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:

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

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 over 129,051 switches, with approximately 37,531 in the Northern and Southern Regions and 91,520 in the South East Region.

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 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. Analysis of defect and failure data and engagement with switch manufacturers and relevant stakeholders will assist with future cost-effective lifecycle management for EQL assets.

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 Regions (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 practice.

1.1 Purpose

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.

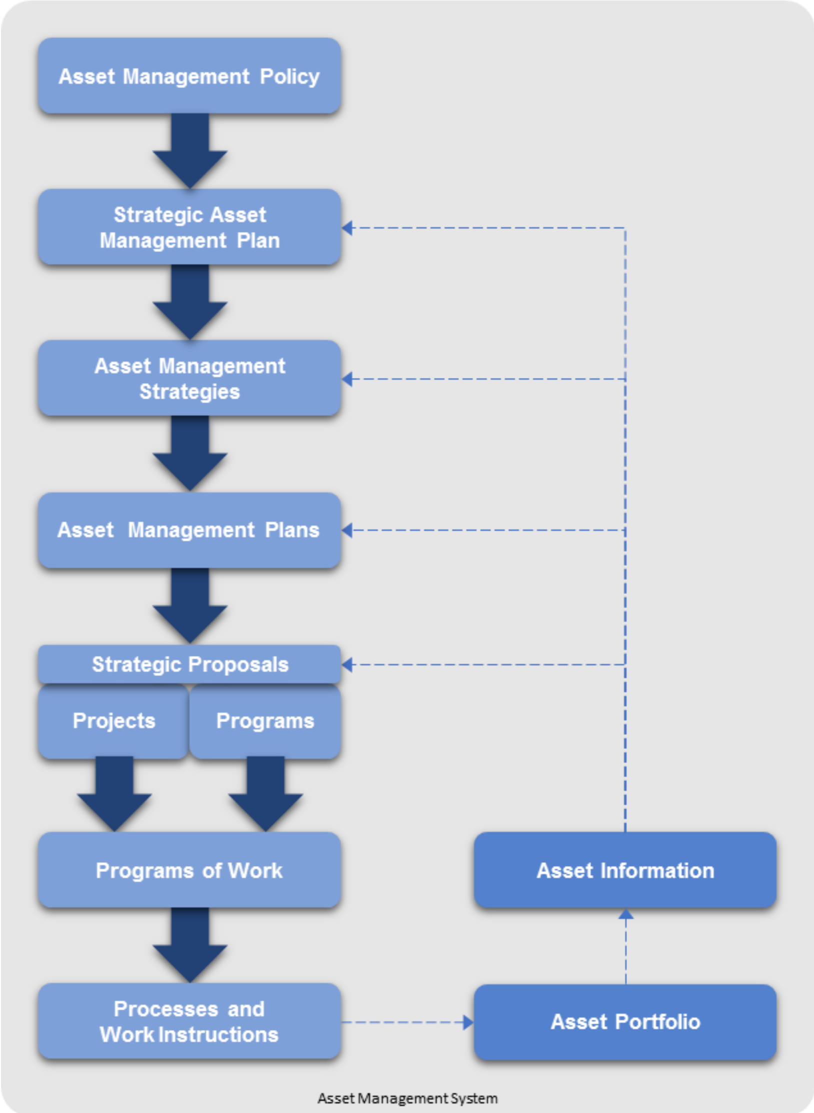


Figure 1: EQL Asset Management System

1.2 Scope

This plan covers the following assets at voltage level 11kV and above:

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

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 $1.8 billion. Figure 2 provides an indication of the relative financial value of EQL switches compared to other asset classes.

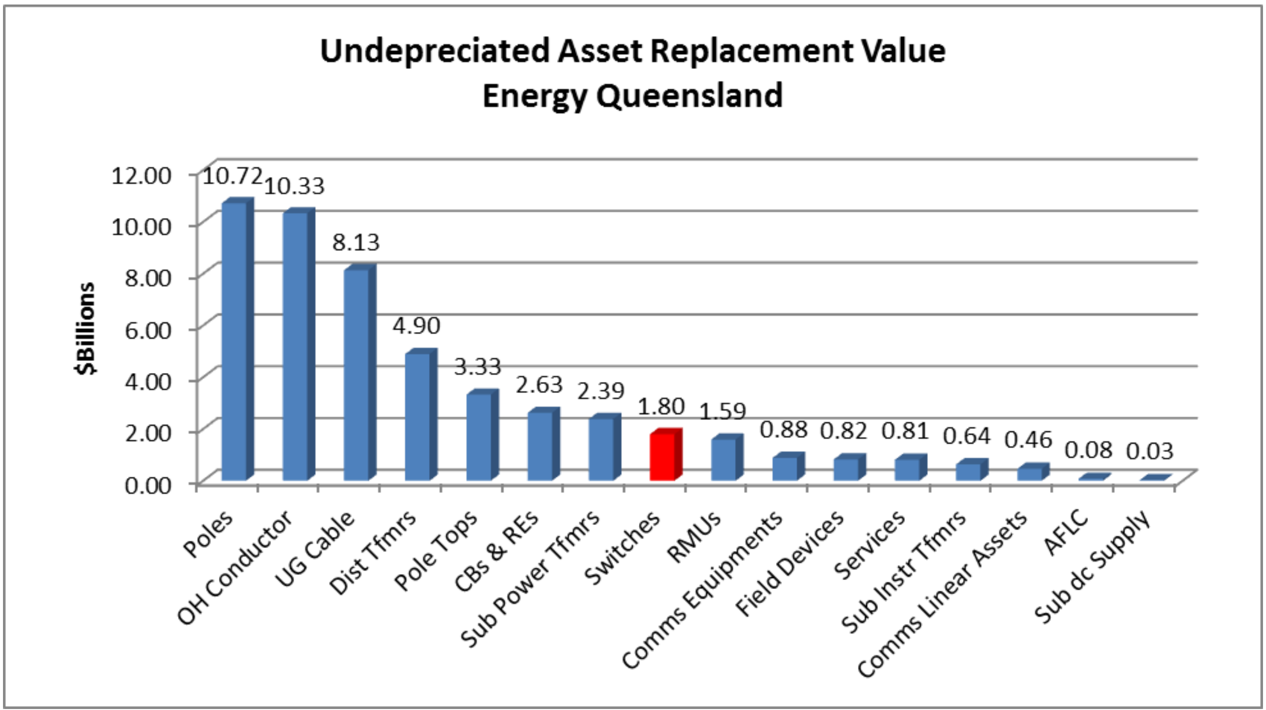


Figure 2: EQL – Total Current Asset Replacement Value

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.

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.
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.

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

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

2.1 Asset Description

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

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).

2.2 Asset Quantity and Physical Distribution

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

Asset Type	Northern & Southern	South East	Total
Isolators and Air Break Switches	13,375	20,187*	33,562
Disconnector Links	21,495	67,477	88,972
Earth Switches	1,096	2,601	3,697

Asset Type	Northern & Southern	South East	Total
Sectionalisers	1,565	179	1,744
Load Transfer Switch	unknown*	1,076*	1,076
Total	37,531	91,520	129,051

Table 3: Asset Quantity

*Individual switch type breakdown is not available due to data quality issues. Refer to section 9.2.1 for further information.

2.3 Asset Age Distribution

Figure 3 and Figure 4 illustrate the overall age profile for EQL's switch asset population in both the Northern and Southern Regions and the South East Region.

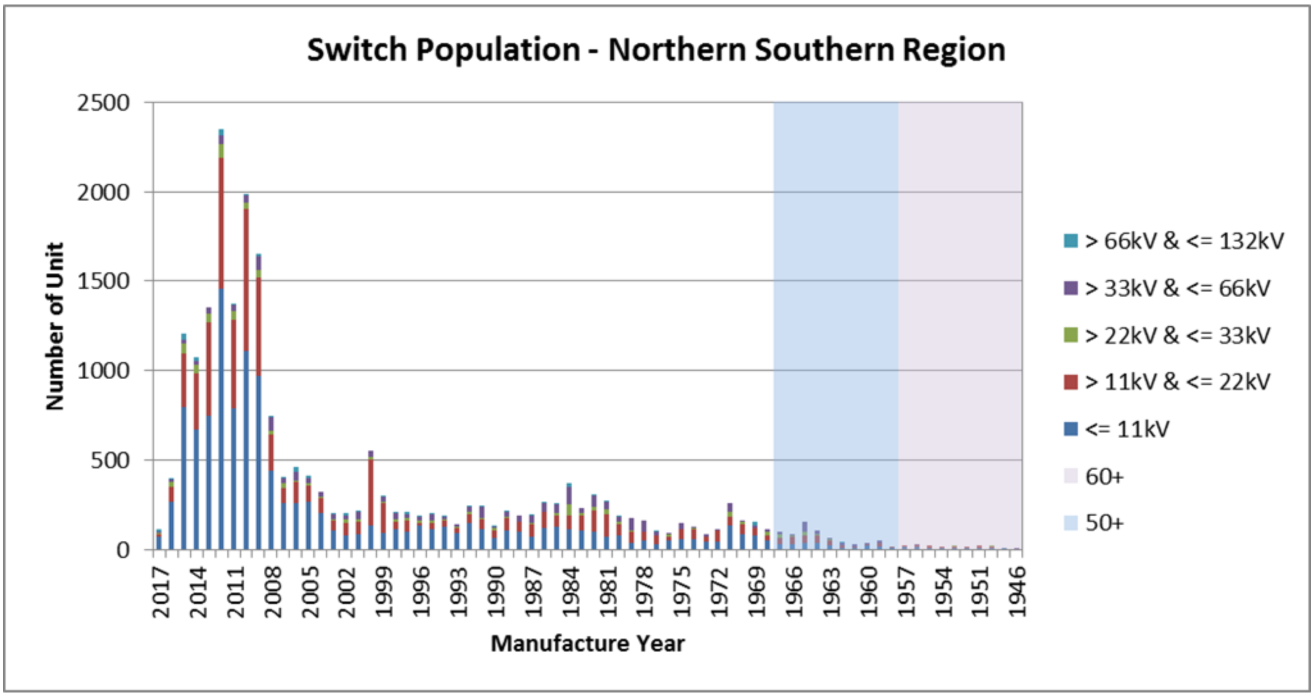


Figure 3: Overall switch population age profile – Northern and Southern Regions

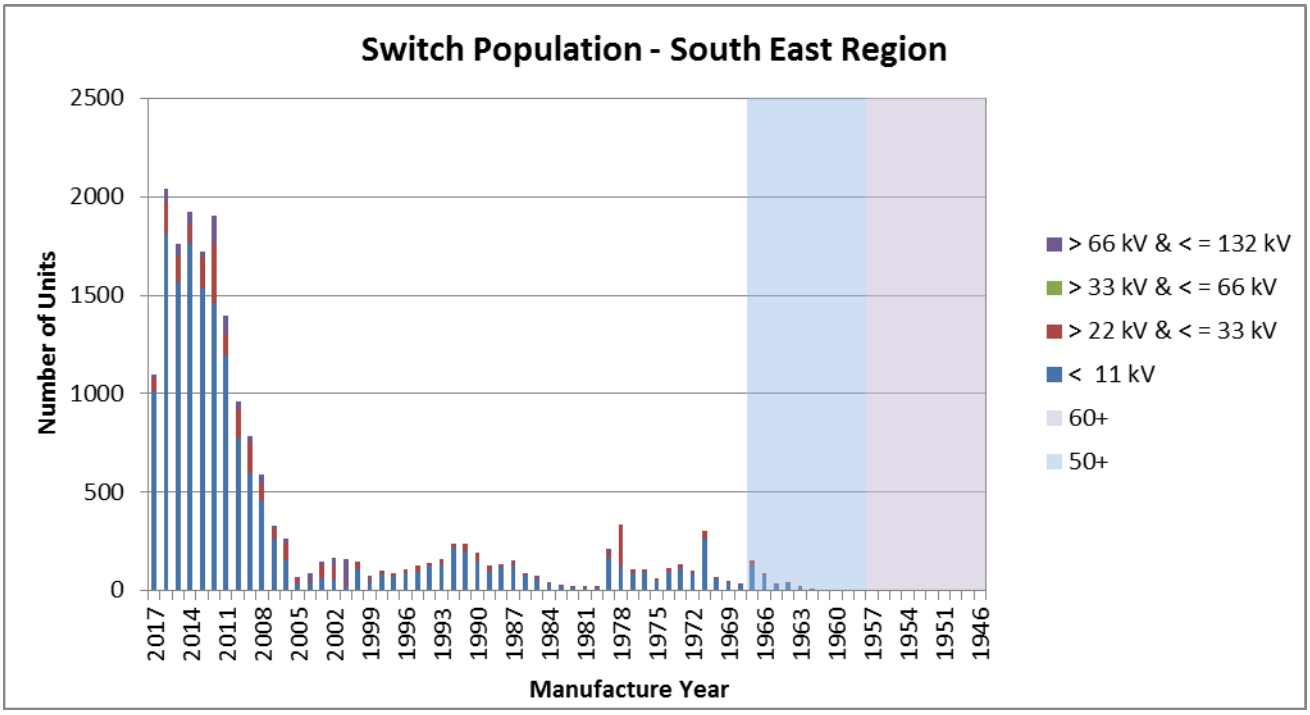


Figure 4: Overall switch population age profile – South East Region

2.4 Population Trends

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 South East Region still has vertical operated gooseneck, braid, and duo roll type substation isolators and distribution ABSs installed on the network up to 33kV. The Northern and Southern 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 Northern and Southern Regions started using gas break switches to gain more remote access in 2008.

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.

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.

DEEs are generally reviewed for severity on an individual basis, with response and investigation driven by severity of 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

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 Northern and Southern 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 South East Region, in-service failures for distribution switches are identified via manually analysing the network outage reports and allocating them to the appropriate asset class. For substation switches, each asset failure event is individually investigated and registered by the Investigation and Response department.

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

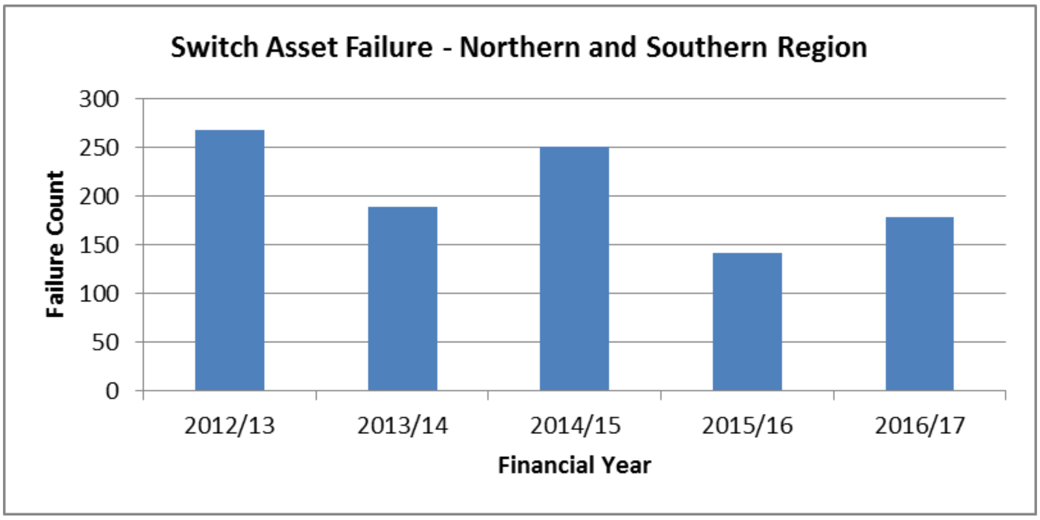


Figure 5: RIN Asset Failure – Northern & Southern Regions

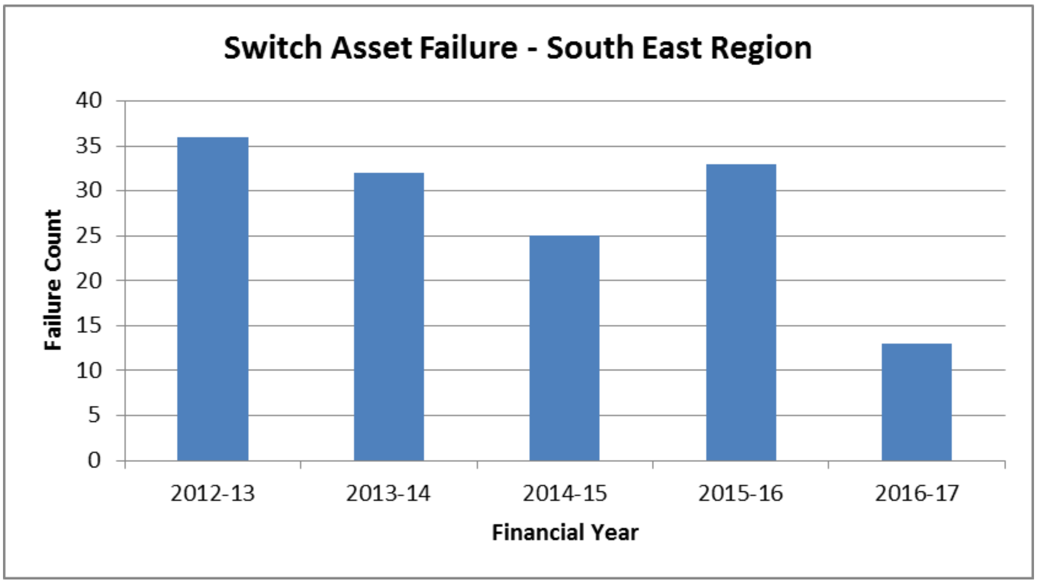
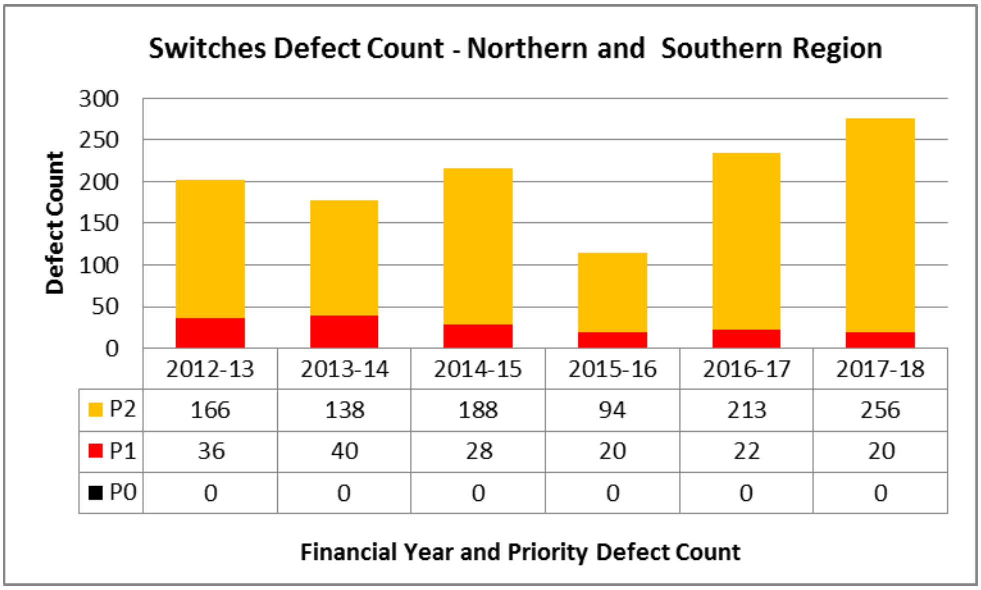


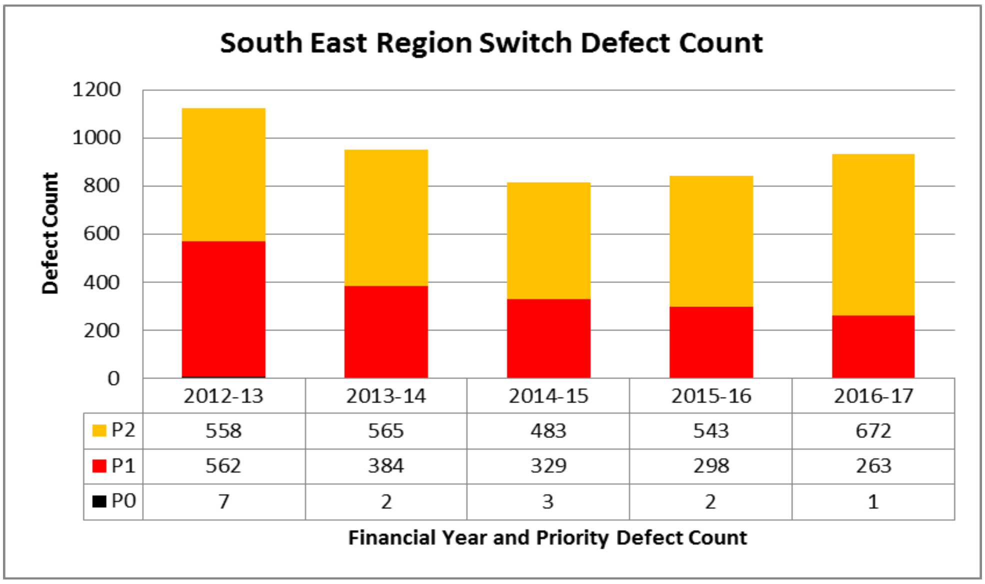
Figure 6: RIN Asset Failure – South East Region

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).



	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18
P2	166	138	188	94	213	256
P1	36	40	28	20	22	20
P0	0	0	0	0	0	0

Figure 7: Switch Defect Numbers – Northern & Southern Regions



	2012-13	2013-14	2014-15	2015-16	2016-17
P2	558	565	483	543	672
P1	562	384	329	298	263
P0	7	2	3	2	1

Figure 8: Switch Defect Numbers – South East 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 South East 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 Northern and Southern Regions by type and by cause. The majority of the defects were found to be caused by deterioration and damage associated with normal wear as well as corrosion.

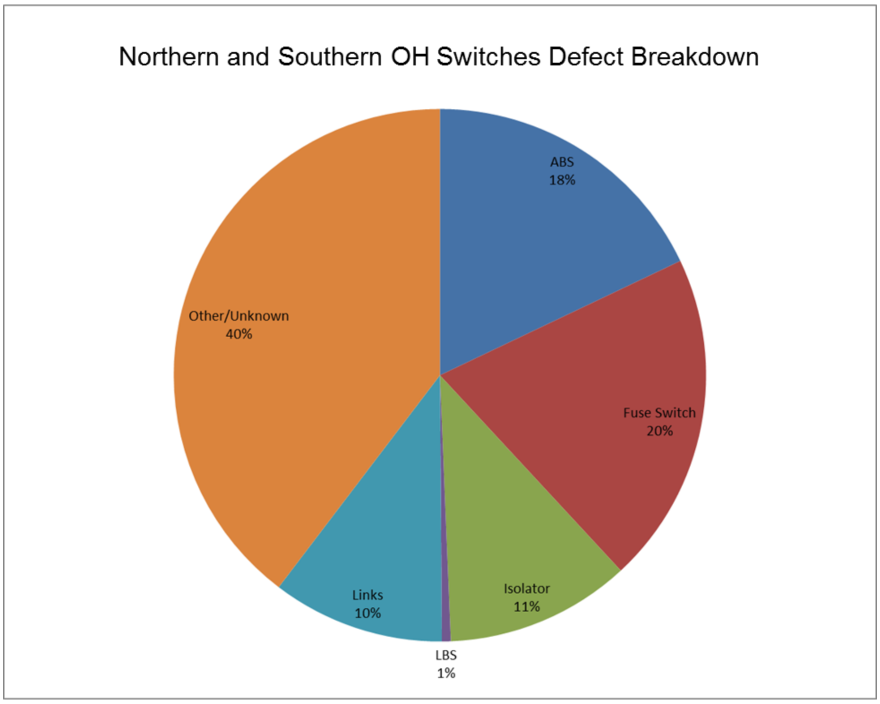


Figure 9: Switch Defects – Northern & Southern Regions

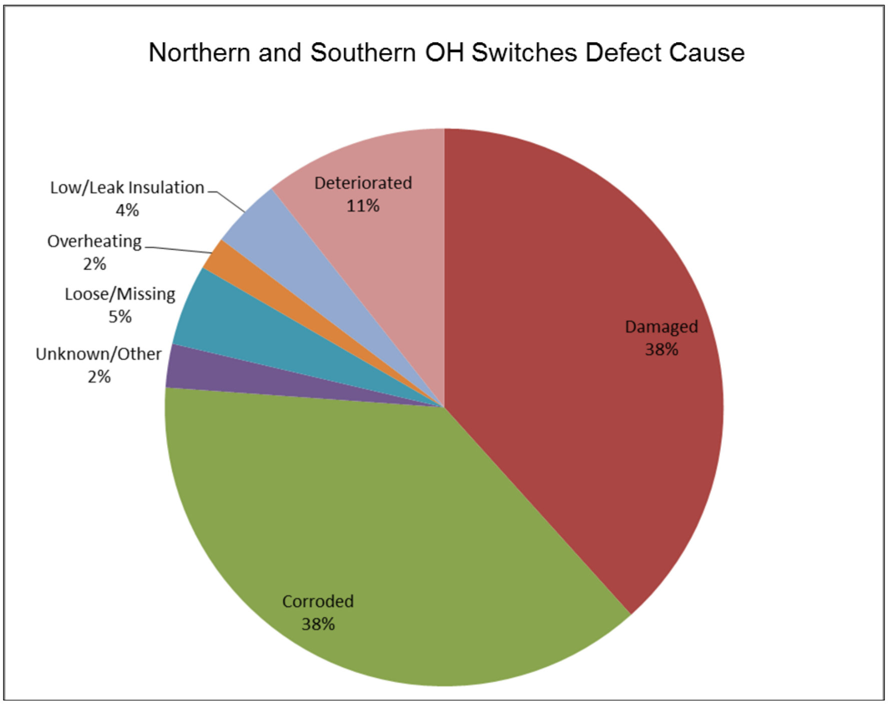


Figure 10: Switch Defect by Cause – Northern & Southern Regions

Figure 11 and Figure 12 show the switch defect counts and costs by manufacturer. As Taplin and AK Power are 13% and 6% of the isolator population respectively, the defect counts towards the two major manufacturers are reasonable.

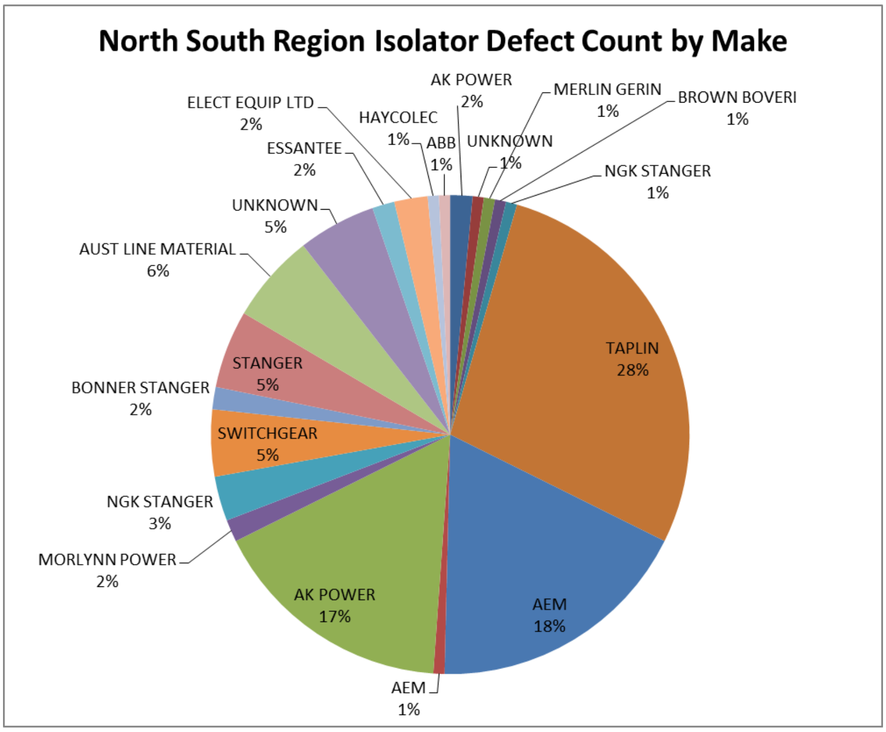


Figure 11: Defect Count by Make – Northern & Southern Regions

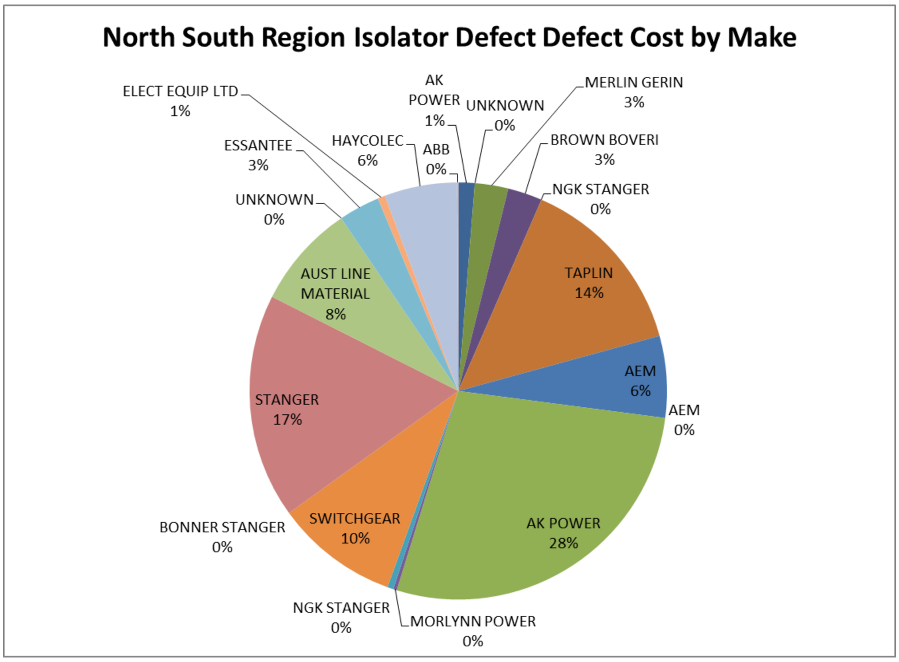


Figure 12: Defect Cost by Make – Northern & Southern Regions

Figure 13 and Figure 14 show the 2017/18 corrective maintenance associated with switches by component and cause of defect.

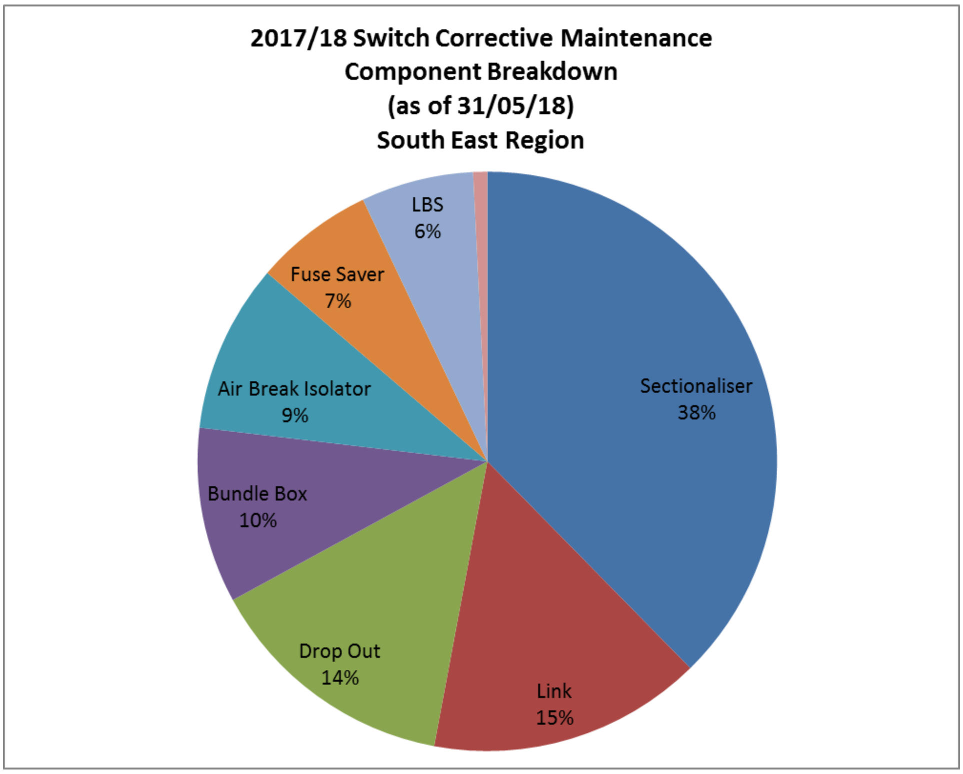


Figure 13: Corrective Maintenance Component Breakdown – South East Region

Figure 13 shows that 38% of the corrective maintenance tasks in the switches class were sectionaliser issues.

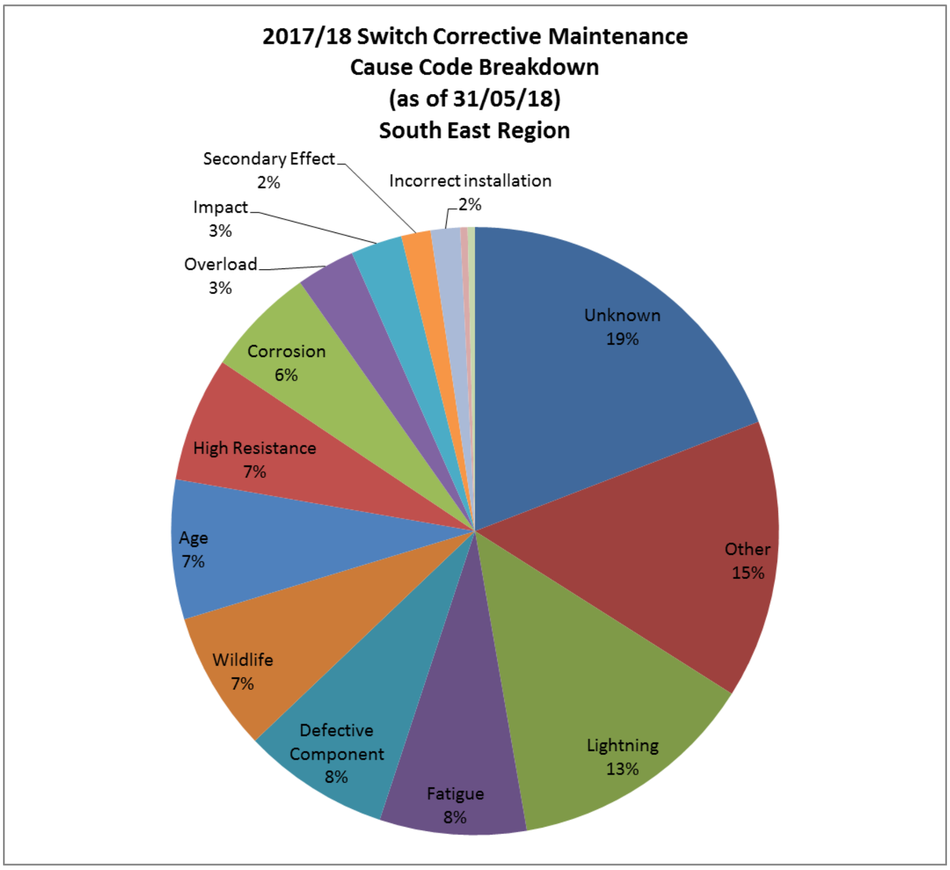


Figure 14: Corrective Maintenance Cause Code Breakdown – South East Region

Figure 14 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 South East becomes more mature.

Figure 15 shows the corrective maintenance in the South East Region by Manufacturer.

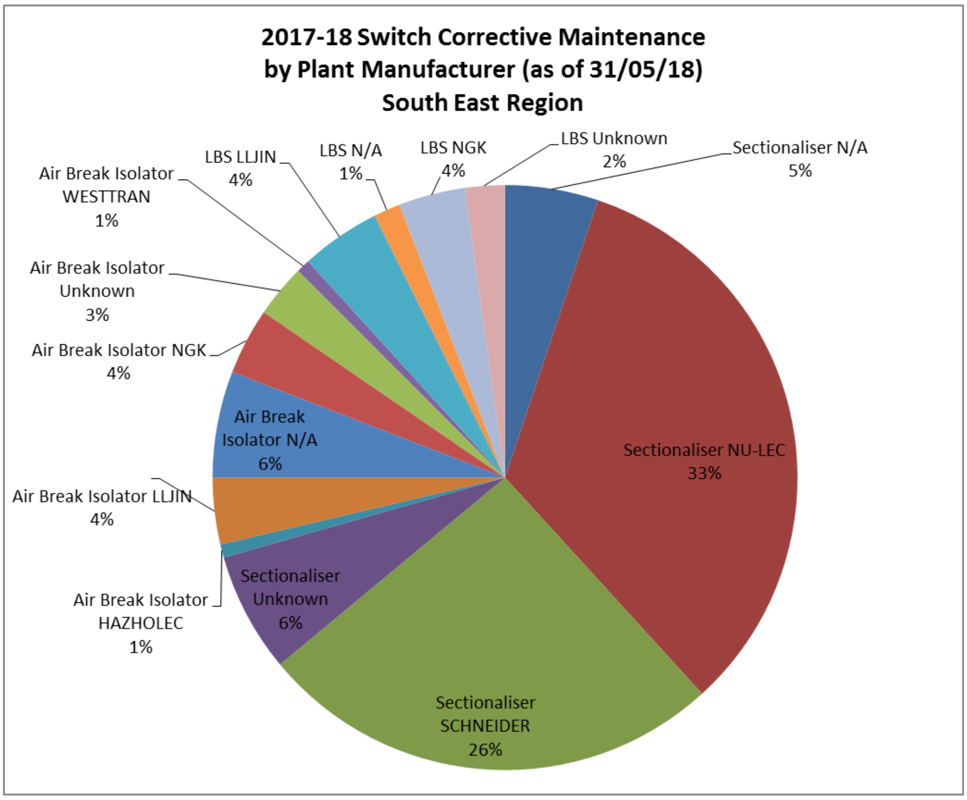


Figure 15: Corrective Maintenance by Plant Manufacturer – South East Region

Figure 15 shows that sectionaliser issues dominate switch corrective maintenance in South East Region with the Nu-Lec and Schneider types which are the predominate populations showing the highest contribution. 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.

4 Asset Related Corporate Risk

As detailed in Section 3.2, 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 16 illustrates a threat-barrier diagram for switches 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, 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. 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.

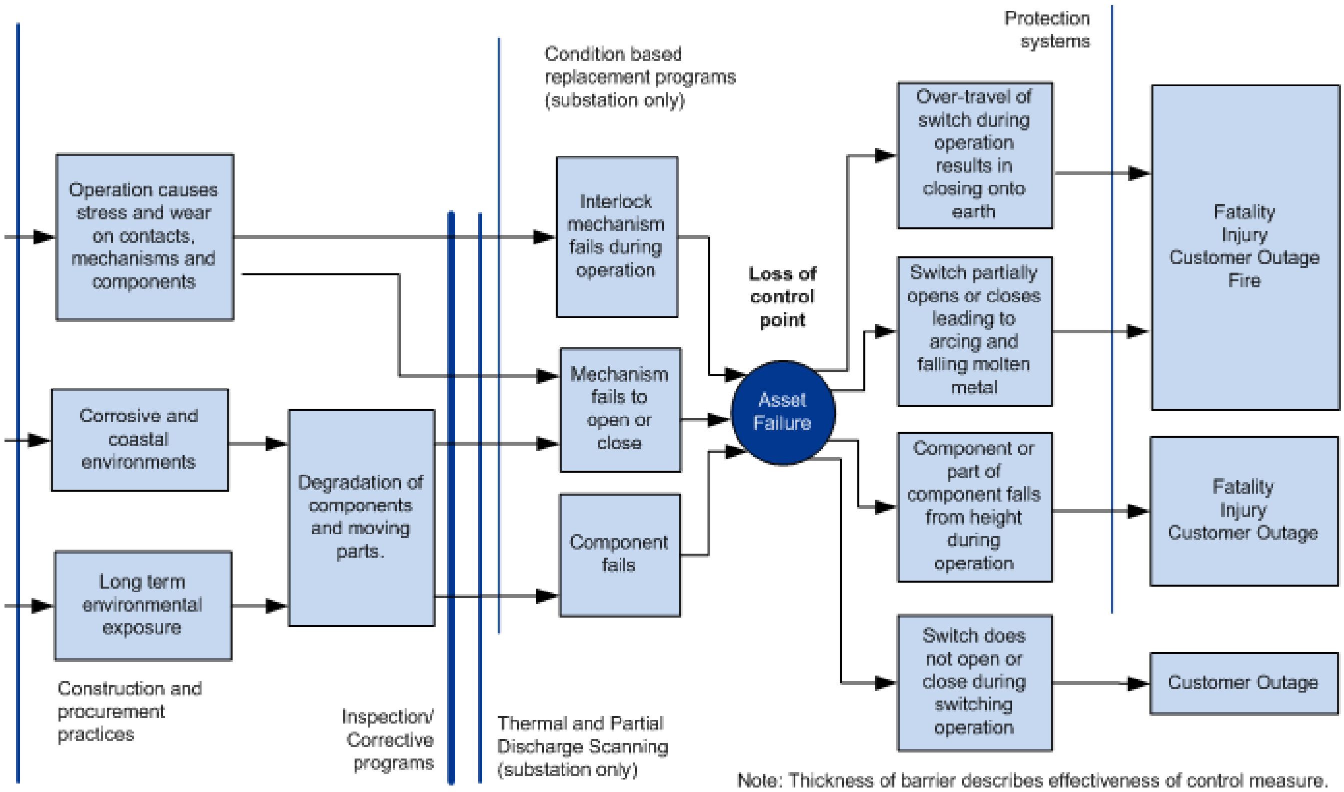


Figure 16: Threat-Barrier Diagram for Switches

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 monitors and controls the release of SF6 gas to the atmosphere by implementing alarm systems throughout switchgear control systems. Corrective works will be raised to rectify 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 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.

The Northern and Southern Regions have replaced all three types of ABB switches, whereas the South East region has only replaced the U and S series so far.

A planned replacement is currently in progress for the 32 problematic R-series switches in the South East region in the next determination period, 2020/25.

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.

Action 6.2-1: Monitor the programs of identification and replacement of problematic and poor condition vertically operated isolators to ensure safety risks associated with this asset class is managed.

6.2.1 Vertically Operated Isolators – South East Region

In the South East 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 South East 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 South East Region with a modern standard equivalent.

6.2.2 Vertically Operated Isolators – Northern and Southern Regions

The Northern and Southern Regions have identified 27 problematic vertically operating isolators in zone substations to date. The asset register for the Northern and Southern Region does not record if isolators are vertically or horizontally operated, making it difficult to source and analyse the vertically operated isolators.

Currently, the Northern and Southern Regions are continuing to identify the problematic isolators during substation condition assessments. 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 South East 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 as they are identified. Asset Lifecycle Management is exploring the possibility of rectifying the faulty switches through a dedicated program.

Action 6.3-1: Investigate the rectification of the issues associated with the AEM Type 33kV Disconnector Switches as a targeted program.

6.4 NU-LEC/Schneider Sectionaliser

An emerging issue has been identified with the use of NU-LEC/Schneider sectionalisers in the South East 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 17 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.

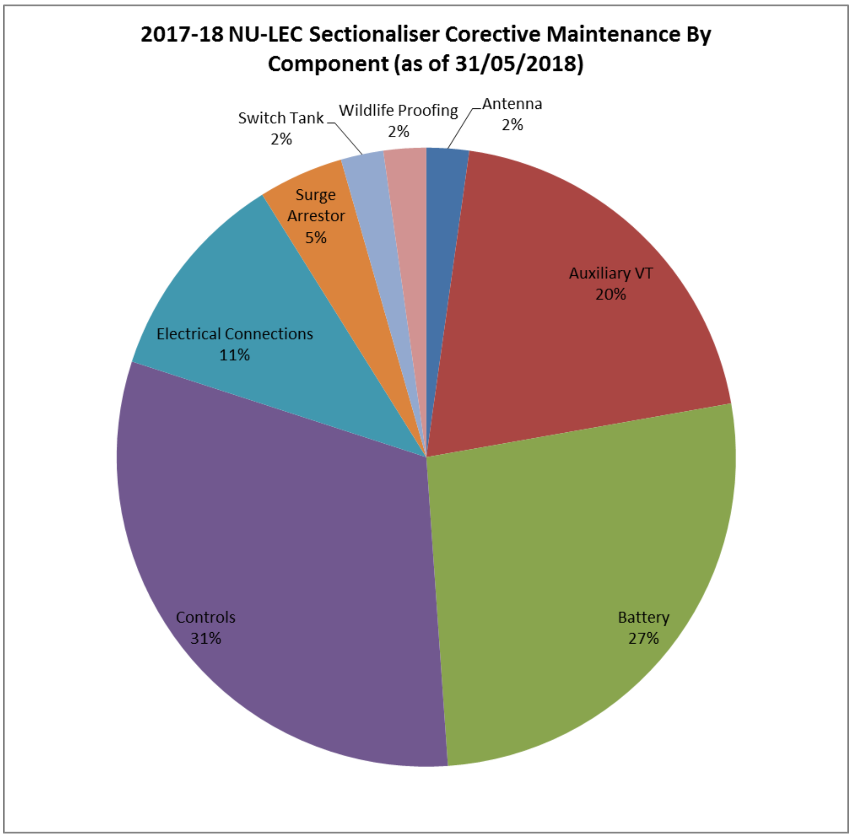


Figure 17: NU-LEC/Schneider sectionaliser corrective maintenance (2017/18) – South East Region

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 the 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.

Action 6.4-1: Investigate the reported moisture ingress and control system/voltage transformer failures in the NU-LEC/Schneider sectionalisers with a view to establishing a prudent and efficient plan to rectify the issues.

Action 6.4-2: Review the work practices associated with the maintenance of assets where multiple skill types; particularly primary and secondary systems skills, are required to correct asset issues to ensure that costing is captured correctly to support asset management processes.

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 Motorised Isolators

In 2017, the South East 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 South East region has 14 sites with single switch cubicle-type 33kV motorised isolators, and one site with a double switch cubicle-type 33kV motorised isolator.

Action 7.1-1: Monitor the condition of the motorised isolators experiencing partial discharge to determine whether a replacement program is required.

7.2 Gas Insulated Switch Leaks

In the Northern and Southern Regions, 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 the Northern and Southern Regions, the South East Region has experienced similar issues to a lesser extent. It is possible that the population in the South East Region could also become an issue in time and should also be considered in the development of any programs.

It is recommended that a strategy is developed to manage the gas leak issue identified in the NGK gas break population and that this strategy consider the gas insulated switch populations in all regions.

Action 7.2-1: Determine if a replacement strategy is required to manage the population of NGK gas break switches due to the frequency of failures attributed to gas leak / low gas levels.

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.

Action 8.1-1: Continue to monitor the advancements in technology with a view to providing more efficient and effective asset lifecycle management and maturing processes associated with intelligent assets.

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 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 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.

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.

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

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 1for 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 risks.

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-Service Condition Assessments (ISCA) – a periodic check on the condition of an asset to ensure it remains fit for purpose.
    - Substation switches: aligned with the routine substation inspection
    - Distribution switches: aligned with pole inspection cycle.
- Out of service condition assessment (OSCA) – involves functional checks and lubrication of the operating handle mechanism.

9.4.2 Corrective maintenance

Corrective maintenance 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.

9.4.3 Spares

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

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

The refurbishment of 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.

9.5.2 Replacement

Replacement of 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	Program	
		Northern & Southern Regions	South East Region
Asset condition and risk	All vertically operated isolators within substations.	□	□
	Gooseneck/Parrot beak Duo/Duro Roll Braid type	Replace as per condition assessment	□
Targeted condition based	R-series ABS		□
	33kV motorised isolators		□
Asset condition and risk	NGK Gas switches	Monitoring for further action	

Table 4: EQL – Current replacement programs

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.

When SF6 gas cannot for any reason be reclaimed or re-used, the gas shall be securely contained and transported to a supplier for either reprocessing 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. For more information refer to Appendix 1.

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.

11 Summary of Actions

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

Action 6.2-1: Monitor the programs of identification and replacement of problematic and poor condition vertically operated isolators to ensure safety risks associated with this asset class is managed.

Action 6.3-1: Investigate the rectification of the issues associated with the AEM Type 33kV Disconnector Switches as a targeted program.

Action 6.4-1: Investigate the reported moisture ingress and control system/voltage transformer failures in the NU-LEC/Schneider sectionalisers with a view to establishing a prudent and efficient plan to rectify the issues.

Action 6.4-2: Review the work practices associated with the maintenance of assets where multiple skill types; particularly primary and secondary systems skills, are required to correct asset issues to ensure that costing is captured correctly to support asset management processes.

Action 7.1-1: Monitor the condition of the motorised isolators experiencing partial discharge to determine whether a replacement program is required.

Action 7.2-1: Determine if a replacement strategy is required to manage the population of NGK gas break switches due to the frequency of failures attributed to gas leak / low gas levels.

Action 8.1-1: Continue to monitor the advancements in technology with a view to providing more efficient and effective asset lifecycle management and maturing processes associated with intelligent assets.

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

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

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.

Legacy organisation	Document Number	Title	Type
Energex	STD0 1133	Maintenance Standard for ABS-IS-ES-FTS	Policy Document
Ergon	STNW0717	Standard for Preventive Maintenance Programs for 2017/18	Policy Document
Energex	BMS04161	Maintenance Standard for OH Fuses – Links and Vacuum-SF6 LBS	Policy Document
Ergon	STNW1155		
Energex	CD002	Standard for Handling of Sulphur Hexafluoride (SF6).	
Energex		Substation Defect Classification Manual	Manual
Ergon			Manual
Energex		Lines Defect Classification Manual	Manual
Ergon			Manual

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