APPENDIX 25

Asset replacement strategic plan

Energex

Asset Replacement Strategic Plan

Asset Management Division

energex

positive energy

Version control

Version	Date	Description
1.0	22/10/2014	Final

Energex Limited (Energex) is a Queensland Government Owned Corporation that builds, owns, operates and maintains the electricity distribution network in the growing region of South East Queensland. Energex provides distribution services to almost 1.4 million domestic and business connections, delivering electricity to a population base of around 3.2 million people.

Energex's key focus is distributing safe, reliable and affordable electricity in a commercially balanced way that provides value for its customers, manages risk and builds a sustainable future.

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1 Introduction

This Strategic Plan addresses the asset replacement current obligations, environment, drivers and future requirements. The result is a number of capital and operational program initiatives that balance outcomes for the network and customers in alignment with Corporate and Network Asset Management Strategies.

The asset replacement program had a slow commencement in this current period due to scheduling priorities for Augmentation projects. The replacement program is proposed to remain at current levels for the period 2015 to 2020.

Key drivers for the asset replacement program are to maintain safety and reliability of the network and minimise cost to the customer while maintaining legislative compliance.

Forecast expenditure in the period 2020 to 2025 is estimated to decrease slightly due to less ageing asset replacements. This excludes any unforeseen asset issues.

Maintenance strategies employed by Asset Management ensure the continued optimised performance of the network and assets. Energex assesses the replacement expenditure for each major asset category based on the Condition Based Risk Management toolkits which accounts for age and asset health.

The following philosophy and principles are applied to the refurbishment and replacement of Energex's electrical network assets:

- Asset replacement plays a vital role in ensuring the ongoing integrity of electrical network assets and the safety of employees, contractors and the general public.
- Decisions are made to optimise the total cost to the community in terms of Safety, Environment, and Financial costs.
- Activities are planned and managed to minimise the risk of environmental damage caused by network assets.
- Refurbishment activities are planned to optimise asset lifecycle costs.
- Works are integrated with maintenance projects and programs. Planning should seek to derive optimal trade-offs between maintenance and capital programs; for example by reducing maintenance costs through capital replacement of assets requiring higher levels of upkeep.
- Programs are integrated with network development planning to ensure that programs for the refurbishment or replacement of existing assets are coordinated with the development of new network assets.
- decisions are to give due consideration to the ability of Energex to continue to operate the asset including availability of spares, obsolescence, skills and knowledge required to effectively maintain the asset and availability of external support.
- Solutions are to be compliant with Energex design and construction standards.

- Decisions, where practicable, are to consider and align with strategic network development objectives for example the adoption of modern network automation capability.

- Where assets are retired prematurely due to accelerated ageing, information is to be fed back to design, specification and procurement processes to prevent recurrence.

- Decisions are to be made based on knowledge of asset condition and risk.

- Solutions are to be certified as fit for purpose and compliant with relevant codes and standards by a registered engineer. Wherever practicable refurbishment solutions should be approved by the original equipment manufacturer.

This Strategy is to be read with the following associated documents:

[1] Network Asset Management Policy (RED00807)

[2] Network Maintenance Protocol (RED01056)

[3] Refurbishment and Replacement Protocol (RED00490)

[4] Enterprise Risk Management Policy (RED00995)

[5] Network Asset Management Program – Distribution Asset Replacement

[6] Network Asset Management Program – Sub-Transmission Plant Replacement

[7] Network Asset Management Program – Secondary Systems

2 Purpose & Structure

2.1 Purpose

The purpose of this Strategic Plan is to:

- Identify the objectives and operational requirements of the business over a rolling five year period, and assist in the forecasting of future replacement expenditure in subsequent five year periods.

- Ensure that actual condition, performance and failure data are used to inform decisions about the refurbishment and replacement of electrical network assets to ensure optimal prioritisation of investment.

- Ensure ageing electrical network assets are identified and scheduled for refurbishment or replacement in sufficient time where an in service failure presents an intolerable risk.

- Assist in the development of asset refurbishment and replacement programs and budgets and ensure that the decisions to refurbish or replace are sound and robust and can be uniformly applied across all asset classes.

This Strategic Plan is prepared in compliance with Energex's Corporate Strategy and the Network Asset Management Strategy.

2.2 Structure

To achieve its purpose, the Strategic Plan is structured according to the following sections:

1) Strategic Objectives – provides an overview of the strategic planning process and explains how the corporate strategic objectives are translated into operational initiatives and outcomes to be delivered by this Strategic Plan;

2) Options Assessment Methodology – describes the process undertaken to determine the appropriate solution for asset replacement;

3) Status of Network Asset Category – Maintenance and Replacement Strategies – details the existing assets installed in the network and dependencies on maintenance and replacement strategies;

4) 2015-2025 Replacement Forecast – outlines the overall replacement forecast including estimated forecast expenditure for the next two regulatory periods;

5) Governance & Review – sets out the governance arrangements associated with this Strategy Plan.

3 Strategic Objectives

This Strategic Plan is part of an overall strategic planning process that ensures that the corporate strategic objectives are operationalised within the business.

3.1 Network Asset Management Strategy

Energex's network asset management strategy aims to achieve the following objectives:

- compliance with statutory obligations including safety, environment, regulation and Energex Distribution Authority, policies and standards.
- business outcomes achieved and customer and stakeholder expectations met including acceptable levels of network reliability.
- investment principles and optimised asset investment plans that balance network risk, cost and performance (service) outcomes.
- a focus on asset life cycle management including asset data and information and communication technology (ICT) initiatives (data adequacy and quality).
- modernisation of the network to meet required business and customer outcomes
- further development of Energex's asset management system (practice).

The network risks being managed as part of this strategic plan will be assessed in accordance with the Network Risk Framework. Detailed network risk information will be incorporated in the specific project/program planning documentation.

3.2 Asset Replacement Objectives

In order to meet the network asset management strategy and fulfil Energex's statutory obligations the following key objectives have been set:

3.2.1 Safety

In accordance with the Energex Network Asset Management Safety objective to manage network asset safety risks within corporate risk tolerance levels, refurbishment and replacement activities shall ensure that equipment related safety risks are maintained below tolerable limits where this cannot be cost effectively achieved by other means such as inspection and maintenance.

3.2.2 Customers

In accordance with the Energex Network Asset Management customer objective to manage assets to deliver and maintain customer value, it is the object of refurbishment and replacement to deliver programs designed to provide required levels of customer service in the most cost efficient manner possible.

3.2.3 People

In order to align with the Energex Network Asset Management People objective of ensuring the workforce possesses the skills and capability to deliver the business requirements, it is the objective of refurbishment and replacement decisions and programs to consider the present and future availability of workforce skill and capabilities.

3.2.4 Financial Performance

In accordance with the Energex Network Asset Management Financial Performance objective of ensuring Network assets are managed within budgetary provisions and in a prudent, efficient and responsible manner. The intent is to minimise costs across the whole of the asset life cycle.

Refurbishment and replacement programs shall be optimized with respect to cost and risk and financial performance. Programs will be integrated with other network development programs and be documented so as to demonstrate the prudency and efficiency of refurbishment and replacement investment.

3.2.5 Network Performance

In accordance with the Energex Network Asset Management Network Performance objective of managing network performance in terms of security, quality, reliability and availability to prescribed standards, refurbishment and replacement programs are planned to ensure that equipment condition related network outage events are within target levels.

3.2.6 Operational Performance

In accordance with the Energex Network Asset Management Operational Performance objective to ensure corporate, customer, legal and regulatory requirements and constraints are recognised, understood and incorporated into systems for managing the assets, Energex's asset refurbishment and replacement strategies are designed to reflect best practice in terms of optimisation of performance and cost, the management of risk and integration with network development. Refurbishment and replacement programs will support Energex's long term vision for future network architectures and capabilities.

3.2.7 Environment

In accordance with the Energex Network Asset Management Environment objective to ensure Asset Management activities are environmentally sustainable throughout the asset life cycle as detailed in the Asset Life-Cycle Management Strategy. Asset refurbishment and replacement programs seek to address known asset related environmental issues and minimise the potential for future environmental liabilities.

3.2.8 Network Asset Management Standards Compliance

In accordance with the Energex Network Asset Management Standards Compliance objective, refurbishment and replacement activities shall be systematically planned, implemented, monitored and be consistent with the principles of ISO 55000 Asset

Management and ISO 31000:2009 Risk Management – Principles and Guidelines through application of the Energex Network Risk Framework (RED 00559).

3.2.9 Asset Information

In accordance with the Energex Network Asset Management Asset Information objective to ensure Asset data records are of sufficient quantity and quality to meet the ongoing needs of the business.

Energex will ensure sufficient data of appropriate quality is available to support the analysis and optimization of asset replacement and refurbishment programs using methods such as Condition Based Risk Management (CBRM) and accurate network records are maintained following refurbishment/replacement activities.

3.2.10 Compliance

In accordance with the Energex Network Asset Management Compliance objective to ensure processes for the management of network assets are adhered to and that compliance is verifiable, refurbishment and replacement processes and activities are documented and recorded for audit purposes.

3.2.11 Network Maintenance Framework

Energex has introduced a new maintenance framework developed as part of joint workings with Ergon Energy to align the processes and standards with the ISO 55000 Asset Management Standard. This maintenance framework improves on the current maintenance systems introducing more condition monitoring and inspections information retrieval. Specific asset condition information is recorded and used to formulate maintenance strategies and replacement requirements.

3.3 Asset Replacement Program Strategy

Energex determines asset replacement options (described in Section 4) using three core maintenance methodologies: Predictive, Preventive, and Reactive. These core methodologies are applied either independently or in combination for a given asset class depending on the nature of the equipment and its failure mode and is optimised using a risk based approach to deliver the lowest whole of life cost. The combination of approaches is represented diagrammatically in Figure 1.

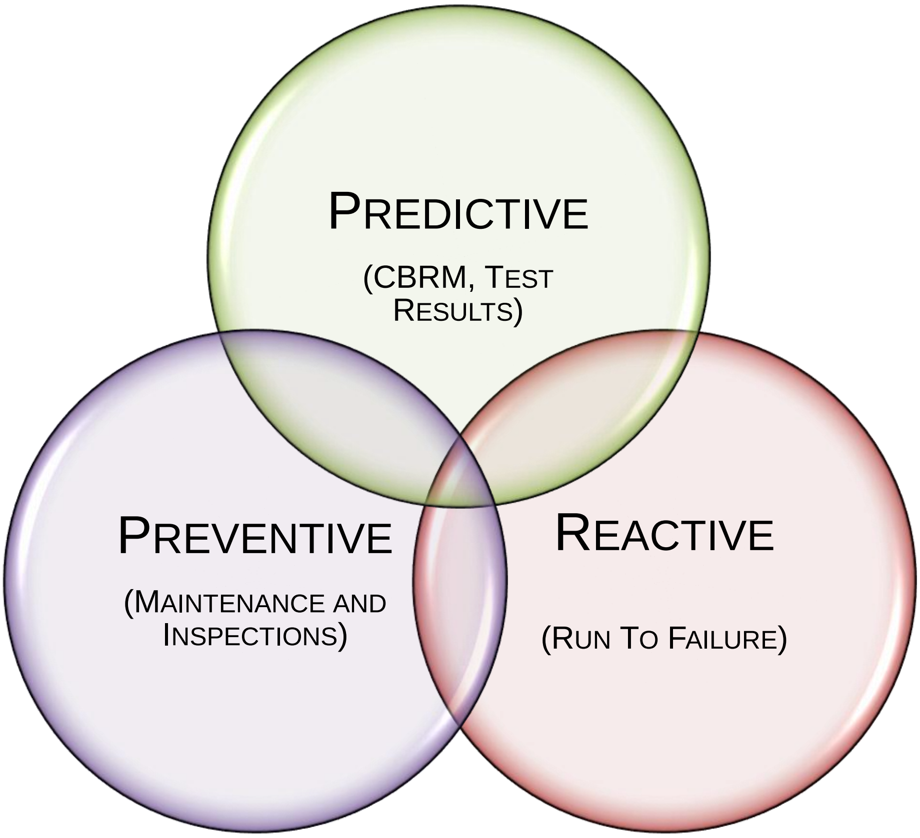

Figure 1: Energex's Asset Life-Cycle Management Strategy

3.3.1 Predictive

The Predictive methodology uses current asset information, engineering knowledge and practical experience to predict future asset condition, performance and risk of failure for network assets.

3.3.2 Preventive

The Preventive methodology uses predefined maintenance and inspection activities applied on a time and/or usage basis as a means of ensuring assets remain fit for purpose over the course of their life. These activities are also used to identify unacceptable conditions which drive corrective works or asset replacement and in many cases to record asset condition information used to support the Predictive methodology.

3.3.3 Reactive

A Reactive methodology is employed for assets where the cost of utilising Predictive or Preventive methodologies exceeds the risk/cost associated with the replacement of the asset after failure. This methodology is generally associated with high population assets with a low consequence of failure.

4 Options Assessment Methodology

4.1 Determination of the Replacement Option

Implementation of Energex's Asset Replacement strategy is achieved through programs developed by analysing requirements at a level of detail appropriate for the level of investment and risk associated with the asset class.

4.2 Options Considered

Energex considers the following replacement options used either exclusively or in combination to achieve its objectives.

- Replace On Condition.
- Bulk Replacement.
- Refurbishment of Equipment.
- Retrofitting of Equipment.
- Replace on Failure.

4.2.1 Replace on condition (Predictive/Preventive)

Where CBRM or asset class risk assessment (inspection) has identified an asset as having an intolerable level of risk on the basis of asset condition, replacement of this asset is considered. The considerations for condition-based replacement of an asset include:

- The asset cannot be returned to an acceptable condition by refurbishment.
- An acceptable retrofit unit is not available or not cost effective.
- Replacement of the asset aligns with strategic network design objectives.
- The replacement equipment can be installed and operated while maintaining the integrity of the network.
- The replacement equipment can be installed and operated while maintaining the safety of employees, contractors and the general public.
- A cost-benefit analysis has shown the replacement to be cost effective.

4.2.2 Bulk Replacement (Predictive)

There may be a justifiable requirement to initiate a bulk asset replacement program for an asset group of similar type, environment and age where it can be demonstrated that the asset group when considered as a statistical population carries a risk that is greater than the cost of the bulk replacement program. Demonstration of the cost versus risk of a bulk replacement program may be demonstrated through either CBRM models or alternatively actuarial techniques such as Weibull analysis or where one or more of the following apply to the asset type:

- Systemic reliability issues.
- Systemic safety issues.
- Systemic environmental issues.
- Obsolescence and spares availability issues.
- Lack of skills and knowledge to operate and maintain the asset.

4.2.3 Refurbishment of Equipment (Predictive)

Where assets have been identified as having an intolerable level of risk due to the condition of the asset or components, this asset may be considered for refurbishment. Considerations for refurbishment of an asset include:

- Refurbishment of the asset can return the asset to an acceptable condition and reduce the risk to a tolerable level.
- Appropriate refurbishment parts are available as spares or from approved sources such as the original equipment manufacturer.
- The equipment is otherwise fit for purpose.
- Suitable spares are available for ongoing maintenance of the equipment.
- Suitable skills and knowledge are available to operate and maintain the equipment.
- Refurbishment of the asset aligns with strategic network design objectives.
- A cost-benefit analysis has shown the refurbishment to be cost effective.

4.2.4 Retrofitting of Equipment (Preventive)

Where CBRM or asset class risk assessment has identified an asset as having an intolerable level of risk on the basis of asset condition and/or specific criticality factors which cannot be addressed by refurbishment, this asset may be considered for retrofitting. Considerations for retrofitting of an asset include:

- Retrofitting of the asset can return the asset to an acceptable condition and reduce the risk to an acceptable level.
- An appropriate retrofit solution is available from the original equipment manufacturer, an approved supplier or certified by a registered professional engineer.
- Suitable skills and knowledge are available to operate and maintain the retrofit equipment.
- Retrofitting of the asset aligns with strategic network design objectives.

- The retrofit equipment can be installed and operated while maintaining the integrity of the network.
- The retrofit equipment can be installed and operated while maintaining the safety of employees, contractors and the general public.
- A cost-benefit analysis has shown the retrofit to be cost effective.

4.2.5 Replace on Failure (Reactive)

A run to failure or replace on failure strategy may be considered for asset types where the consequences of failure do not present a risk to personnel, the public, or the environment and where the cost of failure and subsequent replacement, including allowance for energy not supplied to customers, can be demonstrated to be less than a proactive refurbishment or replacement strategy. Maintenance analysis methodologies such as Reliability Centred Maintenance (RCM) or Failure Modes, Effects & Consequences Analysis (FMECA) will be employed to document failures and validate use of run to failure or replace on failure strategies, or support future adoption of proactive strategies.

4.2.6 Application of the AER's Repex model

The AER indicated in its Expenditure Forecast Assessment guideline for electricity distribution and transmission that it intends to use the Repex model as part of its assessment of proposed replacement capital expenditure. Energex recognises the AER's reasons for applying such high level modelling techniques as an initial review. As such, Energex has applied the Repex models to its replacement capex forecast as a top down assessment of Energex's bottom up program build. For each asset class, further analysis is carried out to validate spend forecast where there is a difference between Repex modelling and the planned Energex investments.

4.2.7 Asset Assessment Tool

Condition Based Risk Management (CBRM) is a structured process that combines asset information, engineering knowledge and practical experience to define the current and future condition, performance and risk for network assets. The process has been progressively applied for those asset classes where sufficient information is available to produce a health index, probability of failure and value of risk for an individual asset.

CBRM, implemented in a manner that is consistent with the principles of Energex's risk management framework, is the preferred method for evaluating condition related risk except in the case of asset classes where the effort required to develop and maintain CBRM models is not warranted. In these cases a formal asset class risk assessment is conducted to document the risks associated with asset failure and the mitigation measures implemented.

5 Status of Network Asset Category - Maintenance and Replacement Strategies

5.1 Introduction

This part of the Asset Replacement Strategy Plan describes the current maintenance and replacement strategies for Energex network assets. Assets are divided into high level groups and a section is devoted to each group. Within these groupings the assets are then divided into categories and the relevant maintenance and replacement strategies discussed. For example, a high level grouping is Overhead Conductors and one of the categories is 11kV conductor.

Each section begins with a brief discussion of the asset and its economic profile (where applicable). Asset maintenance and replacement strategies along with population numbers are also provided. The maintenance strategy is then presented with tasks and the frequency and/or trigger for these tasks. The high level replacement strategy is also presented. Replacement strategy terminology is provided in Section 3.3 - Asset Replacement Program Strategy.

To illustrate the application of maintenance and replacement strategies, the following information is provided on the wood pole population as an example:

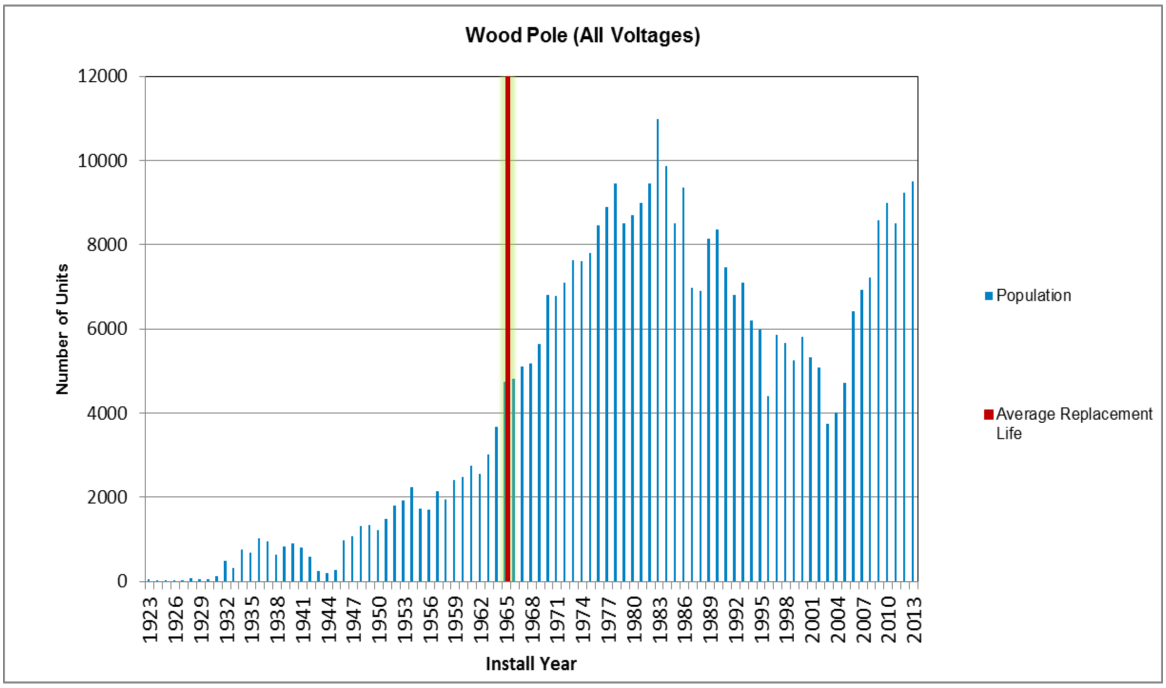

Figure 2 - Wood Pole Population Age Profile

Pole asset condition is assessed using predefined maintenance and inspection activities which are applied on a time basis consistent with legislative requirements. These activities identify defects which drive corrective works (ie refurbishment using structurally effective support system employing nails / stakes, known as nailing) or asset replacement. Asset condition information and population age are used to forecast future investment requirements. Actual spend is driven by inspection outcomes.

The high level asset categories and associated sections are shown in Table 1.

Table 1 - High Level Network Asset Categories and Their Corresponding Section

High Level Asset Category	Section
Poles and Pole Top Structures (Crossarms)	5.3
Overhead Conductors	5.4
Underground Cables	5.5
Service Lines	5.6
Transformers	5.7
Switchgear	5.8
Protection Systems and Audio Frequency Load Control	5.9

5.2 Maintenance and Replacement Strategy Summary

This section provides a summary of the maintenance strategy for each of the asset categories. Replacement strategy terminology is provided in Section 3.3 - Asset Replacement Program Strategy.

Table 2 – Network Asset Categories and Maintenance Strategy

Asset Category	Predictive	Preventive	Reactive
Poles – Wood		✓	
Poles – Wood (Nailed)		✓	
Poles – Concrete		✓	
Pole – Steel		✓	
Pole Top Structures		✓	
Overhead conductors - ≤1kV		✓	
Overhead conductors - >1kV	✓	✓	
Underground Cables - ≤11kV			✓
Underground Cables - >11kV	✓	✓	
Service Lines		✓	
Transformers – Pole Mounted		✓	✓
Transformers – Kiosk Mounted		✓	✓
Transformers – Ground Outdoor/ Indoor Chamber Mounted – 11kV <2MVA		✓	✓
Transformers – Ground Outdoor/ Indoor Chamber Mounted – 33kV <2MVA		✓	✓

Asset Category	Predictive	Preventive	Reactive
Transformers – Ground Outdoor/ Indoor Chamber Mounted – 33kV >2MVA	✓	✓	
Switchgear – ≤11kV Switch	✓	✓	✓
Switchgear – >11kV Switch		✓	✓
Switchgear – <11kV Circuit Breaker		✓	
Switchgear – ≥11kV Circuit Breaker	✓	✓	
Protection Relays	✓		
Audio Frequency Load Control	✓		

5.3 Poles and Pole Top Structures (Crossarms)

5.3.1 Overview

Pole and crossarm failures have significant consequences for public safety, legal compliance and network reliability. Energex takes a preventive approach to pole maintenance.

Predefined maintenance and inspection activities are applied on a time basis to ensure asset condition and safety. These activities are also used to identify defects which drive corrective works or asset replacement. Asset condition information is recorded to support a future predictive approach to maintenance and replacement.

In order to achieve the expected life of pole assets, for poles with structural degradation of their foundations a structurally effective support system employing nails / stakes, known as nailing, is used, where an inspection analysis has determined suitability.

As can be seen in Table 3 the majority of the population in this grouping is wood poles (nailed and un-nailed).

The maintenance and replacement strategic plans for all assets in this grouping are documented in Table 3.

Table 3 - Poles and Pole Top Structures Maintenance and Replacement Strategy

Asset Category	Population	Maintenance Strategy	Replacement Strategy
Poles – Wood	398,179	Performed routinely: • Ground Inspections (Above and below ground) • Aerial Inspections • Thermographic survey • Summer Preparedness Patrol Performed as required: • Poletop Inspections • Pole treatment for decay • Replacement of earth guards and stay guards • Termite and corrosion treatment • Removal of vegetation that impedes inspection • Fitting of site labels	Poles and Pole Top Structures are addressed using a preventive methodology.
Poles – Wood (Nailed)	38,707		
Poles - Concrete	10,186		
Pole - Steel	3,078		
Pole Top Structures (Crossarms)	578,128	Performed routinely: • Summer Preparedness Patrol Performed as required: • Pole Top Inspections • Insulator Cleaning • Aerial Inspections • Thermographic survey	

5.3.2 Maintenance

Table 4 shows the general maintenance tasks and maintenance frequency rates for poles and pole top structures. The main approach to maintaining these assets is to use a variety of time based inspection methods, which identify replacements as required.

Table 4 – Wood Poles Maintenance Tasks, Frequencies and Triggers

Asset Category	Maintenance Task	Frequency or Trigger
Poles – Wood	Overhead and Underground Line Inspection (Asset Inspection) Program	10 year initial inspection, then 5 year routine inspections
Poles – Wood (Nailed)	Overhead and Underground Line Inspection (Asset Inspection) Program	5 year routine inspections
Poles - Concrete	Overhead and Underground Line Inspection (Asset Inspection) Program	No nominated interval. (As requested by the Network Maintenance and Performance Group)
Pole - Steel	Overhead and Underground Line Inspection (Asset Inspection) Program	10 year initial inspection, then 5 year routine inspections
Pole Top Structures (Crossarms)	Pole Top Inspection Program (High Rainfall Areas)	Every 5 years (or as requested by the Network Maintenance and Performance Group)
	Pole Top Detailed Aerial Inspection Program	No nominated interval. (As requested by the Network Maintenance and Performance Group)
	Insulator Cleaning Program	As requested by the Network Maintenance and Performance Group

5.3.3 Replacement

Due to the potential high consequence of pole failures, Energex has elected to use a preventive methodology as the basis for replacement strategy to ensure assets remain fit for purpose over the course of their life.

Table 5 shows Energex's pole and pole top structure replacement strategies. The preventive strategy used is time based inspections to identify replacements as required.

Table 5 – Poles and Pole Top Structures Replacement Strategies

Asset Category	Predictive	Preventive	Reactive
Poles – Wood		✓	
Poles – Wood (Nailed)		✓	
Poles - Concrete		✓	
Pole - Steel		✓	
Pole Top Structures		✓	

5.3.4 Problematic Asset Initiatives

5.3.4.1 Untreated/Bush Poles

In addition to poles that fail inspection, Energex has recognised the need to accelerated replacement of untreated (bush) poles. These are significantly older than the average population age band and are susceptible to rapid degradation and failure. The Energex strategy is to replace all bush poles (current population approx. 60,000) over a 10 year period ending 2022/23 through a combination of:

- Unserviceable poles (US) identified through inspection;
- Replacement through re-conductoring and other capital works; and
- A dedicated ageing pole (Bush pole) replacement program.

5.4 Overhead Conductors

5.4.1 Overview

The Energex overhead network is extensive and a variety of maintenance activities are carried out to ensure that the entire OH network is inspected. These assets are expected to last in situ for long periods in a variety of conditions and so the maintenance strategy is primarily non-intrusive inspections.

11kV OH Conductor Replacement Programs forecast through CBRM include the replacement of 11kV 7/.064 copper, 7/.080 copper and 3/12 steel conductors based on condition and age as identified in specific programs.

LV OH conductor replacements also target small conductor sizes replacing them with LV aerial bundled conductor. This replacement strategy aims to remove wood crossarms and conductor splices as they impact safety and reliability and are potential weak points in the electrical network.

The overhead conductor maintenance and replacement strategic plans are documented in Table 6.

Table 6 - Overhead Conductor Maintenance and Replacement Strategy

<table>
<tr><th>Asset Category</th><th>Population (km)</th><th>Maintenance Strategy</th><th>Replacement Strategy</th></tr>
<tr><td>LV Conductor</td><td>14,250</td><td rowspan="4">The following activities are standard:
• Summer Preparedness Patrol
• Aerial Inspections
• Ground Inspections
• Thermographic survey

The following in service activities are carried out as required:
• Line Profile Survey

The following out of service activities are carried out as required:
• Strength assessment
• Fitting wear assessment
• Broken strand assessment
• Connection resistance test</td><td rowspan="4">Condition, end of life and obsolescence based assessment.</td></tr>
<tr><td>11kV Conductor</td><td>17,495</td></tr>
<tr><td>33kV Conductor</td><td>2,196</td></tr>
<tr><td>110kV and 132kV Conductor</td><td>1,132</td></tr>
</table>

5.4.2 Maintenance

Table 7 shows the general maintenance tasks and maintenance frequency rates for overhead conductor. As with poles and pole top assets the main approach to maintaining these assets is to use a variety of time based inspection methods, which identify replacements as required.

Table 7 - OH Conductor Maintenance Tasks, Frequencies and Triggers

Asset Category	Maintenance Task	Frequency or Trigger
All OH Conductor	Standard Aerial or Ground Line Inspection	Aerial - 12 monthly on rural network Ground patrols are 12 monthly on critical feeders. All other conductor is inspected every 5 years.
Subset of OH Conductor	Summer Preparedness Patrol	This patrol is conducted annually on selected feeders. Feeders are selected based on one or more of the following criteria: • High bushfire hazard area • An outage is considered unacceptable • It supplies critical customer load.
OH Conductor	Thermal Survey Line Profile Survey Strength assessment Fitting wear assessment Broken strand assessment Connection Resistance Test	All these activities are carried out on an as required basis. The trigger would typically be defects found during inspections or an equipment population identified as potentially problematic.

5.4.3 Replacement

Failures of overhead conductor can have significant consequences for public safety, legal compliance and network reliability.

Table 8 shows Energex's overhead conductor replacement strategies. For LV overhead conductor the approach is preventive and inspections identify replacement works. For higher voltage conductors, a combination of preventive and predictive strategies are adopted to identify replacement works.

Table 8 - OH Conductor Replacement Strategies

Asset Category	Predictive	Preventive	Reactive
Overhead conductors - ≤1kV		✓	
Overhead conductors - >1kV	✓	✓	

5.4.4 Problematic Asset Initiatives

5.4.4.1 Insulators

Energex's 132kV and 110kV feeders consist of porcelain, glass and silicon insulators. The typical manufacturer recommended lifespan is approximate 35 years, however Energex experience with these insulators lifespan were typically about 10-15 years, depending on environmental conditions.

Energex has annual helicopter inspections of overhead feeders. An engineering assessment has indicated that a large number of 132kV and 110kV insulators will need to be replaced as they are approaching, have reached or have passed their economic life.

5.4.4.2 Over Head Earth Wires (OHEW)

Over Head Earth Wires (OHEW) on five transmission lines have been assessed as prematurely approaching a condition which, if untreated, will result in in-service failures impacting on the safety and reliability of the network. At least two in-service OHEW failures on one of these transmission lines have occurred in last five years. The failed OHEW caused an outage of the transmission line resulting in extended outages to a large number of customers.

To mitigate the identified risks associated with the in-service failure of these transmission line earth wires, Energex will focus on replacing OHEW displaying signs of advanced degradation due to corrosion of steel with Fibre Optic Ground wire (OPGW).

5.4.5 Condition Monitoring

Energex's strategy is to prudently invest in online monitoring of a range of network assets based on supply criticality, suspected condition limitations and operational / access issues.

Energex will implement a variety of condition monitoring schemes to assess the condition of electrical assets and provide real-time diagnostic data. This information will be used for Statistical (Weibull) analysis of condition and failure data to improve replacement and maintenance strategies for equipment and the development of a tool to visually monitor the health of the network.

For overhead conductors this is done by partial discharge mapping of overhead conductors.

5.5 Underground Cables

5.5.1 Overview

Underground cables are very reliable, however when failures occur these can be difficult to locate and repair. Given direct inspection of underground cables is not practical, attention is directed to known or probable sources of failure. Typical causes of failure include joint degradation, route deterioration (e.g. erosion) and damage caused by a member of the public (cable dig in or vehicle impact to LV pillars).

The underground cable maintenance and replacement strategic plans are documented in Table 9.

Table 9 Underground Cable Maintenance / Replacement Strategy

Asset Category	Population (km)	Maintenance Strategy	Replacement Strategy
LV Cable	10,544	LV Pillar Inspection Inspections overlap with business as usual works and other inspection programs. Public reporting	Condition, end of life and obsolescence based assessment.
11kV Cable	5,407	Thermal Scan	
33kV Cable	891	Thermal Scan Cable joint pit inspection Route patrols Online monitoring and testing.	
110kV and 132kV Cable	146		

5.5.2 Maintenance

Underground cables are typically difficult to inspect and maintain. Issues typically occur at cable joints. Maintenance activities target these through inspecting LV pillars and checking cable pits and cable terminations in substations. Cables are also subject to route degradation and important or at risk routes are patrolled. Table 10 shows the general maintenance tasks and maintenance frequency rates for underground cables.

Table 10 – Underground Cables Maintenance Tasks, Frequencies and Triggers

Asset Category	Maintenance Task	Frequency or Trigger
LV Underground Cable	LV Pillar Inspection	A sample of LV pillars is selected annually to check for any emerging issues.
	Inspections overlap with business as usual works and other inspection programs.	Crews identify and raise work as part of business as usual works and any other defects noticed during other inspections of the network.
Underground Cables - 11kV	Substation Cable Terminations Thermal Scan	18 months.
Underground Cables - >11kV	Substation Cable Terminations Thermal Scan	18 months.
	Cable joint pit inspection	Feeders are grouped by criticality. Based on the category the frequency can vary between monthly and annually.
	Route patrols	
	Testing	
	Online monitoring and testing	Alarms are monitored centrally and then investigated.

5.5.3 Replacement

Replacements are performed due to unacceptable condition or reactive (on failure).

The replacement strategy is shown in Table 11.

Table 11 – Underground Cables Replacement Strategies

Asset Category	Predictive	Preventive	Reactive
Underground Cables - ≤11kV (including Consac Cable)			✓
Underground Cables - >11kV	✓	✓	

In line with Energex Predictive methodology the scope of this program is to replace 35km of 33kV underground cable in the 2015-2020 period. These assets are now approaching, have reached or have passed their economic life. In addition, due to termite damage a further 3km of underground cable is programmed to be replaced.

Continued replacement of the gas cable network is required as spare parts are not available for the gas system. In addition, in areas of high termite activity damage to relatively young XLPE cables has occurred. Cables in these areas are to be progressively replaced by anti-termite XLPE cabling.

5.5.4 Problematic Asset Initiatives

5.5.4.1 Replace Ageing Cable Terminations

Replacement of ageing cable terminations (cast iron pot heads) is required for high risk and "end of life" sites. The deterioration of dielectric material inside the chamber of ageing terminations results in failure or explosion of cast iron pot heads. Where high risk and "end of life" cable terminations exist, the cable needs to be replaced feeding the ground transformer. Problematic pot heads of all voltages are to be replaced as a targeted replacement program.

5.5.5 Condition Monitoring

Energex's strategy is to prudently invest in online monitoring of a range of network assets where there are influences of supply criticality, suspected condition limitations and operational / access issues.

Energex will implement a variety condition monitoring schemes to assess condition of electrical assets and provide real-time diagnostic data. This information will be used for Statistical (Weibull) analysis of condition and failure data to improve replacement and maintenance strategies for equipment and the development of a tool to visually monitor the health of the Network. For underground cables this includes:

- Distributed temperature sensor monitoring of underground cables.
- Partial discharge and ageing mapping of 33kV underground cables.

5.6 Service Lines

5.6.1 Overview

Energex's service lines consist of Open wire (OW), Neutral Screen (NS), Parallel web (PWC), Twisted (TT), XLPE (ABC) and form the point of connection to the distribution network for customers.

Due to the large asset population, service lines can have a significant impact on service levels. Predefined maintenance and inspection activities are applied on a time basis to ensure assets condition and safety. These activities are also used to identify defects which drive corrective works or asset replacement. Asset condition information is recorded to support the use of the predictive methodology in future.

Service Replacement Programs include works as part of an ongoing strategy to ensure compliance with statutory regulations relating to condition assessment of customer services. Initial focus is on a program to remove all open wire and concentric services from the network by 2017/18. As this program reaches completion, replacements based on condition assessment and population age will continue. This includes PVC covered services (Parallel web & Twisted), and a portion of older XLPE insulated services.

The service line maintenance and replacement strategic plans are documented in Table 12.

Table 12 Service Line Maintenance / Replacement Strategy

Asset Category	Population	Maintenance Strategy	Replacement Strategy
Service Lines	587,193	Inspection of PVC Services 18 years and older Inspection program of XLPE services	Condition, end of life and obsolescence based assessment. Opportunistic removal of open wire and concentric neutral services

5.6.2 Maintenance

Due to the location and large population the best approach to maintaining these assets is time based non-intrusive visual assessment of their condition. This approach is shown in Table 13.

Table 13 – Service Lines Maintenance Tasks, Frequencies and Triggers

Asset Category	Maintenance Task	Frequency or Trigger
Service Lines	In service condition assessment	Varies (Age of service)

5.6.3 Replacement

Based on an engineering review, Energex has elected to use a preventive methodology as a basis for its replacement strategy to ensure assets remain fit for purpose over the course of their life. The approach is shown in Table 14.

Table 14 – Service Lines Replacement Strategies

Asset Category	Predictive	Preventive	Reactive
Service Lines		✓	

5.7 Transformers

5.7.1 Overview

Transformers are a major part of our electricity distribution network. Maintenance of these assets is critical in maintaining a safe, reliable and affordable network. For high criticality assets, the predictive methodology is applied to ensure commensurate levels of reliability.

For assets of lower criticality, maintenance and inspection activities are time based to ensure asset condition and safety. These activities are used to identify defects which drive corrective works or asset replacements and to record asset condition information used to support the Predictive methodology.

The lowest criticality assets with redundant capacity or low risk or consequence of failure generally have the reactive methodology applied. These assets include pole transformer and regulators.

The transformer maintenance and replacement strategic plans are documented in Table 15.

Table 15 - Transformers Maintenance / Replacement Strategy

Asset Category	Population	Maintenance Strategy	Replacement Strategy
11kV Pole Mounted Transformers	33,400	In Service Condition Assessment – Defects are rectified as part of non-routine repair activities.	Pole mounted transformers are addressed using a combination of the preventive and reactive methodologies.
11kV Pad Mounted Transformers	10,669	In Service Condition Assessment – Minor corrective actions carried out during visit. Other corrective actions are risk assessed and then programmed. Out-of-Service Condition Assessment is performed on Oil transformers >1MVA Intrusive maintenance is performed on Dry type transformers	Ground and pad mounted transformers are addressed using a combination of the preventive and reactive methodologies
11kV Ground Mounted Transformers	3,709		

Asset Category	Population	Maintenance Strategy	Replacement Strategy
33kV Pole Mounted Transformers	95	In Service Condition Assessment – Defects are rectified as part of non-routine repair activities.	Pole mounted transformers are addressed using a combination of the preventive and reactive methodologies
33kV Power Transformers	489	In Service Condition Assessment – Minor corrective actions carried out during visit. Other corrective actions are risk assessed and then programmed. Out-of-Service Condition Assessment >33kV Non-Intrusive Maintenance Oil Sampling – Transformer and Tap changer	Power transformers are replaced based on expected life. Expected life is adjusted based on condition information available.
66kV Power Transformers	1		
132/110kV Power Transformers	155		

5.7.2 Maintenance

The maintenance activities for non-power transformers are primarily non-intrusive, time based visual inspections. The results of these inspections drive the preventative portion of the maintenance strategy for these assets.

For power transformers, given their cost and impacts of failure, a more rigorous approach is taken. These transformers are taken out of service for assessment and oil samples are taken to track asset health. This approach is shown in Table 16.

Table 16 – Transformers Maintenance Tasks, Frequencies and Triggers

Asset Category	Maintenance Task	Frequency or Trigger
11kV Pole Mounted Transformers	In Service Condition Assessment	15 Months
11kV Pad Mounted Transformers 11kV Ground Mounted Transformers Transformers – Ground Outdoor/ Indoor Chamber Mounted – 33kV >15MVA	In Service Condition Assessment	36 Months
	Out-of-Service Condition Assessment is performed on Oil transformers >1MVA	As required. Driven by inspections and issues identified within populations.
	Intrusive maintenance is performed on Dry type transformers	
33kV Pole Mounted Transformers	In Service Condition Assessment – Defects are rectified as part of non-routine repair activities.	15 Months
33kV Power Transformers	In Service Condition Assessment	18 Months
	Non-Intrusive Maintenance	12 years
	Oil Sampling	36 Months
	Tap Changer Oil Sample	18 Months
66kV/110kV/132kV Power Transformers	In Service Condition Assessment	18 Months
	Out-of-Service Condition Assessment	6 years
	Non-Intrusive Maintenance	12 Years
	Oil Sampling	18 Months
	Tap Changer Oil Sample	18 Months

5.7.3 Replacement

Replacements are carried out due to unacceptable condition or reactive (on failure).

The approach is documented in Table 17.

Table 17 - Transformers Replacement Strategy

Asset Category	Predictive	Preventive	Reactive
Transformers – Pole Mounted		✓	✓
Transformers – Kiosk Mounted		✓	✓
Transformers – Ground Outdoor/ Indoor Chamber Mounted – 11kV <2MVA		✓	✓
Transformers – Ground Outdoor/ Indoor Chamber Mounted – 33kV <2MVA		✓	✓
Transformers – Ground Outdoor/ Indoor Chamber Mounted – 33kV >2MVA	✓	✓	

5.7.4 Problematic Asset Initiatives

5.7.4.1 Transformer Moisture Rectification

Energex performs In-Service Condition Assessments of all power transformers every 18 months and Out-of-Service Condition Assessments on 110kV and 132kV transformers every 6 years. Oil samples are taken 18 monthly for 110kV and 132kV transformers and 3 yearly for 33kV power transformers to assess oil quality and the presence of moisture and contaminants.

As a result of oil testing, a number of Energex's existing Power Transformers have been identified as having excessive levels of moisture in the winding insulation. This increases the risk of failure and reduces their economic life.

In particular, it is recognised that transformers reaching mid-life (20-30 years old) are prone to moisture ingress in oil. This can be rectified with specialised refurbishment works to realise or extend the expected life of the asset. Of the Energex transformer asset base, a number of units have been identified for which substantial mid-life refurbishment benefits can be gained.

The transformers targeted for replacement have been chosen based on tank and oil condition assessments as well as age.

5.7.4.2 Regenerative breather

Existing power transformer assets have been assessed as prematurely approaching a condition which, if untreated, will prematurely reach or pass their original design life.

The moisture content is a critical oil quality measure in vacuum OLTCs. Older types also include measure of carbon and dissolved gas content in the oil which trigger routine periodic maintenance activities, however moisture in these units must be addressed through a combination of regenerative breather installations and on-line dryouts.

This program is specifically for the installation of regenerative breathers to on-load tap-changers on power transformers. The regenerative breather removes the moisture from the air entering the OLTC conservator via a desiccant and the system automatically regenerates the desiccant at time based intervals or on directional air flow movement.

5.7.4.3 Trench Capacitive Voltage Transformers (CVT)

In Powerlink Queensland, an unacceptable number of Trench Capacitive Voltage Transformers (CVT) have failed in-service. The outcome of an investigation into these failures was to replace all Trench CVTs greater than 20 years old to avoid catastrophic failure thereby removing the potential risk of severe injury to personnel.

Energex has 189 132/110kV voltage transformers in service of which 50 units are Trench. In line with the Predictive methodology there is a high risk of catastrophic failure due to moisture ingress based on Powerlink Queensland's findings. Energex plans to replace 110kV capacitive voltage transformers which are greater than 20 years old.

5.7.5 Condition Monitoring

Energex's strategy is to prudently invest in online monitoring of a range of network assets where there are influences of supply criticality, suspected condition limitations and operational / access issues.

Energex will implement a variety condition monitoring schemes to assess condition of electrical assets and provide real-time diagnostic data. This information will be used for Statistical (Weibull) analysis of condition and failure data to improve replacement and maintenance strategies for equipment and the development of a tool to visually monitor the health of the Network. For power transformers these include:

- Online dissolved gas analysis of transformers.
- Online HV bushing DLA monitoring.
- Insulation moisture mapping of transformers.

5.8 Switchgear

5.8.1 Overview

Switchgear forms an essential part of our electricity distribution network. Maintenance of these assets is critical in maintaining a safe, reliable and affordable network. For high criticality assets, predictive methodology is applied to ensure commensurate levels of reliability.

Comprehensive reviews of switchgear performance and condition are undertaken to determine replacement programs. Energex has initiated a program to replace or remove 11kV oil-filled circuit breakers from the network, with a focus on those without remote control and hence require manual operation by staff at the site.

The majority of circuit breaker replacements are due to ageing, deteriorated bushing insulation, excessive preventive maintenance costs, excessive wear of primary contacts, difficulty in achieving correct mechanism adjustments and recorded reliability problems.

The switchgear maintenance and replacement strategic plans are documented in Table 18.

Table 18 – Transformer Maintenance / Replacement Strategy

Asset Category	Population	Maintenance Strategy	Replacement Strategy
Switchgear – ≤11kV Switch	202,595	Mechanisms and internal condition are assessed periodically as part of routine inspection and maintenance activities supplemented by time / duty based intrusive maintenance. Tests vary by type (i.e. vacuum versus oil circuit breakers).	LV switches are addressed using a combination of the predictive, preventive and reactive methodologies
Switchgear – >11kV Switch	4,614		HV switches are addressed using a combination of the predictive, preventive and reactive methodologies
Switchgear – ≤11kV Circuit Breaker	5,349		11 kV circuit breakers are addressed using a combination of the predictive, preventive and reactive methodologies
Switchgear – >11kV Circuit Breaker	1,998		HV switches are addressed using a combination of the predictive, preventive and reactive methodologies

5.8.2 Maintenance

For switchgear assets of lower criticality, maintenance and inspection activities are applied on a time basis to ensure assets condition and safety. These activities are also used to identify defects which drive corrective works or asset replacement. Asset condition information is also captured and used to support the Predictive methodology.

The lowest criticality switchgear assets with redundant capacity or low risk or consequence of failure generally have the reactive methodology applied.

Table 19 shows the general maintenance tasks and maintenance frequency rates for switchgear.

Table 19 – Switchgear Maintenance Tasks, Frequencies and Triggers

Asset Category	Maintenance Task	Frequency or Trigger
Switchgear – ≤11kV Switch	In-Service Condition Assessment	18 months
	Intrusive Maintenance	12 years or condition based
Switchgear – >11kV Switch	In-Service Condition Assessment	18 months
	Out of Service Condition Assessment	6 years
	Intrusive Maintenance	12 years
Switchgear – <11kV Circuit Breaker	In-Service Condition Assessment	18 months
	Intrusive Maintenance	12 years or condition based
Switchgear – ≥11kV Circuit Breaker	In-Service Condition Assessment	18 months
	Specialist Survey + Out of Service Insulation Condition Assessment	As required
	Out of Service Condition Assessment – Mechanism Function Check	Varies by type (3 or 6 years)
	Intrusive Maintenance	Varies by type (6 or 12 years)
	Post Fault Maintenance	Varies by type (based on number of fault operations)

Asset Category	Maintenance Task	Frequency or Trigger
	Mechanism Function Check	Varies by type (3 or 6 years)
	Non-Intrusive Maintenance	Varies by type (6 or 12 years)
	Other Specific Maintenance – Condition Based Maintenance	Condition based
	Other Specific Maintenance – Replacement of Cap Bank Circuit Breakers	Specific types only (25 years or number of operations)

5.8.3 Replacement

Replacements are carried out due to unacceptable condition or reactive (on failure).

The replacement strategy is shown in Table 20.

Table 20 – Switchgear Replacement Strategy

Asset Category	Predictive	Preventive	Reactive
Switchgear – ≤11kV Switch	✓	✓	✓
Switchgear – >11kV Switch		✓	✓
Switchgear – <11kV Circuit Breaker		✓	
Switchgear – ≥11kV Circuit Breaker	✓	✓	

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5.8.4 Problematic Asset Initiatives

5.8.4.1 11kV Circuit Breakers

In line with the predictive strategy, Energex has initiated several programs based on capital replacement of plant which are problematic. These programs encompass several initiatives involving specific types of switchgear and individual issues.

5.8.4.2 Air Break Switches

In line with the predictive strategy, a program is undertaken to replacement specific 36kV Air Break Switches resulting from a series of failure investigations which identified the root cause to be a manufacturing defect. The risk assessment resulted in the need for a capital program of replacement of these specific switches in line with the bulk replacement strategy.

The population of these air break switches requiring capital replacement is 100 switches across 21 substations.

5.8.4.3 11kV Ring Main Unit (RMU)

Potential failures of specific Ring Main Units (RMU) can occur if the RMU develops a serious oil leak and loses a significant volume of the insulating oil. The two immediate failure risks are dielectric failure and failure to switch while being operated. For these RMU's, inspection programs and restrictions have been implemented to alert operators to this risk. The replacement program is based on identified leaking units found during inspection or by operators performing routine switching.

5.8.4.4 33 kV Capacitor Bank Circuit Breaker

Risk of failure of 33kV capacitor bank switchgear is attributed to restrike phenomena occurring in the installed vacuum switchgear. In line with the predictive strategy, Energex has initiated a program for the capital replacement of 33kV capacitor bank vacuum switchgear with SF_6 type switchgear.

5.8.4.5 Air Conditioning

Investigation following failures of 11 kV Hitachi vacuum circuit breakers in service have revealed a correlation between changing humidity and temperature within the substation with the level of partial discharge detectable. In order to mitigate partial discharge issues on switchgear, this program will install air conditioning and perform associated work to seal the substation. Air conditioning the substation control buildings will reduce the probability of surface discharge and extend the life of switchgear by reducing the probability of dielectric failure.

5.8.4.6 Planned Battery Replacements

It is imperative to ensure substation batteries continue to remain in a serviceable condition to avoid an intolerable risk to safety, asset condition and network security. Batteries, by their construction, have an operating life limited by chemical degradation of components during charging and discharging. This necessitates periodic replacement to prevent unacceptable failure rates.

The Network Asset Management Policy requires that Energex implement 5 yearly replacements of substation batteries to ensure an optimal level of performance and cost. The combination of battery type and replacement interval has been chosen to maximise the interval between replacements without incurring high risk of failure and uneconomical ad-hoc replacements under the reactive work program.

5.8.5 Condition Monitoring

Energex's strategy is to prudently invest in online monitoring of a range of network assets where there are influences of supply criticality, suspected condition limitations and operational / access issues.

Energex will implement a variety condition monitoring schemes to assess condition of electrical assets and provide real-time diagnostic data. This information will be used for Statistical (Weibull) analysis of condition and failure data to improve replacement and maintenance strategies for equipment and the development of a tool to visually monitor the health of the Network. For switchgear the proposed monitoring is:

- Switchgear partial discharge monitoring.

5.9 Protection Systems and Audio Frequency Load Control

5.9.1 Overview

Protection relays are essential components that ensure electricity supply is delivered safely and within statutory limits. AFLCs play a vital role in network load management.

Protection relays, being critical secondary systems assets, provide the necessary method of limiting failures and fault situations. As such, they form part of the basis for a safe, reliable and affordable network. Preventative methodology is applied to ensure the highest levels of reliability for all protection relays.

The AFLC system provides a means by which certain network loads can be controlled through remote switching for purposes such as control of street lighting or management of network capacity. As such, the system has a significant impact on service levels, network security and network load management. Predictive methodology is applied to ensure the highest levels of reliability for AFLC units.

Table 21 shows the general maintenance tasks and maintenance frequency rates for protection relays and AFLCs.

Table 21 - Protection Relays & AFLCs Maintenance/Replacement Strategy

Asset Category	Population	Maintenance Strategy	Replacement Strategy
Protection Relays	17,117	A regular schedule of out of service functional checks.	Protection relay replacement is undertaken as reactive works
AFLCs	251	A regular schedule of in-service condition assessment is undertaken every 6 years.	All MG Legacy AFLC sets are to be replaced with solid state signal generator (SFU) equivalent due to obsolescence. SFU type AFLCs are replaced as part of condition based risk assessment.

5.9.2 Maintenance

Protection relays are taken out of service of periodically and functional checks are performed. Where applicable this maintenance program is co-optimised with the Mechanical Functional Check (MFC) of the associated circuit breaker so that breaker functionality is proven in conjunction with the protection testing; removing the need for redundant maintenance work.

AFLCs are regularly visually inspected as part of substation inspections and also have a program of intrusive maintenance.

The maintenance approach for protection relays and AFLCs is shown in Table 22.

Table 22 – Protection Relays & AFLCs Maintenance Tasks, Frequencies and Triggers

Asset Category	Maintenance Task	Frequency or Trigger
Protection Relays	Out of Service Condition Assessment – Functional Check	6 years (offset against MFC)
AFLC (audio frequency load control)	In-Service Condition Assessment + IM: Intrusive Maintenance	ISCA is 18 months, IM is 6 years

5.9.3 Replacement

A program of regular maintenance and replacement of protection relays is required as the function of protection relays is to protect plant and people. Failure of a protection relay device can place members of public and the larger network at risk.

The AFLC motor generator sets, which have reached their capacity in response to the Energex Corporate initiative of the Peak Smart Air Conditioning demand management scheme, will be replaced with an electronic generator type. Also, the aged electronic sets will be replaced as they reach their retirement age thus preventing failure which leads to loss of load control by network operator.

The replacement strategy for Protection relays and AFLCs is shown in Table 23.

Table 23 – Protection Relays & AFLCs Replacement Strategy

Asset Category	Predictive	Preventive	Reactive
Protection Relays	✓		
AFLCs	✓		

5.9.4 Problematic Asset Initiatives

5.9.4.1 Neutral Earthing Resistor (NER)

These assets are now approaching, have reached or have passed their economic life.

A Neutral Earthing Resistor (NER) is directly connected to a transformer's neutral to limit ground fault current. A NER uses the actual resistance of its design material to limit fault current. This makes it costly to construct and regular maintenance is required. A Neutral Earthing Reactor (NEX) has a similar function except that it utilises the inductive reactance of its coil to create an impedance path for the fault current and is thus more economical and maintenance free.

It is Energex's current policy to utilise NEXs instead of NERs. There are existing transformers in the Energex Network with NERs are still installed. It is planned to replace 15 units in the 2015-2020 period with NEXs in a targeted program of replacement with the additional 20 to be replaced in the future 2020-2025 period.

5.9.4.2 Protection Scheme (CB's, Relays & CTs)

Protection schemes are specialised control systems that monitor the power system and, when a fault or abnormal condition is detected, initiate corrective action that may disconnect power system plant. These schemes are essential components that ensure electricity supply is delivered safely and within statutory limits. Energex is required to ensure that its protection schemes are reliable and will operate effectively.

Energex has a range of protection arrangements that are potential risks to safety and network reliability. This situation has arisen due to an increase in load and fault levels since the protection arrangements were originally designed / implemented.

To mitigate the identified risks, Energex will initially focus on implementing 33kV bus zone protection at locations where high fault levels exist, bus schemes are not present and bus faults are currently cleared via low speed overcurrent protection. After the initial phase, Energex will consider other issues that require addressing including (but not limited to) assets without high speed primary protection, transformer ended feeders without diverse communications, 11kV feeders without under frequency load shed control and the replacement of neutral earthing resistors due to safety risks in regular maintenance.

6 2015-2025 Replacement Forecast

Program initiatives described in this document have been developed to support the Asset Replacement Strategic Plan. Energex's program initiatives are built from the replacement programs based on the appropriate asset replacement strategy for each asset category plus replacement of specific problematic assets that have been identified and described in Section 5.

The long-term implementation of these program initiates will extend beyond the 2015-2020 regulatory period.

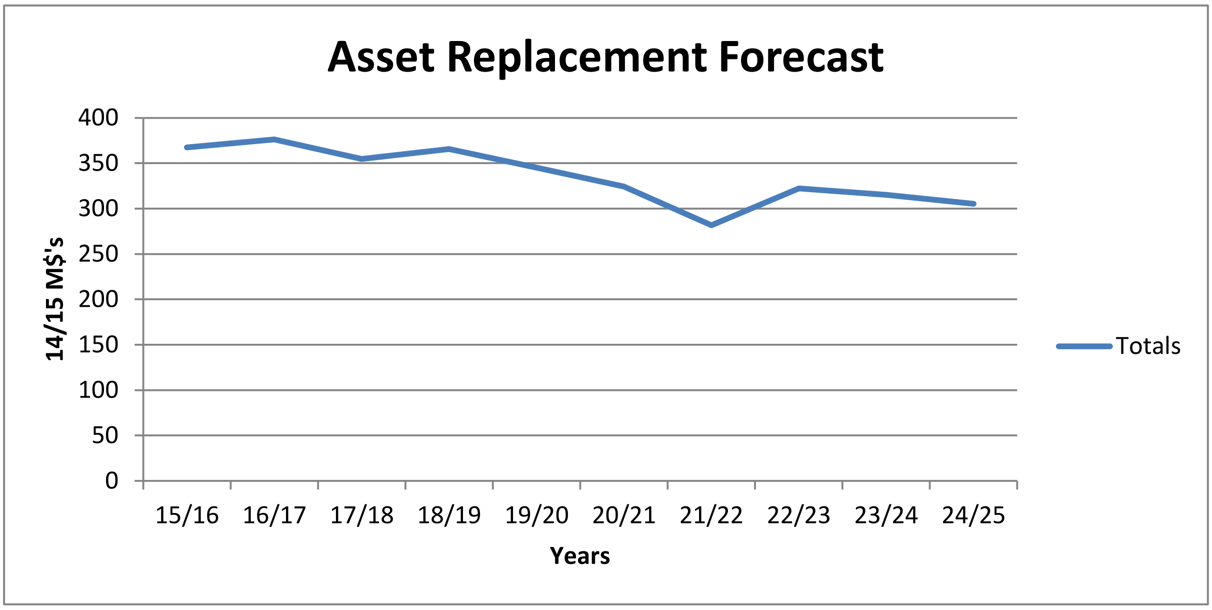

Figure 3 - Asset Replacement Forecast

Figure 3 shows the estimated forecast expenditure including overheads for the next two regulatory periods.

7 Governance & Review

7.1 Ownership

This strategy is owned by Group Manager Network Maintenance & Performance within the Asset Management Division.

7.2 Governance

Energex Program of Work Governance shown in Figure 4 ensures strategy & policy development and resulting portfolio investment approvals align to achieve the strategic objectives of the business. Monitoring and review of the program of work performance against annual targets and performance standards is undertaken by the Network Operations & Steering Committee.

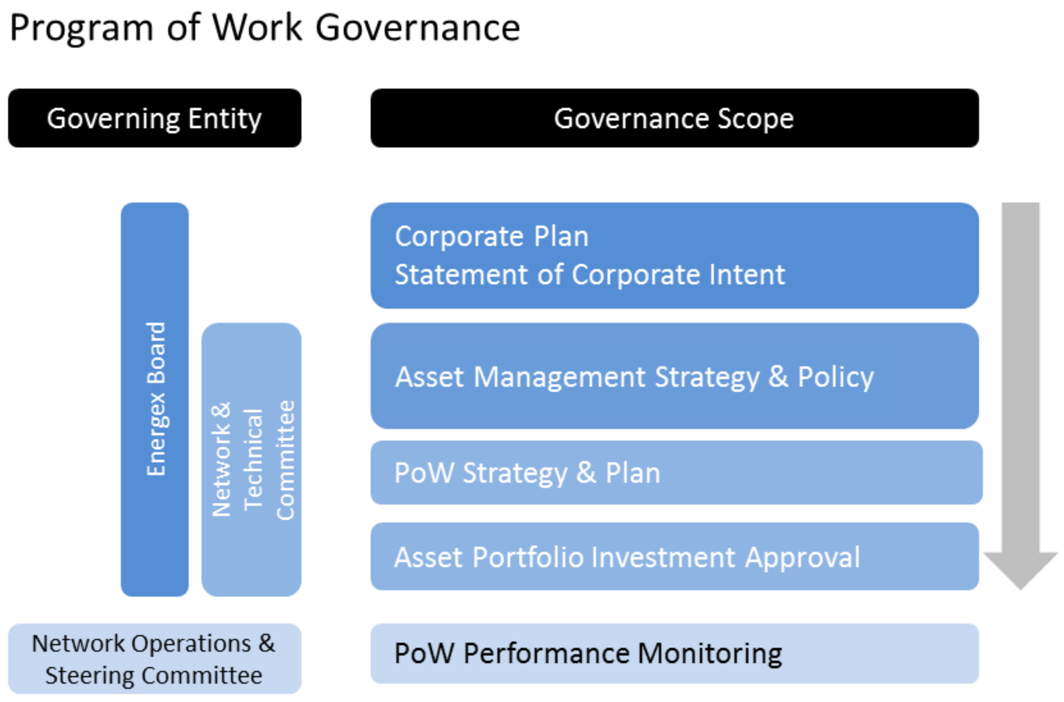

Figure 4: Program of Work Governance Framework Performance Monitoring and Reporting

Monitoring of performance achieved compared to the approved program investment is to be presented on an annual basis to the Network Operations and Steering Committee or earlier if as requested.

Reporting about this strategy/program is facilitated through the following form/methods:

- Asset Replacement Annual Report

Reporting occurs at annual intervals and is produced by the Network Maintenance & Performance Group.

7.3 Review

This Strategic Plan is to be reviewed annually as part of Energex's annual business planning process. Review details can be referenced in the Version Control section at the start of this document.

7.4 Publication

The current version of this Strategic Plan is available on the Energex Intranet and can be accessed via the *Repository of Energex Documents* (RED) page. All other electronic and printed versions of this document are to be deemed as non-current and uncontrolled unless specifically authorised by the owning Group Manager.