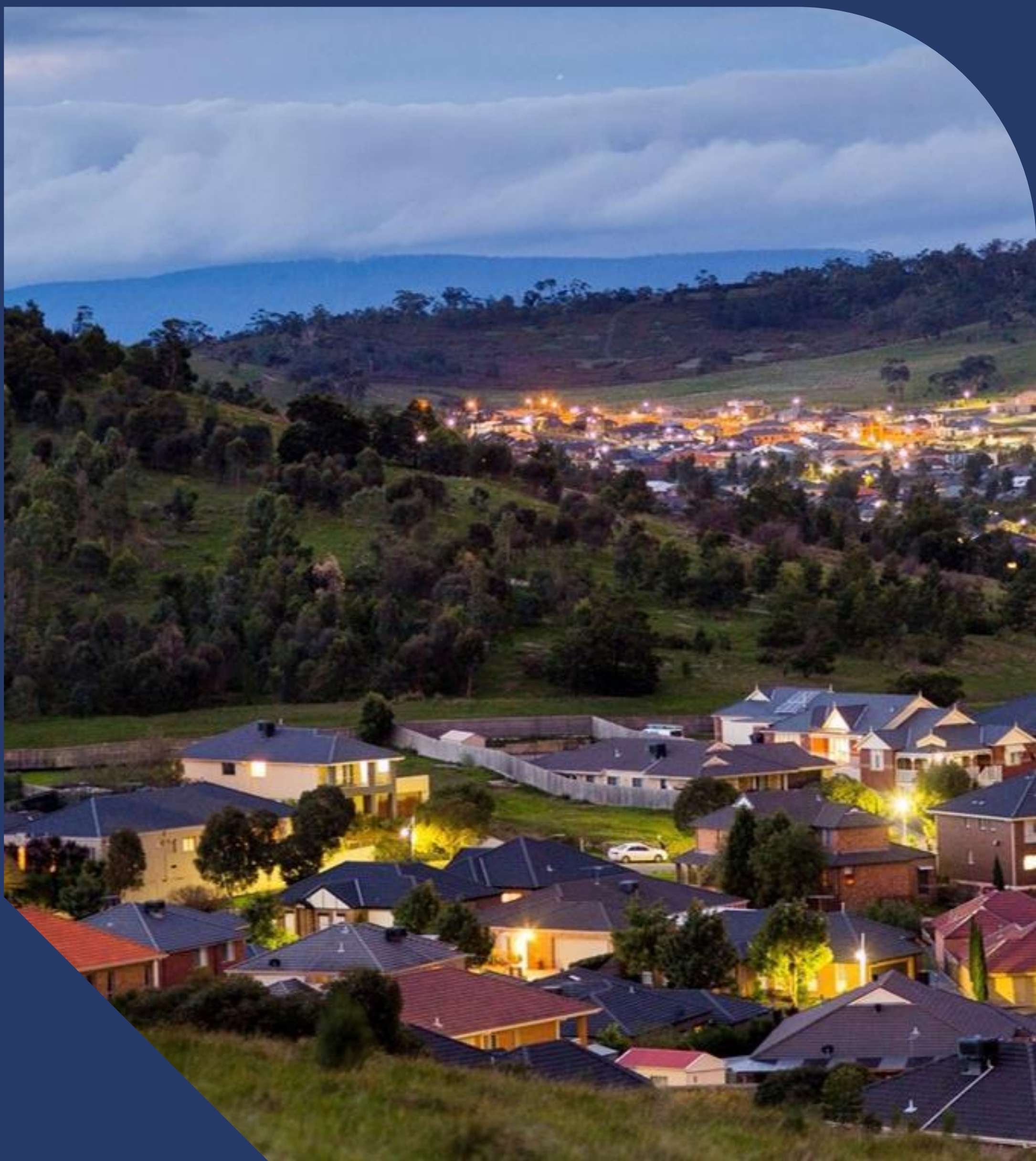
Insulated Cable Systems

AMS – Electricity Distribution Network



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AusNet

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1. Executive Summary

This document is part of the suite of Asset Management Strategies relating to AusNet's 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 insulated cables (Cables) in the distribution network. These consists of high voltage, medium voltage and low voltage underground cables and medium voltage and low voltage overhead cables.

There is over 11,800 km of underground and overhead cables in the eastern part of Victoria. The cable population has been steadily growing at approximately 3% per annum.

Underground and Low Voltage (LV) cable systems have been in service since the 1970's and Medium Voltage (MV) overhead cable systems were introduced in the 1990's. The underground and LV populations have significantly increased over the past three decades, attributed to requirements of housing in underground residential development (URD) estates using medium voltage and low voltage underground cables.

Overhead medium voltage cables systems (Non-Metallic Screen Airial Bundled Cables NMS ABC) are in the poorest condition and are exhibiting high failure rates suggesting end-of-life when compared to underground cable systems. The replacement program continues to see these high-risk cables being replaced with either a more robust design of overhead cable (Light Duty Metallic Screen LDMS ABC) or by underground cable.

Although underground cable systems are exhibiting low failure rates, objective health information of the cable system is required to ensure prudent future economic replacement programs are developed. Condition monitoring programs have been developed and will continue to be rolled out during this EDPR period.

Proactive management of insulated cable systems, application, inspection, condition assessment, maintenance, refurbishment and replacement practice will continue to ensure that stakeholder expectations of cost, safety, reliability and environmental performance are met. This incorporates but is not limited to Hybrid connections which have underground MV assets being brought up poles at selected locations to interface with overhead systems, reducing cost by utilising existing infrastructure and providing a sectionalised -underground solution.

1.1 Asset Strategy Summary

1.1.1 New Assets

- Where practical, vast majority of new installations will use underground cable circuits
- As the cable network continues to be renewed, the population of PILC cables will diminish until eventually they will no longer exist on the network
- All new cable systems shall be subjected to the commission test protocols SMI 12-01-02
- In order to minimise the effect of poor installations and to ensure the maximum cable circuit reliability, the following measures have been implemented
    - Using only accredited installers, trained by the specific accessory manufacturers
    - Where practical, designing (and repairing) of all cable circuits to minimise the number of joints
- Standardisation of components within a cable circuit, cable design, termination type, installed in conduit
- Introduction of new 3 sheath cable design to facilitate sheath integrity tests

1.1.2 Inspections and Monitoring

- On-line testing: Allowing the circuit to remain in service while identify any obvious defects with terminations by visual inspection and attempting to detect significant electrical defects within the circuit by using sophisticated non-invasive monitoring equipment.
- Off-line testing: Incorporating a wide variety of electrical test methods to accurately detect defects at normal and over-voltage conditions. AusNet has developed and started to implement a condition assessment program for its HV and MV underground cable population. This program consists of a suite of electrical diagnostic tests that can yield an economical and accurate assessment of the overall condition of a cable circuit. The tests are identical with those used during commissioning, only at reduced test levels and acceptance criteria, to allow direct comparison to the asset's condition when it was first placed into service, adding credence to determining the degree of aging of the cable circuit.

1.1.3 Maintenance

The following maintenance activities will continue to be refined

- Recording of fault codes to enable disaggregation of failure modes by cable or accessory type
- Fault data collection for each cable failure to determine the root cause of the failure and predict trends
- Recording of installers/jointer details to improve efficiencies
- MV underground cables will continue to be maintained in the following traditional manner
- Critical cables, as defined in the testing Standard Maintenance Instruction (SMI), within stations shall have no joints. Temporary joints may be permitted for a period of no greater than six months to enable supply to be restored
- Following an in-service failure of cable and/or in-line joint, the failed portion shall be cut out and replaced with two joints and a short length of new cable
- A HV or MV customer supply cable that has a circuit length less than 100m shall be replaced rather than repaired
- A MV cable termination failure, where enough spare length cannot be recovered from the cable, will have a new inline joint installed within 4 metres of the base of the pole and a new tail length of cable installed and terminated
- HV Oil Filled Cable (OFC) and MV PILC cable failures will preferably cause the entire cable circuit to be replaced. If this is uneconomical then the repair shall be covered by the above two XLPE methodologies except that the joints to be used will be transition/sealing joints to ensure that the paper/oil system is sealed.

1.1.4 Refurbishment

- Replacement rather than refurbishment is the only viable option in regard to LV, MV and HV cable systems.

1.1.5 Replacement

- Continue replacement of MV Overhead NMS ABC with LDMS ABC or undergrounding
- Continue to identify circuits wherein the integrity of the insulation system has deteriorated to a point that warrants replacement

1.1.6 Research and Development

- Continue to explore economics of alternative overhead covered conductor solutions

2. Introduction

2.1 Purpose

The purpose of this document is to outline the commission, inspection, maintenance, replacement and monitoring activities identified for economic life cycle management of cable assets in AusNet's Victorian electricity distribution network. This document intends to be used to inform asset management decisions and communicate the basis for activities.

In addition, this document forms part of our Asset Management System for compliance with relevant standards and regulatory requirements. It is intended to demonstrate responsible asset management practices by outlining economically justified outcomes.

2.2 Scope

Included in this strategy are cables designed for both overhead and underground installation, divided into the following internationally recognised voltage categories, and simplified for AusNet distribution network:

- High Voltage (HV) : greater than 36kV and up to 150kV or expressed as 36kV < HV ≤ 150kV
- Medium Voltage (MV) : greater than 1kV and up to 36kV or expressed as 1kV < MV ≤ 36kV
- Low Voltage (LV) : greater than 32V and up to 1kV or expressed as 32V < LV ≤ 1kV

The underground cable asset data within the Asset Management database has been going through a systematically data maturity process and is progressively being corrected. The data presented in this strategy is taken from the best data to hand at the time of writing.

2.3 Asset Management Objectives

The high-level asset management objectives are outlined in AMS 01-01 Asset Management System Overview.

The electricity distribution network objectives are stated in AMS 20-01 Electricity Distribution Network Asset Management Strategy.

3. Abbreviations and definitions

TERM	DEFINITION
ABC	Aerial Bundled Cable
Bare Conductor	A metallic conductor having no insulation properties, that requires support from insulating devices (e.g. stand-off insulators or slung insulators) to withstand the service (and testing) voltages imposed on it.
Cable	Insulated cables comprising a metallic conductor surrounded by an insulating material suitable to withstand the service (and testing) voltages imposed on it. The cable can have a metallic screen and then be sheathed with layer(s) of extruded or mechanically wrapped materials to protect it from the environment in which it will be installed.
COF	Consequence of Failure
HDPE	High Density Polyethylene
HV	High Voltage
IUC	insulated unscreened conductor
LDMS	Light Duty Metallic Screen
LV	Low Voltage
MV	Medium Voltage
NMS	Non-Metallic Screen
OFC	Oil Filled Cable
PE	Polyethylene
POF	Probability of Failure
PVC	Polyvinyl Chloride
PILC	Paper Insulated Lead Covered
SCPE	Semi-Conductive Polyethylene
SCS	spacer cable systems
TR-XLPE	Tree-Retardant Cross-Linked Polyethylene
URD	underground residential estates
XLPE	Cross Linked Polyethylene

4. Asset Description

4.1 Function

Insulated cable systems, both overhead and underground, form an integrated portion of the AusNet electricity distribution network. Insulated cables, to be referred to as Cables, are distinct from bare conductors, and are used to transport High Voltage (HV), Medium Voltage (MV) and Low Voltage (LV) electrical power through different parts of the network where safety, environmental or physical space limitations dictate that they be used instead of bare overhead conductors. Underground cables are typically immune to the effects of bushfire, flood or similar natural incidents that would normally have adverse effects on their bare overhead counterparts.

Cables are used throughout the AusNet electricity distribution network to:

- Interconnect zone substations
- Interconnect primary assets within a zone substation
- Interconnect indoor switchgear to the remainder of the zone substation
- Form the backbone of feeder circuits out from a zone substation
- Form sections of circuits that travel through different terrain that might dictate the use of cables
- Supply power to and throughout new industrial and housing estates

4.2 Population

4.2.1 Population Considerations

The population profile for Cables is crucial for effective lifecycle management. This profile includes detailed data on the quantity, types, locations, and specifications of these assets within the electrical distribution network.

A comprehensive understanding of the population profile allows asset managers to:

- **Identify critical assets:** Determine which cables are essential for maintaining the integrity and reliability of the network. For example, a particular high-voltage underground cable serving a critical industrial area might be deemed essential and require more frequent inspections to ensure uninterrupted service.
- **Allocate resources efficiently:** Plan and allocate maintenance resources effectively by knowing the exact number and location of assets. For instance, knowing that a certain region has a high concentration of medium voltage overhead cables can help in scheduling maintenance activities more efficiently.
- **Risk management:** Assess and manage risks associated with different assets. For example, if the population profile indicates that certain sections of low voltage underground cables are in flood-prone areas, additional protective measures can be implemented in those areas.
- **Optimise maintenance schedules:** Develop optimised maintenance schedules based on the distribution and condition of assets. For instance, cables that form the backbone of feeder circuits from a zone substation might be scheduled for more frequent inspections and maintenance to prevent any potential failures.
- **Enhance reliability and safety:** Ensure that all components, including high voltage, medium voltage, and low voltage cables, meet the required standards for reliability and safety. For example, if the profile reveals that certain underground cables have outdated insulation that no longer meets safety standards, these can be prioritised for replacement.
- **Support strategic planning:** Inform long-term strategic planning and investment decisions. For instance, the population profile might show that a significant portion of medium voltage underground cables in a rapidly

developing suburban area need upgrading to support increased demand, guiding future investment in that region.

Targeted Activities (Population Considerations)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Condition assessment electrical testing to be undertaken on all 66kV cable circuits, identifying and scheduling remedial action, ensuring any latent defects are removed
02	Schedule time-based condition assessment electrical testing on all critical cables throughout the network. There is a plethora of cables within the MV network that have never been condition assessed, so this is no small task but one that needs to commence in a controlled manner. The company has identified several ways that access can be gained to these circuits, either as a direct outage or an associated outage with other planned works. Every opportunity to assess the condition of these circuits is being taken.

4.2.2 Geographical Impact Areas

The AusNet electrical distribution network covers a significant portion of Victoria, including Melbourne's northern and eastern suburbs, and extends across eastern and north-eastern Victoria. This region encompasses a diverse range of geographic locations, each with specific environmental impacts on cables. Understanding these impacts is essential for effective asset management within the AusNet electrical distribution network. Notable examples include:

- High Wind Areas: High wind areas, particularly in elevated regions and open plains, subject overhead cables to significant stress and fatigue. Example: The structural integrity of overhead cables in the elevated regions of the Dandenong Ranges must be robust enough to withstand high wind speeds, ensuring they remain securely in place and do not fail under stress.
- Corrosive Areas: Coastal areas and industrial regions where salt and pollutants are prevalent can cause corrosion of metallic components in overhead cables or at the terminations of underground cables. Example: Regular maintenance and the use of corrosion-resistant materials are crucial to prolong the lifespan of these cables. Cables in coastal towns like Wonthaggi require regular inspections and maintenance to mitigate the effects of salt-induced corrosion.
- Bushfire Areas: Bushfire-prone areas, common in many parts of Victoria, pose a risk of fire damage to overhead cable infrastructure. Example: Fire-resistant materials and strategic vegetation management around overhead cable installations are essential for reducing this risk. In the bushfire-prone regions of the Yarra Valley, cables must be designed to withstand high temperatures, and installations must be cleared of nearby vegetation to prevent fire spread. Ultimately the best solution is to underground these circuits, which remove most of these risks.
- Flood-Prone Areas: Areas prone to flooding can impact the performance and integrity of underground cables. Example: Proper waterproofing and drainage systems are essential to protect these assets. In regions like Gippsland, where flooding is more frequent, underground cables must be installed with robust waterproofing measures to prevent water ingress and subsequent failures. The majority of AusNet's cable designs accommodate such protection measures.
- Seismic Zones: Though less common, areas with potential seismic activity may require cables to be constructed with flexibility and resilience to absorb and dissipate seismic forces, reducing the risk of structural failure. Example: In areas near fault lines, cables may need to incorporate seismic-resistant features to ensure stability during earth tremors.

Targeted Activities (Geographic Impact Areas)

REF	DETAILS OF MATERIAL CONSIDERATIONS

01	In bushfire prone areas, consideration is given to undergrounding all, or sections of, feeder circuits in order to increase circuit availability with reduced maintenance costs. This is especially relevant on radial feed circuits.
02	Ground mounted connection cubicles as well as pole mounted Hybrid connections are used to minimise cable exposure to the environment. Both these measures reduce the risk of natural environmental events having an impact on the underground supply by removinge or reducing the sections of exposed cable, that are typically secured to poles to facilitate connection between underground and overhead assets.

4.2.3 Population by Type

MV Overhead Cable

Medium Voltage (**MV**) overhead cables (ABC) are designed to transport electrical power from substations to distribution transformers and other important nodes within the network. These cables are typically used for overhead distribution lines, spanning across streets and neighbourhoods, connecting substations to distribution points. The construction of these cables ensures the safe transmission of electricity.

Their design generally includes a high dielectric strength material to prevent electrical leakage and corona discharge, thereby enhancing the overall efficiency and longevity of the distribution system. Typically constructed with multiple layers of insulation, shielding, and sometimes with armouring, MV overhead cables provide robust protection against environmental factors such as UV radiation, moisture, wind, rain, temperature fluctuations and physical impacts.

They are engineered to maintain their structural integrity and electrical performance over a prescribed service life. In the context of the AusNet distribution network, these cables play a role in maintaining the integrity and reliability of the MV supply, ensuring stable power delivery to both residential and commercial consumers.

The AusNet electricity distribution network contains three design types of MV overhead cable.

- Non-metallic screened high voltage aerial bundled cable (NMS HV ABC),
- Light Duty Metallic Screened high voltage aerial bundled cable (LDMS HV ABC) and
- insulated unscreened conductor (IUC), which includes spacer cable systems (SCS) such as Hendrix spacer cable systems, shown in Figure 1.

Each of these designs use cross-linked polyethylene (XLPE) as the main insulation material.

HV ABC utilise cables whereas IUC systems, such as Hendrix are classed as using covered conductors, rather than insulated conductors.

Figure 1- Typical version of a Hendrix Cable System

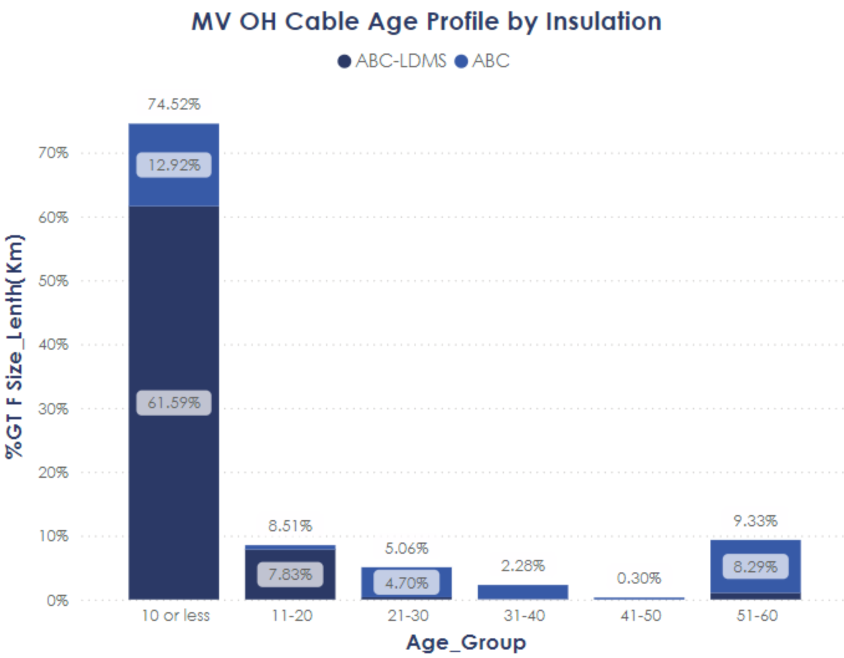

Figure 2 – Population of MV Overhead Cables

Figure 2 illustrates the population distribution for MV overhead cables currently in service as a percentage of cable type, out of the total length of MV OH cable.

There is a fundamental design problem with the NMS HV ABC cable which instigated a replacement program.

To date the program has, along with the installation of new LDMS circuits or undergrounding been effective in reducing the population of NMS HV ABC. The program will continue to replace the remaining NMS cables over this EDPR period.

Figure 3, below is a Google Earth extract of AusNet Services' distribution network. Represented against Victoria, the bare overhead distribution network, shown in orange covers the eastern part of the state. Highlighted in green is the installed MV ABC network, predominantly used in the Mt Dandenong region.

As a consequence of being applied in highly vegetated locations, HV ABC operates in high bushfire risk areas. These circuits are exposed to high environmental effects and have severe consequences of failure.

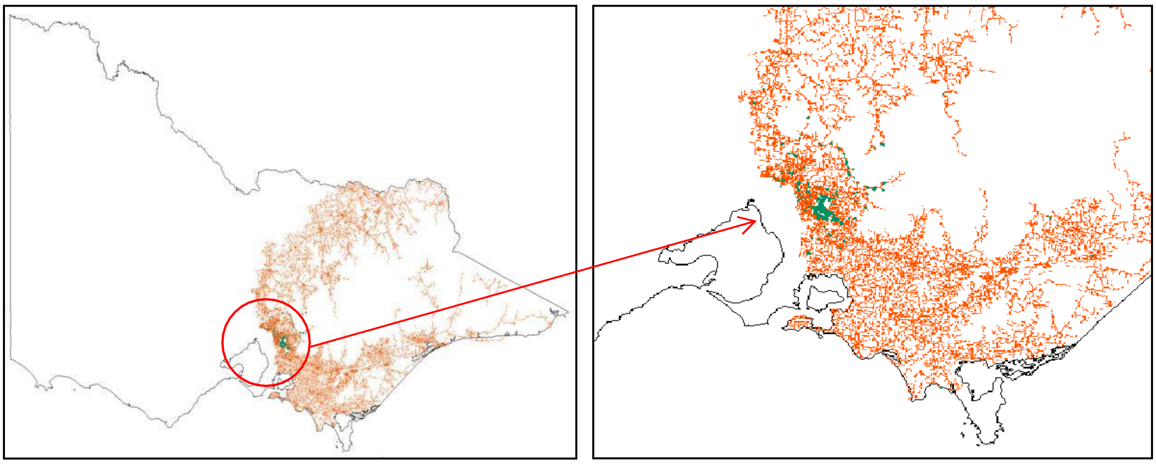

Figure 3 –AusNet Services' distribution network (MV ABC in green)

Figure 4 illustrates cable systems that have been installed in heavily treed environments to reduce vegetation management and improve fire ignition safety

Figure 4 – ABC cable systems in heavily treed environments

Figure 5 shows the extent of cable systems installed in the Mt Dandenong Ranges to reduce the risk of fire ignition as a consequence of trees or stringy bark contacting a bare overhead line.

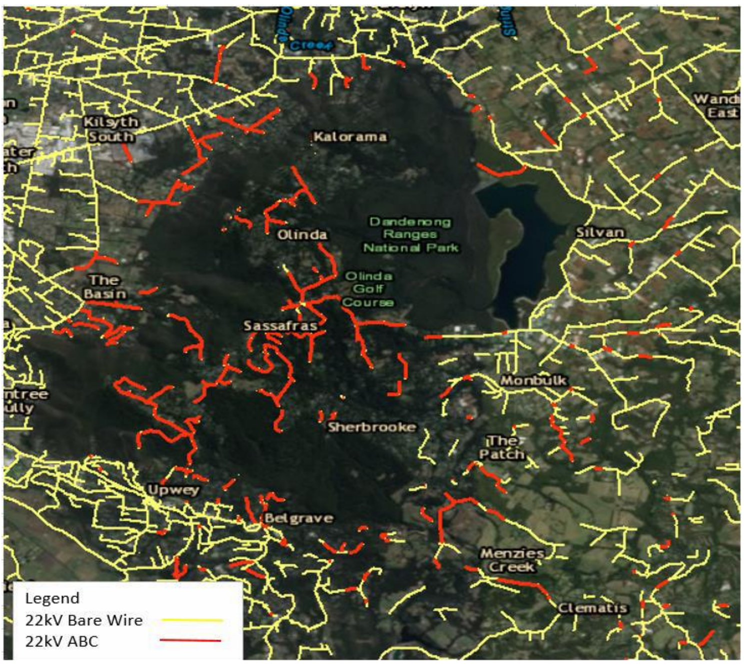

Figure 5 – Google Earth extract of Bare Wire and HVABC lines in the Dandenong's

LV Overhead Cables

Low Voltage (**LV**) overhead cables, are designed to deliver electrical power from distribution transformers to end-users, including residential, commercial, and small industrial consumers.

Fundamentally these cables can be classified as Aerial Bundled Cables (ABC), however they are different to the MV ABC as the LV ABC include neutral cables. Typical arrangements can be A and N or 2C and N or 3C and N.

The primary function of LV overhead cables is to ensure the safe and efficient distribution of electrical power over short distances, maintaining voltage stability and minimising energy losses. In the AusNet distribution network, these cables facilitate the final stage of electricity delivery, ensuring that power is safely and reliably available at the consumer's premises.

The cables are typically suspended from poles or mounted on building facades, making them a familiar sight in urban and suburban areas. These cables are engineered to withstand the rigors of outdoor installation, including exposure to varying weather conditions, temperature fluctuations, and potential mechanical impacts. They are designed with sufficient mechanical strength and flexibility to accommodate the necessary bending and tension during installation and operation.

Figure 6 shows the percentage of each LV OH ABC cable type out of the total length of LV ABC cables. Most of the low voltage electricity reticulation network cables are XLPE insulated having aluminium conductor cross sections ranging from 25 mm2 to 185 mm2.

These cables were introduced in the 1980s, with the majority of the installations in the 1990s. These cable systems were used for all new circuits across the eastern part of Victoria except when underground cables were used to supply underground residential distribution (URD) housing estates.

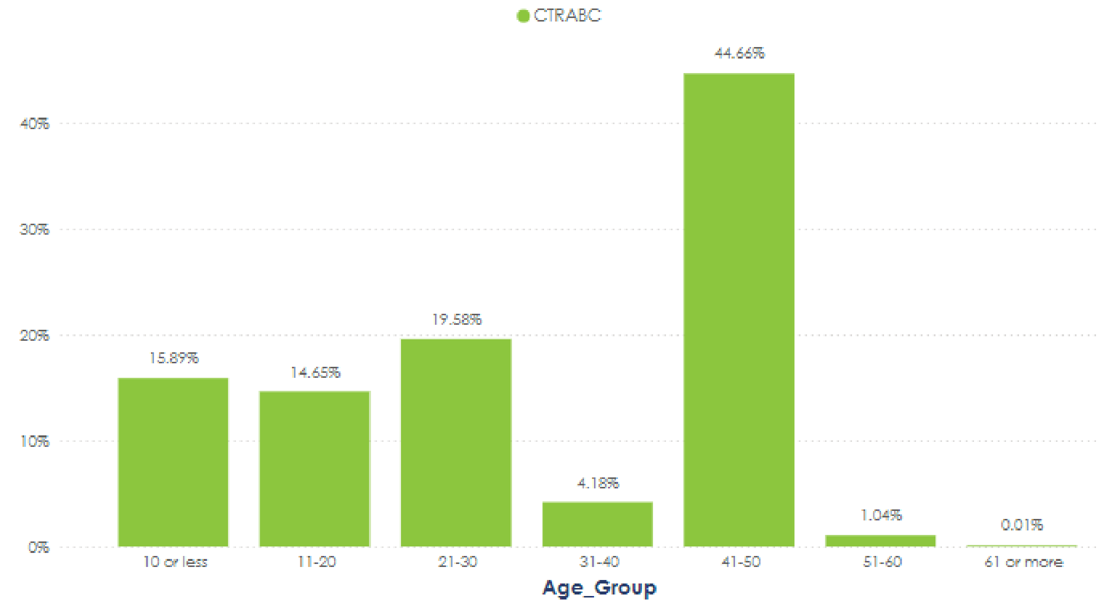

Figure 6 – LV Overhead Cable Population Summary

HV Underground Cables

High Voltage (**HV**) underground cables are designed to transport significant quantities of electrical power. HV underground cables are designed to meet stringent safety standards and are capable of withstanding various environmental conditions, including moisture, temperature fluctuations, and external mechanical stress.

Constructed with advanced materials such as cross-linked polyethylene (XLPE) for insulation and a combination of metallic and non-metallic layers for sheathing, these cables ensure high dielectric strength, thermal stability, and mechanical protection. The typical purpose of HV underground cables is to maintain a stable and uninterrupted power supply, even in densely populated or environmentally sensitive areas where overhead lines are impractical or undesirable. Their design includes features to mitigate electrical losses, resist moisture ingress, and prevent physical damage, ensuring long-term operational reliability and safety.

The sub-transmission HV cable network, whilst being critical infrastructure, forms less than 1% of the Distribution Network cable population length. The majority of the 66 kV circuits are entry cables for zone substations, interconnection of primary assets within zone substations or under-road crossings. They are typically short in length with the entry cables entering a 66 kV switchyard from the bare-overhead/cable-head pole outside the zone substation.

XLPE has been adopted as the standard 66 kV cable insulation material since 1976. There are two types of XLPE insulated HV underground cables, classified by age, as 1st generation (XLPE 1) and 2nd generation (XLPE 2).

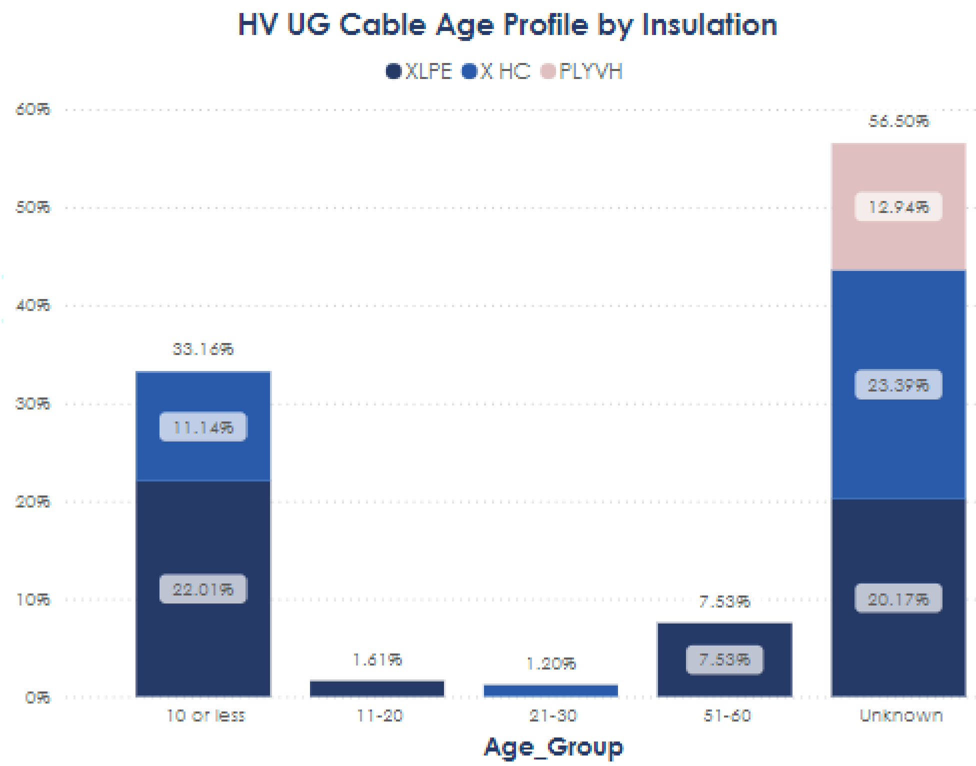

Figure 7 - 66 kV Underground Cable Population Summary

Figure 7 illustrates the percentage of each HV UG cable type out of the total length of HV UG cables. Paper Insulated Lead Covered (PILC) cables and cross-linked polyethylene (XLPE) cables represent two distinct generations of cable insulation technology, each with unique characteristics and applications.

PILC cables, traditionally used in older electrical distribution systems, comprise layers of oil-impregnated paper insulation wrapped around a conductor, typically enclosed in a lead sheath for mechanical protection and moisture resistance. These cables are known for their robust construction and long service life but are heavier and less flexible, making installation and maintenance more challenging.

XLPE insulated cables utilise cross-linked polyethylene as the insulating material, offering significant advantages in terms of electrical performance and physical properties. XLPE insulation provides superior dielectric strength, thermal resistance, and chemical stability, enabling the cables to operate at higher temperatures and voltages with reduced electrical losses. Moreover, XLPE cables are lighter, more flexible, and easier to install compared to their PILC counterparts.

They also exhibit improved ageing characteristics and environmental resistance, making them a preferred choice for modern electrical distribution networks, including both overhead and underground installations. In the context of the AusNet distribution network, the transition from PILC to XLPE cables reflects a shift towards more efficient, reliable, and maintainable infrastructure.

MV Underground Cables

Medium Voltage (MV) underground cables are engineered to deliver electrical power from primary substations to secondary load centres, such as residential areas, commercial areas, industrial facilities and other key distribution points.

Constructed with modern insulation materials such as cross-linked polyethylene (XLPE), MV underground cables offer high dielectric strength, thermal stability, and excellent resistance to moisture and chemical ingress. These characteristics make them well-suited for the diverse and often harsh underground environments encountered in urban and suburban areas. Their deployment also helps reduce visual pollution associated with overhead lines and enhances the resilience of the power distribution infrastructure against environmental and physical disruptions.

The typical purpose of MV underground cables is to maintain a stable medium voltage supply while minimising electrical losses and enhancing the overall reliability of the distribution system. In the AusNet distribution network, MV underground cables facilitate the efficient transfer of electrical energy over moderate distances, supporting the dynamic demands of residential, commercial, and industrial consumers.

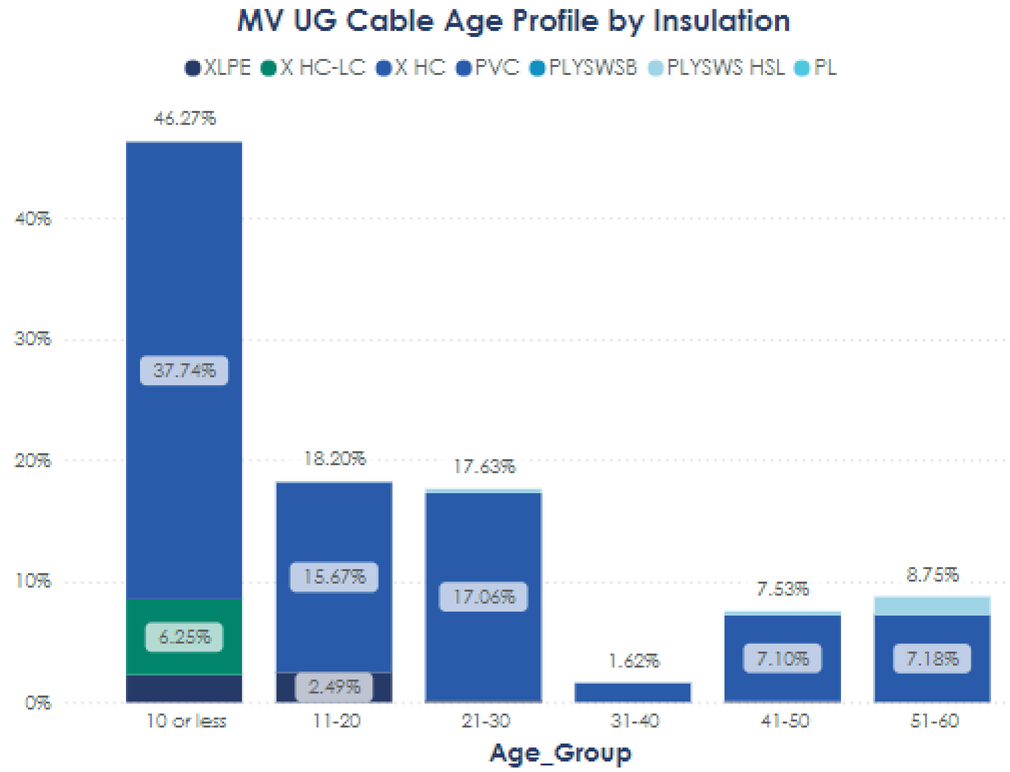

Figure 8 – MV Underground Cables Population Summary

Figure shows the different insulation types found in the MV underground cables network. The MV underground cable network currently comprises over 97% of XLPE insulated cable, the remaining being PILC.

The 11 kV and 6.6 kV underground cables are primarily located in regional high bush fire risk areas (HBRA) and are also installed in the Latrobe Valley open cut mines.

The 22 kV underground cables are generally located in road reserves in underground residential distribution (URD) housing estates.

All MV cables installed after the year 2000 are TR-XLPE insulated.

The majority of underground residential distribution (URD) cables are 185 mm2 or 240mm2 aluminium conductor, three-core XLPE cables, whilst there are also some older paper-insulated three-core cables.

The remaining 22 kV cable fleet facilitate connection to power transformers, capacitor banks, NER's and feeder exit cables that deliver the power either within or out from the zone substations.

Within station boundaries the strategy has been upgraded to only allow copper conductors for power transformer and bus tie connections. Due to the shorter circuit lengths, any potential cost savings for using aluminium conductors are quickly overshadowed by having more robust connections for these highly critical circuits

The older transformer cables are either single-core or 3-core 500 mm^2 copper conductor, paper-insulated, with the more recent cables being either 500mm^2 or 630mm2 Copper single-core XLPE-insulated cables. Feeder exit cables are typically short in length and reticulate from a zone substation to a cable-head pole outside the zone substation, from where the feeder typically reverts to overhead construction. Such feeders are then classed as 'backbone' cables until the criticality and/or number of customers connected diminish to lower risk levels.

The majority of zone substation feeder exit cables are either 300mm^2 or 240 mm^2 aluminium three-core XLPE cables, whilst there are some 185 mm^2 aluminium three-core XLPE cables and some paper-insulated three-core cables still in service.

LV Underground Cables

Low Voltage (LV) underground cables, are designed to distribute electrical power from distribution transformers to residential, commercial, and light industrial consumers. The primary function of LV underground cables is to maintain a reliable and efficient power supply while minimising voltage drops and power losses.

LV underground cables are engineered to meet stringent safety standards and are capable of withstanding environmental conditions, including moisture, temperature fluctuations, and external mechanical stress. Their robust construction typically includes copper or aluminium conductors, surrounded by insulation and protective sheathing, to ensure mechanical protection and electrical safety. Typically constructed with cross-linked polyethylene (XLPE) insulating material, LV underground cables offer good dielectric properties, thermal stability, and resistance to moisture and chemical exposure.

Their underground installation allows very flexible installation practices, helping to mitigate visual pollution, enhance public safety by reducing the risk of accidental contact, and improve the resilience of the power distribution system against environmental factors such as severe weather conditions.

The low voltage underground cable network constitutes the remainder of the cable population. These cables are primarily located in residential estates, connecting kiosk substations to customer's points of supply. This has been the preferred construction technique since the late 1980s.

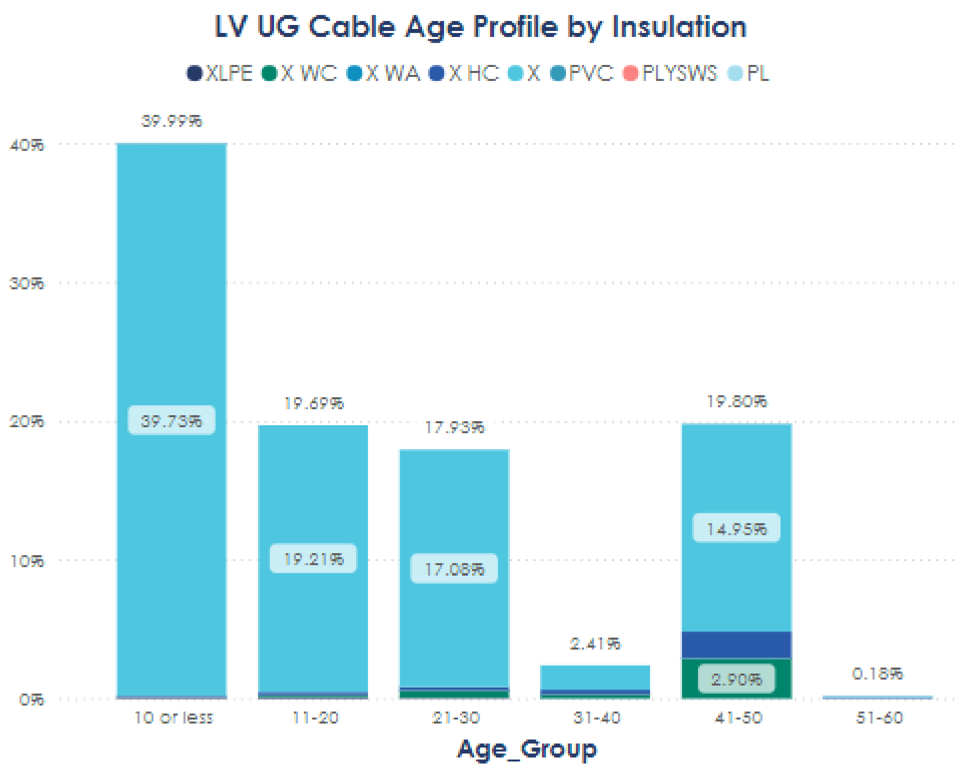

Figure 1 – LV underground cables population summary

Low Voltage (LV) cables can be with different insulation materials, each offering distinct properties suited to various applications within the electrical distribution network. The three common types of insulation materials are cross-linked polyethylene (XLPE), polyvinyl chloride (PVC), and paper insulated lead covered (PILC).

XLPE insulated cables offer the highest performance in terms of thermal and electrical properties, making them ideal for demanding applications. PVC insulated cables provide a cost-effective solution for a wide range of standard LV applications. However, PVC insulation has a lower maximum operating temperature compared to XLPE, which can limit its use in high-temperature, higher power environments.

PILC cables, although historically significant, are not being installed less commonly used today due to their environmental and practical limitations.

Figure 1 illustrates that most of this quantity is indeed XLPE type, with polyvinyl chloride (PVC) and PILC contributing <1%

Targeted Activities (Population by Type)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	LV cables, both overhead and underground, will continue to be replaced on condition or earlier if they fail in service or are replaced during network upgrade works
02	MV underground cables will continue to be maintained in the following traditional manner • Critical cables, as defined in the testing Standard Maintenance Instruction (SMI), within stations shall have no joints. Temporary joints may be permitted for a period of no greater than six months to enable supply to be restored • Following an in-service failure of cable and/or in-line joint, the failed portion shall be cut out and replaced with two joints and a short length of new cable • A HV customer supply cable that has a circuit length less than 100m shall be replaced rather than repaired • Termination failure, where enough spare length cannot be recovered from the cable, will have a new inline joint installed within 4 metres of the base of the pole and a new tail length of cable installed and terminated • MV PILC cable failures, and possible subsequent testing, will preferably cause the entire cable circuit to be replaced. If this is uneconomical then the repair shall be covered by the above two XLPE methodologies except that the joints to be used will be transition/sealing joints to ensure that the paper/oil system is sealed. • HV Self Contained Fluid Filled cable (SCFF) failures will again preferably cause the entire cable circuit to be replaced. If this is uneconomical then the repair shall be covered by the above two XLPE methodologies except that the joints to be used will be stop joints to ensure that the paper/oil system is sealed and pressurised
03	Continue replacement of MV Overhead NMS ABC with LDMS ABC or underground

4.3 Age Profile

4.3.1 Age Considerations

An in-depth understanding of the age profile of cables is crucial for effective asset management and lifecycle planning. Knowing the age distribution of these assets helps in predicting their remaining useful life and planning maintenance, upgrades, or replacements accordingly.

- High Voltage Underground Cables: The age profile of high voltage underground cables can indicate potential issues related to insulation degradation and metallic sheath corrosion. Older cables may require more frequent inspections and condition assessments to ensure they continue to operate safely and efficiently. For example, proactive testing and monitoring of insulation resistance in older high voltage cables can prevent unexpected failures and extend their service life.
- Medium Voltage Underground Cables: Over time, medium voltage underground cables can experience insulation breakdown and joint failures due to thermal ageing and environmental stress. By analysing the age profile, asset managers can identify cables that are at higher risk of failure and prioritise them for maintenance or replacement. For instance, replacing aging joints and terminations in medium voltage cables can prevent costly outages and enhance network reliability.
- Low Voltage Underground Cables: Low voltage underground cables can suffer from insulation deterioration and moisture ingress as they age. Understanding their age profile allows for targeted interventions to replace or refurbish sections of the network that are most vulnerable. For example, replacing sections of low voltage cables in older residential areas can reduce the risk of power outages and improve overall service quality.
- Medium Voltage Overhead Cables: The age profile of medium voltage overhead cables can reveal areas where insulation wear and conductor fatigue are likely. Regular inspections and maintenance based on age-related data can ensure these cables remain safe and functional. For example, replacing aging overhead cables in high wind areas can prevent mechanical failures and enhance network resilience.
- Low Voltage Overhead Cables: As low voltage overhead cables age, they can be prone to insulation cracking and exposure to environmental factors. By monitoring their age, asset managers can plan timely replacements and avoid potential safety hazards. For instance, replacing old low voltage overhead cables in coastal areas can mitigate the effects of salt-induced corrosion and extend the cables' operational lifespan.

Targeted Activities

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Condition assessment electrical testing throughout the network will identify potential failure modes and will confirm insulation deterioration trends on aged cables

4.3.2 Age Profile

MV-ABC Overhead Cable

Figure 10 illustrates the age profile of MV- OH cables age profile as percentage of total MV OH route length.

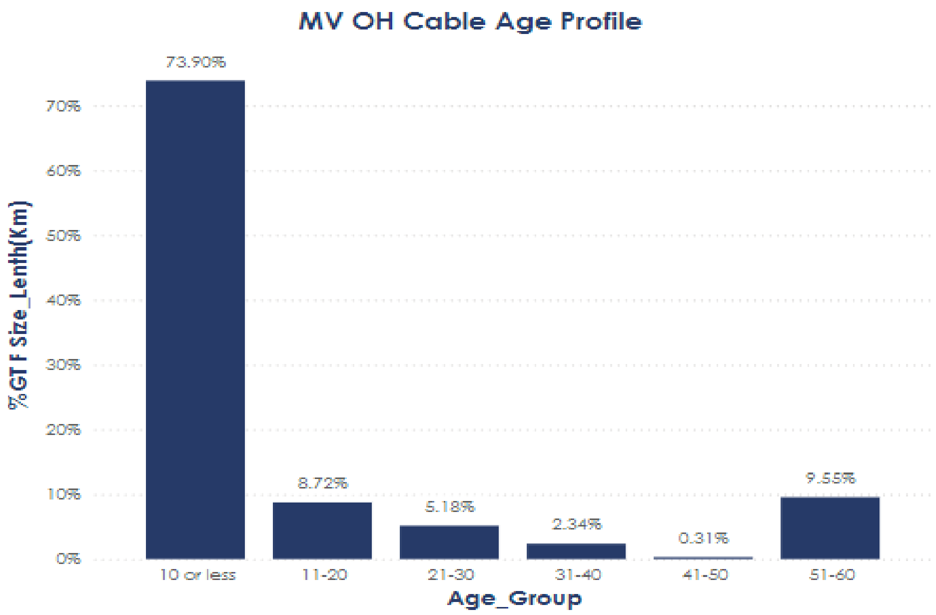

Figure 10 – MV-ABC OH cable Age Profile

LV-ABC Overhead cables

Figure 11 illustrates the age profile of LV- ABC OH cables as percentage of total LV-ABC OH route length

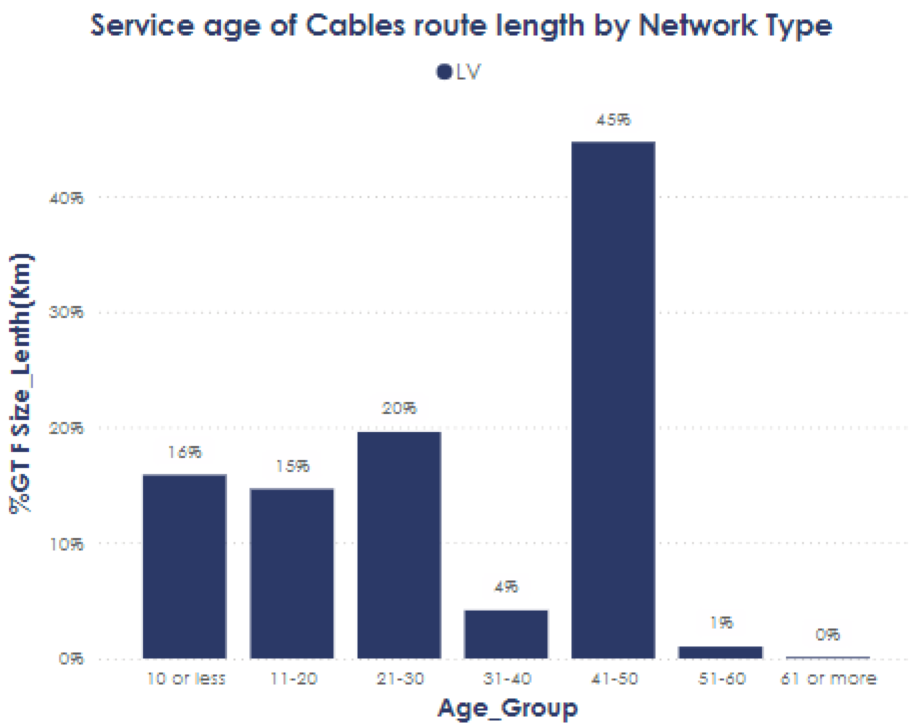

Figure 11 : LV-ABC OH cable age profile

HV Underground cables

Figure 12 illustrates the age profile of HV underground cables as percentage of total HV UGC route length.

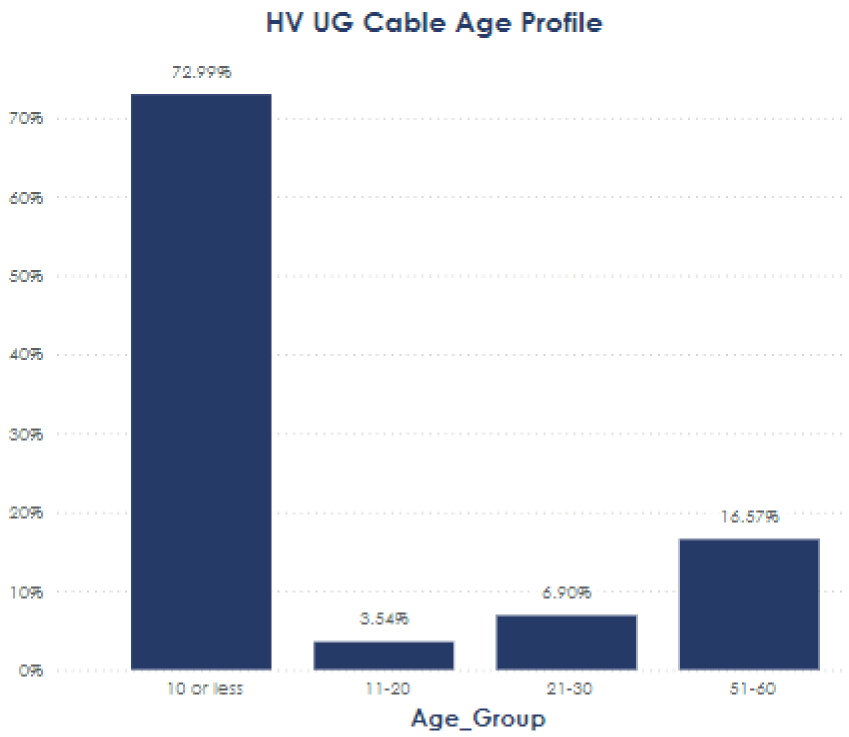

Figure 12: HV UG cable profile

MV Underground cables

Figure 2 illustrates the age profile of MV underground cables as percentage of total MV UGC route length.

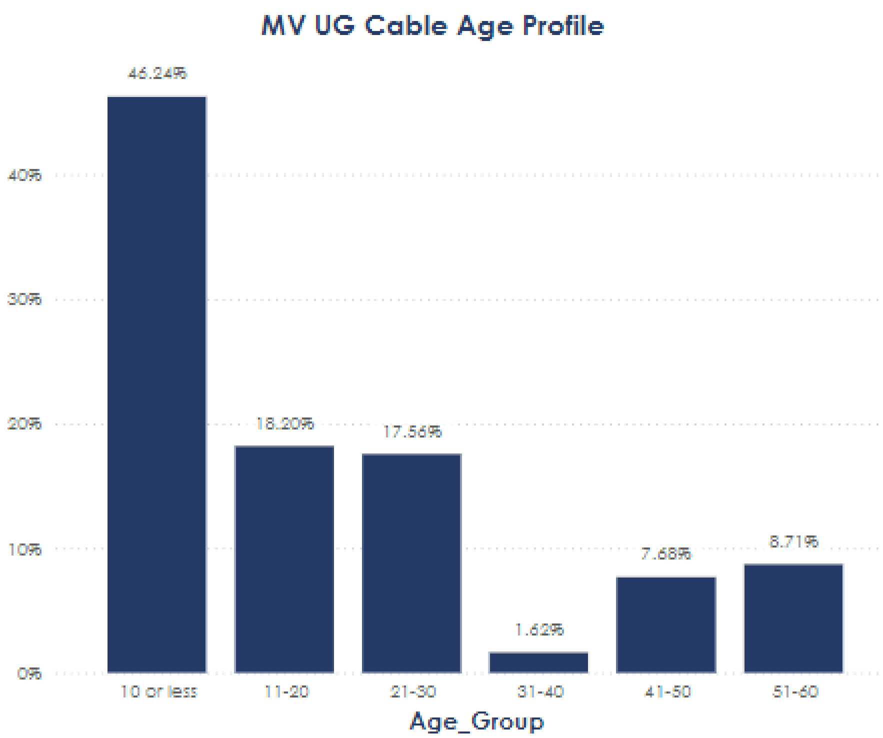

Figure 23: Age profile of MV underground cables

5. Asset Risk

AusNet maintains a risk management system designed in accordance with AS ISO 31000 Risk Management – Guidelines to ensure risks are effectively managed to provide greater certainty for the owners, employees, customers, suppliers, and the communities in which we operate.

The risk of each asset is calculated as the product of probably of failure (PoF) of the asset and the consequence of failure (CoF) of the asset. The risk is then extrapolated into the future as the PoF and CoF are forecast to change.

In the distribution network, AusNet aims to maintain risk. Risk mitigation activities required to achieve this over time include replacement, refurbishment and maintenance activities which are developed based on current risk and extrapolated risk.

The approach and detailed methodology of the risk assessment process are described in AMS -01-09. Section 5.1, 5.2 and 5.3 of this document describe the considerations and methodologies to determine PoF, CoF, and the risk mitigation measures that are unique to Cables

5.1 Likelihood of Failure

There are four categories taken into consideration when determining the likelihood of a functional failure of an asset: asset service life, asset utilisation/duty factor, location, and the measured or observed physical condition of the asset. The four categories are assessed using machine learning or health scores to calculate the probability of failure or the remaining useful life of the asset. Refer AMS 01-09 Asset Risk Assessment Overview

5.1.1 Failure Modes

Understanding failure modes is an important tool that supports measuring the criticality of assets, especially when assessing the risk of potential failures and their potential impact on the overall system. By identifying and analysing the various ways in which an asset can fail (including the root causes and mechanisms of failure), asset managers can better predict and mitigate risks. This understanding allows for a more accurate assessment of the probability of failure (PoF) which is a core aspect of how AusNet approaches determining asset risk.

5.1.2 Specific Failure Modes

Some notable Failure Modes for Cables are detailed below

5.1.2.1 Medium Voltage Overhead Cables

Typical Modes

- **UV Degradation:** Prolonged exposure to ultraviolet (UV) radiation can degrade the insulation/sheathing material, leading to cracking and embrittlement. The significance of this mode is that it can cause insulation failure, leading to electrical faults and outages. **Example:** Implementing regular inspections and using UV-resistant materials can prevent premature degradation, ensuring the longevity and reliability of the cables.
- **Mechanical Damage:** Physical damage from external factors such as falling branches or animal interference can compromise the insulation. The significance of this mode is that it can lead to short circuits and service interruptions. **Example:** Installing physical barriers and conducting regular inspections can mitigate the risk of mechanical damage, maintaining service continuity.

Specific Modes

- **Non-Metallic Screened High Voltage Aerial Bundled Cable (NMS HV ABC)**
  - Insulation Degradation: Over time, UV radiation and environmental exposure can degrade the insulation, leading to potential faults. This is a critical failure mode as it can result in significant outages and safety hazards.

    - Mechanical Damage: Due to external impacts (e.g., falling branches), cables may suffer physical damage. This is moderately important as it can be mitigated with regular inspections and preventive measures.

- **Light Duty Metallic Screened High Voltage Aerial Bundled Cable (LDMS HV ABC)**
    - Corrosion of Metallic Screens: Exposure to moisture can cause corrosion, leading to potential electrical faults. This is a critical failure mode, especially in coastal or humid environments.
    - Insulation Degradation: Common across most cable types, it remains a key issue due to the critical nature of maintaining insulation integrity.
- **Insulated Unscreened Conductor (IUC), Including Spacer Cable Systems (SCS) such as Hendrix Spacer Cable Systems**
    - Spacer Damage or Misalignment: Spacers may suffer damage or misalignment due to environmental factors or mechanical impact, leading to potential phase-to-phase contact. This is a critical failure mode as it can cause short circuits and service interruptions.
    - Insulation Degradation: A common failure mode, it is still crucial to monitor and address promptly.
- **Spacer Cables**
    - Wear and Tear of Spacers: Regular wear and tear can compromise the spacer integrity, leading to similar issues as noted for IUCs. This is a moderately important failure mode, with the potential for severe consequences if not addressed.

5.1.2.2 Low Voltage Overhead Cables

Typical Modes

- Insulation Wear: Over time, the insulation on low voltage overhead cables can wear down due to environmental exposure and mechanical stress. The significance of this mode is that it can lead to electrical faults and potential safety hazards. Example: Regular maintenance and timely replacement of worn sections can prevent electrical faults, enhancing supply reliability and safety.
- **Contamination**: Dust, pollution, and other contaminants can accumulate on the surface of the cable terminations, leading to electrical tracking and flashover. The significance of this mode is that it can cause power outages and damage to the network. Example: Implementing regular cleaning schedules and using insulators with better contamination resistance can mitigate this risk.

Specific Modes

- XLPE Insulated Cables with Aluminium Conductor (25 mm² to 300 mm²)
    - Oxidation of Aluminium Conductors: Aluminium conductors are prone to oxidation, which can increase resistance and cause overheating. This is a critical failure mode due to the potential for fire hazards and loss of service.
    - Insulation Degradation: As with other cable types, this is a common and important failure mode that needs consistent monitoring.

5.1.2.3 High Voltage Underground Cables

Typical Modes

- **Insulation Degradation:** Thermal ageing, moisture ingress, and electrical stress can degrade the insulation material over time. The significance of this mode is that it can lead to partial discharge activity, cable failure, and network outages. **Example:** Using advanced diagnostic tools like partial discharge testing can detect early signs of insulation degradation, allowing for proactive maintenance and replacement.
- **Water Treeing:** The formation of water trees within the insulation material due to moisture ingress can compromise the dielectric strength of the cable. The significance of this mode is that it can lead to insulation failure and significant network disruptions. **Example:** Ensuring cable sheath integrity is maintained is the most formable way to ensure the cable is sealed from external influences. Should moisture enter the cable core, a further precautionary element has been incorporated in the design of all MV cables, namely the use of tree retardant XLPE insulation material (TR-XLPE), reducing the likelihood of water tree growth and enhance cable reliability.

Specific Modes

- Paper Insulated Lead Covered (PILC) Cables

  - Moisture Ingress: Due to breaches in the lead sheath, moisture can enter and degrade the paper insulation. This is a highly critical failure mode as it compromises the cable's dielectric strength.
  - Lead Sheath Corrosion: Corrosion of the lead sheath, particularly in corrosive soils, can lead to cable failure. This is also a critical issue.
- Cross-Linked Polyethylene (XLPE) Cables
  - Water Treeing: This phenomenon occurs when moisture infiltrates the insulation, leading to dielectric breakdown. This is a critical failure mode as it directly impacts the cable's operational reliability.
  - Thermal Overloading: Excessive current can cause thermal degradation of the XLPE insulation. This is moderately important but can be mitigated with proper load management.

5.1.2.4 Medium Voltage Underground Cables

Typical Modes

- Thermal Overload: Excessive current flow can cause the cable to overheat, leading to accelerated thermal degradation of the insulation. The significance of this mode is that it can result in cable failure and prolonged outages. Example: Monitoring cable loads and implementing proper load management strategies can prevent thermal overload and extend the cable's service life.
- Mechanical Stress: Improper installation or ground movement can cause mechanical stress and damage to the cable. The significance of this mode is that it can lead to insulation failure and network interruptions. Example: Ensuring proper installation practices and conducting regular inspections can identify and mitigate mechanical stress, ensuring cable integrity.

Specific Modes

- Paper Insulated Lead Covered (PILC) Cables
  - Same failure modes as HV PILC cables (moisture ingress and lead sheath corrosion).
  - Importance: These remain critical due to the high operational voltage.
- First Generation XLPE (XLPE 1) Cables
  - Water Treeing: Like HV XLPE, this is a critical failure mode.
  - Thermal Overloading: As with other XLPE cables, thermal overloading is a moderately important issue.
- Second Generation XLPE (XLPE 2) Cables
  - Water Treeing: Although improved over XLPE 1, water treeing still poses a significant risk. Critical in terms of potential dielectric breakdown.
  - Mechanical Damage: Installation damage can lead to early failures. Moderately important but manageable with careful handling.
- Tree Retardant XLPE (TR-XLPE) Cables
  - Improved Water Tree Resistance: Less prone to water treeing but still needs monitoring by using sophisticated diagnostic testing methods. This failure mode is of lower criticality compared to non-tree retardant versions.

5.1.2.5 Low Voltage Underground Cables

Typical Modes

- **Rodent Damage:** Rodents can chew on the insulation, leading to exposure of the conductors and electrical faults. The significance of this mode is that it can cause power outages and safety hazards. **Example:** Using rodent-resistant insulation materials and implementing regular inspections can prevent rodent damage, ensuring reliable operation.
- **Chemical Exposure:** Exposure to chemicals in the soil can degrade the insulation material, leading to failures. The significance of this mode is that it can compromise the cable's performance and safety. **Example:** Conducting soil analysis and using chemical-resistant insulation/sheathing materials can mitigate this risk, enhancing the durability and reliability of the cables.

Specific Modes

- Cross-Linked Polyethylene (XLPE) Cables
  - Insulation Degradation: Over time, environmental stress and load cycles can degrade insulation. This is an important but common failure mode.

- Polyvinyl Chloride (PVC) Cables
  - Thermal Aging: PVC insulation can become brittle with thermal cycling and age. This is a moderately critical failure mode due to the risk of insulation cracking.
  - Chemical Exposure: PVC can be affected by chemicals in the soil, leading to insulation degradation. This is moderately important and situational.
- Paper Insulated Lead Covered (PILC) Cables
  - Same failure modes as higher voltage PILC cables (moisture ingress and lead sheath corrosion).
  - Importance: These failure modes remain critical due to the potential for significant degradation in cable performance.

5.2 Consequence of Failure

Failure of a cable has the potential to disrupt supply to customers.

The cost resulting from this failure (cost of failure) is evaluated through three lenses: safety, environment, and customer/reputation for all asset classes. Table 1 is a summary description for each lens.

Table 1: Consequence Lenses

Consequence Lenses	Descriptions
SAFETY	Failure of asset resulting in injury or death of an employee or member of the public
ENVIRONMENT	Bushfire damage or environmental waste.
CUSTOMER AND REPUTATION	Loss of supply to customers
	Breach of regulatory obligations

The Cost of failure associated with any of the consequence lenses is the product of the cost of consequence and likelihood of consequence. Detailed methodology of the consequence assessment is described in AMS -01-09.

5.3 Risk Treatment

Risk mitigation activities, or treatments, are required to maintain risk by targeting reduction of PoF or CoF depending on the nature of the risk. Mitigation measures include asset replacement, asset refurbishment, inspections, testing or system redesign, and are achieved through capital projects or operational expenditure. Risk treatment options are described in the section on 'Risk Treatment' in AMS 01-09.

Capital replacement is a major component of asset risk management. The prerequisites for replacing an asset are:

- replacement of the asset will result in a material risk reduction
- risks can't be feasibly managed through maintenance or refurbishment
- monetised risk exceeds the replacement cost meaning that it is economic to replace the asset

6. Performance

6.1 Performance Analysis

In the context the management of assets and asset types within an Electrical Distribution Network, assessing asset performance is a vital tool for effective lifecycle management. Performance information provides a comprehensive understanding of how these assets behave under various conditions, enabling asset managers to make informed decisions that enhance the reliability, safety, and efficiency of the infrastructure.

Performance data helps identify trends and patterns in asset behaviour, which are crucial for making strategic decisions regarding maintenance, upgrades, and replacements. Understanding how assets perform over time allows for proactive management, reducing the risk of unexpected failures. The assessment employed by AusNet involves analysing failure trends and any significant impacts resulting from failure, which provides valuable insights into the health and reliability of the assets.

6.2 Performance Profile

Figure 15 below shows the leading cause of cable faults is physical damage mostly involving vehicles / third party

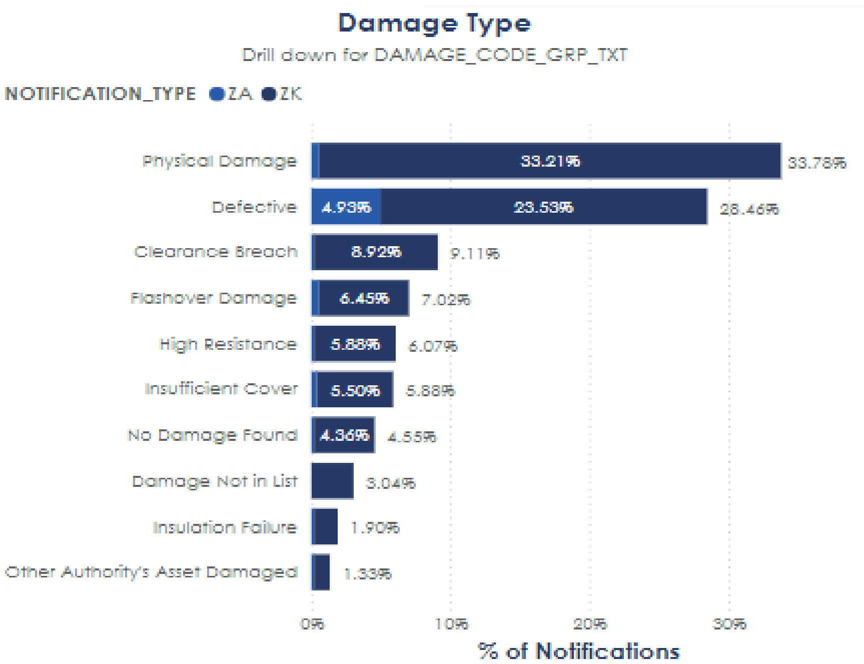

Figure 3 – Cable faults by damage code

7. Related Matters

7.1 Regulatory Framework

7.1.1 Regulatory and Legislative Reference

Effectively managing compliance obligations specific to legislation and policies is a core element of Asset Class Planning and supports the sustainable operation and management of Network Assets. Ensuring adherence to relevant laws, policies and codes helps prevent legal and regulatory breaches, which can lead to significant penalties, operational disruptions, and reputational damage.

Section Nine (9) provides a quick reference table for the legislative and regulatory laws, acts, and policies that are of material consideration for cables.

7.1.2 Technical Standards and Procedures

Effectively managing compliance with technical standards and operational procedures is an important element of Asset Class Planning. Adhering to these standards ensures that the assets are designed, constructed, maintained, and operated in a manner that meets industry best practices, enhances safety, and ensures reliability. Compliance with technical standards helps prevent asset failures, reduces risks, and ensures interoperability within the electrical distribution network. For example, ensuring that all components of various asset types are installed and maintained according to Australian Standards can prevent unplanned failure and operational faults, enhancing network reliability.

7.2 External Factors

7.2.1 Technical Factors

Understanding and managing the technical factors that can directly impact the lifecycle planning for Network Assets across all the AusNet Asset Classes is a core element of effective asset management. These factors encompass various design, engineering, and technical performance considerations that directly impact the ability to manage and maintain these assets efficiently. Ensuring that Network Assets meet specific technical performance standards is vital for maintaining the reliability and safety of the electrical distribution network. For example, selecting construction materials with appropriate durability and weather resistance is essential to prevent faults and ensure consistent performance under varying environmental conditions.

Targeted Activities (Technical Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Exclusive use of Tree Retardant insulation material (TR-XLPE) in all new MV cables
02	All cables for use outside of the control room are to be sheathed with a moisture inhibiting layer (eg High Density Polyethylene HDPE). In the past PVC has been used however this is not impervious to moisture.

7.2.2 Environmental Factors

Targeted Activities (Environmental Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	In geographical areas affected by salt water, typically but not exclusively classed as coastal), cable termination voltage ratings are increased to the next level and specified for heavy pollution application (e.g. 22kV installations are fitted with 33kV terminations)

7.2.3 Stakeholder/ Social Factors

Social Factors

Understanding social factors is essential for the effective management of critical network infrastructure assets. Social factors, including community expectations, public safety, and environmental impacts, play a significant role in shaping asset management strategies. Ensuring that these social considerations are addressed helps build public trust, maintain social license to operate, and enhance the organisation's reputation. For instance, ensuring that maintenance activities for Civil Infrastructure do not disrupt local communities or pose safety risks is crucial for maintaining public support and compliance with social responsibilities.

Targeted Activities (Social Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Underground boring techniques are employed wherever possible to avoid excavations

Stakeholder Factors

Understanding the requirements of stakeholders with a direct interest in the assets associated with the insulated cable systems asset class is an important aspect of effective asset management. Key stakeholders, including customers, regulatory bodies, and industry partners, have specific expectations that influence asset management strategies and operational decisions. Ensuring clear communication and alignment with these requirements helps maintain regulatory compliance, enhance service reliability, and build robust partnerships. For example, customers expect reliable infrastructure and timely responses to issues, which requires minimal disruption during maintenance activities of insulated cable systems. Similarly, regulatory bodies impose standards that must be adhered to.

Targeted Activities (Stakeholder Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Utilise modern installation methodologies to minimise disruption to the community
02	Smart designs for installation ensuring new cables are placed in conduits, to minimise installation and maintenance times

7.3 Internal Factors

7.3.1 Training and Competency Factors

Effective training and competency development is a core element of asset class. Ensuring that asset managers, engineers, operational staff, and field personnel possess the necessary skills, and knowledge is crucial for maintaining the reliability, safety, and efficiency of the asset network. Competent staff can effectively perform inspections, maintenance, and repairs, preventing asset failures and minimising downtime. Continuous training helps in keeping up with technological advancements, regulatory changes, and best practices, thereby enhancing overall asset management performance.

7.3.2 Resource Management Factors

Resource Management is a core element of asset class planning for Network Assets. Proper oversight ensures that the management of AusNet's resource bases meets stringent quality and performance standards, which is essential for preventing asset failures, managing risks, and maintaining compliance with regulatory requirements. Effective resource management contributes to cost efficiency via activities such as leveraging the expertise of specialised in-house skills and contractors while avoiding hidden costs associated with inefficiencies and non-compliance.

There are three sub-categories of consideration for this factor, which are:

- Resourcing strategies
- Outsourcing
- Supply Chain Management

Targeted Activities (Resource Management Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Condition assessment testing and result interpretation is a critical skill base that needs to be gained and maintained. Without such a resource the correct understanding of an assets condition will not be possible. To date, such a group has been established and has over 2 decades worth of testing experience.
02	Considerable work has been done with procurement in establishing a list of approved suppliers for cables, following a 3 fold process of desk top evaluations and factory inspections.

7.3.3 Safety Factors

Safety is a paramount concern in the management of electricity distribution network assets, as outlined in ESMS 20-01. Effective asset management planning and activities are crucial for protecting employees, contractors, the public, and the environment from potential hazards associated with electrical infrastructure. Ensuring adherence to safety regulations and standards through diligent asset management helps prevent accidents, minimise risks, and maintain the integrity of the network.

Targeted asset management activities include conducting regular safety audits and risk assessments, maintaining a robust Bushfire Mitigation Plan, providing ongoing safety training and competency assessments, regularly reviewing and updating emergency response plans, engaging with the community to raise awareness about electrical safety, and adopting new technologies and practices to enhance network safety. By integrating these safety-focused activities into asset management planning, AusNet can effectively minimise safety risks "as far as practicable," as outlined in the Electricity Safety Act 1998 and reflected in ESMS 20-01.

Targeted Activities (Safety Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Use of non-invasive condition assessment tools has enabled scanning and assessment of an assets condition while allowing it to remain in service. This has meant that overhead cable installations and terminations can be monitored for excessive electrical activity that could result in an asset failure

7.4 Future Developments

7.4.1 Technology and Innovation Factors

Effectively managing the process of tracking future technology developments and innovations is a core element of asset class planning. Staying informed about technological advancements ensures that asset management practices remain up-to-date, efficient, and competitive. Innovations can lead to improved materials, better monitoring systems, and enhanced maintenance techniques that increase the reliability, safety, and longevity of critical infrastructure. For example, advancements in diagnostic tools for detecting early signs of deterioration and the development of advanced materials for asset components can significantly enhance their performance and maintenance. For technology and innovation, this is a process that looks to existing technologies, processes, or practices that have been proven in the market and have already been taken to market.

Targeted Activities (Technology and Innovation Factors)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Ensure the correct people are attending seminars or conferences that discuss these latest trends and bring this information back to the company
02	Ensure the leaders of both asset management and electrical testing are involved in CIGRE and its Australian Panel AU B1 focusing on Insulated cables

7.4.2 Research and Development Factors

Effectively managing the process of investing in research and development (R&D) and seeking funds for R&D activities is a core element of asset class planning. R&D investment ensures that the organisation stays at the forefront of technological advancements, develops innovative solutions to emerging challenges, and enhances the reliability, safety, and efficiency of its assets. For example, developing new materials with improved structural properties for buildings or advanced monitoring systems for environmental systems can significantly extend their lifespan and reduce maintenance costs. Research and development is the process of researching and investing in an idea, process, practice, or technology that has not been realised in the market yet; it is a step before tracking innovation and technology because the investment to build and take the item to market still needs to be proven.

7.4.3 Continuous Improvement

Continuous Improvement (CIP) is a critical process in the overall application of asset management, particularly for managing insulated cable systems. CIP ensures that asset management practices remain effective, efficient, and adaptive to changing conditions and emerging challenges. By consistently seeking ways to enhance processes, technologies, and strategies, organisations can maintain high levels of performance, reliability, and safety.

Best practice asset management promotes a culture of continuous improvement, encouraging organisations to regularly evaluate their asset management systems, identify areas for enhancement, and implement changes. This iterative process involves monitoring performance, analysing data, and applying lessons learned to refine practices. By focusing on CIP, organisations can ensure that their asset management activities remain dynamic, resilient, and aligned with best practices and strategic objectives. This approach not only enhances the overall efficiency and effectiveness of asset management but also supports long-term sustainability and success. CIP differs from technology and innovation as well as R&D because it involves the ongoing enhancement of existing processes and practices based on real-world feedback and performance data, rather than the development and introduction of new technologies or the exploration of unproven ideas.

8. Asset Strategies

8.1 New Assets

8.1.1 New Asset Considerations

A strategic asset strategy for the introduction of new assets provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset upgrades or changes, detailing the conditions under which new assets may be introduced into the network. This is not necessarily a like-for-like replacement but rather a strategic change or upgrade to a different type of asset to enhance reliability, improve efficiency, and incorporate advanced technologies. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for integrating new assets into the AusNet network.

Targeted Activities on New Assets

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Where practical, the vast majority of new installations will use underground cable circuits, rather than ABC configurations. While no additional overhead cable systems are being planned in the future, any repaired or replaced installations will utilise LDMS HV ABC. The preference remains to underground such circuits where economically viable, thus removing all risk of tree damage and fire starts, to raise the circuit reliability and to improve the streetscape. Replacement programs will continue to eliminate all NMS ABC MV overhead cable from the network.
02	As the cable network continues to be renewed because of either in-service failure, condition assessment results, high condition score or REFCL testing outcomes, the population of PILC cables will diminish until eventually they will no longer exist on the network.
03	All new cable systems shall be subjected to the commission test protocols that have been developed. SMI 12-01-02
04	To minimise the effect of poor installations and to ensure the maximum cable circuit reliability, the following measures have been or are being implemented • Using only accredited installers, trained by the specific accessory manufacturers • Where practical, designing (and repairing) of all cable circuits to have no joints • Standardisation of components within a cable circuit, cable design, termination type (being dependant on being outdoor or within a switchboard) and if necessary in-line joints. • Introduction of new 3 sheath cable design to facilitate more meaningful sheath integrity tests.

8.2 Inspections and Monitoring

A strategic plan for inspections and monitoring provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for conducting inspections and monitoring activities, such as enhancing reliability, improving efficiency, and incorporating advanced technologies. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for establishing comprehensive inspection and monitoring protocols within the AusNet network.

Targeted Activities (Inspection and Monitoring Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Non-invasive inspection and testing methodologies can be utilised on in-service assets to determine the presence of outward signs of a deteriorated inward condition. Simple things like an oil leak on a HV cable termination can lead to a catastrophic failure if left unchecked.
02	A new Condition Assessment (CA) program has been developed to support the company's Risk Based Asset Management (RBAM) program, to start to move away from a fundamentally reactive maintenance program to a more proactive approach to addressing cable circuit defects. The new program has two areas of focus
02-A	On-line testing: Allowing the circuit to remain in service while identify any obvious defects with terminations by visual inspection and attempting to detect significant electrical defects within the circuit by using sophisticated non-invasive monitoring equipment.
02-B	Off-line testing: Incorporating a wide variety of electrical test methods to accurately detect defects at normal and over-voltage conditions. The Company has developed and started to implement a condition assessment program for its HV and MV underground cable population. This program consists of a suite of electrical diagnostic tests that can yield an economical and accurate assessment of the overall condition of a cable circuit.

8.3 Maintenance Planning

A strategic plan for maintenance provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the ideal framework and objectives for conducting maintenance activities, such as enhancing reliability, improving efficiency, and incorporating advanced technologies. It serves as a roadmap that guides the decision-making process for establishing comprehensive maintenance protocols within the AusNet network. This involves creating a structured approach to regular maintenance activities to ensure optimal performance and longevity.

Targeted Activities (Maintenance Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	The following maintenance activities will continue to be refined • Recording fault codes to enable disaggregation of failure modes by cable or accessory type • Fault data collection for each cable failure to determine root cause of the failure and enable trending • Recording of installers/jointer details to improve efficiencies
02	LV cables • Both overhead and underground, will continue to be replaced on condition as determined by the condition assessment protocol under section, or earlier if they fail in service or are replaced during network upgrade works
03	MV underground cables will continue to be maintained in the following traditional manner • Critical cables, as defined in the testing Standard Maintenance Instruction (SMI), within stations shall have no joints. Temporary joints may be permitted for a period of no greater than six months to enable supply to be restored • Following an in-service failure of cable and/or in-line joint, the failed portion shall be cut out and replaced with two joints and a short length of new cable

	• A HV customer supply cable that has a circuit length less than 100m shall be replaced rather than repaired • Termination failure, where enough spare length cannot be recovered from the cable, will have a new inline joint installed within 4 metres of the base of the pole and a new tail length of cable installed and terminated • MV PILC cable failures, and possible subsequent testing, will preferably cause the entire cable circuit to be replaced. If this is uneconomical then the repair shall be covered by the above two XLPE methodologies except that the joints to be used will be transition/sealing joints to ensure that the paper/oil system is sealed. • HV Oil Filled Cable (OFC) failures will again preferably cause the entire cable circuit to be replaced. If this is uneconomical then the repair shall be covered by the above two XLPE methodologies except that the joints to be used will be stop joints to ensure that the paper/oil system is sealed and pressurised.
04	HV underground cables will continue to be maintained in the following traditional manner • All 66kV cables are classified as critical cables. These shall have no joints unless the circuit length determines that they are required. In-service failures shall be repaired by replacing the entire cable length. • Termination failure, where enough spare length cannot be recovered from the cable, the preference is to replace the entire cable length. If this is impractical or uneconomical, then a new inline joint shall be installed within 4 meters of the termination and a new tail length of cable installed and terminated • HV Oil Filled Cable (OFC) failures will again preferably cause the entire cable circuit to be replaced. If this is uneconomical then the repair shall be covered by the above two XLPE methodologies except that the joints to be used will be stop joints to ensure that the paper/oil system is sealed and pressurised.

8.4 Renewals Planning

A strategic asset strategy for renewals and replacements provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of asset refurbishments or like-for-like replacements, detailing the conditions under which existing assets may be renewed or replaced within the network. This process ensures continued reliability and efficiency, manages obsolescence, and maintains adequate spares. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for renewing or replacing assets within the AusNet network.

Targeted Activities (Renewal Strategies)

REF	DETAILS OF MATERIAL CONSIDERATIONS
01	Replacement, rather than refurbishment, is the only viable option in regards to LV, MV and HV cable systems. Once the cable insulation system has been compromised, it can not be repaired so it must be cut out and replaced.
02	Continue replacement of MV Overhead NMS ABC with LDMS ABC.
03	**Obsolescence and Spares Management**

- Due to the large volume turnover of LV and MV cables, the strategic spare holding levels for such cables is minimal. There is always stock within the stores systems that can be used to respond to failures.
- To protect the network against an unforeseen demand on cable inventory, there is one strategic spare 500m drum of the four most common 3 core cables kept in the store, namely 185mm2 and 300mm2 AL, 2 sheathed and 3 sheathed – 4 drums in all.
- There are some MV underground cable circuits that have a slightly different design than those typically used. These design differences usually dictate that a strategic spare be on hand should a failure occur.
  - Two examples that might help understanding are larger screen wire cross section to carry higher fault ratings in a particular installation or a special outer protective sheath construction. For such cables at least one drum of strategic spare cable would be deemed necessary in order to facilitate the correct repair.
- HV cable circuits are typically bespoke designs for particular applications and as such would dictate the carrying of strategic spares of both cable and possibly accessories. The number of spare joints, if required, shall be sufficient to facilitate the repair of the three phase circuit.
- While HV Oil Filled Cables exist on the network, strategic spare transition and stop joints are required. Again, the preference is to replace these cable circuits, however due to long circuit lengths such replacements may not be economically viable. In such cases the required number of joints shall be sufficient to facilitate the repair of the three phase circuit without the need to have to replace the entire cable.

8.5 Decommissioning

A strategic asset strategy for decommissioning provides high-level guiding principles and overarching goals for asset management, focusing on long-term planning and sustainability. This strategy outlines the aspects of safely and efficiently removing assets from service, detailing the conditions under which decommissioning may occur. It ensures that the process is conducted in a way that minimises disruption, manages environmental impacts, and complies with regulatory requirements. It serves as a roadmap that is ideal to follow if possible, guiding the decision-making process for decommissioning assets from within the AusNet network.

9. Legislative References

NO.	TITLE	LINK
1	Electricity Safety Act 1998	https://content.legislation.vic.gov.au/sites/default/files/2024-06/98-25aa083-authorised.pdf

10. Resource References

NO.	TITLE	LINK
1	Asset Management System Overview	AMS 01-01
2	Electricity Distribution Network Asset Management Strategy	AMS 20-01
3	Asset Risk Assessment Overview	AMS 01-09
4	Risk Management – Guidelines	AS ISO 31000
5	Electricity Safety Management Scheme	ESMS 20-01
6	Power Cable Commission Test Protocols	SMI 12-01-02

11. Schedule of revisions

ISSUE	DATE	AUTHOR	DETAILS OF CHANGE	APPROVED BY
1	02/02/09	M Butson A Rahman	First Draft	
2	02/09/09	S DeSilva G Lukies	Review and update	
3	11/09/09	SD, NB, GL	Updated and included appendix	
4	20/11/09	GL	Updated underground power cable failure data	
5	26/11/09	GT, GL	Review and update	GT
6	27/06/12	MB	HV ABC replacement strategy added	FL
7	27/03/15	A. Cuppen J. Stojkovski T. Gowland	Major rework on document structure Introduced FMECA and Dependability management	J Bridge
8	05/09/2019	R. Wheatland A. Bugheanu	Prepared for EDPR submission 2021-2025	P Ascione
9	31/01/25	R. Wheatland	Prepared for EDPR submission 2026-2030	

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