Asset Management Plan – Distribution Switchgear

Power and Water Corporation

CONTROLLED DOCUMENT

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Executive Summary

Power and Water Corporation (Power and Water) owns and operates the electricity transmission and distribution networks in the Northern Territory (NT) of Australia. Included in its network of assets is distribution switchgear. Distribution switchgear performs a critical function in maintaining the business objectives of delivering a safe and reliable supply of electricity to Power and Water's customers.

Assets contribute a minor proportion to the total asset base *– age compared to expected life is not a great concern.*

Distribution switchgear make up 3% of the total replacement value of the asset base and contributes to around 8% of the total operating expenditure. The distribution switchgear assets consist of three main asset subcategories namely reclosers, switches, and fuses. At an average age of 26 years the asset fleet is past it's mid-life with 3%, or 443 assets projected to exceed the standard expected asset life of 45 years within the next regulatory period. Circa 35% of the population would require replacement based on lifespan over the next two regulatory periods. This requirement for replacement can be managed through condition based assessment and targeted replacement programs as currently applied by Power and Water.

Assets operate across a diverse environment *– temperature, humidity, rainfall, soil type present different challenges to managing the assets.*

The Power and Water power network is subject to unique environmental and operational challenges ranging from the coastal tropical environments prone to cyclones, high temperatures and humidity, and high annual rainfall to desert environments subject to high ambient temperatures, occasional flooding, droughts, dust storms, and aggressive soil conditions. This unique environment results in a more rapid rate of asset deterioration, and lower worker productivity compared to peer distribution businesses.

There is one key challenge that requires management *– equipment fault rating exceedance.*

A number of existing Magnefix switchgear installations in the Darwin area are operating outside their fault level capacity. Development of the network and changes in generation requirements over time has resulted in an increase of system fault levels across the distribution network. Existing Magnefix switchgear, particularly in areas of the Darwin network, are under-rated with respect to the expected system fault levels. This is a key public and worker safety risk with recent failures resulting in the unit doors being dislodged or failing explosively.

Currently, the network has a total of 27 Magnefix switchgear assets in operation for which the system fault level exceeds the rating of the equipment. These units are being targeted for replacement during the next regulatory period.

Maturing condition data associated with distribution switchgear assets is a key asset management challenge. With increasing asset failures in a relatively young asset fleet an increased focus on the collection of condition data and analysis are being put into effect to better support asset management decision making. Focused routine inspections and targeted methodical inspections prioritising assets with higher personnel and public safety risks are some of the proposed undertakings aimed at improving data collection and analysis during business as usual activities.

***Investment programs are targeted to manage the key challenges** – directed replacement.*

The following distribution switchgear asset renewal programs are proposed for the next regulatory period, 2019-20 to 2023-24 to address key asset challenges:

- Magnefix Switchgear Replacement Program. A targeted replacement program to augment the fault ratings of switchgear where the system fault levels exceed the equipment rating.
- Distribution switchgear (reclosers, switches, fuses) pooled replacement program. The pooled program captures those distribution switchgear assets that fail in service.

The investment program has been developed with the objective of maintaining risk over time. To achieve this, an asset health and criticality framework was developed which is expected to provide a consistent method of assessing assets and making value based investment decisions. The health and criticality framework was central to establishing the targeted distribution switchgear asset investment programs focusing on the highest risk assets as a priority.

The investment program is summarised as follows:

Table 1: Forecast renewal and maintenance expenditure for 2019/20 to 2023/24

Program	2019-20 ($ million)	2020-21 ($ million)	2021-22 ($ million)	2022-23 ($ million)	2023-24 ($ million)	Total ($ million)
Renewal Plans	$1.96	$2.04	$2.13	$2.21	$2.29	**$10.63**
Maintenance plans	$1.53	$1.53	$1.53	$1.53	$1.53	**$7.63**
Total	**$3.49**	**$3.57**	**$3.66**	**$3.74**	**$3.82**	**$18.26**

The forecast investment over the regulatory period has been compared to the Australian Energy Regulator's (AER's) repex model output. As shown in Figure 1, Power and Water's forecast investment in distribution switchgear is beneath the repex model's projection over the 2019-24 regulatory period and future regulatory period expenditure requirements are projected to be maintained at a level below the age-based projections of the repex model.

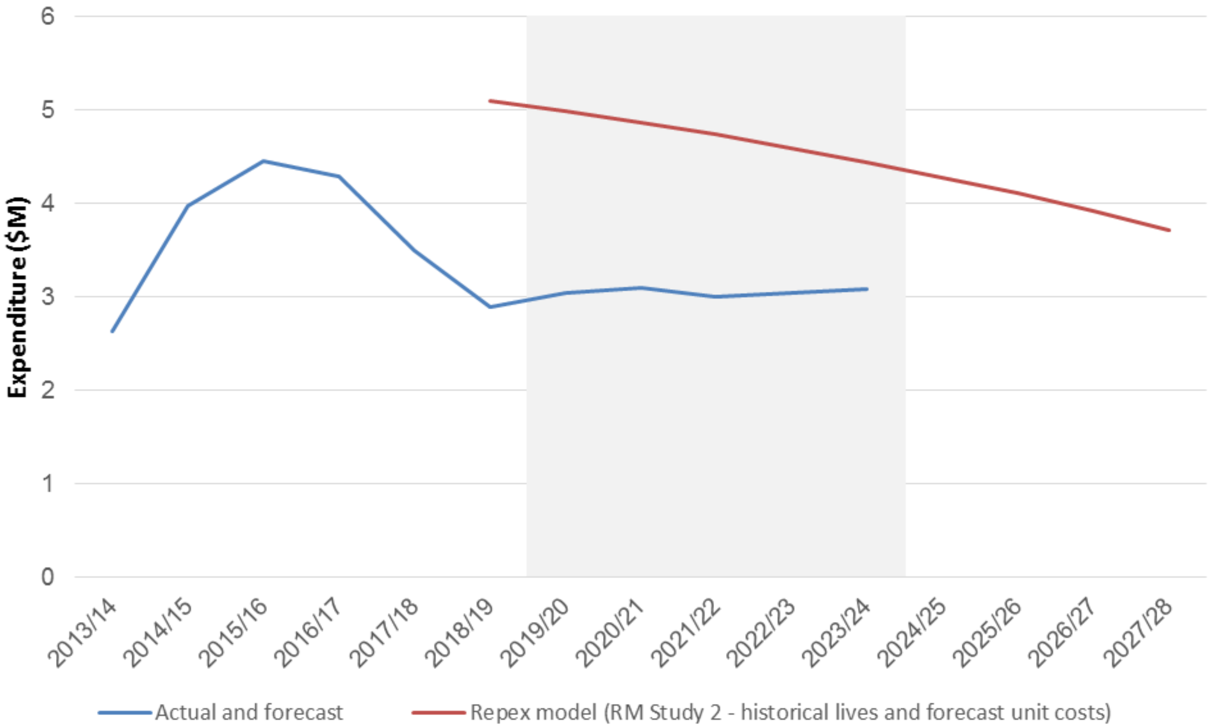


Figure 1: Investment in distribution switchgear over the regulatory period

***<u>Benefits from the investment program</u>** – reliability improvement*

The proposed investment in distribution switchgear renewal is expected to reduce the contribution from distribution switchgear to system SAIDI by around 0.47%, and the SAIFI contribution with up to 0.49% over the next regulatory period.

Allowing for growth and investment over the next five year regulatory period the health and criticality profile for distribution switchgear, including for reclosers, switches and fuses, are expected to change to that shown in the second table below. The mitigated risk is demonstrated in the number of assets that transfer from the H3 health category. For the distribution switchgear assets, a reduced risk is reflected in a 20% reduction in the number of poor health assets in the H3 category.

Distribution switchgear health-criticality matrix (qty) by 2023/24, with no investment

	H1	H2	H3
C1	2,671	124	447
C2	7,671	275	1,103
C3	1,759	108	1,241

Distribution switchgear health-criticality matrix (qty) by 2023/24, with investment

	H1	H2	H3
C1	2,784	124	335
C2	7,985	275	789
C3	1,894	108	1,106

The movement in risk demonstrated by the movement of assets predominantly from the poor health and applicable criticality zones substantiates Power and Water's investment strategy that targets the highest risk assets.

The risk profile snapshot has been based on the current understanding of the distribution switchgear asset class age, condition, and operating environment. The risk profile is expected to evolve as ongoing condition and performance monitoring, methodical inspections, and improved data collection practices provide for better quality data and asset insights.

1 Purpose

The purpose of this asset management plan (AMP) is to define Power and Water's approach to managing the life-cycle activities for distribution switchgears. It defines the rationale and direction that underpins the management of these assets into the future:

- Short Term (0-2 years): Detailed maintenance and capital work plans for the upcoming financial year based on current asset condition.
- Medium Term (2-5 years) 2019-24 Regulatory Period: Strategies and plans based on trends in performance and health indicators.
- Long Term (5-10 years) 2024-29 Regulatory Period: Qualitative articulation of the expected long-term outcomes.

The distribution switchgear assets are managed to comply with the broad external requirements of legislation, codes and standards. This is achieved within an internal framework of policy, strategy and plans that are enabled through interrelated documents, systems and processes that establish the Power Networks asset management practices. The asset management system is summarised in Figure 2.

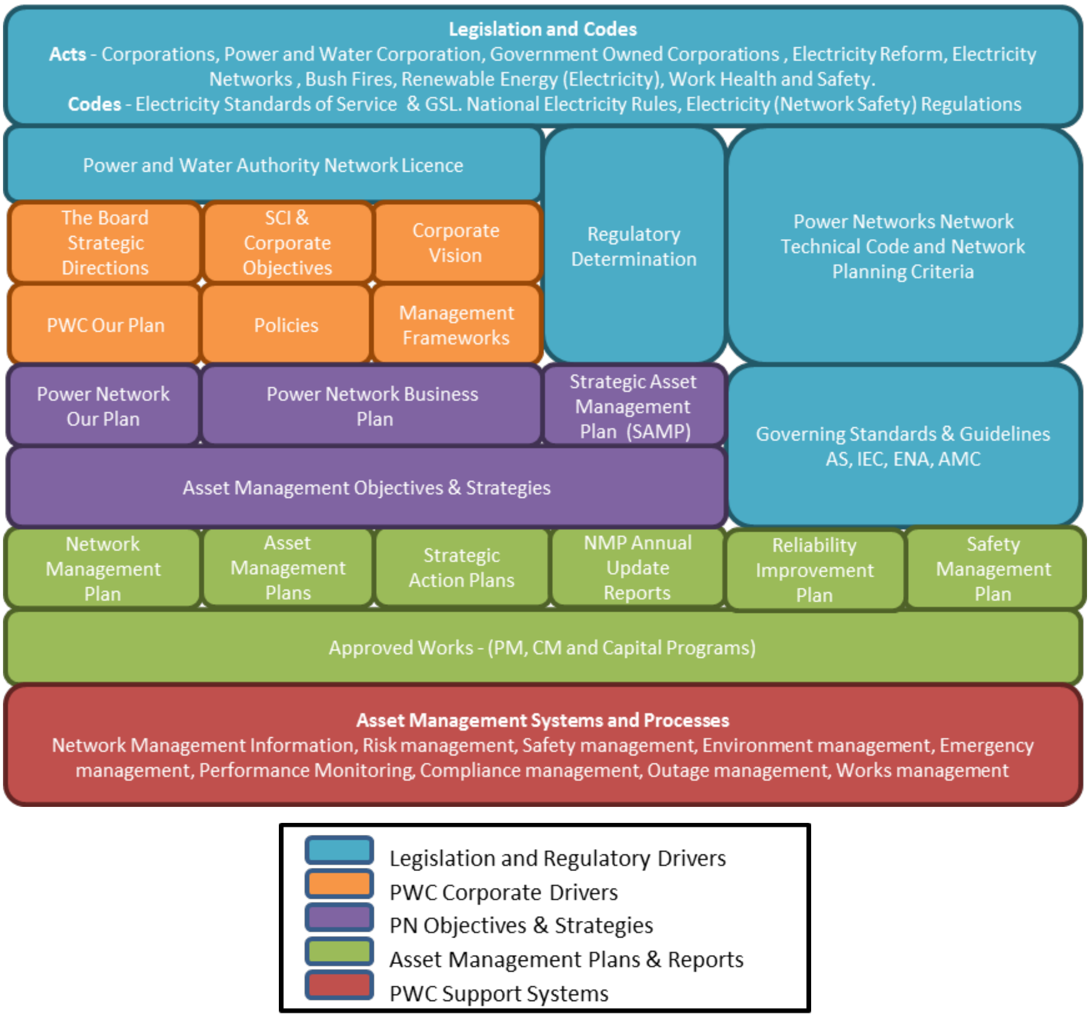


Figure 2: Asset management system

2 Scope and objectives

2.1. Asset class overview

In-scope assets include Power and Water's reclosers, switches and fuses. Table 2 provides an overview of the asset class.

Table 2: Overview of in-scope assets

Asset type	Quantity [1]	Voltage	Average Age	% exceeding 45 years in forecast period [2]	Key points
Reclosers	57	11kV 22kV	16.3	2%	• Circa 85% 22kV • Dating from early 1970s
Switches	2,998	22kV 11kV 415V	21.0	3%	• Consist of load break overhead, ring main unit and switch cabinet types • Dating from the mid-1950s • Renewable expenditure proposed in the forecast regulatory period.
Fuses	11,721	22kV 11kV 415V	28.7*	3%	• Circa 72% 415V • Dating from the 1960s
Total	14,776	132kV to 415V	26.0	3%	• Renewable expenditure proposed in the forecast regulatory period for switches assets.

The distribution switchgear asset class makes up a significance proportion of Power and Water's assets and activities. Currently, the distribution switchgear assets comprise:

- 3% of the network by replacement value;
- 8% of operational expenditure (opex);
- 8% of capital expenditure (capex), including:
  - 10% of replacement expenditure (repex); and
  - 5% of augmentation expenditure (augex).

Power and Water's distribution switchgear assets are distributed throughout its network footprint which covers the (NT).

2.2. Asset class function

Distribution switchgear is equipment used for transferring load between distribution feeders, relocating distribution feeder open points, creating points of isolation to enable work to be performed safely on the distribution network or isolating faulted equipment from the rest of the network. The function of distribution switchgears within Power and Water's electricity network is illustrated by Figure 3.

[1] Age information was only available for circa 2,000 switch assets circa and 4,000 fuse assets

[2] Economic life currently 35 years, this is currently under review and nominal life of 45 years has been adopted for this AMP.

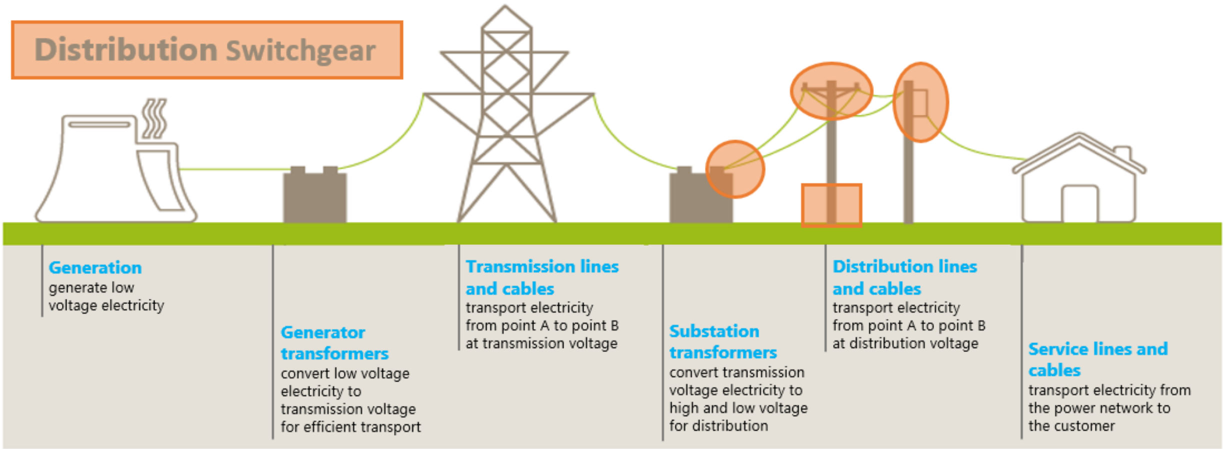


Figure 3: Diagram of in-scope assets

2.3. Asset objectives

The AMP provides a framework which steers the management of the asset class in a manner that supports the achievement of Power and Water's broader organisational goals. The Asset Management strategies are listed in the Strategic Asset Management Plan (SAMP) and are aligned to the Asset Management Objectives and implemented in through Asset Management Plans (specific to asset class) or Strategic Asset Plans as shown in Figure 4.

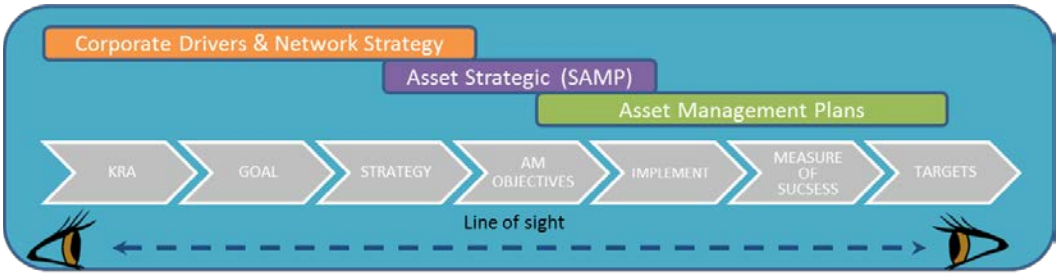


Figure 4: Asset Management Line of sight from Corporate and Network strategies through the Asset Management objective to the targets in the asset management plan.

Table 3 provides the asset management objectives from the strategies that are relevant to this asset class along with the measures of success and the targets. This provides a 'line of sight' between the discrete asset targets and Power and Water corporate Key Result Areas.

Table 3: Asset Management Objectives, Measures of Success and Targets.

Objectives	Measures	Targets
• Network related operation and maintenance tasks are quantified in terms of risk and used to inform investment decisions that affect Health and Safety outcomes for the organisation	• Vehicle Impacts of unprotected assets • Electric shocks or near misses due to exposed conductors • Unauthorised access • Total asset class specific safety incidents	• Total asset class specific safety incidents not exceeding 25 per annum
• Engage with our customers, community and stakeholders to demonstrate that we have delivered the best possible solutions	• Customer Feedback - Track complaints	• Number of Complaints not exceeding TBA

Objectives	Measures	Targets
• All environmental risks have been defined, mitigation controls implemented and responsibility for risk ownership has been assigned to appropriate leaders • Develop Environmental Improvement Plans for significant risks to reduce risk exposures and tracked through a governance framework • Develop performance indicators for intended environmental outcomes.	• Total asset class specific environmental incidents associated. • SF6 Leakage per year • Fires starts caused by asset failure	• Total asset class specific environmental incidents associated not exceeding TBA
• Ensure that the systems and processes provide sufficient and appropriate data and information to drive optimal asset and operating solutions.	• Asset class contribution to system SAIDI • Asset class contribution to system SAIFI • GSL contribution per year Guaranteed Service Levels	• SAIDI to be no more than 8% for this asset class. • SAIFI to be no more than 8% for this asset class. • GSL contribution per year TBA
• Proactively and systematically measure the network power quality	• Asset class related number of poor power quality incidents.	• TBA
• Ensure that the systems and processes provide sufficient and appropriate financial data • Understand the financial risks associated with asset management	• Variance to AMP forecast CAPEX • Variance to AMP forecast OPEX	• Variance to AMP forecast CAPEX +/-10% • Variance to AMP forecast OPEX +/-10%
• Develop systems and data that facilitate informed risk based decisions • Ensure that works programs optimise the balance between cost, risk and performance • Ensure the effective delivery of the capital investment program	• Network risk index quantified (Y/N) • Health and Criticality Parameters defined (Y/N)	• Acheived
• Identify, review and manage operational and strategic risks • Prioritise projects, programs and plans to achieve efficient and consistent risk mitigation. • Achieve an appropriate balance between cost, performance and risk consistent with regulatory and stakeholder expectations. • Define and communicate the level of risk associated with the investment program	• Critical spares analysis completed for asset class • Operator/Maintainer risk assessment completed for asset class and risk register updated	• Achieved
• Ensure that electricity network assets are maintained in a serviceable condition, fit for purpose and contributing positively to Power Networks business objectives.	• All staff are trained and hold appropriate qualifications for the tasks they undertake. • Peer benchmarking, i.e. a reasonableness test of underlying unit costs (capex, opex) • Asset class preventative maintenance completion	• Achieved

3 Context

3.1. Roles and responsibilities

Power and Water operates using an "Asset Owner / Asset Manager / Service Provider" business model. Although there is extensive collaboration and interfacing between the roles, generally speaking:

- The Asset Owner establishes the overall objectives for the assets;
- The Asset Manager develops the strategies and plans to achieve the objectives; and
- The Service Provider performs activities on the ground to deliver the plans.

3.2. RACI

The Responsibility, Accountability, Consulted, Informed (RACI) matrix for the distribution switchgear asset class is provided in Table 4. This defines the roles and accountabilities for each task by allocating to specific roles/personnel in Power and Water.

Table 4: RACI matrix for Distribution Switchgear

Process	Exec GM Power Networks	Group Manager Network Assets	Chief Engineer	Network Planning Manager	Major Project Delivery Manager	Southern Delivery Manager	Group Manager Service Delivery	Field Services Manager	Works Management Manager	Strategic Asset Engineering	Asset Quality & Systems
Establish Condition Limits		A	C	C		I	I	C/I	I	R	I
Performance and condition data analysis	I	A	I	I		I	I	I	I	R	I
Plan capital works (Options, costs, BNIs, BCs etc)	I	R	A		C/I	R	R	R	R	R	I
Execute maintenance plans	I	I	I			A	A	R	R	C/I	I
Deliver identified major projects and programs of work	I	C	A	C	R	R	R	C/I	C/I		
Manage asset data (data entry, verify data)		A	I	I						C/I	R
Monitor delivery of capital plans and maintenance	I	A	I	I	I	R	R	R	R	R	R

- *Accountable **(A)** means the allocated person has an obligation to ensure that the task is performed appropriately*
- *Responsible **(R)** means the allocated person must ensure the task is completed*
- *Consulted **(C)** means the allocated person must be included in the process for input but do not necessarily have specific tasks to do*
- *Informed **(I)** means this person must be kept up to date with progress as it may impact other parts of their responsibilities or accountabilities.*

4 Asset base

4.1. Overview

Power and Water owns and maintains a portfolio of 14,774 reclosers, switches and fuses across the four regions of Alice Springs, Darwin, Katherine, and Tennant Creek, with the largest population in the Darwin Region.

The distribution switchgear function across the different network voltage levels including LV (240V, 415V) and HV (6.6kV, 11kV, 22kV).

4.2. Asset types

An overview of the different distribution switchgear per type and region is provided in Table 5.

Table 5: Distribution switchgear sub asset categories by region

Region	Period of installation	Type	Quantity	Expenditure / risk implications
Alice Springs	*1962 - present*	Recloser Switch Fuse	11 490 1,478	• Oil ring main units require replacement to maintain safe and efficient operation
Darwin	*1955 - present*	Recloser Switch Fuse	31 2,125 8,895	• Oil ring main units require replacement to maintain safe and efficient operation • Some ring main units require replacement due to fault level rating too low
Katherine	*1965 - present*	Recloser Switch Fuse	9 285 1,127	• Oil ring main units require replacement to maintain safe and efficient operation
Tennant Creek	*1960 - present*	Recloser Switch Fuse	6 98 219	
Total			14,774	

4.3. Breakdown of asset population

A detailed breakdown of the distribution switchgear assets is provided in Figure 5 which presents the different asset types per region and voltage.

As previously indicated, the Darwin region is by far the largest region in terms of overall switchgear quantity as can be seen in the Figure 5, which shows the quantity of overhead distribution switchgear in each region. Note that only HV switchgear is shown in this figure.

A detailed breakdown of the underground distribution switchgear assets can be seen in Figure 6.

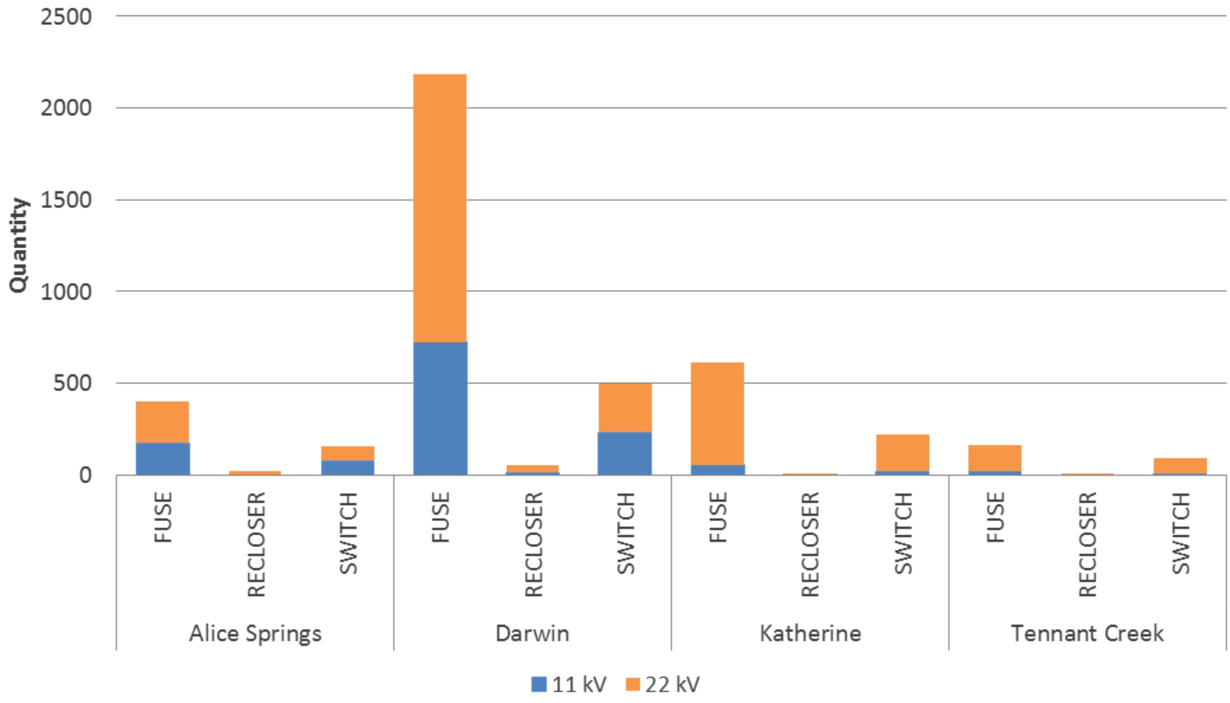


Figure 5: Overhead distribution switchgear by region, type and voltage level

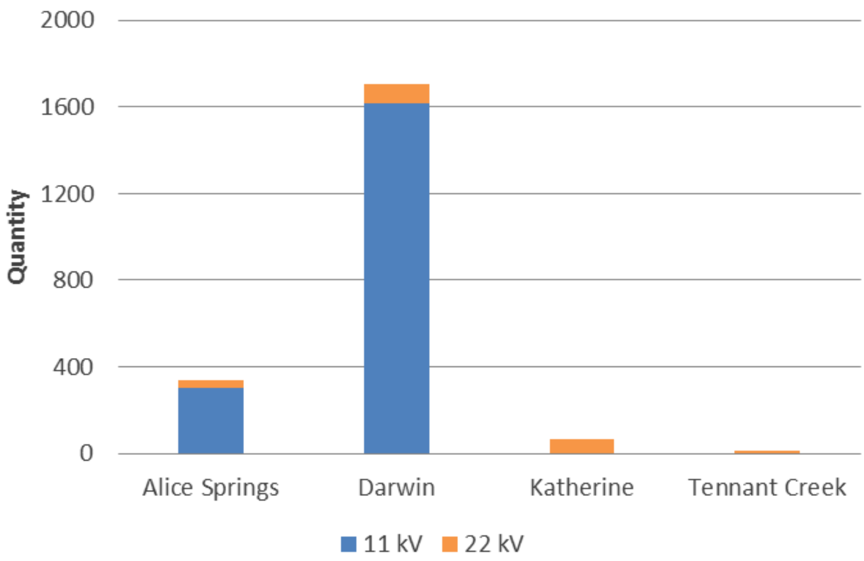


Figure 6: Underground distribution switchgear by region and voltage level

4.4. Growth profiles

4.4.1. Reclosers

As can be seen from Figure 7, large quantities of installations took place during the mid-1970s as well as in the 2015-16 financial year. A strong growth in the asset class is also visible in recent years with a somewhat increasing trend. For the substantial installations in the mid-1970s, the main reason was a strong growth period in the region and the impact from Cyclone Tracy that took place in December 1974. Large portions of the network had to be rebuilt due to this cyclone under the auspices of the Darwin Reconstruction Commission.

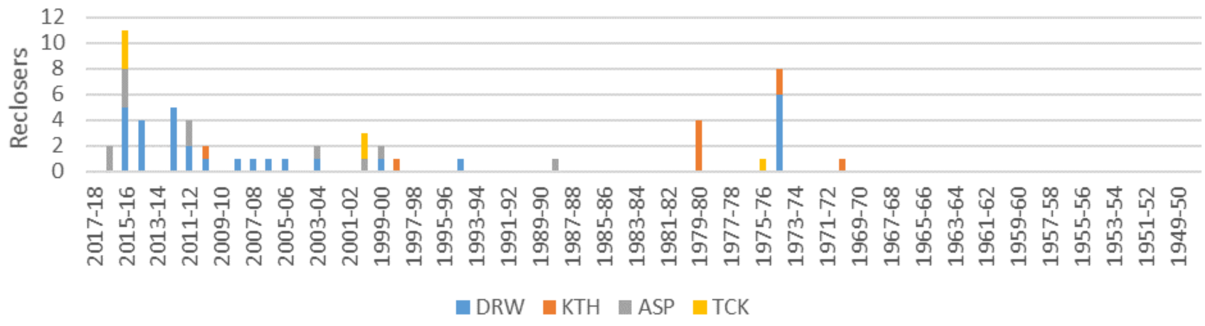
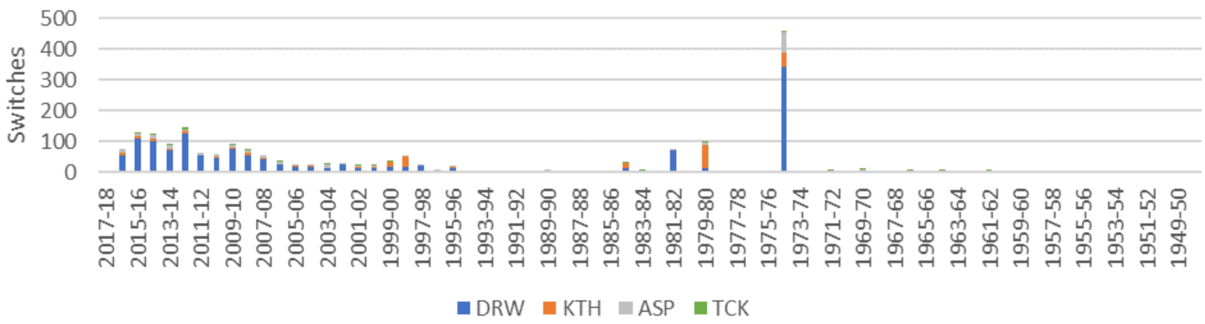


Figure 7: Reclosers by age and region

4.4.2. Switches

Figure 8 provides insight into the installation periods of overhead switches. As can be seen, in all instances there was a large quantity of equipment installed during the mid-seventies. This was due to two factors namely, a strong growth period in the region and the impact from Cyclone Tracy that took place in December 1974. Large portions of the network had to be rebuilt due to this cyclone under the auspices of the Darwin Reconstruction Commission. With this asset class having a lifespan of 45 years, it would seem that the assets installed during the mid-1960s will be exceeding their lifespan.

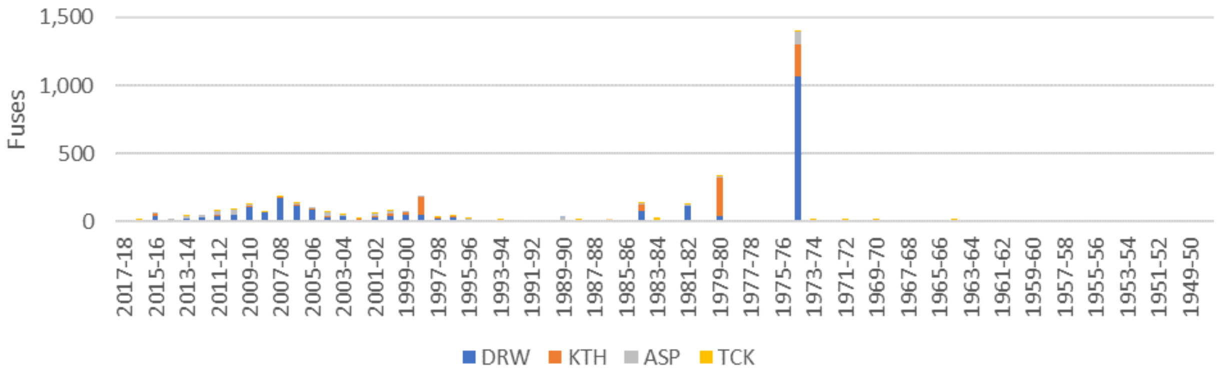


Note: Only assets with confirmed information used for this analysis

Figure 8: Load Break Overhead Switches by age and region

4.4.3. Fuses

Figure 9 shows the age profile for fuses which indicates a large quantity installed during the mid-1970s. This was due to two factors namely a strong growth period in the region and the impact from Cyclone Tracy that took place in December 1974. Large portions of the network had to be rebuilt due to this cyclone under the auspices of the Darwin Reconstruction Commission. With this asset class having a lifespan of 45 years, it would seem that the assets installed during the mid-1960s will be exceeding their lifespan. Please note that Figure 9 only includes the fuses for which information was confirmed to be accurate (circa 65%). Ongoing efforts are made to update asset information as part of the maintenance strategies.



Note: Only assets with confirmed information used for this analysis

Figure 9: Fuses by age and region

4.4.4. Standard Asset Life

The asset life is the period of time that an asset can be expected to reliably and efficiently provide the service capability for which it was designed. Understanding the asset life is important to the establishment of a suitable maintenance regime including a planning and recording system together with its impact on capital and operational expenditure forecasts.

The situation and environment in which an individual asset operates can have a significant impact on both the required level of reliability and the rate of asset deterioration. The asset life is typically determent by factors such as:

- the cost of maintenance versus the cost of replacing the asset;
- the maintainability of the asset, particularly if replacement components are no longer available;
- the risk associated with the failure of the asset, particularly if the consequence of failure increase to unacceptable level.

It is therefore important to note that the asset life represents an average expected life of the asset. Some individual assets will last much longer than the expected asset life and others will fail prematurely.

The asset lives applied by Power and Water as a standard have been based on in-house engineering experience and judgement, supplemented by general industry experience across the National Electricity Market (NEM). The asset life is also referred to in the AMP as the replacement life or the economic life referring to the expected life at which the asset is typically replaced or renewed.

A standard replacement life of 45 years was applied to the distribution switchgear assets. It corresponds with the economic replacement asset life applied by Power and Water in asset valuations and compares with the lower range of lives observed across the NEM as demonstrated in Figure 10.

The comparatively low asset life is reflective of a high replacement rate averaging 2.7% of the recloser and switch population per annum[3]. The annual replacement rates are provided in Figure 11. The high failure and replacement rate is as result of high lightning strike rates, tropical

[3] Pooled asset replacement program forecast model

storms, high corrosion environment, and oil and gas leaks commensurate with the climate and weather conditions within which the power network operates.

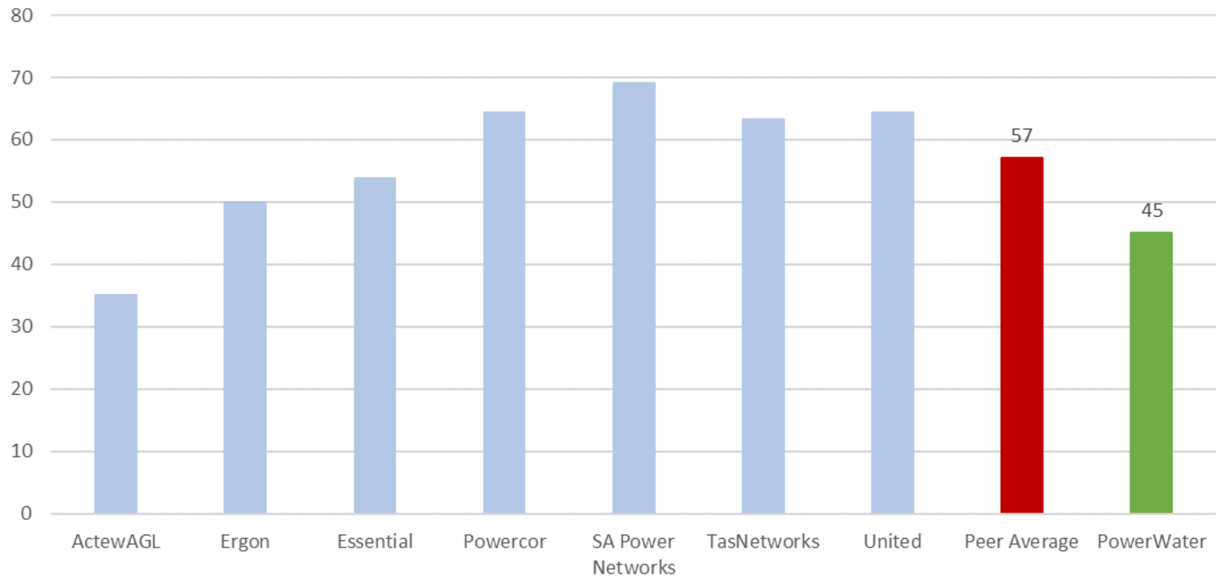


Figure 10: Distribution switchgear replacement life

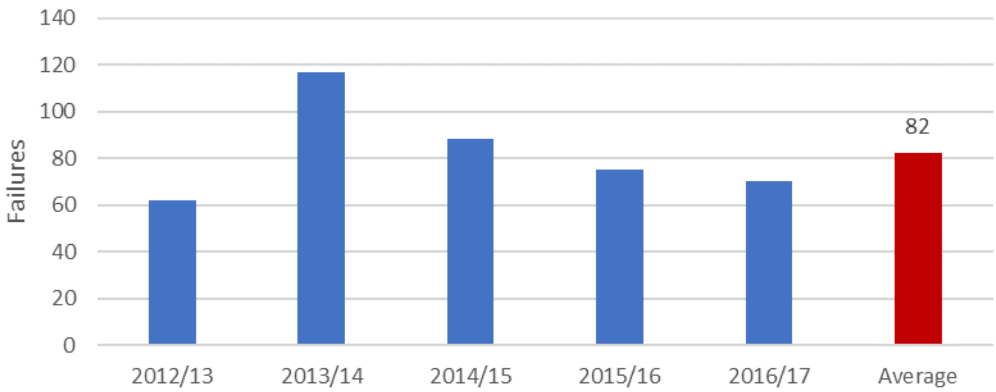


Figure 11: Distribution switchgear replacement rates

4.4.5. Age profiles

The age profiles provide an early indication of expected asset condition and potential life extension or renewal investment requirements.

The distribution switchgear asset profile indicates an asset approaching mid-life. Notwithstanding the relative low average age of the assets, the number of assets exceeding the standard asset life increases rapidly over the next two regulatory periods.

Assets in the Tennant Creek and Alice Springs regions are older than other regions, and between 10% and 30% of switches and fuses already exceeding the standard asset life in these regions. In Katherine around 11% of the reclosers are exceeding the standard asset life. These regions represent around 25% of the switchgear population and are expected to have an increasing effect on replacement volumes going forward.

The recloser age profile indicates that the Katherine region will require increasing replacements over the next regulatory periods with replacement requirements expected to emerge in the other regions from the end of this next regulatory. As Power and Water moves more towards condition based maintenance, asset condition will increasingly drive replacement planning rather than end of life. Table 6 provides a summary of the recloser asset base remaining life against industry standard asset lives.

Table 6: Reclosers average age and remaining life

Region	Average Age	Average Remaining Life	% of asset population	% exceeding replacement life in 2017	% approaching replacement life by 2024	% approaching replacement life by 2029
Alice Springs	8.9	36.1	19.6%	0.0%	0.0%	0.0%
Darwin	14.0	31.0	53.6%	0.0%	20.0%	20.0%
Katherine	34.6	10.4	16.1%	11.1%	33.3%	77.8%
Tennant Creek	13.7	31.3	10.7%	0.0%	16.7%	16.7%
Total	16.3	28.7	100.0%	1.8%	17.9%	25.0%

Note: Only assets with confirmed information used for this analysis

The age profile for switches show 3.2% of assets will require replacements based on lifespan in the next regulatory period. This rises significantly in the next regulatory period to 26.8%. There is an increased requirement for replacements in the medium term for the regions of Alice Springs and Tennant Creek. Even so, with condition based monitoring, the efficiency at which these switches will be replaced in future will be maximised. Table 7 provides a summary of the switch asset base remaining life against these industry standards asset lives. The tables include an illustration of the expected increase in assets that will be exceeding the asset life over the next two regulatory periods.

Table 7: Switches average age and remaining life

Region	Average Age	Average Remaining Life	% of asset population	% exceeding replacement life in 2017	% approaching replacement life by 2024	% approaching replacement life by 2029
Alice Springs	25.4	19.6	13.8%	12.8%	37.4%	40.6%
Darwin	18.3	26.7	68.7%	0.3%	24.7%	31.2%
Katherine	26.7	18.3	13.5%	0.4%	19.0%	47.1%
Tennant Creek	33.1	11.9	4.1%	28.9%	53.0%	60.2%
Total	21.0	24.0	100.0%	3.2%	26.8%	35.8%

Note: Only assets with confirmed information used for this analysis

The age profile for fuses show low levels of required replacements for the next regulatory period, but with a relatively high replacement rate in Tennant Creek. As with reclosers and switches, replacement requirements increase dramatically in the following regulatory period, when steep increases in replacements based on lifespan are expected in the Darwin region.

Table 8: Fuses average age and remaining life

Region	Average Age	Average Remaining Life	% of asset population	% exceeding replacement life in 2017	% approaching replacement life by 2024	% approaching replacement life by 2029
Alice Springs	26.9	18.1	14.0%	9.6%	33.0%	39.8%
Darwin	27.8	17.2	60.4%	0.4%	44.3%	51.1%
Katherine	32.1	12.9	21.4%	1.2%	28.5%	61.5%

Region	Average Age	Average Remaining Life	% of asset population	% exceeding replacement life in 2017	% approaching replacement life by 2024	% approaching replacement life by 2029
Tennant Creek	30.8	14.2	4.2%	20.2%	35.7%	54.8%
Total	28.7	16.3	100.0%	2.7%	39.0%	51.9%

Note: Only assets with confirmed information used for this analysis

4.4.6. Reclosers – Age profiles by region

Figure 12: Alice Springs – Recloser age profile

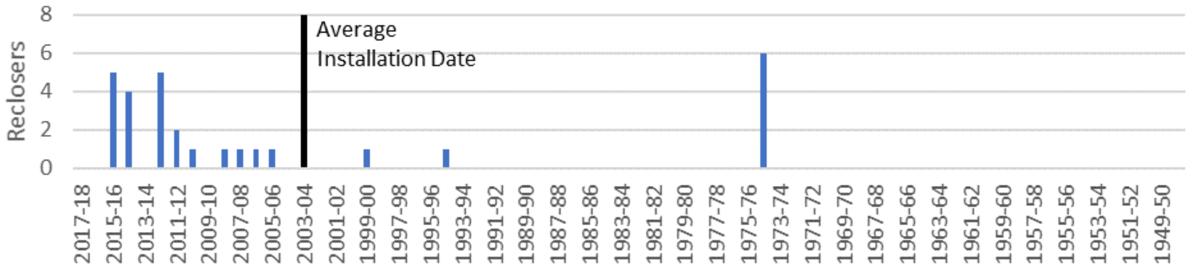


Figure 13: Darwin - Recloser age profile

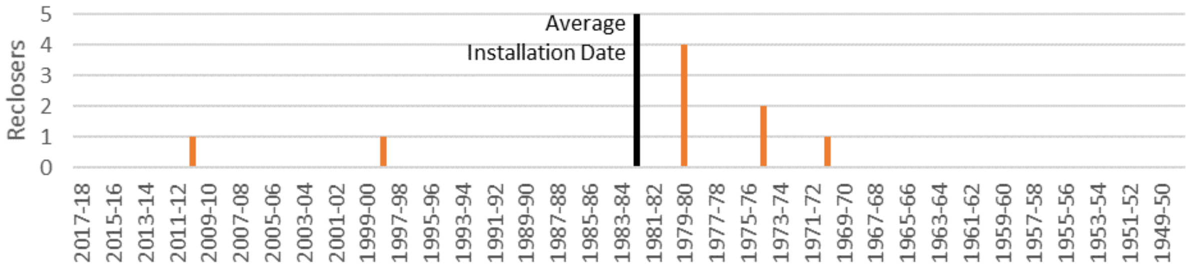


Figure 14: Katherine - Recloser age profile

Figure 15: Tennant Creek - Recloser age profile

4.4.7. Switches – Age profiles by region

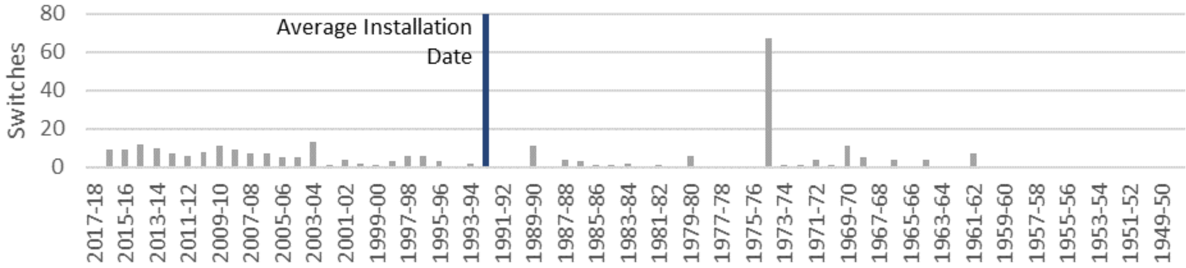


Figure 16: Alice Springs – Switches age profile

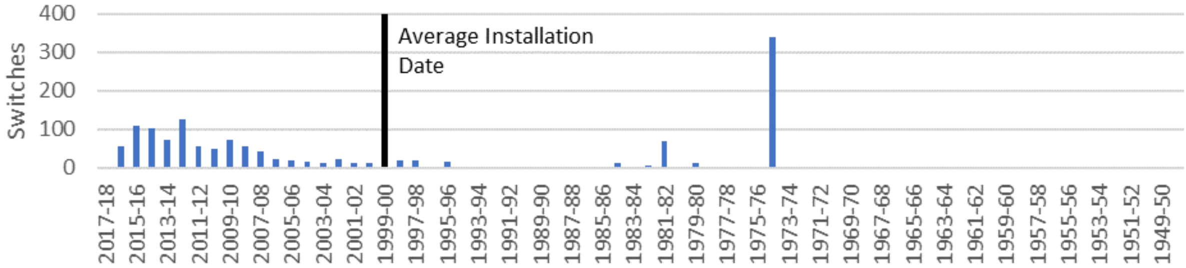


Figure 17: Darwin – Switches age profile

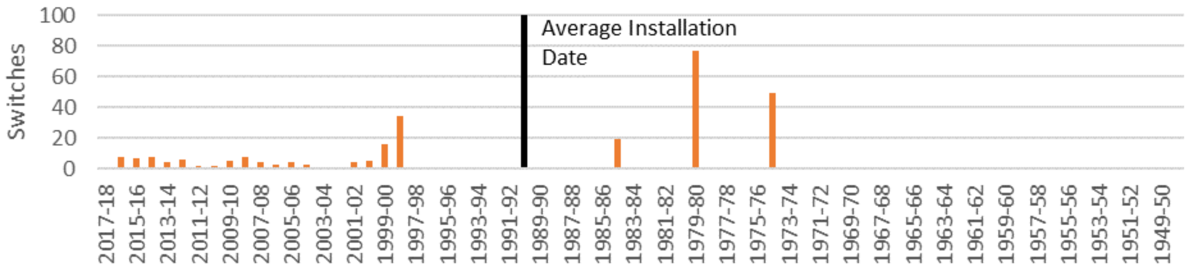


Figure 18: Katherine – Switches age profile

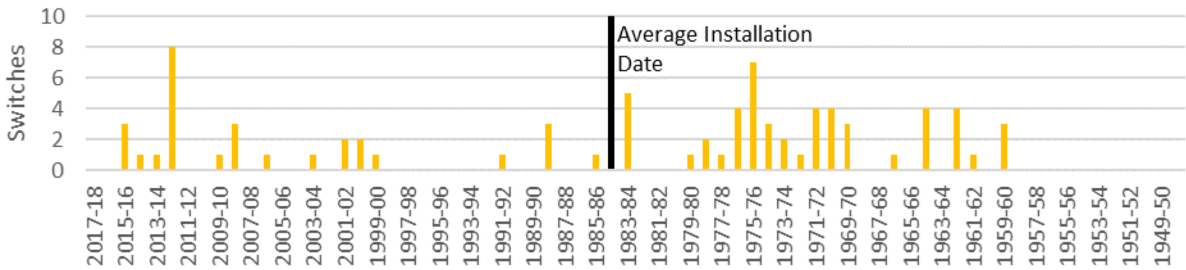


Figure 19: Tennant Creek – Switches age profile

4.4.8. Fuses – Age profiles by region

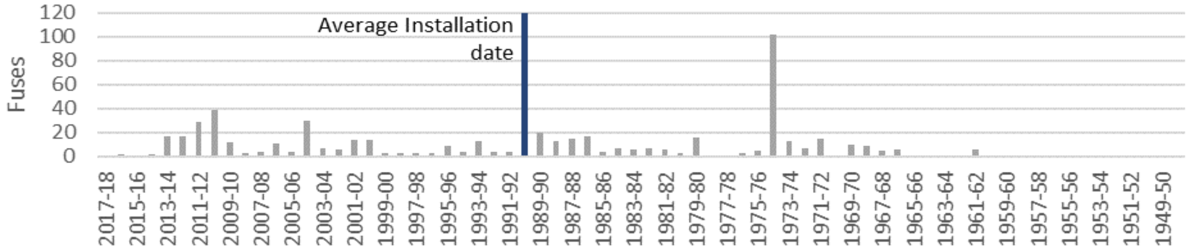


Figure 20: Alice Springs – Fuse age profile

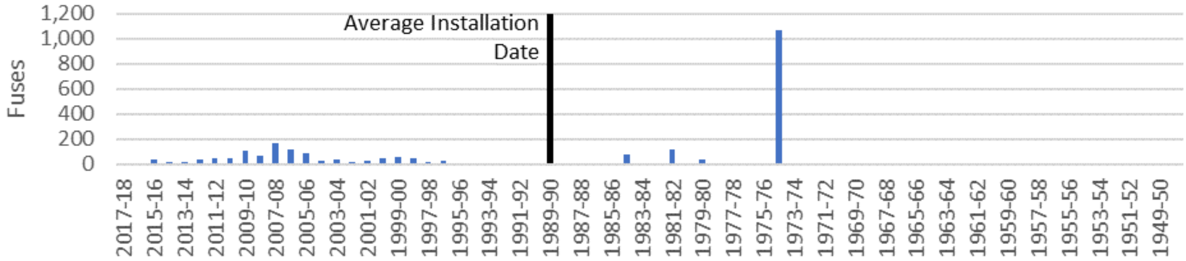


Figure21: Darwin – Fuse age profile

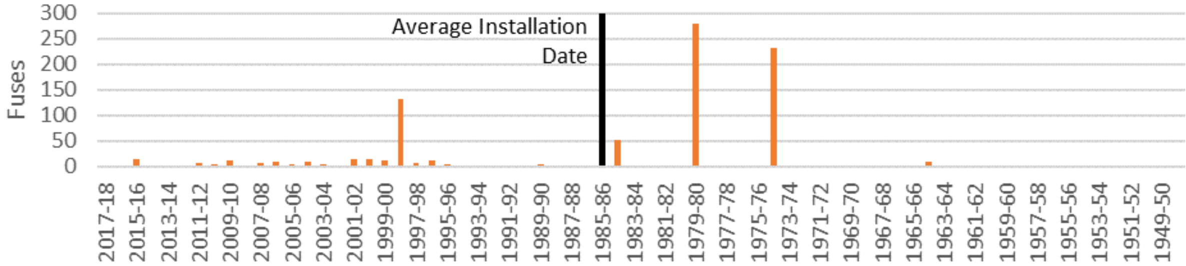


Figure22: Katherine – Fuse age profile

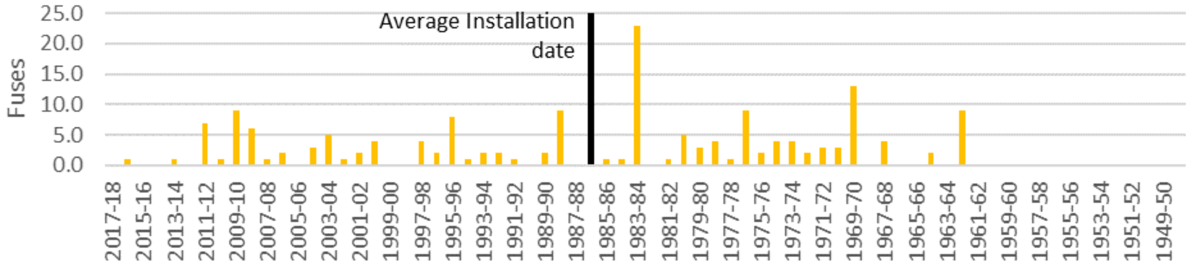


Figure23: Tennant Creek – Fuse age profile

5 Health and criticality profiles

5.1. Health and criticality indices

Risk is that uncertain event or condition associated with an asset failure that, if it occurs, will affect Power and Water's ability to successful execute it's strategies to achieve its organisational objectives of operating a safe and reliable power network at the lowest cost to the customer.

The health and criticality framework[4] provide the basis for calculating the risk associated with the distribution switchgear assets. It combines failure data and recent condition data (routine visual inspection, targeted methodical inspection and testing results) to modify the assessment of expected remaining life and the associated likelihood of failure across the fleet of distribution switchgear.

The health and criticality indices developed for distribution switchgear establishes the context of the risk associated with these assets and defines the parameters that influence how the risk is managed. Asset health is a key driver in the likelihood of asset failure, and the asset criticality is a key determinant in quantifying the risk associated with the failure.

It should be noted that the health and criticality indices rely heavily on available asset data and evolves as the quality of data regarding asset age, condition and operating environment improves. It will continue to evolve over time as the asset composition changes with age, investments and network development. These changes are captured during routine inspections and targeted methodical inspections aimed at recording and updating asset data related to age, condition, and operating environment. These processes and practices are continuously being improved within Power and Water.

The probability of asset failures and the associated risks are therefore continually refined as routine data, and targeted data is collected across the asset base.

Distribution switchgear has a key reliability of supply function within the electrical network. The risk associated with the functional failure of distribution switchgear is extended outages impacting large quantities of customers.

5.1.1. Asset health

The main failure modes observed on distribution switchgear assets are summarised in Table 9. The underlying failure mode for distribution switchgear is the degradation of electrical contacts and switching mechanisms over time. The degradation is accelerated by factors such as design defects, frequency of operation, network development, and system fault rate development. These defects are identified and recorded during routine inspections, targeted methodical inspections and testing, and network development studies.

Table 9: Distribution switchgear failure modes

Failure mode	Description
Fault levels	• Development of the Power and Water network and generation requirements over time has resulted in an increase of system three phase fault levels across the distribution network so that some of the switchgear no longer meet the minimum system fault levels. In particular Magnefix switchgear located in the Darwin distribution areas of Palmerston and Darwin City has been identified as being of high risk, with recent catastrophic failures raising the awareness of public and worker safety associated with this failure mode.
Cable termination failure	• Flashovers as result of partial discharge particularly at paper lead cable terminations. Cross over of paper lead cable terminations with insufficient phase clearance causes partial discharge, leading to localised insulation damage and eventual flashover of phases/earth screen of cables. Increasing failures have been observed in the build-up season and the wet season when high humidity levels are prevalent. Failures are generally catastrophic in nature and in many cases impact the switchgear as well, resulting in changing out the switchgear as well as re-termination of the cables. • Flashovers at dead break elbow connections (11kV), resulting from a high resistance

[4] 'Asset Heath and Criticality Method' decision making process discussion paper

Failure mode	Description
	connection and a thermal runaway causing the catastrophic failure of the termination and also affected the RMU leading to the replacement of the RMU. This is attributed to an installation issue. • Rodent and reptiles (frogs, geckos) causing an arcing path/ bridge to the earth or to phase to phase arc/short circuit. Failures are catastrophic in nature and in many instances impacting the switchgear as well, resulting in changing out the switchgear (the affected cubicle only) as well as re-termination of the cables.
SF6 gas leak	• After termination failures, the second major failure mode observed within the Power and Water network is the leak of SF6 gas and dropping of pressure below allowable related limit for the relevant temperature. The switches remain in service, however cannot be operated as result of low SF6 gas pressure. Gaskets/O-rings failures and some cases of third party impacts resulting in gas leaks and subsequent asset replacement have been recorded; however, the main cause is still being investigated.
Protection relay failure	• Failure of protection relays on circuit breaker cubicles impacting the system reliability from frequent spurious trips.
HV metering unit failure	• Metering unit VT failures impacting the system reliability from frequent spurious trips.

The degradation factors are typically related to changes over time, with age providing a pointer for potential targeted inspections. Asset age, or remaining life, has been used as a proxy for asset health where additional condition data was not available. The criteria applied to allocate a health score is provided in Table 10. Assets with unknown remaining lives were assigned a good health score, H1. Where additional condition data is available for specific asset types, resulting in a deviation from these default criteria, the specific approach is discussed in the sub-asset class sections below.

Table 10: Health indices criteria

Health score	Description	Criteria
H1	Good	More than 15 years remaining life
H2	Average	Between 5 and 15 years remaining life
H3	Poor	Less than 5 years remaining life

5.1.2. Asset criticality

Distribution switchgear contributes to both the reliability and safety risks of the power network. Risk quantification undertaken in the industry across asset classes has found reliability risk to routinely be the more prominent risk associated with asset failures. Reliability risk is that risk related to the frequency and duration of outages. This risk is linked to both the number of customers impacted by an outage and the level of redundancy in the network.

Asset criticality across the distribution switchgear asset class was allocated in the first instance based on the customer density as approximated by the feeder categorisation. Where known feeder performance issues have been identified, adjustments were made to account for these relative performances. Based on good historical performance and a high level of system redundancy CBD feeders were reallocated to C1. Relative low historical performance has resulted in short rural feeders being allocated to C3. The underlying criteria applied in allocating distribution switchgear asset criticality are provided in Table 11.

Table 11: Distribution Switchgear criticality criteria

Criticality score	Description	Criteria
C1	Low	Long rural & CBD
C2	Medium	Urban
C3	High	Short rural

Where appropriate and based on inspection and system data, criticality level adjustments have been made to reflect the contribution to public and worker safety risk. Where applicable these adjustments are discussed in the sub-asset class sections below.

5.2. Reclosers

All reclosers were assigned a health-criticality rating using the default assumptions as no asset specific information is available. The recloser health and criticality profile is provided in Table 10. It prioritises around 8 reclosers in the red and orange zone as being of poor health and higher criticality.

Table 12: Recloser health-criticality matrix (qty)

	H1	H2	H3
C1	8	2	4
C2	7		2
C3	28	2	4

The asset health and criticality is a function of time and is expected to change as the assets continue to age. With no investment and excluding growth over the next five year regulatory period the profile is expected to change to that shown in Table 13. The increase in risk is demonstrated in the increase in the number of assets that enter the H3 health category.

For the recloser assets an increase in risk is reflected in a 40% increase in the number of poor health assets in the H3 category.

Table 13: Recloser health-criticality matrix (qty) with no investment

	H1	H2	H3
C1	8		6
C2	6	1	2
C3	28		6

5.3. Switches

All switches of Magnefix type (also referred to as MD4 or Hazemeyer and currently manufactured by Holec) were separately assessed for health and criticality due to a number of performance and ratings issues. The Magnefix switchgear currently operating in the Power and Water network are the 12kV, 14.4 kA rated equipment. Development of the network and associated changes in generation requirements over time has resulted in an increase of system fault levels across the distribution network so that the Magnefix switchgear no longer meet the minimum system fault levels. The affected switchgear is mainly located in the Darwin region, with the majority installed in the distribution areas of Palmerston and Darwin City. The switchgear assets in these distribution areas are reaching the end of their functional asset life because of the fault rating exceedance. They also present a material safety risk to workers and the public with recent catastrophic failures resulting in the substation doors being dislodged or blown open.

The Magnefix switch assets have therefore been allocated a health index based on the number of recent asset replacements for fault rating exceedances, and the remaining life. The criteria used to assign health to the Magnefix switch assets is provided in Table 14.

Table 14: Magnefix Distribution Switchgear health criteria

Criticality score	Description	Criteria
H1	Good	Remaining Magnefix assets
H2	Average	% Magnefix assets exceeding 50% of asset life, i.e. 22.5 years
H3	Poor	% replacements for fault level exceedance in past 4 years

Those assets where the system fault level already exceeds the equipment rating have been allocated the highest criticality index. The remaining assets were allocated a criticality based on the region with the highest risk of fault level exceedance going forward. The criteria used to assign criticality to the Magnefix switch assets is provided in Table 15.

Table 15: Magnefix Distribution Switchgear criticality criteria

Criticality score	Description	Criteria
C1	Low	Equipment outside Darwin
C2	Medium	Equipment in Darwin
C3	High	Equipment fault rating exceeded

The remaining switches by other manufacturers were assigned a health-criticality rating using the default assumptions. The switch asset health and criticality profile is provided in Table 16. It prioritises around 519 switches in the red and orange zone as being of poor health and higher criticality.

Table 16: Switch health-criticality matrix (qty)

	H1	H2	H3
C1	378	69	127
C2	1,314	227	303
C3	364	62	154

With no investment over the next five year regulatory period the profile is expected to change to that shown in Table 17. The increase in risk is demonstrated in the increase in the number of assets that entered the H3 health category.

For the fuse assets an increase in risk is reflected in a 27% increase in the number of poor health assets in the H3 category.

Table 17: Switches health-criticality matrix (qty) with no investment

	H1	H2	H3
C1	374	50	150
C2	1,312	143	389
C3	350	29	201

5.4. Fuses

All fuses were assigned a health-criticality rating using the default assumptions as no asset specific information is available. The fuse asset health and criticality profile is provided in Table 18. It prioritises around 1,644 fuses in the red and orange zone as being of poor health and higher criticality.

Table 18: Fuses health-criticality matrix (qty)

	H1	H2	H3
C1	2,180	132	211
C2	6,009	253	568
C3	1,292	298	778

With no investment and excluding growth over the next five year regulatory period the profile is expected to change to that shown in Table 19. The increase in risk is demonstrated in the increase in the number of assets that enter the H3 health category.

For the fuse assets an increase in risk is reflected in a 31% increase in the number of poor health assets in the H3 category.

Table 19: Fuses health-criticality matrix (qty) with no investment

	H1	H2	H3
C1	2,158	74	291
C2	5,987	131	712
C3	1,255	79	1,034

6 Key challenges

6.1. Environmental challenges

The network covers a range of environments and geographies which present different challenges for the distribution switchgear asset class. Table 20 provides an overview of environmental challenges in relation to managing Power and Water's distribution switchgear assets across its four operating regions.

Table 20: Environmental challenges in relation to distribution switchgear asset management

Region	Environment	Challenges	Expenditure / risk implications
Alice Springs	Desert	• Dust storms and drought • Occasional flooding after long dry periods.	• Hot desert environment leading to heat related stresses and reduced productivity • Although rare, extreme weather events do occur (e.g. flooding) • Aggressive soil types resulting in high corrosion issues (particularly related to steel assets, eg. earthing systems, poles) • Climatic change may result in increased asset damage and failure from increase quantity or/and severity of dust storms and drought • No immediate distribution switchgear investment programs planned
Darwin	Coastal / Tropical	• Cyclones • Up to 21,924 lightning strikes per year (Global Position And Tracking Systems (GPATS) - 2007 to 2017 Data)	• Hot and humid environment leading to heat related stresses and reduced productivity • Extreme weather events (e.g. cyclones, flooding) • Increased asset damage and failure from increased quantity or/and severity of storms and

Region	Environment	Challenges	Expenditure / risk implications
		• 6-8 Ground strikes per km2 per year (Bureau of Meteorology (BOM)) • Tropical storms with winds in excess of 100 kilometres per hour • Long periods of high supply demands • High corrosion rates	lightning related to climate change • Increased distribution switchgear damage and failure from increased quantity or/and severity of storms and lightning • Magnefix switchgear replacement program (equipment fault ratings)
Katherine	Desert / Tropical	• Dust storms and drought Tropical storms	• Hot and humid environment leading to heat related stresses and reduced productivity • Increased asset damage and failure from increases quantity or/and severity of storms and lightning related to climate change • No immediate distribution switchgear investment programs planned
Tennant Creek	Desert	• Dust storms and drought • Occasional flooding after long dry periods.	• Hot desert environment leading to heat related stresses and reduced productivity • Increased asset damage and failure from increase quantity or/and severity of dust storms and drought related to climate change • No immediate distribution switchgear investment programs planned

The impact from climate change going forward could potentially increase the challenges faced by Power and Water even further. The main impacts on the network are expected to arise from the following:

- the increasing summer and wet season temperature and the increase in the number of hot days will cause disproportionate increases in network demand;
- the capacity of most items of network equipment to supply that demand is dependent upon the ambient temperature and will be adversely affected;
- increased monsoonal rainfall across the north of the NT will narrow the dry season 'window of opportunity', during which major equipment maintenance must be performed;
- increased rainfall in central areas will increase the incidence of flooding, causing equipment damage and impairing access; and
- Increased lightning activity will increase the number of equipment strikes, causing equipment damage.

6.2. Operational challenges

1) Asset access

Unpredictable weather conditions and extended and high rainfall periods limit the ability to access assets and effectively schedule and undertake operational and construction activities during the wet season. This directly impacts on productivity associated with civil and structural works due to ground water levels filling excavations, impacting excavation wall integrity, and distribution switchgear installations in extreme conditions that can affect workmanship due to both water ingress and the physical stress on field crews. This is exacerbated by the majority of distribution switchgear faults occurring during the worst working conditions, as shown in Figure 26.

2) Asset design and maintenance

The impact from animals on ground based and overhead assets cannot be understated. Animals including a range of bird species, rodents, bats and termites all add to a reduction in reliability within the network. Through design considerations and condition based monitoring some of the issues are being resolved.

Further investigations into the potential screening or covering of assets where practical are underway.

3) Operational effectiveness

Power and Water operates in hot and humid environments leading to heat related stresses and reduced productivity resulting in increased time to undertake maintenance and inspection tasks. These environments are not comparable to other networks around Australia and have a significant impact on the productivity of the field crews. To assess and quantify the impact of the climatic conditions, Power and Water undertook a study in selected locations across Australia.

Workability is the term used to describe the productivity impact of climate in both Northern and Southern regions. It is the percentage of time for which work of different physical exertion can be effectively undertaken.

Table 21 describes the work rates used in the study along with a description and examples.

Table 21: Work rate descriptions

Work rate	Description	Work examples
Rest	Rest	Lunch and Crib Breaks
Low	Sitting with light manual hand/arm work. Driving. Standing with light arm work, occasional walking.	Driving, work planning, briefings and toolbox meetings, inspections
Moderate	Sustained moderate hand to arm work, moderate arm and truck work. Light pushing and pulling. Normal walking.	Unpacking tools, spare parts, dismantle/ replace small electronic components, general switching from ground
High	Intense arm and truck work, carrying, shovelling, manual sawing, pushing and pulling heavy loads, walking at a fast pace.	Climbing ladders, working in trenches and cabinets, remove replace larger components
Very High	Very intense activity at fast to maximum pace.	Carrying larger tools and replacement components, lifting, carrying up ladders, digging trenches, hauling cables, moving cable, pillars, poles

The outcome of the study is shown in Table 22 with the impact on Power and Water highlighted in orange. It demonstrates that the climatic conditions, particularly in Darwin where the majority of Power and Water's network is located, result in an average Workability of 65% compared to other major cities in Australia. This would equate to a 35% escalation of labour hours compared with the southern states for similar work and therefore an escalation of opex.

This is supported by feedback received via a heat stress survey which identified that approximately 50% of workers report daily or weekly heat-related impacts on their productivity.

Table 22: Workability for selected Australian locations based upon moderate metabolic rate

Location	Month											
	J	F	M	A	M	J	J	A	S	O	N	D
Alice Springs	94%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Adelaide	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Brisbane	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Darwin	41%	44%	45%	60%	100%	100%	100%	100%	74%	46%	34%	32%
Hobart	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Melbourne	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Perth	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sydney	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

4) Demand profile

The demand profile across the network is flat and consistent across each day, as shown in Figure 24. The daily peak is fairly flat and consistent between 8am and 10pm, and is driven by the use of air conditioners. This shows that all assets are utilised consistently and therefore it is more difficult to remove assets from service for prolonged periods of time.

During the wet season, November to April, the load profile becomes flatter (more consistent) with less difference between the peak and the trough and the demand is about 10% higher.

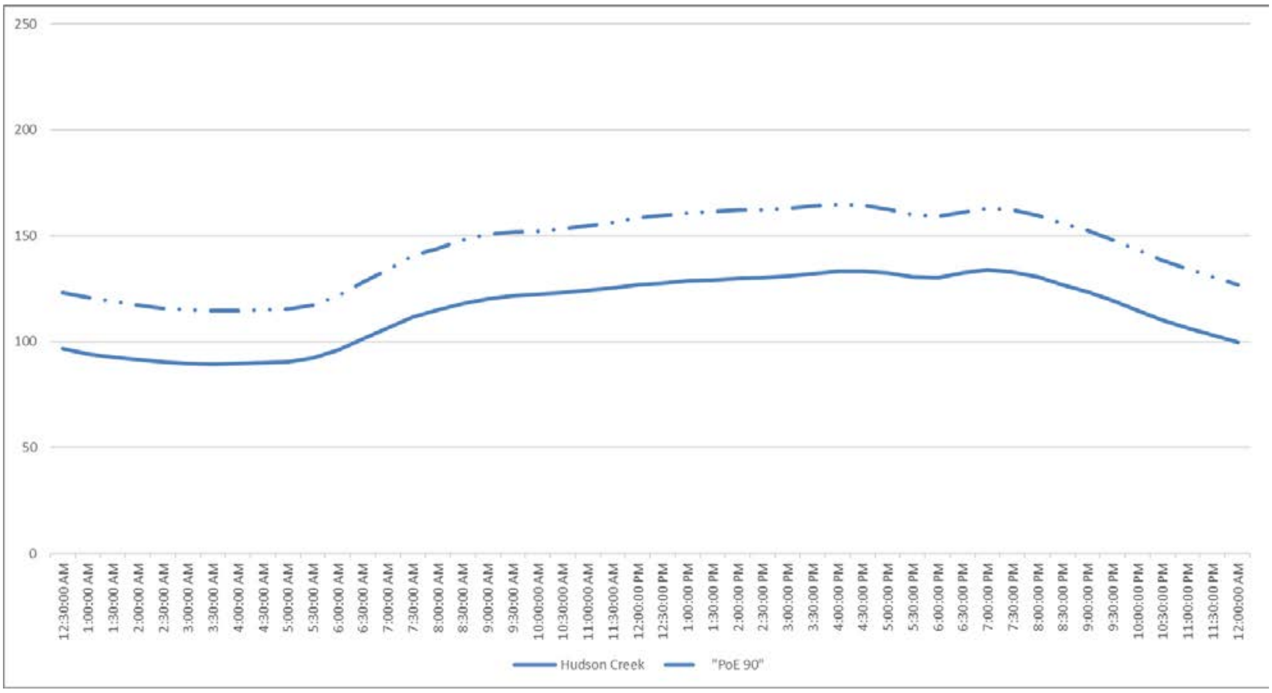


Figure 24: Darwin average daily demand profile (Hudson Creek ZSS) May to October

Figure 25: Darwin average daily demand profile (Hudson Creek ZSS) November to April

The annual maximum shows the demand for the highest half hour interval for the year. This shows that although the average peak was approximately 150MVA, the maximum was 200MVA, or 33% higher.

5) Seasonal challenges

Darwin has two distinct seasons, the 'wet' and the 'dry'. The wet season runs from November until April, and is characterised by high humidity, monsoonal rains, and storms. Temperatures typically range from a minimum of 20°C to a maximum of 33°C[5] as measured by the Bureau of Meteorology (BOM) over a 77 year period from 1941.

Figure 26 shows the 10 year average monthly maximum temperature measured in Darwin indicating the change in season during the year, in comparison with the corresponding average number of distribution switchgear failures. The ‘dry’ season is characterised by average maximum temperatures dropping to around 31°C and the ‘wet’ season with average maximum temperatures up around 34°C.

The distribution switchgear failure profile shows a strong correlation between distribution switchgear failures and the seasonal climate conditions albeit slightly delayed. An increase in asset failures is observed during the time periods when environmental factors, access to assets, workability and demand profiles presents the highest challenges.

As climate conditions continue to change a corresponding increase in distribution switchgear failures are expected to be observed during these worst periods of the year, and especially impacting the Darwin region at the Top End of the NT.

[5] Bureau of Meteorology (BOM), Climate statistics for Australian locations, Darwin

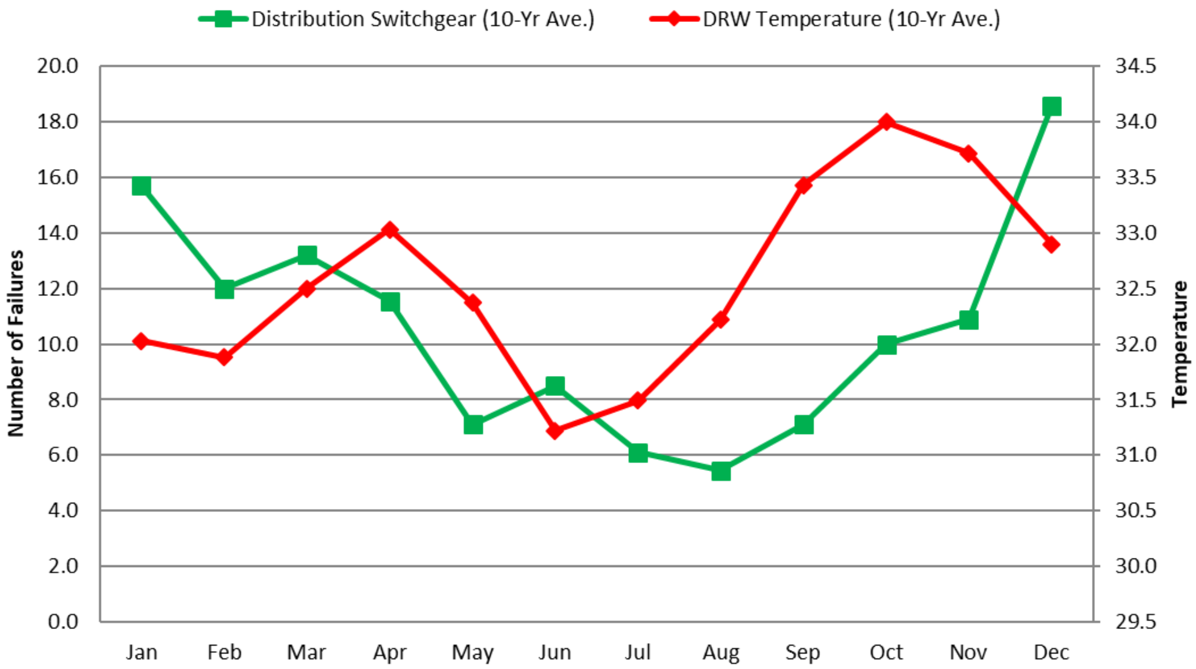


Figure 26: Average annual temperature and distribution switchgear failure profile

6.3. Asset challenges

The key underlying asset challenges associated with distribution switchgear is appropriate equipment ratings, particularly in the Darwin region were system development results in changing system requirements, and asset degradation as result of environmental factors including high lightning and corrosion environments.

The asset challenges have been grouped into overhead installations and ground based installations as listed below, and particular investment programs addressing key asset challenges have been extracted.

1) Magnefix Switchgear Fault Level Management

Included in the fleet of distribution switchgears are 859 Magnefix switches used mainly in the operation of the 11kV networks in Darwin and Alice Springs. The Magnefix switchgear is a compact fully epoxy resin insulated ring main unit for 12kV distribution networks. It is equipped with load-break switches and fused load-break switches with a short-time current withstand rating of 14.4 kA.

Development of the network and changes in generation capacity over time has resulted in an increase of system fault levels across the distribution network such that many Magnefix units no longer meet the minimum system fault levels. The risk of catastrophic equipment failure and the potential injury to workers and the public are a key concern – there have been several instances of switchgear failure in public areas where the fault energy was sufficient to damage the enclosure.

Additionally the industry has moved towards metal-enclosed switchgear to ensure that fault energy is contained during failures and safety risks to works and the public are minimised.

Currently, the network has a total of 27 Magnefix switchgear assets in operation for which the system fault level exceeds the rating of the equipment. A further 38 units have been identified where the system fault level are encroaching on the equipment rating. Table 23 provides a summary of the Magnefix switchgear assets where the system fault level are or encroaching on the equipment rating. The affected switchgear assets are mainly located in the Darwin region, with the majority installed in the distribution areas of Palmerston and Darwin City.

Table 23: Switches with system fault levels close to design rating

Fault Level Condition	Magnefix Switchgear
Exceed equipment fault level by >15%	**3**
Exceed equipment fault level by up to 15%	**3**
Exceed equipment fault level by up to 10%	**3**
Exceed equipment fault level by up to 5%	**7**
At equipment fault level	**11**
Encroaching on 5% of equipment fault level	*12*
Encroaching on 10% of equipment fault level	*15*
Encroaching on 15% of equipment fault level	*11*
Total	**65**

A replacement program targeting those assets where the system fault level exceeds the equipment rating is proposed. The remaining assets will be monitored to identify future replacement requirements.

2) Oil Ring Main Units

A program for the replacement of oil ring main units is currently in place and expected to be completed prior to the next regulatory period. It is generally accepted within the power distribution industry that operation of aging oil ring main units presents a high risk to personnel and the public due to the consequences of a failure to anyone in the vicinity of the equipment. Many oil ring main units are located in public areas such as lane ways, parks, and road reserves.

The highest risk units in publicly accessible areas have already been replaced. Of the remaining units, those installed at critical switching points in the power network have been prioritised for replacement in order to mitigate operational problems due to switching limitations on these units. As these units are replaced with modern equivalent assets, network reliability is expected to improve due to a reduction in failures, removal of operational switching limitations and reduced outages for maintenance.

It is expected that all the oil ring main units will have been replaced prior to the next regulatory period and an extension of the program has not been included.

3) Other Switchgear challenges

Other challenges associated with distribution switchgear that are not the subject of an investment program for the next regulatory period, include:

- Investigation of targeted trifurcation / re-termination of paper lead cable terminations to XLPE single core cable switchgear terminations to mitigate partial discharge and fault conditions and potential catastrophic failures.
- Ongoing investigation of SF6 gas leakage issues on ring main units to ascertain the main causes. The asset management strategy is the replacement of assets where leaks are identified, the investigation and repair of the failed equipment, i.e. the repair of failed gaskets/O-rings and the refilling of switchgear units where possible.
- High failure rate (five since 2013) of gas seals on overhead NGK gas filled load-break switches which are typically not repairable.
- High failure rate (14 since 2013) of semaphores on overhead ABB Sectos gas filled load-break switches. This is a particular concern for safe isolation and access to HV assets for maintenance.
- Arc Fault containment issues requiring investigation to assess the appropriateness of internal arc withstand ratings, in particular the ratings of some Schneider SM6 units are known to be low with a high worker safety risk.
- Equipment failures relating to protection relays, HV metering VT units, Voltage Presence indicators, busbar defects, and more.

6.4. Asset management challenges

Asset management is the application of management, financial, economic, engineering and other practices to infrastructure assets with the objective of providing the required level of service in the most cost-effective manner. It requires the management of the asset condition throughout the asset life cycle, including design, construction, commissioning, operating, maintaining, repairing, modifying, replacing and decommissioning/disposal. A study of condition and performance data captured over time assists in managing the asset to function optimally in a safe and reliable manner throughout its life cycle. The life cycle asset management approach applied by Power Networks is provided in Appendix A.

A key asset management challenge is a lack of comprehensive asset condition assessment data across the network to fully understand and evaluate the health and deterioration of the distribution switchgear assets.

Improvement in the processes for and quality of data collection is a key focus and is being prioritised. Significant steps have already been taken through the introduction of mobile devices to capture data in the field at the time of inspection and testing. The impact of corrosion deterioration on the functional integrity and strength of distribution switchgear are also being investigated through post failure assessments and testing.

7 Performance indicators

The performance of distribution switchgear against the specific objectives and measures identified in section 2.3 are provided here. The performance shown here represents the historical performance of the asset class to date. It is expected that benefits from investments proposed in the next regulatory period will manifest as benefits in these key objectives. The projected investment outcomes in relation to past performance trends are provided in section 11.

7.1. Operational Performance indicators

The performance of the distribution switchgear over the last 10 years from 2006-2007 is provided in Figure 27. The charts show the performance based on sustained outages only, i.e. outages with a duration greater than 1 minute, and excludes major event days (MEDs). In particular, the following events were excluded from the analysis, in calculating the percentage contribution of the asset class into NT SAIDI/SAIFI:

a) Planned outages
b) Generation-related outages
c) Outages that were internal to customer premises
d) Outages initiated in the interest of public safety

The projected distribution switchgear contribution to NT system SAIDI under a 'no investment' scenario indicates an expected increase in contribution of up to around 9% by the end of the regulatory period, 2023-24, a corresponding increase in SAIFI contribution of around 10% is projected.

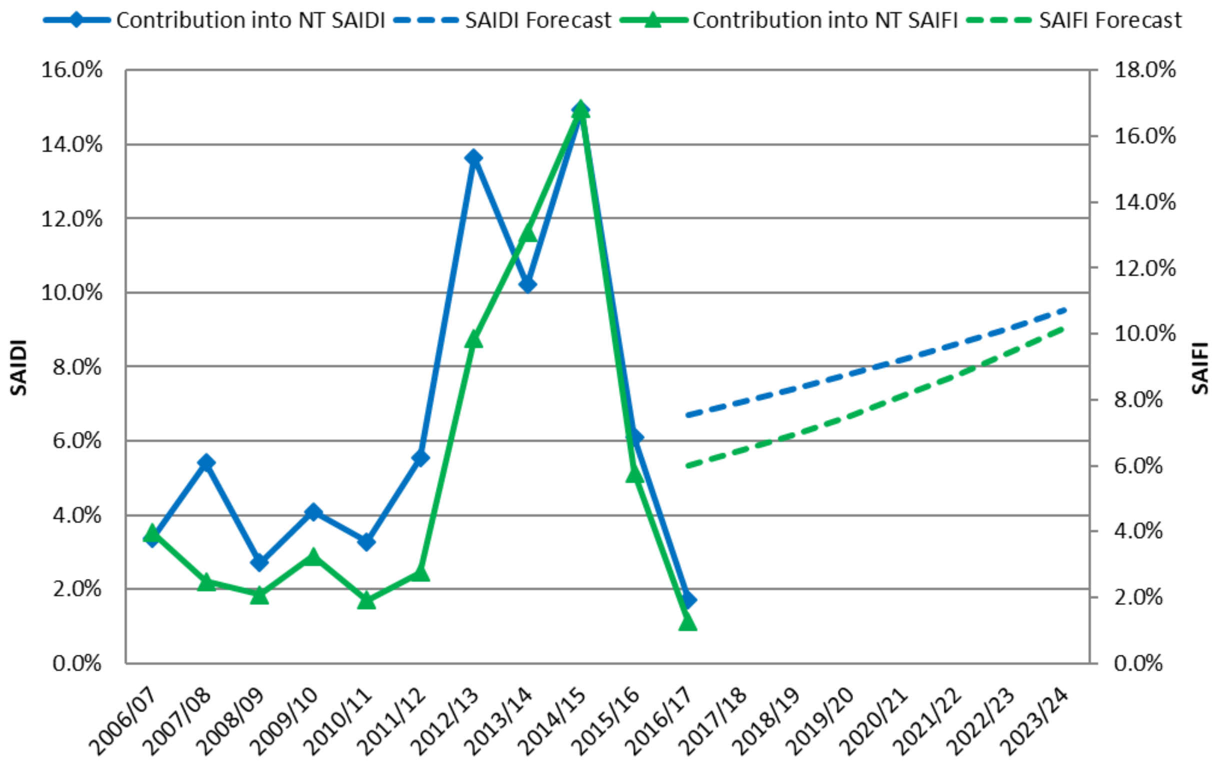


Figure 27: Distribution switchgear (reclosers, switches, fuses) contribution into SAIDI/SAIFI

7.2. Health and Safety indicators

A key corporate objective is the safe operation of the network. The number of safety related events associated with distribution switchgear (reclosers, switches, fuses) as recorded over the last 10 years are shown in Table 24. Safety-related incidents includes those outages which were caused by third party impacts with Power and Water assets, public and worker safety-related outages, and forced outage requested by emergency services.

Table 24: Number of safety-related incidents associated with distribution switchgear

Financial Year	Number of Outages	Comment
2006-07	9	Outage to facilitate safe work by Power and Water
2007-08	21	Outage to facilitate safe work by Power and Water
2008-09	16	Facilitating safe operation
		Outage to facilitate safe work by Power and Water
2009-10	13	Forced outage - Power and Water equipment presents unacceptable risk
		Outage to facilitate safe work by Power and Water
2010-11	72	Incident - Third Party
		Forced outage - Power and Water equipment presents unacceptable risk
		Outage to facilitate safe work by Power and Water
2011-12	61	Isolation for Fire Brigade and Electrical contractors
		Forced outage - Power and Water equipment presents unacceptable risk
		Outage to facilitate safe work by Power and Water
2012-13	38	Fire
		Forced outage - Power and Water equipment presents unacceptable risk
		Outage in the interest of public safety
		Outage to facilitate safe work by Power and Water
2013-14	6	Forced outage - Power and Water equipment presents unacceptable risk
		Outage to facilitate safe work by Power and Water
2014-15	12	Incident - Third Party
		Human error
		Outage to facilitate safe work by Power and Water
2015-16	7	Incident - Third Party
		Outage in the interest of public safety
		Outage to facilitate safe work by Power and Water
2016-17	18	Forced outage - Power and Water equipment presents unacceptable risk
		Incident - Third Party
		Incident - Third Party (Retailer)
		Outage to facilitate safe work by Power and Water
Total	**270**	

7.3. Financial indicators

Power and Water's long term financial sustainability as underwritten by affordable service and shareholder returns are demonstrated in the efficient and competitiveness of its capital and operating costs.

The capital expenditure forecast for distribution switchgear assets has been based on historical unit costs, relying on recent and similarly scoped projects. The approach aligns with industry best practice and relies on data that is continuously validated and updated.

7.3.1. Capital unit costs

The capital unit rates are a significant input towards the capital expenditure forecast and have been calculated and justified to be as efficient and prudent.

The capital unit rates applied in establishing the regulatory capital forecast have been assessed against similar unit costs observed across the National Electricity Market (NEM). The comparison provided an indicative measure of the reasonableness of Power and Water’s costs and has been based on publicly available data sourced from the Australian Energy Regulator’s (AER’s) Repex modelling and utility Regulatory Information Notice (RIN) submissions.

There are a number of internal and external operational, asset type, and environmental factors that influence the benchmark costs and provide a challenge in respect of the ability to undertake accurate comparisons. Normalisation for these factors has not been undertaken and the benchmark comparisons provided are an indicative measure of reasonableness only.

In undertaking the comparison, Power Networks was considered comparable with six Australian utilities of largely rural type networks. Subject to the availability of appropriate data these utilities included ActewAGL, Endeavour Energy, Essential Energy, Ergon Energy, TasNetworks, Powercor, and United Energy. Where historical unit costs have been utilised as part of the bottom-up estimates or historical analysis, these have been escalated to 2017/18 dollars by CPI only. The CPI escalation factor was derived from indexes published by the Australian Bureau of Statistics for all consumer groups and applicable to the Darwin area.

Power and Water’s unit cost for the replacement of distribution switches is provided in Figure 28. In comparison with peer averages observed across the NEM, Power and Water’s cost is above average. This is expected as works undertaken in the NT are typically characterised by higher costs than other areas in Australia. This can partly be attributed to the remoteness of the network attracting additional transport and logistic costs, as well as the harsh weather conditions set apart by extended wet periods that impedes the effective execution of works and a tropical climate that impact on the productivity that can be achieved during normal work hours.

Power and Water’s unit cost for replacing distribution switches is considered reasonable. No investment in reclosers and fuses are considered for the next regulatory period and a comparison on unit costs for these asset replacements has not been undertaken.

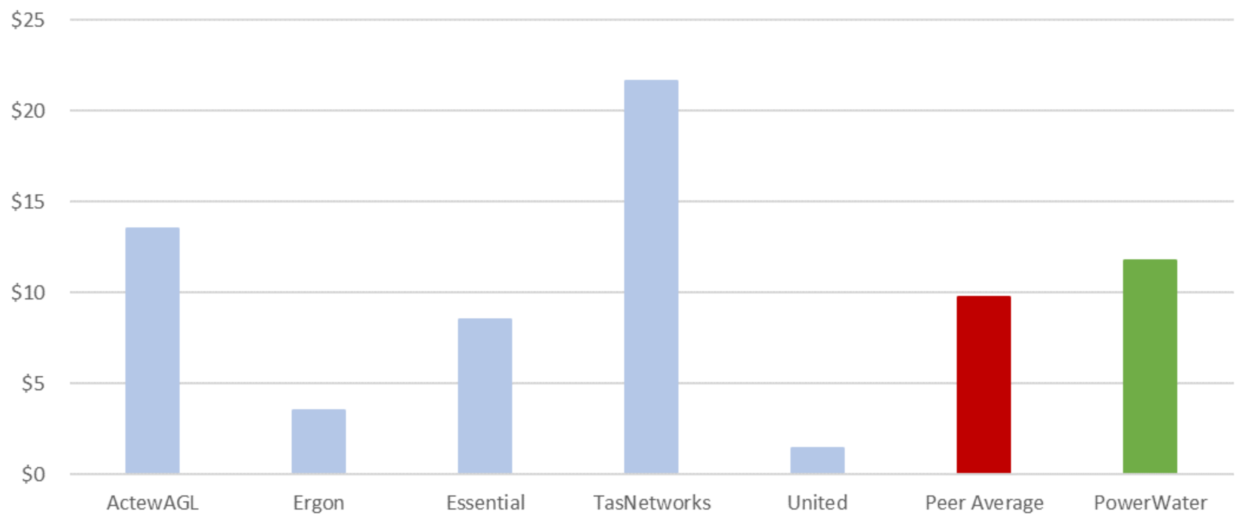


Figure 28: Distribution Switch Replacement unit cost comparison

7.3.2. Operating unit costs

The operational expenditures include that expenditure incurred in operating and managing the distribution switchgear assets, ensuring that the assets continue to provide their pre-determined service capacity and quality of service and achieve their useful life. The operating expenditure therefore includes maintenance and direct overhead expenditure associated with the distribution network.

Maintenance expenditure includes those costs incurred when:

- an asset is restored to its operational condition; and
- to ensure the asset meets its operational performance, reliability; and
- does not extend the useful life of the asset.

Direct overhead expenditure is expenditure associated with scheduling and planning. These support activities cannot readily be identified as belonging to a particular value adding task/activity and has been allocated on a pro-rata basis.

Similar to the capital cost, a comparison with peer utility expenditures has been applied to provide an indicative measure of the reasonableness of Power and Water's costs and has been based on publicly available data sourced from the utility Regulatory Information Notice (RIN) submissions.

Insufficient peer utility data was available to allow for a comparison of operations and maintenance costs associated with emergency response works at the asset class level. Emergency response operation and maintenance costs have therefore been excluded from the comparison.

There are internal and external operational, asset type, and environmental factors that influence the benchmark costs and provide a challenge in respect of the ability to undertake accurate comparisons. Normalisation for these factors has not been undertaken and the benchmark comparisons provided here are indicative measures of reasonableness only.

Where historical unit costs have been utilised as part of the analysis, these have been escalated to 2017 dollars by CPI only. The CPI escalation factor was derived from indexes published by the Australian Bureau of Statistics for all consumer groups and applicable to the Darwin area.

A comparison of Power and Water's average annual routine and non-routine maintenance cost in comparison with peer organisations are provided in Figure 29. The Power and Water cost represent the average annual cost recorded over the last five years.

The high level unnormalised comparison indicates that Power and Water's operating cost is high in relation to costs recorded across the NEM. This is reflective of the historical frequency of routine maintenance activities, the allocation of overhead non-trades labour cost, and capitalisation practices.

Historically asset inspections were undertaken annually contributing to a higher annual routine maintenance cost. This has now been amended to three yearly inspections. In addition, the historic routine maintenance of oil ring main units will continue to decrease as this switchgear is phased out of the network. These changes are expected to reduce routine maintenance costs going forward.

An under recovery of capitalisation costs are currently being reviewed and improvements in the capitalisation of cost practices are expected to result in material reductions in repair and maintenance costs.

In order to better reflect the true cost of maintenance, costs associated with planning, scheduling, and asset management which are related to maintenance activities are recorded as maintenance costs rather than being treated as overheads. This contributes a material proportion of the total repair and maintenance expenditure and negatively affects benchmarks against other utilities.

Power Networks operate in an environment characterised by extreme temperatures, high humidity, heavy and extensive rainfall, high corrosion zones and aggressive soil types present unique challenges for managing the assets. These challenges require Power Networks to employ methodical inspection and maintenance practices to sustain the asset condition. These practices include the careful scrutiny, cleaning, testing, and rectification of equipment defects and abnormalities. This systematic maintenance requirement combined with harsh weather conditions that affect the productivity that can be achieved during normal work hours, contributes to the expected higher cost of routine and non-routine maintenance activities.

Power and Water's historical routine and non-routine maintenance cost associated with distribution switchgear are considered relatively high, but within reason given the differentiating historical maintenance cycles and practices and the extenuating work environment.

Future expenditures are expected to benefit from improved capitalisation practices and amended maintenance cycles. These prospective benefits have not been included in this reasonableness test.

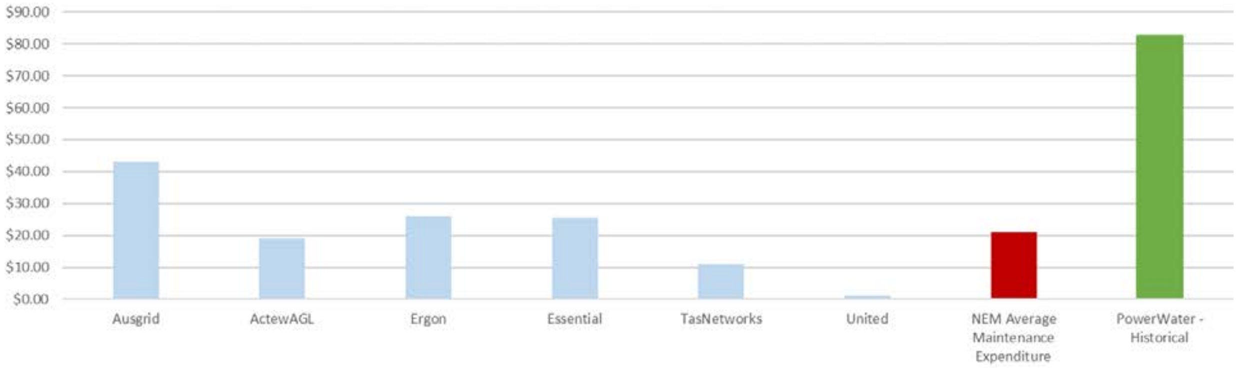


Figure 29: Distribution switchgear routine and non-routine maintenance cost comparison

8 Growth requirements

The demand for power infrastructure is driven mostly by growth in the number of new network connections. To understand this potential growth Power and Water engaged AEMO in 2017 to undertake a connection forecast for the network regions of Darwin-Katherine, Tennant Creek, and Alice Springs[6]. The study outcome identified relative low customer connection growth across the network with the highest expected average growth in Tennant Creek, 1.0% followed by Darwin, 0.8% and Alice Springs, 0.1%. The outcome of the connection forecast is summarised in Figure 30.

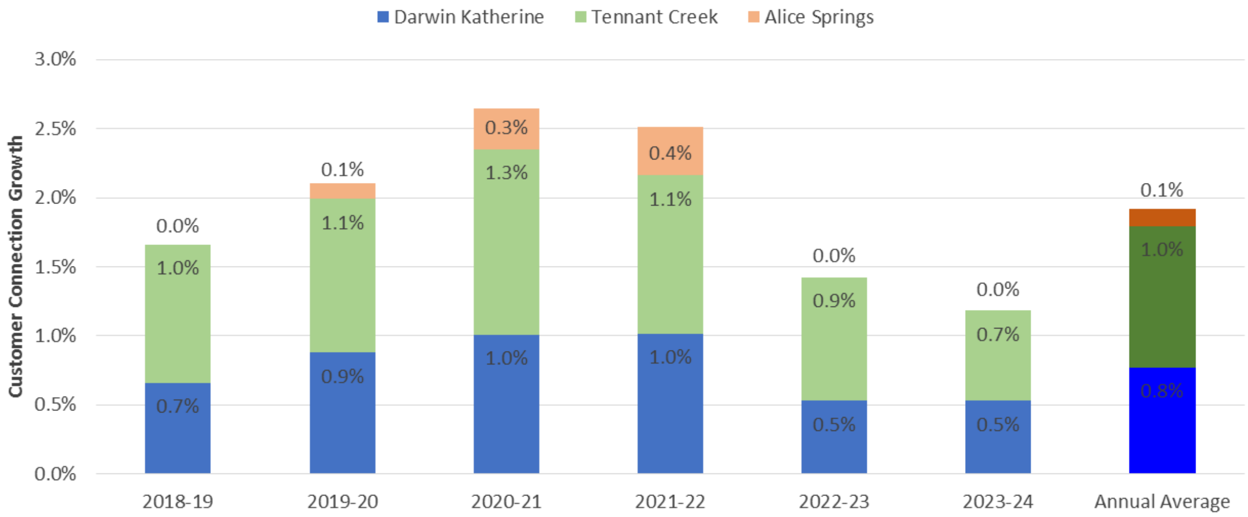


Figure 30: Customer connection growth by region (AEMO 2017 Forecast)

Distribution switchgear provides the ability to operate the network by creating switching points for the transfer of loads, and isolation points for making the network safe for work activities. The location and number of switching points are generally determined as part of the planning and ongoing development of the network to accommodate new connections and network expansions. The projected growth in connections therefore provides a reasonable proxy for the expected increase in distribution switchgear asset requirements over the same period.

[6] AEMO, Power and Water Corporation Maximum Demand, Energy Consumption, and Connections Forecast, September 2017

It is noted that the AEMO connection growth forecast shows a significantly reduced growth rate in comparison with Power and Water's annual average growth in distribution switchgear assets over the recent five years from 2012-13 to 2016-17, as shown in Table 25. The changing environment with reducing demand growth is expected to impact on the requirement for network growth. The AEMO forecast has been adopted to project the expected growth in distribution switchgear assets by the end of the regulatory period, 2023-24.

The projected increase in distribution switchgear assets is provided in Table 25. In summary the following approach was taken in doing the asset growth projections:

- The forecast was based on the customer connection forecasts from AEMO's 2017 report: *Power and Water Corporation Maximum Demand, Energy Consumption, and Connections Forecasts.*
- The current asset base (i.e. number of distribution reclosers, switches and fuses) were increased each year according to percentage change in the forecast number of connections.
- For periods where this percentage change was negative, the asset base remained the same, under the assumption that the existing network size will not reduce as result of short-to-medium term negative customer growth.

Table 25: Distirbution switchgear forecast growth, qty (2012/13 to 2016/17)

Region	Distribution Switchgear	Historical average annual asset growth rate (2012/13 to 2015/16)	AEMO annual connection growth rate	Distribution Switchgear increase by 2023/24
Darwin-Katherine	Reclosers	9.3%	0.8%	2
	Switches	4.8%		114
	Fuses	0.3%		473
Alice Springs	Reclosers	14.4%	0.1%	0
	Switches	2.0%		4
	Fuses	0.5%		11
Tennant Creek	Reclosers	20.0%	1.0%	0
	Switches	2.9%		6
	Fuses	0.2%		14
Totals	**Reclosers**	**10.6%**	**0.7%**	**2**
	Switches	**4.2%**		**124**
	Fuses	**0.3%**		**498**

The growth in assets will impact on the health and criticality profile of the asset class. The new assets are expected to be of good health with a pro-rata spread across the asset criticalities.

The revised forecast health and criticality profiles for distribution switchgear by the end of the regulatory period, assuming no investment and including growth are shown in Table 26, Table 29, and Table 30. The growth numbers are reflected in the increase in the H1 asset quantities and show an expected 6% increase in reclosers and switches and a 5% increase in fuses.

Table 26: Distribution recloser health-criticality matrix (qty) with growth and no investment

	H1	H2	H3
C1	9		6
C2	6	1	2
C3	29		6

Table 27: Distribution switch health-criticality matrix (qty) with growth and no investment

	H1	H2	H3
C1	398	50	150
C2	1,388	143	389
C3	374	29	201

Table 28: Distribution fuse health-criticality matrix (qty) with growth and no investment

	H1	H2	H3
C1	2,265	74	291
C2	6,277	131	712
C3	1,356	79	1,034

9 Renewal and maintenance requirements

Power and Water's renewal and maintenance investment plans are aimed at addressing key asset challenges identified within the asset class.

Targeted inspection and testing are undertaken to investigate assets of concern, and a targeted assessment applying the asset health and criticality decision making approach[7] and the more detailed understanding of the condition of the specific assets is used to assess the risk associated with the assets to identify those assets that bear the greater risk.

Opportunities to maintain the safe and reliable operation of the network are then considered and this typically includes assessing options of run-to-failure, test and replace, and targeted pro-active renewal. The outcome of the assessment is manifested as a preferred investment option with a high level scope and cost estimate.

Maintenance activities are crucial in the early identification of asset health and condition issues and the prioritisation of assets for further investigation. Inspection findings, field service feedback, and performance measures are the main inputs used to identify those assets that are of particular concern, or may have a type issue. Routine asset inspections are therefore a fundamental aspect of Power and Water's maintenance regime to ensure prudent and effective investments.

The process and outcomes of the renewal and maintenance requirement assessments are documented in the Business Needs Identification (BNI) documents that are prepared for and approved by the Chief Executive.

[7] 'Program Replacement Volume Forecast Method' discussion paper

The following projects and programs have been evaluated and provide the distribution switchgear renewal and maintenance requirements proposed for the next regulatory period.

9.1. Asset Renewal Plans

9.1.1. Distribution Switchgear replacement program

Full details on this asset challenge and assessment are available in the BNI document:

- NMP7 – Darwin Distribution Substation Fault Level Replacement Program

Applying the health and criticality criteria laid out in section 5 the assessment of the Magnefix switchgear is provided in Table 29. It prioritises 27 Magnefix installations in the red and orange zones and identifies a further 18 of poor health and higher criticality.

Table 29: Magnefix switch health-criticality matrix (qty)

	H1	H2	H3
C1	150	33	5
C2	511	114	18
C3			27

The projected annual replacement volumes over the regulatory period is provided in Table 30 and will replace 27 Magnefix switchgear targeting those assets identified in the red zone. Consideration will be given to addressing emerging fault rate issues during the next regulatory period.

Table 30: Magnefix switch renewals (qty)

Program	2019-20 Qty	2020-21 Qty	2021-22 Qty	2022-23 Qty	2023-24 Qty	Total Qty
Replacement volumes	8	8	6	6	6	34

9.1.2. Distribution Switchgear pooled asset replacements

Full details of this program evaluation are available in the document:

- 2019-24 Pooled Asset Replacement Forecasting Model Methodology

The pooled program captures those distribution switchgear assets that fail in service. These replacements are typically done under emergency conditions and are therefore of limited scope and cost, however impacts positively on the overall health of the network moving assets out of the poor health category. These failures are expected to be mostly associated with poor health and low criticality assets, i.e. those assets that are of poor health but not necessarily part a proactive replacement program.

The expected distribution switchgear replacements under this program have been projected using a probabilistic approach. The approach forecasts asset failures using a combination of asset age, asset conditional probability of failure, and historical asset failures. A total of 534 distribution switchgear replacements are forecast over the 5 year regulatory period. The projected annual replacement volumes are provided in Table 31.

Table 31: Projected pooled distribution switch replacement volumes

Program	2019-20 Qty	2020-21 Qty	2021-22 Qty	2022-23 Qty	2023-24 Qty	Total Qty
Pooled distribution switchgear replacement volume	97	102	107	111	117	534

The health and criticality assessment of the distribution switchgear assets expected to be replaced through the pooled replacement program is shown in Table 32, Table 33, and Table 34. The pooled replacements are expected to involve those assets of poor health, and varying criticality. A pro-rata allocation of criticality levels has been made based on the volume of assets in each criticality level.

Table 32: Pooled program distribution recloser health-criticality matrix (qty)

	H1	H2	H3
C1			1
C2			
C3			1

Table 33: Pooled program distribution switch health-criticality matrix (qty)

	H1	H2	H3
C1			21
C2			67
C3			21

Table 34: Pooled program distribution fuse health-criticality matrix (qty)

	H1	H2	H3
C1			91
C2			247
C3			86

9.2. Distribution switchgear asset maintenance plans

The maintenance plan for distribution switchgear is to continue with the established maintenance regime, which is based on 3-yearly inspections and repair (or replacement) upon failure. Inspections typically involve both ground based and aerial assessment of condition. Asset defects are prioritised based on risk of failure and included in the maintenance and defect rectification program.

Defects that cannot be identified through visual inspection eventually result in failure of the asset and are repaired or replaced under the pooled asset replacement program.

10 Investment program

The investment program is developed based on the:

- Continuation of the established lifecycle asset management approaches
- Specific requirements related to growth in the asset class – outlined in Section 8, and

- Specific requirements related to renewal and maintenance of the asset class – outlined in Section 9.

10.1. Augmentation expenditure (augex)

The augmentation requirements for the distribution switchgear assets follow on a relative low connection growth forecast in most existing distribution areas. Power and Water engaged AEMO in 2017 to undertake a demand growth forecast for the network areas. The study identified relative low customer connection growth across the network with the highest expected average growth in Tennant Creek, 1.0% followed by Darwin, 0.8% and Alice Springs, 0.1%. The outcome of the connection forecast is discussed in section 8. Pocketed areas of growth are expected in areas of Darwin.

This changing environment with reducing growth is decreasing the need for capital investment on augmentation of distribution switchgear. Where growth is slow, network, non-network, and demand side management support options assist in managing load at risk.

One augmentation program proposed for the asset class over the next regulatory period, 2019-20 to 2023-24 involves the replacement of Magnefix switchgear where network and generation development has resulted in the system fault level exceeding the equipment fault ratings. The program is expected to cost $4.64 million over the five-year period.

The Poorly Performing Feeder Improvement program will likely require some augmentation expenditure for the distribution switchgear class. A typical scenario is the installation of new remote switching devices, or the upgrade of an existing device to achieve remote capability, in order to address a specific reliability issue on a poorly performing feeder. The precise composition of the program is not defined since it is reactive in nature, however historically a significant portion of the program has related to distribution switchgear augmentation.

The augmentation renewal expenditure forecast based on the mention programs are provided in Table 35.

Table 35: Augmentation renewal expenditure forecast

Program	2019-20 ($ million)	2020-21 ($ million)	2021-22 ($ million)	2022-23 ($ million)	2023-24 ($ million)	Total ($ million)
Fault Level Replacement Program	$1.08	$1.06	$0.88	$0.83	$0.80	**$4.64**
Poorly Performing Feeder Program (distribution switchgear augex component)	$0.71	$0.71	$0.71	$0.71	$0.71	**$3.55**

The revised five-year forecast health and criticality profiles for the distribution switchgear asset class following the proposed augmentation investment and including growth is shown in Table 36. The reduction in risk is demonstrated in the number of assets that move from the poor health, H3 category to the good health category, H1 in comparison with the 'current' and 'no investment' risk scenarios provided in section 5.

For the switches asset group the reduction in risk is reflected in a 4% reduction in the number of poor health assets in the H3 category.

Table 36: Distribution switchgear health-criticality matrix (qty) with augmentation investment

	H1	H2	H3
C1	398	50	150
C2	1,388	143	389
C3	401	29	174

10.2. Renewal expenditure (repex)

There is one renewal program proposed for the asset class over the next regulatory period, 2019-20 to 2023-24. The program is expected to cost $10.63 million over the five-year period and involves investment in assets that fail in service.

The renewal expenditure forecast based on the mention program is provided in Table 35.

Table 37: Renewal expenditure forecast

Program	2019-20 ($ million)	2020-21 ($ million)	2021-22 ($ million)	2022-23 ($ million)	2023-24 ($ million)	Total ($ million)
Distribution switchgear pooled asset replacements	$1.96	$2.04	$2.13	$2.21	$2.29	**$10.63**

The revised five-year forecast health and criticality profiles for the distribution recloser assets following the proposed investments are shown in Table 38. For the recloser assets the reduction in risk is reflected in a 15% reduction in the number of poor health assets in the H3 category.

Table 38: Distribution recloser health-criticality matrix (qty) with renewal investment

	H1	H2	H3
C1	9		5
C2	7	1	2
C3	31		5

For the switch assets the reduction in risk is reflected in a 15% reduction in the number of poor health assets in the H3 category, as shown in Table 39.

Table 39: Distribution switch health-criticality matrix (qty) with renewal investment

	H1	H2	H3
C1	418	50	129
C2	1,455	143	322
C3	422	29	153

For the fuse assets the reduction in risk is reflected in a 21% reduction in the number of poor health assets in the H3 category, as shown in Table 40.

Table 40: Distribution fuse health-criticality matrix (qty) with renewal investment

	H1	H2	H3
C1	2,356	74	200
C2	6,524	131	465
C3	1,441	79	948

10.3. Historic, forecast and future expenditure comparison

Historic expenditure on distribution switchgear has been predominantly related to addressing specific switchgear type issues. The oil ring main unit and BBC RGB replacement programs have had the highest contribution to distribution switchgear replacement expenditure in recent years, as well as a material contribution from the replacement of old Air Break Switches with modern Gas Break Switches.

As outlined in the preceding sections, the forecast expenditure on distribution switchgear is targeted to address the key asset challenges expected to manifest over the regulatory period. It is noted that the forecast is constant over the course of the regulatory period and lower than the expenditure in the current regulatory period.

Future expenditure in the asset class has been forecast using the AER's repex model and shows a gradual decline in the investment required in distribution switchgear. Whilst the AER's repex model is age-based model, Power and Water's approach is to target those assets in poor condition. It is expected that future investment in the asset class can be managed at a level around $3 million per annum.

10.4. Operational expenditure (opex)

The operating expenditure for Distribution Switchgear for the next regulatory period is provided in Table 41.

Table 41: Operating expenditure forecast

Asset type	Expenditure category	FY14 (H)	FY15 (H)	FY16 (H)	FY17 (H)	FY18 (H)	FY19 (F)	FY20 (F)	FY21 (F)	FY22 (F)	FY23 (F)	FY24 (F)
Reclosers	Routine	$0.06	$0.05	$0.00	$0.05	$0.04	$0.03	$0.03	$0.03	$0.03	$0.03	$0.03
	Non-routine	$0.05	$0.09	$0.07	$0.04	$0.06	$0.06	$0.05	$0.05	$0.05	$0.05	$0.05
	Fault and emergency	$0.49	$0.61	$0.42	$0.25	$0.41	$0.40	$0.39	$0.39	$0.39	$0.39	$0.39
Total		**$0.60**	**$0.75**	**$0.50**	**$0.35**	**$0.51**	**$0.49**	**$0.47**	**$0.47**	**$0.47**	**$0.47**	**$0.47**
Switches	Routine	$0.44	$0.39	$0.50	$0.26	$0.33	$0.30	$0.28	$0.28	$0.28	$0.28	$0.28
	Non-routine	$0.57	$0.62	$0.66	$0.90	$0.67	$0.61	$0.54	$0.54	$0.54	$0.54	$0.54
	Fault and emergency	$0.41	$0.42	$0.12	$0.14	$0.25	$0.25	$0.24	$0.24	$0.24	$0.24	$0.24
Total		**$1.43**	**$1.43**	**$1.28**	**$1.30**	**$1.26**	**$1.16**	**$1.06**	**$1.06**	**$1.06**	**$1.06**	**$1.06**
Fuses	Routine	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Non-routine	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
	Fault and emergency	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Total		**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**	**$0.00**
All switchgear	Routine	$0.51	$0.44	$0.51	$0.31	$0.36	$0.34	$0.31	$0.31	$0.31	$0.31	$0.31
	Non-routine	$0.62	$0.71	$0.73	$0.94	$0.74	$0.66	$0.59	$0.59	$0.59	$0.59	$0.59
	Fault and emergency	$0.90	$1.03	$0.54	$0.39	$0.66	$0.64	$0.63	$0.63	$0.63	$0.63	$0.63
Total		**$2.03**	**$2.18**	**$1.78**	**$1.65**	**$1.76**	**$1.64**	**$1.53**	**$1.53**	**$1.53**	**$1.53**	**$1.53**

11 Asset class outcomes

11.1. Operating Performance indicators

Investment in the distribution switchgear assets are expected to impact on the performance of the asset class and the contributions made into the system SAIDI/SAIFI performance. The contributions from each investment program have been analysed to identify the potential improvements that could be affected.

The Magnefix switchgear investment program addresses a compliance issue and associated safety risk. It is not aimed at improving system reliability, and although benefits from reduced failures have been calculated, the impact on system performance improvements has been determined to be insignificant.

System performance improvements from the expected replacement of in-service asset failures were calculated as the percentage contribution to total system performance at an asset level based on historical performance and taking into account existing asset quantities, expected growth rates, and renewal volumes.

The SAIDI/SAIFI improvements followed the quantity of assets expected to be replaced or refurbished. The expected benefit in SAIDI and SAIFI contribution from distribution switchgear is provided in Figure 32 and Figure 33.

An improvement of around 0.47% in SAIDI performance by 2023-24 is projected and similarly, a reduction in system SAIFI contribution of around 0.49% is projected by the end of the regulatory period.

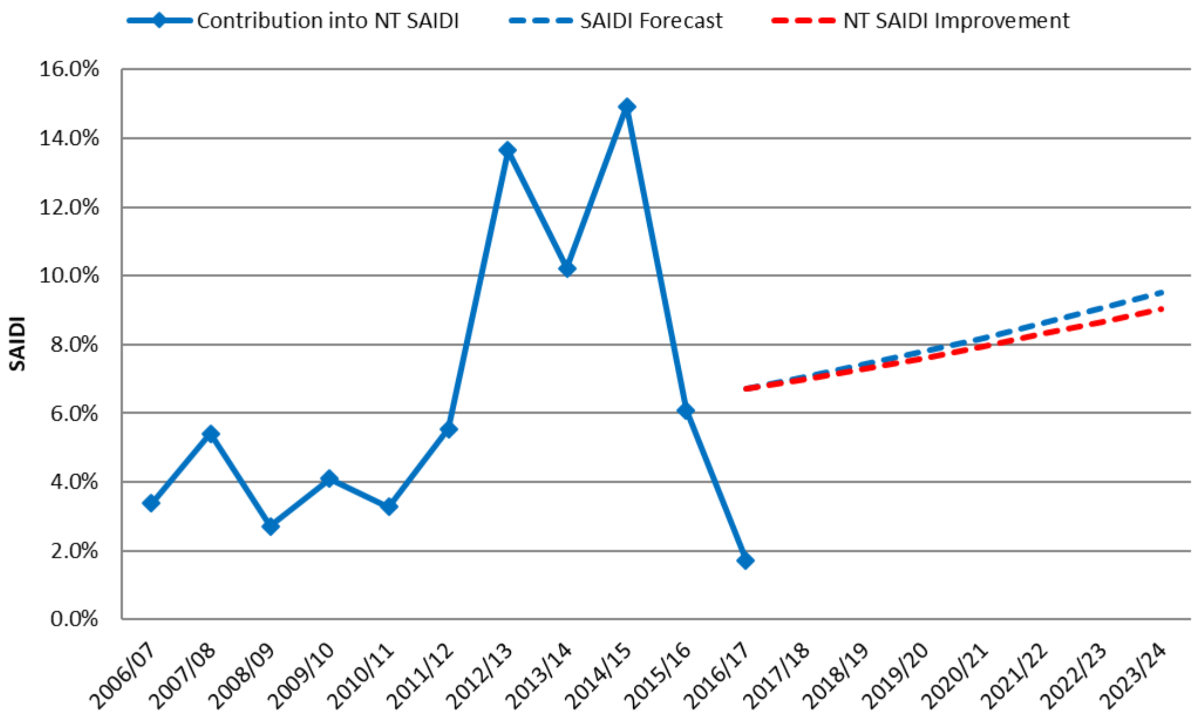


Figure 31: Distribution switchgear (reclosers, switches, fuses) contribution into NT SAIDI following investment

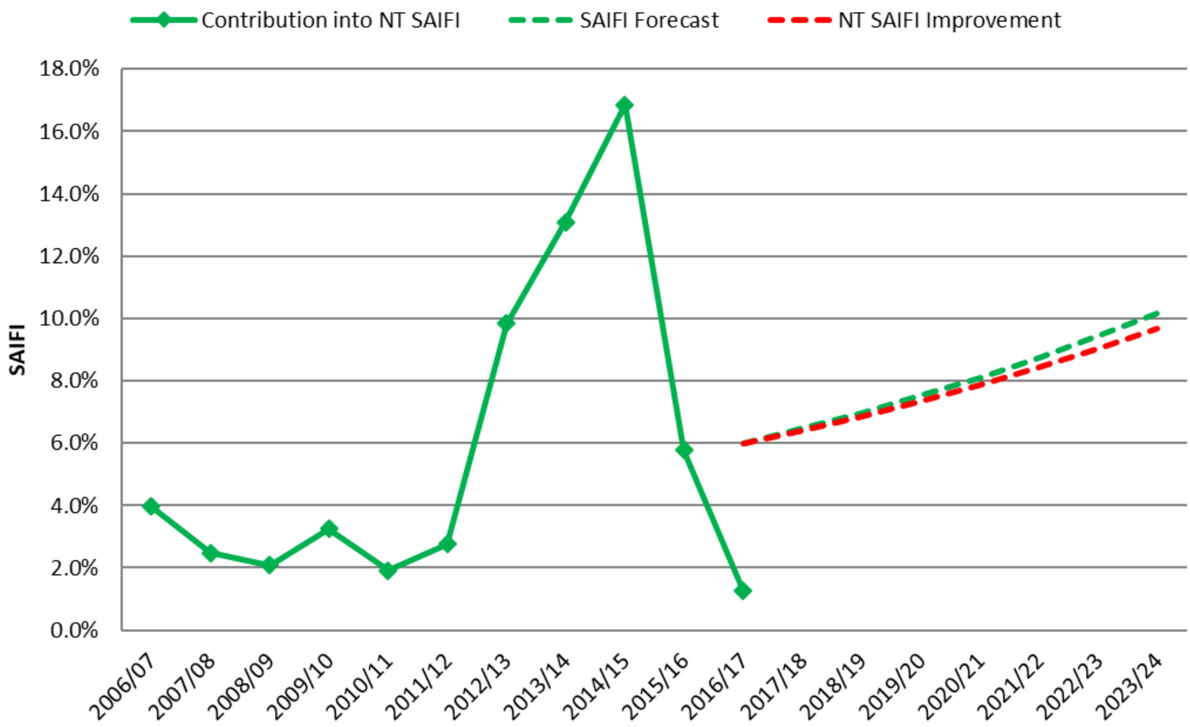


Figure 32: Distribution switchgear (reclosers, switches, fuses) contribution into NT SAIFI following investment

11.2. Health and Safety indicators

A key corporate objective is the safe operation of the network. Historical safety related incidents predominantly consisted of third party impacts with Power and Water assets, public and worker safety-related outages, forced outages requested by emergency services, and house fires. The investment program for the next regulatory period replaces existing equipment like for like or with augmented equipment in the same location. It is not targeted to mitigate against the safety events typically observed involving distribution switchgear, however it is anticipated that the replacement of ageing or underrated assets will have a net benefit on public and worker safety.

12 Performance monitoring and improvement

Ongoing condition and performance monitoring is a key part of Power and Water's performance evaluation and improvement strategy. Study of the condition and performance data captured over time assists in developing valuable insights on distribution switchgear defect modes and trends. These insights provide for informed decision making on whether to repair or replace distribution switchgear assets. It assists in the continuous development of the asset management strategy for distribution switchgear.

This Asset Management Plan will be reviewed at least every two years or when there is a significant driver from the network or other events that requires revision.

Improving data resources, undertaking data analysis and deriving insights will be undertaken as business as usual activities with increased focused. Any improvements in analysis and understanding of the distribution switchgear fleet will be included in this AMP when it is updated.

The RACI model provided in section 3.2 identifies the roles and responsibilities important in the management of the distribution switchgear assets. These responsibilities include ongoing performance monitoring and strategy revisions.

13 Appendix A – Lifecycle asset management

Power and Water exerts great efforts to ensure being a customer oriented organisation that provides a safe, reliable and efficient electricity supply in the Northern Territory. This is demonstrated in the approach it takes in managing its assets. The life cycle asset management approach applied is aimed at making prudent asset management decisions such that its assets do not cause harm to any person, have minimal environmental impact, and meet agreed service performance outcomes, consistent with current and future needs.

The approach includes:

- Maximising the utilisation of its assets throughout its life cycle
- Optimising life cycle asset management costs
- Reducing asset risks as low as reasonably practical
- Continually improving its knowledge in respect of its assets

The following asset management activities details Power and Water's life cycle management of its distribution switchgear assets.

13.1. Planning (augmentation)

The asset planning stage defines the need for an asset to exist. It also establishes the functional requirements of the assets and ultimately the number of assets, design, function, criticality, configuration, level of redundancy, capability, and capacity.

Key criteria to ensure optimal line route selection, establishing prudent, cost efficient, intrinsically safe, and sustainable corridors for the life cycle management of the distribution switchgear assets include consideration of:

- Optimised utilisation of existing distribution switchgears
- Schedule and cost impacts from existing adjacent infrastructure
- Transport and logistics
- Project cost implications
- Safety and reliability risks
- Environmental and approvals risk
- Stakeholder and community requirements
- Design and execution requirements
- Operation and maintenance requirements

13.2. Design

The design phase is where decisions around the physical characteristics and functioning of the asset are made. This life cycle stage defines the quality and reliability of the asset, and the whole of life cycle costs that can be realised. It influences the total cost and the level of service that the assets can deliver to customers and shareholders.

Power and Water's approach to the whole of life cycle prudent and efficient design of assets include the standardisation of distribution switchgears and associated equipment. Standardisation is defined as the process of developing and agreeing on uniform technical design criteria, specifications and processes and is a key aspect of Power and Water's asset management process.

Along with continuity, leverage and scalability, standardisation enables consistent application of best industry practise and continuous performance improvement. It establishes technical commonality that allows for an off-the-shelf, best practice, and fit-for-purpose approach to engineering solutions. It also allows for interchangeability that provides operations and asset management benefits.

Power and Water's distribution switchgear design standardisation offers the following specific benefits to the business. It:

- Helps with the ranking and prioritisation of investment projects
- Gives confidence in the safe and reliable functioning of the assets
- Provides assurance that the assets will do the job they were intended for
- Boost production and productivity
- Encourages higher quality of engineering leveraging specialist knowledge and optimum solutions
- Allows for the uniform execution of projects
- Enables standardisation of construction equipment and processes

During the design of the distribution switchgear assets a key input to the decision making is the current and future planned utilisation or required rating. The required rating is informed from the planning department after completion of load flow and fault level studies guided by the Network Planning Criteria.

13.3. Operation

Asset operations include activities associated with the monitoring, operation and control of the asset to adapt to changing requirements of the network. This includes:

- Planned switching of the network for scheduled works (e.g. maintenance)
- Emergency switching of the network in response to incidents (e.g. fault events)
- Real time switching to operate the asset within its design parameters (e.g. loading)
- Monitoring of the condition of the asset (e.g. alarms)

Power and Water recognises the need to outline and communicate a single, coherent operating model with clear responsibilities across the full asset lifecycle of the distribution switchgear assets. To this end, key competencies required to operate the asset is always identified and adequate training provided. Power and Water works diligently to ensure that different business units of the organisation have clear roles and responsibilities for each asset category.

13.4. Maintenance (opex)

Asset maintenance involves the upkeep of assets to ensure they will function to their required capability in a safe and reliable manner from their commissioning to their disposal. This is achieved though the following maintenance objectives:

- maintain the functional performance of the assets
- identify potential problems before the condition of assets is compromised

- minimise damage to assets during faults
- avoid or limit the duration of customer supply interruptions
- enable a planned and structured approach to repair or replacement of assets
- reduce risk to personnel and public
- mitigate public liability risk

Maintenance requirements evolve as the condition and performance requirements of the assets change through its life. It monitors and provides feedback on asset condition, it incorporates upkeep and repair activities to maintain the condition of the asset, and it also includes the monitoring and management of the deterioration of an asset over time. Three main types of maintenance activities are defined: preventative, corrective, and unplanned maintenance.

- Preventative maintenance involves the controlled care and repair activities carried out to reduce the probability of failure or degradation of asset performance. It includes routine inspection and monitoring, upkeep and repair, testing and component replacements. Preventative maintenance expenditure increases over time as assets age.
- Corrective maintenance involves activities to repair asset defects identified as result of condition assessments or failures. Corrective maintenance expenditure increases over time as assets age and deteriorate.
- Unplanned maintenance involves activities to immediately restore supply or make a site safe in response to unplanned failures. Unplanned maintenance expenditure increases over time as asset age and deteriorate.

Power and Water employs a three yearly ground based visual inspection and an annual visual/aerial inspection cycle to assess the health of distribution switchgear. Included in this inspection is an assessment of the above ground and accessible components of the asset and associated assets. The inspection involves a judgement of condition and risk of failure based on a visual assessment and in conjunction with system performance tracking provides a pointer to potential asset integrity issues. High risk assets are prioritised for further investigation and testing.

Specific types of Distribution Switchgear require additional maintenance activities including Air Break Switches (ABS), reclosers and Magnefix. Further details of maintenance tasks and frequency are detailed in the Power Networks Asset Strategies Procedure[8].

13.5. Renewal (repex)

Asset renewal is the establishment of a new asset in response to an existing asset’s condition. The need for the renewal of existing assets is identified in the asset maintenance stage and verified in the asset planning stage. Asset renewal aims to optimise the utilisation of an asset whilst managing the safety and reliability risk associated with the failure of the asset.

Power and Water has asset replacement programs in place to renew assets of poor condition as close as possible yet prior to the asset failing.

13.6. Disposal

The decision to reuse or dispose of an asset is made with consideration of the potential to:

[8] QDOC2010/37 Power Networks Asset Strategies Procedure, Revision 4

- reuse the asset
- utilise the asset as an emergency spare
- salvage asset components as strategic spare parts

Power and Water ensures that all assets identified for disposal are disposed of in an environmentally responsible manner.