Asset Management Plan
Services

Part of the Energy Queensland Group

Executive Summary

This Asset Management Plan (AMP) covers the class of assets known as Overhead Customer Services (“overhead services”).

Overhead services provide a connection for electricity between the Energy Queensland Limited (EQL) overhead low voltage (LV) mains and designated points of connection owned by individual customers.

EQL manages almost one million Services comprising around 398,000 Services in the Northern and Southern Regions and 594,000 Services in South East Region. These overhead services have been consolidated from the previous management of “legacy organisations” Energex (South East Region) and Ergon Energy (Northern and Southern Regions).

Overhead services are relatively low-cost assets and are typically asset managed on a population basis using periodic inspection and systemic review of recorded performance.

EQL employs several types of overhead services, including:

- Cross-linked Polyethylene (XLPE) Services,
- Polyvinyl Chloride (PVC) (black) Flat Services,
- PVC (grey) aluminium Services,
- Neutral Screened Services, and
- Open Wire Services.

Overhead Service failures present the following significant risks:

- Failure of the neutral circuit leading to elevated risk of customer shock and fatality
- Failure of the active circuit leading to loss of customer supply
- Breakage of the Overhead Service, falling to the ground and remaining energised, leading to elevated public risk of public shock.

Overall Service asset population performance is currently measured in terms of the number of reported public shocks directly related to Overhead Service operations. Where possible, EQL aims to reduce the number of public shocks towards zero so far as is reasonably practicable (SFAIRP).

Customer overhead services represent approximately 2% of the total replacement value of the EQL’s network asset inventory and are associated with around 50% of all reported asset related shocks. This AMP details a range of management strategies commensurate with all public safety issues, as well as the specific issues facing overhead services public safety. Factors influencing prudent management of this asset class include: public safety, the large and geographically dispersed overhead service population, assessed Overhead Service condition, various historical design standards, and diverse environmental and operational conditions.

EQL is actively working to align data collection and record systems relating to customer overhead services across all regions, employing the best and most suitable systems from both legacy organisations. EQL continues to improve safety and the cost-effective management of these assets through the use of and continuous improvement of: inspection and analysis techniques (such as Light Detection and Ranging (LiDAR), imagery and predictive analytics), optimal delivery models/techniques, and industry best practice management through active participation in Energy Networks Australia (ENA) working groups.

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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Document Tracking Details

Network and Non-Network Document Hierarchy Reference Number	Regulatory Proposal Chapter Reference	Document	File Name
NET AMP – 014	7.04	Asset Management Plan - Services	EGX ERG 7.04 Asset Management Plan - Services 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
- Northern and Southern Regions (Legacy organisation: Ergon Energy Corporation Limited).

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

1.1 Purpose

The purpose of this document is to demonstrate the responsible and sustainable management of Overhead Customer Services ("overhead services") 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 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).*
- *Queensland Electrical Safety Code of Practice 2010 – Works (ESCOP).*
- *Work Health & Safety Act 2014 (Qld)*
- *Work Health & Safety Regulation 2011 (Qld)*
- Ergon Energy Corporation Limited Distribution Authority No D01/99.
- Energex Limited Distribution Authority No. D07/98.

This Asset Management Plan forms part of EQL's strategic asset management documentation, as shown in Figure 1. It is part of a suite of Asset Management Plans, which collectively describe EQL's approach to the lifecycle management of the various assets which make up the network used to deliver electricity to its customers. Appendix 1 contains references to other documents relevant to the management of the asset class covered in this plan.

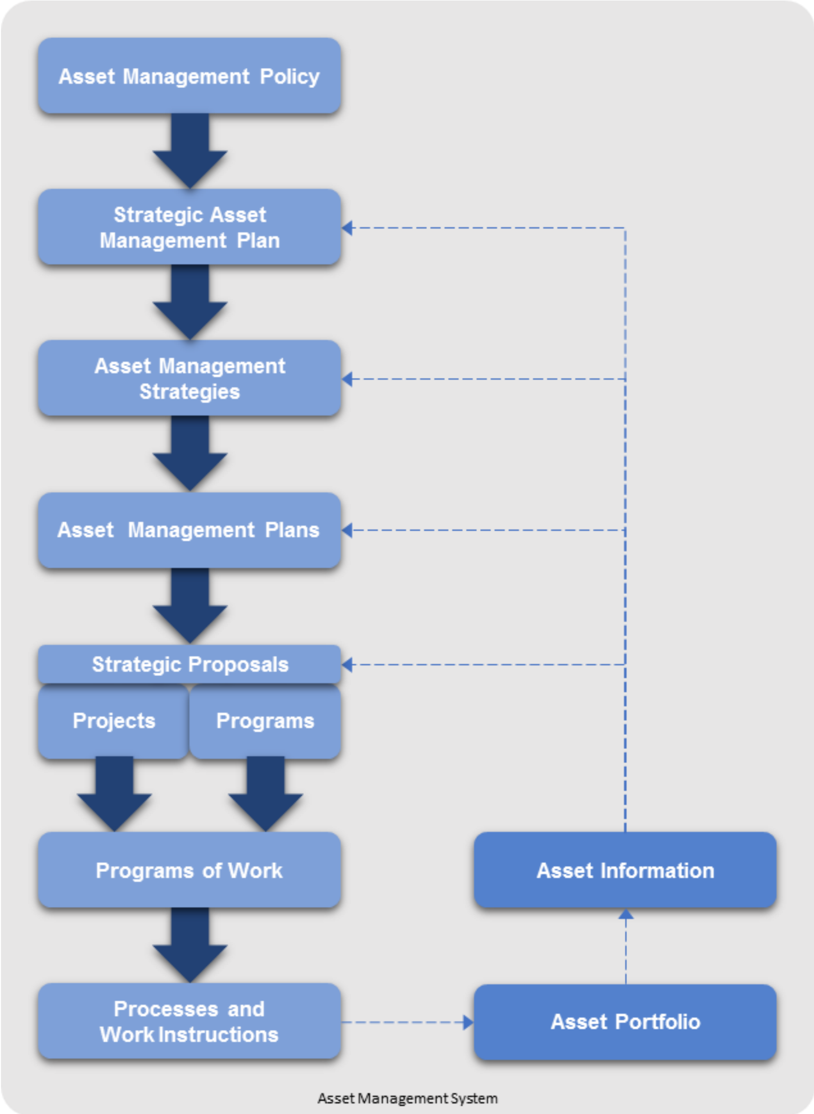


Figure 1: EQL Asset Management System

1.2 Scope

This plan covers the following assets:

- Low voltage Overhead Customer Services
- Mains Overhead Service connection assets and point of connection assets.

Many customers, typically those with high voltage connections, own and manage their own network assets including overhead conductors 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

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

Based upon asset quantities and replacement costs, EQL overhead services have a replacement value of approximately $810 Million (Northern and Southern Regions: $490 Million, South East

Region: $320 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 overhead services compared to other asset classes.

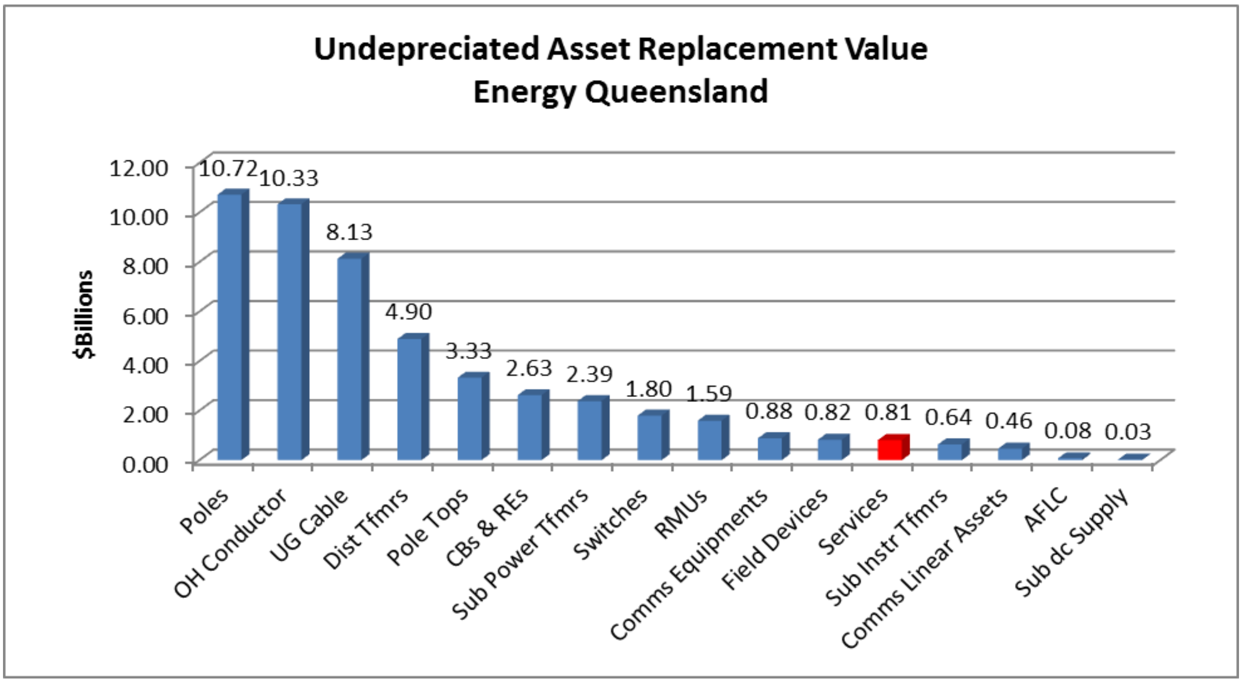


Figure 2: EQL – Total Current Asset Replacement Cost

1.4 Asset Function and Strategic Alignment

Overhead services provide a connection for electricity between the EQL overhead low voltage (LV) mains and designated points of connection owned by individual customers. Table 1 details how this asset class contributes to the corporate strategic asset management objectives.

Asset Management Objectives	Relationship of Asset to Asset Management Objectives
Ensure network safety for staff, contractors, and the community	Diligent and consistent inspection, maintenance and renewal activities support asset performance, which is an enabler for safety for all stakeholders.
Meet customer and stakeholder expectations	Continued asset serviceability supports network reliability, and promotes delivery of a standard quality electrical energy service at optimal cost.
Manage risks, performance standards, and asset investment to deliver balanced commercial outcomes	Failure of this asset can result in increased public safety risk, disruption of the electricity network, and disruption of customer amenity. Understanding asset performance allows optimal investment to achieve intended outcomes. Asset longevity assists in minimising capital and operational expenditure.
Develop asset management capability and align practices to the global ISO 55000 standard	This AMP is consistent with AS ISO 55000 objectives and drives asset management capability by promoting continuous and targeted improvement.

Asset Management Objectives	Relationship of Asset to Asset Management Objectives
Modernise the network and facilitate access to innovative energy technologies	This AMP promotes replacement of assets 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 Operational 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 overhead services provide a connection for electricity between the EQL overhead low voltage (LV) mains and designated points of connection owned by individual customers. EQL has several types of overhead services including:

- Cross-linked polyethylene (XLPE) services
- Polyvinyl chloride (PVC) (black) flat services
- PVC (grey) aluminium services
- Neutral screened services
- Open wire services.

The following sections provide a summary of these.

2.1.1 Cross-linked Polyethylene (XLPE) Services

These cables use XLPE as an insulator covering.

The process of cross-linking or vulcanisation of polyethylene consists of producing chemical bonds at intervals between the long molecular chains to give a “ladder” effect which prevents slippage between molecules. As a result of cross-linking, the material becomes heat resistant and does not soften at high temperatures. It develops resistance to stress cracking and ageing. The material has high corrosion resistance and high resistance to chemical pollutants. XLPE Cables typically have higher current rating and longer service life compared to PVC Cables.

2.1.2 Polyvinyl Chloride (PVC) Services

Polyvinyl Chloride is a thermoplastic material. A versatile and common compound, it has a range of qualities that support its use as conductor insulation. PVC is durable, UV resistant and exhibits good resistance to chemicals and water.

PVC use as insulation has been largely superceded by XLPE insulation, due to the superior performance of XLPE materials.

A flat cable configuration is where the cable conductors are laid in line, connected together by the PVC insulation.

PVC cables are often distinguished by the colour of the outer sheath, of which grey and black are the most common for services. Black PVC has additional carbon added to improve UV resistance.

2.1.3 Neutral Screened Services

These are cables where the neutral conductor surrounds the separately insulated active conductors, and in turn, is covered by an outer sheath. The outer conductor screen of the cable is only permitted to be used for a conductor which is earthed. This means that the screen is at or near earth potential and the insulation provided by the neutral screen cable sheath is adequate.

2.1.4 Open Wire Services

These are essentially bare wire conductors with each phase and neutral wire physically separated and terminated. By Queensland regulation, the last 1.5 metres of the conductors connecting to the premises must be insulated. Open wire services are the oldest type of service used in the network. As these services are not fully insulated they present a higher safety risk than more modern service types. Open wire services are being progressively removed from the network however there are still small numbers of such services across the state.

2.1.5 Service Cable Miscellaneous Hardware

Other asset components included in achieving this connection include:

- Clamps
- IPCs (Insulated piercing connectors)/ HSCs (house service connectors)
- Service fuses
- Service attachments
- Mains boxes (customer owned)
- Raisers (customer owned)
- Service hooks (customer owned).

These components are treated as the part of the overall service connection.

Figure 3 provides a simple representation of a service connection.

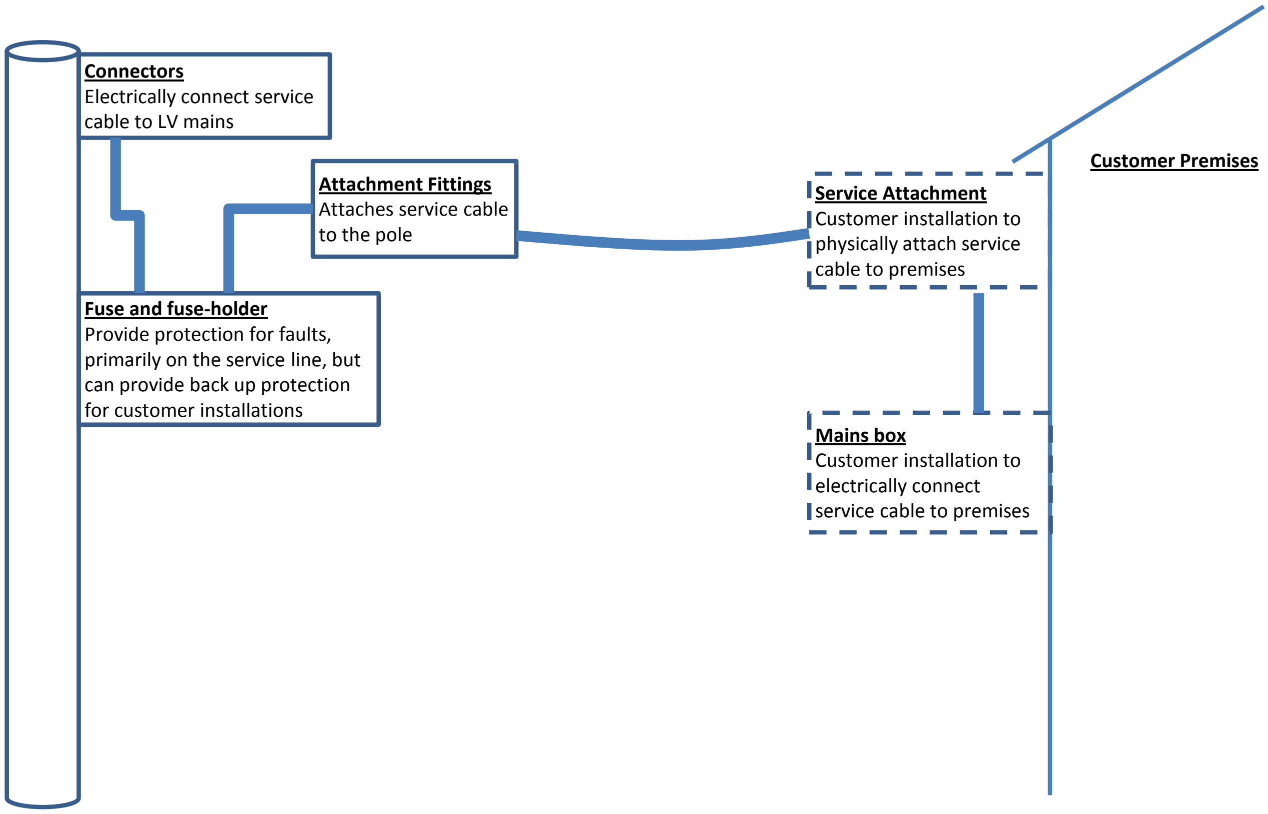


Figure 3: Functional model of an Overhead Service

2.2 Asset Quantity and Physical Distribution

Asset Type	Northern and Southern Regions	South East Region	Total
LV Residential	345,661	546,281	891,942
LV Non Residential	51,972	47,473	99,445
Total	397,633	593,754	991,387

Table 3: Overhead Service Quantity

2.3 Asset Age Distribution

The actual age of overhead services has been problematic to establish, as the year of installation for the overhead services was not generally recorded until around 2006. The age data presented herein is consistent with the information reported in the annual Regulatory Information Notices (RINs) and represents the best information currently available. Figure 4 and Figure 5 show the age profile of EQL's overhead services. While reviewing the following data, it should be assumed that data quality deteriorates with age.

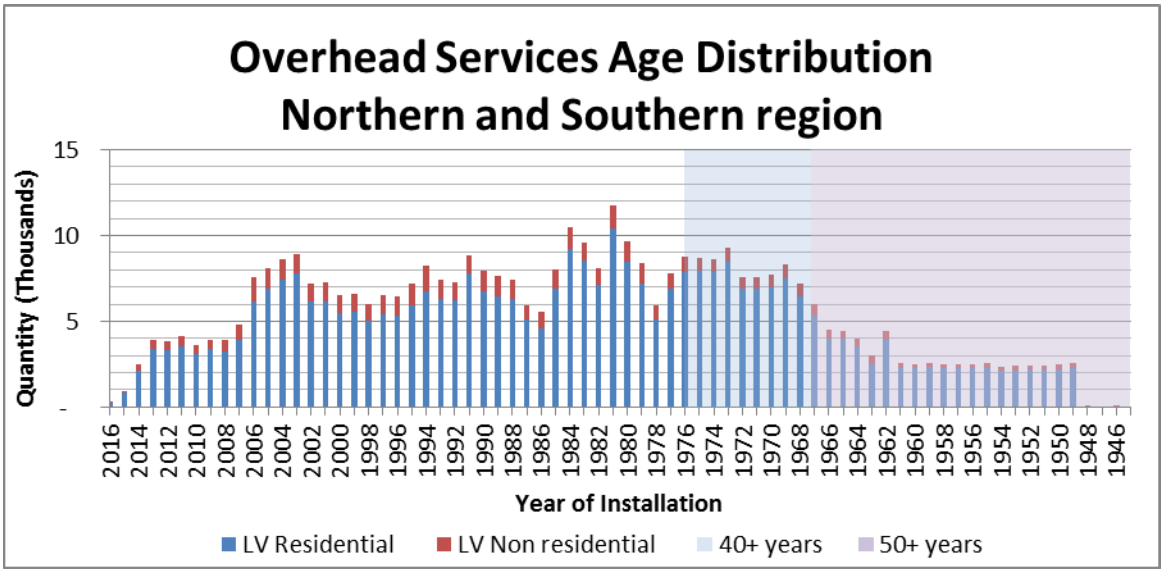


Figure 4: Age profile Overhead Services - Northern and Southern Regions

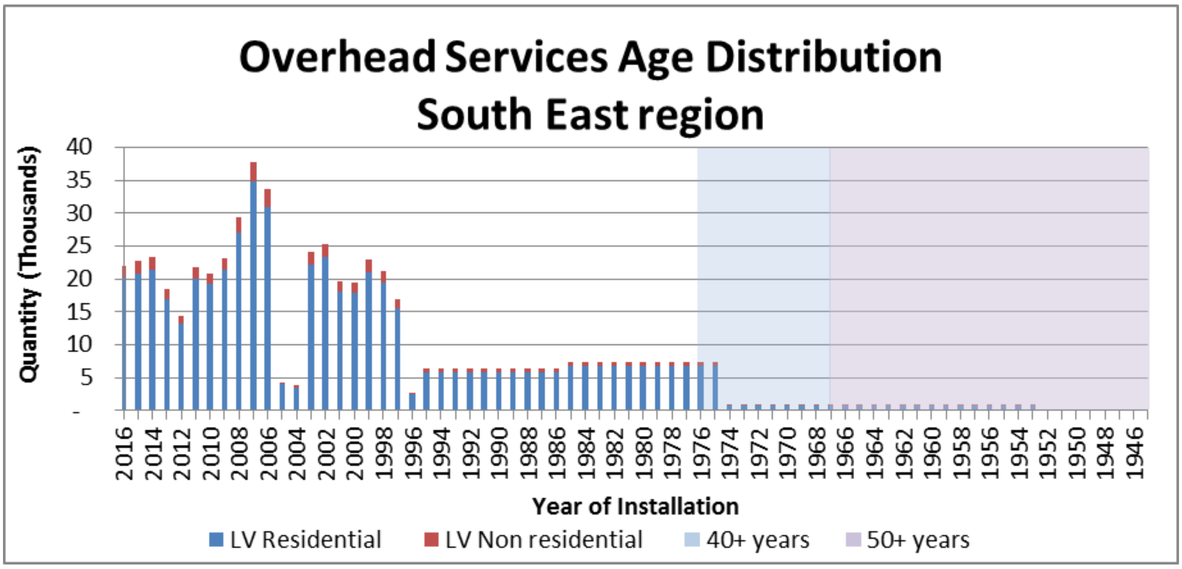


Figure 5: Age profile Overhead Services - South East Region

The sudden increase in the South East Region age profile commencing around 1997 reflects a strong influence by the Queensland Electrical Safety Office to reduce public shocks.

From 2004 to 2006 overhead services installations were reduced significantly as a result of temporary resource redeployment for work related to the Somerville Enquiry in 2003-2004[1]. The replacement work backlog created during this hiatus period was recovered in the following three years commencing 2007.

2.4 Population Trends

Ergon Energy (Northern and Southern Regions) replacement practices have relied upon visual condition inspection and targeted overhead service line volume replacement programs (reflecting known systemic failures of specific Overhead Service cable types). The effect of this approach is

[1] Electricity Distribution and Service Delivery for the 21st Century July 2004

reflected in the relatively consistent age (low standard deviation from the mean) of the Northern and Southern Regions overhead services assets depicted in Figure 4.

Energex (South East Region) has implemented a significant asset replacement program of overhead services in an effort to mitigate public safety issues experienced on the network, effectively placing less reliance upon visual inspections compared to targeted type replacements. This strategy is reflected in the age profile by the volume of assets installed in recent years.

The Energex approach has resulted in a generally younger population and significantly lower rates of public shocks per annum when compared to the Ergon Energy. EQL has now initiated a planned targeted replacement program in Northern and Southern Regions intended to reduce public shocks.

Overhead services fall into 5 basic types as shown in Table 4. New service types were introduced and installed over time as technology advancements improved service offerings.

Overhead Service type	Installation Range
Open Wire	**< 1976**
Neutral Screen	**1976 - 1987**
Parallel Web	**1976 - 1997**
Twisted Multiphase	**1976 - 1997**
XLPE	**1997 - Present**

Table 4: Generic Overhead Service cable types

As the replacement cycle continues, older overhead services are being replaced with the newer XLPE overhead services. The age profile information in Figure 4 combined with Table 4 suggests that around a quarter of all services in the Northern and Southern Regions are likely to be open wire services; however, this is not the case. In 2012-2015 Ergon Energy implemented a significant replacement program of open wire overhead services with XLPE overhead service cables up to the point of connection. However, there is still a number of open wire overhead services in-situ, particularly in rural locations employing privately owned overhead circuits.

A process is currently underway to correctly identify Open Wire overhead services as part of the asset inspection process and continue to improve the data relating to overhead services.

2.5 Asset Life Limiting Factors

Overhead services are completely passive devices without moving parts. End of life is usually signalled by conditions/factors where there is increased risk of public safety incidents (notably shock or electrocution) or increased risk of loss of supply. Risk of public safety incidents is enforced by a regulatory duty of care to minimise safety risks so far as is reasonably practicable, which therefore requires faulty/unsafe overhead services to be replaced.

Table 5 describes the key factors that influence the life of overhead services and as a result have a significant bearing on the programs of work implemented to manage the lifecycle.

Factor	Influence	Impact
Corrosion	Overhead service conductors and terminations are subject to deterioration in the presence of oxygen, dissimilar metals and electrolytes. This is a significant issue at coastal locations.	Corrosion may result in a loss of material and increased resistance which affects the mechanical and electrical characteristics of the overhead service or termination. The reduction in conductivity and strength has an effect on the life of the conductor and presents increased safety risk of public shock, mechanical failure, overheating and fire.
Annealing	Overhead service conductors operated at high temperatures due to high resistance connections or overloading. The accumulation of these effects over time lead to annealing of the conductor.	Annealing leads to a reduction in tensile strength and, ultimately, failure of the conductor. Failure results in increased safety risk and third party damage as above.
Ductile deformation	High mechanical load stretches the conductor material. Stretching beyond the elastic limit results in permanent deformation of the material, including necking of the conductor strands and embrittlement of the metal. Some airborne pollutants (such as sulphides) are absorbed by bare metals, leading to embrittlement.	Necking reduces the tensile strength and current carrying capacity of the conductor. Embrittlement reduces the ability of the conductor material to flex and bend. Failure results in increased safety risk and third party damage as above.
Fatigue	Typically includes annealing; embrittlement; necking; thermal loading; Aeolian vibration; and corrosion.	Metal fatigue can lead to open circuits (causing similar issues as described above), mechanical failure and falling to the ground. This leads to unsafe exposure of live conductors to the public and customer power outages.
Loose connections	Open circuits, high resistance joints, and corrosion	Active circuit wires – customer outages, and dim or flickering voltage. Neutral circuit wires – elevated step and touch potentials, flickering voltages, and customer shock or electrocution.
Insulation aging	Degradation from UV light exposure; abrasion from contact with structures or vegetation, and pollution	Exposure of live conductors to the public; leading to shock or electrocution
Fuse/circuit breaker degradation	Mechanical deterioration of fuse holder or circuit breaker, overcurrent, or cumulative annealing leading to failure.	Phase-phase short circuits leading to upstream customer outages.
Mains Box degradation	UV light degradation, mould and lichen, physical damage, corrosion, pollution	Energisation of metal components of customer fascia leading to shock or electrocution; short circuits of connections leading to fire; loose connections and open circuits leading to loss of supply or customer shock or electrocution.
Lightning and clashing	Direct and indirect lightning strikes can fuse or damage conductor strands and introduce over voltages that may stress line components. Electrical faults induce	Mechanical damage to bare conductor, accessories or the insulation of covered conductor. Increased risk of annealing, fatigue and breakage of conductor strands.

Factor	Influence	Impact
	significant electro-mechanical forces which can cause dramatic conductor movements, exacerbating accumulated fatigue issues.	
Animals	Animals use overhead services as “aerial highways” between houses and trees.	Mechanical damage to insulation of covered conductor.
Vegetation	Falling branches or trees may bring down live conductors. Moving branches induce rubbing damage of the insulation and conductors.	Damage to services and exposure of live conductors to the public, leading to shock or electrocution
Conductor sagging	Pole or riser movement, tensioning, thermal loading and/or mechanical loading.	Exposure of live conductors to the public leading to shock or electrocution

Table 5: Overhead Service 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 life cycle costs for the asset class and application.

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

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

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

Legacy organisation asset management practices have achieved different results for the associated regions. Asset management strategies for this class will focus upon improving shock related performance in Northern and Southern regions and maintaining or improving shock related performance in South East Region. Concurrently, continuous improvement strategies will impact across all regions.

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 *Electrical Safety Codes of Practice*.

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

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

The ESR details some requirements for overhead service lines. These include various general obligations related to the safety of works of an electrical entity and a number of specific obligations, notably:

- ESR Schedule 2 - Exclusion zones for overhead electric lines
- ESR Schedule 5 - Clearance of low voltage overhead service lines
- ESR s76(4) - “The electricity entity must at periodic reasonable intervals inspect and maintain the insulation of the clamp or apparatus”
- ESR s215 - “An electricity entity must ensure the integrity of the insulation of the relevant part of the electrical entity’s works is inspected and maintained … inspection and maintenance must be performed as periodic reasonable intervals”
- ESR s215 - “An electricity entity must ensure the integrity of insulation for the clamp or other apparatus at the point where consumer mains are connected to the electricity entity’s overhead service line is inspected and maintained … inspection and maintenance must be performed at periodic reasonable intervals.”

It is clear from the legislated requirements above that there is an intention to ensure inspection is undertaken “at periodic reasonable intervals”. Its nature and interval are defined by engineering judgement, taking into account overall safety and performance obligations.

3.3 Performance Requirements

Corporate performance outcomes for this asset are effectively rolled up into Asset Safety & Performance group objectives, principally:

- KRA – Customer Index
- KRA – Optimise investments to deliver affordable and sustainable asset solutions for our customers and communities.

Corporate Policies relating to establishing the desired level of service are detailed in the reference documents of Appendix 1.

Public shocks are monitored on a monthly basis, with shocks related to neutral integrity being the most significant factor (60-70%). Public shocks are considered notifiable events, required to be reported to the Electrical Safety Office[2].

In line with EQL's regulatory duty of care, there is an imperative to reduce the incidence of public shocks SFAIRP. As such, a set of performance targets (refer Table 6) have been introduced to actively monitor and manage the issue. The performance target for the Northern and Southern Regions are higher than the equivalent target for the South East Region at this time. Once this performance improves, there is a medium-term intention to establish a common EQL target for all regions.

Region	Performance target
Northern and Southern Regions	0.150 shocks per 1,000 customers per annum
South East Region	0.060 shocks per 1,000 customers per annum

Table 6: Performance targets for asset related public shocks[3]

3.4 Current Levels of Service

The following sections outline current levels of service across the Northern and Southern Regions and the South East Region.

3.4.1 Northern and Southern Regions

Over recent years there have been approximately 157 shocks per annum directly attributable to overhead services. This equates to 0.210 shocks per 1,000 customers per annum which is above the EQL targeted performance for Overhead Service asset related shocks of 0.15 shocks per 1,000 customers per annum.

The annual performance history in Figure 6 demonstrates that these assets have consistently been underperforming relative to the recently established (2017) EQL performance targets.

Shocks predominantly occur in coastal regions, which is consistent with population demographics.

[2] QLD Electrical Safety Regulation 2013 s267-268
[3] Source HSE Management Committee Network Safety Performance Report January 2018.pptx

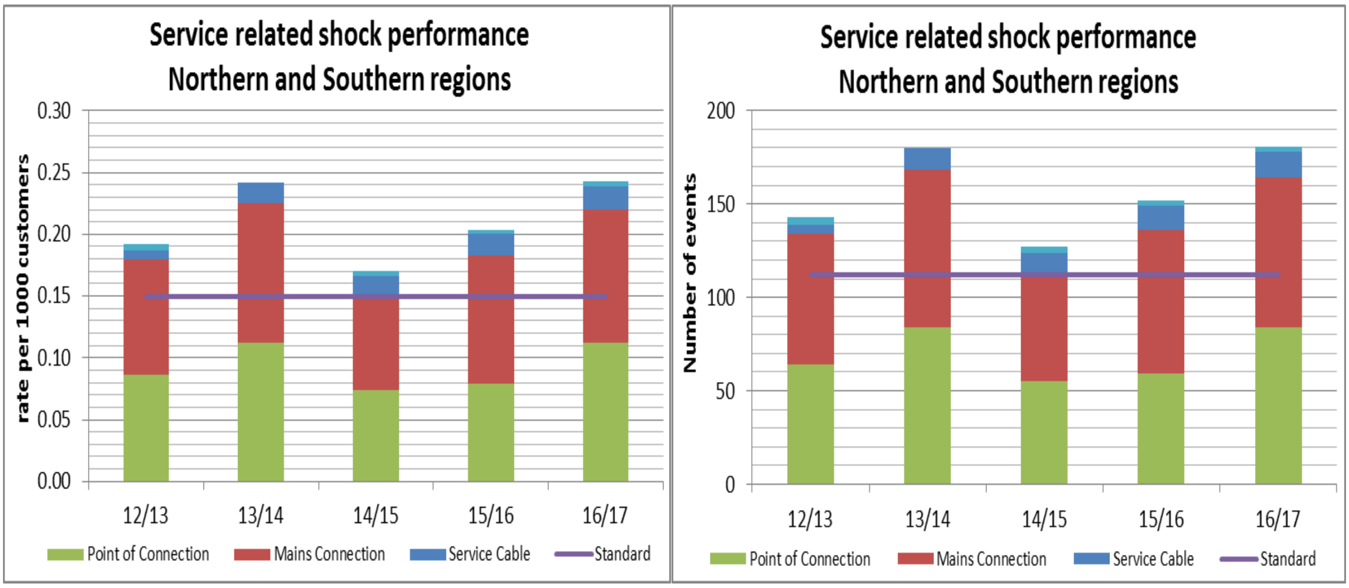
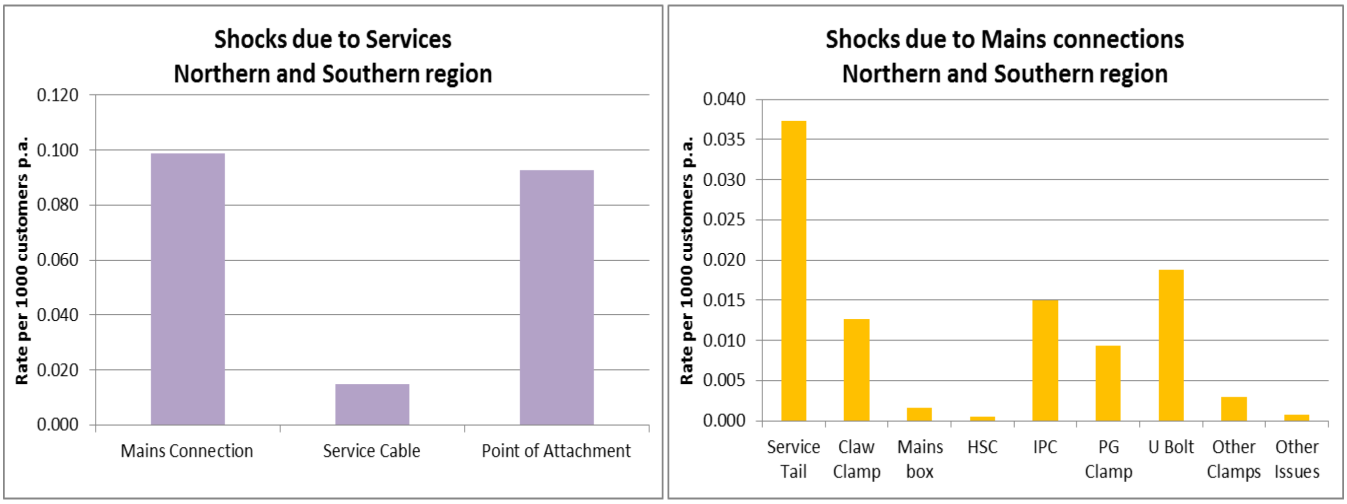
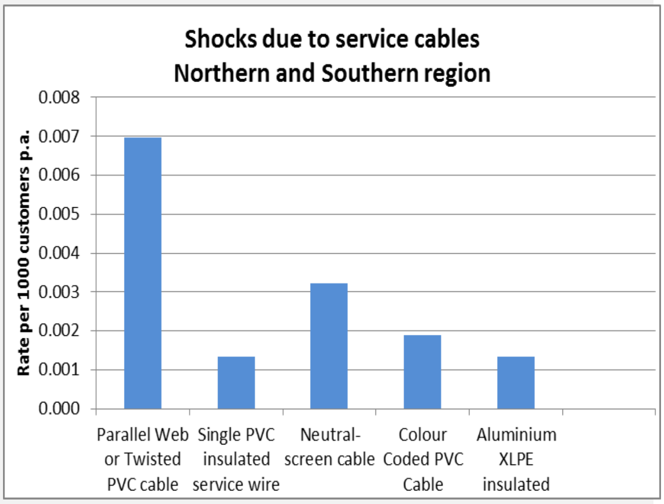


Figure 6: Overhead Service related shock performance trend – Northern and Southern Regions

Figure 7 highlights that for Northern and Southern Regions, there are significant performance issues related to mains connection boxes. These units are customer owned, however, are required to be inspected by EQL under the ESR[4]. Mains connections of all types appear to perform similarly. PVC cables (particularly parallel web or twisted multiphase PVC) are the worst performers.



[4] QLD Electrical Safety Regulation 2013 s215



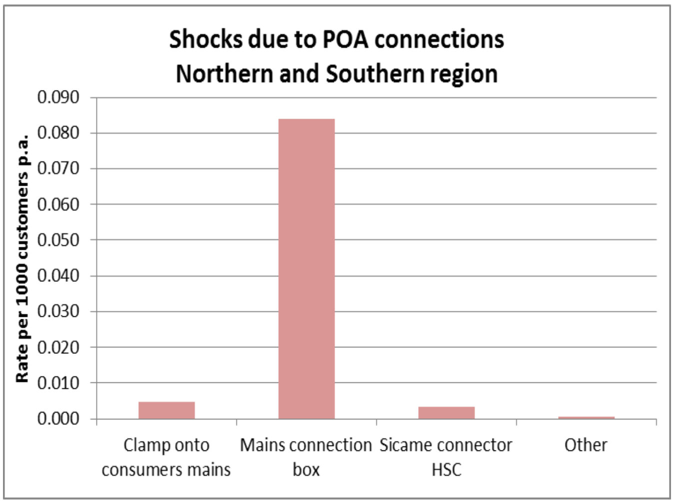


Figure 7: Average (5 year) Overhead Service shock rate – Northern and Southern Regions

Of the almost 400,000 overhead services in place in EQL Regional Queensland, approximately 100,000 are inspected annually, consistent with the regulatory performance obligation to inspect all assets. From these inspections, 43,673 overhead service connections (11%) were proactively repaired or replaced between 2011/12 to 2016/17.

In addition, a significant number of overhead services are inspected, repaired and replaced following major disasters (e.g. cyclone Debbi and Yasi). Due to the urgent nature of these repairs, there is no record of the precise number or locations of repairs which fall under this category.

Figure 8 shows the major overhead service component items that contributed to these works.

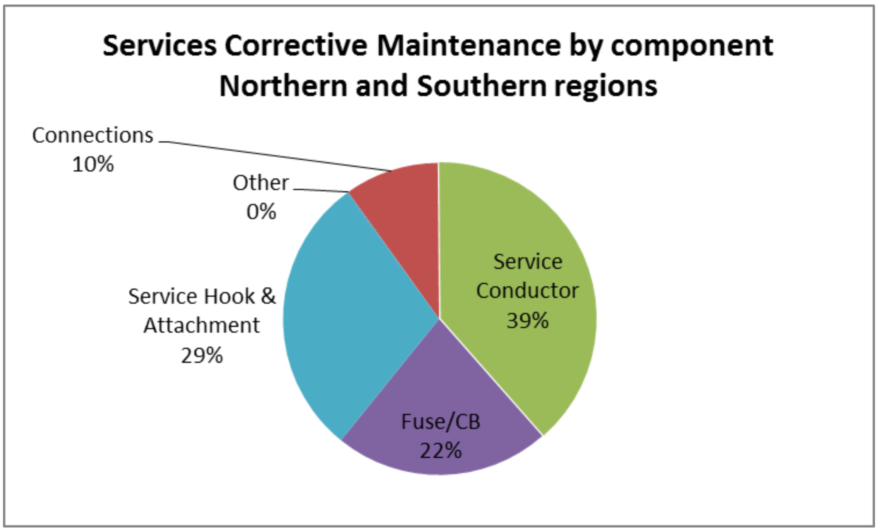


Figure 8: 6 year average defect repair focus – component and root cause – Northern and Southern Regions

Defects are repaired as corrective maintenance. Faults are typically repaired as forced maintenance.

Figure 9 details the number of actual failures of overhead services, excluding failures caused by external influences such as storms or third parties. This represents an actual failure rate of 0.34% per annum on average.

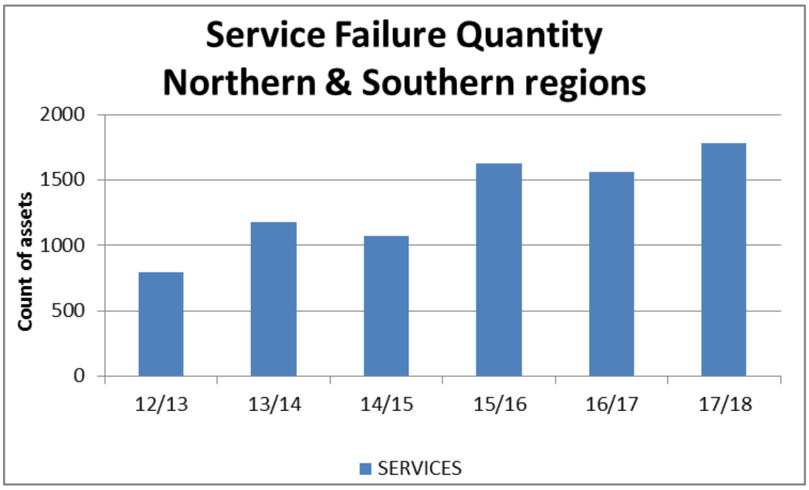


Figure 9 Overhead Service Failure Quantity – Northern and Southern Regions

3.4.2 South East Region

Over recent years there have been on average 85 shocks per annum directly attributable to overhead services as shown in Figure 10. This equates to an average of 0.059 shocks per 1,000 customers per annum, which is close to the performance requirements for the South East Region provided in Table 6.

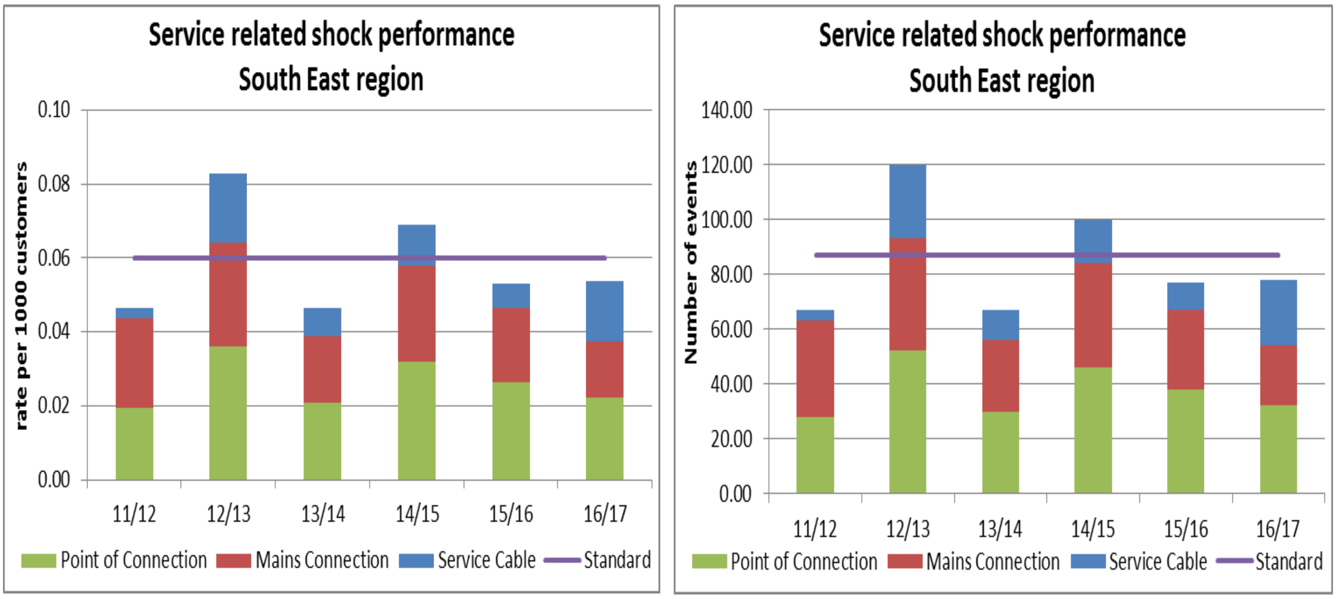


Figure 10: Overhead service related shock performance trend – South East Region

Figure 11 below shows the breakdown of the overhead service shock rate for the South East Region as an average over the last six years.

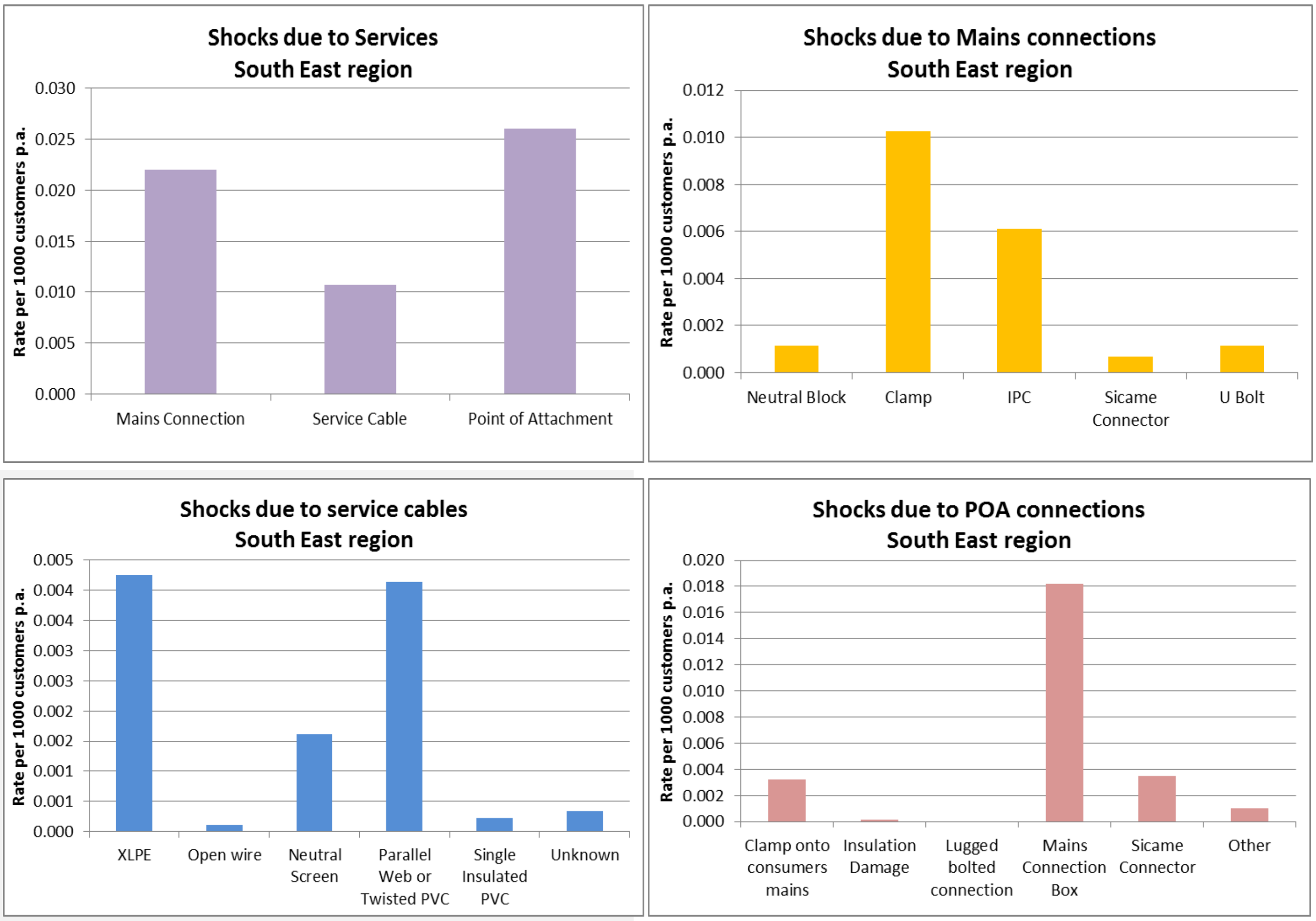


Figure 11: Average (6 years) overhead service shock rate – South East Region

Figure 11 highlights that for South East region, Mains Connection boxes continue to present performance issues. Mains Connection boxes are customer owned but required by regulations to be inspected by EQL. Clamp connections appear to present the most prevalent contributor to shock for mains-services connections. PVC cables, particularly parallel web or twisted multiphase PVC, are the worst performers.

Given XPLE insulated cables are the more modern and current standard in use and that XLPE service cables make up around 70% of the population, the table reflects that both age and technology are influencing asset performance. The lifecycle strategies outlined in Section 9 reflect the different failure rates in the treatment of the different types of cable.

Figure 11 highlights the essential reasons for legacy organisation Energex's asset management approach for services. Connections contribute to around 80% of public shocks involving Services, divided relatively evenly between the mains connections and the customer point of connection. Replacement of problematic services directly targets the two largest root causes of shocks.

Figure 12 shows a focus summary of recent proactive and reactive repair works that have been conducted on overhead services. This supports that EQL is meeting its regulatory obligation to inspect and maintain its assets. The reporting data system (MSSS) was implemented in South East Region on 1 July 2017, and as such, the chart presents 11 months of data.

Inspection defects are repaired as corrective maintenance. Faults are typically repaired as forced maintenance.

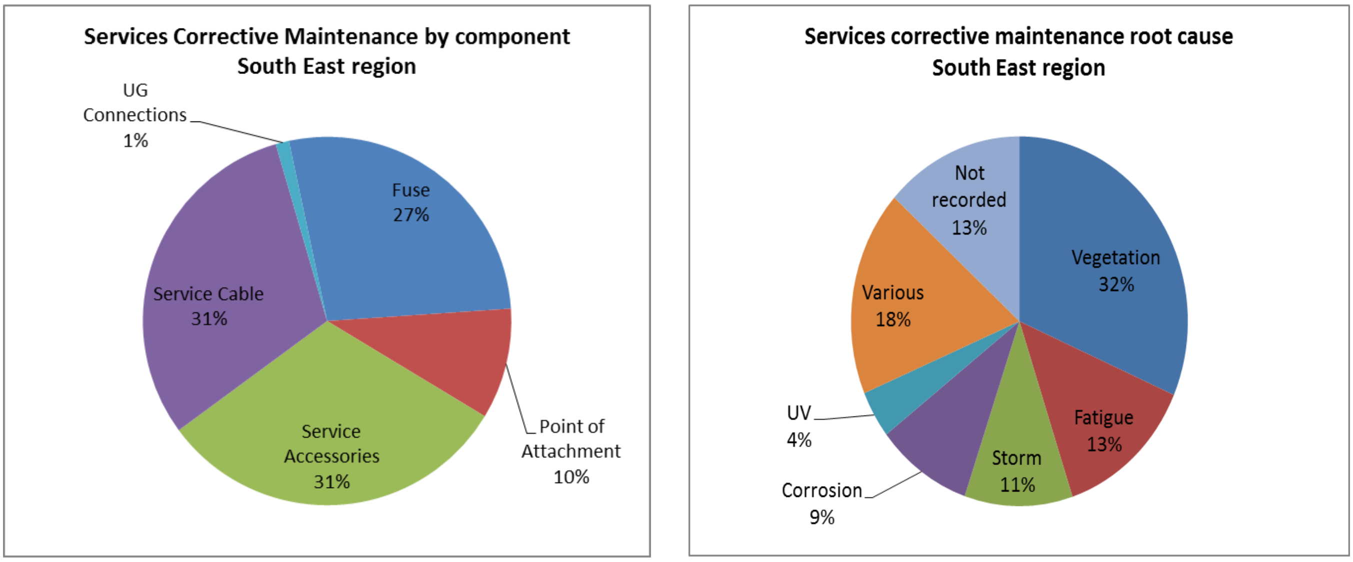


Figure 12: 17/18 Defect repair focus – component and root cause – South East Region

Figure 13 details the number of actual failures of overhead services, excluding failures caused by external influences such as storms or third parties. This represents an actual failure rate of 0.21% per annum.

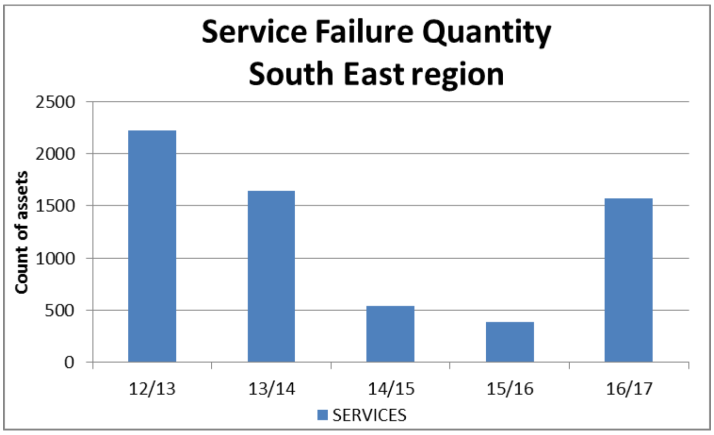


Figure 13: Overhead service failure quantity – South East Region

4 Asset Related Corporate Risk

As detailed in Section 3.2, Queensland legislation details that EQL has a duty to ensure its works are electrically safe. This safety duty requires that EQL 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[5]. Risks in all other categories are managed to levels as low as reasonably practicable (ALARP).

Figure 14 provides a threat-barrier diagram for EQL overhead services assets. Many threats are unable to be controlled (e.g. third party damage), although EQL undertakes a number of actions to mitigate them SFAIRP/ALARP. Failure of an overhead service risks public and staff safety in several ways, most notably:

- bringing energised electrical conductors to easily accessible heights, risking public contact, shock and electrocution;

[5] Queensland Electrical Safety Act 2002 s10 and s29

- neutral circuit failure leading to potential shock and electrocution within the customer premises; and
- loss of supply to customer premises.

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

The asset performance standards described in Section 3 detail EQLs achievements to date in respect of this safety duty. The following sections detail the ongoing asset management journey necessary to continue to achieve to high performance standards into the future. Action items have been raised in the following sections where relevant, detailing the specific actions that EQL will undertake as part of program delivery of this Asset Management Plan.

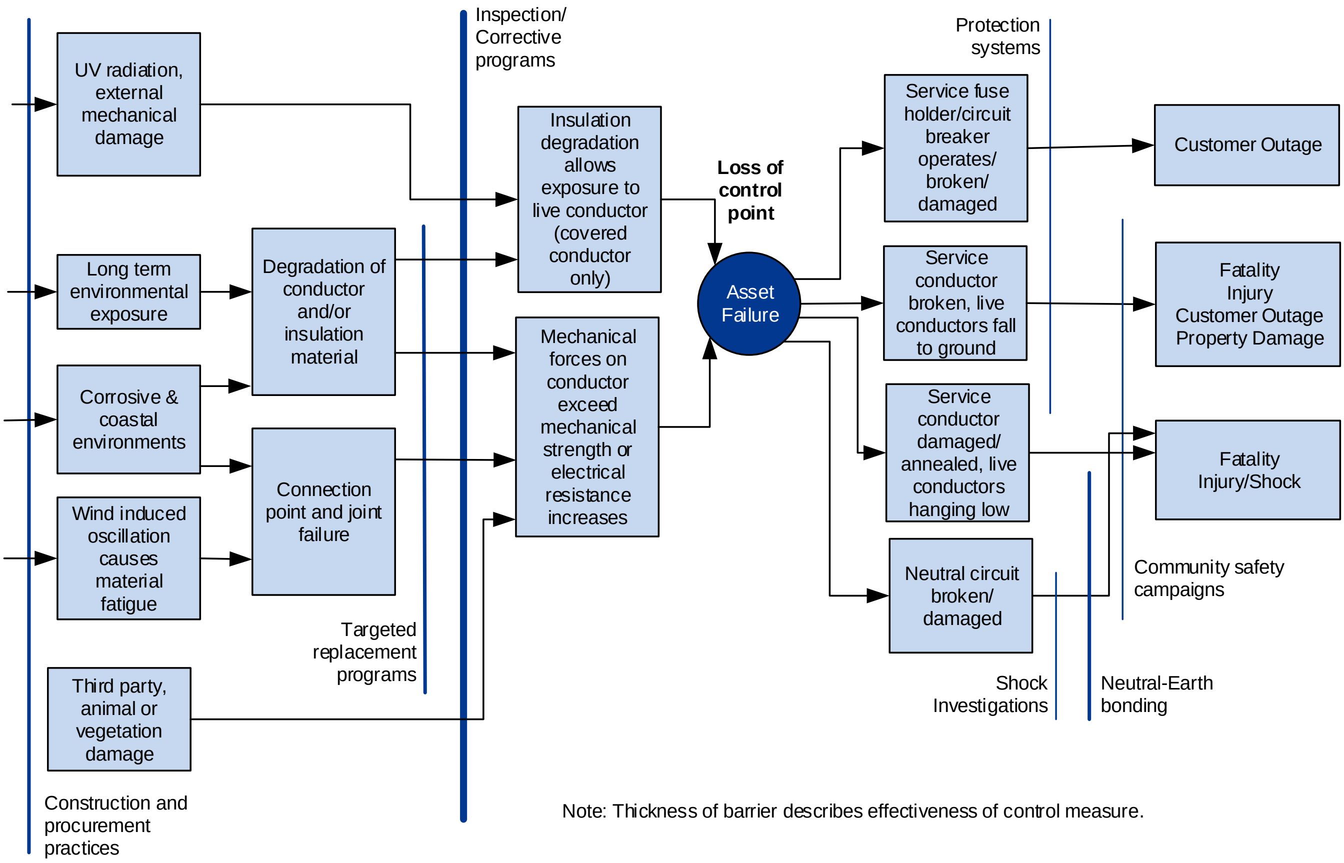


Figure 14: Threat-Barrier Diagram for Overhead Services

5 Health, Safety & Environment

There are no known health, safety and environmental issues associated with materials, handling or disposal of service cables or components.

The relationship between overhead services and public shocks is discussed in Section 3.

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 Obsolete Claw Clamps and Split Bolt Connector Replacements

Energex identified that these types of connectors no longer provide the necessary structural connection for continued operation and are being proactively replaced. EQL continues this approach.

The recorded failure rate for this issue is low in Northern and Southern Regions. Split bolts have not been included in overhead design standards for around 12 years, with IPCs being the preferred standard.

The identification of obsolete claw clamps and split bolt connectors is taking place as part of the Pole Inspection Program, which is scheduled for completion around 2022. In the Northern and Southern Regions, current asset performance (refer Figure 7) suggests ongoing monitoring will be adequate to identify potential replacements.

6.2 Sicame PF100 Fuse Holder Base Replacement Program

Energex identified that these fuse-bases are capable of splitting, which in certain circumstances can cause electrical faults and pole fires. The identification of these faulty fuses is taking place as part of the pole inspection program, which is scheduled for completion around 2021.

In the Northern and Southern Regions, current asset performance suggests ongoing monitoring will be adequate to identify potential replacements.

6.3 Sicame PT100 Fuse Replacement Program

Ergon Energy identified that these fuse types are capable of overheating as they degrade with age. Ergon Energy identified that while there is a low risk of overheating with Sicame PT100 non-ceramic fuses, any overheating while mounted on a customer fascia may result in fire and damage to the property.

Ergon Energy initiated a proactive replacement program to remove all Sicame fuses from customer fascias. EQL has continued this program. Under this program 1,481 Non-ceramic Fuses are planned to be replaced by June 2019. The fuses were identified by use of a C3 criterion under the inspection and defect process. Once the program is completed, the C3 designation will be upgraded to P2 to ensure any units missed will be subsequently found and replaced.

This installation practice did not occur in South East Region and therefore a replacement program is not required.

6.4 PVC Overhead Services Replacement

Energex identified that the South East Region defect rate of PVC insulated services by the inspection program has been around 25%, however, it is anticipated that this replacement rate will be significantly reduced as the periodic inspection process completes its cycle. As such, the rate of PVC overhead service cable defects is expected to fall dramatically over the next few years. Current replacement rate is around 6,500 per year.

South East Region PVC insulated services defect rate continues to be monitored.

6.5 Colour Coded Overhead Services Replacement

Coloured strips are used in the insulation for PVC Insulated colour coded services for phase identification. Ergon Energy identified a risk that the insulation of flat PVC insulated (commonly called “Figure 8”) and twisted colour coded services can prematurely degrade after prolonged exposure to the UV radiation. On investigation, it was identified the degradation was due to lower than specification carbon black content in the coloured strip material. Carbon black is a common UV stabiliser used to extend the life of the insulation.

Figure 8 colour coded services on the Northern and Southern Regions networks were targeted in a proactive replacement program which was completed in May 2016. The remaining Figure 8 and all twisted colour coded services with no deterioration/damage have also subsequently been added as a C3 record in the Line Defect Classification Manual to identify these types of overhead services during asset inspection. This will support a proactive replacement regime should the defect detection rate start to rise.

Ongoing performance of the asset population is being monitored.

6.6 Neutral Screened Overhead Services Replacement

Ergon Energy identified a risk of insulation failure with neutral screened services as a result of investigation of number of incidents including other electricity entities. The colour coded core insulation of the neutral screened service conductors is susceptible to premature degradation when exposed to UV radiation. There is also a risk of corroded copper screen over time due to moisture ingress if the heat shrink is not applied on the termination. The failure rates of neutral screened overhead services with taped connections are higher than those with a heat shrink glove applied.

Ergon Energy adopted a proactive approach to the identification of neutral screened services, and now records a C3 record where a neutral screened service has been installed without heat shrink gloves on the termination. This helps to identify locations and quantities of replacements/repairs for future work programs.

A sample of approximately 60 neutral screened services was recovered for further analysis during the open wire service replacement Program of 2012-2015. Based on the results of sampling and analysing various options, a dedicated proactive replacement program targeting neutral screened overhead services were performed in Far North region, which has the highest prevalence of UV exposure.

Performance of the asset population is being monitored.

6.7 Mitti Overhead Services Replacement

An issue with insulation deterioration of XLPE Mitti type customer service cables was identified in South East Region in 2011. These overhead service cables were installed between 2004 and 2007 and had experienced insulation failure on the top surface of the cable due to UV degradation.

As a precautionary measure, an audit program was established in some specific areas across Northern and Southern Regions to check any insulation deterioration of this particular type of XLPE cable. At the time, Ergon Energy could not confirm any widespread or major deterioration on any overhead service cables.

There are, as yet, no systemic failures of this type of customer service cable relating to insulating degradation in Northern and Southern Regions and hence there is currently insufficient evidence to support significant action. This is possible because the inspection process has already identified and replaced such defective services.

Performance of the asset population is being monitored.

6.8 Planned Replacement Program – Northern and Southern Regions

EQL has determined that the annual number of reported shocks arising from overhead service neutral components needs to be substantially reduced. Given the visual inspection regime already in place, a change in strategic approach is considered the most appropriate method to improve this performance.

EQL has established a planned services replacement program which has been initiated in the Northern and Southern Regions. Initially, the identified problematic service cable types are being targeted (colour coded, neutral screened), generally focussing on the coastal communities where the majority of shocks are being reported.

6.9 Planned Replacement Program – South East Region

Energex identified significant risks related to the insulation of several asset types (open wire, MITTI and concentric neutral) and commenced a proactive replacement program.

The program currently consists of around 3,500 replacements per year. This program is currently scheduled to complete around 2022. Completion or ongoing continuation of this program needs to be reviewed.

6.10 Neutral Connection Integrity

For many years Energex employed double clamping of neutral connections, while Ergon Energy did not.

EQL has adopted a policy that requires application of double clamping to neutral circuit assets as a prudent means of managing public shock risk. Standard overhead line designs incorporating double clamped neutral circuit connections have been published and implemented. As service lines are replaced, they will employ double clamping for neutral connections.

Based upon current asset performance shock volumes, there are no immediate plans to implement a dedicated program to retrofit neutral double clamping. The situation is being monitored.

6.11 Unsupported Terminations

Unsupported overhead services are service cables that rely upon the electrical terminations or the conductors themselves to achieve the mechanical tension and support of the overhead service conductor, either by wrapping around the mains conductor or some other means of support at supply end. Unsupported Services connections tend to be more rigid when compared to supported Service lines, and therefore tend to suffer more readily from metal fatigue. Current EQL standards now require supported mechanisms only.

Table 7 details the number of unsupported service lines in Northern and Southern Regions, and the year of identification. Locational data has been recorded under the inspection and defect management program.

Region	2008-09	2009-10	2010-11	2011-12	2012-13	2013-14	2014-15	Grand Total
Northern	1,620	2,063	3,313	11,122	9,967	11,381	11,400	50,866
Southern	1,246	1,625	2,648	8,772	6,366	7,770	7,292	35,719
Grand Total	2,866	3,688	5,961	19,894	16,333	19,151	18,692	86,585

Table 7: Number of unsupported Overhead Service lines – Northern and Southern Regions

The condition-based programs and the planned replacement programs will progressively remove unsupported overhead services lines from EQL's network over time. Trends in performance will continue to be monitored to determine whether an acceleration of the replacement is required.

6.12 Customer Point of Attachment

EQL, in supplying electricity to a customer, must decide the location of its fuses; circuit breakers disconnect links and other apparatus in accordance with recognised practice[6]. This technical detail is documented and published in the Queensland Electricity Connection and Metering Manual. The provision and location of the connection is the responsibility of the consumer[7], within the technical constraints described in the Manual.

As described in Section 3.1, ESR s215 requires EQL to ensure that the integrity of insulation for the clamp or other apparatus at the point where consumer mains are connected to the EQL's overhead service line are inspected and maintained.

In previous overhead service replacement programs both Ergon Energy and Energex replaced, repaired and relocated points of attachment (POA) and connections in some situations (but not all) and absorbed the associated costs of these activities, despite ownership and maintenance responsibility belonging to the customer. In doing so, Ergon Energy and Energex effectively accepted partial liability for the customer's assets.

The above approach is changing under EQL such that where the POA and connection is unable to be safely accessed and inspected by EQL staff (or customer works have created situations where the overhead service line or connections are readily accessible to others (e.g. installed a pool or shed)) EQL staff will issue the customer with:

- an improvement notice (Form B or Form 3) if immediate customer action is required, or

[6] QLD Electrical Safety Regulation 2013 s211(1)
[7] QLD Electrical Safety Regulation 2013 s211(2)

- a notification of concern if the POA is in a location that may prevent future access.

The notice will detail the issue, recommending that the customer engage an electrician to move the POA to a more suitable location or take action to prevent accessibility by others. EQL may also initiate a follow-up inspection to ensure the issue is managed.

If an immediate unsafe condition exists, the situation will be resolved directly by repair or disconnection of supply, consistent with EQL's regulatory obligations and safe working practices.

7 Emerging Issues

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

7.1 Overhead Service Line Neutral Bonds

A short audit occurred in selected communities (just 10 sites in each of 5 regional centres in Northern and Southern Regions) following an investigation into correct installation of Overhead Service line neutral bonds. One sub-region (Mackay) was found to have an abnormally high number of inadequate installations.

Action 7.1-1: Investigate a larger more comprehensive overhead service line neutral bond audit specifically in the Mackay sub-region to identify inadequate installations.

7.2 Customer Mains Box Performance

Most Mains Boxes are customer owned, however by legislation EQL is required to inspect them.

The shock analysis discussed in Section 3.4 has resulted in an audit of 1,000 overhead services to determine general condition of various components including Mains Boxes. The audit was conducted in the first few months of 2018 and consisted of an average of 45 detailed and close inspections of overhead services connections in each of the larger regional communities and in three separated regions in the South East Region.

Results from the audit reveal that across EQL, around 5% of Mains Boxes were broken or damaged and that almost 6% had some form of significant neutral connection issue in the Mains Box. In Northern and Southern Regions, around 7% had some form of significant Mains Box issue, and despite a smaller sample volume (166) in South East Region, just over 1% had mains box issues.

The audit outcomes suggest that there may be problematic mains box types in overhead service and that there would be a benefit in identifying the types and models of mains boxes in overhead service at all locations, to potentially correlate for future targeted remediation programs.

The audit results support the information presented in Sections 3.4.1 and 3.4.2.

The results suggest a targeted mains box inspection program will be an effective shock mitigation measure.

Action 7.2-1: Review outcomes of overhead services audit and formulate suitable action plans to reduce risk of shocks.

7.3 Overhead Service Cable Ductile Failure

Following an investigation involving an overhead service neutral line, a small volume (25) of similar overhead services in the near vicinity were removed and subjected to tensile and metallurgical analysis. Two (2) overhead services failed during removal due to ductile failure. The stressed locations were covered by insulation. Ductile degradation and failure are typically caused by application of a physical force pulling and stretching the conductor metal. Causes of such force are typically falling debris from trees or very high winds from events such as cyclones.

Action 7.3-1: Develop prudent and efficient criteria to identify ductile failure in overhead service cable. Determine if a targeted inspection program following severe weather events such as cyclones is warranted to identify and mitigate the risk of this failure mode.

7.4 Loss of Customer Earth Reference

An investigation occurred into a serious electrical incident relating to a shock received as a result of cutting through a metallic water pipe used as the neutral earthing point.

The situation is a known safety hazard, identified in Australian Standards for plumbing works with suitable safety systems recommended and mandated. The situation can be mitigated substantially by use of a dedicated copper earth stake as the main neutral earthing point of the consumer-owned switchboard, which was included in electrical standards and regulations around 1977. There is no regulatory imperative to retrofit earth stakes to customer switchboards.

There is a high likelihood that premises built before 1977 will still employ the metallic water pipe system. The audit mentioned in Section 7.2 identified that just 3% of sites (2.9% EQL, 13.2% South East Region, and 0.2% in Northern and Southern Regions) are likely not to employ copper earthing stakes. The sample size (1,011) is quite small compared to the total number of 990,000 overhead services and may not represent a sufficient sample size to provide statistical confidence in these conclusions; however, the information represents the best information to date.

While the choice of neutral earthing method is the responsibility of the premise owner, the existence of reliable earth is relied upon as a partial defence against the risk of failure of the EQL neutral circuit. There is no legislation requiring premise owners to inspect and maintain the neutral earthing system.

EQL approached the Electrical Safety Office with a view to amending legislation to require mandatory use of a separate earth stake, however, this amendment has been denied.

Action 7.4-1: Investigate an EQL program that promotes the retrofit of dedicated copper stake earths on legacy installations that rely on the outdated practice of using metallic water pipes as the earthing medium to minimise the risk of shock.

7.5 Private Overhead Electric Lines

While inspecting Northern and Southern region line assets, asset inspectors also proactively inspect private overhead electric lines (POEL) to identify and report any immediate safety risks in accordance with Section 15 of the Lines Defect Classification Manual (LDCM). Inspection is visual only and from the EQL asset.

If an urgent safety risk is identified, asset Inspectors notify EQL that immediate disconnection is required to ensure the safety of people and property. For non-urgent POEL issues, asset inspectors issue a notification letter to the customer for rectification.

While South East Region line asset inspectors also identify and report any obvious safety risks associated with POEL, the formal inspection and recording practice is not built into the inspection process.

Action 7.5-1: Align the inspection and defect recording process across EQL for private overhead electric lines assets.

8 Improvements 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 Inspection Process Alignment

While both legacy organisations employed a common set of standard processes and inspection defect benchmarks, the practical implementation of the work across the organisations has varied. This difference has developed as a result of different approaches to use of contractors for different tasks, differing contractual obligations, differing asset environments (e.g. CBD vs long rural), differing routine travel distance, diversity of environments promoting different work practices, and differing corporate direction and policy.

With the establishment of EQL, there is intent to merge these practices, policies and procedures where prudent such as where contracts fall due and are renewed, where opportunities for common approach become evident and overhead service delivery performance improvement opportunities arise.

This AMP and its various revisions will effectively document this journey.

Ground based overhead inspections and house-end overhead service line inspections are currently undertaken together in the Northern and Southern Regions, using a mirror stick and stabilised binoculars. The South East Region inspection method employs an inspection of the insulation of the cable from the ground, coupled with an independent program performing a ladder-based inspection of the customer connection. In the Northern and Southern Regions inspection method, the connections at the mains box are inspected from the ground only. In the South East Region, the overhead service cable is inspected from the ground without additional tools. There are potential efficiencies to be gained through inspecting these assets together and consistently, particularly in batching any rectification works together.

There are also further opportunities to align inspection processes through upcoming contract negotiations:

- Energex house-end inspections (2018 renegotiation)
- Energex ground based overhead inspections (2019 renegotiation)
- Ergon Energy combined pole and house-end inspections (2020).

Consideration should be given to aligning the processes between these network areas (in the medium term) to yield Queensland-wide benefits for EQL customers.

Action 8.1-1: Merge pole and overhead services inspections into integrated tasks in South East Region, consistent with Northern and Southern Regions inspection processes.

8.2 Shock Reporting Alignment

EQL's legacy organisations identified and recorded shocks differently. For example, Energex employed a >10 volt threshold to be counted as a "shock"; whereas, Ergon Energy recorded all reports even if the voltage was unable to be repeated. EQL is currently reviewing these existing reporting practices with a view to alignment. This will have some impact on the analysis of this AMP going forward.

8.3 Smart Device Usage

As technology evolves the use of smart devices on the network to deliver customer benefits and risk mitigation becomes more viable and cost effective. Such technology has been successfully trialled in applications on the LV network such as power quality metering where the information has not only been used to manage voltage on a network but also to help identify safety issues such as broken neutrals during investigations. These applications have identified potential for use of sensor technology and smart devices at an overhead service line level to assess condition and reduce the volume of customer shocks.

EQL is considering the benefits of switchboard mounted smart devices intended to identify neutral integrity issues and neutral earthing issues. In concept, the smart devices will transmit alarms to a central location(s) and prompt for immediate remediation action.

To define suitable functionality and performance goals a trial is being considered to confirm appropriate and potential functionality, the costs required, potential benefits to be gained and understanding of the issues that will arise as part of the implementation. The trial will need to establish the internal processes and systems appropriate to the overall intent and establish the regulatory issues that will need to be managed.

8.4 Overhead Service Line Circuit Loop Testing

EQL commissioned an internal report about overall Overhead Service line performance. The report has recommended consideration of a program targeted at performing a circuit loop test on each overhead service on a periodic basis. With around 990,000 overhead service cables to be inspected, the cost of such an inspection will be in the order of $100M-$150M per inspection cycle and almost matching the cost of replacement.

A dedicated program to perform overhead service loop impedance testing is not being considered at this time. Until an innovative cost effective alternative (e.g. an internet of things (IoT) monitoring system, or possibly a smart meter system) can be developed, the expense of this approach is considered to outweigh the potential benefits to the community.

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

EQL actively manages overhead service lines using a combination of condition based visual assessment and preventative maintenance tasks, which include:

- periodic visual inspection of physical condition and immediate environment,
- routine maintenance activities to ensure correct functionality,
- earthing system integrity testing,
- identified defects are resolved through the Corrective Maintenance Program,
- failed assets are replaced under the Failed Overhead Service Program,
- problematic assets are replaced under targeted works programs.

Under the inspection process, overhead service lines are assessed according to a set of pass/fail benchmark criteria documented in the LDCM. Individual benchmark failure records are labelled as “defects”. The benchmark criteria are reviewed periodically based upon overall overhead service line population failure and refurbishment statistics as well as reported situational circumstances that have been encountered.

Defects are scheduled for repair according to a documented risk-based priority scheme. Actual individual repair periods are recorded and monitored, with performance criteria established for the population repair period statistics.

Customers are encouraged to report all shocks and tingles experienced wires down and other common electrical safety hazards. Periodic advertising campaigns on various media are used to reinforce the messages. All reports of hazards from customers are investigated and reported upon.

9.2 Supporting Data Requirements

Historically, recording installation age for overhead services was not considered a cost-effective asset management practice. However, advancements in technology, asset management disciplines and corporate external reporting imperatives have together acted to change this approach. The South East Region has commenced recording the date of overhead service installation as of early 2016, and Northern and Southern Regions have yet to commence recording overhead service installation date. The age and type of overhead services installed is expected to provide valuable asset management information once sufficient portions of the population are recorded.

In the South East Region, overhead services data is being progressively mapped into the corporate Graphical Information System (GIS) to support better systemic analysis.

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. 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.

9.3 Acquisition and Procurement

Assets are created when new overhead service lines are installed, existing overhead service lines are upgraded or extended, or when overhead service lines are replaced.

Most councils now prefer use of underground distribution in new urban land developments, which has significantly reduced the occurrences of new overhead service line installations. Subsequently, this has substantially limited the natural volume expansion of this asset class. The extent of new overhead services is left to small re-developments of existing residential or commercial stock within overhead areas.

Across EQL, the overall asset growth rate is approximately 0-0.5%.

Overhead service lines are purchased in drum rolls of 500 metres with drums routinely placed at all depots and main stores. Procurement is routinely managed as stores inventory, with periodic contracts in place to maximise purchase efficiency. Typical usage is around 25 metres per installation.

EQL procurement policy and practices align with the 2017 Queensland Government procurement policies. There are no known procurement risks related to overhead services components other than normal market-based purchasing risks.

9.4 Operation and Maintenance

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

9.4.1 Preventive maintenance

EQL undertakes an inspection program of each of its overhead service cables and connection assets as part of the existing pole inspections programs. These include the following activities:

- visual inspection of the point of connection of the customer Overhead Service at the supply side (mains) using image-stabilised binoculars;
- inspecting the full length of the customer overhead service using electronic image-stabilised binoculars;
- recording any section of the overhead service or customer point of connection that cannot be viewed clearly;
- visually observing the top and bottom surfaces of the last 1.5 metres of the overhead service conductor, point of connection, customers' mains tails, the overhead service connections and bonding using a concave mirror and image-stabilised binoculars;
- visually inspecting the customer owned point of customer connection; and
- visually inspecting the customer mains box of problematic overhead service cable types.

This program also identifies problematic asset types such as MITTI, concentric neutral and open wire overhead service cables and Sicame fuse bases, which are corrected or replaced via targeted programs of work (refurbishment and replacement). The LDCM defines benchmark defect definitions and level of repair urgency (P1 / P2 / C3 / no defect) for these activities.

Physical defects identified through inspection are repaired, or the asset is replaced through the Line Defect Refurbishment Program (corrective and forced maintenance).

9.4.2 Corrective and forced maintenance

Corrective maintenance is generated from preventive maintenance programs, ad-hoc inspections, public reports and in-service failure. 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.

Due to the low cost of replacement of overhead service cables and associated fittings (typically less than $2,000 per complete overhead service), overhead service lines or their associated equipment are often replaced rather than repaired. Routine corrective maintenance of overhead service lines therefore typically consists of low cost peripheral works at the mains connection end or the point of connection, such as re-insulating a bolted connection. The Overhead Construction Manual defines the repair standards for all overhead service line installations.

9.4.3 Spares

Overhead service cable is procured as described in Section 9.3, and is available for purchase and delivery within days if necessary. Therefore, this asset is not considered a strategic or critical spare. A minimum warehouse stock level is maintained based on historic usage and known future requirements.

IPCs and other clamps and connectors are held in stock at all depots and stored in small volumes on all trucks. Clamps and connectors are available within days of order from suppliers if required. As such, these components are not considered a strategic or critical spare. A minimum warehouse stock level 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

Refurbishment involves replacing faulty/ageing components to restore an asset to achieve its original designed functional performance. The following refurbishment programs are in progress or planned:

- Obsolete claw clamps and split bolt connector replacements (South East Region - Refer to Section 6.1).
- Sicame PF100 Fuse-holder Base Replacement Program (South East Region - Refer to Section 6.2).
- Sicame PT100 fuse Replacement Program (Northern and Southern Regions - Refer to Section 6.3).

9.5.2 Replacement

Replacement involves complete asset replacement, to ensure the asset continues to achieve modern day functional performance expectations. The following replacement programs are in progress or planned:

- PVC overhead services replacement (South East Region - Refer to Section 6.4).
- Aged and problematic overhead services replacement (Northern and Southern Regions - Refer to Section 6.5).
- Targeted replacement programs (Refer to Sections 6.8 and 6.9).

9.6 Disposal

An asset disposal program for Services is currently in place, which recovers various metals from the field as part of the metal recycling and scrapping programs for both Ergon Energy and Energex.

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

Action 7.1-1: Investigate a larger more comprehensive overhead service line neutral bond audit specifically in the Mackay sub-region to identify inadequate installations.

Action 7.2-1: Review outcomes of overhead services audit and formulate suitable action plans to reduce risk of shocks.

Action 7.3-1: Develop prudent and efficient criteria to identify ductile failure in overhead service cable. Determine if a targeted inspection program following severe weather events such as cyclones is warranted to identify and mitigate the risk of this failure mode.

Action 7.4-1: Investigate an EQL program that promotes the retrofit of dedicated copper stake earths on legacy installations that rely on the outdated practice of using metallic water pipes as the earthing medium to minimise the risk of shock.

Action 7.5-1: Align the inspection and defect recording process across EQL for private overhead electric lines assets.

Action 8.1-1: Merge pole and overhead services inspections into integrated tasks in South East Region, consistent with Northern and Southern Regions inspection processes.

Appendix 1. References

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

Organisation	Document Number	Title	Type
Ergon Energy Energex	EPONW01 EX 03595	Network Asset Management Policy	Policy
Ergon Energy Energex	PRNF001 EX 03596	Protocol for Network Maintenance	Protocol
Ergon Energy Energex	PRNF003 EX 04080	Protocol for Refurbishment and Replacement	Protocol
Ergon Energy Energex	STNW0330 EX 03918	Standard for Network Assets Defect/Condition Prioritisation	Standard
Ergon Energy Energex	STNW1160 EX STD00299	Maintenance Acceptance Criteria	Manual
Ergon Energy Energex		Lines Defect Classification Manual	Manual
Ergon Energy Energex	NA000403R328 EX 00294	QLD Electricity and Metering Manual	Manual
Ergon Energy Energex	STNW1140 EX BMS04145	Standard for Overhead Pole Lines	Standard
Ergon Energy	EP26	Risk Management Policy	Policy
Ergon Energy	SGNW0004	Network Optimisation Asset Strategy	Strategy
Ergon Energy	STNW0717	Standard for Preventive Maintenance Programs for 2017-18	Standard
Energex	00569	Network Risk Assessment	Procedure
Energex		Work Category Specification 5.6.	
Energex		Work Category Specification 12.3	
Energex	WP9435	Low voltage overhead services	Work Practice

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 purpose 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 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
ALARP	As low as reasonably practicable
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	Queensland Electricity Safety Code of Practice
ESR	Queensland Electrical Safety Regulation (2013)
HV	High voltage
IoT	Internet of Things
ISCA	In-Service Condition Assessment
LDCM	Lines Defect Classification Manual
LV	Low Voltage
LVR	Low voltage regulator
MSS	Minimum Service Standard
MSSS	Maintenance Strategy Support System
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

Abbreviation or acronym	Definition
RIN	Regulatory Information Notice
RMU	Ring Main Unit
SCAMS	Substation Contingency Asset Management System
SDCM	Substation Defect Classification Manual
SFAIRP	So far as is reasonably practicable
SHI	Security and Hazard Inspection
SVC	Static VAR Compensator
THD	Total Harmonic Distortion
VT	Voltage Transformer
WCP	Water Content of Paper
WTI	Winding Temperature Indicators
WTP	Wet Transformer Profile