Asset Management Plan
Switches

Part of the Energy Queensland Group

Executive Summary

This document is an Asset Management Plan (AMP) for the class of switches at voltage levels of 11kV and above, including:

Overhead network

- Air break switches
- Load break switches
- Isolators
- Earth Switches
- Disconnect links – single phase
- Sectionalisers
- Load transfer switches.

Underground Network

- Ring Main Units (RMU)

Electrical switches are used in distribution and transmission networks to allow for isolation of assets or feeders for maintenance purposes. Switches also have the function of providing the ability to reconfigure the network to enable alternative sources of supply either permanently or temporarily by changing open points between feeders.

These assets are located across the Energy Queensland Limited (EQL) network and their lifecycle management is based on asset condition and risk. EQL manages:

- Approximately 134,889 overhead switches, with approximately 39,904 in Ergon Energy and 94,985 in the Energex; and
- Approximately 24,892 RMUs, approximately 7,059 in the Ergon Energy Regions and 17,833 in the Energex Region.

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.

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

Factors influencing the effective management of switches include large asset population, longevity and determination of effective life, the range of switch makes, types, and models, variability within types due to advances in manufacturing technology, and the diverse range of environmental and operational conditions across EQL networks.

Key lifecycle strategies for addressing the main problems associated with this asset class include

- The requirement for continuous improvement in asset data quality,
- Aligning maintenance and refurbishment practices across EQL
- Replacing problematic vertically operated isolators and reviewing the planned and reactive work for NU-LEC/Schneider Sectionalisers in order to improve asset management efficiency and reduce the frequency of issues associated with allocating maintenance.
- Managing oil and SF6 leak issues in the asset population.
- Addressing safety issues by implementing risk managed safety controls, in particular the switching of certain brands of RMUs.

Revision History

Revision date	Version number	Description of change/revision
31/01/2019	1	AER Document Initial release
01/12/2023	2	Reviewed and updated – Final Version

Document Approvals

Position title	Date
General Manager Asset Lifecycle Management	Jan 2024
Chief Engineer	Jan 2024

Stakeholders / Endorsements

Title	Role
Manager Asset Lifecycle Planning	Endorse
Manager Switching Plant	Endorse

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1 Introduction

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

- Energex Regions (Legacy organisation: Energex Limited); and
- Ergon Energy 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 practice.

1.1 Purpose

EQL has shaped the strategic planning approach to consider what we need to do deliver financial sustainability whilst balancing our ability to transform in an environment of significant market disruption and increased competition as we evolve towards an 'electric life' and renewable targets as described in Queensland Energy and Jobs Plan (QEJP).

The purpose of this document is to demonstrate the responsible and sustainable management of switches 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)
- 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. Appendix 1 contains references to other documents relevant to the management of the asset class covered in this plan.

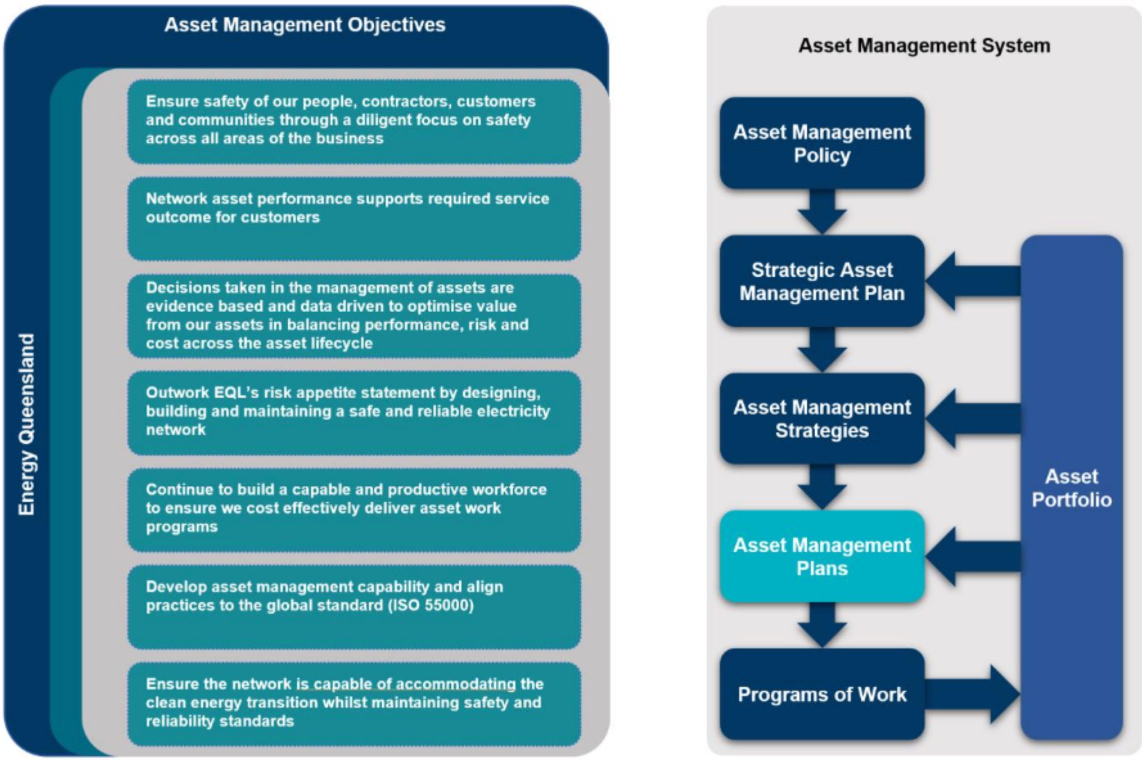


Figure 1: EQL Asset Management System

1.2 Scope

This plan covers the following assets at voltage level 11kV and above for both Overhead and Underground networks and include:

Overhead Network

- Air break switches
- Load break switches
- Isolators
- Earth switches
- Disconnect links – single phase
- Sectionalisers
- Load transfer switches

Underground Network

- Ring Main Units.

Many customers, typically those with high voltage connections, own and manage their own network assets including switches 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 asset quantities and replacement costs, the switches in the EQL network have an undepreciated replacement value of approximately $4.06 billion. Figure 2 provides an indication of the relative financial value of EQL switches compared to other asset classes.

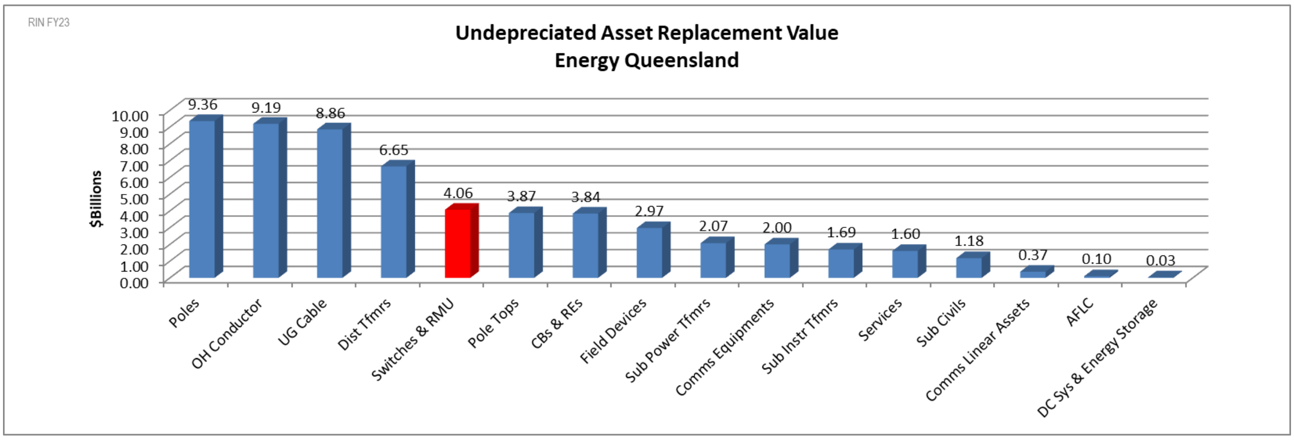


Figure 2: EQL Total Current Asset Replacement Value

1.4 Asset Function and Strategic Alignment

The functions of a switch in an electrical network are to:

- Make, break, or change an electrical connection or
- Isolate the network for safe work.

An RMU is a specialised compact switching 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. 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 below details how switches contribute to the corporate strategic asset management objectives.

Relevant 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 support switches performance and hence safety for all stakeholders.
Meet customer and stakeholder expectations.	Continued switches serviceability supports network reliability and promotes delivery of a cost effective, quality electrical energy service.
Manage risks, performance standards and asset investment to deliver balanced commercial outcomes.	Failure of switch 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.

Relevant Asset Management Objectives	Relationship of Asset to Asset Management Objectives
Modernise the network and facilitate access to innovative energy technologies.	This AMP promotes replacement of switches 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.

Responsible Party	Role
Queensland Government	Development of legislative framework and environment for operation of EQL in Queensland. Development of EQL Distribution Authorities.
Queensland Government as sole shareholder of EQL	Owner of company shares, holding equity in EQL and gaining benefits from EQL financial success.
EQL Board of Directors	Corporate direction, operation, and performance of EQL and its subsidiaries, in compliance with corporate and Queensland law.
Chief Financial officer	Company Asset Owner – ensuring all EQL investments are consistent with EQL corporate objectives with balanced commercial outcomes.
Chief Operating Officer	Overall operational control of EQL networks including maintenance and operation, and execution of project works.
Chief Engineer	Overall strategic control of EQL assets, including asset population performance, risk, and financial management.
All employees and contractors of Energy Queensland Limited	Performing all duties as required to achieve EQL corporate objectives.
All unions that are party to the EQL Union Collective Agreement	Promotion of safe and fair working conditions for all EQL and subsidiary company employees.
Queensland Electrical Safety Office	Regulatory overview and control of electrical safety in Queensland.
Australian Energy Regulator	Regulatory overview and control of economic performance of EQL under its Distribution Authorities to promote the long-term interests of all electrical network customers connected to the National Electricity Market.
Powerlink	Queensland Transmission Network Service Provider. Owner and operator of many 110kV to 330kV transmission grid assets and 74 bulk supply substations that connect and deliver energy to EQL networks.
All consumers, prosumers and generators connecting to the Energy Queensland network	Operating within the electrical technical boundaries defined by legislation, regulation, and connection agreements.
All communities and businesses connected to the Energy Queensland network.	Economic prosperity of Queensland.

Table 2: Stakeholders

2 Asset Class Information

The following sections provide a summary of the key functions and attributes of the assets covered in this AMP.

2.1 Asset Description

Overhead Switches in the EQL network are used for isolation of assets for safe work, and reconfiguration of the overhead network by making or breaking connections for any forced or unforced event.

On the other hand, 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 pad mount distribution transformers in the underground network. 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.

Overhead Switches and RMUs (collectively referred as Switches in this document) are classified according to many criteria such as:

- Operating voltage
- Installed location
- Switch function (isolate / break / make)
- Interrupting medium.

Switches in this document are categorised based on operating voltage and switch function in EQL.

2.1.1 Air Break Switch

An air break switch (ABS) device is a manually operated pole mounted switch that uses air as the 'dielectric medium', an insulating substance which prevents current flow. ABSs are used in the EQL network for isolation or switching purposes, to minimise the number of customers affected during supply outages. They are designed for no-load outdoor operation and are installed on the overhead distribution system.

ABSs are composed of a steel structure with porcelain insulators and have an operation handlebar located at the bottom of the switch. Generally switching is done manually by an operator underneath the device. These distribution switches are spread across the network and located in urban and rural public areas.

These ABSs may operate in either a vertical or horizontal opening/closing configuration. Vertically operating switches are an older design. The additional mechanical force associated with the closing operation of vertically operating switches results in cracking of the porcelain insulators leading to subsequent failure. This design has been superseded by the horizontal operation which is the current standard used by EQL, however, there are still a number of vertically operating switches in service.

2.1.2 Load Break Switch

A load break switch (LBS) functions and operates in a similar fashion to an air break switch, but also has been designed to be able to make or break specified currents. In the EQL asset data systems, LBSs are included in the air break switch asset group (AB). Modern load break switches are gas insulated (SF6 gas).

2.1.3 Zone Substation Isolator

Zone substation isolator switches are used to ensure that an electrical network is completely de-energised for service or maintenance. These switches function and operate in a similar fashion to air break switches, but are located in zone substations away from the public. EQL uses both manually operated and motor driven isolators inside substations with the latter providing capability to undertake remote network switching.

2.1.4 Earth Switch

Zone substation earth switches are designed to connect a de-energised section of an electrical network to earth for safe access by maintenance personnel.

2.1.5 Disconnector Link

Single phase disconnector links are typically used on overhead distribution feeders to provide a visible isolation point for line or equipment maintenance purposes for downstream operational equipment. They are operated from ground level. They have the same function as an ABS, but they are a single-phase switch instead of a three-phase ganged switch.

2.1.6 Sectionaliser

The function of a sectionaliser is to be able to carry normal load current but to switch out automatically when de-energised after detection of pass through fault current. These are located on overhead distribution feeders.

2.1.7 Load Transfer Switch (LTS)

A load transfer switch (LTS) is a remote switching device capable of making, carrying, and breaking currents under normal circuit conditions. LTSs can be configured as sectionalisers or configured without sectionalising settings to be remote load break switches. Modern load transfer switches are gas insulted (SF6 gas).

2.1.8 Ring Main Units (RMU)

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

Table 3 details the total quantity of EQL's switch asset population by type.

Asset Type	Ergon Energy	Energex	Total
Isolators and Air Break Switches	13,809	21,573	35,382
Disconnector Links	24,321	69,184	93,505
Earth Switches	272*	2,834	3,106
Sectionalisers	1,502	139	1,641
Load Transfer Switch	N/A*	1,255	1,255
Ring Main Units	7059**	17,833	24,892
Total	46,963	112,818	159,781

Table 3: Asset Quantity

* Information from Ellipse & Smallworld, which includes integrated earth switches.
*Individual switch type breakdown is not available due to data quality/classification issues. Refer to section 9.2 for further information.
** 7059 is the calculated number of RMU Units from 17,016 individual RMU components.

2.3 Asset Age Distribution

Figure 3 and Figure 4 illustrate the overall age profile for EQL's switch asset population in both the Ergon Energy Region and Energex Region.

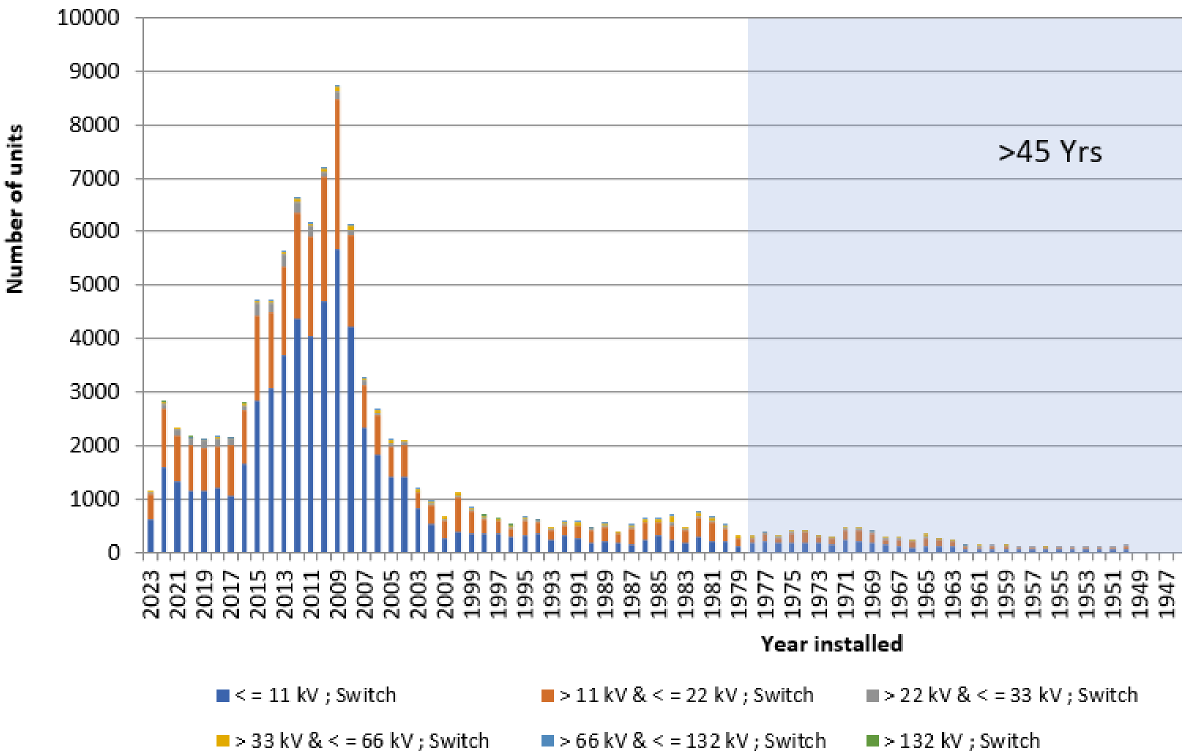


Figure 3: Overall switch population age profile – Ergon

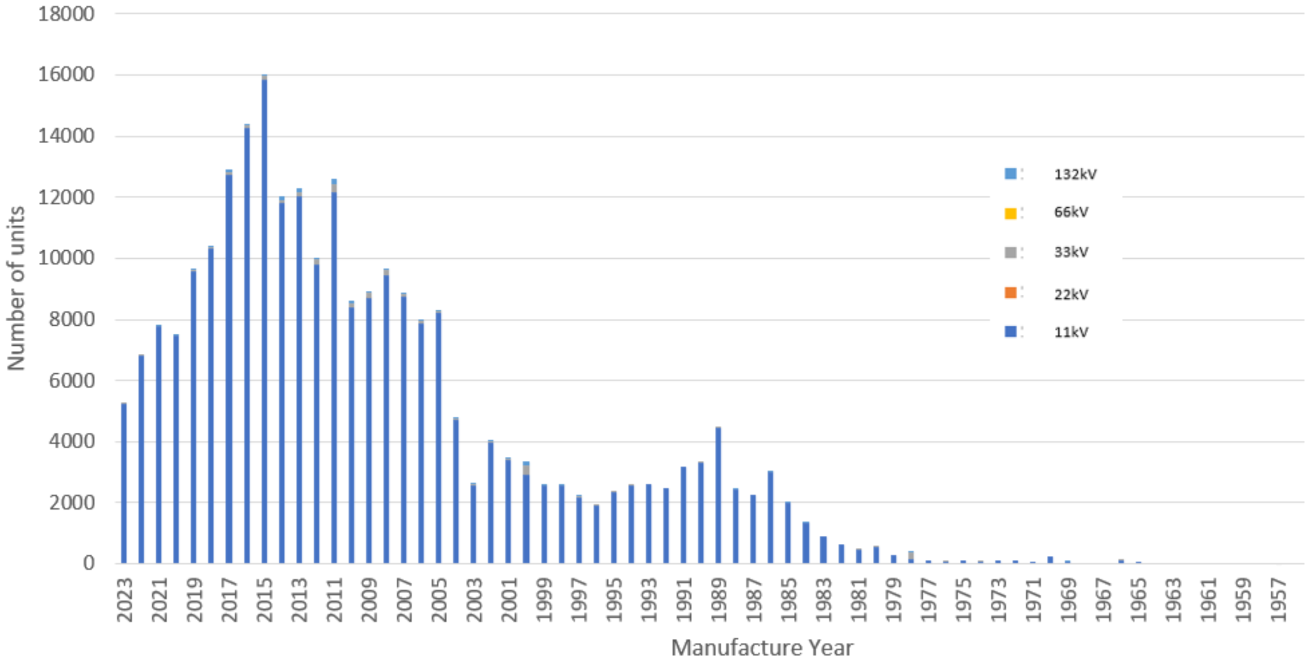


Figure 4: Overall switch population age profile (including fuse switches) – Energex

2.4 Population Trends

2.4.1 Overhead Switches

Overhead Switches in the EQL network have been installed over several decades, both within substations and on the overhead network. The installed asset population consists of a variety of different switch makes and models.

Prior to the 1970s, vertically operated switches were installed at voltages lower than or equal to 66kV. Between 1970 and 1990, horizontally and vertically operated switches were installed. After 1990, horizontally operated copper rod switches formed the majority of the population and are now the current standard for isolators and air break switches.

The Energex Region still has vertical operated gooseneck, braid, and duo roll type substation isolators and distribution ABSs installed on the network up to 33kV. The Ergon Energy Regions have removed all vertically operated ABSs from the distribution network but still, have vertically operated substation isolators up to 66kV installed. Factors affecting the removal of vertically operated substation isolators are further discussed in Section 6.2.2.

The EQL 110kV and 132kV substation isolator asset population consists of vertically and horizontally operated isolators. There are currently no known issues with these models.

The Ergon Regions started using gas break switches to gain more remote access in 2008.

2.4.2 Underground Network Switches - Ring Main Units

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 pad mount 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.

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	Decline in the reliability of operation over time due to wear.	Reduction in the remaining life of the switches.
Environment	Outdoor, corrosive, polluted, and coastal environments result in accelerated degradation of insulators.	Results in accelerated ageing, reduction in reliability of operation, and reduction in useful life.
Operation	Coarse manual operations of switches results in stress and degradation of asset.	Incorrect switch operation and increased safety hazards.
Design	Varies based on make and model and only becomes apparent through operational experience.	Premature ageing, incorrect switch operation, and reduction in useful life.
Fault (RMU)	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: 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 practicable (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 lifecycle 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)* (ESR), 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 it 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 switches, 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).

Switches typically have low impact upon SAIDI and SAIFI overall, however, substation switches 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 Levels of Performance

3.4.1 Overhead Switches

There is currently a disparity in the levels of reported failures between the EQL legacy organisations, due to differences in source data and calculation methodology. EQL is working towards alignment of methodologies to ensure a common approach moving forward.

Failures in the Ergon region have been estimated based on the following approach:

- Distribution switches – The maintenance practice for distribution switches is to run them to failure and then replace, therefore all replacements are assumed to be failures. Similarly, all stores issues for these assets costed to the operating expenditure code are considered to be failures.
- Substation switches – feeder statistics are used to identify an outage, which is then attributed to a particular asset class. In developing this estimate, Ergon Energy has assumed that all failures will lead to an outage.

In the Energex Region, in-service failures for distribution switches are identified via manually analysing the network outage reports and allocating them to the appropriate asset class.

Figure 5 and Figure 6 show the historical five-year annual EQL asset failure numbers reported in the RIN for switches.

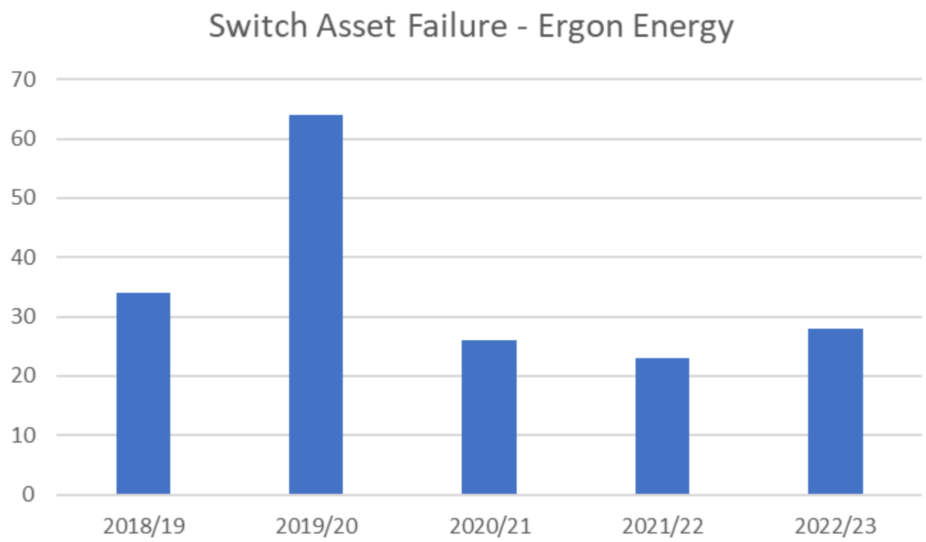


Figure 5: RIN Asset Failure – Ergon Energy Region

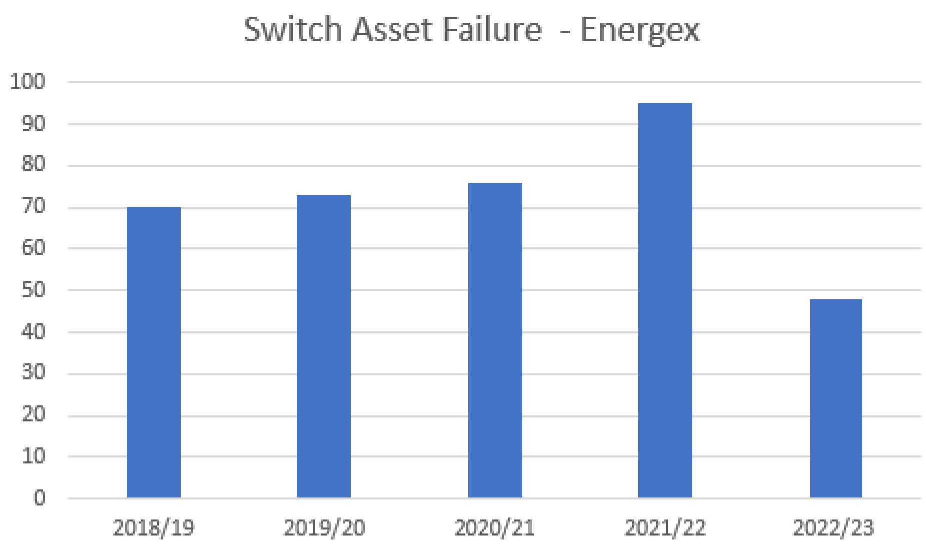


Figure 6: RIN Asset Failure – Energex Region

Figure 7 and Figure 8 show the historical trend of defect replacement and refurbishment works that have been conducted on switches. The P0, P1 and P2 references relate to priority of work required, which dictates whether normal planning processes are employed (P2), or more urgent repair works are initiated (P1 and P0). There has been a reporting change in the way is data has been processed. Key words have been used to filter on the work order description and extended description to identify the asset class and MSSS codes that do not apply to the asset is excluded from the analysis. Where no MSSS codes have been recorded, it is deemed that the work order pertains to that asset. There is a high proportion of P0 defects raised with no MSSS codes against the work order. The data has been back casted to provide visibility of the work.

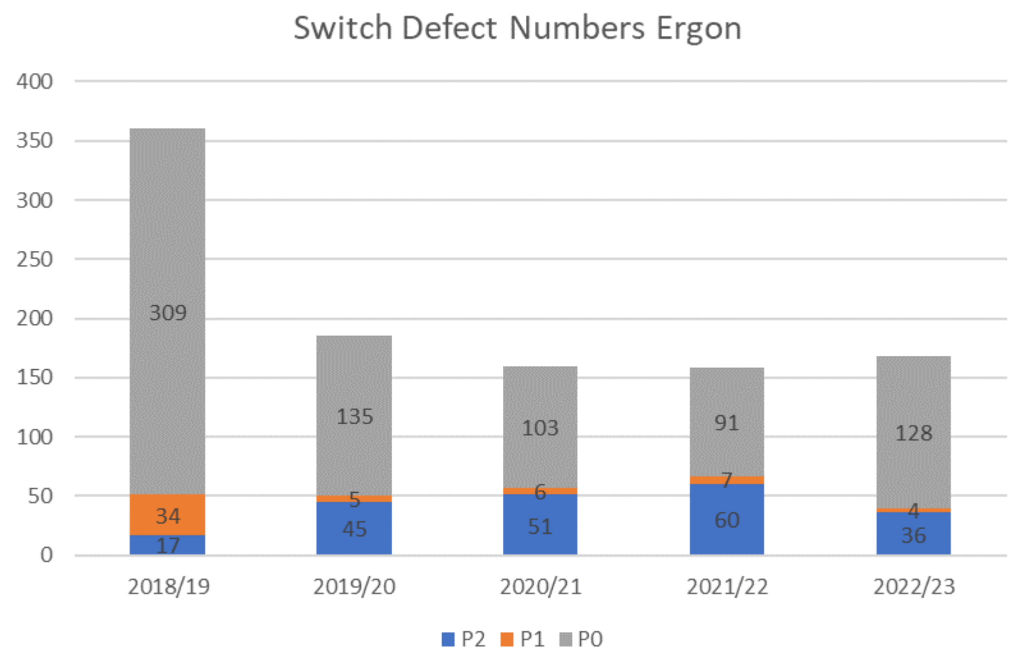


Figure 7: Switch Defect Numbers – Ergon Energy Region

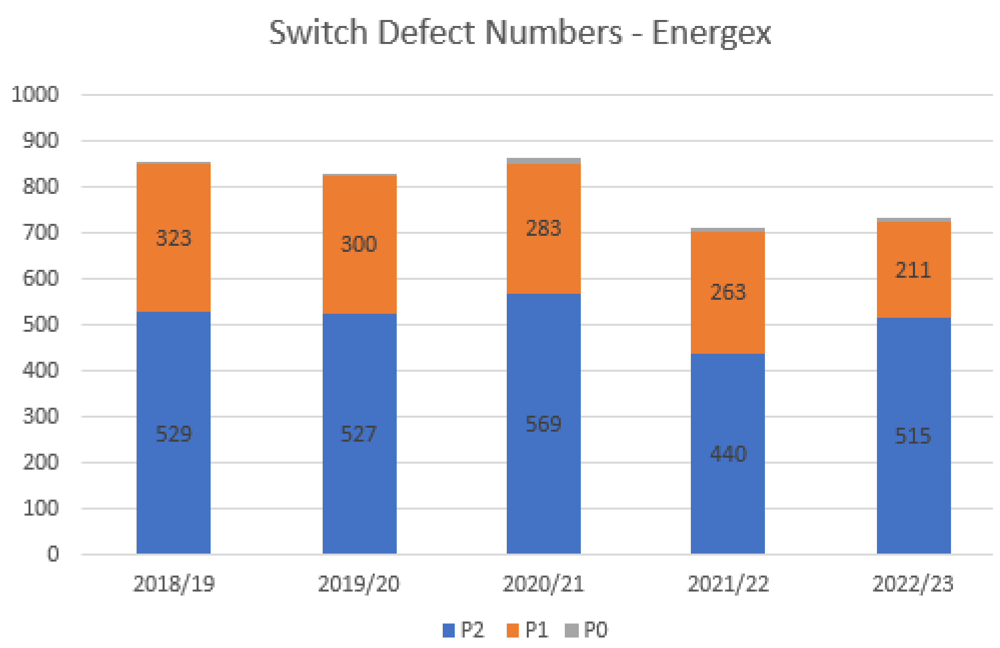


Figure 8: Switch Defect Numbers – Energex Region

Legacy organisation Ergon Energy developed and implemented a record system for all failures, incorporating a requirement to record the asset component (object) that failed, the damage found, and the cause of the failure which has been in place since approximately 2011. The Energex Region also has adopted this approach from 2017/18 financial year. This Maintenance Strategy Support System (MSSS) data set is building over time and starting to provide the systemic information necessary to support improvements in inspection and maintenance practices. There is an expectation that this will also support and influence standard design procurement decisions. The following sections outline the information which has been gathered to date on the performance of this asset class using the MSSS data.

Figure 9 and Figure 10 show the breakdown of switch defects in the Ergon Energy Region by type and by cause over the 5-year period. Most of the defects were found to be air break switches, caused by deterioration and damage associated with normal wear as well as corrosion.

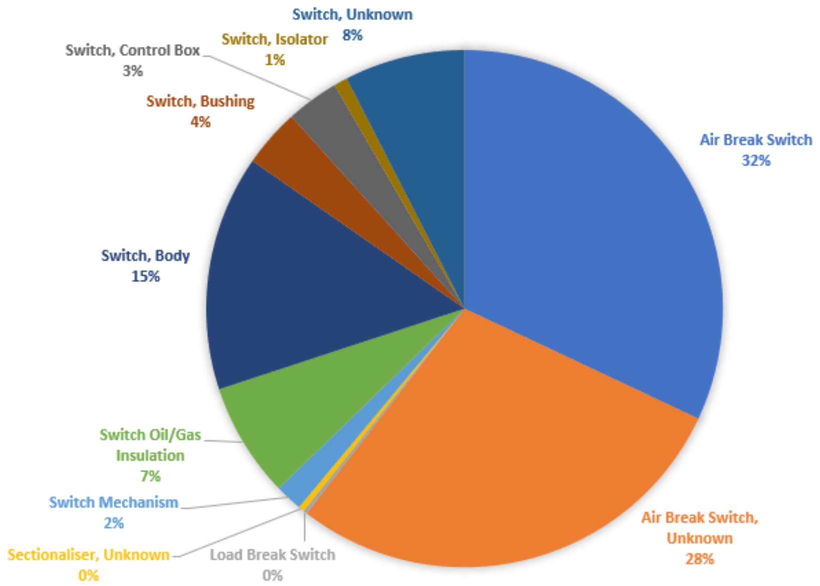


Figure 9: Switch Defects – Ergon Energy Region

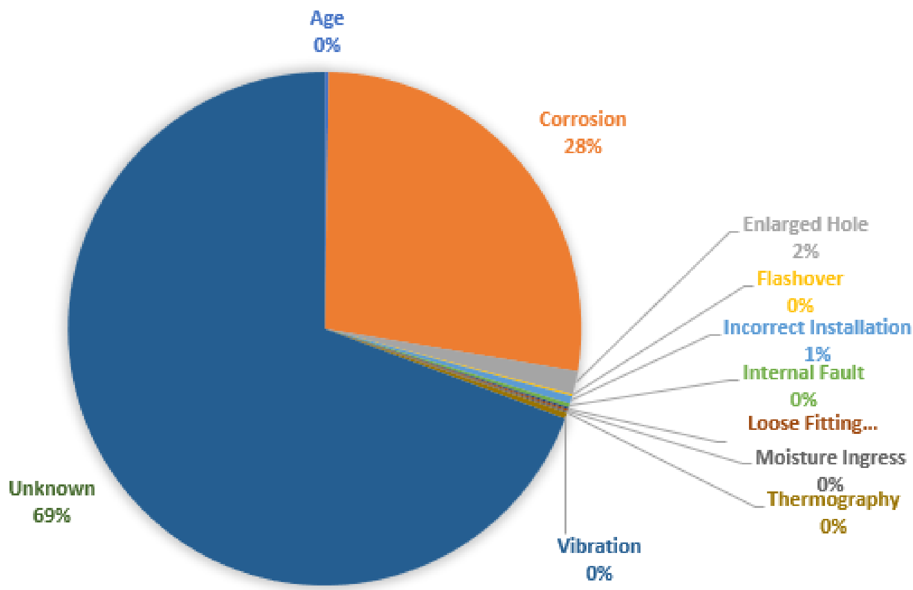


Figure 10: Switch Defect by Cause – Ergon Region

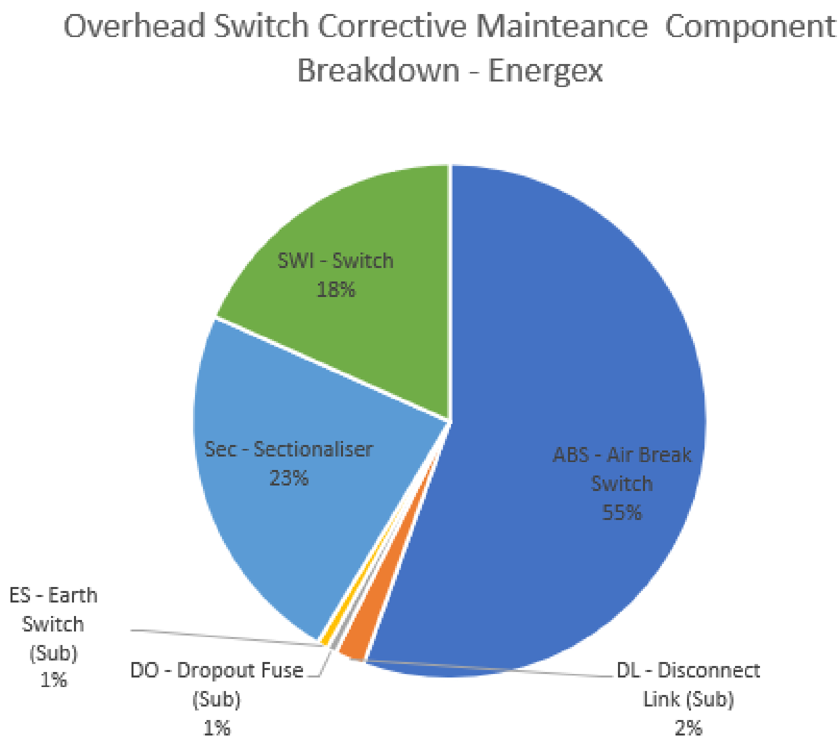


Figure 11: Corrective Maintenance Component Breakdown – Energex Region

Figure 11 shows that after the Air Break switches, 23% of the corrective maintenance tasks in the switches class were sectionaliser issues.

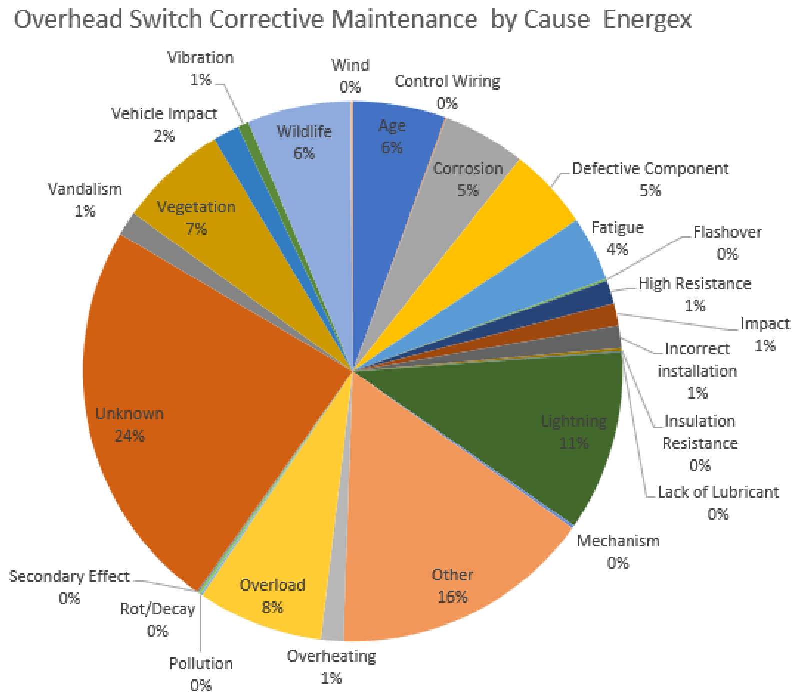


Figure 12: Corrective Maintenance Cause Code Breakdown – Energex Region

Figure 12 shows that the split of the identified causes is relatively even across a number of categories with lightning being slightly more prevalent. This figure also shows that there is still a high percentage of unknown causes for corrective maintenance in this asset class. It is expected that the level of unknown causes will reduce as the MSSS process in the Energex becomes more mature.

Figure 13 shows the corrective maintenance in the Energex Region by Manufacturer with unknown brands removed for clarity.

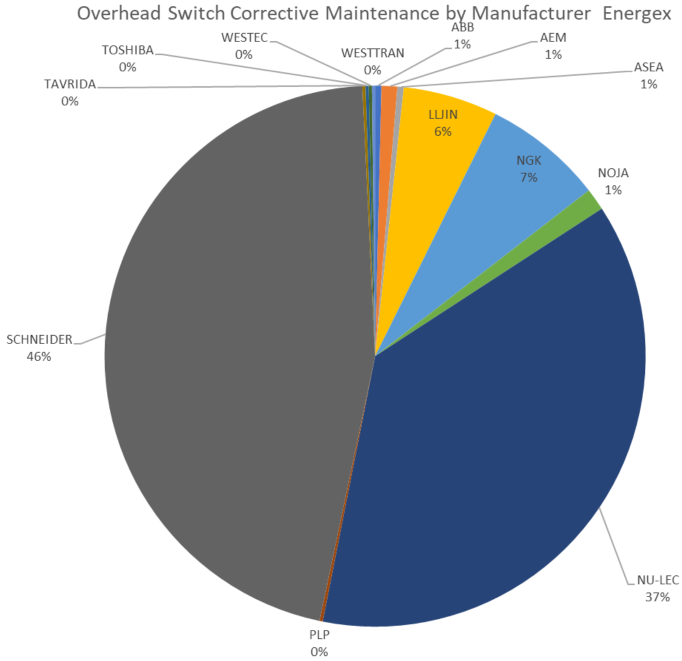


Figure 13: Corrective Maintenance by Plant Manufacturer – Energex Region

Figure 13 shows switch corrective maintenance in Energex with the Nu-Lec and Schneider types showing the highest contribution which are the predominate populations. Note that Nu-Lec was purchased by Schneider and have continued with the same design. As such these assets are considered together in the analysis which is discussed in more detail in Section 6.4.

3.4.2 Underground Switches - Ring Main Units

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.

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 (P0/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/P0). Additionally, a classification of C3 aims to gather information to inform or create a “watching brief” on possible problematic asset conditions. Figure 14 shows the historical defect count for RMUs in the Ergon Energy Region.

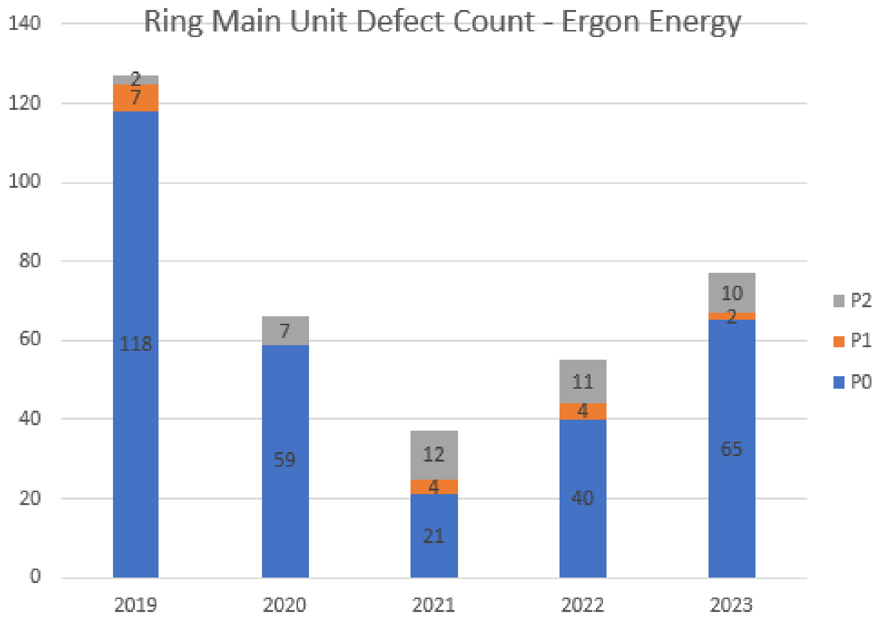


Figure 14: RMU Defect Count – Ergon Energy Regions

The trend in recorded defects in the Ergon Region is increasing. This is due to the expanded detection of Partial Discharge defects for the know population of inherent manufacturer issues. The large number of P0 defects are due to the reactive nature in which defects are found in the Ergon network and the requirement to repair urgently to restore a reliable network configuration. Figure 15 shows the historical defect count for RMUs in the Energex Region.

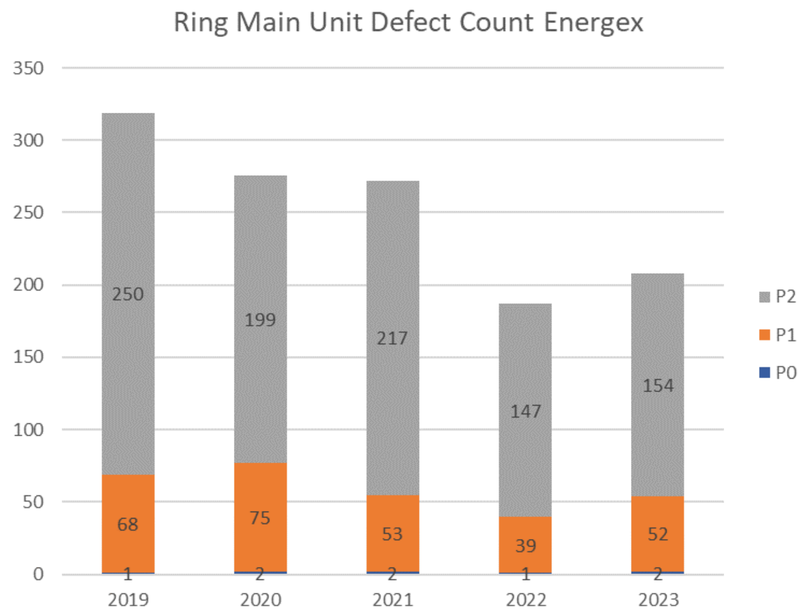


Figure 15: RMU Defect Count - Energex

The defect data available for the Energex Region provides a better sample on which to draw conclusions on performance however there are still variations in defect volumes from year to year. 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 16 and Figure 17 show the historical replacement counts for the Ergon Energy Regions and Energex Region respectively.

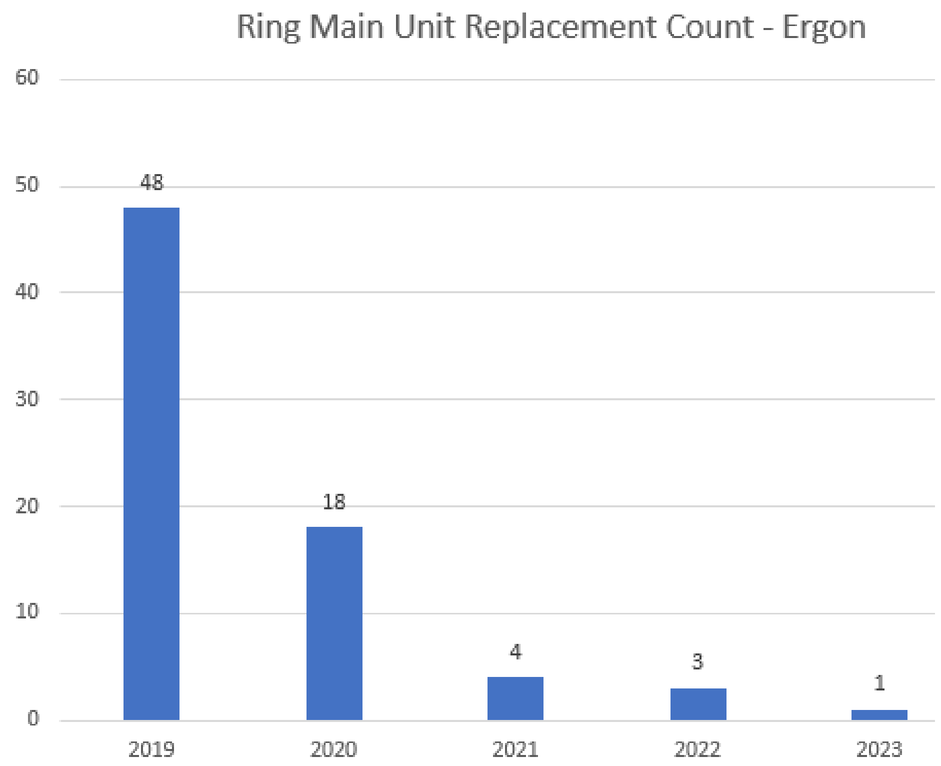


Figure 16: RMU Demand Replacement Count – Ergon Regions

Figure 16 indicates a decreasing demand-based replacement requirement in the Ergon energy Region. The information collected in the MSSS system may be skewed as failures and defects requiring replacement have been assigned to the Return to Service (RTS) process and may not be truly captured in the current system.

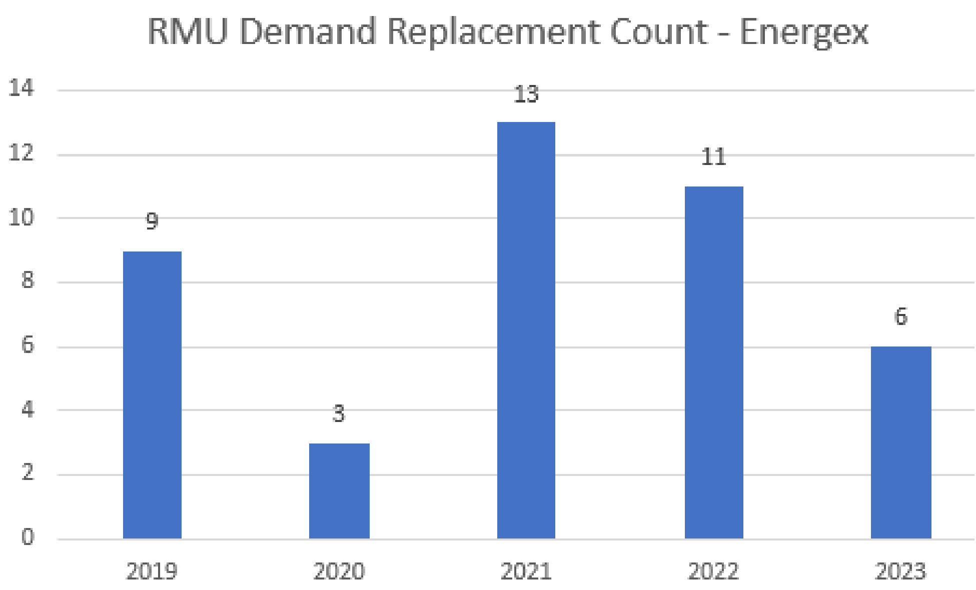


Figure 17: RMU Demand Replacement Count - Energex Region

Figure 17 indicates a decrease in demand-based replacement requirement in the Energex Region. It should be noted that the Energex Region has significantly higher numbers of RMUs in the network due to the prevalence of underground network.

Figure 18 and Figure 19 show a summary of the defects recorded in the Ergon Energy Region by component type and cause.

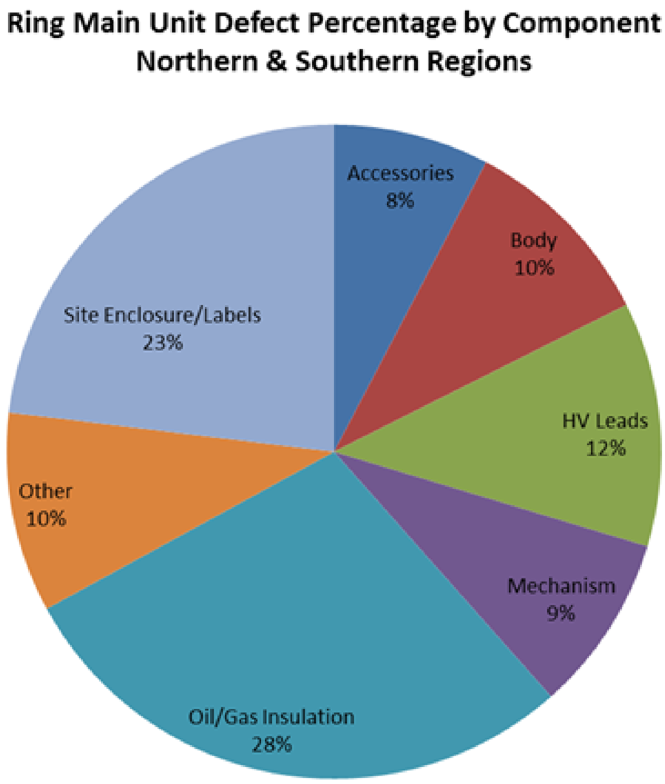


Figure 18: RMU Defect Percentage by Component – Ergon Energy Regions

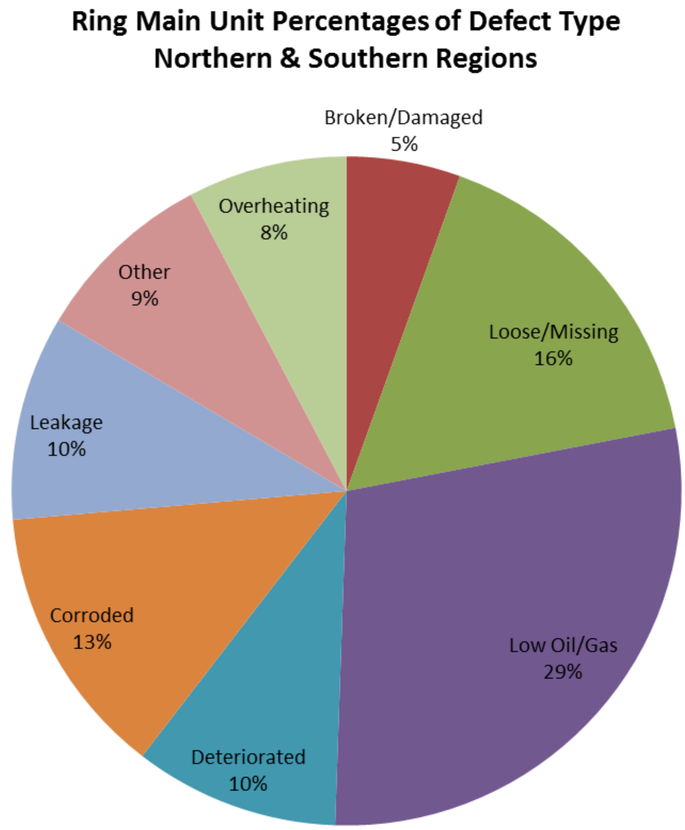


Figure 19: RMU Percentages of Defect Type – Ergon Energy Regions

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

Similar analysis of the defect information in the Energex 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 Energex Region to identify the major contributors to the program. Figure 20 and Figure 21 show the replacements by manufacturer and insulation medium as both a raw count and normalised against the installed population.

Figure 20 and Figure 21 show that the main drivers for RMU replacement in the Energex 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.

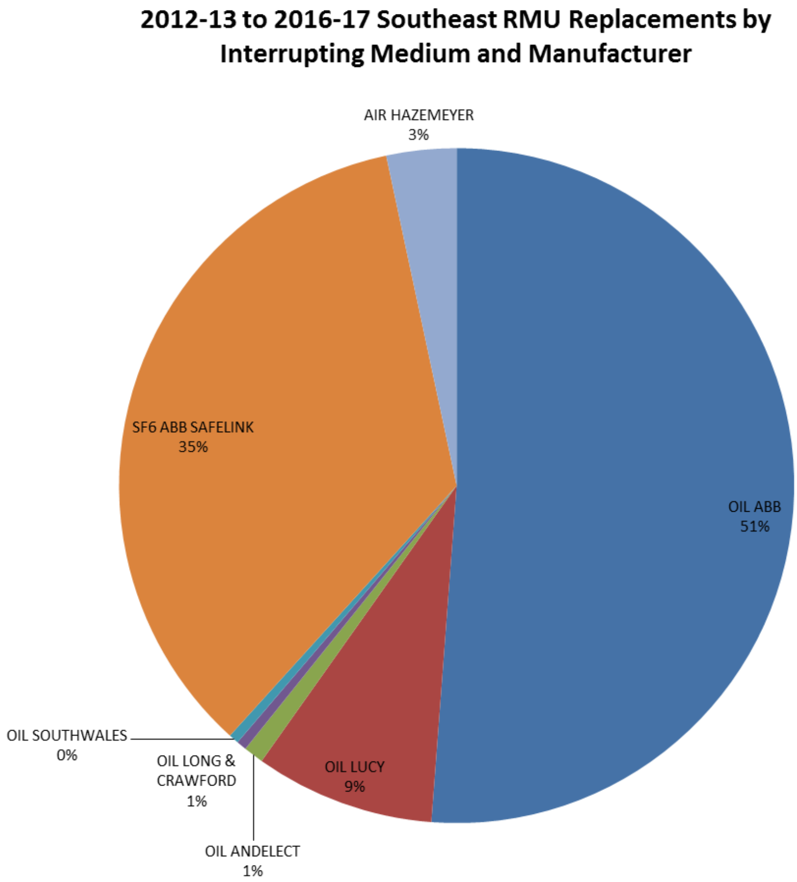


Figure 20: 2017/18 RMU replacement by interrupting medium and manufacturer

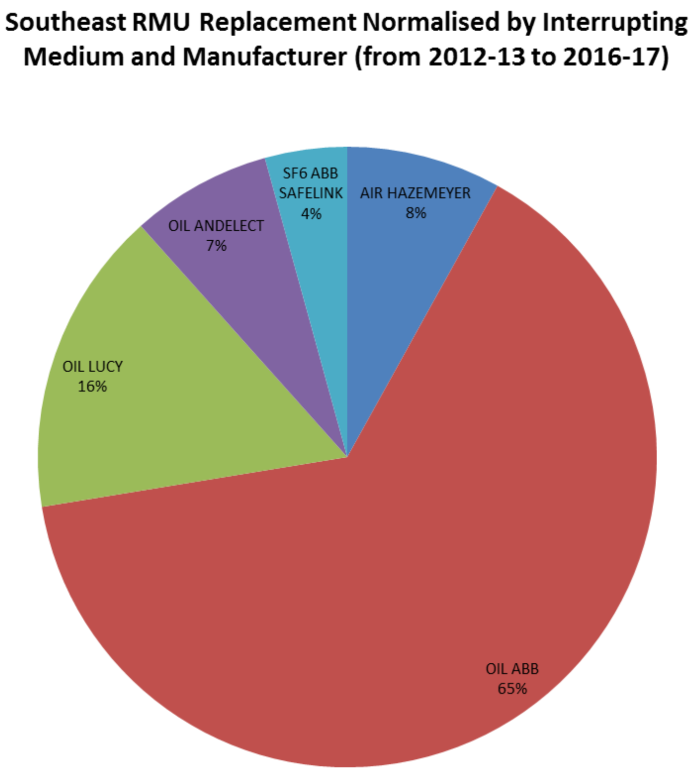


Figure 21: RMU Demand Replacement (normalised) –Energex Region

3.5 Risk Valuation Levels of Performance

EQL is committed to adopting an economic, customer value-based approach when it comes to ensuring the safety and reliability of the network. To substantiate the advantages of this approach for the community and businesses over the modelling period, they have employed Net Present Value (NPV) modelling. This commitment is in line with their efforts to minimize the impact on customer prices.

A cost benefit analysis has been conducted to confirm that the pole replacements are prudent capital investments.

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 act 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).

Figures 22 and 23 illustrate threat-barrier diagrams for switches and RMUs in the EQL network. EQL undertakes several actions such as inspections and maintenance to eliminate or mitigate the risks to SFAIRP/ALARP.

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

The following sections detail the ongoing asset management journey necessary to continue to achieve high performance standards into the future.

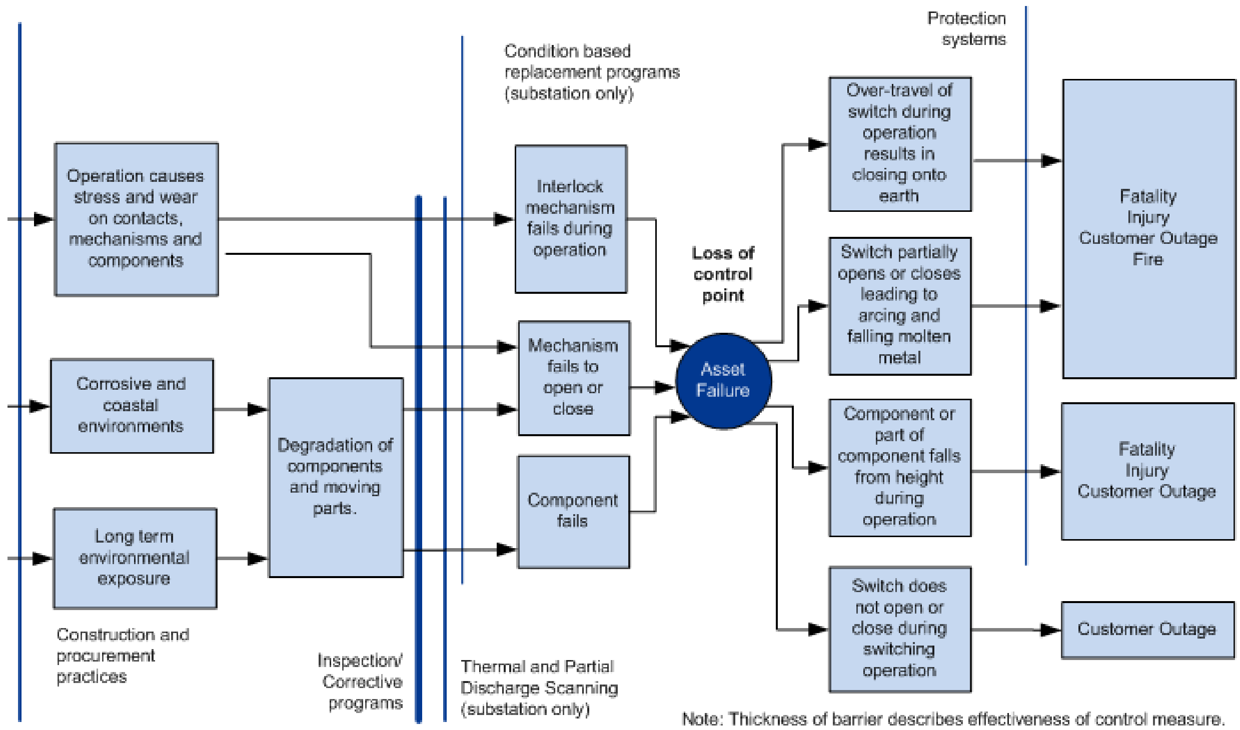
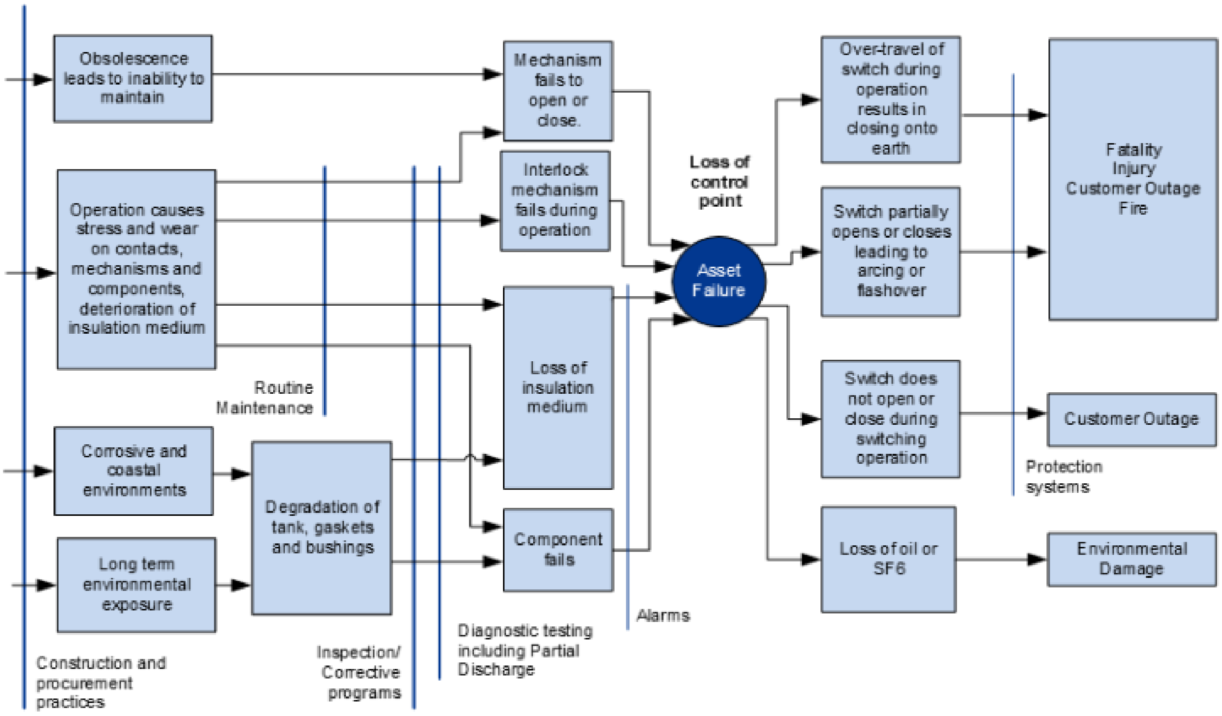


Figure 22: Threat-Barrier Diagram for Switches



Note: Thickness of barrier describes effectiveness of control measure.

Figure 23: Threat-Barrier Ring Main Units

5 Health, Safety & Environment

Sulphur hexafluoride (SF6) is a global warming gas, and although the amount in the atmosphere is small in comparison to carbon dioxide, its global warming potential is approximately 23,900 times greater. As a result, it is important that release of SF6 into the atmosphere is minimised to the extent that is practicable so as to demonstrate responsible use and assure the continuing availability of SF6 to the electricity supply industry.

SF6 has been used in electrical equipment for more than 40 years such as circuit breakers and reclosers. Extensive use continues to be made by the manufacturers of 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 SF6 switchgear population in EQL for the last two to three decades.

EQL records the of SF6 gas released to the atmosphere using an app-based system with a paper based fallback by accounting for the quantity of SF6 usage in accordance with the National Greenhouse & Energy Reporting Act. . The SF6 switches are hermetically sealed by the manufacturer and the SF6 gas of decommissioned switch is collected for recycling or proper disposal. Corrective works will be raised to rectify SF6 gas release issues on a case by case basis.

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 Overhead Switches

6.1.1 ABB R, U, S Series Air Break Switches

There is a targeted replacement program for all Air Break Switches of series ABB R, S, and U series switches in the EQL network. Network failure investigations identified corrosion on the galvanised steel pins cemented into the ceramic insulators of these switches, leading to undetectable hairline cracking of the ceramic. This can lead to complete failure of the ceramic insulator when the switch is activated by an operator positioned underneath the equipment. This targeted replacement program is the cause of the step change in asset quantity for both regions during 2010 and 2013.

In the Ergon network, the 2020/21 ABS Inspection and Maintenance Program has focussed on these problematic Air Break Switches. There are currently 104 units identified from the corporate system and Safety Alert was released to raised awareness for air break switch to be visually inspected to accurately identify these problematic units. To date there are still 65 units in service.

In the Energex's network, ABB Uni-switch is not classified as problematic switch and does not required replacement. Energex has however replaced all the identified ABB U, R and S series air break switches within the network.

6.2 Vertically Operated Isolators

EQL has experienced a number of common failure modes associated with vertically operated substation isolators. Misalignment of fixed finger contacts causes the isolator mechanism to loosen over time, leading to high resistance and heating, and resulting in contact annealing. Vertical operation of these isolators means that the supporting insulator bears the mechanical force of each operation, causing hairline cracks in the insulator over time and resulting in high risk of complete insulator failure. The following sections provide further detail on a regional basis. Section 9.5.2 includes detail relating to the replacement of these problematic assets.

6.2.1 Vertically Operated Isolators – Energex Region

In the Energex Region, vertically operating gooseneck/parrot beak type, braid type, and duo/duro roll type isolators have been identified as problematic, with a common failure mode identified across these isolator types.

Braid type isolators experience rust formation on the copper braids, resulting in degradation.

Operation of duo/duro roll isolators is controlled by two roller movements, requiring the manual switching operation to be applied with a specific force and technique. If operated incorrectly, rebounding from the contact surface is possible and excessive force may result in the supporting insulator failing.

The gooseneck isolator has misalignment issues when operated. During the closing operation of this isolator, where the rod vertically moves towards the fixed latch, it has been noted that the rod does not align with the latch and instead deviates to either side. This results in damaging insulator discs and connection issues.

There are no spare parts available for these three types of isolators, therefore if a defect occurs that restricts switch operation, the entire asset must be replaced.

The Energex Region currently has 390 vertically operating problematic isolators installed. A replacement program is planned for the next AER period, 2020-2025, replacing all problematic switches in the Energex Region with a modern standard equivalent.

6.2.2 Vertically Operated Isolators – Ergon Energy Regions

Ergon Energy identified 27 problematic vertically operating isolators in zone substations when the issue was raised. The asset register for the Ergon Region does not record if isolators are vertically or horizontally operated, making it difficult to source and analyse the vertically operated isolators.

Currently, there are 13 and possibly up to 17 remaining problematic isolators in the Ergon Region. Problematic isolators which are identified are included in the scope of replacement with other assets at the site to deliver efficiency benefits where possible.

6.3 AEM Type 33kV Disconnector Switches

The AEM Type 33kV Disconnector Switches were installed in zone substations from around 2004 in the Energex Region.

The first model of these switches was designed to have a set of four copper tubes with stainless steel rod inserts secured within the tubes by application of retaining clips at both ends. It has been observed that the retaining clips on some of these switches are deforming and are being dislodged over time, allowing the steel rod to protrude out from the tubing. Several retaining clips have been noted to have fallen off completely.

Currently, faulty units are being rectified where practicable as they are identified. Where simple rectification is not achievable, these identified disconnectors are included in the scope of replacement with other assets at the site to deliver efficiency benefits where possible.

6.4 NU-LEC/Schneider Sectionaliser

An emerging issue has been identified with the use of NU-LEC/Schneider sectionalisers in the Energex Region, as discussed in Section 3.4.

The NU-LEC/Schneider sectionaliser uses a 26V secondary voltage and operates the open and close function by sourcing power from the voltage transformer (VT) and battery. Analysis of the maintenance undertaken on these assets indicates that the major issues with the sectionaliser were associated with the auxiliary components such as the control system modules, battery systems, and VTs (see Figure 24 below). After analysing the causes of VT failure, it was found that VTs failed primarily due to control system failure and/or corrosion as a result of moisture ingress in the secondary terminal box. As the secondary system control module is located inside the clearance zone, rectification requires a Live Line crew resource. Therefore, the cost of the rectification work is substantial.

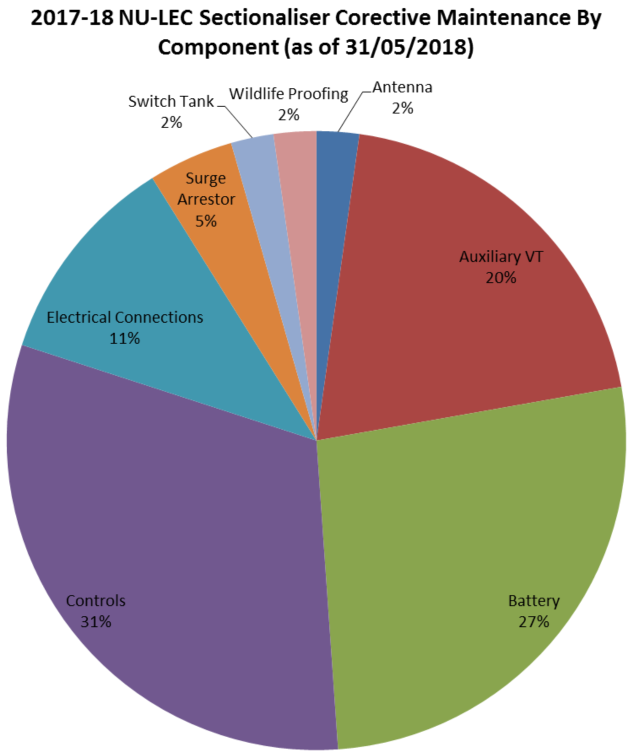


Figure 24: NU-LEC/Schneider sectionaliser corrective maintenance (2017/18) – Energex Region

Currently, the intermediate solutions for preventing NU-LEC sectionaliser failure are:

1) To avoid control system failure, the existing rated fuses are being retrofitted with higher rated fuses
2) To avoid moisture ingress issues, the maintenance crew drill a hole in the secondary terminal box to allow for any water to drain.

Analysis of the control systems and battery systems are covered in the EQL Control System AMP.

Further to the above technical analysis, a detailed review of the costs associated with the maintenance of these assets has identified an inconsistency in allocating work between preventive demand and planned work. This is likely due to the complexity associated with 8the skill types required to address the combination of electrical issues with the primary plant as well as the secondary systems issues associated with the control circuits. This will continue to be a challenge as intelligent assets become more common on the distribution network. It is recommended that work practices be reviewed to address this issue.

6.5 Fault Throw Switch

Fault throw switch has been installed in the Ergon's network, majority of them are in the Southern region. Issues such as faulty auxiliary contact, slow operating mechanism, aged and unreliable have been identified in the field. EQL current position is to replace these fault throw switches as an opportunistic replacement, where there is a project occur in the substation.

6.6 Underground switches

6.6.1 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 Ergon Region, a mechanism replacement program has been completed for 2003 and 2004 Safelink RMUs, replacing the original mechanism with a 'Revision E' 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 E mechanism along with the mechanisms on the other isolating switches and fuse switch in that RMU.

The Energex 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 the majority of the mechanism have been replaced to date. It is still recommended that the extended handle is used for operating the newer version mechanism.

6.6.2 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. The maintenance instructions for these RMUs have been modified where necessary, and additional assessment checks have been added to periodic inspection activities.

6.6.3 Hazemeyer/Magnefix/Holec Polymeric RMUs

EQL and its Legacy Organisations have experienced a series of Hazemeyer RMU failures since 2015. In Energex Region, there were 7 failures during the short period between January 2016 and July 2016. In the Ergon Region, 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 Energex 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.
- Regular maintenance, include clean down of insulation. Replacing leaf springs, cleaning contacts

Similar strategies are being implemented in the Ergon as the number of failures have increased.

One such challenge is considering the policy of introducing a more accurate determination of Partial Discharge results to predict failure of the asset using the Phase Resolved Pattern Preview or on-line monitoring.

6.6.4 Long & Crawford RMU

The Long & Crawford RMU is approaching the end of its useful life. Long and Crawford/GEC/Alstom 11/6/6KV Oil Insulated RMUs are available in a variety of model numbers, including J and GF series

This asset has been the subject of several industry safety advice notices. According to industry sources, fuse contact clips have been found to be cracked or broken at the pivot point, allowing the contact clip and the pivot pin to fall down into the unit. There has not been any significant failure of this unit this nature in EQL.

There are only 14 units remining in Ergon and an operational restriction has been placed to only operate the unit when it is de-energised.

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.

7.1 Overhead Switches

7.1.1 Motorised Isolators

In 2017, the Energex Region identified a number of cubicle-type 33kV motorised isolators experiencing partial discharge which is an early indicator of insulation deterioration and subsequent failure. There are multiple issues associated with the design of these motorised isolators, including:

- Poor ventilation
- Failing actuator arms
- Poor condition of insulators
- Poor condition of cable terminations
- Motorised part of isolator seizing.

During 2012-2017, cable terminations associated with motorised isolators were replaced frequently due to partial discharge. Currently, the Energex region has 14 sites with single switch cubicle-type 33kV motorised isolators, and one site with a double switch cubicle-type 33kV motorised isolator.

7.1.2 Gas Insulated Switch Leaks

In the Ergon Region, there have been a large number of failed or inoperable NGK gas switches due to leakage causing low gas levels. There were 114 NGK gas break switches which failed between 2012 and mid-2016. This includes switches that may never have been operated. The primary cause of gas leaks appears to be from transportation issues caused by the supplier. There is an unknown number of NGK brand switches in service which have the potential to have gas leaks and so present a risk to the continued delivery of customer service levels.

While the main gas leak issue has been identified in Ergon , Energex has experienced similar issues to a lesser extent. It is possible that the population in the Energex Region could also become an issue in time and should also be considered in the development of any programs.

The NGK gas break switch population and that this strategy consider the gas insulated switch populations in all regions. The approximate population of NGK Gas switches are as follows: Ergon – 1100 and Energex – 6100 switches.

7.1.3 Isolators without Flicker Blade

It was identified in the recent investigation where there are numbers of isolator in the Ergon network region without flicker blade or arc horn. A management decision has been made applicable to both Energex and Ergon networks to upgrade these isolators with flicker blade or arc horn to extinguish potential arcing during switching. The change will improve the switching efficiency and the safety of the operators when perform the switching operation.

Approximately 50 isolators have been identified in the Ergon Region and Equipment Operation Restrictions (EOR) raised against those assets. The replacement of these isolators will be conducted under the appropriate Network Asset Management Plan.

7.2 Underground Switches

7.2.1 F&G/Ormazabal RMUs

F&G RMUs majorly installed in FNQ, however they are also installed in CA and SW. 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. Investigation identified the root cause of the failure modes in F&G RMUs being a component deficiency.

EQL is working with the manufacture to manage the risk of the asset failing and safety of the operator in the event of a bushing failure during switching.

Modifications to the cable compartment have been proposed by installing a shield to prevent direct venting of the arc gases onto the operator standing in front of the unit. This shield will minimise the harm caused by the venting arc gases.

7.2.2 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.

7.2.3 Oil Ring Main Unit Intrusive Maintenance

An error was found while reviewing the Ergon Job Cards for RMU maintenance. The Intrusive Maintenance (IM) of Oil RMUs contained only In-Service Condition Assessment activities. This incorrect mapping is believed to have occurred in 2021 when the job cards were transferred from the Network Drive into Sharepoint.

Discussion with the Field Crews from different regions in Ergon also revealed that there was no consistency in the application of the Intrusive Maintenance Job Cards for Oil RMUs. This resulted in the review of all Oil RMU Intrusive Maintenance work orders from 2021 and in some areas back to 2012 to ensure that the requirement for the oil to be replaced was performed. 153 units were identified and Equipment Operating Restriction has been place for de-energised switching only until the oil is replaced in accordance with the maintenance requirement.

8 Improvement and Innovation

The following sections outline any improvements or innovations to asset management strategies relevant to this asset class, being investigated by EQL.

8.1 Prevalence of Intelligent Assets

As technology advancements continue, the integration of intelligent control systems, sensors and other technology with traditional power systems network assets will become more prevalent. This presents both a significant opportunity and a challenge to traditional network businesses. With advancements in technology comes the potential for more efficient operation and maintenance of the electricity network in order to meet asset management objectives. Similarly, the complexity associated with the lifecycle of the assets increases as electronic components which provide the smart functions have a significantly shorter expected life in comparison to the primary asset. Technology advancements will also likely result in the intelligent systems used in these assets becoming obsolete in a short space of time. The issues outlined in earlier section of this AMP are an indicator of challenges the organisation will continue to face into the future.

8.2 Health Index and Risk Monetisation

To support / justify the increased replacement volumes and resolve the economic limitation of Ergon Energy, EQL has:

- Developed a Weibull distribution-based analysis to establish optimum replacement volumes.
- Committed to adopt an economic, customer value-based approach when it comes to ensuring the safety and reliability of the network. To substantiate the advantages of this approach for the community and businesses over the modelling period, we have employed Net Present Value (NPV) modelling. This commitment is in line with their efforts to minimize the impact on customer prices.
    - A cost benefit analysis has been conducted to confirm that the Switch replacements are prudent capital investments.

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

Switches are primarily mechanical in nature and are therefore subjected to wear and tear whilst performing their intended functions. These assets are monitored primarily through inspection and replaced based on asset condition and risk.

EQL undertakes asset lifecycle management of switches through condition and performance monitoring that includes:

- Periodic visual inspection of physical condition and immediate environment
- Routine maintenance activities to ensure correct functionality
- Identified defects are resolved through the Corrective Maintenance Program

- Failed assets are replaced under the Failed in Service Program
- Targeted replacement based on condition and risk.

9.2 Supporting Data Requirements

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 Ergon Energy and Energex. Historical data capture practices restrict the ability to analyse the large volumes of data associated with this asset class without substantial manual effort and offer 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.

Incremental changes to the existing system has been restricted due to the development and impending release of the new digital platform and mobility solution. A harmonised process for data collection will be incorporated the new digital platform.

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.

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.

9.4 Operation and Maintenance

Operation and maintenance include 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 and will begin with the introduction of the new Enterprise Asset Management System, in will be implemented to ensure compliance with maintenance tolerances during the 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.

9.4.1 Preventive maintenance

Preventive maintenance is carried out at predetermined intervals corresponding to prescribed criteria and is intended to reduce the probability of failure or the performance degradation of an asset.

Preventive maintenance strategies aim to ensure that failures occurring between routine maintenance activities are prevented or eliminated.

The preventive maintenance plan for switches includes maintenance and condition monitoring activities such as:

- Intrusive maintenance – comprised of time-based maintenance activities, such as detailed inspection, functional checks, and routine restoration activities, which are intended to restore items to an acceptable condition or to ensure items remain in an adequate condition until the next routine maintenance. In the case of oil and polymeric RMU's, intrusive maintenance requires access to internal components of the RMU the activities such as cleaning, maintenance of internal components, and oil quality check and replacement must be performed
- Non-intrusive Maintenance – applies only to SF6 RMUs, which is a 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
- In-Service Condition Assessments (ISCA) – a periodic check on the condition of an asset to ensure it remains fit for purpose.
  For Overhead Switches
    - Substation switches: aligned with the routine substation inspection
    - Distribution switches: aligned with pole inspection cycle.

  For RMUs
    - 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 pad mount substation also complement the routine visual inspection.

- Out of service condition assessment (OSCA) – applies to Overhead Switches and involves functional checks and lubrication of the operating handle mechanism.

9.4.2 Corrective maintenance

Overhead Switches

Corrective maintenance for overhead switches is generated from preventative maintenance programs, ad-hoc inspections, and public reports. Non-urgent actions to address asset issues identified through customer notification or ad-hoc inspections may be rectified at the time of inspection or scheduled for a later time through corrective maintenance.

For corrective maintenance, assets covered under the scope of this AMP are repaired if cost effective, or replaced with like-for-like to the current standard.

Ring Main Units

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.

9.4.3 Spares

EQL Limited does not currently have a documented spares strategy for high volume overhead switches. A minimum warehouse stock level of this asset is maintained based on historic usage and known future requirements.

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 refurbishment of overhead switches is quite rare and occurs only when it is cost effective to do so. Minor refurbishment activities for switches include:

- Replacement of cracked insulators

- Replacement or realignment of the operating handle
- Realignment of the switching contacts (minor issues only)
- Replacement of ancillary components.

RMUs have a refurbishment program to replace operating mechanisms in ABB Safelink RMUs in Energex to address a design issue. In Ergon, 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.

A program is being developed for the F & G/Ormazabal RMU blast shield and on approval this program will be implement in the Ergon Region.

9.5.2 Replacement

Replacement of overhead switches is predominately driven from inspection programs based on defects identified in accordance with the Defect Classification Manuals. Replacement is typically like for like in accordance with current standards and contract items. Other replacement is driven by defects identified through operation of switches during planned switching events and network reconfiguration.

Targeted programs of replacement are developed where it is prudent based on asset condition and risk. The program of replacement is managed on a risk basis within the portfolio of capital expenditure required for EQL. Table 4 provides details on the replacement programs in place for the current issues discussed in Section 6.

Driver	Asset
Asset condition and risk	All vertically operated isolators within substations.
	Gooseneck/Parrot beak Duo/Duro Roll Braid type
Targeted condition based	R-series ABS
	33kV motorised isolators
Asset condition and risk	NGK Gas switches

Table 4: EQL – Current replacement programs

For RMU's, 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 switches comply with all requirements for the safe disposal of hazardous materials such as sulphur hexafluoride (SF6). 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
- Minimise, reuse or recycle waste as the preferred option over disposal to landfill.

EQL has the statutory obligation to comply with the *National Greenhouse Energy and Reporting Act 2007 (Cth)* in relation to the recording and handling or SF6. For more information refer to Appendix 1.

When SF6 gas cannot for any reason be reclaimed or re-used, the gas is securely contained and transported to a supplier or processing facility for either recycling/refinement or destruction. If the gas is to be destroyed, this shall be done by an accredited provider in a manner that minimises emissions to the atmosphere and safely neutralises any by-products.

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 in network risk.

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 Asset Management Plan.

Document Number	Title	Type
2934927	Standard for Air Break Switches, Isolators, Earth Switches and Fault Throw Switches	Standard
2945234	Standard for Overhead Fuses, Links and Vacuum / SF6 Load Break Switches	Standard
2929480	Standard for Oil Filled ACRs and Sectionalisers	Standard
2934562	Standard for SF6 - Vacuum ACRs and Sectionalisers	Standard
2938160	Standard for LV Switchgear and Fusegear	Standard
2915481	OTA Inspection and Maintenance	Instruction
2598766	Standard for SF6 Ring Main Unit	Standard
2949735	Standard for Oil Ring Main Units	Standard
2947226	Standard for Polymeric Ring Main Units	Standard
2948464	Network Asset Defect and Condition Prioritisation	Standard
12357714	Network Schedule of Maintenance Activity Frequency -	Standard
2928929	Maintenance Acceptance Criteria	Standard
2945521	Standard for Managing Substation Asset Defects	Standard
945509	Standard for Managing Line Asset Defects and Failures	Standard
14691901	Substation Defect Classification Manual SDCM - MSSS (Rev. OCT 2023)	Manual
	Lines Defect Classification Manual	Manual
2875361	HV Switches - Field Data Collection	
2949681	Standard for Handling of Sulphur Hexafluoride (SF6)	Standard

Appendix 2. Definitions

Term	Definition
Condition Based Risk Management	A formal methodology used to define current condition of assets in terms of health indices and to model future condition of assets, network performance, and risk based on different maintenance, asset refurbishment, or asset replacement strategies.
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.
Current transformer	Current transformers are used to provide/transform currents suitable for metering and protection circuits where current measurement is required.
Distribution	LV and up to 22kV (and some 33kV) networks, 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.
Instrument transformers	Refers to Current Transformers (CTs), Voltage Transformers (VTs) and Metering Units (MUs).
Metering Units	A unit that includes a combination of both Current Transformers and Voltage Transformers for the purposes of statistical or revenue metering.
PCB	Polychlorinated Biphenyls are synthetic chemicals manufactured from 1929 to 1977 and was banned for use in 1979 in transformers, voltage regulators and switches.
Preventative maintenance	This type of maintenance involves routine planned/scheduled work, including systematic inspections, detection and correction of incipient failures, testing of the condition and routine parts replacement designed to keep the asset in an ongoing continued serviceable condition, capable of delivering its intended service.
Sub transmission	33kV and 66kV networks.
Transmission	Above 66kV networks.
Voltage Transformers	Voltage or potential transformers are used to provide/transform voltages suitable for metering and protection circuits where voltage measurement is required.

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
SHI	Security and Hazard Inspection

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