Asset Management Plan
Audio Frequency Load Control
2020-25

January 2019

Part of the Energy Queensland Group

Executive Summary

Audio frequency load control (AFLC) units are utilised by Energy Queensland Limited (EQL) in an attempt to mitigate peak loads by temporarily constraining supply for such services as air conditioning, hot water systems, pumping stations, street lights etc. AFLC's are comprised of several components such as local controllers, motor generator or static frequency units (SFU) and coupling cells.

EQL has 296 AFLC units within its network, with the bulk of 232 units localised within the South East Region and remaining 64 items situated throughout Northern and Southern Regions.

EQL's South East Region has previously undertaken efforts in replacing AFLC units that incorporated older styled and obsolete motor generators with SFUs. There is, however, a small number of these styled units within its network and it is recommended that these continue to be replaced.

Another challenge that EQL faces with AFLC's is due to the characteristics of their individual components. Each component has a unique and differing lifespan, and thus over the course of its operational life different AFLC components are expected to fail in operation at different times. Due to this fact, it would be prudent to ensure flexibility and compatibility in components, as well as an appropriate strategic spares depository, is prepared for an immediate need.

More sophisticated AFLC systems are able to be remotely regulated by a control centre, dependent upon the technological capability and functionality of local controllers and SFUs.

Document Tracking Details

Network and Non-Network Document Hierarchy Reference Number	Regulatory Proposal Chapter Reference	Document	File Name
NET AMP – 001	7.027	Asset Management Plan - AFLC	EGX ERG 7.027 Asset Management Plan - AFLC JAN19 PUBLIC

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1 Introduction

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

- South East Region (Legacy organisation: Energex Limited); and
- North and South Regions (Legacy organisation: Ergon Energy Corporation Limited).

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

This document addresses AMP of Audio Frequency Load Control (AFLC) systems for EQL. EQL's strategy towards the management of AFLCs is to undertake a reactive response and replace upon operational failure.

1.1 Purpose

The purpose of this document is to demonstrate the responsible and sustainable management of AFLCs 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 risk associated with operating the assets over their lifespan.
5. Optimise the value EQL derives from the 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 (Qld) (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.

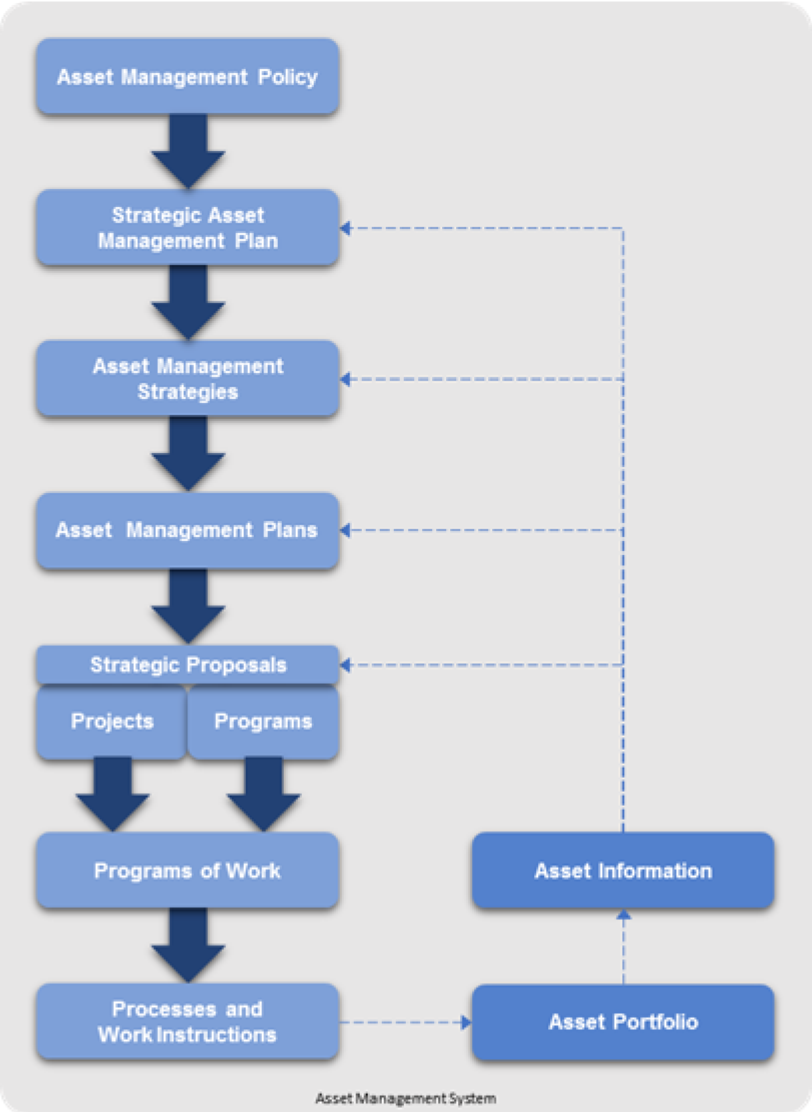

Figure 1: EQL Asset Management System

1.2 Scope

This Asset Management Plan (AMP) will focus upon the AFLC asset class and their associated asset lifecycle maintenance program(s) for the period 2020 to 2025 throughout EQL's networks.

1.2.1 Inclusions

The following inclusions apply to this engineering report:

- Key AFLC Components:
    - Injector or Transmitter including Local Controller, Motor Generator or Static Frequency Unit - SFU and Coupling Cell.

1.1.1 Exclusions

The following exclusions apply to this AMP document:

- Reactive AFLC replacements such as those undertaken by corrective maintenance or failed in service (FIS) procedures
- Central Controller
- Receivers.

1.3 Total Current Replacement Cost

AFLC are low capacity, low volume, low cost assets and are typically asset managed on a population basis using periodic inspection for condition and serviceability and through systemic review of recorded performance.

AFLC assets are classified in accordance with AER asset classification. Based upon asset quantities and replacement costs, EQL Services have a replacement value of the order of $80 million. This valuation is the gross replacement cost of the assets, based on the cost of replacement of modern equivalents, without asset optimisation or age assigned depreciation. Figure 2 provides an indication of the relative financial value of EQL Services compared to other asset classes.

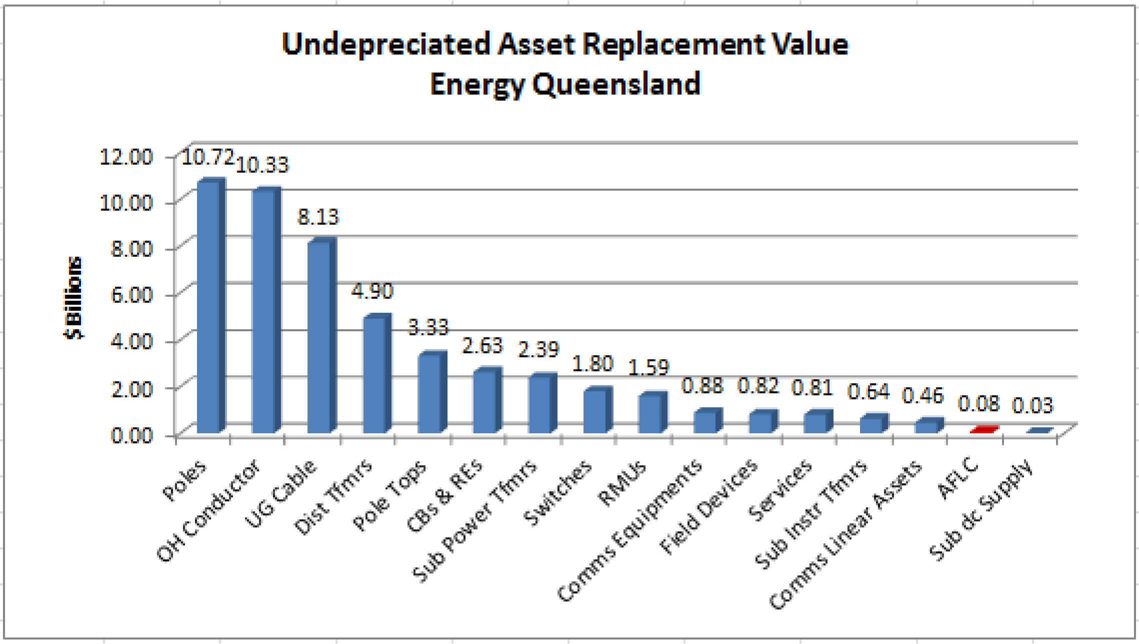

Figure 2: EQL – Total Current Asset Replacement Value

1.4 Asset Function and Strategic Alignment

AFLCs are an instrument of Load Control Demand (LCD) Management and assist in regulating network loads through Ripple Control technology by managing network load (in the short term), customer services and targeted plant (e.g. tariff control, street lighting, air conditioning and hot water supply, pumping stations etc.). AFLC functions are summarized below:

- Ability to switch loads when required
- Improve network security and reliability
- Encourage financial benefits associated with protecting equipment and associated maintenance.

Table 1 below details how protection AFLC contributes 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 asset performance and hence safety for all stakeholders.
Meet customer and stakeholder expectations	Supports energy delivery at reduced price tariff.
Manage risks, performance standards and asset investment to deliver balanced commercial outcomes	Failure of this asset can result in loss of services (e.g. hot water supply) or alternatively can result in higher than normal system loading resulting in overload tripping.
Develop asset management capability & 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 the replacement of assets at end of life to suit modern standards and requirements

Table 1: Asset Function and Strategic Alignment

1.5 Owners and Stakeholders

The following table provides a breakdown of the roles and responsibilities related to AFLC.

Role	Responsible Party
Asset Owner	Chief Financial Officer
Asset Operations Delivery	EGM Distribution
Asset Manager	EGM Strategy, 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

EQL implements a number of Load Control Systems (LCS) including the utilisation of Ripple Control technology to balance the electrical network capacity with customer load demand.

AFLCs utilise Ripple Control technologies in order to switch customer owned loads and plant usually for a defined period of time. Such items can include street lighting, hot water and air conditioning systems, pumping and other services. The diversity and distribution of these customer loads allow EQL to shift energy demand away from high demand peak periods, reducing peak demand while still delivering the required energy each day as unrestrained peak demand risks local plant overload.

Implementing an Audio Frequency Ripple Control system usually has three key items: a Master Load Control Centre; a Local Controller and Transmitter Coupling (i.e. AFLC) at the substation; and receivers at the customer or targeted plant site. The Master Load Control generates commands and remotely supervises substation equipment. At the substation, a transmitter generates an audio frequency signal which is injected into the network via a coupling cell. A local controller normally receives commands from the control master, however, in the absence of communication links back to the Master Load Control Centre; the local controller is able to generate their own commands based upon a pre-programmed backup schedule if necessary. At the customer site, Receivers filter the audio frequency signal supplied via the network and decode the telegram enabling devices and services to be temporarily switched on and off at scheduled times, thus reducing peak load demand by shifting customer energy usage patterns.

AFLCs consists of three key components – the Local Controller; the Transmitter/injector or Static Frequency Unit (SFU); and Coupling Cell.

2.1.1 Local Controller

AFLC Local Controllers established at substations are similar to Remote Terminal Units (RTUs) and are basically computerised electronic devices consisting of multiple functional cards.

Local Controllers are also able to operate independently of the Master Station should a central control or communications failure occur, enabling implementation of its own load-switching program and onsite user controls. Where communications are available, local controllers interface with a Central Control for instructions as well as enabling SCADA and remote engineering support.

These devices also operate the transmitter with telegrams (i.e. ripple control signalling) and provide functions such as check back for transmission indication and monitor alarms. Synchronisation with Transmitter can be undertaken via GPS (Global Positioning System) technology to improve signal coverage, provide precise timing, and high performance without the need for dedicated communications circuits where required.

Modern Local Controllers are capable of SCADA integration, have a DNP3 interface and employ with the EQL network a range of ripple control code protocols including Decabit, Ricontic-B and Pulsadis which are dedicated to the model in question.

It is expected that the operational lifespan of this device is approximately 15 years.

2.1.2 Transmitter

Apart from older style Motor Generators, AFLC Transmitters are a usually a solid state device, generally consisting of multiple functional items, such as the power electronics, computerised controls, power relays etc. Also known as Injectors or Static Frequency Units (SFU) they are capable of injecting a Ripple Control signal, similar to a carrier wave, into the network with the aid of a coupling cell.

The key functions of this device include:

- providing the minimum required injection signal voltage under all operating conditions
- ensuring the output voltage independent of system load with low internal resistance
- providing the required frequency injection within tolerances
- containment of short circuit and overload protection
- supervision of coupling cell operation with check back and alarm signalling.

The Transmitter is usually required to be time synchronised with the other nearby injection sites via the Local Controller using a GPS time synchronising module that provides accurate scheduled timing actions across all injection sites in an area. This time synchronisation capability enables Ripple Control signals to be sent simultaneously reducing the effects of signal interference and attenuation and incorrect operations caused by signal interference by neighbouring injection sites. This method also provides a greater signal strength injection site act in unison, thus improving signal coverage to marginal regions. Moreover, time synchronisation has the added benefit of redundancy by taking advantage of the spill-over effect should a neighbouring transmitter fail in its operation.

There are two distinct technological types of AFLC Transmitters namely Motor Generators and Static Frequency Units (SFU) as detailed in the following subsections.

2.1.2.1 Motor Generators

Motor Generator sets are considered to be the first generation of AFLC Injectors first introduced in the 1950s.

This component is not usually able to be monitored or controlled by SCADA systems remotely (depending upon the associated Local Controller); however, their operational life is considered to be approximately 40 years. It is anticipated there will be no more motor generator units by 2020.

2.1.2.2 Static Frequency Unit (SFU)

SFUs are considered to be the second generation of AFLC Injections introduced in the 1980s as a replacement of motor generator designs.

This component usually has communications capability and able to be controlled from a Network

Control Centre and is considered to have an operational life of approximately 25 years.

2.1.3 Coupling Cells

The coupling cell consists of high voltage (HV) equipment including a tuned isolating transformer; tuning coils; and coupling capacitors combination designed to act as a bandpass signal filter tuned for maximum signal throughput at a designated carrier frequency. The coupling cell performs a voltage step-up function suitable for the injection voltage, carrier frequency, and power level required by the network.

Coupling Cells are also required to:

- protect the transmitter against influences of the power network.
- isolate the low-voltage coupling section from the network.
- provide a sufficient control frequency injection level allowing for load impedance variations, have a low variation of control signal level due to a variation of network load and power factor.
- have good injection voltage stability.
- have good absorption of spill-over signals from adjacent substations.

This component is considered to have an operational life of approximately 40 years.

2.2 Asset Quantity and Physical Distribution

Table 3 below reflects the population numbers of AFLC in the EQL network.

AFLC Component	Northern	Southern	South East	Total
AFLC	32	32	232	296

Table 3: AFLC In-Service Populations as of 2017/18

2.3 Asset Age Distribution

The age distribution of key AFLC components is depicted in Figure 3 below:

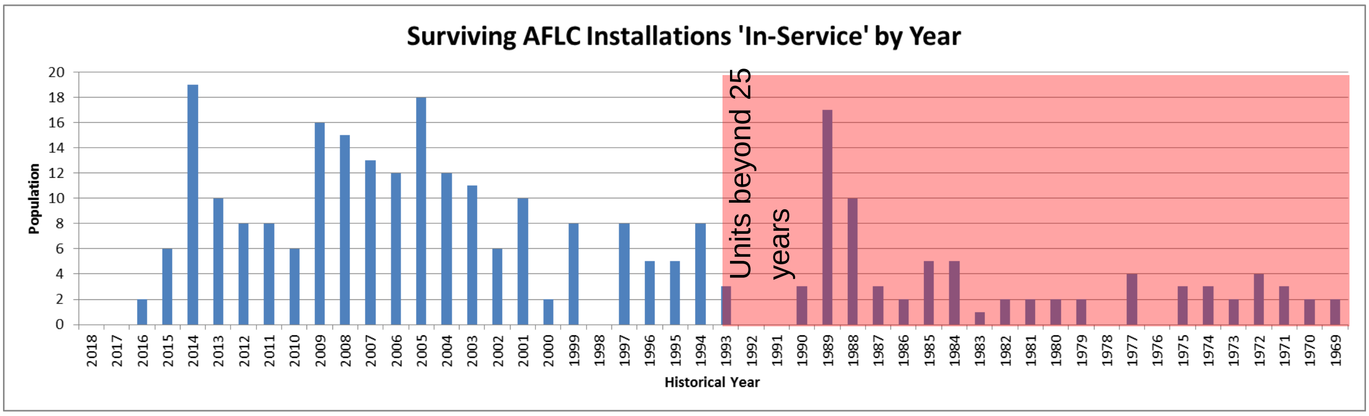

Figure 3: Distribution of AFLCs by Installation Year

It is noted that EQL's South East region has recently underwent significant AFLC replacements targeting older style motor generation units which were prone to overheat due to load duty issues.

As previously stated, AFLCs is comprised of three distinct units namely the local controller, transmitter/injector and coupling cell, with each item having a different operational lifespan. Because of this, individual components are usually replaced at differing intervals of time compared to other components throughout the AFLC's operational life.

2.4 Population Trends

EQL has a heavy investment of AFLC systems within the South East Region. The South East Region also has a diverse range of AFLC units which include limited numbers of the older style motor generators. Northern and Southern Regions have a significantly smaller AFLC population with initial installations beginning from the early 1980s.

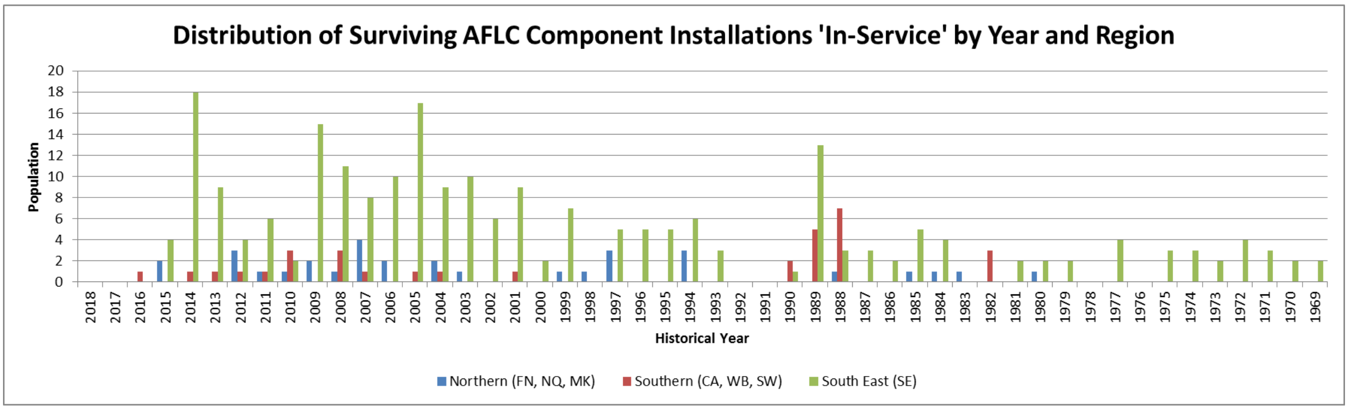

Figure 4: Distribution of AFLC by Region and Installation Year

2.5 Asset Life-Limiting Factors

Table 4 describes the key factors that influence the life of industrial electronic assets and as a result, have a significant bearing on the programs of work implemented to manage the lifecycle.

Factor	Influence	Impact
Age	Gradual deterioration of materials and components used in construction	Reduction in useful life and component failure.
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 early replacement
Environment	Unvented enclosure, corrosive, high humidity or coastal environments result in degradation of the physical asset and components	Accelerated ageing leading to a reduction in useful life.

Table 4: 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, mitigated SFAIRP. All other risks associated with this asset class will be managed “as low as reasonably practicable” (ALARP).

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

AFLC substation assets will be inspected regularly and allowed to operate as long as possible, as AFLC’s typically become obsolete before end of life. Once the asset type is obsolete, assets will be managed, replaced, and reallocated as appropriate to achieve appropriate risk management and optimum asset class longevity and performance.

End of asset life (EOL) for AFLC substation assets will be determined by reference to the benchmark standards defined in the Defect Classification Manuals and or Maintenance Acceptability Criteria.

Replacement of substation assets is typically by specified projects where holistic analysis of nearby assets will also be performed to support the overall optimal life cycle cost and customer impact.

3.2 Legislative Requirements

The assets described in this AMP are not specifically referenced in legislation, and therefore are expected to achieve general obligations surrounding asset safety and performance and service delivery. These obligations include compliance with all legislative and regulatory standards, including the *Electrical Safety Act 2002 (QLD)* and the *Electrical Safety Regulation 2013 (QLD)*.

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.

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 low probability high consequence 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).

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.

Loss of substation power transformers, regulators, or reactors is usually a significant event and may require Safety Net contingency plans to be exercised.

Both Safety Net and MSS performance information is publically reported annually in the Distribution Annual Planning Reports (DAPR).

3.3 Performance Requirements

There are no specific business targets relating to AFLC performance. These assets are classified low risk plant with failure events unlikely to result in safety consequences. As a result, these assets have a 'run to failure' methodology.

3.4 Current Levels of Service

Although EQL has allocated MSSS (Maintenance Strategy Support System) codes within its corporate asset systems for AFLC, this is a recently new development with records collated from 2012.

The total number of AFLC critical failures (i.e. events requiring the replacement of significantly costly operational plant or components as opposed to simple operational or transient issues that are resolved with little effort or intervention) for the previous 5 years are detailed in Table 5 below.

Region	FY2013/14	FY2014/15	FY2015/16	FY2016/17	FY2017/18
Northern Region	0	0	2	0	0
Southern Region	1	1	0	1	0
South East Region	9	18	4	0	0
Totals	10	19	6	1	0

Table 5: Critical Failures for AFLC

As portrayed in Table 5, the majority of critical failures of AFLC systems reside within EQL's South East Region due to the high population and older composition of injector units.

4 Asset Related Corporate Risk

As detailed by Queensland legislation, EQL has a Duty to ensure its works are electrically safe. This safety Duty requires EQL to take action '*So Far as is Reasonably Practical*' (SFAIRP) to eliminate safety related risks, and where it is not possible to eliminate these risks, to mitigate them SFAIRP[1].

Figure **5** provides a threat-barrier diagram for EQL Services assets. Many threats are unable to be controlled (e.g. obsolescence), although EQL undertakes a number of actions to mitigate these to ALARP. Failure of an AFLC Service risks several categories, most notably:

- Reliability of network supply and security, and
- Potential financial loss due to equipment damage and/or replacement.

EQL's safety Duty results in the implementation of inspection, maintenance, refurbishment and replacement work with expenditure related to the prevention and mitigation of Service connection failures and security of supply.

[1] Queensland Electrical Safety Act 2002 s10 and s29

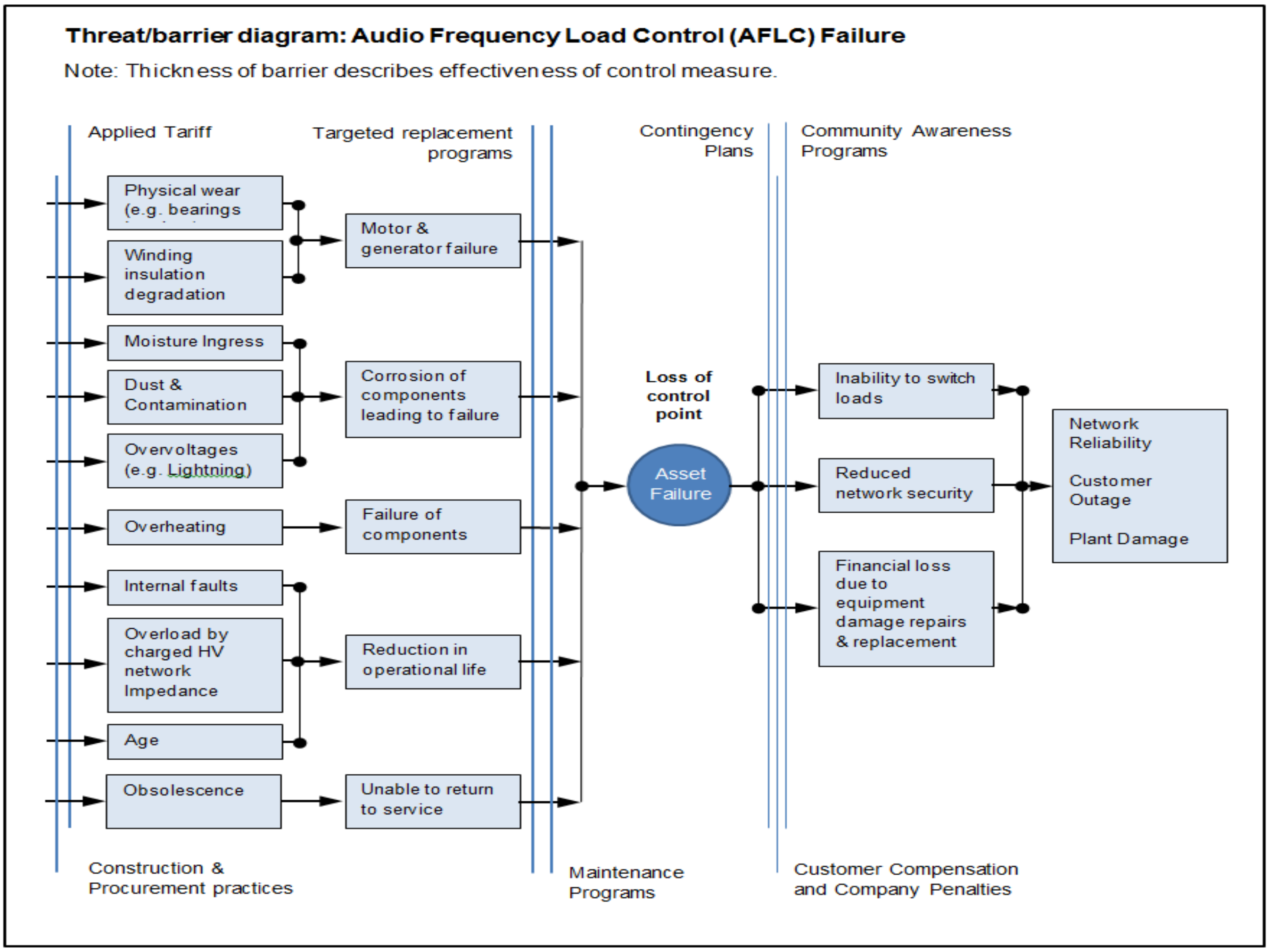

Figure 5: Threat Barrier flow diagram – Protection AFLC Failures

5 Health, Safety & Environment

EQL is required to take all reasonable and practical measures to avoid environmental harm. AFLC systems usually include isolating transformers and hence, maintenance of transformer oil is required. This includes handling and disposal of oil including management of leaks. In addition, a safety consideration is also in play with the handling of toxic PCBs that reside within transformer oil.

6 Current Issues

The following subsections outline the current issues surrounding AFLCs and associated measures currently in place to address them.

6.1 Quality of Asset Records

The quality of EQL corporate asset records with regard to AFLC units is insufficient to accurately assess AFLC condition, performance or analyse greater populations in determining asset lifecycle trends.

In an attempt to alleviate and manage corporate asset records several programs are in place including on-site plant audits when considering significant on-site works on a project by project basis. For Northern and Southern Regions, the NAIQ (Network Asset Information Quality) program designed to improve future data quality. In addition, MSSS (Maintenance Strategy Support System) codes and assignment are available for operators to record operational and plant issues including the associated nature of plant failure.

7 Emerging Issues

The following subsections outline emerging issues and associated actions intended to address them.

7.1 Potential Negative Impact of PV Inverters on AFLC Systems

Anecdotal evidence has been reported by electricity network operators suggesting that solar PV (photovoltaic) inverters may be interacting with AFIC signalling. External studies are being carried out investigating the impact of common solar PV inverters on audio frequency injection control (AFIC) signal levels. Of main concern is the inverter's front-end filter interacting with the high frequency AFIC signals either through attenuation or amplification.

Action 7-1: EQL to monitor this potential issue and associated studies and consider approaching manufacturers to provide inverter impedance measurements at AFLC signalling frequencies or other alternate solutions.

7.2 Aging AFLC

EQL has an aging AFLC population. Presently there are no proactive programs in place for planned replacements targeting AFLC units or components that are approaching end of life (EOL). Consequently, EQL is responding reactively to fail in service (FIS) events or undertaking corrective maintenance once issues are identified.

This is a suitable strategy while EQL investigates smarter load control technologies or metering technologies as a possible future replacement and allows the natural attrition of AFLCs.

Action 7-2: Investigate possible smart technologies as alternatives load control solutions for future replacement of AFLC systems.

Action 7-3: Period review and analysis of the cost benefits of a proactive and planned ALFC replacement program versus reactive replacements strategy should continue to determine future replacement strategies.

8 Improvements and Innovation

EQL consider future technologies could potentially replace load control systems such as AFLCs. This includes smart meters or other similar intelligent devices as a potential replacement for AFLC units that could manage load control for customers. This could potentially enforce the application of tariffs (including tariff 14) by scheduling and temporally restricting services during peak periods such as air conditions, hot water, pumping services.

Action 8-1: Investigate possible smart technologies as alternatives load control solutions for future replacement of AFLC systems.

9 Lifecycle Strategies

The following sections detail the proposed lifecycle philosophies and strategies adopted by EQL

9.1 Philosophy of Approach

The philosophical approach towards the lifecycle management of AFLCs has been considerate. Historically, EQL's South East Region has experienced a replacement regime targeting aged motor generator units. For Northern and Southern Regions, EQL has taken a more conservative approach with AFLC condition assessments undertaken when bundling substation project work on a case by case basis.

AFLC lifecycle management is undertaken by several means:

- Operational and augmentation programs
- MSSS reporting
- REPEX modelling
- Risk analysis and condition assessments
- Preventative maintenance programs
- Opportunistic bundling of work for near end of life assets
- Corrective and forced maintenance responses, and
- Management of spares.

9.2 Acquisition and Procurement

AFLC are procured on an as needed basis driven by network augmentation and replacement of assets which have failed in-service. 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.

9.3 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.

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

9.3.1 Preventive Maintenance

EQL has an AFLC maintenance program in place in accordance with standards:

- 'EX STD01116 & EE STNW1132 Maintenance Standard for Audio Frequency Load Control (AFLC) Systems'
- 'STNW0705 Standard for Preventative Maintenance Programs'

9.3.2 Corrective Maintenance

EQL has guidelines for corrective maintenance regimes in accordance with such guidelines as:

- '00411 Standard for Maintenance Acceptance Criteria'
- 'EX 00707 & EE STNW0330 Maintenance Standard for Network Assets Defect and Condition Prioritisation'
- 'STNW1160 Standard for Maintenance Acceptance Criteria'

9.3.3 Spares

EQL currently does not currently have a strategic spares management plan.

Action 9-1: EQL to develop a strategic spares management plan for the management of AFLC systems.

9.4 Refurbishment and Replacement

The following sections detail the aspects of refurbishment and replacement of AFLC.

9.4.1 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. Refurbishment activities are determined via assessment of the condition and can vary in complexity, from resolving corrosion issues and off-site moisture removal, through to component replacement or a full rewinding of the asset.

As AFLC is comprised of three key components (i.e. local controller; transmitter and coupling cell) of varying lifespans, these individual items are able to be refurbished or replaced in the sense of extending their operational life of the AFLC as a whole.

9.4.2 Replacement

EQL has no consideration for investing towards planned AFLC replacement program for the near future (i.e. regulatory period 2020-2025). EQL does, however; wish to complete the targeting and replacement of motor generators situated within the South East Region within the current regulatory period 2015-2020.

EQL will, however, consider condition assessment of AFLC systems on a substation site by site basis when undertaking bundling of projects. Once significant defects are identified EQL will consider replacement in line with prudently bundled works scheduled for the same site where possible.

In addition, EQL will react to reported maintenance issues and failed in service events as they arise.

9.5 Disposal

Safety is a paramount concern of EQL and all design and supply of equipment and materials must take into account all safety implications for its construction, maintenance, operations, and ultimate disposal of AFLC components. AFLCs usually incorporate an isolating transformer in their operations. As with all transformers, consideration is taken in the disposal of transformer oil where required.

10 Program Requirements and Delivery

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

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

11 Summary of Actions

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

Action 7-1: EQL to monitor this potential issue and associated studies and consider approaching manufacturers to provide inverter impedance measurements at AFLC signalling frequencies or other alternate solutions.

Action 7-2: Investigate possible smart technologies as alternatives load control solutions for future replacement of AFLC systems.

Action 7-3: Period review and analysis of the cost benefits of a proactive and planned ALFC replacement program versus reactive replacements strategy should continue to determine future replacement strategies.

Action 8-1: Investigate possible smart technologies as alternatives load control solutions for future replacement of AFLC systems.

Action 9-1: EQL to develop a strategic spares management plan for the management of AFLC systems.

Appendix 1 – References

It is expected that the integration of all standards and documents after a merger between two large corporations will take several years to accomplish. This table details all documents authorised/approved for use in either legacy organisation, and therefore authorised/approved for use by EQL, that supports this Management Plan.

Legacy Organisation	Document Number	Title	Type
EQL		*EQL Business Plan*	Plan
EQL		*Network Asset Management Strategy*	Strategy
EQL		AER – AMP – AFLC Statistics Graphs.xlsx	Report
EQL	01_CAPEX Data.xlsx (issued January 2018)	*CAPEX Data*	Report
Ergon & Energex	00411	*Standard for Maintenance Acceptance Criteria*	Standard
EQL	STNW0705	*Standard for Preventative Maintenance Programs*	Standard
EQL	STNW0717	*Standard for Preventative Maintenance Programs for 2017-18*	Standard
EQL	STNW1160	*Standard for Maintenance Acceptance Criteria*	Standard
EQL	STNW3383	*Standard for Intelligent Electronic Devices (IED)*	Standard
Energex & Ergon Energy Joint Workings	STD01116 STNW1132	*Maintenance Standard for Audio Frequency Load Control AFLC*	Standard
EQL	ES000901R102	*HSECH Risk Control Guide*	Standard
Ergon & Energex	VIS2009-01	*Network Vision Outlook to 2030*	Vision Statement
Energex		*Energex's 2020 Transition Roadmap*	Vision Statement
EQL	STNW3383	*Standard for Intelligent Electronic Devices (IED)*	Standard
EQL	STCR001: Standard for Corporate Risk Management	*Standard for Corporate Risk Management*	Standard
EQL	GC000400R102 Corporate Risk Assessment Tables	*Corporate Risk Assessment Tables*	Corporate Guideline
EQL	GC000400R101: Network Risk Assessment Guideline	*Network Risk Assessment Guideline*	Corporate Guideline
EQL	ES000901R102	*HSECH Risk Control Guide*	Corporate Guideline
EQL	Management Plan Protection and Control	Management Plan Protection and Control	Management Plan
EQL	NI000401R121	SS-1-1.4 Substation Design Manual	Standard

Legacy Organisation	Document Number	Title	Type
Ergon Energy	ES000904R122	Environmental Management of Fuel and Oil	Standard
Ergon Energy	ES000904W101	Implement Controls - Management of Disposal of Regulated Waste	Work Instruction Manual
Ergon Energy	ES000901R100	Manage Hazardous Chemicals	Standard
Department of Health and Environment		Waste Management Guidelines – Identifying and managing equipment containing polychlorinated biphenyls (PCBs)	Guideline
Joint Workings	01298	Maintenance Standard for Protection Systems	Standard
Energex	00807	Network Asset Management Policy	Standard
Joint Workings	01056	Network Maintenance Protocol	Policy
Joint Workings	EX STD01116 EE STNW1132	Maintenance Standard for Audio Frequency Load Control (AFLC) Systems	Standard
Joint Workings	EX 00707 EE SENW0330	Maintenance Standard for Network Assets Defect and Condition Prioritisation	Standard

Appendix 2 – Legislation, regulations, rules and codes

The following table lists legislation, regulations, rules and codes that might impact this asset management plan.

Legislation, Regulations, Rules and Codes
Electricity Act 1994 (QLD)
Electricity Distribution Industry Code (QLD)
Electricity Regulation 2006 (QLD)
Energex Limited Distribution Authority No. D07/98
Environmental Protection Act 1994 (QLD)
EQL Corporation Limited Distribution Authority No D01/99
National Electricity Law - National Electricity (South Australia) Act 1996
National Electricity Rules (NER)
National Electricity Scheme (Queensland) Act 1997
QLD Electrical Safety Act 2002
QLD Electrical Safety Code of Practice 2010 - Works (ESCOP)
QLD Electrical Safety Regulation 2013 (ESR)
QLD Work Health & Safety Act 2014
QLD Work Health & Safety Regulation 2011
Work Health and Safety Act 2011

Appendix 3 – Definitions

The following listing offers a description of definitions.

Term	Definition
Audio Frequency Load Control	A method of switching loads by modulating audio frequency signals transmitted over the powerline.
Asset Condition	The health of an asset assessed during preventative maintenance testing or monitored while in service.
Bundled	Refers to the bundling or collation of various asset projects as one major project in an effort towards efficiency.
Distribution	LV and up to 22kVnetwork, all SWER networks.
Electricity Legislation	Refers to the Electricity Act, Electrical Safety Act, the Electricity – National Electricity Scheme (Queensland) Act 1997 and regulations, standards, codes, protocols and rules made under those Acts.
Ellipse	EQL’s asset management system (includes assets register).
End of Life	An asset’s predicted operational age where it begins to fail or not operate as expected.
Engineering Report	A high level engineering business report based upon on the analysis of technology applications, asset performance and characteristics, offering engineering solutions for achieving Ergon’s network vision.
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.
In-service	The state of plant or equipment that is considered operating within the network.
Legacy Projects	Legacy projects mentioned within this document refer to older AFLC replacement projects formally initiated or inherited by the Asset Lifecycle Management (ALM) workgroup. These projects are in-train within EQL’s project management processes and are not necessarily associated with projects assigned to the target regulatory period.
Pickup Value	Actual level (current or voltage) measured by an AFLC that identifies that a fault event has started to occur.
Program	Strategic work defined by work sites and scheduled timelines.
Service Life	In service life expectancy of a protection AFLC.
Strategy	A high level business direction on technology applications recommended for achieving Ergon’s network vision.
Sub transmission	33kV and 66kV networks.
Target Models	Protection AFLC models with known performance issues, which exhibit relative failure rates higher than the greater population of AFLC subjected to maintenance testing.
Transmission	Above 66kV networks.
Uplift Factor	A loading factor to the standard estimate which includes travel and accommodation but excludes overhead costs.
Joint Workings	Co-operative joint workings between Ergon Energy and Energex.

Appendix 4 – Acronyms and Abbreviations

The following abbreviations and acronyms may appear in this Asset Management Plan.

Abbreviation or acronym	Definition
A	Amperes - unit measure of electrical current
AER	Australian Energy Regulator
AFLC	Audio Frequency Load Control
AIDM	Asset Inspection & Defect Management system
AMP	Asset Management Plan
AP	Approved Value
AR	Autoreclose protection scheme
AUGEX	Augmentation Expenditure
BAU	Business as usual
BZ	Bus Zone
CA	Central Queensland (Capricornia) region
CAPEX	Capital Expenditure
CB	Circuit Breaker
CBRM	Condition Based Risk Management
CIS	Customer Information System
CT	Current Transformer
CVT	Capacitor Voltage Transformer
DAP	Direct Approved Value
DCV	Direct Contract Value
DEE	Dangerous Electrical Event
DGA	Dissolved Gas Analysis
DIFF	Differential protection scheme
DLA	Dielectric Loss Angle
EF	Earth fault protection scheme
Ellipse	Corporate asset management system
EOL	End of Life
EQL	EQL Limited
ESCOP	Electricity Safety Code of Practice
ESR	Queensland Electrical Safety Regulation (2013)
FN	Far North Queensland region
FR	Failure Rate
GPS	Global Positioning System – communications system that delivers information around the world using satellite technology.

Abbreviation or acronym	Definition
GW	Gigawatt: one thousand million watts
HAN	Home area network
IoT	Internet of Things
IPS	Intelligent Process Solutions - is the asset performance management solution for electrical power systems implemented at EQL.
IPS	A corporate asset system
ISCA	In-Service Condition Assessment
JAMIT	Joint Asset Management Inspection Tool - is to provide core functionality to complete the required asset management functions.
JW	Joint Workings – between Ergon Energy and Energex
kV	Kilovolts - unit measure of electrical potential
LDCM	Lines Defect Classification Manual
LDIFF	Line differential protection scheme
LV	Low Voltage
MK	Mackay region
MSSS	Maintenance Strategy Support System
MU	Metering Unit
MVAr	Mega-VAr, unit of reactive power
NAIQ	Network Asset Information Quality
NCC	National Contact Centre
NER	Neutral Earthing Resistor
NER	National Electricity Rules
NEX	Neutral Earthing Reactor
NQ	North Queensland region
OC	Overcurrent protection scheme
OLTC	On-load tap -changers
OMS	Outage Management System
OTI	Oil Temperature Indicators
PCB	Polychlorinated Biphenyls
PDS	Protection Database System
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

Abbreviation or acronym	Definition
RMU	Ring Main Unit
RTU	Remote Terminal Unit
SCADA	Supervisory Control and Data Acquisition
SCAMS	Substation Contingency Asset Management System
SCI	Statement of Corporate Intent
SDCM	Substation Defect Classification Manual
SEF	Sensitive Earth Fault
SFAIRP	So Far as Reasonably Practical
SHI	Security and Hazard Inspection
SM	Small
SME	Subject Matter Expert
SVC	Numeric VAR Compensator
SW	South West Queensland region
SWOT	Strength, weakness, opportunity, threat
TOU	Time of use
VCR	Value to Customer Reliability
VT	Voltage Transformer
WB	Wide Bay Queensland region
WCP	Water Content of Paper
WTI	Winding Temperature Indicators
WTP	Wet Transformer Profile

Appendix 5 – Regional References

The following outlines the regional distinctions between Ergon and Energex as well as their amalgamation into EQL.

Company						
	Energy Queensland (EQL)		**Ergon Energy (Legacy)**		**Energex (Legacy)**	
Regions	N	North Queensland	FN	Far North including the district of Far North incorporating - Thursday Is, Bamaga, Cooktown, Mossman, Mareeba, Atherton, Ravenshoe, Normanton, Georgetown		
			NQ	North Queensland including districts of Tropical Coast and Herbert		
			MK	Mackay including districts of Flinders and Pioneer		
	S	Southern Queensland	CA	Capricornia including districts of Capricornia and Central West		
			SW	South West including districts of South West and Darling Downs		
			WB	Wide Bay including districts of Bundaberg Burnett, Fraser Burnett		
	SE	South East Queensland			SE	South East Queensland including districts of Sunshine Coast, Brisbane, Ipswich Lockyer, Gold Coast

Appendix 6 – AFLC Component Age Limitations

The following section outlines the recommended age ‘limitations’ as an attempt to predict the end of life (EOL) for specific AFLC components.

AFLC Component	Predicted Age Limitation (EOL)
Motor Generator (MG)	45 years
Coupling Cell (CC)	40 years
Signal Frequency Unit (SFU)	25 years
Local Controller	15 years

Appendix 7 – Protection AFLC MSSS Codes

The following table is an extract of the '*NA000403R478 Substation Outage / Failure Code Reference Guide'*, outlying the key MSSS code associated with AFLC failure events.

COMPONENT		OBJECT		DAMAGE		CAUSE	
CBSA	AFLC	M8551	AF Motor/Generators	M0018	Deteriorated	M0011	Corrosion
						M7002	Defective Component
						M7007	Humidity
						M7009	Inadequate Coating
						M7011	Loose/Missing Component
						M0023	Moisture Ingress
						M0004	Vibration

Appendix 8 – EXTRACT of Defect Classification

The following table is an extract from the '*21.04 - Cap Banks SVC AFLC - AF motor generator v1.1*' for prioritisation and classification of defects.

P1	
Object	AF Motors & Generators
Damage	Deteriorated
Cause	Corrosion, Defective Component, Humidity, Inadequate Coating, Loose/Missing Component, Moisture Ingress, Vibration
Task	Repair, Replace
Priority	P1
Description The motor/generator has major deterioration. There may be abnormal noise indicating rotating plant bearing deterioration or severe degradation of coupling rubbers. There is: - An immediate risk to safety or the environment; or - An immediate risk of equipment damage, plant failure, or outage.	
P2	
Object	AF Motors & Generators
Damage	Deteriorated
Cause	Corrosion, Defective Component, Humidity, Inadequate Coating, Loose/Missing Component, Moisture Ingress, Vibration
Task	Repair, Replace
Priority	P2
Description The motor/generator has major deterioration. There may be abnormal noise indicating rotating plant bearing deterioration or degradation of coupling rubbers. There is: - No immediate risk to safety or the environment; or - No immediate risk of equipment damage, plant failure, or outage.	

C3	
Object	AF Motors & Generators
Damage	Deteriorated
Cause	Corrosion, Defective Component, Humidity, Inadequate Coating, Loose/Missing Component, Moisture Ingress, Vibration
Task	Record, Reassess Next Inspection
Priority	C3
Description The motor/generator is deteriorated with minor loss of functionality. There may be abnormal noise indicating rotating plant bearing deterioration or degradation of coupling rubbers.	