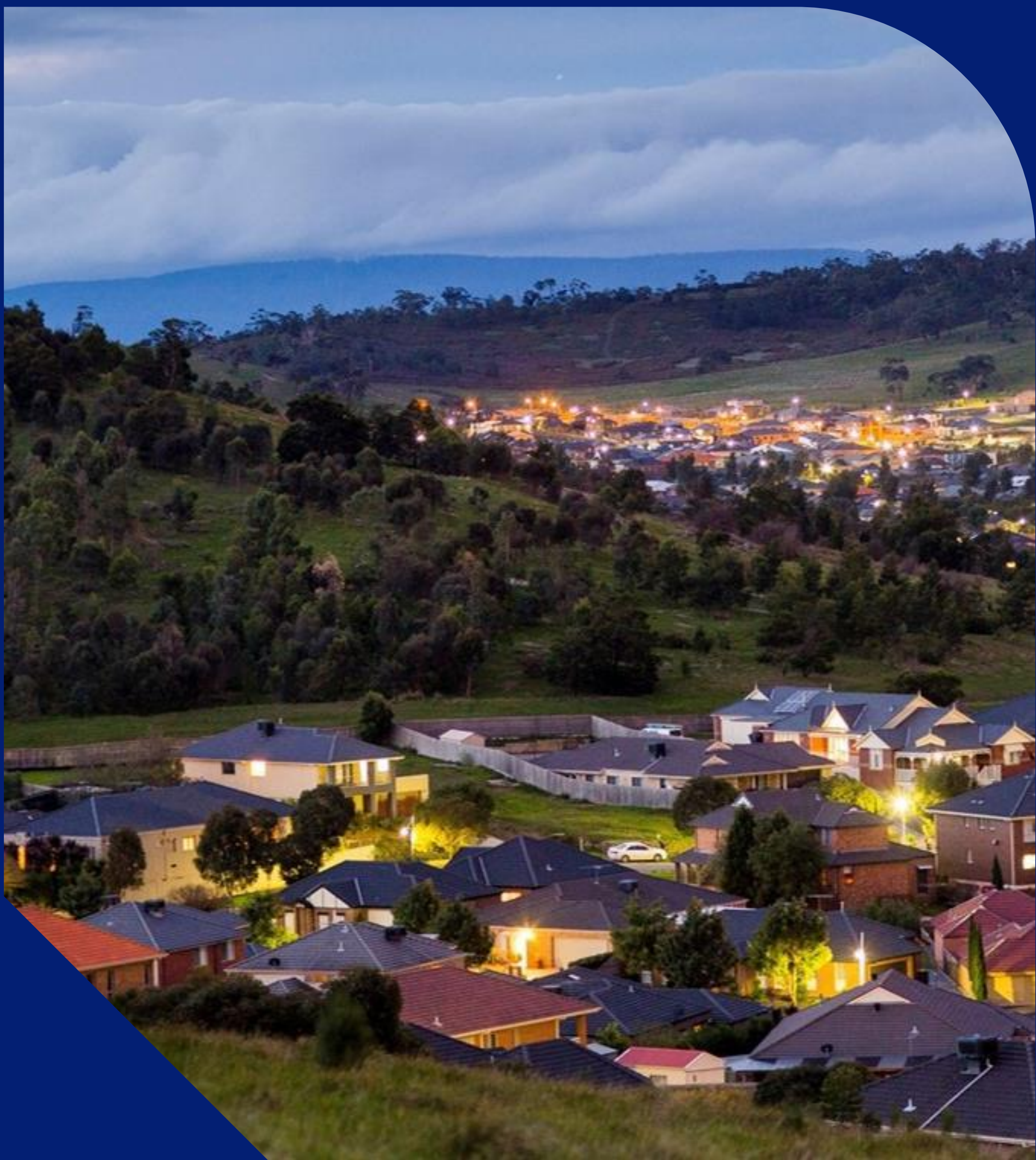
AusNet

Asset Risk Assessment Overview

Asset Management System



Document number:	AMS 01-09
Issue number:	3
Status:	Approved
Approver:	Mathieu Durox
Date of approval:	16/12/2024

Asset Risk Assessment Overview

AusNet

Table of contents

1. Purpose

Understanding asset risk informs the development and optimisation of inspection regimes, maintenance schedules, replacement programs, short- and long-term CAPEX and OPEX forecasts, and work prioritisation.

This document describes the methodologies used by AusNet to determine the asset risk and the mitigating methods for regulated network assets. The results of the risk assessment can be reported in a risk matrix. The document is not intended to be prescriptive for every asset class, it details accepted methods. The unique characteristics of an asset class will determine the specific methods used.

2. Scope

The scope of this document is limited to enterprise risk (relating to network assets), covering AusNet's three regulated businesses (Electricity Transmission, Electricity Distribution, and Gas Distribution). Engineering risk (relating to engineering solutions or problems) and project risks (encompassing project budget and schedule) are excluded from this assessment.

The assessment applies to asset classes as listed in Appendix A. In most cases, the asset classes are very similar to a combination of SAP Equipment Class, Object Type, and Catalog Profile.

AusNet maintains a risk management system designed in accordance with AS ISO 31000 Risk Management – Guidelines to ensure risks are effectively managed to provide greater certainty for the owners, employees, customers, suppliers, and the communities in which it operates.

According to AS ISO 31000, managing risk is based on a set of principles, a framework, and process as shown in Figure 1

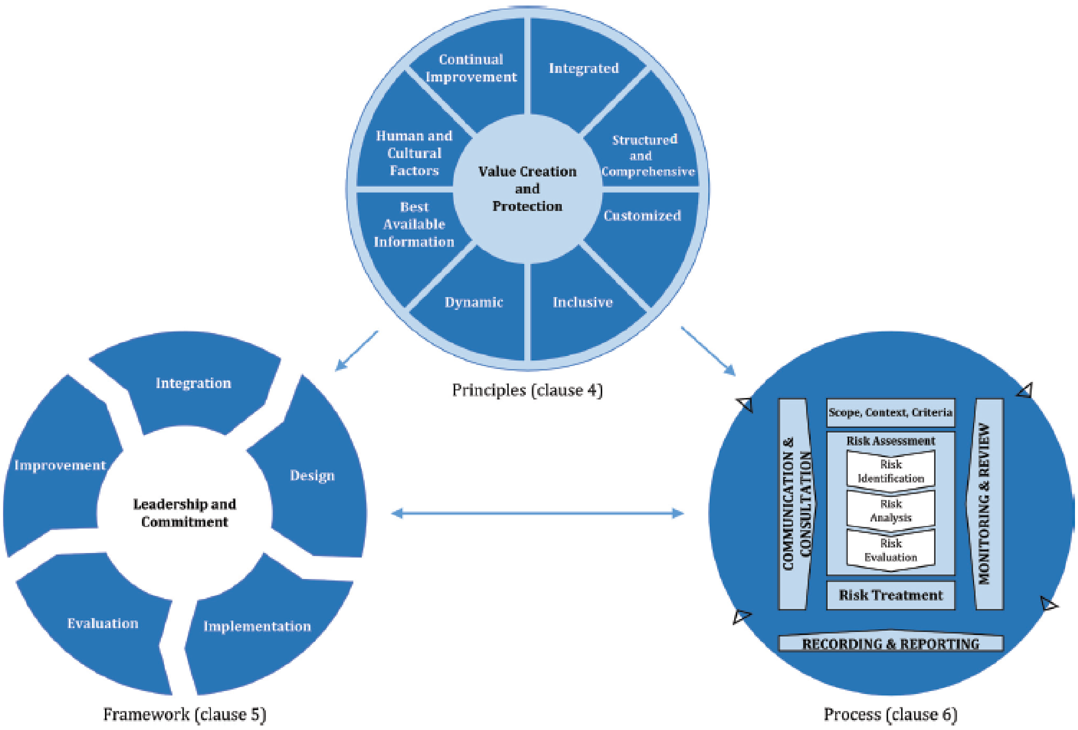


Figure 1: Risk Management Principles, Framework and Process[1]

[1] AS ISO 31000

2.1. Risk Management Principles

The principles provide guidance on the characteristics of effective and efficient risk management, communicating its value and explaining its intention and purpose.

Risk management should be an integral part of the organisation activities, provide consistent and comparable results, should relate to the context of the organisation, involve stakeholders in the management of risk, respond to changes in a timely manner, use best available information, and continually improve through learning and experience.

2.2. Risk Management Framework

The risk management framework assists in integrating risk management into significant activities and functions. The framework components include integrating, designing, implementing, evaluating, and improving risk management across the organisation.

Risk management should be part of the organisational governance, objectives, and operations. The leadership team should demonstrate commitment to risk management and ensure responsibilities and accountabilities are appropriately assigned and suitably resourced.

Communication and consultation should be timely to ensure information is collected, shared, and when feedback is provided improvements are made. When designing the framework, data, information systems, standards, and guidelines should be examined.

The risk management framework should be periodically reviewed and continually improved.

2.3. Risk Management Process

The risk management process (which is the focus of this document) involves the systematic application of policies, procedures, and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording and reporting risks.

Risk in AS ISO 31000 is defined as:

"The effect of uncertainty on objectives".

Uncertainty is captured in the likelihood of the functional failure of an asset and the effect on objectives is measured as the consequence of asset function failure.

Consequence is defined as "Outcome of an event and can have positive or negative effects on objectives".

There are three types of consequences covered in this methodology and referred to as lenses:

- Health and Safety (Employee and Public)
- Environmental
- Customer and Reputation

The activities of the risk management process relating to this methodology are summarised in the following sections

2.3.1. Communication and Consultation

The key stakeholders in understanding asset risk are the business lines (Distribution, Transmission, and Gas), Corporate risk management group and the AusNet Executive Leadership Team (ELT) who provide overall oversight and decision-making.

Subject matter experts for various asset classes are consulted and provide information on defining and evaluating asset risk

2.3.2. Scope, Context and Criteria

The assessment focuses on asset risk across the three business lines. The outcome of this process is the establishment of risk-based asset management programs. These outcomes demonstrate to the regulatory organisations and AusNet board that assets are optimally maintained.

The treatment of risk in this process is governed by the risk appetite of the AusNet board as viewed from the three individual lenses of Safety, Environment, Customer/Reputation and the combined consequence. Risk will be depicted on a 5x5 matrix and ranked from 1 (lowest) to 25 (highest) – the risk levels are detailed in Table 9. There are five categories of risk as shown on the matrix in Figure 2. The boundaries of the risk levels are defined by the corporate risk appetite and consequently drive the risk treatment strategies to be established.

		Consequence				
		Insignificant	Minor	Moderate	Major	Catastrophic
Likelihood	5	L	M	H	E	E
	4	N	L	M	H	E
	3	N	N	L	M	H
	2	N	N	N	L	M
	1	N	N	N	N	L

Extreme (E), High (H), Medium (M), Low (L), Negligible (N)

Figure 2: Risk Matrix

Reliability Centred Maintenance (RCM) methodologies form the basis of identifying appropriate maintenance policies and tasks to achieve the required safety, availability and economy of operation for all systems and equipment.

2.3.3. Risk Assessment

Risk assessment is the process which includes risk identification, risk analysis, and risk evaluation.

Risk Identification

In the context of this methodology, risk identification is about understanding how assets fail, what causes the assets to fail, and the effect of the assets failing.

Failure Mode and Effects Analysis (FMEA) and Failure Modes, Effects and Criticality Analysis (FMECA) are the techniques employed to identify risks of the systems and equipment of the networks. These techniques subdivide the systems into elements (or subsystems) and for each element pinpoints the ways in which it might fail, what causes failure, and the effects of the failure.

When necessary, the Ishikawa analysis (fishbone) method may be employed to enhance FMEA/FMECA analysis to understand the causes of potential events and the drivers of risk. This understanding is then used to design strategies to prevent adverse consequences or enhance positive ones.

Risk Analysis

Risk analysis is undertaken to understand the nature of the risk and its characteristics. The factors considered in this methodology are

- the likelihood of an asset functional failure and consequence
- the nature and magnitude of consequences

Historical data analysis, machine learning, Event Tree Analysis (ETA), and Fault Tree Analysis (FTA) are used in this process to understand consequence and likelihood.

Using statistical methods (Weibull analysis as the preferred method), probability of failure and remaining asset lives are estimated. In circumstances where historical failure data is inadequate, a points scoring method is used to estimate remaining asset life.

Consequence of failure is calculated from the cost of what could happen, moderated by the Likelihood of the consequence occurring.

Remaining life is scored on a scale of 1(least likely to fail) to 5 (very likely to fail) and the consequence similarly scored on a scale of 1 (negligible) to 5 (catastrophic) to provide a view of the asset risk profile.

Risk Evaluation

At the conclusion of the risk analysis, each asset is ranked between 1 and 25 and mapped to the risk criteria matrix. The monetary value of risk is used in the calculations of economic assessment.

2.3.4. Risk Treatment

Risk treatment is the process of selecting and implementing options for addressing risk. Risk treatment options will include the following

- changing the likelihood (replacement, refurbishment, maintenance)
- changing the consequence (redesign)
- retaining the risk (inspection/testing)

From a financial consideration, risk treatment plans can be either Capital Expenditure (CAPEX) or Operational Expenditure (OPEX). CAPEX plans include asset replacement, redesign, and refurbishment. OPEX plans cover inspections, measurements, routine maintenance, and testing.

CAPEX plans will be supported by an economic assessment.

2.3.5. Monitoring and Review

A periodic review of the risk management process will be undertaken to improve the quality and effectiveness of the process, implementation and outcomes.

Actual outcomes are compared with predicted risk assessment and the result of the comparison will drive the need for further improvement or enhancement.

2.3.6. Recording and Reporting

The outcomes of the risk management process are reported on a risk matrix dashboard. The dashboard display is a 5x5 Consequence/Likelihood matrix for each of the consequence lenses and a combined consequence matrix. The risk matrix assists in determining the type of interventions required – e.g. replace asset vs add redundancy.

3. Abbreviations and definitions

TERM	DEFINITION
ACR	Automatic Circuit Reclosers
AER	Australian Energy Regulator
CBMO	Circuit Breaker Minimum Oil
CBVU	Circuit Breaker Vacuum Type
COF	Cost of Failure
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DF	Disproportionality Factor
DFA	Distribution Feeder Automation
DNO UK	Distribution Network Operators UK
DSI	Death or Severe Injury
EUE	Expected Unserved Energy
FFDI	Forest Fire Danger Index
FMEA	Failure Mode and Effects Analysis
FMECA	Failure Mode, Effect and Criticality Analysis
HBRA	Hazardous Bushfire Risk Area
HSE	Health and Safety Executive
IRU	Ignition Risk Unit
LBRA	Low Bushfire Risk Area
LOC	Likelihood-of-Consequence
LTI	Loss Time Injury
MIP	Market Impact Parameters
NPV	Net Present Value
POF	Probability of Failure
REFCL	Rapid Earth Fault Current Limiter
VBRC	Victorian Bushfire Royal Commission
VCR	Value of Customer Reliability
ZSS	Zone Substation

4. Consequence of Asset Failure

All assets on the three energy networks fulfil a function that enables delivery of energy to customers. Therefore, failure of an asset has the potential of resulting in, loss of energy to customers, injury to an employee or member of the public, an environment hazard.

The cost resulting from this failure (cost of failure) is viewed through three lenses: Safety, Environment, and Customer/reputation for all asset classes. Table 1 is a summary description for each lens.

Table 1: Consequence Lenses

Consequence Lenses	**Descriptions (including but not limited to)**
SAFETY	Threat to health and safety of public and employees
ENVIRONMENT	Sulfur hexafluoride (SF6) uncontrolled discharge
	Oil spills
	Bushfire damage
CUSTOMER AND REPUTATION	Loss of Supply to customers
	Impact on energy market
	Breach of regulatory obligations

A monetary value of consequence following an asset failure (cost of failure) is calculated using the cost of consequence and the probability that the consequence will occur (likelihood of consequence).

The cost of consequence is the estimated financial cost resulting from the asset failing (what could happen). The probability of the consequence occurring, which is the likelihood of occurrence, is dependent on factors like the

Cost of Failure = Cost of consequence × Likelihood of Consequence

location of the asset, characteristics of the asset, and the human activity in proximity to the asset.

Sections 4.1. , 4.2. and 4.3. discuss the cost of consequence, whilst the likelihood of consequence is discussed in section 4.4.

4.1. Safety Cost of Consequence

The Safety lens incorporates all potential health and safety effects that could impact the public and employees. It includes the possibility of injury, incapacity, and/or death. There are two sources of potential costs that could result from a safety consequence:

- Death or Severe Injury (DSI)
- Lost Time Injury (LTI)

The value of DSI is obtained from the Australian Government Best Practice Regulation Guidance Note "Value of statistical life" and the value of LTI is quoted from Safe Work Australia's "The Cost of Work-related Injury and Illness for Australian Employers, Workers, and the Community".

DSI as of 2024 is $5.7M[2] and LTI as of 2013 is $162,780[3] per incident. LTI is Indexed at 3% p.a. over 10 yrs to give a value of $225,000 in 2024 dollars.

Safety costs are further modified by a Disproportionality Factor (DF) which recognises the high-risk nature of the electricity industry. The value is a guide when identifying reasonably practicable costs of mitigation. "The greater the risk, the more should be spent in reducing it, and the greater the bias should be on the side of safety"[4]. This methodology applies a similar factor as proposed by the UK distribution networks, known as distribution network operators or DNOs.

Table 2 shows the applicable disproportionality factors for safety consequences in this methodology. The scenario used is based on the credible outcome associated with each type of failure – for example, multiple fatalities resulting from a bushing failure is a credible outcome, therefore a DF 6 is appropriate. Appendix C provides more background in this method.

Table 2: Applicable Disproportionality Factors

Scenario	Disproportionality Factor
Public Trespass	1
Single Fatality (public or worker)	3
Multiple Fatality (public or worker)	6

Note: VSL values are based on a 2007 quantification with an applied consumer price index (CPI) of 3%. If extrapolating a stated VSL a CPI value of 3% is appropriate.

4.2. Environmental Cost of Consequence

The Environmental lens covers consequences relating to the environment which includes bushfire, contamination, and pollution. The potential costs arise from the effects of bushfire, uncontrolled release of oil or gas, and waste generated when assets fail.

4.2.1. Bushfire

The cost of consequence associated with bushfires is calculated using the expected house loss, and the bushfire loss value. The financial impact of bushfires is sourced from the Victorian Bushfire Royal Commission 2009 VBRC - Final Report (royalcommission.vic.gov.au), Bureau of Meteorology, and CSIRO.

Table 3: Fire Estimated Costs

Forest Fire Danger Index (FFDI)	FFDI $k per house
70_re	367
100_r	940
1400_r	2,450

Table 4: Fire Estimated Fatalities

Category	Housing	Fatality

[2] Australian Government, Office of Best Practice Regulation, *Best Practice Regulation Guidance Note: Value of Statistical Life*, Value of statistical life | The Office of Impact Analysis

[3] Safe Work Australia, The Cost of Work-related Injury and Illness for Australian Employers, Workers and the Community: 2012–13, https://www.safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf

[4] Energy Networks Association, DNO Common Network Asset Indices Methodology, https://www.energynetworks.org/assets/images/Resource%20library/DNO%20Common%20Network%20Asset%20Indices%20Methodology_v2.0%20Draft%20Final.pdf

LBRA	0.2	1
HBRA	1	3
REFCL	4.6	6
Codified	19.8	10

4.2.2. Oil

Discharge of oil into land and/or water bodies can lead to ecosystem disruptions. The environmental cost of oil leakages is determined by the Environment Protection Australia (EPA) through penalty units, and the cost per penalty unit is determined by the Department of Treasury and Finance. Significant oil leak that creates a risk to environment would result in a penalty of 10,000 penalty units[5] at $197.59 per penalty unit as of the 2024-25 financial year[6]. This resulting in $1,975,900 per environmental incident.

The Department of Treasury and Finance adjusts the penalty rate annually, so the latest published value can be used at the time of assessment.

Costs for remediation as well as penalties for failure to meet improvement notice also apply, however for the purposes of risk modelling, the penalties above are considered sufficient.

4.2.3. Sulfur hexafluoride (SF6)

Uncontrolled discharge of SF6 can lead to costs associated with ozone layer protection and greenhouse gas emissions.

No specific penalty scheme has been implemented for SF6, so by default, a significant SF6 leak can be treated as an environmental incident creating an environmental risk. As a result, the penalties in section 4.2.2. apply.

4.3. Customer and Reputation Cost of Consequence

The community and reputation financial costs arise from customers not being supplied with energy and the energy market not dispatching the cheapest generators.

4.3.1. Unit Costs

The cost of consequence for unavailability of supply on the electricity distribution network is measured by Expected Unserved Energy (EUE) which is driven by:

- Value of Customer Reliability (VCR)
- Load at risk
- Duration of outage

The current VCR values in appendix D are expressed as an average rate ($/kWh) per substation based on the values published by the Australian Energy Regulator (AER)[7] or based on studies where customers quantify the value they place on a range of benefits[8].

For the transmission network the cost of consequence has a component of Expected Unserved Energy and cost for constraining generation to the market, the value of which, is approximated using the Market Impact Parameters (MIPs) model.

Gas network costs are not included as part of issue 3 of this document.

---

[5] Section 25(2), Part 11.5, Chapter 11, Environment Protection Act 2017, Authorised Version 5 June 2024, https://content.legislation.vic.gov.au/sites/default/files/2024-06/17-51aa015-authorised.pdf

[6] https://www.gazette.vic.gov.au/gazette/Gazettes2024/GG2024S225.pdf, Published 7 May 2024

[7] AER VCR reference

[8] See Advancing customer outcomes through Quantifying Customer Values | AusNet Tomorrow Customer Insights Series | Research | Community Hub

4.3.2. Consequence Factors

Load at risk

Load at risk for the distribution network is calculated using the number of impacted customers and the average consumption per customer (kW). The load at risk for the sub-transmission and transmission networks is calculated using the probability that an asset failure and subsequent events lead to a station black or load-shedding event (MW).

Duration of outage

Outage duration is assessed in three stages:

T1 - Fault: time between initial circuit protection trip operation and automatic switching to reconfigure the network

T2 - Switching: time in which manual switching is carried out to reconfigure the network and minimise risk associated with further asset failure

T3 - Repair: time taken to repair failed asset

Typical times of the three stages for the asset classes is shown in AMS 01-09-02.

4.3.3. Electricity Distribution

The energy at risk is estimated using the number of customers interrupted during each of the three outage duration phases considered for the asset class.

The number of customers affected is related to the asset class and circuit configuration. The duration of outage for customers during T1 and T2 will depend on the existence of distribution feeder automation (DFA) and isolating switches

Distribution Transformers

The customers affected during the T3 outage stage will be equal to the customers directly connected to the transformer. The number of customers per transformer can be obtained from the Kinetiq database.

Pole and Pole Top Assets (conductors, insulators, crossarms)

The customers affected during the T3 outage stage will be equal to the customers in an isolatable section. An isolatable section may have one or more distribution transformers.

Switches and Control boxes

There is likely to be no customers affected during the T3 outage stage

The energy at risk is calculated using the average consumption per customer in an isolatable section or the annual average distribution transformer demand in the isolatable section.

- T1 duration is a function of the feeder circuit breaker, Automatic Circuit Reclosers (ACRs), sectionalisers, and DFA.
- T2 is a function of manual switching operations by the field crew to isolate the faulted assets.
- T3 is the time it takes to repair or replace the failed asset.

$$Customer/reputation\ Cost\$ = ((C\_1 \ * T\_1) + (C\_2 \ * T\_2) + (C\_3 \ * T\_3)) * kW * VCR$$

Where C_1, C_2, C_3 are the numbers of customers interrupted during periods T_1, T_2, T_3 respectively

kW = Average consumption per customer

Equation 1: Customer Cost - Distribution

4.3.4. Sub-transmission and Zone Substations

In the sub-transmission network (including ZSS), the load at risk (MW) during each of the three outage duration phases is used to calculate the cost of customer consequence. The station load at risk is obtained from data developed by the Network Planners.

- T1 duration is a function of the ZSS protection systems.
- T2 is a function of manual switching operations by the field crew to isolate the faulted asset.
- T3 is the time it takes to repair or replace the failed sub-transmission line asset or station asset.

$$Customer/reputation\ Cost\$ = ((MW\_1 * T\_1) + (MW\_2 * T\_2) + (MW\_3 * T\_3)) * VCR$$

Where MW1, MW2, MW3 are the loads at risk during periods T1, T2, T3 respectively

Equation 2: Customer Cost - Sub-transmission

4.3.5. Transmission

There are two potential costs associated with a transmission network asset failure: customer load at risk and market impact cost. Load at risk (MW) during each of the three outage duration phases is used to calculate the cost of customer outage consequence, and the market impact cost is calculated using load impacted during T3 phase of the outage.

The station load at risk is obtained from summated transformer loads from the OSI PI SCADA historian.

- T1 duration is a function of the terminal station protection systems.
- T2 is a function of manual switching operations by the field crew to isolate the faulted asset.
- T3 is the time it takes to repair or replace the failed transmission line asset or station asset.

The value of market impact is based on the Market Impact parameter (MIC) provided by AEMO.

$$Customer/reputation\ Cost\$ = ((MW\_1 * T\_1) + (MW\_2 * T\_2) + (MW\_3 * T\_3)) * VCR + (MW\_MIC * T\_3)$$

Where:

MW_1, MW_2, MW_3 are the customer loads at risk during periods respective durations,
MW_MIC is the market impact component value.

Equation 3: Customer Cost – Transmission

4.3.6. Gas

Cost of consequence for gas assets has not been quantified a part of issue 3 of this document.

4.4. Likelihood of Consequence

Event tree analysis is the main technique employed to determine the Likelihood-of-Consequence (LoC) following an asset failure. The failure modes identified in the FMECA analysis, or a summary of the potential failure modes provided by SMEs form the basis of building the event trees.

Typically, the initiating event is an asset failure followed by analysing the following.

- Type of failure (explosive, crushing, flooding, discharge)
- Type of consequence (safety, environment, customer)
- Other conditions necessary to cause consequence

The probabilities obtained from the event trees are then modified by individual asset characteristics and the location of the asset. For example, an environment likelihood of consequence of a circuit breaker will increase for CB object type CBMO and reduce for the object type CBVU.

Details of event trees, location and asset specific characteristics are in the addendum to this document (*AMS 01-09-02)*.

4.5. Presenting Consequence on Risk Matrix

The Cost of Failure (CoF) is summarised on a five-level consequence scale as described in Table 5 for depiction on the risk matrix. Each of the lenses and the combined cost use the same scale levels:

Table 5: Consequence Scale

LEVEL	DESCRIPTION	BUCKET THRESHOLD
5	Catastrophic	≥ 90
4	Major	≥ 60
3	Moderate	≥ 40
2	Minor	≥ 20
1	Negligible	< 20

There are two methods to assign an asset to a consequence bucket – quantitative normalisation and qualitative normalisation.

4.5.1. Quantitative Normalisation

The monetised consequences - produced using methods described in section 4.1. through section 4.4. – can be scaled with other asset classes using the empirical cumulative distribution function (ECDF) and normalised to 100. Assets are then assigned to consequence buckets using Table 5.

Qualitative Normalisation

Whereas the quantitative method is used to analyse asset consequence of failure, there are instances, especially for low value assets, when a semi-qualitative approach is required. Appendix B details a point allocation per qualitative descriptions of several consequence categories. The points are weighted, summated, normalised to 100, and compared with the threshold levels shown in Table 5.

5. Probability of Asset Failure

An asset is deemed to have failed when it does not meet the functional requirements for which it was acquired. Both quantitative and qualitative analysis is used to assess the condition of the asset and determine the probability of failure and to estimate the remaining life.

Table 6 lists the categories taken into consideration when determining the likelihood of an asset failure. Asset physical condition is a direct measure of the state of the asset whereas utilisation and location influence the rate at which an asset is projected to deteriorate.

Analysis of each asset should include all the four categories, but there are instances, when data is not available for all the categories in which case it is acceptable to use a subset of the categories.

Table 6: Assessment Categories for Probability of Failure Estimate

Category	Description	Data Source
Asset Life	Ratio of current service age to normal expected life	Design, maintenance records
Asset utilisation/duty factor	Capacity, loading, strength, number of operations	Maintenance records
Location factor	Geographical climate, corrosivity, environment	Design/operations
Asset physical condition	Observed condition, measured conditions	Inspections/testing

Note: normal expected age is age at which failures observed in the asset group begins to rapidly increase

The asset Probability of Failure (PoF) is determined using either Machine Learning (ML) models or health score calculations. Using Weibull distribution parameters or parameters from other statistical distributions which best fits the data, the PoF and remaining life can be estimated. Conditional probability of failure is calculated Equation 4.

$$PoF_t = \frac{F_{age+t} - F_{age+t-1}}{1 - F_{age+t-1}}$$

Equation 4: Conditional Probability of Failure

Where:
- $PoF_{(t)}$ = conditional probability of failure
- F = Cumulative distribution function (CDF)
- t = number of years from current age
- age = current service age

5.1. Machine Learning (ML)

Machine learning models use multiple characteristics from SAP which reflect the four categories in Table 6. Rules have been created to generate targets used in the ML models.

Random Forest is the method used at AusNet, whereby a target is selected, which is the definition of a functional failure. Past failures that meet the target definition are analysed for all available features, in line with Table 6, to determine how prevalent each feature was in the historical failures. The features for the in-service population are then analysed and based on the features and the influence of each feature, a probability of failure value is produced for each in service asset. Features can be positive or negative, respectively making a feature for an in-service asset more likely to fail or less likely to fail. The sum of all the features, their influence and their direction (positive/negative) of influence will result in the PoF. Before settling on a final model, subject matter experts determine if the correlation between a feature and the likelihood of a failure are causative or coincidental. Erroneous or unrealistic features are removed from the list and the analysis is re-run.

The correlations between different features are determined as a decision tree, whereby, the target is the start of the of the tree, and the different features form the branches. A decision tree works well in a system where all the outputs are clearly known – for example in a finite population, where each item has a limited and clearly understood set of defining features. In an engineering system the feature and cause are not well understood, making it very difficult to create a single decision tree. The random forest methodology addresses this challenge by running multitudes of trees using randomly selected branches.

ML models calculate probability of failure (PoF) for the next one year. The remaining life and future PoF forecasts are calculated using typical Weibull parameters that have been established by AusNet (shown in Appendix E). The Weibull parameters of the ML asset is calculated on the assumption that the failure mode of the typical asset is the same as the failure mode of the asset being modelled in ML.

Based on the assumption that the failure mode is the same, the Weibull distribution shape parameter (beta) of the typical asset class is the same as the asset modelled. The characteristic life (eta) of the asset is then calculated using the ML PoF (conditional probability of failure) and the typical beta parameter using Equation 5

$$\eta = \left(\frac{(Age)^{\beta} - (Age+1)^{\beta}}{ln(1-PoF)}\right)^{\frac{1}{\beta}}$$

Equation 5: Estimating Characteristic Life

The inferred beta value and calculated eta value are then used to calculate remaining life and forecast future PoF values.

5.2. Health Score (HS)

The health score is a calculation performed using the four categories – as per Table 6 - which reflect the life of an asset in an operating environment. The length of time an asset has been in service, how often it is used or how much of its rated capacity is used, the location or environment in which the asset operates, and a visual assessment and/or test measurement of the asset are all key indicators of the condition of the asset. Recognising that not all asset classes have relevant data for all the four categories, the health score is calculated using available (and relevant) data.

Apart from the age category, each of the other categories can have more than one factor for consideration. The factors in each category are then combined into a score of 1 to 5 by taking an average or maximum of the factors. The four categories are then aggregated using a nonlinear methodology to determine the health score. The health score methodology is described in Appendix F

$$Health\ Score\ (HS) = \sum_{n=0}^{k-1} x_n i^n$$

Where: - k = number of levels, i = number of categories, x = count of categories in a level

Equation 6: Calculate Health Score

The steps to convert the health score to a probability of failure depend on the failure history. If there is a statistically significant set of failure data then the Weibull method is used, otherwise the normalised heath score method is more applicable.

5.2.1. Health Score Weibull Analysis

The health score is analysed using the Weibull distribution (or other statistical distribution with a better fit to the data) to determine the statistical parameters for calculating PoF and remaining life.

The health score (HS) substitutes time (t) in the equation to calculate the cumulative distribution function (F) in Equation 4 and Equation 7. The resulting Weibull parameters are HS Characteristic life (eta) and HS Shape parameter (beta).

One year equivalent of health score is calculated based on the relationship between age and health score which is determined by regression plotting. Regression can be linear or non-linear depending on the regression with the best goodness-of-fit. Figure 3 shows an example of a linear regression used for power transformers.

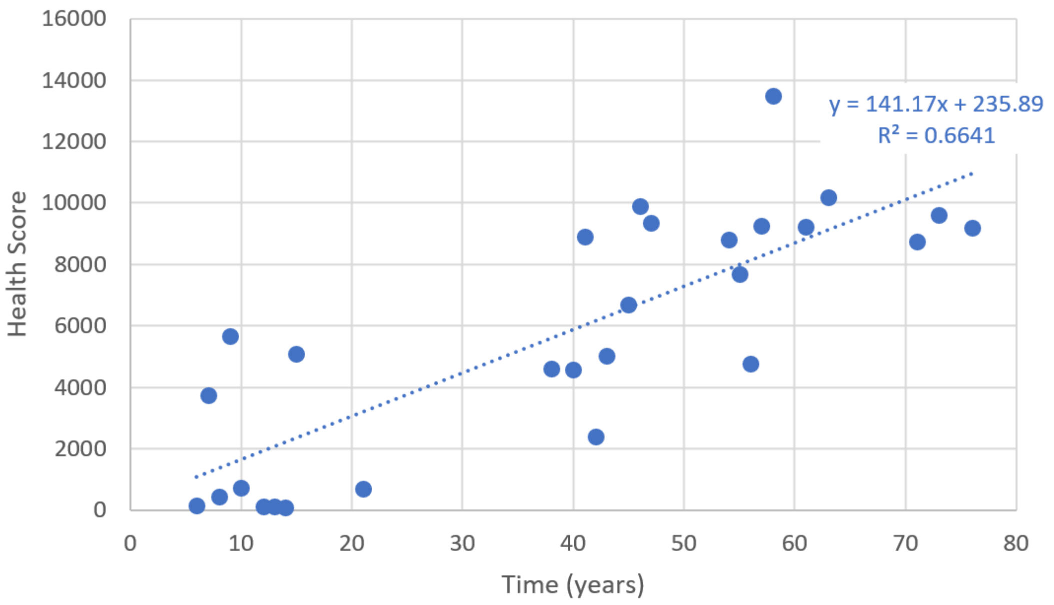


Figure 3 - Health Score vs Time

5.3. Extrapolating Probability of Failure

The conditional PoF values as produced in sections 5.1. and 5.2. are the probability that an asset will fail within 12 months from the current point in time. To understand how to forecast risks, the PoF values are extrapolated. The main assumption is that probability of failure increases over time as assets degrade. This will preclude assets that don't have a wear out pattern. In these cases, risk is likely to increase as a function of growing obsolescence.

Where PoF values are produced using the method described in 5.2.1. the process of incrementing health score by regression is continued by incrementing the health score age relationship.

Otherwise, if conditional probability of failure is all that has been produced – such as machine learning output- then an alternative method is required to extrapolate PoF. In these instances, statistical parameters in Table 14 can be used with the current cumulative PoF is compared the cumulative PoF of the time-based Weibull distribution. The t component is adjusted until the cumulative PoF matches the Heath Score or Machine Learning based cumulative PoF value. This is illustrated in Figure 4.

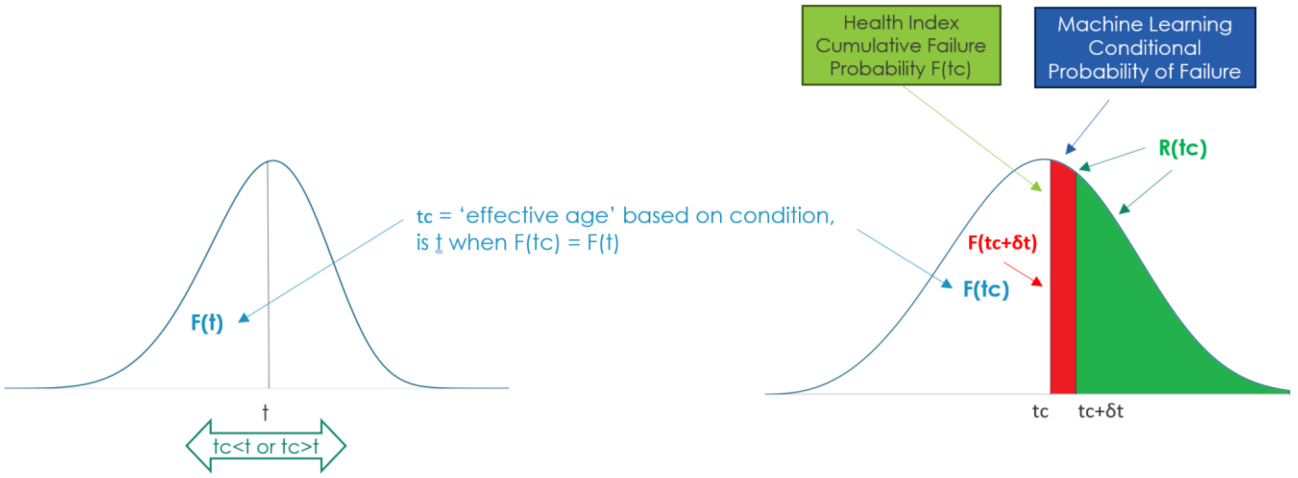


Figure 4 - Cumulative PoF Comparison

The cumulative PoF – F(t) – is produced by creating cumulative and conditional probability of failure charts using the values in Table 14 and matching the value of t that matches the cumulative PoF. This adjusted t is an effective conditional age. The effective age is incremented into the future with the conditional PoF produced using the time-based Weibull parameters.

5.4. Presenting Likelihood on a Risk Matrix

Likelihood is a term used on a risk matrix to describe the chance of an asset failure occurring. At AusNet, likelihood is a 1 to 5 scale, where the 1 'bucket' depicts the lowest chance, where bucket 5 depicts the highest chance. There are two methods to allocate an asset to a likelihood bucket – statistical probability of failure translation (5.4.1.) and health score normalisation (5.4.2.

5.4.1. Statistical Probability of Failure Translation

The remaining life of the asset is estimated using the quantile function. It is the number of years until the probability of failure reaches 10% (B10) given the asset has survived until the current time. In some circumstances, where safety is critical, 5% (B5) probability of failure may be used. The equation to calculate remaining life is the inverse F(t). For a Weibull distribution Equation 7 applies.

$$t_{remaining} = \eta * \left(-\ln\left(p + (1-p) * F_{age}\right)\right)^{\frac{1}{\beta}}$$

Where:

F = Cumulative density function (cdf) = $F_{age} = 1 - e^{-\left(\frac{age}{\eta}\right)^{\beta}}$
$t_{remaining}$ = number of years from current age
p = quantile (0.1)
age = current service age of asset
β = shape parameter
η = characteristic life

Equation 7: Remaining Life to p-quantile

The remaining life of an asset is used to classify it into one of five likelihood categories to be shown on the risk matrix.

Table 7: Conversion of Remaining Life to Likelihood Scale

Likelihood Scale	Years remaining for asset to reach B10 (10% unreliability)
Very Likely	Remaining life <= 1 year
Likely	Remaining life > 1 year but <= 2 years
Possible	Remaining life > 2 years but <=3
Unlikely	Remaining life > 3 years but <= 4 years
Very Unlikely	Remaining life > 4 years

5.4.2. Health Score Normalisation Method

The normalised method is a simplified analysis where a suitable statistical distribution cannot be produced from the available historical failure data. The health scores are normalised to 100 and a likelihood level is assigned based on Table 8.

Table 8: Converting Normalised Health Score to Likelihood Level

LEVEL	Likelihood Scale	Health Score
5	Very Likely	90-100
4	Likely	60-89
3	Possible	40-59
2	Unlikely	20-39
1	Very Unlikely	0-19

6. Risk Evaluation

The consequence of failure (CoF) and probability of failure (PoF) determined in section 4. and section 5. respectively are used to determine the risk ranking of assets and in the calculations of economic assessment.

6.1. Likelihood/Consequence

The CoF and PoF results are scaled into Likelihood and Consequence levels and ranked as shown in Table 9. The results are then depicted on a risk matrix as shown in Figure 2.

Table 9: Risk Ranking

Rank	Likelihood	Consequence
25	5	5
24	4	5
23	5	4
22	3	5
21	4	4
20	5	3
19	2	5
18	3	4
17	4	3
16	5	2
15	1	5
14	2	4
13	3	3
12	4	2
11	5	1
10	1	4
9	2	3
8	3	2
7	4	1
6	1	3
5	2	2
4	3	1
3	1	2
2	2	1
1	1	1

6.2. Economic Considerations

Asset replacement justification based on comparing monetised Risk – as per Equation 8 – and the replacement cost - $C_{replace}$.

$$Risk\ Cost\ \$ = PoF \times CoF_{total}$$

Equation 8 - Risk Cost

Where:

PoF: Probability of Asset Failure

CoF_{total}: Combined Consequence cost of Failure

The economic optimal time of replacing an asset is determined by either calculating the year when the Net Present Value (NPV) of asset risk cost and asset replacement cost is optimised over a 20-year period (section 6.2.1. , or finding the year in which the asset replacement cost becomes lower than the asset risk cost (section 6.2.2.). Typically, maximising NPV is an appropriate method when considering a group of assets and NPV greater than zero for a single asset.

6.2.1. Optimized NPV

The NPV is optimising using NPV using Equation 9. The equation is evaluated for every value of t_r from 1 to 20, with the optimal replacement timing the first value of t_r where NPV is positive.

$$NPV = \sum_{i=1}^{t_r} \left(\frac{F_{age+i} * CoF_{total}}{(1+r)^i} \right) - \sum_{i=1}^{T-t_r} \left(\frac{F_{t_r+i} * CoF_{total}}{(1+r)^{t_r+i}} \right) - \frac{C_{replace}}{(1+r)^{t_r}}$$

Equation 9: Maximise NPV

Where:
- r = discount factor,
- T = analysis period (20 yrs),
- t_r = replacement year,
- F = Cumulative density function (CDF)
- age = current age of asset

6.2.2. Hurdle Rate

In the hurtle rate method shown in Equation 10 the replacement timing is the value of t where the risk cost exceeds the replacement cost.

$$NPV = \sum_{t=1}^{n} \left(\frac{F_{age+t} - F_{age+t-1}}{1 - F_{age+t-1}} * \frac{1}{(1+r)^t} \right) * CoF_{total} - \frac{C_{replace}}{(1+r)^t}$$

Where:
- r = discount factor,
- F = cumulative density function (CDF)
- age = current age of asset

Equation 10: NPV Greater than Zero

7. Risk Treatment

Risk treatment targets changing the likelihood, changing the consequence, and/or retaining the risk. Risk mitigation activities include asset renewal (replacement), asset refurbishment (overhaul), inspections, testing, and redesign of systems. Asset replacements, redesign, and some instances of overhauling are executed as capital projects, whereas inspections and testing are treated as operational maintenance tasks.

The risk treatment model in Figure 5, which is overlayed on the risk matrix has five CAPEX response options and three OPEX options.

The CAPEX treatment options are related to time horizons

- Immediate renewal typically means acting within one to two years
- Medium term action ranges from two to five years
- Long-term response typically looks to act more than five years in the future
- Generally, assets in the reactive renewal region will be run-to-failure, however there are instances when it may be economical and prudent to plan for replacing assets at the Very-Likely (5) level.

The OPEX response main objective is to ensure the likelihood of asset failure does not come as a surprise, or when practical, slow the deterioration of the asset moving to a higher failure probability. The three maintenance types will typically represent reducing interval and increasing testing:

- Maintenance type 3 is most onerous
- Maintenance type 1 is the least onerous

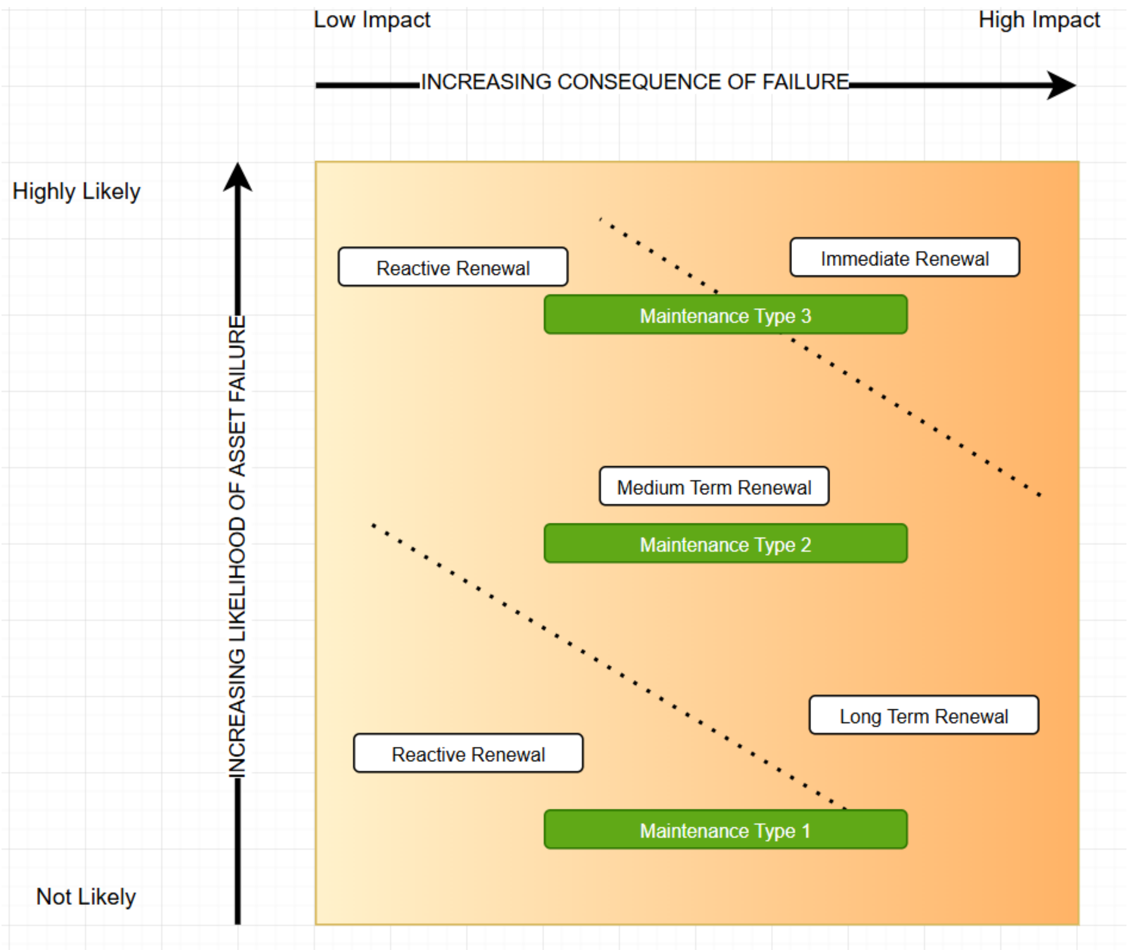


Figure 5: Risk Treatment Model

8. Recording and Reporting

The outcomes of the risk management process are reported using the risk matrix which displays risks according to the consequence and likelihood as a rating for the significance of risk. The matrix shows a view for each of the consequence lenses and a combined view for the total consequence.

The matrix helps to visualize the type of action AusNet may take to address the risk in conjunction with the economic analysis. Figure 6 shows an example of an asset in the 'likely' likelihood and 'high' consequence. This shows that, left to deteriorate, the asset may result in an unacceptable risk. It also shows that proactive replacement in conjunction with preventive maintenance are actions that may be considered.

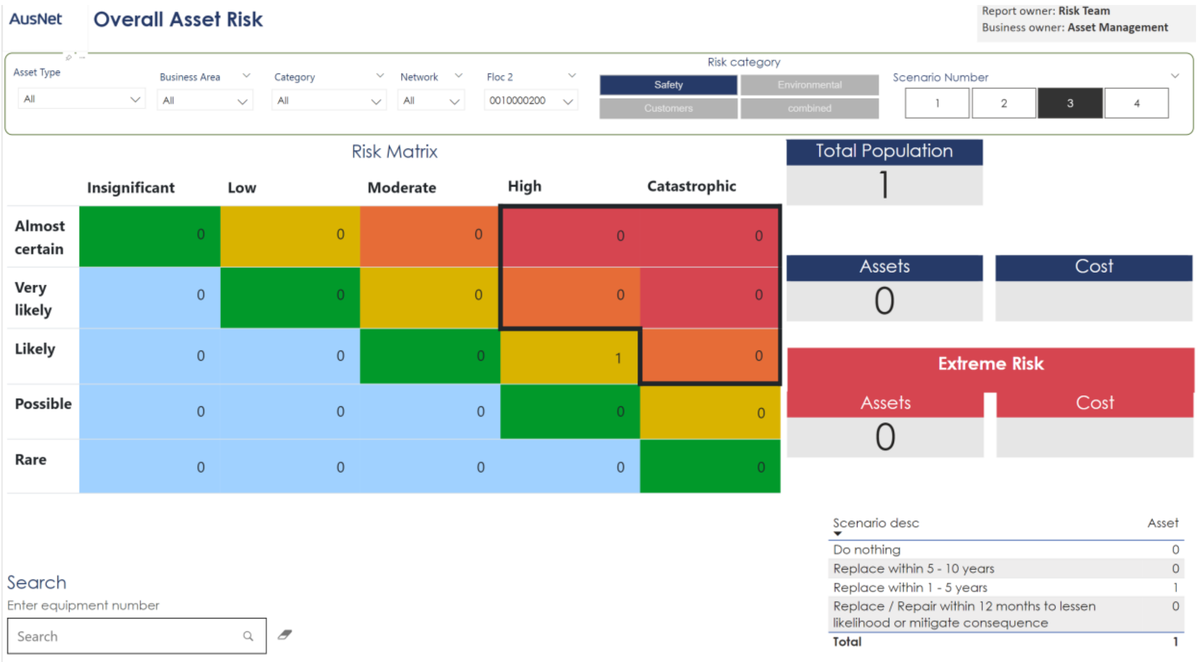


Figure 6: Risk Matrix Dashboard Example

9. Legislative references

STATE	REGULATOR	REFERENCE
VIC	WorkSafe Victoria	Occupational Health and Safety Act 2004
	EPA Vic	Environment Protection Act 2017

10. Resource references

DOCUMENT ID	DOCUMENT TITLE
AMS 01-09-02	Consequence Analysis - Addendum

11. Appendices

A. Asset Classes

Table 10:List of Asset Classes

Station type	Asset Class
DS, TS	AIR SYSTEMS
DL, TL	ANTENNA
DL	AUTOMATICSWITCH
DL	BATTERY
DL	BUS
DS, TS	BUS SYSTEMS
DL	CABLE
DL, TL	CABLE
TL	CABLEJOINT
TL	CABLELINKBOX
DS, TS	CABLES
DL	CABLESEGMENT
TL	CATHODICPROTECTUNT
DL, DS, TS	CIRCUIT BREAKERS
DL, TL, DS, TS	COMMUNICATION TECHNOLOGIES
DL	CONDUCTOR
DL	CONTROLBOX
DS, TS	COOLING SYSTEMS
DL, TL	CROSSARM
DL	CURRENTTRANSFORMER
DS, TS	DCAC SUPPLY SYSTEMS
DL	DISTCABINET
DL	DISTTRANSFORMER
DL	EARTHINGSWITCH
DS, TS	ENERGY STORAGE SYSTEMS
TL	ENVIRONMENTALSYS
DS, TS	FAULT LIMITERS
DL	FAULTINDICATOR
DL	FAULTLOCATOR
DS, TS	FIRE EQUIPMENT

Station type	Asset Class
DL	FUSEDISCONNECTOR
DL, TL	GROUNDWIRE
DS, TS	INSTRUMENT TRANSFORMERS
DL, TL, DS, TS	INSULATOR
DL	LINECAPACITOR
DL	MANUALSWITCH
DS, TS	NON SYSTEM EQUIPMENT
DL	ONLOADTAPCHGR
DL	ONLOADTAPCHGRME
DS, TS	PHYSICAL PLANT PROPERTY
DL, TL	POLE
DL	PRIVELECTRICLINE
DS, TS	PROTECTION AND CONTROL
DS, TS	REACTIVE SUPPORT
DS	REFCL
DL	RELAY
DS, TS	SECURITY
DL	SECURITYCAMERA
TL	SHEATH
DL	SHELF
DL	STATICVARGEN
DL, TL, DS, TS	STRUCTURES
DL	SUBSTATION
DL, DS, TS	SURGE DIVERTERS
DL	SWITCH
DS, TS	SWITCHGEAR
DS, TS	TRANSFORMERS
DL	VOLTAGEREGULATOR
DL	VOLTAGETRANSFORMER
DL, TL	WIRESEGMENT

B. Consequence - Points Scoring

B.1. Safety

Category	Category level	Score	Weight	Point Score	Comment
Contributing Substance/ factor	blast_explosion	5	4	20	objects from a blast -shrapnel/debris
	flame_chemical_radiation	4		16	Burns
	low_oxygen	3		12	Gas or liquid leading to asphyxiation or drowning
	collapsed_structure	2		8	Crushed under the weight or electrocution
	other	1		4	undefined
	none	0		0	
Health and Safety	fatality_or_multiple_injury_to_multiple_people	5	8	40	
	serious_or_permanent_injury	4		32	
	serious_medical_treatment	3		24	
	medical_treatment_or_lti	2		16	
	first_aid_treatment	1		8	
Location of Failed Asset	restricted_operational_area	5	3	15	Terminal Station, ZSS, City Gate
	commercial_areas	5		15	Shopping centres, industrial areas
	residential_areas	4		12	Housing estates
	major_roadways_rail_line	3		9	Major road/ railway line
	minor_roadways	2		6	
	private_property	1.5		4.5	
	open_space	1		3	Paddock, open grassland, isolated area
Frequency of Consequence	>=0.2_events_per_year	4	2	8	>=1_every_5_years
	>=0.1_and_<0.2_events_per_year	3		6	1_in_10_year_event
	>=0.05_and_<0.1_events_per_year	2		4	1_in_20_year_event
	>=0.02_and_<0.05_events_per_year	1.5		3	1_in_50_year_event
	<=0.02_events_per_year	1		2	<=1_every_50_years
Source of Consequence	primary	3	2	6	Consequence causing asset
	secondary	1		2	Mitigating asset
Network Hierarchy Position	>220kv_level	4	3	12	
	>132kv_<=220kv_level	3		9	
	>22kv_<=132kv_level	2		6	
	<=22kv_level	1.5		4.5	
	isolatable_section	1.5		4.5	
	other_station_wide	1		3	

B.2. Environment

Category	Category level	Score	Weight	Point Score	Comment
Contributing factor /Pollutant /Contaminant	oil	3	4	12	spillage or cause fire
	sf6	3		12	Escape into space
	collapsed_structure	2		8	Cause a fire
	not_applicable	0		0	
Volume/ Quantity of Substance	>80%_largest	4	5	20	Worst consequence asset
	>60_<=80%_largest	3.5		17.5	Relative size compared to worst asset
	>40_<=60%_largest	3		15	Relative size compared to worst asset
	>20_<=40%_largest	2		10	Relative size compared to worst asset
	<20%_largest	1		5	Relative size compared to worst asset
	not_applicable	0		0	
Affected Environment	open_water_course	4	5	20	River, lake
	atmosphere	4		20	Air, space
	land_vegetation	3.5		17.5	Affecting flora and fauna
	underground	3		15	Discharge to roadway, drains
	land_absorption	2		10	Discharge on ground in open space
	contained_locally	1		5	Within private property
	no_impact	0		0	
Location of failed Asset	near_water_mass_river	3	5	15	
	bushfire_area	2		10	
	other	1		5	
Frequency of Consequence	>=0.2_events_per_year	4	4	16	>=1_every_5_years
	>=0.1_and_<0.2_events_per_year	3.5		14	1_in_10_year_event
	>=0.05_and_<0.1_events_per_year	3		12	1_in_20_year_event
	>=0.02_and_<0.05_events_per_year	2		8	1_in_50_year_event
	<=0.02_events_per_year	1		4	<=1_every_50_years
Source of Consequence	primary	3	2	6	Consequence causing asset
	secondary	1		2	Mitigating asset
Network Hierarchy Position	>220kv_level	4	3	12	
	>132kv_<=220kv_level	3.5		10.5	
	>22kv_<=132kv_level	3		9	
	<=22kv_level	2		6	
	isolatable_section	2		6	
	other_station_wide	1		3	

B.3. Customer and Reputation

Category	Category level	Score	Weight	Point Score	Comment
Type of Customers Affected	electricity_energy_market	5	4	20	
	utility_or_generator	4		16	VICTRACK, small to medium generators
	industrial_and_commercial	3		12	shopping centres, restaurants
	school_or_public_venues	2		8	
	residential	1		4	
	not_applicable	0		0	
Number of Customers Affected	system_black_cbd_interruption	5	5	25	
	major_ts_city_gate	4.5		22.5	Major TS includes interstate connection points
	ts_ds_>50mw	4		20	
	ds_>10mw_<=50mw_fdr_>??customers_	3.5		17.5	
	ds_<10mw_fdr_>??customers_	3		15	
	fdr_>??customers_	2		10	
	isolatable_section	1		5	
	no_customers	0		0	
Duration of outage	more_than_8_hours	3	3	9	
	3_to_8_hours	2		6	
	less_than_3hours	1		3	
	not_applicable	0		0	
Difficulty of asset repair	obsolete_no_spares_no_skills	3	4	12	
	obsolete_reverse_engineering_scarce_spares_and_skills	2.5		10	
	decommissioned_equipment_used_as_spares	2		8	
	mid_life_some_increase_in_maintenance_costs	1.5		6	
	modern_supported	1		4	
Source of Consequence	primary	3	1	3	Consequence causing asset
	secondary	1		1	Mitigating asset
Network Hierarchy Position	station_wide	3	2	6	
	>220kv_level	2.5		5	
	>132kv_<=220kv_level	2		4	
	>22kv_<=132kv_level	1.5		3	
	<=22kv_level	1		2	
	isolatable_section	0.5		1	
Redundancy	no_alternative	5	5	25	
	at_least_one_alternative	2		10	
	more_than_one_alternative	1		5	

C. Disproportionality Factor

Safety legislation requires investment 'as far as practicable' – that is, invest until the costs are disproportionate to the benefits. Disproportionality factors (DF) are used to provide guidance on a cut off when to stop spending money to reduce safety risk, when the cost is disproportionate to the risk reduction. According to the UK's Health and Safety Executive (HSE), DFs that may be considered gross vary from upwards of 1 depending on several factors including the magnitude of the consequences and the frequency of realising those consequences, i.e. the greater the risk, the greater the DF. A DF of greater than 10 is unlikely. HSE submission to the1987 Sizewell B Inquiry6 suggesting that a factor of up to 3 (i.e. costs three times larger than benefits) would apply for risks to workers; for low risks to members of the public a factor of 2, for high risks a factor of 10. HSE has not formulated an algorithm which can be used to determine when the degree of disproportion can be judged as 'gross'; the judgement must be made on a case-by-case basis. It is generally understood that the greater the risk, the more that should be spent in reducing it, and the greater the bias on the side of safety. Additionally, the choice of DF may be higher when there is a low level of trust between the duty-holder and the community they operate in. In these circumstances, when trust levels are low, there may be an expectation to spend more to reduce risks.

The DFs given in Table 11 are to be applied to fatalities caused by electrical infrastructure, excluding fatalities caused by a bushfire started by electrical infrastructure. These values have been selected following a review of values used across the electricity industry within Australia and by other industries across Australia and internationally.

Table 11 - Disproportionality Factors – Fatality caused by Electrical Infrastructure (excluding bushfire start)

Scenario	Disproportionality Factor
Public Trespass	1
Single Fatality (public or worker)	3
Multiple Fatality (public or worker)	6

Table 12 gives the disproportionality factors to be used when assessing the risk of a fatality cause by a bushfire started by electrical infrastructure.

Table 12 - Disproportionality Factors – Fatalities due to bushfires started by electricity assets

Scenario	Disproportionality Factor
Asset in LBRA	1
Asset in HBRA	3
Asset in REFCL Area	6
Asset In Codified Area	10

The disproportionality factors for fatalities due to bushfires started by electrical infrastructure have been selected considering the weighting scale for the geographic dimension of the Ignition Risk Unit (IRU) calculation () as a guide of the community's expectation around preventing bushfires and the resulting fatalities.

D. Values of Customer Reliability by zone substation

Table 13 shows the average value of customer reliability by zone substation. The value reflects the make-up of the station output by type of customer – commercial, residential, industrial, agricultural.

Table 13 - Average Values of Customer Reliability (VCR) by zone substation

ZSS	VCR ($/kWh)
BDL	52.5
BGE	52.5
BN	56.7
BOM	52.3
BRA	53.3
BRT	51.5
BWA	59.0
BWN	51.7
BWR	56.0
CF	50.9
CLN	52.4
CNR	52.8
CPK	56.5
CRE	51.7
CYN	53.8
DRN	52.6
ELM	52.6
EPG	51.9
FGY	53.3
FTR	49.9
HPK	53.1
KLK	51.4

ZSS	VCR ($/kWh)
KLO	52.3
KMS	52.9
LDL	53.3
LGA	53.8
LLG	52.6
LYD	52.2
LYS	70.3
MBY	51.9
MDG	52.4
MDI	48.7
MFA	51.1
MJG	51.7
MOE	52.8
MSD	51.6
MWE	57.1
MWL	65.0
MWT	
MYT	55.5
NLA	52.7
NRN	51.0
NW	53.4
OFR	52.1

ZSS	VCR ($/kWh)
PHI	53.0
PHM	52.5
RUBA	50.7
RVE	52.1
RWN	53.5
RWT	54.4
SFS	52.7
SLE	53.0
SMG	51.7
SMR	53.8
TGN	52.9
TRC	50.1
TT	55.1
UWY	53.3
WGI	52.4
WGL	51.2
WN	56.6
WO	56.7
WOTS	56.6
WT	52.5
WYK	52.0
YN	64.1

E. Typical Weibull Parameters

Table 14: Asset Class Weibull Parameters

Asset Class	Eta	Beta
Insulators	46 years	6.6
Structures	71 years	6.5
Conductor	70 years	7
Circuit Breakers	45 years	3.5
Instrument transformers	45 years	3.5
Surge Arresters	45 years	3.5
Transformer	50 years	3.5

F. Health Score Calculation

As an example of developing a health score for assets using four categories and subcategories in Table 15. The assessment uses a five-level condition scoring system (Table 16) and the category assessment method is shown in Table 17

Table 15: Example Categories and Subcategories

Category	Subcategory
CAT01	CAT01-01
CAT02	CAT02-01
CAT03	CAT03-01
	CAT03-02
	CAT03-03
CAT04	CAT04-01
	CAT04-02

Table 16: Example Condition Levels

Condition Levels
5
4
3
2
1

For a given asset, Equipment ID 300000, the condition scores, category score and category count per condition level is shown in Figure 7

Health score calculation using Equation 11

$$Health\ Score = \sum_{n=0}^{k-1} x_n i^n$$

Equation 11: Formula to Calculate HS

K = number of condition levels = 5

i = number of categories = 4

x = count of categories in each condition level

Example:

For the following x values: CL1 = 0, CL2 = 1, CL3 = 1, CL4 = 2, CL5 = 0

HS = $0 \times 4^0 + 1 \times 4^1 + 1 \times 4^2 + 2 \times 4^3 + 0 \times 4^4 = 148$

Table 17: Condition Scoring System and Category Assessment

Category	Subcategory	Condition Description	Condition Score	Category Assessment
CAT01	CAT01-01		5	CS = Condition Score
			4	
			3	
			2	
			1	
CAT02	CAT02-01		5	CS = Condition Score
			4	
			3	
			2	
			1	
CAT03	CAT03-01		5	CS = Average Condition Score of sub-categories (Roundup)
			4	
			3	
			2	
			1	
	CAT03-02		5	
			4	
			3	
			2	
			1	
	CAT03-03		5	
			4	
			3	
			2	
			1	
CAT04	CAT04-01		5	CS = Max Condition Score of sub-categories
			4	
			3	
			2	
			1	
	CAT04-02		5	
			4	
			3	
			2	
			1	

Condition Measurements				
Asset	Category	Sub Category	Condition	Category Score
Eqpt ID 30000000	CAT01	CAT01-01	3	3
Eqpt ID 30000000	CAT02	CAT02-01	4	4
Eqpt ID 30000000	CAT03	CAT03-01	4	2
Eqpt ID 30000000	CAT03	CAT03-02	1	2
Eqpt ID 30000000	CAT03	CAT03-03	1	2
Eqpt ID 30000000	CAT04	CAT04-01	4	4
Eqpt ID 30000000	CAT04	CAT04-02	1	4

Asset Category Scores		
Asset	Category	Category Score
Eqpt ID 30000000	CAT01	CS3
Eqpt ID 30000000	CAT02	CS4
Eqpt ID 30000000	CAT03	CS2
Eqpt ID 30000000	CAT04	CS4

	Categories per Condition Level				
	CL5	CL4	CL3	CL2	CL1
	No. Cat	No. Cat	No. Cat	No. Cat	No. Cat
Tower Eqpt ID 30000324	0	2	1	1	0

Figure 7: Example Asset Condition Score and Categories per Condition Level

12. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE
1	03/10/2019	A Dickinson	Original issue
2	06/10/2020	A Dickinson A Payne-Billard	▪ Updated with feedback from organisation. ▪ Fix minor typing errors. ▪ Clarified AusNet Services uses FMECA rather than FMEA. ▪ Section 3.3 added further details on the derivation of the asset replacement risk matrix, including the addition of Appendix C. Consequence scale on asset replacement matrix changed. ▪ Section 3.6.3 added emphasis on criticality being combination of consequence and frequency of occurrence. ▪ Section 5.1 clarified that deterioration in condition leads in an increase in likelihood of failure and a subsequent increase in risk. ▪ Section 5.3 added new subsection on how condition-based probabilities are determined and deleted subsection on small population assets. ▪ Section 6.1 clarified proactive preventative maintenance. ▪ Section 6.2 included proactive preventative maintenance and refurbishment in addition to replacement. ▪ Appendix Schedule of Revisions. ▪ Appendix Acronyms added. ▪ Appendix added for Weibull Rates ▪ Appendix added for Obsolescence Model ▪ Appendix added Transformer Market Impact ▪ Appendix added Road/Rail crossing effects costs ▪ Appendix added Easement Type effects costs ▪ Section 4.7 added for Asset Obsolescence ▪ Section 4.8 added for Asset Criticality for Transformers and Transmission Lines
3	13/12/2024	A Nainhabo C Yates	▪ Updated document template ▪ Updated to align with asset risk modelling methods ▪ Incorporated learnings from 2026-31 EDPR submission modelling

AusNet Services

Level 31
2 Southbank Boulevard
Southbank VIC 3006
T +613 9695 6000
F +613 9695 6666
Locked Bag 14051 Melbourne City Mail Centre Melbourne VIC 8001
www.AusNetservices.com.au

Follow us on

@AusNetServices
@AusNetServices
@AusNet.Services.Energy

AusNet