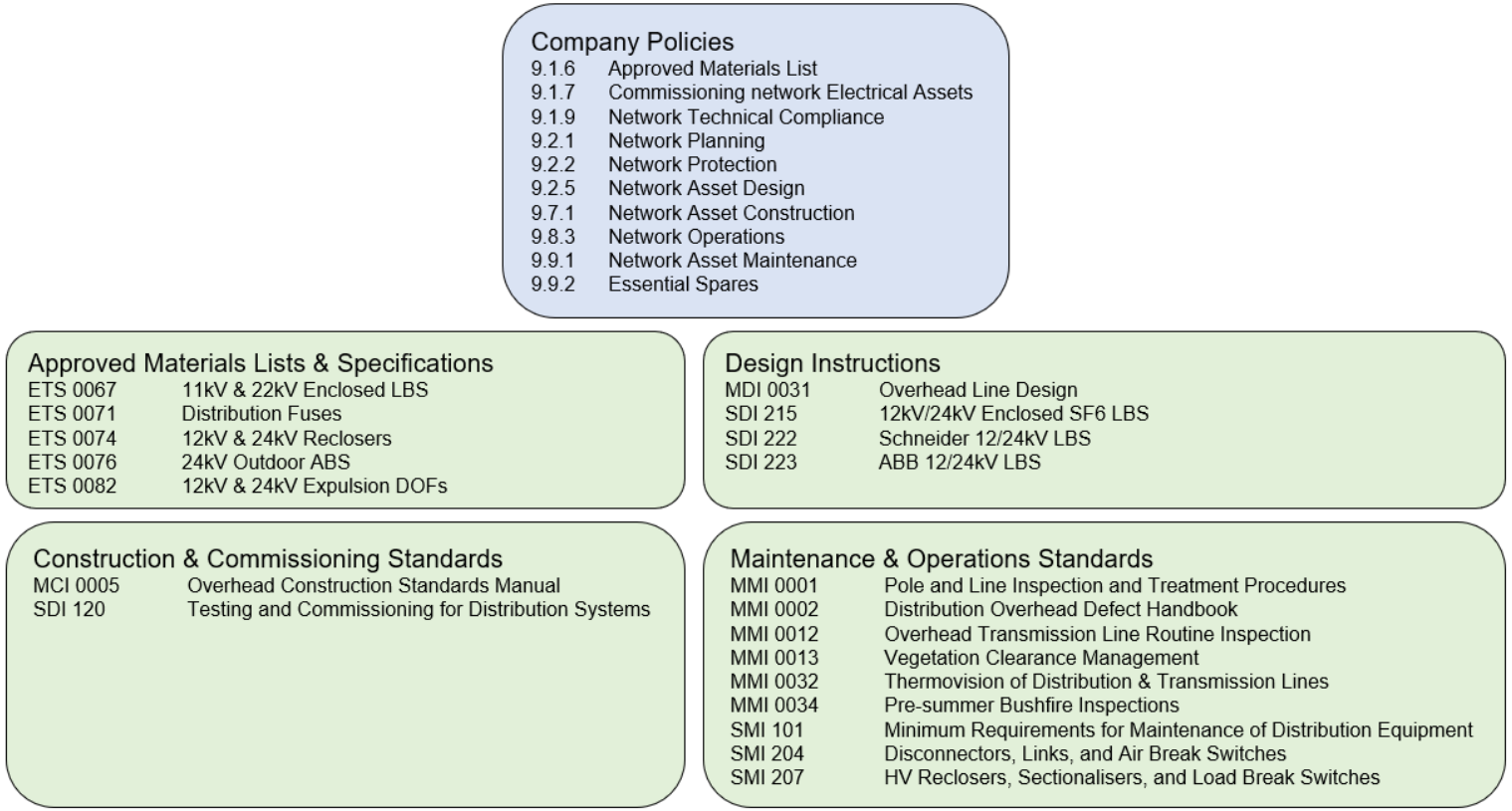
The relationship between this document and the other artefacts within Endeavour Energy's asset management system is illustrated below:



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 HV overhead switchgear:



8.2 Asset Management Tools

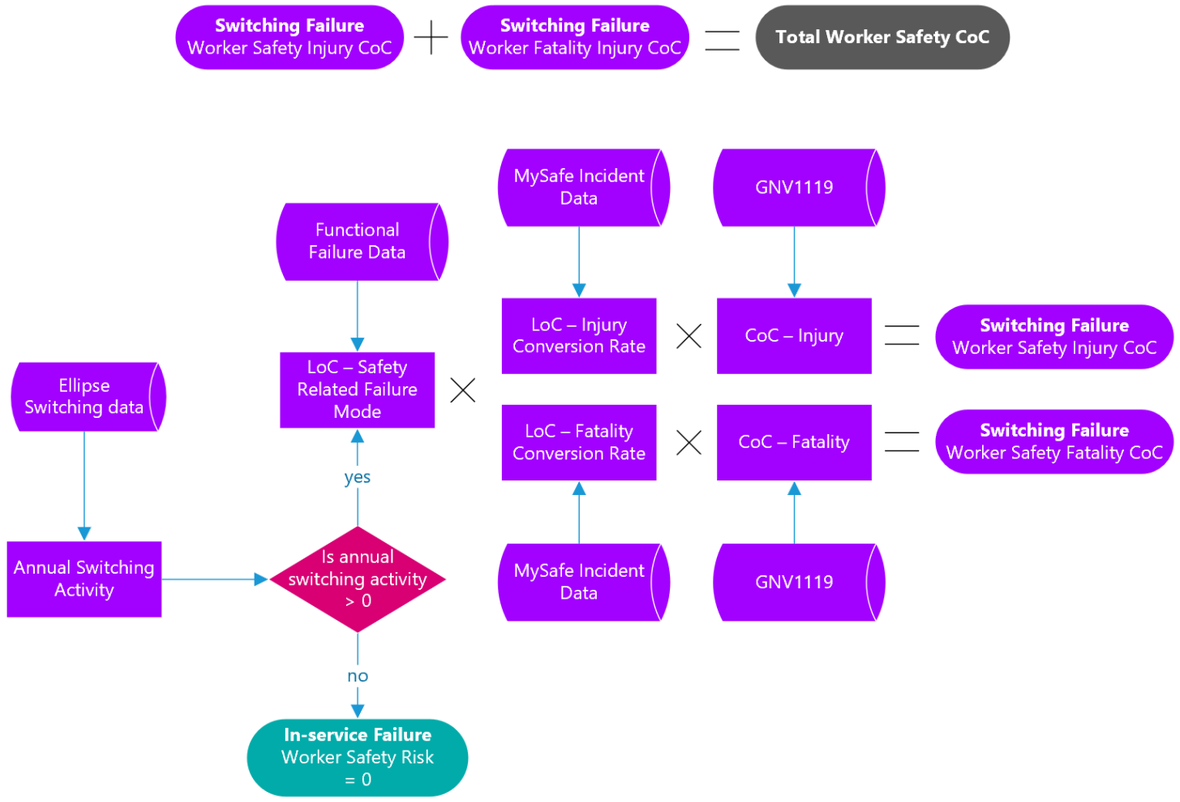
Endeavour Energy use numerous integrated data-base and geographical information system related tools to aid in the management of HV overhead switchgear assets.

Key tools used for the management of HV overhead switchgear 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

Safety

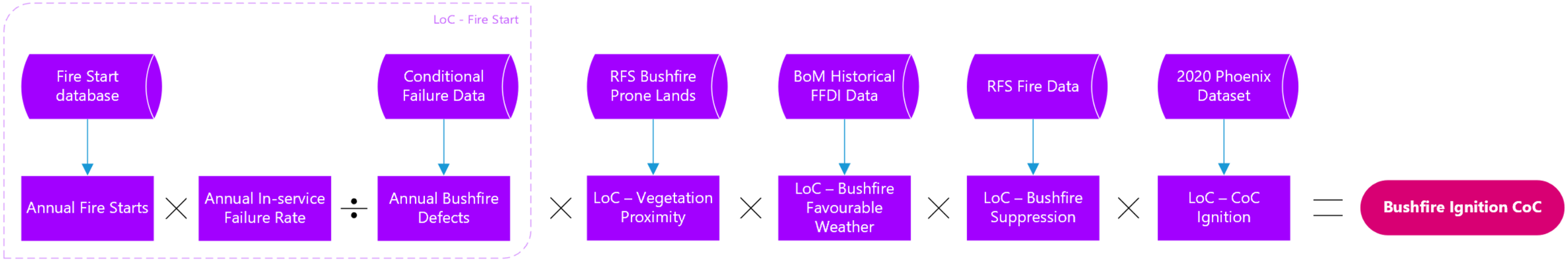


Parameter	ABS	USL	DOF	LBS	Description	Source/Assumptions
LoC – Failure Mode	0.46	0.12	0.56	0.05	Likelihood that a failure will relate to a safety incident	Endeavour Energy's defect data via Ellipse workorders
LoC – Injury Severity	0.24	0.06	0.06	0.05	Likelihood that a safety incident will result in an injury	Endeavour Energy's historical Safety Incidents via MySafe database
LoC – Fatality Severity	0.003	0.003	0.001	0.003	Likelihood that a safety incident will result in a fatality	Endeavour Energy's historical Safety Incidents via MySafe database had 0 fatalities in the last 10 years. Assumed 1 fatality every 60 years.
LoC – Switching	Varies by asset	Varies by asset	Varies by asset	Varies by asset	The annual switching frequency for each switch	Endeavour Energy's SwitchIt database. Assumed 1 operation every 20 years for switches which were not operated in the last 10 years
CoC – Injury	$51,000	$51,000	$51,000	$51,000	Cost of a single injury	Disproportionate factor used alongside CoC – Fatality and GNV979 – Quantitative Determination of Reasonably Practicable Risk Control Measures when Assessing Health and Safety Risks
CoC – Fatality	$5,100,000	$5,100,000	$5,100,000	$5,100,000	Cost of a single fatality	Office of Best Practice Regulation

Reliability

Parameter	ABS	USL	DOF	LBS	Description/Justification	Source/Assumptions
Load factor	0.7	0.7	0.7	0.7	Factor applied to maximum feeder loadings to represent the magnitude of load during a network outage.	Endeavour Energy's Outage Management System
Outage duration - (Failure on switching)	2	2	2	2	Time taken to restore load. Hour 1-100% load loss Hour 2-100% load loss	Endeavour Energy's Outage Management System
Outage duration - (Failure in-service)	5	5	5	5	Time taken to restore load. Hour 1-100% load loss Hour 2-100% load loss Hour 3-100% load loss Hour 4-75% load loss Hour 5-50% load loss	Assumed additional 3 hours of travel and fault locating
LoC – Switching	Varies by asset	Varies by asset	Varies by asset	Varies by asset	The annual switching frequency for each LBS	Endeavour Energy's SwitchIt database. Assumed 1 operation every 20 years for switches which were not operated in the last 10 years
LoC – In-Service	0.62	0.27	0.07	0.38	A multiplier to calculate the annual failures which fail in service (not during switching) Backwards calculated using the annual no. of in-service failures.	Endeavour Energy's Outage Management System
VCR ($/MWh)	Varies by asset	Varies by asset	Varies by asset	Varies by asset	The value customers place on having reliable electricity supplies under different conditions. Calculated as an average VCR across each LGA	PowerFactory load data
Load (MVA)	Varies by asset	Varies by asset	Varies by asset	Varies by asset	The HV load distributed across each feeder at each pole.	PowerFactory load data

Bushfire



Parameter	ABS	USL	DOF	LBS	Description/Justification	Source/Assumptions
LoC – Fire Start	Varies by asset	Varies by asset	Varies by asset	N/A	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	Varies by asset	Varies by asset	N/A	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	Varies by asset	Varies by asset	N/A	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

Appendix B – Weibull Parameters

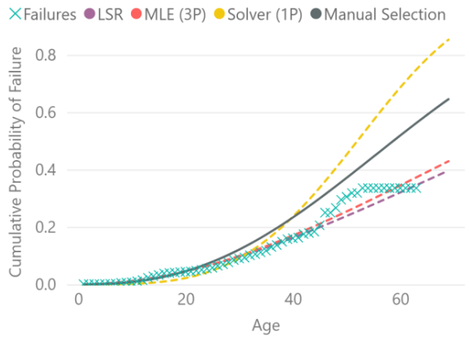
Conditional Weibull Parameters

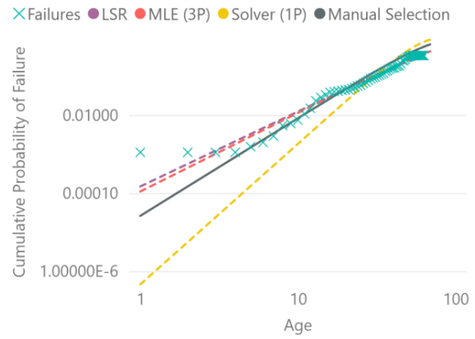
Air Break Switch

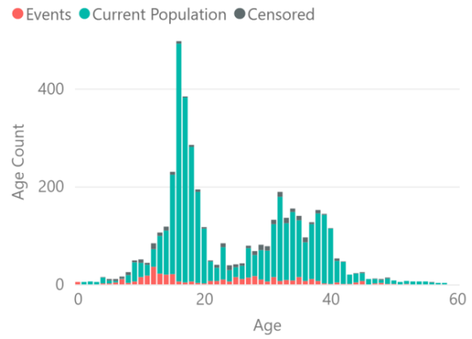
Porcelain General

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0.00	0.00
Shape	1.92	2.02	3.60	2.50
Scale	98.46	91.96	57.60	68.00
Predicted average failure age	87	81	52	60
Predicted no. of failures p.a.	22	23	40	35

Input Data Statistics	Value
Mean failure age	22
Population size	3879
Avg number of historical annual failures	40
Age Earliest Failure	0
Age Oldest Asset	62



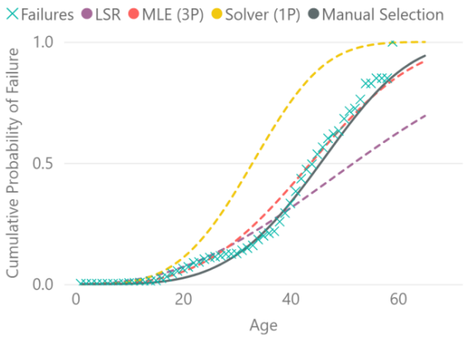


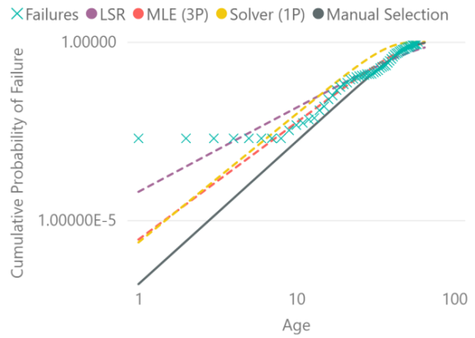


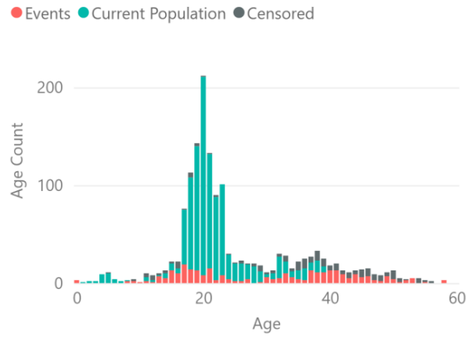
Porcelain Problematic

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	2.36	3.28	3.6	4
Scale	60.49	48.97	36	50
Predicted average failure age	54	44	33	45
Predicted no. of failures p.a.	10	12	30	8

Input Data Statistics	Value
Mean failure age	30
Population size	1030
Avg number of historical annual failures	30
Age Earliest Failure	0
Age Oldest Asset	58



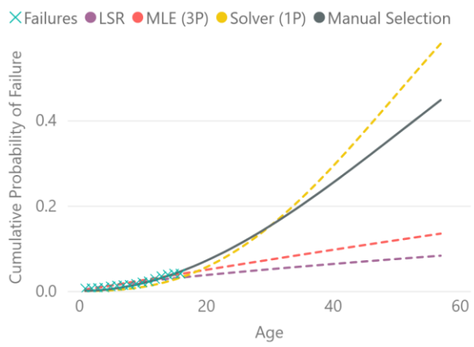


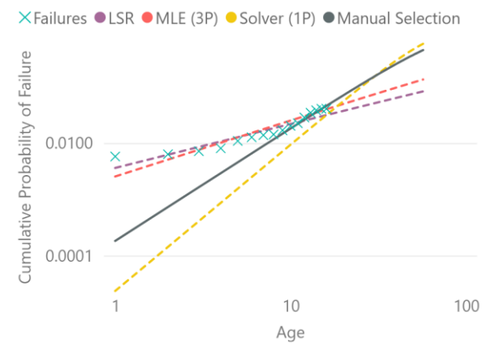


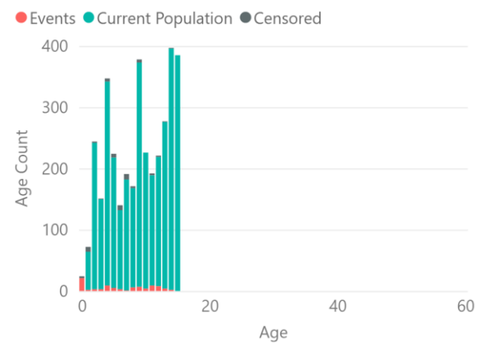
Polymer General

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	0.78	1.00	2.6	2
Scale	1292.94	396.05	60	74
Predicted average failure age	1486	396	53	66
Predicted no. of failures p.a.	6	9	9	12

Input Data Statistics	Value
Mean failure age	6
Population size	3496
Avg number of historical annual failures	9
Age Earliest Failure	0
Age Oldest Asset	15





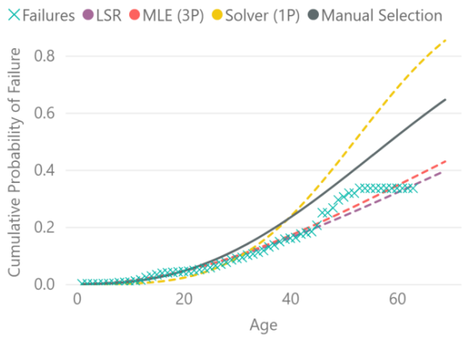


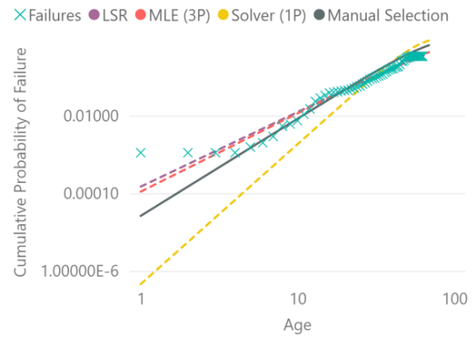
Load Break Switch

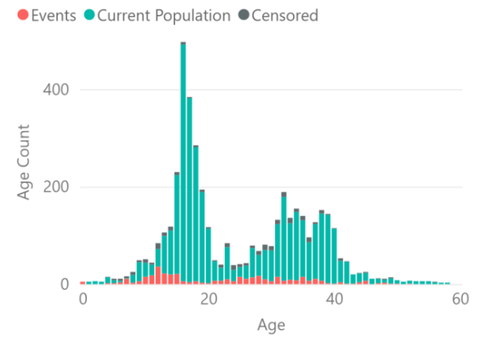
Automated

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0.00	0.00
Shape	1.92	2.02	3.60	2.50
Scale	98.46	91.96	57.60	68.00
Predicted average failure age	87	81	52	60
Predicted no. of failures p.a.	22	23	40	35

Input Data Statistics	Value
Mean failure age	22
Population size	3879
Avg number of historical annual failures	40
Age Earliest Failure	0
Age Oldest Asset	62



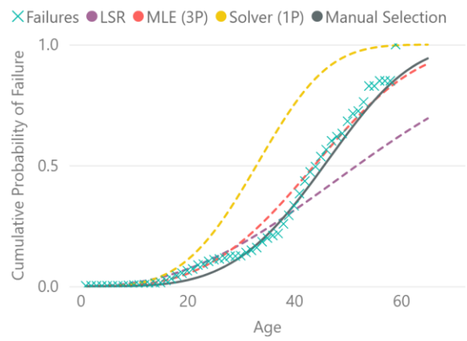


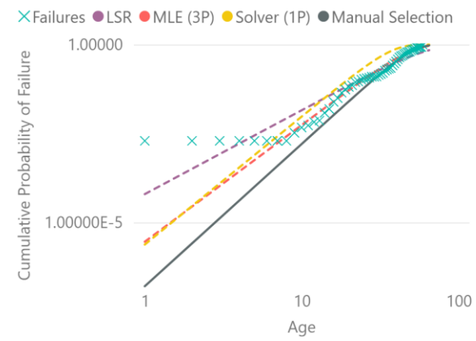


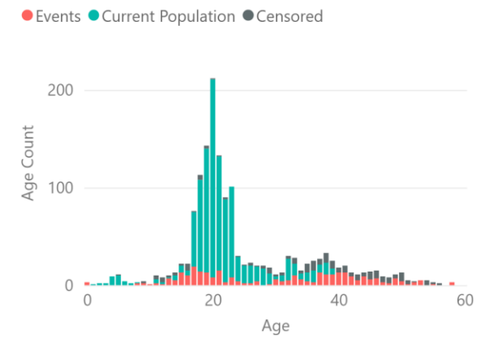
Manual

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	2.36	3.28	3.6	4
Scale	60.49	48.97	36	50
Predicted average failure age	54	44	33	45
Predicted no. of failures p.a.	10	12	30	8

Input Data Statistics	Value
Mean failure age	30
Population size	1030
Avg number of historical annual failures	30
Age Earliest Failure	0
Age Oldest Asset	58





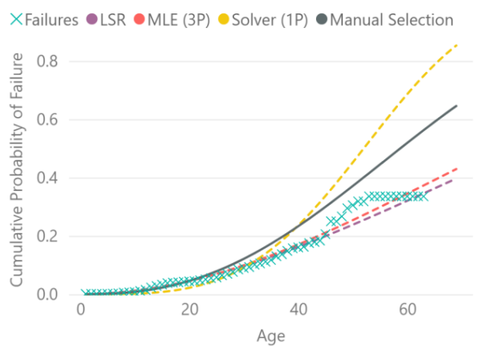


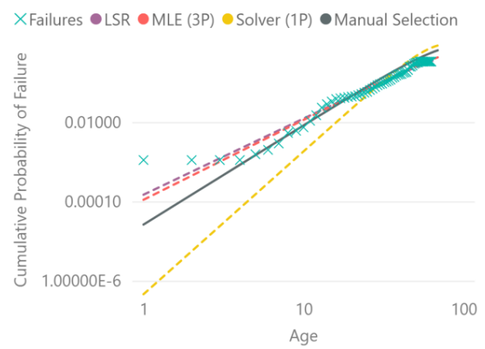
Under Slung Link

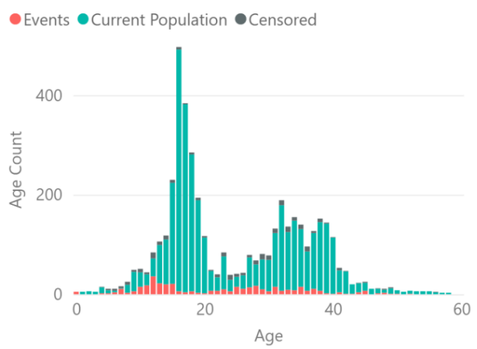
Porcelain

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0.00	0.00
Shape	1.92	2.02	3.60	2.50
Scale	98.46	91.96	57.60	68.00
Predicted average failure age	87	81	52	60
Predicted no. of failures p.a.	22	23	40	35

Input Data Statistics	Value
Mean failure age	22
Population size	3879
Avg number of historical annual failures	40
Age Earliest Failure	0
Age Oldest Asset	62



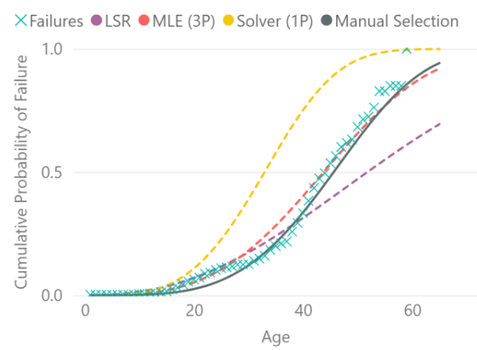


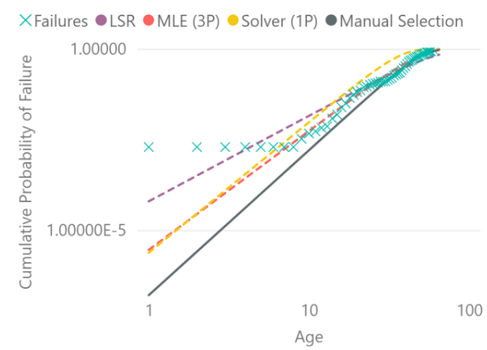


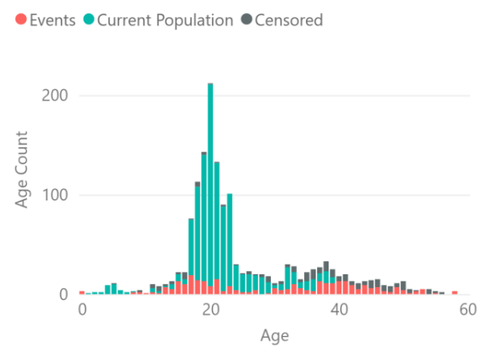
Polymer

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	2.36	3.28	3.6	4
Scale	60.49	48.97	36	50
Predicted average failure age	54	44	33	45
Predicted no. of failures p.a.	10	12	30	8

Input Data Statistics	Value
Mean failure age	30
Population size	1030
Avg number of historical annual failures	30
Age Earliest Failure	0
Age Oldest Asset	58





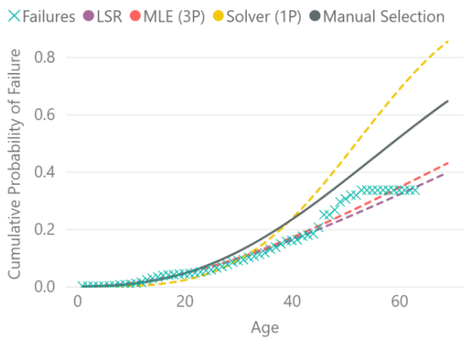


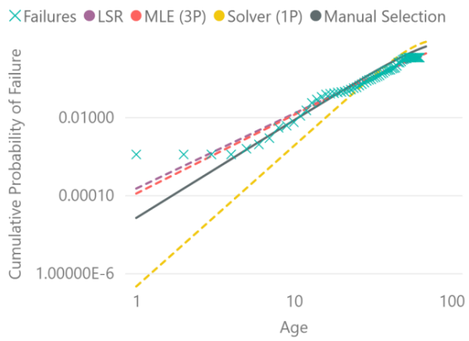
Drop Out Fuse

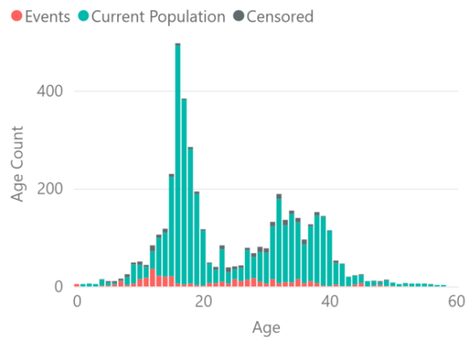
Porcelain

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0.00	0.00
Shape	1.92	2.02	3.60	2.50
Scale	98.46	91.96	57.60	68.00
Predicted average failure age	87	81	52	60
Predicted no. of failures p.a.	22	23	40	35

Input Data Statistics	Value
Mean failure age	22
Population size	3879
Avg number of historical annual failures	40
Age Earliest Failure	0
Age Oldest Asset	62



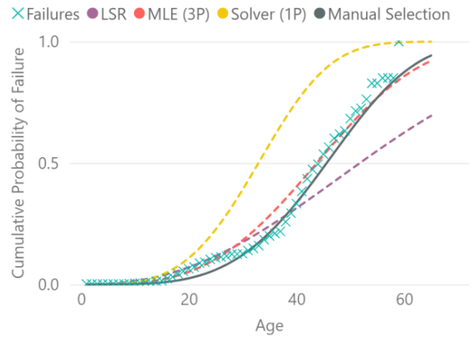


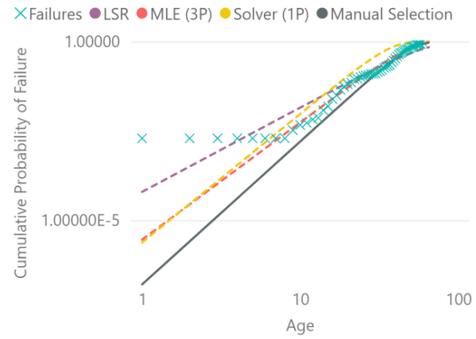


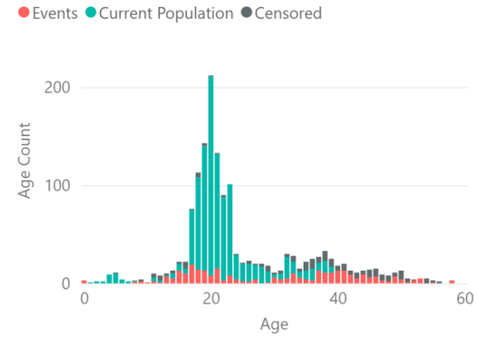
Polymer

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	2.36	3.28	3.6	4
Scale	60.49	48.97	36	50
Predicted average failure age	54	44	33	45
Predicted no. of failures p.a.	10	12	30	8

Input Data Statistics	Value
Mean failure age	30
Population size	1030
Avg number of historical annual failures	30
Age Earliest Failure	0
Age Oldest Asset	58







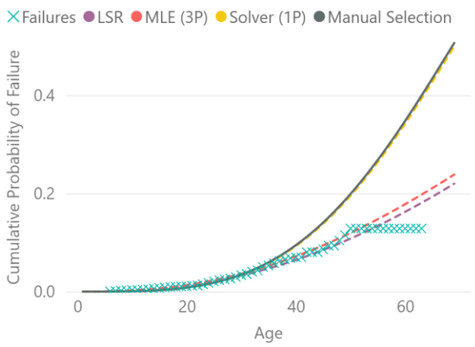
Functional Weibull Parameters

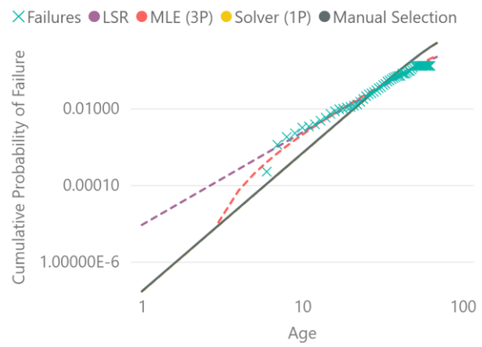
Air Break Switch

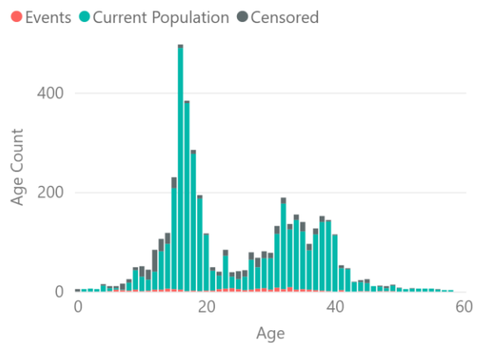
Porcelain General

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	2.23	0.00	0.00
Shape	2.41	2.27	3.60	3.60
Scale	122.96	118.30	76.43	76.00
Predicted average failure age	109	107	69	68
Predicted no. of failures p.a.	9	10	14	15

Input Data Statistics	Value
Mean failure age	25
Population size	3879
Avg number of historical annual failures	14
Age Earliest Failure	5
Age Oldest Asset	62



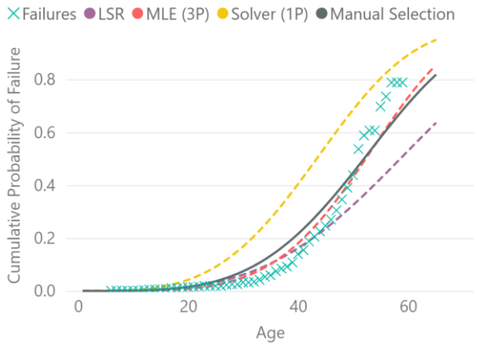


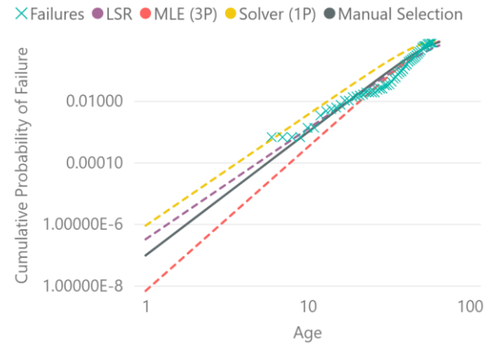


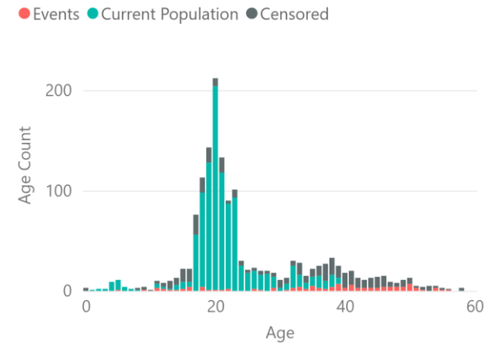
Porcelain Problematic

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	2.23	0.00	0.00
Shape	2.41	2.27	3.60	3.60
Scale	122.96	118.30	76.43	76.00
Predicted average failure age	109	107	69	68
Predicted no. of failures p.a.	9	10	14	15

Input Data Statistics	Value
Mean failure age	25
Population size	3879
Avg number of historical annual failures	14
Age Earliest Failure	5
Age Oldest Asset	62



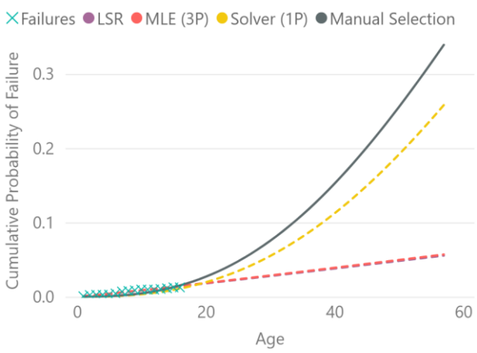


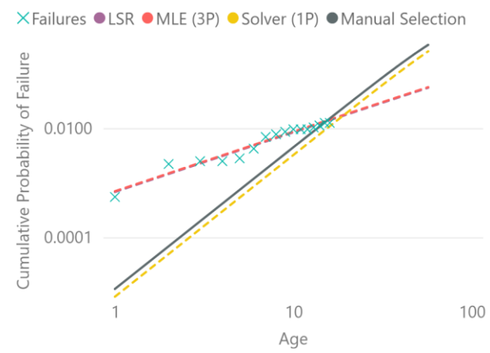


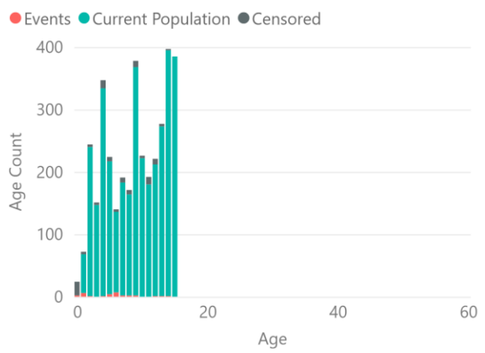
Polymer General

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	2.23	0.00	0.00
Shape	2.41	2.27	3.60	3.60
Scale	122.96	118.30	76.43	76.00
Predicted average failure age	109	107	69	68
Predicted no. of failures p.a.	9	10	14	15

Input Data Statistics	Value
Mean failure age	25
Population size	3879
Avg number of historical annual failures	14
Age Earliest Failure	5
Age Oldest Asset	62





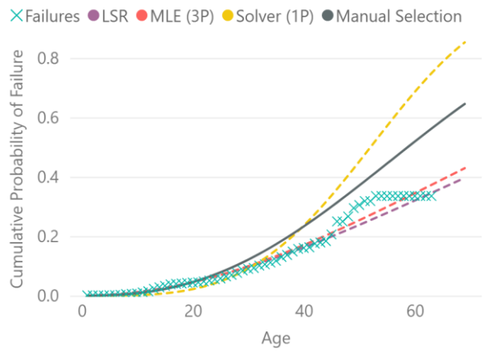


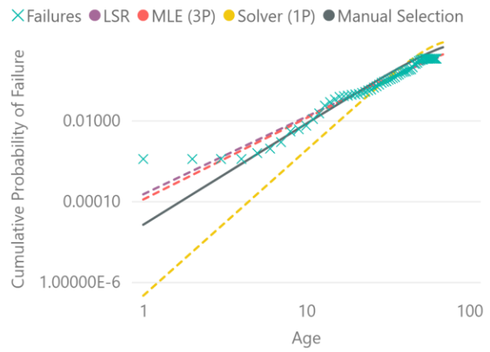
Load Break Switch

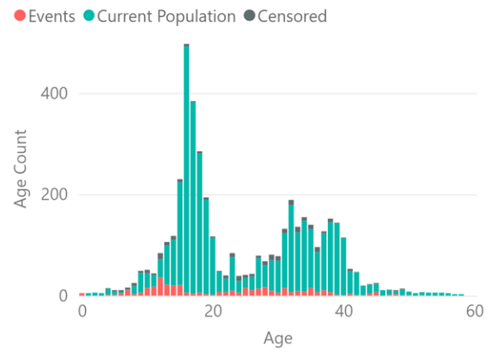
Automated

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0.00	0.00
Shape	1.92	2.02	3.60	2.50
Scale	98.46	91.96	57.60	68.00
Predicted average failure age	87	81	52	60
Predicted no. of failures p.a.	22	23	40	35

Input Data Statistics	Value
Mean failure age	22
Population size	3879
Avg number of historical annual failures	40
Age Earliest Failure	0
Age Oldest Asset	62



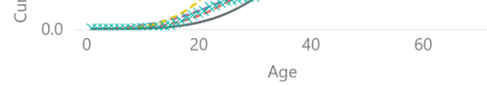




Manual

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	2.36	3.28	3.6	4
Scale	60.49	48.97	36	50
Predicted average failure age	54	44	33	45
Predicted no. of failures p.a.	10	12	30	8

Input Data Statistics	Value
Mean failure age	30
Population size	1030
Avg number of historical annual failures	30
Age Earliest Failure	0
Age Oldest Asset	58

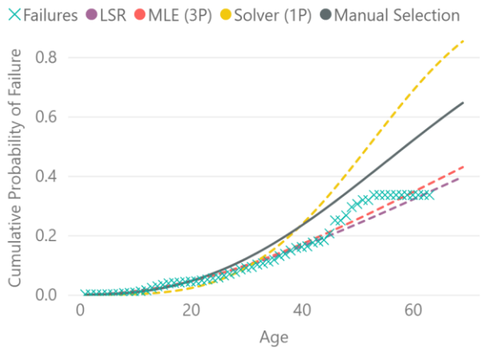


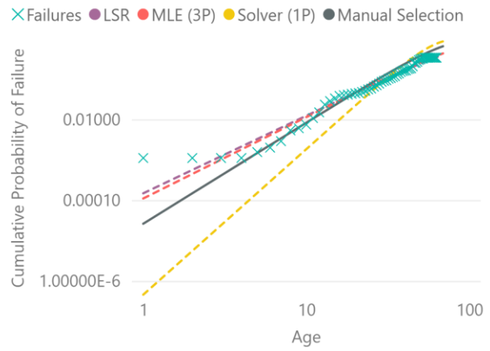
Under Slung Link

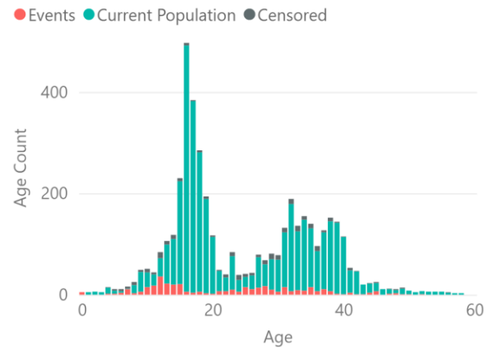
Porcelain

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0.00	0.00
Shape	1.92	2.02	3.60	2.50
Scale	98.46	91.96	57.60	68.00
Predicted average failure age	87	81	52	60
Predicted no. of failures p.a.	22	23	40	35

Input Data Statistics	Value
Mean failure age	22
Population size	3879
Avg number of historical annual failures	40
Age Earliest Failure	0
Age Oldest Asset	62



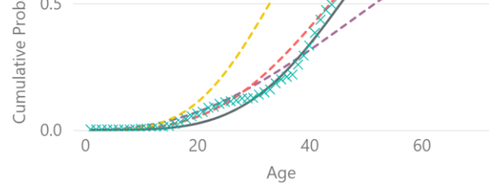


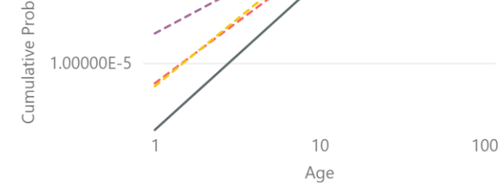


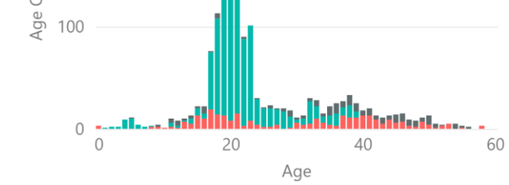
Polymer

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	2.36	3.28	3.6	4
Scale	60.49	48.97	36	50
Predicted average failure age	54	44	33	45
Predicted no. of failures p.a.	10	12	30	8

Input Data Statistics	Value
Mean failure age	30
Population size	1030
Avg number of historical annual failures	30
Age Earliest Failure	0
Age Oldest Asset	58





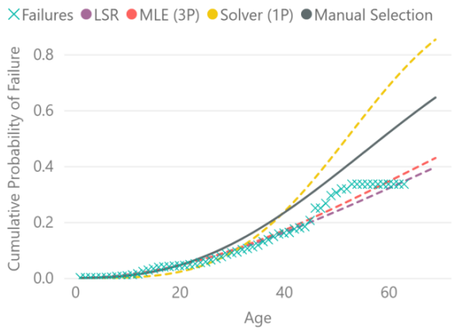


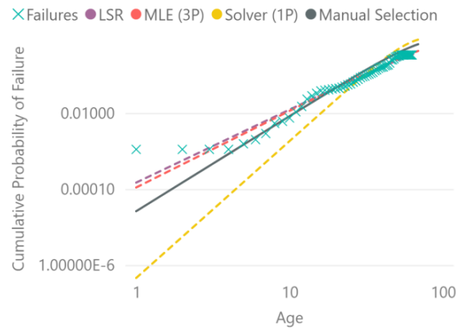
Drop Out Fuse

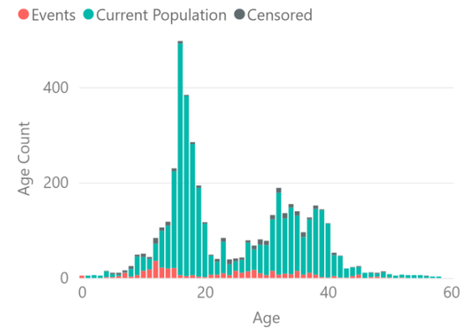
Porcelain

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0.00	0.00
Shape	1.92	2.02	3.60	2.50
Scale	98.46	91.96	57.60	68.00
Predicted average failure age	87	81	52	60
Predicted no. of failures p.a.	22	23	40	35

Input Data Statistics	Value
Mean failure age	22
Population size	3879
Avg number of historical annual failures	40
Age Earliest Failure	0
Age Oldest Asset	62



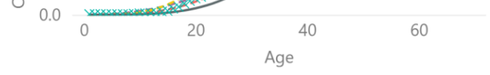


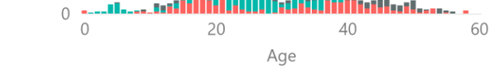


Polymer

Parameters	LSR	MLE	Solver	Selected
Shift	0.00	0.00	0	0
Shape	2.36	3.28	3.6	4
Scale	60.49	48.97	36	50
Predicted average failure age	54	44	33	45
Predicted no. of failures p.a.	10	12	30	8

Input Data Statistics	Value
Mean failure age	30
Population size	1030
Avg number of historical annual failures	30
Age Earliest Failure	0
Age Oldest Asset	58





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