POWER AND WATER CORPORATION

Risk Quantification Procedure for Investment Decision-Making (Power Services)

Procedure

CONTROLLED DOCUMENT

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APPROVED	Stephen Vlahovic Executive General Manager, Power Services Power and Water Corporation

THIS PROCEDURE IS UNCONTROLLED WHEN PRINTED

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1 Introduction

This procedure sets out a common approach for quantifying and valuing risks, opportunities, and benefits to help inform investment decision-making. The procedure is intended to support the uplift of Power Water Corporation's (Power and Water) asset management practices so that they are more in line with industry best practice and support the identification of prudent and 'no regrets' investment decision-making.

It has also been developed to address feedback made by the Australian Energy Regulator (AER) during Power and Water's last regulatory determination, where it was noted that Power and Water applied a more conservative and risk averse approach towards capital planning and adopted a subjective rather than quantified risk management approach relative to other network service providers (NSPs).1

Risk quantification is a best practice approach used in asset investment planning. It offers several benefits to Power and Water and our customers including:

- providing transparency and line of sight between our corporate objectives, enterprise risks and how these risks are valued and subsequently managed
- allowing different investment options to be compared using a common set of economic measures in a consistent, repeatable and efficient manner
- enabling Power and Water to improve affordability without increasing its risk profile ("better bang for buck") in a consistent and methodical way
- clear alignment with relevant AER expenditure guidance notes, guidelines, and regulatory precedent
- supporting investment prioritisation and optimisation based on the degree to which different risks are sought to be mitigated, other benefits maximised and the desired objectives achieved

To enable consistent quantification of risk, this procedure has been developed to define the organisational wide value dimensions, the associated value metrics, and how these are modelled across the organisation.

However, because different lines of Power and Water's business are at differing levels of maturity in asset management this procedure has been developed to apply to Power and Water's electricity line of business (i.e. the Power Services business unit) only at this point in time. It is envisaged that over time this procedure will be adapted and rolled out to other lines of business as part of a staged implementation to enhance Power and Water's asset management practices.

1.1 Purpose

While Power and Water's Enterprise Risk Management Standard (ERMS) provides guidance for undertaking Qualitative and Semi Quantitative risk assessment, this procedure is aimed at providing greater guidance to Power and Water's Power Services business unit on how to quantify risk in a manner which is consistent with guidance provided by the AER in its expenditure guidance notes, guidelines, and regulatory determinations to inform Cost Benefit Analysis (CBA) of investment options. It describes the principles to be applied, common (preferred) approaches that can be used, and values for specific consequences and probabilities.

The objective is to ensure efficient and prudent decisions are made for each project and program. This will be achieved by consistent quantification of risk in dollar terms, across a consistent set of consequence areas for all projects (network and non-network), and then incorporating the risk in a CBA model to identify the optimal option.

Since the risk is quantified as a dollar value, the risk avoided by implementing a mitigation option is the benefit attributed to that option in the CBA model. The CBA model also captures the capital cost of each option, changes to opex and other benefits identified that are related to that option and applies a

[1] AER, 2018, Power Water Corporation Draft Decision, Attachment 5 – Capex, pp57-58.

discounted cash flow assessment. All mitigation options can then be compared on a common basis using common financial metrics such as the Net Present Value (**NPV**) and Benefit Cost Ratio (**BCR**). This assessment will enable Power Services to ensure the optimal solution is identified.

Further, with all risks assessed on the same basis, the portfolio of projects can be prioritised to achieve a specific objective, while also understanding the impact on network risk of the selected suite of projects and programs. This will promote prudent and efficient expenditure across the network to get the best customer outcomes.

1.2 Scope

This Risk Quantification Procedure covers transmission and distribution assets across the Power Services business unit. This includes both network and non-network assets, including IT and OT investments that support the operation of the network. The Risk Framework is used to assess a network constraint (need) and is an input to the analysis undertaken to determine the preferred solution.

Power Water recognises that we are at an early stage on our asset management and risk management journey. We consider that this procedure represents a significant step in our understanding of the importance of robust risk analysis and is a good first step to take. The principles applied bring our approach in line with the AER's guidance notes and the approaches taken by other DNSPs.

1.3 Continuous improvement

We plan to review this procedure periodically to ensure it remains appropriate and reflects the latest risk assessment approaches, changes to values or probabilities, data availability and any regulatory obligations or guidance. We will also assess how well it is being applied in the business when assessing investment options.

Any remedial actions required to continue improving our methodology and/or application will be determined following the review.

1.4 Document structure

This document has the following structure:

Chapter	Title	Description
2	Procedure overview	Describes how the procedure fits within the internal risk and project governance frameworks and alignment with regulations
3	Overview of risk assessment	Provides a high level overview of the components of, and approach to, risk analysis
4	Value Dimensions	Describes the criteria and values for each consequence category (Value Dimension)
5	Calculating and applying probabilities	Describes the approach to calculating probabilities and how to apply them for calculating risk. Defines some specific methods for calculating energy at risk.
Appendix A	ERMS alignment	Demonstrates the alignment from Power Waters Corporate Objectives through to the Value Dimensions
Appendix B	Basis of financial values	Describes how the values for each value metric are derived and the sources of the data used.
Appendix C	Basis of probabilities	Describes how the information sources that were used to create the probability and likelihood values and any calculations used.
Appendix D	Analytical methods	Provides an overview of the different types of analysis that can be applied to risk analysis and quantification.

2 Procedure Overview

Figure 1 shows the components of this procedure and how they align within the existing ERMS and PIDF frameworks. These relationships are described in more detail below.

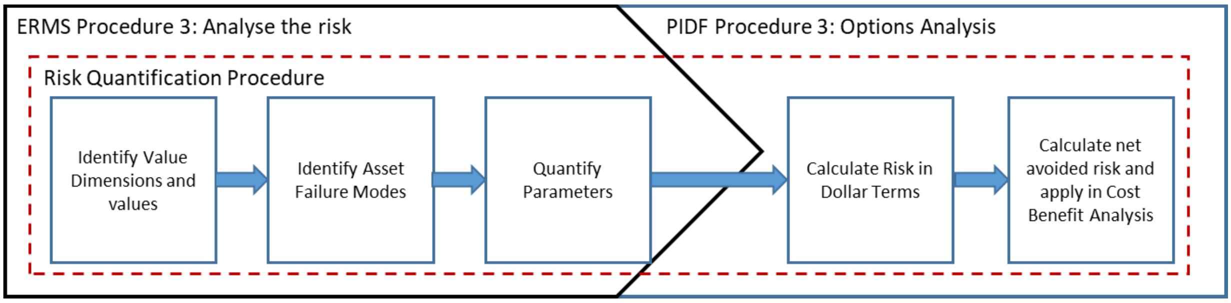


Figure 1 Components of this procedure and how they fit within existing frameworks

2.1 Relationship with corporate frameworks

This procedure is aligned to and is intended to complement existing corporate frameworks. In particular, it is aligned to Power and Water's:

- Enterprise Risk Management Standard (ERMS) and is intended to support the existing *Analyse the Risk* procedure[2] by providing guidance on how to quantify risks.
- Project Investment Delivery Framework (PIDF), which includes the approach to cost benefit analysis.

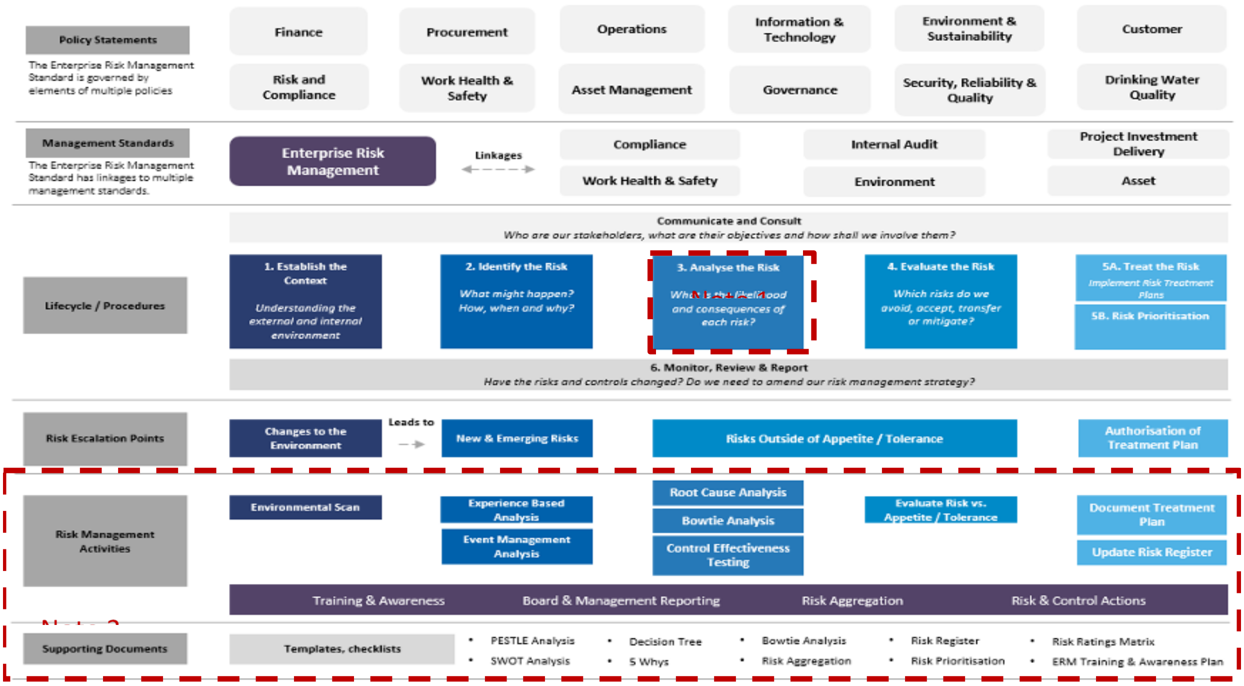
2.1.1 Enterprise Risk Management Framework

The Enterprise Risk Management Framework (ERM Framework) is the term used to describe the set of Policy Statements, Management Standard, Procedures and Templates that enable Power and Water to effectively manage organisational risk by applying a consistent and integrated risk approach.

The ERMS framework, highlighting how this Risk Quantification Procedure fits within it, is shown in Figure 2 below.

[2] Power Water document reference CONTROL478

FIGURE 2 ENTERPRISE RISK MANAGEMENT FRAMEWORK



Note 1: This Risk Quantification Procedure extends from ERM Procedure 3

Note 2: This Risk Quantification Procedure uses these analysis tools to quantify the parameters required

The ERMS sets how Power and Water undertakes risk management at the corporate level and how it is governed. The key steps set out are:

- Assessment and management of risk
- Communication and consultation
- Governance, Risk Escalation and Reporting Structure
- Monitoring of risk

The Enterprise Risk Management Standard (ERMS) supports the Risk and Compliance Policy Statement by providing a framework to manage risks and guide decision making and outcomes towards corporate objectives. It is based upon the international standard ISO 31000:2018 Risk management – Principles and Guidelines (ISO31000).

The ERMS contains categories of consequence with a scale that ranges from insignificant to severe and likelihoods that range from Rare to Almost Certain. The consequence categories are:

- Health and safety
- Financial
- Legal/regulation
- Environmental
- Service delivery
- Reputation,

The descriptions are qualitative and provide a broad qualitative view of risk that is appropriate at a corporate level.

However, at the asset level within Power Services, a quantitative risk assessment is required to enable effective decision making to be made based on economic assessments. This approach allows for projects to be compared on a like for like basis, regardless of the type of project or need being addressed, to ensure the best outcome for our customers.

To enable consistent economic assessment of projects, the Risk Quantification Procedure aligns to, and expands on, ERM Procedure 3 Analyse the Risk. This is highlighted by ‘Note 1’ in Figure 2. It provides additional guidance on how to quantify the probability of an event occurring, likelihood of consequences occurring, and the value of those consequences. This enables Power and Water to derive an economic (dollar) value so that all risks and investment options can be compared and prioritised on a uniform basis.

Quantifying the risk will have two key benefits:

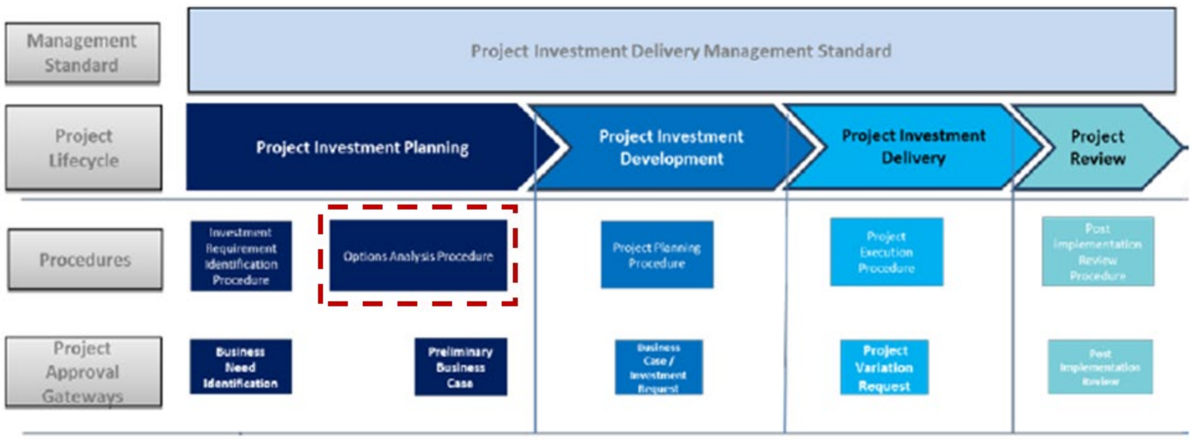
- improve Power Services ability to identify if any actions need to be taken to manage the risk in accordance with the ERMS risk tolerances,
- enable an option evaluation using a discounted cash flow methodology to enable a quantitative assessment of the investment and to be able to compare the options on a financial basis (such as NPV or BCR). This will ensure the lowest cost/highest value option will be selected and therefore provide the most benefits to customers.

This Risk Quantification Procedure is also aligned with the assessment methodologies set out under the ERM Framework, as highlighted by Note 2. These approaches will assist Power Services to analysis the asset information available to derive appropriate quantified inputs to undertake risk modelling.

2.1.2 Project Governance Framework

The PIDF is the set of procedures and supporting models that guide the identification of an investment need, analysis of options to resolve the need, project development, delivery and post implementation review. The scope of the PIDF that is relevant to this Risk Quantification Procedure is the Project Investment Planning phase as shown in Figure 3.

FIGURE 3 PROJECT INVESTMENT DELIVERY FRAMEWORK



The Options Analysis Procedure provides guidance on the steps required to identify a complete set of options, identify and quantify risk and identify other investment benefits.

For Power Services, the procedure requires that this Risk Quantification Procedure is applied to identify the risk of each option, and therefore the net avoided risk compared to the base case scenario.

2.2 Alignment with Regulatory Requirements

A key driver for the development of this Risk Quantification Procedure is the need to better align and embed requirements under the Northern Territory National Electricity Rules (NT NER) and AER guidelines and practice notes into Power and Water's business as usual (BAU) practices. The application of the Risk Quantification Procedure is intended to enable and support the development of an efficient and prudent investment portfolio that maximises the benefits to customers.

The AER's Industry practice application note for asset replacement planning (the ARP note) is the key source of regulatory requirements for asset risk (benefit) modelling. Investment programs supported by modelling that is consistent with the approaches outlined in the ARP note are considered to be aligned to the requirements specified by the AER and meet the forecast capital expenditure objectives outlined in the NT NER.

The AER Better Resets Handbook provides guidance on capital expenditure forecasts for regulatory submissions and includes the latest guidance on the AER's expectations. The AER expects forecasts for total capital expenditure to be not materially above recent historic expenditure levels. Any increase will be considered in the context of network performance measures (such as SAIDI) and may be rejected if the AER is not provided sufficient evidence that the network cannot maintain performance levels without the increase.

There are circumstances where the AER recognises a business' actual total capital expenditure is a less useful top-down test of the forecast. This includes where capital expenditure is predominately made up of large non-recurrent projects or where a capital efficiency sharing scheme is not in place. Where this is the case, the AER expects networks to provide quantitative cost benefit analysis to demonstrate that the major project/programs driving the total forecast maximises net benefits.

3 Overview of risk assessment

We define 'Risk' as the 'effect of uncertainty on objectives', in accordance with AS ISO 31000, where the effect on objectives can be positive (an opportunity) or negative (a threat). Hence, using the term risk refers to both a possible negative outcome such as the result of an asset failing in service, and a possible positive outcome such as a change of process that will improve efficiency.

The specification of Power and Water's Risk Quantification Procedure is also guided by the need to align with regulatory rules, guidelines and expectations. In the regulatory context, the Risk Quantification Procedure supports the development of an efficient and prudent investment portfolio that maximises the benefits to customers.

The ARP note[3] is the key source of regulatory requirements for asset risk (benefit) modelling. Investment programs supported by modelling that is consistent with the approaches in the note are then aligned to the requirements specified by the AER. The ARP note lists a number of 'typical consequence areas' as:

- Reliability and security
- Safety and Health
- Environment
- Legal / regulatory compliance
- Financial

The Risk Quantification Procedure builds upon the typical consequence areas outlined by the ARP note by providing further definition and the approach to determine the values to be used in the investment analysis. It is then used to quantify the economic cost or benefit to Power and Water, our stakeholders and the community and aggregates the value across the different consequence categories to determine the total economic risk cost.

3.1 Risk identification and assessment

The process of risk identification is governed by the Risk Identification Procedure (ERM Procedure 2). Common approaches for undertaking risk identification include:

Experience-based and trend analysis (including FMEA/FMECA)

- Brainstorming
- Bowtie analysis
- Scenario analysis
- Decision tree analysis

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

- 'PESTLE' analysis
- 'SWOT' analysis

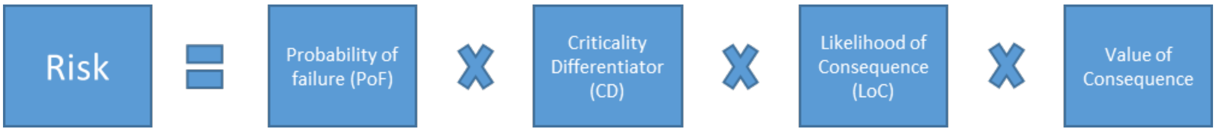
These methods are described in Appendix D and in addition to being used to identify the risk, they are also useful in informing the probability of asset failure. Hence, there is an interrelationship with this procedure to calculate the Probability of Failure (PoF) of an asset (network or non-network) and ERM Procedure 2.

The methodologies for calculating the PoF are described in section 5.1.

3.2 Risk analysis

The assessment involves consideration of the areas where risk or opportunities are likely to materialise as costs or benefits, their magnitudes and the probability of them occurring. The approach to calculating risk is shown at a high-level in Figure 4.

FIGURE 4 HIGH-LEVEL VIEW OF CALCULATION RISK



Each of these components have the following definitions:

- The probability of failure, or more broadly the probability of an event, is the initiation of the risk materialising. These are discussed in section 5.1.
- Criticality differentiators are factors applied to account for assets in different network locations or of different construction types that may result in a different risk (higher or lower) than the average asset. These are discussed in section 5.2.
- Likelihood of consequence represents the probability of each consequence occurring. This must include the effect of any mitigation controls. The total LoC for each consequence must be equal to 1 to demonstrate, statistically, that all possible outcomes have been accounted for and the result is the expected (probability weighted) value.

  The LoC is made up of the likelihood of a particular consequence type (ie safety or service delivery) and the probability of the severity of that outcome. Hence it can also be shown as

  $LoCc,s = LoCc \times PoSs$

  These are discussed in section 5.3.
- Value of consequence is the quantified cost of each of the possible outcomes. These are discussed in section 4.

The risk equation shown is per asset, therefore, it needs to be completed for each asset with the associated parameters adjusted to suit each individual assets situation.

The risk cost is the sum of the product of the three parameters for each possible combination of consequence category and severity and is a modelled value. Over a portfolio of assets the risk value can be expected to materialise. However, when assessing individual assets it can be binary – all or nothing – but valuing the risk provides a probabilistic economic approach for assessing when interventions should be undertaken.

3.3 Cost benefit analysis and evaluation

The assessment is undertaken for the base case and each of the identified credible options. The difference between the resulting network risk of the proposed option and the risk of the base case represents the net benefit (if positive) or cost (if negative) to the network.

The net value of quantified risk is then used in the cost benefit analysis[4] of the options to determine the option with the highest net benefit to customers.

For consistency with the cost benefit model, all costs included in the risk analysis should be done in the same base year. Any escalation applied should only be to adjust costs from historical data to the appropriate base year for forecasting.

3.4 Input data

Power and Water aims to use the most accurate and recent data available to inform its investment decision. However, we recognise that due to the long services lives of our assets and the rapid changes in technology during the past decades, there can be issues with data quality and availability.

Electricity network assets are long lived, highly reliable and are managed to avoid failures. Hence, data regarding failures and resulting consequences can be sparse and difficult to determine statistically significant probabilities.

Therefore, to identify the most appropriate information to use in the risk assessment, Power Services uses the best data available with the following order of preference:

- Historical data from Power and Water's data systems
- Historical data or information from peer DNSPs
- Data published by the AER
- Data available from other regulators (for example Ofgem[5])
- Other public information and engineering judgement.

Where possible and meaningful, the risk model should be compared to actual historical data and be reviewed by a subject matter expert to assess how realistic the outcome is and whether further investigation or refinement of the inputs is required.

During the evaluation of different investment options using the cost benefit model, sensitivity and scenario analysis are carried out in to test how sensitive the outcome is to key individual inputs and how the options perform under different scenarios (ie, expected, worst case and best case).

This approach to data and testing of outcome provides insight into how robust the modelling is against the different uncertainties and assurance that the selected actions will have the highest net benefit to customers in most cases.

4 Value dimensions

The quantified value of the consequence of an event or opportunity is commonly termed the Value (or Cost) of Consequence. The cost represents the economic impact on business outcomes and customer service levels. These consequences can be grouped into common categories and are referred to as Value Dimensions. Each Value Dimension is comprised of one or more Value Metrics which enable assessment at a more granular level.

Figure **5** shows how the Value Dimension (the value of the consequence fits in the risk calculation.

FIGURE 5 VALUE OF CONSEQUENCE IN THE RISK CALCULATION

[4] The approach to options analysis is governed by the Options Analysis Procedure, Power Water document reference: CONTROL394
[5] DNO Common Network Asset Indices Methodology, Ofgem, 2017

Eight Value Dimensions have been used to reflect the broad categories into which economic value can be allocated. These take into account internal requirements, external guidelines and assessment of the consequences that typically drive investment for Power and Water's electricity line of business.

- Health and safety (worker / public)
- Direct financial cost
- Compliance
- Environmental
- Service delivery
- Customer experience
- Fire
- Investment benefits

These Value Dimension have been developed to ensure alignment with Power and Water's Enterprise Risk Management Standard and with regard to the typical areas of consequence set out by the AER in the guidance note. Full details describing the alignment of the Value Dimension is in Appendix A.

The following sections describe the breakdown of the Value Dimensions into Value Metrics and the assigned values for each level of severity. Full details on the justification of these values are provided in in Appendix B.

4.1 Value metrics

Value metrics are determined based on the combination of societal and organisational value. Valuing impacts based on societal value is considered appropriate because, as a rule, it is the Network Service Provider's customers that receive the benefits (or incur the costs) associated with network investment.

The unique character of each value dimension means that the framework has application for modelling and comparing risks for a variety of investment scenarios. The relativity of the value metrics (to each other) is of crucial importance as the output considers how varying expenditure scenarios impact on the risk profile of the network.

As shown in Table 1, one or more Value Metrics have been identified for each Value Dimension. Each Value Metric accounts for the economic value of network events across a range of magnitudes of severity. For each level of severity a dollar values have been assigned. The total consequence presented by the Value Dimension then is calculated as the sum of the probability weighted consequences across the Value Metrics.

Depending on the value metric and the asset, the economic value is determined using either one of two methods:

1. Value Scale: A value scale approach is used where the drivers of the event are not currently quantifiable[6] based on identified characteristics or if the economic impact varies between defined levels of severity, such as penalties specified in legislation. The Value Scale sets costs for events that range from Insignificant to Severe. These approaches are described in section 4.2.
2. Value Attribution: The value attribution approach is used when the economic impact of an event varies based on quantifiable characteristics, such as load interrupted. The characteristics of the event are used to calculate a specific economic value using common industry approaches. These approaches are described in section 4.3.

The Value Metrics were based on analysis of the components of each Value Dimension that could be reasonably estimated and were considered to provide a reasonably complete view of the risk cost in each Value Dimension.

Table 1 presents an overview of the Value Dimensions and the Value Metrics and the following sections summarise their values and components.

[6] Power Services is at the start of a journey to improve risk assessment. Over time, and where practicable, we aim to progress towards value attribution for most risks.

TABLE 1: VALUE DIMENSIONS AND THEIR VALUE METRICS

Value Dimensions	ERMS Consequence	Value Metrics			
Health and Safety	Health and Safety	Disability Weighted Value of Life / WHS Cost	Grossly Disproportionate Factor	Investigation costs	Litigation costs
Direct Financial Costs	Financial	Reactive Replacement Premium	Asset Repairs	Investigation Costs	Property Damage
Compliance	Legal / Regulation	Penalties	Investigation costs	Litigation costs	
Environmental	Environmental	Remediation Costs	Greenhouse Gas Emissions	Penalties	Investigation and litigation costs
Service Delivery	Service Delivery	Unserved energy	Customer export curtailment	Investigation costs	
Customer Experience	Reputation	Internal use only			
Fire	Multiple	Health and Safety	Property Damage	Environmental Damage	

4.2 Value Scale

Each of the Value Dimensions is shown in Table 2 along with the definition of the metric extracted from the ERMS and its assigned value. This demonstrates how the Value of Consequence is derived for each Value Dimension. The source of the values and breakdown of each Value Dimension into the Value Metric subcomponents is detailed in Appendix B.

TABLE 2 SUMMARY OF THE VALUE METRICS WITH DEFINITION OF THE CATEGORY AND ITS DOLLAR VALUE

	Definitions and values				
	Insignificant	Minor	Moderate	Major	Severe
Measure of consequence of incident	Minor event with or without injury; and/or No on-going impact to health.	Injuries requiring first aid treatment; and/or Minor short term inconvenience.	Medical Treated injury; and/or Short term reversible disabling effect to human health; and/or Lost Time Injury <1 week lost.	Hospitalisation; and/or Injuries resulting in Lost Time Injury > 1 week lost; and/or Long term (chronic) chemical health exceedance or short term chemical exceedance of chemical with acute health impacts; and/or Long term aesthetic exceedance with health impact on supply.	One or more fatalities; and/or One or more persons seriously injured (includes long term disabling effect); and/or Widespread release of untreated water (eg due to disinfection failure).
Health and Safety: Worker	$14,638	$60,570	$277,750	$5,550,000	$25,050,000
Health and Safety: Public	$29,256	$106,140	$440,500	$10,050,000	$40,050,000
Measure of consequence of incident	< $500k	≥$500k and <$2m	≥$2m and <$10m	≥ $10m and < $25m	≥ $25m
Direct financial costs	Value Attribution	Value Attribution + $15,000†	Value Attribution + $15,000†	Value Attribution + $50,000†	Value Attribution + $50,000†
Measure of consequence of incident	Legal issues managed by corporate procedures or practices; and/or Breach of internal policies or procedures without the need for formal investigation.	Matter requires legal advice to address issues; and/or Internal breach of policies or procedures requiring a formal investigation.	Required to operate under limited regulatory restrictions or orders; and/or Incident which requires legal representation resulting in court proceeding.	Required to operate under significant regulatory restrictions or orders; and/or Government inquiry/ intervention.	Criminal charges / civil litigation against the Corporation and/or Officers; and/or Operating licences revoked.

	Definitions and values				
	Insignificant	Minor	Moderate	Major	Severe
Compliance	$0	$35,000	$155,000	$1,550,000	$12,050,000
Measure of consequence of incident	Localised low level damage controlled but no remedial action required.	Localised low level damage controlled and remedied with minimal resources.	Widespread temporary damage with extended resources to remedy.	Long-term detrimental effect on environment and once controlled results in minor permanent damage.	Substantial permanent damage to widespread and sensitive areas.
Environmental	Value Attribution	Value Attribution + $15,000[†]	Value Attribution + $35,000[†]	Value Attribution + $165,000[†]	Value Attribution + $1,550,000[†]
Measure of consequence of incident	A single event results in an outage equivalent to 5% of annual target	A single event results in an outage equivalent to 10% of annual target	A single event results in an outage equivalent to 20% of annual target	A single event results in an outage equivalent to 50% of annual target	A single event results in an outage equivalent to 100% of annual target
Service Delivery	Value Attribution	Value Attribution	Value Attribution + $15,000[†]	Value Attribution + $50,000[†]	Value Attribution + $50,000[†]
Measure of consequence of incident	<2% increase in complaints Local or individual stakeholder attention	2-5% increase in complaints Adverse public or stakeholder attention from multiple stakeholder groups <1 week	5-10% increase in complaints Adverse public or stakeholder attention from multiple stakeholder groups <1 month	10-20% increase in complaints Adverse public or stakeholder attention from multiple stakeholder groups >1 month	>20% increase in complaints Irreparable damage to brand or reputation
Customer experience	$0	$1,500	$11,500	$90,000	$190,000
Measure of consequence of incident	Fire start	Land damage, no property lost	< 10 properties lost	< 20 properties lost	> 20 properties lost
Fire	$0	$35,000	$815,000	$3,050,000	$25,050,000

[†] The dollar amount is the expected cost of penalties and litigation based on the Value Scale amounts defined in Appendix section B.8 that is added to the amount calculated by Value Attribution.

4.3 Value Attribution

The four metrics which apply Value Attribution are described below. The justification and detail supporting these approaches are set out in Appendix B.

4.3.1 Direct financial costs

Direct Financial Cost quantifies costs incurred by the business as a result of an asset failure that are not included within any other value dimension. There are three value metrics for direct financial costs:

1. Reactive replacement premium represents the higher cost of asset replacement in reactive conditions compared to a planned replacement. This should be calculated based on historical data but if there is insufficient actual data available, a default value of 20% of the planned replacement unit rate should be applied.
2. Asset repairs (linear assets only) represents the cost of repairing assets after failure and only applies to linear assets due to their reparability. This should be calculated based on historical expenditure.
3. Property damage represents the replacement or repair cost of property damaged or destroyed by the asset that failed (excluding damage due to a fire caused by the asset failure). This should be calculated based on historical expenditure.

Investigation and litigation costs are added to the costs outlined above.

4.3.2 Environmental

This value metric incorporates costs incurred to remediate environmental damage. This is limited to the clean-up of oil and the economic cost of greenhouse gas emissions. However, this may be expanded over time to include other scenarios.

Oil clean-up costs are related to the quantity of oil spilled. The total cost for each severity level is as follows:

$$\text{Cleanup cost} = \text{Oil Capacity (Litres)} \times \text{\% lost to environment} \times \text{Cleanup Cost per Litre}$$

GHG emissions result in societal costs due to their contribution to climate change. The economic cost of greenhouse gas (GHG) emissions is directly related to the volume of greenhouse gas equivalent emitted:

$$GHG\ cost = Volume\ of\ GHGe\ (tons) \times Market\ price$$

The market prices is based on EU ETS credits which have a historical average cost of approximately $80 (real FY22 AUD) per ton.

4.3.3 Service Delivery

Service Delivery covers the economic impact of loss of supply to customers. It is calculated as the total volume of energy not supplied multiplied by the economic value of that energy. The volume of energy not supplied must include and alternative supplies, switching time and restoration times.

The calculation, expressed at a high-level to describe the individual components:

$$Value\ of\ EUE = PoF \times \sum_{1}^{i} (EAR_i \times VCR_i)$$

There are four general inputs to the calculation:

- **Value of Customer Reliability (VCR)** is published by the AER annually and describes the dollar value per kilowatt hour (kWh) disaggregated across multiple customer demographics, including customer type and location. The values relevant to Power Services are shown in Table 3[7].
- **Energy At Risk (EAR)** is the total amount of energy that would not be supplied to customers if the event occurs. It must incorporate the demand that is off supply for each stage of the fault: the initial response time and each stage of the repair/restoration process.
- **Probability of Failure (PoF)** is the likelihood of the event occurring. Outages that are within the scope of this procedure are typically caused by asset failure.

Three different approaches to implement this in different circumstances are described in section B.5.1.

TABLE 3 VCR VALUES FOR THE NORTHERN TERRITORY (AER VCR ANNUAL ADJUSTMENT, PUBLISHED DECEMBER 2021)

Customer segment	VCR ($ per kWh, real FY22)
Residential	$18.99 per kWh
Commercial	$46.18 per kWh
Industrial	$66.16 per kWh
Agricultural	$39.28 per kWh

4.3.4 Customer export curtailment value

The AER released a Draft DER integration expenditure guidance note in July 2021 and a Draft Customer export curtailment value methodology in April 2022. The documents discuss the integration and value of DERs, and in particular, the value to the market and customers of enabling additional hosting (connection) of DERs. This has been termed the Customer Export Curtailment Value (CECV).

The Explanatory Statement[8] which accompanies the draft methodology states that the CECV will not apply to Power and Water, however, it expects that Power and Water will develop its own estimation of the benefits associated with avoided dispatch costs which reflects the AER's CECV methodology and accounts for the temporal nature of those cost and alleviation profile associated with any DER integration investments[9].

Power and Water has undertaken the appropriate analysis of their network and market characteristics to develop a CECV that is applicable to our unique situation. In the Northern Territory gas is the marginal fuel source, and a unit increase in solar exports results in a unit decrease in gas-fired generation. Power and Water's analysis found that the value of additional DER exports, predominately from embedded solar PV, was derived from a reduction in the usage, and therefore cost, of natural gas used by the thermal generation as well as a reduction in electricity losses from transmission and distribution.

The savings are therefore the benefits received by customers from additional capacity for DERs and are the proposed Customer Export Curtailment Value (CECV). The value has been calculated to be between

[7] The latest published version of the VCR update located at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability
[8] AER, Explanatory statement: Draft Customer export curtailment value methodology, April 2022
[9] Ibid, page 19

$103/MWh and $121/MWh over the 30 year horizon. This is made up of the gas fuel cost, which varies over time, the efficiency of a gas generator, and the distribution and transmission losses.

The CECV is applied by calculating the quantity of additional exports (in MWh) that could be achieved through a particular action and then multiplying it by the CECV. The monetized value can then be used in a cost benefit analysis to identify the net benefit of the proposed investment.

5 Calculating and applying probabilities

As described in section 1.2, the value of the consequence (Value Dimensions) must be multiplied by the probability of that event occurring. The probability of any consequence is a combination of the probability of an asset failing and the probability that, given failure, it will fail in a certain mode with a specific cost impact.

This framework describes three key parameters that are required for modelling quantified risk. These parameters are:

- Probability of Failure (PoF)
- Criticality Differentiators (CD)
- Likelihood of Consequence (LoC).

The approaches used to calculate the probabilities and how to apply them to the Value Metrics to determine the expected risk cost of an asset failure are described in the following sections.

5.1 Probability of Failure

Probability of Failure (PoF) is the first element of the risk equation shown in Figure 6. It represents the likelihood of an asset failing while in service and needs to be expressed as conditional probability. That is, the probability of the asset failing in a specific year given that it had survived until the preceding year.

FIGURE 6 PROBABILITY OF FAILURE IN THE CALCULATION OF RISK COST

The Probability of Failure (PoF) of an asset can be modelled as a function of time (the assets age or years in service) to represent the deterioration of its condition due to use and environmental conditions. To provide a link between age and condition, common industry practice is to use the cumulative form of a probability distribution to determine the likelihood of an asset failing in a specific year.

The Weibull function is a very common probability discontinuation used across many industries, especially the electricity industry. Consistent with electricity industry practice, Power Services has adopted the Weibull Distribution to model probability of asset failure.

To calculate the PoF for an asset, the Weibull function is used to determine the survival curve for an asset based on conditional probability. This means that the derived curve will determine the probability of the asset failing in a specific year given that it had survived until the preceding year.

For a Weibull Distribution, the probability of failure in at age T+1 given that it had survived to age T, can be written as:

$$PoF_{age} = \frac{CDF_{age} - CDF_{age-1}}{1 - CDF_{age-1}}$$

The CDF is the Cumulative Distribution Function (CDF). It has three parameters: shape; scale; and shift and can be expressed as a with the following equation:

$$CDF = 1 - e^{-\left(\frac{age - shift}{\beta}\right)^{\alpha}}$$

Where:

$$\alpha = Weibull\ shape\ parameter$$

$$\beta = Weibull\ scale\ parameter$$

$$shift = Weibull\ shift\ parameter$$

$$age = Asset\ conditional\ age$$

The sections below discuss approaches to estimating the three Weibull parameters. The typical order in which the parameters are estimated is to begin with the shift parameter, followed by the shape parameter and finally the scale parameter.

Shift

The Shift parameter is often set to zero which reduces the Weibull Distribution to the two-parameter version of the equation. The two parameter Weibull is commonly used in the electricity industry, particularly where there is insufficient data to estimate the Shit parameter.

The shift parameter can be estimated from a sample of failure data using the following formula:

$$shift = Min(fail\ age) - 1/n$$

Where:

- $fail\ age = ages\ of\ all\ failed\ assets\ at\ the\ date\ of\ failure$
- $n = number\ of\ failures$

As n becomes large, this is equivalent to setting the shift parameter to the age of the youngest observed failure for each asset class. For any value on n where the final term doesn't become very small there is likely to be too much uncertainty for the result to be used.

Where there is sufficient failure data for an asset class, the shift parameter is estimated using Power and Water's data. Where there are no failures, the shift parameter is set to zero due to a lack of data to indicate otherwise.

When there is not a large enough sample size for a reliable calculation of the Shift parameter, Power Services will set the Shift parameter to zero, which is consistent with industry practice.

Shape and Scale

The Shape and Scale parameters can be estimated using numerical methods. Two commonly applied methods are:

- Maximum Likelihood Estimation, and
- Median Rank Estimation

However, both of these methods rely on having a sufficient amount of reliable data that includes sufficient asset characteristics to group assets into similar types and also the age at failure.

Network datasets are often characterised by highly censored data. Assets may have been replaced before they had the chance to fail or have not yet failed (right censored) or the failures were not correctly recorded, usually due to the installation date not being known (likely to be left-censored). Most networks, only have reliable failure data for the few most recent years, which is a significant driver of this issue.

Over time, more data of a sufficient quality may be collected, which may enable a revisiting of the estimation of shape parameters.

Where Power and Water does not have sufficient data to calculate the scale or shape parameters, information from peer DNSPs and guidance from the AER has identified some appropriate assumptions. Calibration or sensitivity analysis can also be applied to ensure the values assumed are consistent with historical network experience.

The typical default values for the Shape parameter are:

- approximately 3.6, which corresponds to an approximation of the normal distribution.
- the AER[10] has suggested an upper limit for reasonable shape parameters of 5
- a value of 1.0 results in a uniform (constant) value equal to $\frac{1}{Scale}$ and can be used to denote or constant or random failures.

The typical default value for the Scale parameter is the expected serviceable life of the asset.

<u>Age</u>

Since the Weibull is used to assess probability over time, with the Shift, Shape and Scales parameters fixed, the age of the asset is the main variable. In most cases, an asset can be assumed to deteriorate at a rate consistent with the whole fleet, and the Weibull parameters will reflect this rate of deterioration.

However, some assets will be in situations where they deteriorate at a faster rate than the rest of the fleet. For example, poles located in corrosive salty soil may have an actual age of 40 years but be in the condition of a typical 60 year old pole. In these cases, the conditional age of the asset should be used. The conditional age is the actual asset age adjusted for any accelerated or reduced levels of deterioration. In this case, the asset age and aging rate should be adjusted to reflect the specific situation. Alternatively, the population can be separated out into a separate model and customised Shift, Shape and Scale parameters determined. The approach with the best data to support it should be selected.

5.2 Criticality Differentiators

Since the probability of each consequence is set for the network average, Criticality Differentiators (CD) are applied to modify these probabilities based on network location and asset type. This adjusts the risk cost outcome to account for locations where the probability of consequence may be higher or lower than that network average based on locational factors, safety features or type issues.

FIGURE 7 CRITICALITY DIFFERENTIATOR IN THE CALCULATION OF RISK COST

Power Services has adopted the approach set out by Ofgem[11] which has the following key parameters:

- Each asset is allocated to a Low, Moderate or High location risk rating. This denotes the proximity to locations where risk will be higher, relative to the average network asset. For example, with respect to safety it would represent proximity to population centres where the public will be in closer proximity more often to assets. In the case of the environment it would represent proximity of assets to sensitive environmental sites such as rivers. Typically, this will relate to Rural, Urban and CBD feeders, respectively. However, it should be considered for each assessment and the allocation of assets adjusted appropriately.
- The asset is also denoted a Low, Moderate or High risk rating based on its type (construction and materials). This denotes how likely the asset is to fail in a catastrophic manner due to the construction and materials of the asset which differentiate it from the average network asset.

[10] AER - Asset replacement forum -Discussion summary - 26 February 2019.pdf. The AER stated that Weibull shape factors greater than 5 are generally not considered plausible. Hence, where sufficient data is not available to calculate a shape factor, Power Services has taken the AER's concerns into account and limits the maximum shape factor to 4.5.

[11] Ofgem DNO Common Network Asset Indices Methodology, Health and Criticality, v1.1, page 168

For example, with respect to safety it could represent whether or not the asset is rated to contain an arc-fault, while for environment it could represent the presence of oil or other hazardous materials.

The CD is then calculated using a matrix style approach and can take on values between 0.7 up to 1.6. The default value is 1, meaning the network average probability of consequence is used.

5.3 Likelihood of Consequence

This section describes how Likelihood of Consequence (LoC) is used. It covers the parts of the risk equation highlighted in Figure 8.

FIGURE 8 LIKELIHOOD OF CONSEQUENCE IN THE CALCULATION OF RISK COST

Likelihood of Consequence (LoC) is the probability that any given non-repairable functional failure of an asset results in a consequence occurring. When an asset fails, it can often fail in multiple ways. It is comprised of two components:

- Likelihood of Consequence Category (LoCC): the probability that a particular Value Dimension will be impacted
- Probability of Severity (PoS): the probability of each severity level occurring

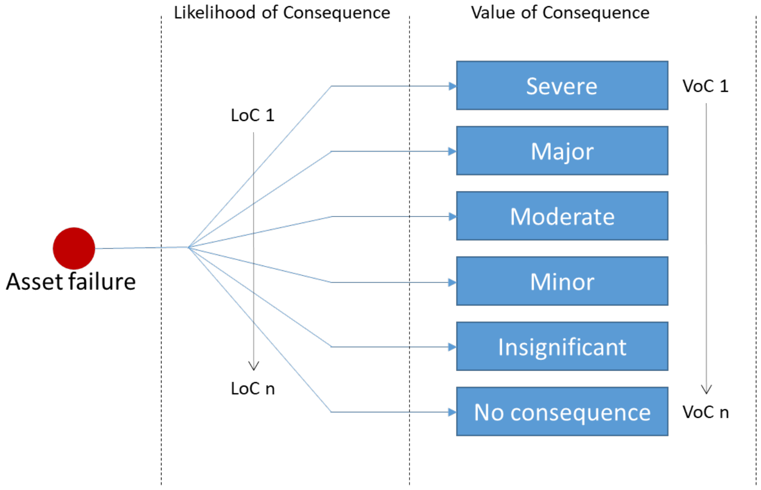
These can be treated separately or combined into one set of probabilities as described below. Both methods are equivalent mathematically, once the probabilities are multiplied out, and the approach should suit the data available and implementation of the model.

The likelihoods and probabilities must consider the controls in place to mitigate the consequence from occurring. The values of each LoC, LoCC and PoS should be based on historical data if there is sufficient granularity, however, since assets are managed to avoid failure in most cases, there can be limited data for some assets. In these cases, the use of other published information that can provide valuable insight into suitable probabilities to directly apply, or to inform and support calculation of parameters tailored to Power Services Network.

5.3.1 LoC

As shown in Figure 9, each Likelihood of Consequence must multiply the associated Value of Consequence and this must occur for each Value Dimension. These are then these values are summed together to give the expected consequence value, that is, a probability weighted cost that represents the likely total cost of consequence if the asset fails.

FIGURE 9 APPLICATION OF LIKELIHOOD OF CONSEQUENCE



As a formula this can be written as:

$$Expected\ Consequence\ Value = \sum_{VD_1}^{VD_i} \sum_{1}^{n} LoC_{i,n} \times VoC_{i,n}$$

Where

$$\sum_{1}^{n} LoC_n = 1$$

$VD = Value\ Dimension,\ and\ \boldsymbol{i}\ is\ the\ number\ of\ Value\ Dimensions$

$\boldsymbol{n} = the\ number\ of\ severity\ levels$

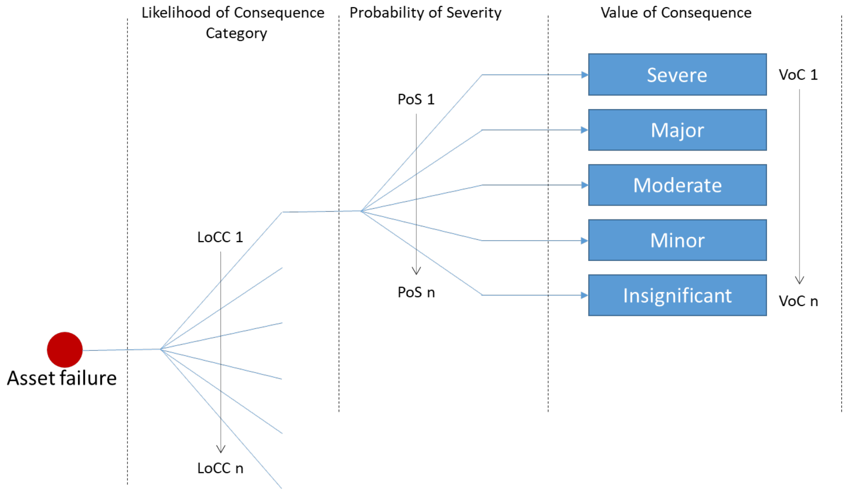
It is essential that the sum of probabilities is equal to 1. That means that one of the consequences must occur for each Value Dimension, even if that is 'No Consequence' which is a zero cost impact.

5.3.2 LoCC and PoS

As shown in Figure 10, the Likelihood of Consequence Category (LoCC) defines the probability of the Value Dimension materialising. The Probability of Severity then defines the probability of each severity level given that the consequence has occurred.

Therefore, each Probability of Severity must multiply the associated Value of Consequence which are then summed together and multiplied by the Likelihood of Consequence Category. This is then repeated for each Value Dimension. The 'no consequence' severity level (zero cost outcome) is equal to 1 – LoCC, but is not explicitly modelled.

FIGURE 10 APPLICATION OF LIKELIHOOD OF CONSEQUENCE CATEGORY AND PROBABILITY OF SEVERITY



This must be applied to each Value Dimension, according to the application of a Value Scale or Value Attribution approach as described below.

As a formula it can be written as:

$$Expected\ Value = \sum_{VD_1}^{VD_i} LoCC_i \times \left(\sum_{1}^{n} PoS_{i,n} \times VoC_{i,n} \right)$$

Where

$$\sum_{1}^{n} PoS_n \quad = 1$$

VD = Value Dimension, and **i** is the number of Value Dimensions

n = the number of severity levels

It is essential that the sum of Probability of Severity is equal to 1. That means that one of the consequences must occur if the Value Dimension materialises. However, the sum of LoCC can be greater than or less than one. This is because there are a range of outcomes from no Value Dimensions materialising to all Value Dimensions materialising simultaneously as the Value Dimensions are largely independent.

5.3.3 Application with Value Attribution

Generally, with value attribution approaches, the methodology used to calculate the value of the impact is based on historical data or assumptions which already includes the LoC or LoCC and PoS. Therefore, the calculated value is already probability weighted for the outcome and only needs to be multiplied by the probability of an event occurring.

5.3.4 Likelihood values by Value Scale

The probabilities applied in the risk analysis are set out in Appendix C. This describes the basis of the values used and any assumptions.

These values should be used as a starting point and where actual data is not available. Where sufficient asset failure and consequence data is available for Power and Water's network assets, the actual data should be analysed to derive customised probabilities.

6 Definitions

Where terms or words are not included in the definitions section, refer to Power and Water's intranet glossary.

Term	Definition
AER	Australian Energy Regulatory
ARP	Asset Replacement Planning
BAU	Business as Usual
BCR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CECV	Customer Export Curtailment Value
DNSP	Distribution Network Service Provider
ERM	Enterprise Risk Management
ERMS	Enterprise Risk Management Standard
FMEA	Failure Mode Effects Analysis
FMECA	Failure Mode Effects Criticality Analysis
LoC	Likelihood of Consequence
NPV	Net Present Value
NSP	Network Service Providers
NT NER	Northern Territory National Electricity Rules
PoF	Probability of Failure
PoS	Probability of Severity
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
VCR	Value of Customer Reliability

7 Change management and continuous improvement

7.1 Consultation, approval and communication

This procedure must be endorsed by the Responsible Manager and approved by the Accountable Manager.

Role / title	Requirement
Executive General Manager Power Services	Accountable - approve this document
Senior Manager Asset Management Power Services	Responsible - endorse this document
Organisational Governance	Consult for changes and support implementation
Power Services Staff	Communicate – inform of any changes

7.2 Review

The requirements of this procedure are mandatory and shall be reviewed and updated periodically for its ongoing effectiveness. This procedure will be reviewed, at a minimum, every three years or in the event of any significant change in our vision, values, long term goals, risk appetite, policy statement business model or organisational structure, or related systems or processes.

7.3 Internal references and related documents

Document Tile	Record Number
Risk and Compliance Policy Statement	CONTROL0012
Enterprise Risk Management Standard	CONTROL0013
Establish the Risk Context (ERM Procedure 1)	CONTROL0480
Identify the Risk Procedure (ERM Procedure 2)	CONTROL0479
Analyse the Risk Procedure (ERM Procedure 3)	CONTROL0478
Evaluate the Risk Procedure (ERM Procedure 4)	CONTROL0477
Treat the Risk Procedure (ERM Procedure 5a)	CONTROL0487
Prioritise the Risk Procedure (ERM Procedure 5b)	CONTROL0488
Monitor, Review and Report Risk Procedure (ERM Procedure 6)	CONTROL0489

7.4 External references, legislative and regulatory obligations

- National Electricity Rules - Northern Territory
- AER Better Resets Handbook - Towards consumer-centric network proposals

7.5 Records management

This procedure and all related documents, are captured, stored and managed in our Electronic Document and Records Management System and controlled in the Controlled Document Register.

7.6 Improvement suggestions

Have an improvement suggestion? Feedback and improvement suggestions for this document can be lodged by completing the online form on your browser or using the QR code from your mobile device.

URL: https://forms.office.com/r/gxsQ1v1grd

7.7 Document history

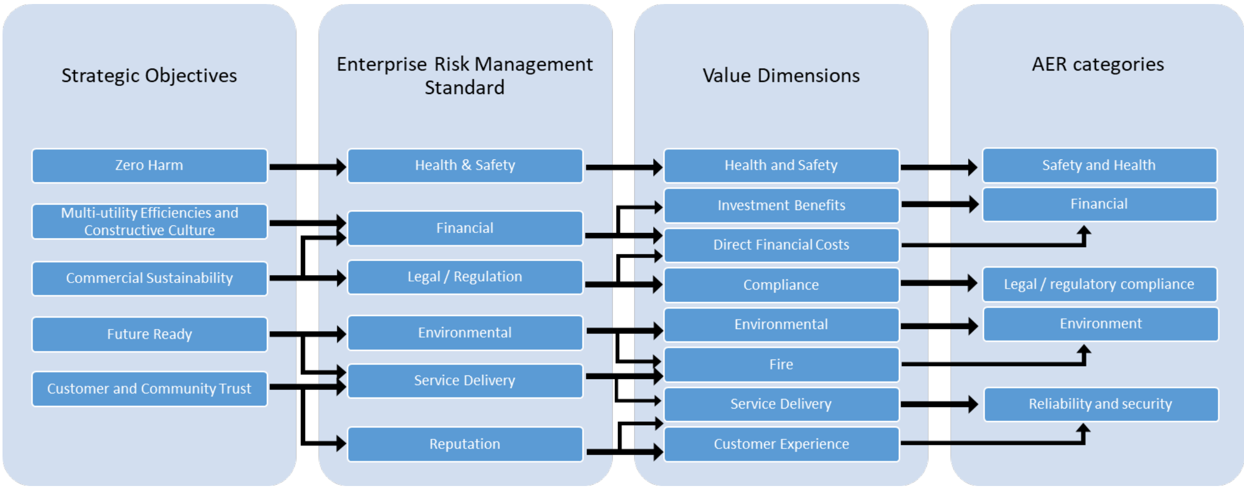
Date of issue	Version	Prepared by	Description of changes
15/12/2022	0.1	Stuart Easie	Initial Draft
15/12/2022	0.2	Chris Hanlon	Document migrated to PWC template
16/12/2022	0.3	Lachlan Vale	Reviewed from risk perspective, minor changes to typos and alignment with risk framework. Some comments made.
16/12/2022	0.4	Cristina Ditoro	Reviewed from risk perspective, some comments made.
20/12/2022	0.5	Stuart Easie	Feedback adressed, minor amendments to typos and formatting.
21/12/2022	0.6	Chris Hanlon	Final review in preparation for approval, track changes assessed and accepted.
27/01/2023	1.0	Document Control	Published approved controlled document

8 Appendices

Appendix A. Alignment with the Enterprise Risk Management Standard

These are based on the ERMS to ensure alignment with the Strategic Objectives, and consider the categories identified by the AER. Figure 11 shows the Value Dimensions adopted by Power and Water and how these are in alignment with the Strategic Objectives, Enterprise Risk Management Standard and the typical categories identified by the AER.

FIGURE 11: MAPPING STRATEGIC OBJECTIVES, ENTERPRISE RISKS AND VALUE DIMENSIONS



The Value Framework defines eight Value Dimensions, each containing several Value Metrics against which dollar values are assigned.

Appendix B. Basis of financial values

This appendix describes the information sources that were used to create the Value Metrics and any calculations used. The alignment to the ERMS and relevant definition of each severity level is also provided to assist with application and to demonstrate alignment with the corporate standard.

All forecast costs should be done on a real basis. Physical parameters that may impact the cost, such as network growth rates affecting the volumes of assets impacted, should be included however CPI should be excluded.

For the Value Dimensions with multiple severity levels, the approach to calculate and model the probability of each severity occurring is described in Appendix C.

B.1 Health and Safety (Worker and Public)

The value dimension of Safety quantifies company, individual and community costs associated with injuries and fatalities caused by the failure of, or interaction with, network assets.

The value components for safety comprise:

1. Disability Weighted Value of Life represents society's willingness to pay to avoid serious injuries and/or fatalities (used for the minor, moderate, major and significant severity levels)
2. WHS Cost represents the cost to the network, individual and the community of minor injuries for which a value of life approach is not appropriate (used for the insignificant severity level only)
3. Grossly Disproportionate Factor is a multiplier applied to safety consequences to align with NT Work Health and Safety Regulations to invest in consequence avoidance whenever the costs are not grossly disproportionate to the risk reduction achieved.

The value of safety risk is shown in Table 4 and is calculated for five severity levels, ranging from Insignificant to Severe, using the above value metrics.

TABLE 4 HEALTH AND SAFETY VALUE SCALE

ERMS definitions and values					
	Insignificant	Minor	Moderate	Major	Severe
Measure of consequence of incident	Minor event with or without injury; and/or No on-going impact to health.	Injuries requiring first aid treatment; and/or Minor short term inconvenience.	Medical Treated injury; and/or Short term reversible disabling effect to human health; and/or Lost Time Injury <1 week lost.	Hospitalisation; and/or Injuries resulting in Lost Time Injury > 1 week lost; and/or Long term (chronic) chemical health exceedance or short term chemical exceedance of chemical with acute health impacts; and/or Long term aesthetic exceedance with health impact on supply.	One or more fatalities; and/or One or more persons seriously injured (includes long term disabling effect); and/or Widespread release of untreated water (eg due to disinfection failure).
Risk Framework derived values					
Disability Weighted Value of Life / OHS costs (per injury/fatality)	$4,876	$15,190	$54,250	$1,500,000	$5,000,000
Disproportionality factor (worker / public)	3 / 6	3 / 6	3 / 6	3 / 6	3 / 6
Investigation costs	$0	$0	$15,000	$50,000	$50,000

ERMS definitions and values	Insignificant	Minor	Moderate	Major	Severe
Litigation costs	$0	$15,000	$100,000	$1,000,000	$10,000,000
TOTAL COSTS Worker	$14,638	$60,570	$277,750	$5,550,000	$25,050,000
TOTAL COSTS Public	$29,256	$106,140	$440,500	$10,050,000	$40,050,000

Severity levels from Minor through to Severe use the disability weighted value of life approach (refer to section B.1.1 below) while the Insignificant severity level uses a Work Health & Safety (WHS) cost approach (refer to section B.1.2 below). The WHS cost approach is used because the value of life approach is too coarse to apply to very low severity injuries.

The proposed values presented in Table 5 below are shown as per incident per individual. The value should be multiplied by the number of individuals injured or the number of fatalities based on the type of asset and failure mode analysis. Sources for the individual values are discussed in the following sub-sections.

For forecasts, each safety severity level value can be inflated using a Wage Price Index forecast. This should be higher than the inflation forecast and result in an increase in real terms over the forecast period.

B.1.1 Disability Weighted Value of Life

Disability Weighted Value of Life is used for the severity levels of Minor through to Severe, as shown in Table 5. This approach values the loss of quality of life (disability weightings), using an estimate of societal willingness to pay (value of statistical life). An alternative source of information is from WorkSafe Australia, however, the VSL approach is more widely used in the electricity sector and uses more up-to-date information so is the preferred source for all but Insignificant safety consequences.

Two values for the Value of Statistical Life (VSL) are published by the federal government[12]; a whole of life value (VSL) and an annual value (VSL year or VSLY). VSL is appropriate for fatalities and permanent injuries that have a lifelong impact on the victim where the victim has no quality of life. VSLY is used for temporary impairment where the injury is expected to persist for less than a year and some quality of life will be retained.

A disability weighting is applied to account for different levels of severity for both VSL and VSLY. The Best Practice Regulation Guidance Note refers to a source for disability weightings, The Burden of Disease and Injury in Australia (Mathers et al 1999) from the Australian Institute of Health and Welfare[13].

For major injuries, the weighting foot and leg amputations of 0.3 is used. As this is a permanent injury, it is applied to the full VSL value. Moderate and minor injuries are temporary, so the single year VSLY value is used. For moderate injuries, a disability weighting of 0.25 was selected. This value is within range of several broken bone values, such as vertebra (0.266), pelvis (0.247) and patella, tibia or fibula (0.271). For minor injuries the weighting of 0.07 was selected. This is based on the values for nerve damage (0.064), sprains (0.064) and dislocation (0.074).

[12] Federal Government Department of Prime Minister and Cabinet (Office of Best Practice Regulation) in the Best Practice Regulation Guidance Note: Value of Statistical Life The publication is available here: https://pmc.gov.au/resource-centre/regulation/best-practice-regulation-guidance-note-value-statistical-life

[13] The report is available here: https://dro.deakin.edu.au/eserv/DU:30046704/stevenson-burdenofdisease-1999.pdf, page 201-202

TABLE 5: SAFETY VALUE OF CONSEQUENCE USING VSL AND VSLY

Severity Level	Power Water Description	Value Metric Assumption	Calculation Assumption	Value of Consequence[14] (FY21)	Average of peers[15]
Minor	Non-permanent injuries/work related illnesses requiring medical treatment	Temporary injury that limits the victim's quality of life for 1 year. Valued using VSLY multiplied by the weighting for a minor injury (e.g. nerve damage, sprain, dislocation).	VSLY * 0.07[16]	$15,190	$39,257
Moderate	Significant non-permanent injury/work related illnesses requiring emergency surgery or hospitalisation for more than 7 days	Temporary injury that limits the victim's quality of life for 1 year. Valued using VSLY multiplied by the weighting for a bone fracture of a major bone (e.g. femur, pelvis).	VSLY * 0.25[17]	$54,250	$276,212
Major	Permanent injury/work related illnesses to one or more persons	Severe injury that permanently reduces the victim's quality of life. Valued using VSL multiplied by the weighting for an arm/leg amputation.	VSL * 0.3[18]	$1,500,000	$1,766,579
Severe	One or more fatalities. Multiple significant permanent injuries/work related illnesses	Fatality or severe injury that prevents the victim from working for the rest of their life. Valued using VSL	VSL * 1[19]	$5,000,000	$5,513,315

The Best Practice Regulation Guidance Note is updated annually to escalate the values of VSL and VSLY. The escalation approach is to use the Wage Price Index, which is typically higher than the rate of inflation. Forecasts of VSL and VSLY should use the same approach. If a forecast for the Wage Price Index is not available, a historic average growth rate should be used[20].

[14] Values are per incident. Where multiple consequences are expected from a single incident, the value should be multiplied by the expected number of consequences

[15] Power and Water sought external advice regarding the values in use by peer networks. The values are the average of the corresponding severity levels in use by ten Australian DNSPs

[16] Refer section 6.1.1

[17] ibid

[18] ibid

[19] ibid

[20] ABS data on the Wage Price Index is available here: https://www.abs.gov.au/statistics/economy/price-indexes-and-inflation/wage-price-index-australia/latest-release#data-download

B.1.2 WHS Cost

For low severity safety consequences, an alternate approach has been used. The value of life approach was determined to be too coarse to apply to these very low severity injuries. Estimates for costs of minor injuries are available from SafeWork Australia and consider[21]:

- Direct costs
  - Workers' compensation premiums paid by employers
  - Payments to injured or incapacitated workers from workers' compensation jurisdictions
- Indirect costs
  - lost productivity
  - loss of current and future earnings
  - lost potential output and the cost of providing social welfare programs for injured or incapacitated workers

Table 6 summarised the Insignificant safety consequence category.

TABLE 6 SAFETY VALUE OF CONSEQUENCE USING OHS COST

Severity Level	Power Water Description	Value Metric Assumption	Calculation Assumption	Value of Consequence [22] (FY21)	Average of peers[23]
Insignificant	Low level injury/symptoms requiring first aid only	Minor injury requiring limited treatment. Valued using SafeWork Australia short term absence cost.	OHS Cost (Short term absence)	$4,876	$2,612

B.1.3 Grossly Disproportionality Factor

The application of AS 5577 Electricity Network Safety Management Systems in managing safety risks associated with the operation of an electricity network is a mandated requirement in Northern Territory. The standard requires network safety risks to be eliminated, and if this is not reasonably practicable, then to be reduced to as low as reasonably practicable (ALARP).

Reasonably practicable as described by Safe Work Australia[24] represents that which is, or was at a particular time, reasonably able to be done, taking into account and weighing up all relevant matters including those already mentioned previously including:

- the likelihood of the hazard or the risk concerned occurring; and
- the degree of harm that might result from the hazard or the risk; and
- what is known, or ought reasonably is known, about the hazard or risk, and about the ways of eliminating or minimising the risk; and
- the availability and suitability of ways to eliminate or minimise the risk; and

[21] The report is available here: https://www.safeworkaustralia.gov.au/system/files/documents/1702/cost-of-work-related-injury-and-disease-2012-13.docx.pdf. Refer to page 26, Table 1.9

[22] Values are per incident. Where multiple consequences are expected from a single incident, the value should be multiplied by the expected number of consequences

[23] Power and Water sought external advice regarding the values in use by peer networks. The values are the average of the corresponding severity levels in use by ten Australian DNSPs

[24] How to Determine What is Reasonably Practicable to Meet a Health and Safety Duty, Safe Work Australia (May 2013)

- after assessing the extent of the risk and the available ways of eliminating or minimising the risk, the cost associated with available ways of eliminating or minimising the risk, including whether the cost is grossly disproportionate to the risk.

Where possible a quantified approach is adopted for the evaluation of health and safety risks so far as is reasonably practicable (SFAIRP) for the purpose of asset related decision making through the monetisation of risk. As noted in point 'e' above where the risk and the treatment are quantified the effort and expense of a treatment must be shown to be grossly disproportionate to the risk before it is discounted as a treatment.

Guidance from the Health Safety Executive[25] (UK) suggests that a Grossly Disproportionate Factor (GDF) between 2 and 10 can be used. Higher values are used for situations where extensive harm is possible if the risk event were to occur. The application of the GDF allows for the model to prioritise investment to meet community expectations that the organisation should invest a greater multiple to reduce some risks as compared to others.

The AER has provided guidance on acceptable Disproportionate Factors (DFs) for regulatory purposes in the draft and final determinations. In particular, the AER stated the following in its Final Determination for SA Power Networks[26]:

> *The disproportionality factor is an index used to represent an organisations' appetite to spend more than the calculated value of the safety risk to reduce that risk. It is usually multiplied by the average value of consequence to ensure that any uncertainty is accounted for. In previous decision and the repex guidance note, we have relied on values between 3 (workers) to 6 (public). The use of values beyond those are likely to overestimate the expenditure required.*

The application of a GDF to the consequence value represents an organisations appetite to spend more than the value of the safety risk avoided to reduce the risk. Power Water has adopted the AER's guidance (above) for GDFs as shown in Table 7 below.

TABLE 7: GROSSLY DISPROPORTIONATE FACTOR BY SEVERITY LEVEL

Exposure category	Insignificant	Minor	Moderate	Major	Significant
Public	**6**	**6**	**6**	**6**	**6**
Worker	**3**	**3**	**3**	**3**	**3**

B.2 Direct Financial Costs

The Value Dimension of Direct Financial Cost quantifies costs to the business that occur as a result of an asset failure that are not included within any other value dimension (i.e. excluding environmental clean-up and fines, etc.).

The value of Direct Financial Costs is made up of multiple components, some of which are closely linked to other value dimensions (for example, litigation costs are higher for severe fires compared to minor fires). Some financial costs relating to the network are excluded to avoid double counting, including payments related to regulatory incentive schemes. There are four value metrics included for direct financial costs:

- Reactive replacement premium represents the additional costs incurred to replace an asset reactively after a failure relative to a planned replacement, including overtime costs and productivity costs due to diverting resources from other tasks.

[25] Cost Benefit Analysis (CBA) checklist, Health and Safety Executive, United Kingdom, viewed on 8 October 2020 <http://www.hse.gov.uk/risk/theory/alarpcheck.htm>.

[26] https://www.aer.gov.au/system/files/Final%20decision%20-%20SA%20Power%20Networks%20distribution%20determination%202020-25%20-%20Attachment%205%20-%20Capital%20expenditure%20-%20June%202020.pdf

- **Asset repairs (linear assets only)** represents the cost of repairing assets after failure and only applies to linear assets due to their reparability.
- **Investigation costs** represent the cost of investigating the cause of consequences after-the-fact.
- **Property damage** represents the replacement or repair cost of property damaged or destroyed by the asset that failed (excluding damage due to a fire caused by the asset failure).

Most of the individual value metrics are calculated for five severity levels, with the remainder having a single fixed value (such as the reactive replacement premium, which can be assumed a single value that is independent of the failure mode or any other consequences).

TABLE 8 DIRECT FINANCIAL COST VALUE SCALE

ERMS definitions and values					
Rating of incident consequence	Insignificant	Minor	Moderate	Major	Severe
Measure of consequence of incident	< $500k	≥$500k and <$2m	≥$2m and <$10m	≥ $10m and < $25m	≥ $25m
Value attribution metrics					
Reasonable estimate of the costs if it can be calculated for an asset class. If not, a default value of 20% of the planned replacement unit rate.					
Current unit rates for repairs. If unit rates are not available, the rate should be calculated from a sample of recent historic repairs.					
Property damage costs are calculated for each asset class based on historic data.					
Risk Framework derived values					
Investigation costs (only applied when no other consequences are incurred)	$0	$15,000	$15,000	$50,000	$50,000
TOTAL COSTS	Value Attribution	Value Attribution + $15,000	Value Attribution + $15,000	Value Attribution + $50,000	Value Attribution + $50,000

Some financial costs to the network are excluded to avoid double counting. This includes payments related to regulatory incentive schemes.

The justification for each of these costs is set out in the following sections.

B.2.1 Reactive Replacement Premium

The reactive replacement premium should be based on the additional costs incurred to replace failed assets reactively. This should consider:

- After hour call-outs and overtime rates payable.
- Productivity loss due to diverting staff from planned works.
- Allocation of the annual cost of retaining on-call or reserve staff for emergency response.
- Allocation of the cost of equipment and spare parts kept at depots for emergency response.

If a reasonable estimate of the above costs can be calculated for an asset class, this should be used. If an estimate cannot be found a default value of 20% of the planned replacement unit rate should be used. This assumption is used by several of Power Water's peers when there is insufficient data available for a bottom up assessment.

For forecasts, reactive replacement premiums can be inflated using a network cost growth rate that is consistent with other forecasts and/or parameters used for regulatory forecasting purposes. If available, different escalation rates can be applied to the materials, labour and other cost components as appropriate.

B.2.2 Asset Repairs

Repair costs should be based on current unit rates for repairs of assets. Repair costs will differ depending on the type of failure that has occurred so should be calculated on a failure mode basis rather than a single value per asset. Repairs will only be applicable for a sub-set of failure modes. If unit rates are not available, the rate should be calculated from a sample of recent historic repairs.

B.2.3 Property Damage

Property damage costs cover damage to both network and non-network assets and other property caused by the failure of a network asset, excluding damage caused by fires which is calculated separately in the fire value dimension.

Property damage costs are calculated for each asset class based on historic data.

For forecasts, property damage costs can be inflated using a CPI forecast or held constant in real terms. If network assets are included within the damage costs and are significant, a network cost growth rate should be used instead.

B.3 Environmental

The value dimension of environment quantifies the cost of damage to the environment caused by the failure of network assets.

There are five value metrics for environment:

1. **Remediation costs** represents costs incurred by the network to return the environment to its pre-asset failure state
2. **Greenhouse gas emissions** represents the cost to society of the emission of gasses that may contribute to climate change
3. **Penalties** represents fines that could be levied by regulators or other bodies for allowing the damage to the environment to occur
4. **Investigation costs** represents the cost of carrying out investigations into the cause of the incident
5. **Litigation costs** represents the costs associated with any legal dealing resulting from the incident

Environmental costs may be incurred without the functional failure of an asset. This includes when an asset has defects that cause the leaking of liquids or gasses into the environment. Replacing the asset will address the defect and reduce the annual environmental cost to zero however there are costs to remediate the spilt liquid or gas.

The value of environmental risk shown in Table 9 and is calculated for five severity levels using the above value metrics. For significant scale investment decisions potential environmental impacts may be calculated directly using the value attribution methodology.

TABLE 9 ENVIRONMENTAL COSTS BY VALUE ATTRIBUTION AND VALUE SCALE

ERMS definitions and values					
Value scale metrics					
Rating of incident consequence	Insignificant	Minor	Moderate	Major	Severe
Measure of consequence of incident	Localised low level damage controlled but no remedial action required.	Localised low level damage controlled and remedied with minimal resources.	Widespread temporary damage with extended resources to remedy.	Long-term detrimental effect on environment and once controlled results in minor permanent damage.	Substantial permanent damage to widespread and sensitive areas.
ERMS definitions and values					
Remediation costs	This value metric incorporates costs incurred to clean-up environmental damage. This is limited to the clean-up of oil but may be expanded over time to include other materials that require clean-up. Oil clean-up costs are related to the quantity of oil spilled. The total cost for each severity level is as follows: Clean-up cost = Oil Capacity (Litres) × % lost to environment × Clean-up Cost per Litre				
Greenhouse gas emissions	This value metric places a value on greenhouse gas (GHG) emissions. GHG emissions result in societal costs due to their contribution to climate change. Value attribution is based on ~€50 (~AUD$80) per ton for EU ETS credits.				
Risk Framework derived values					
Penalties	$0	$0	$5,000	$50,000	$500,000
Investigation costs	$0	$0	$15,000	$15,000	$50,000
Litigation costs	$0	$15,000	$15,000	$100,000	$1,000,000
TOTAL COSTS	Value Attribution + $0	Value Attribution + $15,000	Value Attribution + $35,000	Value Attribution + $165,000	Value Attribution + $1,550,000

B.3.1 Remediation Costs

This value metric incorporates direct costs incurred by Power Water to remediate environmental damage. This is currently limited to the clean-up of oil but may be expanded over time to include the release of other materials that require environmental remediation. This value metric excludes fines and penalties incurred due to the release of materials.

Oil clean-up costs are related to the quantity of oil spilled. This is the same value as used for the Fines and Penalties value metric.

Severity levels relate to the percentage of the oil in the asset that escapes into the environment. The total cost for each severity level is as follows:

$$Remediation\ Cost = Oil\ Leaked\ into\ the\ Environment\ (Litres) \times Cleanup\ Cost\ per\ Litre$$

The volume of oil that leaks into the environment will depend on the oil capacity unique to each asset and the failure mode and the presence of protective equipment, such as bunding.

The clean-up cost per litre of oil released into the environment is monetised using the financial equivalence $3,000 per litre[27] in direct cost ground water impact. For self-contained fluid filled (SCFF) cables a detectable leak is one of at least 5L per day.

[27] Direct Cost Ground Water Impact (Deloitte Access Economics 2013, referenced in UPSS RIS)

For leaking assets that have not failed, the remediation cost is captured under the ongoing repair costs for the asset.

For the purposes of forecasting, environmental remediation costs can be inflated using a network cost growth rate that is consistent with other forecasts and/or parameters used for regulatory forecasting purposes.

B.3.2 Fines and Penalties

The key environmental statute for Northern Territory is Waste Management and Pollution Control Act 1998. Where an Act states that an offence is an environmental offence, the penalty for the level of environmental offence is set by the Environmental Offences and Penalties Act 1996 (NT). Environmental offences are expressed in one of four levels that relate to the penalties set out under the Act, by reference to a number of "penalty units". The penalties for level 1 offences are the most serious and the penalties decrease for level 2, 3 and 4 offences. The value of penalty units changes each year and is reported in the Penalty Unit Regulations. From 1 July 2018 the value of one penalty unit is $155.

Under the Environmental Offences and Penalties Act 1996, the maximum penalty amount for level 1 environmental offence is 19,240 penalty units (approx. $2.98 million). Detailed penalties for the different levels of offences can be found in sections 4 to 7 of the Act[28].

For simplicity of implementation, the Fines and Penalties component of Environmental will use the Penalties Value Metric (refer to appendix B.8.3) which is based on the likely costs and similar approaches by peer DNSPs.

B.3.3 Greenhouse Gas Emissions

This value metric places a value on greenhouse gas (GHG) emissions. GHG emissions result in societal costs due to their contribution to climate change.

Greenhouse gas (GHG) emissions can be valued using carbon prices and the mass, and an associated cost per unit mass (expressed in $/kg) of carbon emitted. Gasses other than carbon dioxide can be converted to a carbon-dioxide equivalent (CO2-e) using an appropriate conversion factor[29].

Although many stakeholders place a value on GHG emissions and would encourage investments to minimise such emissions, the NER limits the use of emissions pricing to cases where actual costs are incurred by a network. Currently, Power Water is not required to pay for emissions of GHG gasses so this value metric cannot be used in most cases for regulatory modelling. The main GHG that may be released by network assets is SF6, which is used as an insulator in switchgear. From the source above, 1kg of SF6 gas is equivalent to 22,800kg of CO2.

Future government policy relating to SF6 remains uncertain. This includes a future risk of a carbon price being applied to our SF6 leakages or stock.

There is in general no penalty associated with the release of SF6, but networks recognise that the release of this gas should be discouraged and that this needs to be incorporated into risk modelling to ensure replacement of assets that could release SF6 is appropriately prioritised. For this reason, several networks have included the equivalent carbon price of SF6 as a risk in REPEX modelling. This approach has been discussed with AER staff and has been allowed, in part due to the low contribution to aggregate risk from this value metric.

There are two prices that can be used:

- European Union (EU) Emissions Trading System prices, quoted in Euros and converted to Australian dollars. The EU scheme is one of the most well-established carbon pricing schemes

[28] Environmental Offences and Penalties Act 1996
[29] Conversion factors can be found here: https://www.industry.gov.au/data-and-publications/national-greenhouse-accounts-factors

globally and has high trading volumes and interacts with other international carbon pricing schemes so is an appropriate international price for carbon[30].

- Australian Carbon Credit Units (ACCU) prices, published by the Clean Energy Regulator represent a local price for carbon. The market is shallow compared to international markets and prices are in part determined by government policy, which does not currently require most emitters to participate in the market[31].

As of June 2021, the most recent prices are approximately €50 (~AUD$80) per ton for EU ETS credits and AUD$16.90 per ton for ACCUs. The higher EU ETS price is more representative of societal costs, although academic studies into the true societal cost (as opposed to a market-based price) may calculate different values. Market prices are preferred as a value metric due to the uncertainty of, and lack of agreement between, other sources. Accordingly, the EU prices are the preferred method for valuing the economic costs.

If Power Water is required to pay for emissions at a future date, the value metric could be the higher of either the previously used value (the societal cost) or the emissions price (a financial cost) or be set to the emissions price. Retaining the higher societal cost is justified on the basis of it still being representative of actual societal costs and avoids the case of risk dropping significantly if Power Water becomes liable for only small payments related to emissions.

If an emissions price becomes applicable, the societal cost and financial cost are not additive as the financial cost relates to the same societal cost.

Penalties incurred due to failing to meet emissions targets are included in the fines and penalties value metric. If these penalties represent recovery of a societal cost (i.e. are not additive), they must be subtracted from the greenhouse gas emissions value metric to avoid double counting.

For the purposes of forecasting, the carbon price can be inflated using a CPI forecast or held constant in real terms. If a carbon price forecast is available that should be used instead.

B.4 Compliance

The Compliance measure reflects the costs of non-compliance with legal or regulatory obligations. The implementation of the compliance Value Dimension is generally reserved for business cases to justify expenditure for individual projects and programs, rather than for risk costs associated with an asset failure.

Power and Water considers that it is not an acceptable position to not comply with obligations. However, not all compliance obligations are set based on the same criteria. For instance, some obligations require best endeavours to comply whereas other obligations require more strict compliance.

In this regard, the cost of the most efficient option to achieve compliance is the first aspect of assessing the priority of the expenditure against other drivers. The costs of not complying can then be considered and both costs used to assess and determine the timeframe over which the expenditure will be incurred.

There are two value metrics for Compliance:

1. **Penalties** represents fines that could be levied by regulators or other bodies for not complying
2. **Litigation costs** represents the costs associated with any legal dealing resulting from the non-compliance

The Penalties value metric reflects the costs of penalties / fines levied on the business, generally associated with not meeting legal or regulatory obligations.

Costs associated with penalties are estimated for different consequence severities as shown in Table 10.

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[30] Historical and current prices can viewed here: https://ember-climate.org/data/carbon-price-viewer/

[31] Prices are available in quarterly market report: http://www.cleanenergyregulator.gov.au/csf/market-information/Pages/quarterly-Market-report.aspx

TABLE 10 COMPLIANCE COST VALUE SCALE

ERMS definitions and values					
Rating of incident consequence	Insignificant	Minor	Moderate	Major	Severe
Measure of consequence of incident	Legal issues managed by corporate procedures or practices; and/or Breach of internal policies or procedures without the need for formal investigation.	Matter requires legal advice to address issues; and/or Internal breach of policies or procedures requiring a formal investigation.	Required to operate under limited regulatory restrictions or orders; and/or Incident which requires legal representation resulting in court proceeding.	Required to operate under significant regulatory restrictions or orders; and/or Government inquiry/ intervention.	Criminal charges / civil litigation against the Corporation and/or Officers; and/or Operating licences revoked.
Risk Framework derived values					
Penalties	$0	$5,000	$50,000	$500,000	$2,000,000
Litigation costs	$0	$15,000	$100,000	$1,000,000	$10,000,000
TOTAL COSTS	$0	$35,000	$155,000	$1,550,000	$12,050,000

B.5 Service Delivery

The value dimension of Service Delivery quantifies costs associated with the network failing to provide its primary objective, to transport electricity from sources to loads. The value metric for network performance is Loss of Supply (Expected Unserved Energy) and represents the economic cost associated with a failure of the network to supply electricity

There are three value metrics for Service Delivery:

1. **Unserved energy** represents the volume of energy not supplied due to a failure of the network to supply electricity.
2. **Distributed energy resources including** lost generation output due to a failure of the network that prevents export of energy or delivery of the generated electricity to loads.
3. **Value of Customer Reliability (VCR)** represents the economic cost due to lost supply.

Each of these are described in detail below.

B.5.1 Unserved Energy (Loss of Supply)

The energy at risk or load impacted is the expected amount of energy interrupted due to a network failure or constraint. Unserved energy is the quantity of energy, measured in kilowatt hours (kWh), that would not be supplied to customers due to a network outage, capacity constraint or otherwise an inability to supply the existing demand.

Unserved energy can be calculated using common industry approaches and is typically a critical input to assessing the economic cost of, and benefits of addressing, an identified constraint or issue. There are three common approaches to calculating the value of unserved energy, however, other methods can be applied provided the methodology is suitable and achieves the intended outcome for determining the quantum of energy not supplied. The three approaches can be applied as appropriate to the constraint or network need that is being identified. These are explained under Value attribution along with Lost embedded generation and customer export curtailment.

For investments where the potential energy at risk and loss of supply impact is significant, more detailed load flow and network state numeration techniques are used to derive more accurate representations of the energy at risk.

The total energy is then multiplied by the probability of failure to calculate the Expected Unserved Energy, and then it is multiplied by the Value of Customer Reliability (VCR) to calculated the dollar value.

The VCR is a dollar value per MWh that represents the economic cost of the energy not supplied. The value is disaggregated by customer type, state and network region based on analysis by the AER with updates published by the AER annually. Refer to section 4.3.3 for further information.

B.5.2 Historical data from the outage management system

The outage management system calculates the energy not supplied for each outage event. This data is easily available and includes asset information including the asset type, outage cause, network region, feeder data and customers affected.

Basing the amount of unserved energy on historical data is the preferred approach for distribution assets where there is sufficient historical information and events for the particular issue being investigated. Analysis of this data can be used to determine an expected value and can be disaggregated to network area and scenarios as appropriate for the analysis.

B.5.3 Approximation based on network characteristics

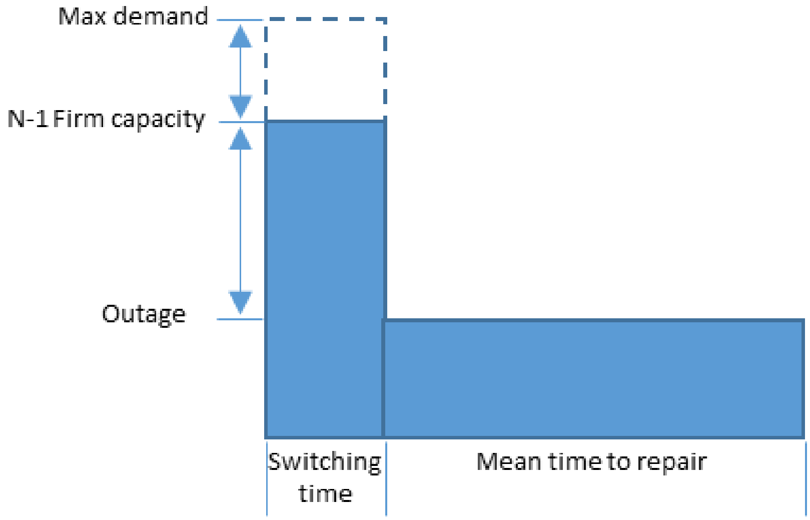
Where there is insufficient data available in the outage management system, or the basis of the data is not appropriate for the analysis, a simplified assessment on an individual outage basis can be undertaken. This approach is suitable for network distribution assets.

The following parameters are required:

- Average maximum demand in MW on the asset type. This can be determined based on the feeder demand history or the number of customers downstream from the asset and either their actual billing data or customer average demand.
- The Firm Capacity, which is the amount of load covered by redundant supply (the N-1 capacity)
- The amount of transfer capacity, that is, how much load can be transferred away using network switching which enables calculation of the demand that will not be supplied for the
- Switching time which is the duration to switch the network to isolate the asset to allow work to commence.
- Mean time to repair (MTTR) the asset, taken from the time the asset is isolated through to restoration of full supply.

Figure 12 below shows how this is used to determine a high-level estimate for an outage.

FIGURE 12 OVERVIEW OF THE PARAMETERS TO APPROXIMATE ENERGY AT RISK



The calculation as a formula is:

$$Unserved\ Energy = Firm\ Capacity\ x\ Switching\ time + \ Outage\ x\ MTTR$$

This amount is then multiplied by the number of assets expected to fail and cause an outage and the probability of the assets failing to determine the total expected unserved energy.

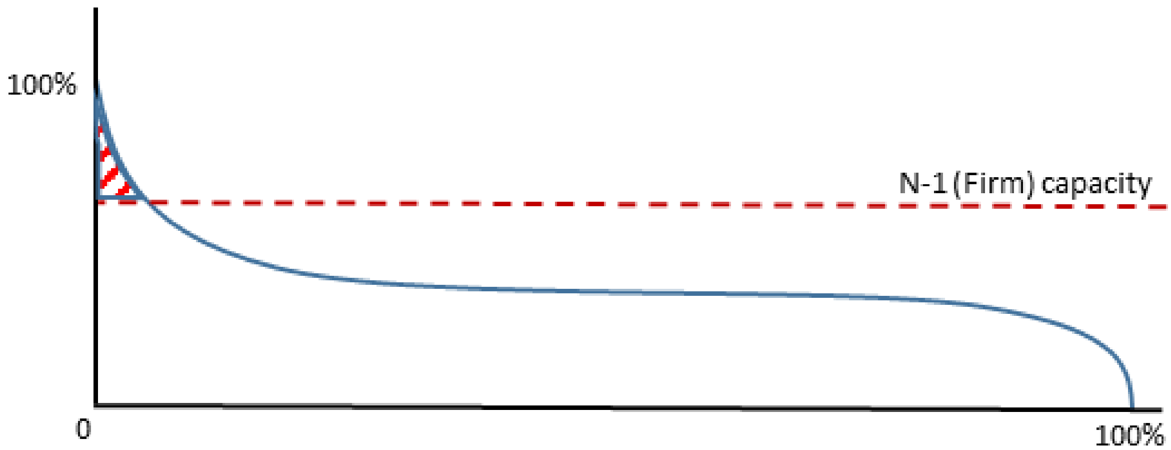
B.5.4 Calculation using load duration curves

When considering high value assets, in particular power transformers and circuit breakers at zone substations, using Load Duration Curves (LDC) is the preferred method. An example LDC is shown in Figure 13 below. A LDC is created by gathering a full year of demand data as measured at the zone substation, arranging it from highest to lowest and plotting it on a chart.

The shaded section on the LDC shows the amount of energy that would be at risk in the event of the outage of the largest capacity asset. The N-1 rating of the substation can be shown to identify the amount of energy that would not be supplied during an outage that lasted a year. Since load will typically be resolved in a shorter time period, the energy at risk is multiplied by the duration of an expected outage (as a proportion of the year)

The energy at risk is then multiplied by the probability of the event occurring to calculate the expected energy at risk. The expected energy at risk is then multiplied by the VCR to calculate the value of the risk cost.

FIGURE 13 INDICATIVE LOAD DURATION CURVE



B.5.5 Value of Customer Reliability

Value of Customer Reliability (VCR) is published by the AER annually and describes the dollar value per kilowatt hour (kWh) disaggregated across multiple customer demographics, including customer type and location. The values relevant to Power Services are shown in Table 11[32].

TABLE 11 VCR VALUES FOR THE NORTHERN TERRITORY (AER VCR ANNUAL ADJUSTMENT, PUBLISHED DECEMBER 2021)

Customer segment	VCR ($ per kWh, real FY22)
Residential	$18.99 per kWh
Commercial	$46.18 per kWh
Industrial	$66.16 per kWh
Agricultural	$39.28 per kWh

B.5.6 Distributed energy resources

Distributed Energy Resources (DERs) cover a range of energy sources including residential solar PV and community batteries through to commercial scale embedded generators (regardless of fuel source/type). DERs present risks and opportunities to networks and the increase in penetration has led the AEMC, and subsequently the AER, to consider their integration and approaches to valuing their impact on networks.

The CECV is proposed to reflect the benefits to the generator as well as to all consumers on the network and applied in a similar manner as the Value of Customer Reliability (VCR), but when assessing investments that are focused on increasing the hosting capacity of the network.

The AER released a Draft DER integration expenditure guidance note in July 2021 and a Draft Customer export curtailment value methodology in April 2022. The documents discuss the integration and value of DERs, and in particular the value to the market and customers of enabling additional hosting (connection) of DERs. This has been termed the Customer Export Curtailment Value (CECV).

The Explanatory Statement[33] which accompanies the draft methodology states that the CECV will not apply to Power and Water, however, it expects that Power and Water will develop its own estimation of the benefits associated with avoided dispatch costs which reflects the AER's CECV methodology and accounts for the temporal nature of those cost and alleviation profile associated with any DER integration investments[34].

Power and Water has undertaken the appropriate analysis of their network and market characteristics to develop a CECV that is applicable to our unique situation. In the Northern Territory gas is the marginal fuel source, and a unit increase in solar exports results in a unit decrease in gas-fired generation. Power and Water's analysis found that the value of additional DER exports, predominately from embedded solar PV, was derived from a reduction in the usage, and therefore cost, of natural gas used by the thermal generation as well as a reduction in electricity losses from transmission and distribution.

The savings are therefore the benefits received by customers from additional capacity for DERs and are the proposed Customer Export Curtailment Value (CECV). The value has been calculated to be between $103/MWh and $121/MWh over the 30 year horizon. This is made up of the gas fuel cost, which varies over time, the efficiency of a gas generator, and the distribution and transmission losses.

[32] The latest published version of the VCR update located at https://www.aer.gov.au/networks-pipelines/guidelines-schemes-models-reviews/values-of-customer-reliability
[33] AER, Explanatory statement: Draft Customer export curtailment value methodology, April 2022
[34] Ibid, page 19

The CECV is applied by calculating the quantity of additional exports (in MWh) that could be achieved through a particular action and then multiplying it by the CECV. The monetized value can then be used in a cost benefit analysis to identify the net benefit of the proposed investment.

B.6 Customer experience

The Customer Experience measure represents the impacts associated with customer complaints arising from an adverse experience with Power Water as a service provider.

There are two value metrics for Customer Experience:

1. **Customer engagement** represents cost incurred to manage customer experience
2. **Investigation costs** represents the costs to investigate customer complaints

The customer experience value dimension is included for so that certain investments with potentially higher (i.e. more positive) customer experience benefit are prioritised over similar investments that do not. The value we have applied to this dimension is based on analysis of peer DNSPs. Table 12 provides a comparison to values used by peer DNSPs and Table 13 summarises how they combine to create a total value for each severity level.

TABLE 12: CUSTOMER EXPERIENCE COSTS BY SEVERITY LEVEL

Severity Level	Typical Event	Value per Event	Average of peers[35]	Median of peers
Insignificant	No additional costs incurred	$0	$8,811	$1,000
Minor	Media briefing made available through website (or equivalent)	$1,500	$40,748	$4,993
Moderate	Engagement with councils and media	$11,500	$106,120	$55,000
Major	Door knocks, community consultation, government briefing	$75,000	$322,476	$100,000
Severe	Extensive consultation across all stakeholder groups	$175,000	$852,224	$287,500

TABLE 13 CUSTOMER EXPERIENCE COST VALUE SCALE

ERMS definitions and values					
Rating of incident consequence	Insignificant	Minor	Moderate	Major	Severe
Measure of consequence of incident	<2% increase in complaints Local or individual stakeholder attention	2-5% increase in complaints Adverse public or stakeholder attention from multiple stakeholder groups <1 week	5-10% increase in complaints Adverse public or stakeholder attention from multiple stakeholder groups <1 month	10-20% increase in complaints Adverse public or stakeholder attention from multiple stakeholder groups >1 month	>20% increase in complaints Irreparable damage to brand or reputation
Risk Framework derived values					
Customer engagement	$0	$1,500	$11,500	$75,000	$175,000
Investigation costs	$0	$0	$0	$15,000	$15,000
TOTAL COSTS	Value Attribution plus $0	Value Attribution plus $1,500	Value Attribution plus $11,500	Value Attribution plus $90,000	Value Attribution plus $190,000

B.7 Fire

The value dimension of Fire quantifies losses, both property and lives, as a result of fires started by the failure of network assets.

There are three value metrics that contribute to the Fire value dimension:

1. **Safety, property and other costs** represents the cost to the community as a result of a fire start
2. **Investigation costs** represents the costs to investigate customer complaints
3. **Litigation costs** represents the cost of legal representation, court fees and the possible awarding of costs against Power Water

The value of Fire is determined for five severity levels, as shown in Table 14, based on a comparison and assessment of the fire risk determined by peer DNSPs. These values have been adjusted based on the fire risk of those networks compared to that in which Power and Water operates.

[35] Ibid 15

TABLE 14 FIRE COST VALUE SCALE

ERMS definitions and values					
Value scale metrics					
Rating of incident consequence	Insignificant	Minor	Moderate	Major	Severe
Measure of consequence of incident	Fire start	Land damage, no property lost	< 10 properties lost	< 20 properties lost	> 20 properties lost
Risk Framework derived values					
Safety, property and other costs	$0	$20,000	$750,000	$2,000,000	$15,000,000
Investigation costs	$0	$0	$15,000	$50,000	$50,000
Litigation costs	$0	$15,000	$100,000	$1,000,000	$10,000,000
TOTAL COSTS	$0	$35,000	$815,000	$3,050,000	$25,050,000

Table 15 describes the severity levels and how they compare to peer DNSPs. There has only been one known network fire start in recent times that resulted in damage to a property, and the costs claimed by the affected party were $600k and the final settlement amount was $191k. The values have been scaled down from the peer DNSPs to a level that is reflective of Power and Water's circumstances.

TABLE 15: FIRE VALUE OF CONSEQUENCE BY SEVERITY LEVEL

Severity Level	Typical Event	Value per Event	Average of peers[36]	Median of peers
Insignificant	Fire start	$0	$5,095,493	$14,167
Minor	Land damage, no property lost	$20,000	$20,581,310	$233,677
Moderate	< 10 properties lost	$750,000	$23,961,238	$2,626,905
Major	< 20 properties lost	$2,000,000	$61,459,734	$32,375,000
Severe	> 20 properties lost	$15,000,000	$238,377,979	$175,389,897

B.8 Other cost components

The items described below are not individual value dimensions, but contribute to multiple different value dimensions. These sections describe the severity of each level and provides a comparison to values used by peer DNSPs.

B.8.1 Investigation Costs

Investigation costs represent the cost of investigating the root-cause of an event after it has occurred. The value of these costs can be categorised into three levels of investigation based on the resources involved and the extent of the investigation.

[36] Ibid 15

TABLE 16: INVESTIGATION COSTS BY INVESTIGATION SIZE

Level	Investigation Cost	Average of peers[37]
Internal	$0	$4,462
Internal with external support	$15,000	$47,455
Independent external	$50,000	$236,200

For the purpose of forecasting, investigation costs can be inflated using a CPI forecast or held constant in real terms.

B.8.2 Litigation Costs

Litigation costs cover the cost of legal representation, court fees and the possible awarding of costs against Power Water due to any litigation triggered by an asset failure.

Reparation payments that may be awarded against Power Water following litigation are presumed to convert societal risks incurred into financial costs. As such, these risks are already included within other value metrics so are excluded from the litigation costs value metric to avoid double counting. For example, if a court orders payments to a person severely injured by a failed network asset, the financial payment received by the victim would only offset some of the personal costs already incurred (and already counted in total risk by the safety value metrics) by the individual due to being injured.

Litigation costs are estimated for different consequence severities.

TABLE 17: LITIGATION COSTS BY SEVERITY LEVEL

Severity Level	Typical Event	Value per Event	Average of peers[38]
Insignificant	Litigation or dispute unlikely. Briefing to regulator, government.	$0	$1,028
Minor	Non litigated dispute or negotiation.	$15,000	$19,189
Moderate	Up to 1 year litigation.	$100,000	$62,282
Major	Up to 3 years litigation.	$1,000,000	$989,653
Severe	More than 3 years of litigation.	$10,000,000	$10,541,515

B.8.3 Penalties

The Penalties value metric reflects the costs of penalties / fines levied on the business, generally associated with not meeting legal or regulatory obligations. Costs associated with penalties are estimated for different consequence severities as shown in Table 18.

TABLE 18: PENALTY COSTS BY SEVERITY LEVEL

Severity Level	Typical Event	Value per Event	Average of peers[39]
Insignificant	Customer complaints.	$0	$0
Minor	Information or briefing to regulator. Fines unlikely.	$5,000	$6,392
Moderate	Negotiation with regulator (minor litigation). Voluntary amendments to practises. Potential fines up to $100k.	$50,000	$53,701
Major	Direction from regulator to amend practices. Potential fines up to $500k.	$500,000	$504,765
Severe	Licence restrictions	$2,000,000	$1,678,937

[37] Ibid 15
[38] Ibid 15
[39] Ibid 15

Appendix C. Basis of probabilities

This appendix describes the information sources that were used to create the probability and likelihood values and any calculations used.

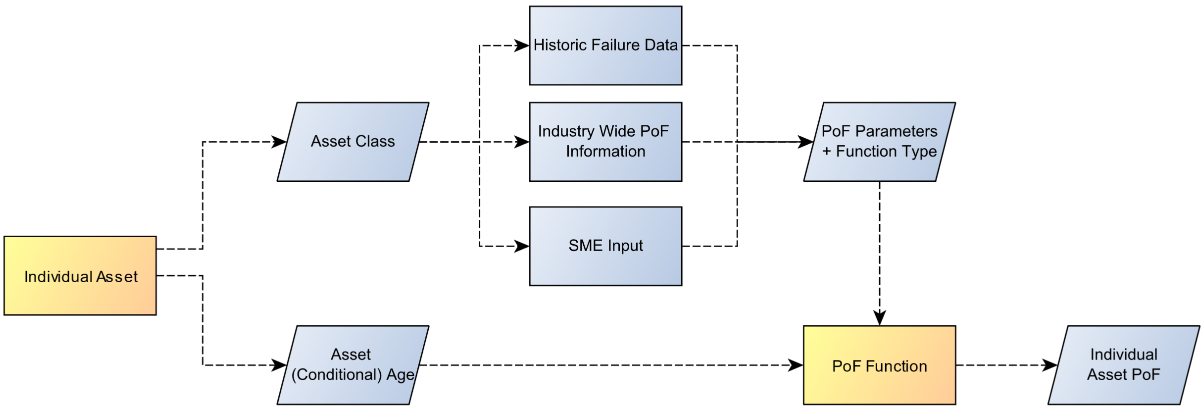
C.1 Probability of failure

A common approach to predicting an asset/asset class probability of failure is to use past failure data to derive a relationship between an asset's age and its probability of failure at that age.

This is typically done by analysing historical data for the age at failure (or replacement to supplement small data sets) and fitting it to a statistical distribution. Power Services prefers the use of a Weibull Distribution followed by a Normal Distribution. The Weibull function is among the most commonly used PoF functions in the electricity industry, has been endorsed by the AER and is widely used in other industries[40], particularly where mechanical wear is a major contributor to asset failure. For assets which provide little or no correlation with age, suitable alternative methods can be used such as a simple trend of historical failure data.

The parameters of the Weibull function are calculated for each asset group by assessing and considering the data and steps shown in Figure 14.

FIGURE 14 APPROACH TO CALCULATING PROBABILITY DISTRIBUTION PARAMETERS



If any sub-groups of assets within a group of assets exhibit a sufficiently different PoF function to the rest of the group, this indicates that the group should be split to enable some of the assets to have a different PoF function.

Evidence should be provided to support assumptions, especially where there are forecast increases to failure rates/probability, as these assumptions will influence the timing of retirement indicated by the economic analysis.

The use of a probability distribution is commonly used where a single asset failure mode is the dominate source of failure and assumes that an asset experiences a non-repairable[41] functional failure during a given year.

C.2 Likelihood of consequence

Likelihood of consequence (LoC) is determined for each asset type for each consequence category. That is, for each asset type and each possible consequence, a value is determined for the likelihood of that consequence occurring.

[40] Australian Energy Regulator, industry practice application note Asset Replacement Planning, Common methods of statistical distribution (pg 44), 25 January 2019

[41] This only applies to non-linear assets. Linear asset failures may be repairable.

Depending on data availability, the LoC for each consequence category is estimated using one of the following three approaches (in order of preference):

1. Historic observed consequence rates after functional failures of Power and Water's assets of a particular asset type
2. Bottom-up estimates where other events are required to occur near-simultaneously for a consequence to be observable. This is appropriate for redundant systems where the probability of multiple failures occurring is the main driver of LoC.
3. Industry Average LoC values used by related businesses/organisations for similar asset types

The preference is to use historic Power and Water data. Using this approach, the LoC is calculated by dividing the number of observed consequences (for each risk type) by the number of observed functional failures for that asset type. This approach requires both asset failures and consequences to have occurred (and have been accurately recorded) in the past so that an LoC can be determined.

Bottom-up estimates are a reasonable alternative for low probability risks that are unlikely to have been observed historically in sufficient numbers to obtain a reasonable sample size. In these cases, using a LoC with the correct order of magnitude may be sufficient. The probability of other events that need to occur may be known (for instance the failure rates for other assets) and a SME estimate of the likelihood of a consequence occurring given all other events occur will be sufficient.

If neither of the other approaches are available, an external source will be used. The LoC in the external source should be compared to the historic data available for Power and Water to ensure the estimate is reasonable. For example, if Power and Water has had historic failures within the asset type but has not observed any consequences for a particular type of risk, the LoC should be sufficiently low that there would be a reasonable chance of not observing a consequence in the following years.

Sources of industry values used include data from other networks in Australia and from Ofgem (UK). A summary of the key data sources are listed in Table 19.

C.3 Probability of severity

The PoS input parameters are estimated using historic consequence data where available. This is preferably related to consequences of an individual asset type, but where different asset types have similar consequences, averages over a larger number of asset types may be used.

Where historic data and/or SME/industry estimates are only available for some of the severity levels, a log-normal distribution is used to extrapolate the probabilities for other severity levels. This can be applied as:

- Where none or one severity level has an observed consequence:
  - Each increase in severity has 1/10th of the probability of the lower severity event (order of magnitude approach)
- Where two severity levels have observed consequences:
  - Use the available data points to calculate a logarithmic function for the PoS at each severity level

A summary of the key data sources are listed in Table 19.

TABLE 19 LIKELIHOOD OF CONSEQUENCE SOURCES

Consequence Category	Likelihood of Consequence	Probability of Severity
Network Performance	Outage reporting data	N/A
Worker Safety	Derived from Ofgem values	Derived from Ofgem values
Public Safety	Derived from Ofgem values	Derived from Ofgem values
Environment	Power and Water historical incident rate	Initial basis is from PoS values in use by peer networks, refined through Power and Water SME input.
Fire	Power and Water historical incident rate	Initial basis is from PoS values in use by peer networks, refined through Power and Water SME input.
Other	Power and Water historical incident rate	Initial basis is from PoS values in use by peer networks, refined through Power and Water SME input.

C.4 Summary of probability values

The following tables set out the likelihoods of consequence and probabilities of severity that should be used as a starting point and amended or replaced to suit Power and Water network specific data that is relevant to the asset class being assessed.

SME discretion is required to ensure the values are appropriate. Where different values are selected, the SME must provide a justification for the revised values.

C.4.1 Probability of severity by value metric (excluding safety)

Value Metric	Insignificant	Minor	Moderate	Major	Significant
Investigation	70.0%	20.0%	9.0%	0.9%	0.1%
Worker - Investigation and Litigation	50.0%	25.0%	15.0%	7.5%	2.5%
Public - Investigation and Litigation	50.0%	25.0%	15.0%	7.5%	2.5%
Fines and Penalties	70.0%	20.0%	9.0%	0.9%	0.1%
Safety	70.0%	20.0%	9.0%	0.9%	0.1%
Property	70.0%	20.0%	9.0%	0.9%	0.1%
Investigation and Litigation	70.0%	20.0%	9.0%	0.9%	0.1%
Investigation Costs	50.0%	25.0%	15.0%	7.5%	2.5%
Litigation Costs	50.0%	25.0%	15.0%	7.5%	2.5%
By third party	50.0%	25.0%	15.0%	7.5%	2.5%
To third party	50.0%	25.0%	15.0%	7.5%	2.5%
Compliance	50.0%	25.0%	15.0%	7.5%	2.5%
Customer Engagement	50.0%	25.0%	15.0%	7.5%	2.5%
Investigation Costs	50.0%	25.0%	15.0%	7.5%	2.5%

C.4.2 Probability of severity for Safety

Asset type	Worker Minimal	Worker Minor	Worker Moderate	Worker Major	Worker Severe	Public Minimal	Public Minor	Public Moderate	Public Major	Public Severe	Worker LoC	Public LoC
20kV Poles	0.49020	0.32680	0.16340	0.01471	0.00490	0.49020	0.32680	0.16340	0.01471	0.00490	0.00028	0.00055
LV Poles	0.49020	0.32680	0.16340	0.01471	0.00490	0.49020	0.32680	0.16340	0.01471	0.00490	0.00083	0.00166
6.6/11kV Poles	0.49020	0.32680	0.16340	0.01471	0.00490	0.49020	0.32680	0.16340	0.01471	0.00490	0.00028	0.00055
66kV Pole	0.49020	0.32680	0.16340	0.01471	0.00490	0.49020	0.32680	0.16340	0.01471	0.00490	0.00028	0.00055
33kV Fittings	0.41667	0.27778	0.13889	0.12500	0.04167	0.41667	0.27778	0.13889	0.12500	0.04167	0.00065	0.00013
66kV Fittings	0.41667	0.27778	0.13889	0.12500	0.04167	0.41667	0.27778	0.13889	0.12500	0.04167	0.00065	0.00013
132kV Fittings	0.41667	0.27778	0.13889	0.12500	0.04167	0.41667	0.27778	0.13889	0.12500	0.04167	0.00065	0.00013
33kV OHL (Tower Line) Conductor	0.41667	0.27778	0.13889	0.12500	0.04167	0.41667	0.27778	0.13889	0.12500	0.04167	0.00065	0.00013
66kV OHL Conductor	0.41667	0.27778	0.13889	0.12500	0.04167	0.41667	0.27778	0.13889	0.12500	0.04167	0.00065	0.00013
132kV OHL (Tower Line) Conductor	0.41667	0.27778	0.13889	0.12500	0.04167	0.41667	0.27778	0.13889	0.12500	0.04167	0.00065	0.00013
33kV UG Cable (Non Pressurised)	0.45455	0.30303	0.15152	0.06818	0.02273	0.45455	0.30303	0.15152	0.06818	0.02273	0.00000	0.00000
66kV UG Cable (Non Pressurised)	0.45455	0.30303	0.15152	0.06818	0.02273	0.45455	0.30303	0.15152	0.06818	0.02273	0.00000	0.00000
6.6/11kV Transformer (GM)	0.01953	0.03906	0.05860	0.22070	0.66210	0.01953	0.03906	0.05860	0.22070	0.66210	0.00022	0.00026
20kV Transformer (GM)	0.01953	0.03906	0.05860	0.22070	0.66210	0.01953	0.03906	0.05860	0.22070	0.66210	0.00022	0.00026
132kV Transformer (GM)	0.01953	0.03906	0.05860	0.22070	0.66210	0.01953	0.03906	0.05860	0.22070	0.66210	0.00355	0.00007
6.6/11kV Switch (GM)	0.01953	0.03906	0.05860	0.22070	0.66210	0.01953	0.03906	0.05860	0.22070	0.66210	0.00022	0.00026

6.6/11kV CB (GM) Primary	0.01953	0.03906	0.05860	0.22070	0.66210	0.01953	0.03906	0.05860	0.22070	0.66210	0.00222	0.00013
66kV CB (Air Insulated Busbars)(ID)(GM)	0.01953	0.03906	0.05860	0.22070	0.66210	0.01953	0.03906	0.05860	0.22070	0.66210	0.00222	0.00013
132kV CB (Air Insulated Busbars)(ID)(GM)	0.01953	0.03906	0.05860	0.22070	0.66210	0.01953	0.03906	0.05860	0.22070	0.66210	0.00355	0.00007

C.4.3 Likelihood of consequence by asset class

Asset Class Description	Network Performance – Loss of Supply	Network Performance – Investigation	Safety – Worker	Safety – Worker – Investigation and Litigation	Safety – Public	Safety – Public – Investigation and Litigation	Environment – Remediation Costs	Environment – Fines and Penalties	Environment – GHG	Fire – Safety	Fire – Property	Fire - Investigation and Litigation	Direct Financial - Reactive Replacement Premium	Direct Financial - Asset Repairs	Direct Financial - Investigation Costs
Poles-> 22 kV & < = 66 kV; Concrete	20%	20%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	80%
Poles-< = 1 kV; Steel	100%	100%	0.083%	0.083%	0.166%	0.166%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Poles-> 1 kV & < = 11 kV; Steel	100%	100%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Poles-> 11 kV & < = 22 kV; Steel	100%	100%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Poles-> 22 kV & < = 66 kV; Steel	20%	20%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	80%
Poles-> 66 kV & < = 132 kV; Steel	20%	20%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	80%
Pole Tops-< = 1 kV	100%	100%	0.083%	0.083%	0.166%	0.166%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Pole Tops-> 1 kV & < = 11 kV	100%	100%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Pole Tops-> 11 kV & < = 22 kV	100%	100%	0.065%	0.065%	0.013%	0.013%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Pole Tops-> 22 kV & < = 66 kV	100%	100%	0.065%	0.065%	0.013%	0.013%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Pole Tops-> 66 kV & < = 132 kV	20%	20%	0.065%	0.065%	0.013%	0.013%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	80%
Overhead Conductors-< = 1 kV	100%	100%	0.083%	0.083%	0.166%	0.166%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	0%
Overhead Conductors-> 1 kV & < = 11 kV	100%	100%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	0%
Overhead Conductors-> 11 kV & < = 22 kV ; SWER	100%	100%	0.028%	0.028%	0.055%	0.055%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	0%
Overhead Conductors-> 11 kV & < = 22 kV ; Multiple-Phase	100%	100%	0.065%	0.065%	0.013%	0.013%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	0%
Overhead Conductors-> 22 kV & < = 66 kV	20%	20%	0.065%	0.065%	0.013%	0.013%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	80%
Overhead Conductors-> 66 kV & < = 132 kV	20%	20%	0.065%	0.065%	0.013%	0.013%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	80%

Underground Cables-< = 1 kV	100%	100%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	0%
Underground Cables-> 1 kV & < = 11 kV	100%	100%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	0%
Underground Cables-> 11 kV & < = 22 kV	100%	100%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	0%
Underground Cables-> 33 kV & < = 66 kV	20%	20%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0.09%	0.09%	0.09%	0%	100%	80%
Service Lines-< = 11 kV ; Residential ; Simple Type	100%	100%	0.083%	0.083%	0.166%	0.166%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Service Lines-< = 11 kV ; Commercial & Industrial ; Simple Type	100%	100%	0.083%	0.083%	0.166%	0.166%	0%	0%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Pole Mounted ; < = 22kV ; < = 60 kVA ; Single Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Pole Mounted ; < = 22kV ; > 60 kVA and < = 600 kVA ; Single Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Pole Mounted ; < = 22kV ; < = 60 kVA ; Multiple Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Pole Mounted ; < = 22kV ; > 60 kVA and < = 600 kVA ; Multiple Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Pole Mounted ; < = 22kV ; > 600 kVA ; Multiple Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Kiosk Mounted ; < = 22kV ; < = 60 kVA ; Single Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Kiosk Mounted ; < = 22kV ; > 60 kVA and < = 600 kVA ; Single Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Kiosk Mounted ; < = 22kV ; > 60 kVA and < = 600 kVA ; Multiple Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Kiosk Mounted ; < = 22kV ; > 600 kVA ; Multiple Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Ground Outdoor / Indoor Chamber Mounted; < 22 kV ; > 60 kVA and < = 600 kVA ; Multiple Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Ground Outdoor / Indoor Chamber Mounted; < 22 kV ; > 600 kVA ; Multiple Phase	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Ground Outdoor / Indoor Chamber Mounted; > = 22 kV & < = 33 kV ; < = 15 MVA	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%

Transformers-Ground Outdoor / Indoor Chamber Mounted; > = 22 kV & < = 33 kV ; > 15 MVA and < = 40 MVA	20%	20%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	77%
Transformers-Ground Outdoor / Indoor Chamber Mounted; > 33 kV & < = 66 kV ; < = 15 MVA	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Transformers-Ground Outdoor / Indoor Chamber Mounted; > 33 kV & < = 66 kV ; > 15 MVA and < = 40 MVA	20%	20%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	77%
Transformers-Ground Outdoor / Indoor Chamber Mounted; > 33 kV & < = 66 kV ; > 40 MVA	20%	20%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	77%
Transformers-Ground Outdoor / Indoor Chamber Mounted; > 66 kV & < = 132 kV ; < = 100 MVA	20%	20%	0.355%	0.355%	0.007%	0.007%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	77%
Transformers-Ground Outdoor / Indoor Chamber Mounted; > 66 kV & < = 132 kV ; > 100 MVA	20%	20%	0.355%	0.355%	0.007%	0.007%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	77%
Transformers-Other	100%	100%	0.022%	0.022%	0.026%	0.026%	2.6%	3%	0%	0.09%	0.09%	0.09%	100%	0%	0%
Switchgear-< = 11 kV ; Switch	100%	100%	0.022%	0.022%	0.026%	0.026%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	0%
Switchgear-< = 11 kV ; Circuit Breaker	100%	100%	0.222%	0.222%	0.013%	0.013%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	0%
Switchgear-> 11 kV & < = 22 kV ; Switch	100%	100%	0.022%	0.022%	0.026%	0.026%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	0%
Switchgear-> 11 kV & < = 22 kV ; Circuit Breaker	100%	100%	0.222%	0.222%	0.013%	0.013%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	0%
Switchgear-> 33 kV & < = 66 kV ; Switch	20%	20%	0.222%	0.222%	0.013%	0.013%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	79%
Switchgear-> 33 kV & < = 66 kV ; Circuit Breaker	20%	20%	0.222%	0.222%	0.013%	0.013%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	79%
Switchgear-> 66 kV & < = 132 kV ; Switch	20%	20%	0.355%	0.355%	0.007%	0.007%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	78%
Switchgear-> 66 kV & < = 132 kV ; Circuit Breaker	20%	20%	0.355%	0.355%	0.007%	0.007%	1.1%	1%	100%	0.09%	0.09%	0.09%	100%	0%	78%
SCADA, NETWORK CONTROL AND PROTECTION SYSTEMS BY-Field Devices	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
SCADA, NETWORK CONTROL AND PROTECTION SYSTEMS BY-Local Network Wiring Assets	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%

SCADA, NETWORK CONTROL AND PROTECTION SYSTEMS BY-Communications Network Assets	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
SCADA, NETWORK CONTROL AND PROTECTION SYSTEMS BY-Master Station Assets	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
SCADA, NETWORK CONTROL AND PROTECTION SYSTEMS BY-Communications Site Infrastructure	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
SCADA, NETWORK CONTROL AND PROTECTION SYSTEMS BY-Communications Linear Assets	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Buildings	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Instrument Transformers	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Metering Units	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Pillars	0%	0%	0.042%	0.042%	0.049%	0.049%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Substation Auxiliary Plant	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Voltage Regulators	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Civil and Grounds	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Fire Systems	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Capacitor Banks	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Power Transformer Refurbishment	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%
Other-Pole Refurbishment	0%	0%	0.000%	0.000%	0.000%	0.000%	0%	0%	0%	0%	0%	0%	100%	0%	100%

Appendix D. Analytical methods

D.1 Experience-based and trend analysis (including FMEA/FMECA)

Where similar opportunities, projects or activities have been undertaken in the past, or where similar issues and situations have arisen, it is helpful to refer to the risks identified at the time, and leverage 'lessons learned'. For example, the likelihood of a fatality occurring may be validated by analysis of incident management data to determine the frequency of fatalities. Where internal expertise is limited, external peer groups or subject matter experts may be consulted.

D.2 Failure Mode Effects (Criticality) Analysis (FMEA/FMECA)

Failure Mode Effect Analysis (FMEA) or the extended version of Failure Mode Effect and Criticality Analysis (FMECA) is another approach to assessing the likely failure modes, their likelihoods, effects/consequences of the failure, and criticality of the asset to network operations.

FMEA/ FMECA is a systematic method to identify primary and secondary functions of the system and the failure modes that prevent the system from performing its designed purpose. It involves reviewing as many components, assemblies, and subsystems as possible to identify failure modes, and their causes and effects. This should be undertaken as a quantitative analysis and use the Value Dimensions in assessing criticality and consequence.

This is a bottom-up analytical method and the findings from FMEA/FMECA can then be combined with, or used to inform, failure rate models, probabilities and values of consequence which are required to be used in risk quantification.

D.3 Brainstorming

Brainstorming involves free-flowing conversation. It is quick, 'off-the-cuff', unrestrained thoughts about potential risks relating to the business or potential objectives under review. The aim of brainstorming is to identify as many risks as possible, and to go broad rather than deep (i.e. focus on quantity over quality). The categorisation, articulation and quality in terms of how those risks are grouped and described is undertaken at a later stage.

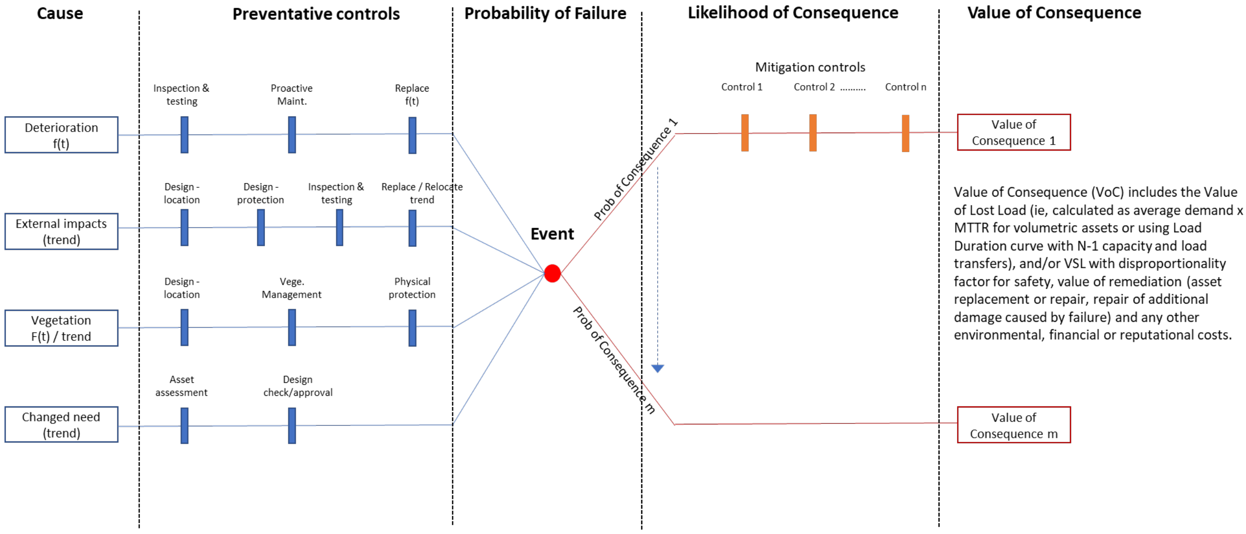
A good brainstorming session is often aided by time pressure, a supporting handout to prompt thinking, and a 'no holds-barred' approach – i.e. attendees are encouraged to think as widely and creatively as possible where there are no 'silly' ideas and thinking outside the box is encouraged.

On a practical level, for example, attendees may be given 10 minutes at the start of the workshop to individually write-down as many risks as possible on separate sticky-notes. A PESTLE analysis and a list of key objectives may be provided to assist in the process. Attendees may then be asked to share their thoughts with the group (e.g. 'Top 3') and place them on butcher paper around the room under certain themes which emerge from the discussion.

D.4 Bowtie analysis

The bowtie method is a user friendly and visual risk assessment technique. It breaks each risk into 5 component parts: risk event, cause, consequence, preventive controls, and mitigating controls. It is a useful workshop technique that enables participants to visualise the risk and thoroughly describe the risk.

An example of a bow tie is shown below.



D.5 Scenario analysis

Scenario analysis is a simulation method that compares and measures the effects of different scenarios on strategic, business or project objectives. For analysis investments, is applies different values to select variables/inputs to assess the project outcome under a range of scenarios, such as expected, best and worst case. Common parameters selected include capex and opex inputs, discount rates, probabilities and dates.

This analysis is used to plan for the risks posed in these scenarios and allows projects to:

- Evaluate the outcome of options analysis to make sure the best option under most scenarios is selected
- Prepare contingency and response plans to project risks; and
- Identify key risk factors.

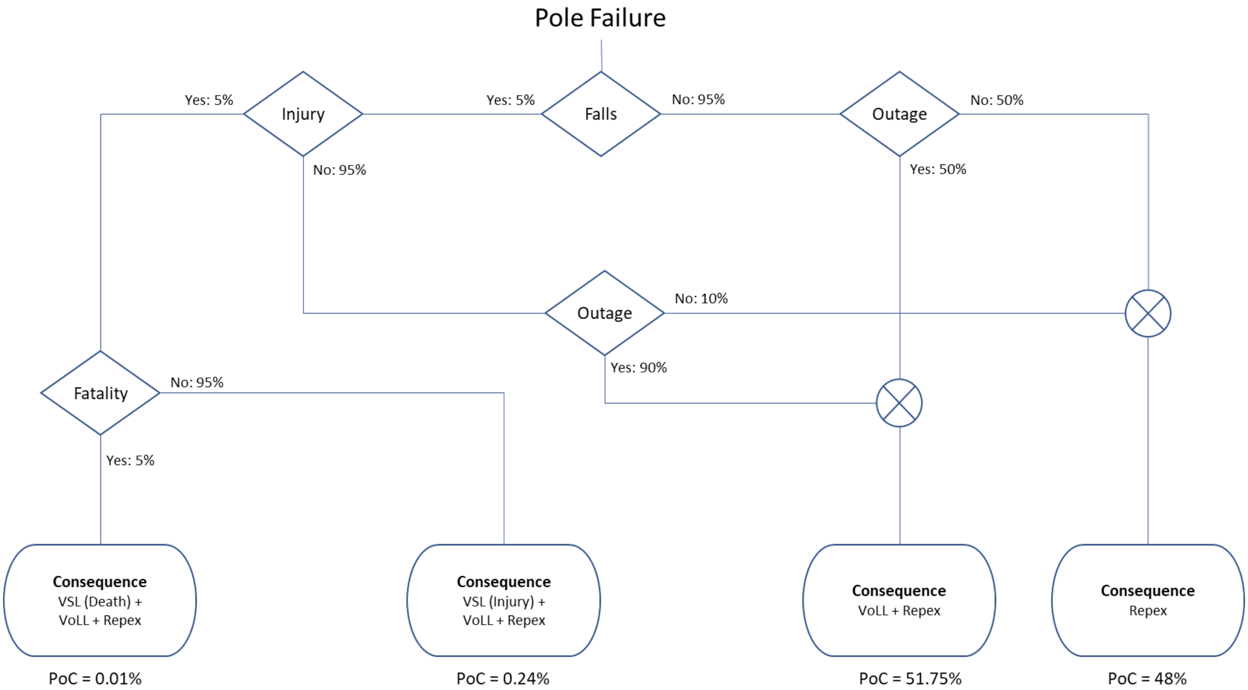
The most common simulation technique used in scenario analysis for projects is ‘Monte Carlo’ analysis. For Monte Carlo analysis, probability distributions are applied to each of the selected inputs, a random value is extracted from the distribution and the cost benefit model is run. This is typically repeat several thousand times to determine a distribution of likely results which is used to provide certainty of, and confidence intervals for, the outcome.

D.6 Decision tree analysis

‘Tree’ analysis is a simple visual drawing of the connections or dependencies between particular scenarios or risk events. This method enables focus to be placed on those areas which would cause the most change or impact.

In risk analysis, common types of tree analysis methods are ‘decision trees’. Decision trees are a decision support technique that uses a tree-like graph or model of decisions and their possible consequences including the likelihood of potential outcomes. Decision trees are also very useful to help determine the value of certain information (e.g. the value of appraisals etc).

A fault tree is a type of decision tree that can be used to help define the interactions between consequences and mitigation controls under different failure modes. This can help calculate the appropriate probabilities that should be applied to each Value Metric. An example of a fault tree analysis is shown below.



D.7 'PESTLE' analysis

PESTLE analysis is a useful template for understanding the 'big picture' or 'macro' environment in which an organisation is operating. PESTLE can be helpful for understanding risks associated with market growth or decline, such the position, potential and direction for an individual business or organisation. This framework groups issues or risks into the following categories and often feeds a 'SWOT' analysis (see below):

- Political
- Economic
- Social
- Technological
- Legal and
- Environmental.

D.8 'SWOT' analysis

S.W.O.T. is an acronym that stands for Strengths, Weaknesses, Opportunities, and Threats. A SWOT analysis is an organized list of your business's greatest strengths, weaknesses, opportunities, and threats. Strengths and weaknesses are internal to the company (quality of assets, reputation, people, processes and systems). You can change them over time but not without some work. Opportunities and threats are external (refer to PESTLE)—they are largely outside of our control.

Appendix E. ERMS consequence and likelihood tables

The following tables are an extract of the ERMS (version 1.2, 21/09/2020) and is provided as an example only. Refer to the latest version of the ERMS for the most up to date version if required.

TABLE 20 ERMS CONSEQUENCE TABLE

	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Health & Safety	Minor event with or without injury; and/or No on-going impact to health.	Injuries requiring first aid treatment; and/or Minor short term inconvenience.	Medical Treated injury; and/or Short term reversible disabling effect to human health; and/or Lost Time Injury <1 week lost.	Hospitalisation; and/or Injuries resulting in Lost Time Injury > 1 week lost; and/or Long term (chronic) chemical health exceedance or short term chemical exceedance of chemical with acute health impacts; and/or Long term aesthetic exceedance with health impact on supply.	One or more fatalities; and/or One or more persons seriously injured (includes long term disabling effect); and/or Widespread release of untreated water (eg due to disinfection failure).
Financial (impact on EBITDA)	Loss less than $500K.	Impact between $500K and $2M.	Impact between $2m and $10m.	Impact between $10m and $25m.	Impact greater than $25m.
Legal/ Regulation	Legal issues managed by corporate procedures or practices; and/or Breach of internal policies or procedures without the need for formal investigation.	Matter requires legal advice to address issues; and/or Internal breach of policies or procedures requiring a formal investigation.	Required to operate under limited regulatory restrictions or orders; and/or Incident which requires legal representation resulting in court proceeding.	Required to operate under significant regulatory restrictions or orders; and/or Government inquiry/ intervention.	Criminal charges / civil litigation against the Corporation and/or Officers; and/or Operating licences revoked.
Environmental	Localised low level damage controlled but no remedial action required.	Localised low level damage controlled and remedied with minimal resources.	Widespread temporary damage with extended resources to remedy.	Long-term detrimental effect on environment and once controlled results in minor permanent damage.	Substantial permanent damage to widespread and sensitive areas.
Service Delivery (external customers only)	Category 1 loss of service (refer to Appendix C of this document)	Category 2 loss of service (refer to Appendix C of this document)	Category 3 loss of service (refer to Appendix C of this document)	Category 4 loss of service (refer to Appendix C of this document)	Category 5 loss of service (refer to Appendix C of this document)
Reputation	No media attention; and/or Isolated community or individual issue-based concern; and/or Localised dissatisfaction which is managed by normal business processes; and/or Short term aesthetic exceedance.	Occasional once-off negative media attention; and/or Localised community impacts and customer concerns; and/or Localised staff dissatisfaction which requires Human Resources in resolution; and/or Long term aesthetic exceedance.	Brief adverse media attention and/or community/customer condemnation (days); and/or Limited, localized loss of confidence by the community; and/or Localised staff dissatisfaction with localised impacts to service deliver and/or Short term chemical health exceedance.	Prolonged adverse media attention and/or community/ customer condemnation (weeks); and/or Prolonged, widespread community/ customer loss of confidence (weeks); and/or Widespread dissatisfaction and loss of confidence by staff resulting in temporary service delivery issues.	Sustained adverse media attention and/or community/customer condemnation (months); and/or Irreconcilable community/ customer loss of confidence; and/or Loss of stakeholder confidence in Board and/or Management; and/or Widespread dissatisfaction by staff resulting in sustained service delivery issues.

TABLE 21 ERMS SERVICE DELIVERY CATEGORY

	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Water Services1,2	Remote Sites only Loss of service <= 2 hours in any community All Other Customers No loss of service. Issues rectified with corrective action.	Remote Sites only Loss of service >2 hrs land <= 6 hours in any community All Other Customers Loss of service, restored within expected timeframes (<=2 hours)	Remote Sites only Loss of service >6 and <=12 hours in any community All Other Customers Loss of service outside of expected timeframes (> 2 hours and <=12 hours).	Remote Sites only Loss of service >12 hours < =24 hours in any community. All Other Customers Loss of service with extended resources required to remedy (> 12 hours <= 24 hours).	Remote Sites only Complete and indefinite loss of service (>24 hours) in any community. All Other Customers Complete and indefinite loss of service (>24 hours).
Power Services1,3	A single event results in an outage equivalent to 5% of annual target	A single event results in an outage equivalent to 10% of annual target	A single event results in an outage equivalent to 20% of annual target	A single event results in an outage equivalent to 50% of annual target	A single event results in an outage equivalent to 100% of annual target
Gas Services	No loss of service. Issues rectified with corrective action.	Curtailment or loss of service, restored within expected timeframes (<=2 hours).	Short term curtailment or loss of service outside of expected timeframes (> 2 hours and <=12 hours).	Long term curtailment or loss of service with extended resources required to remedy (>12 hours and <= 24 hours).	Complete and indefinite loss of service (>24 hours).
System Control	No loss of service, issue identified and rectified within 15 minutes	An event resulting in loss of a Single Residential Feeder for 15 to 30 minutes	An event resulting in loss of a Single Residential Feeder for up to 3 hours or loss of Multiple Residential Feeders for up to 1 hour	An event resulting in loss of a Single to Multiple Zone Substations affecting CBD, Town Centres, Commercial, and Emergency Services lasting up to 2 hours	A System Wide Event causing System Black lasting up to 4 Hours

Notes:

1. The number of customers affected (ie exposure) is a key consideration in the criticality of each asset. This is not included in this risk rating matrix because it is factored into the prioritisation of risk treatment plans.
2. The definition of consequence has been adjusted for remote communities to align to the Indigenous Essential Services (IES), where there is an implied outage KPI of 6 hours.
3. For Remote Operations - Power Services: The same definition of consequences is applied, however, it must be noted that these KPIs align to the IES service level agreement with the Department of Local Government Housing and Community Development (DLGHCD) 'The Funder', and not limited to SAIDI and SAIFI alone as remote operations is not regulated by AER.

TABLE 22 ERMS LIKELIHOOD SCALE AND RISK MATRIX

The likelihood of a risk occurring is assessed using the following scale:

(E) Almost Certain	Event is expected to occur on a regular basis. One or more times per annum.	Not Applicable
(D) Likely	An event is expected to occur from time to time. Once every 1 – 3 years	Probability of occurring is greater than 33%
(C) Possible	An event should occur at some time. Once every 4 – 10 years.	Probability of occurring is greater than 10% and up to and including 33%
(B) Unlikely	An event could occur at some time. Once every 11 to 30 years	Probability of occurring is greater than 3% and up to and including 10%
(A) Rare	An event not expected but possible. Less than once in 30 years	Probability of occurring is up to and including 3%

Consequences and Likelihood

Likelihood \ Consequence	Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
Almost Certain (E)	Medium	High	Very High	Extreme	Extreme
Likely (D)	Low	Medium	High	Very High	Extreme
Possible (C)	Low	Low	Medium	High	Very High
Unlikely (B)	Low	Low	Medium	High	High
Rare (A)	Low	Low	Low	Medium	Medium