Asset Management Plan – Poletop Assets

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 are poletop assets. Poletop assets perform 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.*

Poletop assets make up 3.5% of the total replacement value of the asset base and contributes to around 6% of the total operating expenditure. The poletop assets consist of two main asset subcategories namely transmission and distribution assets. At an average age of 33 years the asset fleet is past its mid-life with 2.6%, or 1,203 assets projected to exceed the standard expected asset life of 60 years within the next regulatory period. Circa 3.9% 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 and rainfall 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 require management *– asset corrosion.*

A key asset challenge is corrosion in the Darwin region. Advanced corrosion on both transmission and distribution poletop assets have been identified. The poletop assets in the Darwin region are expected to start impacting on system reliability over the next two regulatory periods as the assets continue to deteriorate and become increasingly likely to fail. Condition data collected in recent months identified a need for investment in the replacement of transmission and distribution poletop assets. A health and criticality assessment prioritises around 319 transmission poletop assets and 8,582 distribution poletop assets. This is a considerable number of structures in need of investment.

Maturing condition data associated with poletop assets is a key asset management challenge. With few condition based functional failures observed in the network to date, poletop condition issues have generally been managed as corrective maintenance. With asset failures starting to emerge and the assets approaching the expected asset replacement life, an increased focus on the collection of corrosion and condition data and analysis are being put into effect to better support asset management decision making. Focused routine inspections and targeted methodical inspections prioritising high corrosion areas 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 poletop asset renewal programs are proposed for the next regulatory period, 2019/20 to 2023/24 to address key asset challenges:

- Transmission poletop replacement program. A replacement program targeting 310 transmission poletops. The scope of the program includes the replacement of around 90 cross-arms on 66kV poles and 220 insulator strings on 132kV towers to rectify corrosion defects.
- Distribution poletop replacement program. A replacement program targeting 790 distributon poletops is proposed for the next regulatory period. The scope involves the replacement of 429 LV and 361 HV poletop cross-arms and insulators to rectify corrosion defects.
- Pooled Poletop replacement program. The pooled program captures those poletop assets that fail in service. A total of 45 distribution poletop replacements is forecast over the 5 year regulatory period allowing for 35 insulator string and 10 cross-arm replacements. No in-service failure of transmission poletops have been projected as a result of the transmission poletop replacement program.

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 poletop asset investment programs focusing on the highest risk assets as a priority.

The investment program is summarised as follows:

Table 0.1: 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)
Transmission poletop replacements	$0.38	$0.38	$0.38	$0.38	$0.38	**$1.91**
Distribution poletop replacements	$0.43	$0.45	$0.47	$0.49	$0.52	**$2.36**
Pooled poletop replacements	$0.02	$0.02	$0.02	$0.02	$0.02	**$0.11**
Maintenance plans	$1.31	$1.31	$1.31	$1.31	$1.31	**$6.55**
Total	**$2.14**	**$2.14**	**$2.14**	**$2.14**	**$2.14**	**$10.92**

Power and Water's forecast investment in poletop assets is generally consistent with historic expenditure levels; however, there is an upward trend that is consistent with the increasing deterioration of the assets.

Based on the rate of deterioration and the targeted approach that Power and Water is adopting, it is expected that future expenditure in poletop assets will be between $0.9 million and $1.0 million per annum.

***Benefits from the investment program** – reliability improvement*

The proposed investment in poletop renewal is expected to reduce the contribution from poletop assets to system SAIDI by around 0.4%, and the SAIFI contribution with up to 0.2% over the next regulatory period.

With investment and including for growth over the next 5 year regulatory period the health and criticality profile for transmission poletop assets is 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 transmission poletop assets, a reduced risk is reflected in a 97.2% reduction in the number of poor health assets in the H3 category.

Transmission poletop health-criticality matrix (quantity) by 2023/24, with no investment

	H1	H2	H3
C1	1,632	299	
C2	204	486	155
C3	249	2	164

Transmission poletop health-criticality matrix (quantity) by 2023/24, with investment

	H1	H2	H3
C1	1,632	299	
C2	350	486	9
C3	413	2	

With investment and including for growth over the next 5 year regulatory period the health and criticality profile for distribution poletop assets is 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 poletop assets, a reduced risk is reflected in a 4.8% reduction in the number of poor health assets in the H3 category.

Distribution poletop health-criticality matrix (quantity) by 2023/24, with no investment

	H1	H2	H3
C1	5,276	716	417
C2	3,997	3,811	7,330
C3	12,583	3,269	7,829

Distribution poletop health-criticality matrix (quantity) by 2023/24, with investment

	H1	H2	H3
C1	5,264	716	429
C2	3,979	3,811	7,348
C3	13,359	3,269	7,054

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 poletop assets 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 Corporation's (Power and Water) approach to managing the life-cycle activities for poletop assets. 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 poletop 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 1-1.

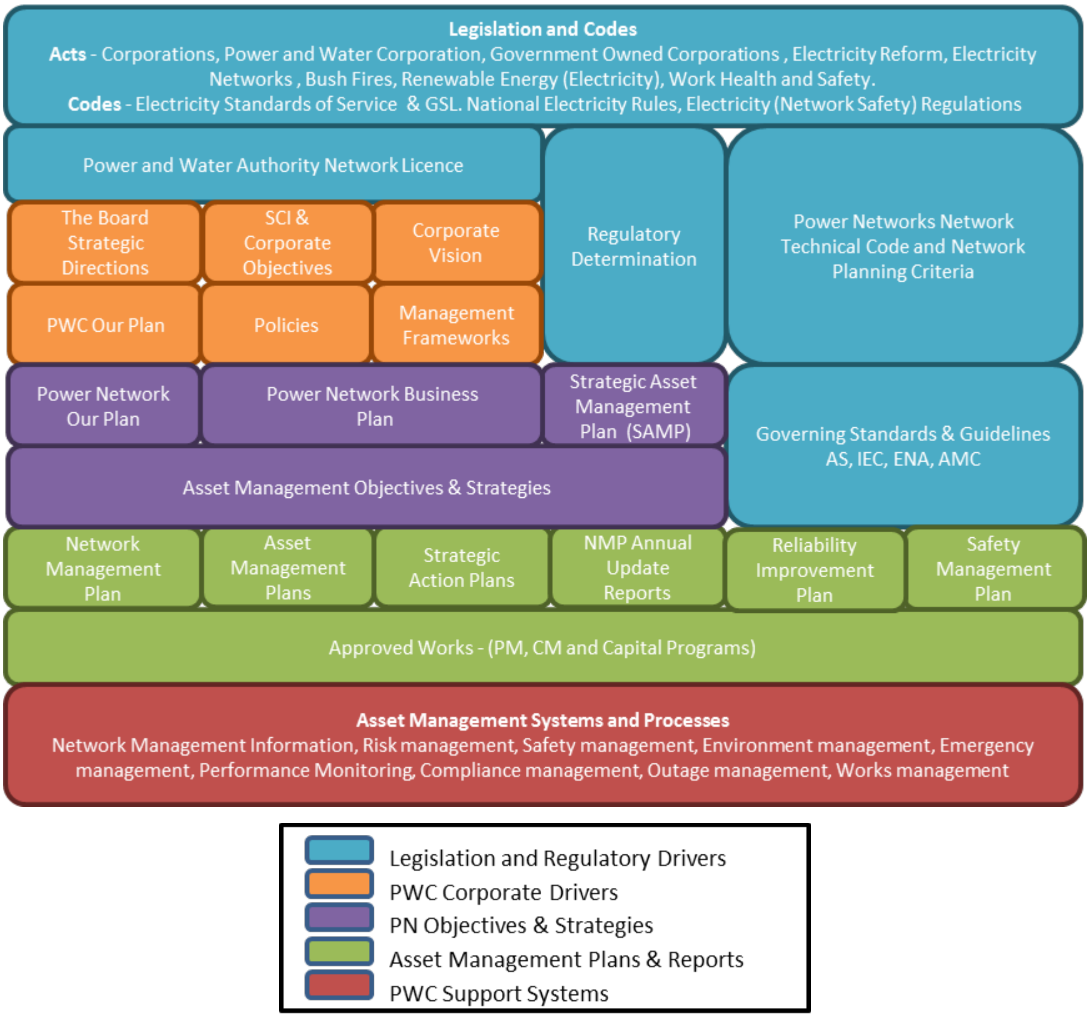

Figure 1-1: Asset management system

2 Scope and objectives

2.1 Asset class overview

In-scope assets include Power and Water's poletop (crossarm, insulator) assets. Table 2.1 provides an overview of the poletop asset class.

Table 2.1: Overview of in-scope assets

Asset type	Quantity	Voltage	Average Age	Nominal Lifespan	% exceeding lifespan in 2024	Key points
Transmission Poletops	847	132kV	28 years	60 years	0.0%	• Located in Darwin, Katherine, and Alice Springs. • Dating from the 1965s • Majority steel type • Replacement program proposed for the Darwin region over next regulatory period.
	2,344	66kV	29 years	60 years	0.0%	
HV poletops	19,917	22kV	31 years	60 years	3.3%	• Located in Darwin, Katherine, Tennant Creek, and Alice Springs. • Dating from the 1950s • Majority steel type • Replacement program proposed for the Darwin region over next regulatory period.
	5,775	11kV	37 years	60 years	1.2%	
LV poletops	17,682	415 V	37 years	60 years	3.1%	• Located in Darwin, Katherine, Tennant Creek, and Alice Springs. • Dating from the 1950s • Majority steel type • Replacement program proposed for the Darwin region over next regulatory period.
Total	46,565	66kV-415V	33 years	60 years	2.6%	• Replacement program proposed for critical poletop assets.

Note: Assets with unknown voltage levels have been allocated prorate across the HV and LV asset types

The poletop asset class make up a relative small proportion of Power and Water's asset replacement value. Although much of the network is supplied using overhead assets and the volume of these assets are significant, the monetary value of the assets is small in comparison. Currently, the poletop asset class comprise:

- 3.5% of the network by replacement value;
- 6% of operational expenditure (opex);
- 1.3% of capital expenditure (capex), including:
  - 1.7% of replacement expenditure (repex); and
  - 0.7% of augmentation expenditure (augex).

Power and Water's poletop assets are distributed throughout its network footprint which covers the NT.

2.2 Asset class function

Poletop assets are used for maintaining safe conductor-to-conductor, conductor-to-structures, and conductor-to-people/pet/stock clearances. The assets have a key function in the safe and reliable operation of the network. The function of poletop assets within Power and Water's electricity network is illustrated by Figure 2-1.

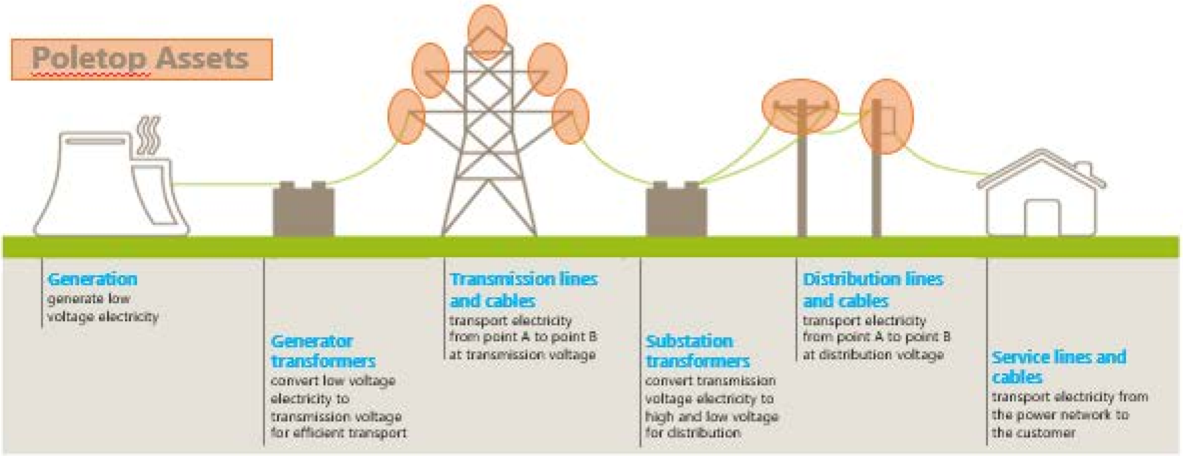

Figure 2-1: Diagram of in-scope assets

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 2-2.

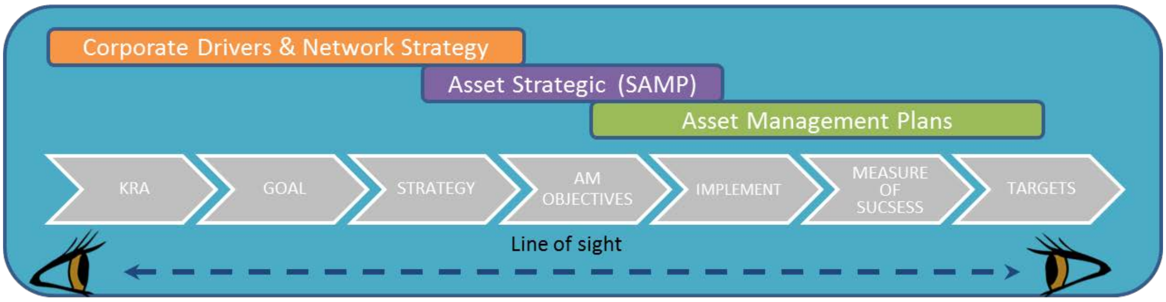

Figure 2-2: Asset Management Line of sight from Corporate and Network strategies through the Asset Management objective to the targets in the asset management plan.

Table 2.2 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 2.2: 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 • Ensure the safety of its employees and the public.	• Known conductor clearance breaches (from ground) • Vegetation clearance breaches between cutting cycles	• Total asset class specific safety incidents not exceeding 2 per annum
• 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. • 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. • Reduce network system damage and supply interruptions, particularly during storms.	• 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 5% for this asset class. • SAIFI to be no more than 3.5% 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)	• Achieved
• 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 poletop asset class is provided in Table 3.1. This defines the roles and accountabilities for each task by allocating to specific roles/personnel in Power and Water.

Table 3.1 RACI matrix for Poletops

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 3,191 transmission and 43,374 distribution poletop assets across the four regions of Alice Springs, Darwin, Katherine, and Tennant Creek, with the largest population in the Darwin Region. The elements that make up the poletop structure include the cross-arm, insulators, and fittings.

Power and Water's 132kV and 66kV transmission network consist of mainly steel poles/towers and poletops distributed across the regions of Alice Springs, Darwin and Katherine. There are no transmission assets in the Tennant Creek region. The majority, 93%, of the transmission structures are located in the Darwin-Katherine Region. The remaining 7% of transmission network structures are located in the Alice Springs region.

Distribution poletop assets are present in all regions and can be classified into Low Voltage (415V) and High Voltage (11kV, 22kV). Each distribution pole can carry multiple pole top assets, across both LV and HV, with the most on a single pole being five (2xLV + 3xHV). The majority, 78% of the distribution structures are located in the Darwin-Katherine Region. The remaining, 22% are located in the Tennant Creek and Alice Springs regions.

The pole designs applied by Power and Water consist largely of a welded steel type design, where both the pole and poletops are steel and welded together. The vast majority of the poletops, 97%, consists of steel with the remainder a mix of fibre and wood.

4.2 Asset types

An overview of the different poletop assets per voltage and region is provided in Table 4.1.

Table 4.1: Poletop Assets per region and voltage

Region	Network Category	Period of installation	Voltage levels	Challenges	Expenditure / Risk implications
Alice Springs	*Transmission*	*2011 - present*	• 66kV		
	Distribution	*1960 - present*	• 415V • 11kV • 22kV	• Identified weld defects from sample inspections	• Assets reaching end of their expected functional life (54 years) • Increased risk of physical harm and electrical shock to public and workers • Negative impact on system reliability as result of increased asset failures and reactive replacement requirements • Increasing replacement expenditure requirements
Darwin	*Transmission*	*1965 - present*	• 132kV • 66kV	• Corrosion of aged assets • Lightning damage	• Diminishing remaining life of poletops as result of progressive corrosion deterioration • Increased risk of electrical shock to public and workers • Negative impact on system reliability performance • Increasing refurbishment expenditure requirements

Region	Network Category	Period of installation	Voltage levels	Challenges	Expenditure / Risk implications
	Distribution	*1955- present*	• 415V • 11kV • 22kV	• Early surface corrosion	
Katherine	*Transmission*	*1975 - present*	• 132kV • 66kV	• As above	
	Distribution	*1950 - present*	• 415V • 11kV • 22kV	• As above	
Tenant Creek	*Distribution*	*1960- present*	• 415V • 11kV • 22kV	• As above	

4.3 Asset population analysis

A detailed breakdown of the poletop assets is provided in Figure 4-1 which presents the different asset types per region and voltage.

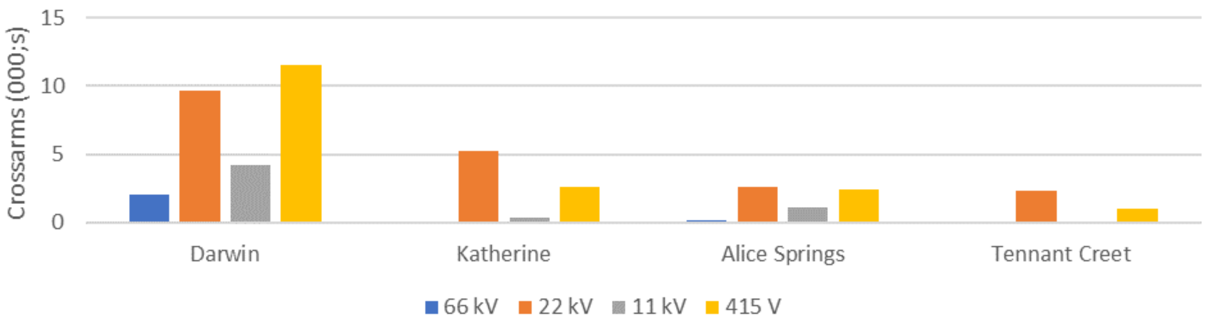

Figure 4-1: Poletop Assets per voltage and region

Figure 4-2 shows the crossarm material used in the population of poletops and it is clear that most are manufactured from steel[1]. Where the material is not known it is assumed to be steel.

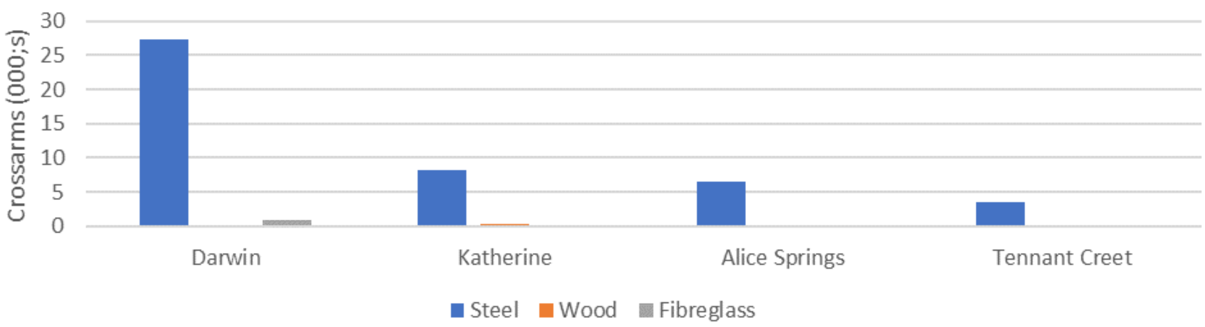

Figure 4-2: Poletop Assets per material and region

[1] Note: For poletop assets without confirmed information it was assumed that the material used was steel.

As the poletop assets form an integral part of the distribution pole assets, Figure 4-3 shows a breakdown of pole types on which the poletop assets are installed, by voltage level.

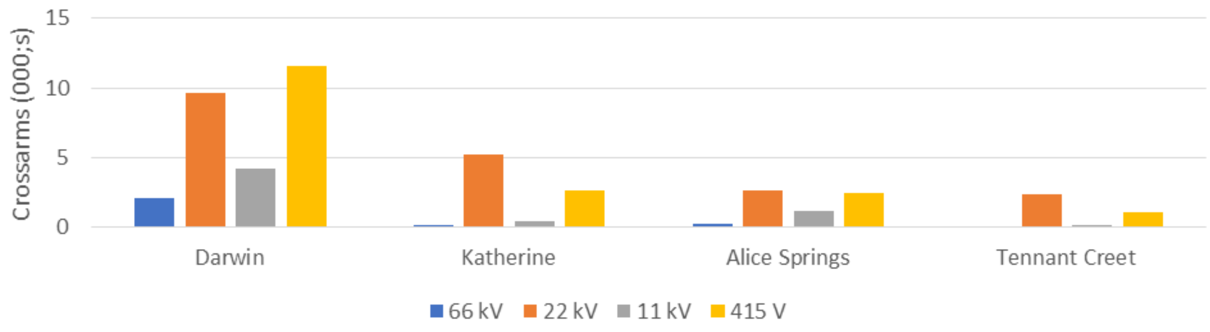

Figure 4-3: Poletop assets by voltage

4.4 Growth profiles

4.4.1 Transmission

As can be seen from Figure 4-4, most of the Darwin and Katherine installations took place during the 1970's and 1980's with ongoing installations in Darwin after that. The Alice Springs transmission assets were installed in the last 7 years. The installations in the mid-1970s were the result of strong growth in the region during that period and the impact from Cyclone Tracy that took place in December 1974. Large portions of the network had to be rebuilt following the cyclone under the auspices of the Darwin Reconstruction Commission. With this asset class having a standard asset life of 60 years it is anticipated that relatively few end of life asset replacements will be required over the next regulatory period.

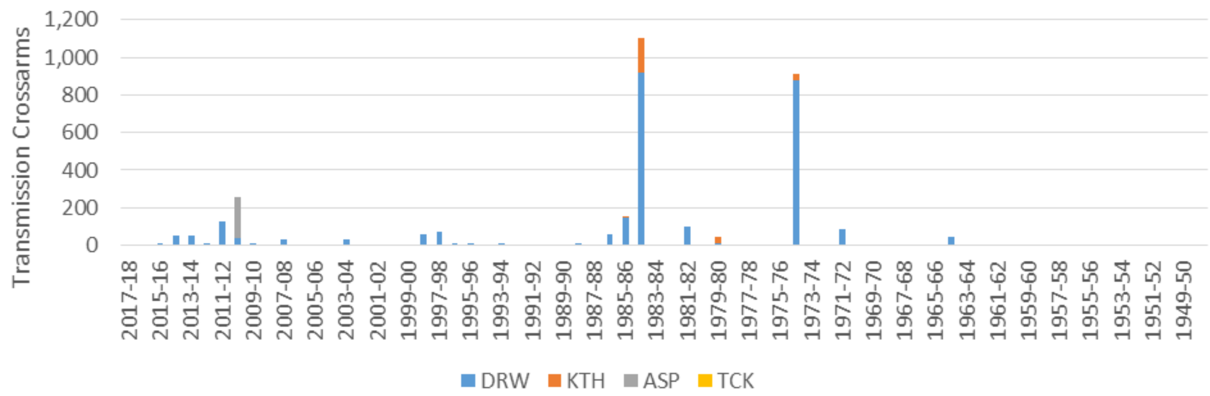

Figure 4-4: Transmission poletop assets by age and region

4.4.2 HV Distribution

Figure 4-5 shows large quantities of HV installations took place during the mid-1970s and mid-1980s. There was also a period of moderate growth in the late 2000's. The installations in the mid-1970s were due to network expansion during 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. At a glance, with this asset class having a standard asset life of 60 years it would seem that minor asset replacements will be required over the next regulatory period based on lifespan only.

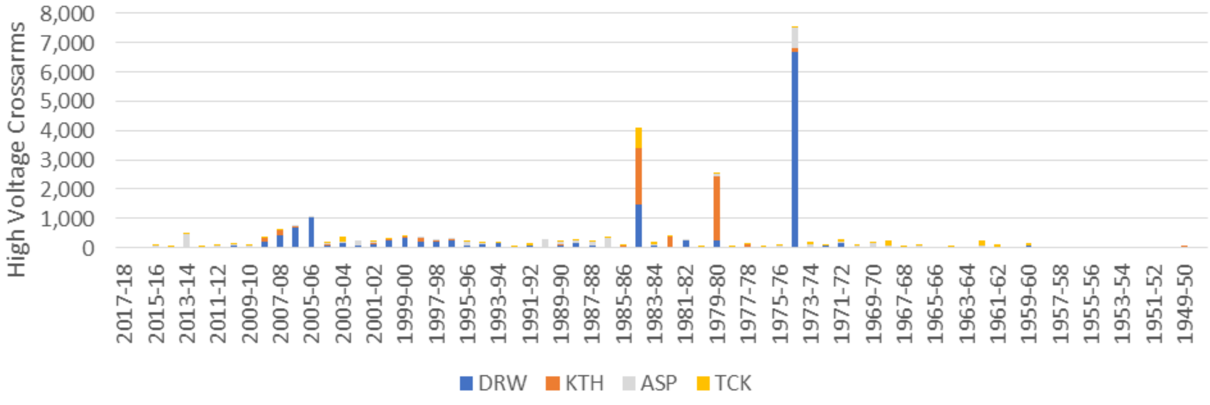

Figure 4-5: HV Distribution poletop assets by age and region

4.4.3 LV Distribution

Similar to the HV installations, large quantities of LV installations took place during the mid-1970s and mid-1980s. The installations in the mid-1970s, were due to network expansion during 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. At a glance, with this asset class having a standard asset life of 60 years it would seem that minor asset replacements will be required over the next regulatory period based on lifespan only.

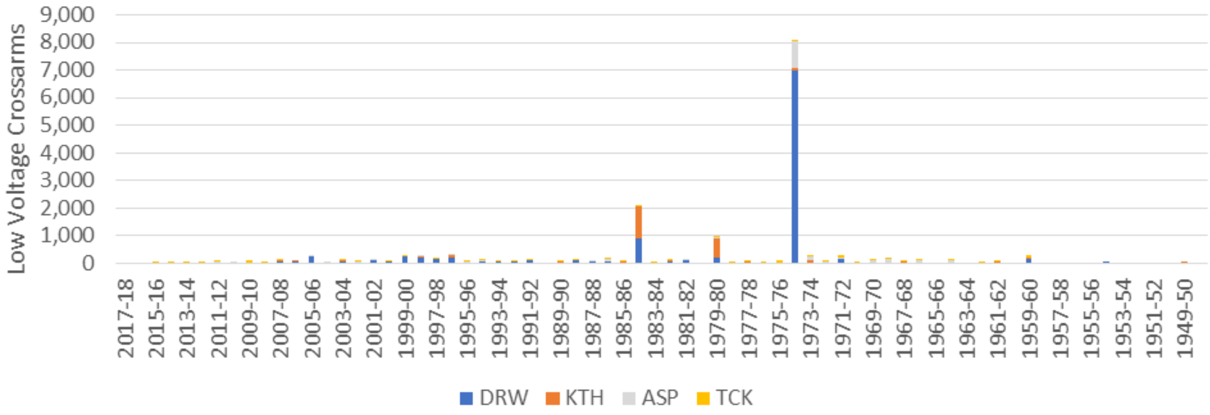

Figure 4-6: LV Distribution poletop assets by age and region

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 60 years was applied to the poletop assets. It corresponds with the economic replacement life of steel poles applied by Power and Water in asset valuations. Experience indicates that crossarms generally achieve shorter lives than poles, however insufficient information is currently available to quantify a typical replacement life for steel crossarms across the NEM. The asset life compares with steel pole and tower asset lives observed across the NEM as demonstrated in Figure 4-7.

The comparatively high asset life is reflective of a low failure rate averaging 0.02% of the poletop population per annum[2]. The Power and Water asset base is fairly young and with insufficient data available across the NEM to make a valid assessment, the adopted asset life seems reasonable. As the poletop assets continues to age the failure rates are expected to increase and more industry data is expected to become available. At this time the standard asset life may need to be reassessed.

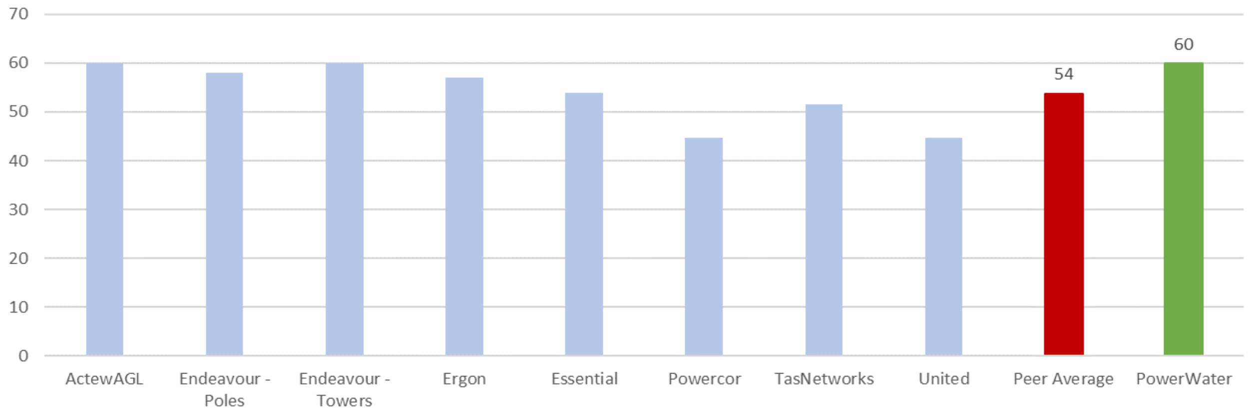

Figure 4-7: Steel pole and tower replacement life

[2] Pooled asset replacement program forecast model

4.4.5 Age profiles

The transmission pole/tower and poletop age profile shows a relatively young asset base. There are no transmission assets that currently exceed the replacement life of 60 years. During the next two regulatory periods, around 1.6% of the Darwin assets are projected to exceed the industry standard asset life. No assets in the other regions will reach the replacement life before 2029.

The Darwin transmission assets are a particular concern. These assets make up 85.4% of the total transmission structure population and although none have reached their replacement age, asset condition issues related to corrosion are starting to emerge. This deterioration in asset condition is expected to have an increasing impact on system reliability over the next two regulatory periods.

Table 4.2: Transmission poletop average age and remaining life

Region	Weighted Average Age (years)	Weighted Average Remaining Life (years)	% of asset population	% exceeding replacement life in 2017	% approaching replacement life by 2024	% approaching replacement life by 2029
Alice Springs	6.0	54.0	6.8%	-	-	-
Darwin	32.0	28.0	85.4%	-	-	1.6%
Katherine	33.9	26.1	7.8%	-	-	-
Tennant Creek	-	-	-	-	-	-
All regions	**30.4**	**29.6**	**100.0%**	**-**	**-**	**1.4%**

The distribution poletop age profile shows a rapidly aging asset base with 18% of Tennant Creek and 6.5% Alice Springs assets projected to exceed the standard asset life of 60 years within the next two regulatory periods.

The Darwin distribution assets are a particular concern. These assets make up 58.8% of the total distribution poletop population and although only a small percentage have reached their replacement age, asset condition issues related to corrosion are starting to emerge. This deterioration in asset condition is expected to have an increasing impact on system reliability over the next two regulatory periods.

Table 4.3: Distribution poletop average age and remaining life

Region	Weighted Average Age (years)	Weighted Average Remaining Life (years)	% of asset population	% exceeding replacement life in 2017	% approaching replacement life by 2024	% approaching replacement life by 2029
Alice Springs	32.2	27.8	14.1%	0.0%	1.1%	6.5%
Darwin	33.6	26.4	58.8%	0.4%	1.6%	1.9%
Katherine	33.2	26.8	19.0%	1.4%	3.0%	3.3%
Tennant Creek	36.5	23.5	8.0%	0.0%	14.1%	18.0%
All regions	**33.5**	**26.5**	**77.9%**	**0.7%**	**1.9%**	**2.3%**

4.4.6 Transmission poletops – Age profiles by region

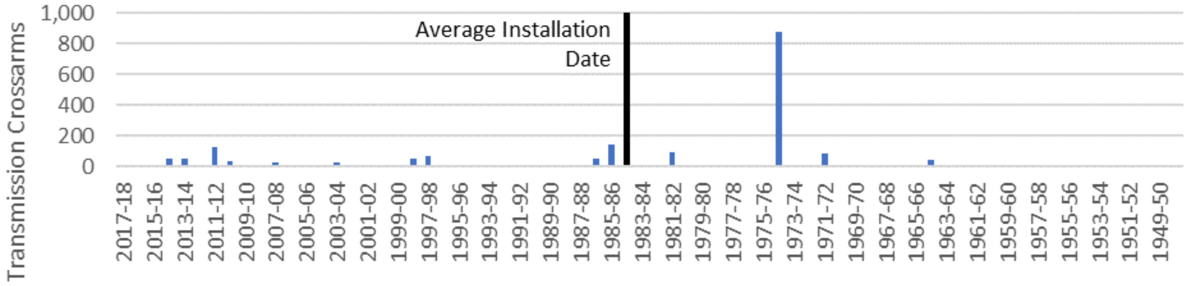

Figure 4-8: Darwin – Transmission poletop age profile

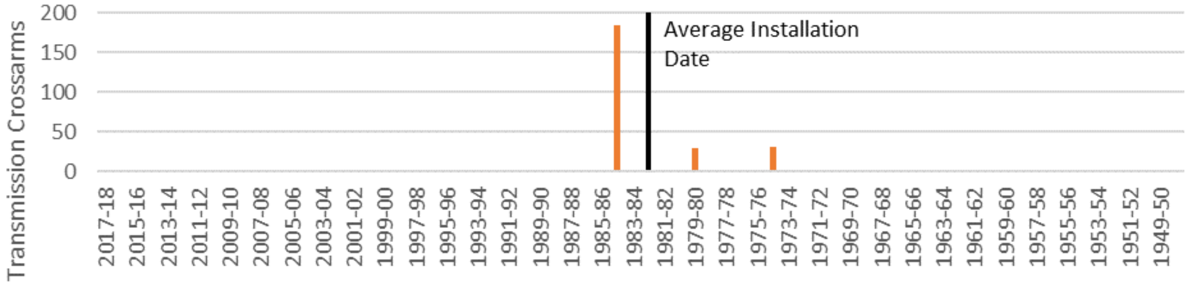

Figure 4-9: Katherine – Transmission poletop age profile

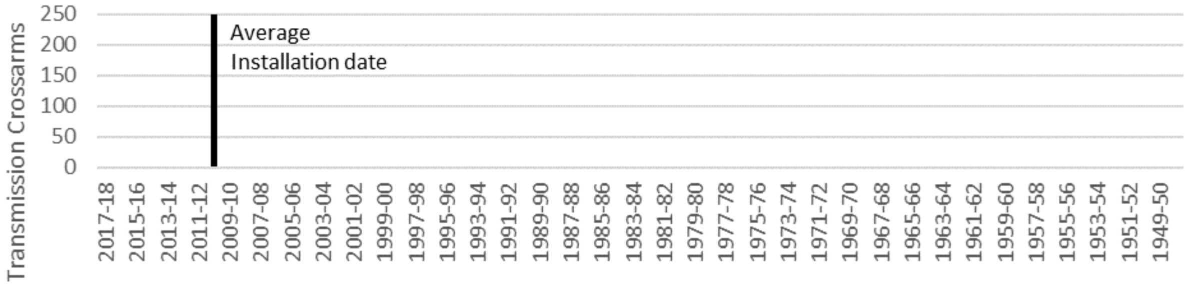

Figure 4-10: Alice Springs – Transmission poletop age profile

4.4.7 HV Distribution poletops – Age profiles by region

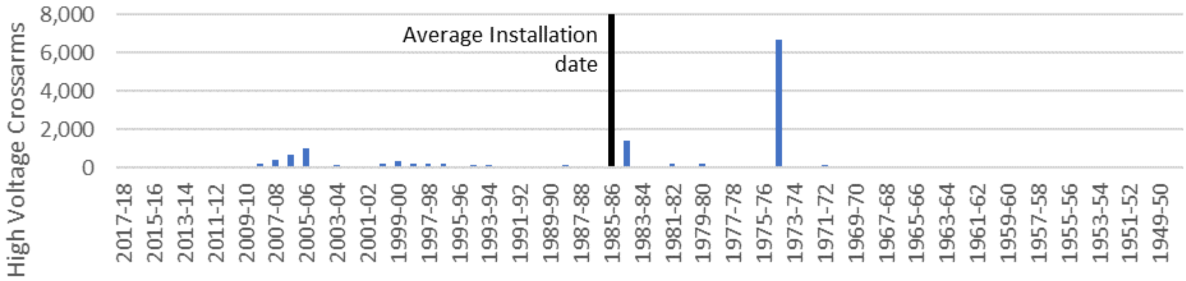

Figure 4-11: Darwin – HV Distribution poletop age profile

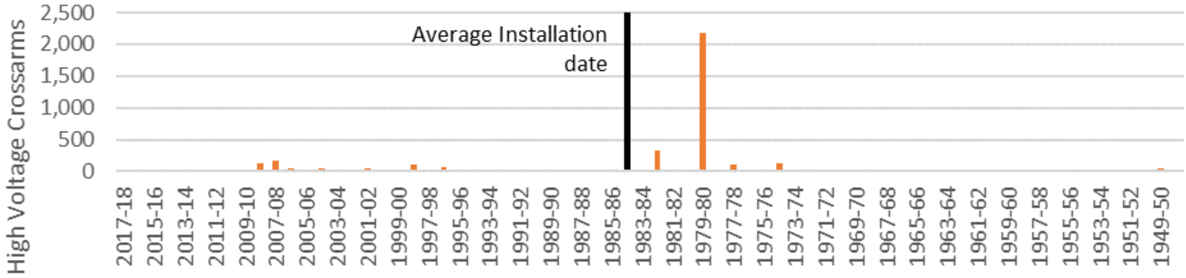

Figure 4-12: Katherine – HV Distribution poletop age profile

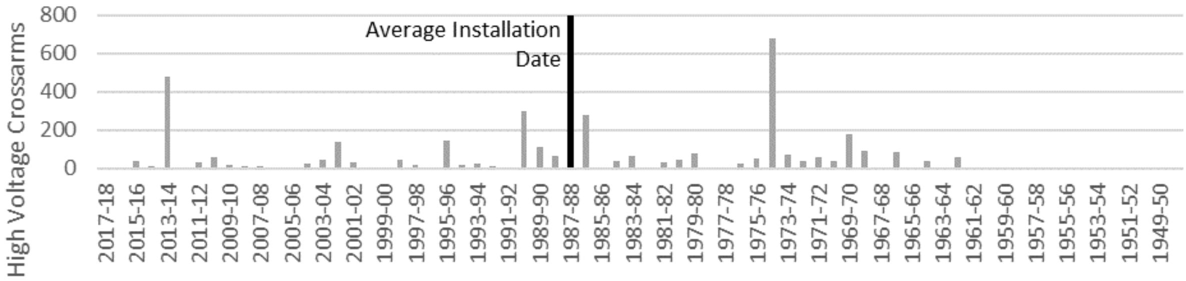

Figure 4-13: Alice Springs – HV Distribution poletop age profile

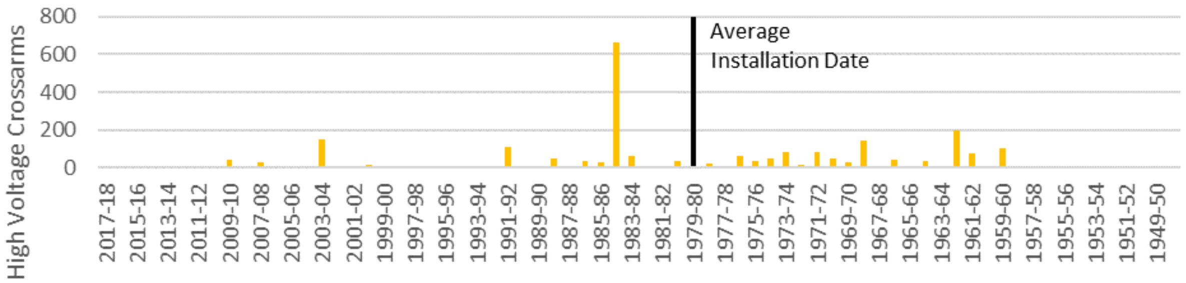

Figure 4-14: Tennant Creek – HV Distribution poletop age profile

4.4.8 LV Distribution poletops – Age profiles by region

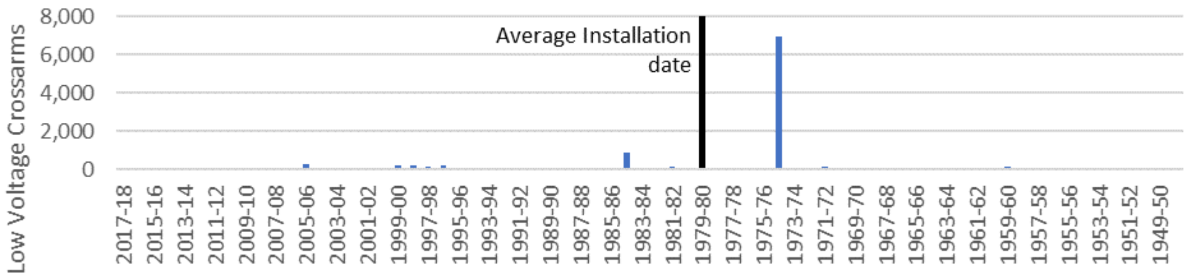

Figure 4-15: Darwin – LV Distribution poletop age profile

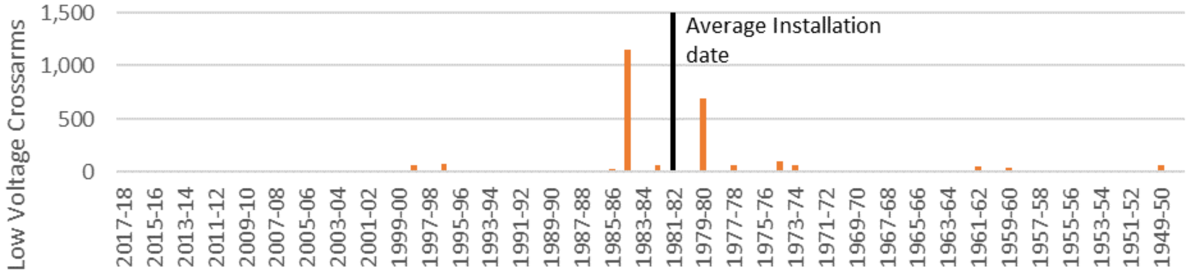

Figure 4-16: Katherine – LV Distribution poletop age profile

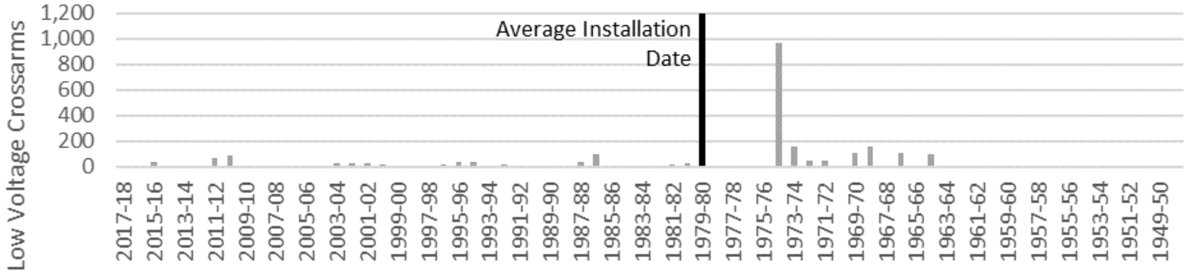

Figure 4-17: Alice Springs – LV Distribution poletop age profile

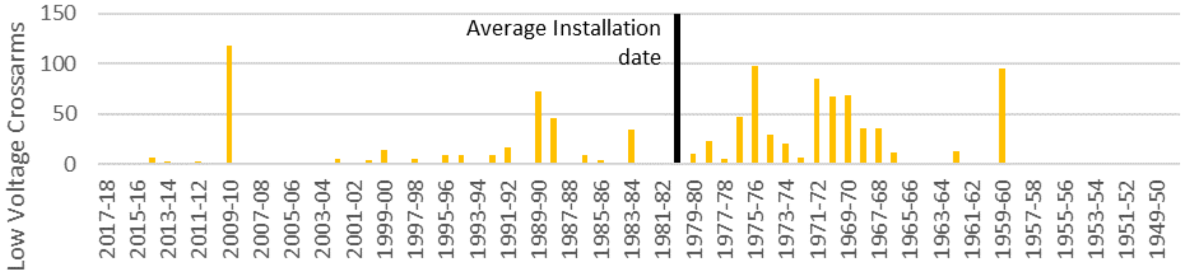

Figure 4-18: Tennant Creek – LV Distribution poletop age profile

5 Health and criticality profiles

5.1 Asset 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 its 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[3] provides the basis for calculating the risk associated with the poletop 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 poletop assets.

The health and criticality indices developed for poletops establishes the context of the risk associated with these assets and defines the parameters that influences 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.

[3]D2018/72550 Asset Heath and Criticality Method

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.

Poletops have a key safety function within the electrical network, maintaining safe conductor-to-ground/structure clearances. The risk associated with the functional failure of poletops is physical and electrical harm to the public and to Power and Water employees that traverse the power network daily. Poletops also contribute to the reliability of the electrical network. The reliability risk associated with the functional failure of poletops is system outages impacting large quantities of customers.

5.1.1 Asset health

The underlying failure mode for poletops is mechanical fatigue resulting from corrosion and leading to a deterioration in the asset health, and ultimately the functional failure, or collapse of the asset. The deterioration in asset health is accelerated by factors such as design defects, third-party impacts, and damage during severe weather events. The main failure modes observed on the poletop assets are summarised in Table 5.1.

Table 5.1: Poletop failure modes

Failure mode	Description
Corrosion	Structural degradation and mechanical fatigue as result of corrosion ultimately leading to poletop failures. Corrosion can affect crossarms, fittings, insulators, etc.
Structural damage	Structural degradation and mechanical fatigue as result of vehicles colliding with a pole or tower, debris strikes, and wind force during severe storm events ultimately leading to poletop failures
Insulator Failure	Failure of insulators due to cracking or contamination. Cracking can be caused by impact damage, mechanical stress (overtightening, conductor tension, bolt/ball corrosion) and lightning. Modern insulator materials are generally less susceptible to these failure mechanisms.
UV/Exposure Damage	Timber crossarms are subject to additional ageing mechanisims including timber rot. Fibreglass or composite materials are also susceptible to UV damage if protective coatings are inferior, causing delamination. While this hasn’t been found to affect structural integrity, it causes health and safety issues when working on or handling damaged arms.

Power and Water assesses and records asset condition during routine inspections, as part of other works in the vicinity, and through targeted methodical inspections and testing.

- Routine inspections done by Power and Water on poletops in the Darwin region are finding an increase in the number of advanced corrosion issues. Inspection criteria are currently being adapted to more accurately capture poletop condition data to allow for trending analysis.
- The *AS/NZS 2312 - Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the Use of Protective Coatings*, and a study on corrosion rates developed by

Wattyl Industrial Coatings in 2004 (*GUIDE TO AS/NZS 2312:2002*) provided guidance on the disparate corrosion related issues observed by Power and Water in the power network. The coastal area of Darwin is identified as an area subject to higher corrosion rates, whereas the inland areas of the power network are subject to relatively lower expected corrosion rates.

The outcomes of the inspections and studies mentioned above have been used to inform the poletop asset health segregation. Where insufficient data was available asset age, or remaining life was used as a proxy for asset health.

Recent fault rates, test results, and corrosion rates based on AS/NZS 2312 were used to assess the probability of asset failure across the individual asset health categories. The method and approach applied to the transmission and distribution poletop assets are discussed in more detail in the sections below.

5.1.2 Asset criticality

The poletop assets contribute to both the reliability and safety risk 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 duration and frequency of outages resulting from asset failures, and is linked to the number of customers impacted by an outage.

The criticality of the poletop assets within the network has in the first instance been based on the expected contribution to the system reliability risk resulting from asset failure. Where appropriate and based on specific inspection and test data, the criticality level for particular assets may have been adjusted to reflect the higher level of understanding and or contributions to public and worker safety risk. Any adjustments that may have been included are discussed in the sections below.

5.2 Transmission poletops

For transmission poletops the asset **health** segregation has been based on corrosion zones and asset age. Assets in higher corrosion zones and older age were assigned a poorer health whereas assets in lower corrosion risk areas, and younger age were allocated a better health score. The health segregation adopted a three-point health index scale used to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. The approach is described in the Asset Health and Criticality Method discussion paper. The criteria applied to allocate a health score are provided in Table 5.2. Assets with unknown ages were assigned to the highest health category, H1.

Table 5.2: Transmission poletop health indices criteria

Health score	Description	Criteria
H1	Good	Outside of Darwin region
H2	Average	In Darwin region & between 5 and 15 years remaining life
H3	Poor	In Darwin region & less than 5 years remaining life

Line inspections undertaken in 2016 and 2017 identified consistent advanced poletop corrosion on parts of the 132kV feeders between Channel Island Power Station and Hudson Creek Terminal Station (CI-HC Line A and B), and on the 66kV Weddell Power Station to Strangways Zone Substation (66 WD-SY) transmission line. These assets have been allocated a poor health, H3 based on the inspection findings.

Criticality ratings have been assigned at feeder level based on the impact of contingencies on the security of supply and system loading conditions as shown in Table 5.3. A workshop involving key Power and Water planning and asset management personnel as well as external expertise were undertaken to assess the relative criticality of transmission feeders. The main criteria included an assessment of contingencies resulting in radialisation of the network, system overload conditions, and system critical supply feeders.

Table 5.3: Transmission poletop criticality criteria

Criticality score	Radialisation criteria	Overload Criteria
C1	No radialisation	No overload
C2	System radialisation	Exceed normal rating but not contingency rating
C3	Power station link	Exceed emergency rating

The transmission poletop asset health and criticality profile is provided in Table 5.4. It prioritises around 319 structures in the red and orange zone as being of poor health and higher criticality.

Table 5.4: Transmission poletop health-criticality matrix (quantity)

	H1	H2	H3
C1	1,910		
C2	717		155
C3	245		164

The asset health and criticality is a function of time and is expected to change as the assets continue to age. With no investment over the next 5 year regulatory period and with no growth expected in the number of transmission poletops over this period, the profile is expected to change to that shown in Table 5.5. The increase in risk is demonstrated in the increase in the number of assets that entered the H2 health category.

Table 5.5: Transmission poletop health-criticality matrix (quantity) with no investment

	H1	H2	H3
C1	1,632	299	
C2	204	486	155
C3	249	2	164

5.3 Distribution poletops

The asset **health** segregation of the distribution poletops has been based on corrosion zones and age. A replacement life of 60 years was applied for distribution poletops.

Based on *AS/NZS 2312 - Guide to the Protection of Structural Steel Against Atmospheric Corrosion by the Use of Protective Coatings*, and a study on corrosion rates developed by Wattyl Industrial

Coatings in 2004 (*GUIDE TO AS/NZS 2312:2002*) the coastal areas of Darwin have been identified as being subject to a higher corrosion rates than inland areas. Investigations undertaken in 2016 and 2017 found an emerging issue of advanced corrosion of poletop assets in the Darwin area. At an average age of 34 years these advanced corrosion issues are unexpected and indicative of a potential shorter asset life for the assets in the Darwin region.

Poletop assets in the Darwin region have therefore been assessed based on a shorter asset life. Assuming a normal distributed failure rate and allowing for one standard deviation an asset life of 50 years was applied. This asset life would be commensurate with emerging failures being observed now. Assets outside the Darwin region have been assessed using the standard asset life of 60 years and adopting the three-point health index scale used to categorise assets in terms of their expected remaining life where conditional factors were not evident to suggest a different segregation. The approach is described in the Asset Health and Criticality Method discussion paper.

The criteria applied to allocate a health score are provided in Table 5.6. Assets with unknown remaining lives were assigned a good health score, H1.

Table 5.6: Distribution poletop health indices criteria

Health score	Description	Criteria
H1	Good	Outside Darwin region: 60 years asset life and more than 15 years remaining life In Darwin region: 50 years asset life and more than 15 years remaining life
H2	Average	Outside Darwin region: 60 years asset life and between 5 and 15 years remaining life In Darwin region: 50 years asset life and between 5 and 15 years remaining life
H3	Poor	Outside Darwin region: 60 years asset life and less than 5 years remaining life In Darwin region: 50 years asset life and less than 5 years remaining life

Asset criticality across the asset class was allocated in the first instance based on the customer density as approximated by the feeder categorisation. Based on good historical performance and a high level of system redundancy CBD feeders were allocated to C1. Relative low historical performance resulted in short rural feeders being allocated to C3. The underlying criteria applied in allocating poletop asset criticality are provided in Table 5.7.

Table 5.7: Distribution Poletop criticality criteria

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

The distribution poletop asset health and criticality profile is provided in Table 5.8. It prioritises around 8,582 structures in the red and orange zone as being of poor health and higher criticality.

Table 5.8: Distribution poletop health-criticality matrix (quantity)

	H1	H2	H3
C1	5,298	503	229
C2	6,206	8,143	345
C3	14,413	7,961	276

With no investment over the next 5 year regulatory period and excluding growth, the profile is expected to change to that shown in Table 5.9. The increase in risk is demonstrated in the increase in the number of assets that entered the H3 health category. For the distribution poletop assets an increase in risk is reflected in a 94.5% increase in the number of low health assets. This step increase is indicative of the rapid deterioration projected for the Darwin assets.

Table 5.9: Distribution poletop health-criticality matrix (quantity) with no investment

	H1	H2	H3
C1	4,897	716	417
C2	3,553	3,811	7,330
C3	11,552	3,269	7,829

6 Key challenges

6.1 Environmental challenges

The network covers a range of environments and geographies which present different challenges for the poletop asset class. Table 6.1 provides an overview of environmental challenges in relation to managing Power and Water's poletop assets across its four operating regions.

Approximately 80% of Power and Waters network is coastal tropical environments prone to cyclones, monsoons, high ambient temperatures and humidity, and high annual rainfall. The remainder of the network is desert environments subject to high ambient temperatures, occasional flooding, droughts, dust storms, and aggressive soil conditions.

The unique environment results in a more rapid rate of asset deterioration, and lower worker productivity compared to peer distribution businesses.

The harsh climatic environment has required Power and Water to standardise on the use of steel poles and crossarms to mitigate the safety and reliability risks associated with accelerated degradation and damage of wood crossarms.

Climate change is also expected to further exacerbate the environmental conditions over time, resulting in increased asset damage and failure from increase quantity or/and severity of cyclones, storms, lightning activity, dust storms, and droughts.

These factors impact uniquely on the Power and Water network and assets.

Table 6.1: Environmental challenges in relation to poletop 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 (eg. 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

Region	Environment	Challenges	Expenditure / risk implications
Darwin	Coastal / Tropical	• Cyclones • Up to 21,924 lightning strikes per year (Global Position And Tracking Systems (GPATS) - 2007 to 2017 Data) • 6-8 Ground strikes per km^2 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	• Hot and humid environment leading to heat related stresses and reduced productivity • Extreme weather events (eg. cyclones, flooding) • Increased asset damage and failure from increased quantity or/and severity of storms and lightning related to climate change • Transmission poletop replacement program • Distribution poletop replacement program
Katherine	Inland / Tropical	• Tropical storms and lightning • High corrosion rates	• 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 investment programs planned
Tenant 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 investment programs planned

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.

2) Asset design

The key operational challenge related to poletop assets is the unique design of the distribution and transmission poles. The Power Network distribution and transmission poles are largely of a welded steel type design, i.e. both the pole and crossarms are of steel and welded together. The design calls for additional equipment, resourcing, and outage times to allow for the placement and removal of crossarms during poletop replacements.

This challenge significantly adds to the reliability measures for the assets class. An escalation in asset failure is likely to significantly impact the reliability measures of the asset class, and significantly increase the risk associated with public and worker safety.

Development of efficient procedures, including live line, to reduce the planning effort and customer impact associated with poletop replacements is an area of focus due to the expected increasing rate of intervention as the asset class ages.

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

Table 6.2 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 6.3 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 6.3 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 6-1. 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.

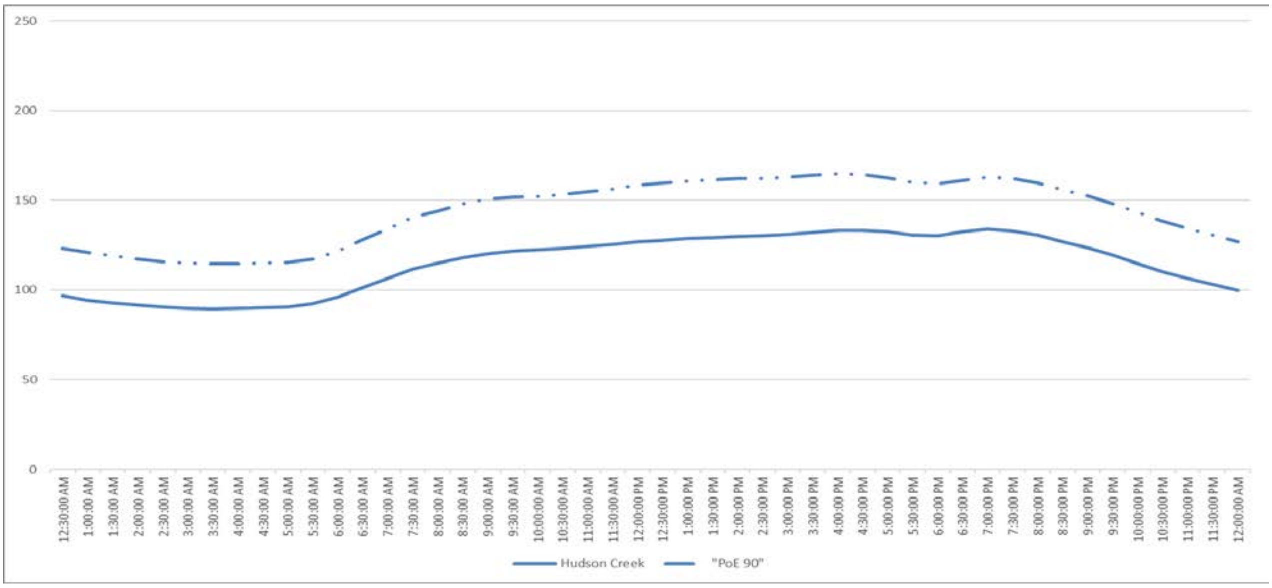

Figure 6-1 Darwin average daily demand profile (Hudson Creek ZSS) May to October

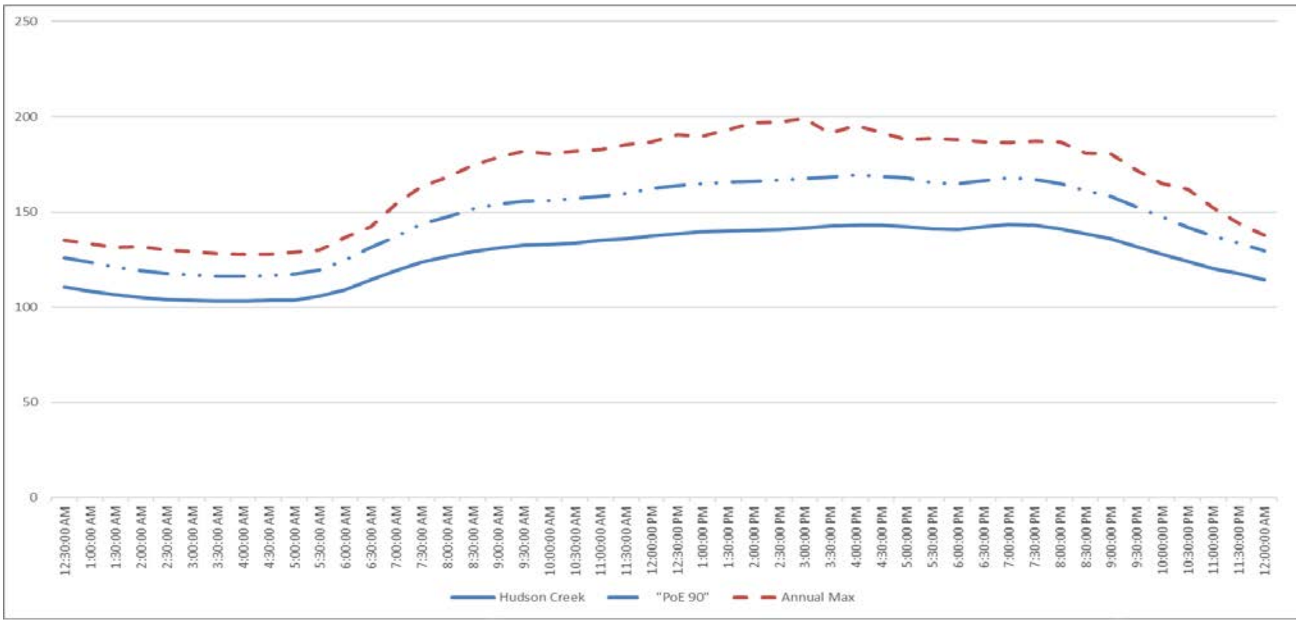

Figure 6-2 Darwin average daily demand profile (Hudson Creek ZSS) November to April

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

5) Seasonal and fauna 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[4] as measured by the Bureau of Meteorology (BOM) over a 77 year period from 1941.

Figure 6-3 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 poletop 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 poletop asset failure profile shows a lagging correlation between poletop failures and the seasonal climate conditions. An increase in asset failures and replacements are observed following the time periods when environmental factors present the most damaging weather conditions. Animal movements and nesting also have an increasing impact during the dry season when temperatures are lower and migration events occur for some bats and birds. Poletop designs have evolved over time to reduce the impact of animals however some forms of animal protection utilised have also caused asset damage.

As climate conditions continue to change a corresponding increase in poletop 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.

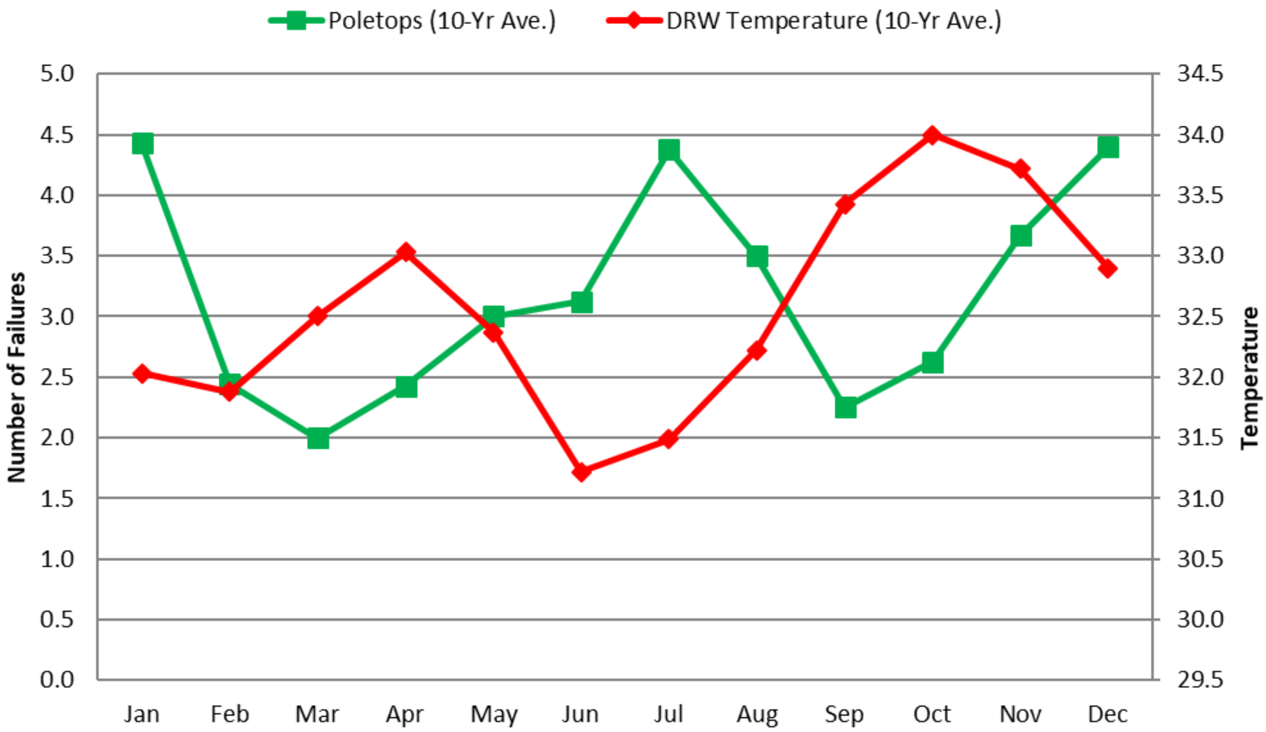

Figure 6-3: Average annual temperature and poletop asset failure profile

6.3 Asset challenges

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

The health of poletop assets are uniquely challenged in the Power and Water network. The key underlying issue relate to corrosion. The poletop assets in the Darwin region are subject to a high corrosion environment.

This underlying factor is a key consideration in the following asset challenges identified in the transmission and distribution overhead networks.

6.3.1 Transmission Poletops

1) Transmission Line Poletop corrosion

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

- NMP20 - Transmission Line Poletop Replacement Program

Line inspections undertaken in 2017 identified consistent advanced corrosion on the 132kV feeders between Channel Island Power Station and Hudson Creek Terminal Station (CI-HC Line A and B). Particularly affected were sections of line between Channel Island and the Elizabeth River involving approximately 70 towers that traverse inter-tidal mangrove areas. The failure mode associated with the corrosion issue is the mechanical failure of the insulator string, either due to the loss of steel section, or the corrosion affecting the grout which bonds the pin to the insulator.

Feeder inspections completed in 2016/17 identified areas of advanced crossarm corrosion particularly on the 66kV Weddell Power Station to Strangways Zone Substation (66 WD-SY) transmission line. The aged assets on this line were noted as having particularly advanced levels of corrosion. The crossarm construction is unique in that hollow box section steel was used and not galvanised. This is thought to be creating a “micro-environment” inside the sections due to the humid conditions allowing corrosion to advance at a higher rate than observed on “Angle” or “Channel” section steel generally used elsewhere on the network.

A replacement program targeting 310 transmission poletops is proposed for the next regulatory period. The scope involves the replacement of around 90 crossarms on 66kV poles and 220 insulator strings on 132kV towers to rectify corrosion defects.

6.3.2 Distribution Poletops

2) Distribution Line Poletop corrosion

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

- NMP18 – Darwin Coastal Poletop Corrosion Replacement Program

An emerging issue associated with damaged and breaking HV and LV crossarms has been identified, particularly in the coastal region of Darwin. These assets are starting to show signs of advanced corrosion defects. Routine inspections aimed at the early identification of asset condition issues has been found to be ineffective when assessing corrosion degradation and the remaining mechanical strength in poletop structures. In most cases it is only when severe material decay becomes visible that an assessment is made. This advanced stage of deterioration is preceded by a gradual decay in mechanical strength that is not easily identifiable during routine inspections and carries a high risk.

A replacement program targeting 790 HV and LV distribution poletops is proposed for the next regulatory period. The scope involves the replacement of 429 LV and 361 HV crossarms and insulators to rectify corrosion defects.

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 poletop assets.

Improvement in the processes for and quality of data collection is a key focus is are 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 poletop assets is also being investigated through post failure assessments and testing.

The unique pole and integrated poletop design and widely varying environmental factors associated with the Power Network assets does not allow for easy benchmarking and learnings from industry peers. Particular techniques to assess the condition and remaining life of steel crossarm assets is a key challenge and is currently being investigated.

7 Performance indicators

The performance of poletops 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[5]

The historical performance impact from poletop assets over the last 10 years is provided in the figures below.

[5] NT regulated system performance excluding instantaneous and major event days. Other excluded events include: Planned outages, Generation-related outages, Outages that were internal to customer premises, Outages initiated in the interest of public safety.

The transmission poletop performance over the last 10 years is provided in Figure 7-1. Transmission poletop outages are very rare and there are zero outages some years. The low rate of outages is forecast to continue into the future.

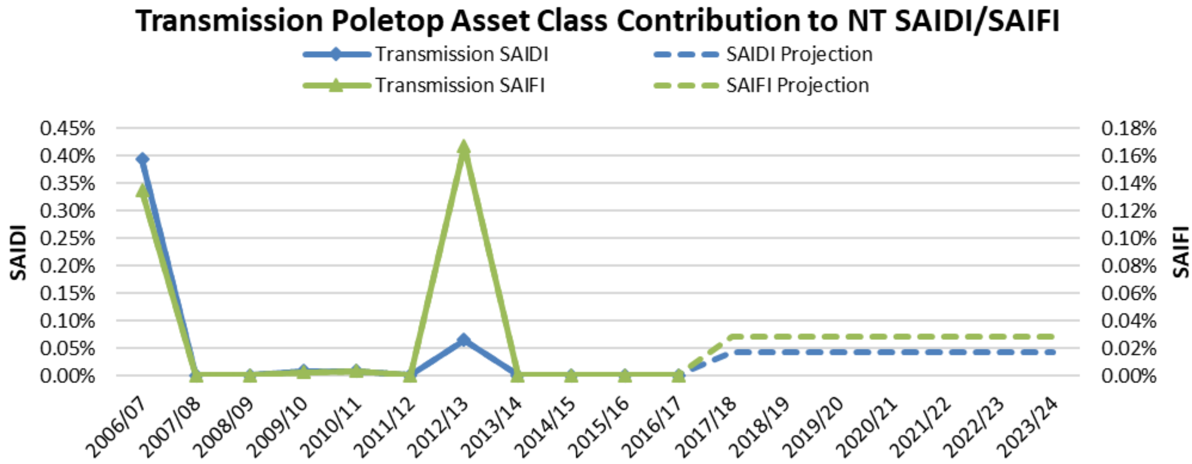

Figure 7-1: Transmission poletop contribution into SAIDI/SAIFI

The distribution poletop performance over the last 10 years is provided in Figure 7-2. Distribution poletop outages peaked with a contribution of around 12% of SAIDI in 2009/10. The SAIDI contribution is much higher than SAIFI, indicating outage events caused by distribution poletops last longer than the average outage event. Over the last 10 years outages have been steady but there is a lot of year-to-year variation so SAIDI and SAIFI are forecast to be flat at the long-term average level.

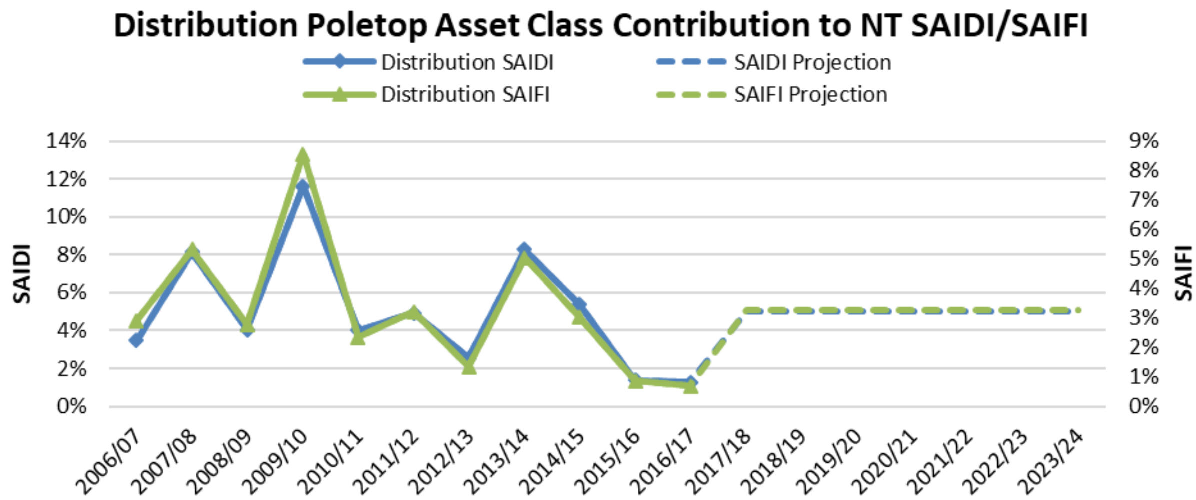

Figure 7-2: Distribution poletop contribution into SAIDI/SAIFI

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 poletop assets as recorded over the last 10 years is shown in Table 7.1. There were no recorded incidents for transmission poletop asset over this period. Safety-related incidents include those outages which were caused by vehicle collision with Power and Water assets, public safety-related outages requested by emergency services, and house fires.

Table 7.1: Number of safety-related incidents associated with distribution poletops

Financial Year	Number of Outages	Comment
2006/07	1	Incident - Third Party
2007/08	3	Incident - Third Party
2012/13	1	Outage in the interest of Power and Water worker safety
2014/15	2	Incident - Third Party
		Outage in the interest of Power and Water worker safety

7.3 Financial Performance indicators

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

The capital expenditure forecast for poletop 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 transmission poletops, i.e. insulators and crossarms, are provided in Figure 7-3. In comparison with peer averages observed across the NEM Power and Water's insulator replacement costs meets the NEM average and the crossarm replacements appears high. The higher crossarm replacement cost may be affected by the low volumes of historic replacements; both by the reduced economies of scale when undertaking replacements and the volatility of the unit rates based on a small sample size. Taking into consideration the unique asset design, the transmission poletop replacement unit costs are considered reasonable.

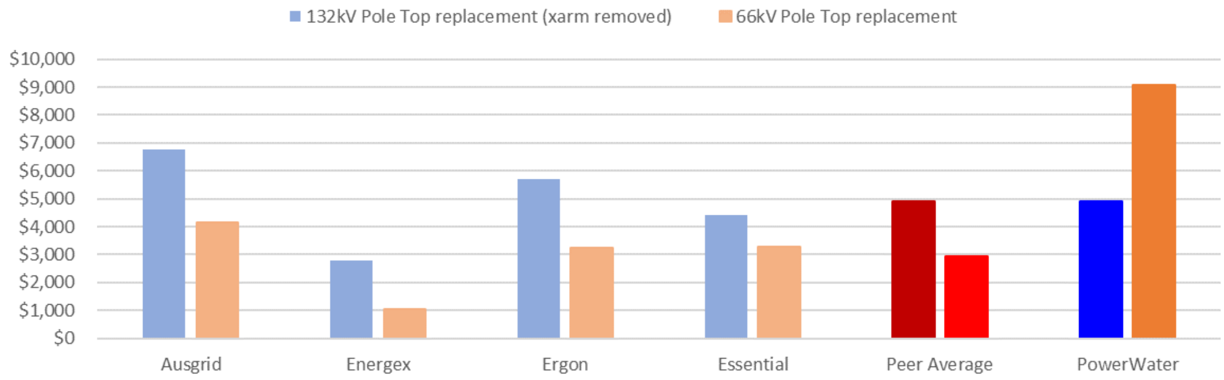

Figure 7-3: Transmission poletop replacement Unit cost comparison

Power and Water's unit cost for the replacement of distribution, i.e. LV and HV poletops, are provided in Figure 7-4. In comparison with peer averages observed across the NEM Power and Water's LV and HV poletop replacement costs are in the upper range of the NEM costs. Similar to transmission, the higher poletop replacement costs reflects the unique welded design of the steel poles that require additional equipment, resourcing, and outage times to allow for the placement and removal of crossarms. Taking into consideration the unique asset design, the distribution poletop replacement unit costs are considered reasonable.

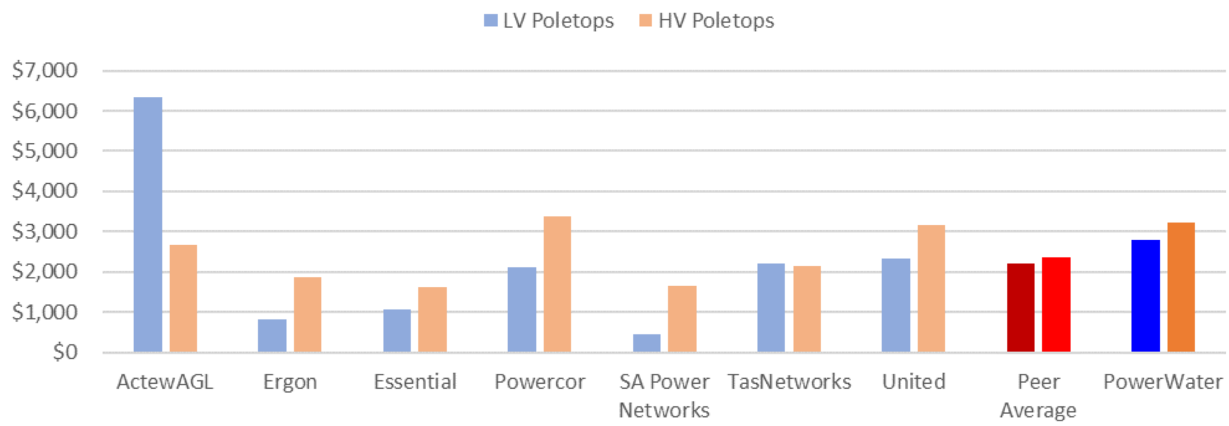

Figure 7-4: Distribution poletop replacement Unit cost comparison

7.3.2 Operating unit costs

The operational expenditures include that expenditure incurred in operating and managing the poletop asset fleet, 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 poletop assets.

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 an indicative measure 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 7-5. The Power and Water cost represent the average annual cost recorded over the last 5 years. In the absence of sufficient data to determine the number of crossarms in each of the peer utility networks, the maintenance unit cost has been calculated using the total number of transmission and distribution poles as a proxy for the number of crossarms.

The high level unnormalized comparison indicates that Power and Water's costs are in the lower range of costs recorded across the NEM. However it should be noted that differences could relate to the weighting of cost allocation to asset classes for maintenance that is performed across multiple asset classes such as feeder inspections.

Power and Water's routine and non-routine maintenance costs associated with poletop assets are considered reasonable.

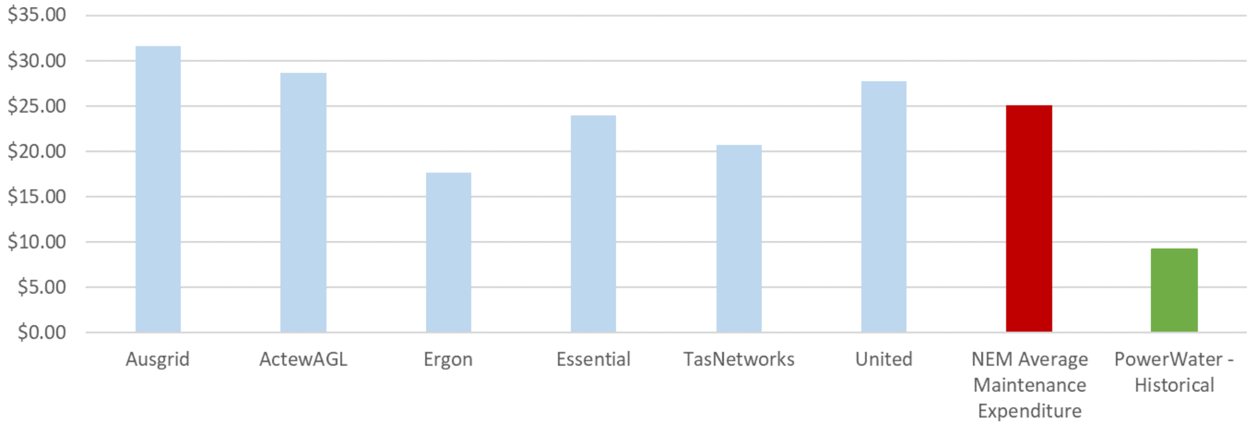

Figure 7-5: Poletop routine and non-routine maintenance cost comparison

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 8-1.

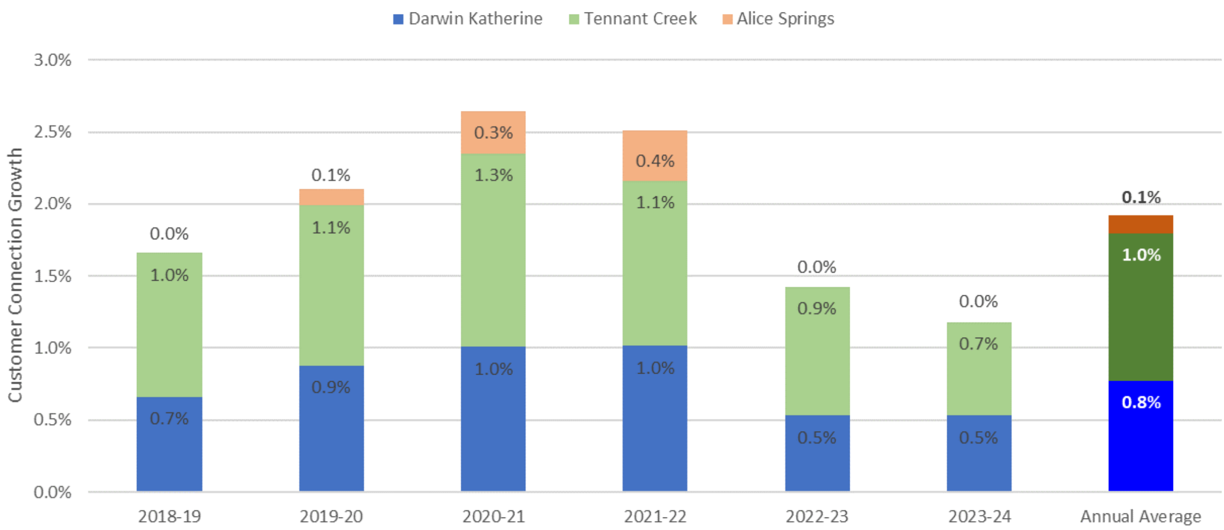

Figure 8-1: Customer connection growth by region (AEMO 2017 Forecast)

Overhead power lines generally remain the lowest-cost method of power distribution to most new urban and commercial developments in the Power and Water network, making the projected connection growth a very reasonable proxy for the expected increase in overhead infrastructure asset requirements over the same period.

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

It is noted that the AEMO connection growth forecast shows an increased growth rate in comparison with Power and Water's annual average growth in poletop assets over the recent 5 years from 2012/13 to 2015/16. This is mainly as result of new developments expected in pocketed areas of Darwin and Tennant Creek. The AEMO forecast has been adopted to project the expected growth in poletop assets by the end of the regulatory period, 2023/24.

The projected increase in poletop assets are provided in Table 8.1. In summary the following approach was taken in doing the asset growth projections:

- No growth in transmission poletop assets are expected/planned.
- 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 poletops) 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 8.1 Poletop forecast growth, quantity (FY19 to FY24)

Region	Historical average annual asset growth rate (2012/13 to 2016/17)	AEMO annual connection growth rate	Transmission Poletop increase by 2023/24	Distribution Poletop increase by 2023/24
Darwin-Katherine	0.03%	0.8%	0	1,588
Alice Springs	2.0%	0.1%	0	47
Tennant Creek	0.1%	1.0%	0	219
Totals	**0.3%**	**0.7%**	**0**	**1,855**

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 prorate spread across the asset criticalities

The revised forecast health and criticality profiles for both transmission and distribution poletops by the end of the regulatory period, assuming no investment and including growth are shown in Table 8.2 and Table 8.3. The growth numbers are reflected in the increase in the H1 asset quantities. No growth increase is forecast for the transmission poletop assets. A 9.3% increase in H1 distribution poletop assets are projected.

Table 8.2: Transmission poletop health-criticality matrix (quantity) with growth and no investment

	H1	H2	H3
C1	1,632	299	
C2	204	486	155
C3	249	2	164

Table 8.3: Distribution (HV & LV) poletop health-criticality matrix (quantity) with growth and no investment

	H1	H2	H3
C1	5,276	716	417
C2	3,997	3,811	7,330
C3	12,583	3,269	7,829

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 separate 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 and to identify those assets that bears 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 outcomes of the assessment manifests in 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.

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

9.1 Transmission Poletops

9.1.1 Transmission Poletop asset renewal plans

1) Transmission Poletop Replacement

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

- NMP20 - Transmission Line Poletop Replacement Program

Applying the health and criticality criteria laid out in section 5.2 the assessment of the transmission poletops identified for renewal investment is provided in Table 9.1. It prioritises the replacement of those assets in the H3 health category.

Table 9.1: Transmission poletop replacement, health-criticality matrix (quantity)

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

	H1	H2	H3
C1			
C2			146
C3			164

The projected annual replacement volumes over the regulatory period is provided in Table 9.2. This replacement program is expected to be continued in future regulatory periods.

Table 9.2: Projected annual Transmission poletop replacement volumes (quantity)

Program	2019-20 quantity	2020-21 quantity	2021-22 quantity	2022-23 quantity	2023-24 quantity	Total quantity
Crossarm Replacement Volumes	18	18	18	18	18	90
Insulator Replacement Volumes (towers/poles)	44	44	44	44	44	220
Total	**62**	**62**	**62**	**62**	**62**	**310**

9.1.2 Transmission Poletop asset maintenance plans

The maintenance plan for transmission poletop assets is to continue with the established maintenance regime, which is based on annual patrols, 3 or 5-yearly detailed inspections (depending on line criticality) and repair (or replacement) upon failure. Patrols 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 under maintenance or replaced under the pooled asset replacement program.

9.2 Distribution Poles

9.2.1 Distribution Poletop renewal plans

1) Distribution Line Poletop replacements

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

- NMP18 – Darwin Coastal Poletop Corrosion Replacement Program

Applying the health and criticality criteria laid out in section 5.3 the assessment of the Distribution poletops is provided in Table 9.3. It prioritises the replacement of those assets in the H3 health category and highest criticality, C3.

Table 9.3: Distribution poletop health-criticality matrix (quantity)

	H1	H2	H3
C1			
C2			
C3			790

The projected annual replacement volumes over the regulatory period is provided in Table 9.4 and will replace 790 poletops in the Darwin region targeting those assets identified in the red zone. This replacement program is expected to be continued in future regulatory periods.

Table 9.4: Projected annual Distribution poletop replacement volumes (quantity)

Program	2019-20 quantity	2020-21 quantity	2021-22 quantity	2022-23 quantity	2023-24 quantity	Total quantity
LV Poletops	78	82	86	90	93	429
HV Poletops	65	69	72	76	79	361
Total	**143**	**151**	**158**	**166**	**172**	**790**

2) Pooled poletop 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 poletop assets that fail in service. These replacements are typically done under emergency conditions and are therefore of limited scope and cost, however they may impact positively on the overall health of the network by 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 poletop replacements under this program has 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 45 distribution poletop replacements are forecast over the 5 year regulatory period. The projected annual replacement volumes are provided in Table 9.5. No in-service failure of transmission poletops have been projected.

Table 9.5: Projected pooled poletop replacement volumes

Program	2019-20 quantity	2020-21 quantity	2021-22 quantity	2022-23 quantity	2023-24 quantity	Total quantity
Poletop replacements - Insulators	7	7	7	7	7	35
Poletops replacements - Crossarms	2	2	2	2	2	10
Total poletop replacements	**9**	**9**	**9**	**9**	**9**	**45**

The health and criticality assessment of the distribution poletop assets expected to be replaced through the pooled replacement program is shown in Table 9.6. 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 9.6: Pooled program distribution poletop health-criticality matrix (quantity)

	H1	H2	H3
C1			12
C2			18
C3			15

9.2.2 Distribution Poletop asset maintenance plans

The maintenance plan for distribution poletop assets is to continue with the established maintenance regime, which is based on 3-yearly inspections and repair (or replacement) upon failure. Inspections typically involve ground based 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.

10.1Augmentation expenditure (augex)

No augmentation related requirements associated with poletop assets have been identified for the next regulatory period.

10.2Renewal expenditure (repex)

There are three renewal programs proposed for the asset class over the next regulatory period, 2019/20 to 2023/24. The programs are expected to cost $4.37 m over the 5-year period and include investment in both the transmission and distribution assets.

The renewal expenditure forecast based on the mention programs are provided in Table 10.1.

Table 10.1: Poletop asset replacement expenditure forecast per voltage group

Year	2019-20 ($'000)	2020-21 ($'000)	2021-22 ($'000)	2022-23 ($'000)	2023-24 ($'000)	Total ($'000)
Transmission Poletops	$381	$381	$381	$381	$381	$1,905
LV Poletops	$220	$230	$240	$251	$261	$1,202

HV Poletops	$211	$221	$232	$243	$255	$1,162
Pooled program - Insulators	$13	$13	$13	$13	$13	$64
Pooled program - Crossarms	$8	$8	$8	$8	$8	$39
Total	**$833**	**$853**	**$874**	**$896**	**$918**	**$4,373**

The revised five-year forecast health and criticality profiles for the transmission and distribution poletops following the proposed investments are shown in Table 10.2 and Table 10.3. The reduction in risk is demonstrated in the number of assets that move from the low health, H3 category to the high health category, H1 in comparison with the 'current' and 'no investment' risk scenarios provided in section 5.2 and section 5.3.

For the transmission poletop assets the reduction in risk is reflected in a 97.2% reduction in the number of poor health assets in the H3 category.

Table 10.2: Transmission poletop health-criticality matrix (quantity) with investment

	H1	H2	H3
C1	1,632	299	
C2	350	486	9
C3	413	2	

For the distribution poletop assets the reduction in risk is reflected in a 4.78% reduction in the number of poor health assets in the H3 category.

Table 10.3: Distribution poletop health-criticality matrix (quantity) with investment

	H1	H2	H3
C1	5,264	716	429
C2	3,979	3,811	7,348
C3	13,359	3,269	7,054

10.3 Historic, forecast and future expenditure comparison

Historic expenditure on poletop assets has been predominantly to address conditional and functional failures discussed in Section 6.3.

As outlined in the preceding sections, the forecast expenditure on poletop structures is targeted to address the key asset challenges expected to manifest over the regulatory period. It is noted that the forecast shows a steady increase in expenditure over the regulatory period to address the condition of transmission poletops.

It is expected that through continuing to target poor health assets, future investment in the asset class can be managed at a level below $1 million per annum.

10.1Operational expenditure (opex)

The operating expenditure for Poletops for the next regulatory period is provided in Table 10.4.

Table 10.4: 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)
Transmisison poletops	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	$0.13	$0.24	$0.40	$0.19	$0.17	$0.15	$0.15	$0.15	$0.15	$0.15
	Fault and emergency	$0.00	$0.85	$0.00	$0.28	$0.26	$0.25	$0.25	$0.25	$0.25	$0.25	$0.25
Total		**$0.00**	**$0.98**	**$0.24**	**$0.68**	**$0.45**	**$0.42**	**$0.40**	**$0.40**	**$0.40**	**$0.40**	**$0.40**
Distribution poletops	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	$0.20	$0.20	$0.64	$0.28	$0.32	$0.29	$0.26	$0.26	$0.26	$0.26	$0.26
	Fault and emergency	$0.45	$0.83	$1.66	$0.03	$0.68	$0.67	$0.65	$0.65	$0.65	$0.65	$0.65
Total		**$0.65**	**$1.03**	**$2.30**	**$0.30**	**$1.01**	**$0.96**	**$0.91**	**$0.91**	**$0.91**	**$0.91**	**$0.91**
All poletops	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	$0.20	$0.33	$0.88	$0.68	$0.51	$0.46	$0.41	$0.41	$0.41	$0.41	$0.41
	Fault and emergency	$0.45	$1.68	$1.66	$0.31	$0.94	$0.92	$0.90	$0.90	$0.90	$0.90	$0.90
Total		**$0.65**	**$2.01**	**$2.54**	**$0.98**	**$1.46**	**$1.38**	**$1.31**	**$1.31**	**$1.31**	**$1.31**	**$1.31**

11 Asset class outcomes

11.1Key performance indicators

11.1.1 Operating Performance indicators

Transmission

Outage events associated with transmission poletop failures are rare with only two events recorded in the past 10 years. As such no performance improvements are expected from the proposed investments, however, the poletop replacement programs are expected to mitigate against the emerging asset condition issues with benefits in avoided future events. The SAIDI and SAIFI benefits from avoided future events have not been quantified.

Distribution

No material improvements in system performance are forecast as a result of the proposed investment program. A 0.4% improvement in SAIDI contribution and 0.2% improvement in SAIFI contribution to NT system performance is expected. Distribution poletop investments only affect a small proportion of the assets and most of the historical causes of outages are not related to the condition of the poletop assets (i.e vehicle crashes).

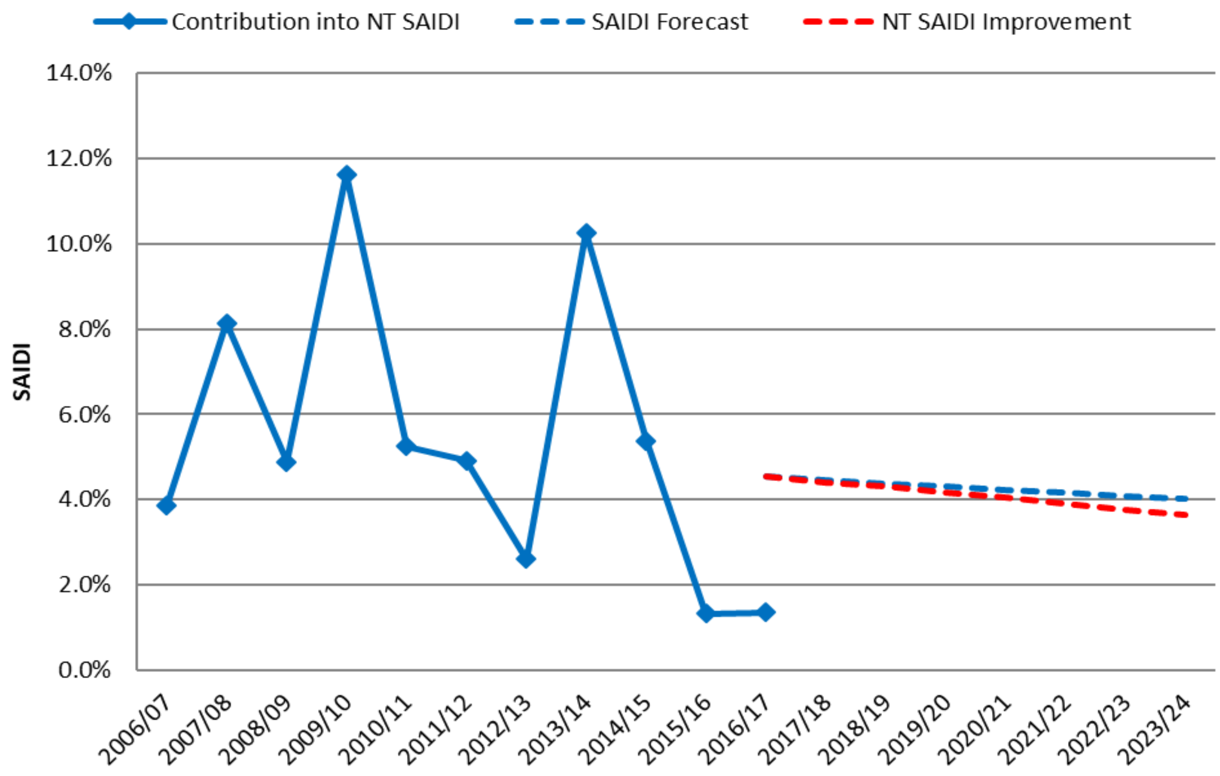

Figure 11-1: Distribution poletop asset contribution into system SAIDI following investment

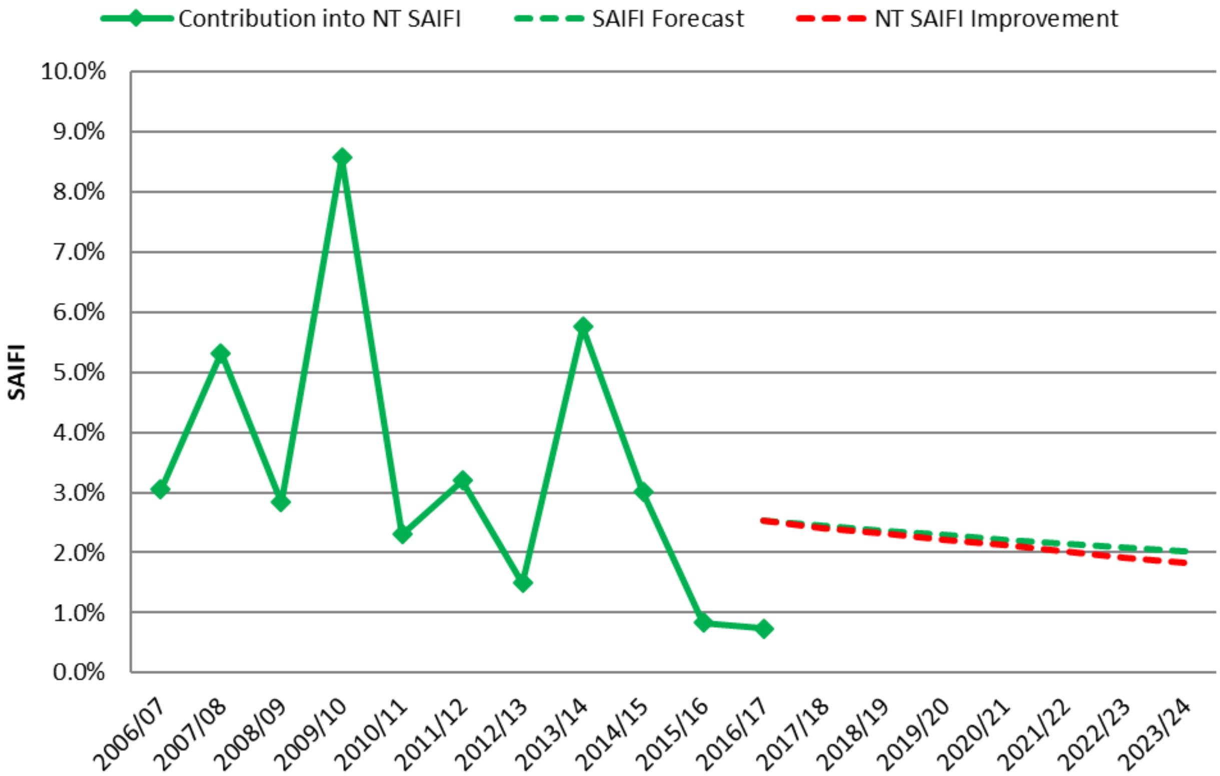

Figure 11-2: Distribution poletop asset contribution into system SAIFI following investment

11.1.2 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 operational outages, and forced outages requested by emergency services. The investment program for the next regulatory period replaces existing equipment like-for-like in the same location. It does not mitigate against any of the safety events typically observed involving poletop assets.

No particular improvement in safety related incidents are forecast as result of the proposed investments.

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 poletop defect modes and trends. These insights provide for informed decision making on whether to repair or replace poletop assets. It assists in the continuous development of the asset management strategy for poletop assets.

This Asset Management Plan will be reviewed at least every two (2) 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 poletop asset 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 poletop assets. These responsibilities include ongoing performance monitoring and strategy revisions.

13 Appendix B – 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 NT. This is demonstrated in the approach it take 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 poletop 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 poletop assets include consideration of:

- 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 is 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 poletop assets 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 poletop asset 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

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 (eg. maintenance)
- Emergency switching of the network in response to incidents (eg. fault events)
- Real time switching to operate the asset within its design parameters (eg. loading)
- Monitoring of the condition of the asset (eg. 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 poletop 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 3 yearly ground based visual inspection and an annual visual/aerial inspection cycle to assess the health of poletop 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.

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:

- 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.