Asset Management Plan
Ring Main Units

Part of the Energy Queensland Group

Executive Summary

This Asset Management Plan (AMP) focuses on the management of ring main units (RMUs).

RMUs typically connect underground cable sections together, allowing for segmentation of feeder sections and meshed network arrangements. Energy Queensland Limited (EQL) manages over 21,000 RMUs, approximately 5,700 in the Northern and Southern Regions and 15,300 in the South East Region.

EQL undertakes lifecycle management of RMUs through performance and condition monitoring that includes periodic routine inspections, maintenance, and refurbishment to achieve optimum performance, and where possible extend asset service life.

There are no specific performance targets dedicated to this asset class. Overall asset population performance is evaluated as part of the general organisation obligations for reliability (minimum service standard (MSS)), and annual dangerous electrical event (DEE) incidents.

Key asset challenges for RMUs include:

- The requirement for continuous improvement in asset data quality
- Aligning maintenance and refurbishment practices
- Managing oil and SF6 leak issues in the asset population.

EQL is continuing with the alignment of maintenance and operating practices to drive efficiency, delivery of customer outcomes and to mitigate risks.

Revision History

Revision date	Version number	Description of change/revision
31/01/2019	1	AER Document Initial release

Document Approvals

Name	Position title	Date
Tim Hart	General Manager Asset Lifecycle Management	31/01/2019
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1 Introduction

Energy Queensland Limited (EQL) was formed 1 July 2016 and holds Distribution Licences for the following regions:

- South East Region (Legacy Organisation: Energex Limited); and
- Northern and Southern Regions (Legacy Organisation: Ergon Energy Corporation Limited).

There are variations between EQL's operating regions in terms of asset base and management practice, as a result of geographic influences, market operation influences, and legacy organisation management practices. This Asset Management Plan (AMP) reflects the current practices and strategies for all assets managed by EQL, recognising the differences that have arisen due to legacy organisation management. These variations are expected to diminish over time with the integration of asset management practices.

1.1 Purpose

The purpose of this document is to demonstrate the responsible and sustainable management of ring main units (RMU) on the EQL network. The objectives of this plan are to:

1. Deliver customer outcomes to the required level of service.
2. Demonstrate alignment of asset management practices with EQL's Strategic Asset Management Plan and business objectives.
3. Demonstrate compliance with regulatory requirements.
4. Manage the risks associated with operating the assets over their lifespan.
5. Optimise the value EQL derives from this asset class.

This Asset Management Plan will be updated periodically to ensure it remains current and relevant to the organisation and its strategic objectives. Full revision of the plan will be completed every five years as a minimum.

This Asset Management Plan is guided by the following legislation, regulations, rules and codes:

- *National Electricity Rules (NER)*
- *Electricity Act 1994 (Qld)*
- *Electrical Safety Act 2002 (Qld)*
- *Electrical Safety Regulation 2013 (Qld).*
- *Queensland Electrical Safety Code of Practice 2010 – Works (ESCOP).*
- *Work Health & Safety Act 2014 (Qld)*
- *Work Health & Safety Regulation 2011 (Qld)*
- Ergon Energy Corporation Limited Distribution Authority No D01/99.
- Energex Limited Distribution Authority No. D07/98.

This Asset Management Plan forms part of EQL's strategic asset management documentation, as shown in Figure 1. It is part of a suite of Asset Management Plans, which collectively describe EQL's approach to the lifecycle management of the various assets which make up the network used to deliver electricity to its customers. **Error! Reference source not found.** contains references to other documents relevant to the management of the asset class.

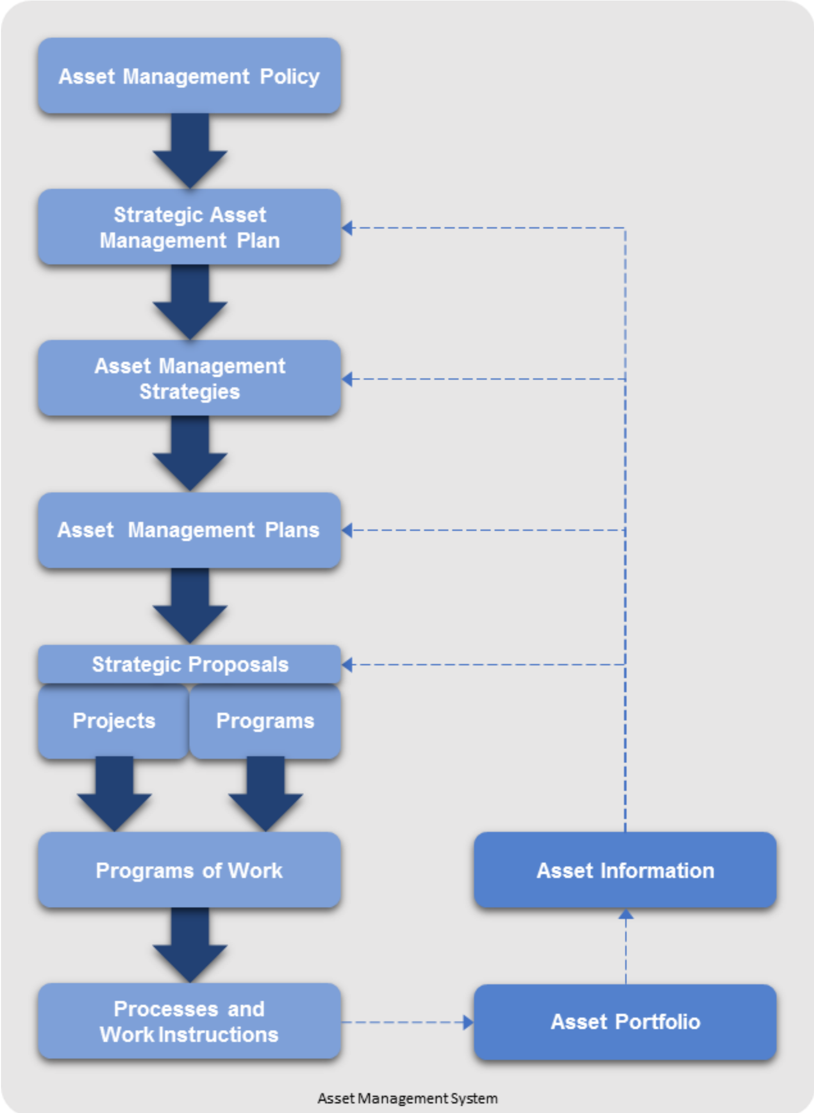

Figure 1: EQL Asset Management System

1.2 Scope

This plan covers the following asset type:

- Ring main units (RMU).

Many customers, typically those with high voltage connections, own and manage their own network assets including RMUs and ancillary equipment. EQL does not provide condition and maintenance services for third party assets, except as an unregulated and independent service. This AMP relates to EQL owned assets only, and excludes any consideration of such commercial services.

1.3 Total Current Replacement Cost

Based upon current asset quantities and replacement costs, EQL RMUs have a replacement value of the order of $1.6 billion. This valuation is the gross replacement cost of the assets, based on the cost of modern equivalents, without asset optimisation or age assigned depreciation. Figure 2 provides an indication of the relative financial value of EQL switches compared to other asset classes

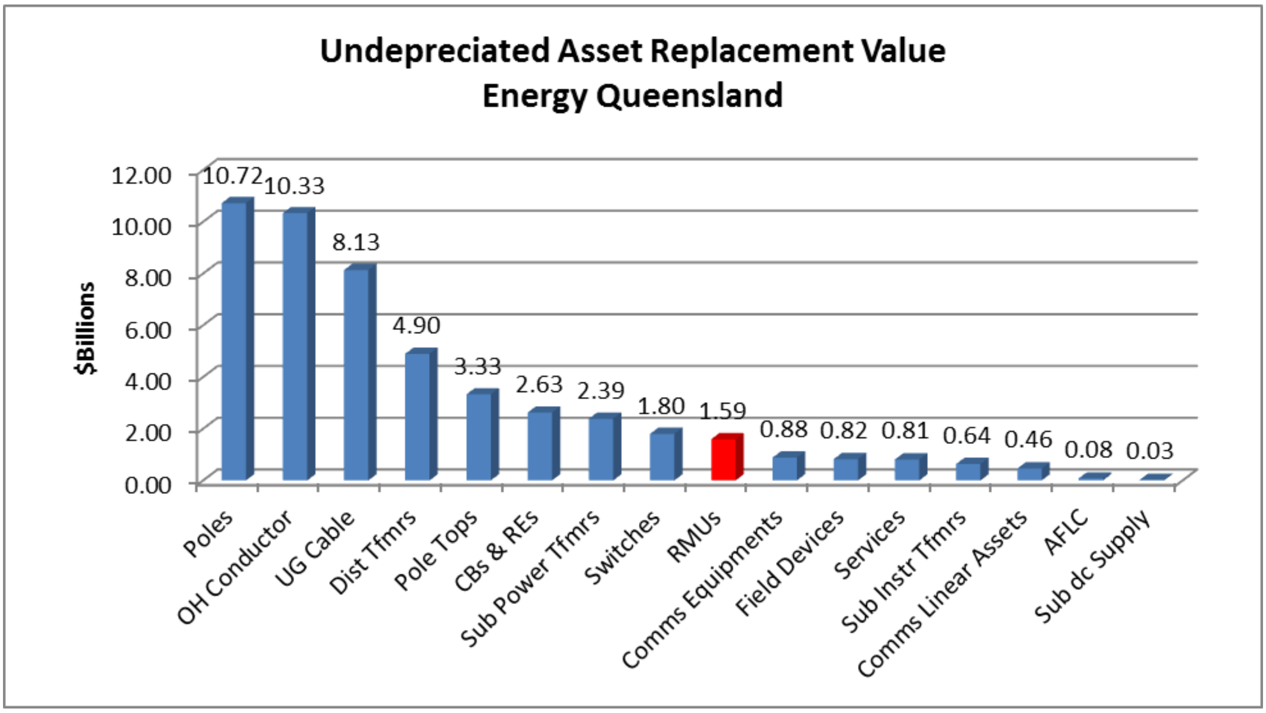

Figure 2: EQL – Total Current Asset Replacement Value

1.4 Asset Function and Strategic Alignment

An RMU is a compact unit containing high voltage distribution switchgear connected to a common bus. The primary switchgear can be a combination of earth switch/isolators, fused combination earth switch/isolators or circuit breakers. All components are rated to carry the load current and make or break the current. RMUs are typically used to connect underground cable sections together allowing segmentation of feeder sections often organised as high voltage "rings" (meshed networks).

Table 1 shows details how RMUs contribute to EQL's corporate strategic asset management objectives.

Asset Management Objectives	Relationship of Asset to Asset Management Objectives
Ensure network safety for staff, contractors and the community.	Diligent and consistent maintenance and operations of the RMU supports performance, which in turn supports safety for all stakeholders.
Meet customer and stakeholder expectations.	The reliable performance of the RMU supports network reliability and promotes delivery of a standard quality electrical energy service.
Manage risks, performance standards and asset investment to deliver balanced commercial outcomes.	Failure of an RMU can result in increased public safety risk and disruption of the electricity network. Asset longevity assists in minimising capital and operational expenditure.
Develop asset management capability and **align practices to the global ISO55000 standard.**	This AMP is consistent with ISO55000 objectives, and drives asset management capability by promoting a continuous improvement environment.
Modernise the network and facilitate access to innovative energy technologies.	This AMP promotes modernisation through industry leading condition and health assessments, including replacement of RMUs at end of economic life as necessary to suit modern standards and requirements.

Table 1: Asset Function and Strategic Alignment

1.5 Owners and Stakeholders

The key roles and responsibilities for the management of this asset class are outlined in Table 2.

Role	Responsible Party
Asset Owner	Chief Financial Officer
Asset Operations Delivery	EGM Distribution
Asset Manager	EGM Asset Safety & Performance

Table 2: Stakeholders

2 Asset Class Information

RMUs are an essential part of the underground distribution network providing switching and access within that network. RMUs also provide a protection function for associated large ground and padmount distribution transformers in the underground network. RMUs are classified according to several criteria including:

- Operating voltage
- Installed location
- External design characteristics
- Medium used for interruption.

The most common configuration is two isolating switches and a switch fuse in a single tank enclosure (or box) referred to as an RMU. However, individual isolating switches and switch fuse units are available for installation on their own or to extend RMUs depending on network requirements.

The RMUs in this document are primarily categorised based on the operating voltage in the EQL network.

2.1 Asset Description

RMUs are used to switch load currents and interrupt fault currents in underground electrical networks using a range of electrical and mechanical mechanisms, and in doing so allow safe and efficient operation of the network. RMUs also: protect plant and equipment from damage; and staff and the general public from safety hazards that arise when faults occur in the electricity network.

The primary function of RMU switchgear is to carry load current and to make or break current within designated ratings, provide protection to ground mounted distribution transformers and to earth underground cable sections to allow safe access and maintenance.

2.2 Asset Quantity and Physical Distribution

Currently EQL has an in-service population of approximately 21,000 RMUs. Table 3 data shows EQL's population of Ring Main Units.

Ring Main Unit	Northern & Southern	South East	Total
=11kV	4,415	15,326	19,741
>11kV & <=22kV	1,311	-	1,311
>22kV & <=33kV	10	-	10
Total	5,736	15,326	21,062

Table 3: Asset Quantity

2.3 Asset Age Distribution

Figure 3 and Figure 4 below show the populations of RMUs in the Northern and Southern Regions and South East Region respectively. The expected life of an RMU is 45 years.

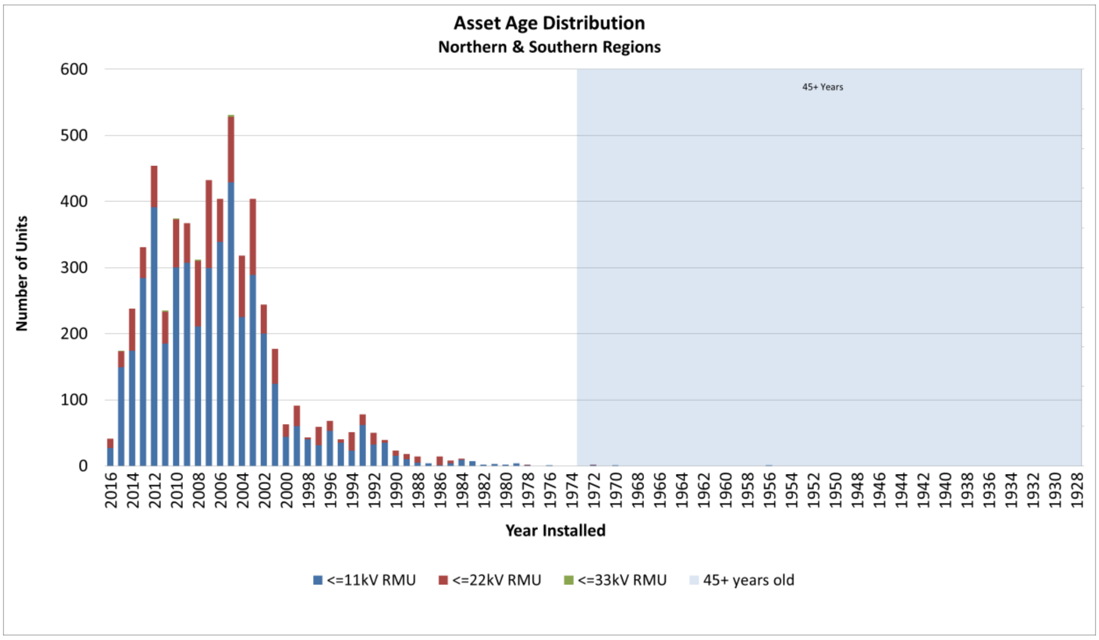

Figure 3: Northern and Southern Regions - Asset Age Profile

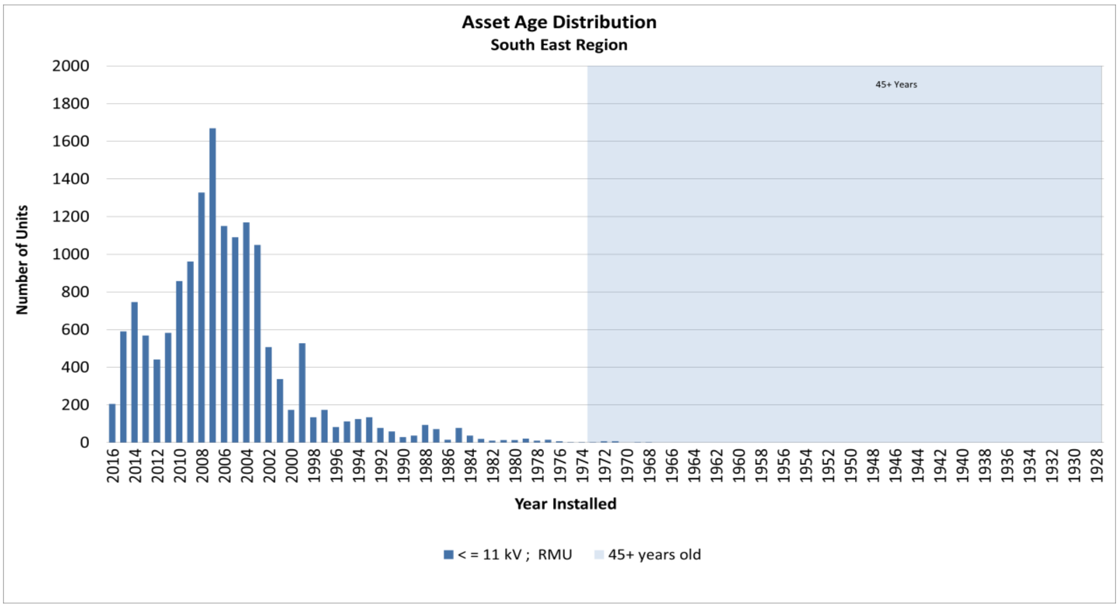

Figure 4: South East Region - Asset Age Profile

The figures above show that the EQL population of RMUs in relatively young in comparison to the expected life.

2.4 RMU Population Trends

RMUs in the EQL network have been installed over a period of decades by various Legacy Organisations as underground cable networks expanded initially in town centres where loads were higher and access for overhead lines difficult. In the late 1970's and early 1980's the growth of underground residential distribution resulted in widespread underground mains networks using RMUs in padmount transformers to facilitate distribution mains mesh arrangements and LV network load injection points. As a result, the population of these assets is geographically diverse and spread across all Queensland population centres. During the last 50 years, RMU technology and capability has also advanced so that the RMU population consists of variations of design including several insulating and interrupting mediums (e.g. oil, gas, air and vacuum).

In the last decade, oil filled RMUs have been steadily replaced with modern standard equivalent units with mostly SF6 gas and vacuum interrupting medium. The main driver behind this is, when oil filled RMU has an oil leak or partial discharge activity, due to the design constraint the mitigation techniques are not permanent, result in high safety consequence for the operator. This resulted in a decline in the oil filled RMU population and an increase in gas type RMUs. The following figures depict the RMU population across each region over time, for three different types of insulating and interrupting mediums.

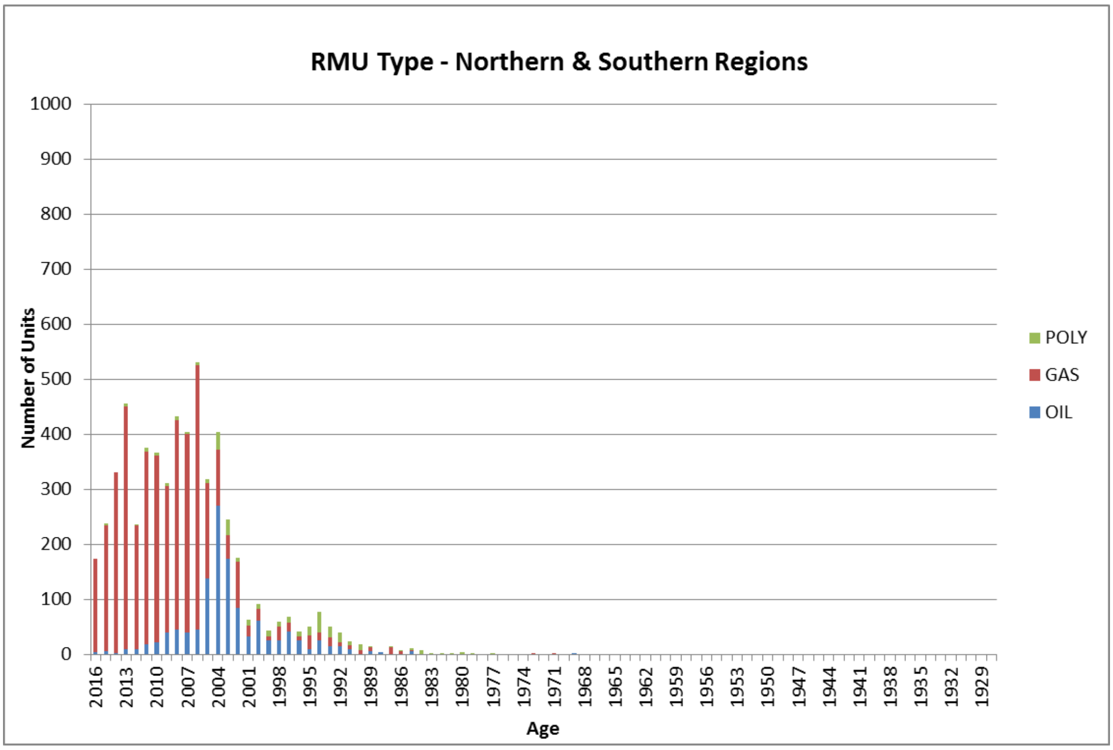

Figure 5: RMU Type – Northern and Southern Regions

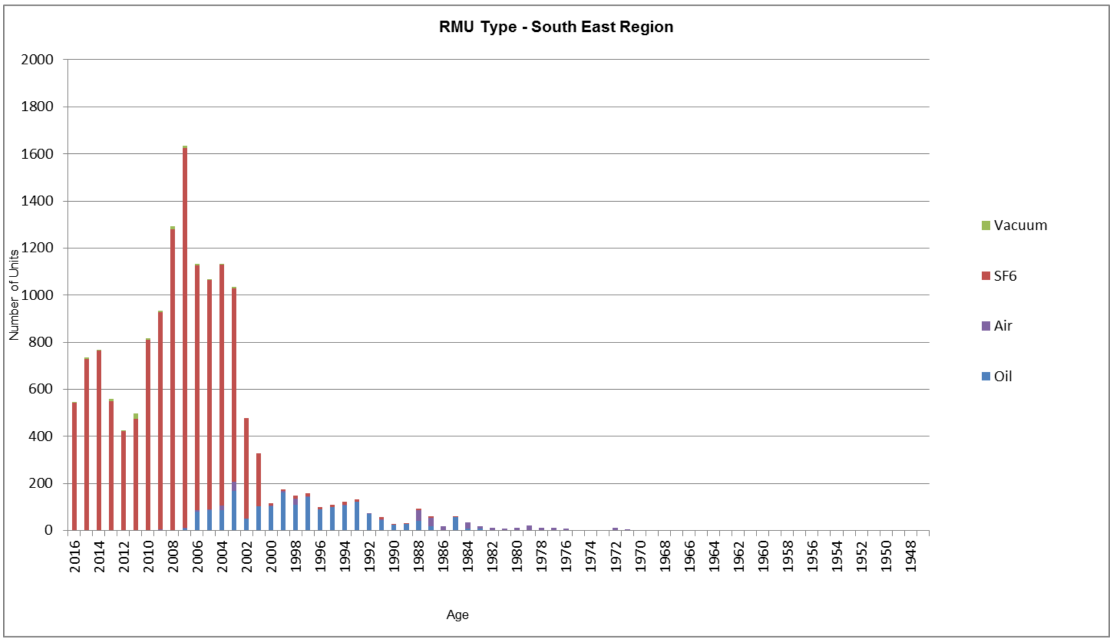

Figure 6: RMU interrupting medium - South East Region

2.5 Asset Life Limiting Factors

Table 4 describes the key factors that influence the life of the assets covered by this asset management plan, and as a result have a significant bearing on the programs of work implemented to manage the lifecycle.

Factor	Influence	Impact
Age	Electrical and mechanical degradation.	Degradation leads to electrical and mechanical failure. Failure to operate correctly.
Environment	Outdoor, corrosive and coastal environment, vermin, especially ants and lizard nesting resulting in degradation of the physical structural integrity of an asset.	Accelerated aging, failure to operate correctly and reduction of useful life and replacement earlier than anticipated life in more benign environments.
Design	Inadequate design, material specification or installation leading to premature component degradation and mal-operation.	Increased maintenance, early life refurbishment and sometimes replacement much earlier than anticipated life.
Fault	Electrical and mechanical stress on the internal components leading to physical damage.	Internal fault leading to failure (potentially catastrophic) requiring emergency replacement.
Obsolescence	Inability to source components required to maintain or repair the asset	Unable to return to service in the event of a failure resulting in replacement.

Table 4: Asset Life Limiting Factors

3 Current and Desired Levels of Service

The following sections define the level of performance required from the asset class, measures used to determine the effectiveness of delivering corporate objectives, and any known or likely future changes in requirements.

3.1 Desired Levels of Service

This asset class will be managed, consistent with corporate asset management policy, to achieve all legislated obligations and any specifically defined corporate key performance indicators and to support all associated key result areas as reported in the Statement of Corporate Intent (SCI).

Safety risks associated with this asset class will be eliminated so far as is reasonably (SFAIRP), and if not able to be eliminated, will be mitigated SFAIRP. All other risks associated with this asset class will be managed to be as low as reasonably practicable (ALARP).

This asset class consists of a functionally alike population, differing in age, brand, technology, material, construction design, technical performance, purchase price, and maintenance requirements. The population will be managed consistently based upon generic performance outcomes, with an implicit aim to achieve the intended and optimised life cycle costs for the asset class and application.

All inspection and maintenance activities will be performed consistent with manufacturers' advice, good engineering operating practice, and historical performance, with the intent to achieve the longest practical asset life overall.

Life extension techniques will be applied where practical, consistent with overall legislative, risk, reliability, and financial expectations. Problematic assets such as very high maintenance or high safety risk assets in the population will be considered for early retirement.

Assets of this class will be managed by population trends, inspected regularly, and allowed to operate as close as practical to end of life before replacement. End of asset life will be determined by reference to the benchmark standards defined in the Defect Classification Manuals and or Maintenance Acceptability Criteria. Replacement work practices will be optimised to achieve bulk replacement to minimise overall replacement cost and customer impact.

3.2 Legislative Requirements

Regulatory performance outcomes for this asset include compliance with all legislative and regulatory standards, including the *Electrical Safety Act 2002 (Qld)*, the *Electrical Safety Regulation 2013 (Qld)*, and the *Queensland Electrical Safety Codes of Practice*.

The *Electrical Safety Act 2002 (Qld)* s29 imposes a specific duty of care for EQL, which is a prescribed Electrical Entity under that Act:

1) An electricity entity has a duty to ensure that its works—
    a) are electrically safe; and
    b) are operated in a way that is electrically safe.
2) Without limiting subsection (1), the duty includes the requirement that the electricity entity inspect, test and maintain the works.

3.3 Performance Requirements

There are no specific business targets specifically relating to RMUs, nor maximum business levels for safety incidents arising from these failures.

Under its distribution licences, EQL is expected to operate with an 'economic' customer value-based approach to reliability, with "Safety Net measures" aimed at managing increased outage risks. EQL is expected to employ all reasonable measures to ensure it does not exceed minimum service standards (MSS), assessed by feeder type, as:

- System Average Interruption Duration Index (SAIDI), and
- System Average Interruption Frequency Index (SAIFI).

RMUs typically have low impact upon SAIDI and SAIFI overall, however loss of RMUs in substations can result in more widespread outages because of their location within the network.

Safety net measures are intended to mitigate against the risk of low probability high consequence network outages. Safety net targets are described in terms of the number of times a benchmark volume of energy is undelivered for more than a specific time period.

Both Safety net and MSS performance information is publicly reported annually in the Distribution Annual Planning Reports (DAPR). MSS Performance is monitored and reported within EQL daily.

Dangerous electrical events (DEEs) are generally reviewed for severity on an individual basis, with response and investigation driven by severity of the incident. DEE volumes are reported monthly. There are no specific targets for DEEs other than a general intent to minimise the quantities.

3.4 Current Performance

The data available to assess the performance of RMU assets is limited due to historical data capture processes. Similarly the treatment of the data associated with RMU assets varies with each legacy organisation. EQL has recognised these limitations and has a focus on improving the quality of data associated with this asset class. Refer to Section 9.2 for further detail.

The following section uses the currently available defect information and historical replacements driven from both defects and in-service failures to describe the performance of the asset class.

Defects identified via inspection and maintenance programs are classified and prioritised according to the EQL Defect Classification Manuals. Identified defects are scheduled for repair according to a risk-based priority scheme (P1/P2/C3/no defect). The P1 and P2 defect categories relate to priority of repair, which effectively dictates whether normal planning processes are employed (P2), or more urgent repair works are initiated (P1). Additionally, a classification of C3 aims to gather information to inform or create a "watching brief" on possible problematic asset conditions.

Figure 7 shows the historical defect count for RMUs in the Northern and Southern Regions.

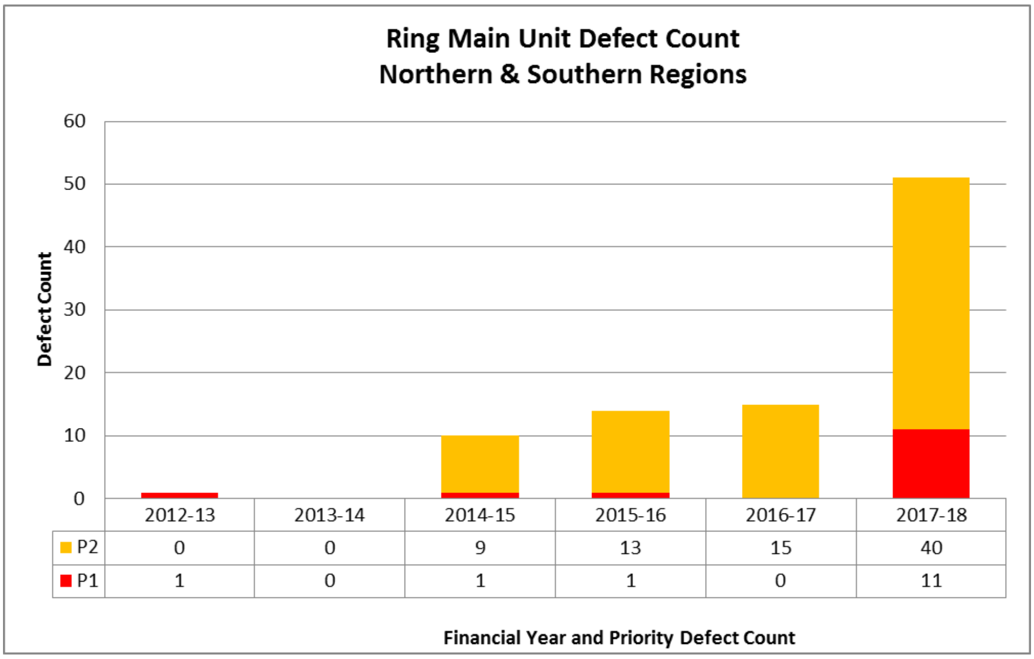

Figure 7: RMU Defect Count – Northern & Southern Regions

The trend in recorded defects in the Northern and Southern Regions indicates an increasing trend. Noting the challenges around data in this space the trends presented are considered inconclusive. While the performance trend is inconclusive the figure does indicate a continuing improvement in the capture of discrete defect data associated with RMUs.

Figure 8 shows the historical defect count for RMUs in the South East Region.

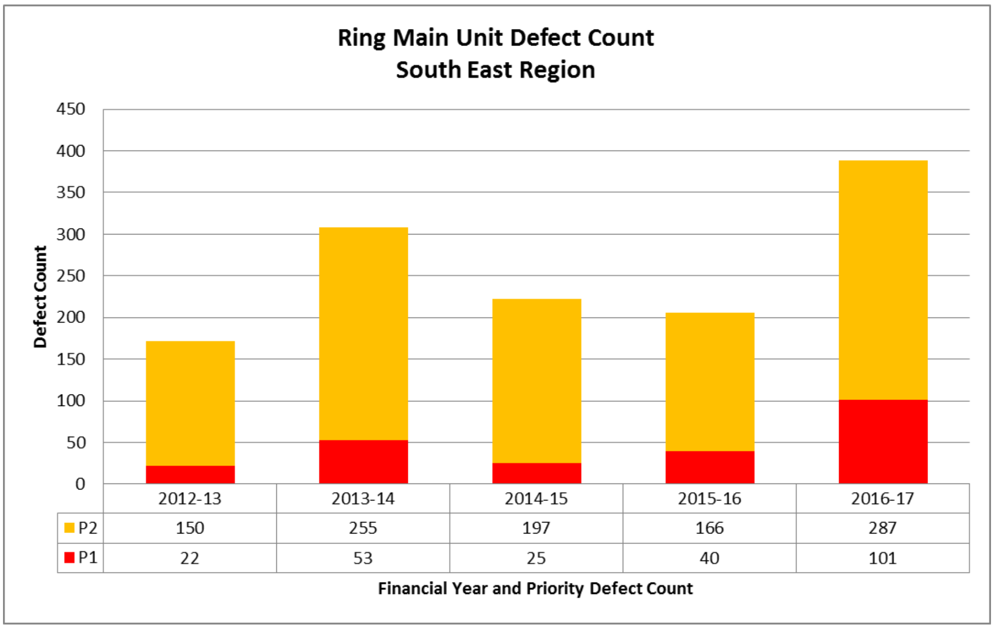

Figure 8: RMU Defect Count - South East Region

The defect data available for the South East region provides a better sample on which to draw conclusions on performance however there are still significant variations in defect volumes from year to year. Trends are being monitored.

The historical replacement rates provide the most consistent information available in both organisations on which to assess the overall performance of the class. Replacements are driven from in-service failure as well as demand based replacement from inspections where defects could not be repaired to extend the life of the asset.

Figure 9 and Figure 10 show the historical replacement counts for the Northern and Southern Regions and South East Region respectively.

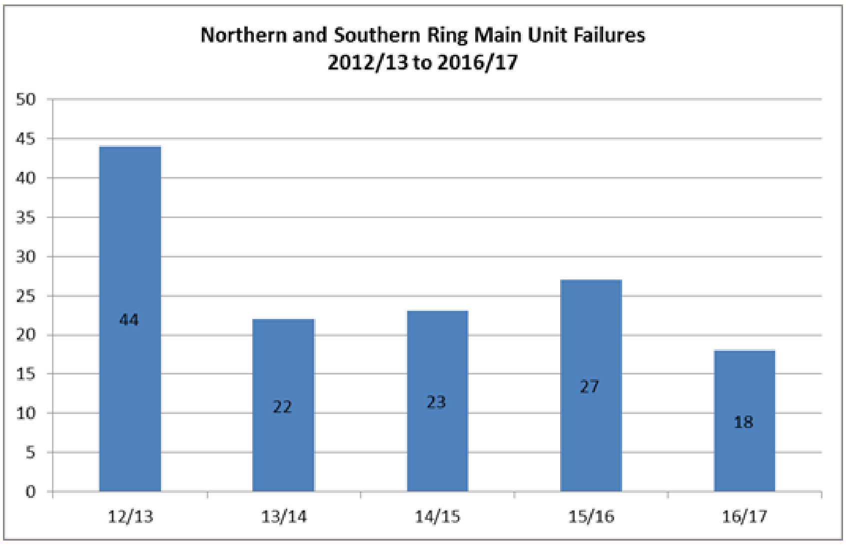

Figure 9: RMU Demand Replacement Count - Northern and Southern Regions

Figure 9 indicates a decreasing demand based replacement requirement in the Northern and Southern Regions.

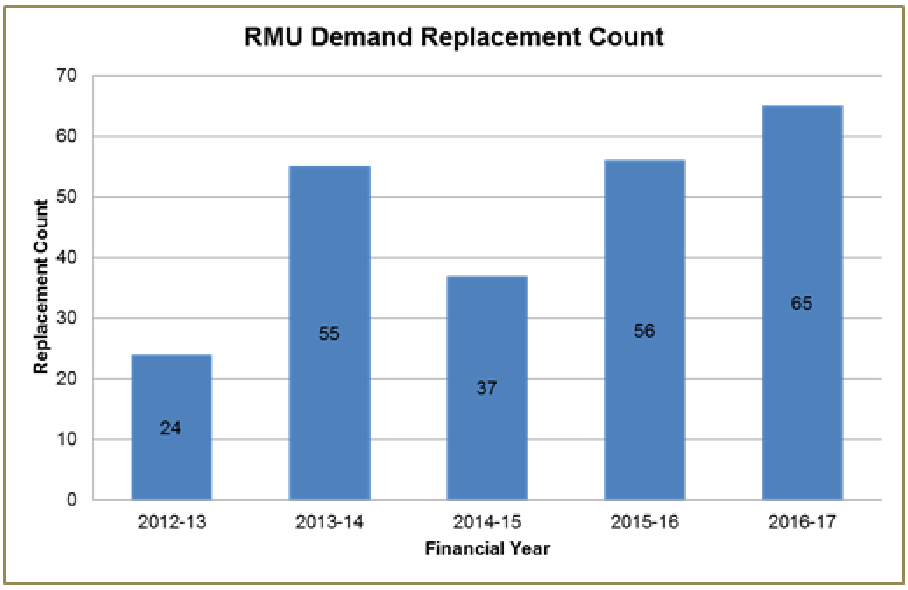

Figure 10: RMU Demand Replacement Count - South East Region

Figure 10 indicates an increasing demand based replacement requirement in the South East Region. It should be noted that the South East Region has significantly higher numbers of RMUs in the network due to the prevalence of underground network.

Figure 11 and Figure 12 show a summary of the defects recorded in the Northern and Southern Region by component type and cause.

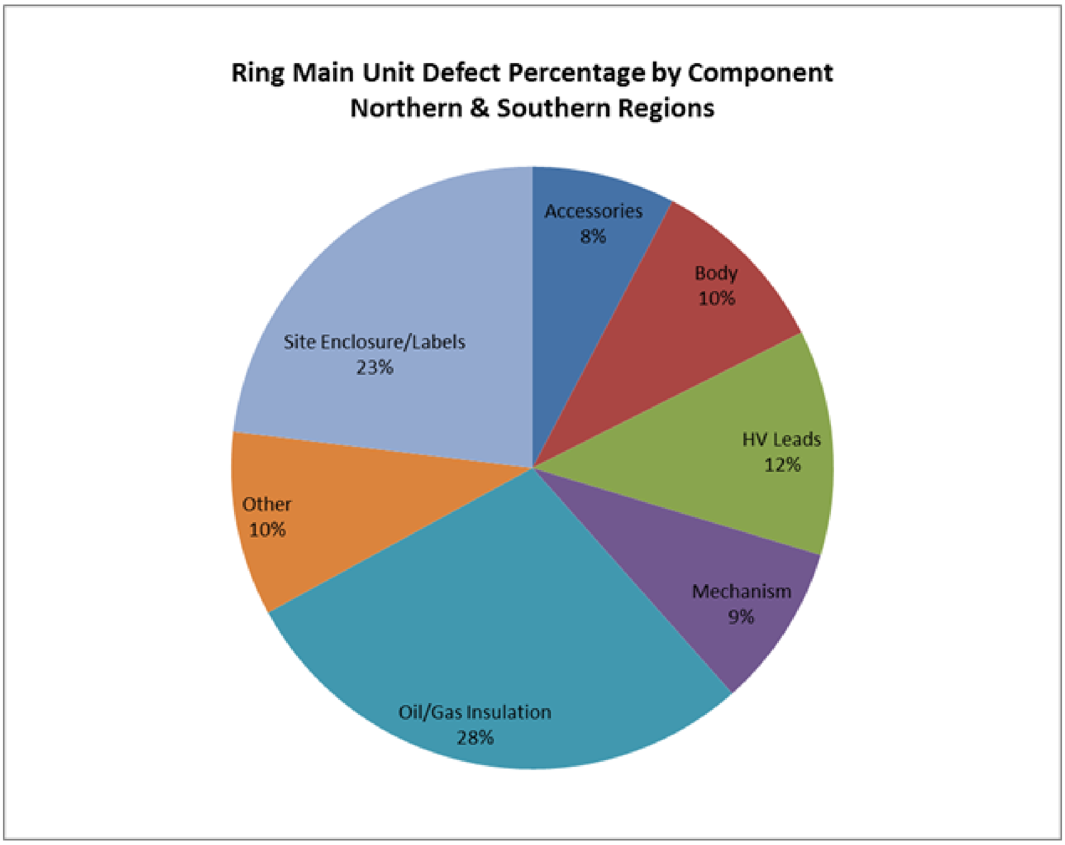

Figure 11: RMU Defect Percentage by Component - Northern and Southern Regions

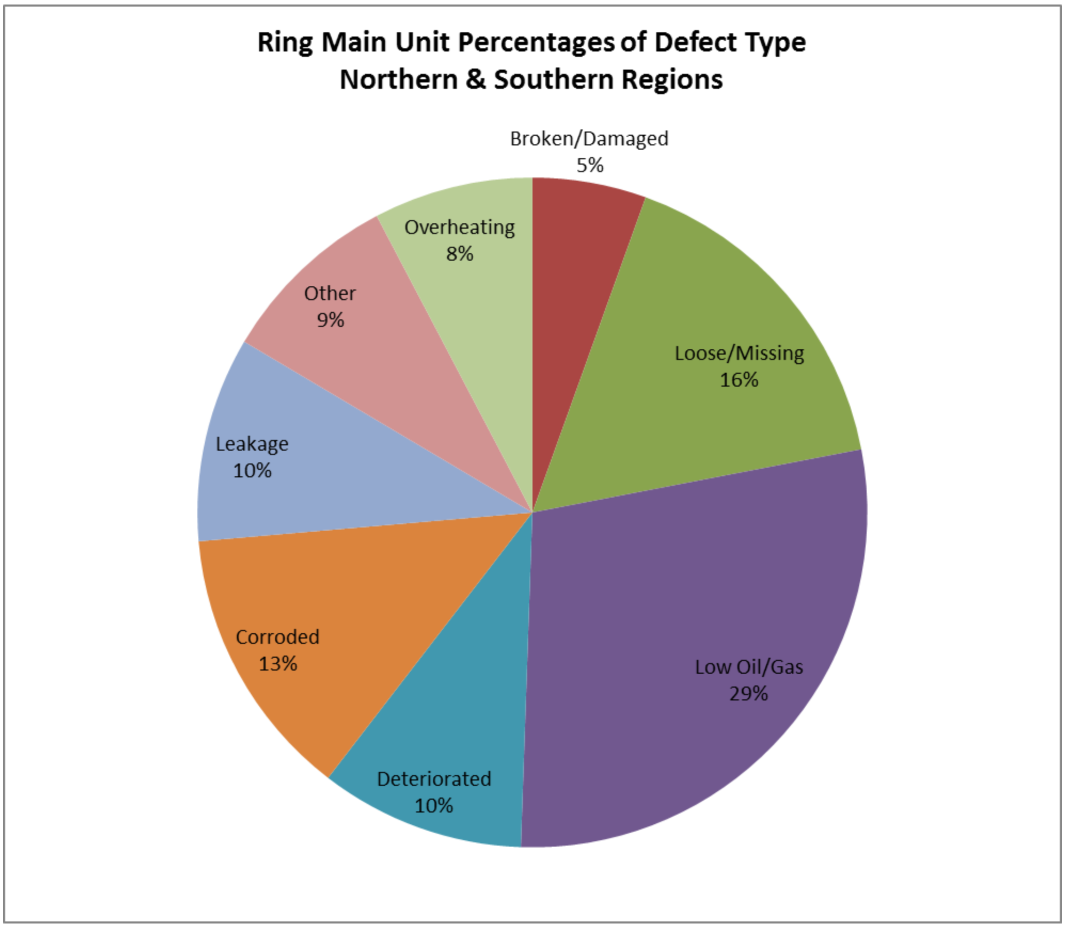

Figure 12: RMU Percentages of Defect Type - Northern and Southern Regions

These figures show that the largest proportion of defect issues in the Northern and Southern region are associated with the insulation medium. The other identified defects are relatively evenly distributed.

Similar analysis of the defect information in the South East Region has been attempted however it was not possible due to the quality of the data available. It was however possible to analyse the demand driven replacements in the South East Region to identify the major contributors to the program. Figure 13 and Figure 14 show the replacements by manufacturer and insulation medium as both a raw count and normalised against the installed population.

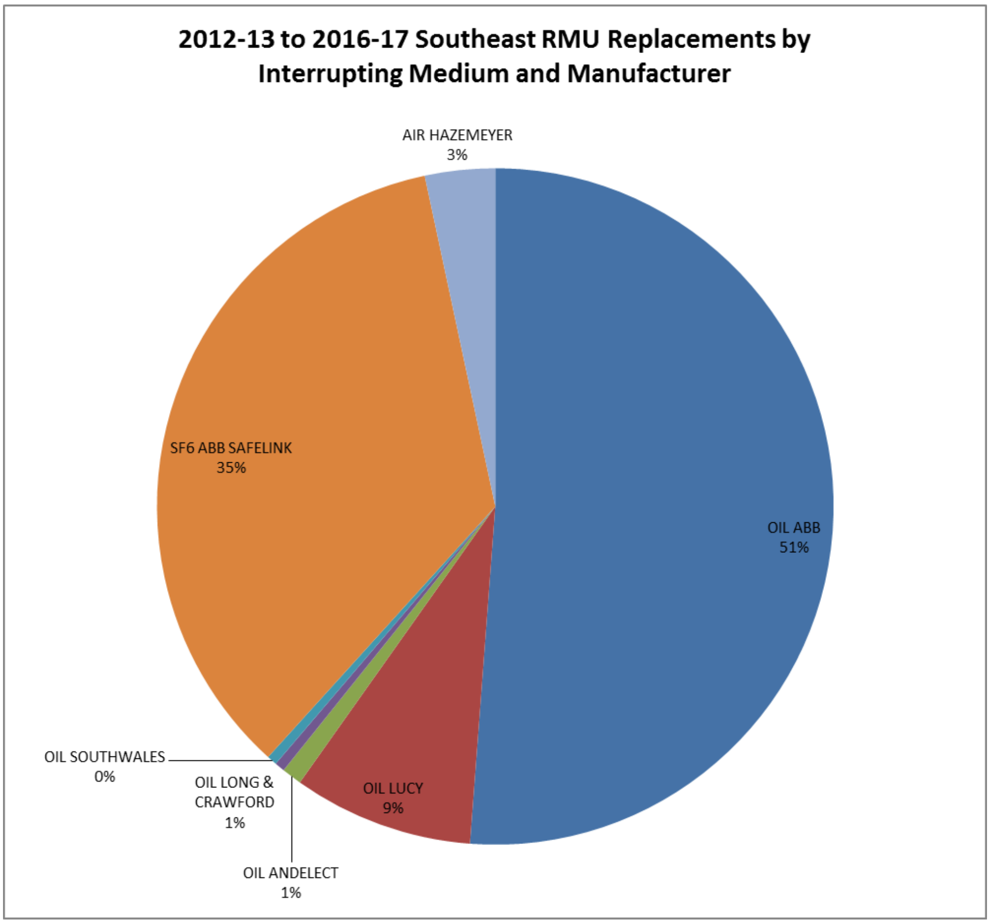

Figure 13: 2017/18 RMU replacement by interrupting medium and manufacturer

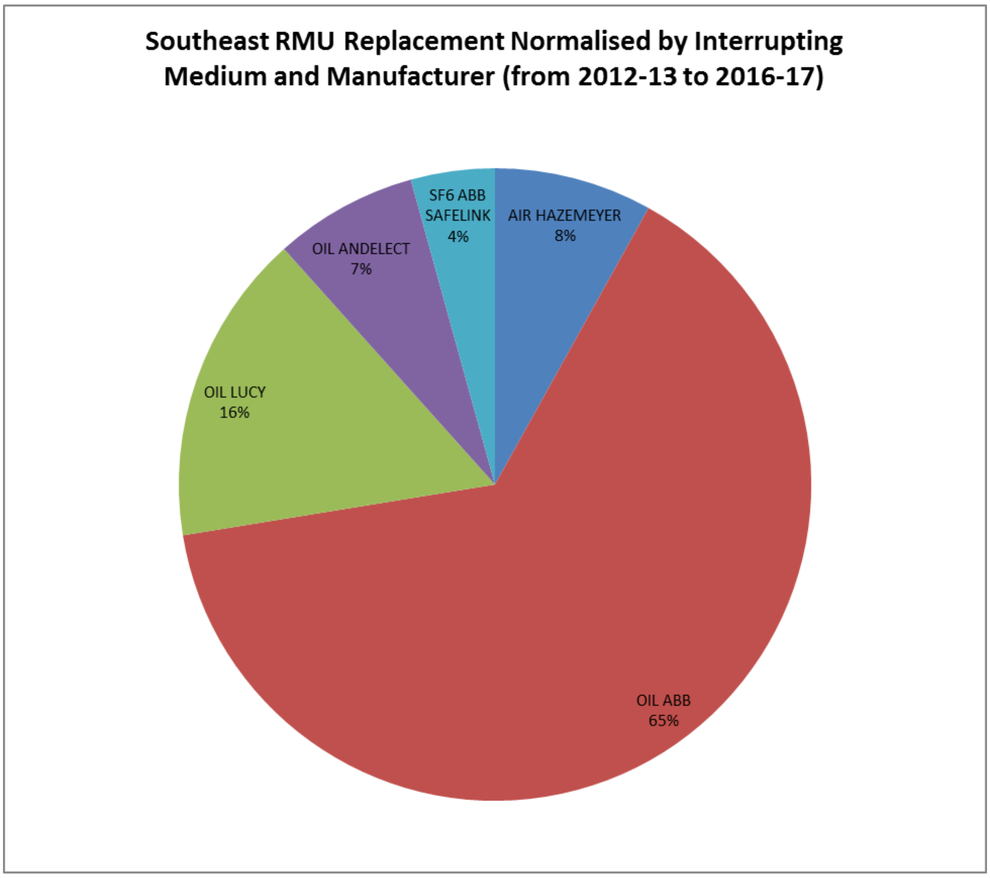

Figure 14: RMU Demand Replacement (normalised) –South East Region

Figure 13 and Figure 14 show that the main drivers for RMU replacement in the South East Region were associated with oil filled units. This is consistent with removal of the oldest assets from the network as well as removal of safety risks associated with oil filled switchgear through replacement with a modern standard of gas or vacuum.

4 Asset Related Corporate Risk

As detailed in Section 3.2, EQL has a Duty to ensure its assets are electrically safe. This safety duty requires EQL to take action so far as is reasonably practicable (SFAIRP) to eliminate safety related risks, and where it is not possible to eliminate these risks, to mitigate them SFAIRP. Risks in all other categories are managed to levels as low as reasonably practicable (ALARP).

Figure 15 illustrates a threat-barrier diagram for instrument transformers in the EQL network. EQL undertakes a number of actions such as inspections and maintenance to eliminate or mitigate the risks to SFAIRP/ALARP.

EQL's safety duty results in most inspection, maintenance and replacement works and expenditure related to RMUs being entirely focused upon preventing and mitigating failure.

The following sections detail the ongoing asset management journey necessary to continue to achieve to high performance standards into the future. Action items have been raised in the following sections where relevant, detailing the specific actions that EQL will undertake as part of program delivery of this Asset Management Plan.

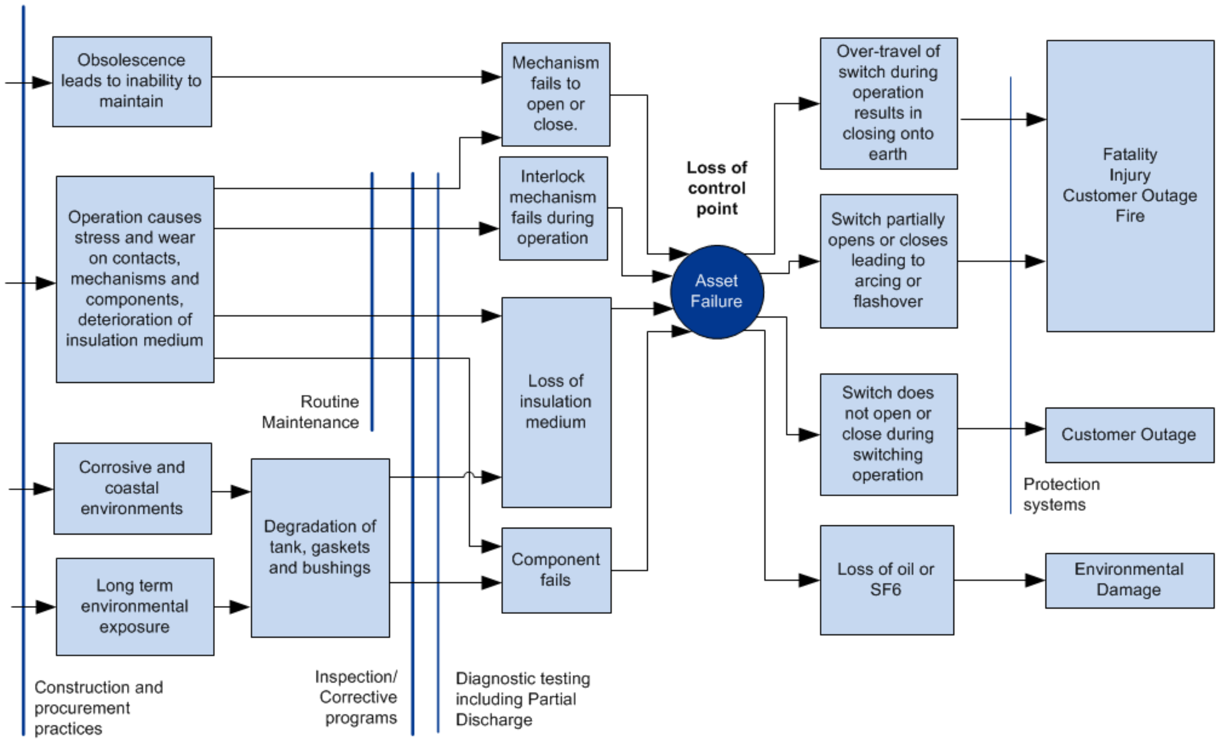

Figure 15: RMU - Threat Barrier Diagram

5 Health, Safety & Environment

Sulphur Hexafluoride (SF_6) has been used in electrical equipment for more than two decades. Manufacturers continue to use SF_6 extensively in high voltage switchgear because of its high dielectric strength (2.5 times that of air under the same conditions), excellent arc quenching capabilities, high thermal conductivity, and chemical stability. This resulted in an increase of the SF_6 switchgear population in EQL for the last two to three decades as shown in Figure **5** and Figure 6.

EQL monitors the release of SF_6 gas to the atmosphere by implementing alarm systems through the switchgear control system. Corrective works will be raised to rectify the issue when required.

6 Current issues

The following sections outline current issues that have been identified as having the potential to impact EQL's ability to meet corporate objectives.

6.1 ABB Safelink Gas RMUs

EQL and its legacy organisations have experienced a series of ABB Safelink RMU failures since 2008. There are number of issues associated with the design and operation of the Safelink RMUs including:

- Selector interlock failure
- Latch failure and slow opening of the switch mechanism
- Abnormal indication with faulty indicator lamps
- Foreign material ingress leading to corrosion
- Fuse door interlock malfunction.

Following several failures, EQL implemented a ban on Safelink RMUs manufactured between years 2003 and 2010 with original mechanism type RMUs, prohibiting operation of these assets whilst energised. Because EQL is a merger of two entities the timing and detailed actions to address these deficiencies were different (refer below). Alignment of these approaches will be progressive over time.

In the Northern and Southern Regions, a mechanism replacement program has been completed for 2003 and 2004 Safelink RMUs, replacing the original mechanism with a 'Revision C' mechanism, to address the latch failure issue. However, it is believed that as the RMUs age further, latch failures will occur in more recent models and further replacements will be necessary. An internal Engineering report 'ABB Safelink Ring Main Unit Mechanism Replacement' has recommended that as a mechanism fails it will be replaced with a Revision C mechanism along with the mechanisms on the other isolating switches and fuse switch in that RMU.

The South East Region established a reference group to investigate the issues and to develop solutions and safe work practices to address these issues. The permanent solution is to replace the original mechanism with newer version C or E mechanisms. Due to large number of assets (approximately 6000 RMUs) impacted by this issue, during the replacement period alternative methods of operating the RMUs have been established to keep risk ALARP. The intermediate solution was to use an over travel arrestor, which prevents arcing between the moving and fixed contacts, and an extended operating handle. This has allowed a safe method of switching Safelink whilst they are energised and therefore allowed the ban on energised operation to be lifted.

The mechanism replacement program was initiated in the financial year 2010/11 and is planned to be completed by 2021/22.

Action 6.1-1: Review and align the management of mechanism design flaw present in some ABB Safelink Ring Main Units to ensure a common EQL approach and mitigating the safety risk SFAIRP.

6.2 ABB SDAF Oil RMUs

ABB SDAF RMUs are prone to leaking oil from the bottom of the tank. Operating restrictions are in place on these units where oil level is below the nominal level whilst the unit is energised. Modified maintenance instructions are in place for these RMUs. Tanks have been strengthened and repaired where required and additional assessment checks were introduced in periodic inspection activities.

6.3 Hazemeyer/Magnefix/Holec Polymeric RMUs

EQL and its Legacy Organisations have experienced a series of Hazemeyer RMU failures since 2015. In South East Region, there were 7 failures during the short period between January 2016 and July 2016. In Northern and Southern Regions, there were three catastrophic failures during operation.

There are number of issues associated with this type of RMU, such as:

- Partial discharge (PD) in switches
- Out of alignment arcing contact
- PD in cable termination.

The following strategies are currently in place in the South East region to achieve operation safety:

- 18month periodical PD testing.
    - If the PD is detected in switches, replace the RMU.
    - If the PD is detected in cable termination, re-terminate, retest and if PD is still detected, replace the RMU.
- Operating restrictions are in place for all types of Hazemeyer.

Similar strategies are being developed in the Northern and Southern Regions considering recent failures.

Action 6.3-1: Implement Partial Discharge testing and subsequent remedial actions on Hazemeyer / Magnefix / Holec Polymeric Ring Main Units in the Northern and Southern Regions to align with the strategies present in the South East Region.

7 Emerging issues

The following sections outline emerging issues which have been identified as having the potential to impact on EQL's ability to meet corporate objectives in the future.

Issues associated with specific models and situations which are not completely understood at the current time are also discussed below.

7.1 F&G RMUs

F&G RMUs are exclusively used in the 22kV network in Far North Queensland. There have been several failures of these units over recent years, particularly relating to bushing flashover. These issues are possibly caused by lightning as well as cracked bushings caused by additional cantilever load from the cables due to subsidence or incorrect installation. Investigations are ongoing to identify the root cause and corrective actions.

Action 7.1-1: Investigate and identify the root cause of the failure modes present in F&G RMUs to drive corrective actions and improvements in the lifecycle strategy of this asset population.

7.2 Siemens RMU

EQL has issues with Siemens RMUs purchased indirectly as part of padmount substations supplied by Wilson Transformers. There are two issues of concern that may impact on future costs:

There is a current safety document in place related to installation of cables in a non-commissioned isolator with these RMUs live. This is a normal practice; however, in the Siemens RMU the overpressure / internal fault vent is located in the cable box. Thus, if a fault occurs inside the tank the overpressure will be directed out at the cable jointer. In previous designs the venting is to the rear and risk is considered to be much lower. Despite a risk assessment, the safety alert cannot be lifted, and further work is yet to be done to see if the risk can be managed. If the issues / risks persist, EQL may consider purchasing a more expensive unit over existing RMUs.

The second issue is that this RMU has no gas filling point. The manufacturer has declared it will not leak. EQL does not have confidence in this claim as experience indicates all SF6 equipment can leak. This means that any leaking Siemens RMU will require complete replacement. As this equipment has only been in service a very short time, no failure rate evidence is yet available.

Action 7.2-1: Conduct further investigation on the Siemens RMUs being supplied in padmount substations from Wilson Transformers in order to come to a decision on the purchase and use of this equipment in the EQL network.

8 Improvement and Innovation

There are currently no improvements or innovations in consideration for this type of equipment within EQL.

9 Lifecycle Strategies

The following sections outline the approach of EQL to the lifecycle asset management of this asset class.

9.1 Philosophy of Approach

RMUs are a significant volume and medium cost asset. These assets are mechanical and electrical in nature and as such are prone to wear and tear associated with performing their intended function. EQL actively manages RMUs based on condition and risk using a combination of inspection-based assessment, preventative maintenance tasks and replacement.

9.2 Supporting Data Requirement

The following sections detail some of the data quality issues that can impact efficient asset lifecycle assessment and management.

9.2.1 Historical Failure and Condition Data

There is a disparity between asset records being kept in the Northern and Southern Regions and the South East Region. Historical data capture practices restrict the ability to analyse the large volumes of data associated with this asset class without substantial manual effort and offers significant potential for improved asset management.

Legacy organisation Ergon Energy developed and implemented a recording system for all failures, incorporating a requirement to record the asset component (object) that failed, the damage found, and the cause of the failure using the Maintenance Strategy Support System (MSSS) in Ellipse; the current Enterprise Asset Management (EAM) System. Energex has historically relied on the manual assessment of distribution network outages to determine asset failure records. EQL has adopted the MSSS approach and is building this system of record over time, providing the information necessary to support improvements in inspection and maintenance practices. There is an expectation that this will also support and influence standard design and procurement decisions. Alignment of failure and defect data capture across regions is required to take full advantage of the larger data set available across the state.

Action 9.2-1: Align and improve defect, failure and dangerous electrical event data capture processes and reporting methodologies to ensure consistency across EQL.

9.2.2 Asset Attribute Data

Historically, it was not considered cost-effective to record detailed attribute data for the various switches used across the network. The advancement in technology, asset management discipline, and corporate external reporting imperatives have together acted to change this approach. EQL recognises the need to improve the data quality associated with this asset class and has initiated improvements in the capture of information at time of commissioning as well as where prudent in association with other works. Further improvements will be undertaken with the implementation of the new Enterprise Asset Management System which is currently proposed. This will include and alignment of asset hierarchy.

Action 9.2-2: Implement asset data structure changes in the new Enterprise Asset Management system being proposed for EQL to enable the consistent and accurate capture of RMU data. This will improve failure and condition monitoring capability to support the asset management objectives.

9.2.3 Commissioning and Decommissioning Data

In the South East Region, historical data analysis showed that significant numbers of RMUs were decommissioned well before their expected life of 40 years. Due to data quality issues, the reasons for decommissioning had not been recorded properly. Recent depot visits and discussion with relevant stakeholders also revealed that there are significant data and reporting gaps that led to the large gap in information regarding RMU commissioning and decommissioning.

Action 9.2-3: Implement a process to improve the data capture of plant commissioning and decommissioning to ensure appropriate information is available to drive decision making in the lifecycle management of these assets.

9.3 Acquisition and Procurement

EQL's procurement policy and practices align with the 2017 Queensland Government procurement policies. Switches are procured via period contracts based on forecast requirements and historical usage driven by network augmentation and replacement of assets based on condition and risk. Contracts for these assets typically span at least several years for various logistical and pricing reasons and are based on technical specifications guided by the needs of the network. The contract periods determine the opportunity available to EQL to change technical specifications and improve asset performance by engineering out identified defects, standardising products, or implementing new technologies.

RMUs are procured on an as needs basis driven by condition-based replacement, network augmentation and replacement of assets which have failed in service. Minimum and maximum holdings in the stores system are set based on historical usage.

9.4 Operation and Maintenance

Operation and maintenance includes planned and corrective maintenance. Operation and maintenance procedures are supported by a suite of documentation which describes in detail the levels of maintenance applicable, the activities to be undertaken, the frequency of each activity, and the defect and assessment criteria to which the condition and testing are compared to determine required actions. The relevant documents are included in Appendix 1 for reference.

EQL has commenced an ongoing process of alignment of maintenance practices between regions where it is prudent and efficient. This alignment will occur over a number of years, in order to maintain compliance with maintenance tolerances during any transition.

The following sections provide a summary of the key aspects of the operation and maintenance of switches as they relate to the management of the asset lifecycle.

Action 9.4-1: Continue the alignment of maintenance and operating practices for EQL to drive efficiency, deliver customer outcomes and mitigate risk.

9.4.1 Preventive maintenance

Preventive maintenance consists of inspection and testing and routine maintenance activities as follows:

- In-service Condition Assessment – periodic inspection of external condition to identify defects in components such as gauges, mechanisms and connections. Inspections are also used to collect condition data for performance / risk analysis and replacement programs. An online partial discharge survey, a thermographic survey of all assets (within the zone and bulk substation site), and visual inspection under the padmount substation also complement the routine visual inspection.
- Non-intrusive Maintenance – combination of detailed inspection, functional checks, electrical testing and routine restoration activities intended to restore serviceable items to an acceptable condition such as: inspect and maintain gas pressure, partial discharge testing, functional operation checks, contact quality and alignment, measuring contact and busbar insulation resistance. Non-intrusive maintenance does not require access to internals of RMU and currently this maintenance activity is only applied for SF6 RMUs.
- Intrusive Maintenance – combination of detailed inspection, functional checks, electrical testing and routine restoration activities intended to restore serviceable items to an acceptable condition, such as: cleaning, maintenance of internal components, and oil quality check and replacement. Intrusive maintenance requires access to internal components of the RMU and this maintenance activity is applied only for oil and polymeric RMUs.

Action 9.4-2: Review preventive maintenance practices in light of results of new MSSS data in order to avoid or reduce corrective maintenance or replacement on failure. This may result in a review of the maintenance intervals for the ISCA or NIM and a review of the nature of tests / inspections to be undertaken.

9.4.2 Corrective maintenance

Corrective maintenance activity is driven by system alarms, inspection and scheduled preventative maintenance activities where defects are identified that require immediate rectification.

The triggers for corrective and forced maintenance include:

- Defect found during the inspection and maintenance activities
- System alarms such as low gas or oil
- Equipment failure
- Fault indication on protection and monitoring equipment.

Minor corrective actions usually occur during routine inspection and maintenance activities to avoid scheduling another visit to the site. Subsequent scheduling of required corrective actions that did not occur at the time of inspection is performed as specific corrective maintenance activities.

RMUs are repaired if cost effective or otherwise replaced.

Action 9.4-3: Monitor corrective maintenance activities to identify and address any opportunities to reduce and/or eliminate the number of RMUs experiencing repetitive defects.

9.4.3 Strategic Spares

Strategic spares holdings for RMUs are held as part of general stores holdings and minimum stock levels.

9.5 Refurbishment and replacement

The following sections outline the practices used to either extend the life of the asset through refurbishment or to replace the asset at the end of its serviceable life.

9.5.1 Refurbishment

Refurbishment activities aim to extend the life of assets and postpone the need for complete replacement. An economic assessment of the cost and potential useful life is used to determine whether refurbishment is viable.

The only current refurbishment program for RMUs is to replace operating mechanisms in ABB Safelink RMUs in the South East Region to address a design issue. Approximately 2,000 RMUs have already been replaced with new mechanisms and the remaining 4,000 RMUs are programmed to be refurbished by the financial year 2021/22. In the Northern and Southern regions, operating mechanisms in ABB Safelink RMUs are only replaced when found to exhibit the known problem and rely on operating procedures to control the failure. Depending on the outcome of an audit of a sample of F&G RMU's in the Cairns area during 2018, a program of retrofitting of additional cable supports may be introduced to mitigate risk of bushing failures caused by settling or poor installation practices.

9.5.2 Replacement

The forecasting program for RMU replacement is determined by the historical replacement of units. EQL replaces RMUs based on asset condition and risk, such as: when assets are identified to be problematic through failure investigations, detailed maintenance and inspection, or have failed in service.

9.6 Disposal

Replacement and refurbishment activities of RMUs comply with all requirements for the safe disposal of hazardous materials (e.g. sulphur hexafluoride (SF_6)). EQL will adopt all reasonable and practicable measures to:

- Store, transport and dispose of all waste streams in accordance with state and local authority requirements;
- Segregate waste streams to prevent the generation of wastes requiring disposal as hazardous (regulated) wastes due to contamination; and
- Minimise, reuse or recycle wastes as the preferred option over disposal to landfill.

The *National Greenhouse Energy and Reporting Act 2007 (Cth)* places a statutory obligation on EQL to report emissions of SF_6 gas associated with its network operations including disposal of SF_6 RMUs. Processes and procedures are in place to recover SF_6 prior to disposal as well as ensure SF_6 emission is quantified and recorded in compliance with the statutory requirements.

10 Program Requirement and Delivery

The programs of maintenance, refurbishment and replacement required to outwork the strategies of this AMP are documented in Network Program Documents and reflected in corporate management systems. Programs are typically coordinated to address the requirements of multiple asset classes at a higher level such as a substation site or feeder to provide delivery efficiency and reduce travel costs and overheads. The Network Program Documents provide a description of works included in the respective programs as well as the forecast units.

Program budgets are approved in accordance with Corporate Financial Policy. The physical and financial performance of programs is monitored and reported on a monthly basis to manage variations in delivery and resulting network risk.

11 Summary of actions

The following provides a summary of the specific actions noted throughout this AMP for ease of reference.

Action 6.1-1: Review and align the management of mechanism design flaw present in some ABB Safelink Ring Main Units to ensure a common EQL approach and mitigating the safety risk SFAIRP.

Action 6.3-1: Implement Partial Discharge testing and subsequent remedial actions on Hazemeyer / Magnefix / Holec Polymeric Ring Main Units in the Northern and Southern Regions to align with the strategies present in the South East Region.

Action 7.1-1: Investigate and identify the root cause of the failure modes present in F&G RMUs to drive corrective actions and improvements in the lifecycle strategy of this asset population**.**

Action 7.2-1: Conduct further investigation on the Siemens RMUs being supplied in padmount substations from Wilson Transformers in order to come to a decision on the purchase and use of this equipment in the EQL network**.**

Action 9.2-1: Align and improve defect, failure and dangerous electrical event data capture processes and reporting methodologies to ensure consistency across EQL.

Action 9.2-2: Implement asset data structure changes in the new Enterprise Asset Management system being proposed for EQL to enable the consistent and accurate capture of RMU data. This will improve failure and condition monitoring capability to support the asset management objectives.

Action 9.2-3: Implement a process to improve the data capture of plant commissioning and decommissioning to ensure appropriate information is available to drive decision making in the lifecycle management of these assets.

Action 9.4-1: Continue the alignment of maintenance and operating practices for EQL to drive efficiency, deliver customer outcomes and mitigate risk.

Action 9.4-2: Review preventive maintenance practices in light of results of new MSSS data in order to avoid or reduce corrective maintenance or replacement on failure. This may result in a review of the maintenance intervals for the ISCA or NIM and a review of the nature of tests / inspections to be undertaken.

Action 9.4-3: Monitor corrective maintenance activities to identify and address any opportunities to reduce and/or eliminate the number of RMUs experiencing repetitive defects.

Appendix 1. References

It takes several years to integrate all standards and documents after a merger between two large corporations. This table details all documents authorised/approved for use in either Legacy Organisation, and therefore authorised/approved for use by EQL, that supports this Management Plan.

Legacy organisation	Document Number	Title	Type
Energex	STD01128 STD01129 STD01130 STD01109	Maintenance Standards for Oil RMU Maintenance Standards for SF6 RMU Maintenance Standards for Polymeric RMU Maintenance Standards for Oil RMU	Policy Document
Energex	CD002	Standard for Handling of Sulphur Hexafluoride (SF6).	
Energex		Substation Defect Classification Manual	Manual
Ergon Energy			Manual
Energex		Lines Defect Classification Manual	Manual
Ergon Energy			Manual

Appendix 2. Definitions

Term	Definition
Corrective maintenance	This type of maintenance involves planned repair, replacement, or restoration work that is carried out to repair an identified asset defect or failure occurrence, in order to bring the network to at least its minimum acceptable and safe operating condition. An annual estimate is provided for the PoW against the appropriate category and resource type.
Distribution	LV and up to 22kVnetwork, all SWER networks
Forced maintenance	This type of maintenance involves urgent, unplanned repair, replacement, or restoration work that is carried out as quickly as possible after the occurrence of an unexpected event or failure; in order to bring the network to at least its minimum acceptable and safe operating condition. Although unplanned, an annual estimate is provided for the PoW against the appropriate category and resource type.
Preventative maintenance	This type of maintenance involves routine planned/scheduled work, including systematic inspections, detection and correction of incipient failures, testing of condition and routine parts replacement designed to keep the asset in an ongoing continued serviceable condition, capable of delivering its intended service
Subtransmission	33kV and 66kV networks
Transmission	Above 66kV networks

Appendix 3. Acronyms and Abbreviations

The following abbreviations and acronyms may appear in this asset management plan.

Abbreviation or acronym	Definition
AIDM	Asset Inspection & Defect Management system
AMP	Asset Management Plan
Augex	Augmentation Expenditure
CBRM	Condition Based Risk Management
CB	Circuit Breaker
CT	Current Transformer
CVT	Capacitor Voltage Transformer
DEE	Dangerous Electrical Event
DGA	Dissolved Gas Analysis
DLA	Dielectric Loss Angle
EQL	Energy Queensland Limited
ESCOP	Electricity Safety Code of Practice
ESR	Queensland Electrical Safety Regulation (2013)
IoT	Internet of Things
ISCA	In-Service Condition Assessment
LDCM	Lines Defect Classification Manual
LV	Low Voltage
MU	Metering Unit
MVAr	Mega-VAr, unit of reactive power
NER	Neutral Earthing Resistor
NEX	Neutral Earthing Reactor
OLTC	On-load tap -changers
OTI	Oil Temperature Indicators
PCB	Polychlorinated Biphenyls
POC	Point of Connection (between EQL assets and customer assets)
POEL	Privately owned Electric Line
PRD	Pressure Relief Device
QLD	Queensland
REPEX	Renewal Expenditure
RIN	Regulatory Information Notice
RMU	Ring Main Unit
SCAMS	Substation Contingency Asset Management System
SDCM	Substation Defect Classification Manual

Abbreviation or acronym	Definition
SHI	Security and Hazard Inspection
SM	Small
SVC	Static VAR Compensator
VT	Voltage Transformer
WCP	Water Content of Paper
WTI	Winding Temperature Indicators
WTP	Wet Transformer Profile