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POWERLINK QUEENSLAND REVENUE PROPOSAL

Supporting Document - PUBLIC

Powerlink Queensland
Asset Risk Managment - Framework

Delivering better value

Powerlink – Asset Risk Management - Framework

Policy stream	Asset Management	
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Version history

Version	Date	Section(s)	Summary of amendment
1.0	31/12/2015	All	Original version
1.1	25/01/2016		Formatting changes

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1. Introduction

1.1 Purpose

The purpose of the Powerlink Asset Risk Management Framework (hereafter referred to as “the Framework”) is to provide a high level overview of the quantitative risk assessment technique used by Powerlink within the Asset Management Plan.

1.2 Scope

This document provides an overview of the Framework and methodology used to quantify the relative levels of risk for assets approaching the end of their technical or economic life.

The Framework outlines a process which enables the key risks to be quantified in a structured, transparent and consistent manner for assets within the Powerlink high voltage network.

The quantification of risks for assets reaching end of life are important, since this enables Powerlink to make prudent investment decisions, and to effectively prioritise and rank projects which address these risks within the Asset Management Plan.

1.3 References

Document code	Document title
	ISO 31000:2009 - Risk Management – Principles and Guidelines
A1956394	RSK-F&BP-STD-A1956394 -Powerlink – Risk Management - Standard
A1956393	RSK-F&BP-PRO-A1956393 - Powerlink – Risk Management - Procedure
A1165080	RSK-FBP-CKL-A1165080 -Powerlink Risk Assessment Matrix

1.4 Defined terms

Terms	Definition
AEC	Annualised Equivalent Cost. The annualised cost of the investment to address the end of life asset risk.
CoF	Consequence of Failure. Consequences associated with a risk event.
LoF	Likelihood of Failure. Comprises of two components – the probability of asset failure and the exposure factors.
PoAF	Probability of Asset Failure. Used in the calculation of Likelihood of Failure.
Risk Cost	The probability weighted cost of the consequence associated with the risk event (LoF x CoF).
SFAIRP	So Far As Is Reasonably Practicable. A guiding principle where all people are given the highest level of health and safety protection based on what could reasonably be done at a particular time.

1.5 Roles and responsibilities

Who	What
Executive Manager Investment & Planning	Ensuring that the asset risk management approach is fit for purpose and supports the Asset Management Framework.
Group Manager Strategy & Planning, Investment & Planning	Setting the asset risk management approach for assessing key asset risks.
Manager High Voltage Asset Strategies, Investment & Planning	Applying the asset risk approach to high voltage assets.
Manager Digital Asset Strategies, Investment & Planning	Applying the asset risk approach to digital assets.
Network Integration Manager, Investment & Planning	Recommending enhancements to the Asset Risk Management Framework and applying the asset risk management approach in the development of the Asset Management Plan.

2. Framework

2.1 Overview

The Framework provides a quantitative based method to assess the key risks for assets reaching the end of their technical or economic life in a structured, consistent and transparent manner.

The Framework is based on assigning financial costs to risk events, and uses a probabilistic framework to assess a representative cost of key risk events occurring over a period of time. This cost is referred to as Risk Cost, and forms the basis of assessing risk levels within the Asset Management Plan.

Risk costs are used to assess risk in a quantitative manner for individual risks and in aggregate across an asset or group of assets. Risk costs are expressed in financial terms (dollars), and are useful for appraising aggregate risk on a like for like basis in order to make relative comparisons between investment needs.

This methodology is a tool to provide guidance on investment priority, and is used along with other considerations and factors in the investment decision making process. It is not used as an economic decision-making framework.

2.1.1 Risk Cost Definition

The Risk Cost provides a measure of the expected or long term equivalent cost associated with the risk event over a defined period of time.

The Risk Cost is defined as the probability weighted cost of the consequence associated with the risk event.

The probability of the event occurring is referred to as the Likelihood of Failure (LoF). The impact of the risk event is referred to as the Consequence of Failure (CoF).

The Risk Cost is defined as:

Risk Cost = Likelihood of Failure (LOF) x Consequence of Failure (COF)

<u>Example</u>

An event is expected to occur once every 100 years. The financial cost of the event is $10 million.

Risk Cost = 0.01 x $10 million = $100,000 per annum.

Note that it is necessary to define the time frame over which the risk cost is calculated. Risk Cost is expressed on a per annum basis within the Asset Management Plan.

2.1.2 Quantitative Risk Model

The quantitative Asset Risk Management Framework adopted by Powerlink is based on the Cumulative Act Model, or “Swiss Cheese” model. This model recognises that failures and breakdowns of a number of components and controls need to occur coincidentally for the high impact event to result.

The Cumulative Act Model involves assessing the probability of failure for each individual component of the system.

The first component within the building block model generally comprises of failure of the asset. The subsequent components comprise of further events or situations which need to happen for the risk event to occur. The probability of these events are referred to as exposure factors.

The building block components of the quantitative risk model used by Powerlink are shown in Figure 1.

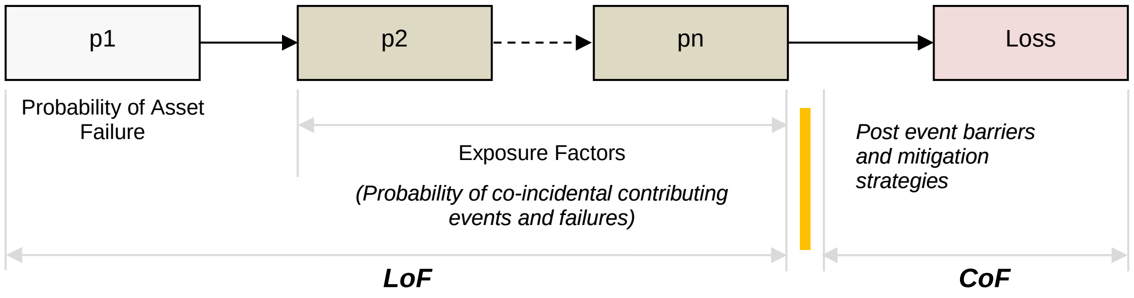

Figure 1 – Cumulative Act Model Building Blocks

2.1.3 Quantified Risk Approach

The steps involved with quantifying risk levels for the asset or system include the following.

2.1.3.1 Risk Scenario

The Risk Scenario provides the operating context for the risk event, specifically the type and mode of asset failure, the contributing events, and the impact of the event.

2.1.3.2 Risk Assessment Level

The level at which the risks are quantified needs to be determined. Risks are usually assessed at the equipment or asset level. The level at which the risk is quantified depends on the type and mode of failure.

As an example, a substation can incorporate a number of bays. Each bay comprises of a number of components including circuit breakers, instrument transformers, earth switches, surge arrestors and structures. Substation bays are defined as assets; however, it may be necessary to assess risks at the equipment level, since each item of equipment may be of different age and condition, or have different failure characteristics. The asset risk level is subsequently determined by summating the risk costs for each component.

2.1.3.3 Probability of Asset Failure

The probability of asset failure needs to be quantified. In most cases, these are represented as failure curves which define how the rate of failure changes over time. The probability of failure generally increases as the asset ages and the condition of the asset deteriorates.

2.1.3.4 Exposure Factors

The probability of contributing failures and breakdowns need to be quantified.

2.1.3.5 Network Criticality

The consideration of inbuilt redundancy within the high voltage transmission network is taken into account when assessing the impact of asset failure on network operations.

2.1.3.6 Controls

The consideration of controls, such as the availability of spares and ability to restore the network, are taken into account.

2.1.3.7 Consequence of Failure

The financial cost associated with the impact of the risk event needs to be determined.

2.1.3.8 Calculation of Risk

The Risk Cost is calculated for every relevant category of risk. The risk cost for the asset or system is determined by adding the individual risk costs for each component across each risk category.

2.1.3.9 Evaluation of Risk

Appropriate actions to address the forecast levels of risk are taken. For safety based risks, this also includes consideration of So Far As Is Reasonably Practicable (SFAIRP).

2.2 Risk Model Components

The quantitative risk model requires that both the likelihood of failure (LoF) and consequence of failure (CoF) be calculated. This section outlines the methods used to determine these values.

2.2.1 Likelihood of Failure (LoF)

The likelihood of failure (LoF) comprises two components – the probability of failure and the exposure factors.

2.2.1.1 Probability of Asset Failure (PoAF)

The first step is to define what is meant by asset failure, and which failure modes are primarily due to the deteriorated condition of the asset. For most asset classes, the probability of asset failure generally increases over time as the asset ages and the condition deteriorates.

Failure curves are generally a function of the level of deterioration, condition based age or health index. Powerlink endeavours to derive failure curves that are functions of parameters that reflect actual asset condition (such as health index). However, these models are generally more complex since the change in health index over time also needs to be modelled.

The methodology used for deriving failure curves will depend on a number of factors. Where there is a large population of the component within Powerlink's fleet, and there are reliable historical failure records; failure curves can be derived from actual recorded equipment failures.

Where there are insufficient failure records to develop statistically valid failure models, data from external industry sources, such as research organisations (e.g. CIGRE or EPRI) or manufacturers, may be used. Failure rates from research organisations are in many cases based on surveys from participating industry members based on real experiences.

Failure models derived from historical failure rates are compared against published data to verify the reasonableness of the failure rates.

Since risk costs within the Asset Management Plan are expressed on yearly timeframes, failure curves also need to express failure rates on a per annum basis (probability of failure per year).

2.2.1.2 Exposure Factors

Exposure factors represent the probability of contributing failures or conditions that lead to the risk event occurring. These contributing events can be quite different in nature to the source asset failure event.

For example, field personnel may sustain serious injury if they are in the vicinity of aged instrument transformers when they fail in an explosive manner. Under the cumulative act model, it is necessary to determine the probability that field personnel will be adjacent to the instrument transformers when they fail in this way.

Powerlink bases the calculation of exposure factors from various sources of information, including internal records and/or publically available data and reports. For example, historical substation attendance logs can be used to determine the probability that field personnel may be present at substations during the year.

Where suitable data is not available, it may be necessary to estimate exposure factors using engineering professional judgement.

2.2.1.3 Consequence of Failure (CoF)

There may be a range of consequences associated with a risk event, including financial, safety, network and environmental impacts. Powerlink examines the consequences of failure in accordance with the categories outlined within the Risk Assessment Matrix. Example of consequences include:

Financial

- Replacement of the asset in an emergency manner.
- Damage to adjacent items of plant in the event of explosive failure or fire.
- Emergency restoration work to restore supply.

Legal and Compliance

- Fines or infringement notices as a result of non-compliance with design standard and regulations.
- Class action and litigation due to injury to the public or damage to property.

Stakeholder

- Negative media attention and reputational damage associated with asset failures (for example, collapse of towers, falling overhead live conductors, or equipment fires).

Projects

- Delays to projects and rescheduling of planned works due to the unexpected failure of equipment.

Network Operations

- Interruptions to supply and volatile pool prices as a result of plant failures and outages.
- Tripping of multiple items of plant when equipment fails in an explosive manner.
- Extended outages of plant where spares or emergency replacements are not readily available.

Safety

- Serious injuries to field personnel working in the vicinity of equipment which fails in an explosive manner.
- Serious injury to members of the public due to failure of assets in publicly accessible places.
- Serious injury or fatalities as a result of car accidents caused by falling conductors or earthwires that cross motorways.

Environmental

- Contamination and breach of oil outside the substation where containment measures fail.
- Release of greenhouse gases (SF_6) into the environment as a result of equipment failures.

The above are examples, and are not intended to be an exhaustive list of consequences which are considered within risk assessments.

2.2.1.4 Assigning Costs to Consequences

Under a quantitative risk framework, it is necessary to assign financial costs to consequences.

The Powerlink Risk Assessment Matrix details dollar values for the “Financial and Contractual” category of consequence. These same costs have been extrapolated and are used as a basis of equivalence for the other consequence categories, such as safety, stakeholder, network and environment.

These costs are not considered to be calibrated to the expected cost of safety, stakeholder, network and environmental events, but are a proxy for the relative impact of each consequence. This is appropriate as Powerlink’s quantitative risk framework is used to describe the relative levels of risk across different assets. It is not used as an economic decision-making framework.

2.3 Mapping Risk Cost to Risk Levels

The mapping of risk cost to risk levels is carried out by examining the likelihood and consequence within the Risk Assessment Matrix.

The mid-point for each likelihood level within the Risk Assessment Matrix is shown in Table 1. The mid-point for each consequence level is shown in Table 2.

The Risk Cost for each square of the Risk Assessment Matrix can subsequently be calculated, and is shown in Figure 2.

Table 1 – Corporate Risk Matrix Likelihood Scale

Likelihood	Description	Frequency	No. Events/Year	Return Period
A	Almost Certain	Daily to once every three weeks	31.25	0.032
B	Likely	Every three weeks to every three months	6.25	0.16
C	Possible	Every three months to annually	1.25	0.8
D	Unlikely	Annually to every 7 years	0.25	4
E	Rare	Every 7 to 35 years	0.05	20
F	Very Rare	Every 35 to 175 years	0.01	100
G	Almost Incredible	Every 175 to 800 years	0.002	500

Table 2 – Corporate Risk Matrix Consequence Scale

Consequence	Description	Range	Cost
7	Catastrophic	> $80M	$225M
6	Extreme	$15M to $80M	$45M
5	Major	$3M to $15M	$9M
4	Moderate	$600K to $3M	$1.8M
3	Minor	$120K to $600M	$360K
2	Insignificant	$30K to $120K	$72K
1	Negligible	< $30K	$14.4K

	1	2	3	4	5	6	7
A	$450,000	$2,250,000	$11,250,000	$56,250,000	$281,250,000	$1,406,250,000	$7,031,250,000
B	$90,000	$450,000	$2,250,000	$11,250,000	$56,250,000	$281,250,000	$1,406,250,000
C	$18,000	$90,000	$450,000	$2,250,000	$11,250,000	$56,250,000	$281,250,000
D	$3,600	$18,000	$90,000	$450,000	$2,250,000	$11,250,000	$56,250,000
E	$720	$3,600	$18,000	$90,000	$450,000	$2,250,000	$11,250,000
F	$144	$720	$3,600	$18,000	$90,000	$450,000	$2,250,000
G	$29	$144	$720	$3,600	$18,000	$90,000	$450,000

Figure 2 – Risk Costs within the Corporate Risk Matrix

It can be seen that there are significant variations in risk cost between the different risk levels due to the logarithmic nature of the matrix. The risk costs are the same for each diagonal line of risk squares.

The risk cost for each square is 5 times higher than the horizontally adjacent square, due to the base 5 logarithmic design of the risk matrix.

The mapping of risk cost to risk levels can be derived by taking the logarithmic mid points between adjacent risk levels. The levels of risk and equivalent risk cost thresholds are shown in Table 3.

As an example, a risk cost greater or equal to $1.01 million but less than $25.2 million would correspond to a "significant" risk.

Table 3 – Risk Levels and Equivalent Risk Costs

Risk Level	Equivalent Risk Cost
Critical	≥ $629 million
High	≥ $25.2 million
Significant	≥ 1.01 million
Moderate	≥ $40,249
Low	≥ $1,610
Very Low	< $1,610

2.4 Cumulative Risk

The risk cost methodology is used to determine cumulative risk levels across a number of assets or items of equipment wherever applicable.

Consider a system where there are two separate components and the failure of each component occurs in an independent manner. The cumulative risk of the system is defined as:

Cumulative Risk = L1 x C1 + L2 x C2 + L1 x L2 x C3

Where: L1 and L2 represent the likelihood of failure for components 1 and 2

C1 and C2 represent the consequences of failure for components 1 and 2

C3 represents the consequence of a co-incidental failure of both components 1 and 2.

For high impact low probability events, the third term can often be ignored since the consequence associated with a coincidental failure of both components does not increase in the same proportion to the probability of the combined failure.

Under these circumstances, the cumulative risk level can be expressed as:

Cumulative Risk = L1 x C1 + L2 x C2 + … + Ln x Cn = ∑ L x C

The above is valid only where the failures are independent events and the outcomes are comparable.

This methodology is used for determining the cumulative risk level associated with an asset, system or project, and can subsequently provide a view of the full risk exposure across the network.

2.5 Risk Reduction Ratio

Residual asset risk levels are evaluated based on implementation of the proposed risk mitigation measure or project. It is often not possible to entirely eliminate risks, however it is important to ensure that the risk mitigation measure reduces risks to acceptable levels (and where safety related in line with SFAIRP).

The residual risks are determined by calculating risk levels based on implementation of the risk mitigation measure. However, for reasons of computational expediency, it may be sufficient to determine the reduction of risk as a percentage of risk prior to the mitigation measure for one year, and use this risk reduction ratio for the ten year outlook period.

The risk reduction ratio is defined as:

Risk Reduction Ratio = [Risk Cost Prior Mitigation – Risk Cost Post Mitigation] / Risk Cost Prior Mitigation

A higher ratio indicates a better risk reduction than a lower ratio.

Applying a constant risk reduction ratio for the outlook period is an approximation since the ratio would be expected to increase as the probability of asset failure increases over time.

2.6 Conclusions

This Framework provides a quantitative based method to aggregate the key risks for assets approaching the end of their technical or economic life. The key risks relate to a range of disparate consequences of failure, including financial, safety, network and environmental impacts. Providing a quantitative measure for the key risks in a structured, consistent and transparent manner allows Powerlink to make relative comparisons between competing investment needs. The Framework is not an economic decision-making framework of itself and is used along with other considerations and factors in the investment decision making process.

3. Distribution list

Internal	Contact details
☐ Finance and Business Performance	Manager Governance and Risk
☐ Investment and Planning	Group Manager Strategy and Planning Group Manager Portfolio and Business Management
☐ Infrastructure Delivery & Technical Services	Group Manager Infrastructure and Technical Services
☐ Operations and Field Services	Group Manager Network Operation Services Group Manager Technical and Network Services