Volumetric asset replacement program (NMFCR)

Regulatory Business Case (RBC) 2024-29

PowerWater

Contents

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 the network risk associated with failure of low value assets on the network referred to as 'Pooled Assets'.

1.1 Business need

Power and Water has a large number of low value assets on its network that are managed based on periodic inspection. These are collectively and interchangeably referred to as either the 'Pooled Assets' or 'volumetric assets'. Since they are low in value and individually have a lower impact on network risk than other assets, they have historically been managed by a replace on functional or conditional failure strategy consistent with other DNSPs.

The Pooled Assets are distribution network assets and typically do not have any redundancy associated with their design, and therefore failure will generally result in an outage to customers.

Since 2018, Power and Water has addressed the replacement of these assets under the program NMFCR. Analysis of this program since that time has demonstrated that there is a benefit to consumers by undertaking condition-based replacement for these assets, predominately due to their impact on reliability and safety.

Power and Water has developed a detailed model that enables us to assess the risk-cost trade-off for different approaches to managing these assets. The modelling demonstrates that without taking action, the network risk associated with failure of these assets will increase and there will be a significant cost resulting from the necessary reactive replacements to restore supply following failure.

1.2 Options analysis

To address the identified need, five options were identified and analysed. The table below provides an overview of each credible option and the outcomes of the options analysis:

Table 1 Summary of credible options

Option	Option Name	Description	Recommended Option
1	Do Nothing (only replace at failure)Note 1	Replaces the assets following failure.	No
2	Condition based replacement (current practice)	Replaces assets based on condition as well as following failure.	Yes

3	Proactive (economic based) replacement	Replaces assets based on economic efficiency, as well as based on condition and following failure.	No
4	Maintain network risk	Replaces sufficient volumes of assets to maintain the level of network risk over the next 10 years	No

Note 1: Option 1 was set as the reference case for the other options

As part of a holistic assessment, non-network solutions, capex/opex trade-offs and retirement or derating options were also considered, but it was found that none of these options addressed the underlying network issues.

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. The options were assessed against a range of criteria. Our analysis found that Option 2 – Condition based replacement maximises benefits, is deliverable and addresses the identified network.

1.3 Recommendation

The recommended option is Option 2 – Condition based replacement at an estimated cost of $32.2 million (real 2021/22) for the 2024-29 regulatory period.

This option reflects a continuation of the NMFCR program which has been operating since 2018 as a defined program, hence the scope of work and assessment practices are known and proven to be deliverable. There is no change program or training on new asset assessment techniques required.

Prior to 2018 the replacement works were carried out under individual asset programs. Since 2018, the average annual expenditure for the NMFCR program has been $5.1 million (real 2021/22). The forecast for the next regulatory period is a slight increase to an average annual expenditure of $6.4 million per year. The slight uplift in expenditure is considered consistent with the aging nature of the network, resulting in increasing replacement requirements, and cost uplifts associated with the current economic conditions.[1]

The forecast expenditure is supported by detailed asset replacement modelling, which has been updated to reflect recent replacement volumes. Consistent with historical practices the program is dominated by replacement of distribution switchgear and distribution transformers.

Table 2 shows a summary of the expenditure requirements for the 2024-29 regulatory period.

Table 2 Annual capital and operational expenditure ($'000, real 2021/22)

Item	FY25	FY26	FY27	FY28	FY29	Total
Capex	5,917	6,170	6,428	6,691	6,956	32,162
Opex	-	-	-	-	-	-
Total	**5,917**	**6,170**	**6,428**	**6,691**	**6,956**	**32,162**

[1] This has been partly offset by unit cost reductions in some areas.

In addition to this program, targeted replacement programs to address specific issues relating to key asset classes and asset types have been included in the capex forecast, which enable a better risk-cost outcome for the expenditure. For example, a services replacement program has been develop to address specific type issues with overhead service wires. Accordingly, these assets have been largely excluded from this analysis. A small residual is retained for replacement of assets that fail in service and cannot be addressed by a planned replacement program.

2. Identified need

Power and Water has a large number of low value assets on its network that are collectively referred to interchangeably as either 'Pooled Assets' or 'Volumetric Assets'.

Individually, these assets are low in value and have a lower impact on network risk than other assets. They are managed based on periodic inspection (typically three-to-five-year cycles) to assess condition and undertake any maintenance or replacement works. When assessed by field crews to have functionally failed (no longer able to safely provide their intended service based on condition) or following actual failure, they are typically replaced with a modern equivalent asset.

This section reviews the current fleet of the assets included as Pooled Assets and assesses the most efficient option to manage these assets for the five-year review period.

2.1 Background

Power and Water has a relatively small network compared to other Distribution Network Service Providers (DNSP) in the National Electricity Market (NEM). Table 3 provides an overview of the types and volumes of assets that are part of the Pooled Assets group.

Table 3 Asset population overview

Asset Group	As at November 2021	Average expected life
Overhead conductors	5,377 km	55
Poles	44,732 units	55
Pole top structures Note 1	44,732 units	55
Underground cables Note 2	1,477 km	56
Service lines	56,935 units	35
Distribution transformers	4,865 units	45
Distribution switchgear	6,299 units	35

Note 1: Based on one pole top structure per pole.

Note 2: Excludes the Northern Cables (approx. 143km) that are modelled separately.

The age profile of assets on the Power and Water network is shown below in Figure 1. It is significantly influenced by Cyclone Tracy (1974) which destroyed a significant portion of the network and as a result there is a large peak in age profiles between 1974 and 1976 as the network was rebuilt. There was also a period of rapid expansion of the network that was driven by development of new suburbs between 1979 and 1985. These two events have created a large peak in the volume of assets installed during those years across most asset classes in the Pooled Assets group.

By the end of the next regulatory period these assets will be between 42 and 62 years old, and operating beyond the expected lives of between 35 and 58 years as shown in Table 3. This indicates that a large volume of assets will be approaching or exceeding their expected functional lives during the next regulatory period, and is likely to result in an increase to the volume of assets in deteriorated condition or failing in service.

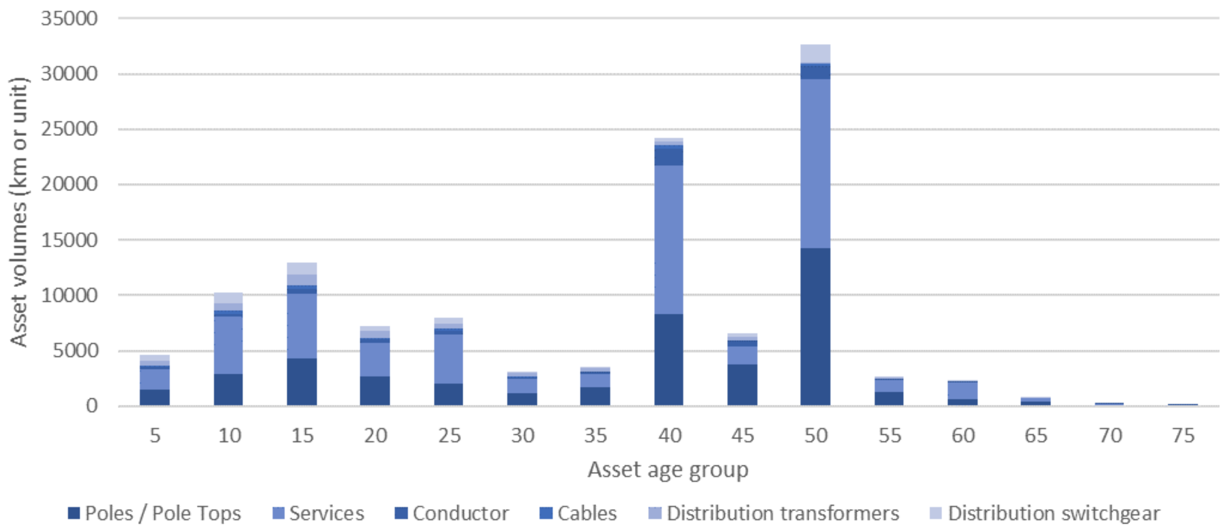

Figure 1 Distribution asset age profile

2.2 Common industry practice

As noted above, the assets included in the Pooled Asset category are typically referred to as 'volumetric' assets by other DNSPs. That means, individually, each asset is low value, but there are high volumes that need to be replaced each year, so overall the program has a significant cost.

Since these are simple and low value assets, there is not a lot of condition data that can be economically ascertained from condition assessments or analysis of deterioration rates. Therefore, the typical approach for forecasting future needs is based on probabilistic modelling making use of the age profile and expected life of each asset category. The AER applies the same principles in its Repex Model.

Where there is sufficient data capturing the age of assets when they were replaced or failed, a specific distribution for the asset class can be calculated and used for modelling. If data is not available, which is common throughout the industry, assumptions are made for the key parameters and then the model is calibrated to ensure the forecast is consistent with past practices and network needs. This provides a forecast of the volumes of assets, not specific assets that will require replacement each year during the forecast period so a budget can be established.

Actual replacements are made based on condition assessments completed by field crews throughout the forecast period. This ensures that only assets requiring replacement are replaced.

2.3 Historical and current mitigation programs

The historical actual and estimated expenditure for the remainder of the current regulatory period are shown in Figure 2. Also included, for reference, the portion of the original forecast (included in the capex allowance) attributed to Pooled Assets for the current regulatory period.

Figure 2 shows that the actual expenditure incurred for managed of the Pooled Assets has been volatile from year to year, which is a function of the asset age profile and environmental conditions (ie, storms) in each year. For example, the network was subject to Tropical Cyclone Marcus in 2018 which had a devastating impact on the network, requiring significant maintenance and network restoration work which diverted focus away from other planned works.

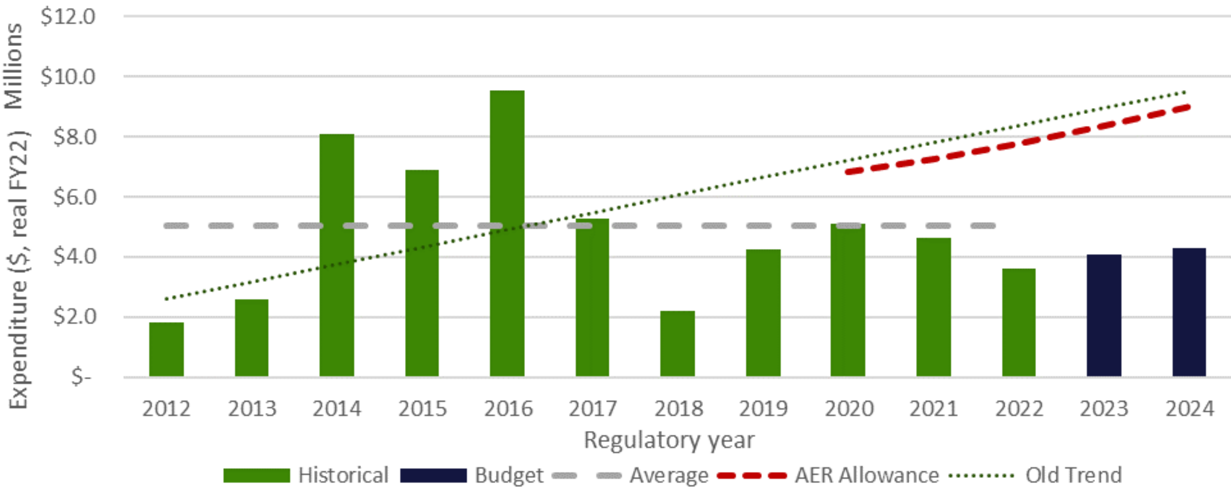

Figure 2 Summary of actual and forecast expenditure against the AER allowance

Understanding the basis of the previous forecast

In 2017 and 2018 the forecast expenditure requirements of the Pooled Assets was developed for the current regulatory control period by using two common industry approaches:

- For most asset classes a survival curve was applied to develop a probabilistic forecast for the replacement volumes. The approach applied the same principles as the AER's Repex Model.
- For asset classes with less data, or where a probabilistic approach was not appropriate, a trend of historical levels of replacement volumes and expenditure was applied.

Top-down checks to test that the forecast was consistent with historical data were applied and, as shown in Figure 2, the forecast reflected the increasing trend evident from 2011/12 to 2016/17. It is important to note that this analysis was undertaken during 2017/18. The complete program data for that year was not available to include in our analysis, and at the time had not taken account of the impact of Tropical Cyclone Marcus.

In the AER's Final Determination for the 2019-24 regulatory period, the program was included in the capex allowance based on a forecast capex requirement of $36 million (real 2016/17 dollars). This indicated to us that the AER considered the methodology applied to the data available at the time was sound.

Current period actual expenditure has been lower than forecast

Like most businesses, COVID-19 impacted the overall delivery of the asset replacement program.

While asset failures / outages to customers were addressed and supply restored, the constraints on the workforce during the pandemic resulted in delays to the delivery of the asset replacement program, and in some cases an increase in the backlog of defects.

This is further compounded by our aging asset fleet. The age profile of pooled assets is strongly influenced by the rebuild/recovery following Cyclone Tracy in 1975 and network expansion in the early 1980's. This means that a large proportion of our asset fleet will reach the end of its expected serviceable life by the end of the next regulatory period.

Our program has been re-profiled and expect that the backlog of asset replacement requirements for Pooled Assets to be addressed by the end of the current regulatory period. This has led to a slight uplift in expenditure against trend, and a trend that will be required to continue to manage the risk profile of the network.

The historical data (2011/12 to 2020/21) shows that an annual average expenditure of approximately $5.1 million has been required to manage the level of risk. However, this does not allow for the aging asset base and increased defect backlog which is expected to result in increasing volumes of assets reaching end of life and either failing or becoming unsafe and presenting a safety hazard.

2.4 Environmental conditions

Power and Water's network is located in a harsh environment that includes heat, humidity, monsoons, fauna and flora that put pressure on distribution assets. The Northern Territory is subject to Australia's highest:

- frequency of lightning
- UV intensity
- rainfall
- humidity, and
- average temperatures.

Each of these environmental factors damages our assets and causes them to deteriorate over time. In addition, larger animals, such as snakes, bats and birds cause faults and damage on overhead assets.

Care needs to be taken in making direct comparisons with other DNSPs due to differing operating environment factors such as the harsh operating environment which has strongly influenced the design and construction materials used on the network. At times this also necessitates different inspection and maintenance practices, such as more frequent visual inspections of critical assets.

Detail regarding the conditions, causes of deterioration and failure modes are described in Appendix B.

2.5 Risk assessment

The risk posed by switchgear due to the identified issues has been quantified by applying Power and Water's Risk-Quantification Procedure[2]. This procedure has been developed based on good electricity industry practice and taking into account the recent guidelines and determinations made by the AER, the ISO 31000 Risk Management Standard, and other professional publications.

The dominant impacts were found to be the economic cost of outages and the economic cost of safety:

- **public health and safety risks**: these assets are located in publicly accessible areas and can result in arcing and fires, step and touch potential rises, insufficient ground clearance and conductors falling to the ground.
- **deterioration in network reliability**: there is generally no redundancy for distribution assets so a failure will result in an outage to customers. The type of asset and its location on the network will impact the number of customers affected by the outage and how long it takes to restore supply.

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

While the consequence of public health and safety risk impacts are significant, the probability of them materialising is very low, hence the economic cost is found to be moderate. The assessment has been undertaken based on the counterfactual case that is, on the basis that Power and Water does not undertake any specific measures to address the increasing risks demonstrated by the increasing defect backlog and only reactively replaces assets that fail in service.

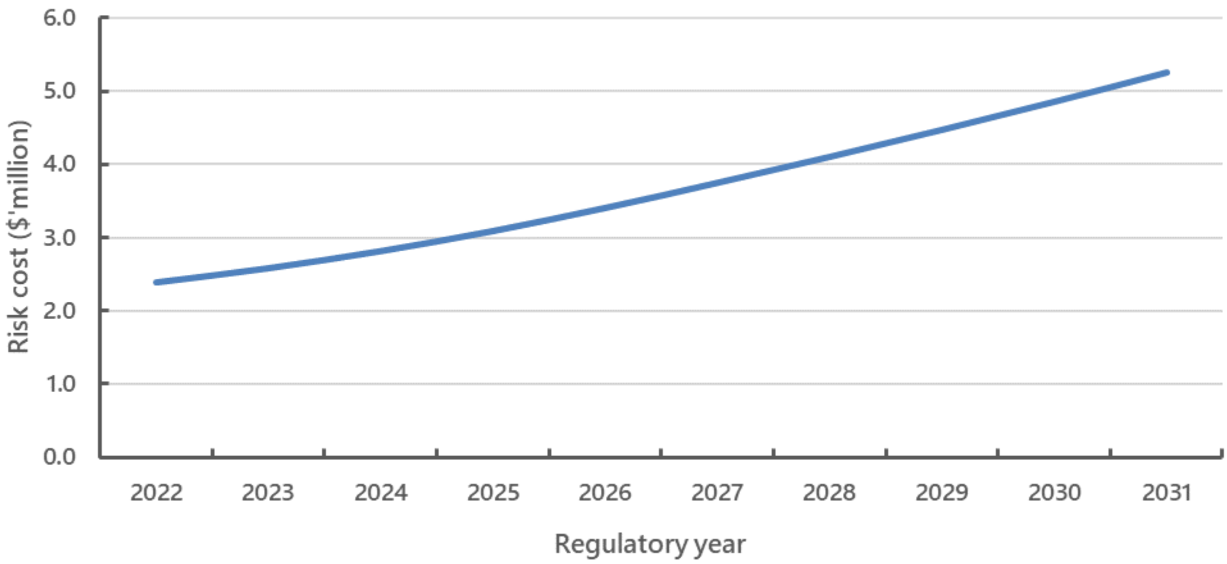

Figure 3 Annual risk cost with base case scenario

The risk assessment demonstrates that there is an increasing risk. The reduction in risk that is achieved by different credible mitigation options, along with the cost of the option and any other direct financial cost savings, is used to identify the preferred option for managing this asset fleet. The options analysis is provided in section 3.

2.6 Summary

The Pooled Assets make up a significant number of assets on Power and Water network that are critical for supplying consumers. They are individually low in value and, since they are on the distribution network, often do not have any redundancy so a failure will typically result in an outage.

Since 2018, Power and Water has addressed the condition-based replacement and post-fault replacement of these assets under the NMFCR program. Analysis of this program has demonstrated that there is an ongoing risk posed by these assets, predominately due to their impact on reliability and safety.

Application of a forecasting approach based on probabilistic modelling, making use of the age profile and expected life of each asset category, is consistent with common industry practice and the AER requirements for Pooled Assets. The outputs of the forecasting methods are reviewed against historical expenditure trends to provide confidence in the forecast.

The long-term trend has been volatile and remains a function of the asset age profile and environmental conditions. It is important to understand the contributing factors to levels of activity that may be considered 'off-trend' to ensure an efficient level of expenditure to restore and maintain supply to customers. More recently a reduced program has led to an increase in the number of defects and backlog which will be addressed by the end of the current regulatory control period.

3. Options analysis

This section describes the options that were analysed to address the increasing risk. The options are analysed based on their ability to address the identified need, 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

Credible options are identified that address the identified need, are technically feasible and can be implemented within the required timeframe. The following options have been identified:

- Option 1 – Do nothing (replace on failure). This option proposes to reactively replace assets once they have failed but not undertake any proactive replacement of assets.
- Option 2 - Conditions based replacement. This option proposes to continue the current network practices of condition-based replacement, as well as reactively replacing assets once they have failed.
- Option 3 - Proactive replacement. This option proposes to replace all assets that meet a BCR > 1 in addition to those assets identified under Option 2.
- Option 4 - Maintain risk (over 10 years). This option proposes to maintain network risk at the level it is projected to be at the start of the next regulatory period over the next 10 years.

A comparison of the four 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

Assessment metrics	Option 1	Option 2	Option 3	Option 4
NPV ($m, real FY22)		$2.3m	$1.4m	-$78.8m
BCR		0.11	-1.14	-0.10
Capex ($m, real FY22)	$34.5m	$32.2m	$45.9m	$135.3m
Meets customer expectations	○	●	◑	◑
Aligns with Asset Objectives	○	●	◑	◑
Resolved identified need	○	●	●	●
Technical Viability	◑	●	●	●
Deliverability	●	●	○	○
Preferred	✗	✓	✗	✗

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

Notes:

- The NPV and BCR have been adjusted to be relative to the counterfactual case (option 1)
- The risk reduction included (attributed to this program) starts in 2025 and is included through to 2029. It incorporates the forecast change to the risk profile based on the budget for the volumetric program during the current regulatory period.
- The NPV was calculated over the 5 year period of regulatory control period FY24 to FY29
- While this is likely to be an ongoing program of work, the capex presented in the table is only the amount required for the regulatory period 2024-29 and also excludes estimated expenditure for the remainder of the current regulatory period.

3.1.1 Option 1 – Do Nothing (replace at failure)

This option proposes to reactively replace assets once they have failed but not undertake any proactive replacement of assets, neither based on condition nor economic benefit.

As shown in Figure 4, our analysis demonstrates that this option will result in progressively increasing risk, driven by deterioration of network safety and reliability. This is consistent with the aging profile of the network and the 'replacement wall' – that is, the assets that were installed following Cyclone Tracy and the growth periods in the early 1980's and are now approaching the end of their serviceable lives.

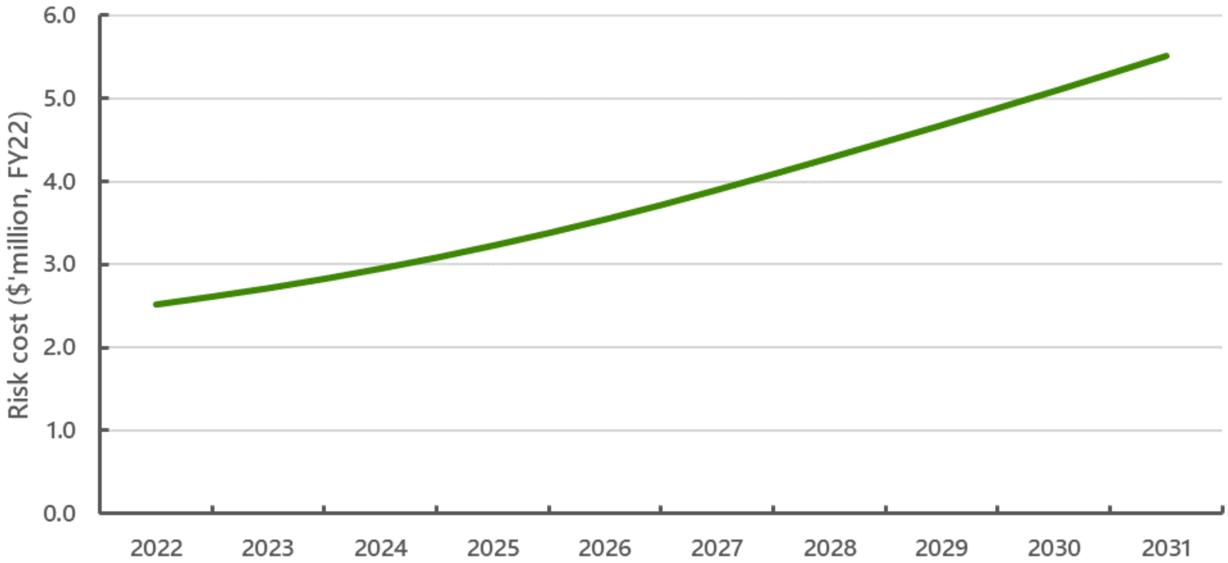

Figure 4 Risk profile for Option 1

Assets that fail will need to be replaced so there is a capital cost to this option. In addition, as set out in the Risk Quantification Procedure, reactive replacements have a higher unit cost (compared to the same asset replaced within a planned replacement program) due to the unplanned nature of the work. As a result, each replacement incurs the reactive replacement 'cost premium'.

The forecast expenditure profile for Option 1 is shown in Figure 5. The estimated cost of this program is expected to be higher than, but in line with, the trend that has emerged during the past few years.

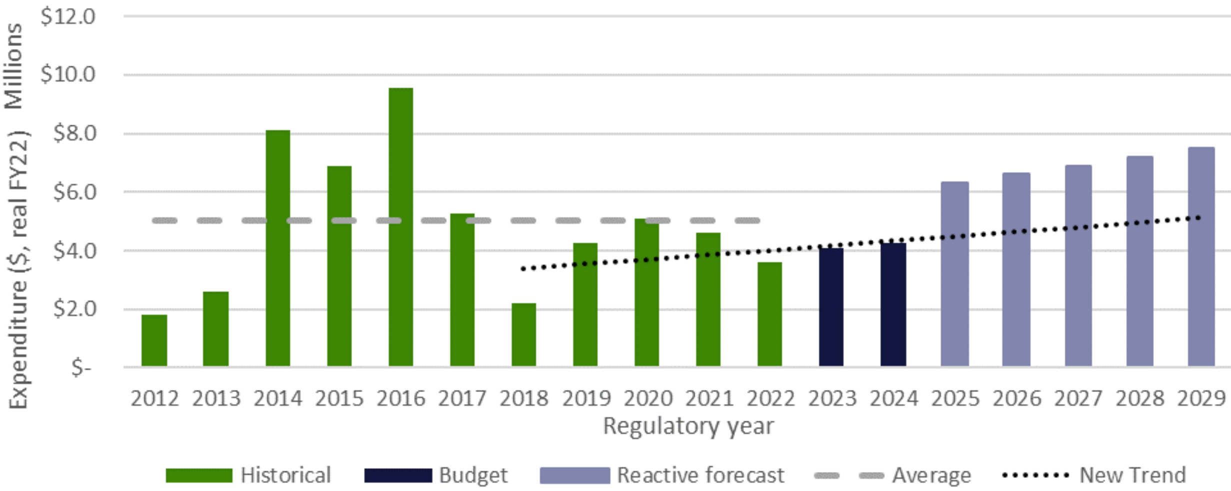

Figure 5 Historical expenditure and the forecast for Option 1

Since this option only replaces assets following a failure, each replacement incurs the full reactive replacement 'cost premium', resulting in an estimated cost of $34.5 million (real 2021/22). Additionally, it has the poorest network risk-cost outcome of the options assessed.

Since this option is the basis for assessment, there is no risk-cost reduction assigned. An NPV of the program was determined to be -$30.1 million based on the capital cost of the program over the assessment period.

Option 1 is a change to Power and Water's approach to managing the Pooled Assets. This approach is based on the premise that assets will only be replaced when they fail and not prior to failure when identified by inspections to be at end of life. Hence, Option 1 will result in an increase in asset failures. This is not in line with our Asset Objectives and does not comply with the NT NER Objectives of maintaining network safety and reliability.

In addition, with an increased number of assets replaced reactively, the unit rate will increase as a result of the reactive cost premium. This is reflected in our cost benefit analysis which also demonstrated that this option has the worst outcome for our customers.

This option is not recommended.

3.1.2 Option 2 – Condition based replacement (current practice)

Option 2 proposes to continue the current network practices that involve undertaking condition-based replacement of assets as they are identified to be unserviceable, through normal cyclic inspection or otherwise, as well as reactively replacing assets once they have failed.

For this option, the reactive replacement of assets that fail in service (disruptive failure) as well as assets identified for replacement at end of life due to field crew inspections are considered. This provides a view of network risk based on the current practices of Power and Water.

Replacing assets prior to failure reduces the risk-cost incurred and is shown in Figure 6. The risk profile is found to be similar to Option 1, but slightly lower.

Since both Option 1 and Option 2 include assets that fail in service, the actual difference in risk cost is fairly low. This is due to current inspection techniques whereby assets can only be identified as at end of life following failure. However, the reduction in the unit cost due to proactive replacement compared to incurring the reactive replacement premium is significant and in total there is approximately $2.3 million (real 2021/22) in savings for Option 2 when compared to Option 1.

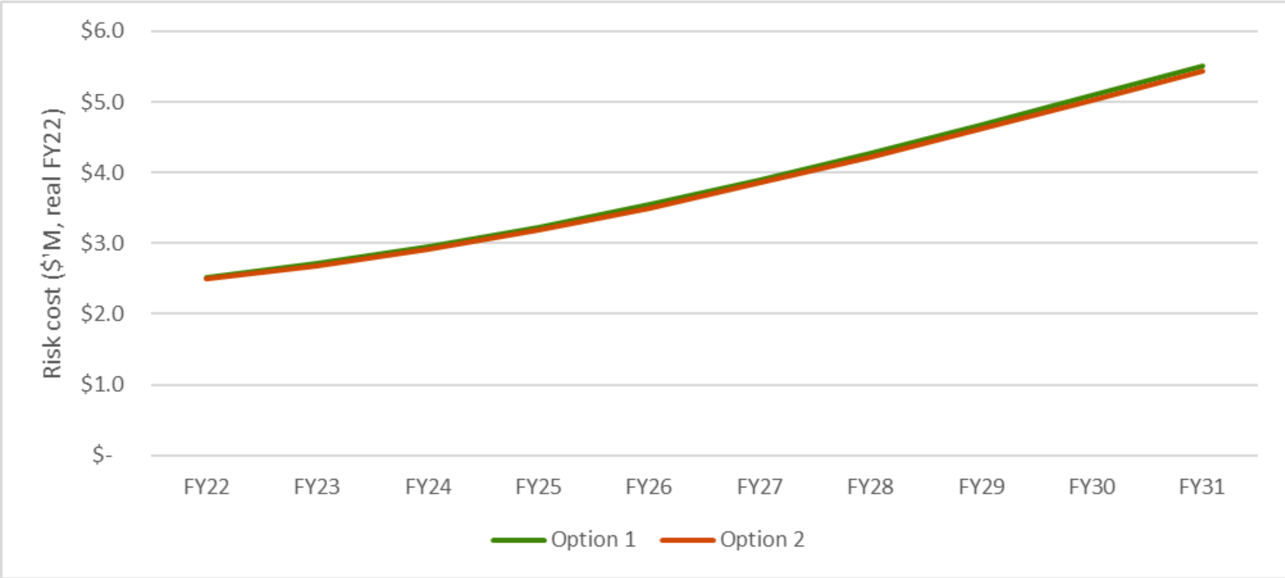

Figure 6 Forecast risk profile for Option 2

As shown in Figure 7, this approach results in a similar level of capex as Option 1, however the risk profile is slightly lower as more assets are replaced prior to failure, reducing the impact of outages and the higher cost of reactively replacing assets.

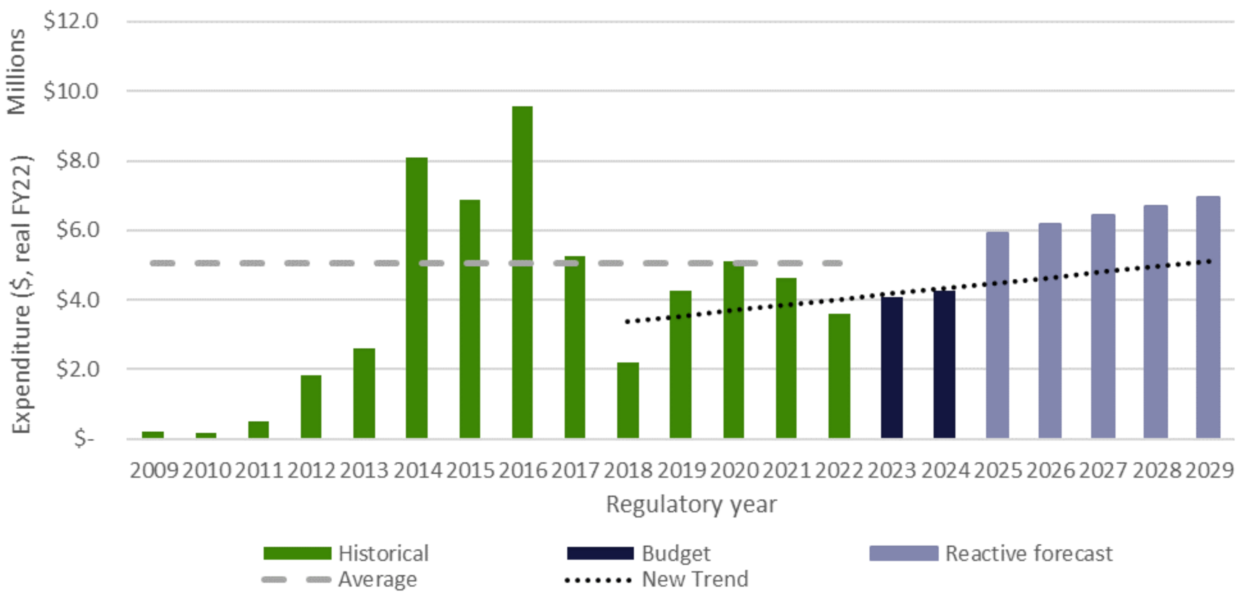

Figure 7 Historical expenditure and the forecast for Option 2

As Option 2 is the approach currently being applied and is contributing to Power and Water achieving the reliability targets set by the Utilities Commission of the Northern Territory (the Commission) and maintaining network performance. Hence, Option 2 will enable Power and Water to continue to meet its performance targets set by the Commission; its obligations under the NT NER which set out the requirements for Power and Water to maintain network reliability and safety; and is aligned to our Asset Objectives.

The total capital cost of this program is $32.2 million (real 2021/22) for the 2024-29 regulatory period. The benefit of the program was assessed using Option 1 as the base. Option 2 was found to have a NPV of $2.3 million and BCR of 0.11 relative to Option 1.

Option 2 has a lower estimated cost than Option 1 and has the highest NPV relative to Option 1 (base case) of all options assessed and provides the most certain delivery option based on current practice and meets our regulatory obligations. Option 2 also provides the highest level of certainty for delivery.

Option 2 is the recommended option.

3.1.3 Option 3 – Proactive replacement

This option proposes to change Power and Water's approach to inspection and replacement of the distribution assets with the intent of replacing all assets that meet a BCR > 1 as well as any assets that are identified to require replacement based on condition or that fail in service (consistent with the criteria for which Option 2 is based).

To determine the forecast requirements, the risk associated with each asset is calculated and compared to the annual equivalent cost of the asset. If the risk-cost is higher than the annual equivalent cost of the asset, it is deemed prudent and efficient to replace.

By removing assets with a risk-cost higher than their replacement cost, the overall risk of the network will be reduced in an efficient manner. The resultant risk on the network is shown in Figure 8. This shows that the risk starts from a lower level in FY25 compared with other options and increases at a slower rate compared to both Option 1 and Option 2.

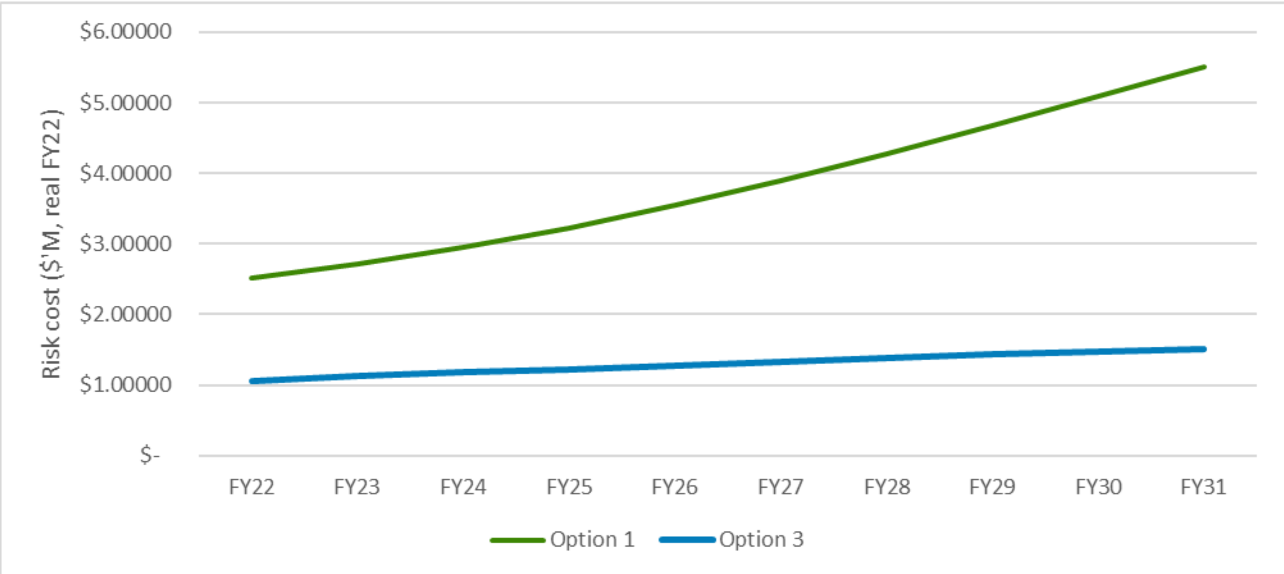

Figure 8 Forecast risk profile for Option 3

This option provides the best risk outcome for this set of assets. However, the cost is considerably higher than both Option 1 and Option 2, as shown in Figure 9, due to the increased expenditure on the proactive replacements.

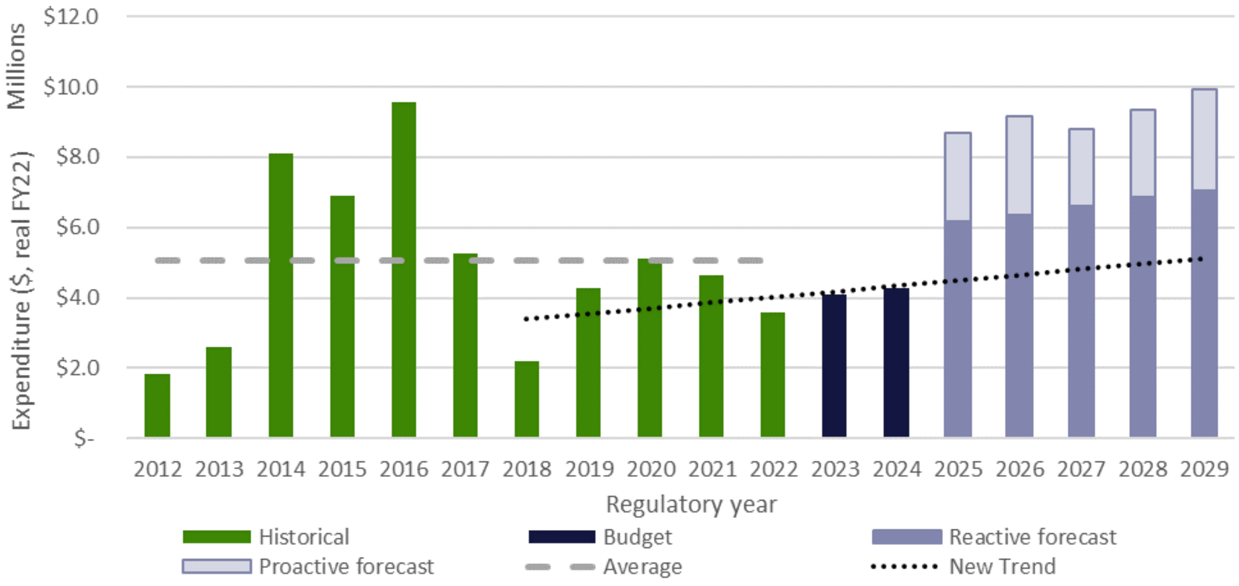

Figure 9 Historical expenditure and the forecast for Option 3

Power and Water recognises there is potential to replace assets on economic grounds to further improve network risk. However, Power and Water is not currently able to accurately select the assets required nor deliver the required volumes to derive the full benefit of this option. Figure 9 shows a step increase in delivery from 2023/24 to 2024/25 that is considered feasible. Accordingly, this represents an aspirational methodology.

The reduced risk-cost forecast of this Option is the upper limit of the benefit that could be expected, whereas in practice a lower level of benefit is more likely (higher resultant net risk-cost). Sensitivity analysis shows that the selection of assets for replacement on an economic basis must by at least 84% accurate in order to be preferred over Option 2.

Further, our assessment is that network risk can be managed more effectively by undertaking the targeted programs in our portfolio of works, rather than lifting the replacement rate significantly above our historical practices for the NMFCR program.

Feedback from our customers has shown that the level of service that Power and Water currently delivers is appropriate and the additional investment is not required purely for service improvements. However, a proactive approach may be required in the near future to enable us to manage increased replacements when the ‘replacement wall’ starts to impact the network.

To prepare for that situation, Power and Water is improving its asset management practices and asset data quality. This is a critical enabler of the capability to target the economically justified assets in addition to the condition-based asset replacements.

The total capital cost of this option is $45.9 million (real 2021/22) for the 2024-29 regulatory period.

Option 3 was found to have a NPV of $1.4 million and BCR of -1.14 compared to Option 1. While this has a positive NPV, it has significantly higher expenditure to achieve its improved risk outcome and the analysis shows that the additional expenditure does not provide a sufficient reduction in risk to result in a positive BCR.

For Option 3 to provide a superior outcome to Option 2, our selection of assets for proactive replacement must be at least 84% accurate or the NPV will be lower than Option 2. At this time, this level of accuracy is not able to be achieved. Further, Option 3 requires significantly more capex which is not considered deliverable.

Option 3 is not recommended.

3.1.4 Option 4 – Maintain network risk over 10 years

This option proposes to change Power and Water's approach to inspection and replacement of the distribution assets with the intent of maintaining network risk at the level it is projected to be at the start of the next regulatory period over the next 10 years.

The model assumes that the condition-based replacement approach is carried out (as per Option 2) and then additional replacements are undertaken so that the risk is maintained for each asset class. To achieve this, the risk associated with each asset is calculated and the assets are ranked from lowest to highest risk contribution. The assets that are above the risk threshold are replaced.

The resultant risk on the network is shown in Figure 10. This shows that the risk starts from a lower level in 2021/22, increases through to 2024/25 and is then maintained at a constant level.

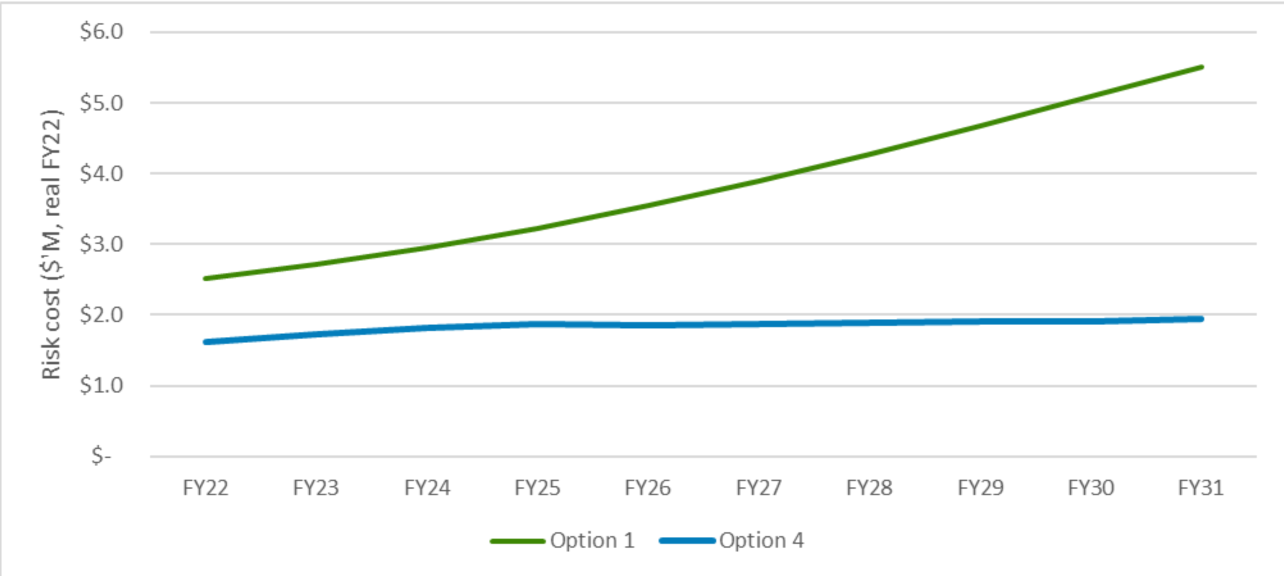

Figure 10 Forecast risk profile for Option 4

Power and Water recognises that while there is potential to replace assets in order to maintain network risk, it is not clear how this would be achieved in practice. This would require accurately identifying the risk of each asset based on condition in the field and understanding how it ranks compared to other assets in the fleet which is beyond our current capability.

The flat (maintained) risk-cost forecast as an outcome of this modelling is the upper limit of the benefit that could be expected, whereas in practice a lower level of benefit is more likely to be achieved (higher and increasing resultant net risk-cost) or require more expenditure to achieve the projected benefits.

The analysis also identified that to achieve this risk-profile, assuming accurate replacement of the appropriate assets, a significant step increase to our expenditure is required, as shown in Figure 11. The expenditure requirements under the maintain risk scenario is consistent with the aging profile of the network and the ‘replacement wall’ – that is, the assets that were installed following Cyclone Tracy and the growth periods in the early 1980’s and are now approaching the end of their serviceable lives. These assets will need to be replaced at an accelerated rate to maintain risk.

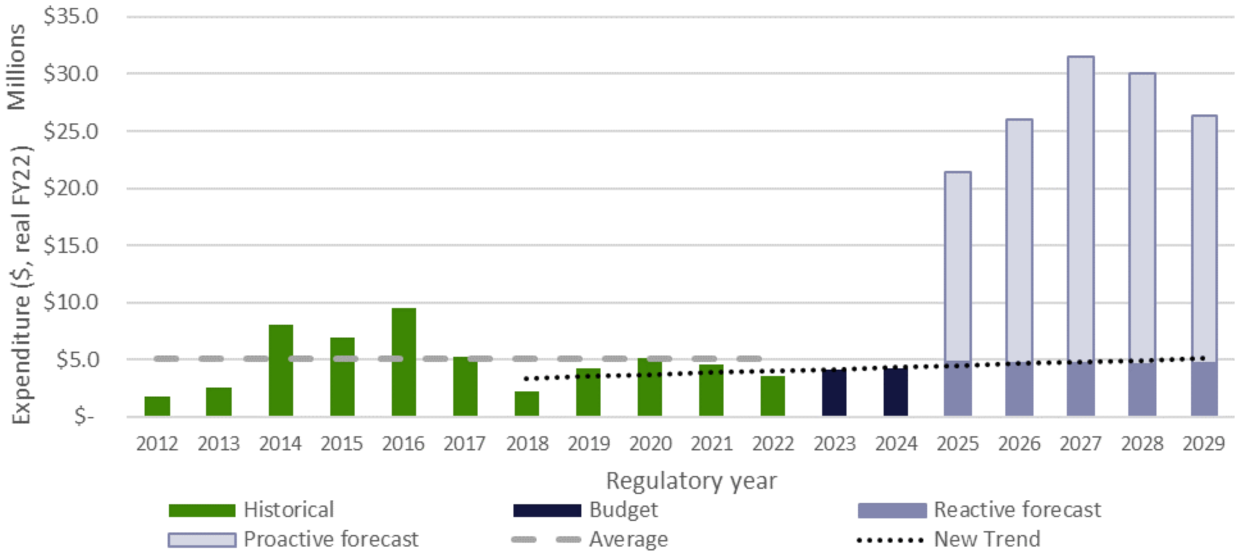

Figure 11 Historical expenditure and the forecast for Option 4

Our analysis of our portfolio of projects and programs demonstrates that network risk can be managed more effectively by undertaking the targeted programs in our portfolio of works, rather than lifting the replacement rate significantly above our historical practices for the NMFCR program. Our analysis is that this provides a better risk trade off (value of risk reduction per unit of capex).

Feedback from our customers has shown that the level of service that Power and Water currently delivers is appropriate and the additional investment is not required purely for service improvements. However, this analysis demonstrates that it is likely that the volume of asset replacement will need to be increased in the near future to manage risk in the longer term.

To prepare for that situation, Power and Water is improving its asset management practices and asset data quality. This is a critical enabler of the capability to target the economically justified assets in addition to the condition-based asset replacements.

The total capital cost of this program is $135.3 million (real 2021/22) for the 2024-29 regulatory period.

Option 4 was found to have a NPV of -$78.8 million and BCR of -0.1 relative to Option 1. While this option resulted in the greatest reduction in risk, the analysis demonstrates that the cost of program exceeds the benefits it would achieve.

The cost benefit analysis outcomes demonstrate that this is not a prudent or efficient option. So, while this program addresses the need and meets the regulatory obligations, it is not considered to be deliverable or beneficial on a cost benefit basis compared to the other options.

Option 4 is not recommended.

3.2 Non-Credible Options

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

3.2.1 Defer replacement to extend life – does not address the need

Based on the risk to public safety and risk to network reliability, Power and Water does not consider full deferral of replacement to be a prudent approach to managing the risk. However, the options identified consider different approaches to replacement and rates of replacement in order to assess the most efficient approach to addressing the identified need.

3.2.2 Retire or de-rate assets to extend life – does not address the need

Total retirement of the assets is not a credible option as the Pooled Assets are required for safe and reliable distribution of the electricity network. However, each option will assess where an individual asset can be retired or the topology can be changed to ensure prudency and efficiency of the option.

3.2.3 Non-Network alternatives – does not address the need, not technically feasible

Due to the type and function of the assets within the scope of this program, there are no non-network alternatives or solutions that can be implemented in place of direct asset replacement with like for like or modern equivalent assets.

3.2.4 Capex/Opex Substitution – does not address the need

All network assets are inspected on a cyclic basis by field crews to assess condition. However, due to limited maintenance or repairs that can be undertaken on these types of assets, it is not possible to extend their life through increased maintenance. Therefore, capex opex substitution is not a viable solution for these asset types. Typically, once the asset has deteriorated sufficiently and reached end of life it can only be replaced.

4. Recommendation

The recommended option is Option 2 – Condition based replacement at an estimated cost of $32.2 million (real 2021/22) to be the most prudent and efficient option to meet the identified needs.

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.

4.1 Strategic alignment

This program aligns with the Asset Objectives defined in the Strategic Asset Management Plan (SAMP) and Asset (Class) Management Plans (AMP). The capital investment into the distribution assets outlined in this program will contribute to the corporation achieving the goals defined in the boards Strategic Directions and SCI Key Result Areas of Health and Safety and Operational Performance.

4.2 Dependent projects

There are no projects or programs dependent on the completion of this program of works, and this program is not dependent on the completion of any other projects or programs.

4.3 Deliverability

This is a standard program of works that has been implemented historically and it is forecast to continue at volumes consistent with historical practice. Therefore, Power and Water is confident that the scope of works can be delivered based on historical practices and resources available.

4.4 Customer considerations

As required by the AER's Better Resets Handbook[3], 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 preparing this business case, has demonstrated strong support amongst the community for appropriate expenditure to enable long term maintenance of the network to ensure continued reliability, security and safety of supply.

4.5 Expenditure profile

This is the continuation of the NMFCR program which has been operating since 2018 as a defined program.

Prior to 2018, the replacement works were carried out under individual asset programs. Since 2018, the annual expenditure for the NMFCR program has been $5.1 million (real 2021/22) on average. The forecast for the next regulatory period is an increase to an average of $6.4 million per year. This increase is based on detailed modelling and is consistent with the aging nature of the network and significant volumes of assets that were installed post Cyclone Tracy and in the early 1980's growth period which will soon be reaching their end of life. This will start to impact the volumes of replacements required to manage network risk.

[3] Better Resets Handbook – Towards Customer Centric Network Proposals, Australian Energy Regulator, Dec 2021

The forecast expenditure is supported by detailed asset replacement modelling, which has been updated to reflect recent replacement volumes. Consistent with historical practices the program is dominated by replacement of distribution switchgear and distribution transformers.

The annual expenditure by asset category is shown in Table 5.

Table 5 Annual capital and operational expenditure by asset category ($'000, real 2021/22)

Asset category	FY25	FY26	FY27	FY28	FY29	Total
Poles	505	543	582	623	666	2,918
Pole Tops	630	675	721	770	820	3,616
Overhead Conductors	52	53	53	54	55	267
Underground Cables	544	553	561	569	575	2,802
Service Lines	20	21	21	22	23	107
Transformers	2,155	2,249	2,346	2,447	2,551	11,748
Switchgear	2,010	2,078	2,143	2,206	2,267	10,704
Total Expenditure	**5,917**	**6,170**	**6,428**	**6,691**	**6,956**	**32,162**

In addition to this program, targeted replacement programs to address specific issues relating to key asset classes and asset types have been included in the capex forecast, which enable a better risk-cost outcome for the expenditure. For example, a services replacement program. Accordingly, these assets have been largely excluded from this analysis. A small residual is retained for replacement of assets that fail in service and cannot be addressed by a planned replacement program.

4.6 Scope of works

Option 2 is comprised of two components:

- replacing assets that have failed in service, and
- replacing assets that are identified to be in poor condition during cyclic inspection programs.

Current replacement requirements based on asset condition and safety that have driven replacement activity in the current period will be maintained, and where possible optimised.

Other targeted programs to improve reliability to poorly served customers will be proposed and justified separately. These two approaches will therefore continue to be the mechanism through which network performance targets will be met.

The forecasting model is explained in detail in *Volumetric model description RevA*[4].

Table 6 Forecast annual replacement volumes by asset category

Asset category	FY25	FY26	FY27	FY28	FY29	Total
Poles	34	36	39	41	44	193
Pole Tops	89	96	102	109	116	513
Overhead Conductors (m)	57	58	59	60	60	294
Underground Cables (m)	17	17	17	17	18	86
Service Lines	7	7	7	7	8	36
Transformers	49	51	53	55	57	264
Switchgear	41	42	43	44	46	216

[4] TRIM reference D2022/474748

Appendix A. Cost estimation

The unit rates applied in this model are based on analysis of actual historical replacements as assessed by RIN category. These unit rates have been compared to peer DNSPs based on publicly available data from the Category Analysis RIN for the year 2018 to 2021, inclusive.

Refer to the Cost estimation methodology and approach document[5] for more details.

[5] TRIM reference D2022/474750

Appendix B. Modelling approach and assumptions

A consistent modelling approach has been applied to assess each of the options for managing the Pooled Assets.

To forecast the expenditure requirement for this option, Power and Water developed a probabilistic model that uses the principles set out by the AER in their application note for replacement planning[6] and are documented in Power and Water's Risk Quantification Procedure.

The approach applies good industry practice to forecast the level of expenditure required to address the forecast volume of assets that will fail in service. The model is calibrated to reflect recent historical replacements required on the network. This includes failed assets and those that were replaced based on condition but would have failed within a short period of time if not replaced, but excludes those that were replaced under a specific targeted program.

The model functionality is described in Volumetric model description RevA[7]. The basis of the models for each option is the same, with some changes to the logic to match the scenario being assessed.

[6] Industry practice application note for asset replacement planning, Australian Energy Regulatory, January 2019

[7] TRIM reference D2022/474748

Appendix C. Network and asset supporting information

C.1 Climate

Approximately 80% of Power and Waters network is located in a tropical coastal environment that is prone to tropical storms, tropical lows and cyclones. High humidity and high annual rainfall have multiple negative impacts on the condition of distribution assets. The issues are a challenge that is unique to Power and Water compared to other distribution networks throughout Australia. Key environment factors, which are the highest in Australia and that contribute to deterioration include:

- The highest frequency of lightning: direct strikes or surges resulting from strikes damage assets or result in immediate failure
- Highest UV intensity: results in damage to polymer materials and is related to time in service and exposure to sunlight
- Highest rainfall/humidity:
    - increases water ingress into assets which accelerates deterioration, corrosion and results in early asset failure.
    - can make access to assets or undertaking maintenance difficult, and along with the high temperatures, reduces the productivity of field crews[8].
- Highest average temperatures: reduces the efficiency of cooling and limits the capacity of assets. Particularly high underground temperature reduces the current carrying capacity of cables, either reducing the power transfer or requiring larger cables to be installed (resulting in higher capex and repex).

C.2 Fauna

Throughout the Northern Territory there are issues with fauna damaging assets. In particular, very aggressive termites and boring insects eat through external sheaths of cables and cause failures. This is a common occurrence and can present issues with identifying the location of the fault and then replacement of the faulted section. Other common fauna issues include:

- Large populations of larger animals, such as snakes, bats and birds cause faults and damage on overhead conductors and insulators.
- Bats are significant issue during migration periods (often multiple periods each year) and commonly cause phase to phase and phase to earth faults as they hang between conductors or aggregate on crossarms.
- During the dry season, small snakes and frogs commonly enter cable termination compartments in switchgear for warmth causing flashovers that can often damage switchgear beyond economical repair.

C.3 Asset replacement drivers

This business case describes issues with distribution assets due to normal in-service failures and unserviceability due to poor condition. The replacement program targets the following asset types that are regarded as 'volumetric' meaning high volumes but low unit costs:

- Distribution transformers
- Distribution switches
- Overhead conductor
- Connectors
- Surge arrestors
- Pole top structures

[8] Labour Efficiency and Work Management in Hot Humid Climates, Thermal Hyperformance

- Underground cables
- Service lines

These distribution assets are found in publicly accessible locations as they are required for supplying electricity from zone substations at distribution voltages of 22kV through to connection to customer premises at voltages of 415V.

Over time the condition of these assets deteriorates and they eventually fail or become inoperable. Causes of asset deterioration are described by asset type in section C.4 below, and include adverse environmental conditions, repeated operation of mechanical parts, and use above rated capacity.

Events such as severe storms and lightning, animal contact, manufacturing defects and various other external influences can also cause premature failure of an asset or damage an asset in a way that is not economical to repair.

Asset failure or inoperability have two key consequences which are modelled under the Risk Quantification Procedure:

- **public health and safety risks:** these assets are located in publicly accessible areas and can result in arcing and fires, step and touch potential rises, and conductors falling to the ground. These failure modes pose hazards to public safety.
- **deterioration in network reliability:** there is generally no redundancy for these assets so a failure will result in an outage to customers.

Power and Water undertakes inspection and testing in accordance with the maintenance policy and associated strategies. The detailed tasks and frequency of inspection and testing to be undertaken for each asset type is generally based on analysis of observed asset failure modes, manufacturer's recommendations and benchmarking with other utilities through various industry forums. During testing and inspection, assets are identified that require repair, or if repair is not possible or not economical, replacement. The specific assets requiring replacement are not known until cyclic inspection/testing is undertaken. Asset condition data is not generally available for these assets, and neither is it generally possible to undertake major repairs.

C.4 Asset deterioration and failure modes

Some of the common causes of deterioration are described below by asset class. These failure modes are age related in that the impact of use and the environment progressively deteriorates the assets over time. The rate of deterioration will depend on utilisation, location (i.e. proximity to the ocean), frequency of operation and other environmental factors. Further information on failure modes, causes, maintenance activities and replacement decision making criteria is available in relevant Asset Class Management Plans.

Distribution transformers

- Deterioration due to environmental condition and use, including external corrosion, leaking oil and deterioration of internal insulation that can lead to failure.
- Moisture ingress due to leaks that reduce insulation performance of oil, increasing susceptibility to surge (lightning) related internal flashovers.
- Over utilisation resulting in deterioration of internal components and eventually failure.
- Over utilisation (above rated capacity) can result in destruction of the asset and potentially fire (i.e. under rated distribution transformer).
- Direct lightning strikes that cause internal insulation, tank or bushing damage.
- Severe weather events such as tropical storms, tropical lows and cyclones.

Distribution switches

- Deterioration due to environmental condition and use, including external corrosion, leaking oil/gas and arcing during operation damaging contacts.
- UV degradation of insulation and plastic components in switch mechanisms and arc suppressors.
- Deterioration of mechanical and operational parts due to environmental conditions (corrosion) or high number or frequency of operations.
- Deterioration of insulation performance due to ageing and a hot and humid operating environment with short annual periods of extremely dry conditions that promote the build-up of dust on insulating surfaces.
- Cable termination failures due to various causes that directly damage the switchgear.
- Direct lightning strikes that damage switchgear components.
- Severe weather events such as tropical storms, tropical lows and cyclones.

Overhead conductor

- Damage at joints or connection to insulators due to movement and vibration.
- Corrosion of metallic components (i.e. galvanised strands ACSR or steel conductors).
- Damage from direct lightning strikes causing annealing, broken strands and damage to galvanising.
- Damage from external causes such as debris during annual wet season storms, tropical lows and cyclones or contact with vegetation or animals.

Underground cable

- External causes, such as digging equipment damaging cables.
- Water ingress damaging components such as the sheathing, screening and XPLE.
- Failure of the joint due to poor installation (often compounded by environmental conditions).
- High utilisation and high ground temperatures that stress insulation, connectors and joints.
- Damage caused by fauna such as termites.

Surge arrestors

- Failures (operation) in service and due to high volume of lightning related operations.
- Direct lightning strikes that exceed the capacity of the arrestor causing internal damage.
- Deterioration of external casing resulting in flash over/water ingress/other.

Poles

- Corrosion of underground sections due to salt and moisture.
- Damage from external causes such as vehicles or during annual wet season storms, tropical lows and cyclones or contact with vegetation or animals.

Pole Top structures

- Corrosion of sections due to salt and moisture, predominately in coastal locations.
- Damage from direct lightning strikes.
- Damage from external causes such as debris during annual wet season storms, tropical lows and cyclones or contact with vegetation or animals.

The impact of these modes of deterioration are an increased likelihood of asset failure and risk to safety and network reliability.

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