Asset Specific Plan

UG Cables

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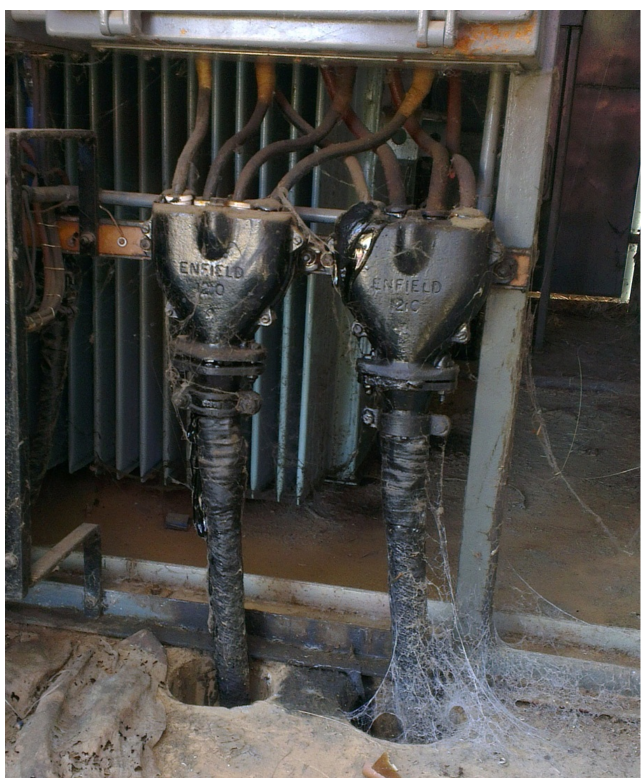

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1 Purpose

This document forms the ActewAGL Asset Specific Plan for the UG Cables suite of assets within ActewAGL Distribution. It is intended to define the specific approach to, and principles for, the management of the nominated assets within ActewAGL Distribution.

It provides a justified and evidence based Asset Specific Plan that is used to forecast the volumes and types of intervention and associated costs considered necessary to achieve the defined level of infrastructure, system or asset capability or output, for UG Cables. As such it provides a whole-life, whole-system based intervention and cost analysis for these assets.

This document and the principles captured within it are derived from and consistent with the overall ActewAGL Asset Management Policy and form a key element of the ActewAGL Distribution Asset Management Plan.

It is a live document which forms the framework for the implementation of Asset Management relating to UG Cables. It is intended to define the approach to Asset Management taken by ActewAGL Distribution to the management of these assets for both internal and external communication.

2 Good Practice Alignment

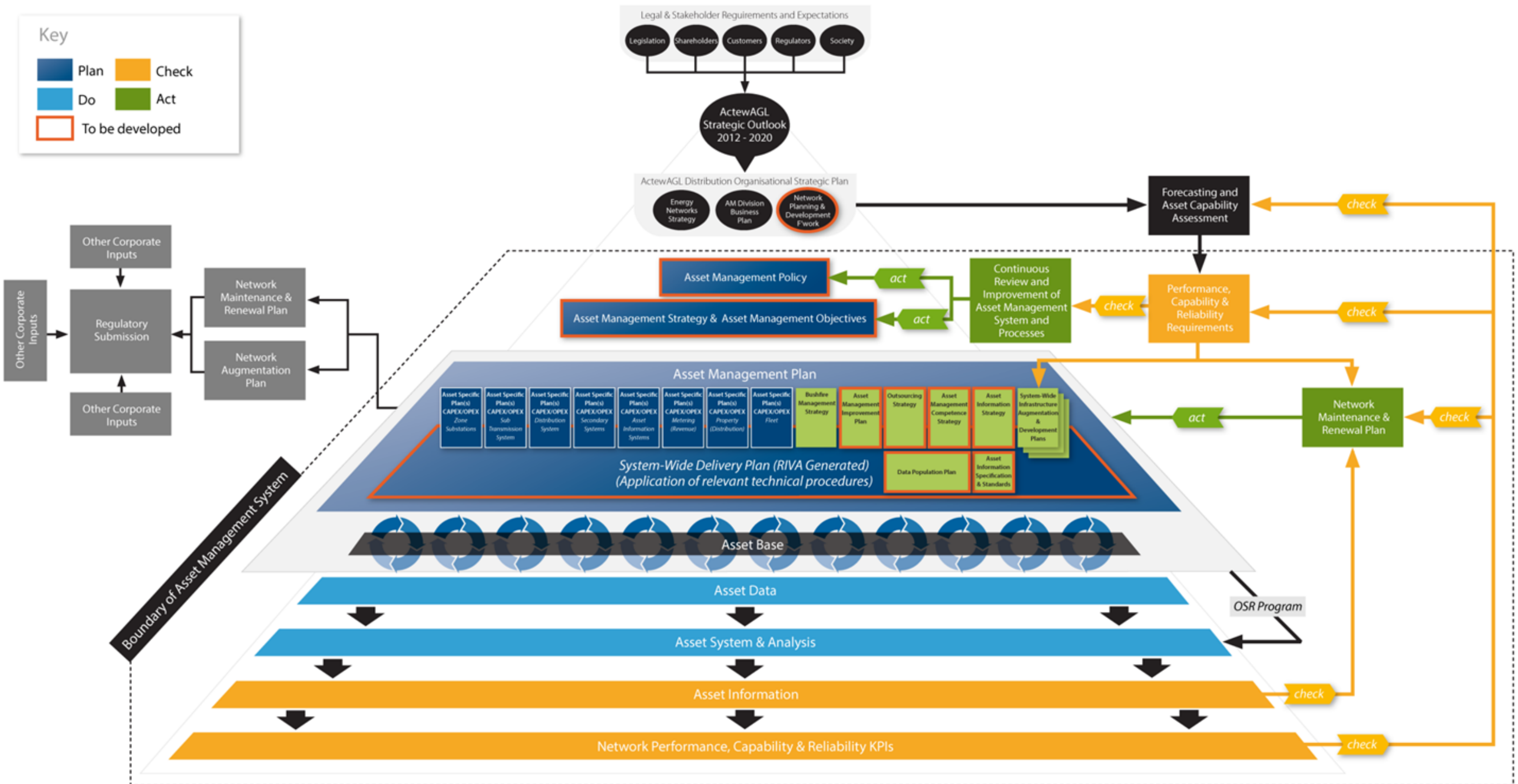
This document has been developed based on good practice guidance from internationally recognised sources, including the Global Forum on Maintenance and Asset Management (GFMAM) and the Institute of Asset Management (IAM). It has been specifically developed to comply with the relevant clauses of BSI PAS 55:2008 and the emerging requirements of ISO55000.

3 Corporate Alignment

This Asset Specific Plan forms a key element of the Asset Management Strategy, as applied to the asset class "UG Cables". The Asset Management Strategy contains the overarching principles and objectives for the management of this asset class.

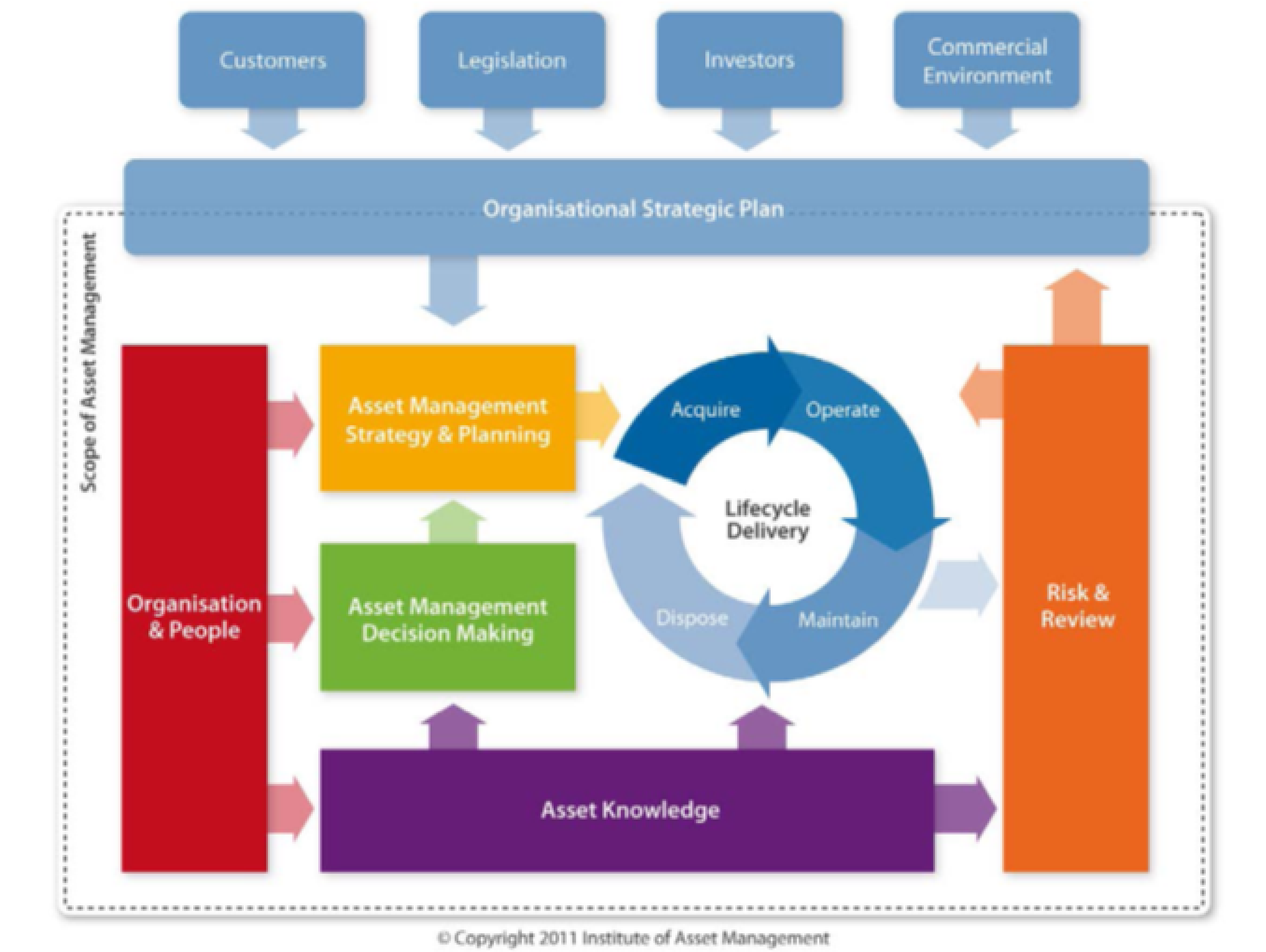
By employing a comprehensive and transparent approach to Asset Management, this Asset Specific Plan provides the evidence for, and justifies the inspection, maintenance and renewal regimes that support the delivery of the required outputs (e.g. safety and asset, system or infrastructure capacity, capability and service reliability, and availability) in conjunction with the Network Augmentation Plan. It also demonstrates that this is planned to be achieved, where appropriate, at minimum whole-life, whole-system cost.

This document's role within the overall Asset Management Framework is shown overleaf.



Key
Plan
Check
Do
Act
To be developed
Legal & Stakeholder Requirements and Expectations
Legislation
Shareholders
Customers
Regulators
Society
ActewAGL Strategic Outlook 2012 - 2020
ActewAGL Distribution Organisational Strategic Plan
Energy Networks Strategy
AM Division Business Plan
Network Planning & Development F'work
Forecasting and Asset Capability Assessment
check
Other Corporate Inputs
Other Corporate Inputs
Regulatory Submission
Network Maintenance & Renewal Plan
Network Augmentation Plan
Other Corporate Inputs
Asset Management Policy
act
Asset Management Strategy & Asset Management Objectives
act
Continuous Review and Improvement of Asset Management System and Processes
check
Performance, Capability & Reliability Requirements
check
Asset Management Plan
Asset Specific Plan(s) CAPEX/OPEX Zone Substations
Asset Specific Plan(s) CAPEX/OPEX Sub Transmission System
Asset Specific Plan(s) CAPEX/OPEX Distribution System
Asset Specific Plan(s) CAPEX/OPEX Secondary Systems
Asset Specific Plan(s) CAPEX/OPEX Asset Information Systems
Asset Specific Plan(s) CAPEX/OPEX Metering (Revenue)
Asset Specific Plan(s) CAPEX/OPEX Property (Distribution)
Asset Specific Plan(s) CAPEX/OPEX Fleet
Bushfire Management Strategy
Asset Management Improvement Plan
Outsourcing Strategy
Asset Management Competence Strategy
Asset Information Strategy
System-Wide Infrastructure Augmentation & Development Plans
System-Wide Delivery Plan (RIVA Generated)
(Application of relevant technical procedures)
Data Population Plan
Asset Information Specification & Standards
act
Network Maintenance & Renewal Plan
check
Boundary of Asset Management System
Asset Base
Asset Data
OSR Program
Asset System & Analysis
Asset Information
check
Network Performance, Capability & Reliability KPIs
check

4 Scope - Asset Management Activities



The diagram above represents a conceptual model, intended to describe the overall scope of Asset Management and the high level groups of activity that are included within this discipline. The Model highlights the fact that Asset Management is about the integration of these groups of activity and not just the activities in isolation. It also emphasises the critical issue that Asset Management is there to serve the goals of the organisation. The "line of sight" from an organisation's goals to its Asset Management activities or "alignment" that is promoted in PAS55 is a concept that is carried through to this asset specific plan.

5 UG Cables Assets

This section contains a subsection for each UG Cables asset.

5.1 Asset Classification

System/Non-System:	System
Asset Group:	On-Ground and Underground
Asset Class:	UG Cables
Asset Type:	HV Cables, LV mains cables, Service Cables
Asset Rating:	High Voltage and Low Voltage

5.2 Brief Description

Cables are insulated conductors, normally installed underground to transmit electricity for high voltage (HV), low voltage (LV) mains and services. Since the 1980s, all new sub-division development in Australian Capital Territory (ACT) is reticulated with underground distribution network. The underground cable asset is managed and categorised by the voltage level, insulation type and the type of cable construction. The scope of this document covers high voltage cables, low voltage mains cables, underground service cables, underground joints and terminations. The management of ActewAGL transmission cable is covered in the Transmission Conductor asset specific plan.

HV, LV and Services Cable Types

The majority of high voltage cables are three core cable type. The cable conductor material is either stranded aluminium or copper for HV and LV mains power cable and copper for LV service cable.

Cable types normally falls into three different categories:

· Paper insulated lead covered (PILC) cables

· Paper insulated aluminium covered cables or Concentric Neutral Solid Aluminium Conductor (Consac) cables

· Polymeric insulated cables

Older cables in the ActewAGL Distribution Network are mainly PILC with smaller amounts of Consac cables. PILC cables are paper insulated with a lead metallic sheath covering over the insulation. These cables normally have a steel wire or tape armouring between two layers of bitumen compounded hessian tapes as an oversheath for mechanical protection.

Consac cables were installed from the 1960s to mid-1970s. These cables are paper insulated with an aluminium metallic sheath which is commonly used for the concentric conductor. Consac cables have a bitumen layer between the PVC oversheath for corrosion protection and to prevent moisture ingress between the PVC oversheath and the aluminium metallic sheath in an event of oversheath damage.

Since the 1980s, polymeric cables have been used in the industry. Polymeric cable insulation is either Polyvinyl Chloride (PVC) or cross-linked polyethylene (XLPE). The XLPE cable type is commonly used for HV cables. The cable metallic sheath or screen is made out of aluminium sheath, lead sheath or copper screen wires. The cable oversheath is made from Polyvinyl Chloride (PVC) and high density polyethylene (HDPE).

Cable Terminations

Cable terminations are used to connect the underground cable to other distribution equipment such as an overhead line or switchgear. They are normally installed inside weatherproof enclosures, inside a chamber substation, or are installed outdoor on overhead poles.

Their main function is to provide insulation to the cable ends, up to the point of electrical connection to other equipment. At the same time, the termination must control the high stress point at the area where the semi-conductive screen is stripped back for the cable preparation.

Cable terminations can be classified into the following main categories based on their installation method:

1. Taped and porcelain/cast iron

2. Heat shrink applied with a flame torch

3. Elbow separable connector, cold shrink and cold applied

Older PILC cables have a paper taped stress cone with compound filled porcelain or cast iron as the insulator and finally sealed with a lead plumbing or wipe joint. Due to safety concerns, ActewAGL has replaced all cast iron HV cable terminations installed on overhead poles with heat shrink cable terminations. Several hundred cast iron cable terminations for LV mains and services cable remain in service.

All new HV and LV outdoor cable terminations are heat shrink type. Heat shrink cable terminations use high permittivity material for stress control.

Elbow separable connectors have also been installed in ActewAGL since the late 1990s. Elbow separable connectors are used to connect cables to transformer and switchgear.

Underground Joints

Because of the limitation of cable drum lengths, joints are required to join two cable sections together. Joints are also required for cable repair and for connecting new substations into a section of the existing cables. The principle of underground joints are similar to cable termination. Joint construction consist of a ferrule to connect the two cable conductors, stress control feature at the screen cut area, insulation to provide the same or better electrical performance as the underground cable, and finally mechanical and environmental protection in the outer jacket or casing.

5.3 Asset Function

Underground cables transmit electric power between two termination points at HV (11kV), LV mains (415V) and services (240V).

A cable termination provides insulation to the cable ends up to the point of electrical connection to other equipment such as switchgear, overhead line or transformers.

A cable joint provides continuity of two underground cable sections.

5.4 Asset Interfaces

Cables (underground cable with cable termination) interface with other equipment such as a transformer, switchgear or overhead line. They also provide services to our customers up to the point of connection.

5.5 Data Sources

Data sources include WASP, GIS and the ActewAGL electrical data manual. AMP data is built from extracted HV Cable and LV Cable asset data from the GIS database.

5.5.1 Data Quality

The minimum cable asset information required to confirm cable thermal rating, failure investigations and overall asset management is:

· voltage level,

· cable insulation type,

· conductor size,

· conductor material,

· screen type and size,

· manufacturer name and year,

· laying arrangement (trefoil, flat, spacing),

· minimal laying depth.

All reactive or routine maintenance histories on the cable assets provided relevant information for asset management.

5.6 Asset Base

ASSET BASE	
ASSET	**Route Length (Kilometres)**
HV Cables	1,475
LV mains cables	1,236
Service Cables	1,878

6 Service and Performance Requirements

6.1 Availability

Cables are designed to have a high level of service availability. In an event of a cable or joint failure, after the location of the fault is identified, the damaged cable section is typically removed and replaced with two repair joints and new cable section. Because they are installed underground, any fault of the cable will require time to detect the fault location, excavate, repair, test, and backfill the trench.

The average time to install a repair joint is 2.5 days.

The expected service life for an XLPE cable is 45 years.

Availability = (MTBF-RT)/MTBF = (45 - (2.5/365))/45 = 99.98%.

MTBF = Mean Time Between Failure

RT = Repair Time

6.2 Reliability

Underground cables are designed to be reliable. When installed properly, these assets are designed to be in service for more than 45 years with minimal maintenance.

Assuming that a cable circuit incur 12 failures during its operational life, the reliability is determined as:

Reliability = (Expected life - downtime) / Expected life = (45 - 12 x 2.5 / 365) / 45 = 99.93%

6.3 Capacity

Cables are designed to operate at a maximum conductor temperature which will define the cable current rating (Amps).

The cable rating depends on the ability to dissipate heat to the surrounding, based on the following factors:

· Cable construction and material

· Cable dimension

· Cable arrangement

· Installation condition

· Depth of installation

· Ambient temperature

· Initial conductor temperature

· Thermal stabilised backfill and natural soil thermal resistivity

· Surrounding underground service and heat sources

As a part of the design process, the required capacity needs to be confirmed before selecting a sufficient cable size. While it is possible to operate the cable beyond its thermal limit, it can reduce its cable life expectancy.

6.4 Asset Utilisation

Modern XLPE cables can operate continuously at maximum conductor temperature of 90°C. It can also operate up to conductor temperature of 130°C for a short period of time every year, for emergency purposes. However, operating beyond 90°C will accelerates the insulation degradation and reduces the expected service life.

Belted paper insulated cables can operate at a maximum conductor temperature of 65°C. Screened paper insulated cables can operate at a maximum conductor temperature of 70°C.

High voltage cables are normally 75% utilised. The remaining 25% is reserved for contingency events where loads can be switched from other feeders circuits during outages.

6.5 Asset Criticality

Underground cable is critical for power delivery through the connection of equipment or directly to the customer's point of connection. If an underground cable, termination or joint fails, the connected equipment or customer will also lose connection to the electricity distribution network.

The criticality of each cable asset depends on the voltage level and the customer type. Typically, the higher the voltage, the more customers it can potentially affect in an event of a cable fault.

6.6 Geographical Criticality

Cable thermal rating is affected by the natural soil property. Geographic location of the cable route, where the natural soil is susceptible to drying out or the natural soil's thermal resistivity is high, can limit the cable thermal rating or result in the cable overheating in instances where it is operated beyond its maximum conductor temperature for prolong period.

The natural soil property should be tested during the design process. Cable route selection or cable sizing must take the results into consideration.

7 Asset Failure Modes

This section provides tabularised and prioritised details for failure rates by asset type failure mode or best available data.

7.1 Deterioration Drivers

- Mechanical or external damages to cable oversheath and/or armouring
- Corrosion of metallic sheath causing pitting or localised hole
- Cracking of leading plumbing on porcelain cable terminations
- Leaking oil from porcelain cable terminations
- Backfill or natural soil drying out causing thermal resistivity to surpass its design limits
- Connector or clamps not secured properly (poor contact) causing hot spots
- Corrosion on cable lug and terminal from indifferent metal surface
- Insulation deterioration from ageing reducing cable dielectric strength
- Fault current exceeding cable thermal design limits
- Ageing and crystallisation of lead sheath causing lead sheath to become brittle
- Cracking of lead sheath
- Water ingress from poorly installation termination or joints

7.2 Failure Modes

These are the failure modes associated with each of the asset types.

HV Cables

FAILURE MODES						
TYPE	DESCRIPTION	OCCURRENCE	SEVERITY	DETECTION	RPN	UNIT COST
Physical Mortality	Aging leads to crystallisation of lead sheath. Lead sheath becomes brittle and cracks. Water ingress into paper insulation and deteriorate insulation. Probability is once in 60 years for entire cable fleet.	Inevitable Failures	Minor	Almost Certain	60	
Variable manufacture quality	Manufacturing defects in insulation causing localised increase of electrical stress. Cable failure causing loss of supply to customer. Probability is once in ten years for entire cable fleet.	Relatively Few Failures	Minor	Almost Certain	15	
Vehicle or Third party impact	Severed cable from 3rd Party dig-in or vehicle collision into underground to overhead connection. Instant cable failure, potential fatality and unplanned loss of supply. Present control mechanism is to install cable inside PVC conduit or have a mechanical protective layer above cable. Probability is once every two years.	Relatively Few Failures	Moderate	Certain	12.5	
Incorrect installation	Damaged cable during installation, for example, sharp backfill, over bending, or excessive compaction. Premature cable failure causing loss of supply to customer. Probability is 5 times per year for entire cable fleet.	Relatively Few Failures	Very Minor	Certain	5	
	Accelerated thermal aging of					

Thermal overload	insulation due to operating beyond thermal design limits, backfill dry out, and entrapped air void in backfill or conduit. Premature cable failure causing loss of supply to customer. Probability is once in ten years for entire cable fleet.	No Known Occurrences	Very Minor	Almost Certain	4	

LV mains cables

FAILURE MODES						
TYPE	**DESCRIPTION**	**OCCURRENCE**	**SEVERITY**	**DETECTION**	**RPN**	**UNIT COST**
Physical Mortality	Aging leads to crystallisation of lead sheath. Lead sheath becomes brittle and cracks. Water ingress into paper insulation and deteriorate insulation. Probability is once in 60 years for entire cable fleet.	Inevitable Failures	High	Almost Certain	150	
External Damage	Severed cable from 3rd Party dig-in or vehicle collision into underground to overhead connection. Instant cable failure, potential fatality and unplanned loss of supply. Present control mechanism is to install cable inside PVC conduit or a mechanical protective layer above cable. Probability is once every two years.	Occasional Failures	High	Almost Certain	75	6,993.08
Incorrect installation	Damaged cable during installation, for example, sharp backfill, over bending, or excessive compaction. Premature cable failure causing loss of supply to customer. Probability is 20 times per year for entire cable fleet.	Occasional Failures	Minor	Certain	15	
Thermal overload	Accelerated thermal aging of insulation due to operating beyond thermal design limits, backfill dry out, and entrapped air void in backfill or conduit. Premature cable failure causing loss of supply to customer. Probability is once in ten years for entire cable fleet.	Relatively Few Failures	Minor	Almost Certain	15	
Variable manufacture quality	Manufacturing defects in insulation causing localised increase of electrical stress. Cable failure causing loss of supply to customer. Probability is once in ten years for entire cable fleet.	Relatively Few Failures	Minor	Certain	7.5	

Service Cables

FAILURE MODES						
TYPE	DESCRIPTION	OCCURRENCE	SEVERITY	DETECTION	RPN	UNIT COST
Physical Mortality	Aging leads to crystallisation of lead sheath. Lead sheath becomes brittle and cracks. Water ingress into paper insulation and deteriorate insulation.	Inevitable Failures	Minor	Almost Certain	60	
External Damage	Severed cable from 3rd Party dig-in or vehicle collision into underground to overhead connection. Instant cable failure, potential fatality and unplanned loss of supply. Present control mechanism is to install cable inside PVC conduit or a mechanical protective layer above cable. Probability is once every two years.	Relatively Few Failures	Minor	Almost Certain	15	

7.3 Consequences

The consequence of a failed cable, joint or termination depends on the cause of the event and the type of cable asset.

The effects of a cable failure can be loss of supply to customers, consequential damage to other parts of the network due to flow through fault current, risk to the public, surges or spikes causing damage to customers appliances or premises.

8 Maintenance and Replacement Strategies

8.1 Description of Strategies

ActewAGL has an aged and growing underground distribution network. There is approximately 1,475km of high voltage underground cables in the ActewAGL Distribution network. Up until now, ActewAGL has adopted the strategy of running the underground cables to failure. Any replacement decisions have been driven by repeated root cause failure which has been identified from failure investigation.

Example of this scenario is the replacement program of all Concentric Neutral Solid Aluminium conductor (Consac) cables with T-jointed service cables. After ActewAGL had experienced multiple failures on the T-joint of Consac cable in 2009, it was found that the failure was associated with water ingress into the Consac cables' T-branch joints which eventually lead to a joint failure. As a result, all known Consac cables with T-branch joints were identified and prioritised for replacement.

Between 2008 and 2013, reactive repairs and replacements have been increasing. Whilst most repair work is on the cable joint or termination, an increasing number of underground cables are reaching the end of their nominal operational life. For example, during repairs to an ageing cable at Parkes (which was installed in the 1950s), it was observed that the steel armour tape and the lead metallic sheath of the cable showed signs of corrosion.

The table below shows the historical and forecast number of high voltage cable fault.

	Historical Data							Forecast										
Year	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Forecasted HV cables length (km)	1301	1325	1326	1357	1389	1439	1476	1510	1548	1586	1626	1667	1709	1751	1795	1840	1886
Number of cable faults (High estimate)	19	19	26	23	35	29	26	33	37	41	46	51	57	64	71	79	87
Number of cable faults (Low estimate)								25	26	27	28	29	30	31	32	33	34

To address this trend ActewAGL Distribution has developed an asset management strategy that involves condition monitoring of high voltage underground cables and prioritisation of the high voltage underground cable replacement with suspected problems.

The program of work for the upcoming regulatory period is follows:

Condition Monitoring

ActewAGL is implementing a cable condition assessment program to assess the condition of some of the oldest HV cable in the network and the worst performing HV cable feeder to prioritise the cable replacement.

ActewAGL plans to assess the condition of over 20 HV cable feeders in the next five years.
The purpose of this program is to stop the growth of the increasing number of reactive cable or joint failure every year by detecting imminent failures and replacing the cable section before the failure occurs.

Planned Replacement

It is anticipated that 3% of the condition assessed HV cable or joints will require replacement every year. An estimate of 0.7 kilometres of HV cable section will be identified for replacement in 2014/15 from the condition monitoring, and 4.5 kilometres of cable section will be identified for replacement from 2015/16 and onwards.
It is expected that this program will reduce the risk of asset failure and associated reactive maintenance expenditure levels in future regulatory periods.

The LV CONSAC cable replacement program will continue throughout the 2014-19 and subsequent regulatory periods at two suburbs every year.

Unplanned Maintenance

- It is anticipated that there will be 20 LV or Service cable with poor cable or pothead condition identified from pole inspection every year.
- Due to pole replacements from unplanned events, 85 service cable terminations are allowed for replacement every year.

Reactive Maintenance

It is expected that the number of cable failures will rise as the cable ages. As a result, the funding for the unplanned/ reactive maintenance may increase until the condition monitoring and replacement program is fully implemented.

For the next regulatory period, the budget for unplanned/reactive maintenance has been based on the historical failure rate, and includes allowances for:

- 26 HV cable or joint repairs due to in-service failures (OPEX)
- 3 HV cable repairs due to third party dig-in (OPEX)
- 10 HV cable termination repair due to in-service failure (OPEX)
- 26 LV cable or joint repairs due to in-service failures (OPEX)
- 10 LV cable repairs due to third party dig-in (OPEX)
- 11 LV cable termination repair due to in-service failure (OPEX)
- 30 service cable replacement due to in-service failures (CAPEX)

8.2 Minimum Whole-of-Life Whole-of-System Cost

The software product, Riva DS, was used to evaluate the minimum, whole-life, whole-system cost approach to determine the optimal intervention options and scenarios.

8.3 Alternative Scenarios

A detailed analysis of alternative scenarios will be carried out after the Riva DS software is fully implemented at ActewAGL.

Optimisation has been done on the basis of balancing intervention (maintenance) costs with asset risk over the lifetime of the asset. This is done by calculating the value of risk that accrues to a given asset, which escalates year on year as that asset ages and deteriorates. Eventually, the annual cost of risk is high enough to warrant the capital expenditure to replace the asset, and hence reduce the risk cost to that of a new asset. Riva will optimise the Life Cycle Asset cost with respect to the life span versus risk cost trade off. The types of interventions which have been considered include replacement, refurbishment and inspections. Riva has chosen the optimum combination of these interventions.

Scenario 1: Reactive Replacement or Run-to-failure

Historically, ActewAGL generally adopted a run-to-failure scenario where in-service cable assets were only replaced when the cable assets failed. This strategy was based on the manufacturer's advice, internal risk assessment, operational requirements, service experience and industry experience.

Scenario 2: Planned replacement program

Where ActewAGL experiences a repeated failure on a particular cable, joint or termination types, a failure investigation will be initiated to identify the root cause failure. In some cases, failure investigation may recommend proactive replacement as the solution. Example of this scenario is the replacement program of Concentric Neutral Solid Aluminium conductor (Consac) cables with T-jointed service cables. After ActewAGL had experienced multiple failures on the T-joint of Consac cable in 2009, it was found that the failure was associated with water ingress into the Consac cables' T-branch joints which eventually lead to a joint failure. As a result, all known Consac cables with T-branch joints were identified and prioritised for replacement.

Scenario 3: Condition based replacement

Condition based replacement is used in Australian distribution utilities to identify cable assets which are likely to fail in the near future by performing condition assessment. The purpose of condition based replacement is reducing unplanned loss of supply to the customer, thus improving the performance of the cable assets. ActewAGL is implementing a cable condition assessment program to assess the condition of some of the oldest HV cable in the network and the worst performing HV cable feeder to prioritise the cable replacement.

ActewAGL plans to assess the condition of over 20 HV cable feeders in the next five years. The purpose of this program is to reduce the increasing number of reactive cable or joint failure every year.

8.4 Asset Costs

Unit costs for work on this asset class have been estimated by Program Development Branch. Details of the estimate are available in \\jeeves\energynetwk\Program of Work\future pow\AMP Reg Submission.

8.4.1 Planned Maintenance

UNIT COSTS

ASSET TYPE	TASK	COST BASIS	UNIT COST
HV Cables	Replace HV cable feeder section due to poor condition (FY14/15)	(Planned list) ActewAGL estimate 3% of the condition assessed HV cable or joints will require replacement.	$250
HV Cables	Replace HV cable feeder section due to poor condition (FY15/16 and onwards)	(Planned list) ActewAGL estimate 3% of the condition assessed HV cable or joints will require replacement.	$250
LV mains cables	Replace LV CONSAC Cable	(Planned List)	$250,000

8.4.2 Unplanned Maintenance

UNIT COSTS			
ASSET TYPE	TASK	COST BASIS	UNIT COST
HV Cables	Investigate root cause failure	(Unplanned) Failure investigation is to identify the root cause of the failure of high voltage cable, terminations and joints Each failure investigation will require approximately 40 man hours at a $100 rate if independent experts are involved. There are approximately 32 HV cable faults per year. If ActewAGL investigate 6 HV cable fault with different failure mechanism every year, a budget of $40,000 (40 man hours x $100 x 6 faults per year) is required for failure investigation every year.	$3,876
HV Cables	Repair cable due to third party damage	(Reactive) 33 accidental damages incidents occurred from 2002 to 2012. There are typically 3 incidents per year where cable are damaged by excavators or damaged by fault switching.	$8,296
HV Cables	Replace HV cable section or joint due to in service failures	(Reactive) 260 HV cable fault occurred in the past ten years. To repair failed cable section or joint, cable section must be excavated, two new joints and a new cable section of around 10 meters. Assuming water ingress has not gone longitudinally through the cable.	$8,296
HV Cables	Replace HV cable termination due to in service failures	(Reactive) More than 110 HV three core cable terminations have failed in the past 10 years. It is assumed that at least 10 three core terminations fail every year. A new three core termination, a new cable joint, and 10 meters of cable is required for the repairs.	$8,296
LV mains cables	Repair LV cable due to third party damage	(Reactive) From 2002 - 2012, there are 110 known accidental incident on LV cable where excavator or vehicle has damaged the LV cable terminations and joints. (Localised damages)	$8,296
LV mains cables	Replace LV Mains Cable and Joint	(Reactive) From 2002 - 2012, there were approximately 285 known LV cable & joints fault. Failure rate for these 11 years is = Number of cable/joints fault per number of LV cable units divided by 11 = 0.001	$8,296
LV mains cables	Replace LV Mains Cable termination due to in-service failure	(Reactive) Approximately 89 known LV termination failed from 2002 to 2012. Thus 11 LV terminations replacement per year.	$4,189
	Replace		

Service Cables	service cable due to in service failure (reactive)	(Reactive)	$14,422
Service Cables	Replace service cable due to poor condition	(Unplanned) Estimated there will be 20 service cable replacements per year. Service cables are selected based on known areas where T-joints are failing. Service cable replacement $14886 per job, on average 20 meters per connection from pillar.	$14,422
Service Cables	Replace service cables due to new pole replacement	(Initiated from Pole Replacement) Estimated 85 UG service cable will be replaced with the pole replacement every year.	$1,800

8.4.3 Condition Monitoring

UNIT COSTS			
ASSET TYPE	**TASK**	**COST BASIS**	**UNIT COST**
HV Cables	Test HV cables	(Planned list) Cable condition assessment program based on monitoring of 3 worst performing feeders. Cable condition assessment cost of $50k per feeder x 3 feeders per year = $150k. Program will progressively increase the number of HV feeders for condition assessment to a maximum of 10 per year.	$48,896
HV Cables	Test HV cables	(Planned list) Cable condition assessment program where we trail on 3 worst performing feeders and compare the results. Cable condition assessment 50k per feeder x 3 feeders per year = 150k. Progressively increase the number of HV feeders for condition assessment to a maximum of 10 per year.	$48,896

8.4.4 Asset Unit Costs

UNIT COSTS		
ASSET TYPE	**TASK**	**$/metre**
DistributionConductorsUGHV	Replacement Cost	$250
DistributionConductorsUGLV	Replacement Cost	$285
UG-Services	Replacement Cost	$774

Note: The per metre cost of installing LV underground cables and service cables is higher than HV underground cables because the cable runs are typically shorter and there is a high installation fixed cost. More joints and terminations are also required to reticulate an urban suburb.

8.5 Rationalisation Opportunities

Not applicable.

8.5.1 Other Options

Not applicable.

8.5.2 Feasibility and Business Case

Not applicable.

8.6 Disposal Plan

Cables which will not be utilised in the future, or replaced should be physically removed where possible.

However, most unused cable have historically been abandoned and left underground due to costs associated with removal or access problems.

Recovered cables are scrapped to recover the copper screen wire, and copper and aluminium conductors from the cable.

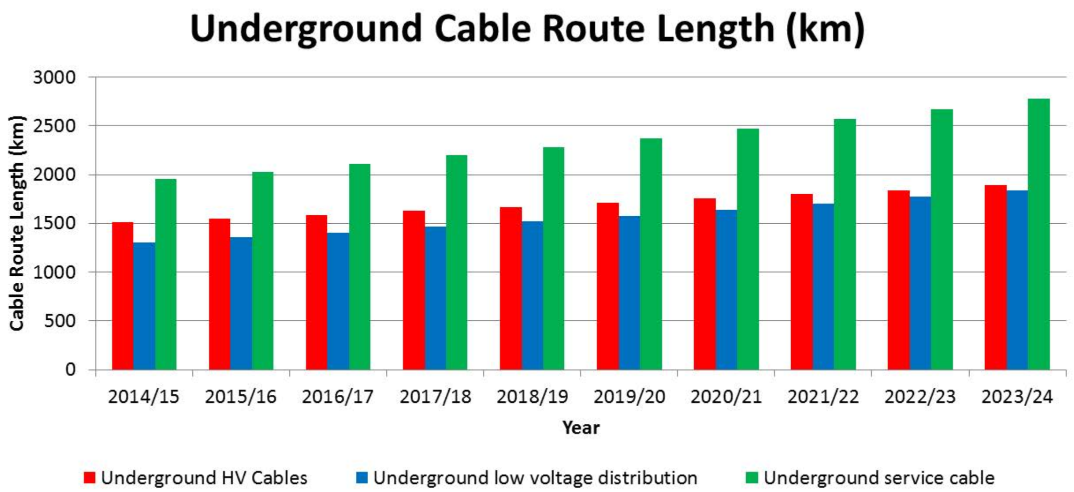
In some cases, ActewAGL will perform residual life assessment on a specific high voltage underground cable prior to scrapping to determine the rate of ageing for comparison with similar in-service cable with the same manufacturer, type, year and installation condition.

Care must be taken to responsibly dispose paper insulated cables, cast iron and porcelain cable termination. Paper insulated cables are mass impregnated with oil compounds and may contain bitumen on the surface of the metallic sheath. Cast iron and porcelain cable termination may have oil or compound filled inside the insulator.

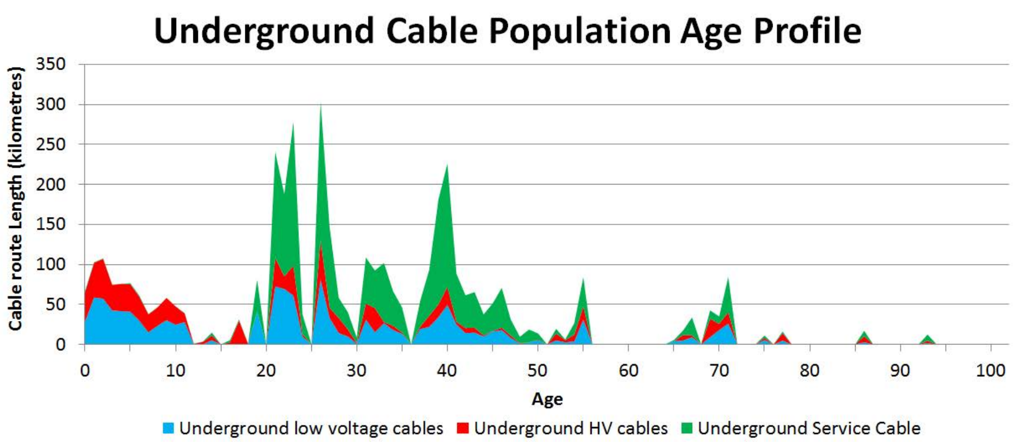
The disposal procedure for underground cables is documented in "Recovery and disposal of reclaimed network assets".

9. Asset Condition and Expenditure Forecast

9.1 Projected Asset Count



9.2 Age Profile of Assets



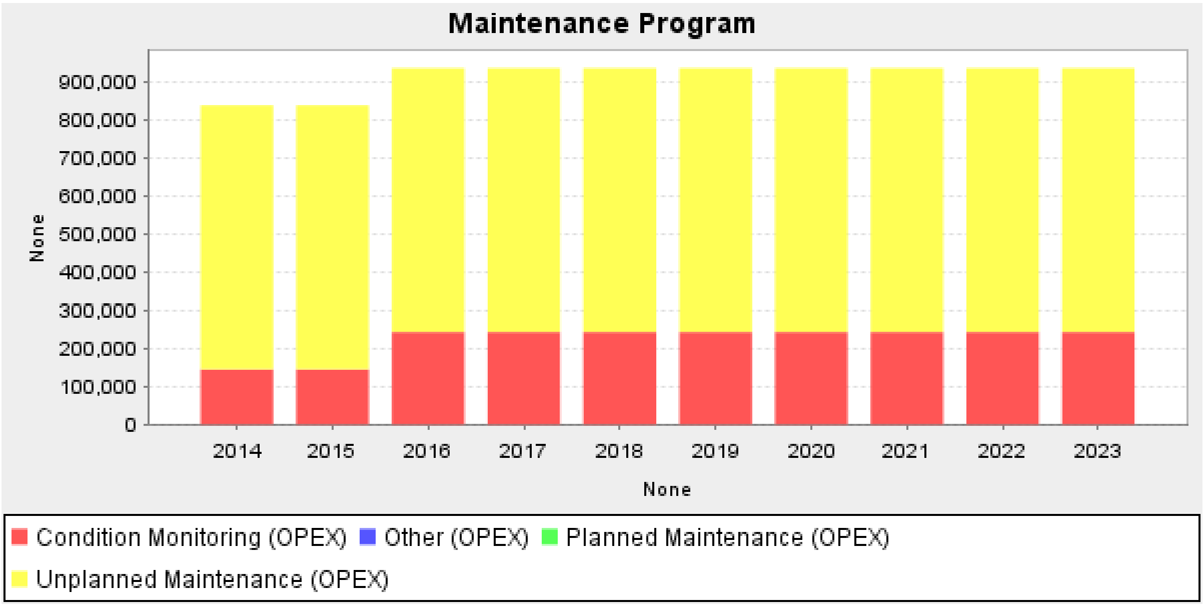
Note: Over 650 km of underground cable assets with unknown estimated age is not plotted on this chart.

9.3 Health Profile

Health profile is determined by combining the asset condition rating with its criticality rating. Condition is determined by the asset's capacity to meet requirements, the asset reliability and its level of obsolescence. Obsolescence will be determined by maintenance requirements and availability of support from manufacturers. Criticality is determined from operational, safety and environmental consequences due to asset failure.

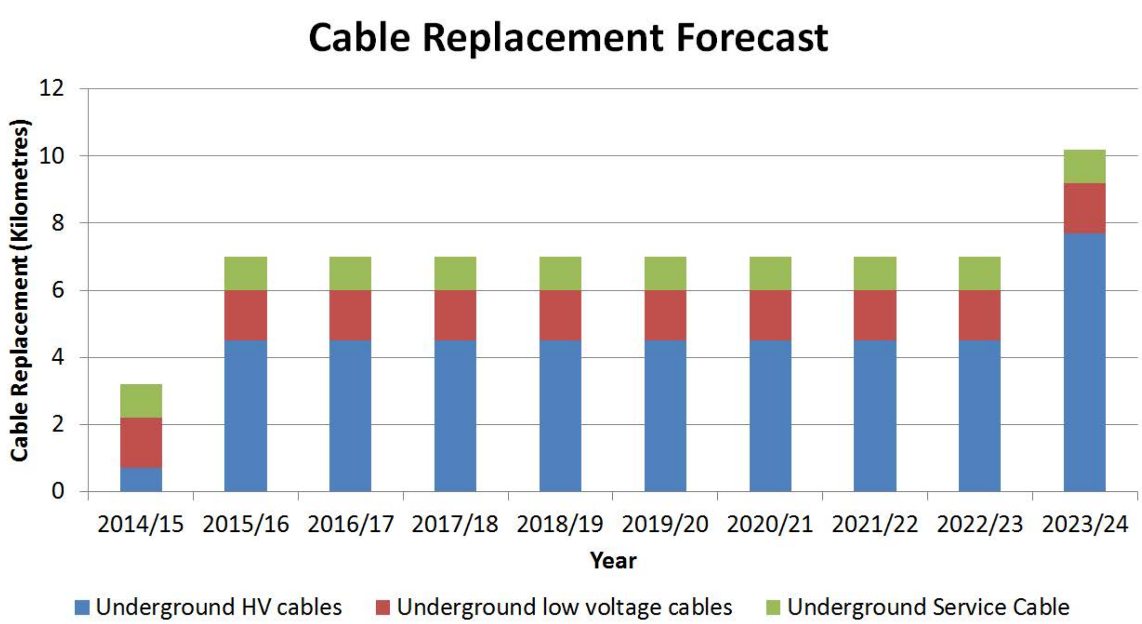
A health profile for underground cable asset will be developed once the condition monitoring program is fully implemented to input condition results to the model.

9.4 Maintenance Program



9.5 Replacement Program

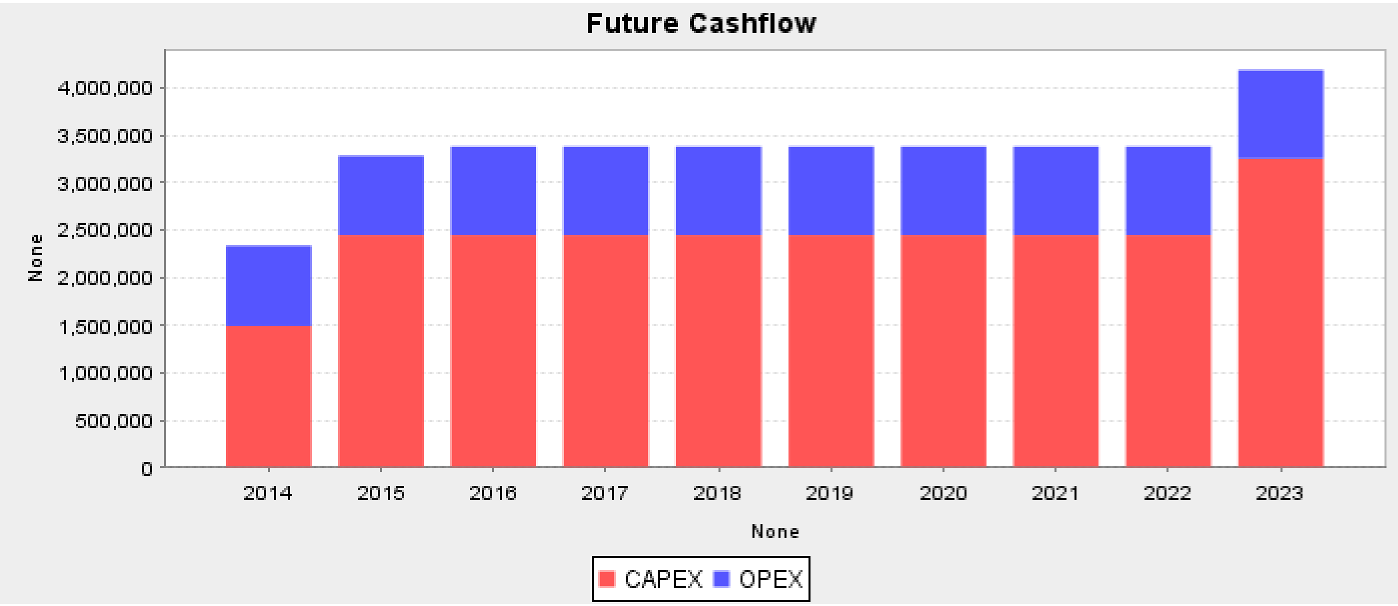
This is a summary of the units being replaced or refurbished each year. In general, assets with the lowest health will be scheduled for earliest replacements.



9.6 Forward Cashflow

The followig table summarises the OPEX and CAPEX forecast for the next 10 years.
All values shown are in real 2012 dollars.

Expenditure	10 yr total	2014/15	2015/16	2016/17	2017/18	2018/19	2019/20	2020/21	2021/22	2022/23	2023/24
Replacement total (CAPEX)	$24,321,061	$1,496,224	$2,446,224	$2,446,224	$2,446,224	$2,446,224	$2,446,224	$2,446,224	$2,446,224	$2,446,224	$3,255,045
Maintenance total (OPEX)	$9,164,566	$838,223	$838,223	$936,015	$936,015	$936,015	$936,015	$936,015	$936,015	$936,015	$936,015
Condition monitoring (OPEX)	$2,249,216	$146,688	$146,688	$244,480	$244,480	$244,480	$244,480	$244,480	$244,480	$244,480	$244,480
Planned maintenance (OPEX)	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Unplanned maintenance (OPEX)	$6,915,350	$691,535	$691,535	$691,535	$691,535	$691,535	$691,535	$691,535	$691,535	$691,535	$691,535



10 Performance Monitoring

All cable, termination and joint failure should be recorded. Failure investigation on all HV cables failure should be completed to find the root cause. The findings from the root cause analysis will provide continuous improvement to ActewAGL asset strategy, standards and installation workmanship.