Asset Management Plan

Overhead Switchgear - Distribution

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Responsibilities

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ABN 24 167 357 299 (hereafter referred to as "TasNetworks").
Please contact the Asset Strategy Team Leader with any queries or suggestions.

- Implementation   All TasNetworks staff and contractors.
- Compliance   All group managers.

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Record of revisions

Section number	Details
	New Document

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1 Purpose

The purpose of this document is to describe for distribution overhead switchgear assets:

- TasNetworks' approach to asset management, as reflected through its legislative and regulatory obligations and strategic plans;
- The key projects and programs underpinning its activities; and
- Forecast capital and operational expenditure, including the basis upon which these forecasts are derived.

2 Scope

This document covers all mechanical overhead switchgear in the distribution network including:

- low voltage switch fuses;
- low voltage links;
- high voltage links;
- expulsion drop out fuses; and
- air break switches.

The scope of this Overhead Switchgear - Distribution Asset Management Plan also includes the primary components of gas or vacuum enclosed:

- High voltage switches;
- sectionalisers;
- automatic circuit reclosers (reclosers); and
- capacitors.

It does not include secondary components of gas or vacuum enclosed high voltage switches, sectionalisers, automatic circuit reclosers and capacitors.

3 Strategic alignment and objectives

This asset management plan has been developed to align with both TasNetworks' Asset Management Policy and Strategic Objectives.

It is part of a suite of documentation that supports the achievement of TasNetworks strategic performance objectives and, in turn, its mission. The asset management plans identifies the issues and strategies relating to network system assets and detail the specific activities that need to be undertaken to address the identified issues.

Figure 1 represents TasNetworks documents that support the asset management framework. The diagram highlights the existence of, and interdependence between, the Plan, Do, Check, Act components of good asset management practice.

The asset management objectives are to:

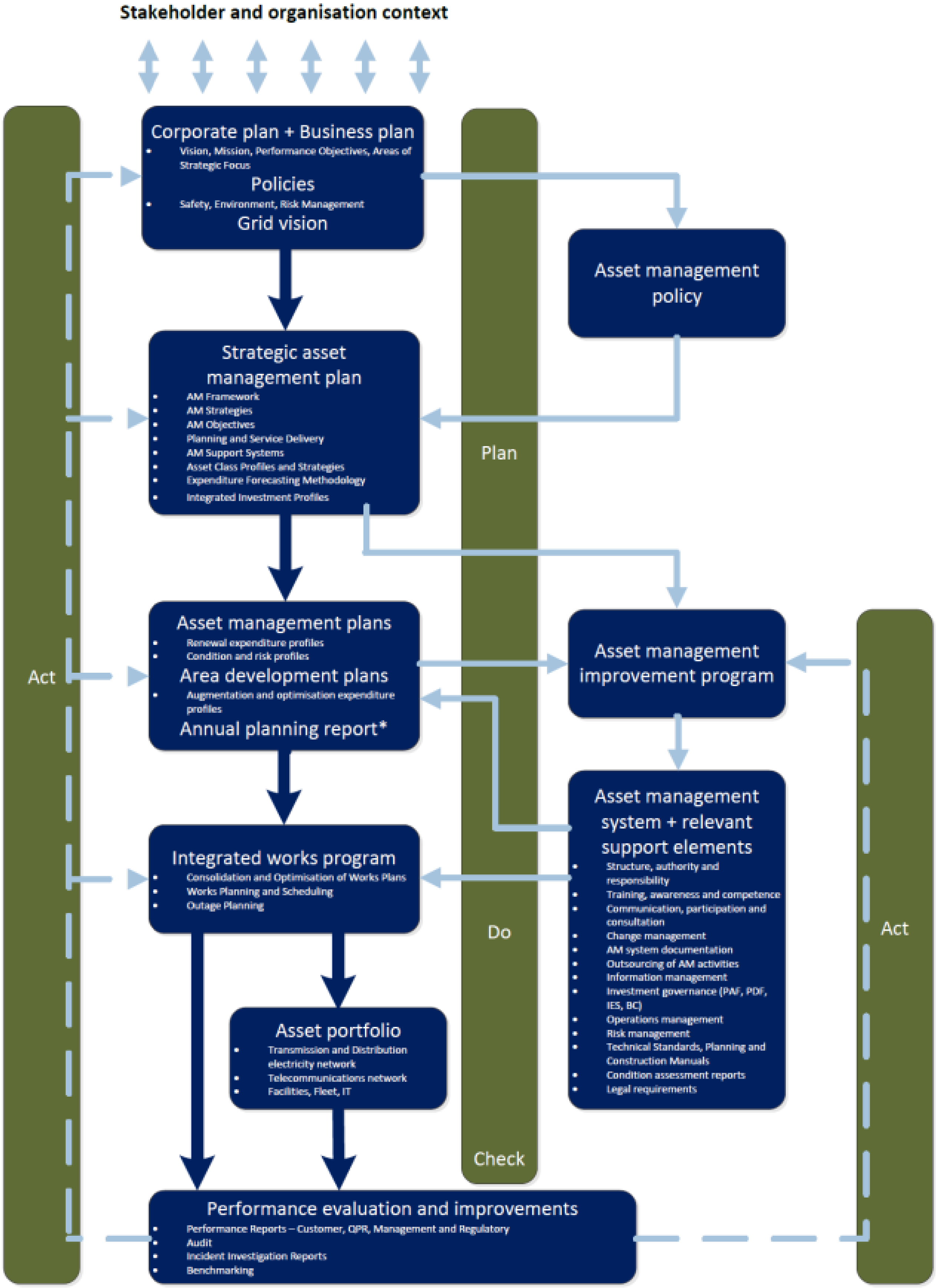
1. Manage and meet the strategic goals, measures and initiatives outlined in the Corporate Plan;
2. Comply with relevant legislation, licences, codes of practice, and industry standards ; and
3. Continually adapt, benchmark and improve asset management strategies and practices and apply contemporary asset management techniques, consistent with industry best practices.

This asset management plan describes the asset management strategies and programs developed to manage the overhead switch assets, with the aim of achieving these objectives:

1. Present an overview of the overhead switchgear asset populations;
2. Manage business risk presented by the assets to within acceptable limits;
3. Achieve reliable asset performance consistent with prescribed service standards;
4. Assess the risks specific to the assets and identify corresponding risk mitigation strategies;
5. Ensure the effective and consistent management and coordination of asset management activities relating to the assets throughout their life-cycle;
6. Ensure our team members are trained, authorised and competent to undertake their work activities;
7. Demonstrate that the assets are being managed prudently throughout their life-cycle;
8. Ensure asset management issues and strategies, as they relate to the assets, are taken into account in decision making and planning; and
9. Define future operational and capital expenditure requirements of the assets.

This asset management plan describes the asset management strategies and programs developed to manage the distribution overhead switchgear and overhead primary components with the aim of achieving these objectives.

Figure 1 – TasNetworks Asset Management Documentation Framework



* The Annual Planning Report (APR) is a requirement of sections 5.12.2 and 5.13.2 of the National Electricity Rules (NER) and also satisfies a licence obligation to publish a Tasmanian Annual Planning Statement (TAPS). The APR is a compilation of information from the Area Development Plans and the Asset Management Plans.

4 Asset support systems

4.1 Asset management information systems

Distribution asset information is recorded and stored in WASP and G/tech. The location in which data is stored and maintained is dependent on the particular nature of the data, but systems are often configured to enable the flow of changes in one system to be reflected in the other.

TasNetworks maintains an asset management information system (AMIS) that contains detailed information relating to the overhead switchgear asset populations.

To deliver the asset data, business processes and asset information management practices required for the prudent and efficient management of network assets, TasNetworks is developing a comprehensive asset management information system (AMIS).

TasNetworks maintains an Asset Management Information System (AMIS) that contains detailed information relating to the overhead switchgear population. AMIS is a combination of people, processes, and technology, applied to provide the essential outputs for effective asset management, such as:

- reduced risk
- enhanced distribution system performance
- enhanced compliance, effective knowledge management
- effective resource management and
- optimum infrastructure investment

AMIS is a tool that interlinks asset management processes through the entire asset lifecycle and provides a robust platform for extraction of relevant asset information.

4.2 Asset management information improvement initiative

To realise this capability at TasNetworks, the AMIS improvement program is delivering a rigorous and methodical series of targeted initiatives designed to build capability. When implemented, this program will deliver trusted, timely and high quality asset information that supports the strategic and operational asset management processes required for best-practice asset management. This program is complimentary with the current TIBS project and will rely on and benefit from the integrated asset and works management system provided by that project.

The AMIS improvement program is currently delivering the foundations of a mature asset management system including the establishment of:

- asset hierarchies
- asset data integrity standards and
- asset nomenclature standards

The establishment of a contemporary asset condition inspection system for network assets (including, but not limited to distribution poles) has also been identified as a priority initiative within the scope of the AMIS improvement program. TasNetworks currently relies on an out dated and unsupported product for pole mounted transformer inspections. Whilst this tool captures rudimentary pole mounted transformer condition data, the application is no longer supported and cannot be enhanced to take account of altering asset management practices, changing work practices or varying asset configurations. Options for an enhanced, extensible and future-proofed solution are currently being investigated by TasNetworks.

4.3 Asset information

Information such as geographical location, kVA rating, number of connected customers and number of connected life support customers is generally well documented however it is acknowledged that asset information accurate, integrity and quality for overhead switchgear requires improvement and includes information relating to asset health, asset performance, costs and risks.

The AMIS improvement program initiative plan underpins TasNetworks' strategy to improve asset information and thereby enable improved decision making.

5 Description of assets

Overhead switchgear is installed to provide isolation or disconnection of sections of high voltage or low voltage overhead lines for the purposes of maintenance, management of load or protection.

TasNetworks manages 76,000 overhead switchgear assets.

Overhead switchgear can be described as follows:

- reclosers
- sectionalisers
- gas switches
- air break switches
- high voltage links
- high voltage fuses
- high voltage capacitors and
- low voltage links

5.1 Reclosers

Reclosers are three phase fault break devices that operate to clear temporary faults in the network where necessary and isolate permanent faults, a Noja recloser can be seen in

Figure 2. When a fault is detected by a recloser, after a defined period of time, the recloser will open to isolate the fault. A number of attempts will be made to re-energise the network section downstream of the recloser. If the fault was temporary, the reclose process will be successful, and supply will be restored to that section of network. If the fault was permanent, after the defined number of attempts, the recloser will open and remain open, isolating the faulted network from supply.

Figure 2: Noja recloser mounted to a wooden distribution pole

TasNetworks' asset base comprises gas-insulated, solid dielectric (vacuum) and oil-filled reclosers, which are manufactured by Schneider-Nulec, Noja Power and Reyrolle OYT respectively. TasNetworks intends to remove its OYT reclosers from service in the near future due to the units being oil filled, under failure the oil creates a safety and environmental risk, where other non-oil filled types of recloser perform similar without this risk.

5.2 Sectionalisers

Sectionalisers are off-load devices that work in conjunction with reclosers to disconnect sections of the network under fault conditions, to attempt to isolate faulted sections of the network.

Sectionalisers are located downstream of reclosers and monitor the fault current and circuit interruption of the up-stream devices. After a pre-programmed number of recloser re-energisation attempts, the sectionaliser will open during the open period of the recloser. If the fault was on the section of line that the sectionaliser disconnected, the next reclose attempt will result in the successful re-energisation of network section downstream of the recloser.

With the exception of the Nulec RL27 gas switches, seen in

Figure 3 (configured as a sectionaliser), sectionalisers are not rated for breaking load current, and must be opened during the open cycle of the upstream recloser.

Figure 3: Nulec RL27 load break switch

TasNetworks has installed in its network a variety of ABB (thermal) sectionalisers that, due to inconsistent operation reliability, have been actively removed from the distribution network. There have also been performance issues identified with AK Power sectionalisers and a program to remove these devices from service has also been undertaken.

5.3 Gas switches

Gas or vacuum enclosed switches are three phase switching devices with the ability to make and break load currents. They are generally not rated for breaking fault current. Gas or vacuum enclosed switches are installed where there is a requirement to open or close switchgear when feeders are energised and have load on this, such as during paralleling operations. Assets such as Nulec NL27's, as seen in

Figure 3, can be configured as gas switches and sectionalisers.

5.4 Air breaks switches

Also known as ganged isolators, air break switches are high voltage switching assets that allow the connection and disconnection of sections of the high voltage network under load. A single operating lever that is located 5m up the pole is used to operate the device. This lever is normally accessed using a ladder and requires a physical force to operate. air break switches are typically rated to withstand faults up to 16 kA, however older units may have experienced some reduction in fault withstand capacity as a result of damage and deterioration over the life of the asset.

Figure 4: Horizontally operated air break switch

TasNetworks' asset information stored on air break switches is limited to the device plate identification numbers and the geographical location of the device. There is currently no attribute or condition data stored for air break switches installed in the network, however a project is being implemented to collect and store this information appropriately.

5.5 High voltage links

High voltage links are single phase devices and have a single break action, as shown in

. They are generally installed as a set of three for use on three phase systems. High voltage links are not rated for breaking load current but allow the connection and disconnection of energised network elements. High voltage links may be mounted vertically, horizontally upright or under slung. In Table 1, the term "Link + Arc Break" refers to high voltage links that have arc break devices installed, but are not ganged, as is the case with air break switches.

Figure 5: Typical high voltage link vertical arrangement in its closed position

5.6 High voltage fuses

TasNetworks overhead high voltage fuses occur most commonly as expulsion drop out fuses and consist of a porcelain insulator with a hinged fibre tube held in place by a fusible link. When the expulsion drop out fuses experiences a fault current that exceeds the curve rating for the device, the fusible link melts, causing the fuse to drop open to isolate the equipment or section of network that it is protecting.

Expulsion drop out fuses are mostly used to protect pole mounted transformers and spur lines, although there are still a number of feeder trunks that use them as in-line fusing.

Figure 6: Boric acid drop out Fuselink

The risk management plan for high bushfire consequence areas is for continued introduction a more sophisticated fuse, namely the Boric Acid drop out fuse, in replacement of the expulsion drop out fuse. While the operation of this device is similar to the expulsion drop out fuse, in that when operated the fuse tube falls through an arc to break the circuit, the actual fuse is a powder filled fuse arc and a spring loaded striker actuates the solid boric acid to extinguish the arc.

The benefits are that under high fault operation only a small amount of plasma is released and no molten particles unlike expulsion drop out fuses. The probability of a 'hang-up' is removed because the fuse is released by a dedicated mechanical action not reliant on a tension release and gravity, as with the expulsion drop out fuse. The fuse tube is also not open to the weather.

The fuse element is made from pure silver and is thus not susceptible to surges on the line to the same extent that affect expulsion drop out fuse elements.

5.7 High voltage capacitors

Where TasNetworks experiences poor voltage regulation as a result of reactive losses from long feeder lengths and heavy loading, reactive support can be utilised to maintain the voltage within acceptable limits. TasNetworks has installed two high voltage capacitor banks on Railton Feeders 85001 and 85006 to provide reactive support for the highly inductive agricultural loads on these feeders. More of these devices are expected to be introduced to the distribution network in the short term.

5.8 Low voltage fuse links & links

The purpose of low voltage switchgear is to provide protection of the low voltage network and allow low voltage network reconfiguration for fault restoration and maintenance. Low voltage switch fuses can be used as both a link and a fuse. They are used as isolation points at transformers and to protect low voltage circuit from faults.

Low voltage links are used as isolation points at transformers and as a connection/disconnection point between low voltage circuits. Low voltage links can be used to parallel low voltage circuits when sections of network or assets must be taken out of service, to maintain supply to low voltage customers.

Figure 7: Pole mounted ABB capacitor bank

6 Overhead switchgear population

6.1 Population volumes

Table 1: Installation volumes of specific assets in their respective categories

Category	Description	Numbers Installed
Reclosers	Unknown	3
	Recloser NOJA	1
	Recloser Nulec N-Series	342
	Recloser Reyrolle OYT	9
	Total	**355**
Sectionalisers	Unknown	7
	Sectionaliser	84
	Sectionaliser ABB	1
	Sectionaliser AK	52
	Sectionaliser Nulec RL27	32
	Total	**176**
Gas switches	Unknown	2
	Gas switch NGK Stanger	1
	Gas switch Nulec N-Series	3
	Gas switch Nulec RL27	143
	Total	**149**
Air break switches[1]	Air break switch	4 183
	Fuse/air break switch	33
	Total	**4 216**

[1] Note: Switch type of fuse/air break switch refers to a fuse/air break switches parallel combination to allow the bypass of the fuse elements where needed.

Category	Description	Numbers Installed
High voltage links	Link	1,710
	Link + arc break	285
	Total	**1,995**
High voltage fuses	Unknown	28
	Drop out fuses	27,958
	Expulsion drop out fuse with solid Link	694
	Fuse	7,048
	Fuse/air break switch	33
	Fuse/link	3
	high voltage links	1
	No switchgear	1,972
	Unknown	19
	Total	**37,756**
High voltage capacitors	ABB, 3 phase, 390 kvar	1
	ABB, 3 phase, 900 kvar	1
	Total	**2**
Low voltage switchgear	Low voltage fuse links	25,499
	Low voltage links	3,610
	No switchgear	896
	Unknown	1,221
	Total	**31,226**[2]

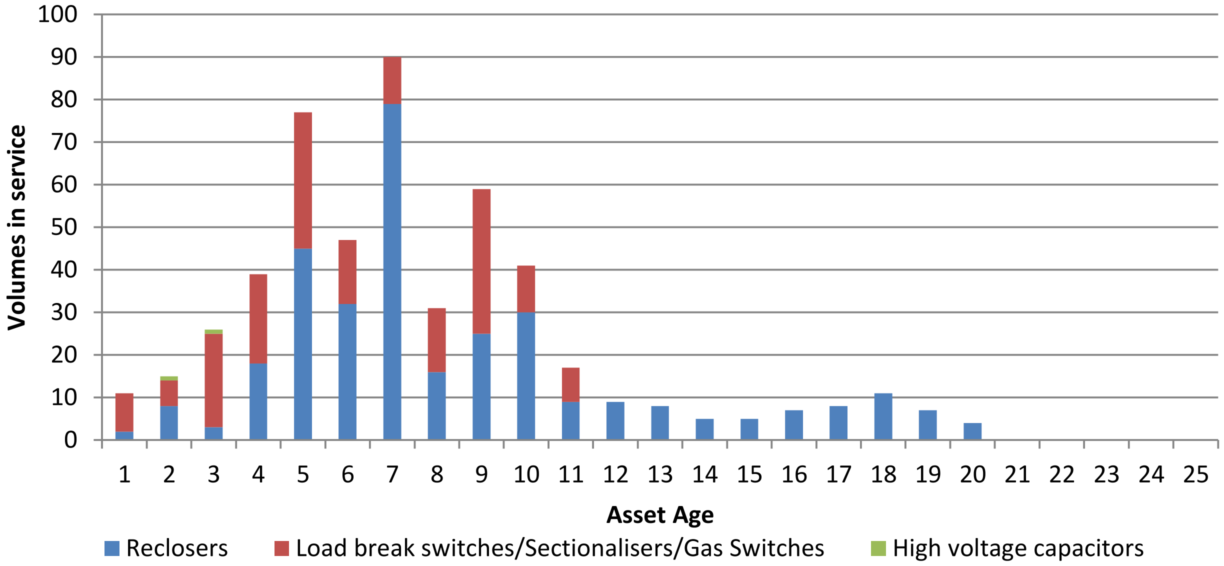
Network total is 75 875 overhead switchgear assets.

[2] Volumes of low voltage protection from overhead transformers

6.2 Population age trend

The below figure shows the current ages and in service volumes for Nulec and Noja: gas switches, sectionalisers and reclosers; and ABB high voltage capacitor banks.

Figure 8: Primary components installed volumes, by year.



There are no age records stored on the age of: low voltage links & fuses, high voltage links & fuses and air break switches. There are no age records stored on non Nulec or Noja: gas switches, sectionalisers and reclosers.

7 Risk

TasNetworks has adopted the risk management principles detailed in Australian Standard AS 4360 'Risk Management' in managing risks associated with its overhead switchgear population. The primary goals of the risk management strategy are to:

1. Ensure the safety of personnel and the public as far as practicable.
2. Reduce the likelihood of switching device failure; and
3. Minimise the impact of a switching device failure on distribution system performance.

The level of risk pertaining to the protection and control assets and associated work programs is a function of both likelihood and consequence. Factors affecting the level of risk are listed as follows:

- Safety;
- Age;
- Location;
- data quality;
- Financial;
- product support/obsolescence;
- Reputation;
- connected load;
- regulatory/legal;
- network performance;
- Environment;
- customer considerations;
- Trending; and
- Benchmarking.

Risk levels are assessed against the TasNetworks risk management framework, which sets a consistent and structured approach to managing asset-related risk. The assessment of risk against this standard ensures that risk is controlled to a level that aligns with the TasNetworks risk appetite. Any risks which fall outside the permissible limits may require further control in the form of a risk treatment plan and are managed subjectively as required.

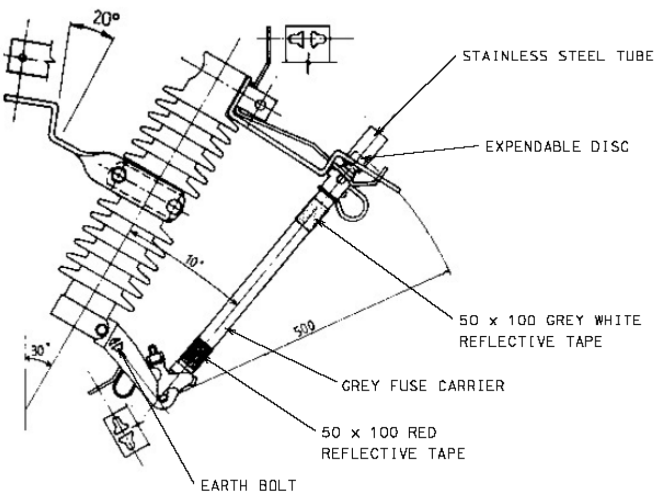
7.1 Asset specific risk

The overhead switchgear assets have their role specific application limitations of performance and usability in the network. Although there may be overlap between the functions that each provide, each has its risk management based place in the network and the following information details the limitations that TasNetworks has found in which is used to continually improve the network.

Sectionalisers

TasNetworks has approximately 52 expulsion drop out fuse sectionalisers manufactured by AK power, installed in the distribution network. This population of units have been identified as unreliable, as the unit fail to operate on faults where they are required to; even under proper operation they have the potential to start fires, due to operation creating sparks. This results in the persistence of the fault, which may result in the operation of upstream protection, and/or the damage of distribution network assets.

Figure 9: Expulsion drop out fuse side view explanatory diagram



Sectionalisers are cheap and effective methods for providing isolation capability for large volumes of distribution feeder spurs. However, the necessity for field crews to be dispatched onsite for the fault restoration process incurs significant cost to the business. Additionally, while sectionalisers and load break switches are effective at providing single shot protection, their inability to reclose limits their capability to fault clearance, and not fault restoration.

Air break switches

Since 2011, TasNetworks have seen a number of mechanical failures in the porcelain insulator pins of certain air break switches while the devices are being operated. The most likely mode of failure is a function of moisture ingress through the end connections of the porcelain insulators, resulting in pin corrosion and expansion. These forces are sufficient to compromise the structural integrity of the insulators causing the unit to fail when the device is next operated; an example of a failure is shown in **Figure 10**. Under failure the pin insulator disintegrates, sending shards of broken porcelain falling to the ground and the field service operator on the ladder below. This presents an unacceptable health and safety risk to TasNetworks personnel.

At this point in time, the only air break switch units that have been observed to fail, are “S-Series” units that are manufactured by ABB, prior to November 2005 and “USB” unit types manufactured by NGK Stanger. Units manufactured by ABB after November 2005 have a stainless steel insulator pin, and are believed to not be susceptible to the same failure mode as those manufactured prior to this date. Other units that are believed to be unaffected by the issue are “Morlynn Stanger” units (model unknown) and a variety of unit colloquially known as “Old School” (manufacturer and model unknown).

Although the primary failure mode is understood to be a function of pin corrosion and expansion, the lack of maintenance has been empirically reported to result in the sticking of mechanical elements. This additional friction requires a larger torque to be applied to the insulator pins for opening and closing actions, which is transmitted through the porcelain. It is possible that the lack of maintenance has resulted failure of these defective units failing sooner than if maintenance was not ceased. Details from the current and previous manufacturers operating manual state that regular maintenance should be undertaken to realise maximum service life.

Many Australian distribution utilities have been contacted to determine what the industry wide approach to the management of defective air break switches has been, however formal responses have only been received from Ergon and Energex.

Ergon had ABB U (12kV), S (24 kV) and R series (36 kV) units installed in their network, that were failing under the same failure mechanism that TasNetworks has observed. They immediately implemented an immediate program to have these removed from the network, which was completed for each of these air break switch models by 2014.

Energex had ABB U (12 kV) and R (36 kV) series units installed in their network that were failing under the same mechanism that TasNetworks has observed. They implemented a program to have these removed from the network, replacing them with air break switches with composite post insulators, and load break switches where appropriate. They have indicated that as a result of their replacement program, they have few ABB units remaining in their network.

No information has been received on whether other utilities have had ABB units (or other units) installed in their networks.

High voltage links

Where high voltage links are used as disconnection devices, the requirement to have no load current flowing imposes restrictions on the way that the links are used. Where network conditions have changed, or load has grown, it may be appropriate to have high voltage links replaced with a load break device, such as an air break switch. Feeder switch topology changes with protection scheme needs, fault levels and load growth.

Low voltage fuse links

A transformer with low voltage links instead of fuse links will not be capable of clearing low voltage faults, which may result in conductors melting and falling to the ground, dropping molten metal in the process. If fault current is insufficient to damage the conductor, then the transformer will be significantly overloaded, which may result in the failure of the unit. Low voltage links therefore do not provide appropriate protection of low voltage circuits.

Lower risk assets

The following categories installed on the distribution network have been identified to not having major condition or functional performance issues, they are: low voltage links, high voltage links, high voltage fuses, gas switches, reclosers and high voltage capacitors. An age based risk review, a rating match to circuit changes review, and a condition assessment based on field operator prework risk review feedback, are all considered to determine emerging risks.

7.2 Asset specific risks

The following section details the unmanaged risk of various asset types, the risks have been assessed against TasNetworks Risk Management Framework. The managed risk levels can be seen in Table 11: Program of work risk and expenditure summary table.

Reclosers

The key risks associated with reclosers in the network is that if the fault is not cleared and the circuit is closed multiple times it can create secondary faults which effects reliability, safety and the environment.

One of the issues identified with Nulec reclosers is a small trend in relation to the SCEM card failing in the recloser tank (blown componentry). The issue is being managed in consultation with the manufacturer.

Some reclosers include a solid insulation high voltage transformer to be risk assessed by partial discharge testing periodically. Newer rural recloser innovations include the use of fuse savers on spur lines to help prolong spur fuse link life.

Sectionalisers

The key risks associated with sectionalisers in the network are that expulsion drop out fuse sectionalisers have not been operating under fault conditions on occasion. This effects reliability and safety due to the increased likelihood of conductors exceeding there safe operating temperatures and failing because of mal operation of the fuses.

Gas switches

The key risks associated with lack of gas switches in the network is that field switching is atmospheric weather condition dependent,

The key risk associated with lack of gas switches in the network is that field switching is atmospheric weather condition dependent, with possible persistence of arcing in mist, fog or smoke conditions. Enclosed gas switches may also facilitate modification to SCADA applications if required in the future.

Air break switches

The risk associated with the defective air break switch populations (without appropriate treatment) is the mechanical failure of the switch under operation or loading. It poses a safety risk due to the increased likelihood of falling conductors and insulators; this type of failure can lead to bushfires and injury.

Figure 10: air break switch porcelain insulator pin failure

High voltage links

The main risk associated with high voltage links is the unnecessary disconnection of kVA, through network reconfigurations, where load is too great to be switched phase-by-phase and the next upstream ganged device must be used. This will have an adverse impact on TasNetworks' unplanned outage performance. The occurrence of ferroresonance over voltage in single phase switchings with high voltage links may be managed in operational procedures; typically maximising resistive loading during switching. However, the preferred option is the installation of a three phase switching device.

High voltage fuses

The main risk associated with high voltage fuses is associated with the potential of bushfires starting through fuses that are not appropriately sized and rated for the network/assets that they protect. Fuse selection is risk managed with accordance with TasNetworks Protection Philosophy.

A high bushfire risk consequence area risk management review is underway to replace expulsion drop out fuses with Boric Acid Fuses as appropriate, noting research conducted by Victorian Networks.

High voltage capacitors

The key risk associated with high voltage capacitors in the network is capacitor bank device failure, such as arcing faults within the capacitor bank, resulting in a reduction in network performance and possibly loss of supply. Some faults may be undetectable if there is no signal unbalance detection.

High voltage capacitor risk when commissioning can be managed with a commissioning procedure such as Western Powers.

Low voltage switchgear

The key risk associated with the low voltage switchgear asset class is the presence of links installed on transformers, where fused links should be installed for protection purposes.

Table 2: Asset risk framework summary

Category	Risk category	Risk	Likelihood	Consequence	Risk Rating
Reclosers	Customer	Interruption of supply as a result of inadequate protection.	Likely	Negligible	Low
	Network Performance	Increases in load connected or fault frequency, will result in reduction of reliability (SAIDI and SAIFI).	Likely	Minor	Medium
	Reputation	Negative impacts on image through unplanned outages	Unlikely	Negligible	Low
Sectionalisers	Customer	Interruption of supply as a result of inadequate protection.	Likely	Negligible	Low
	Network Performance	Increases in load connected or fault frequency, will result in reduction of reliability (SAIDI and SAIFI).	Likely	Minor	Medium
	Reputation	Negative impacts on image through unplanned outages	Unlikely	Negligible	Low
	Environment and Community	Failure of AK power expulsion drop out fuse sectionalisers to operate may result in bushfire.	Unlikely	Major	Medium
Air break switches	Regulatory Compliance	Failure to comply with Work and Safety Act 2012	Unlikely	Minor	Low
	Network Performance	Increased SAIDI due to loss of supply during asset failure on operation	Unlikely	Minor	Low
	Safety and People	Serious injury or death as a result of asset failure.	Unlikely	Severe	High
		Injury that takes greater than 10 days to return to work	Possible	Major	High
High voltage links, High voltage fuses, gas switches	Customer	Non material supply interruption to less than 1,000 distribution customers	Possible	Negligible	Low
	Network Performance	Maintain current performance WRT unplanned outages	Likely	Negligible	Low
	Reputation	Negative impacts on image through unplanned outages	Possible	Negligible	Low

Table 2: Asset risk framework summary continued.

Category	Risk category	Risk	Likelihood	Consequence	Risk Rating
High voltage Capacitor Banks	Network Performance	Insufficient voltage regulation results in the supply of non-compliant voltage in distribution network.	Likely	Negligible	Low
Low voltage switchgear	Financial	Premature failure of assets requires replacement.	Likely	Negligible	Low
	Network Performance	Increased SAIDI/SAIFI through outage as conductor or transformer replacement required	Possible	Negligible	Low
	Environment and Community	Starting of bushfire through persisting Low voltage faults.	Rare	Major	Moderate
	Safety and People	Serious injury or loss of life of a member of public, through conductor failure	Rare	Major	Moderate

8 Management plan

8.1 Historical

Most overhead switchgear assets have historically been managed on a run-to-failure basis. The Asset Management strategic objectives informing this approach included:

- minimising the cost of supply to the customer to the lowest sustainable level;
- maintaining network performance;
- managing the business risks at an appropriate level; and
- complying with regulatory, contractual and legal responsibilities.

Assets have either been assessed before and after manual switching operations or on a periodic cycle, this assessment was conducted visually. Defects were then rectified or the switching asset replaced or upgraded, depending on condition and network demands.

In order to more effectively and efficient manage distribution pole mounted transformers through their life TasNetworks has introduced asset management strategies. These strategies are described in the following section.

8.1.1 2010–15 overhead switchgear works programs

The following tables show the historical overhead switchgear work programs and there operational and capital expenditure over the 2010-11 to 2014-15 period.

Table 3: 2010–15 operational expenditure for overhead switchgear inspection, maintenance and repair

Work category	Description	10–11	11–12	12–13	13–14	14–15
AIOSW	Overhead switchgear inspection and monitoring	$28,358	$826.75	-[3]	-[3]	-[3]
AROSW	Overhead switchgear asset repair	$147,018	$392,931	$305,465	$55,939	$18,558
REOHS	Air break switch audit (once off)	-	-	-	-	$55,777

Table 4: 2010–15 capital expenditure for overhead switchgear asset replacement

Work category	Description	10–11	11–12	12–13	13–14	14–15
REOHS	Replace Switchgear Overhead	$380,174	$427,103	$447,303	$502,763	$892,793
REOHQ[4]	Replace Low voltage links with fuse links	-	-	-	$5,965	$288

[3] AIOSW has been conducted under AIOHS since 2012-13
[4] REOHQ has been conducted since 2013-14

8.2 Current maintenance plan

General corrective maintenance is performed on overhead switchgear as a part of the AROSW work category, with general overhead work performed through the AROCO work category. This corrective maintenance is performed where asset defects have been identified through routine overhead inspection (visual or thermal), incidental identifications (through asset area managers) or under fault. Corrective maintenance is generally only performed on assets where defects have been identified as problematic, which usually only occurs when the condition of the asset has degraded significantly.

8.2.1 Routine maintenance

Routine maintenance on overhead switchgear is performed on all overhead switchgear to ensure that minor defects and issues with these assets are identified before further degradation of the asset occurs. This work is performed through the work category AROSW, overhead Switchgear routine maintenance. Further to this the work category AROSW will be continued in the forthcoming regulatory period and complemented by the AIOSW category.

The level of detail and interval between routine maintenance on switchgear will vary on the specific requirements of each asset class. Recommended maintenance schedules are detailed in Table 8.

8.2.2 Renewal

Where an asset defect is identified through routine maintenance, routine inspection or other means and the defect severity is beyond rectification, to prevent the negative impacts of asset failure, that asset should be replaced in a timely manner. This renewal work will be performed through the work category REOHS, Replace overhead switchgear, or for reclosers in particular, RERER.

8.2.3 Network augmentation

Where distribution network augmentation is required, it may be appropriate to install new overhead switchgear in that new network section. The definition of overhead switchgear requirements for network augmentations is the responsibility of the network planning, asset engineering, and design teams.

8.2.4 Benchmarking

TasNetworks participates and works closely with distribution companies in key industry forums such as CIGRE (International Council on Large Electric Systems), IEEE, ANSI, AS/NZ and Energy Networks Australia (ENA), to compare asset management practices and performance to ensure we keep abreast of industry good practice and contemporary asset management. In addition, affiliation and representation on Australian Standard and other international standards bodies helps TasNetworks maintain influence on designs and standards and ensure that TasNetworks maintains a strong asset management focus with the objective being continually improvement.

8.3 Investment evaluation

Investment evaluation is undertaken using TasNetworks' Investment Evaluation Summary template. The template includes:

- a brief description of the asset(s)
- a description of the issues and investment drivers
- alignment with regulatory objectives
- alignment with TasNetworks' corporate objectives
- alignment with TasNetworks' corporate risks
- impacts to customers
- analysis of options to rectify the issues including operational and capital expenditures
- a summary of NPV economic analysis for the identified options
- the preferred option and why
- the timing of the investment and
- the expected outcomes and benefits

8.4 Spares management

Spares holding are assessed during the asset management plan review cycle and minimum and maximum stock levels and spares holdings are amended in alignment with TasNetworks' spares policy.

When overhead switchgear either fails prematurely during service, and repair is not economically feasible, or the electrical and mechanical condition of the overhead switchgear deteriorates to such an extent, then it is considered appropriate to retire particular overhead switchgear. Replacement switchgear is sourced from the stock pool.

8.5 Disposal plan

Overhead switchgear that is de-commissioned and removed from the network and are disposed. Required assets are retained for system spares. Environmental Risk Management guidelines applied for disposal relate to waste materials such as oil or SF6 gas.

8.6 Key performance indicators

TasNetworks monitors distribution assets for major faults through its outage and incident reporting processes.

Asset failures resulting in unplanned outages are recorded in the InService outage management tool by field staff, with cause and consequence information being subsequently made available to staff for reporting and analysis. Those outages with a significant enough consequence are also recorded in RMSS and are investigated by the business to establish the root cause of the failure and to recommend remedial strategies to reduce the likelihood of reoccurrence of the failure mode. Reference to individual fault investigation reports can be found in RMSS.

TasNetworks also maintains a defect management system that enables internal performance monitoring and statistical analysis of asset faults and/or defects that either may not result in unplanned outages, or whose failure may only result in a minor consequence not requiring full investigation.

TasNetworks' Service Target Performance Incentive Scheme (STPIS), which meets the requirements of the Australian Energy Regulator's (AER's) Service Standards Guideline, imposes service performance measures and targets onto TasNetworks with a focus on outage duration and frequency. While the STPIS does not target specific asset classes, good asset performance will have a significant impact on TasNetworks' ability to meet the STPIS targets.

STPIS parameters include:

- System Average Interruption Duration Index (SAIDI) and
- System Average Interruption Frequency Index (SAIFI)

Details of the STPIS scheme and performance targets can be found in the "*Electricity distribution network service providers - Service target performance incentive scheme - November 2009*".

8.7 Summary of programs

The following provides a summary of all of the programs described in this management plan.

Table 5: Summary of Overhead Switchgear Programs

Work Program	Work Category	Project/Program
Routine Inspection	AIOSW	Overhead switchgear inspection and monitoring
	AIOFD	Overhead system aerial inspections
	AIOTI	Thermal imaging inspection
Routine Maintenance	AROSW	Overhead switchgear asset minor repair/maintenance
Reliability and Quality Maintained	REOHS	Replace overhead switchgear
		Replace air break switches
		Replace low voltage links with fuse links
		Replace AK Power sectionaliser with recloser
		Upgrade fuses/sectionaliser to recloser
	RERER	Upgrade reclosers
		Replace reclosers
Regulatory Obligations	REOHQ	Replace low voltage links with fuse links

9 Financial summary

The 15-16 budget is set from the 12-17 revenue proposal whilst the 16-17 budget is brought through from the 17-19 revenue proposal, due to changes in risks in the network.

Table 6: 2015–25 overhead switchgear maintenance and repair operational expenditure

Work Category	Project title	15–16 $000's	16–17 $000's	17–18 $000's	18–19 $000's	19–20 $000's	20–21 $000's	21–22 $000's	22–23 $000's	23–24 $000's	24–25 $000's
AROSW	Overhead switchgear asset repair	-[5]	424	424	424	424	424	424	424	424	424
AIOSW	Overhead switchgear inspection and monitoring	-[6]	420	420	420	420	420	420	420	420	420
AIOFD[7]	Overhead system aerial inspections	460	350	350	350	550	550	550	320	320	320
AIOTI[7]	Thermal imaging	430	374	374	374	181	181	181	181	181	181

[5] Funds have not been allocated to AROSW in 15/16.
[6] AOISW is a reinstated program as of 2016/17.
[7] This work category is replicated from the Distribution Pole Mounted Transformer Asset Management Plan for information purposes only. It is not included in overhead switchgear financials.

Table 7: 2015–25 overhead switchgear maintenance and repair capital expenditure

Work Category	Project title	15–16 $000's	16–17 $000's	17–18 $000's	18–19 $000's	19–20 $000's	20–21 $000's	21–22 $000's	22–23 $000's	23–24 $000's	24–25 $000's
REOHQ	Replace Low Voltage Links with Fuse Links	250[8]	-	-	-	-	-	-	-	-	-
REOHS	Replace air break switches/low voltage Links (general)	100[9]	-	-	-	-	-	-	-	-	-
REOHS	Upgrade Fuses/Sectionaliser to Recloser	-	162	162	162	162	162	162	162	162	162
REOHS	Replace Low Voltage links with Fuse Links	-	244	244	98	98	98	98	98	98	98
REOHS	Replace AK Power sectionaliser with recloser	102	108	108	108	108	108	108	108	108	108
REOHS	Replace air break switch (defective)	3,000	1,993	1,993	1,993	1,993	72	72	72	72	72
RERER	Upgrade Reclosers	104[10]	-	-	-	-	-	-	-	-	-
RERER	Replace Reclosers	-	108	108	108	54	54	54	54	54	54

[8] REOHQ will be conducted under REOHS – replace low voltage links with fuse links from 2016-17 onwards.
[9] REOHS Replace air break switches/low voltage links (general) will be split into the 3 below programs for better asset replacement tracking
[10] RERER – upgrade reclosers will be conducted under RERER – Replace reclosers from 2016-17 onwards.

10 Lifecycle management plan

The life cycle management of overhead switchgear and primary components is based on achieving robust network flexibility, with the ability to reliably switch between circuits for the purposes of: fault finding, back feeding, planned and unplanned maintenance and repair whilst ensuring lowest cost to customers.

Routine inspection was conducted prior to 2011/12, the suspension of inspections has led to an increase in reactive maintenance. Their will now be a reintroduction with an emphasis on streamlined processes and targeting assets to best utilise resources with appropriate inspection cycles.

Benchmarking

Jemena’s line inspection process involves evaluating the condition of all assets on the pole including: surge arrestors, switchgear and transformers. The inspections are performed in conjunction with pole base inspections every 3 years for high bushfire risk areas and 4 years for low bushfire risk areas; and the inspection is conducted according to a utility defined asset inspection manual.

High voltage fuses are considered maintenance free and replacement is based on age and performance requirements. Air break and remote controlled switches are inspected on a 5 yearly basis cycle whilst manual gas switches are inspected on a 10 yearly basis.

Jemena have been storing high-quality images of their pole tops for office based visual inspection of pole top assets and condition trending over time. The purpose of this is to assist maintenance planners on the appropriate rectification of defects. The prioritisation is based on the magnitude of the impact on reliability and safety which ensures the best cost/benefit trade-off.

The condition data recorded feeds into a condition based condition based risk management (CBRM) model; to better predict future asset replacements to maintain network reliability.

It is important to note the size of Jemena’s network as it consists of approximately 100,000 poles and approximately 2,000 overhead switchgear assets.

Energex inspect their poles and all ancillaries on a 5 yearly cycle after the pole has been in service for 10 years. Pre-storm season inspections are undertaken by vehicles and helicopter of their 33 and 11 kV network annually. The inspection program gives input to their CBRM based repair methodology which is used to forecast quantities for proactive replacement.

ETSA have ramped up expenditure for air break switches and inoperable switchgear and their assets will be inspected more frequently. This ensures that their asset management practices reflect the appropriate strategies for the network condition.

Table 8: Inspection, maintenance and renewal intervals on overhead switchgear

Asset class	Inspection interval[11]	Maintenance interval	Renewal interval
Reclosers	5 yearly	Reactively on condition or failure	Condition based
Sectionalisers	5 yearly	Reactively on condition or failure	Condition based
Gas switches	5 yearly	Reactively on condition or failure	Condition based
Air break switches	5 yearly	Reactively on condition or failure	Condition based
High voltage links	5 yearly	Reactively on condition or failure	Condition based
High voltage fuses	Nil	Reactively on condition or failure	Age based
High voltage Capacitors	5 yearly	Reactively on condition or failure	Condition based
Low voltage links + fuse links	Nil	Reactively on condition or failure	Age based

10.1 Preventive maintenance regimes

10.1.1 AIOSW overhead switchgear asset inspection and monitoring

The driver for this program is to effectively manage the overhead switchgear population through contemporary risk and condition based practices. The focus is on the following asset classes:

- reclosers;
- sectionalisers;
- gas switches;
- air break switches;
- high voltage links; and,
- high voltage capacitors;

Air break switches are targeted as they are the most at risk of mal-operation if not maintained.

The inspections are conducted on a 5 year basis. As part of the inspections important asset information will be verified or recorded to aid in further strategic asset decision making. The information documented will include: switchgear manufacturer and model, geographical location and various condition measures.

The collection of this attribute and condition information will provide detail that allows the effective management of these asset populations into the future. The assets are inspected with live line techniques which make for less planned outages and efficient inspections.

[11] Inspection intervals reflect the nominal inspection period, this does not include, that as a part of TasNetworks procedures switchgear is visually inspected prior to switching operations.

10.1.2 AIOFD Overhead system aerial inspections

TasNetworks introduced aerial inspection for overhead structures in 2014/15 which included the inspection of distribution pole mounted transformers. Initial trials found that aerial helicopter inspections provided a cost effective and efficient method of assessing defects and condition not possible through ground patrols. The aerial patrols have been targeted in the following areas:

- High Bushfire Consequence Areas (HBCAs),
- High Soil Dryness Index areas (HSDIA), and
- Worst performing feeders.

The patrols targeting the HBCA and HSHIA should be planned well prior to the start of the bush fire season to allow for any defects to be rectified.

Aerial inspection program are to be expanded to cover 20 per cent of the network on an annual basis with targeted aerial patrols planned for HBCAs pre bush fire session annually.

10.1.3 AIOTI Thermal Imaging

The AIOTI program was implemented in 2013/14 FY as an outcome of reliability centred maintenance (RCM) review. The RCM review found that the taking no action to identify hot joins within the distribution network resulted in the exposure of the business to an unacceptable level of risk, with regards to bushfires which is consistent with TasNetworks corporate risk appetite. A review of this program was recently undertaken, to determine the program's effectiveness, and recommendations were made on changes that could be made to improve value.

The original program required 1000 kVA of load to be connected downstream of an asset, for that asset to be to be inspected, to ensure that there is sufficient loading at that point in the network for defective connections to produce detectable heat. Through analysis of the locations in the network that hot joints have been found to date, it has been identified that further value may be developed by refining this connected kVA requirement to:

- 1000 kVA in high bushfire consequence areas, and on the "worst performing feeders"; and
- 4000 kVA in all other network areas.

Additionally, feeders should be excluded from analysis, where the loading is below 20 A for the vast majority of time.

The original program has been amended to ensure that inspections take place when loading is as high as possible, typically in the mornings and evening peak periods (7am-10am and 4pm-7pm).

The frequency of inspection to remains at three years which included the thermal inspection of distribution pole mounted transformer terminal bushing and overhead line connections.

10.1.4 AROSW overhead switchgear asset repair

The driver for this program is to manage the business risk and maintain network performance by performing maintenance on overhead switchgear.

Due to requirements for reductions in operational expenditure there was a large decrease in spend in this category over the 13/14 and 14/15 financial years. In 16/17, the inspection and maintenance of overhead switchgear will be reinstated as a standard program.

The aim of this program will be to maintain the existing overhead switchgear and primary components appropriately, with the program of work largely defined by the outcomes of overhead inspections. The key drivers for this targeted maintenance regime are to extend the switchgear asset life whilst maintaining network performance.

10.2 Replacement programs

10.2.1 REOHS replace overhead switchgear

The primary driver for this program is to manage safety operating risks whilst also maintaining network performance.

This program has two components:

- replace air break switches/high voltage links; and
- replace overhead switchgear.

There are no major changes to this program although the budget has been reduced to better reflect historical spend.

Replace air break switches/high voltage links

The aim of this program is to replace air break switches and high voltage links that are in poor condition as identified during TasNetworks' asset inspection programs, replace devices that fail in service or replace devices where other business drivers require a three phase switching device or high current switching.

This work category was previously in REOHQ due to the replacement of low voltage links with fuse links as it was a regulatory obligation. The updated category is a better fit as it suits maintaining the reliability and quality of the network. The type of work actioned within each category has not changed.

Replace overhead switchgear

This program involves the replacement of switchgear that is considered to be unsuitable to remain in service because of condition and/or risk, specifically expulsion drop out type sectionalisers manufactured by AK Power and ABB for example.

Replacement of sectionalisers that are found to be defective is necessary as they are key components in the overhead distribution system that disconnects specific sections of high voltage line when a fault occurs. Mal-operation of the equipment may result in increased duration and number of outages for customers requiring greater resources to restore supply.

In 2014/2015 there were three separate line items included to replace expulsion drop out sectionalisers with pole-mounted automatic reclosers at specific locations, namely Geeveston, Mawbanna and Cressy.

10.2.2 RERER replace reclosers

This program covers the replacement of reclosers in TasNetworks' overhead system due to the condition of the asset. TasNetworks 'current reclosers only have a manufacturer assessed asset life of 20 years. Replacement of reclosers will be undertaken based on condition assessments or as required.

The budget for this program will be developed in response to any identified recloser replacement jobs that have been identified from the 2014/15 Program of Work.

Nulec reclosers

Nulec N-series reclosers are primarily replaced due to the failure of the tanks. Common causes are lightning strikes or bushfire. As TasNetworks now has a recloser supply contract with Noja Power, any recloser requiring replacement in its entirety will be replaced with a Noja recloser.

There is also a Nulec N-series tank issue which relates to the failure of the SCEM card, this requires the tank to be temporarily removed from service so the card may be replaced.

Upgrading reclosers

TasNetworks' fleet of OYT reclosers is actively being replaced due to age and condition. The modern replacement has many added advantages including:

- improved protection functionality and accuracy;
- remote monitoring and control capability; and
- improved product support.

10.2.3 REOHQ replace low voltage links with fuses

The driver for this program is managing business operating risks.

This program involves replacing low voltage links with fuses to enable faster clearance of low voltage faults and thus reducing the risk of equipment damage and public harm.

This program has been in place for a number of years but has not been actively managed so progress has been minimal. Significantly more detail has been provided in the scope for the 2015/16 program, so activity under this program is planned to increase.

This program will transition into REOHS as of the start of 16/17.

11 Financial summary

11.1 Proposed operational expenditure plan

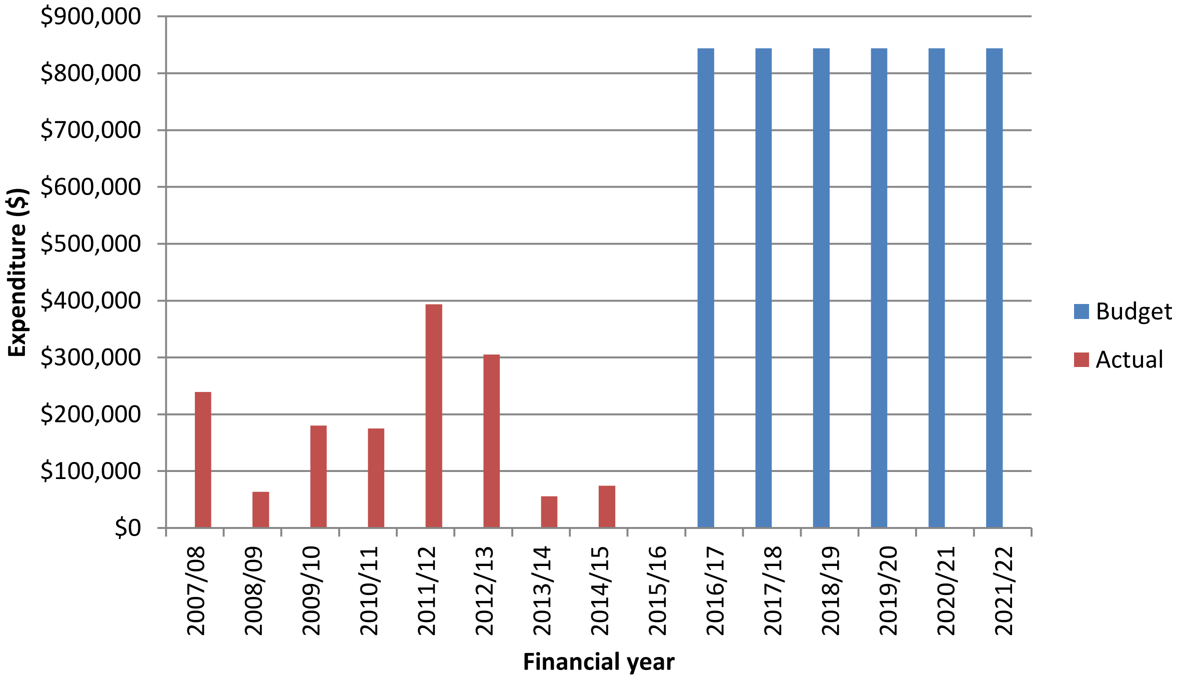
TasNetworks proposes a total operating expenditure of $3.38 million over the next 5 years (FY2015/2016 – FY2019/2020) on overhead distribution switchgear and primary components, with an average expenditure of $0.68 million per annum.

The increase in OPEX spend is a result of the renewed overhead switchgear inspection program.

Table 9: OPEX for period between <start FY> and <end FY> financial years

	FY12/13	FY13/14	FY14/15	FY15/16	FY16/17
Budget	$154,988	$0	$0	$0	$844,000
Actual	$305,465	$55,939	$74,335	$-	$-

Figure 7: Operation expenditure profile



11.2 Proposed capital expenditure plan

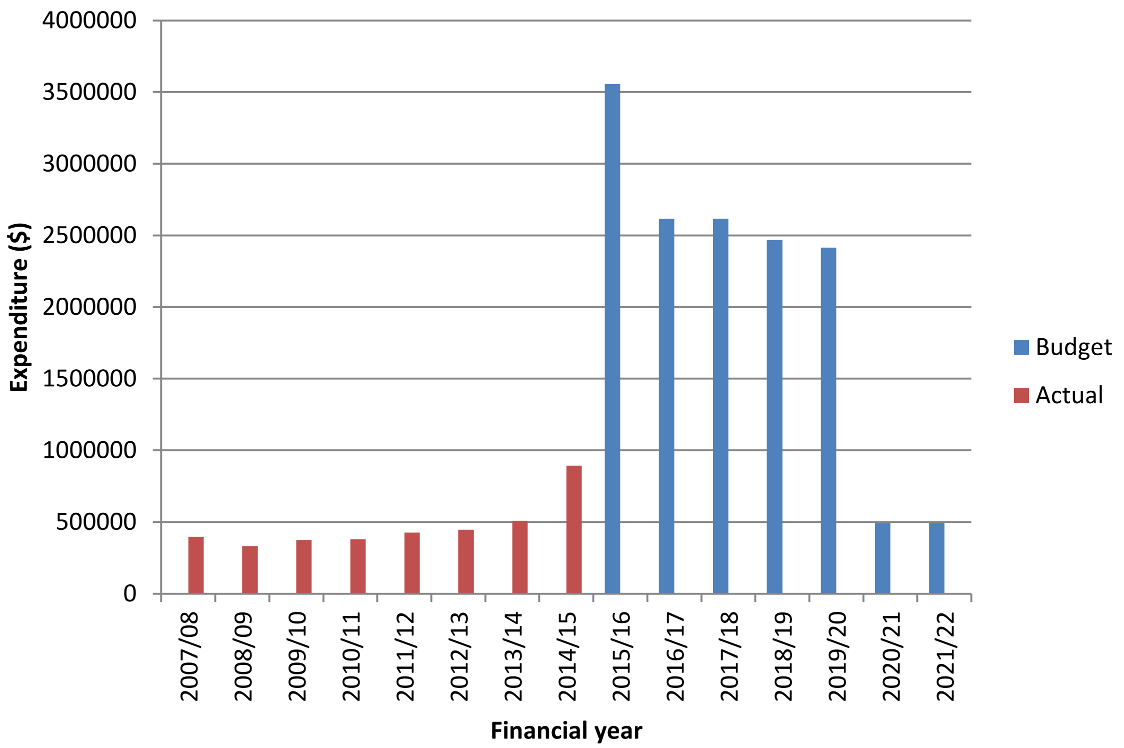
The capital programs and expenditure identified in this management plan are necessary to manage operational and safety risks and maintain network reliably at an acceptable level. All capital expenditure is prioritised expenditure based on current condition data, field failure rates and prudent risk management.

TasNetworks proposes a total capital expenditure of $13.67 million over the next 5 years, with an average expenditure of $2.73 million per annum.

Table 10: CAPEX for period between 12/13 and 16/17 financial years

	FY12/13	FY13/14	FY14/15	FY15/16	FY16/17
Budget	$799,513	$516,222	$749,255	$3,592,000	$2,669,000
Actual	$447,103	$508,268	$893,081	$-	$-

Figure 8: Capital expenditure profile for the 2007/08-2021/22 period



12 Responsibilities

Maintenance and implementation of this management plan is the responsibility of the Asset Strategy Team.

Approval of this management plan is the responsibility of the Asset Strategy and Performance Leader.

13 Related standards and documentation

The following documents have been used either in the development of this management plan, or provide supporting information to it:

General specifications:

- GS30 - Distribution Pole Mounted Automatic Circuit Reclosers, Sectionalisers and Load Break Switches
- GS40 - Distribution Pole Mounted Switchgear
- GS35 – Low Voltage Fuses, Fuse Holders & Circuit Breakers & high Voltage Fuses

Other related standards and documentation:

- Distribution Protection and Control Asset Management Plan R301645
- Review of the Victorian Network AER Submissions on Bushfire Risk Management Plans
- Distribution Protection and Control Manual (R231574)
- Reliability-centred Maintenance, second edition, John Moubray, Elsevier, Oxford,
- Jemena Electricity Networks (Vic) Ltd, 2016-20 Electricity Distribution Price Review Regulatory Proposal, Attachment 7-5, Asset Management Plan 2016-2020, ELE PL 0004
- ETSA Utilities Regulatory Proposal 2010-2015, 1 July 2009.

14 Appendix A – Summary of programs and risk

Table 11: Program of work risk and expenditure summary table

<table>
<tr><th>Description</th><th>Work category</th><th>Risk level</th><th>Driver</th><th>Expenditure type</th><th>Residual risk</th><th>11/12</th><th>12/13</th><th>13/14</th><th>14/15</th><th>15/16</th><th>16/17</th></tr>
<tr><td>Overhead switchgear asset maintenance</td><td>AROWS</td><td>Medium</td><td>Safety/Reliability</td><td>OPEX</td><td>Low</td><td>$392,931</td><td>$305,465</td><td>$55,939</td><td>$18,558</td><td>-</td><td>$424,000</td></tr>
<tr><td>Overhead switchgear inspection and monitoring</td><td>AIOSW</td><td>Medium</td><td>Safety/Reliability</td><td>OPEX</td><td>Low</td><td>$827</td><td>-</td><td>-</td><td>-</td><td>-</td><td>$420,000</td></tr>
<tr><td>Replace low voltage links with fuse links</td><td>REOHQ</td><td>Medium</td><td>Safety/Reliability</td><td>CAPEX</td><td>Low</td><td>-</td><td>-</td><td>-</td><td>-</td><td>$250,000</td><td>-</td></tr>
<tr><td>Air break switch audit</td><td>REOHS</td><td>High</td><td>Safety/Reliability /Environment</td><td>OPEX</td><td>Low</td><td>-</td><td>-</td><td>-</td><td>$55,777</td><td>-</td><td>-</td></tr>
<tr><td>Replace low voltage links with fuse links</td><td>REOHS</td><td>Medium</td><td>Safety/Reliability /Environment</td><td>CAPEX</td><td>Low</td><td>-</td><td>-</td><td>$5,965</td><td>$288</td><td>-</td><td>$244,000</td></tr>
<tr><td>Replace overhead switchgear</td><td>REOHS</td><td>High</td><td>Safety/Reliability /Environment</td><td>CAPEX</td><td>Low</td><td rowspan="4">$184,380</td><td rowspan="4">$230,287</td><td rowspan="4">$300,505</td><td rowspan="4">$892,506</td><td rowspan="4">$3,202,000</td><td rowspan="4">$2,263,000</td></tr>
<tr><td>Upgrade fuses/sectionalisers to reclosers</td><td>REOHS</td><td>Medium</td><td>Safety/Reliability /Environment</td><td>CAPEX</td><td>Low</td></tr>
<tr><td>Replace AK Power sectionaliser with recloser</td><td>REOHS</td><td>Medium</td><td>Safety/Reliability /Environment</td><td>CAPEX</td><td>Low</td></tr>
<tr><td>Replace air break switch</td><td>REOHS</td><td>High</td><td>Safety/Reliability /Environment</td><td>CAPEX</td><td>Low</td></tr>
<tr><td>Upgrade reclosers</td><td>RERER</td><td>Medium</td><td>Safety/Reliability</td><td>CAPEX</td><td>Low</td><td>-</td><td>-</td><td>-</td><td>$533</td><td>$104,000</td><td>-</td></tr>
<tr><td>Replace recloser</td><td>RERER</td><td>Medium</td><td>Safety/Reliability</td><td>CAPEX</td><td>Low</td><td>-</td><td>-</td><td>-</td><td>-</td><td></td><td>$108,000</td></tr>
</table>