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POWERLINK QUEENSLAND REVENUE PROPOSAL

Supporting Document

Powerlink Queensland
Transmission Line Asset Methodology Framework

Delivering better value

Powerlink – Transmission Line Asset Methodology - Framework

Policy stream	Asset Management	
Endorsed by	Manager HV Asset Strategies	[redacted]
Authored by	Group Manager Strategy and Planning	[redacted]
Approved by	Executive Manager	[redacted]

Version history

Version	Date	Section(s)	Summary of amendment
1.0	5/3/2009	All	Transmission Line Plant Strategy migrated to new template
2.0	10/11/2010	All	Migrated to Asset Methodology by [redacted]
2.1	17/10/2014	All	Review by [redacted]
3.0	12/11/2015	All	Document reviewed and aligned with new DMF by [redacted]

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1. INTRODUCTION

1.1 Purpose

In order to implement the organisation's Asset Management Strategy, specific planning criteria must be developed for each major asset group within Powerlink.

This document sets out the whole of life management philosophy for Powerlink's Transmission Line assets, provides a planning tool for maintenance activities and acts as a reference for the development of maintenance and project budgets and forecasts.

1.2 Scope

This document covers the maintenance, refurbishment and reinvestment of the following Powerlink overhead transmission lines: 22kV, 66kV, 110kV, 132kV, 275kV, and 330kV including

- aerial conductors
- insulators
- attachments
- lattice steel towers and their foundations
- concrete poles
- wood poles.

Transmission Line augmentation is addressed via the network planning process.

Easement and vegetation management are addressed within the scope of the Land Asset Methodology.

1.3 Objectives

Powerlink's asset management strategy ensures the organisation's assets are managed in a manner consistent with its overall corporate vision objectives to responsibly deliver electricity transmission services that are valued by shareholders, consumers, customers and the market in a safe, commercial and performance focused way.

The Transmission Line Asset Methodology sets out how the following key performance areas are to be addressed:

- levels of service
- lifecycle Management
- asset management drivers
- asset management activities
- environmental and safety compliance.

1.4 Asset Management Overview

The key elements of the Powerlink's asset management framework can be summarised as follows:

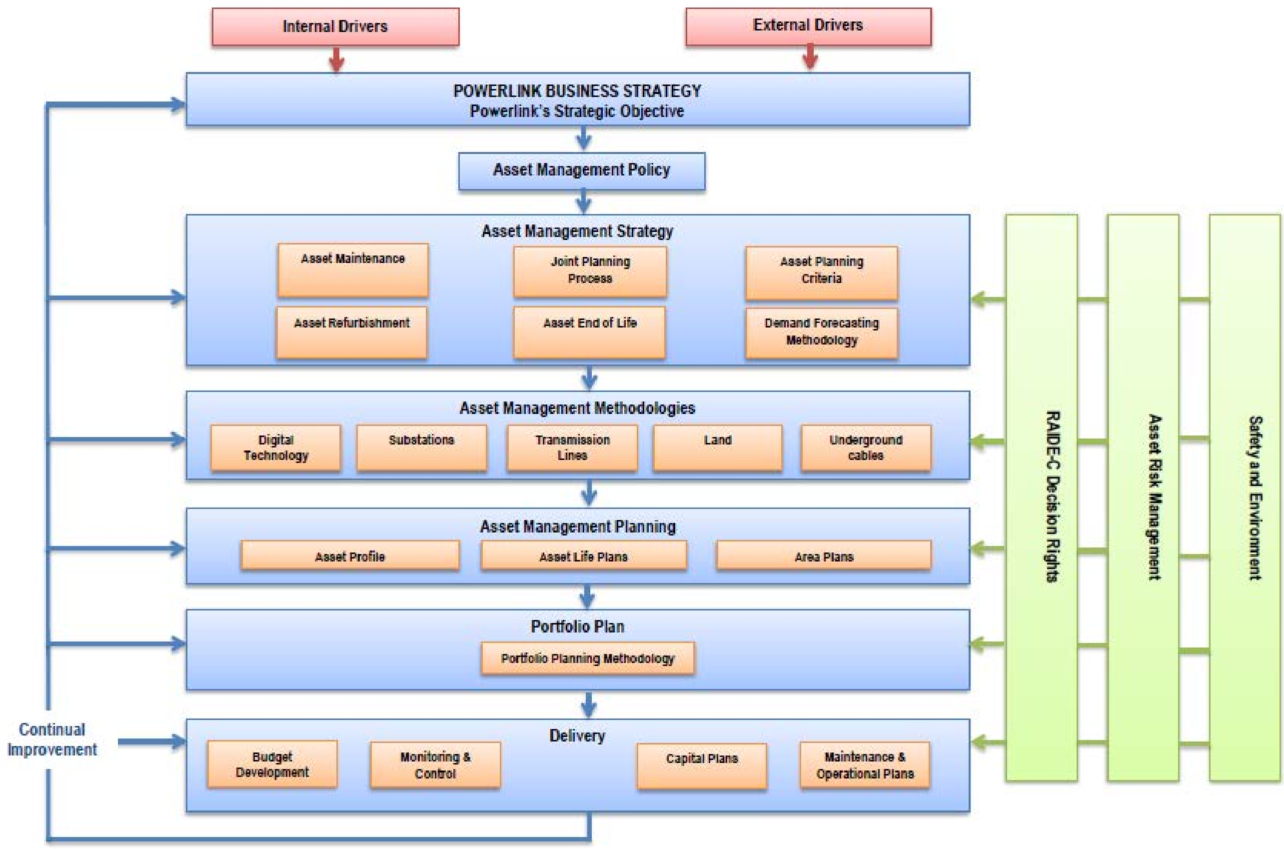

Figure 1 - Asset Management Framework

1.5 References

Document code	Document title
ASM-I&P-STR-A969433	Asset Management Strategy
AM-POL-0880	Asset End of Life
ASM-I&P-FRA-A968358	Powerlink – Land Asset Methodology – Framework
Electrical Safety Act	Electrical Safety Act 2002
Electrical Safety Regulations	Electrical Safety Regulation 2013
Electrical Safety Code	Electrical Safety Code of Practice for Works 2010
Work Health and Safety	Work Health and Safety 2011
Electricity Act	Electricity Act 1994
NER	National Electricity Rules
EPA	Environmental Protection Act
AM-PR-0835	Galvanised Bolts - Visual Grading Guide

Document code	Document title
SMS03 Electrical Safety Management System SM-STD	Electrical Safety Management System - Standard

1.6 Defined terms

Terms	Definition
Grade 2 Corrosion	Defined as the ”Initial onset of rust – light rust in the form of scattered pinholes, up to the equivalent to AS/NZS 2312 2% level.”
Grade 3 Corrosion	Defined as the “Breakdown of the protective coating. Bare, rusting steel over most of the surface, with isolated traces of remaining galvanising. The steel surface is rough but not pitted, exceeding AS/NZS 2312 50% level.”
Grade 4 Corrosion	Defined as the “Complete rusting of the steel surface. Minor or deep pitting of bare steel leading to noticeable reduction of cross-section.”

1.7 Roles and responsibilities

Who	What
Group Manager Strategy and Planning, I&P	Endorse the framework and support an undertaking to manage assets in accordance with this framework.
Manager HV Asset Strategies, I&P	Endorse action to manage assets in accordance with this framework.
Senior Line Strategies Engineer, I&P	Take action to manage assets in accordance with this framework.
Group Manager Technical and Network Services, O&FS	Establish operational policies and procedures in-line with this framework and perform audits on maintenance processes.
Group Manager Field Services, O&FS	Implementing Transmission Line Asset Methodology as part of field services.
Group Manager Specialist Services, O&FS	Auditing OH Line Assets in the maintenance phase, including Ergon Energy.
Group Manager Network Operation Services, O&FS	Provision of fault data and analysis relating to OH Line Assets.
Group Manager Infrastructure Delivery, ID&TS	Implementing Transmission Line Asset Methodology as part of Infrastructure Delivery.
Group Manager Infrastructure Technical Services, ID&TS	Aligning design and other technical services with Transmission Line Asset Methodology.
Group Manager Infrastructure Management Systems, ID&TS	Auditing the construction phase in-line with Transmission Line Asset Methodology.

2. ASSET INFORMATION

2.1 Asset Overview

Powerlink owns and operates a broad variety of overhead transmission lines at voltages from 22kV to 330kV. The age of Powerlink's transmission lines vary, the oldest being built in 1957, and the youngest currently under construction. Transmission line statistics can be found in the Annual Report.

2.2 Built Sections

Transmission lines can be composed of a series of Built Sections representative of an individual asset. The definition of the asset at the Built Section level allows the assignment of an appropriate asset value and technical life based on environmental factors and other conditions. The use of Built Sections also supports the implementation of appropriate life cycle management practices for each asset, while at the same time recognising that the management practices applied on a complete transmission line may differ based on the characteristics of built sections forming part of the line.

Powerlink also recognises different ageing and performance characteristics of each Built Section component by breaking down the asset into fourteen sub-components related to the Structure and Span. Asset management practices are normally applied at the sub-component level.

In more aggressively corrosive coastal and industrialised locations, Powerlink's experience is that for some Built Sections the anticipated technical life of at least 50 years is not achievable without major intervention, such as specialised condition based maintenance, refurbishment or refit, which will be discussed in subsequent sections.

2.2.1 Transmission Line Structures

The transmission line structures have to be designed in such a way to provide adequate distance between the ground and conductors and to provide mechanical support for insulators, wires and other hardware. They have to be designed to provide maintenance access to the conductors, insulators and hardware.

Powerlink uses different types of transmission line structures such as guyed steel masts, wood, concrete and steel poles, but the majority of structures are self-supporting lattice steel towers.

In general, there are two main functional types of structures, tension and suspension. Approximately 15% of all structures are tension structures.

2.2.2 Transmission Line Spans

The transmission line spans comprise of conductors, overhead earthwires and associated hardware located between two adjacent structures.

There are a range of conductor types, predominately Aluminium Conductor Steel Reinforced (ACSR) and All Aluminium Alloy Conductor (AAAC). On some lines twin conductors per phase are used to achieve the required electrical rating.

The standard practice is to have two overhead earth wires on the double circuit lines for lightning shielding with earthwires containing optical fibres (OPGW) as required.

3. LEVELS OF SERVICE

3.1 Stakeholder Requirements

Powerlink has a number of service level requirements derived from its strategic drivers, statutory authorities, transmission authority, and associated operating obligations. The main requirements applicable to transmission lines are considered below.

3.1.1 Safety Compliance

The fundamental requirement is for Powerlink to give effect to a Safety Management System in accordance with the Electrical Safety Act. The main purpose of the Safety Management System is to ensure that the works are designed, constructed, operated, inspected, and maintained in a safe manner. Transmission lines, due to their location in public areas, are inspected and maintained to ensure integrity of the earthing systems and structure climb deterrent devices.

Equally important is to have work practices to target zero accidents. The Work Health and Safety Act requires the safety risk to be eliminated or minimised so far as is reasonably practicable (SFAIRP). This is achieved through a number of design and maintenance measures, some of which are listed below.

Design measures include:

- Compliance with the Electrical Safety Act, Section 4, Code of Practice for Works 2010, which covers the requirements for design and installation of transmission lines. This Code has assigned a minimum three year moving average reliability against failure of 99.99% per year, excluding extreme weather events. This equates to a failure ratio of lines as 1 per 10,000 structures per year.

Maintenance measures include:

- routine patrols and the annual review of patrol outcomes
- routine footing resistance measurement for structure earthing
- effective asset information systems for maintenance, geospatial mapping and asset registers
- annual review of continuous current and fault current ratings
- compliance with all Work Health and Safety legislation, translated into Powerlink's Safety Management System when designing, working in close proximity, maintaining or switching of transmission lines
- monitoring of outage data and investigations.

3.1.2 Reliability of Supply

Powerlink ensures transmission lines that are required to meet the long term needs of the network are maintained, replaced or life extended where indicated necessary through condition assessment to ensure the ongoing safe and reliable operation of the transmission line.

Powerlink has established a business process for obtaining outages that involves negotiation of a suitable time with regard to market impacts and customer impact (generators and direct connect loads). All planned outages are managed and co-ordinated by Network Operations in the period of low loads, where possible. The routine maintenance is reviewed by O&FS to ensure only appropriate routine maintenance is undertaken, especially those tasks involving plant outages.

For unplanned outages, a business process and complementary system have been developed to enable the review of the root cause of transmission line outages, to enable the identification of actions or plans to improve reliability where required.

Powerlink owns and maintain the emergency restoration structures that can be deployed in the case of a major transmission line collapse.

To minimise the number of unplanned transient outages, Powerlink has undertaken to ensure auto-reclose functionality is available on all relevant transmission feeders.

3.1.3 Compliance with National Electricity Rules

As part of network investment Powerlink is required to:

- plan network development in accordance with the transmission authority, the Electricity Act and National Electricity Rules
- monitor the condition of all transmission lines to provide safe, reliable electricity supply
- minimise the risk of actual loss of supply events
- meet the needs of our customers.

By monitoring load growth and network capability, network needs are identified, various options for network reinvestments are considered, and the planned projects needs identified. Options are developed to address these needs and the one providing the lowest long run cost to consumers selected.

3.1.4 Customers and Connection Agreements

Powerlink is required to meet the terms of Connection and Access Agreements. Each connection agreement specifies the requirements of the particular customer with respect to the availability and reliability of the connecting assets. Forced outages are routinely analysed and those that relate to a Powerlink customer are reviewed with Network Customers group where there is a significant impact to the affected customer.

Powerlink's maintenance programs are also coordinated to occur in conjunction with shut down of customer plant or at times of lower load to minimise production impact or associated market impacts.
Specific audits and condition assessments are initiated as required to complement Powerlink's normal maintenance strategy, in order to ascertain the condition of transmission line connection assets.

3.1.5 Environment Compliance

Powerlink has an obligation to comply with the Environmental Protection Act 1994 and other environmental legislation.

For transmission lines, significant environmental compliance issues are associated with the maintenance of access tracks, transmission line corridors and the management of associated vegetation, bio-security and community stakeholder issues. These issues are addressed within the Land Asset Methodology.

4. LIFECYCLE MANAGEMENT

In order to achieve the best outcome for its stakeholders, Powerlink must optimise the asset's whole of life cycle cost, risks and benefits. This is the basis of Powerlink's asset management approach and involves the following:

- optimisation of the concept and the design process
- consideration of the asset's likely operating life
- the effective management of the asset's lifecycle through targeted maintenance, refurbishment, refit, replacement and disposal activities. Refer to Appendix 1 for a typical asset life cycle.

This approach is often referred to as the Asset Life Cycle and includes 3 main stages:

- planning and Investment
- operation, maintenance and refurbishment
- end of life.

4.1.1 Planning and Investment

The **Planning and Investment stage** for transmission lines involves;

- network planning
- easement acquisition
- design
- construction.

The transmission lines must be suitable for the intended environment, the required capacity, the required electrical parameters, and meet community expectations.

Once all the requirements are clarified and agreed, and the majority of the easement is known, then the specification and design of the transmission line commences, with the following objectives:

- achieve the desired Levels of Service over the life of the asset
- ensure the expected or desired asset life is achieved
- optimise total lifecycle costs
- ensure the maintainability and supportability of the asset over its intended life
- allow for the potential use of Live Line maintenance techniques
- comply with corporate and statutory Environmental and Safety requirements such as, but not limited to:
    - Code of Practice for Works 2010 – Electrical Safety Act 2002 has assigned a minimum three year moving average reliability against failure of 99.99 % per year, excluding extreme weather events. This equates to a failure ratio of 1 per 10,000 structures per year, but also to meet any other specific requirements specified in the customer connection agreement as well as maintainability requirements
    - Safety in Design as per Work Health and Safety Act
    - Ground Clearance as per Electrical Safety Regulations
    - Environmental Protection Act.

At the end of the specification stage, all technical details are determined and required documentation and drawings produced.

The final part of the planning and investment stage includes determination of the procurement method, contract, project and construction management, variations, testing, commissioning, production of "as-built" documentation and final handover.

4.1.2 Operation, Maintenance and Refurbishment

The **Operation, Maintenance and Refurbishment stage** is the longest stage out of all and for transmission lines can typically be expected to last 50 years or more. During this stage maintenance and operating policies and procedures have to be in place to ensure transmission lines are operated within technical parameters and they are performing as per initial requirements. To achieve this, both their condition and performance have to be monitored and relevant activities undertaken to ensure their optimum performance. Such activities may include, but are not limited to routine maintenance, condition based maintenance, emergency maintenance and even partial components replacement and/or refit.

Refurbishment may be undertaken during this part of the lifecycle, which for transmission lines involves any activities required to bring transmission lines from a degraded state back to normal operation condition, modify assets to meet current standards or to meet improved safety or operational requirements. Examples of such activities are:

- upgrade of structure earthing systems
- insulator and hardware replacement
- earthwire replacement
- replacement of climbing aids
- early life tower painting.

4.1.3 End of Life

The **End of Life** stage includes replacement of transmission lines when deemed necessary for the ongoing operation of the network. Transmission line assets may also be disposed of when identified that there is no enduring need for the asset and it is economic and is prudent to do so from a stakeholders perspective. Disposal can be complex, as it includes meeting a number of statutory regulations mainly aimed at ensuring the disposal of the transmission line meets environmental and safety requirements for workers and the general public.

5. ASSET MANAGEMENT DRIVERS

Transmission lines represent one of the largest asset groups in Powerlink, with an expected long technical life typically in excess of 50 years. It is critical to manage these assets in such a way as to achieve a long operating life (depending on the environment and other conditions) but to do so at an optimal lifecycle cost This can only be achieved by setting the asset management strategy right at the beginning of each of the transmission line's lifecycle incorporating timely response to the range of internal and external factors.

Internal

- transmission line condition assessments
- component group assessments
- technical investigations
- data modelling and reporting
- fault statistical data
- transmission line ratings.

External

- innovation and technology
- emerging issues
- demand and energy consumption.

5.1 Condition Assessment

Powerlink's transmission line assets typically deteriorate by natural aging processes as a result of environmental conditions rather than due to any network electrical loading. A transmission line contains many galvanised components. The end-of-life of a transmission line in Queensland is typically dependent on the integrity of component corrosion protection which is controlled by the environmental conditions along each transmission line. Typically for Powerlink's transmission lines, in moderate environmental conditions, once a transmission line is visibly corroded, if left unchecked, it will continue to deteriorate to its ultimate end of life within around 10 years.

All field data captured (via patrols, climbing or site inspection, etc.) is required to be entered into Powerlink's corporate data management system (SAP). The detail in the notification should be to a level that enables field staff to scope work or perform analysis on the data.

Condition assessment provides an indication of defective and deteriorated components and initiates further investigation and analysis of the data to determine the level of component deterioration, the holistic condition of each transmission line and the potential options to achieve asset reliability for a technical asset life of at least 50 years.

5.2 Condition Assessment Process

The condition assessment process for transmission line assets involves the analysis of the maintenance, engineering aspects, component investigations and other relevant data to develop a holistic view of the condition of the asset. The model below demonstrates how these inputs contribute to the condition assessment process.

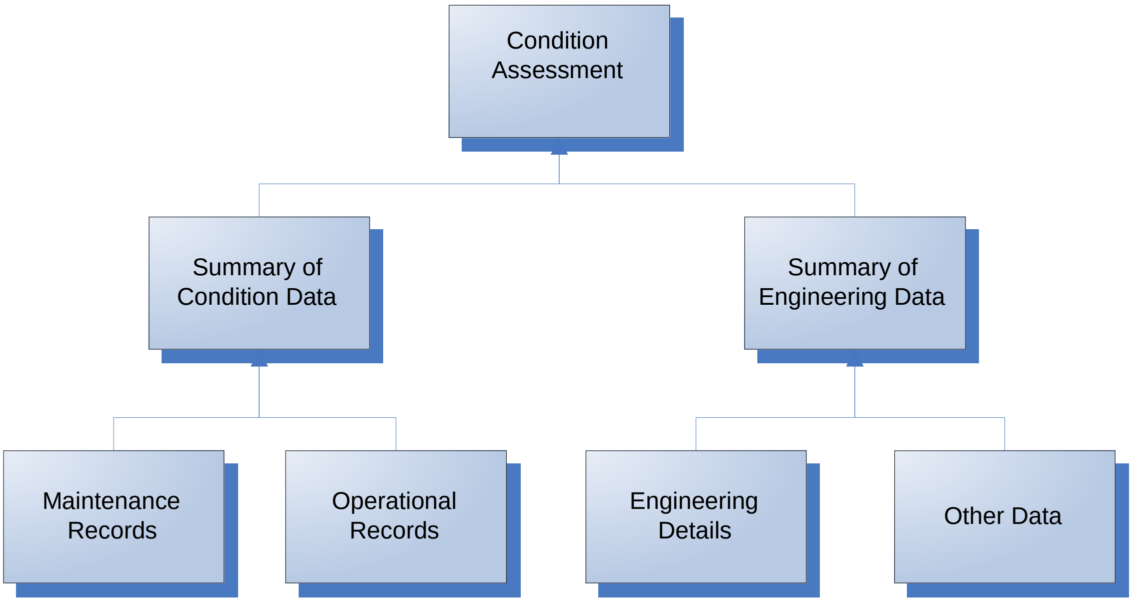

Figure 2 - Transmission Line Condition Assessment Process

5.2.1 Condition Data

The Summary of Condition Data will provide information relating to the known transmission line condition and performance. This could include field inspection reports, component condition assessment reports, outage history, preventative and corrective maintenance reports and plant service history. This activity may be managed by Powerlink Asset Strategies and Technical and Network Services in consultation with design groups and the respective maintenance service provider.

In undertaking these investigations, consideration shall be given to the impact of environmental conditions on the corrosion rates of galvanised steel structures and components.

Powerlink's network is located in areas that experience a hot humid summer, high average temperatures, high or very high numbers of rainfall days and high or very high rainfall. These conditions combined with the network's proximity to the coast produce high corrosion rates for galvanised components of transmission lines. The characteristics of galvanised steel components are that zinc is sacrificed during the oxidation process over the life of the asset until no adequate protection for the steel remains. The steel will then oxidise and generally lose cross section area and strength. In parts of Queensland away from coastal regions the expected average life span of a transmission line is longer than a line in a coastal area. To assist in categorising expected life of transmission lines corrosion zones A to F are defined in Table 1 based on environmental conditions.

Table 1 – Corrosion Zone Definitions

Corrosion Zone Designation	Environmental Conditions
A	Benign corrosion environment, such as arid rural areas with very low humidity and rainfall, minimal or no rural activity, and/or little or no vegetation encroachment into the easement. Average Annual Rainfall < 400 mm.
B	Very mild corrosion environment, such as semi-arid rural environment, with low humidity and rainfall, some rural activity, and/or minor vegetation encroachment into the easement. Average Annual Rainfall 400 – 900 mm.
C	Mild corrosion environment, such as typical rural areas with moderate humidity and rainfall, average rural activity, and/or moderate vegetation encroachment into the easement. Average Annual Rainfall 900 – 1200 mm.
D	Moderate corrosion environment, such as low density urban development or high activity rural areas, inland coastal regions, moderate to high humidity and rainfall, and/or moderate to heavy vegetation encroachment into the easement. Average Annual Rainfall 1200 – 1800 mm.
E	Aggressive corrosion environment and/ or close proximity to high salt coastal regions. Average annual rainfall may vary. Moderate to dense urbanised area with high public exposure will be included in this category.
F	Very aggressive corrosion environment in immediate proximity to heavy industry (incl. power stations), major highways or roads, and/or high salt coastal areas. Average Annual Rainfall may vary.

Figure 3 - Climatic zones based on temperature and humidity

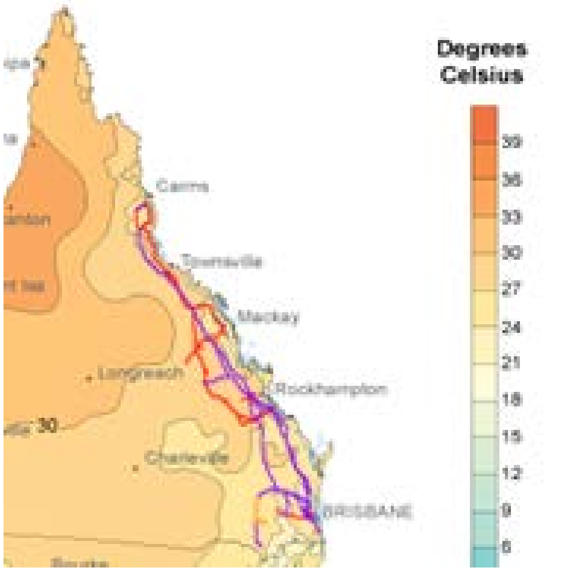

Figure 4 - Average Daily Maximum Temperatures Annual

The network is also located in areas of high thunder-days which expose transmission lines to hazardous storms which impact on the lightning performance of the electricity network. The following diagrams indicate key aspects of the operating environment and incorporate an overlay of the Powerlink network.

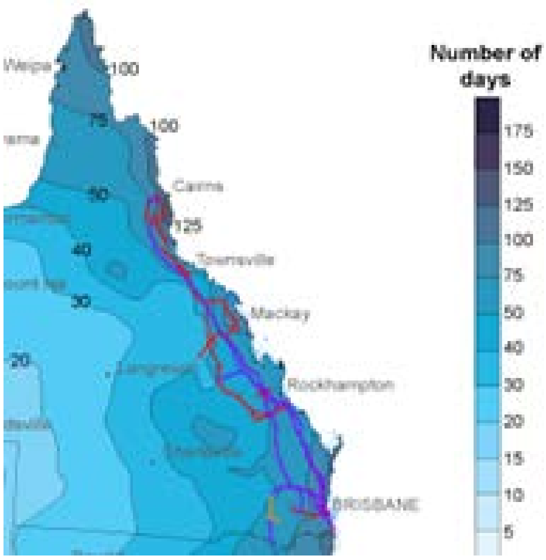

Figure 5 - Average Annual Rainfall days

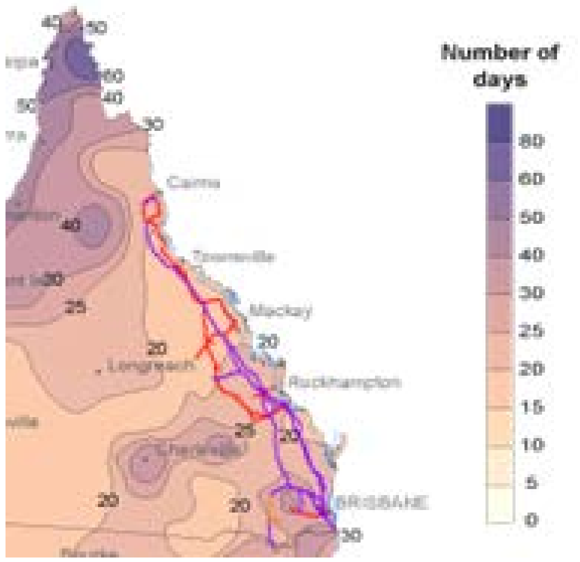

Figure 6 - Average Annual Thunder days

Figure 7 - Queensland Wind Code – 50km Cyclone Zone AS1170-2002 Wind Code

5.2.2 Condition Assessment Report

The Engineering Assessment for a transmission line asset is the product of the Condition Assessment Process. The Condition Assessment Report Engineering Assessment will take the engineering and condition data and apply analytical techniques, modelling, expected future performance criteria and probabilistic evaluation to determine the decision criteria for the condition assessment. This activity will be managed by HV Asset Strategies and may include consultation with design groups and the respective maintenance service provider for the asset.

The objectives of the Condition Assessment Report are to

- determine the condition of the asset with respect to policy criteria
- validate or recommend changes to the maintenance strategy of the asset based on condition
- provide condition information to enable a high level scope of work to be determined for refurbishment, life extension or decommissioning of the asset.

5.2.3 Component Group Assessment

A component group is defined as a group of components that contains >75% of identical components (make, type and age), have a similar function or form part of a system which should be condition assessed and refurbished as a system.

The condition of the components of a component group will vary along the built section and the recorded condition reflects the condition for at least 5% of the group. A P-F interval of 5 years (P-F Interval = Interval between the identification of a “Potential Failure” and occurrence of the “Function Failure”) is typically used for completing corrective actions after identification of a defective condition.

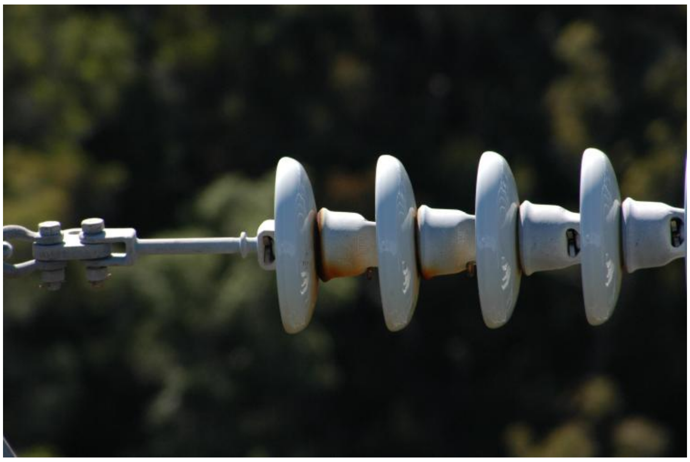

Figure 8 - Example of Line Insulator Corrosion

5.2.4 Data Modelling and Reporting

The SAP maintenance system model for transmission line assets forms a part of the condition reporting process between maintenance service providers, Technical and Network Services group and the HV Asset Strategies Team. The data is audited on an annual basis by maintenance service providers themselves as well as by the Technical and Network Services group. This includes a review of associated maintenance costs and root causes of defects and based on these and other inputs the overall strategy may be modified if required.

5.2.5 Fault Statistical Data

Powerlink maintains the database of all forced outages. Annually forced outage data related to the transmission line defects are analysed by the Technical and Network Services group and discussed with maintenance service providers at the transmission line maintenance forums. The causes for the outages are also analysed by O&FS to determine any further actions required. These are monitored for any significant trend changes and overall outage rate. Various methods are then implemented to either minimise the number of forced outages or to minimise the outage duration. The majority of Powerlink feeders are equipped with auto re-close to minimise the impact of transient faults predominantly caused by environmental issues. All transient outages are investigated to determine a root cause. The outcomes of long term trend analyses should be provided to the HV Asset Strategies Team.

5.3 Engineering Data

A Summary of Engineering Data will collate information relating to the designed performance of the asset. This could include structural, electrical and layout design information and easement information. It will also include consideration of material performance in the service environment, design vulnerabilities and assumptions, historical performance of similar assets and industry experience. Engineering data requirements are assessed and managed by the HV Asset Strategies and design groups.

5.3.1 Technical Investigations

To support transmission lines asset strategies, technical specialists are engaged from time to time, to assist with investigations and resolution of site, technical and asset performance issues. These activities include species management, earthing, community complaints, circuit performance, component or tower performance, and new technology.

The HV Asset Strategies Team will initiate technical Investigations driven, for example by the following:

- possible impact on public safety
- major network corridors
- system security (N-1-50MW).

5.3.2 Transmission Line Ratings

Transmission line continuous and dynamic ratings and overhead earth wire fault ratings are reviewed annually.

In March each year the Technical and Network Services group in O&FS performs a review of the actual continuous maximum feeder currents for the previous 12 months across summer, winter and shoulder periods and reports to the HV Asset Strategies Team a condition to be investigated for any line that exceeds 90% of its respective continuous rating. By June each year the ID&TS Primary Systems Design group conducts an annual review of the overhead earth wire short time fault ratings and reports by exception installations that exceed their rated thermal capacity.

Operational refurbishment or capital reinvestment projects may be initiated for any line or overhead earth wire where the required performance exceeds the design capacity of the asset. This may result in short term network constraints.

5.4 Innovation and Technology

The HV Asset Strategies Team are continuously looking at technology and methods to improve the operational performance of transmission lines for example, monitor lightning performance and bird activity around transmission line assets and to reduce the potential of double circuit outages on the Powerlink transmission network due to a bird streamer or lightning strike and explore design enhancements to improve performance.

In striving to maintain Powerlink’s rating as a top performing transmission utility, the HV Asset Strategies Team will continue to research projects to ensure technological advancements are evaluated for their application on the network, with an emphasis on increased reliability and performance consummate with investment.

One important input into transmission line research has been Powerlink’s membership of the Electric Power Research Institute (EPRI). All Powerlink staff have access to the EPRI website to download research reports. Examples of this are:-

- EPRI Zed Meter – device which measures the surge impedance of transmission line structures.
- EPRI Daytime Discharge Diagnostic Guide – indicates the probable cause of corona discharges detected by a Corona Camera.
- EPRI Live Line Polymer Insulator Tester – detects and indicates extent of an electrical tracking under the polymer sheath covering the insulator fibreglass core allowing live line work to be undertaken safely on polymer insulators.
- Unmanned Aerial Vehicles (UAVs) – investigation into the potential uses of UAVs for transmission line maintenance.

HV Asset Strategies will continue to sponsor and monitor projects of this nature.

5.5 Emerging Issues

5.5.1 Climate Change Adaption

Climate change adaptation dictates that the resilience and durability of the transmission lines needs to be determined and a solid understanding of the impact of these changing conditions on line asset components over its useful life. Climate change and its resulting impacts have the potential to shorten the life of transmission line components. Any impact on any individual asset component will be determined and assets may require modification to adapt to meet changes in environmental conditions.

Projected impacts of climate change in Queensland result from:

- increase in number of days over 35° C
- changing annual rainfall and increased evaporation
- increase in severe storm events and flash flooding
- more frequent and severe droughts and increased fire risk.

5.5.2 Connection of renewable energy sources

One of the responses to the climate change will be the increase of renewable energy sources which will need to be connected to the electricity grid. The impact for Powerlink is likely to be:

- An increase in the number of long feeders located in remote areas;
- Organising quick and easy defect detection and maintenance for an increased number of long feeders in remote locations;
- Increases in the number of connection points on existing feeders; and
- Changes in power flows in various feeders.

6. ASSET MANAGEMENT ACTIVITIES

Electricity transmission assets have a relatively long expected operating life. During the Planning and Investment phase it is important to influence design, configuration and topology aspects of the transmission line asset to provide a platform for achieving desired reliability, maintainability and life cycle cost outcomes. Once such assets are acquired, there are a number of additional asset management activities that can be used to:

- minimise overall lifecycle cost
- achieve the expected operating life in safe manner and within defined number of outages
- extend the expected operating life without impact on availability
- organise timely replacement with minimal impact on the network operation and public.

6.1 Planning and Investment

At the Planning and Investment stage, a range of transmission line augmentation, replacement, and life extension needs are considered and coordinated to ensure an optimum program of overall transmission line investment. An essential requirement for initiation of transmission life extension or replacement is to establish the ongoing requirement for the asset to meet the long term needs of the network. Hence, there is an imperative for asset reinvestment planning to be structured to reflect future network needs and also for network planning to be undertaken with cognisance of the underlying conditions of the asset.

The approach to planning and investment also involves ensuring the proposed configuration of the transmission line asset, established through forums that steer network investment decisions, meets the high level Planning and Investment objectives discussed in Section 4.

6.2 Operation, Maintenance and Refurbishment

6.2.1 Operation

The transmission line performance is also analysed by monitoring the number of forced outages, number of notifications involving breakdown, and maintenance testing results captured within measurement documents.

Powerlink has also developed maintenance service provider capability in live line maintenance techniques. This capability allows options to be available for undertaking corrective maintenance, planning condition based maintenance and refurbishment. Live Line maintenance allows quick restoration of defects with limited network outages.

Transmission line spares are defined for operational transmission line assets for prescribed scenarios to allow quick repair of defects. These spares are quarantined for maintenance work and are not available for planned major maintenance or network augmentation works.

6.2.2 Maintenance

Maintenance strategies for transmission lines are developed using Reliability Centred Maintenance (RCM). RCM provides a rigorous and auditable analysis framework for identifying only those maintenance tasks that are applicable and effective in managing possible failures. RCM analyses are undertaken by facilitated review teams of technical experts and field personnel with the greatest knowledge of the Network Assets being analysed. RCM also identifies failure modes that cannot be dealt with effectively by maintenance alone and thus require other approaches to deal with them. This ensures that only practicable, achievable and effective maintenance tasks are adopted.

Prior to the introduction of a new transmission line component a review of potential failure modes and countermeasures should be undertaken to confirm that the component life-cycle can be accommodated in existing RCM studies, if not a new Reliability-Centred Maintenance analysis is undertaken to determine the appropriate routine maintenance for that component.

To meet the stakeholder's expectations and comply with the Electricity Safety Act 2002 and other applicable regulations and standards, transmission lines have to be inspected at regular intervals and maintained.

6.2.2.1 Routine/Scheduled Maintenance

This is comprised of:

1. Transmission line patrols - these are either ground or aerial and are undertaken annually on all lines.
2. Structure inspections - frequency is set up to different intervals based on the age and location of transmission line.
3. Insulator in-situ inspections - 5 yearly but sample only.
4. Insulator Testing - based on the expected life but sample only.
5. Footing resistance measurement - 5 yearly on structures located within 2.5 km of substation and 15 yearly on all other structures.
6. Infrared inspection of joints on tension structures - 5 yearly once they reach threshold equivalent age and condition, where required.

6.2.2.2 Condition Based Maintenance

Based on the routine inspections and tests, knowledge of the condition of the plant is developed. Once the condition deteriorates to a level requiring action, appropriate maintenance is initiated. This work is classified as condition based maintenance.

6.2.2.3 Emergency Corrective Maintenance

Emergency corrective maintenance is the immediate work that must be performed to prevent danger to personnel, equipment or system performance. The emergency work is typically initiated through the control centre requesting that staff be immediately called out to rectify a situation. Typically for transmission lines this would happen if the automatic reclose was unsuccessful and the control centre requested an immediate line patrol to identify the problem.

6.2.2.4 Deferred Corrective Maintenance

Deferred corrective maintenance, is all work associated with rectifying an unacceptable or non-functional plant condition to an acceptable functional condition, which is not emergency in nature. In addition to the actual “hands on” work to rectify a fault, this category of maintenance also includes the subsequent investigations and reports relating to plant failures. Typically for transmission lines this would be for example the replacement of the flashed over insulator string due to the either contamination or lightning strike.

6.2.2.5 Maintenance Support

Maintenance support tasks are those activities which are related to the ongoing maintenance and operations of the plant, but which do not specifically involve the plant itself. Examples include carrying out fault analysis and periodically reviewing each or some of the transmission lines to consider changes in operational duties (loading, average ambient temperatures, fault level, etc.). Maintenance tasks resulting from these investigations and reviews are documented as quality procedures and incorporated into the policies, procedures and secondary documentation for the different asset groups. Typically for transmission lines, the loading of lines is analysed and the output goes into the ratings documents. The fault level and capacity of overhead earth wires is analysed annually and the recommendations are submitted where the potential limits are noted.

The transmission lines asset management model is based on the following maintenance activities.

Table 1 - Asset Maintenance Types

Maintenance Type		Activity	Frequency
Preventative Maintenance	Routine Preventative Maintenance	Transmission line patrols (aerial or ground patrols)	Annually
		Structure Inspection	Based on age and condition.
		Insulator in situ inspections	5 yearly (sample only)
		Insulator testing	Based on the expected life (sample only)
		Landing span inspections	5 yearly
		Footing resistance measurements	5 or 15 year cycle depending on location
		Infrared inspection of joints on tension structures	5 yearly on aged circuits, where required.
	Condition Based Maintenance	Conductor mid-span joint testing	Based on age and observed condition of ACSR conductor
		Inspection of K point areas on towers	Triggered by condition and/or age and micro location
		Insulator washing	Triggered on critical circuits with known pollution problems
Corrective Maintenance	Emergency Corrective	**Immediate** work that must be performed to prevent danger to personnel, equipment or system performance	Initiated through Control Centre requests
	Deferred Corrective	All work, including subsequent investigations and report, associated with rectifying an unacceptable plant condition to an acceptable state that is not emergency in nature.	
Refurbishment		Insulator replacement	Routine inspection and sampling trigger projects
		Damper retrofitting and replacement	Triggered by damper End of Life
		Upgrading of anti-climbing barriers, signs	Triggered by age or land use
		Upgrading of structure earthing	Triggered by circuit fault level or land use.
		Tower K point/foundation refurbishment	Triggered by deterioration
		Conductors and OHEW	Triggered by routine inspections and deterioration
		Early Life Tower Painting in highly corrosive environments or environmentally sensitive areas.	On a needs basis, where economic.

6.2.2.5.1 Built Section Meters Condition Indicators

Annually the Maintenance Service Providers are required to review all known condition assessment data associated with transmission line built sections and indicate condition based (non-routine) maintenance requirements. This built section data is reviewed with the Lines Strategies Engineer to determine the long term maintenance requirements for each built section. The maintenance indicators used for assessing the condition of Transmission Lines components are as follows.

Structure Component Groups

- tower earthing
- foundations
- structure (above K point)
- suspension insulators
- suspension hardware
- tension insulators
- tension hardware
- OHEW/OPGW hardware
- signage.

Span Component Groups

- conductors
- conductor mid span joints
- conductor hardware
- OHEW/OPGW
- OHEW/OPGW mid span joints.

Action Indicators for Component Groups

- no Investigation
- investigation OK
- investigation follow-up required
- refurbishment required
- refurbishment in progress.

The primary database used for maintenance management activities is SAP, which utilises a notification/work order system to record details of the fault or defect, measurements/test results and the work that was completed. In addition to this, the HV Asset Strategies Team also utilises the following databases:

- TIS insulator sampling database to record photos and condition of insulators removed from service for inspection, or inspected in situ;
- Helicopter asset inspection services which records photographs of in service inspections during aerial patrols for all line assets;
- the FOD fault analysis database which records details of all network fault events; and
- photos in corporate M drive.

Asset condition data for transmission line assets is reviewed annually to identify the lines which need to undergo capitalised or operational maintenance work.

6.2.2.6 Condition Based Maintenance

Condition based maintenance activities are generated from routine inspections, condition assessments or other information sourced from the physical condition of the transmission line. Condition based maintenance activities can include:

- line patrols after flooding, storm activity, bushfires, or surveillance
- condition based climbing inspections
- thermal imaging line surveys
- conductor mid span joint resistance testing

- lightning surge impedance/earthing resistance measurements
- Corona camera survey techniques on polymer insulators
- insulator, conductor sampling
- engineering inspection.

6.2.2.6.1 Additional Maintenance

Transmission line assets may be classed as requiring additional maintenance if increased reliability is required from the asset to meet a commercial or business driver.

Assets identified as requiring increased reliability performance fall outside the scope of the normal asset management model. These assets require condition assessment every five years in addition to the normal transmission lines maintenance strategies. Advancing defect rectification is required to ensure the desired reliability is achieved.

The transmission line population includes built sections where a large proportion of specific asset components are nearing End of Life while there is a long remaining asset life of the whole built section. A transmission line built section identified in this category requires additional maintenance activities to ensure safe and reliable operation for their remaining life. Transmission lines in this category shall be assigned a decommissioning date to allow control of maintenance costs or as an alternative may be scheduled for a Line Refit to extend life.

6.2.2.6.2 Short Transmission Line Connections

Many generators and major loads are connected by short sections of transmission line circuits to and from major network substations. These shorts sections of transmission lines typically have a high tension structure to suspension structure ratio, high continuous loads and adverse pollution conditions. Maintenance of these assets is often difficult due to the need to align with generator, plant or customer outages.

Short Line Condition Assessments are conducted state wide on an approximate five yearly basis on short built sections that interface with a generator or non-regulated commercial entity. These activities have the benefit of alignment with customer expectations and maintenance regimes, and increased reliability of the connection. (NB. These assessments are typically aligned with generation plant overhauls to allow easy access to all components on the asset.)

The criteria for the assessments are the 14 maintenance indicators used for routine and condition based work. The outcomes of the condition assessment may require further investigation or condition based work orders to effect defect rectification. Notifications will be raised for all recorded defects.

These condition assessments should be co-ordinated by the Technical and Network Services group in O&FS and are conducted in conjunction with a Maintenance Service Provider Representative.

6.2.2.6.3 Short Transmission Line Built Sections

The growth in the transmission network is accompanied by progressive building of new substations and sections of transmission lines. A result of this staggered construction is that circuits may consist of a number of built sections which have varying ages. In particular short built sections of transmission lines do not align with the standard asset model and may present the critical components limiting the reliability of the circuit.

To meet the reliability requirement of the network, a strategy may be undertaken to increase the maintenance of short built sections to match the reliability of younger connecting built sections. Otherwise the maintenance plan would be adjusted in-line with the oldest section of the line or oldest components.

Typical activities which may be undertaken include:

- engineering condition assessments
- development of a schedule of works to maintain/replace critical components.

6.2.2.6.4 Significant Failure Zones

Transmission lines run over areas of diverse land usage. They frequently cross major roads, highways and railways, and on occasions cross intensive industry, residential housing, and public areas. Special attention should be given to the condition of the transmission line components at crossing locations, near property, and public spaces to ensure that the risk of component failure remains acceptable.

6.2.3 Refurbishment

Transmission lines consist of a number of components which are often assigned significantly different useful life durations. Powerlink's experience is that different components are impacted by the environment in different ways and require activities identified in Table 3 below.

Table 3 – Refurbishment Activity and Trigger

	Activity	Trigger
1	Insulator replacement	• Routine inspection/sampling • Performance Enhancement Strategy
2	Damper retrofitting/replacement	• Damper End of Life, typically 15-20 years • Routine inspections
3	Upgrading of anti-climbing barriers/signs	• Changes in land use around structure, deterioration of signs.
4	Upgrading of structure earthing	• Circuit performance, changes in land use around structures, deterioration of buried components, vandalism, high earth resistance measurements
5	Tower base/foundation refurbishment	• Deterioration of foundations at K-point. • Deterioration of foundation's condition below ground.
6	Marking balls replacement	• Faded marking balls which are not easily visible.
7	Tower Painting	• Deterioration of zinc layers on steel to Grade 2 in areas of high corrosion or environmentally sensitive areas, where economic.

Singular component replacements are implemented as refurbishment projects as they generally contribute to the achievement of the full useful life. However, where replacements can be combined and the timing is such that they result in the extension of it beyond nominal useful life (including in some areas of low corrosion) the replacement of these components at the appropriate time may be considered as extending the useful life of the asset.

Transmission lines are designed to achieve a specific performance level and specific environmental conditions. Over the years environmental factors (industry, housing, weather patterns and climatic conditions) may change and the lines may therefore be more exposed to factors that were not taken into account when the line was designed and constructed. The factors that most commonly change are:

- increased pollution levels leading to the requirement for the increased insulation level
- higher fault currents due to increased generation connected to the network, or increased network capacity, leading to the requirement for the increased overhead earthwire capacity
- increased lightning storms or/and decrease of moisture level increasing the tower earthing resistance leading to the upgrade of tower earthing or changes in the shielding angle of overhead earth wires
- change of wildlife (birds, snakes, flying foxes, etc.) and/or vegetation

- increase in amount of adjacent industry or housing resulting in an increased level of pollution and frequency of habitation near assets.

The performance of the lines in such situations can be compromised and impact on the security and reliability of the network. By enhancing the performance of the line in response to these conditions through refurbishment it is possible to mitigate the causes of potential outages on the transmission network and hazards to the public.

Powerlink considers that tower refurbishment using a paint system is an important option to ensure we maintain our steel lattice towers in accordance with our obligation as a Transmission Authority under the Electricity Act, which is to ensure we preserve the condition of the assets “so far as is reasonably practical” (SFAIRP). In particular, early life tower painting can help to preserve the condition of the steel lattice towers in highly corrosive environments. Where it can be economically justified, the steel lattice towers should be painted before Grade 2 (red rust) appears in order to preserve the zinc coating and reduce the need for abrasive blasting. Tower Painting results in a duplex paint system and improves the durability of the painting system with synergistic effects, which provides an increased life for those steel towers.

6.3 End of Life

A transmission line in Queensland has a nominal technical life span of 50 years and is monitored for defects throughout its life. Some components get replaced throughout the technical life of transmission lines. Despite this, there is a point where a condition assessment for a transmission line asset identifies that the structure or foundations have reached their technical End of Life.

The technical End of Life of an overhead transmission line is when an asset no longer meets its minimum requirements and presents an unacceptable risk to the business. For steel lattice towers this is considered to be when more than 10% of a tower bolts and nuts exceed Grade 3 corrosion at which point approximately 1% of tower bolts and nuts have reached Grade 4 corrosion and significant maintenance is required.

6.3.1 Transmission Line Reinvestment

Powerlink has three primary reinvestment strategies for transmission lines:

1. Transmission line refit or life extension.
2. Transmission line replacement.
3. Transmission line disposal when there is no enduring need.

To make the correct decision regarding these three options a number of additional factors needs to be considered such as:

- lowest long run cost to customers
- present and future load flows and network topology
- existing easement width, conditions and access for line works
- level of difficulty involved in obtaining a new easement for overhead line
- condition of transmission line and the technical or cost implications associated with life extension and/or reinvestment
- safety and environmental risks
- maintenance costs.

The decision making process requires data associated with the asset to be gathered well in advance of the anticipated major deterioration of the asset to ensure that all options remain feasible for the asset. This means that in many cases a condition assessment is required 10years before the End of Life of the asset.

6.3.2 Transmission Line Refit or Life Extension

Transmission line life extension projects will be proposed for deteriorated transmission line assets that are required to operate reliably past their normal end of economic life with little or no increase in capacity, or where technical constraints, such as the availability of easements for a replacement alternative, constrain available options.

A refit or life extension project allows the combining of multiple activities on different transmission line components into a single scope of work, however primarily involves the refit of structures. Life extension works have the effect of returning the transmission line to a standard where the asset is in a condition that provides for ongoing service beyond the end of its original economic life.

Powerlink's refit strategy timing is on average 5 years earlier than the end-of-life replacement timing. The refit timing aligns with grade 3 corrosion (50% or more red rust) on approximately 5% of bolts/nuts. The 5 year advancement is based on the following factors:

- As a significant part of tower painting is surface preparation, increased surface rust from delaying refit works to closer to end-of-life will require greater abrasive blasting to ensure the corrosion products are removed and the paint bonds to the existing surface. While this additional cost is allowed for in economic modelling, it increases the risk of the preparation being inadequate and reduces the synergies achieved from the duplex system of galvanising and paint. This will impact on the ability of the paint system to achieve the full life extension of 20 years and potentially lead to a less effective refit with additional costs over time.
- A large number of transmission towers were installed from the mid 1960's to the mid 1970's and without intervention the ageing of these structures will lead to an exponential increase in the quantity of corroded components. This is due to the combined effect of; the rate of corrosion as the galvanizing layer breaks down; together with an increasing population of towers which are at the age when grade 3 corrosion commences. Timely painting to restore the protective coating on steel components will prevent this exponential increase becoming potentially unmanageable.
- If the exponential increase in corroded components takes hold there is increased risk of not identifying all severely corroded items through normal maintenance activities which are currently based on routine and sample-based inspection.
- Delaying refit works until the end-of-life timing in all cases reduces flexibility in portfolio management and will result in highly fluctuating resource requirements due to the large number of towers that were installed in the 1960's and 1970's with similar end-of-life dates.
- Providing some flexibility in timing of refit works allows for the bundling of work packages across the transmission line asset (structure, earth wire, insulators) to achieve synergies, minimise network outages and achieve a more effective life extension of the total built section asset.

Structure refit normally includes tower painting and a typical asset life cycle plan is shown in Appendix 1. A structure refit process without paint is when all steelwork at Grade 2 or greater corrosion is replaced and may be employed in average corrosion regions where it is estimated to extend the life of a transmission line by 10yrs.

While it may be possible to defer refit works for a single transmission line asset, it would not be prudent to attempt this across the entire fleet of more than 20,000 structures. The NPV costs of line refit and replacement are equivalent, within the accuracy of estimates, for refits up to 10 years prior to end-of-life. That is, the benefit of deferring refit timing to be closer to end-of-life timing is offset by the extra cost of remediating additional structure deterioration that occurs as a result of the deferral.

As there is no clear economic benefit from deferring refit works, and there are significant risks across the fleet of transmission towers from deferral, Powerlink considers that an average advancement for refit works of 5 years provides the best long-run outcome to electricity consumers.

6.3.3 Transmission Line Replacement

Transmission line reinvestment projects will be proposed for deteriorated transmission line assets which have many component groups that have reached End of Life, where the option to undertaken reinvestment is economic compared to life extension and alternative or widened easements are available. This is related to like for like replacement and does not necessarily involve significant capacity increase.

The reinvestment of a transmission line asset should consider:

- replacement with a like for like overhead line asset

- replacement of structure e.g. replacement of towers with poles and retaining existing conductors
- replacement with an alternative solution e.g. underground cable combined with overhead line
- future capacity and capability requirements
- update of design requirements considering current standards and environmental factors and
- retaining strategic easement for future replacement.

6.3.4 Transmission Line Disposal or Mothball

Disposal of transmission line assets is considered if they are deemed as not required in the current and future network topology and require significant costs to be maintained. Once these have been decommissioned and are non-operational, they may be demolished.

To minimise the cost impact of demolition, assets can be mothballed to defer the cost of disposal to an appropriate time. This may have the advantage of being able to reuse the asset at a later date or preserve the easement if circumstances change. To mothball an asset, the asset shall be electrically disconnected from the network with conductors earthed to eliminate electrical induction and bush fire risks. It does not however eliminate the physical risks of tower collapse or conductor failure, and although insulator corrosion rates will be reduced by removal of the voltage, the line is still exposed to lightning and high wind weather events, and vulnerable to corrosion of structures, insulator pins, conductors, earth wires and hardware, as well as vandalism and other threats. As such this option may not provide a viable long term solution. Some maintenance will still be required to keep safe, particularly anti-climbing barriers, as well as regular ground and aerial inspections.

Decommissioning and removal of the asset in a timely fashion eliminates the ongoing safety risk and eliminates the need for further expense on the asset. The timing for removal should consider: exposure to the public, costs of maintenance and available resources.

It is important to note that for all of these options, worker and public safety so far as is reasonably practicable (SFAIRP) needs to be ensured.

Asset Disposal for overhead lines has three main stages.

1. Removal of conductors from the structures, therefore de-loading the structures and significantly reducing the risk of structure failure.
2. Dismantling of the structure and removal of the foundations, therefore clearing the site of any obstructions.
3. Rehabilitating the site and access to reduce environmental impacts.

During this process poles or towers may be identified as being suitable as strategic spares or for future works and are left in situ at the completion of the decommissioning process. In this case there is a requirement for these assets to be maintained to ensure the asset remains in an acceptable condition and to ensure Powerlink's obligations to the community and private land owners are satisfied.

Hardware and insulators that have been identified as being suitable as strategic spares are returned to Powerlink stores for assessment and cataloguing. All other assets that have not been identified as being suitable as strategic spares will be demolished and disposed of as a part of the project decommissioning works. A condition assessment shall be carried out on selected components that are disposed of to determine their performance.

Since there are significant changes in the regulations and standards applicable, as well as in the requirements, Powerlink has a family of orphan transmission line assets located on easements across the state. The strategic direction for the management of these assets is to locate them, register and perform a condition assessment to determine which assets are to be retained as strategic spares with a maintenance plan and which assets are to be managed through the demolition and disposal process.

7. EMERGENCY RESPONSE AND NETWORK SECURITY

7.1 Emergency Response

Cyclones and natural disasters are a part of the climate in which we live and operate our assets. The failure rate for steel tower transmission lines in Australia is 2 x 10^{-5} failure events per structure years. Based on the current population a failure event is likely every 2 years. In preparation for these events Powerlink owns and maintains the following emergency restoration systems.

- Wood Pole Restoration System (sets are available at Brisbane, Rockhampton and Townsville)
- Lindsey Restoration System (one set is available in Brisbane).

In addition to the maintenance of these systems annual training is conducted in the use of these systems involving ID&TS Primary Systems Design group and Maintenance Service Providers.

Figure 9- Example of Lindsey Structure

7.2 Network Security

Transmission line assets are identified as critical national infrastructure and have become a focus and easy target of vandalism and terrorism due to their relative ease of access via maintained access tracks, remoteness and low rate of presence of Powerlink's personnel.

Powerlink will continue to actively invest in the security of our critical transmission lines assets with a focus on signage, anti-climbing barrier development, tamper proof tower nuts and surveillance through patrols, land management activities and community channels.

8. SUPPORTING ACTIVITIES

8.1 Risk Management

To successfully manage Powerlink's transmission line assets, it is necessary to identify and manage a range of hazards and risks. The following tables summarises the identified hazards and their corresponding control measures.

Table 4 - Identified Hazards and Control Measures

Performance Related Hazard	Residual Risk	Risk Treatment
Transient Double circuit outages	Moderate [D3]	• AM Policies and Procedures • Structure footing resistance checks
Tower earthing arrangements e.g. Step/touch	Moderate [C3]	• AM Policies and Procedures • Monitoring of land use changes
Conductor loading – ground clearance	Moderate [C3]	• AM Policies and Procedures • Annual check of peak circuit loads
Conductor vibration	Moderate [C2]	• AM Policies and Procedures • Routine inspection
Structural member failure	Moderate [C3]	• AM Policies and Procedures • Routine inspection
Foundation integrity	Moderate [E4]	• AM Policies and Procedures • Routine inspection
Mechanical failure of high voltage conductor (and associated hardware, mid span joints)	Moderate [E4]	• AM Policies and Procedures • Routine inspection
Mechanical failure of insulator and associated hardware	Moderate [D4]	• AM Policies and Procedures • Sample in-situ testing
Mechanical failure of OHEW/OPGW conductor (and associated hardware)	Moderate [D4]	• AM Policies and Procedures • Routine inspection
General Deterioration of Equipment	Moderate [C3]	• Design Standards • Equipment Strategies • AM Policies and Procedures • Refurbishment Plan
Catastrophic Failure of Equipment	Significant [D5]	• Maintenance Procedures • Equipment Strategies • Design Standards • Emergency Response Procedures
Incorrectly Performed Maintenance by MSP	Moderate [B2]	• Maintenance Procedures

Table 5 – Other Associated Hazards and Control Measures

Other Associated Hazards	Residual Risk	Risk Treatment
Lightning strikes	Moderate [C2]	• Design Standards
Bushfire	Moderate [C2]	• AM Policies and Procedures
Flood	Moderate [D4]	• AM Policies and Procedures
Acts of Theft and Vandalism	Low [D2]	• AM policies and procedures • Design Standards
Exposure to EMF	Moderate [C3]	• Site Radiation Folders • AM Policies and Procedures • Monitoring of bare hand work levels
Working at Heights	Moderate [B2]	• AM Policies and Procedures • Installation of fall restraint systems
Unauthorised access to site	Low [E2]	• Design Standards • Maintenance Policies and Procedures • Installation of the anti-climbing devices
Electric shock to personnel	Low [D2]	• QEE Safe Access to High Voltage Apparatus • AM Policies andProcedures

8.2 Project Handovers

The construction of new transmission line assets, component replacement or life extension of the transmission line assets involves the interaction of design, construction, project management, material acquisition and strategies groups both within and external to Powerlink. The transition from the practical completion of the transmission line to an operational asset and the maintenance of that asset requires the recording and communication of critical information and related data about the asset.

The Project Handover process has been implemented to provide the conduit for transferring design and construction information between the designers, construction contractor and the maintenance service provider. It further provides an opportunity for the HV Asset Strategies Team to proactively seek feedback from Project Managers, the project team and stakeholders about the project and the project handover process to ensure that opportunities for improvement are implemented.

The Project Handover process should be completed prior to commissioning of the asset. As part of the handover process a pre-commissioning inspection shall be completed prior to the site inspection along with the maintenance manual. The pre-commissioning inspections should be completed with the objective to provide a visual reference of the new asset and a defect report for a percentage of the new line. The inspection should provide a snap shot of the new asset for visual reference and include overview photos of each structure type, close-up photo of structures with arrangements such as flying angles, buck-arms, third crossarms, etc, and an overview photo of the landing span arrangements into the substation strain beam. The inspection should look for defects along the entire line with detailed inspection of at least 20% of each structure type (0°C, 2°C, 40°C, 70°C, transposition, etc). The inspection should also use the same service provider that is engaged for annual aerial patrols with the data loaded into the corporate management system (SAP, Objective, M drive, etc).

8.3 Equipment Spares

An annual review of transmission lines spares will be performed to ensure that:

- The quality and quantity of transmission lines spares held in Southern, Central and Northern Regions are adequate and appropriate.
- The storage practices and facilities of transmission lines spares are satisfactory to ensure component life span is not compromised as a result of incorrect or inadequate storage practices.
- Spares have been provided for new assets and component changes.

8.4 Human Resource Training

The HV Asset Strategies and Technical and Network Services Teams provide a Line Forum annually to reinforce key concepts and strategies with maintenance service providers. This is the way to communicate changes that have been implemented based on the reviews conducted previously. Powerlink operates transmission line training facilities for maintenance contractor training.

8.5 Documentation

The HV Asset Strategies Team will review relevant strategic Asset Management documents on a three yearly basis and will promote the development of documentation and field guides to ensure transmission lines strategies remain relevant and in accordance with good industry practice.

8.6 Strategic Linkages

The HV Asset Strategies Team will develop and maintain strategic linkages internally within Investment and Planning and other groups external to the division to ensure a seamless integration of network topography is maintained.

Alignment is maintained between Principal Maintenance Service Providers such as Ergon Energy and Operations and Field Services (O&FS), with other preferred service providers (i.e. Aerial Services) to ensure consistency in the provision of maintenance services.

Channels of active communication are maintained with other Transmission Network Service Providers to facilitate emergency restoration activities, provide discussion forums for work delivery protocols such as climbing or live work, transmission line rating calculation methods and share information on the implementation of new technology will continue through CIGRE, EPRI and other avenues.

9. SAFETY AND ENVIRONMENT

9.1 Safety Management

The design and implementation of transmission line maintenance strategies will incorporate Powerlink's Safety Management System WHS-P&C–STD- A1955230. This includes the use of risk and hazard management processes to ensure safety of workers, the safety of the public and the safety of plant and equipment.

9.2 Environment

9.2.1 Environmental Management

The design and implementation of transmission line maintenance strategies will incorporate Powerlink's Environmental Policy. This includes the use of environmental risk assessment processes to identify risks and to appropriately manage the risk.

9.2.2 Species Management

The HV Asset Strategies Team actively participates in seeking beneficial outcomes with the Environmental Protection Agency for the professional and humane management of bird and reptile species that interact with Powerlink assets. Species interactions with transmission line assets are actively monitored and processes for the responsible management of these interactions are regularly reviewed.

10. FORWARD PLANNING

A 10 year Asset Management Plan is prepared by the Network Integration Team based on Area Plans, outlining capital projects by type, location and expected completion date as well as operational projects for major components.

All routine maintenance plans are entered into SAP by built section number to ensure automatic generation of work orders. The Maintenance Service Providers shall prioritise all notifications 12 months in advance assigning action by end dates for all high priority work.

11. DISTRIBUTION LIST

Internal	Contact details
☒ Investment and Planning	Executive Manager Investment and Planning Group Manager Strategy and Planning Group Manger Portfolio and Business Management Main Grid and Controls Manager HV Asset Strategies Manager Network Integration Manager Senior Lines Strategies Engineer Senior Network Strategies Engineer
☒ Infrastructure Delivery and Technical Services	Group Manager Infrastructure Support Services Group Manager Infrastructure Delivery Group Manager Infrastructure Technical Services Group Manager Infrastructure Management Systems
☒ Operations and Field Services	Group Manager Technical and Network Services Group Manager Field Services Group Manager Specialist Services Group Manager Network Operation Services

12. APPENDIX 1 – GENERIC TRANSMISSION LINE LIFE CYCLE