Service Cables

AMS– Electricity Distribution Network

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Table of Contents

1 Executive Summary

This document is part of the suite of Asset Management Strategies relating to AusNet Services' electricity distribution network. The purpose of this strategy is to outline the inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of service cable connecting customers to low voltage (LV) circuits in AusNet Service's electricity distribution network.

This asset management strategy applies to the overhead and underground service cables that connect customers to the LV circuits in the electricity distribution network.

There are approximately 245,000 XLPE underground and 290,000 Overhead service cables in AusNet Services' URD and OH distribution network, respectively. Among the overhead service cables, Twisted Black XLPE service cables has the largest percentage at 59%, followed by Twisted Grey service cables at 35%, Neutral Screen service cables at 5%, and the remaining 1% is comprised of obsolete types.

Condition assessment shows that approximately 60% of the fleet are in "Very Good" to "Average" condition (C1 to C3), while 35% are in "Poor" condition (C4) and 5% are in "Very Poor" (C5) condition. Majority of the service cables that are in C5 condition are Neutral Screens.

The risk assessment methodology undertaken considers as inputs, the probability of failure, consequences of a failure and cost of replacement. The Benefit gained for each option is calculated by obtaining the difference in probability of failure (for doing the action) multiplied by the consequence. The NPV of a particular option is calculated by subtracting the Cost of the option from the Benefits gained. The Recommended Option is determined by identifying the option with the highest NPV.

The semi-quantitative risk assessment indicates that for the period 2022–26, the replacement of 4,540 service cables is to be undertaken using a mix of proactive and end-of-life replacements. The assets to be targeted are those that have the worse condition and the highest consequence of a failure.

Ongoing proactive management of service cable installation, inspection, maintenance and replacement practice is required to ensure AusNet Services meet stakeholder expectations of cost, safety, reliability and environmental performance. The summary of proposed asset strategies are listed below.

1.1 Asset Strategies

1.1.1 New Assets

- Install XLPE insulated underground service cables to connect new customers in the URD areas
- Install XLPE insulated aerial service cables to connect new customers in overhead distribution areas

1.1.2 Condition Monitoring

- Monitor failure performance and failure modes of each type of service cable.
- Monitor failure performance of Twisted Grey PVC Aluminium service cables to quantify if preventative connection testing and remediation is economic.
- Capture relevant data of failures in AMS for effective management of service cables.

1.1.3 Maintenance

- Analyse AMI meter data and dispatch fault crews to emerging service cable failures, e.g. Loss of Neutral to mitigate risk of electrical shocks in customers' premises.
- Maintain service cable height risk management in accordance with the 'Aerial Lines and Service Cables Clearance Management Plan' 30-2669.

- Continue to replace neutral screened service cables in conjunction with other maintenance works such as deteriorated LV cross arm replacements and deteriorated timber pole replacements

1.1.4 Replacement

- Implement a replacement program of approximately 908 units per annum across the period 2022-26 with focus on Neutral Screened cables.

2 Introduction

2.1 Purpose

The purpose of this document is to outline the maintenance, replacement and performance of the service cables connecting customers to low voltage (LV) circuits in AusNet Service's electricity distribution network.

This document summarises the key strategies used to manage these assets in order to maintain the reliability, safety and security of the distribution network. This document is intended to inform asset management decisions and communicate the basis for these decisions.

In addition, this document forms part of our Asset Management System for compliance with relevant standards and regulatory requirements, as well as responsible asset management by outlining economically justified outcomes.

2.2 Scope

This asset management strategy applies to the overhead and underground service cables that connect customers to the LV circuits in the electricity distribution network.

Overhead service cables are connected between AusNet Services' overhead mains and the customer's first point of connection, while underground service cables connect customers to the underground residential distribution (URD) network in newer estates.

2.3 Asset Management Objectives

As stated in *AMS 01-01 Asset Management System Overview*, the high-level asset management objectives are:

- Comply with legal and contractual obligations;
- Maintain safety;
- Be future ready;
- Maintain network performance at the lowest sustainable cost; and
- Meet customer needs.

As stated in *AMS 20-01 Electricity Distribution Network Asset Management Strategy*, the electricity distribution network objectives are:

- Improve efficiency of network investments;
- Maintain long-term network reliability;
- Implement REFCL's within prescribed timeframes;
- Reduce risks in highest bushfire risk areas;
- Achieve top quartile operational efficiency; and
- Prepare for changing network usage.

3 Asset Description

3.1 Asset Function

AusNet Services' aerial or overhead service cables and underground service cables connect the customers to the overhead and underground residential distribution network, respectively.

Aerial service cables are connected between AusNet Services' overhead mains and the customer's first point of connection (POC). Underground services connect the service t-joint on AusNet Services' LV underground mains to the customer's service pit located on the property boundary. In this arrangement, the customer owns the insulated cable, which connects the service pit to the installation switchboard. Larger installations are directly connected from the LV mains to the customer switchboard, pillar or cabinet.

3.2 Asset Population

The population of aerial service cables in AusNet Services' electricity distribution network predominantly consist of Twisted Black cross-linked polyethylene insulated Aerial Bundled Cable (XLPE – ABC), Twisted Grey PVC insulated aluminium conductors, and Neutral Screened cables with aluminium neutral screen and copper conductors.

Insulated XLPE cable is the only type of underground service cable in use. The quantities and proportion of each service type are shown in Table 1 and Figure 1.

Table 1- Service Cables by Type[1]

Connection method	Cable Type	Number	Percentage of Fleet
Underground	XLPE – Under Ground	244,346	46%
Overhead	Twisted Black (XLPE – ABC)	170,198	32%
Overhead	Twisted Grey (PVC Aluminium)	101,198	19%
Overhead	Neutral Screened (Al & Cu)	15,317	3%
Overhead	Other (Obsolete Aerial)	3,696	1%
	TOTAL	**534,755**	

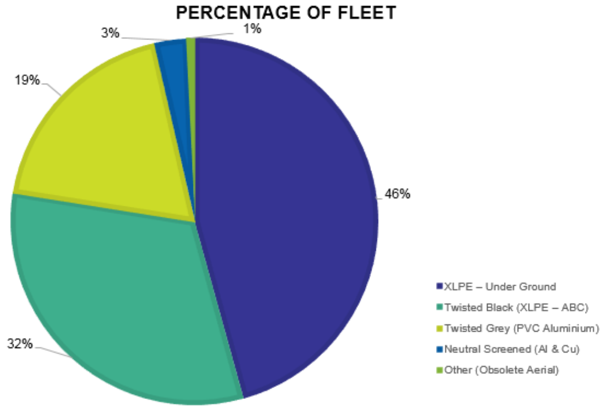

Figure 1 – Service Cable Fleet

3.2.1 XLPE Underground Service Cables

Underground service cables are an aluminium conductor with a XLPE outer sheath predominantly associated with Underground Residential Distribution (URD) systems. Typical systems consist of the cable between the service t-joint on the mains cable and the underground service pit. The other major source of underground servicing is referred to as pole to pit. These services run between the existing overhead low voltage reticulation

[1] 2018 AusNet Services (Distribution) Category Analysis

network to underground service pits located on the customer's property boundary or to customer pillars or switchboards.

URD commenced in approximately 1979, and accelerated rapidly in the late 1980s when Victorian planning rules mandated the servicing of medium density residential estates by underground cable techniques. Underground XLPE cables now represent 46% of the service cable population. Taking into consideration the non-tangible financial benefits associated and the requirements of Section 7.3 of the Service & Installation Rules, underground is a preferred method of servicing.

3.2.2 Twisted Black Aerial Service Cables

Twisted Black aerial service cables are an aluminium conductor with a XLPE outer sheath. These are the preferred replacement option and installation material for aerial service cables.

This fleet is steadily growing due to new connections and replacement of other aerial service types. Since 2014, the population has grown from 23% to 32% of the entire aerial service cable population, the largest type of service cables in the network. Figure 2 shows a typical Twisted Black XLPE ABC cable.

Figure 2 – Twisted Black XLPE ABC

3.2.3 Twisted Grey Aerial Service Cables

Twisted Grey aerial service cables are an aluminium conductor, with a PVC outer sheath, comprising 19% of the entire service cable population. This fleet is diminishing due to the replacement of this cable type with Twisted Black post cable failure. Figure 3 shows a typical Twisted Grey cable.

Figure 3 – Grey PVC Service & 'Dog-bone' Termination Fitting

3.2.4 Neutral Screened Aerial Service Cables

Neutral Screened service cables are constructed with the active, Aluminium or Copper conductor/s surrounded by a fine stranded aluminium sheath, serving as the neutral, which is then covered by an outer PVC insulated sheath. These types are rapidly diminishing in the network, proof of which is that from 7% in 2014 these are now just 3% of the service cable population. The driver for the preventative replacement program is to economically address the assets in poor condition and high failure rates due to deterioration of the aluminium neutral screen. Figure 4 shows sheath damage on an aluminium neutral screened service cable.

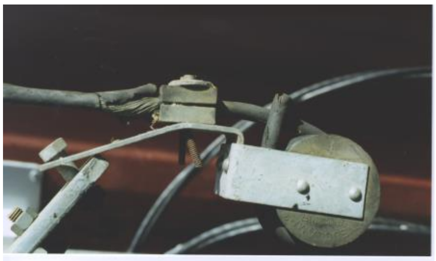

Figure 4 – Neutral Screened Service & Roller Clamp

3.2.5 Other Aerial Service Cables

The remaining "other" aerial service cables on AusNet Services' electricity distribution network primarily consist of open wire, red lead and black webbed PVC service cables as shown in Figure 5. These contribute a small (1%) proportion of the overall service cable population and are progressively being replaced with Twisted Black cables.

Open Wire Service Cable

Red Lead Service Cable

Black Webbed PVC

Figure 5 – Obsolete Aerial Service Cables

3.3 Asset Age Profile

The overall age profile of service cables on the distribution network is illustrated in Figure 6. The dark blue profile depicts the underground proportion of the population that has progressively increased since the late 1970s. The underground population shows a significant increase around 17 years ago when changes in Victorian planning laws mandated that medium density residential estates were to be supplied electricity via underground cable systems. Underground service cables continue to be predominantly used for new customer connections, particularly via Underground Residential Distribution (URD) residential housing developments.

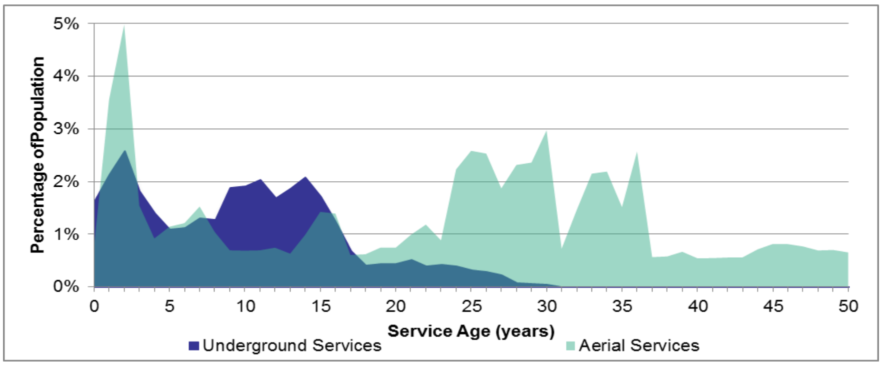

Figure 6 – Service Cable Age Overview[2]

[2] Data Sourced for the 2014 RIN Submission

Figure 7 below illustrates the introduction and transition between aerial service cable types.

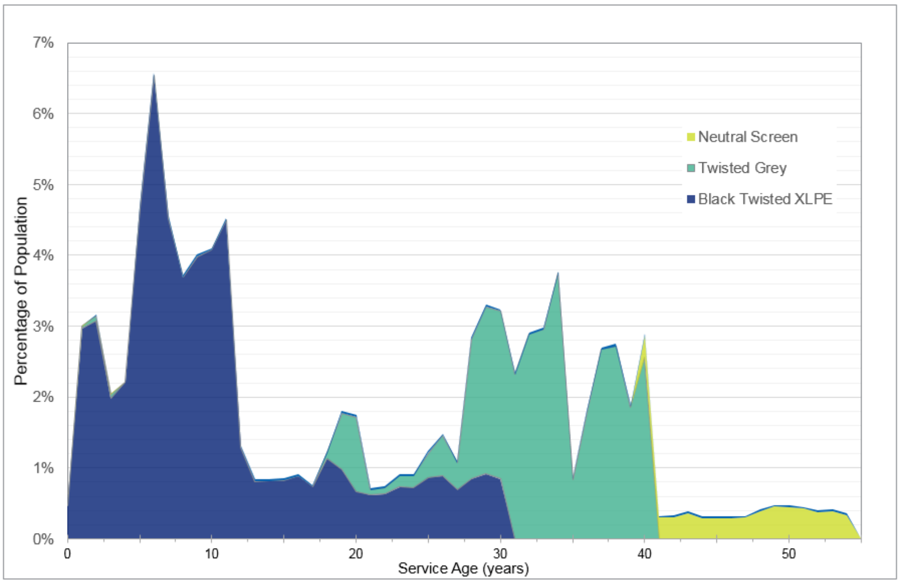

Figure 7 – Aerial Service Cable Age Profile[3]

Neutral Screen service cables were predominantly used between 1964 and 1978. These are among the oldest services installed on the distribution network and are now approaching 60 years of age.

Twisted Grey (PVC) service cables were the preferred material prior to the introduction of Twisted Black (XLPE) service cables. The installation of Twisted Black service cables has been steady in non-underground reticulated areas, but increased over the past ten years due to replacement of failing neutral screened cables.

3.4 Asset Condition

In order to provide a consistent assessment of the condition of the whole asset group a common condition scoring methodology has been developed, this methodology uses the known condition details of each asset and grades that asset against common asset condition criteria. There are 5 different condition scores that have been applied to each distribution pole, ranging from “Very Good” (C1) to “Very Poor” (C5). Table 2 describes the typical attributes which determine the condition score rating.

Table 2 – Aerial Service Cable Methodology

Condition Scoring Methodology			
Condition Score	**Condition Description**	**Summary of details of condition score**	**Remaining Life**
C1	Very Good	Generally, in excellent operating condition with no history of significant defects, extremely low failure rates that are generally driven by external causes.	95%
C2	Good	Includes assets in better than average condition for service history and material type. Very low failure rates predominately due to external causes.	70%
C3	Average	This category includes assets which are in an average condition for its respective service history and material type. End of life failure mode related events beginning to emerge. Maintenance activities such as re-termination of service cable can be completed to achieve desired	45%

[3] Aerial Other has been omitted from the profile as this represents 1% of the entire population

		functional requirements	
C4	Poor	Includes assets which are in worse than average condition for its respective service history and material type. These assets are showing end of life failure modes with deterioration becoming observable. Decreasing opportunity to maintain these assets typically requiring replacement post inspection.	25%
C5	Very Poor	This category includes assets which are exhibiting high deterioration related failure rates with observable deterioration. These assets cannot be maintained and require replacement prior to imminent failure.	15%

The underground service cable fleet is relatively young in its expected service life and very low failures have been observed. Further, underground service cables are less susceptible to the range of external agencies and mechanisms that cause faults in aerial services, due to the mechanical protection provided by undergrounding. As a result, they are considered to be in Condition C1 and C2.

The overhead service cable fleet has been assessed based on historical performance and failure rates. From this condition assessment, scores were assigned in the Asset Information System for each aerial service cable. When reviewing the breakdown of service cable type and condition, Figure 8 demonstrates that Neutral screened service cable contributes to the majority of the "Very Poor" service cables.

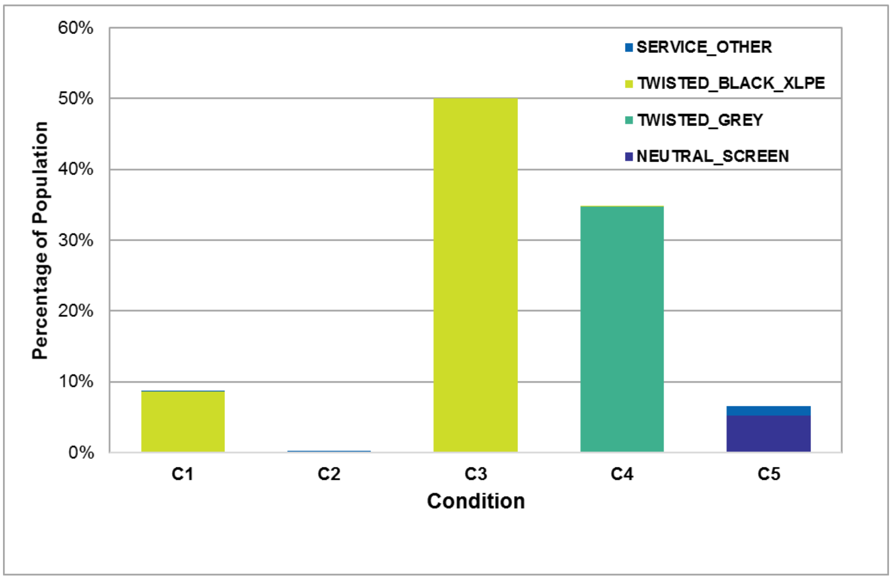

Figure 8 – Overall Condition for all Service Cables

3.5 Asset Criticality

3.5.1 Failure Mode Effects Criticality Analysis

Failure Mode, Effects Criticality Analysis (FMECA) is a technique for analysing and evaluating a life cycle strategy to ensure that the function has the desired reliability characteristics by managing critical failure modes through redundancy, maintenance, refurbishment or replacement.

FMECA includes a criticality analysis, which charts the probability of failure modes against the severity of their consequences. The result highlights failure modes with relatively high probability and severity of consequences, allowing remedial effort to be directed where it will produce the greatest value.

3.5.2 Failure Modes

Analysing the failures as recorded in DOMS, the four dominant failure modes for service cables are connection failure, clearance encroachment, mechanical damage/failure, and service termination failure.

3.5.2.1 Connection failure

There are two dominant root causes behind connection failures, namely dry joints which can be rectified through maintenance activities, and corrosion of the active or neutral conductors themselves which requires replacement of the service cable.

Connection failures are generally caused by corrosion of conductor connections (dry joints) at pole end or house end connection points. These faults which relate to Twisted Grey cables are partly the result of inadequate brushing to remove aluminium oxide and greasing at the time the joint was made. They can generally be rectified by the attending fault crew remaking the electrical joints. Poor electrical connection on the neutral conductor may also result in electric shocks to customers.

The second root cause of electrical discontinuity is corrosion of the conductors within the cable itself. Upon deterioration or failure of the outer PVC sheath, moisture ingress results in corrosion of the fine stranding of the fine aluminium neutral screening conductor and the subsequent electrical failure of the neutral connection within the service cable. Mid-span deterioration or failure of the outer sheath can be attributed to age related ultra violet radiation or mechanical abrasion by large vehicles, vegetation or birds (cockatoos) chewing the sheath.

3.5.2.2 Clearance Encroachment

Clearance encroachment failures are generally caused by vegetation or third party's encroaching on minimum distances from aerial or underground service cables. These are generally related to over dimensional vehicle incidents and third party 'dig-ins' both of which maintenance activities can be performed in the majority of cases, eliminating the need to replace the service cable. The main mitigation controls against this failure mode is "Dial before you dig" and "No go zone" programs. Additionally, AusNet Services have initiated a program to identify impeding vegetation and increasing the clearance height of "at risk" cables over roads where large vehicles travel.

3.5.2.3 Mechanical Damage / Failure

Mechanical damage and failure is caused by third party's coming into contact with the service cables. These failures are a result of causes attributed to a 'Clearance Encroachment' failure mode; maintenance will not rectify the mechanical damage or failure and will require replacement.

3.5.2.4 Service Termination Failure

Service termination failures are caused by mechanical failure of the termination fitting at the service point of attachment. The typical termination fittings include 'dog-bone' fittings, 'roller clamps', 'PG clamp' and 'helical wraps'. These failures generally require a maintenance activity on the termination itself, provided the cable has not been damaged by the termination failure the service cable generally does not require replacement.

3.5.3 Failure Effects

The failure of a service cable introduces four consequences namely bushfire, electric shocks, customer outage that translates to unserved energy and non-compliance to regulations.

3.5.3.1 Bushfire

Service cable system failures can cause a fire start, which may result into a bushfire during a hot day. The risk associated with a bushfire is calculated by applying the probability of fire ignition, probability of unfavourable weather conditions, expected house loss consequence and house loss value. Data has been sourced from the Victorian Bushfires Royal Commission findings, Government departs, Bureau of Meteorology and CSIRO.

3.5.3.2 Health and Safety Risk

There have been 213 electric shock incidents involving customers over a 5-year period from January 2015 to December 2018. This number represents an improvement (i.e. decrease) of 56% from the previous 5-year period (2009 to 2014) which had 388 electric shock incidents.

Majority of these incidents involve the failure of the neutral conductor within the service cable that can result to severe consequences. During the early part of 2019, a serious incident occurred (on a different network) involving a neutral screen service cable wherein a toddler and her mother both suffered serious burns which required hospitalisation[4].

3.5.3.3 Unserved Energy

Values of expected unserved energy were calculated by using the value of customer reliability (VCR) and the expected outage time. Mean time to restore (MTTR) is used to estimate the expected outage time. The approach taken is consistent with AEMO's energy forecasting approach as detailed in paper by AEMO and in AusNet Services Distribution Annual Planning Report (DAPR)[5]

3.5.3.4 Replacement Costs

Corrective replacements undertaken following failure of a service cable involve 'ad hoc' remedial actions with a higher unit cost compared with planned actions. AusNet Service's estimate that 'ad hoc' replacement of service cables following failures costs approximately [C.I.C] per replacement.

Preventative replacements targeted at high failure rate service cables eliminate the safety hazard to customers and minimise the reliability impact on customers. Resources undertaking preventative replacements are significantly more productive and can replace service cables at approximately [C.I.C] per unit as they amortise non-productive travelling time over a significant number of replacements in a single locality.

As illustrated in Figure 9, a preventative replacement program is significantly more economic than a corrective replacement program for service cables.

[C.I.C]

3.5.4 Overall Criticality

The consequence of failure is allocated into five criticality bands based on their economic impact as the result of a failure. These asset criticality or consequence impacts are irrespective of the likelihood of the actual failure.

Asset Criticality is calculated as the ratio of the service cable's consequence of failure by its replacement cost. The five-criticality band thresholds are given below in Table 3 while the Service Cable population's Criticality

[4] The neutral screen service suffered a fault at the house end helical termination, which resulted to the service active becoming "welded" to the service neutral. The supply neutral to the house was heavily corroded and was discontinuous at the junction box on the service pole. As the metal window frame was in contact with the foil thermal insulation, which was also connected to the installation earth electrode, the frame became energised to phase voltage

[5] Distribution Annual Planning Report – AusNet Services 2018-2022

distribution is given in Figure 10. (Note that the ratios expressed in the figure uses the reactive replacement costs. This means doing a proactive replacement provides a better outcome.)

Table 3 - Criticality Band Thresholds

Criticality Band	Economic Impact
1	<= 0.3 replacement cost due to failure
2	0.3 to 1 x replacement cost due to failure
3	1-3 x replacement cost due to failure
4	3 to 10 x replacement cost due to failure
5	>10 x replacement cost due to failure

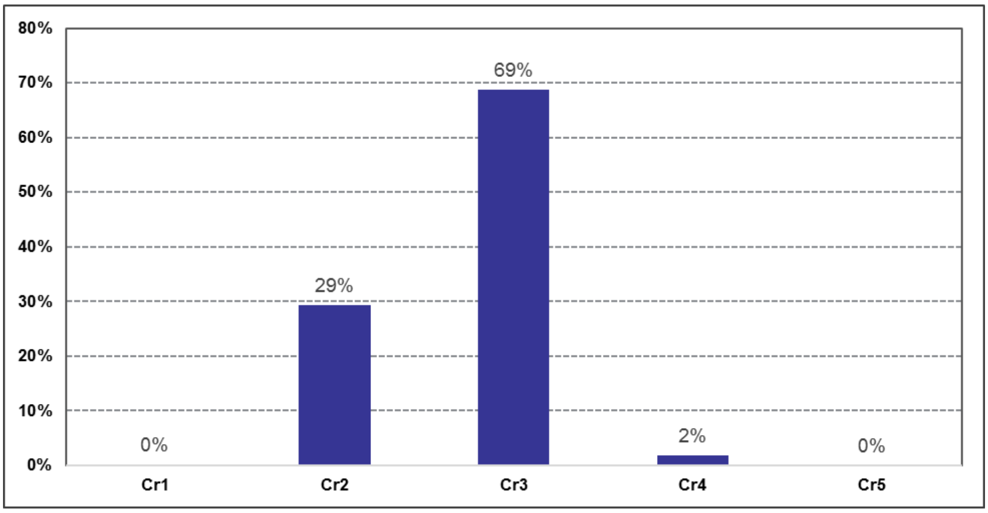

Figure 9 – Service Cable criticality distribution

3.6 Asset Performance

Underground service cables have performed reliably with no reports of major failures, whereas the overhead service cables have experienced failures due to corrosion, degradation brought about by service age, vegetation and third party damage.

3.6.1 Failure Analysis

Analysis of the service cable failures in the last five years (2013 to 2017) revealed an average of 3,244 failure per year. The breakdown of failures is shown in the table below. (Note: Failures on the Neutral & Junction Boxes were discounted in the failure rate calculations as the DOMS record did not specify what service type actually failed

Table 4 – Service Cable Failures

Asset Type	CY13	CY14	CY15	CY16	CY17
Grey Twisted Service	350	359	323	349	675
Junction Box	190	183	179	141	95
Neutral	114	24	59	43	341
Neutral Screen Service	510	456	349	411	497
Unknown	1804	1891	1744	2405	976
XLPE (Black) Service	267	257	256	257	716
Grand Total	3235	3170	2910	3606	3300

Table 5 below shows the failure rate for each service cable type that is currently in service:

Table 5 – Service Cable Failure Rates

Service Cable Type	Annual Failure Rate
Neutral Screen	3.53%
Grey Twisted	0.39%
XLPE Black Twisted	0.19%

As seen from above, Neutral Screens are the worst performing service cable type in the network, which are almost ten times more likely to fail than the Grey Twisted service cables and 19 times worse than the XLPE Black Twisted service cables.

Figure 11 illustrates the distribution of failure causes, which identifies age & corrosion as being the highest contribution of failures, 93%; followed by vegetation at 4%, then a combination of animals and other factors.

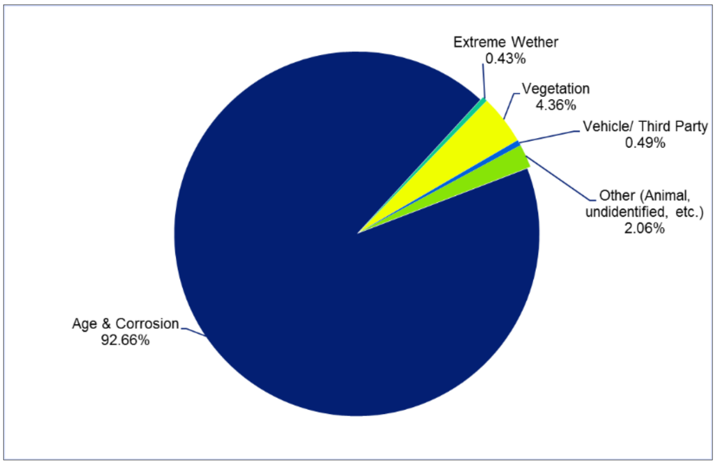

Figure 10 – Service Cables, Failure causes

3.6.2 Customer Impact

3.6.2.1 Electric Shock

The number of reported incidents involving this service cable has decreased as shown in Figure 12. Since 2015, there has been 153 electric shock incidents in the network, which represents a decrease by 60% in electric shock incidents reported to Energy Safe Victoria – which amounts to 3.3 electric shocks per year in December 2018.

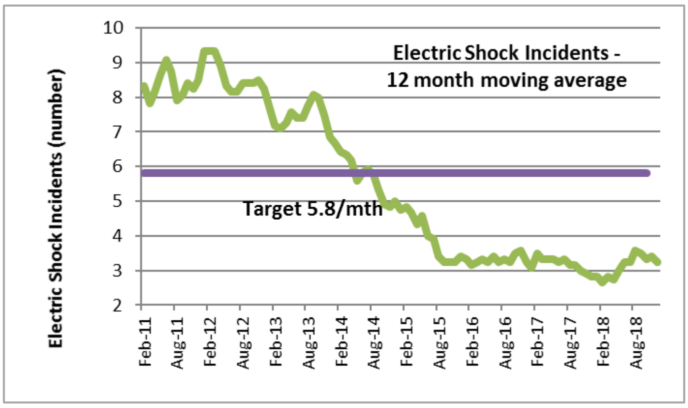

Figure 11- Electric Shock Incidents (12-month rolling average)

3.6.2.2 Customer Outage

The second pertinent customer impact of a service cable failure is customer outage. The failure mode of the service cable directly affects the duration a customer is off supply as observed in Table 6.

Table 6 – Service Cable Failure Rates

Failure Mode	Average Fault Duration
Cable Clearance Encroachment (Underground)	55 hours
Mechanical Damage / Failure	22 hours
Clearance Encroachment (Aerial)	4 hours
Connection Failure	3 hours
Service Termination	2 hours

Analysis of the unserved energy and STPIS impact from unplanned sustained outages from January 2014 to December 2018 identified an average of 923 service cable failures per year. These failures resulted in an average STPIS penalty of $105 per failure.

4 Other Issues

4.1 Regulatory Compliance – Ground Clearance

AusNet Services will continue to manage the risks associated with overhead service cables that don't meet the required ground clearance as per Aerial Lines and Service Cables Clearance Management Plan, 30-2669. This plan is included in AusNet Services' Electricity Safety Management Scheme (ESMS) with Energy Safe Victoria's acceptance.

This plan requires a prioritised response to increase the service cable ground clearance if the risk is considered unacceptable with regards to the cable being hit by passing vehicles. For the rest of the service cable fleet that don't meet the required clearance, these will be addressed in the future via planned asset replacement works.

4.2 Loss of neutral detection

Loss of Neutral (LoN) which can lead to electric shocks and other HS&E Incidents can be detected by interrogating the data collected by the 740,000 AMI meters installed on AusNet Services' residential and small business customers. This capability to identify emerging faults and remediate it prior to eventuating has been implemented customer meters since its introduction in 2013. The high level process includes:

- Power Quality data is recorded over a three-hour window for processing
- Algorithms are completed on the recorded power quality data
- Potential faults are flagged for manual validation
- Control room are notified of the potential fault
- Field crew dispatched for make-safe and service cable replacement works.

The duration from detection to rectification has remained at an average of three days since middle of 2014. This rectification speed has improved from an average of 11-days when the monitoring system was first introduced in 2013.

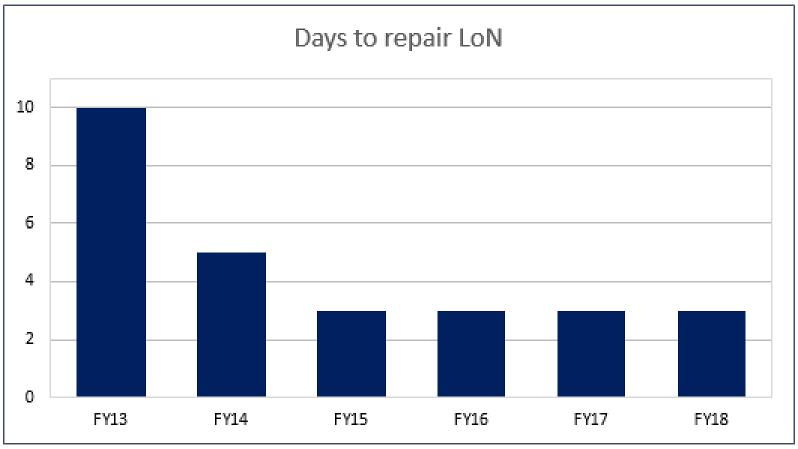

Figure 12 – Loss of neutral detection and rectification duration

This process has a fundamental safety benefit for customers supplied from aerial service cables nearing end of life. However, it is a reactive process and hence suffers from lower economic efficiency when compared with a planned replacement program targeted on aerial service cables with high failure rates, e.g. Neutral Screens and Grey Twisted service cables.

5 Risk and Options Analysis

This section outlines the risks associated with Service Cables and discusses how these risks should be addressed in the most efficient and economic manner.

5.1 Risks

As discussed in Section 3.5.4 Criticality (Cr) is the ratio between the *Consequence of Failure plus the Cost of Reactive Replacement* divided the *Cost of Reactive Replacement*. Interrogating historical costs in SAP indicate that reactive replacement costs [C.I.C] per overhead service cable, whereas pro-active replacement costs [C.I.C] per overhead service cable.

Table 6 below shows the risk matrix for the service cable fleet.

Table 6 – Risk and Condition Matrix of Overhead Service Cable Fleet

		Condition - Service Cables					Quantity
		C1	C2	C3	C4	C5	
Criticality	Cr5	-	-	-	-	-	-
	Cr4	480	4	2,914	1,668	375	5,441
	Cr3	19,199	164	99,865	67,380	13,488	200,096
	Cr2	5,270	60	50,189	27,485	2,387	85,391
	Cr1	11	-	57	244	-	312
	Quantity	24,960	228	153,025	96,777	16,250	291,240

Table 6 highlights that using the criticality values discussed in section 3.5, there are 15,531 service cables that belong to Risk Level IV. The service cables that belong to this cohort have the worse condition score, as well as highest criticality.

The various options to remove these service cables in the fleet are explored and discussed in the succeeding section.

5.2 Options Analysis

5.2.1 Reactive Replacement

Neutral Screen service cables have been actively replaced in the past due to its performance. As a result, the number of in-service service cables of this type have declined in the distribution network, albeit its failure rate remains the highest as discussed in Section 3.6.1.

In terms of the failure rates among service cable types, Grey Twisted service cables have steadily increased, as these are the second oldest cohort in the fleet. The increasing failures of the Grey Twisted type is clearly shown by the reactive replacement trend in Figure 14 below.

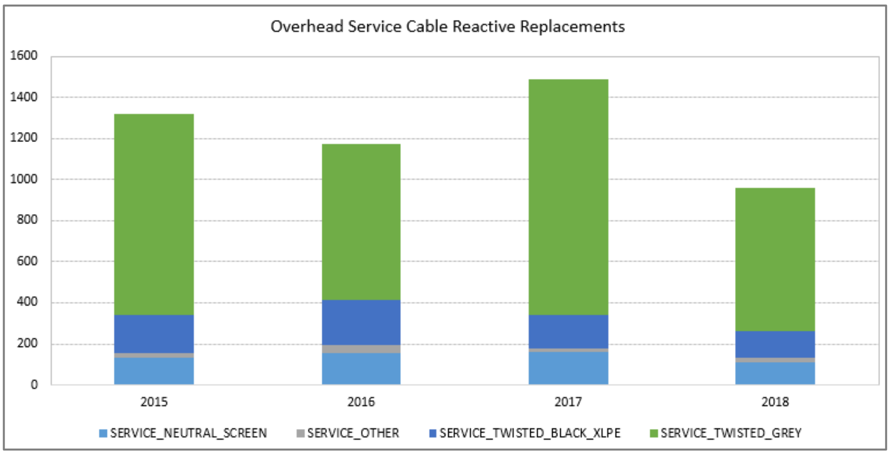

Figure 13- Service cable reactive replacements

Based from the above chart and considering the decreasing number of Neutral Screen cables, it is projected that 750 service cables will be replaced annually.

5.2.2 Proactive Replacement

The proactive replacement forecast is achieved using a semi-quantitative risk assessment method wherein the probability of failure is associated with the asset condition and the consequence is calculated from the bushfire effect cost, value of unserved energy and the cost for reactive replacement, which is two and a half times higher than planned replacement.

The components of the replacement cost are the cost of service cable, truck hire and labour to replace the asset. The labour component of the replacement cost is the amount of time required to perform the corrective maintenance activity on a per hour basis.

In order to meet the requirements of the Electricity Safety Act in managing the risk "as far as practicable", the location of the Neutral Screen service cables which is the worst performing type, was spatially plotted and it is recommended that the following criteria be followed in identifying the service cables to be replaced:

- Neutral Screen service cables - which has the highest failure rate and LoN incidents;
- Close proximity to one another, which results to a lower unit rate;
- Condition score of C5
- Located in Non-Codified areas[6]

The service cables meeting this requirement is shown inside the red dashed line in Figure 15 below.

[6] Project 110777946 will replace Neutral Screens and Grey Twisted service cables in Codified Areas

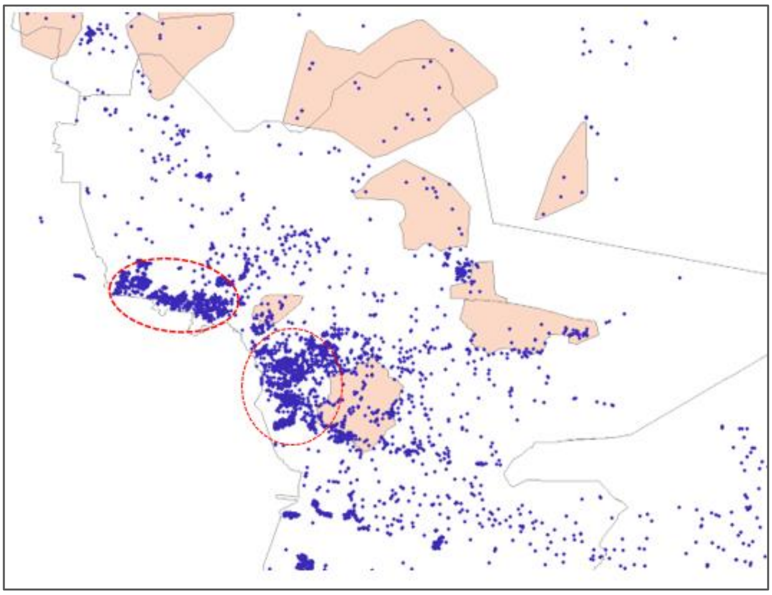

Figure 14– Neutral Screens in Non-Codified areas in the Central Region

5.2.3 Replacements due to other programs

Separate from specific service cable replacement programs, overhead services will get replaced as 'collateral items.' The programs and quantities, which fall in these categories, are discussed below. (Note that these quantities are excluded in the Final Number of the Service Cable replacements).

5.2.3.1 Pole replacements

It is estimated that 65% of poles with LV feeders which will be replaced in FY22 to 26 have service cables. Using the projected number of LV poles to be replaced, it is anticipated that 3,382 service cables will be replaced.

5.2.3.2 Cross-arm replacements

From the estimated number of LV cross-arms to be replaced in FY22 to 26, 69% of these is anticipated to have service cables. This gives an estimated number of 2,065 service cables to be replaced in FY22 to 26.

5.2.3.3 Safety program – LV line assets replacement program

SAP Project number **110777946:** *LV Line Assets Replacement program* will replace LV assets, including service cables in the Codified Areas. There are 4,183 service cables flagged for replacement in this program.

5.2.4 Overall Replacement Forecast

The result of the risk and options analysis, that's have factored in the quantities replaced stated in sections 5.2.1 and 5.2.3 .gives a forecasted summary shown in Table 7. This forecast has excluded the quantities stated in sections 5.2.1 and 5.2.3 are excluded in the forecast).

Table 7 – Replacement Forecast

Identifier	Justification	Contribution in EDPR 2022-26
Proactive	Proactive replacement of assets (Neutral Screens) with highest risk of failure	2,754
End of Life replacements	Replacement of assets due risk of failure based on condition assessment inspection	1,786
Total Replacement		4,540

6 Asset Strategies

Management of service cables to mitigate safety, reliability and business risks shall include the following strategies.

6.1 New Assets

- Install XLPE insulated underground service cables to connect new customers in the URD areas
- Install XLPE insulated aerial service cables to connect new customers in overhead distribution areas

6.2 Condition Monitoring

- Monitor failure performance and failure modes of each type of service cable.
- Monitor failure performance of Twisted Grey PVC Aluminium service cables to quantify if preventative connection testing and remediation is economic.
- Capture relevant data of failures in AMS for effective management of service cables.

6.3 Maintenance

- Analyse AMI meter data and dispatch fault crews to emerging service cable failures, e.g. Loss of Neutral to mitigate risk of electrical shocks in customers' premises.
- Maintain service cable height risk management in accordance with the 'Aerial Lines and Service Cables Clearance Management Plan' 30-2669.
- Continue to replace neutral screened service cables in conjunction with other maintenance works such as deteriorated LV cross arm replacements and deteriorated timber pole replacements

6.4 Replacement

- Implement a replacement program of approximately 908 units per annum across the period 2022-26 with focus on Neutral Screened cables.