Business Rules

Documented business rules for PoF, CoF and asset risk models

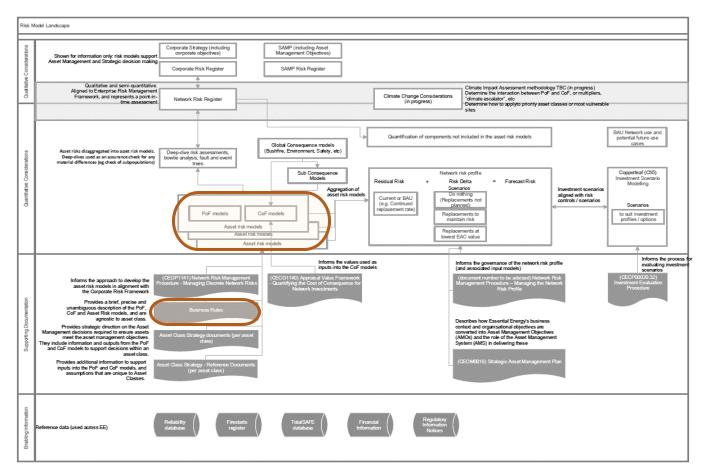
14th February 2022



Commercial-in-confidence



This document captures the business rules for Probability of Failure (PoF), Consequence of Failure (CoF) and asset risk models.

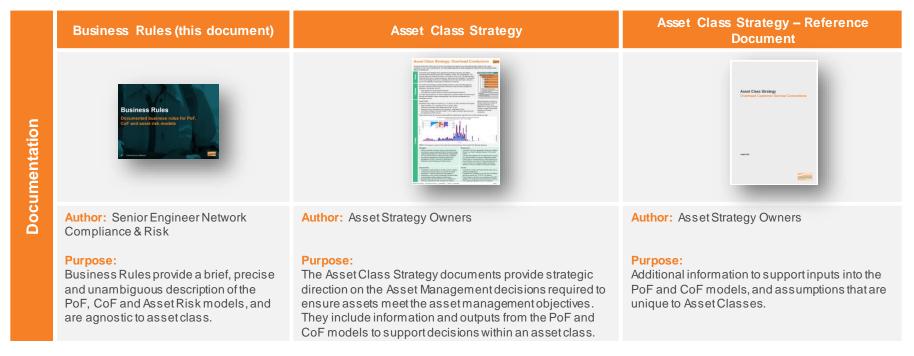






Business Rules are an important tool used to provide clarity and align on a common understanding within an organisation.

Collectively, with the Asset Class Strategy and associated reference documents; this suite of documents is important in quantitative analysis as they identify assumptions, methods and constraints of the underlying models.



Further information on the contents of the Asset Class Strategy and Reference Documents is included in Appendix B.





Risk and Value Frameworks are key input documents to allow for a consistent approach for assessing risk.

This document does not contain explanatory material for how to create value calculators or outline the risk assessment process or risk management principles. This information is contained within the documents referenced below:



Further information on the contents of the Asset Class Strategy and Reference Documents is included in Appendix B.





Calibration of asset risk models is an important process step to provide assurance that the model outputs are reflective of reality.

This document does not contain guidance on the approach to calibration of the asset risk models. This information is contained within the document referenced below:

	Approach for calibration of quantitative asset risk models
Documentation	Calibration approach - Quantitative Documented approach for calibration of quantitative asset risk models
Δ	Author: Manager Network Risk & Performance

Purpose:

This document captures the calibration of the asset risk models, in order to improve confidence that these aggregate to a credible and realistic representation of the total network risk as a result of unassisted asset failures.

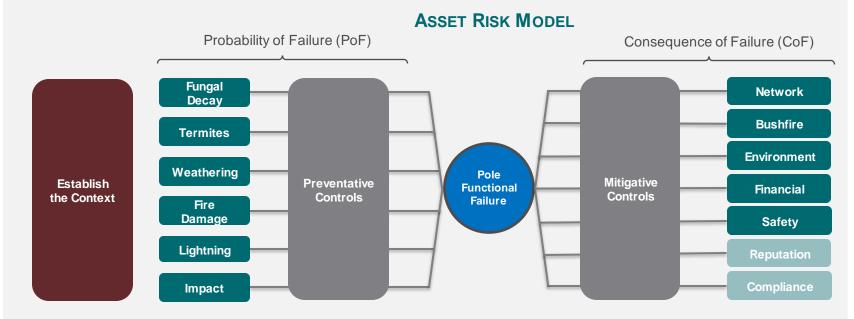


Asset Risk Models



Asset Risk Models – Summary

A high-level example to illustrate the scope of the asset risk models is captured below, including consideration of contextual factors:



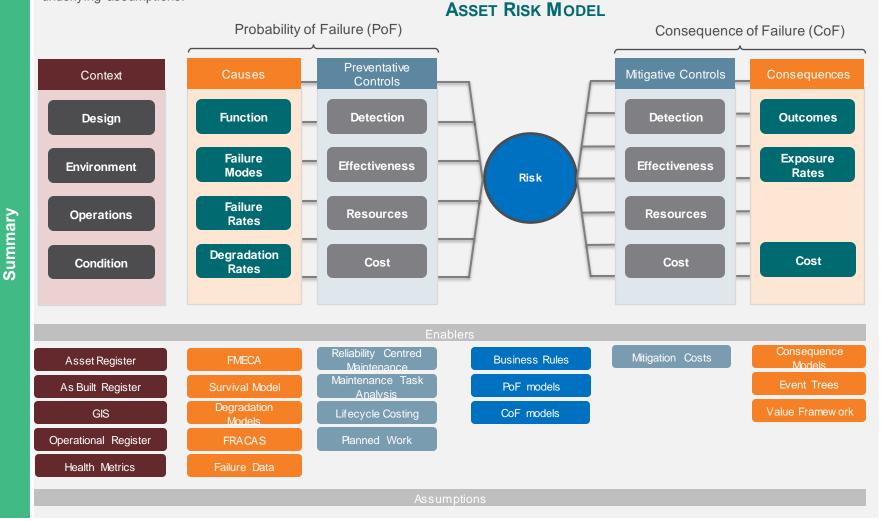
Summary



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Asset Risk Models – Summary

In order to establish an asset risk model, there are a number of items that need to be considered, in conjunction with key enablers and underlying assumptions.





Asset Risk Models – Summary

Asset risk is a function of the probability of failure and the consequence of failure.

The asset risk models represent the relationship between the drivers of the probability of functional failures and the consequence of failure. They provide a quantitative understanding of expected performance of assets.

- Understanding of context:
 - Asset Register
 - As Built Register
 - GIS

Purpose

Enablers

Considerations

- · Operational Register
- Health Metrics
- Business Rules (this document)
- · PoF models
- · CoF models

Assumptions:

1. As per the PoF and CoF business rules sections.

Constraints:

1. Underlying data sources utilised have some limitations, as there is varying degrees of confidence in their accuracy.

Areas for future improvement:

1. As per the PoF and CoF business rules sections.



Asset Risk Models – Assumptions

Common Assumptions across Asset Risk Models:

- 1. Operational cost and resource estimates are as per the WASP Estimates table. Summarised consistently across the three system strategies. These estimates were confirmed as valid estimates by the relevant SMEs.
- 2. Replacement cost and resources were estimated as part of the Asset Class Strategies (ACS) and confirmed in a SME workshop.
- 3. Actual cost and resource by single asset replacement or task are not readily available and as such a bottom-up calibration was not possible. Estimates have been generated using direct costs with on-costs from task estimates excluding travel and overheads. These have been aggregated into larger groups and were validated with the involved SMEs.
- 4. Unplanned replacements (i.e. failures) cost are assumed at 1.7x a planned replacement for the distribution network and 1.3 xa planned replacement for zone substations.
- 5. Unit rate estimates were developed in consultation with SMEs, including through the Unit Rates Working Group. The results are based on a data extract from 3 May 2021 which has been used consistently across the system strategies. These unit rates are based on FY20 data, and not inclusive of travel hours.
- 6. Growth of the asset base in the underground system is not accounted for in modelling estimates.
- 7. Defined projects, such as the RM6 type fault replacement & warranty claim are not accounted for in modelling estimates. Such projects would be expected to somewhat offset required replacements.

Global Variables	Description
CoC	Cost of Consequence, should it eventuate
CoF	Consequence of Failure – considers the LoC and the CoC
LoC	Likelihood of Consequence
PoF	Probability of Failure - is the probability that the asset will fail during a specified period



Asset Risk Models – Methodology

Establishing the context

Before any quantitative asset risk model can be developed, an understanding of the context in which the assets operate must be established. This includes consideration of factors such as:

- · Asset design life and performance requirements
- · Environment of assets, e.g. geographical location
- · Asset operations, e.g. duration of operation, maintenance approaches
- · Current condition and remaining life of assets

All assets risk models must be created in alignment with the Asset Management Framework.

Defining the Risk Event

Method

The asset risk models have been established to calculate the risk associated with asset failures. To properly define the scope of the model, a definition of an asset failure is required.

For an asset to be considered failed it must no longer provide its primary function. For most network assets the primary function is to transmit, or assist another asset to transmit, electricity.

The definition of failure excludes minor or potential failures where the asset continues to provide its required function. For instance, a conditional failure where a pole is tagged for immediate replacement due to significant degradation is not considered a functional failure as the pole continues to support the conductor (however, the pole would be expected to functionally fail in a short timeframe if it were not replaced).

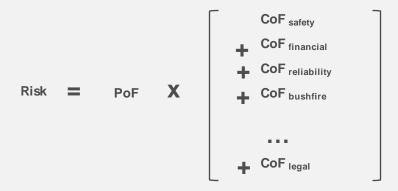


Asset Risk Models – Methodology

Calculating Risk

The Risk is defined as the monetised value of the consequences that are expected to be realised following the failure of the asset, multiplied by the probability of the asset failure occurring.

Risk is calculated using the following formula:



The Probability of Failure (PoF) is the probability that the asset will fail during a specified period and is covered in further detail in the PoF Business Rules section.

Likelihood of Consequence (LoC), Cost of Consequence (CoC) and Disproportionate Factors (DFs) are used to inform the Consequence of Failure (CoF) and these terms are covered in further detail in the CoF Business Rules section.

The expected consequence per asset failure is summated across each of the consequence categories, which is then multiplied by the PoF to produce total risk per asset failure.



Asset Risk Models – Governance

	Responsibility	Role
	Accountable (A): Final sign-off on the output	Manager, Network Risk and Performance
lities	Responsible (R): Completes work required	Asset Class Strategy Owner
Responsibilities	Supports (S): Assists with work required	Manager Asset Management Framework
odse		Head of Engineering
& R	Consulted (C):	Senior Engineer, Network Risk & Performance
Roles	Contributes information / feedback / data	Consequence SMEs (refer summary table in Appendix)
Ro		Other Asset Class Strategy Owners (refer summary table in Appendix)
	Informed (I):	Head of Asset Management
	Kept up-to-date on progress	Group Head Asset Engineering Risk and Compliance

The models have the following review cycle: Minor:

Annually

Major:

- 5 years, or;
- · When triggered, as per the overarching maintenance and change control approach contained within CECPXXXX Managing the Quantitative Network Risk Profile

All updates are to be approved by the Accountable Party, with consultation with key parties as deemed appropriate for the context. Key input values should not be changed without going through a formal maintenance and change control process.



Governance

PoF Models



PoF Models – Summary

The Probability of Failure (PoF) models represent the probability that the asset experiences a failure during a single year. For most assets, the probability of failure increases over time, as the asset degrades. In other cases, the probability of failure is somewhat random, such as lightning strikes and fauna activity. PoF models are used as an input into the overall asset risk models.

PoF models enable asset management decisions across the asset lifecycle of acquisition through to intervention, dependent on their level of development.

- Applicable hazards / causes and their likelihood of contributing to the occurrence of a risk event, through various analysis, dependent on the asset class, including:
 - FMECA

Purpose

Enablers

Considerations

- Survival models
- · Degradation Models
- FRACAS
- Failure Data
- Understanding of preventative controls, through Operations & Maintenance information and analysis, including:
 - Reliability Centred Maintenance (RCM)
 - Maintenance Task Analysis
 - Life Cycle Costing (LCC)
 - Planned Work
- Knowledge from Subject Matter Experts (SMEs) captured through expert elicitation
- · Understanding of CNAIM / OFGEM methodology for asset classes with limited data

Constraints:

- 1. Underlying data sources utilised have some limitations, as there is varying degrees of confidence in their accuracy.
- 2. PoF models have been developed to various levels of complexity across asset classes.

Areas for future improvement:

- 1. Review of the taxonomy of hazards / events for standardisation. Consider how consistency across models can be achieved for common hazard inputs.
- 2. Asset condition / health has not been considered in the PoF models, and could be incorporated in future revisions.
- 3. There is potential for increased usage of the engineering digital twin for improved accuracy.



PoF Models – Assumptions

Common Assumptions across PoF Models:

- 1. Functional Failures have been sourced from the Network Asset Failure Report (NAFR) and the Pole Failure Database.
- 2. Conditional Failures have been sourced from WASP.
- 3. New assets have a negligible failure rate in the first 20 years of their life so the probability of failure for replacement assets is ignored in these instances.
- 4. Assets with missing or inaccurate dates are not included when determining failure rates, but are included when producing forecasts. For forecasting purposes, the age is set to the average age for the population.
- 5. PoF models used in the system strategy analysis were developed from population-level statistical analysis, which allow for population-level asset management decisions.
- 6. Given the population-level statistical probability of failure approach used against an asset subpopulation, the OPEX impact can not be related. As such there are no proposed changes to the OPEX tasks or frequency.

System Interactions:

- 1. Pole replacements are not triggered by other asset classes. Conductor replacements currently trigger pole replacements, and it is noted that this is a conservative assumption regarding the volume of upgraded poles.
- 2. Pole Top Equipment replacements are triggered by 100% of Pole replacements and 80% of conductor replacements.
- 3. Conductor replacements are not triggered by other Asset Classes as failures involving conductors are always repaired.
- 4. Interactions between UG System assets were accounted for at an enclosed substation level. In this first iteration, failures of RMUs were modelled with a 90% chance of elevation to whole-of-substation consequence (replacement), whereas LV Switchboards were modelled with a 10% chance of this same elevation (based on SME elicitation). UG Cable terminations were treated as non-interacting.



PoF Models – Methodology

Cause of a Risk Event

In addition to defining a failure (risk event), consideration must also be given to the cause of the failure and the network's response to the failure.

Failure Cause

There are two main modes through which an asset failure can be caused:

- 1. Unassisted failure: the failure of the asset is caused by its condition. Asset condition degrades over time and may be accelerated by environmental factors, wear and tear and random events, causing the probability of failure to increase over time. The asset condition can be improved by refurbishing or replacing the asset, which will result in a lowering of the probability of an unassisted conditional failure.
- 2. Assisted failure: the failure of the asset is caused by an exogenous factor. This type of failure is independent of the asset condition. If the asset were replaced like-for-like with a new equivalent asset the exogenous factor would still result in the failure of the asset. The only way to prevent this type of failure is to replace the asset with a different asset (such as undergrounding the network in areas where trees are prone to falling on lines). The probability of an assisted failure does not change over time as the condition of the asset changes.

The Australian Energy Regulator (AER) in its Industry Practice Application Note – Asset Replacement Planning [1] (Table 1: Definitions) defines asset failure as:

"when an asset can no longer perform its intended function safely and in compliance with jurisdictional regulations, but not as a result of external impacts such as extreme or atypical weather, third party interference (e.g. traffic or vandalism), wildlife or vegetation interference. The asset may still be operating but may not be capable of delivering all of its required functionality. The asset may or may not be repairable."

The purpose of the practice note is to guide modelling for determining when assets should be replaced. Replacement cannot infuence assisted failures so these are excluded from the AER's definition.

The AER definition, which excludes assisted failures, is used for determining the PoF and risk in Essential Energy's asset risk models. Therefore, the **PoF that is calculated for an asset** is only required to estimate the probability that an **unassisted failure** occurs.

[1] https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%2025%20January%202019.pdf



PoF Models – Methodology

Cause of a Risk Event

Repairable and Non-Repairable Failures

As per the AER definition of an asset failure, the failed asset may be either repairable or non-repairable (requiring replacement). Within the model each asset type is categorised as either repairable or non-repairable. This categorisation is based on standard post-failure practices by Essential Energy.

A **repairable failure** is defined as a situation where the failed asset can be returned to service following the replacement of a component/part of the asset, while retaining other components that were not affected by the failure. Following a repair, the asset's **PoF remains at the same value** as it was before the failure.

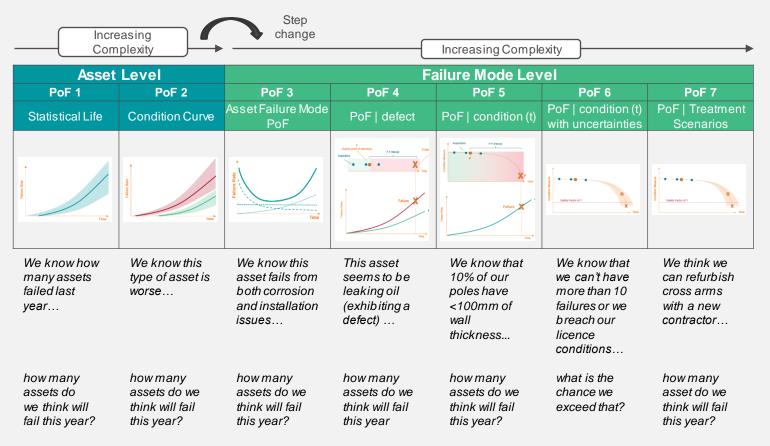
A non-repairable failure is defined as a situation where the failed components of the asset are not easily or efficiently replaced without replacement of the entire asset, so the entire asset (or a majority of) is replaced. The key result of a replacement is that the **asset's PoF is** reset to that of a brand new asset.

PoF Models – Methodology

Likelihood of a Risk Event

Failure Modes

Depending on the quality of data, a PoF model can be developed at the asset level (including sub-populations) or failure mode level. The asset management decisions that can be addressed increase in complexity with the 7 levels as shown in the diagram below. Appendix D captures the current state of the PoF modelling per asset class.





PoF Models – Application

Asset Management Decisions

PoF models enable asset management decisions across the asset lifecycle of acquisition through to intervention.

		Asset	Level		Fail	ure Mode L	.evel	
		PoF 1	PoF 2	PoF 3	PoF 4	PoF 5	PoF 6	PoF 7
Asse	t Strategy Levers	Statistical Life	Condition Curve	Asset Failure Mode PoF	PoF defect	PoF condition (t)	PoF condition (t) with uncertainties	PoF Treatment Scenarios
	Replacement Demand	•	•	•	•	•		•
	Design Life	•		•				
Acquisition	Procurement Specification			•				
	Acceptance Criteria			•				
	Operational Profile							
	Duty Cycle							
On and in a g	Inspection / PM Techniques							
Operations & Maintenance	Rectification Time							
waintenance	Corrective Maintenance							
	Inspection / PM Frequency							
	Condition Definitions							
	Thresholds							
	Coincident Replacements							
	Repair Cost Limits							
Intervention	Upgrade	•						
Intervention	Modifications	•						
	Replacements							
	Augmentation Demand	٠						
	Intervention Option							
	Parts Management							
Asset Support	Parts Holding Policy							
System	SpecialistTools	•	•					
	FTE Requirement	•	•					•



PoF Models – Governance

	Responsibility	Role
ß	Accountable (A): Final sign-off on the output	Head of Engineering
Capilingicilodeav	Responsible (R): Completes work required	PoF Model SMEs (refer summary table in Appendix)
	Supports (S): Assists with work required	Manager Engineering Management System
Č ð		Manager Asset Management Framework
	Consulted (C): Contributes information / feedback / data	Manager, Network Risk and Performance
		Asset Class Strategy Owners
	Informed (I):	Head of Asset Management
	Kept up-to-date on progress	Group Head Asset Engineering Risk and Compliance

The models have the following review cycle:

Minor:

Annually

Major:

- 5 years, or;
- When triggered, as per the overarching maintenance and change control approach contained within CECPXXXX Managing the Quantitative Network Risk Profile

All updates are to be approved by the Accountable Party, with consultation with key parties as deemed appropriate for the context. Key input values should not be changed without going through a formal maintenance and change control process.



CoF Models

CoF Models – Summary

Purpose

Enablers

The Consequence of Failure (CoF) models represent the impact of an equipment failure on Essential Energy. CoF models are used as an input into overall asset risk models. They can also be used as a benchmarking tool to compare Likelihood of Consequence with peers externally at an asset class level.

- · Mitigation Costs
- Global Consequence Models (where applicable)
- · Likelihood of Consequence (distribution) captured in Event Tree Analysis
- Cost of Consequence as per the Appraisal Value Framework
- Disproportionate Factor (DF) for each consequence category as per the Appraisal Value Framework
- Subpopulation classifications

Constraints:

1. Underlying data sources utilised have some limitations, as there is varying degrees of confidence in their accuracy.

Areas for future improvement:

1. Nil identified.



CoF Models – Assumptions

Common Assumptions across CoF Models:

- 1. Confidence intervals have been applied to likelihood of consequence and utilise a mean and a standard deviation input.
- 2. For corrupted data sources, default values have been adopted.
- 3. Duplicative data has been excluded.
- 4. Calculations are based on the most exposed reasonably behaved person for a generalised scenario.

Clarifications for Consequence Categories:

- 1. Generally, the CoF models utilise the formula captured in the methodology (within this document), and based on the assessment of Likelihood of Consequence (LoC), the Cost of Consequence (CoC) and the Disproportionate Factor (DF)
- 2. Safety calculations utilise the Safety Exposure Method, captured in Global Consequence Model Documentation_Safety Exposure
- 3. Bushfire calculations utilise information from the Bushfire global consequence model.
- 4. Reputation: this consequence only occurs in addition to network, safety, bushfire and environmental as reputational consequence is already incorporated in each of these other consequence categories. The reputation category captures reputation impact to the organisation from industry, community, government, media or other stakeholders in circumstances other than those captured in the previous consequence categories. The likelihood of reputation impact should be estimated as a proportion of events which are likely to receive attention from stakeholders.
- 5. Compliance: this consequence category captures the need for completing programs to comply with a legislated requirement, for example a breach of the National Electricity Rules or failing to comply with an IPART directive. The consequences of non-compliance are determined on a case-by-case basis through discussion with the appropriate regulatory body (AER or IPART).
- 6. Financial: this captures both financial consequences that incurred to Essential Energy and the community. For instance in the case of high voltage on a line causing a community member's fridge to prematurely fail, this cost is rarely covered by EE, however this cost implication is still considered within the financial consequence category.
- 7. Network: there are two components to the network, namely the VCR calculation and the additional costs to EE, which are quantified via the network table contained within the Value Framework.



CoF Models – Assumptions

	Global Variables		Description
	Bushfire Priority Level	[P1-P4]	Bushfire priority level refers to the likelihood that a fire start will spread into a bushfire.
	CAIDI	N/A	Customer Average Interruption Duration Index [SAIDI / SAIFI]
	DF	[0-10]	Disproportion factor as described in CECG1140.
JS	Phoenix Bushfire Value	Number	The expected number of properties lost if a fire were to start in that location. See CEOP8067 for more detail. https://utilnsw.sharepoint.com/sites/PolicyLibrary/Policy%20Documents/CEOP8067.pdf#search=bushfire%20priority%20zone
otio	PoF	[0-1]	Probability of Failure
Assumptions	P _{Severe} , P _{Major} , P _{Moderate} , P _{Minor} & P _{Insignificant}	[0-1]	Probabilities that describe the severity of each consequence event.
	C _{Severe} ,C _{Major} , C _{Moderate} ,C _{Minor} & C _{Insignificant}	\$	Consequence costs assigned in the Appraisal Value Framework - CECG1140
	SAIDI	N/A	System Average Interruption Duration Index [Duration of outage in minutes x Number of customers impacted by outage] / 855000
	SAIFI	N/A	System Average Interruption Failure Index [Number of Failure outage in minutes x Number of customers impacted by outage] / 855000
	VCR	\$	Value of Customer Reliability



CoF Models – Methodology

Subpopulation aggregation

Assets have been allocated to subpopulations within asset classes based on SME input. Where this has occurred, CoF models have a subpopulation input sheet which captures the allocation of assets to the associated subpopulation.

This allows for differentiators in severity across different subpopulations to be captured. For example, a pole failure in a particular environment may have a different impact than that in an alternate environment.

Likelihood of Consequence

The Likelihood of Consequence (LoC) is the percentage probability that given consequence outcome will be observed following a failure.

Each asset class has an LoC parameter for each consequence type. The following types of consequences are incorporated into the CoF models:

- Safety Public & Worker
- Financial

Method

- Reliability
- Environment (Bushfire)
- Legal / Regulatory Compliance
- Environmental

The LoC incorporates a range of information. This includes:

- The various failure modes that an asset may experience and the frequency with which each failure mode is expected to occur;
- The likelihood of a consequence eventuating as a result of a failure
- · The presence and effectiveness of mitigative controls

This information has been developed by Subject Matter Expert (SME) input for each Asset Class.

Where significant differences in the likelihood of a consequence occurring exist within an asset class, the LoC parameters may differ between subpopulations. Documentation of the approaches to calculating LoC parameters for each asset class is covered in the relevant Asset Class Strategies for each asset class.



CoF Models – Inputs & Methodology

Cost of Consequence

Inputs regarding costs of consequence per severity level and Disproportionate Factors (DF) captured in CECG1140 Appraisal Value Framework (VF2.0) are used as static inputs into the CoF models. These are shown below for information as at the time of issue of this document, however the Appraisal Value Framework should be referred to for the costs of consequence and the determination and application of the Disproportionate Factor.

The Cost of Consequence (CoC) is the cost that will result from a given consequence occurring. Each consequence could result in a range of outcomes with varying levels of severity.

			Co	st of Consequen	ce		Dispro	oportionate Facto	or (DF)
	VFT Category	Insignificant	Minor	Moderate	Major	Severe	Insignificant / Minor	Moderate	Major / Severe
Method	Safety (Societal – VoSL)	\$713	\$4,990	\$24,951	\$499,019	\$4,990,190	6	6	6
Ň	Safety (EE)	\$3,725	\$65,545	\$406,914	\$1,821,601	\$13,489,184	1	1	1
	Network (Societal – VCR)	TBC *	TBC *	TBC *	TBC *	TBC *	1	1	1
	Network (EE)	\$2,668	\$77,165	\$81,060	\$656,870	\$2,415,515	1	1	1
	Financial	\$132,100	\$2,774,100	\$51,852,000	\$39,630,000	\$73,976,000	1	1	1
	Environment (bushfire)	\$3,697	\$122,677	\$2,626,905	\$18,323,672	\$175,389,897	1	3	6
	Environment (other)	\$3,442	\$46,297	\$240,016	\$1,532,068	\$12,524,244	2	2	2
	Compliance	\$3,442	\$46,297	\$240,016	\$1,532,068	\$12,524,244	2	2	2
	Reputation	\$1,057	\$6,986	\$85,218	\$579,858	\$2,238343	2	2	2

* VCR Calculations are underway and being completed by Essential Energy



CoF Models – Inputs & Methodology

Disproportionate Factor

Demonstrating that risk is As Low As Reasonably Practicable (ALARP) is undertaken through an economic test where risk is reduced to ALARP by

"incurring expenditure up to the point at which the expenditure would be 'grossly disproportionate' to the benefit (risk reduction) achieved. That is, if it is not grossly disproportionately uneconomic to do so, then the source of the risk should be eliminated" [1]

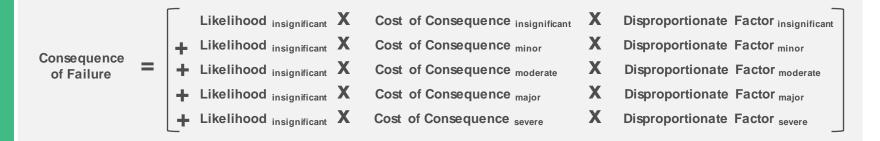
Disproportionate Factors (DFs) are commonly applied to risk considerations across Network Service Providers (NSPs) as a means of demonstrating that ALARP has been met.

Higher DFs indicate a higher level of societal dread associated with the event, e.g. multiple fatalities or outcomes with large social impact, and/ or a higher level of uncertainty in the risk assessment.

Consequence of Failure

Method

The overall Consequence of Failure (CoF) is based on the likelihood of the consequence eventuating, the cost of the consequence and the disproportionate factor, as per the Appraisal Value Framework:



[1] https://www.aer.gov.au/system/files/D19-2978%20-%20AER%20-Industry%20practice%20application%20note%20Asset%20replacement%20planning%20-%2025%20January%202019.pdf



CoF Models – Governance

	Responsibility	Role
	Accountable (A): Final sign-off on the output	Manager, Network Risk and Performance
lities	Responsible (R): Completes work required	Asset Class Strategy Owner
Responsibilities	Supports (S): Assists with work required	Manager Asset Management Framework
odse		Head of Engineering
କୁ ଅନୁ	Consulted (C):	Senior Engineer, Network Risk & Performance
Roles	Contributes information / feedback / data	Consequence SMEs (refer summary table in Appendix)
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The models have the following review cycle:

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Major:

Governance

- 5 years, or;
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Appendix A

Acronyms



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Acronyms

Acronym	Definition
ACS	Asset Class Strategies (project)
AER	Australian Energy Regulator
CNAIM	Common Network Asset Indices Methodology
CoF	Consequence of Failure
DF	Disproportionate Factors
FMECA	Failure Mode, Effects and Criticality Analysis
FRACAS	Failure Reporting, Analysis and Corrective Action System
LCC	Life Cycle Costing
MTA	Maintenance Task Analysis
NSP	Network Service Provider
OFGEM	Office of Gas and Electricity Markets
PoF	Probability of Failure
RCM	Reliability Centred Maintenance
SME	Subject Matter Expert
VCR	Value Customer Reliability
VoSL	Value of Societal Life



Appendix B

Asset Class Strategy and Reference Document Overview



Asset Class Strategy Overview

Phase 1 Asset Class Strategies: Load control, Pole top equipment, & HV Ring Main Units

- > Context Purpose and Assets Profile
- > Performance and Line of Sight by AM objective: Current and target performance
- > Gaps (in AMO performance)

	Asset (Class Strategy –	Pole '	Top Equipment – S	ummary	essential
	Pole top equi to cost, risk a without increa	nd performance. Our value bas	e asset clas ied approa	ises across Essential Energy's network to asset management reduces the	ork and a major cont e cost of doing busine	fibutor tes
Context	asset with sig consequence between asse the public and amount of ath The transition and increasin are driving str extract the mo	Ipment is a high volume infrant variations in the s, environment and design th. Pole tops are visible to a tratact a dispoportionate ention from customers. to composite crossams g defect detection rates along improvements to bet value from assets easers of Truckland Falare	insulator	 1.30 million crossams with storadily replacing Sinbor A dama 1.00 million crossams with example of the single of the	however, historical been inferred from sources in WASP	
	-			formal records. 2.90 million on insulators and conductors the terms for the terms of the terms.	support future ass and is one of the p	vement is required to et strategy approaches minary goals of this
	Line of Sight	Objective		Current Performance	Parts	rmance Targets
	Dushfire Prevention	B1. Decrease controllable Busi by 20% within 20 years	tre Rak	 40 fire starts p.a. (2015-2019) will 94.5% caused by unassisted fails 	h Fires caused by United	is larget executed Fadures CO2 pa. Acc rankows 412 months
ight	Asset intervention and Refirement	AR1. Maximise opportunity in t identification of asset relinement AR2. Maximise benefits in the of asset referencent options AR3. Manage network safety ri- corporate risk appette	it events selection	Interventions timing is adjusted to align with major investment activit Maintenance threadest is not used major investment decisions Asset cost and risk is disaggrega Technical triggers axis but only support basic forecasting	in Namesana Para	 BOS accuracy at 2 years BOS accuracy at 2 years BOS accuracy at 5 years
Line of S	Reliability	R1. Maintain network reliability R4. Improve SAIDI on poor per feeders	forming	 Targets set against current performance. Actions in place to prevent growth of failures caused decay, taitgue and contamination 	by Pueder SA Type Lar Littus 21 Stotomi 11 Largoual 31	17 E.04 71.75 54 E.54 500.29
Performance & Line of Sight	Asset Information	Define data requirements, qual purpose to prepare pole top eq for EAM, DAM & CS5		Availability is limited Definitions are controlled in WAS Standards in development Quality is lew, but not a priority Certification process in developm	Data Darred Data Standard	80% 80% 80% 90%
Perto	Network Buctsinability	costrategy in development >>		<< strategy in development >>	<ratalogy d<="" in="" td=""><td>evelopment>></td></ratalogy>	evelopment>>
	Legislative Obligations	General obligations + QLD Rul L01. Failure Rate < 0.01% p.a		Documented inspection intervals and condition monitoring process for pole equipment.		rs Leget Rote <0.01%
	Nefwork Bately	N 81-N84. Manage asset safet SFARP within corporate risk to and legislative requirements. N 86. Compliance with FEA N 80. Compliance with safety o and regulatory requirements	lerance	 SFARP embedded in decision ma FSA controls identified; however, are not evaluated through BAU. Consequence model developed, not in use 		nsi tangat MPBA Corecela 900% akity citigatona 100% akitya sukno with secretabil 50%
sdeg	Improved the det Using defect sav maintenance task AM Bush Asset Ref	fire			to constition based in Instead of using inspe- prioritise maintenance identify detects and e when constined with maintenance priority. Align causes across Use a common PMEC interventions, mainte Data driven decision Record asset, mainte	sciens to achedule and b, they should be used to alculate condition, which, value determines comporting systems A to report talues, sance, sately incidents, etc.

- > Lifecyle Strategic Directions and Actions
- Asset Support Process & Information, People & Training: Current Approach and Improvement Actions
- Forecast: Short term forecast annual quantities, AVG Replacements by Reason, AVG Task completion by month & category
- > AMS: Roles & Responsibilities, Enablers, & Governance

	Acquisition	Crossa choice timber	ion Criteria Irm6. Compositor standard in only in exception	site is the default sitaliations. Siteel o lonal	dependir r Polymer of damag Conduct	R. Polymer or porcelain ig on pole top construction, avoided in areas with high rates ge due to wildHe. In the Preferrm or hand ties to conductor material		Asset Data, Recording of all asset data when new pole top equipment is installed. Innovation. Continue to evaluate new products and solutions against EE's need.		
lfecycle Strategic Direction	Inspectors Identification and categorisation of defects and categorisation of CEONTOSE. CEONTOSE. CONTRACT Search and CEONTOSE Of Constanting Inspection. Sciencidad every 4.5 years to detect detect and monitor constain. PSE. Annualy in tuutifier picelity areas. CONTRACT Antal Inspection. And Insvestance and LDAR to monitor asset conclose. Nearch are the pincipil		NE. On o inspectio Correctil Tighten 1 installatis with com Breakdo Pole Top in accoro r Broken a i.e. Repk	stive Maintanance onsilion tasks triggered by ne. ve Maintanance (Repairs) ardhare and address as errors. Cleaning of insulators aminiation. vem Maintenance (FAE) equipment blaves are rectified fance to CEUPRIOTO. Replace set and any dependent assets one conductor (se when jinualators.		targetcine Data during injugations in measurements during injugations in enable condition monitoring. Cause Descriptions. Along Cause descriptions to the FMECA to achieve desired granularity. Drose targementables. Support defect data.				
Lifecycle St	under enders by Cipital Anast Monty, BerticasSIII) Anast serviceability as per CIC/DP2440 and Natif.: Unrevendion options include: angeological and and and and and and and angeological and and and and and and angeological and and and and and angeological and and and and angeological and and and and angeological and and and angeological and and and angeological and and and angeological and and angeological and angeological and angeological and angeological and angeological and angeological and angeological angeo			ion options include lew pole top ted as per Changes that the rate of h as anti-split bolts	: severity i criticality interventi reduces Replace Assets to as per C • PEC	ation ions prioritised by defect and informally by asset increased lead time for ions decreases cost and pressure on operational staff, mand programs be replaced on identification EOM7064: and laminate crossamms adplantic insulators		 Infervention Coefs. Unit rates for Interventions broken down into encough deall (admin, tasket, etc.) Replacement of Parent Assets. Record reglacements that are biggered by pole replacements. 		
	Disposais	Pole to per CE Asset Develo CEOPS system	OM7094. Variant Phose p disposal pla	n as per e asset support appropriately	CEOM70 13 Guide	sle top components as per 194 and Technical Brief 15- for Assessing Equipment for n our Network		Sustainability Reporting. Report asset reuse rates to drive sustainable behaviour.		
ų,	1	-		Current Approact				ent Actions		
	-		Process & Data quality and availability grad Information improving in preparation for EAM			Continue to enhance the utilit				
						cases for EAM		and advergence of a stand of an		
Asset Supp		mation sie &	Improving in Highly train		M		aintena	ance forecast to ensure maintainers		
Asset Supp	Info	mation sie & sing	Improving in Highly train	n preparation for E ed workforce with I match demand	M	Develop accurate long term m	uainteru future o	ance forecast to ensure maintainers		
Forecast Asset Supp	Peop Train	Mation No & Short Astivity Inspectio Modificate Replacem Replain aled Accel	Improving in Highly train- elasticity to Torm Foreca na na anta	h preparation for E match demand ast Dueshty 286,000 7,000 86,000 16,000 6,000	M	Develop accursite long term in can be trained to be need the personal by Reason	AV	ance forecast to ensure maintainers demand in a sustainable way.		
Forecast Asset Supp	Infor Peop Trail	mation de 8 ling Short Astrit Inspecto Modification Replacem Repairs alot Asset Named on	Improving in Highly train elasticity to Term Foreca na na na Fature	h preparation for E match demand ast Dueshty 286,000 7,000 86,000 16,000 6,000	AVG Replan	Develop accurate long term in can be trained to be reset the comments by Reason	AV	inconsiderated to ensure maintainers denand in a sustainable way. To Tatk competition by Booth Competition by Booth Competition and Competition Competition and Competition Competition and Competition Competition and Competition Competition and Competition Co		
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 Improvement actions by category (i.e. AM objective) and responsible area

Asset Class Strategy – Pole Top Equipment – Actions

Category	Actions	Responsible Area
Bushfire	Report on the completeness of asset information for newly installed pole top equipment	Asset Management
Bushfre	Evaluate the efficacy of the PSBI, focusing on its impact on bushfire risk for pole top equipment	Asset Management
Bushfre	Align fire start causes to the causes used elsewhere across the pole top equipment. It is suggested that this should be aligned to a FMECA managed in EAM.	Network Compliance and Risk
Bushfire	Investigate why fungal decay is the leading cause of the starts given the leading cause of crossam replacements are cracking/splitting and weathering	Engineering
Bushfre	investigate detection methods for contamination on insulators and evaluate the feasibility for inclusion in PSBI for coastal regions.	Engineering
Reliability	Replacement of timber crossams with composite crossams in poor reliability performing areas with high customer loads.	Asset Management, Engineering
Reliability	Investigation of the inspection interval of known timber crossams in poor performing and high customer load areas.	Engineering
Reliability	Alignment of reliability failure modes with other reporting systems against a unified failure mode catalogue (ideally FMECA based) to be utilised across departments.	Asset Management
Safety	Enhance the failure reporting systems to include outcomes that align with the consequence model developed in this strategy	Network Failure and Investigations
Salety	Evaluate the SFARP maturity (once developed by the Network Strategy Load) against each stage of the asset lifecycle and develop a roadmap to remediate any gaps identified.	Asset Strategy Load
Safety	Contrived development of the consequence models to demonstrate compliance against safety principles and to support performance monitoring and reporting for safety.	Asset Strategy Load
Asset Intervention & Retirement	Gapture the asset information required to evaluate all technical triggers required for all new Pole Top Equipment and evaluate the impact of current asset information gaps.	Asset Management
Asset Intervention & Retroment	Evaluate the accuracy of intervention forecasts and use this performance to improve forecasts	Network Planning
Asset Intervention & Retirement	*	Digital Asset Management
Acquisition	Engage with internal stakeholders and the market to identify innovative products and solutions for evaluation.	Asset Management, Innovation, Engineering, C&NS
OBM	Establish a condition rating system to support condition monitoring of pole top equipment.	Engineering supported by Asset Management
OSM	Define cause descriptions to the right level of granularity and align reporting across essential energy to this nomenclature.	Asset Management
OSM	Implement a robust data capture pregnam with drones that provides a comparable quality to existing overhead inspection programs and supports condition monitoring programs	Engineering
Interventions	Calculate unit rates for interventions with enough detail to support future maintenance strategies and coincident maintenance.	Enterprise Data Enablement
Interventions	Establish intervention thresholds for pole top equipment based on condition and tolerance for risk.	Engineering
Disposals	Calculate unit rates for interventions with enough detail to support future maintenance strategies and coincident maintenance.	Inventory and Logistics Management Team
Asset Support	Investigate the integration of probability of failure models into PowerLines Pro for the primary causes of unassisted failures	Digital Asset Management
Asset Support	investigate the integration degradation models in PowerLines Pro for the primary causes of unassisted failures.	Digital Asset Management
Asset Support	Investigate the enhancement of load models in PowerLises Proto include the stress uncertainty caused by variations in environmental conditions.	Digital Asset Management
Asset Support	investigate the integration of the consequence model into PowerLines Pro	Digital Asset Management
Asset Support	Mitigate the supply risk for crossarms by maintaining a collaborative strategic partnership with Wagners while continuing market engagement with other potential supplers.	Asset Engineering
Enablers	Integrate the legacy crossers dataset into WASP to essure the baseline population data is available to all stakeholders in a central location	Enterprise Data Enablement
Enablers	Embed processes to capture all relevant asset data during the installation of new assets and capture legacy asset data during multine inspections and maintenance.	EAM
Enablers	Megrate the compliance and reputation categories from the value thansework into the consequence model	Asset Management
Enablers	Calculate the direct and indirect costs of interventions to allow coincident and F&E interventions to be evaluated correctly	Asset Management
Eashiers	investigate the use of Total Safe as the reporting mechanism for safety incidents and	Asset Management supported by H



Asset Class Strategy Overview

Phases 2 and 3 All other Asset Class Strategies

- Scope: Assets in scope for this iteration
- > Purpose
- > Context:
 - Assets Profile
 - SWOT: External and internal drivers that will impact lifecycle asset management



- Line of sight Linkages to Network Strategies & Corporate Objectives
- Performance by new AM objectives: Historical and target performance



 Lifecyle Forecasts: Lifecyle improvements, Short term forecasts, 20 year cost and risk forecasts for different scenarios (see next page)

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- > Context:
 - Probability of Failure Model parameters
 - Consequence of failure values (Appraisal Value Framework)
 - Power BI Map by depot: Consequence of Failure values
 - Asset Risk Model (Bow-tie)
- Strategic Directions by Lifecyle stages and Asset Management System: Current approach and actions for Process & Information, People & Training, & Supply Chain
- Strategic Directions: Key Assumptions
- > Key Enablers
- Roles & Responsibilities, Information & Interfaces & Governance
- Summary of key changes in this iteration









Asset Class Strategy Overview

Phases 2 and 3 All other Asset Class Strategies

The Reference document (in WORD) contains more technical information and assumptions that support the strategy. It is an informal notepad to drop in details supporting the strategy. An example from ACS Underground Cables is illustrated below.

	Scope
2 →	Purpose
3 →	Context
3.1 →	External
	Essential Energy
3.3 →	Asset Class
	3.3.1 → Asset Function
	3.3.2 → Asset Need
	3.3.3 → Asset Profile
	3.3.4 → Emerging Issues
3.4 →	Asset Class Strategy Decision
	3.4.1 → Asset Class Strategy Decision Process
	3.4.2 → Asset·Risk·Model
	3.4.3 → Asset Task Mapping
	3.4.4 → Asset Probability of Failure
	3.4.5 → Replacement Modelling & Forecasts
	3.4.6 → Asset Consequences from Failure
	3.4.7 → Asset Differentiators
	3.4.8 → Asset Condition
4 →	Line-of-Sight
4.1 →	Asset Management Objectives
4.2 →	Obligations
	4.2.1 → Technical Standards
5 →	Performance
5.1 →	Performance Overview
	Lifecycle-Strategic-Direction
	Acquisition
	Acquisition → O&M·Strategy →
	Intervention-Strategy
	Asset-Support
7.1 →	Processes and Information
	7.1.1 → UG·Cables·Specific·Processes
	7.1.2 → Information Sources
	7.1.3 → Tools
	7.1.4 → Actions
	People & Training
7.3 →	Supply Chain (optional section)
	7.3.1 → Demand
	7.3.2 → Supply
	7.3.3 → Actions
8 →	Lifecycle-Improvement-Roadmap

■ 3.3.3 → Asset-Profile¶

In-service-assets-and-their-age-/-natural-grouping¶

- → David·Shepherd:¶
 - $\circ \rightarrow Split \cdot into \cdot ST \cdot (33kV, \cdot 66kV, \cdot 132kV, \cdot 220kV), \\ \cdot HV \cdot (11kV, \cdot 22kV), \\ \cdot LV \cdot (<11kV)$
 - → ST: clear runs, lower fault rates¶
 - → <u>HV</u> shorter runs, more complex¶

o → NB:¶

- Anomalous group exists where we might have HV-voltage but currents high enough to be effectively ST-near solar generators¶
- → Some DC cables exist (mostly link between QLD and NSW; very small %)¶
- → John Ward / Joe Barry
 - → XLPE has both old and new manufacturing technique.
 - Old batch~1980s susceptible to water trees, cracks (prior to water tree retardant introduction; steam used in processing, which introduced moisture from the beginning)¶
- → Ross Kempnich¶
 - o → Ageing network: XLPE cables from the <u>mid-1980s</u> (without water tree retardant) may be coming up on their end of life, suggesting we could have an uptick in failures on its way¶
 - → Information requested: paper on 40y expected life of this older type of XLPE

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3.4.4 → Asset-Probability-of-Failure¶

OFGEM·vs. ·Weibull¶

- $\bullet \rightarrow \mathsf{UG}\text{-}\mathsf{cable}\text{-}\mathsf{data}\text{-}\mathsf{quality}\text{-}\mathsf{has}\text{-}\mathsf{the}\text{-}\mathsf{following}\text{-}\mathsf{limitations}\text{-}(\mathsf{amongst}\text{-}\mathsf{others})\P$
 - $o \rightarrow \mathsf{Tasks}\xspace{-}are \cdot \mathsf{not}\xspace{-}directly \cdot \mathsf{attributable}\xspace{-}to \cdot \mathsf{individual}\xspace{-}cables \cdot \mathsf{the}\xspace{-}cables \cdot \mathsf{the}\xspace{-}same{-}are \cdot \mathsf{not}\xspace{-}represented \cdot \mathsf{in}\xspace{-}WASP\P$
 - $o \rightarrow \text{High-number-of-cable-attribute-data-fields-either-missing,-invalid,-or-conflicting} \P$
- → OFGEM·is·a·useful·approach·in·that·¶
 - $o \rightarrow \text{It-can-incorporate-what-data-is-available-regarding-asset-health,-age,-and-attributes} \P$
 - $o \rightarrow \text{It-produces-reasonable-results-even-when-data-quality-is-poor} \P$
- → Weibull·in·comparison¶
 - $o \rightarrow Is \cdot more \cdot flexible \cdot than \cdot OFGEM, allowing \cdot a \cdot closer \cdot match \cdot to \cdot historical \cdot failure \cdot and \cdot local \cdot conditions where \cdot the \cdot data \cdot is \cdot available, \cdot but \cdot as \cdot a \cdot result \P$
 - $o \rightarrow Is\ less\ for giving\ than\ OFGEM\ where\ data\ quality\ is\ poor,\ as\ fit\ parameters\ can\ vary\ wildly\ and\ be easily\ misrepresented\ or\ misinterpreted\ to\ show\ results\ which\ do\ not\ reflect\ reality\ \P$
- → OFGEM·was·deemed·most·appropriate·for·UG·Cables·PoF.¶





Appendix C Summary of Subject Matter Experts



Subject Matter Experts - Asset Class

System	Asset Class Strategy	PoF Model Status	CoF Model status	Asset Class Strategy Owners ¹	PoF Model Owners ²
	Distribution Power Transformers	Completed	To be updated to VF2		David Shephard
	Overhead Conductors	Completed	To be updated to VF2		James Baker
	Overhead Customer Service Connections	Completed	To be updated to VF2	(Vacant role)	Not created yet
Overhead	Overhead Links, Switches and Fuses	Completed	To be updated to VF2		James Baker
Overneau	Pole Top Equipment (PTE)	Completed	To be updated to VF2		James Baker
	Poles	Completed	To be updated to VF2		James Baker
	Voltage Regulators and Voltage Regulating Relays	No PoF model	No CoF model		James Bowman
	Vegetation	Completed	To be updated to VF2	Health Frewin	TBC by EE
	Auxiliary AC/DC Systems	Completed	To be updated to VF2		Sam Mulquiney (TBC by EE)
Secondary	Electrical Network Telecommunications System	No PoF model	No CoF model	Warren McLean	TBC
Systems	Load Control	No PoF model	No CoF model	vvarren McLean	ТВС
eyetetne	Meters	No PoF model	No CoF model		ТВС
	Protection and Control Systems	Completed	To be updated to VF2		Peter Tree (TBC by EE)
	HV Ring Main Units	Completed	To be updated to VF2		David Shephard
Underground	Underground Cables	Completed	To be updated to VF2	David Mason	Graeme Barnewall / Andrew Laing
.	Underground Pits, Pillars and Cubicles	Completed	To be updated to VF2		Daniel Kelly / Andrew Laing
	CircuitBreakers	Completed	To be updated to VF2		Aaron Thompson
	Earthing and Lightning Protection	No PoF model	No CoF model		ТВС
	Instrument Transformers	Completed	To be updated to VF2		Aaron Thompson
Zone Substation	Reactive Plant	Completed	To be updated to VF2		Majid Tavakoli
	Substation Buildings and Property	No PoF model	No CoF model	Comontho Lloymon	TRC
	Surge Arrestors	Completed	To be updated to VF2	Samantha Haynes	Sam Mulquiney
	Switchboards	Completed	To be updated to VF2		Majid Tavakoli
	Zone Substation Outdoor Busbar, Isolators and Disconnectors	Completed	To be updated to VF2		Majid Tavakoli
	Zone Substation Transformers	Completed	To be updated to VF2		Sam Mulquiney

¹ Asset Class Strategy Ow ner list has been sourced from the System Register

² PoF Model Owners have been provided by Head of Engineering and potentially require updating in the System Register

Subject Matter Experts - Consequence

Consequence Category	Consequence SM E	Cost of Consequence SME
Safety and Wellbeing	Jason Lindley	
Network Reliability	Steve Ashton	
Financial (F&E)	John Chilko	Alex Derden
Financial (insurance claims)	David Chinn	Alex Bardon
Environment (Bushfire)	lan Fitzpatrick	
Environment (other)	Brett Hayward and Ian Fitzpatrick	



Appendix D Levels of PoF Modelling



Levels of PoF Modelling

Previous PoF model level

Endorsed Asset Class Strategy		Le	vel o	f Mo	delli	ng			Resulting PoF Model	Key Challenges	
		1	2	3	4	5	6	7	needing i ei medei		
Poles 2 Timber poles, Pole cap, Stay assembly		•							(1) Weibull PoF model at sub population level → (2) asset condition	Interaction between failure modes	
Pole Top Equipment Crossarms (including anti-split bolts), insulators, conductor ties		•							(1) Weibull PoF model at sub-population level	Missing condition data	
OH Conductors Focus on bare OH conductors due to data availability and high level of maturity		•	•						Weibull parameters from AER submission (for ACSR, SC & HDBC) & OFGEM methodology(for AAAC).	Missing condition data, segments not represented in WASP	
OH Customer Service Connections Includes the conductor, electrical connections, and mounting hardware. Low Voltage overhead conductors are in OH Conductors	•	•							Weibull PoF model at population level	Assets not represented in WASP	
OH Links, Switches and Fuses Gas switches, Air Break Switches (ABS), LV and HV Links, Expulsion Drop Out Fuses (EDOs), LV Fuses and Fuse Savers. No PoF for LV Fuses and Fuse Savers this iteration.		•							Weibull PoF model at population level	Assets only partially represented in WASP	
HV Ring Main Units RMUs for the underground power distribution network, including HV switchgear and related ancillaries	•	•							Weibull PoF model at sub-population level and failure modes	Poor failure and condition data (Maintenance recovery program recently started)	
UG Pits, Pillars & Cubicles Pits (direct buried, switching and pulling pits), pillars (including service and pot bellied pillars) and cubicles	•	•							Weibull and OFGEM PoF model at population level	Assets only partially represented in WASP, Previous PoF models unavailable	
UG Cables UG Cables and their terminations including ST, HV, LV, and Service cables both inside and outside zone substation boundaries	•		•						OFGEM PoF model at population level	Assets not represented in WASP	



Levels of PoF Modelling

Previous PoF model level

Endorsed Asset Class Strategy		Le۱	vel of	f Mo	delli	ng			Resulting PoF Model	Key Challenges	
	N/A	1	2	3	4	5	6	7	Recalling For model	Rey Ghanenges	
Zone Sub Transformers Power transformers that are located within zone substations, including their key subassemblies of windings, tank, bushings and on load tap changers		•							Weibull PoF model at sub-population level - Windings, Tap changers, Bushings, All	Significant effort required for prepare data & model the PoF	
Switchboards Switchboards located within zone substations, including circuit breakers that are integral to those switchboards		•	•						Weibull PoF model at CB population level with OFGEM methodologyto differentiate sub-populations	Previous Weibull calculations were unavailable. Significant effort building failure list.	
Circuit Breakers Two subpopulations: 1) Outdoor circuit breakers and reclosers located within zone substations; 2) reclosers and sectionalisers located on the OH network.	•	•	•						Weibull PoF model at subpopulation level with OFGEM methodologyto differentiate CB sub-populations	Key challenge was the OH assets as only partially represented in WASP. Previous Weibull calculations were unavailable. Significant effort building failure list.	
Earthing & Lightning Protection Earthing equipment on pole top transformers, and specificallyHV/LV upgrade tasks*; all other earth sites will be addressed in subsequent iterations									No PoF Model was developed. Focus was to improve the process for end-to-end overhead earthing inspections	*Upgrade tasks are tasks to remediate earth sites with high earth resistance readings	
Zone subs outdoor busbars, isolators and disconnectors Air-break switches / isolators / disconnectors, earth switches and links. Fuses, gas switches, capacitor bank isolators and fault throwers have been excluded from this iteration given their relatively low defect rate.	•	•							Weibull PoF model at sub-population level: Air-break switches isolators / disconnectors, earth switches and links	Task categories in source dataset did not provide a clear indicator of end-of-life / failed assets. Limited availability and consistency of data made it difficult to classifyfailures as repair or replace.	
Load Control Load control plant used in zone substations & some TransGrid bulk supplypoints (BSP) Load control relays mounted on customer switchboards		•							Population level PoF (proportion of failures due to causes)	Assets not represented in WASP, condition/maintenance data poor	



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* essentialenergy



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