Asset Management Plan

Protection and Control – Distribution

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Authorisations

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Review cycle	30 months	

Responsibilities

This document is the responsibility of the Asset Strategy Team, Tasmanian Networks Pty Ltd, ABN 24 167 357 299 (hereafter referred to as "TasNetworks").

The approval of this document is the responsibility of the General Manager, Strategic Asset Management.

Please contact the Asset Strategy Leader with any queries or suggestions.

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

Record of revisions

Section number	Details
	SCADA removed from document

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1 Purpose

The purpose of this document is to describe for distribution protection, control and related 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 CAPEX and OPEX, including the basis upon which these forecasts are derived.

2 Scope

This document covers protection and control assets within the distribution network. It does not cover the primary assets protected by the protection and control assets.

It does not cover the SCADA or Automation equipment.

3 Strategic alignment and objectives

This asset management plan has been developed to align with both TasNetworks' Asset Management Policy and Strategic Objectives. This management plan describes the asset management strategies and programs developed to manage the distribution protection, control and related assets with the aim of achieving these objectives.

For these assets the management strategy focuses on the following objectives:

- Safety will continue to be our top priority and we will continue to ensure that our safety performance continues to improve
- Service performance will be maintained at current overall network service levels, whilst service to poorly performing reliability communities will be improved to meet regulatory requirements
- Cost performance will be improved through prioritisation and efficiency improvements that enable us provide predictable and lowest sustainable pricing to our customers
- Customer engagement will be improved to ensure that we understand customer needs, and incorporate these into our decision making to maximise value to them
- Our program of work will be developed and delivered on time and within budget

4 Asset information systems

4.1 Systems

TasNetworks has a number of asset support systems in place to ensure the distribution protection and control assets are managed proficiently. They are listed as follows:

- PSS SINCAL, a power system network modelling tool with a protection module for grading and coordination studies;
- DIgSILENT StationWare, a protection settings database and management system used to manage the control parameters and to store substation related information; and
- purpose-built configurable database tools such as WASP and WebMap LV to access secondary asset data such as communications settings and device information. These tools provide real time linkages to TasNetworks' Spatial Data Warehouse (SDW), where various secondary asset data is captured.

4.2 Asset information

Asset data information for the distribution protection, control and related assets has varying availability and quality limitations across the asset portfolio, as summarised in Table 1.

There are a number of initiatives underway such as various asset audits and asset information system reviews, which aim to increase TasNetworks' asset data capability. Some asset data such as zone substation protection relay age information has to be assumed based on the most recent modernisation project date.

The Protection and Control - Distribution Thread is working with Network Information Systems team to increase TasNetworks' secondary asset data capability. An example of this is the development of asset data capture information pertaining to overhead fault indicators, resulting from the associated work program. Another such example is a longer term project, TasNetworks Integrated Business Solution (TIBS), which aims to fully integrate and improve TasNetworks processes and systems in relation to asset planning, operation and lifecycle management.

Table 1 Secondary asset information summary

Asset Type	Device	Information Availability	Information Quality
Overhead Assets	Fault indicators	Poor	Poor
	Controllers	Average	Average
Ground Mounted Distribution Substation Assets	Protection relays	Poor	Poor
	Battery systems	Poor	Poor
	Controllers	Average	Average
	Fault Indicators	Poor	Average
Zone Substation Assets	Protection relays	Poor	Poor
	Battery systems	Average	Average
	Control devices	Average	Average

5 Description of the assets

TasNetworks manages distribution protection and control assets pertaining to:

a) 12 major zone substations (with another under construction);
b) 26 sub-transmission feeders;
c) 240 distribution feeders; and
d) over 30,000 distribution substations.

The distribution protection and control asset class encompasses the secondary protection/control assets from the low voltage service fuse to:

a) the 22 kV feeder breaker (excluding); and
b) the 33 kV and 44 kV sub-transmission feeder breakers (excluding).

The protection systems generally comprise current differential, over-current, earth fault and sensitive earth fault protection schemes. The focus of managing protection and control assets is to ensure that faults are rapidly detected and cleared to minimise asset damage and to maximise reliability benefits.

Due to its extensive coverage across the state and being a major determinant of supply reliability there has been a focus on overhead network protection. The higher reliability of underground cabling has required a lesser reliability-based focus with an emphasis on fault detection and clearance design performance requirements.

The protection systems within zone substations have all been replaced or upgraded with modern electronic (numeric) relays. The overhead system uses multi-level protection comprising protection within

substations, modern electronic reclosers, sectionalisers, and fuses. The coordination of this multi-level protection requires considerable management time to ensure adequate and accurate protection.

For many underground feeders there is only one level of HV protection located within zone and distribution substations that typically comprise current differential, over current, earth fault and sensitive earth fault protection schemes. The underground HV network protection includes legacy electro-mechanical relays as well as modern electronic relays. As the protection is unit-based, there is a lesser need for management time to co-ordinate with lower voltage level protection.

The programs under the Protection and Control (distribution) asset class pertain to asset maintenance and replacement activities to ensure they are always in good working order to protect the primary plant in event of a network fault. The drivers behind these programs are various and relate to:

a) age;
b) condition;
c) in-service failure;
d) new functionality requirements;
e) replacement based on obsolescence/lack of product support; and
f) network performance improvement.

Economic lives for TasNetworks assets are sourced from TasNetworks' Regulated Asset Base. In the case of network control and protection systems this equates to fifteen years.

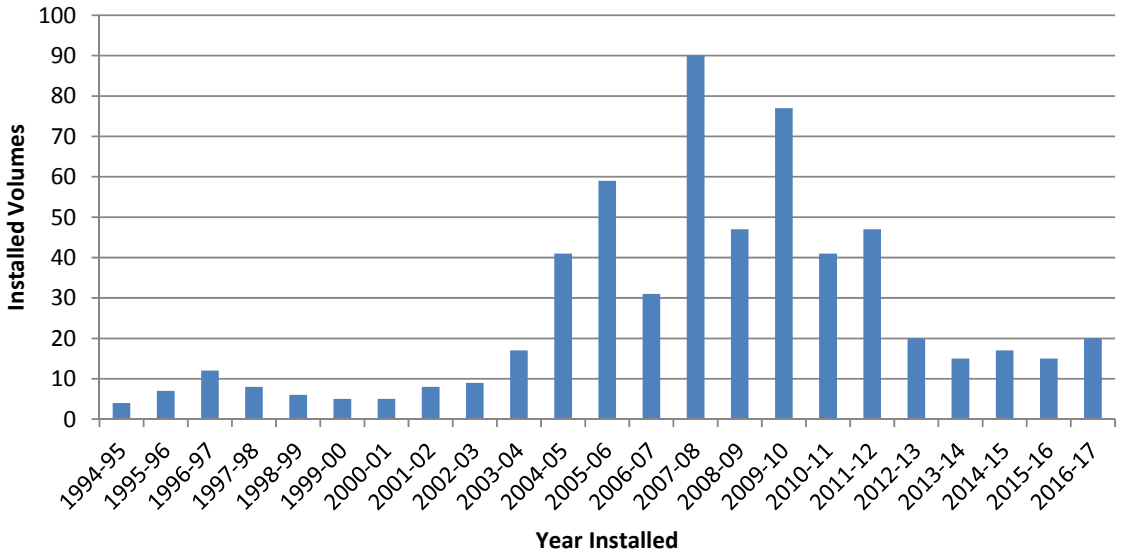
5.1 Overhead assets

Overhead protection and control assets are listed in Table 2 below.

Table 2 Overhead asset volumes

Device	Description	Volume
Reclosers/ load break switch controllers	Schneider and Noja recloser/ load break switch controllers	581

Figure 1 Overhead asset controller age profile, including reclosers, sectionalisers, LBSs and voltage regulators



TasNetworks' recloser and LBS populations are almost entirely Schneider Electric (Nulec) devices, although TasNetworks secured a supply contract with Noja Power in 2014 for new devices in the future. Maintenance tasks for the associated controllers relate to proactive battery change-overs and the replacement of failed secondary components under fault. Over the next ten year planning horizon (R19 regulatory period), TasNetworks plans to introduce proactive injection testing regimes to ensure the protection operates as designed.

5.2 Kiosk distribution substation assets

TasNetworks' population of kiosks substations is serviced by a network of underground distribution feeders. The HV protection for kiosks is located within zone and distribution substations that typically comprise over current and earth fault schemes. Historically kiosks have HV fused protection for the transformer and fuses LV protection for the outgoing LV circuits. Modern Kiosks are equipped with both HV and LV circuit breakers and ancillary protection. The protection is typically self-powered microprocessor based relays that are external to the HV circuit breaker or integrated in the LV circuit breakers. The table below shows the numbers of fuse and circuit breaker based kiosk substations located in the TasNetworks distribution network.

Ground mounted distribution substation protection and control assets are listed in Table 3 below.

Table 3 Kiosk distribution substation asset volumes

Device	Description	Number of Units	Years Installed	HV Protection	LV Protection
Other	Fuse protection	320	1960 - 1999	Fuse	Fuse
RM6	Merlin Gerin / Schneider	504	1999-2017	VIP	Masterpact
Total		824			

5.3 Ground mounted distribution substation assets

TasNetworks' population of ground-mounted substations is largely serviced by a network of underground distribution feeders. For many of these underground feeders there is only one level of HV protection located within zone and distribution substations that typically comprise differential schemes, over current, earth fault and sensitive earth fault detection schemes. The underground HV network protection includes legacy electro-mechanical relays as well as modern electronic relays. As the protection are unit based schemes there is a lesser need for management time to co-ordinate with lower voltage level protection.

Ground mounted distribution substation protection and control assets are listed in Table 4 below.

Table 4 Ground mounted distribution substation asset volumes

Device	Description	Number of Units
Protection relays	Unit protection scheme and associated relays	445
Battery systems	DC systems for substations with unit protection	160
Total		605

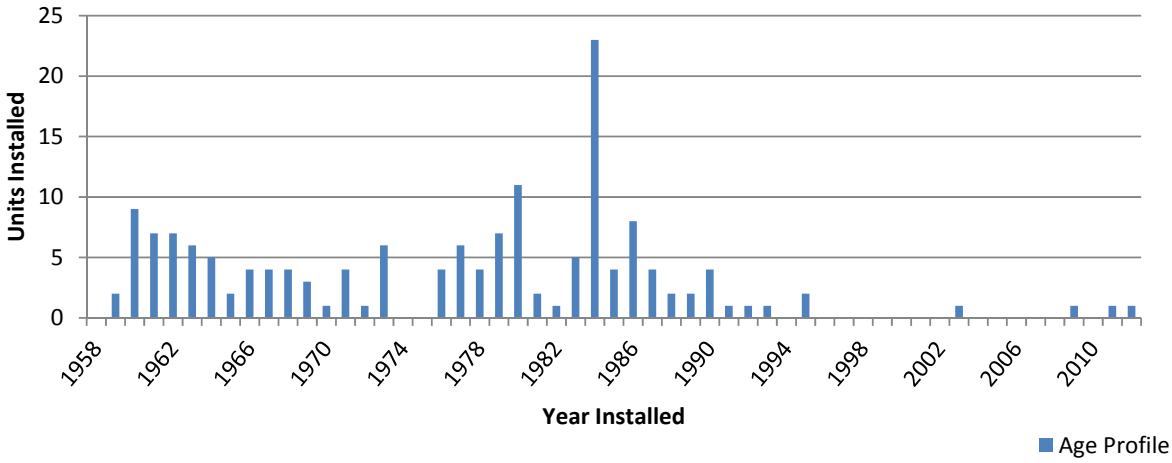
Electro-mechanical protection relays in the ground-mounted substations include:

a) Alstom MiDOS MHOB 04 relay;
b) Alstom MiDOS MHOA 04 relay;
c) Alstom MiDOS MHOA 02 relay;
d) Alstom Translay relay;
e) Reyrolle B24 "send" relay; and
f) Reyrolle B33 "receive" relay.

The exact numbers of the above relays are not known, but TasNetworks is undertaking exhaustive surveys to help remedy the current limitations in asset visibility.

Ground mounted distribution substation battery system numbers relate directly to the substations with feeder differential protection schemes, referred to colloquially as “Translay”. These systems total 178 in number.

Figure 2 Age profile of ground mounted unitised protection devices



5.4 Zone substations

Zone substation protection and control assets are listed in Table 5 below.

Table 5 Zone substation asset volumes

Device	Description	Number of Units
Protection relays/field devices	Unit protection scheme and associated relays	392
Battery systems	DC systems for substations with protection	12
Total		404

TasNetworks’ zone substations serve as 33 kV and 44 kV injection points across the distribution network. There are 12 zone substations (at the time of writing Rosny Zone Substation is still under construction), with all but Trial Harbour Zone Substation located in the Greater Hobart area.

Zone substation discriminative protection schemes are designed to provide:

a) co-ordination of protection, including with existing upstream and downstream protection;
b) detection and clearing of system abnormalities in industry accepted time to minimise the impact on plant and public safety;
c) selectivity such that the minimum amount of plant is removed or operated to limit its impact on downstream customers and retain firm capacity;
d) be available to operate under all foreseeable system conditions;
e) designed to allow the system to perform under normal operating conditions;
f) compatibility with upstream protection devices and schemes;
g) whole of life reliable and dependable service; and
h) compliance to all regulatory code requirements.

Protection schemes at zone substations detect and clear the following types of faults from incoming sub-transmission feeders to the outgoing feeders at the zone substation:

a) all phase to phase faults;
b) all phase to earth faults;
c) all power transformer faults at the zone substation;
d) high impedance earth faults;
e) all sub-transmission broken conductor faults;
f) internal faults in the switchgear; and
g) faults on the downstream distribution system in the event of a circuit breaker failure.

Whilst many of the zone substations were installed in the 1950s and 1960s, they have undergone significant modernisations over the past fifteen years. Due to limitations in asset data capability, the age of the protection equipment contained in these stations is associated with the most recent modernisation project as per Table 6 below.

Table 6 Zone substation age profile

Zone Substation	Voltages	Install Date	Date Modernised (protection)	DC Voltage
Geilston Bay	33/11 kV	1964	2001	32 V
Bellerive	33/11 kV	1971	2001	32 V
West Hobart	33/11 kV	1956	2002	125 V
Derwent Park	33/11 kV	1964	2003	32 V
New Town	33/11 kV	1966	2003	32 V
East Hobart	33/11 kV	1958	2004	125 V
Claremont	33/11 kV	1958	2006	125 V
Trial Harbour	44/22 kV	2007	2007	125 V
Cambridge	33/11 kV	2009	2009	125 V
Howrah	33/11 kV	2012	2012	125 V
Sandy Bay	33/11 kV	1967	2014	32 V
Summerleas	33/11 kV	2014	2014	125 V
Rosny (under construction)	33/11 kV	2015	2015	125 V

TasNetworks is moving to standardise on the protection equipment installed at zone substations to gain benefits from reduced spares holdings, operator and maintenance staff familiarity and training requirements. The preferred relay types are detailed in Table 7.

Table 7 Preferred relay types

Description	Manufacturer	Model
Line current differential	AREVA/Schneider	MiCOM P541
	Siemens	7SD610
11kV CBD protection	Siemens	7SD82
Transformer differential	AREVA/Schneider	MiCOM P632

Description	Manufacturer	Model
11kV feeder protection	AREVA/Schneider General Electric	MiCOM P143 Multilin SR760
Bus couplers	AREVA/Schneider General Electric	MiCOM P143 Multilin SR760
SEF check	AREVA/Schneider	MiCOM P122

Zone substation feeder relays are configured to provide a number of different settings groups including Live Line Settings On/Off, Auto-Reclose On/Off and Under-frequency Load Shedding On/Off.

Battery systems at zone substations are either 32 V DC or 125 V DC, in accordance with Table 7 above. TasNetworks mostly uses single battery chargers at zone substation sites. The risk in not having full redundancy (a second charger in parallel) has been mitigated by the following:

a) designing batteries to withstand 8 hours on full station load;
b) facilitating rapid deployment of back-up chargers with an external connection pedestal; and
c) adequate spares holdings.

The modern batteries used within zone substations are relatively reliable with regards to asset life, so TasNetworks has moved to a program of replacing the zone substation batteries at ten-year intervals with no annual discharge testing. Any potential savings in life extension by annual discharge testing of the batteries to determine their condition were less than the cost of the discharge testing and battery maintenance.

6 Standard of service

6.1 Technical standards

The following legislative requirements and technical standards dictate the standard of service required by Distribution protection and control assets.

Legislation

- Tasmanian Electricity code;
- National Electricity Rules (Section 6.5.7(a));

Standards

- R040766 TasNetworks Asset Management Policy;
- R750976 Distribution Standard Protection and Control;
- R301624 Underground System Asset Management Plan;
- R181933 Overhead Switchgear Asset Management Plan;
- R301380 Zone Substations Asset Management Plan;
- R209871 TasNetworks – Risk Management Framework;
- R209885 TasNetworks – Risk Appetite Statement; and
- R209890 TasNetworks – Risk Metric

6.2 Performance objectives

Protection is required to be secure and reliable to ensure that primary system faults are isolated quickly ensuring the least disturbance and instability to the remaining network. It is important that protection co-ordinates appropriately with adjacent protection schemes to only disconnect the faulted parts of the

network and optimise transmission and distribution circuit availability. The timeframe to restore failed protection services often has a high impact on primary equipment availability and system capacity.

Under the requirements of clause 6 of the NER, TasNetworks participates in the AER's service target performance incentive scheme (STPIS).

The components of the scheme are monitored annually and include:

(a) Average circuit outage rate;

(b) Loss of supply event frequency;

(c) Average outage duration; and

(d) Correct operation of equipment.

Components (c) and (d) have been included in the STPIS since July 2014 and at present do not impact on performance bonus/penalty payments but are an important measure of asset management.

Full details of the STPIS and associated performance targets can be found on the AER's website in the 'Electricity transmission network service provider's service target performance incentive scheme (December 2012)' literature.

TasNetworks also has a performance incentive scheme in place with Hydro Tasmania for connection assets between the two companies under the connection and network service agreement (CANS 2). The scheme includes connection asset availability and is described in more detail in the CANS 2 connection agreement.

6.2.1 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 continuous improvement.

6.3 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:

a) System Average Interruption Duration Index (SAIDI); and

b) 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"*.

7 Associated risk

7.1 Risk Management Framework

TasNetworks has developed a Risk Management Framework for the purposes of assessing and managing its business risks, and for ensuring a consistent and structured approach for the management of risk is applied.

An assessment of the risks associated with the Distribution Protection and Control assets has been undertaken in accordance with the Risk Management Framework. For each asset in this class the assessments have been made based on:

- Condition of Distribution Protection and Control assets in service across the network
- Criticality of Distribution Protection and Control assets and associated assets
- Probability of failure (not meeting business requirement)
- Consequence of failure
- Performance
- Safety risk
- Environmental risk
- Customer

The quantification of risk is supported by the Condition Based Risk Management (CBRM) framework. This approach allows the risks of individual assets to be quantified against the defined assessment.

Due to the level of risk identified in some of the assessment criteria a requirement to actively manage these risks has been identified.

Where unacceptable risks have been identified treatment plans have been developed. The sections below provide information on identified risks and the associated treatment plans.

7.2 Overhead assets

Overhead protection and control asset work program risk is generally quite low due to its low complexity and relatively low likelihood/consequence combined risk ratings. Maintenance tasks associated with overhead protection and control assets are straight forward and managed in accordance with corresponding maintenance intervals.

The following table summarises the (unmanaged) risk levels for the various work programs pertaining to protection and control overhead assets:

Table 8 Overhead asset risk

Program	Category	Level of risk untreated	Level of risk treated
Recloser and LBS Maintenance	AROPC	Low	Low
Asset Repair OH Protection Switchgear Maintenance	AROPC	Low	Low
Replace LV Fuses for Fuse Reach	REOPC	Low	Low
Replace Recloser and or Control Box	RERPC	Low	Low

7.3 Ground mounted distribution substation assets

7.3.1 Hobart CBD

The ground mounted distribution substation asset work program mostly concerns maintenance and replacement activities on forty-year old protection and control equipment. Largely due to age and locality (the Critical Infrastructure reliability area in the Hobart CBD), the associated risk is considered medium in relation to TasNetworks' risk framework. TasNetworks' Translay assets are approaching their forty-year end of life, and whilst there have been few relay failures to date, the number of failures is expected to sharply rise with end of life failures as characterised by the bathtub failure phenomenon. The copper pilot network which serves as the inter-relay communications medium is also showing signs of deterioration with channel failures common on approximately 50 % of a recent sample size of 40 distribution substations.

Figure 3 Translay protection relay

The Translay system requires targeted replacements over the forthcoming regulatory period to ensure the ongoing protection of the associated primary equipment and the maintenance of the current reliability levels over the next ten years.

The following table summarises the (unmanaged) risk levels for the various work programs pertaining to protection and control ground mounted distribution substation assets:

Table 9 Ground mounted distribution substation asset risk

Program	Category	Level of risk untreated	Level of risk treated
Routine Maintenance Distribution Subs (Battery System Tests)	RMDPC	Medium	Low
Routine Maintenance Distribution Subs (Protection System Tests)	RMDPC	Medium	Low
Replace Battery (Once every 4 years same time as switchgear maintenance)	REGAU	Medium	
Replace Distribution Substation Battery System	REGAU	Medium	Low
Replace Translay protection relays in Distribution Substations	REGAU	Medium	Low

Distribution substation protection is comprised of electromechanical relays which service the pilot wire protection schemes throughout the Hobart CBD. TasNetworks recently became aware of the approaching obsolescence of one relay model, the Alstom MiDOS MHOB 04 Feeder Protection Relay. Accordingly, a strategy revision was prompted which is discussed under Section 8.4.10.

7.3.2 Kiosks

Protection setting audits are required for kiosk substations to determine fuse sizing or protection relay settings for both HV and LV switchgear. The "as found" settings shall be entered into the Stationware software package. These sizes /settings will require review to ensure the correct protection is being installed both for protection of plant and for protection discrimination.

An issue exists with the VIP relay protection settings applied to Schneider kiosks rated at 1500kVA and above. The setting applied is for 1.5 times the transformer rating, this setting is greater than the rating of the LV board. There have been two failures of this equipment within TasNetworks.

7.4 Zone substations

The zone substation asset work program concerns maintenance and replacement programs on the 33/11kV substations across the distribution network. With large levels of customer load and high criticality, the risk has been assessed as medium for these programs.

The following table summarises the (unmanaged) risk levels for the various work programs pertaining to protection and control zone substation assets:

Table 10 Zone substation asset risk

Program	Category	Level of risk untreated	Level of risk treated
Urban Zone Substation Protection and SCADA Maintenance	RMZPC	Medium	Low
Battery and Charger Maintenance - Zone Substation	RMZPC	Medium	Low

8 Management plan

8.1 Historical

The Protection and Control – Distribution asset thread became detached from the Overhead, Structures, Substations and Underground threads in 2012 and the SCADA and Automation Thread in 2016. Prior to this protection and control asset management activities were undertaken under each respective thread whereby most of the initiatives were OPEX and maintenance based. In 2012/13 the maintenance activities pertaining to protection and control were combined under one thread and additional OPEX and CAPEX based initiatives were introduced as a new strategic focus began.

Subsequently the spend profile for the Protection and Control Thread does not precede the 2012/13 financial year.

8.1.1 Overhead assets

Asset management programs pertaining to overhead (secondary) assets are listed as follows:

Table 11 Overhead protection and control work programs

CAPEX/ OPEX	Work Program Level	Project/Program Description	Category Code
OPEX	Non-routine maintenance	Recloser & LBS Maintenance	AROPC
OPEX	Non-routine maintenance	Asset Repair OH Protection Switchgear Maintenance	AROPC
CAPEX	Reliability & quality maintained	Replace LV Fuses for Fuse Reach	REOPC

CAPEX	Reliability & quality maintained	Replace Recloser & or Control Box	RERPC

8.2 Ground mounted distribution substation assets

Asset management programs pertaining to ground-mounted distribution substation (secondary) assets are listed as follows.

Table 12 Ground mounted distribution substation work programs

CAPEX/ OPEX	Work Program Level	Project/Program Description	Category Code
OPEX	Routine maintenance	Routine Maintenance Distribution Subs (Battery System Tests)	RMDPC
OPEX	Routine maintenance	Routine Maintenance Distribution Subs (Protection System Tests)	RMDPC
CAPEX	Reliability & quality maintained	Replace Battery (Once every 4 years same time as per protection test and switchgear maintenance)	REGAU
CAPEX	Reliability & quality maintained	Replace Distribution Substation Battery System	REGAU

8.3 Zone substation assets

Asset management programs pertaining to zone substation (secondary) assets are listed as follows.

Table 13 Zone substation work programs

CAPEX/ OPEX	Work Program Level	Project/Program Description	Category Code
OPEX	Routine maintenance	Urban Zone Substation Protection Maintenance	RMZPC
OPEX	Routine maintenance	Battery and Charger Maintenance - Zone Substation	RMZPC

8.4 Strategy

The asset management strategies pertaining to the distribution Protection and Control asset class are described in the subsequent sections.

8.4.1 Settings management

All protection settings for distribution assets shall be stored in the Stationware software package. These settings include but are not limited to:

1) Zone substation protection relay settings;
2) Ground substation protection settings for HV and LV equipment; and
3) Pole mounted reclosers and sectionalisers.

Where there is a deficiency in data or data quality a setting audit shall be conducted.

8.4.2 CAPEX versus OPEX

The Control aspect of Protection and Control management provides opportunities to trade operating expenses for capital investment effectively. Remote controlling distribution network devices for network control can provide significant savings in operational costs versus manual switching. The Protection and Control Thread works closely with Network Innovation in actively seeking these opportunities.

Remote control is most cost effectively introduced through new equipment with factory fitted capabilities, and is becoming a common feature of new switchgear. TasNetworks expects this to be a standard feature of all new switchgear in the near future, and considers these features when renewing switchgear supply period contracts.

The Protection and Control Thread is also taking the opportunity to capitalise the replacement of batteries in distribution substations by introducing a cyclic replacement program, as an alternative to performing routine battery testing. This aligns with a key TasNetworks strategic focus in meeting customer needs at the lowest sustainable cost.

A cyclic battery replacement program for zone substations has also recently been introduced to the Program of Work, to reduce operational expenditure associated with routine testing.

8.4.3 Routine maintenance

There is a fundamental requirement for TasNetworks to periodically inspect the assets to ensure their physical state and condition does not represent a hazard to the public. Other than visiting the assets, there is no other economic solution to satisfy this requirement, although some asset statuses can be monitored remotely once a device has been equipped with remote communications. Where equipment is protected by protection relays these relays shall be routinely tested as per the table below.

Table 14 Testing regimes

Protection Classification	Frequency
Zone substation protection testing, calibration (electromechanical, static)	Every four years
Zone substation protection testing, calibration (microprocessor)	Every eight years
Protection testing, calibration (pole recloser)	Every ten years
Ground Substation HV and LV protection devices	Every six years
Kiosk Substation HV and LV protection devices	Every six years

8.4.4 Routine maintenance versus non routine maintenance

Distribution protection and control asset failure may cause serious or catastrophic damage to the associated primary asset. These assets are generally located in close proximity to the public, so allowing failures to occur represents a significant risk to the public and surrounding infrastructure. These assets also have a high unit value, so a preventative corrective maintenance program represents a cost effective alternative to a reactive corrective maintenance program.

8.4.5 Refurbishment

Where distribution protection and control assets are removed from the network in good operating condition by activities such as capacity and power quality drivers, these assets are assessed for redeployment back into the network where such refurbishment is deemed to be an economic proposition.

8.4.6 Planned asset replacement versus reactive asset replacement

A reactive replacement generally does not represent an attractive alternative to a planned renewal activity. Distribution protection and control assets are predominately servicing high density urban, commercial or CBD communities, with a high service level expectation in the Tasmanian Electricity Code. Also reactive replacements are generally several times more expensive, incurring over time, call out penalties and additional repair costs to cable terminations and nearby infrastructure.

Replacement is generally only preferred when this is a more economic proposition compared to ongoing maintenance costs over the estimated remaining service life of the asset. These are identified from the

maintenance and inspections activities and feed into the list of proposed capital expenditure projects for prioritisation.

8.4.7 Non network solutions

Protection systems provide an essential function in providing protection from the release of large amounts of damaging energy. In general there are no non-network solutions that provide this protection function.

Control systems equipment however, forms part of the Network Innovation team's portfolio and they spend considerable time evaluating new and emerging technologies. The Protection and Control Thread work closely with the Network Innovation team in this regard.

The introduction of some non-network solutions such as embedded generation adversely impact protection systems through increased fault levels and changes in power flow direction. Network Innovation and Strategic Asset Management will jointly manage this issue.

8.4.8 New technology

Modern protection systems, through their implementation in microprocessor-controlled relays, are changing rapidly as new technological improvements continue. New technology will continue to be trialled by TasNetworks and implemented where cost/benefits exist.

8.4.9 Network augmentation impacts

TasNetworks' requirements for developing the power Distribution system are principally driven by five elements:

1. Demand forecasts;
2. New customer connection requests;
3. New generation requests;
4. Network performance requirements; and
5. National electricity rules (NER) compliance.

Reliability and Safety are the key drivers for the increasing number of Pole Mounted Reclosers and Sectionalisers being installed on the TasNetworks distribution network. The increase in numbers are responsible for the increasing OPEX costs.

8.4.10 Hobart CBD (CI Zone)

8.4.10.1 General

TasNetworks' (TN) Critical Infrastructure (CI) reliability category as defined by The Office of the Tasmanian Regulator (OTTER) in the Distribution Network Reliability Standards. Section 4.2.1 of this standard refers to a sensitive reliability area within the Hobart Central Business District which comprises a number of important government, private facilities and businesses. The Hobart CBD Critical Infrastructure (CI) zone has several work programs to remedy the current identified risks of an end of life of the unitised protection relay fleet and pilot wires associated with the unitised protection. This work includes replacement of the protection relays with modern microprocessor based equivalents and repairing or replacing the copper pilot wires with fibre optic cables.

To ensure compatibility of all protection in the Hobart CBD including future augmentation work, a single model of protection relay shall be utilised at distribution substations, zone substations and transmission substations within this area. This includes all CBD Distribution substations, East Hobart, West Hobart 11kV Zone substations and North Hobart Transmission substation 11kV feeder units. This strategy allows for a simple "cut and shut" strategy for future CBD augmentation work.

8.4.10.2 Protection capability

The protection relay shall have the following functionality and capability as a minimum:

1) capable of providing 87 and 51 protection elements;
2) have enough inputs and outputs for protection functionality and to collect all SCADA points within the distribution substation;
3) capable of IEC61850 (rev 2) GOOSE messaging to allow bus overcurrent protection to be enabled at distribution substations that do not have bus bar protection;
4) have capability for protection communications of both copper and single mode fibre;
5) capable of the 75 degrees Celsius or greater maximum temperature; and
6) power supply range from 32 – 125 VDC.

8.4.10.3 SCADA capability

The relay will require sufficient digital inputs and outputs to monitor and control all equipment within the substation via a SCADA connection to the protection relay. The relay shall be capable of being programmed in IEC-6113 to perform automated restoration schemes where required and be capable of both Ethernet DNP3.0 and IEC61850 (rev 2) compliance.

8.4.10.4 Communications

The existing copper pilot wire assets are currently installed, operated and maintained as a Protection and Control regulated asset. In December 2016 the Protection and Control and SCADA Threads were separated, with a decision to move the responsibility for managing the pilot wires to the SCADA Thread.

The copper pilot wire assets are in poor condition and require remediation works to restore them to an acceptable level of reliability. For more information on this work category please refer to the Distribution – SCADA and Automation Asset Management Plan.

Where possible the pilot wires will be replaced with fibre-optic cables with ownership of these assets remaining with the SCADA Thread as a regulated asset to ensure network security is maintained. For more information on this work category please refer to the Distribution –SCADA and Automation Asset Management Plan.

8.5 Routine maintenance

The following sections outline the routine maintenance programs for this asset class.

8.5.1 Routine maintenance distribution subs (battery system tests) - RMDPC

This operational program concerns the maintenance of ground-mounted substation DC battery systems to ensure correct ongoing operation. Activities include discharge tests on battery systems and the replacement of individual charger components or cells where necessary. The maintenance interval for these activities is six-monthly. This program does not concern battery systems recently upgraded as part of the associated CAPEX-based battery system replacement program (REGAU, Section 8.7.4) but rather, the older systems yet to be replaced. As the CAPEX program advances, the volumes tested under this battery system testing program will decrease until eventually no longer required as will occur in the 2022/23 financial year.

This program has been developed to manage associated asset risk in accordance with TasNetworks' risk framework. It also aligns with a key TasNetworks strategic focus in meeting customer needs at the lowest sustainable cost.

The summary of the forecast for expenditure and volumes for the CAPEX and OPEX program of work can be located at the following link http://reclink/R0000776614.

8.5.2 Routine maintenance distribution subs (protection system tests) - RMDPC

This operational program concerns the maintenance of ground-mounted substation protection systems to ensure correct ongoing operation. Activities include secondary injection and functional testing of relays and pilot wire circuit integrity testing. The maintenance interval for these activities is four-yearly. Asset repairs are raised as required for defects identified during the site visit. Unlike Section 8.5.1, this program includes all ground-mounted substations in the fleet (which have DC-powered protection systems, known as Translay).

This program has been developed to manage associated asset risk in accordance with TasNetworks' risk framework, and is an essential program in ensuring the ongoing protection of all associated primary equipment.

The summary of the forecast for expenditure and volumes for the CAPEX and OPEX program of work can be located at the following link http://reclink/R0000776614.

8.5.2.1 Kiosk protection testing

Where kiosks have protection relays installed, the protection shall be tested as part of the eight yearly kiosk switchgear routine maintenance, this includes any HV or LV protection. As at 2017 TasNetworks has a fleet of 504 kiosks that have protection relays installed with an estimated 48 units to be tested per annum. These numbers will increase as the current works program to replace existing kiosks with modern protection relay based units continues at 34 units per annum.

The summary of the forecast for expenditure and volumes for the CAPEX and OPEX program of work can be located at the following link http://reclink/R0000776614.

8.5.3 Battery and charger maintenance - zone substation - RMZPC

This operational program concerns maintenance of zone substation DC battery systems to ensure correct ongoing operation. Activities include discharge tests on battery systems and the replacement of individual charger components or cells where necessary. The maintenance interval for these activities is twelve-monthly. The discharge testing component pertains to zone substation sites yet to have battery banks upgraded under the associated CAPEX-based battery replacement program (REUZO). Once all sites receive new battery banks, the OPEX-based testing regime can be phased out, leaving a residual program funding portion for ongoing charger maintenance, the phasing out of this activity is scheduled for the 2027/28 financial year.

The summary of the forecast for expenditure and volumes for the CAPEX and OPEX program of work can be located at the following link http://reclink/R0000776614.

8.5.4 Urban zone substation protection maintenance - RMZPC

This operational program concerns the maintenance activities associated with the protection systems at TasNetworks' 12 zone substations. Activities include:

a) primary/secondary injection and functional testing of relays and protection schemes;
b) insulation resistance of CT/VT secondary wiring;
c) testing of trip circuitry;
d) device setting back-up to Stationware;
e) spares management;
f) software version control and licensing management;
g) equipment calibration;
h) visual checks and inspections;
i) cleaning of secondary equipment;
j) fault response;

k) incident investigations; and
l) ad-hoc works.

The maintenance intervals for these activities vary between monthly to four-yearly in accordance with the following table:

Table 15 Zone substation maintenance intervals

Classification	Frequency
Protection testing, calibration (electromechanical, static)	Every four years
Protection testing, calibration (microprocessor)	Every six years
Device setting back-up, cleaning, software	Twelve-monthly
Inspections, checks	Monthly
Fault response, ad-hoc works, investigations	As required

Until August 2015 the entire services program were provided by an external contractor, selected through a competitive tender process. Following the recent merger, in-house expertise was gained allowing these activities to be provided internally excluding fault response and some ad-hoc works.

Since the advent of microprocessor relays with watch-dog alarming, the opportunity exists to extend maintenance intervals. Whilst the opportunity exists to push injection testing regimes out further, TasNetworks considers six yearly intervals the most appropriate maintenance frequency for microprocessor based protection relays as per industry best practice and four-yearly intervals for electromechanical or static relays.

This program has been developed to manage associated asset risk in accordance with TasNetworks' risk framework, and is an essential program in ensuring the ongoing protection of all associated primary equipment.

Table 16 Relay testing volumes

	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Planned	66	53	53	53	53	53	53	53	53	43	33	33	33
Actual	40												

8.6 Corrective maintenance

Corrective Maintenance consists of work to remedy asset failures that may occur to the fleet during the assets expected life. As assets are replaced with modern equivalents it is expects the amount of corrective maintenance should reduce. Corrective maintenance budgets exist for zone substations and overhead assets.

8.6.1 Zone substation routine protection maintenance - RMZPC

The thirteen zone substations have routine protection maintenance based on the volumes and protection regimes illustrated in Table 17.

Table 17 Zone substation routine maintenance regimes

	16/17	17/18	18/19	19/20	20/21	21/22	22/23	23/24	24/25	25/26	26/27	27/28	28/29
Planned	66	43	43	43	43	43	43	43	43	43	43	43	33
Actual	40												

8.7 Reliability and quality maintained

The following sections outline the 'reliability and quality maintained' programs for this asset class.

8.7.1 Replace LV fuses for fuse reach - REOPC

The aim of this capital program is to proactively evaluate and redesign/repair substandard LV sites to ensure that under fault conditions the LV network is appropriately protected. This program is related to a program in the Overhead and Structures thread, REOHQ Replace OH Switchgear, which also aims to reduce the risk associated with LV links and fuses.

The difference between the two programs is:

a) REOHQ simply replaces the LV links on a transformer with an LV fuse sized to the size of the transformer; and
b) this program has a design component to ensure the fuse is sized to protect the whole LV circuit and may require the reconfiguration of LV circuits.

This program aims to address 260 sites per year, starting with sites that have no LV protection.

Testing expenditure and volumes can be found at the following link http://reclink/R0000776614

8.7.2 Replace recloser and/or control box - RERPC

This capital program is a reactive program developed to substitute damaged or faulty controllers or associated circuit boards. Volumes are based on historical overhead switchgear controller failure data. The 2017 estimated work for this item is based on six replacements per annum for the existing fleet of 581 reclosers or sectionalisers.

Expenditure and volumes can be found at the following link http://reclink/R0000776614

8.7.3 Replace battery (distribution substation) - REGAU

This capital program concerns the replacement of ground-mounted substation 32 V battery banks at four-yearly intervals. This program applies to all distribution substation sites which have had battery systems upgraded in accordance with the 'Replace Battery System' CAPEX program per Section 8.7.4.

This program has been developed to manage associated asset risk in accordance with TasNetworks' risk framework, and is an essential program in ensuring the ongoing protection of all associated primary equipment.

8.7.4 Replace distribution substation battery system - REGAU

This capital program is associated with the replacement of old ground-mounted substation battery chargers which in some cases are as old as 25 years. The replacement chargers are equipped with remote monitoring facilities which will allow TasNetworks to move away from 6-monthly inspection activities. As this program is delivered, the volumes under RMDPC (Section 8.5.1) will reduce to nil resulting in significant operational savings.

This program has been developed to manage associated asset risk in accordance with TasNetworks' risk framework, and is an essential program in ensuring the ongoing protection of all associated primary equipment. This program works on a ten year cyclic replacement of battery chargers.

Expenditure and volumes can be found at the following link http://reclink/R0000776614

8.7.5 Recloser secondary injection testing - AROPC

This new program involves performing secondary injection testing on 10% of the recloser fleet (per year) based on a 10-year cyclic regime. This is being introduced to help in managing the risks associated with an ageing recloser fleet, to ensure the protection will operate as designed.

Based on the current recloser fleet of 529 units, in the 2016-2017 financial year 53 units shall be tested.

The summary of the forecast for expenditure and volumes for the CAPEX and OPEX program of work can be located at the following link http://reclink/R0000776614.

8.8 Regulatory obligations

The lead regulatory obligations to be met are National Electricity Rules clauses S5.1a.8, Fault clearance times and S5.1.9(c) Protection systems and fault clearance times. In addition to meeting these obligations protection and control is key to maintaining the performance to the Reliability Standards in the Tasmanian Electricity Code.

Key considerations in meeting the aforementioned are as follows.

8.8.1 Maintain network performance

Accurate discrimination of protection systems will isolate faulted areas, disconnect the minimum number of customers, and minimise impacts on reliability performance. The coordination between protection devices needs to be monitored and maintained as the network grows and develops over time.

Fast protection operation time will minimise asset damage and customer impacts from voltage dips due to reflected faults on the network.

8.8.2 Manage business operating risks at an appropriate level

Protection Systems provide protection to assets to minimise the severity of asset damage under fault conditions.

The operation of protection and control devices must remain safe under a growing and developing network.

8.9 Replacement

8.9.1 Translay relay replacement - REGAU

TasNetworks owns and maintains an aged fleet of electromechanical protection and control assets in the Hobart CBD reliability area with an average age of 40.59 years (2017/18). The relays form part of a unit protection scheme known by the tradename, Translay. Faced with significant issues such as obsolescence and age, TasNetworks wishes to invest in this infrastructure in order to meet the needs of the network, taking into consideration the reliability requirements of the area and the projected load growth. There are 178 Translay and 267 associated relays in this asset fleet, protecting 87 feeder segments in 160 substations.

TasNetworks' planned solution is to replace the Translay and associated relays with modern microprocessor equivalents based on age profile and a nominal forty year life cycle. Along-side will be with a staged fibre-optic cable installation to replace the aged pilot wire network. The new protection relays will be compatible with both fibre-optic and pilot wire communication systems and will facilitate connection to either communications medium, based on how advanced the fibre-optic upgrade is. More information on this program is contained in Section 7.3.1

Expenditure and volumes are contained in Appendices A and B.

8.10 Spares management

The management of spares is a joint strategic and operational responsibility across TasNetworks and is key in managing asset risk. Deficiencies in spares holdings are identified during the asset management plan development and where these models of protection relay are not obsolete, spares are ordered in alignment with TasNetworks' spares policy.

8.11 Disposal plan

Distribution protection and control equipment that has been removed from service as part of a capital replacement project is disposed as part of the project. Asset types which are not obsolete may be refurbished and retained for system spares, as identified by TasNetworks operational staff.

8.12 Summary of programs

The needs assessment and options analysis for undertaking an asset management activity is documented in the Investment Evaluation Summary for that activity.

The delivery of these activities follows TasNetworks' end to end (E2E) works delivery process.

Table 18 provides a summary of all of the programs described in this management plan under both:

a) the 16/17 Program of Work cycle;
b) the current asset management plan review cycle; and
c) the R19 review period

Table 18 Summary of distribution protection and control work programs

CAPEX/ OPEX	Work Program Level	Project/Program Description	Category Code	IES Line Item
OPEX	Routine maintenance	Recloser Secondary Injection Testing	AROPC	724
OPEX	Routine maintenance	Routine Maintenance Distribution Subs (Battery System Tests)	RMDPC	401
OPEX	Routine maintenance	Routine Maintenance Distribution Subs (Protection System Tests)	RMDPC	402
OPEX	Corrective Maintenance	Urban Zone Substation Protection Maintenance	RMZPC	403
OPEX	Routine maintenance	Battery and Charger Maintenance - Zone Substation	RMZPC	404
OPEX	Corrective Maintenance	Asset Repair OH Protection Switchgear Maintenance	AROPC	386
OPEX	Routine Maintenance	Distribution Substation Protection Maintenance	RMDPC	???
CAPEX	Reliability & quality maintained	Replace LV Fuses for Fuse Reach	REOPC	392
CAPEX	Reliability & quality maintained	Replace Battery (Once every 4 years same time as per protection test and switchgear maintenance)	REGAU	400
CAPEX	Reliability & quality maintained	Replace Distribution Substation Battery System	REGAU	395
CAPEX	Reliability & quality maintained	Translay Protection Scheme Replacement Program	REGAU	396
CAPEX	Reliability & quality maintained	Replace Recloser Control Box	RERPC	393

Each of these projects/programs is described in the following sections.

9 Program delivery

TasNetworks makes a concerted effort to prepare a considered deliverability strategy based on the planned operational and capital programs of work for distribution network assets. A number of factors contribute to the successful delivery of the program of work. These factors are utilised as inputs to prioritise and optimise the program of work, to ensure sustainable and efficient delivery is maintained. This program prioritisation or optimisation can impact delivery of individual work programs, to favour delivery of other programs. Factors considered include:

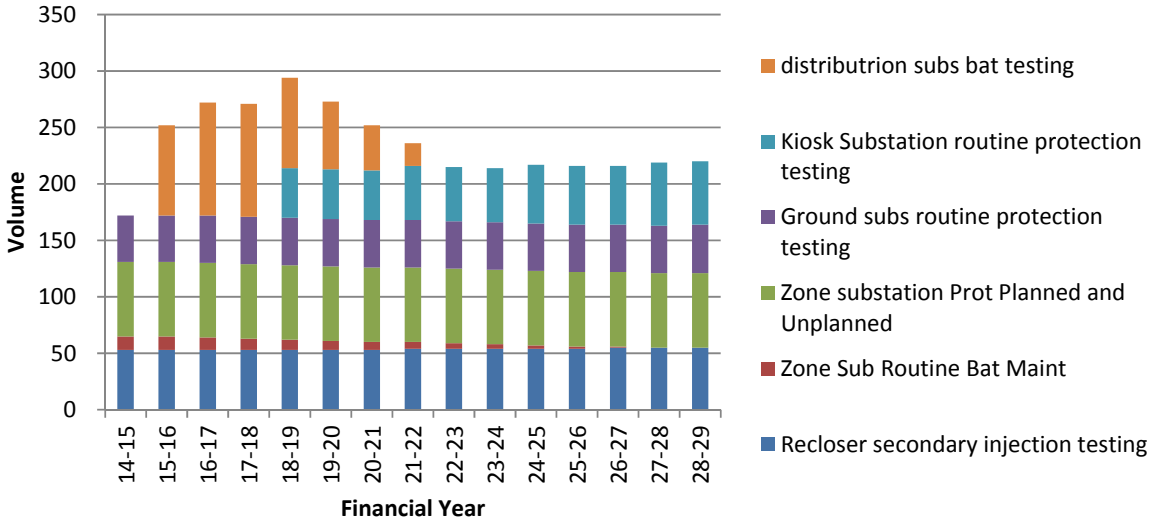
a) customer-driven work we must address under the National Electricity Customer Framework (NECF);
b) priority defects identified through inspection and routine maintenance activities;
c) identified asset risks as they relate to safety, the environment and the reliability of the electrical system;
d) adverse impacts of severe storms and bushfire events;
e) system outage constraints;
f) changes to individual project or program delivery strategy;
g) size and capability of its workforce;
h) support from external contract resources and supplementary service provision;
i) long lead equipment and materials issues;
j) resolution of specific technical and functional requirement issues;
k) complex design/construct projects with long lead times;
l) approvals, land acquisition or wayleaves; and
m) access issues.

Specific to the Protection and Control - Distribution asset management plan, these factors have resulted in the (essentially) successful delivery of the operational and delayed delivery of the capital programs of work.

9.1 Proposed OPEX plan

The operational 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 operational expenditure is prioritised expenditure based on current condition data, field failure rates and prudent risk management in accordance with TasNetworks' risk management framework.

Figure 4 Total OPEX volumes, with forecast to 2028/29



The increase in OPEX from 2014/15 to 2016/17 from $310K to $400K that is attributable to:

a) the increase of asset repair budgets to align with the increased of HV switchgear fleet;
b) the introduction of the testing program for Kiosk substation HV and LV protection schemes; and
c) the introduction of the recloser secondary injection testing program.

The flattening the operational expenditure with an increase in installed assets can be attributed to:

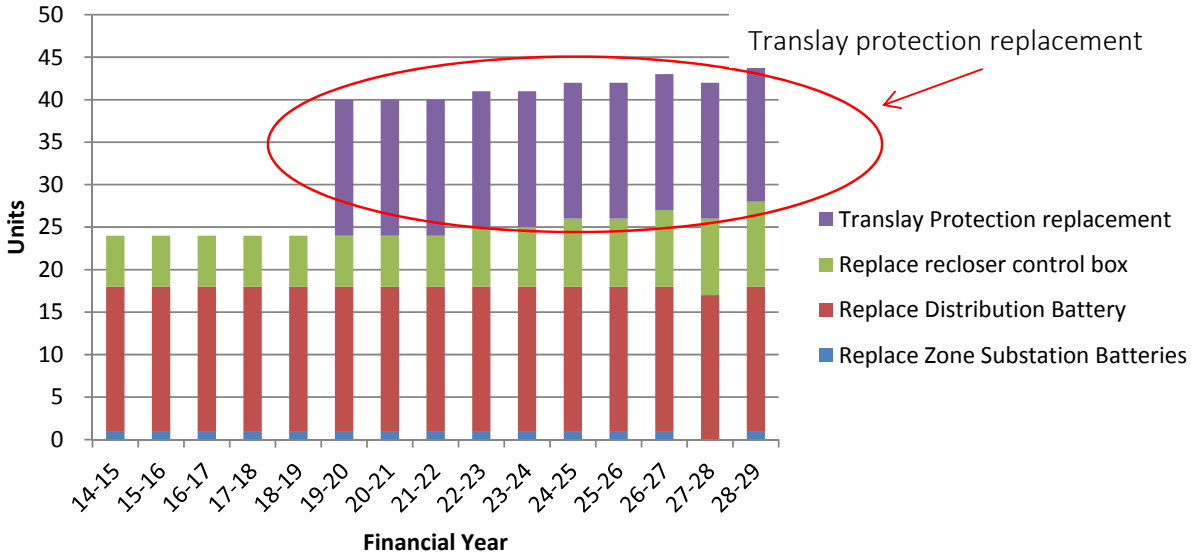
a) cessation of routine battery testing once new systems have been installed;
b) Translay protection replacements have extended testing times for distribution substations; and
c) Works optimisation to even out the planned annual OPEX.

9.2 Proposed CAPEX 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 in accordance with TasNetworks' risk management framework.

Figure 5 shows the historical operational expenditure and the proposed future spend.

Figure 5 Total CAPEX volumes with forecast to 2028/29



9.2.1 CAPEX increase

The increase in CAPEX over the forthcoming regulatory period is attributable to the introduction of a number of key programs which have been designed to manage TasNetworks' risk. These programs are discussed in Section 8.9 specifically 8.9.1 Translay protection replacement.

A summary of the forecast for expenditure and volumes for the CAPEX and OPEX program of work can be located at the following link http://reclink/R0000776614.