2023-27
POWERLINK QUEENSLAND REVENUE PROPOSAL

Supporting Document – PUBLIC

Transmission Line Asset Methodology Framework

Powerlink – Transmission Line Asset Methodology – Framework

Policy stream	Asset Management	
Authored by	Team Leader Lines Strategies	[redacted]
Reviewed by	Senior Lines Strategies Engineer	[redacted]
	Senior Lines Strategies Engineer	[redacted]
	Manager Asset Strategies	[redacted]
	General Manager Asset Strategies and Planning	[redacted]
Approved by	Executive General Manager Strategy and Business Development	[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	AM-STR-0388 document reviewed and aligned with new DMF by [redacted]
4.0	1/06/2018	All	All areas have been updated as part of NER rule change requirements.
5.0	21/07/2020	All	Updated content related to roles, processes, and references.

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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 Overhead 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 line voltages: 66kV, 110kV, 132kV, 275kV, and 330kV including:

- aerial conductors;
- insulators;
- hardware and attachments;
- structure foundations;
- lattice steel towers;
- steel poles; and
- concrete 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 Framework.

Transmission Line Ratings are not covered within the scope of this document. Refer to the Transmission Line Ratings document (see 1.3) for further details.

1.3 References

Document code	Document title
ASM-I&P-STR-A969433	Asset Management Strategy
WHS-P&C–STD-A1955230	SMS03 Electrical Safety Management System - Standard
ASM-FRA-A2417558	Asset Risk Management Framework
BUR-SR&CS-FRA-A2294813	Security Management – Framework
CIGRE	CIGRE Australia
Electricity Act	Electricity Act *1994* (Qld)
Electrical Safety Act	Electrical Safety Act *2002* (Qld)
Electrical Safety Regulations	Electrical Safety Regulation *2013* (Qld)
Electrical Safety Code	Electrical Safety Code of Practice *2010* – Works (Qld)
EPA	Environmental Protection Act *1994* (Qld)
EPRI	Electric Power Research Institute
NER	National Electricity Rules
Land Asset Methodology	Powerlink Land Asset Methodology – Framework
Transmission Line Ratings	Powerlink Transmission Line Ratings
Work Health and Safety	Work Health and Safety Regulations *2011* (Qld)

1.4 Defined terms

Terms	Definition
IUSA	Identified User Shared Assets
DCA	Dedicated Connection Assets
SAP	Computerised maintenance management system - SAP is the enterprise business application which supports the core processes of asset management, including project management and maintenance. SAP facilitates the flow of information between all asset management functions within Powerlink, including those activities undertaken by external maintenance service providers.
MSP	Maintenance Services Provider which is an internal or external party that provides a maintenance service.
High Voltage Live Line Work	High voltage live line work means live work on exposed live high voltage conductors or exposed live parts of high voltage electrical equipment as defined in the Electrical Safety Regulations 2013

1.5 Roles and responsibilities

Who	What
General Manager Asset Strategies & Planning, SBD	Endorse the framework and support an undertaking to manage assets in accordance with this framework.
Manager Asset Strategies, SBD	Endorse action to manage assets in accordance with this framework.
Team Leader Lines Strategies, SBD	Take action to manage assets in accordance with this framework.
Senior Lines Strategies Engineers, SBD	Initiate and manages condition assessments for all lines assets. Initiate technical investigations and research projects as required. Recommend life extension methods. Monitor asset condition. Initiate lines asset refurbishments and selective equipment and component replacement.
General Manager Technical and Network Solutions, OSD	Establish operational documents in-line with this framework and perform audits on maintenance processes.
General Manager Field Delivery, OSD	Implement relevant section of this framework as part of field services.
General Manager Service and Supply Partners, OSD	Manage MSPs and audit maintenance activities in accordance with this framework.
General Manager Network Operations, OSD	Provide fault data, analyse outages, and manage planned and forced outages in accordance with this framework.
General Manager Infrastructure Delivery, DTS	Deliver project scopes and outcomes in accordance with this framework.
General Manager Design Solutions, DTS	Align design and other technical services with this framework.
General Manager Community and Delivery Services, DTS	Manage Easements and Asset Data during the project delivery phase in-line with this framework.
General Manager Network Portfolio, SBD	Recommend investment options in-line with this framework.
General Manager Business Development, SBD	Manage Connection and Access agreements and Network Operating Agreements in-line with this framework.
General Manager HSE, PCS	To ensure Safety Management System documents reference this document.

1.6 Monitoring and compliance

The success of this document can be measured by the corporate use of Asset Management Plans, lifecycle planning, condition assessments and management of asset data. This document should be reviewed every three years to ensure compliance is maintained with current legislation and standards.

The Lines 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.

1.7 Risk management

To successfully manage transmission line assets in accordance with Powerlink's Asset Risk Management Framework, it is necessary to identify and manage a range of hazards and risks. The following tables summarise the identified hazards and their corresponding control measures.

Table 1 – Identified Transmission Line Hazards and Control Measures

Performance Related Hazard	Residual Safety Risk	Risk Control Treatment
Transient double circuit outages	Moderate	• Policies and Procedures • Structure footing resistance measurement
Hazardous step or touch voltages at structures	Moderate	• Policies and Procedures • Monitoring of land use changes
Conductor clearance and management of non-statutory ground and other clearances	Moderate	• Policies and Procedures • Annual check of peak circuit loads
Conductor damage due to vibration	Moderate	• Policies and Procedures • Routine inspection
Structural member failure due to inadvertent damage or corrosion	Moderate	• Policies and Procedures • Routine inspection
Foundation integrity	Moderate	• Policies and Procedures • Routine inspection
Mechanical failure of high voltage conductor (including associated hardware and mid span joints)	Moderate	• Policies and Procedures • Routine inspection
Mechanical failure of insulator and associated hardware	Moderate	• Policies and Procedures • Routine sample inspection
Mechanical failure of OHEW/OPGW conductor (or associated hardware)	Moderate	• Policies and Procedures • Routine inspection
General Deterioration of Components	Moderate	• Design Standards • Equipment Strategies • Policies and Procedures • Refurbishment Plan
Catastrophic Failure of Structures or Components	Significant	• Maintenance Procedures • Equipment Strategies • Design Standards • Emergency Response Procedures
Incorrectly Performed Maintenance by MSP	Moderate	• Maintenance Procedures • Audits

Table 2 – Other Associated Hazards and Control Measures

Other Associated Hazards	Residual Safety Risk	Risk Control Treatment
Lightning strikes	Moderate	• Design Standards • Structure footing resistance measurements
Bushfire initiation due to dropped conductor	Moderate	• Policies and Procedures • Insulator management
Flood (damage to structures)	Moderate	• Policies and Procedures
Acts of Theft and Vandalism	Low	• Policies and Procedures • Design Standards
Exposure to EMF	Moderate	• Site Radiation Folders • Policies and Procedures • Monitoring of bare hand work levels
Working at Heights	Moderate	• Policies and Procedures
Unauthorised access to structures	Low	• Design Standards • Maintenance Policies and Procedures • Installation and inspection of anti-climbing devices
Electric shock to personnel due to induction	Low	• QEE Safe Access to High Voltage Electrical Apparatus • Policies and Procedures

2. Asset Management Overview

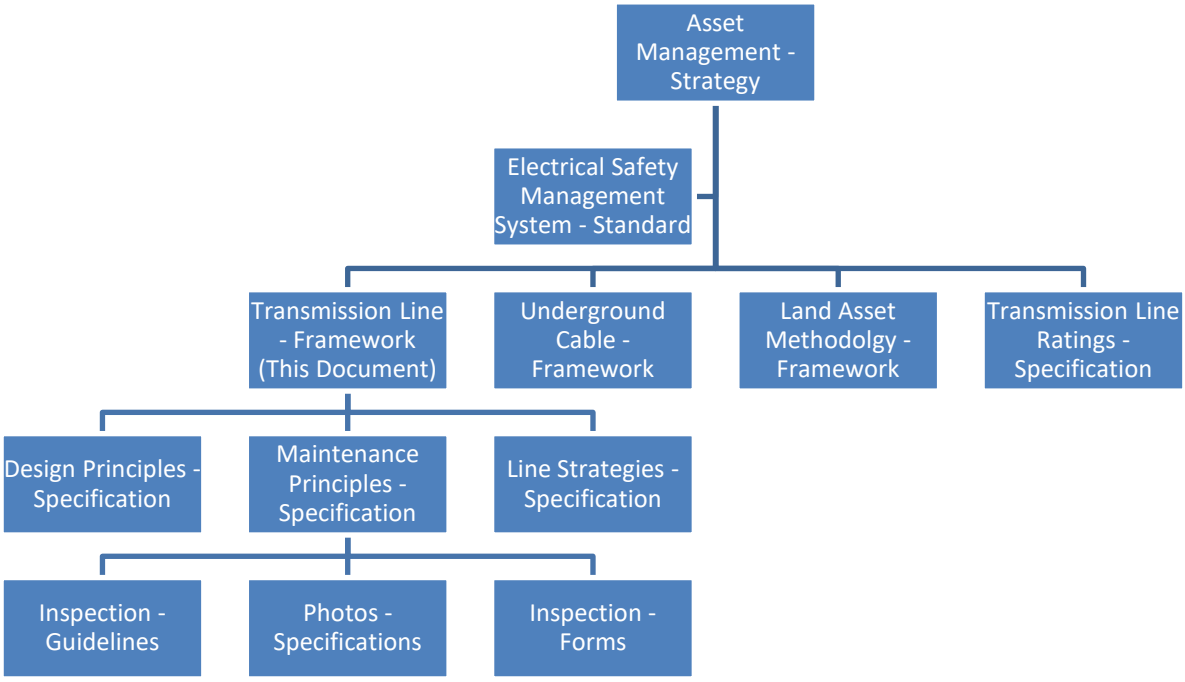
Powerlink's Asset Management Strategy ensures the organisation's assets are managed in a manner consistent with its overall corporate vision objectives including innovation, customer and business focus and reputation.

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.

2.1 Document Hierarchy

Powerlink's document hierarchy for transmission lines is as follows.



3. Asset Information

3.1 Asset Overview

Powerlink owns and operates a broad variety of overhead transmission lines at voltages from 66kV to 330kV. The age of Powerlink's transmission lines vary, the oldest having been built in 1957. Transmission line statistics can be found in the Annual Report.

3.2 Built Sections

Transmission lines can be composed of a series of Built Sections, each considered to be an 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 vary based on the characteristics of built sections forming parts of the line.

Powerlink's experience is that the anticipated technical life of a built section varies from less than 40 years to greater than 60 years depending on the environment. In more aggressively corrosive coastal, high humidity, elevated and industrialised locations, the anticipated technical life may not be achievable without major intervention, such as specialised condition based maintenance, refurbishment or refit, which will be discussed in subsequent sections.

3.2.1 Transmission Line Structures

Transmission line structures are designed to provide adequate distance between the ground and conductors and to provide mechanical support for insulators, wires and other hardware. They have also been designed to provide maintenance access to the conductors, insulators and hardware.

Powerlink uses a variety of transmission line structure types such as guyed steel masts, concrete poles 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.

3.2.2 Transmission Line Spans

Transmission line spans are comprised of HV conductors, overhead earthwires and associated hardware located between two adjacent structures.

A range of conductor types and sizes is used by Powerlink: predominately Aluminium Conductor Steel Reinforced (ACSR) and All Aluminium Alloy Conductor (AAAC). On some lines two conductors per phase are used to achieve the required electrical rating or to manage surface voltage gradient.

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

4. Levels of Service

4.1 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.

4.1.1 Safety Compliance

A fundamental requirement is for Powerlink to give effect to an Electrical Safety Management System in accordance with the Queensland Electrical Safety Act. Powerlink complies with this requirement by the use of a Health, Safety and Environment Management System, of which an integral part is an Electrical Safety Management System. The main purpose of this is to ensure that all plant and equipment is 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 the integrity of the earthing systems and structure climb deterrent devices.

Equally important is to have work practices to target zero accidents. The Queensland Work Health and Safety Act requires 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 rate 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; and
- safety in Design as per the Work Health and Safety Act (Queensland).

Maintenance measures include:

- routine patrols and an annual review of patrol outcomes;
- measurement of structure footing resistances to manage prospective touch and step voltages in line with the Electrical Safety Code of Practice;
- effective asset registers and information systems for maintenance management and geospatial mapping;
- an 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 transmission lines; and
- monitoring of outage data and investigations.

4.1.2 Reliability of Supply

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

Powerlink has established a business process for obtaining circuit outages that involves negotiation of a suitable time with regard to market and customer impacts (including generators and direct connect loads). All planned outages are managed and co-ordinated by Network Operations and where possible outages are scheduled in periods of low loads. Routine maintenance tasks are reviewed by Operations and Service Delivery (OSD) to ensure that only appropriate routine maintenance is undertaken, especially when those tasks involve 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, and to enable the identification of actions or plans to improve reliability where required.

Powerlink owns and maintains 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 that auto-reclose functionality is available on all relevant transmission feeders.

4.1.3 Compliance with National Electricity Rules

As part of network investment, Powerlink is required to:

- plan network development in accordance with Powerlink's Transmission Authority, the Electricity Act and National Electricity Rules (including a Regulatory Test for Transmission);
- monitor the condition of all transmission lines to provide safe, reliable electricity supply;
- minimise the risk of actual "loss of supply" events; and
- meet the needs of our customers.

By monitoring load growth and network capability, network needs are identified, all viable options for network reinvestments are considered, and the planned project's long term value is identified. Options are developed to address these needs with the option providing the lowest long run cost to consumers selected.

4.1.4 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 the Network Customers group where there is a significant impact to any customer.

Powerlink's maintenance programs are also coordinated to occur in conjunction with customer plant shut downs 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 and monitor the condition of transmission line connection assets.

4.1.5 Identified User Shared Assets (IUSA)

Identified User Shared Assets are not owned by Powerlink, however they are operated and maintained by Powerlink under a Network Operating Agreement. These assets will be operated and maintained in accordance with Powerlink current strategies and procedures unless otherwise stated.

The Network Operating Agreement should include information on the following:

- Powerlink supplied feeder number,
- Powerlink supplied Built Section number and Structure numbers,
- Powerlink functional locations and asset data requirements for SAP,
- Emergency spares and response times for corrective maintenance,
- Maintenance spares for condition based maintenance,
- Patrol and Inspection cycles and
- Maintenance requirements for components that are non-standard or where requirements do not align with Powerlink's.

4.1.6 Environment Compliance

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

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

5. 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; and
- effective management of all phases of the asset's lifecycle through targeted maintenance, refurbishment, refit, replacement and disposal activities.

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

- planning and investment;
- operation, maintenance and refurbishment; and
- end of life.

5.1 Planning and Investment

The Planning and Investment stage for Powerlink transmission lines involves:

- network planning;
- option analysis and RIT-T assessment;
- easement acquisition;
- design; and
- construction.

Transmission lines must be suitable for the intended environment in which they operate, providing the required structural and electrical capacity, and meeting community expectations.

For new or replacement lines, 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 customer Levels of Service over the life of the asset;
- ensure the desired asset life is achieved;
- optimise total lifecycle costs;
- ensure the maintainability and supportability of the asset over its intended life ;
- allow for the use of Live Line maintenance techniques (in most situations); and
- comply with corporate and statutory Environmental and Safety requirements such as, but not limited to:
    - The Queensland Electrical Safety Code of Practice 2020 – Works. The 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 and can be typically achieved by transmission structures. Other requirements specified in the customer connection agreement must also be met, as well as maintainability requirements;
    - Safety in Design as per the Queensland Work Health and Safety Act;
    - Ground Clearance as per the Primary Systems design manual; and
    - The Queensland Environmental Protection Act.

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

The final part of the planning and investment stage includes determination of the procurement method, and finalisation of all aspects of contract, project and construction management. Activities associated with testing, commissioning, production of "as-built" documentation and final handover also need to be planned.

5.2 Operation, Maintenance and Refurbishment

The Operation, Maintenance and Refurbishment stage is the longest of all life stages for transmission lines and can typically be expected to last 50 years or more. During this stage, maintenance and operating standards and procedures have to be in place to ensure that transmission lines are operated within technical parameters and to confirm that 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, corrective maintenance and even partial component replacement and/or refit.

Refurbishment may be undertaken during this part of the lifecycle. For transmission lines this involves any activities required to bring a transmission line from a degraded state back to a serviceable operating condition. It may also involve modification of assets to meet current standards or to meet increased safety or operational requirements. Examples of such activities are:

- upgrade of structure earthing systems;
- insulator and hardware replacement;
- earthwire replacement;
- replacement of climbing aids;
- improved security; and
- tower painting.

The operation of the network must be managed in a way to ensure that system security is preserved.

5.3 End of Life

Transmission line assets may be disposed of when there is no enduring need for the asset and when it is economic and prudent to do so from a stakeholder’s perspective. Disposal of transmission lines is complex, involving requirements to meet all statutory regulations including environmental and safety requirements for workers and the general public.

6. Asset Management Drivers

Transmission lines represent one of the largest asset groups in Powerlink, with an expected technical life between 30 and 60 years depending on environmental factors. It is critical to manage these assets in such a way as to achieve the desired operating life at an optimal lifecycle cost. This can only be achieved by setting an appropriate asset management strategy at the beginning of the transmission line's life, and incorporating timely and suitable responses to the range of internal and external drivers.

Internal

- transmission line condition assessments;
- component group assessments;
- technical investigations;
- data modelling and reporting;
- statistical fault data collection and review; and
- transmission line ratings (required and actual).

External

- innovation and technology;
- emerging issues including renewable generation; and
- demand and energy consumption.

6.1 Condition Assessment

Powerlink's transmission line assets typically deteriorate by natural aging processes as a result of environmental conditions as well as due to 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 most environmental conditions, once a transmission line is visibly corroded, it will continue to deteriorate to its ultimate end of life if left unchecked.

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

Condition assessment of transmission lines is an important activity providing an indication of the extent of defective and deteriorated components. While processes to automate and visualise asset condition are being developed, specific investigations and analyses of data to determine the level of component deterioration, and the holistic condition of transmission lines are still important. Analyses may also provide potential options to achieve asset reliability for a technical asset life of between 30 and 60 years depending on environment.

6.2 Innovation and Technology

The Lines Strategies Team is continuously looking at technology and methods to improve the management of transmission lines assets such as:

- data capture and management processes;
- automation of condition assessments;
- data transfer systems including the "Internet of Things" (IOT);
- data visualisation and dashboards;
- artificial Intelligence;
- pre-programmed drone flights;

- systems for monitoring lightning performance and bird activity around transmission line assets in order to reduce the potential of double circuit outages on the Powerlink transmission network due to a bird streamer or lightning strike;
- technology for monitoring the integrity of “mothballed” feeders; and
- research into alternate structure coating systems for extending life.

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

6.3 Emerging Issues

6.3.1 Climate Change Adaption

Concerns about climate change require that the resilience and durability of transmission lines needs to be reviewed on a regular basis and a solid understanding of the impact of these changing conditions on line asset components (over the line’s useful life) developed.

Projected impacts of climate change in Queensland are likely to be:

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

6.3.2 Connection of renewable energy sources

A recent development within the electricity industry is the increase in the number of renewable energy sources which seek to be connected to the electricity grid. The impacts for Powerlink have been:

- an increase in the number of connection points on existing feeders;
- an increase in the number of short overhead lines and underground cables connecting to existing substations;
- increased complication in obtaining maintenance outages;
- changes in power flows on various feeders; and
- increased variability in generation.

7. Asset Management Activities

Electricity transmission assets have a relatively long expected operating life. During the Planning and Investment phase it is important to optimise the design, configuration and topology of the transmission network to provide improved reliability, maintainability and life cycle cost outcomes. Once such assets are acquired, a number of additional asset management activities can be used to:

- minimise overall lifecycle cost;
- achieve the expected operating life in a safe manner with minimal outages;
- extend the expected operating life without impact on availability; and
- organise timely refurbishment and replacement with minimal impact on network operation and to the public.

7.1 Planning and Investment

At the Planning and Investment stage, a range of transmission line augmentation, replacement, and life extension options 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 condition of the assets.

The approach to planning and investment also involves ensuring that 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 5.1.

7.2 Operation, Maintenance and Refurbishment

7.2.1 Operation

Transmission line performance is analysed by monitoring the number of forced outages, the number of notifications involving breakdown, and maintenance inspection and test results captured within measurement documents.

Powerlink has also developed maintenance service provider capability in helicopter and 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 rectification of defects with limited network outages.

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

7.2.2 Maintenance

Maintenance strategies for transmission lines are developed using Reliability Centred Maintenance (RCM) techniques. RCM provides a rigorous and auditable analysis framework for identifying maintenance tasks that are applicable and effective in preventing and 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 appropriately maintained.

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

The transmission lines asset management model is based on the maintenance activities defined in Appendix A.

7.2.3 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 their environment in different ways and require a range of activities to be performed.

Transmission lines are designed to achieve a nominal performance level in standard environmental conditions. Over the years environmental factors (industry, housing, weather patterns and climatic conditions) may change and the lines may therefore be 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 increased insulation levels;
- higher fault currents due to increased generation connected to the network, or increased network capacity, leading to the requirement for increased overhead earthwire capacity;
- a higher than expected incidence of lightning storms and/ or decrease of moisture level increasing the tower earthing resistance leading to a higher than expected outage/trip frequency;
- a change or un-anticipated level of wildlife (birds, snakes, flying foxes, etc.) and/ or vegetation; and
- a decrease in separation from industry or housing resulting in an increased frequency of people near assets, and the need for earth grading rings and other mitigation.

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

7.3 Technical End of Life

A transmission line in Queensland has a nominal technical life span of between 30 and 60 years and is monitored for general condition and specific defects throughout its life. Some components (such as insulators) may require replacement during the life of a transmission line, however condition assessment techniques are used to identify the year in which the overall transmission line, based on structure and foundation condition, is expected to reach technical End of Life. It is noted that condition can vary significantly along a line, but the End of Life definition is based on the proportion of structures being significant, and in excess of what can be managed by normal levels of maintenance: thus requiring intervention.

7.3.1 Transmission Line Reinvestment

Powerlink has two primary reinvestment strategies for transmission lines:

1. Transmission line refit or life extension.
2. Transmission line replacement.

To make the correct decision regarding these two options, additional factors need to be considered such as:

- The lowest long run cost to customers;
- The impact to customers from outages and network interruptions;
- The present and future load flows and network topology;
- The existing easement width, as well as conditions and access for line works;
- The level of difficulty involved in obtaining a new easement for an overhead line;
- The condition of transmission line and variation in condition along the line (homogeneity) ;
- The technical or cost implications associated with life extension and/or reinvestment;
- safety and environmental risks; and
- maintenance costs.

The decision making process for line reinvestment requires asset data to be gathered well in advance of the anticipated major deterioration of the asset to ensure that all options remain feasible. This means that in many cases a condition assessment is required 6 to 10 years before the End of Life of the asset. Condition data collected from field inspections is stored in the SAP maintenance management system, and automated systems to calculate and display line condition information and risk have been developed. These systems, primarily the Portfolio Risk System (PRS) also provide the ability to project existing condition into the future to help predict "need" timing for action on individual structures and for complete transmission lines.

7.3.2 Transmission Line Refit or Life Extension

Transmission line life extension projects will be considered 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 or practical constraints, such as the availability of easements for a replacement alternative, constrain available options.

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

Structure refit may include tower painting depending on the corrosivity of the environment. A structure refit process without paint may be employed in corrosion regions with low to medium rates of corrosion.

7.3.3 Transmission Line Replacement

Transmission line replacement projects will be considered for deteriorated transmission line assets where many component groups have reached End of Life, where the option to undertake replacement is economic compared to life extension and where alternative or widened easements are available. Line replacement is usually essential where an increase in capacity is required, but even if no capacity increase is required, replacement projects usually involve an update to current design standards.

The replacement of a transmission line asset should consider:

- replacement with a like for like or uprated 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; and
- retention of strategic easements for future replacement.

7.3.4 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 are likely to require significant expenditure for ongoing maintenance. Once these assets have been electrically 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 allowing re-use of the asset at a later date or preserving the easement to cater for a change in circumstances or need. To mothball an asset, the asset shall be electrically disconnected from the network with conductors appropriately earthed to eliminate electrical induction and bush fire risks. Mothballing 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 to vandalism and other threats. As such this option may not provide a viable long term solution. Some maintenance will still be required to keep the asset safe, particularly maintenance of 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 the need for further expense. The timing for removal should consider: exposure to the public, costs of maintenance and available resources.

Selection of the preferred option for reinvestment is generally based on a Net Present Value (NPV) comparison of the long term cost of each option. Options above a cost threshold are compared and published as part of a Regulatory Test for Transmission (RIT-T).

8. Emergency Response and Network Security

8.1 Emergency Response

Cyclones and natural disasters are a part of the climate in Queensland, and as such, transmission line assets must be suitably designed and constructed for these climatic conditions. The failure rate for steel tower transmission lines in Australia is in the order of 2 x 10^{-5} failure events per structure year: generally all in extreme weather events. Based on the current Powerlink population a failure is likely on average every 1 to 2 years, however in practice failures coincide with higher category cyclones. 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 their use, involving Delivery and Technical Solutions (DTS) Primary Systems Design group and Maintenance Service Providers.

8.2 Network Security

Security is defined as the state of being protected against danger, loss or harm. It is achieved through the mitigation of adverse consequences associated with the intentional or unwarranted actions of others.

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

9. Supporting Activities

9.1 Asset Handovers

The construction of new transmission line assets, component replacement and transmission line life extension projects all involve 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 project to an operational asset and the maintenance of that asset requires the recording and communication of critical information and related asset data.

The Project Handover process has been implemented to provide the conduit for the transfer of design and construction information between the designers, the construction contractor and the maintenance service provider. It further provides an opportunity for the Lines 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.

9.2 Equipment Spares

An annual review of transmission line spares is performed to ensure that:

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

9.3 Human Resource Training

The Technical and Network Services Team provides a Line Forum annually to reinforce key concepts and strategies with maintenance service providers. This is an important means to communicate changes that have been recently implemented. Powerlink has transmission line training facilities for maintenance contractor training.

9.4 Strategic Linkages

The Lines Strategies Team will develop and maintain strategic linkages internally within Asset Strategies and Planning, the Strategy and Business Development Group, and to other groups external to the division to ensure that a seamless integration of network topography is maintained.

Alignment is maintained between principal Maintenance Service Providers such as Ergon Energy and Operations and Service Delivery (OSD), 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, to provide discussion forums for work delivery protocols such as climbing or live work, transmission line rating calculation methods and to share information on the implementation of new technology through, for example, CIGRE and EPRI and by other avenues.

10. Health, Safety and Environment

The design and implementation of transmission line maintenance strategies will incorporate Powerlink's Health, Safety and Environment Policy. This includes the use of environmental risk assessment processes to identify and appropriately manage risks in accordance with the Powerlink Health, Safety and Environmental Management System.

Electrical safety is managed in accordance with Powerlink's Electrical Safety Management System. This includes the use of risk and hazard management processes to ensure electrical safety of workers, the safety of the public and the safety of plant and equipment.

11. Forward Planning

A 10 year Asset Management Plan is prepared by the Portfolio Planning and Optimisation Team based on Area Plans. This outlines potential capital and major operational 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 by assigning action by end dates for all high priority work, and by a prioritisation system.

12. Distribution list

Divisional Distribution	Contact details
Chief Executive	N/A
Delivery and Technical Solutions (DTS)	Executive GM Delivery & Technical Solutions General Manager Design Solutions General Manager Community and Delivery Services General Manager Infrastructure Delivery
Finance and Governance (FG)	N/A
Operations and Service Delivery (OSD)	Executive GM Operations & Service Delivery General Manager Technical and Network Solutions General Manager Field Delivery General Manager Service and Supply Partners General Manager Network Operations
People and Corporate Services (PCS)	General Manager Health Safety and Environment
Strategy & Business Development (SBD)	Executive GM Strategy & Business Development General Manager Network Portfolio General Manager Strategy General Manager Business Development General Manager Asset Strategies & Planning Manager Portfolio Planning and Optimisation Manager Network and Alternative Solutions Manager Asset Strategies
Group/Team Distribution	**Contact details**
Lines Strategies Team – SBD	Team Leader Lines Strategies Senior Lines Strategies Engineers Land Strategist
Substations Strategies Team – SBD	Senior Network Ratings Strategist
Primary Systems Design – DTS	Principal Engineer Civil Principal Engineer Transmission Lines and Cables
External Distribution	**Contact details**

Appendix A Asset Maintenance Types

Maintenance Type		Activity	Frequency
Preventative Maintenance	Routine Preventative Maintenance (MR)	Transmission line patrols (aerial or ground patrols)	Annually
		Climbing Inspections	Based on corrosion region 3 or 6 yearly (sample only). Starts at half service life.
		Insulator condition inspections	Based on corrosion region 3 or 6 yearly (sample only). Starts at 2/3 estimated life.
		Landing span inspections of insulators and earthwire connections.	6 yearly to be aligned with substation strung bus inspections.
		Footing earth resistance measurements	6yrs where classified as Aquatic, MEN, or Backyard (see Appendix Y). 12 years where the feeder carried by the structure is defined as a “Critical Feeder”, and where the structure is “Inside 2.5kms”, and is not classed as Aquatic, MEN, or Backyard (see Appendix Y). 18yrs Urban locations where not classed as “Aquatic”, “MEN”, “Backyard”, “Inside 2.5kms”, or a “Critical Feeder”.
		Cathodic Protection (applies to only a small number of structures in network)	Annual Inspection, 6 yearly testing or as per maintenance manual.
		Built Section Meters Review	Yearly.
		Detailed Earthing Assessment Follow up	6 yearly following initial assessment to ensure that no significant changes have taken place.
	Condition Based Maintenance (MB)	Conductor mid-span joint testing	As required based on reported condition.
		Inspection of K point areas on towers	Triggered by reported condition and/or age and micro location.
		Insulator washing	Triggered on critical circuits by reported pollution problems.
		Insulator in-situ inspections	As required based on condition.
		Insulator sampling and testing	As required based on condition.
		Detailed Earthing assessment	All Aquatic, MEN and Backyard structure classifications where

Maintenance Type		Activity	Frequency
			the structure is within 20m of the exposure.
		Infrared inspection of joints on tension structures	6 yearly on aged circuits, where required.
		Replacement of structure fasteners, member, insulators or other components that are corrosion level grade 3.	As required based on condition.
		Structure and or Component Inspections	As required.
Corrective Maintenance	Emergency Corrective (ME)	**Immediate** work that must be performed to prevent danger to personnel, public, equipment or system performance	Initiated through Network Operations.
	Deferred Corrective (MA)	All work, including subsequent investigations and report, associated with rectifying an unacceptable plant condition to an acceptable state that is not emergency in nature.	Triggered by notifications and condition data.
Refurbishment	OR projects or small quantities under MB	Insulator replacement	Triggered by notifications and condition data.
		Damper retrofitting and replacement	Triggered by notifications and condition data, or damper end of life which aligns with insulator replacement.
		Upgrading of anti-climbing barriers and/or signs	Triggered by notifications and condition data or land use.
		Upgrading of structure earthing	Triggered by notifications, condition data, land use, fault level, lightning performance.
		Tower K point/foundation refurbishment	Triggered by notifications and condition data.
		OHEW replacement	Triggered by notifications and condition data.
		Tower Painting in highly corrosive environments or environmentally sensitive areas.	On a needs basis, where economic.

This list is not complete and is provided as a guide only.