Transmission Line Pole Top Corrosion Program (RP17)

Regulatory Business Case (RBC) 2024-29

PowerWater

Contents

1. Summary **2**
1.1 Business need 2
1.2 Options analysis 2
1.3 Recommendation 3
2. Identified need **5**
2.1 Asset profile 5
2.2 Asset condition issues 6
2.3 Current and historical mitigation program 7
2.4 Consequence of failure 8
2.5 Risk assessment 9
2.6 Summary 10
3. Options analysis **12**
3.1 Comparison of credible options 12
3.2 Non-credible options 15
4. Recommendation **17**
4.1 Strategic alignment 17
4.2 Dependent projects 18
4.3 Deliverability 18
4.4 Customer considerations 18
4.5 Expenditure profile 18
4.6 High-level scope of works 19
Appendix A. Cost estimation **20**
Appendix B. Key assumptions **21**

1. Summary

This business case has been prepared to support the 2024-29 Regulatory Proposal. The business case demonstrates that Power and Water has undertaken appropriate analysis of the need for the expenditure and identified credible options that will resolve the need and ensure that Power and Water continues to meet the National Electricity Objectives and maintain the quality, reliability, and security of supply of standard control services and maintain the safety of the distribution system.

The proposed investment identified in this business case will undergo further assessment and scrutiny through Power and Water's normal governance processes prior to implementation and delivery.

This business case addresses corrosion of the pole top components of transmission lines in the Darwin-Katherine Integrated System (DKIS).

1.1 Business need

Power and Water is experiencing corrosion of the pole top components of its transmission lines in the Darwin-Katherine Integrated System (DKIS). These transmission lines supply power to the Darwin region from the two largest existing power stations in the Northern Territory and will supply power from the Darwin-Katherine BESS that is currently under construction to provide system security support of the Darwin to Katherine transmission line.

During the current regulatory period Power and Water has been actively managing risks for customers associated with transmission pole top corrosion, through a targeted replacement program. The necessary works are driven by transmission line pole top observed condition and risk related to insulator corrosion, flashover damage and cross-arm corrosion.

The corrosion is caused by ongoing leakage current through the insulators where they connect with conductors (the "hot" end), particularly when wet. An increasing awareness of corrosion issues has led to more insulators being identified for replacement during tower inspections. Highly corroded insulators have also been identified by inspections as an issue on the DKTL. Inspections of transmission line pole tops during the current regulatory period have identified that despite an active replacement effort there is an ongoing need for investment to uphold the health of the transmission network insulator population.

The consequence of not dealing with the corroded insulator issue is mechanical failure of the relevant insulator strings due to compromised strength. Similarly, highly damaged 66 kV insulators due to flashover have been identified in several areas of the DKIS.

Risks to inspection, maintenance and emergency repairs personnel working on towers on all transmission lines are key considerations, and without action are likely to increase. System security risks associated with potential loss of the Channel Island to Hudson Creek, Weddell to Strangways and Darwin to Katherine transmission line remain primary considerations. As the backbone to the DKIS, failure of these components and loss of the transmission line is likely to cause widespread outages to customers.

1.2 Options analysis

The options considered to resolve this need are shown in Table 1.

Table 1 Summary of credible options

Option No.	Option name	Description	Recommended
1	Do nothing	Standard maintenance strategy for transmission line towers. Replacement on failure.	No. Continued use of corroded assets until failure occurs does not manage increased risk to reliability and security of supply, public and worker safety risk. Not an accepted industry approach.
2	Inspection and repair/replace	Detailed inspection of every Transmission pole top structure and insulator and evaluation for remedial action	No. Not economically feasible across all DKIS Transmission line insulators and cross-arms
3	Business as usual (targeted proactive replacement)	Targeted proactive replacement of heavily corroded transmission pole top insulators and cross-arms	Yes. Prudent and efficient approach.

A cost benefit analysis was completed for each of the options where the risk reduction, compared to Option 1, was used as the benefit achieved by the option.

1.3 Recommendation

The recommended option is Option 3 – Targeted proactive replacement of corroded insulators at an estimated to cost $3.0 million (real 2021/22) for the 2024-29 regulatory period.

It is essential that this program commences as proposed to manage the continued safe and reliable operation of the network. Insulators on the 132 CI-HC A/B and DKTL lines need to be proactively replaced to mitigate the risk of failure. Similarly, 66kV flashed insulators across the DKIS require replacement to avoid the risk of catastrophic failure. Some 66kV cross-arms on the 66 WD-SY line are also in an advanced state of corrosion and require replacement to avoid catastrophic failure.

The recommended option:

- Is aligned to our strategy and asset objectives.
- Assists satisfy our compliance obligations.
- Continues and expands upon the minor program for transmission line pole top corrosion replacement for the Channel Island to Hudson Creek and Weddell to Strangways transmission lines being undertaken during the current regulatory period.
- Had the highest NPV of the options assessed.
- Is aligned to customer expectations for maintaining the security, reliability and safety of the network.

The scope includes replacement of 200 of 132kV insulators, 150 of 66kV insulators and 30 of 66kV cross-arms, across the primary transmission lines of Channel Island Power Station to Hudson Creek transmission line; corroded cross-arms on the Weddell Power Station to Strangways transmission line; and targeted insulators on the Darwin to Katherine transmission line.

The program will address safety, compliance with the Network Technical Code and the Network Planning Criteria objective of providing safe, secure, reliable, high quality power supply at minimal cost. Replacement of corroded insulators on the 132 CI-HC A/B and DKTL lines, flashed 66 kV insulators across the transmission network and corroded cross-arms on the 66 WD-SY line will ensure continued maintenance of system security and achievement of Power and Water' system security obligations.

Table 2 shows a summary of the expenditure requirements for the 2024-29 Regulatory Period.

Table 2 Annual capital and operational expenditure ($'000, real FY22)

Item	FY25	FY26	FY27	FY28	FY29	Total
Capex	342	973	973	342	342	2,972
Opex	-	-	-	-	-	-
Total	342	973	973	342	342	2,972

The opex for Option 3 is assumed to be part of regular inspection costs and has not been included here.

2. Identified need

This section provides the background and context to this business case, identifies the issues that are posing increasing risks of overhead services wires to Power and Water and its customers, describes the current mitigation program and its delivery status, highlights the consequence of asset failure, and provides a risk assessment of the inherent risk if no investment is undertaken.

2.1 Asset profile

The Darwin–Katherine Integrated System (DKIS) network supplies the city, suburbs and surrounding areas of Darwin and Palmerston, the township of Katherine and its surrounding rural areas. There are 2,781 transmission towers in the DKIS. The DKIS is made up of the following key transmission components as depicted in the figure below:

- Generator connections at 132kV network comprising Channel Island to Hudson Creek 132kV A and B
- Darwin-Katherine Transmission Line (DKTL) comprising
  - Channel Island to Manton 132kV
  - Manton to Pine Creek 132kV (with tee-off to Batchelor 132kV)
  - Pine Creek to Katherine 132kV
- DKIS 66kV network, connecting each of the substations from Pine Creek, and Hudson Creek

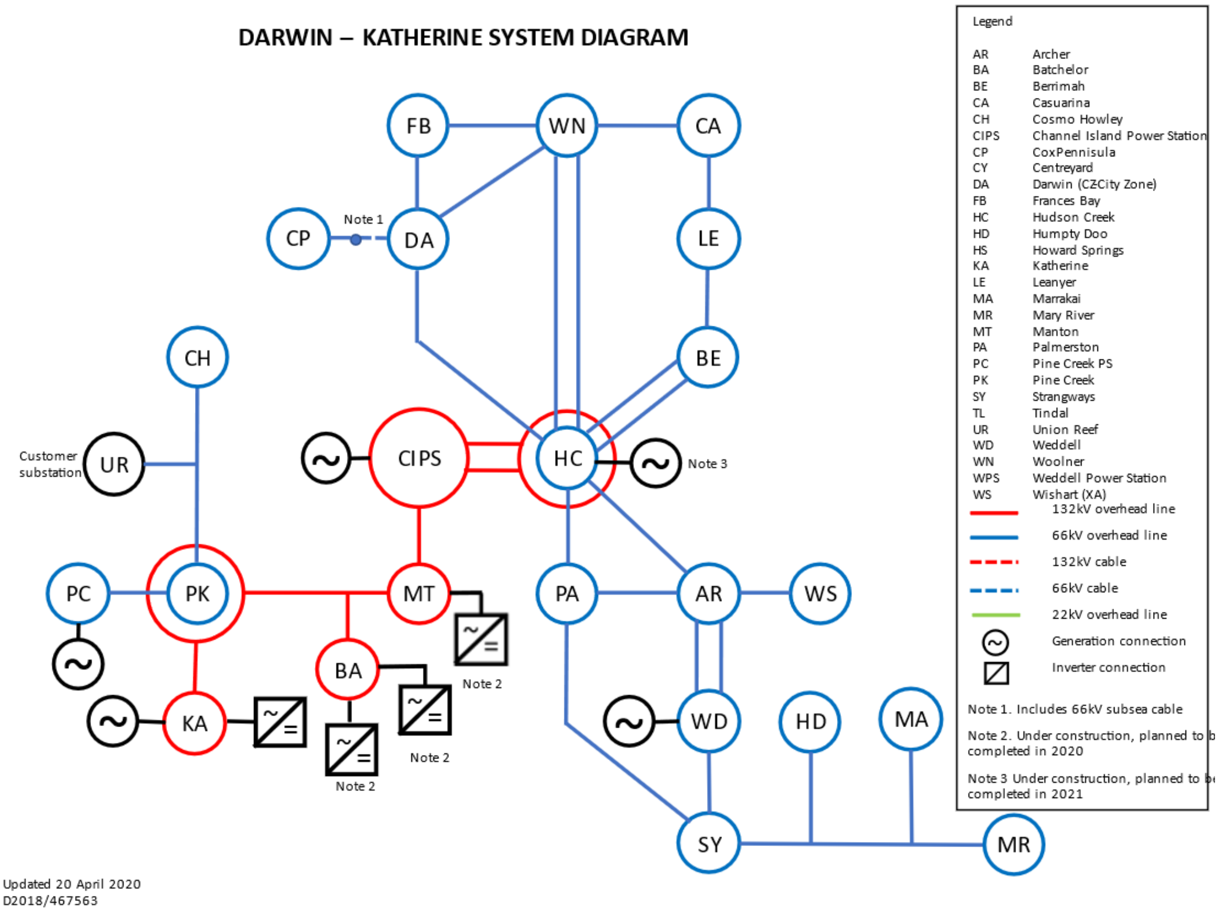

Figure 2: Darwin-Katherine System diagram

The 132 kV Channel Island Power Station to Hudson Creek transmission lines A and B (132 CI-HC A/B), and the 66 kV Weddell Power Station to Strangways transmission line (66 WD-SY) are generator connection points for the two largest power stations in the Northern Territory, which are the sole source of utility-scale generation capacity for the Darwin region. The 35 MVA Darwin-Katherine utility-scale BESS is currently under construction at Channel Island and is expected to be operational in 2023, providing security services to the 132 kV Darwin to Katherine Transmission Line (DKTL).

2.2 Asset condition issues

Extensive inspection of the 132 CI-HC A/B lines since 2017 has identified advanced corrosion of porcelain insulators. This initially involved approximately 70 towers that traverse inter-tidal mangrove areas. The reason for the corrosion is leakage current through the insulators where they connect with conductors (the "hot" end), particularly when wet. An increasing awareness of corrosion issues has led to more insulators being identified for replacement during tower inspections. Highly corroded insulators have also been identified by inspections as an issue on the DKTL. Inspections of transmission line pole tops during the current regulatory period have identified that despite an active replacement effort there is an ongoing need for investment to uphold the health of the transmission network insulator population.

The consequence of not dealing with the corroded insulator issue is mechanical failure of the relevant insulator strings due to compromised strength. Similarly, highly damaged 66 kV insulators due to flashover have been identified in several areas of the DKIS.

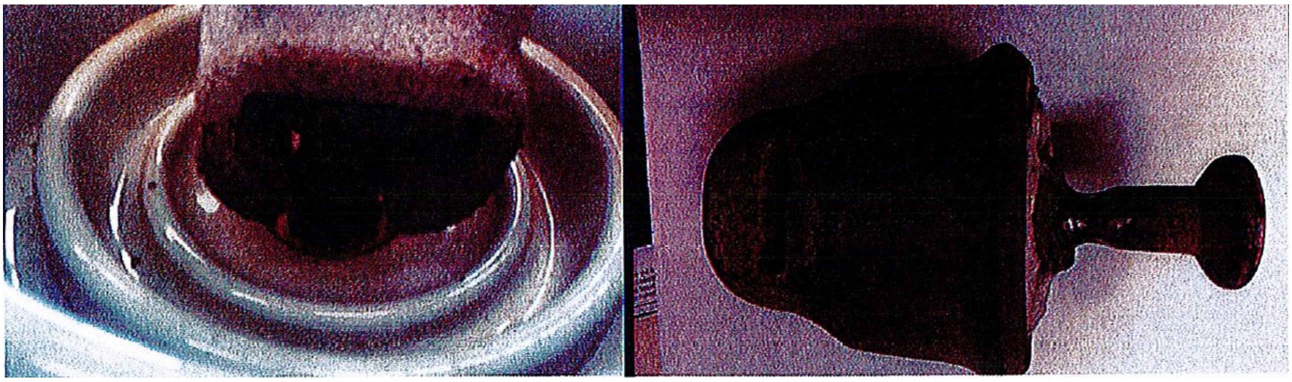

Figure 1 Example of corrosion and section loss after cleaning of an insulator disc from a tower on the 132 CI-HC A/B lines

Inspection of the 66 WD-SY line in 2016/17 identified areas of advanced cross-arm corrosion on the feeder, which was built in 1987. The reason for the corrosion is thought to be use of ungalvanized hollow box section steel, creating a humid 'micro-environment' which exacerbates corrosion, examples are shown in Figure 2. The consequence of not dealing with the cross-arm issue is mechanical failure.

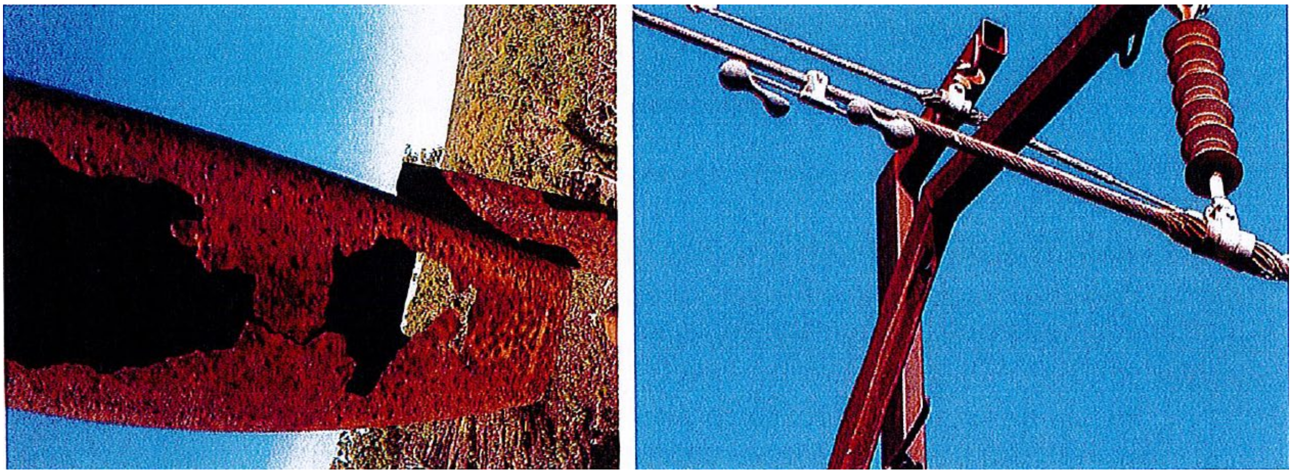

Figure 2 Example of cross-arm corrosion on the 66 WD-SY line

2.3 Current and historical mitigation program

Presently, detailed inspections are only undertaken at selected towers and pole tops due to the large numbers of assets involved. Inspections are by annual aerial and ground patrol. Ground-based detailed inspection is performed every 3-5 years for 132kV lines and every 5 years for 66kV lines. Tower climb inspections are undertaken on a subset of towers across each feeder line route every 3-5 years, with 132kV line climb inspections of each tower every 6-50 years (frequency depends on the line criticality and tower accessibility), and 66kV line climb inspections of each tower every 25 years.

The full extent of corrosion associated with insulator failures can only be measured after removal from site. Cross-arm corrosion loss of section is not apparent from the ground. Determining loss of section for every pole cross-arm would involve performing loss of section measurements in situ during a planned outage, using sophisticated measuring devices. Computer modelling (finite element analysis) would then be required to determine the minimum section requirements to maintain cross-arm function. The measurements required to determine the need for individual asset remediation or replacement are expensive and impractical, with additional difficulties of access to remote sites, requirement of a high number of safety barriers and potential risk to system security.

In response to emerging condition issues identified, Power and Water has an established replacement program for at risk pole top components in the current regulatory period. The targeted proactive replacement of ageing transmission pole top insulators and cross-arms is directed at maintaining system safety and reliability in a prudent and cost-effective manner. A risk-based prioritisation of transmission pole top structures, taking into consideration asset health and criticality, is used to inform a replacement program.

A summary of the actual number of replacements in the current regulatory period as part of the existing transmission line pole top replacement program is shown in Table 3 below.

Table 3 Volume of assets for transmission line pole top corrosion replacement program in the current regulatory period

Unit Type (location)	Actual / estimated volume of replacements					
	FY20	FY21	FY22	FY23	FY24	Total
132kV Insulator (CI-HC)	9	30	78	64	84	265
66kV Cross-arm (WD-SY)	1	3	7	30	30	71
132kV Insulator (DKTL)	1	2	6	4	4	17
66kV Insulator (DKIS)	1	4	12	7	7	31
TOTAL	**12**	**39**	**103**	**105**	**125**	**384**

Power and Water had planned to complete 310 cross arms during the current period at a constant rate of 62 per year. However, due to COVID, delivery of the program was reduced during calendar years 2020 and 2021, impacting the delivery during the 2019-20 and 2020-21 financial years. During 2021-22, the rate of delivery was increased, and we aim to continue at the elevated rate for the remainder of the current regulatory period to replace a total of 384 pole tops.

Power and Water has gained several key learnings from the transmission pole top corrosion replacement program in the current regulatory period.

- Live line works add significantly to the costs of replacing insulators. Accordingly, live line works are avoided when possible for replacement of pole top assets.
- A comparison has been done on the costs and benefits of polymer versus porcelain insulators. Polymer insulators are lightweight, have lower lead time, are more resistant to corrosion in particularly high humidity areas and are lower cost than porcelain insulators. Replacement of corroded porcelain insulators in the Channel Island area and replacement of flashed insulators along the DKTL is now undertaken with polymer insulators.
- Replacement of bare iron cross-arms is now undertaken with galvanised steel. This is done in order to increase the resistance of the replacement cross-arms to corrosion. Additionally, plugs are now used on hollow box ends to avoid issues with wildlife accessing the interior of the cross-arms and causing additional internal corrosion.

2.4 Consequence of failure

The outcome of not dealing with the corroded insulator issue is mechanical failure of the relevant insulator strings due to compromised strength. This can result in the conductor falling and causing a fault or remaining suspended but breaching minimum clearance requirements. There are three key consequence areas of transmission pole top failure that are aligned to the Risk Quantification Procedure:

- **Health and Safety.** All of PWC's high voltage network needs to be operated and managed in a manner that it meets its safety obligations towards its employees, contractors, and the members of public at all times. If the transmission pole tops fail, the main consequences are:

- The conductors can contact the tower or ground and result in a fault. This can cause a potential rise and members of the field crew present on site, or members of the public in the vicinity, could be at risk of electric shock.
- The conductor will sag further than its design and is likely to breach requirements for the minimum clearance from the ground. Insufficient ground clearance poses a safety risk to the public and PWC's workforce involved in working on, or near, the transmission lines. Particularly where the transmission lines cross over roads and large or oversize vehicles could come into contact with the conductor.

- **Service delivery.** Due to redundancy designed into the transmission network, failure of a single transmission line generally does not result in an outage to customers. However, while one line is out of service for repair, the network will have a reduced level of security as it will rely on a single transmission line for the supply of the Darwin region.
  Further, with the deteriorating condition of the pole tops, the probability of two transmission lines failing concurrently is increasing. Since the 132 CI-HC A/B lines are the only connection from Channel Island Power Station to Darwin, the failure of these critical assets will result in loss of supply to the majority of Darwin and potentially a system black event.
- **Direct financial costs**. Reactive repair of assets has an increased cost compared to proactive and planned replacement. Analysis of historical cost data has demonstrated that there is generally a significant increase in the cost of asset replacement in reactive replacement scenarios compared to planned replacements.

There is minimal risk to the environment, fire ignition or of property damage as a result of these failure of the transmission lines failing due to the terrain and easement requirements for these transmission lines.

The quantified risk assessment is shown in section 2.5 below includes the economic cost of outages to customers.

2.5 Risk assessment

The risk posed by these transmission lines due to the identified issue has been quantified by applying Power and Water Risk Quantification Procedure[1]. This framework has been developed based on good industry practice and take into account recent guidelines and determinations made by the AER, AS ISO 31000 Risk Management, and other professional publications.

Specific risks associated with insulator and cross-arm failure include:

- Risk to inspection, maintenance and emergency repairs personnel from falling power lines associated with pole top asset failure and electrical hazards due to failure during live work.
- Risk to public safety due to tower and pole top structure failure.
- Risk to system security from loss of 132 CI-HC A/B critical assets as the only connection between Channel Island Power Station and the Darwin area.

The expected risk profiles of all options are estimated from health and safety, service delivery and direct financial costs associated with reactive replacement of failed assets (assuming implementation of proposed assets replacements programs associated with each option). The risk is based on the replacement profile and a calculated expected events profile derived from the pole top assets age profile and a normal distribution age-based survival curve (45 year mean life, 6.7 years standard deviation).

[1] CONTROL0932, Risk Quantification Procedure for Investment Decision making

Figure 3 Forecast risk profile without intervention (counterfactual case) shows the annual risk-cost from FY22 to FY51 associated with doing nothing to deal with pole top asset corrosion issues. The increasing risk-cost is dominated by worker and public health and safety risk due to assets reaching end of life. There is a steady increase in the annualised risk-cost from $1.2M in FY22 to $7.8M in FY51. This increasing risk-cost is an indication of the need for pole top asset corrosion program to partially abate the increasing risk cost, by taking appropriate corrective measures.

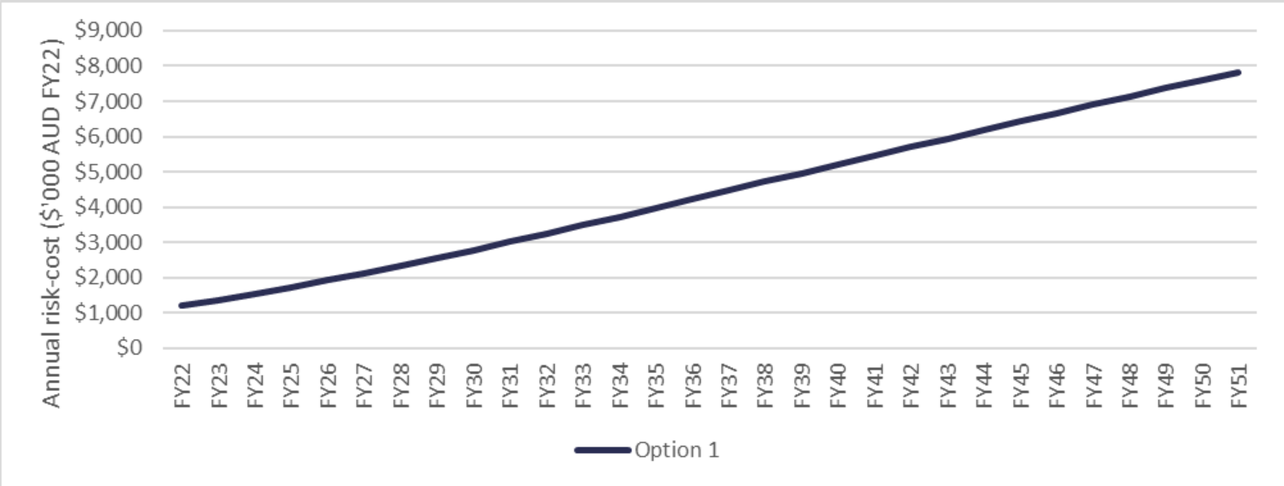

Figure 3 Forecast risk profile without intervention (counterfactual case)

2.6 Summary

Power and Water is experiencing corrosion of the pole top components of its transmission lines in the Darwin-Katherine Integrated System (DKIS). These transmission lines supply power to the Darwin region from the two largest existing power stations in the Northern Territory and will supply power from the Darwin-Katherine BESS that is currently under construction to provide system security support of the Darwin to Katherine transmission line.

During the current regulatory period Power and Water has been actively managing risks for customers associated with transmission pole top corrosion, through a targeted replacement program. The necessary works are driven by transmission line pole top observed condition and risk related to insulator corrosion, flashover damage and cross-arm corrosion.

Extensive inspections have found advanced corrosion of porcelain insulators on the 132 CI-HC A/B lines due to leakage current through the insulators where they connect with conductors (the “hot” end), particularly when wet, and advanced cross-arm corrosion on the 66 WD-SY line due to the use of ungalvanized hollow box section steel, creating a humid ‘micro-environment’ which exacerbates corrosion.

Highly corroded insulators have also been identified by inspections as an issue on the DKTL. Inspections of transmission line pole tops during the current regulatory period have identified that despite an active replacement effort there is an ongoing need for investment to uphold the health of the transmission network insulator population. Similarly, highly damaged 66 kV insulators due to flashover have been identified in several areas of the DKIS.

The consequence of not dealing with the corroded insulator issue is mechanical failure of the relevant insulator strings due to compromised strength. This can result in the conductor falling and causing a fault, or remaining suspended but breaching minimum clearance requirements, resulting in a risk to the health and safety of our field crews and the public.

Failure of a pole top will also reduce the system security as the majority of the Darwin region will rely on a single line connecting to the Channel Island Power Station. As the backbone to the DKIS, failure of these components and loss of the transmission line is likely to cause widespread outages to customers.

Section 3 assesses the options to manage this issue.

3. Options analysis

This section describes the various options that were analysed to address the increasing risk associated with transmission line pole top corrosion to identify the recommended option. The options are analysed based on ability to address the identified needs, prudency and efficiency, commercial and technical feasibility, deliverability, benefits and an optimal balance between long term asset risk and short-term asset performance.

3.1 Comparison of credible options

Three options to maintain the safe and reliable operation of the DKIS have been identified as credible, based on experience gained in the transmission line pole top corrosion replacement program for the current regulatory period. The three credible options are:

- Option 1: Do nothing (Run to failure)
- Option 2: Inspection and repair/replace
- Option 3: Targeted proactive replacement of corroded assets

A comparison of the three identified credible options and the issues they address in the identified need is depicted in the table below. A detailed discussion of each option is provided below.

Table 4 Summary of options analysis outcomes relative to the base case (Option 1)

Assessment metrics	Option 1	Option 2	Option 3
NPV ($'000, real FY22)	-	18,792	19,515
BCR	-	5.46	7.78
Capex ($'000, real FY22)	-	4,350	2,972
Meets customer expectations	○	●	●
Aligns with Asset Objectives	○	●	●
Technical Viability	○	●	●
Deliverability	●	●	●
Preferred	✗	✗	✓

● Fully addressed the issue ◕ Adequately addressed the issue ◑ Partially addressed the issue ○ Did not address the issue

3.1.1 Option 1 – Do nothing (Run to failure)

A run to failure option does not address the increasing risk issue associated with ageing pole top assets, as shown in Figure 3. Continued use of corroded or flashover damaged assets until failure occurs does not manage the increasing risk to reliability and security of supply, plus public and worker safety risk.

PowerWater

A run to failure approach is not an accepted industry approach and is not advocated by Power and Water as a responsible approach to network risk management.

This option is not recommended.

3.1.2 Option 2 – Inspection and Repair/Replace

This option proposes inspection and repair/replace of all transmission pole top structures and insulators across the DKIS, based upon an evaluation of condition and remedial action as appropriate. Presently, detailed inspections are only undertaken at selected towers and pole tops due to the large numbers of assets involved, with inspection frequency dependant on the line criticality and tower accessibility.

Line accessibility is a key issue for inspection frequency and associated inspection costs, with substantial additional costs each year associated with building / rebuilding / maintaining access tracks. Extending inspections and repair/replace across all towers and pole tops in the DKIS would result in substantial additional accessibility costs.

On the basis of 2,781 transmission towers in the DKIS, this option proposes 556 inspections per year over the regulatory period. Assuming that 20 per cent of pole top inspections lead to an actual replacement (as per assumption in the Transmission Line Pole Top Replacement Program BNI 2018). This means about 111 replacements of assets per year are required across the network during the 2024-29 regulatory period. The cost has been estimated to be $4.4 million (real 2021/22), based on a proportional increase to option 3, based on higher replacement volumes.

For 556 inspections per year, the incremental opex cost associated with option 2 (relative to option 1) is about $9.7 million (real 2021/22) over the 2024-29 regulatory period or an additional $2.0 million (real 2021/22) per year (rounded). This has been based on a minimum cost of $3,500 for each tower top detailed inspection, including detailed insulator and/or cross-arm inspection involving at least two skilled electrical workers, post-visit interpretation of measurements, remote tower access, any safety barrier and planned outage costs is assumed (see Appendix A).

Option 2 has a slightly lower net present value than Option 3 but has a much higher capex requirement. There is also a higher incremental opex associated with the increased number of inspections relative to the other options. The higher opex due to more detailed inspections plus the additional capex for anticipated extra replacements, offsets the more favourable risk profile and makes option 2 less attractive than option 3 but more attractive than option 1.

Deliverability of option 2 is another key consideration. Due to the significant increase in the number of inspections, and the specialist skills required to undertake the work, additional appropriately skilled field crew would be required. Power and Water considers that it is unlikely to be able to recruit appropriate staff to properly resource this program.

Option 2 is not recommended.

3.1.3 Option 3 – Targeted Proactive Replacement of corroded assets

The targeted proactive replacement of ageing transmission pole top insulators and cross-arms is directed at maintaining system safety and reliability in a prudent and cost-effective manner. A risk-based prioritisation of transmission pole top structures, taking into consideration asset health and criticality, is used to inform a replacement program. This option is anticipated to replace 200 of 132kV insulators, 150 of 66kV insulators and 30 of 66kV cross-arms in the next regulatory period at an estimated cost of $3.0 million (real 2021/22).

A summary of the anticipated asset quantities to be replaced by this option for the 2024-29 regulatory period is shown in the table below. The actual / estimated replacement volumes for the current regulatory period are also provided.

Table 5 Volume of assets for transmission line pole top corrosion replacement program in the 2024-29 regulatory period

Unit Type (location)	Actual plus estimated volume	Option 3	Variance
132kV Insulator (CI-HC)	265	150	-115
66kV Cross-arm (WD-SY)	71	168	+97
132kV Insulator (DKTL)	17	50	+33
66kV Insulator (DKIS)	31	150	+119
TOTAL	**384**	**518**	**+134**

Option 3 proposes to replace all the known high risk 132kV insulators on the 132 CI-HC A/B and DKTL lines, 66kV cross-arms on the 66 WD-SY line and 66kV flashed insulators across the DKIS that have been identified through the inspection program undertaken in 2017, annual inspections and additional pole tops identified while carrying out this program during the current regulatory period. An allowance has been included for expected emerging replacement requirements, building on the increased awareness and focus on corrosion issues achieved during the implementation of the current transmission line pole top corrosion replacement program.

The proposed program will address the identified need by progressively replacing the highest risk, most damaged transmission pole top assets, in accordance with experience gained using the same targeted proactive approach in the current regulatory period to successfully deal with these issues. It will also undertake a targeted replacement of cross arms on the 66 WD-SY line across a two year period. The approach has been shown to be technically feasible in the current regulatory period.

The forecast replacement volume has an increase of about 35% in terms of number of units addressed compared to the 2019-24 regulatory period. The driver of the increase is planned replacement of cross arms on the 66kV WD-SY line during the 2025-26 and 2026-27 regulatory years. The timing for targeted replacement is based on the known condition of the cross arms and alignment with the portfolio of projects.

Excluding the 66kV WD-SY line, the work is forecast to be spread evenly across the regulatory period. The program will not represent a deliverability issue for Power and Water and is considered deliverable within the timeframe.

This option focuses on selected feeder sections, based on mobilisation costs and system performance impacts. Asset criticality for maintaining security of supply, asset health and probability of failure are used to prioritise the replacement of transmission pole top assets at highest risk. The severity of corrosion identified to date combined with structure age provide an indication of asset health. Probability of failure is based on the findings of recent pole top inspections, considering replacements undertaken over the last five years.

Figure 4 shows the annual risk-cost from 2021/22 to 2050/51 associated with targeted proactive replacement and with doing nothing to deal with pole top asset corrosion issues. Option 3 still has an increasing annualised risk-cost (from $1.2 million in 2021/22 to $5.2 million in 2050/51) but the rate of increase is substantial lower than the do nothing counterfactual and is tending to a maximum over time. Hence targeted proactive replacement is effective in limiting the increase in risk-cost associated with corrosion of transmission pole top assets.

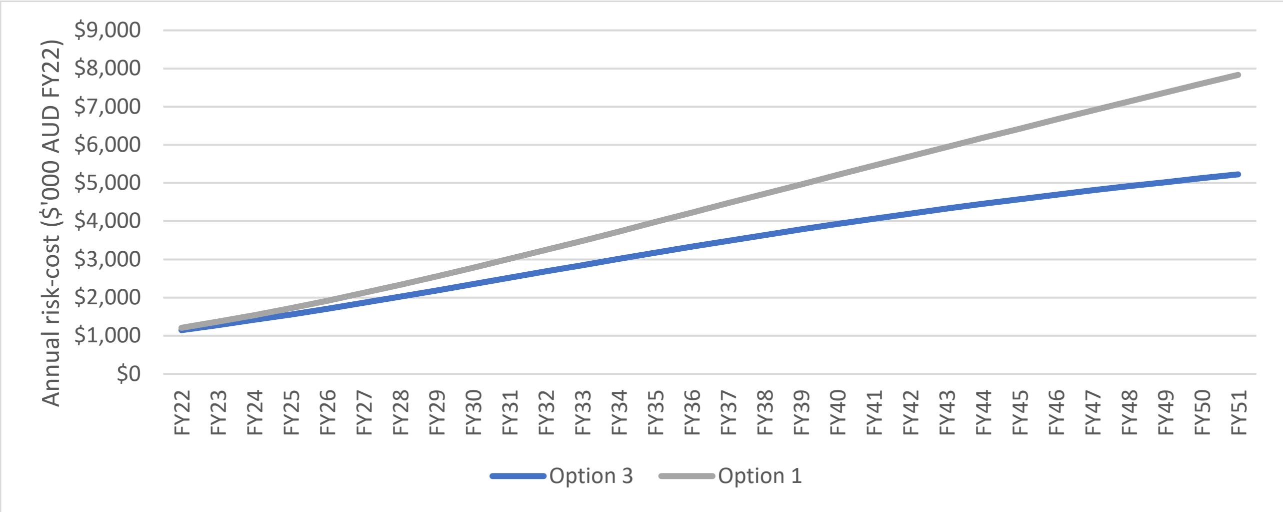

Figure 4 Forecast risk profile with targeted proactive replacement (Option 3) and without intervention (Option 1)

Option 3 is recommended, as:

- Option 1 is not considered technically acceptable, due to the increased risk associated with a run to failure approach. As a consequence, Option 1 is ranked the lowest of the credible options in terms of NPV.
- Option 3 has the most favourable NPV and is preferred. Option 3 has a BCR of about 7.78 relative to the Option 1 base case.
- Option 3 is preferred over Option 2– Inspection and Repair/Replace because of:
  - The incremental opex saving with a present value of about $8.1 million (real 2021/22) associated with the decreased number of inspections
  - A decreased capex of about $1.38 million (real 2021/22) for anticipated decreased replacements for Option 3 relative to Option 2.
- While Option 2 results in a lower risk profile, the reduced opex and capex for Option 3 compared to Option 2 result in a more favourable economic outcome (higher NPV and BCR) for Option 3.

3.2 Non-credible options

Our analysis also identified a number of options found to be non-credible. These options are described below and were not taken through to detail analysis for the reasons provided.

3.2.1 Non-Network alternatives – does not address the need

Due to the type and function of these assets, there are no non-network alternatives or solutions that can be implemented in place of direct asset replacement with like for like (modern equivalent) assets. When an insulator or cross-arm is identified for replacement, Power and Water undertakes an assessment of whether the size or type can be changed to reduce cost or to meet future demand most efficiently.

3.2.2 Capex/Opex Substitution – does not address the need

Since the driver of this investment is significant deterioration across a fleet of assets caused by the same design deficiency and environmental conditions, it is not feasible to substitute capital expenditure with operational expenditure to resolve the risk. Only capital expenditure to replace the poor condition transmission pole top insulators and cross-arms that are most at risk of failure will resolve the underlying issues.

3.2.3 Refurbishment – does not address the need

Refurbishment is not a viable option in most instances due to the severity of the insulator corrosion, flashover insulator damage and cross-arm corrosion.

4. Recommendation

The recommended option is Option 3 –Targeted Proactive Replacement with an estimated cost of $3.0 million (real 2021/22). This option has a positive NPV of about $19.5 million when compared to the Option 1 base case.

The proposed program is consistent with the National Electricity Rules Capital Expenditure Objectives as the expenditure is required to maintain the quality, reliability, and security of supply of standard control services and maintain the safety of the distribution system.

The program will address safety, compliance with the Network Technical Code and the Network Planning Criteria objective of providing safe, secure, reliable, high quality power supply at minimal cost. Replacement of corroded insulators on the 132 CI-HC A/B and DKTL lines, flashed 66 kV insulators across the transmission network and corroded cross-arms on the 66 WD-SY line will ensure continued maintenance of system security and achievement of Power and Water' system security obligations.

The recommended option:

- Is aligned to our strategy and asset objectives.
- Assists satisfy our compliance obligations.
- Continues and expands upon the minor program for transmission line pole top corrosion replacement for the Channel Island to Hudson Creek and Weddell to Strangways transmission lines being undertaken during the current regulatory period.
- Had the highest NPV of the options assessed.
- Is aligned to customer expectations for maintaining the security, reliability and safety of the network.

4.1 Strategic alignment

The "Power and Water Corporation Strategic Direction" is to meet the changing needs of the business, our customers and is aligned with the market and future economic conditions of the Northern Territory projected out to 2030.

This proposal aligns with Asset Management System Policies, Strategies and Plans that contributes to the D2021/260606 "PWC Strategic Direction" as indicated in the table below.

Table 6 Strategic alignment

	Strategic direction focus area	Strategic direction priority
1	Customer and the community at the centre	Improve Public Health and Safety
2	Always Safe	Cost Prudency

4.2 Dependent projects

There are no known projects or other network issues that are directly dependent on the resolution of this network issue.

4.3 Deliverability

Deliverability and timing will take into account extreme weather being a catalyst for potential failures with increased risk of failure. Transmission pole top replacements during the build-up and wet season will be avoided due to the concerns around placing personnel at risk of heat related illness. Power and Water recognises that such work during the hotter months is characterised by significantly shorter working hours per person and may adversely affect deliverability.

Resourcing requirements for the preferred option are considered to be business as usual. Power and Water has the experience and track record in undertaking the transmission line pole top corrosion program in the current regulatory period to complete the proposed scope of works associated with the preferred option during the next regulatory period.

4.4 Customer considerations

As required by the AER's Better Resets Handbook, in developing this program Power and Water has taken into consideration feedback from its customers.

Feedback received through customer consultation undertaken at the time of writing this PBC, has demonstrated strong support amongst the community for appropriate expenditure to enable long term maintenance of the network to ensure continued reliability, maintainability and safety of supply.

4.5 Expenditure profile

Table 7 Annual capital and operational expenditure ($'000, real FY22) shows a summary of the expenditure requirements associated with the preferred option (Option 3) for the 2024-29 Regulatory Period.

Table 7 Annual capital and operational expenditure ($'000, real FY22)

Item	FY25	FY26	FY27	FY28	FY29	Total
Capex	342	973	973	342	342	2,972
Opex	-	-	-	-	-	-
Total	342	973	973	342	342	2,972

The opex for Option 3 is assumed to be part of regular inspection costs and has not been included here.

4.6 High-level scope of works

The forecast volumes associated with the Option 3 have been determined using a risk-based prioritisation of assets focusing on the replacement of the highest risk installations. Works on insulator and cross-arm replacements will be completed in phases and when efficient to do so, included as part of other works programs, minimising mobilisation costs.

A yearly breakdown of the scope of the works in the preferred option across the next regulatory period is shown in Table 8.

Table 8 Volume of replacements for recommended Option 3

Type (location)	2024-25	2025-26	2026-27	2027-28	2028-29	TOTAL
132kV Insulator (CI-HC)	30	30	30	30	30	**150**
66kV Cross-arm (WD-SY)	6	75	75	6	6	**168**
132kV Insulator (DKTL)	10	10	10	10	10	**50**
66kV Insulator (DKIS)	30	30	30	30	30	**150**
TOTAL	**76**	**151**	**151**	**76**	**76**	**518**

Compared to the current regulatory period, there is an increase in the anticipated number of cross-arm replacements but an decrease in the number of insulator replacements, with an overall increase of 35% in the total number of units anticipated to be replaced. See Table 8 for a comparison of anticipated number of units for replacement in the 2024-29 regulatory period with those actual for the current regulatory period.

Appendix A. Cost estimation

The expenditure for Option 3 has been calculated based on unit rates derived from the recent works undertaken during the current period. Due to these costs being specific to the asset types targeted, these cost are slightly different to the unit rates set out in the Cost Estimation Methodology which are averaged across a wider range of asset types (pole top configurations), but are closely aligned. The costs applied are shown in Table 9 below.

Table 9 Unit costs for replacement of transmission pole top assets

Unit Type	Unit cost ($)
132kV Insulator	4,942
66kV Insulator	3,000
66kV Cross-arm	9,090

A minimum cost of $3,500 is assumed for each tower top detailed inspection. This is based on a detailed insulator and/or cross-arm inspection by two skilled electrical workers at an estimated labour cost of about $3000 for inspection of a single tower top over a one-day period. The labour cost is derived from the Power and Water 2020-21 category analysis RIN response estimates for total labour expenditure, average productive hours of ordinary time per staff member and average staffing level for skilled electrical workers. An additional minimum cost of $500 per tower inspection is associated with post-visit expert interpretation of measurements, remote tower access, any safety barrier and planned outage costs.

Higher tower top inspection costs increase the difference in NPV between Option 3 and Option 2, resulting in Option 3 being more strongly preferred than Option 2. Higher tower inspection costs still result in Option 3 being preferred over Option 1.

Appendix B. Key assumptions

The transmission pole top assets age profile is derived from the 66 kV and 132 kV poles asset age profile (number commissioned yearly) in the Power and Water category analysis 2020-21. The age profile is re-normalised to reflect the total number of transmission towers in the DKIS (2,781 according to TDAPR 2021).

It is assumed that in any year the number of 66 kV cross-arms equals the number 66 kV steel poles, the number of 66 kV insulator strings equals three times the number of 66 kV steel poles, and the number of 132 kV insulator strings equals three times the number of 132 kV steel poles. Replacements of pole top assets in recent years are also considered.

Power and Water Corporation

55 Mitchell Street, Darwin NT 0800

Phone 1800 245 092

powerwater.com.au

PowerWater